Final Report

FEHMARNBELT FIXED LINK BIRD SERVICES (FEBI)

Fauna and Flora - Birds – Impact Assessment

Birds of the Fehmarnbelt Area

E3TR0015

Prepared for: Femern A/S
By: DHI / BioConsult SH Consortium
in association with University of Copenhagen and BIOLA

Responsible editor:
FEBI consortium / co DHI
Agern Allé 5
DK-2970 Hørsholm
Denmark

FEBI Project Director: Anders Malmgren Hansen, DHI
www.dhigroup.com

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Photos:
Monika Dorsch (Cover page, p 193), Martin Laczny (p 209)

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Note to the reader:
In this report the time for start of construction is artificially set to 1 October 2014 for the tunnel and 1 January 2015 for the bridge alternative. In the Danish EIA (VVM) and the German EIA (UVS/LBP) absolute year references are not used. Instead the time references are relative to start of construction works. In the VVM the same time reference is used for tunnel and bridge, i.e. year 0 corresponds to 2014/start of tunnel construction; year 1 corresponds to 2015/start of bridge construction etc. In the UVS/LBP individual time references are used for tunnel and bridge, i.e. for tunnel construction year 1 is equivalent to 2014 (construction starts 1 October in year 1) and for bridge construction year 1 is equivalent to 2015 (construction starts 1st January).

1 EXECUTIVE SUMMARY

1.1 Introduction

In this report the time for start of construction is artificially set to 1 October 2014 for the tunnel and 1 January 2015 for the bridge alternative. In the Danish EIA (VVM) and the German EIA (UVS/LBP) absolute year references are not used, but instead the relative time references from start of construction works (year 0, year 1, etc.), i.e. year 0 corresponds to 2014; year 1 corresponds to 2015 etc.

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 two main alternatives that being considered for the fixed link are:

- An immersed tunnel
- A cable stayed bridge

In addition to two main alternatives of a fixed link, a Zero-Alternative has also been considered, which refers to a solution without constructing a fixed link.

As part of the EIA for the Fehmarnbelt Fixed Link, Femern A/S has commissioned the Fehmarnbelt Fixed Link Bird Services (FEBI) consortium to conduct baseline studies and undertake the Impact Assessment for birds in marine areas of the Fehmarnbelt as outlined in the scoping report (Femern A/S and LBV-SH-Lübeck 2010).

1.2 Description of the project

Zero-Alternative
The Zero-Alternative describes the future situation without the establishment of a fixed link. The assessment year for the operation phase of the fixed link is considered to be 2025 and 2030, corresponding to 15 and 20 years after the baseline study was finalised. The Zero-Alternative will be influenced by human-induced changes that happen within the 15-20 year time span between the baseline study and assessment years of the fixed link operation. Defining the Zero-Alternative involves identifying and quantifying human-induced changes that could significantly change the situation described in the baseline studies and thereby influence the outcome of the comparison between Zero-Alternative and a preferred fixed link alternative in the EIA.

The following human activities were identified as pressures affecting landscape, nature, habitats and thus also birds in the Fehmarnbelt which are also expected to continue in the years 2025 to 2030:

- Establishment of new offshore wind farms
- Intensive fishing with gillnets and trawls

- Mortality of waterbirds from hunting
- Pollution with contaminants including toxic substances originating from a range of different sources
- Eutrophication

Changes due to implementation of new international legislation are considered affecting the conditions for birds in the years 2025 and 2030 and thus the Zero-Alternative. Therefore all known relevant EU legislation have been taken into consideration with respect to possible implications for the Zero-Alternative:

- The Water Framework Directive (Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy
- The Marine Strategy Framework Directive (Directive 2008/56/EC of the European Parliament and the council of 17 June 2008)

However, changes occurring according to this are unpredictable or unquantifiable at the present stage.

No relevant changes with regard to the Zero-Alternative are expected to result from current spatial planning and forecasts on traffic intensity and demography.

Climate change scenarios predict a reduced habitat suitability of the Fehmarnbelt region for wintering waterbirds for the next decades, thus having possible implications for the Zero-Alternative.

Tunnel alternative
The alignment for the immersed tunnel passes east of Puttgarden, crosses the Fehmarnbelt in a soft curve and reaches Lolland east of Rødbyhavn. The immersed tunnel will be constructed by placing tunnel elements in a trench dredged in the seabed. Reclamation areas are planned along both the German and Danish coastlines to accommodate the dredged material from the excavation of the tunnel trench. The landfall of the immersed tunnel passes through the shoreline reclamation areas on both the Danish and German sides. Temporary harbours will be integrated into these coastal reclamations to service tunnel construction operations from both the German and Danish ends of the immersed tunnel.

Bridge alternative
The main bridge is a twin cable stayed bridge with three central pylons and two main spans of 724 m each. The superstructure of the cable stayed bridge consists of a double deck girder with the dual carriageway road traffic running on the upper deck and the dual track railway running on the lower deck. The main bridge is connected to the coasts by two approach bridges. The southern approach bridge is 5,748 m long and consists of 29 spans and 28 piers. The northern approach bridge is 9,412 m long and has 47 spans and 46 piers. As for the tunnel option, temporary harbours and reclamation areas will be required.

1.3 Birds in the Fehmarnbelt

The Fehmarnbelt area is of considerable importance for many bird species. A high number of waterbirds, such as wintering seaducks, moulting swans and many other species spend their non-breeding season in the region. The area also provides suitable and important breeding habitats for several waterbird species. Large parts of the Fehmarnbelt area and adjacent inland habitats are protected as Natura 2000 sites, which have been designated to protect important areas for staging and breeding birds. During spring and autumn large numbers of landbirds and waterbirds pass the Fehmarnbelt area on migration. Landbirds such as birds of prey and other daytime migrating species concentrate in the area, using the relatively short distance between Fehmarn and Lolland to cross the Baltic Sea. Many species of daytime migrating landbirds try to minimise the distance they fly over water, therefore Fehmarnbelt has a channelling effect for these. Waterbirds which prefer to fly over water, pass the Fehmarnbelt in large numbers parallel to the coast line, most of them during daytime, but some also during night-time. Nocturnally migrating birds also pass the area on their broad-front migration. The large numbers of birds migrating through the area twice a year make the Fehmarnbelt an internationally important migration corridor between breeding areas in Fennoscandia, Eastern Europe and Siberia and wintering areas in Europe and Africa.

The Impact Assessment on birds in marine areas was conducted separately for the following environmental components:

- Breeding waterbirds: only impacts on birds breeding in marine habitats, and birds breeding in inland SPAs but using marine areas were assessed.
- Non-breeding waterbirds
- Migrating birds

The Impact Assessment for each environmental component was conducted on the species level wherever possible.

1.4 Relevant project pressures

Among the pressures, which could potentially affect birds in marine areas, as described in the scoping report (Femern A/S and LBV-SH-Lübeck 2010), the pressures listed below (Table 6.1 – Table 1.4) were identified as relevant for birds from construction and operation of the tunnel or bridge main alternatives. The pressures are listed separately for the tunnel and bridge alternatives and for construction and operation periods. For every pressure the possible effects, the environmental components affected, the duration of a pressure and – if applicable – the extent of the impact zone is given below.

Tunnel alternative

Construction phase

For the construction phase of an immersed tunnel in the Fehmarnbelt six different pressures were identified as being relevant for birds in marine areas. Pressures 'barrier from construction vessels' and 'collision with construction vessels' are relevant for all three environmental components. Habitat loss from footprint, habitat change from sediment spill, reduced water transparency and disturbance from construction vessels are relevant for two components only, breeding and non-breeding waterbirds (Table 6.1).

Table 1.1 Overview of pressures resulting from construction of an immersed tunnel in the Fehmarnbelt with identified pressure effect, affected environmental components, duration of impact and impact zone.

Tunnel – Construction phase	
Pressure	**Habitat loss from footprint**
Pressure effect	Displacement from lost habitats
Affected environmental components	• Breeding waterbirds • Non-breeding waterbirds
Duration of impact	Construction phase
Impact zone	Tunnel footprint
Pressure	**Habitat change from sediment spill**
Pressure effect	Displacement from areas with reduced food (benthic flora/fauna, fish) availability (indirect impact from the sediment spill)
Affected environmental components	• Breeding waterbirds • Non-breeding waterbirds
Duration of impact	Construction phase
Impact zone	Extent depends on relevant food organisms (benthic fauna, benthic flora, fish)
Pressure	**Reduced water transparency**
Pressure effect	Displacement from areas with reduced water transparency below a certain threshold (direct impact from the sediment spill)
Environmental components affected	• Breeding waterbirds • Non-breeding waterbirds
Duration of impact	Construction phase
Impact zone	Varies with year of construction
Pressure	**Disturbance from construction vessels**
Pressure effect	Displacement from the disturbance zone (impact zone)
Affected environmental components	• Breeding waterbirds • Non-breeding waterbirds
Duration of impact	Construction phase
Impact zone	Tunnel footprint and 3 km buffer zone around it
Pressure	**Barrier from construction vessels**
Pressure effect	A barrier effect results, depending on species' sensitivity, in minor reactions, detour flights around or above the barrier (extra energy expenditures) to birds not crossing the barrier at all; possible changes in habitat use of local waterbirds
Affected environmental components	• Breeding waterbirds • Non-breeding waterbirds • Migrating birds
Duration of impact	Construction phase
Impact zone	not applicable

Tunnel – Construction phase	
Pressure	**Collision with construction vessels**
Pressure effect	Collision with structures of construction vessels (accidentally or attracted by lights)
Affected environmental components	• Breeding waterbirds • Non-breeding waterbirds • Migrating birds
Duration of impact	Construction phase
Impact zone	not applicable

Operation and structures

For the operation phase of an immersed tunnel in the Fehmarnbelt no pressures were identified being relevant for the assessment of migrating birds. For breeding and non-breeding waterbirds the pressures 'habitat loss from footprint', 'provision of artificial reefs' and 'hydrographical changes' are considered relevant (Table 1.2).

Table 1.2 Overview of pressures resulting from structure and operation of an immersed tunnel in the Fehmarnbelt with identified pressure effect, affected environmental components, duration of impact and impact zone.

Tunnel – Operation and structures	
Pressure	**Habitat loss from footprint**
Pressure effect	Displacement from lost habitats
Affected environmental components	• Breeding waterbirds • Non-breeding waterbirds
Duration of impact	Operation phase
Impact zone	Tunnel footprint
Pressure	**Provision of artificial reefs**
Pressure effect	Changes in distribution due to changes in food availability, possible attraction
Affected environmental components	• Breeding waterbirds • Non-breeding waterbirds
Duration of impact	Operation phase
Impact zone	Submerged hard substrate areas of the tunnel footprint
Pressure	**Hydrographical changes**
Pressure effect	Changes in distribution due to changes in food availability, possible attraction
Affected environmental components	• Breeding waterbirds • Non-breeding waterbirds
Duration of impact	Operation phase
Impact zone	Areas close to tunnel footprint (land reclamations)

Bridge alternative

Construction phase

The same six pressures, which were identified as being relevant for the tunnel construction, were also assessed to be relevant for the impact assessment for the construction of a cable stayed bridge, though the extent of the impact zones vary between the main alternatives. The pressures 'barrier from construction vessels' and 'collision with construction vessels' are relevant for all three environmental components where 'habitat loss from footprint', 'habitat change from sediment spill', 'reduced water transparency' and 'disturbance from construction vessels' are considered relevant for breeding and non-breeding waterbirds only (Table 1.3).

Table 1.3 An overview of pressures resulting from construction of a cable stayed bridge in the Fehmarnbelt with identified pressure effect, affected environmental components, duration of impact and impact zone.

Bridge – Construction phase	
Pressure	**Habitat loss from footprint**
Pressure effect	Displacement from lost habitats
Affected environmental components	• Breeding waterbirds • Non-breeding waterbirds
Duration of impact	Construction phase
Impact zone	Bridge footprint
Pressure	**Habitat change from sediment spill**
Pressure effect	Displacement from areas with reduced food (benthic flora/fauna, fish) availability (indirect impact from the sediment spill)
Affected environmental components	• Breeding waterbirds • Non-breeding waterbirds
Duration of impact	Construction phase
Impact zone	Extent depending on relevant food organisms (benthic fauna, benthic flora, fish)
Pressure	**Reduced water transparency**
Pressure effect	Displacement from areas with reduced water transparency below a certain threshold (direct impact from the sediment spill)
Affected environmental components	• Breeding waterbirds • Non-breeding waterbirds
Duration of impact	Construction phase
Impact zone	Varies with year of construction
Pressure	**Disturbance from construction vessels**
Pressure effect	Displacement from the disturbance zone (impact zone)
Affected environmental components	• Breeding waterbirds • Non-breeding waterbirds
Duration of impact	Construction phase
Impact zone	Bridge footprint and 3 km buffer zone around alignment
Pressure	**Barrier from construction vessels**
Pressure effect	A barrier effect results, depending on species' sensitivity, in minor reactions, detour flights around or above the barrier (extra energy expenditures) to birds not crossing the barrier at all; possible changes in habitat use of local waterbirds
Affected environmental components	• Breeding waterbirds • Non-breeding waterbirds • Migrating birds
Duration of impact	Construction phase
Impact zone	not applicable

Bridge – Construction phase	
Pressure	**Collision with construction vessels**
Pressure effect	Collision with structures of construction vessels (accidentally or attracted by lights)
Affected environmental components	• Breeding waterbirds • Non-breeding waterbirds • Migrating birds
Duration of impact	Construction phase
Impact zone	not applicable

Operation and structures

During the operation phase of a cable stayed bridge in the Fehmarnbelt, eight pressures were identified as relevant for breeding and non-breeding waterbirds (Table 1.4). Of these, the pressures 'barrier from bridge structure and traffic', 'collision with bridge structures' and 'collision with traffic' are relevant for migrating birds as well.

Table 1.4 Overview of pressures resulting from structure and operation of a cable stayed bridge in the Fehmarnbelt with identified pressure effect, affected environmental components, duration of impact and impact zone.

Bridge – Operation and structures	
Pressure	**Habitat loss from footprint**
Pressure effect	Displacement from lost habitats
Affected environmental components	• Breeding waterbirds • Non-breeding waterbirds
Duration of impact	Operation phase
Impact zone	Bridge footprint
Pressure	**Provision of artificial reefs**
Pressure effect	Changes in distribution due to changes in food availability, possible attraction effects
Affected environmental components	• Breeding waterbirds • Non-breeding waterbirds
Duration of impact	Operation phase
Impact zone	Submerged hard substrate areas of the bridge (piers, pylons) and embankment structures
Pressure	**Hydrographical changes**
Pressure effect	Changes in distribution due to changes in food availability, possible attraction effects
Affected environmental components	• Breeding waterbirds • Non-breeding waterbirds
Duration of impact	Operation phase
Impact zone	Areas close to the bridge structures (piers and pylons)
Pressure	**Disturbance from bridge structure and traffic**
Pressure effect	Displacement from the disturbance zone (impact zone)
Affected environmental components	• Breeding waterbirds • Non-breeding waterbirds
Duration of impact	Operation phase
Impact zone	Bridge structure and 2 km buffer zone around alignment

Bridge – Operation and structures	
Pressure	**Disturbance from channelling of shipping**
Pressure effect	Displacement from the disturbance zone (impact zone); likely reduction of disturbance in areas where shipping gets reduced due to the channelling effect
Affected environmental components	• Breeding waterbirds • Non-breeding waterbirds
Duration of impact	Operation phase
Impact zone	Central Fehmarnbelt
Pressure	**Barrier from bridge structure and traffic**
Pressure effect	A barrier effect results, depending on species' sensitivity, in minor reactions, detour flights around or above the bridge (extra energy expenditures) to birds not crossing the bridge at all; possible changes in habitat use of local waterbirds
Affected environmental components	• Breeding waterbirds • Non-breeding waterbirds • Migrating birds
Duration of impact	Operation phase
Impact zone	Not applicable
Pressure	**Collision with bridge structures**
Pressure effect	Collision with bridge structures (accidentally or attracted by lights)
Affected environmental components	• Breeding waterbirds • Non-breeding waterbirds • Migrating birds
Duration of impact	Operation phase
Impact zone	Not applicable
Pressure	**Collision with traffic**
Pressure effect	Collision with car or train traffic on the bridge (accidentally or attracted by lights or while scavenging on other collision victims)
Affected environmental components	• Breeding waterbirds • Non-breeding waterbirds • Migrating birds
Duration of impact	Operation phase
Impact zone	Not applicable

1.5 *Approach and Impact Assessment methodology*

The baseline investigations undertaken by FEBI provide information on the spatial and temporal use of the Fehmarnbelt and adjacent waters by birds (FEBI 2013). The area of investigation for the Impact Assessment for non-breeding waterbirds stretches from a line between Kiel and Langeland in the west to a line between Gedser and Dahmeshöved in the east. The bird migration studies were conducted primarily in the alignment area with radar stations operated in Puttgarden, Rødbyhavn and offshore in the central Fehmarnbelt. The importance of the study area to different bird species is assessed in the baseline reports (FEBI 2013).

Femern A/S provided all consortia with a standard methodological protocol for the Impact Assessment, which was followed by FEBI adjusting it for specific needs in the assessment of birds. As a first step, the sensitivity of bird species to the different pressures was assessed using baseline data and literature information. The sensitivity of a species to a pressure and the magnitude of a pressure define the degree of impairment. However, the magnitude of pressure and the sensitivity of a bird species to a pressure often cannot be treated separately as the magnitude of pressure in some cases cannot be assessed without assessing the species' sensitivity. The degree of impairment describes a species response to a particular pressure, e.g. the proportion of birds getting displaced from the impairment zone. FEBI defined criteria for assessing the degree of impairment of the different pressures as shown in Table 4.8. A very high degree of impairment is regarded to correspond to loss of function (very high magnitude of pressure) within the impairment zone.

Table 1.5 Criteria for assessing the degree of impairment affecting the environmental components breeding waterbirds, non-breeding waterbirds and migrating birds (incl. waterbirds and landbirds) based on the sensitivity of a species to a pressure.

Construction-, structure- or operation-related pressures of the project	Degree of impairment	Description of the degree of impairment
Barrier effect	Very high	Barrier is complete for a large proportion of a population or a complete population concerning migration routes (migrating birds) and exchange flights (breeding and non-breeding waterbirds). There are no alternative flight routes since birds do not fly over land. No connectivity between resting and foraging areas at both sides of the barrier.
	High	Barrier is not complete, but migrating birds show strong reactions to the barrier, e.g. modification of migration routes. Reduced connectivity between breeding, resting and foraging areas at both sides of the barrier for breeding and non-breeding waterbirds.
	Medium	Barrier results in additional reactions, but will be crossed eventually (migrating birds, breeding and non-breeding waterbirds).
	Minor	Minor barrier effect; birds show minor reactions and fly above or below the structure (migrating birds, breeding and non-breeding waterbirds).
Collision risk	Very high	A high proportion of birds migrating through or breeding/resting/wintering in the Fehmarnbelt is expected to collide with the structure on a regular basis.
	High	A small proportion of birds migrating through or breeding/resting/wintering in the Fehmarnbelt is expected to collide with the structure on a regular basis. Adverse weather conditions* are expected to increase collision rates.
	Medium	Collisions are unlikely, but adverse weather conditions may result in collision incidents (migrating birds, breeding and non-breeding waterbirds).
	Minor	Collisions are unlikely. Only single birds are expected to collide with the structure (migrating birds, breeding and non-breeding waterbirds).

Construction-, structure- or operation-related pressures of the project	Degree of impairment	Description of the degree of impairment
Disturbance	Very high	50–100% of breeding or non-breeding waterbirds are expected to get displaced from the impairment zone, or the degree of displacement is not assessable.
	High	25–50% of breeding or non-breeding waterbirds are expected to get displaced from the impairment zone.
	Medium	5–25% of breeding or non-breeding waterbirds are expected to get displaced from the impairment zone.
	Minor	Disturbance does not lead to a detectable displacement of breeding or non-breeding waterbirds (<5% displacement).
Habitat change	Very high	Habitat changes result in 50–100% reduction in bird numbers within the impairment zone, or the degree of reduction in bird numbers in not assessable.
	High	Habitat changes result in 25–50% reduction in breeding or non-breeding waterbird numbers within the impairment zone.
	Medium	Habitat changes result in 5–25% reduction in breeding or non-breeding bird numbers in the impairment zone.
	Minor	Habitat changes do not result in a detectable reduction in breeding or non-breeding bird numbers (<5% displacement).

** Adverse wheather conditions, when considering collision risk, refer to bad visibility, fog, strong rain, strong head winds.*

The severity of impairment was assessed by combining the degree of impairment with the importance of the area to the respective bird species (using GIS tools where possible). Likewise, the assessment of the severity of loss (habitat loss from the project footprint) corresponds to the importance level of the area lost to a species. As a final step of the Impact Assessment the significance of impact was assessed.

1.6 Impact assessment of the tunnel alternative

Construction phase

Habitat loss from footprint

During the construction of an immersed tunnel marine habitats will be lost for waterbirds from dredging the tunnel trench, building working harbours, elevated protection reefs and land reclamations. A habitat loss is given either from complete loss of marine areas (land reclamations) or from loss of the natural seabed (covered by additional substrate or removed by dredging).

For breeding waterbirds the severity of loss is assessed as minor, since the areas that will be lost to the footprint are assessed to be of minor importance to these birds.

Regarding non-breeding waterbirds the severity of loss is assessed to be high for two diving duck species, Common Pochard and Tufted Duck (Table 1.6). Coastal areas, which are predicted to be lost from the land reclamations, especially at the Danish side, are assessed to be of high importance as resting and possibly foraging habitat for these species. For all other non-breeding waterbirds the severity of loss is assessed as minor.

The pressure 'habitat loss from footprint' is not relevant for migrating birds.

Table 1.6 Summary of impact assessment for the pressure 'habitat loss from footprint' during the construction of an immersed tunnel in the Fehmarnbelt to the environmental components breeding waterbirds (waterbirds breeding in Natura 2000 areas only), non-breeding waterbirds and migrating birds.

Tunnel – construction phase – habitat loss from footprint			
Species	**Number of displaced birds**	**% biogeographic/ relevant reference population**	**Severity of loss**
Breeding waterbirds			
All breeding waterbird species	low number	-	Minor
Non-breeding waterbirds			
Common Pochard	710	0.20	High
Tufted Duck	7,100	0.59	High
Other non-breeding waterbird species	low number	<0.10	Minor
Migrating birds			
All migrating bird species	no impact	no impact	no impact

Habitat change from sediment spill

During the construction of an immersed tunnel a large amount of sediments would be moved while dredging the tunnel trench and the working harbours, backfilling the trench, depositing the material at land reclamation sites and other construction activities. A certain percentage of the material handled is predicted to be spilled into the open water and the suspended sediments would reduce the water transparency and increase sedimentation processes in certain areas. Marine organisms, such as benthic fauna and flora as well as fish are predicted to be impaired by this pressure, which has an indirect effect on birds feeding on these organisms. This indirect effect from the sediment spill is named 'habitat change from sediment spill' in the following text.

It is assumed that the reduction of more than 5% in food biomass in an area equals the same reduction in waterbird numbers in the same area (e.g. 10% food reduction equals to 10% of birds becoming displaced). Although areas in the vicinity of the tunnel trench, along the coast of Lolland and in Rødsand Lagoon are predicted to be affected by medium degree of impairment for benthivorous waterbirds, the severity of impairment is assessed to be minor for all breeding and non-breeding waterbird species considering numbers of displaced individuals (Table 1.7). The degree of impairment and thus the severity of impairment for piscivorous waterbirds are assessed as minor.

The pressure 'habitat change from sediment spill' is not relevant for migrating birds.

The duration of the impact is restricted to the construction period and mostly to the first two years of the construction. No impact from this pressure is predicted to occur after finalisation of the construction works.

Table 1.7 Summary of impact assessment for the pressure 'habitat change from sediment spill' during the construction of an immersed tunnel in the Fehmarnbelt to the environmental components breeding waterbirds (waterbirds breeding in Natura 2000 areas only), non-breeding waterbirds and migrating birds. Numbers of displaced birds represent estimates for the year of maximum impact (first construction year).

Tunnel – construction phase – habitat change from sediment spill			
Species	**Degree of impairment**	**Number of displaced birds**	**% biogeographic/ relevant reference population**
Breeding waterbirds			
Common Eider	Minor – High	low number	-
Other breeding waterbird species		low number	-
Non-breeding waterbirds			
Common Pochard	Minor – High	7	<0.01
Tufted Duck	Minor – High	63	<0.01
Greater Scaup	Minor – High	25	<0.01
Common Eider	Minor – High	610	0.08
Long-tailed Duck	Minor – High	33	<0.01
Common Scoter	Minor – High	57	<0.01
Velvet Scoter	Minor – High	low number	<0.01
Common Goldeneye	Minor – High	5	<0.01
Other non-breeding waterbird species		low number	<0.1
Migrating birds			
All migrating bird species	no impact	no impact	no impact

Colour code of severity of impairment	Minor	Medium	High	Very high

Reduced water transparency

The sediment spill caused by the dredging works is predicted to have a direct impact on diving waterbirds, which are expected to be sensitive to reduced water transparency when foraging (divers, grebes, daytime active diving ducks, seaducks, some mergansers, auks). A very high degree of impairment was assumed for areas, for which it is predicted that water transparency levels would drop considerably below natural conditions. Thus, all individuals of sensitive species would be displaced from the impairment zone. The predicted extent of the impairment zone varies with the construction year with the greatest impact predicted for the first two years of the construction.

Among breeding waterbirds a very high degree of impairment is assessed for Red-necked Grebes and Red-breasted Mergansers. However, due to low numbers of birds expected to be affected by this pressure, the severity of impairment is assessed as minor for these species (Table 1.8).

Several species of non-breeding waterbirds are assessed to experience a very high degree of impairment in the impairment zone, but predicted numbers of displaced birds are usually low (Table 1.8). However, for the first two construction winters more than 1% of the biogeographic population of Common Eider is predicted to be displaced, thus the severity of impairment is assessed as very high for this species.

For the Red-breasted Merganser the severity of impairment is assessed as medium for the first construction winter (Table 1.8).

The pressure 'reduced water transparency' is not relevant for migrating birds.

The duration of the impact is restricted to the construction period. The severity of impairment level is assessed to be minor for all species in the fourth season of the construction and later on. No impact from this pressure is predicted to occur after finalisation of the construction works.

Table 1.8 Summary of impact assessment for the pressure 'reduced water transparency' during the construction of an immersed tunnel in the Fehmarnbelt to the environmental components breeding waterbirds (waterbirds breeding in Natura 2000 areas only), non-breeding waterbirds and migrating birds. Given numbers of displaced birds represent the maximum impact year for each species.

Tunnel – construction phase – reduced water transparency				
Species	**Degree of impairment**	**Number of displaced birds**	**% biogeographic/ relevant reference population**	
Breeding waterbirds				
Red-necked Grebe	Very high	low number	-	
Red-breasted Merganser	Very high	low number	-	
Other breeding waterbird species		low number	-	
Non-breeding waterbirds				
Divers	Very high	32	0.01	
Red-necked Grebe	Very high	69	0.13	
Common Eider	Very high	8,823	1.16	
Long-tailed Duck	Very high	594	0.01	
Common Scoter	Very high	512	0.03	
Velvet Scoter	Very high	low number	<0.01	
Red-breasted Merganser	Very high	892	0.53	
Razorbill	Very high	3	<0.001	
Black Guillemot	Very high	low number	<0.1	
Other non-breeding waterbird species		low number	<0.1	
Migrating birds				
All migrating bird species	no impact	no impact	no impact	
Colour code of severity of impairment	Minor	Medium	High	Very high

Disturbance from construction vessels

The construction of an immersed tunnel will require various shipping activities in the offshore part of the alignment area and between the construction sites and working harbours and reclamation sites at Lolland and Fehmarn. The shipping and other construction activities will cause disturbance to a number of waterbird species assessed as being sensitive to disturbance originating from shipping. A 3 km buffer zone around the tunnel footprint and the footprint area itself were defined as disturbance zone, for which a very high degree of impairment, thus a complete displacement of all birds of sensitive species, is assumed.

Although breeding birds are generally considered being highly sensitive to disturbance at their breeding habitats, the severity of impairment is assessed as minor for all breeding bird species in the area either due to minor degree of impairment (e.g. gull species are regarded not be sensitive to shipping in their feeding areas) or due to the minor importance of the impairment zone to the species (Table 1.9).

For most non-breeding waterbird species that occur in the area, a very high degree of impairment is assumed for the disturbance zone. However, estimated numbers of displaced birds are low for most of the species. The severity of impairment is assessed as high for Common Pochard and Tufted Duck (Table 1.9). However, affecting mostly the same birds as assessed to be affected from habitat loss from the footprint (Table 1.6). A medium severity of impairment is assessed for Eurasian Wigeon, Common Eider and Red-breasted Merganser. For all other non-breeding waterbird species the severity of impairment from disturbance from construction vessels is assessed as minor (Table 1.9).

The pressure 'disturbance from construction vessels' is not relevant for migrating birds.

The duration of the impact is restricted to the construction period. No impact from this pressure is predicted to occur after finalisation of the construction works.

Table 1.9 Summary of impact assessment for the pressure 'disturbance from construction vessels' during the construction of an immersed tunnel in the Fehmarnbelt to the environmental components breeding waterbirds (waterbirds breeding in Natura 2000 areas only), non-breeding waterbirds and migrating birds.

Tunnel – construction phase – disturbance from construction vessels			
Species	**Degree of impairment**	**Number of displaced birds**	**% biogeographic/ relevant reference population**
Breeding waterbirds			
All breeding waterbird species		low number	-
Non-breeding waterbirds			
Divers	Very high	10	0.003
Red-necked Grebe	Very high	26	0.05
Great Cormorant	Very high	500	0.12
Eurasian Wigeon	Very high	1,500	0.10
Common Pochard	Very high	710	0.20
Tufted Duck	Very high	7,100	0.59
Greater Scaup	Very high	130	0.04
Common Eider	Very high	4,882	0.64
Long-tailed Duck	Very high	120	0.003
Common Scoter	Very high	391	0.02
Velvet Scoter	Very high	low number	<0.01
Common Goldeneye	Very high	91	0.008
Red-breasted Merganser	Very high	208	0.12
White-tailed Eagle	Very high	low number	<0.10

Tunnel – construction phase – disturbance from construction vessels			
Species	**Degree of impairment**	**Number of displaced birds**	**% biogeographic/ relevant reference population**
Common Coot	Very high	340	0.02
Razorbill	Very high	11	0.002
Black Guillemot	Very high	low number	<0.1
Other non-breeding waterbird species		low number	<0.1
Migrating birds			
All migrating bird species	no impact	no impact	no impact

Colour code of severity of impairment	Minor	Medium	High	Very high

Barrier from construction vessels
Construction vessels would operate mostly in defined working areas and would not exhibit a total barrier over the Fehmarnbelt. Flying birds usually respond to an obstacle by vertical or horizontal changes in their intended flight route, thus birds are expected to always be able to detour a construction vessel while passing the area. Therefore, the sensitivity and also degree of impairment for all bird species (breeding waterbirds, non-breeding waterbirds and migrating birds) is assessed as minor. Consequently the severity of impairment is assessed to be minor as well for all birds in the Fehmarnbelt (Table 1.10).

The duration of the impact is restricted to the construction period. No impact from this pressure is predicted to occur after finalisation of the construction works.

Table 1.10 Summary of impact assessment for the pressure 'barrier from construction vessels' during the construction of an immersed tunnel in the Fehmarnbelt to the environmental components breeding waterbirds (waterbirds breeding in Natura 2000 areas only), non-breeding waterbirds and migrating birds.

Tunnel – construction phase – barrier from construction vessels		
Species	**Degree of impairment**	**Severity of impairment**
Breeding waterbirds		
All breeding waterbird species	Minor	Minor
Non-breeding waterbirds		
All non-breeding waterbird species	Minor	Minor
Migrating birds		
All migrating bird species	Minor	Minor

Collision with construction vessels
Construction works for a fixed link in the Fehmarnbelt will take place 24 hours per day with variable numbers and type of vessels included. This will increase the overall number of ships in the area with already high shipping intensity. Subsequently, increased numbers of ships would also increase the birds' risk of collision with vessels in the alignment area. During daylight hours collisions are highly unlikely, but during night a certain degree of risk exists.

Breeding waterbird species and most non-breeding waterbirds (foraging, resting, wintering) are mostly diurnal active, and for wintering waterbird species a relatively low overall flight activity is expected, though some species are known to regularly commute between resting and foraging habitats, such as nocturnal diving ducks. However, all these species are assumed to be at low risk to collide with construction vessels, thus the degree of impairment is assessed as minor for all breeding and non-breeding waterbird species (Table 1.11).

Migrating birds might get attracted by the lights of the construction vessels during adverse weather conditions and during night. The impact of the construction vessels would however be limited to a relatively small area at any time and the number of collisions is expected to be low, thus the degree of impairment is assessed as minor for all migrating bird species (Table 1.11).

Consequently, the severity of impairment is assessed to be minor for all breeding and non-breeding waterbirds and migrating birds in Fehmarnbelt (Table 1.11).

The duration of the impact is restricted to the construction period. No impact from this pressure is predicted to occur after finalisation of the construction works.

Table 1.11 Summary of impact assessment for the pressure 'collision with construction vessels' during the construction of an immersed tunnel in the Fehmarnbelt to the environmental components breeding waterbirds (waterbirds breeding in Natura 2000 areas only), non-breeding waterbirds and migrating birds.

Tunnel – construction phase – collision with construction vessels		
Species	**Degree of impairment**	**Severity of impairment**
Breeding waterbirds		
All breeding waterbird species	Minor	Minor
Non-breeding waterbirds		
All non-breeding waterbird species	Minor	Minor
Migrating birds		
All migrating bird species	Minor	Minor

Overall assessment of severity and significance of impacts

The different pressures of the construction of an immersed tunnel in the Fehmarnbelt are assessed to result in minor severity of loss/impairment to all breeding waterbird species in the area. All impacts to breeding waterbirds are assessed as insignificant.

For non-breeding waterbirds the degree of impairment from some pressures (disturbance from construction vessels and reduction of water transparency) is assessed as very high for several species. However, numbers of birds actually affected from displacement are low for most species, thus the severity of impairment is assessed as minor for most non-breeding waterbird species. A severity of impairment level higher than minor for one or more pressures is assessed for the Eurasian Wigeon, Common Pochard and Tufted Duck, Common Eider and the Red-breasted Merganser.

The assessment of aggregated impacts from the construction of an immersed tunnel (accounting for spatial overlays of the different pressures) revealed that internationally important numbers of Common Eiders would be displaced due to different pressures in the first two construction winters (maximum: 12,114 birds;

1.59% of the biogeographic population). However, this impact is assessed as insignificant, because individual based modelling showed that excluding birds from the overall impact zone would mostly result in a redistribution of the birds. The model indicates that the carrying capacity of the Fehmarnbelt for wintering Common Eiders is not reached and that exclusion of the birds from the impact zone would result in only slightly increased mortality (maximum estimate of 600 birds additionally dying) and slightly reduced body weight of Common Eiders. For none of the other non-breeding waterbird species displacement of 1% of the population is predicted from the project impact. The severity of impairment levels for the pressures related to barrier and collision are assessed as minor to all non-breeding waterbirds. Thus, the project impact from construction of an immersed tunnel is assessed as insignificant for all non-breeding waterbird species in the area.

The degree of impairment from the two pressures barrier from construction vessels and collision with construction vessels and therefore also the severity of impairment is assessed as minor for all migrating bird species. Thus, the project impact of the construction of an immersed tunnel in the Fehmarnbelt is regarded as insignificant for migrating birds.

Operation and structures

Habitat loss from footprint

The same area of the tunnel footprint as assessed for the construction period (see above) is regarded as an area of permanent loss to breeding and non-breeding waterbirds in the Fehmarnbelt. However, parts of the footprint will be re-established and thus useable for birds again (such as parts of working harbours not becoming land reclamation). Nevertheless, the land reclamation areas remain permanently and due to this habitat loss especially along the Lolland coast the severity of loss is assessed as high for Common Pochard and Tufted Duck. The severity of loss for all other non-breeding waterbird species and breeding waterbirds is assessed as minor.

The pressure ‘habitat loss from footprint’ is not relevant for migrating birds.

The duration of the impact is permanent for land reclamation and protection reef areas of the footprint. For other areas different recovery periods of seabed and accompanying benthic fauna and flora is predicted. Re-established areas offering suitable habitats for waterbirds are considered to be used by birds without relevant additional recovery period.

Table 1.12 Summary of impact assessment for the pressure ‘habitat loss from footprint’ during operation of an immersed tunnel in the Fehmarnbelt to the environmental components breeding waterbirds (waterbirds breeding in Natura 2000 areas only), non-breeding waterbirds and migrating birds.

Tunnel – operation and structures – habitat loss from footprint			
Species	**Number of displaced birds**	**% biogeographic/ relevant reference population**	**Severity of loss**
Breeding waterbirds			
All breeding waterbird species	low number	-	Minor
Non-breeding waterbirds			
Common Pochard	710	0.20	High
Tufted Duck	7,100	0.59	High

Tunnel – operation and structures – habitat loss from footprint			
Other non-breeding waterbird species	low number	<0.10	Minor
Migrating birds			
All migrating bird species	no impact	no impact	no impact

Provision of artificial reefs

During the construction of an immersed tunnel in the Fehmarnbelt large areas of the footprint will be covered by additional solid substrates (embankments, protection reefs, protection layer above the tunnel elements). These structures will be available for the establishment of hard-bottom benthic communities, so called artificial reefs. Hard bottom benthic flora and fauna communities can either directly provide foraging habitats for waterbirds (e.g. benthivorous ducks) or attract fish species, which likewise may attract piscivorous waterbirds.

There is no displacement of birds (breeding waterbirds, non-breeding waterbirds) predicted to result from provision of artificial reefs, but distribution of some species could change due to possible attraction effects. The degree of impairment and thus the severity of impairment are assessed as minor or negligible for all breeding and non-breeding waterbird species (Table 1.13).

The pressure 'provision of artificial reefs' is not relevant for migrating birds.

The duration of the impact is permanent for embankments and elevated protection reefs. In other areas (tunnel trench) the additional hard substrate will be covered by sediments over time (re-establishment of the seabed) and are therefore temporary artificial reefs.

Table 1.13 Summary of impact assessment for the pressure 'provision of artificial reefs' during operation of an immersed tunnel in the Fehmarnbelt to the environmental components breeding waterbirds (waterbirds breeding in Natura 2000 areas only), non-breeding waterbirds and migrating birds.

Tunnel – operation and structures – habitat change from sediment spill				
Species	**Degree of impairment**	**Number of displaced birds**	**% biogeographic/ relevant reference population**	
Breeding waterbirds				
All breeding waterbird species	Minor	0	-	
Non-breeding waterbirds				
All non-breeding waterbird species	Minor	0	0	
Migrating birds				
All migrating bird species	no impact	no impact	no impact	
Colour code of severity of impairment		Minor	Medium	High	Very high

Hydrographical changes

Close to land reclamation areas slight changes in current conditions are predicted. The changes are either negligible or local water turbulences could possibly attract some waterbird species. The degree of impairment and thus the severity of impairment are assessed as minor or negligible for all breeding and non-breeding waterbirds (Table 1.14).

The pressure 'hydrographical changes' is not relevant for migrating birds.

The duration of the pressure is permanent.

Table 1.14 Summary of impact assessment for the pressure 'hydrographical changes' during operation of an immersed tunnel in the Fehmarnbelt to the environmental components breeding waterbirds (waterbirds breeding in Natura 2000 areas only), non-breeding waterbirds and migrating birds.

Tunnel – operation and structures – habitat change from sediment spill				
Species	**Degree of impairment**	**Number of displaced birds**	**% biogeographic/ relevant reference population**	
Breeding waterbirds				
All breeding waterbird species	Minor	0	-	
Non-breeding waterbirds				
All non-breeding waterbird species	Minor	0	0	
Migrating birds				
All migrating bird species	no impact	no impact	no impact	
Colour code of severity of impairment		Minor	Medium	High	Very high

Overall assessment of severity and significance of impacts
The different pressures from operation of an immersed tunnel in the Fehmarnbelt are assessed to result in minor degree of impairment and minor severity of loss/impairment to all breeding waterbird species in the area. All impacts to breeding waterbirds are assessed as insignificant.

For non-breeding waterbirds for Common Pochard and Tufted Duck a high severity of loss is assessed. For none of the non-breeding waterbird species displacement of 1% of the population is predicted from the project impact. Thus, the project impact from operation of an immersed tunnel is assessed as insignificant for all non-breeding waterbird species in the area.

No pressure was identified being relevant for migrating birds during operation of an immersed tunnel. Thus no impact is predicted for migrating birds.

Cumulative impacts
Cumulative impacts were assessed for the tunnel alternative of a fixed link in Fehmarnbelt in conjunction with planned offshore wind farm projects. For breeding birds no cumulative impacts are assumed. For non-breeding waterbirds and migrating birds the cumulative impacts are assessed being insignificant.

1.7 *Impact assessment of the bridge alternative*

Construction phase

Habitat loss from footprint

During the construction of an immersed tunnel marine habitats are lost for waterbirds from working harbours, bridge constructions and land reclamations.

For breeding and non-breeding waterbirds the severity of loss is assessed as minor, since the areas lost are assessed to be of minor importance to the species or only low numbers of a species are predicted to be displaced from lost areas (Table 1.15).

The pressure 'habitat loss from footprint' is not relevant for migrating birds.

Table 1.15 Summary of impact assessment for the pressure 'habitat loss from footprint' during the construction of a cable stayed bridge in the Fehmarnbelt to the environmental components breeding waterbirds (waterbirds breeding in Natura 2000 areas only), non-breeding waterbirds and migrating birds.

Bridge – construction phase – habitat loss from footprint			
Species	**Number of displaced birds**	**% biogeographic/ relevant reference population**	**Severity of loss**
Breeding waterbirds			
All breeding waterbird species	low number	-	Minor
Non-breeding waterbirds			
All non-breeding waterbird species	low number	<0.10	Minor
Migrating birds			
All migrating bird species	no impact	no impact	no impact

Habitat change from sediment spill

During the construction of a cable stayed bridge dredging works would increase the amount of suspended sediments and sedimentation processes in certain areas. However, the resulting changes in benthic communities and fish (reductions in biomass) are either negligible or minor for birds; therefore the degree of impairment is assessed as minor for all breeding and non-breeding waterbird species in the area. Thus, the severity of impairment is assessed as minor as well (Table 1.16).

The pressure 'habitat change from sediment spill' is not relevant for migrating birds.

The duration of the impact is restricted to the construction period. No impact from this pressure is predicted to occur after finalisation of the construction works.

Table 1.16 Summary of impact assessment for the pressure' habitat change from sediment spill' during the construction of a cable stayed bridge in the Fehmarnbelt to the environmental components breeding waterbirds (waterbirds breeding in Natura 2000 areas only), non-breeding waterbirds and migrating birds.

Bridge – construction phase – habitat change from sediment spill				
Species	**Degree of impairment**	**Number of displaced birds**		**% biogeographic/ relevant reference population**
Breeding waterbirds				
All breeding waterbird species	Minor	low number		-
Non-breeding waterbirds				
Other non-breeding waterbird species	Minor	low number		<0.1
Migrating birds				
All migrating bird species	no impact	no impact		no impact
Colour code of severity of impairment		Minor	Medium	High / Very high

Reduced water transparency

Increased values of suspended sediments and related reduced water transparency resulting from the sediment spill represent a pressure directly impairing waterbirds sensitive to this (see also description of this pressure for the tunnel alternative above). The extent of the impairment zone varies with the construction year with the highest impact predicted for the first year of bridge construction. The impairment zone affects mostly areas in the western part of Rødsand Lagoon.

Among breeding waterbirds a very high degree of impairment is assessed for Red-necked Grebes and Red-breasted Mergansers. Due to the low numbers of birds expected to be affected by this pressure in Rødsand Lagoon the severity of impairment is assessed as minor for these species (Table 1.17). For other breeding waterbird species the degree of impairment and thus the severity of impairment are assessed as minor.

Several species of non-breeding waterbirds are assessed to experience very high degree of impairment in the impairment zone, but predicted numbers of displaced birds are usually low (Table 1.17). However, for the first construction winter more than 2,000 Common Eiders are predicted to be displaced from the impairment zone, thus the severity of impairment is assessed as medium for this species. For all other non-breeding waterbirds the severity of impairment is assessed to be minor.

The pressure 'reduced water transparency' is not relevant for migrating birds.

The duration of the impact is restricted to the construction period. The severity of impairment levels are assessed as minor for all waterbird species in the second season of construction and later on. No impact from this pressure is predicted to occur after finalisation of the construction works.

Table 1.17 Summary of impact assessment for the pressure 'reduced water transparency' during the construction of a cable stayed bridge in the Fehmarnbelt to the environmental components breeding waterbirds (waterbirds breeding in Natura 2000 areas only), non-breeding waterbirds and migrating birds. Given numbers of displaced birds represent the maximum impact year for each species.

Bridge – construction phase – reduced water transparency			
Species	**Degree of impairment**	**Number of displaced birds**	**% biogeographic/ relevant reference population**
Breeding waterbirds			
Red-necked Grebe	Very high	low number	-
Red-breasted Merganser	Very high	low number	-
Other breeding waterbird species		low number	-
Non-breeding waterbirds			
Divers	Very high	10	0.003
Red-necked Grebe	Very high	6	0.012
Common Eider	Very high	2,029	0.27
Long-tailed Duck	Very high	174	0.004
Common Scoter	Very high	183	0.011
Velvet Scoter	Very high	low number	<0.01
Red-breasted Merganser	Very high	158	0.09
Razorbill	Very high	low number	<0.001
Black Guillemot	Very high	low number	<0.1
Other non-breeding waterbird species		low number	<0.1
Migrating birds			
All migrating bird species	no impact	no impact	no impact
Colour code of severity of impairment		Minor / Medium	High / Very high

Disturbance from construction vessels

Similar to the same pressure for the tunnel alternative described above the footprint area of the cable stayed bridge and a 3 km buffer zone around is defined as disturbance zone for waterbird species (breeders and non-breeders) sensitive to disturbance from shipping. Within this disturbance zone a very high degree of impairment is assumed, resulting in a complete displacement of all birds from the impaired area.

Though breeding birds are assessed to generally be highly sensitive to disturbance at their breeding habitats, the severity of impairment is assessed as minor for all breeding bird species in the area either due to minor degree of impairment (e.g. gull species are regarded not be sensitive to shipping in their foraging habitats) or due to the minor importance of the impairment zone to the species (Table 1.18).

For most non-breeding waterbird species in the area a very high degree of impairment is assumed for the disturbance zone. However, estimated numbers of displaced birds are usually low. The severity of impairment is assessed as high for Common Pochard and Tufted Duck (Table 1.18). A medium severity of impairment is assessed for Eurasian Wigeon and Common Eider. For all other non-breeding waterbird species the severity of impairment from disturbance from construction vessels is assessed as minor (Table 1.18).

The pressure 'disturbance from construction vessels' is not relevant for migrating birds.

The duration of the impact is restricted to the construction period. No impact from this pressure is predicted to occur after finalisation of the construction works.

Table 1.18 Summary of impact assessment for the pressure 'disturbance from construction vessels' during the construction of a cable stayed bridge in the Fehmarnbelt to the environmental components breeding waterbirds (waterbirds breeding in Natura 2000 areas only), non-breeding waterbirds and migrating birds.

Bridge – construction phase – disturbance from construction vessels			
Species	**Degree of impairment**	**Number of displaced birds**	**% biogeographic/ relevant reference population**
Breeding waterbirds			
All breeding waterbird species		low number	-
Non-breeding waterbirds			
Divers	Very high	8	0.003
Red-necked Grebe	Very high	19	0.04
Great Cormorant	Very high	500	0.12
Eurasian Wigeon	Very high	1,500	0.10
Common Pochard	Very high	710	0.20
Tufted Duck	Very high	7,100	0.59
Greater Scaup	Very high	130	0.04
Common Eider	Very high	3,919	0.52
Long-tailed Duck	Very high	110	0.002
Common Scoter	Very high	383	0.02
Velvet Scoter	Very high	low number	<0.01
Common Goldeneye	Very high	57	0.004
Red-breasted Merganser	Very high	115	0.068
White-tailed Eagle	Very high	low number	<0.1
Common Coot	Very high	340	0.02
Razorbill	Very high	10	0.002
Black Guillemot	Very high	low number	<0.1
Other non-breeding waterbird species		low number	<0.1
Migrating birds			
All migrating bird species	no impact	no impact	no impact

Colour code of severity of impairment	Minor	Medium	High	Very high

Barrier from construction vessels

The assessment of the pressure barrier from construction vessels during construction of a cable stayed bridge is identical with the respective assessment of the same pressure for the tunnel construction (see above). The severity of impairment to all birds (breeding waterbirds, non-breeding waterbirds and migrating birds) is assessed as minor (Table 1.19).

Table 1.19 Summary of impact assessment for the pressure 'barrier from construction vessels' during the construction of a cable stayed bridge in the Fehmarnbelt to the environmental components breeding waterbirds (waterbirds breeding in Natura 2000 areas only), non-breeding waterbirds and migrating birds.

Bridge – construction phase – barrier from construction vessels		
Species	**Degree of impairment**	**Severity of impairment**
Breeding waterbirds		
All breeding waterbird species	Minor	Minor
Non-breeding waterbirds		
All non-breeding waterbird species	Minor	Minor
Migrating birds		
All migrating bird species	Minor	Minor

Collision with construction vessels

The assessment of the pressure 'collision with construction vessels' during construction of a cable stayed bridge is identical with the respective assessment of the same pressure for the tunnel alternative (see above). The severity of impairment to all birds (breeding waterbirds, non-breeding waterbirds and migrating birds) is assessed as minor (Table 1.20).

Table 1.20 Summary of impact assessment for the pressure 'collision with construction vessels' during the construction of a cable stayed bridge in the Fehmarnbelt to the environmental components breeding waterbirds (waterbirds breeding in Natura 2000 areas only), non-breeding waterbirds and migrating birds.

Bridge – construction phase – collision with construction vessels		
Species	**Degree of impairment**	**Severity of impairment**
Breeding waterbirds		
All breeding waterbird species	Minor	Minor
Non-breeding waterbirds		
All non-breeding waterbird species	Minor	Minor
Migrating birds		
All migrating bird species	Minor	Minor

Overall assessment of severity and significance of impacts

The different pressures of the construction of a cable stayed bridge in the Fehmarnbelt are assessed to result in minor severity of loss/impairment to all breeding waterbird species in the area. All impacts to breeding waterbirds are assessed as insignificant.

For non-breeding waterbirds the degree of impairment from some pressures (disturbance from construction vessels and reduction of water transparency) is assessed as very high for several species. However, bird numbers actually affected from displacement are low for most species, thus the severity of impairment is assessed as minor for most non-breeding waterbird species. A severity of impairment level higher than minor for one or more pressures is assessed for the Eurasian Wigeon, Common Pochard and Tufted Duck and Common Eider.

For none of the non-breeding waterbird species a displacement of 1% or more of the population is predicted from the overall project impact (accounting for spatial overlays of the impact zones of different pressures). The severity of impairment levels for the pressures related to barrier and collision are assessed as minor to all non-breeding waterbirds. Thus, the project impact from construction of a cable stayed bridge is assessed as insignificant for all non-breeding waterbird species in the area. For the Common Eider this is confirmed by the result of the individual based model, which predicts that exclusion of all birds from the maximum impact zone (4,969 birds (0.65% of the biogeographic population) in the first construction winter) would result in only marginal changes in bird survival and body weight of Common Eiders.

The degree of impairment from the two pressures barrier from construction vessels and collision with construction vessels and therefore also the severity of impairment is assessed as minor for all migrating bird species. Thus, the project impact of the construction of an immersed tunnel in the Fehmarnbelt is regarded as insignificant for migrating birds.

Operation and structures

Habitat loss from footprint

The same area of the bridge footprint as assessed for the construction period (see above) is regarded as an area of permanent loss to breeding and non-breeding waterbirds in the Fehmarnbelt. However, parts of the footprint will be re-established and thus useable for birds again (construction harbours).

For breeding and non-breeding waterbirds the severity of loss is assessed as minor, since the areas lost are assessed to be of minor importance to the species or only low numbers of a species are predicted to be displaced from lost areas (Table 1.21).

The pressure 'habitat loss from footprint' is not relevant for migrating birds.

Table 1.21 Summary of impact assessment for the pressure 'habitat loss from footprint' during operation of a cable stayed bridge in the Fehmarnbelt to the environmental components breeding waterbirds (waterbirds breeding in Natura 2000 areas only), non-breeding waterbirds and migrating birds.

Bridge – operation and structures – habitat loss from footprint			
Species	**Number of displaced birds**	**% biogeographic/ relevant reference population**	**Severity of loss**
Breeding waterbirds			
All breeding waterbird species	low number	-	Minor
Non-breeding waterbirds			
All non-breeding waterbird species	low number	<0.10	Minor
Migrating birds			
All migrating bird species	no impact	no impact	no impact

Provision of artificial reefs
During the construction of a cable stayed bridge in the Fehmarnbelt structures of the bridge (piers and pylons) and embankments would provide additional solid substrate to areas lost from the footprint. These structures are available for the establishment of hard-bottom benthic communities, so called artificial reefs. Hard bottom benthic flora and fauna communities can either directly provide foraging habitats for waterbirds (e.g. benthivorous ducks) or attract fish species, which likewise may attract piscivorous waterbirds.

There is no displacement of birds (breeding waterbirds, non-breeding waterbirds) predicted to result from provision of artificial reefs, but distribution of some species could change due to possible attraction effects. The degree of impairment and thus the severity of impairment are assessed as minor or negligible for all breeding and non-breeding waterbird species (Table 1.22).

The pressure 'provision of artificial reefs' is not relevant for migrating birds.

The duration of the impact is permanent.

Table 1.22 Summary of impact assessment for the pressure 'provision of artificial reefs' during operation of a cable stayed bridge in the Fehmarnbelt to the environmental components breeding waterbirds (waterbirds breeding in Natura 2000 areas only), non-breeding waterbirds and migrating birds.

Bridge – operation and structures – habitat change from sediment spill				
Species	**Degree of impairment**	**Number of displaced birds**	**% biogeographic/ relevant reference population**	
Breeding waterbirds				
All breeding waterbird species	Minor	0	-	
Non-breeding waterbirds				
All non-breeding waterbird species	Minor	0	0	
Migrating birds				
All migrating bird species	no impact	no impact	no impact	
Colour code of severity of impairment		Minor	Medium	High	Very high

Hydrographical changes
Close to bridge pillars and pylons changes in current conditions are predicted. The changes are either negligible or local water turbulences could possibly attract some waterbird species. The degree of impairment and thus the severity of impairment are assessed as minor or negligible for all breeding and non-breeding waterbirds (Table 1.23).

The pressure 'hydrographical changes' is not relevant for migrating birds.

The duration of the pressure is permanent.

Table 1.23 Summary of impact assessment for the pressure 'hydrographical changes' during operation of a cable stayed bridge in the Fehmarnbelt to the environmental components breeding waterbirds (waterbirds breeding in Natura 2000 areas only), non-breeding waterbirds and migrating birds.

Bridge – operation and structures – habitat change from sediment spill				
Species	**Degree of impairment**	**Number of displaced birds**		**% biogeographic/ relevant reference population**
Breeding waterbirds				
All breeding waterbird species	Minor	0		-
Non-breeding waterbirds				
All non-breeding waterbird species	Minor	0		0
Migrating birds				
All migrating bird species	no impact	no impact		no impact
Colour code of severity of impairment		Minor	Medium	High	Very high

Disturbance from bridge structure and traffic

The presence of a cable stayed bridge is expected to result in disturbance of sensitive birds using the area. The bridge structure itself, noise and light emissions from cars and trains and illumination of the bridge structure are considered to result in avoidance reactions of sensitive breeding and non-breeding waterbirds. Based on the sensitivity analysis of waterbirds to the pressure a disturbance zone of 2 km around the bridge structure was defined. Within the disturbance zone a very high degree of impairment, thus complete displacement of all birds of sensitive species, is assumed.

Though breeding birds are assessed to generally be highly sensitive to disturbance at their breeding habitats, the severity of impairment is assessed as minor for all breeding bird species in the area either due to minor degree of impairment (local birds might habituate to the pressure) or due to the minor importance of the impairment zone to the species (Table 1.24).

For most non-breeding waterbird species in the area a very high degree of impairment is assumed for the disturbance zone. However, estimated numbers of displaced birds usually are low. The severity of impairment is assessed as high for Common Pochard and Tufted Duck and medium for the Common Eider. For all other non-breeding waterbird species the severity of impairment from disturbance from construction vessels is assessed as minor (Table 1.24).

The pressure 'disturbance from bridge structure and traffic' is not relevant for migrating birds.

The duration of the impact is permanent.

Table 1.24 Summary of impact assessment for the pressure 'disturbance from disturbance from bridge structure and traffic' during operation of a cable stayed bridge in the Fehmarnbelt to the environmental components breeding waterbirds (waterbirds breeding in Natura 2000 areas only), non-breeding waterbirds and migrating birds.

Bridge – operation and structures – disturbance from bridge structure and traffic			
Species	**Degree of impairment**	**Number of displaced birds**	**% biogeographic/ relevant reference population**
Breeding waterbirds			
All breeding waterbird species	Minor	low number	-
Non-breeding waterbirds			
Divers	Very high	6	0.002
Red-necked Grebe	Very high	8	0.016
Eurasian Wigeon	Very high	low number	<0.10
Common Pochard	Very high	710	0.20
Tufted Duck	Very high	7,100	0.59
Greater Scaup	Very high	130	0.04
Common Eider	Very high	1,889	0.25
Long-tailed Duck	Very high	61	0.001
Common Scoter	Very high	118	0.01
Velvet Scoter	Very high	low number	<0.001
Common Goldeneye	Very high	23	0.002
Red-breasted Merganser	Very high	53	0.03
Common Coot	Very high	low number	<0.01
Razorbill	Very high	6	0.001
Black Guillemot	Very high	low number	<0.1
Other non-breeding waterbird species		low number	<0.1
Migrating birds			
All migrating bird species	no impact	no impact	no impact

Colour code of severity of impairment	Minor	Medium	High	Very high

Disturbance from channelling of shipping

The Fehmarnbelt is an area of high shipping intensity with a main navigational route passing the area. The structure of a cable stayed bridge would funnel the main vessel traffic from an area covering a third to half of the width of Fehmarnbelt to the two openings of the main bridge, each spanning 724 m. This would result in an increase of vessel traffic in the Natura 2000 site SCI Fehmarnbelt, where the main bridge would be located.

Although it is predicted that vessel traffic and therefore disturbance to sensitive waterbirds would increase, the degree of impairment to all breeding and non-breeding waterbirds is assessed as minor, since this intensification would occur in an already highly disturbed area and the channelling would reduce the disturbance from other areas where shipping intensity would drop. Therefore, the severity of impairment is assessed as minor for all breeding and non-breeding waterbird species in the area (Table 1.25).

The pressure 'disturbance from channelling of shipping' is not relevant for migrating birds.

The duration of the impact is permanent.

Table 1.25 Summary of impact assessment for the pressure 'channelling of shipping' during operation of a cable stayed bridge in the Fehmarnbelt to the environmental components breeding waterbirds (waterbirds breeding in Natura 2000 areas only), non-breeding waterbirds and migrating birds.

Bridge – operation and structures – disturbance from channelling of shipping				
Species	**Degree of impairment**	**Number of displaced birds**		**% biogeographic/ relevant reference population**
Breeding waterbirds				
All breeding waterbird species	Minor	low number		-
Non-breeding waterbirds				
All non-breeding waterbird species	Minor	low number		<0.1%
Migrating birds				
All migrating bird species	no impact	no impact		no impact
Colour code of severity of impairment		Minor	Medium	High	Very high

Barrier from bridge structure and traffic

A bridge presents a barrier as it is a vertical structure reaching into the air space and potentially affecting birds which intend to pass the area while on migration (migration birds) or conducting local movements (breeding and non-breeding waterbirds). A barrier effect of a structure is basically meant as a barrier to movement and thus is different from other pressures resulting in displacement or redistribution of birds such as disturbance effects. If and to what degree birds would perceive a bridge as a barrier and associated behavioural reactions would depend on the status of a bird in its annual cycle. For example a migrating bird may perceive a structure as a barrier, while local (breeding and non-breeding) birds exposed to this barrier may habituate to the pressure to some degree, and e.g. fly below or above without additional reactions. A barrier effect can be complete (birds do not cross the barrier at all), can cause weak to strong avoidance reactions resulting in additional flight time and energetic costs. For local waterbirds (breeders and non-breeders) a strong barrier effect can have implication on the habitat use of the species.

To assess species-specific sensitivities to barrier from the bridge structure and traffic and thus degree of impairment, literature information and data from the effect studies on existing Baltic Sea bridges have been used, during which reaction types and flight behaviour of birds approaching a bridge were recorded. Energy expenditures for birds flying over or around a bridge were calculated assuming different reaction scenarios.

Though most breeding birds were assessed to be medium sensitive to the barrier effect from a bridge structure, the severity of impairment is assessed as minor for all breeding bird species in the area either due to the minor degree of impairment (local birds might habituate to the pressure) or due to the minor importance of the impairment zone to a species (Table 1.26).

FEBI effect studies at the Baltic Sea bridges revealed that some of the non-migrating birds, e.g. Great Cormorant, Mute Swan, diving ducks, waders and Common Eiders, occasionally flew under bridges, a behaviour which was not registered for migrating birds. However, some proportions of not migrating birds did show reactions suggesting a barrier effect. According to the sensitivity assessment, the degree of impairment is very high for all auk species, for which a complete barrier cannot be excluded. A high degree of impairment is assessed for divers and scoters, species which are known to exhibit the highest sensitivity to human-caused disturbances. For all other non-breeding waterbird species the degree of impairment is medium, except for Great Cormorant, White-tailed Eagle, gulls and terns, for which the degree of impairment is assessed as minor.

Following the assessed degree of impairment and accounting for the importance level, the severity of impairment is high for divers, scoters and the Black Guillemot. For 10 non-breeding waterbird species the severity of impairment is assessed to be medium (Table 1.26). For the rest of non-breeding waterbird species the severity of impairment is assessed to be either minor or negligible, resulting in no relevant barrier effect to these species (Table 1.26).

For the migrating bird species, the degree of impairment is assessed as very high for auks (Common Guillemot, Razorbill, Black Guillemot), for which the FEBI bridge effect studies and published results suggest that a complete barrier cannot be excluded. For the seaducks (Common Eider, Long-tailed Duck, Common and Velvet Scoter) the degree of impairment is assessed as high based on the reaction type results from the effect studies at the Baltic Sea bridges. For the other waterbird species (divers, grebes, swans, geese, ducks) the degree of impairment is medium, except for Great Cormorant, Grey Heron, White Stork, Greylag Goose and the wader species, for which the degree of impairment is minor (because they migrate parallel to the alignment or at high altitudes).

Daytime and night-time migrating landbirds were assessed as having minor sensitivity to this pressure, because their migration direction is mostly parallel to the bridge, thus the degree of impairment is minor.

Following this, the severity of impairment is assessed as very high for the three auk species Common Guillemot, Razorbill and Black Guillemot (as migrating birds). A high severity of impairment is assessed for migrating Common Eiders and Common Scoters; and for a total of 16 migrating waterbird species the impairment from a barrier effect of a bridge is assessed as medium (Table 1.26). For all other migrating species the severity of impairment is either minor or negligible, resulting in no relevant barrier effect to these species.

The duration of the pressure ‘barrier from bridge structure and traffic’ is permanent.

Table 1.26 Summary of impact assessment for the pressure 'barrier from bridge structure and traffic' during the construction of a cable stayed bridge in the Fehmarnbelt to the environmental components breeding waterbirds (waterbirds breeding in Natura 2000 areas only), non-breeding waterbirds and migrating birds.

Bridge – operation and structures – barrier from bridge structure and traffic		
Species	**Degree of impairment**	**Severity of impairment**
Breeding waterbirds		
Red-necked Grebe	Medium	Minor
Red-breasted Merganser	Medium	Minor
Other breeding waterbird species		Minor
Non-breeding waterbirds		
Divers	High	High
Red-necked Grebe	Medium	Medium
Eurasian Wigeon	Medium	Medium
Common Pochard	Medium	Medium
Tufted Duck	Medium	Medium
Greater Scaup	Medium	Medium
Common Eider	Medium	Medium
Long-tailed Duck	Medium	Medium
Common Scoter	High	High
Velvet Scoter	High	High
Common Goldeneye	Medium	Medium
Red-breasted Merganser	Medium	Medium
Common Guillemot	Very high	Minor
Razorbill	Very high	Medium
Black Guillemot	Very high	High
Other non-breeding waterbird species		Minor
Migrating birds		
Red-throated Diver	Medium	Medium
Black-throated Diver	Medium	Medium
Red-necked Grebe	Medium	Medium
Slavonian Grebe	Medium	Medium
Mute Swan	Medium	Medium
Bewick's Swan	Medium	Medium
Whooper Swan	Medium	Medium
Bean Goose	Medium	Medium
Barnacle Goose	Medium	Medium
Dark-bellied Brent Goose	Medium	Medium
Eurasian Wigeon	Medium	Medium
Gadwall	Medium	Medium
Northern Pintail	Medium	Medium
Northern Shoveler	Medium	Medium
Greater Scaup	Medium	Medium

Bridge – operation and structures – barrier from bridge structure and traffic		
Species	**Degree of impairment**	**Severity of impairment**
Common Eider	High	High
Long-tailed Duck	High	Minor
Common Scoter	High	High
Velvet Scoter	High	Minor
Red-breasted Merganser	Medium	Medium
Common Guillemot	Very high	Very high
Razorbill	Very high	Very high
Black Guillemot	Very high	Very high
Other migrating bird species		Minor

Collision with bridge structures

Since long it has been known that birds may collide with non-moving and moving structures for various reasons, e.g. due to collisions with lighthouses and light vessels. Structures vertically protruding from an offshore environment are of particular concern. While estimates concerning the overall number of collisions with structures such as buildings, platforms or wind turbines do exist, they usually include a high uncertainty. And overall, very little quantitative information exists on actual collision rates and collision risk at bridges.

Factors influencing the collision risk include the configuration, location and placement of a structure with respect to other structures or topographic features as well as visibility of the structure parts, e.g. the diameter of the cables, as well as weather conditions and time of day (visibility). Collision rates may increase if lights on the structures attract and disorient flying birds particularly during night and inclement weather conditions.

To assess species-specific sensitivity and thus the degree of impairment related to collision with bridge structures, three approaches have been followed. 1) data on flight behaviour in relation to bridges was used to calculate potential daytime collision rates of selected waterbird species; 2) pencil beam radar results on migration intensity and altitude distribution in Fehmarnbelt have been used to calculate potential collision rates of nocturnal migrating passerines; 3) collision counts from the Öresund Bridge main bridge have been used to calculate potential collision rates at a Fehmarnbelt Bridge main bridge.

Since most waterbird species are mainly daytime active when breeding or wintering in the Fehmarnbelt area, a minor sensitivity to this pressure was assessed. However, nocturnally active Common Pochard, Tufted Duck and Greater Scaup, which are known to regularly commute between (daytime) resting and (night-time) foraging habitats were regarded to be medium sensitive to collisions Therefore the degree of impairment for these three species is assessed as medium. Although some species with a high wing load (e.g. ducks, divers or auks) may appear as being at risk of colliding with structures due to their high flight speed, they were assessed to be minor sensitive to collisions, since the barrier effect expected for these species would make it unlikely for the birds to fly close to the structures and thus collisions are assumed to be unlikely during daytime. Therefore, for all non-breeding waterbird species, except the above mentioned three nocturnal duck species, the degree of impairment is minor (Table 1.27). Accounting for the species' importance a minor severity of impairment is assessed for all breeding and non-breeding waterbird species, except for wintering Common Pochard, Tufted Duck and Greater Scaup, for which the severity of impairment is medium.

Regarding migrating birds, calculations of different collision scenarios indicate generally low daytime collision rates of waterbirds. A minor sensitivity and degree of impairment with regards to collision with structures are assessed for the mainly daytime active waterbird species such as Northern Gannet, Great Cormorant, Grey Heron (migration parallel to the alignment), White Stork, mergansers and the wader species, which frequently fly at high altitudes and are not dependent to migrate over water.

However, waterbirds also regularly migrate during night-time when they often fly at low altitudes over water. Therefore, most waterbird species (divers, grebes, swans, geese, ducks, gulls, terns) were assessed as medium sensitive to this pressure and subsequently the degree of impairment is also assessed as medium. Considering the importance level, medium severity of impairment is assessed for these waterbird species (Table 1.27).

Collision risk of daytime active landbird migrants is minor. Therefore the degree of impairment and thus the severity of impairment are minor as well (Table 1.27).

For the nocturnally migrating species such as rails, owls as well as facultative and obligatory nocturnally migrating passerines, collision estimates result in potential collision rates, which are below 1% of the passing individuals. However, based on this and uncertainties in collision estimates the degree of impairment was assessed as high (see Table 4.8). When assessing the severity of impairment, the potential collision rates relative to the respective biogeographic/relevant reference populations are low (<0.01%). Accounting for uncertainties in the collision estimates the severity of impairment is assessed as medium based on the high degree of impairment and a medium importance level for some species (Table 1.27).

Table 1.27 Summary of impact assessment for the pressure 'collision with bridge structures' during operation of a cable stayed bridge in the Fehmarnbelt to the environmental components breeding waterbirds (waterbirds breeding in Natura 2000 areas only), non-breeding waterbirds and migrating birds.

Bridge – operation and structures – collision with bridge structures		
Species	**Degree of impairment**	**Severity of impairment**
Breeding waterbirds		
All breeding waterbird species	Minor	Minor
Non-breeding waterbirds		
Common Pochard	Medium	Medium
Tufted Duck	Medium	Medium
Greater Scaup	Medium	Medium
Other non-breeding waterbird species	Minor	Minor
Migrating birds		
Red-throated Diver	Medium	Medium
Black-throated Diver	Medium	Medium
Red-necked Grebe	Medium	Medium
Slavonian Grebe	Medium	Medium
Mute Swan	Medium	Medium

Bridge – operation and structures – collision with bridge structures		
Species	**Degree of impairment**	**Severity of impairment**
Bewick's Swan	Medium	Medium
Whooper Swan	Medium	Medium
Bean Goose	Medium	Medium
Greylag Goose	Medium	Medium
Barnacle Goose	Medium	Medium
Brent Goose	Medium	Medium
Eurasian Wigeon	Medium	Medium
Gadwall	Medium	Medium
Northern Pintail	Medium	Medium
Northern Shoveler	Medium	Medium
Greater Scaup	Medium	Medium
Common Eider	Medium	Medium
Common Scoter	Medium	Medium
Little Gull	Medium	Medium
Black-headed Gull	Medium	Medium
Waterrail	Medium	Medium
Corncrake	Medium	Medium
Moorhen	Medium	Medium
Common Coot	Medium	Medium
Common Gull	Medium	Medium
Herring Gull	Medium	Medium
Great Black-backed Gull	Medium	Medium
Sandwich Tern	Medium	Medium
Common Tern	Medium	Medium
Long-eared Owl	Medium	Medium
Short-eared Owl	Medium	Medium
Obligatory nocturnal migrating passerines	High	Medium
Facultative nocturnal migrating passerines	High	Medium
Other migrating bird species		Minor

Collision with traffic
Beside the collision risk with the bridge structure itself (see above) birds may collide with trains and vehicles crossing the bridge. Although some species are assessed to have a medium sensitivity to colliding with traffic the overall proportion of birds affected by such collision incidents is regarded to be low. Therefore, the degree of impairment is minor for all breeding, non-breeding and migrating bird species. Subsequently, the severity of impairment is minor for all birds in the area as well (Table 1.28).

The duration of the pressure is permanent.

Table 1.28 Summary of impact assessment for the pressure 'collision with traffic' during operation of a cable stayed bridge in the Fehmarnbelt to the environmental components breeding waterbirds (waterbirds breeding in Natura 2000 areas only), non-breeding waterbirds and migrating birds.

Bridge – operation and structures – collision with traffic		
Species	**Degree of impairment**	**Severity of impairment**
Breeding waterbirds		
All breeding waterbird species	Minor	Minor
Non-breeding waterbirds		
All non-breeding waterbird species	Minor	Minor
Migrating birds		
All migrating bird species	Minor	Minor

Overall assessment of severity and significance of impacts

The different pressures from operation of a cable stayed bridge in the Fehmarnbelt are assessed to result in minor severity of loss/impairment to all breeding waterbird species in the area. All impacts to breeding waterbirds are assessed as insignificant.

For non-breeding waterbirds the degree of impairment from some pressures is very high (disturbance from bridge structure and traffic for several species, barrier effect for auks) or high (barrier effect for scoters). Regarding overall displacement of birds, numbers predicted to be displaced from disturbance of the bridge are low for most species, thus the severity of impairment is minor for most non-breeding waterbird species. The severity of impairment is high for Common Pochard and Tufted Duck and medium for Common Eider. Regarding a barrier effect, the severity of impairment is medium for 10 waterbird species and high for divers, scoters and Black Guillemot. The severity of impairment from collision is minor for most non-breeding waterbirds, except the nocturnally active duck species Common Pochard, Tufted Duck and Greater Scaup.

Predicted displacement due to the project impacts does not exceed 1% of the population for any of the non-breeding waterbird species. The predicted barrier effect is not considered as interruption of ecologically functional connections between foraging and resting habitats. Collision numbers are predicted to be low, well below a threshold, for which a population effect could be expected (according to Potential Biological Removal, PBR) or a very high severity of impairment would be concluded (1% of the biogeographic/relevant reference population). Thus, the project impact from operation of a cable stayed bridge in the Fehmarnbelt is assessed as insignificant for all non-breeding waterbird species in the area.

Regarding migrating birds the pressure 'barrier from bridge structure and traffic' results in a very high degree of impairment and also very high severity of impairment to the three auk species Common Guillemot, Razorbill and Black Guillemot. An interruption of migration flyways and disruption of the connectivity between wintering and breeding habitats of these species cannot be excluded. The project impact from operation of a cable stayed bridge in the Fehmarnbelt is thus assessed to be significant for Common Guillemot, Razorbill and Black Guillemot. Though medium to high severity of impairment is assessed for the pressure 'barrier effect from bridge structure and traffic' for other migrating species, the project impact is assessed as being insignificant with regard to barrier effect for other migrating birds than auks. For the pressure 'collision with bridge structures', a medium severity of impairment is assessed for numerous species. However, collision numbers are predicted to stay well below a threshold, for which a population effect could be expected (according to Potential Biological Removal, PBR) or a very high severity of impairment would be concluded (1% of the biogeographic/relevant reference population). Therefore, the impact from collision is assessed as insignificant for migrating birds.

Cumulative impacts

Cumulative impacts were assessed for the bridge alternative of a fixed link in Fehmarnbelt in conjunction with planned offshore wind farm projects. For breeding birds no relevant cumulative impacts are assumed. For non-breeding waterbirds and migrating birds the cumulative impacts are assessed being insignificant.

1.8 Comparison of bridge and tunnel main alternatives

Breeding waterbirds

Regarding breeding waterbirds for none of the main alternatives a significant impact is predicted and the severity of impairment levels do not exceed minor for any pressure and alternative. During the construction phase a slight advantage is given for the bridge alternative. During the operation phase a slight advantage is predicted for the tunnel alternative. Regarding both, construction and operation, and taking the duration of impact into account a slight overall advantage is assigned to the tunnel alternative since this option has a slight advantage during the permanent operation phase.

Non-breeding waterbirds

Regarding non-breeding waterbirds none of the main alternatives is clearly more advantageous than the other.

With regards to the construction phase, a clear overall advantage is predicted for the bridge alternative. Numbers of waterbirds getting displaced from the impaired and lost areas would be lower for the bridge alternative compared to the tunnel alternative.

Regarding the operation phase of a fixed link in the Fehmarnbelt there is an overall advantage for the tunnel solution. Fewer birds are predicted to be displaced due to habitat loss and disturbance, and the absence of a barrier effect and collision risk is an advantage for the tunnel solution.

Taking the duration of impact into account, regarding both, construction and operation, a slight overall advantage is assigned to the immersed tunnel alternative since this alternative has an advantage during the permanent operation phase.

Migrating birds

During the construction period both alternatives are predicted to have a comparable (minor) impact to migrating birds. However, there is a significant impact on migrating auks from operation of a bridge which is predicted due to the barrier effect. No impact on migrating birds is predicted from operating a tunnel in this area. Therefore, the tunnel alternative would be clearly advantageous to migrating birds.

Conclusion
Regarding all three environmental components of birds – breeding waterbirds, non-breeding waterbirds and migrating birds – due to the significant impact predicted for the bridge alternative, it is concluded that the tunnel solution would be more advantageous for birds.

1.9 Assessment of strictly protected species

For both the tunnel and the bridge alternatives, a decision is needed whether any of the identified pressures may lead to a violation of the objectives of Article 12 of the Habitats Directive and Article 5 of the Birds Directive, including the deliberate capture or killing of specimens (including injury), deliberate disturbance of birds and the deterioration or destruction of resting habitats.

Concerning the deliberate killing, neither the bridge nor the tunnel alternative would cause mortalities for which a violation of Article 5 of the Birds Directive or Article 12 of the Habitats Directive would be expected.

Deliberate disturbance will occur during construction of both, the bridge and the tunnel alternatives, mainly for non-breeding waterbirds. Relatively high proportions of local populations of several duck species, namely Eurasian Wigeon, Common Pochard, Tufted Duck, Greater Scaup, Common Eider, Long-tailed Duck, Velvet Scoter and Common Goldeneye, will be displaced due to construction activities. Additionally, construction activities will displace more than 1% of local populations of divers (Red-throated and Black-throated Diver), Red-necked Grebe, Red-breasted Merganser, Razorbill and Great Cormorant.

Deliberate disturbance during the operation stage would mainly occur for the bridge alternative as the bridge and the traffic on the bridge would result in displacement of birds and the bridge structure would cause a barrier effect. Among non-breeding waterbirds, Tufted Duck, Greater Scaup, Velvet Scoter and Great Cormorant would be displaced by disturbance affecting more than 1% of local populations. Among migrating birds, Common Scoter, Velvet Scoter and the auk species, Common Guillemot, Razorbill and Black Guillemot, would be strongly affected by the barrier effect. Thus, the deliberate disturbance by the bridge alternative would violate Article 5 of the Birds Directive and Article 12 of the Habitats Directive.

Deterioration and destruction of resting habitats would occur due to construction activities and land reclamation for both, the tunnel and the bridge alternative for non-breeding waterbirds. Four duck species Common Pochard, Tufted Duck, Greater Scaup and Common Goldeneye and the Great Cormorant would lose some of their resting habitats due to the construction of the tunnel alternative. The bridge alternative would impair resting habitats only for Common Pochard, Tufted Duck and Great Cormorant, but to a lesser extent than the tunnel alternative. It must be noted, that resting habitats in marine environment are not stable and not necessarily linked to geographical locations, but more to geomorphological and habitat features. It is expected that resting sites can re-establish after completing the construction activities.

1.10 Mitigation

Mitigation is defined as actions taken to minimise or eliminate impacts on protected species during design, construction and/or operation of a fixed link. In the project design substantial measures have been taken to avoid impacts on birds, both for the tunnel and bridge alternatives, such as selection of visible, 2.5 m high wind screens reducing the collision risk of birds or cables designed with dimensions clearly visible to birds in order to reduce collision risk.

In addition to the mitigation measures already included in the planning and design of the project, it is recommended to reduce and control light emissions during construction activities as long as this is not in conflict with safety requirements. Light emissions may attract birds during bad weather conditions and consequently enhance collision risk, or act as a barrier during other situations, when birds would avoid intensively lit areas.

During operation of the bridge alternative, the recommendations with respect to light reductions are similar to the recommendations during construction.

2 INTRODUCTION

2.1 Environmental theme

On September 3, 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.

Denmark is responsible for the planning and design as well as financing, construction and operation of the Fehmarnbelt Fixed Link. The combined rail and road project 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 the Road Construction and Transport, Department of Lübeck (Landesbetrieb für Verkehr und Straßenbau des Landes Schleswig-Holstein, Lübeck Niederlassung (LBV)), is the project applicant for the motorway section of the link in Germany.

2.2 Environmental components assessed

Femern A/S has commissioned the FEBI consortium to conduct the baseline studies on birds and to assess the impacts of the different possible solutions for a fixed link. In the Fehmarnbelt the bird community is dominated by non-breeding waterbirds which use the area for moulting, staging or wintering. In addition, a variety of bird species passes through the area on migration. Although a high number of migratory birds do not touch ground in the Fehmarnbelt area, it serves a special function for a number of species which concentrate here outside the breeding season. The coastal areas also offer suitable habitats for breeding waterbirds.

As part of the transition area between the polyhaline Skagerrak and the oligohaline Baltic Sea, the Fehmarnbelt (and the Belt Sea) is characterised by permanent vertical and horizontal salinity gradients in connection with extensive areas of shallow waters. A wide range of shallow water habitats gives rise to rich food supplies for benthivorous, herbivorous and piscivorous waterbirds. Waterbirds aggregate within areas shallower than 25 m. As a result of the high level secondary benthic production, the Fehmarnbelt is a region of high abundance of several waterbird species, with species such as Red-necked Grebe *Podiceps grisegena*, Great Cormorant *Phalacrocorax carbo*, Mute Swan *Cygnus olor*, Tufted Duck *Aythya fuligula*, Common Eider *Somateria mollissima*, Common Scoter *Melanitta nigra* and Red-breasted Merganser *Mergus serrator* occurring regularly in numbers of international importance. The Fehmarnbelt area is less important for breeding waterbirds, yet nationally important colonies of terns and gulls are found in suitable breeding areas near Fehmarn and in the Rødsand Lagoon.

The salinity gradient in the Belt Sea is particularly important for the structure of the non-breeding waterbird community showing a decrease in the proportion of Common Eiders and an increase in the proportion of Long-tailed Ducks with decreasing salinity, - a direct function of the differential size-distribution of their primary prey Blue Mussels *Mytilus edulis* across the salinity gradient (Nilsson 1972, Durinck et al. 1994). Besides, seasonal oxygen deficiency which occurs regularly below the pycnoline provides another stress factor affecting the available supply of mussels to waterbirds such as seaducks in the Belt (FEMA 2013a). Major hydrographic changes regularly affect the oxygen regime which also influences the stocks of Blue Mussels which again give rise to potential secondary effects on the food supply to the regional seaduck populations. It is estimated that a large majority of non-breeding waterbirds in the Fehmarnbelt traditionally has been dependent on a rich supply of Blue Mussels (Skov et al. 1995).

Eelgrass meadows and mussel beds are the most important habitats to birds in the Belt Sea with a potential habitat area of approximately 10,000 km^2 as defined by sufficient light intensity at the bottom (i.e. larger than 10 to 15% of the incident surface insolation (FEMA 2013b)). The benthic fauna in the Fehmarnbelt area is distributed according to depth and substrate. The important Blue Mussels and other filter-feeding benthic fauna that are a prerequisite for staging seaducks are mainly occurring at or above the pycnocline where phytoplankton is available in large quantities. Dense mussel beds are located where currents are strong. These areas provide continuous supply of food to seaducks such as areas west of Fehmarn and along the coast of Lolland (FEMA 2013a). In addition, small fish like sticklebacks (*Gasterosteidae*) and gobies (*Gobiidae*) concentrate in the ecotones between the lagoons and offshore waters (FeBEC 2013a), and here large numbers of piscivorous mergansers and grebes are found.

This report covers the Impact Assessment of the following environmental components:

- Breeding waterbirds (breeding in Natura 2000 areas only)
- Non-breeding waterbirds (resting, wintering and moulting waterbirds)
- Migrating birds (waterbirds and landbirds)

3 RELEVANT PROJECT PRESSURES

This report describes the pressures and the assessment of the potential effects on birds from the different alternatives of a fixed link during construction, pressures caused by the permanent physical structures, and pressures due to the operation of the link. Pressures from construction and operation of a fixed link are different and thus treated separately in the following section. The list of pressures follows the scoping report of the project (Femern A/S and LBV-SH-Lübeck 2010), but takes the information from the technical documents, which have been prepared since then, into account.

The main pressures during construction and the potential effects have been defined in the scoping report (Femern A/S and LBV-SH-Lübeck 2010) as follows:

- Restricted working areas, equipment, facilities and physical structures of the fixed link structures, that will take up land and sea areas and may:
  - cause barrier effects for birds
  - influence the hydrodynamic regime, which in turn may cause effects on flora and fauna changing the food resources available for birds
- Construction activities that emits noise, vibrations, visual disruption and light, which may affect birds
- Dredging, excavation and disposal activities, that directly affect the seabed sediments and destroy flora and fauna which constitute a food resource for birds
- Spill and spreading of marine sediments from dredging, which affect the water quality, and potentially flora and fauna constituting a food resource for birds
- Emissions of CO_2, nutrients and contaminants to air, water and soil which may affect flora and fauna constituting a food source for birds, or emissions of contaminants that may affect birds directly

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

- Loss of sea areas (footprints)
- Loss and/or deterioration of habitats for fauna and flora constituting a food source for birds
- Barrier effects on birds
- Threat to birds due to collision risks

Environmental pressures related to the operation of the fixed link:

- Emission of noise, vibration, visual disruption and light, which may disturb birds

- Emissions of CO_2 and pollutants to air, water and soil which may affect flora and fauna constituting a food source for birds, or emissions of contaminants that may affect birds directly

- Traffic related collision risks of birds

Based on the information from the baseline studies the Impact Assessment on birds is structured along the following main pressures:

Construction:

- Habitat loss from footprint

Marine habitats utilised by breeding, non-breeding and migrating birds will be lost through land reclamation areas and construction harbours on Lolland and Fehmarn. This will affect both the seabed and the water column. Though shore habitats will be re-established, benthic and pelagic habitats will be lost and the total area will be reduced. At the tunnel trench the benthic habitats and communities will be removed. The water column will be affected to a lower degree, but subject to very high turbidity from sediment spill, so a total loss of function is assumed during the construction phase.

- Habitat change from sediment spill

The sediment spill from the dredging works at the tunnel trench or for the pylons and piers of a cable stayed bridge and the land reclamations will lead to increased sedimentation and affect benthic habitats in the Fehmarnbelt. This may impair fish and benthic flora and fauna communities (reduction in biomass, growth and productivity) and thus affect food resources of breeding and non-breeding waterbirds in the area.

- Water transparency

The direct sediment spill as well as resuspension of mobilised sediments will decrease water transparency. Where this exceeds background levels this may impair the ability of birds to find food and thus lead to a displacement of birds preferring clear water.

- Disturbance from construction vessels

The construction of both a tunnel and a bridge will need presence and activity of various types of construction vessels which may cause disturbance to breeding and non-breeding waterbirds in the marine areas through their physical presence, noise and light emissions.

- Barrier from construction vessels

The presence of a large number of construction vessels might result in a barrier, reducing the movements of birds between staging areas and on migration.

- Collision with construction vessels

Birds may collide with construction vessels especially at night if they are attracted by lights.

Operation and structures:

- Habitat loss and habitat change from footprint

Marine habitats utilised by breeding and non-breeding waterbirds will be lost through the footprint structures of a bridge or tunnel, including land reclamation areas and the loss and deterioration of areas at sea through project structures, embankments and protection layers/structures. This will affect both the seabed and the water column.

- Provision of artificial reefs

The underwater structures such as pylons, piers, embankments and protection layers will provide additional hard substrate at the seafloor and in the water column. These structures will be colonised by hard substrate benthic communities which may attract fish and birds.

- Hydrographical changes

The piers and pylons of a bridge and to a lesser extent the land reclamations of a tunnel will change the hydrography at the alignment by increasing turbulence.

- Disturbance from bridge structure and traffic

The physical structure of a bridge as well as emission of light and noise are likely to disturb birds and cause displacement.

- Disturbance from channelling of shipping

In the case of a bridge the main shipping routes through the Fehmarnbelt would be directed through the main gates of the bridge. This might cause increased disturbance from shipping in some areas but also a relief in other areas.

- Barrier from bridge structure

A bridge through its physical structure might constitute a barrier to breeding and non-breeding waterbirds and migrating birds which prefer to fly over open waters and are reluctant to pass such obstacles.

- Collision with bridge structures

Birds migrating through the Fehmarnbelt might collide with the structure of the bridge either if they do not perceive the obstacle during inclement weather conditions and during the night or if they would be attracted by the lights of bridge or traffic.

- Collision with traffic

Birds flying at the altitude of the traffic lanes or birds which perch on the structure of the bridge or scavenging on collision victims are in the risk of colliding with traffic.

The project related CO_2 emissions during construction and operation of a fixed link in the Fehmarnbelt are considered not to have a relevant impact on the environmental components breeding waterbirds, non-breeding waterbirds and migrating birds beside the general predictions of impacts from climate change. Therefore, this pressure is not further included in the Impact Assessment on birds.

The general predictions of climate change to birds and their implications to the project are assessed in chapter 6.

The release of toxic substances (heavy metals, organic pollutants) would have an impact on birds if these substances accumulate in the food chain and thus poison the birds. According to FEMA (2013d) the concentrations of toxic substances in the sediment are below existing national and international sediment quality guidelines and it is predicted that water quality standards set by EU would not be exceeded during dredging operations (FEMA 2013d). The impact on benthic organisms is assessed as negligible (FEMA 2013d). Therefore, this pressure is regarded as irrelevant for birds and is not further assessed in this report.

4 DATA AND METHODS

4.1 Description of the planning area

The fixed link across the Fehmarnbelt may be constructed as a bridge or a tunnel leading to impacts in the marine habitats and on the land-approaches on Fehmarn and Lolland.

A project area has been defined between Puttgarden on Fehmarn and Rødby on Lolland (Figure 4.1). In this area, the most suitable route for a fixed link will be chosen. The 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.

Figure 4.1 Demarcation of the project area for the planning of a fixed link.

4.2 Area of investigation

The area of investigation for the bird studies stretches from a line between Kiel and Langeland in the west to a line between Gedser and Dahmeshöved in the east (Figure 4.2). The demarcation of the area of investigation ensures that all Natura 2000 sites, namely the SPAs designated for the protection of birds 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 bird 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.

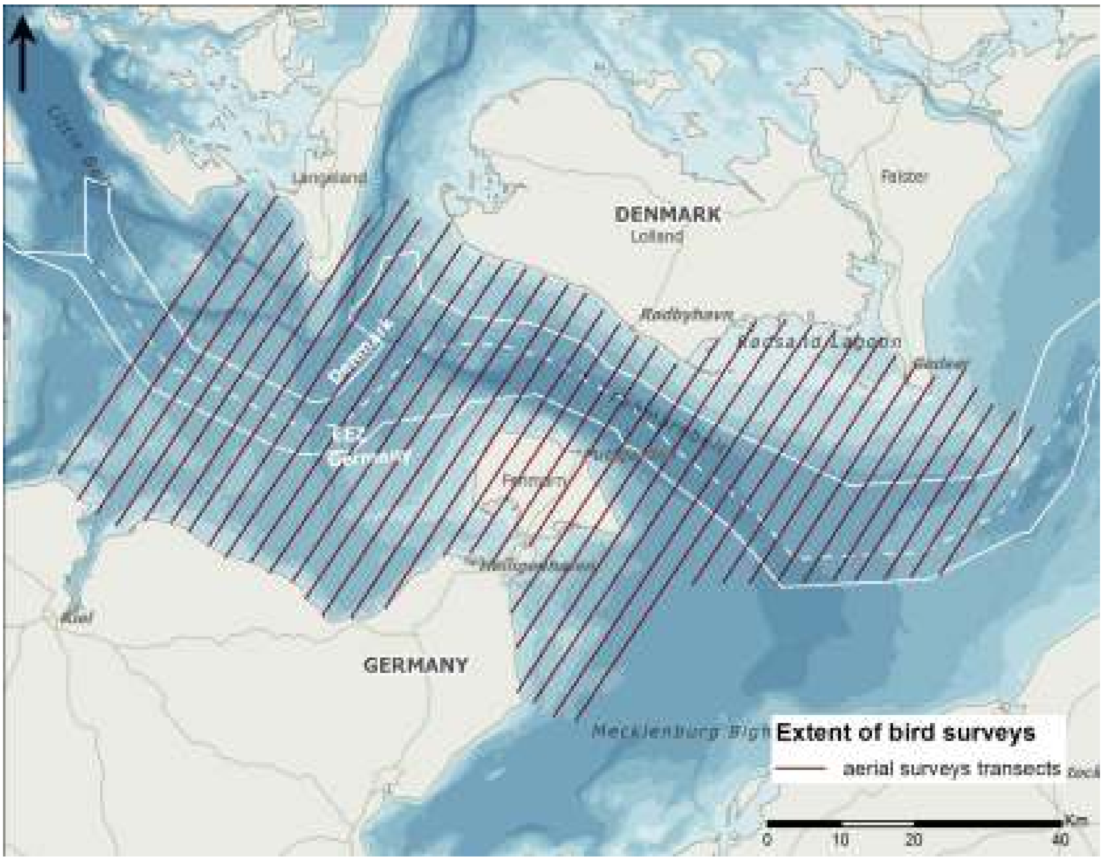


Figure 4.2 Demarcation of the project-specific area of investigation as described by the extent of the aerial surveys.

4.3 Content of the investigations and methodological approach

In order to describe the seasonal abundance of birds, their distribution within the area and in order to analyse the relationships of their abundance to available habitats and existing pressures, FEBI developed a survey programme using different methods from visual surveys to individual tracking. The survey programme has been described in the scoping report (Femern A/S and LBV-SH-Lübeck 2010), and the results are presented in the baseline report (FEBI 2013).

The methods applied followed international standards and comply with the German Standards for Environmental Impact Assessments for Offshore Wind Farms (StUK3) (Bundesamt für Seeschifffahrt und Hydrographie, BSH 2007a).

Overall, the baseline investigations of bird life include the following:

- Quantitative surveys of abundance, distribution and trends of breeding and non-breeding waterbirds in the two land-approach and ramp areas
- Quantitative surveys of abundance, distribution and trends of seabirds and waterbirds at sea
- Qualitative and quantitative (where possible) surveys of waterbirds' use of feeding grounds
- Investigations of the feeding ecology of waterbirds using habitat modelling, telemetry methods and analysis of diet composition
- Quantitative surveys of abundance and migratory behaviour of migrating waterbirds and landbirds, applying visual and radar observations as well as acoustic night-time observations at both sides and in the middle of the alignment
- Additional evaluation of existing Danish weather radar data with regard to bird migration.

The baseline report provides detailed information on abundance, distribution and habitat use of birds in the project area and adjacent waters, as well as a description of the numbers and patterns of bird migration at the location of the Fehmarn link.

4.4 Marine Protected Areas (Natura 2000)

The Fehmarnbelt area is of international importance for a variety of waterbird species, and several Special Protection Areas (SPAs) have been declared by Germany and Denmark under the Natura 2000 network. Four SPAs are of special relevance for the EIA of a fixed link:

- **SPA DK 006X087 Maribo Lakes**: Possible impacts on Tufted Ducks that stay on Maribo Lakes during the day and possibly utilise the Fehmarnbelt as feeding ground during the night.
- **SPA DK 006X083 Hyllekrog-Rødsand**: Possible impacts on bird species, e.g. through potential effects on benthic fauna and flora from sediment spill.
- **SPA DE 1530-491 Eastern Kiel Bight**: Possible structural and functional impairment of resting and feeding grounds, and impact of local flyways of birds due to construction works. In the northern part of the area benthic fauna and flora may be directly or indirectly affected by sediment spill.
- **SPA DE 1633-491 Baltic Sea east of Wagrien**: In the northern part of the area, benthic fauna and flora may be directly or indirectly affected by sediment spill and subsequently affect foraging conditions of staging birds.

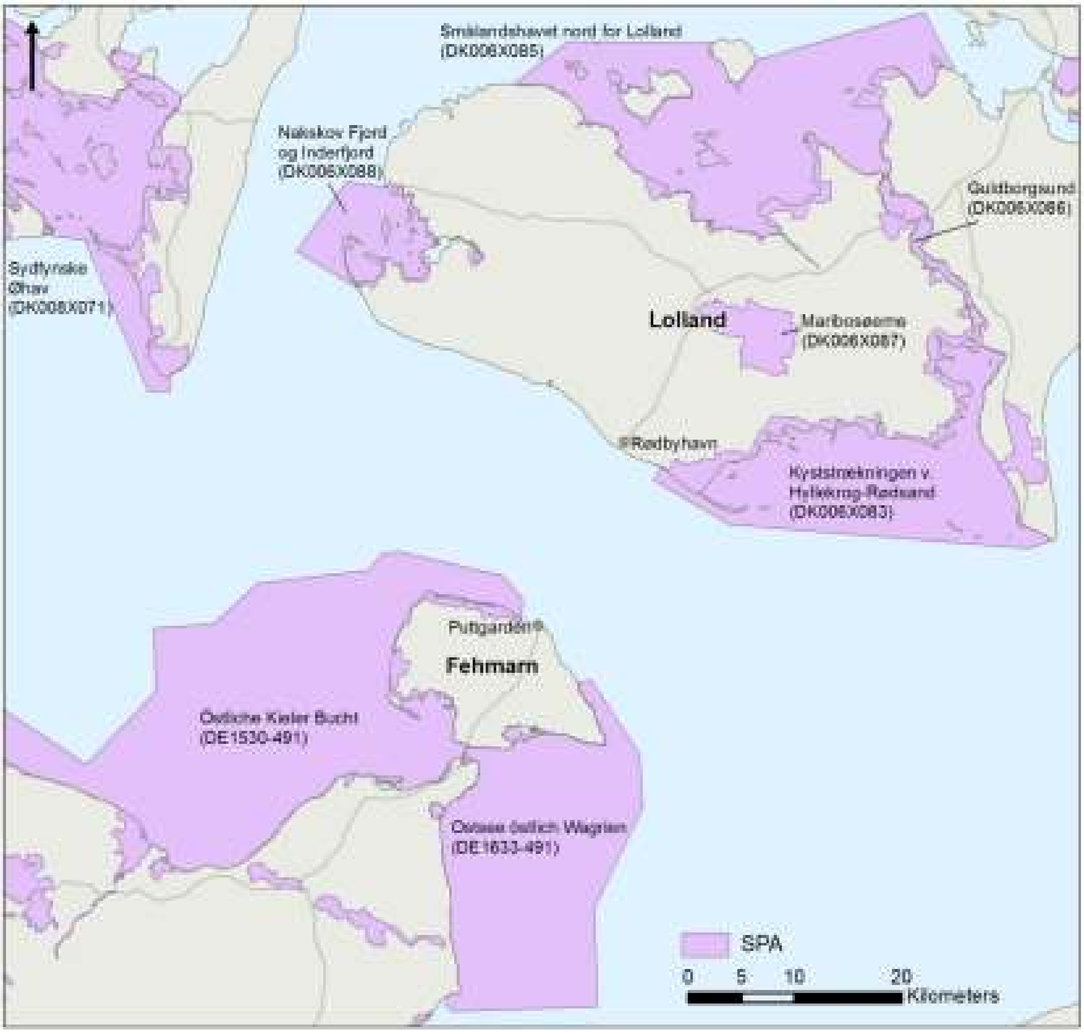


Figure 4.3 German and Danish SPAs in the region around the planned Fehmarnbelt Fixed Link.

In addition, the SCI (Sites Eligible for identification as sites of community importance) Fehmarnbelt (DE1332301), which is situated in the German EEZ between Lolland and Fehmarn, has also been in focus of the Impact Assessment, as several bird species are listed in the standard data forms of this protected area.

The Natura 2000 areas and impacts from the construction of a fixed link are described in detail in the contribution to the Appropriate Assessment.

4.5 The Assessment Methodology

To ensure a uniform and transparent basis for the EIA, a general impact assessment methodology for the assessment of predictable impacts of the Fixed Link Project on the environmental factors (see box in section 4.5.1) has been prepared by Femern A/S. The methodology is defined by the impact forecast methods described in the scoping report (Femern A/S and LBV-SH-Lübeck 2010, section 6.4.2). In order to give more guidance and thereby support comparability, the forecast method has been further specified.

As the impact assessments cover a wide range of environs (terrestrial and marine) and environmental factors, the general methodology is further specified and in some cases modified for the assessment of the individual environmental factors (e.g. the optimal analyses for migrating birds and relatively stationary marine bottom fauna are not identical). These necessary modifications are explained in Section 4.5.14. The specification of methods and tools used in the present report are given in the following sections of this chapter.

4.5.1 *Overview of terminology*

To assist reading the background report as documentation for the German UVS/LPB and the Danish VVM, the Danish and German terms are given in the columns to the right.

Term	Explanation	Term DK	Term DE
Environ-mental factors	The environmental factors are defined in the EU EIA Directive (EU 1985) and comprise: Human beings, Fauna and flora, Soil, Water, Air, Climate, Landscape, Material assets and cultural heritage. In the sections below only the term environmental factor is used; covering all levels (factors, sub-factors, etc.; see below). The relevant level depends on the analysis.	Miljøforhold/ -faktor	Schutzgut
Sub-factors	As the Fixed Link Project covers both terrestrial and marine sections, each environmental factor has been divided into three sub-factors: Marine areas, Lolland and Fehmarn (e.g. Marine waters, Water on Lolland, and Water on Fehmarn)	Sub-faktor	Teil-Schutzgut
Components and sub-components	To assess the impacts on the sub-factors, a number of components and sub-components are identified. Examples of components are e.g. Surface waters on Fehmarn, Groundwater on Fehmarn; both belonging to the sub-factor Water on Fehmarn. The sub-components are the specific indicators selected as best suitable for assessing the impacts of the Project. They may represent different characteristics of the environmental system; from specific species to biological communities or specific themes (e.g. trawl fishery, marine tourism).	Component/ sub-komponent	Komponente
Construction phase	The period when the Project is constructed; including permanent and provisional structures. The construction is planned for 6½ years.	Anlægsfase	Bauphase
Structures	Constructions that are either permanent elements of the Project (e.g. bridge pillar for bridge alternative and land reclamation at Lolland for tunnel alternative), or provisional structures such as work harbours and the tunnel trench.	Anlæg	Anlage
Operation phase	The period from end of construction phase until decommissioning.	Driftsfase	Betriebs-phase
Permanent	Pressure and impacts lasting for the life time of the Project (until decommissioning).	Permanent	Permanent

Term	Explanation	Term DK	Term DE
Provisional	Pressure and impacts predicted to be recovered within the life time of the Project. The recovery time is assessed as precise as possible and is in addition related to Project phases.	Midlertidig	Temporär
Pressures	A pressure is understood as all influences deriving from the Fixed Link Project; both influences deriving from Project activities and influences originating from interactions between the environmental factors. The type of the pressure describes its relation to construction, structures or operation.	Belastning	Wirk-faktoren
Magnitude of pressure	The magnitude of pressure is described by the intensity, duration and range of the pressure. Different methods may be used to arrive at the magnitude; dependent on the type of pressure and the environmental factor to be assessed.	Belastnings-størrelse	Wirk-intensität
Footprint	The footprint of the Project comprises the areas occupied by structures. It comprises two types of footprint; the permanent footprint deriving from permanent confiscation of areas to structures, land reclamation etc., and provisional footprint which are areas recovered after decommissioning of provisional structures. The recovery may be due to natural processes or Project aided re-establishment of the area.	Areal-inddragelse	Flächen-inanspruch-nahme
Assessment criteria and Grading	Assessment criteria are applied to grade the components of the assessment schemes. Grading is done according to a four grade scale: very high, high, medium, minor or a two grade scale: special, general. In some cases grading is not doable. Grading of magnitude of pressure and sensitivity is method dependent. Grading of importance and impairment is as far as possible done for all factors.	Vurderings-kriterier og graduering	Bewertungs-kriterien und Einstufung
Importance	The importance is defined as the functional values to the natural environment and the landscape.	Betydning	Bedeutung
Sensitivity	The sensitivity describes the environmental factors capability to resist a pressure. Dependent on the subject assessed, the description of the sensitivity may involve intolerance, recovery and importance.	Sårbarhed	Empfindlich-keit
Impacts	The impacts of the Project are the effects on the environmental factors. Impacts are divided into Loss and Impairment.	Virkninger	Auswirkung
Loss	Loss of environmental factors is caused by permanent and provisional loss of area due to the footprint of the Project; meaning that loss may be permanent or provisional. The degree of loss is described by the intensity, the duration and if feasible, the range.	Tab af areal	Flächen-verlust

Term	Explanation	Term DK	Term DE
Severity of loss	Severity of loss expresses the consequences of occupation of land (seabed). It is analysed by combining magnitude of the Project's footprint with importance of the environmental factor lost due to the footprint.	Omfang af tab	Schwere der Auswir-kungen bei Flächen-verlust
Impairment	Impairment is a change in the function of an environmental factor.	Forringelse	Funktions-beeinträchti-gung
Degree of impairment	The degree of impairments is assessed by combining magnitude of pressure and sensitivity. Different methods may be used to arrive at the degree. The degree of impairment is described by the intensity, the duration and if feasible, the range.	Omfang af forringelser	Schwere der Funktions-beeinträchti-gung
Severity of impairment	Severity of impairment expresses the consequences of the Project taking the importance of the environmental factor into consideration; i.e. by combining the degree impairment with importance.	Signifikans	Erheblich-keit
Significance	The significance is the concluding evaluation of the impacts from the Project on the environmental factors and the ecosystem. It is an expert judgment based on the results of all analyses.		

It should be noted that in the sections below only the term environmental factor is used; covering all levels of the receptors of the pressures of the Project (factors, sub-factors, components, sub-components). The relevant level depends on the analysis and will be explained in the following methodology sections.

4.5.2 *The Impact Assessment Scheme*

The overall goal of the assessment is to arrive at the severity of impact where impact is divided into two parts; loss and impairment (see explanation above). As stated in the scoping report, the path to arrive at the severity is different for loss and impairments. For assessment of the *severity of loss* the footprint of the project (the areas occupied) and the *importance* of the environmental factors are taken into consideration. On the other hand, the assessment of severity of impairment comprises two steps; first the *degree of impairment* considering the magnitude of pressure and the sensitivity. Subsequently the severity is assessed by combining the degree of impairment and the importance of the environmental factor. The assessment schemes are shown in Figure 4.4 - Figure 4.6. More details on the concepts and steps of the schemes are given below. As mentioned above, modification are required for some environmental factors and the exact assessment process and the tools applied vary dependent on both the type of pressure and the environmental factor analysed. As far as possible the impacts are assessed quantitatively; accompanied by a qualitative argumentation.

4.5.3 *Assessment Tools*

For the Impact Assessment the assessment matrices described in the scoping report have been key tools. Two sets of matrices are defined; one for the assessment of loss and one for assessment of impairment.

The matrices applied for assessments of severity of loss and degree of impairment are given in the scoping report (Table 6.4 and Table 6.5) and are shown below in Table 4.1 and Table 4.2, respectively.

Table 4.1 The matrix used for assessment of the severity of loss. The magnitude of pressure = the footprint of the Project is always considered to be very high.

Magnitude of the predicted pressure (footprint)	**Importance of the environmental factors**			
	Very high	High	Medium	Minor
Very High	**Very High**	**High**	**Medium**	**Minor**

The approach and thus the tools applied for assessment of the degree of impairment varies with the environmental factor and the pressure. For each assessment the most optimal state-of-the-art tools have been applied, involving e.g. deterministic and statistical models as well as GIS based analyses. In cases where direct analysis of causal-relationship is not feasible, the matrix based approach has been applied using one of the matrices in Table 4.2 (Table 6.5 of the scoping report) combining the grades of magnitude of pressure and grades of sensitivity. This method gives a direct grading of the degree of impairment. Using other tools to arrive at the degree of impairment, the results are subsequently graded using the impairment criteria. The specific tools applied are described in the following sections of this chapter.

Table 4.2 The matrices used for the matrix based assessment of the degree of impairment with two and four grade scaling, respectively.

Magnitude of the predicted pressure	**Sensitivity of the environmental factors**			
	Very high	High	Medium	Minor
Very high	**General 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**

Magnitude of the predicted pressure	**Sensitivity of the environmental factors**	
	Special	General
Very high	**General loss of function, must be substantiated for specific instances**	
High	**Very High**	**High**
Medium	**High**	**Medium**
Low	**Medium**	**Low**

To reach severity of impairment one additional matrix has been prepared, as this was not included in the scoping report. This matrix is shown in Table 4.3.

Table 4.3 The matrix used for assessment of the severity of impairment.

Degree of impairment	**Importance of the environmental factors**			
	Very high	High	Medium	Minor
Very High	**Very High**	**High**	**Medium**	**Minor**
High	**High**	**High**	**Medium**	**Minor**
Medium	**Medium**	**Medium**	**Medium**	**Minor**
Low	**Minor**	**Minor**	**Minor**	**Negligible**

Degree of impairment	**Importance of the environmental factors**	
	Special	General
Very high	**Very High**	**Medium**
High	**High**	**Medium**
Medium	**Medium**	**Medium**
Low	**Minor**	**Minor**

4.5.4 *Assessment Criteria and Grading*

For the environmental assessment two sets of key criteria have been defined: Importance criteria and the Impairment criteria. The importance criteria is applied for grading the importance of an environmental factor, and the impairment criteria form the basis for grading of the impairments caused by the project. The criteria have been discussed with the authorities during the preparation of the EIA.

The impairment criteria integrate pressure, sensitivity and effect. For the impact assessment using the matrix approach, individual criteria are furthermore defined for pressures and sensitivity. The criteria were defined as part of the impact analyses (severity of loss and degree of impairment). Specific assessment criteria are developed for land and marine areas and for each environmental factor. The specific criteria applied in the present impact assessment are described in the following sections of this chapter and as part of the description of the impact assessment.

The purpose of the assessment criteria is to grade according to the defined grading scales. The defined grading scales have four (very high; high; medium; minor) or two (special; general) grades. Grading of magnitude of pressure and sensitivity is method dependent, while grading of importance and impairment is as far as possible done for all factors.

4.5.5 *Identifying and quantifying the pressures from the Project*

The pressures deriving from the Project are comprehensively analysed in the scoping report; including determination of the pressures which are important to the individual environmental sub-factors (Femern and LBV SH Lübeck 2010, chapter 4 and 7). For the assessments the magnitude of the pressures is estimated.

The magnitudes of the pressures are characterised by their type, intensity, duration and range. The *type* distinguishes between pressures induced during construction, pressures from the physical structures (footprints) and pressures during operation. The pressures during construction and from provisional structures have varying duration while pressures from staying physical structure (e.g. bridge piers) and from the operation phase are permanent. Distinctions are also made between direct and indirect pressures where direct pressures are those imposed directly by the Project activities on the environmental factors while the indirect pressures are the consequences of those impacts on other environmental factors and thus express the interactions between the environmental factors.

The *intensity* evaluates the force of the pressure and is as far as possible estimated quantitatively. The *duration* determines the time span of the pressure. It is stated as relevant for the given pressure and environmental factor. Some pressures (like footprint) are permanent and do not have a finite duration. Some pressures occur in events of different duration. The *range* of the pressure defines the spatial extent. Outside of the range, the pressure is regarded as non-existing or negligible.

The magnitude of pressure is described by pressure indicators. The indicators are based on the modes of action on the environmental factor in order to achieve most optimal descriptions of pressure for the individual factors; e.g. mm deposited sediment within a certain period. As far as possible the magnitude is worked out quantitatively. The method of quantification depends on the pressure (spill from dredging, noise, vibration, etc.) and on the environmental factor to be assessed (calling for different aggregations of intensity, duration and range).

4.5.6 Importance of the Environmental Factors

The importance of the environmental factor is assessed for each environmental sub-factor. Some sub-factors are assessed as one unity, but in most cases the importance assessment has been broken down into components and/or sub-components to conduct a proper environmental impact assessment. Considerations about standing stocks and spatial distribution are important for some sub-factors such as birds and are in these cases incorporate in the assessment.

The assessment is based on *importance criteria* defined by the functional value of the environmental sub-factor and the legal status given by EU directives, national laws, etc. the criteria applied for the environmental sub-factor(s) treated in the present report are given in a later section.

The importance criteria are grading the importance into two or four grades (see section 4.5.4). The two grade scale is used when the four grade scale is not applicable. In a few cases such as climate, grading does not make sense. As far as possible the spatial distribution of the importance classes is shown on maps.

4.5.7 Sensitivity

The optimal way to describe the sensitivity to a certain pressure varies between the environmental factors. To assess the sensitivity more issues may be taken into consideration such as the intolerance to the pressure and the capability to recover after impairment or a provisional loss. When deterministic models are used to assess the impairments, the sensitivity is an integrated functionality of the model.

4.5.8 *Severity of loss*

Severity of loss is assessed by combining information on magnitude of footprint, i.e. the areas occupied by the Project with the importance of the environmental factor (Figure 4.4). Loss of area is always considered to be a very high magnitude of pressure and therefore the grading of the severity of loss is determined by the importance (see Table 4.2). The loss is estimated as hectares of lost area. As far as possible the spatial distribution of the importance classes is shown on maps.

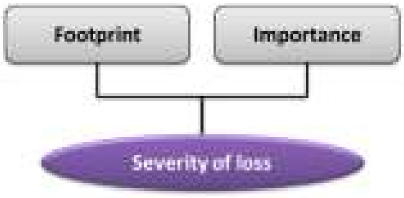


Figure 4.4 The assessment scheme for severity of loss.

4.5.9 *Degree of impairment*

The degree of impairment is assessed based on the magnitude of pressure (involving intensity, duration and range) and the sensitivity of the given environmental factor (Table 4.3). In worst case, the impairment may be so intensive that the function of the environmental factor is lost. It is then considered as loss like loss due to structures, etc.

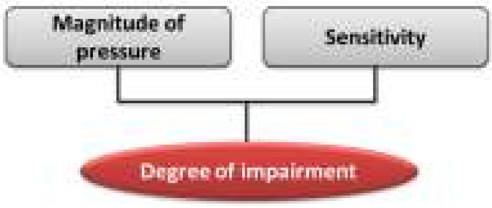


Figure 4.5 The assessment scheme for degree of impairment.

As far as possible the degree is worked out quantitatively. As mentioned earlier the method of quantification depends on the environmental factor and the pressure to be assessed, and of the state-of-the-art tools available for the assessment.

No matter how the analyses of the impairment are conducted, the goal is to grade the degree of impairment using one of the defined grading scales (two or four grades). Deviations occur when it is not possible to grade the degree of impairment. The spatial distribution of the different grades of the degree of impairment is shown on maps.

4.5.10 *Severity of impairment*

Severity of impairment is assessed from the grading of degree of impairment and of importance of the environmental factor (Figure 4.6) using the matrix in Table 4.3. If it is not possible to grade degree of impairment and/or importance an assessment is given based on expert judgment.

Figure 4.6 The assessment scheme for severity of impairment.

4.5.11 Significance

The impact assessment is finalised with an overall assessment stating the significance of the predicted impacts. This assessment of significance is based on expert judgement. The reasoning for the conclusion on the significance is explained. Aspects such as degree and severity of impairment/severity of loss, recovery time and the importance of the environmental factor are taken into consideration.

4.5.12 Range of impacts

Besides illustrating the impacts on maps, the extent of the marine impacts is assessed by quantifying the areas impacted in predefined zones. The zones are shown in Figure 4.7. If relevant the area of transboundary impacts are also estimated.

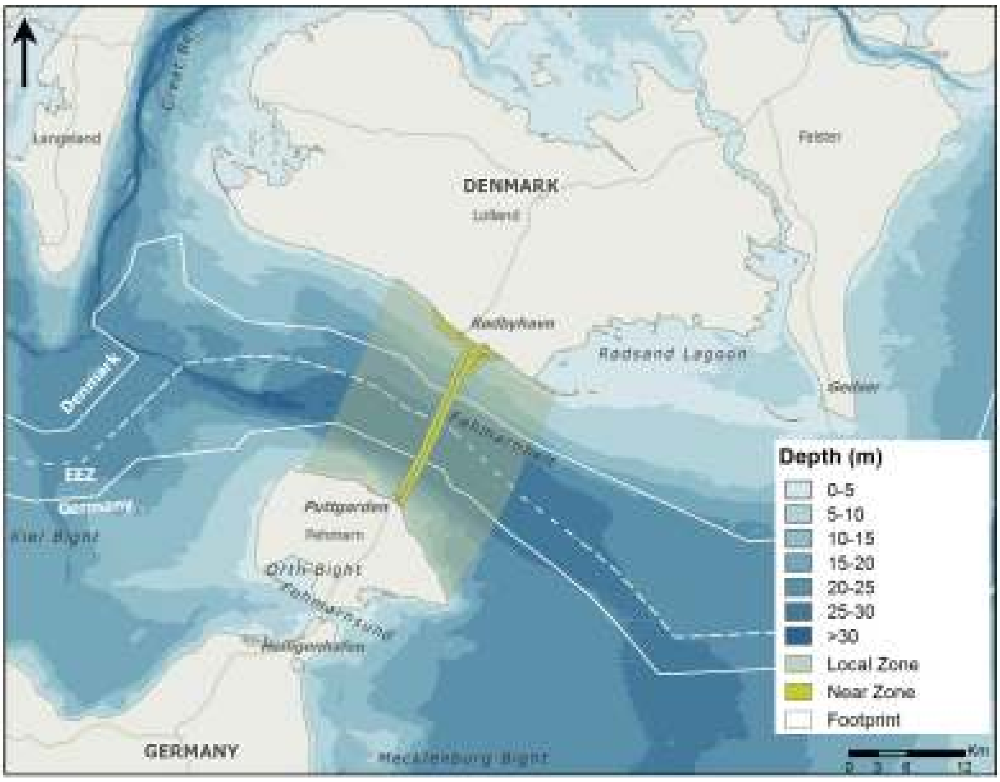


Figure 4.7 The assessment zones applied for description of the spatial distribution of the impacts. The near zone illustrated is valid for the tunnel alternative. It comprises the footprint and a surrounding 500 m band. The local zone is identical for the two alternatives. The eastern and western borders are approximately 10 km from the centre of the alignment.

4.5.13 Duration of impacts

Duration of impacts (provisional loss and impairments) is assessed based on recovery time (restitution time). The recovery time is given as precise as possible; stating the expected time frame from conclusion of the pressure until pre-project conditions is restored. The recovery is also related to the phases of the project using Table 4.4 as a framework.

Table 4.4 Framework applied to relate recovery of environmental factors to the consecutive phases of the Project.

Impact recovered within:	In wording
Construction phase+	recovered within 2 year after end of construction
Operation phase A	recovered within 10 years after end of construction
Operation phase B	recovered within 24 years after end of construction
Operation phase C	recovery takes longer or is permanent

4.5.14 Application of the Assessment Methodology by FEBI

In the following text these elements are described how they are applied for the FEBI Impact Assessment:

Importance

The importance of the Fehmarnbelt area was determined on the species level by accounting both for the conservation status of a species and the numerical abundance of a species in the area in relation to its biogeographic population (waterbirds) or relevant reference population (for all non-waterbird species the breeding populations of Sweden and Finland multiplied by 4 were considered as relevant reference populations, FEBI 2013) (Table 4.5). This approach was also used for assessing the importance of the number of birds affected by a pressure in a particular impact area.

Table 4.5 Scheme of determination of the environmental sub-component's (bird species') importance: the importance level is the result of the combination of the species' abundance in relation to its biogeographic/relevant reference population and the species' protection/conservation status. For explanation how abundance criteria and protection/conservation status are defined see Table 4.6 and Table 4.7.

Abundance in% of the biogeographic/relevant reference population	Protection/conservation status: Very high	High	Medium	Minor
Very high	very high	very high	very high	very high
High	very high	high	medium	Medium
Medium	high	high	medium	Minor
Minor	minor	minor	minor	Minor

The abundance criteria for the determination of importance levels are based on the proportion of the respective biogeographic/relevant reference population registered in the area (Table 4.6).

Table 4.6 Classification of the environmental sub-component (bird species) based on species abundance in relation to its biogeographic/relevant reference population.

Criterion	Description
Very high	≥1% of the biogeographic/relevant reference population, or ≥20,000 individuals of a waterbird species*
High	≥0.5%, but <1% of the biogeographic/relevant reference population
Medium	≥0.1%, but <0.5% of the biogeographic/relevant reference population
Minor	<0.1% of the biogeographic/relevant reference population

* For populations over 2 million birds, Ramsar Convention criterion 5 (20,000 or more waterbirds) applies. This criterion only applies for non-breeding waterbirds.

Two international conservation statuses were chosen for classification of a species importance based on its protection and conservation status: whether a species is listed in the Annex I of the EU Birds Directive or not, and the SPEC status according to BirdLife International (2004a) (Table 4.7). If a species is listed in Annex I of the EU Birds Directive, but is classified to a lower SPEC status, the higher classification applies (i.e. very high).

Table 4.7 Classification of the environmental sub-component (bird species) based on the protection/conservation status of the species according to the EU Birds Directive and the SPEC status of a species according to BirdLife International (2004a).

Criterion	EU Birds Directive	SPEC Status
Very high	Listed in Annex I	SPEC 1 or 2
High		SPEC 3
Medium		Non-SPEC^{E}
Minor		Non-SPEC

Explanations to Table 4.7 (BirdLife International 2004a):

SPEC 1 — European species of global conservation concern, i.e. classified as Critically Endangered, Endangered, Vulnerable, Near Threatened or Data Deficient under the IUCN Red List Criteria at a global level (BirdLife International 2004a, IUCN 2004).

SPEC 2 — Species whose global populations are concentrated in Europe, and which have an Unfavourable Conservation Status in Europe.

SPEC 3 — Species whose global populations are not concentrated in Europe, but which have an Unfavourable conservation status in Europe.

Non-SPEC^{E} — Species whose global populations are concentrated in Europe, but which have a Favourable conservation status in Europe

Non-SPEC — Species whose global populations are not concentrated in Europe, and which have a Favourable conservation status in Europe.

Magnitude of pressure

The magnitude of pressure is regarded as the technical description of the construction works, the structure of a bridge or tunnel or the operation of a fixed link. The magnitude of pressure and the sensitivity of a bird species to a pressure often cannot be treated separately as the magnitude of pressure in some cases cannot be assessed without assessing the species' sensitivity. For example the magnitude of pressure regarding e.g. a bridge structure is only determined by the species response. Thus, the sensitivity (the qualitative response) to a given pressure is used in an initial screening to identify species which may be subject to relevant impacts and thus require a detailed assessment. The degree of impairment, for example the proportion of local bird numbers displaced, is then assessed only for those species, and is directly assessed by available information of a species response to a pressure. If the assessment results in a very high degree of impairment to a species, i.e. a complete displacement of all birds from impaired areas is expected, this corresponds to a very high magnitude of pressure and thus a loss of function of this area to the respective species.

Sensitivity

For the environmental components 'breeding waterbirds', 'non-breeding waterbirds' and 'migrating birds' the sensitivity is assessed on a species level (environmental sub-component). The sensitivity (the qualitative response) to a given pressure is used in an initial screening to identify species which may be subject to relevant impacts and thus require a detailed assessment.

Degree of impairment

The degree of impairment representing the proportion of birds within the impairment zone getting impaired by a pressure was directly assessed by available information about species response to a particular pressure. The different levels of degree of impairment were defined separately for the different pressure types (Table 4.8). It must be noted that a very high degree of impairment corresponds to a loss of function of the impairment zone for the respective species. For birds which get displaced from an area as a consequence of a pressure, it has been defined that the displacement of >50% of the birds within the impairment zone equals to a very high degree of impairment, 25–50% to a high, 5–25% to a medium and <5% to a minor degree of impairment.

Table 4.8 Criteria for assessing the degree of impairment affecting the environmental components breeding waterbirds, non-breeding waterbirds and migrating bird' (incl. waterbirds and 'landbirds') based on the sensitivity of a species to a pressure.

Construction-, structure- or operation-related pressures of the project	Degree of impairment	Description of the degree of impairment
Barrier effect	Very high	Barrier is complete for a large proportion of a population or a complete population concerning migration routes (migrating birds) and exchange flights (breeding and non-breeding waterbirds). There are no alternative flight routes since birds do not fly over land. No connectivity between resting and foraging areas at both sides of the barrier.
	High	Barrier is not complete, but migrating birds show strong reactions to the barrier, e.g. modification of migration routes. Reduced connectivity between breeding, resting and foraging areas at both sides of the barrier for breeding and non-breeding waterbirds.
	Medium	Barrier results in additional reactions, but will be crossed eventually (migrating birds, breeding and non-breeding waterbirds).
	Minor	Minor barrier effect; birds show minor reactions and fly above or below the structure (migrating birds, breeding and non-breeding waterbirds).
Collision risk	Very high	A high proportion of birds migrating through or breeding/resting/wintering in the Fehmarnbelt is expected to collide with the structure on a regular basis.
	High	A small proportion of birds migrating through or breeding/resting/wintering in the Fehmarnbelt is expected to collide with the structure on a regular basis. Adverse weather conditions are expected to increase collision rates.
	Medium	Collisions are unlikely, but adverse weather conditions may result in collision incidents (migrating birds, breeding and non-breeding waterbirds).
	Minor	Collisions are unlikely. Only single birds are expected to collide with the structure (migrating birds, breeding and non-breeding waterbirds).

Construction-, structure- or operation-related pressures of the project	Degree of impairment	Description of the degree of impairment
Disturbance	Very high	50–100% of breeding or non-breeding waterbirds are expected to get displaced from the impairment zone, or the degree of displacement is not assessable.
	High	25–50% of breeding or non-breeding waterbirds are expected to get displaced from the impairment zone.
	Medium	5–25% of breeding or non-breeding waterbirds are expected to get displaced from the impairment zone.
	Minor	Disturbance does not lead to a detectable displacement of breeding or non-breeding waterbirds (<5% displacement).
Habitat change	Very high	Habitat changes result in 50–100% reduction in bird numbers within the impairment zone, or the degree of reduction in bird numbers in not assessable.
	High	Habitat changes result in 25–50% reduction in breeding or non-breeding waterbird numbers within the impairment zone.
	Medium	Habitat changes result in 5–25% reduction in breeding or non-breeding bird numbers in the impairment zone.
	Minor	Habitat changes do not result in a detectable reduction in breeding or non-breeding bird numbers (<5% displacement).

Severity of impact

The severity of impact is either a severity of loss or a severity of impairment. A severity of loss is assessed by combining the area lost by the footprint with the importance level of the impact zone or number of birds affected (Table 4.9). The severity of impairment is assessed by combining the degree of impairment with the importance of a species (Table 4.10). This is either done in a spatial approach based on species importance maps or based on the number of birds of a species estimated to be affected by a pressure. For assessing the severity of loss or severity of impairment wherever possible a quantitative approach was followed. The assessment of severity of impairment and severity of loss was conducted for the season of maximum abundance of a species in the study area (FEBI 2013). For species for which the modelled distributions and densities were similar between the two baseline seasons, the mean distribution of both seasons was used for the assessment.

Table 4.9 Scheme of determination of the severity of loss by the footprint. The severity of loss corresponds with the importance level of affected areas (in a spatial assessment) or the importance level of the number of birds affected by the loss (in a quantitative assessment).

	Importance level			
	Very high	**High**	**Medium**	**Minor**
Severity of loss	Very high	High	Medium	Minor

Table 4.10 Scheme of determination of the severity of impairment. The severity of impairment is based on the degree of impairment (very high degree of impairment = loss of function) and the importance level of impaired areas (in a spatial assessment) or the importance level of the number of birds impaired (in a quantitative assessment).

Degree of impairment	Importance level: Very high	High	Medium	Minor
Very high (loss of function)	Very high	High	Medium	Minor
High	High	High	Medium	Minor
Medium	Medium	Medium	Medium	Minor
Minor	Minor	Minor	Minor	Negligible

For pressures related to displacement and collision of birds a quantitative approach for determining the severity of impairment was followed wherever possible. Here, the severity of impairment is assessed accounting for the number of birds predicted to be removed from the impairment zone in relation to the species biogeographic/ relevant reference population and the species' conservation status (see importance criteria above) due to mortality or displacement or which are predicted to collide with structures.

Assessment of significance

The assessment of the significance of the project impact to breeding waterbirds, non-breeding waterbirds and migrating birds was conducted on a species level considering the overall impact of the project. An impact from the construction and operation of the project was considered significant if at least one of the following criteria was met:

- the total number of displaced individuals (resulting from different pressures) corresponds to more than 1% of the biogeographic population, unless it can be excluded that the displacement of >1% of the biogeographic population would result in a population effect for a species;
- the severity of impairment of barrier effect is assessed as being very high and leading to an interruption of migration flyways (migrating birds) or ecologically functional connections between breeding, resting and foraging habitats (breeding and non-breeding waterbirds);
- the number of birds predicted to collide with the project structures (i.e. be killed) exceeds the threshold of Potential Biological Removal (PBR; see chapter 8) or >1% of the biogeographic/relevant reference population, and could therefore potentially lead to population effects.

When assessing the significance of the project impact, the duration of different pressures (i.e. duration of significant impacts) was taken into account.

Range of impacts
In the Impact Assessment for birds the range of impact – where applicable at all – was determined as accurate as possible as pressure-specific impact zone, thus the above mentioned general impact zones (near and local zone as defined in Figure 4.7) were not applied in the FEBI Impact Assessment.

Duration of impacts
The duration of impacts on birds were described as accurate as possible for each pressure, thus the general recovery phases as defined in Table 4.4 were not applied in the FEBI Impact Assessment.

4.6 Assessment methods for particular pressures

4.6.1 Determination of threshold levels for water transparency

Selection of water transparency thresholds for the Impact Assessment
It was assumed that areas affected by sediment spill in such a way that water transparency would decrease below natural values of the Fehmarnbelt area, would be avoided by species described as being sensitive to this pressure (chapter 7.2). The assessment thus focuses on areas where sediment spill is predicted to lead to water transparency below background levels. Measuring Secchi depth is a standard technique allowing assessment of visibility in the water irrespective of turbidity sources. During the Fehmarnbelt baseline investigations Secchi depth was calculated from light attenuation measured using light sensors mounted on the profiling CTD (FEMA 2013e). Also, Secchi depth was modelled for the entire Fehmarnbelt area for the baseline period and future scenarios including zero solution, immersed tunnel and cable stayed bridge (FEHY 2013).

Winter period
Although water transparency is relatively high across most of the Fehmarnbelt (excluding lagoons) throughout the winter period, wintering waterbirds also regularly experience high turbidity conditions under natural phenomena such as late winter – early spring phytoplankton bloom and frequent winter storms (Figure 4.8, FEMA 2013e). The average measured Secchi depth at offshore stations in the Fehmarnbelt during bird wintering period of 2009 and 2010 was 6.62 m (95% CI 4.01-9.22 m, n=117).

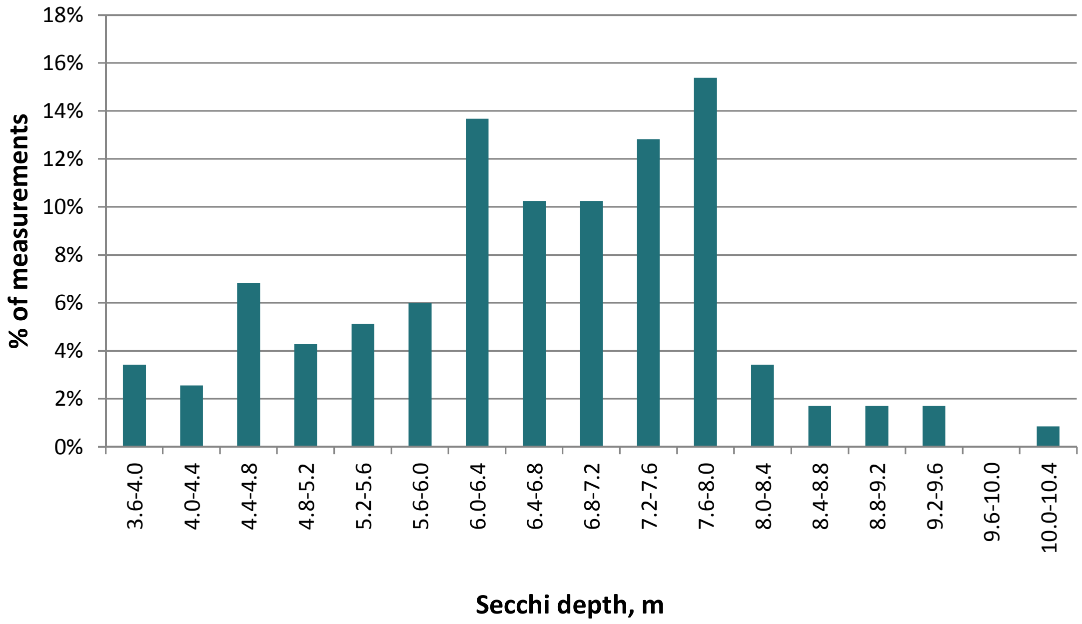


Figure 4.8 *Water transparency: distribution of Secchi depths measured at offshore stations in the Fehmarnbelt during bird wintering period (November – March) in 2009 and 2010 (FEMA 2013e).*

The average values of modelled Secchi depth for two winters of the baseline investigation years were calculated on data extracted for every 12 hours at 100 randomly generated points within the bird survey area (Figure 4.9). The results suggested that the average Secchi depth for baseline conditions was 7.09 m (95% CI 3.74-10.43 m, n=60,400) during bird wintering seasons of 2008/2009 and 2009/2010 (November – March). Modelled Secchi depth data were used as a basis when assessing possible impacts of decreased water transparency on birds. Compared to empirical measurements conducted at a few offshore stations only (Figure 4.8), model results covered the entire study area and were also used for creating impact scenarios.

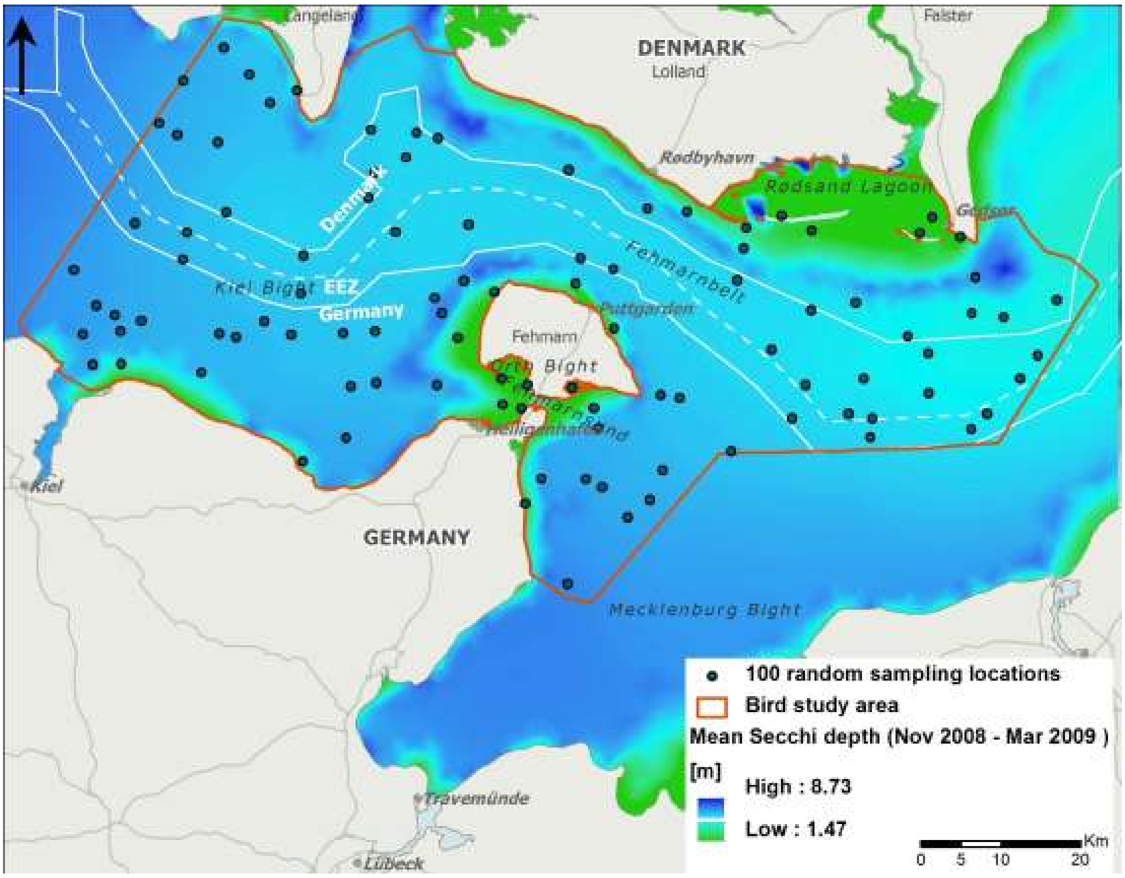


Figure 4.9 Locations of randomly generated points within the bird study area, which were used to calculate average Secchi depth in the Fehmarnbelt.

When information about species tolerance to water transparency was lacking from other sources, using the precautionary principle, it was assumed that birds would abandon areas where water transparency frequently drops below naturally encountered conditions – lower than the 95% confidence interval of 3.74 m.

Considering the modelled Secchi depth under the baseline conditions in the entire Fehmarnbelt area, average values lower than 3.74 m occur only in Rødsand Lagoon and Orth Bight (Figure 4.10). The model predicts that, although infrequently, low water transparency conditions regularly occur over the entire study area (Figure 4.11, Figure 4.12). As Secchi depths lower than 3.74 m also occurred during the baseline conditions, the decrease in water transparency during period of a fixed link construction was measured by subtracting frequency of occurrence of Secchi depths below 3.74 m during modelled baseline conditions from those of impact scenarios. The results indicated difference in frequency of occurrence of low Secchi depth values.

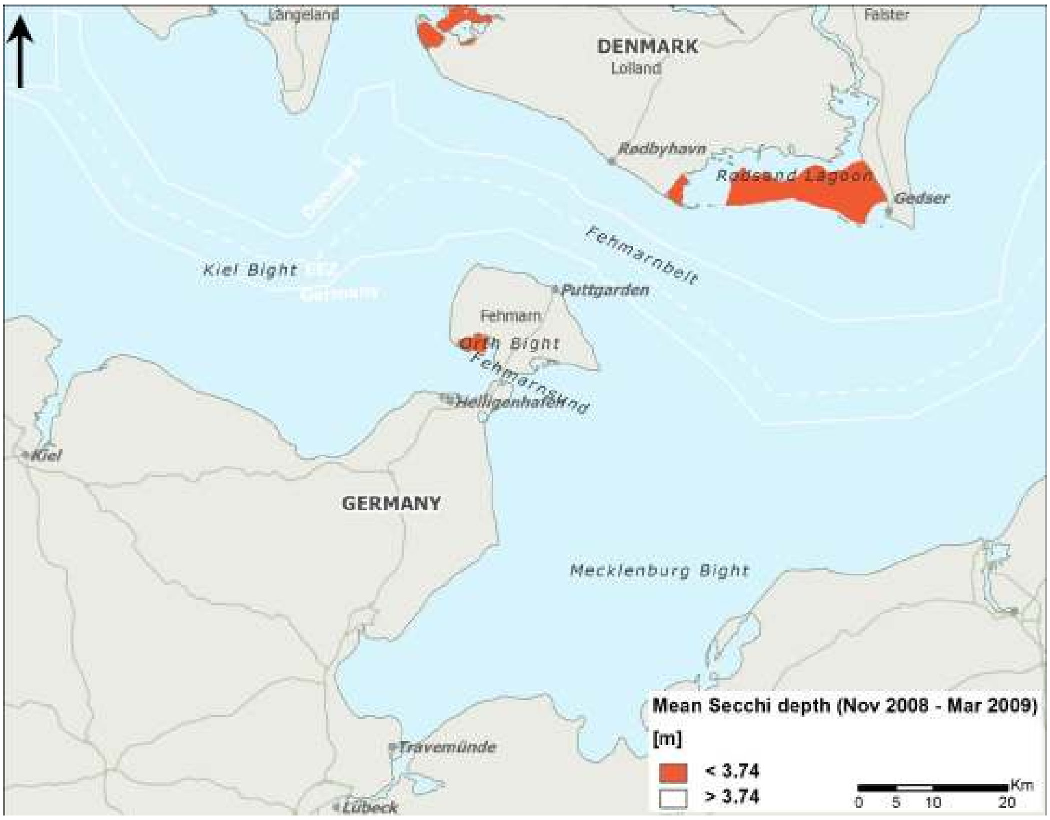


Figure 4.10 Water transparency: areas of average Secchi depth less than 3.74 m during the baseline conditions.

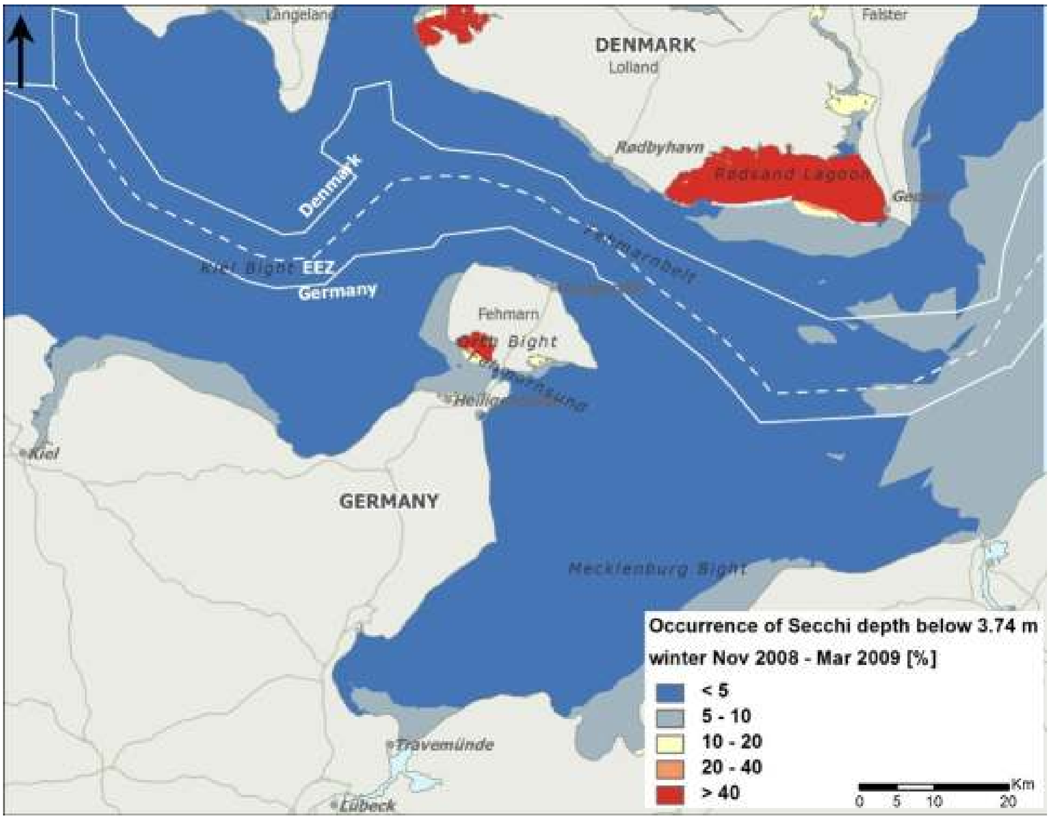


Figure 4.11 Water transparency: frequency of occurrence of Secchi depth less than 3.74 m during the baseline conditions.

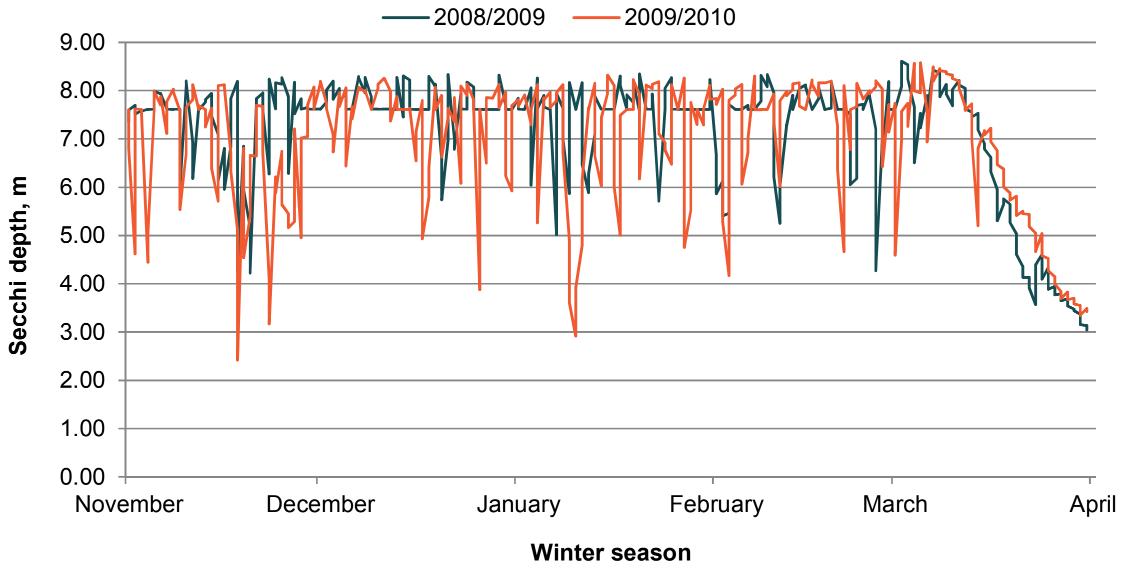


Figure 4.12 Modelled Secchi depth in the Fehmarnbelt during two winters of baseline investigations. Lines represent average Secchi depth assessed for 100 randomly generated points within the study area at 12 hour time intervals (Figure 4.9).

Review of Secchi depths during the baseline conditions revealed substantially lower values in semi-enclosed areas, such as Rødsand Lagoon (Figure 4.10). Therefore Secchi depth was additionally analysed for Rødsand Lagoon, as this area is important for some waterbird species. When assessed at 100 random points within Rødsand Lagoon (at time steps of every 12 hours between November 1 and March 31 during the two winter seasons of baseline investigations), it appeared that the average Secchi depth was substantially lower compared to the rest of the Fehmarnbelt and also more variable: average 4.19 m, SD = 2.95, 95% CI 0.00-9.97 m, n=60,400.

Summer period

The average Secchi depth for the baseline conditions, calculated using 100 randomly selected points (as described above), was 6.92 m (95% CI 3.73-10.10 m, n=24,600) during the summer season of 2009 (May – August). Similar to winter seasons, water transparency fluctuates widely in summer (Figure 4.13). Therefore, as for wintering birds, it was assumed that birds during summer would abandon areas where Secchi depths frequently drop below naturally encountered conditions – lower 95% confidence interval of 3.73 m.

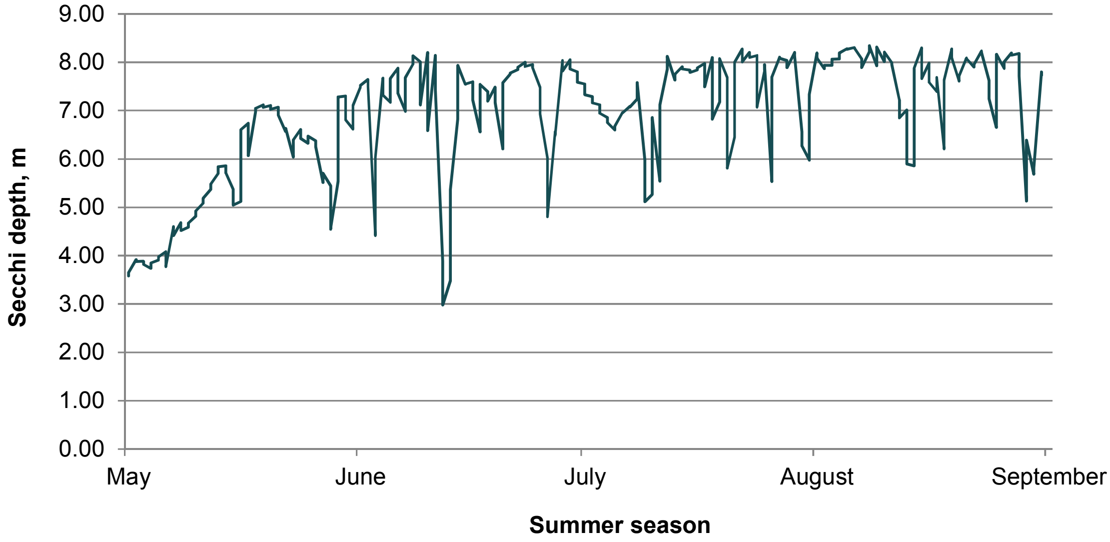


Figure 4.13 Modelled Secchi depth in the Fehmarnbelt during the summer 2009 of baseline investigations. The line represents average Secchi depth assessed for 100 randomly generated points within the study area (Figure 4.9).

Criteria for assessing water transparency impact

The degree of impairment on diving waterbirds is assessed using arbitrarily set criteria about deviations from the baseline conditions. It was assumed that birds would redistribute avoiding areas for which the difference in frequency of decreased water transparency would be higher than 5% compared to the baseline conditions. A very high degree of impairment was assumed for affected areas, i.e. complete displacement of birds from the impairment zone. This is regarded to be a conservative approach to assess the impact of decreased water transparency to waterbirds, because a complete exclusion of birds from turbid areas was assumed for the entire assessed season, which is unlikely to happen.

Because Secchi depth was found being low and highly variable in Rødsand Lagoon during the baseline, an a priori assumption was made that waterbird species, which predominantly stay on Rødsand Lagoon with respect to species distribution in the greater Fehmarnbelt area, are insensitive to decreased water transparency due to a fixed link construction, as they frequently experience low water transparency under natural conditions.

4.6.2 FEBI effect studies at Baltic Sea bridges

The southern Baltic Sea, including Fehmarnbelt, is an important area for waterbirds passing the area during migration or while staging. The planned fixed link across the Fehmarnbelt would be directed perpendicular to the flyways of a large proportion of migrating bird populations. Information about bird reactions to human-made structures such as bridges is very scarce and unavailable for the majority of species. Therefore dedicated effects studies have been conducted at existing bridges in the Baltic Sea aiming to assess specific behaviour of different species (groups) when approaching a bridge.

Between spring 2009 and spring 2010 FEBI collected qualitative and quantitative data on behavioural reactions of waterbirds when approaching bridges in the Baltic Sea, which are located in the same greater geographical region and of similar shape as the proposed cable stayed bridge in Fehmarnbelt: Kalmarsund (Öland Bridge), Farøsund (Queen Alexandrine Bridge and Farø Bridges), Storebælt (Great Belt Bridge) and Fehmarnsund (Fehmarnsund Bridge). The collected data are supplemented by studies carried out at the Öresund Bridge by Lund University (Nilsson et al. 2009, 2010).

Visual observations were carried out to record flight tracks of birds approaching bridges using optical and laser-rangefinder. Results include reaction behaviour of the tracked flocks (see Table 4.11). The recorded tracks have been transformed into geo-referenced, three-dimensional tracks of birds or bird flocks. For most flight tracks, changes of altitude (vertical) and changes of direction (lateral) could be used for a breakpoint analysis. A breakpoint in this context is defined as the distance to the bridge, at which a reaction (change in flight direction or altitude) of birds is recorded. Analysis of the plots of the reaction distances (lateral/vertical) could identify monotonous trends from either side of the breakpoints. Breakpoints were determined both by visual analysis of the recorded tacks and by using non-linear regression. Least square loss functions were fitted to the reaction distances using the quasi-Newton general algorithm, and estimation of standard errors were based on the second-order partial derivatives for the parameters.

During these effect studies at different Baltic Sea bridges (Kalmar, Farø, Storstrøm, Møn, Storebælt, Fehmarnsund), data have been collected on a total of 55 species. However, the numbers of observations are too low for many species to give meaningful and statistically robust results. Sufficient data are only available to calculate reaction types for Great Cormorant, Mute Swan, geese (6 species pooled together), dabbling ducks (4 species pooled together), diving ducks (3 species pooled together), Common Eider, other seaducks (3 species pooled together) and mergansers (2 species pooled together).

The collected data cover both, birds performing long-distance migration and local movements, respectively. The separation into these migration types has been carried out by the field observers based on time of year, species and flight behaviour assessed, but must be considered subjective in some cases. Data analyses revealed that mean reactions in flight direction and altitude varied considerably between bridges and species. The different bridges differ with regard to length, height and orientation. Also, the areas, where the different bridges are located, differ in their importance to migrating and staging waterbirds. Some represent major migration routes such as the Kalmarsund, whereas in other areas, such as the Fehmarnsund, local movements prevail. Species show species-specific reaction norms and differences at local scale in migration speed and general flight directions. Furthermore, landscape features and the temporal variation in the predominating weather conditions during the study also account for variation in the results and the variety of recorded reactions. This has been acknowledged when drawing potential conclusions from the bridge study results in the Impact Assessment.

Several reaction types have been registered during the effect studies. Allocations of sensitivity levels to these reaction types are shown in Table 4.11.

Table 4.11 Reaction types registered during the effect studies on Baltic Sea bridges and assessment of sensitivity.

Type	Reaction type description	Assessment for sensitivity
A	No reaction - continue below bridge	minor
B	No reaction - continue above bridge	minor
C	Lowering - continue below bridge	minor
D	Rising - continue above bridge	medium
E	Changing flight direction	medium
F	Circling - flock disintegrating	medium
K	Crossing over land	high
H	Landing on water	high
G	Avoiding bridge and flying back	very high
L	Out of range	not assessed

Analyses of the reaction types recorded at all bridges are presented as observation counts of reaction types per species or species group and displayed as frequencies of corresponding different sensitivity levels (Table 4.12). This information is taken into account when assessing species' sensitivity to the pressure barrier effect from bridge structure (chapter 7.2.9).

Table 4.12 Numbers of observed waterbirds reaction types to bridge structures, combined in categories for the assessment of sensitivity (see Table 4.11), per species group, given in % of total number of flocks registered; results from all bridges studied.

Species / species group	Number of flocks	Reaction type classified as [in %]:			
		Minor	Medium	High	Very high
Divers	13	15.4	69.2	15.4	0.0
Great Cormorant	55	18.2	72.7	7.3	1.8
Swans	8	12.5	25.0	25.0	12.5
Geese	120	20.8	35.8	36.7	2.5
Dabbling ducks	16	37.5	50.0	6.3	0.0
Diving ducks	21	4.8	47.6	0.0	42.9
Common Eider	1,080	8.6	26.6	39.5	24.1
Seaducks excl. Common Eider	46	6.5	60.9	10.9	2.2
Mergansers	17	41.2	47.1	0.0	11.8

A large proportion of birds on long-distance migration showed clear avoidance behaviour when approaching a bridge, such as increasing altitude and changing flight direction, eventually crossing over the bridge at its lowest point or crossing over land. No birds categorised as being on long-distance migration were reported crossing under the bridge. Birds performing local movements showed less strong reactions to a bridge, including occasional crossings under the bridge. However, data on local movements are only available for a few species, such as for Common Eider and Great Cormorant at the Great Belt Bridge and several species recorded at the Fehmarnsund Bridge.

It could be shown, that significant alterations of flight directions and flight altitudes occur at considerable distances (>1,500 m) from the bridge and in many cases it is assumed, that reactions already occur beyond the observer's detection range (>4,000 m) (Table 4.13).

Table 4.13 Results of breakpoint analyses for waterbird species recorded at the different bridges by visual analysis of recorded flight tracks and by non-linear regression analysis; R² is the respective regression coefficient of the regression analysis.

Bridge	Species (group)	Maximum value or range of breakpoint (m, visual analysis)	Breakpoint (m, regression analysis)	R^2
Changes in flight direction				
Öland	All	1,500-2,000	1,724	0.01
Öland	Common Eider	1,400-1,700	1,714	0.02
Öland	Barnacle Goose	800-1,200	850	0.145
Farø	Mute Swan	100-200		
Great Belt	All (long-distance)	>2,500		
Great Belt	All (local)	1,200		
Great Belt	Geese	1,200		
Changes in flight altitude				
Öland	All	>4,000	4,268	0.165
Öland	Common Eider	ca. 4,000	2,883	0.584
Öland	Barnacle Goose	>4,000	938	0.144
Öland	Common Scoter	>4,000		
Farø	All	300-350	303	0.06
Farø	Great Cormorant	300-350	306	0.113
Queen Alexandrine Bridge	Geese	>2,000		
Great Belt	All	1,800-2,200	767	0.159
Great Belt	Geese	1,800-2,200		
Great Belt	Common Eider	1,800-2,200	724	0.298
Fehmarnsund	All		786	0.659
Fehmarnsund	*Aythya* sp.	400-500	1,096	0.039

Changes in flight direction and height (Table 4.14), which birds exhibit when passing a bridge, add additional energetic costs to the overall migration costs of birds. Also the overall migration time might increase. Based on results of the FEBI bridge effect studies calculations estimating these additional energetic costs in relation to overall migration costs were conducted aiming to assess the degree of impairment from this pressure for birds (see chapter 10.3.6).

Table 4.14 Mean recorded flight altitudes of birds before passing the studied bridges (the mean is covering all birds at 250 m distance from the bridge).

Species (group)	Bridge	Mean flight altitude, m
All species	Öland Bridge	139
	Queen Alexandrine Bridge	90
	Farø Bridge	64
	Great Belt Bridge*	104
	Fehmarnsund Bridge	13
Common Eider	Öland Bridge	124

Species (group)	Bridge	Mean flight altitude, m
	Queen Alexandrine Bridge	74
	Great Belt Bridge*	93
	Fehmarnsund Bridge	4
Geese	Öland Bridge**	196
	Farø Bridge	37
	Great Belt Bridge*	131

* Birds on long-distance migration only

** Barnacle Goose

For some species performing local movements, no changes in mean flight altitude or flight direction were found when the birds were approaching the bridges, indicating that the bridges (observed at the Great Belt and Fehmarnsund Bridge) had little effect on the flight paths of these birds. Some individuals have been observed crossing under the bridge. These results indicate that local birds may habituate to the presence of a bridge and might not perceive a bridge as a barrier. However, there are only few data on local movements for only a few species available, thus different reactions to bridges cannot be excluded for other species using the area as breeding or non-breeding waterbird.

4.6.3 Estimation of energetic expenditures due to barrier effect

Except for very few species (e.g. auks), results from the effect studies at Baltic Sea bridges (see chapter 4.6.2, Nilsson et al. 2009, 2010) generally show that waterbirds cross bridges of very different shapes and orientations by either crossing over or flying around the bridge structure. This alteration in the flight paths adds extra flight distance, extra flight time and therefore extra energetic costs. These extra energetic costs were calculated for different selected species assuming different flight scenarios aiming to use these results in the assessment of the degree of impairment for the pressure barrier effect from bridge structure (chapter 10.3.6).

Selection of species

A total of 11 waterbird species have been included in the estimation of energy expenditures based on data availability per species in the effect studies at the Baltic Sea bridges (see chapter 4.6.2, Nilsson et al. 2009, 2010). Only species showing medium or stronger reactions to bridges have been included in the analyses.

Selection of scenarios

The estimation of energy expenditures for birds crossing a bridge follows four different scenarios (presented below). The scenarios represent species-specific behavioural responses, movement status, mean and maximum flight heights (based on measurements of the planned Fehmarnbelt cable stayed bridge, see chapter 10.3.7) and avoidance behaviour / tracks observed during the effect studies at the Baltic Sea bridges (see chapter 4.6.2) and the separate Öresund Bridge studies (Nilsson et al. 2009, 2010).

Only birds on long-distance migration and observations of birds that eventually crossed the studied Baltic Sea bridges were considered in the additional energy expenditure analyses. Local bird movements, tracks of birds turning back and flying away from the bridge and birds landing on the water in front of the bridge were excluded from the analyses. In the first approach, species-specific and bridge-specific data have been compiled in order to formulate different scenarios for which calculations were carried out. However, in order to formulate a common approach for the scenarios applied for the Fehmarnbelt bridge alternative, data from different bridges were lumped and some generalised assumptions were made based on the variety of results. Four scenarios were considered:

1) Birds react to the bridge by increasing their flight altitude and crossing over the bridge. The registered species-specific mean flight altitudes of the birds crossing individual bridges have been used as measures for the climb needed for the birds to cross the bridge. It is assumed that birds initiate migration at sea level when approaching the bridge. A climb of 120 m is assumed for this scenario, applicable for most parts of the bridge (but see scenario 4).

2) Birds circumvent the bridge and cross over land. In this scenario it has been assumed that birds approach the central section of the bridge and have to make a (maximum) detour around the bridge equal to the length of the bridge (half the length to cross over land and half the length to return to the original route), summing up to some 18 km. An additional climb of 20 m is assumed as this would be the mean flying altitude when crossing over land.

3) Birds circulate in front of the bridge for 10 minutes before crossing over the bridge; following scenario 1) above.

4) Birds cross over the bridge at the maximum flight height recorded during our studies. Here the purpose is to provide a more conservative approach compared to scenario 1. The maximum climbing height was set to 250 m.

Application of *"Flight"* model

The energetic costs are presented as energy requirement in kilojoules (kJ) to perform the described flights. For migrating birds all results are compared with the estimated energy expenditure of the total migration distance as a proportion of the total energy requirement (Masden et al. 2009). The species-specific migration distance was estimated using the FEBI ring-recovery analyses (FEBI 2013 – Volume II, Appendix) and measured for the most likely route chosen. Due to low numbers of recoveries of the merganser species, the migration distance was calculated based on information in Fransson and Pettersson (2001) and Bønløkke et al. (2006).

Energy expenditures for the different flight scenarios were calculated by using the software FLIGHT 1.23 (Pennycuick 2008). Physiological measures were taken from the "Wings database" contained within the FLIGHT software. It must be noted that these physiological measurements (weight, wind-load etc.) are taken from samples from a large geographical range and may not always exactly match the species' characteristics in the Fehmarnbelt region. Air speed was calculated as 1.3 times the minimum power speed (Pennycuick pers. comm.). Chemical power (W) is supplied by FLIGHT software taken for the minimum power speed (Vmp) and for birds with a 20% fat gain. Body fat reserves vary between species, seasons and individuals. A 20% fat gain is considered as representative value for birds on migration between birds being lean (almost no fat) and birds being fat with a maximum fat ratio of about 60%. Most of the individuals passing Fehmarnbelt on migration are expected to be on transit to or from their wintering areas, and therefore not assumed to be carrying full fat reserves. Also, fat birds may react differently to the bridge e.g. choose to circumvent rather than crossing over because the cost of climbing for a fat bird is almost twice that for a lean bird.

Energy expenditure for climbing was calculated as the birds' body weight multiplied with the height gain, i.e. mass × gravity × height gain. This value was divided by the conversion efficiency (default 0.23; Pennycuick 2008) to get an estimate of the fuel energy used (Pennycuick 2008). This is the amount of energy required for the climb alone, in addition to the energy needed to fly the distance horizontally, which is estimated using the Power Curve output from the FLIGHT software. The potential extra energy gained from climbing, which can benefit the birds when coming down again to sea level may potentially be available to cover some additional distance without spending any additional energy. This potential energy gained is not included in the analyses.

For calculating the energy expenditure of the detours around the bridge, the Power Curve output from the FLIGHT software was used (Pennycuick 2008) to estimate the energy requirements. The chemical power from the power curve is multiplied by the flight time. The assumption here is that the mass and the air speed stay constant throughout the flight, which is considered reasonable when birds fly distances shorter than 50 km (Pennycuick 2008, Pennycuick pers. comm.). A multiple of 1.3 times of the minimum power speed was used (Vmp) as a default value.

For migrating birds the results of energy expenditure was assessed in relation to the total migration costs of a species, calculated for the entire estimated migration length of a species. For this the Migrate section of the FLIGHT software was used for estimating energy demands for longer flights.

For non-breeding waterbirds the calculated energy expenditures to cross the bridge was assessed in relation to the daily energy expenditure. This was done for the Common Eider, the most abundant wintering waterbird species in the Fehmarnbelt, for which daily energy expenditures have been calculated during the FEBI baseline investigations (FEBI 2013).

It should be noted that scenario 2 and 4 are conservative approaches using maximum detour (birds migrating closer to land would not have such a long detour) and maximum climbing height (calculations assume the birds crossing the main bridge, which is higher than the approach bridges). However, weather conditions and local factors such as human activities in combination with the bridge structure could make birds fly in circles or attempt crossing several times at more than one crossing point potentially causing even higher energy expenditures.

4.6.4 Estimating numbers of bird collisions with the bridge

To investigate potential collision rates with a cable stayed bridge in the Fehmarnbelt, three approaches have been chosen. The first approach used migration behaviour data from the effect studies at the Baltic Sea bridges for daytime migrating species. The second approach calculated a potential collision rate based on nocturnal migration rates in relation to the probability of collision with the bridge structure. The third approach used the collision data from the Öresund Bridge and a) related it to weather parameters and lighting features, b) calculated potential collision rates at the proposed Fehmarnbelt Bridge relative to the Öresund collision rates, taking the migration intensities and directions at both places into account.

Results of these calculations were used to assess the degree and the severity of impairment of the pressure 'collision with bridge structures'.

Calculation of potential collision rates of selected daytime migrating bird species

Collisions do not occur regularly but happen in separate events, most probably driven by weather conditions (Drewitt and Langston 2006, Hüppop et al. 2009, Aumüller et al. 2010, Ballasus et al. 2010). Effect studies at some Baltic Sea bridges (see chapter 4.6.2) recorded numbers of birds approaching these bridges, their reactions and changes in flight direction and altitude. As a first proxy to assess the risk of collision, the number of birds approaching the Baltic Sea bridges beyond a defined distance was determined.

Data for 14 waterbird species are available from the effect studies at the Baltic Sea bridges, for which the behaviour of at least 10 flocks has been recorded. Based on the results from the effect studies on the Baltic Sea bridges (see chapter 4.6.2) and additional results from the Öresund Bridge (Nilsson et al. 2009, 2010), reaction types and flight paths have been registered for a number of bridges and species groups. Registered flight paths include distances to the bridge until the bird/flock passed the bridge.

Three scenarios were considered. For scenarios 1 and 2, it was assumed that birds flying closer than 10 m of a bridge structure have a certain risk of colliding with it due to e.g. sudden wind/turbulence, disturbance from traffic, artificial lights or just by chance. The number of potential collisions was calculated based on three different assumptions of collision risk level:

- Scenario 1: 0.01%, i.e. one out of 10,000 birds coming closer than 10 meters to the bridge structure would collide,

- Scenario 2: 1%, i.e. one out of 100 birds coming closer than 10 meters to the bridge structure would collide.

- For scenario 3, solely the numbers of individuals registered during the effect studies were used and the actual collisions observed. During the effect studies at the Baltic Sea bridges no incidences of actual collisions were detected by the observers; thus, in all cases the best estimate of collision risk is zero. However, as the confidence of this estimate is highly dependent on the sample size, for this scenario 3 the results for two groups of species were lumped according to their size and provide the 95% confidence limit using the group-specific probability assuming collisions to be binomially distributed. In total 12,243 individuals of larger species (divers, cormorants and geese) were observed during the effect studies equal to an upper 95% binomial probability of 0.000301 and 80,504 individuals of smaller species (ducks and mergansers) equal to an upper 95% probability of 0.00056. These measures were used to estimate the species-specific confidence intervals.

Data on migration status (long-distance vs. local movements) and the minimum distance to the bridges for each flock/bird were included from the effects studies. The latter was achieved by calculating the closest distance to the bridge structure at any time during the crossing of the bridge alignment (ArcGIS 10, 3D analyses tool) for each tracked flock of migrating birds. All birds/flocks from the field season spring 2009 were included. For the field seasons of autumn 2009 and spring 2010 only birds/flocks assessed by the observers as being on long-distance migration were included (see chapter 4.6.2).

Calculation of potential collision rates of nocturnally migrating species based on migration traffic rates (migration intensity)

It is accepted that the majority of migrating individuals are nocturnal migrants, and of those the majority are passerines (Bloch et al. 1981). These birds can potentially collide with structures protruding into air space. Currently no methods exist to record and quantify species-specific numbers or migratory behaviour of these species as for daytime migrants. Collision rate data exist from onshore wind farm studies (e.g. Grünkorn et al. 2009, Kerlinger et al. 2010), also collision rates with building windows (day- or night-time, e.g. Klem 2009), light-houses or other lit structures (Hansen 1954, Ballasus et al. 2010), but little information is available from offshore structures (Aumüller et al. 2010, Bellebaum et al. 2010, Nilsson et al. 2010). To our knowledge, there are no effect studies on nocturnal migrants.

It was necessary to have several assumptions and formulate additional considerations in order to calculate the potential collision numbers of nocturnal migrants:

1. Migration intensity was estimated from pencil beam radar data collected during the baseline investigations in 2009 (pencil beam radar at Lolland) and 2010 (pencil beam radar at Fehmarn). The pencil beam was directed parallel to the coast in order to be perpendicular to the expected migration direction. Migration intensities are expressed as migration traffic rate (MTR, signals per km) for altitude bands of 100 m up to 4.5 km, i.e. for each 100 m altitude band the number of birds passing through a projected 2-dimensional air plain of 1,000 m x 100 m altitude band (for details see FEBI 2013 – Volume III, Appendix). The average MTR is 210,605 birds/km/season, considering all altitudes up to 4.5 km.

Signals of passerine type birds according to wing beat frequency during the two baseline years largely outnumbered all other types of the signals; for example, in autumn 2010, 94.5% of all signals were of passerine type (FEBI 2013 – Volume III, Appendix). Consequently, only nocturnally migrating passerine species were included into species-specific assessment of collision risks based on this method. Other bird species (ducks, geese, waders) often migrate in flocks and are underestimated by the radar measurements.

2. The proportions of nocturnal passerines for the relevant altitude bands for the four seasons of migration observations in 2009 and 2010 are: 0-99 m – 9.80%, 100-199 m – 12.10% and 200-299 m – 8.72%. Thus, 30.6% of the passerines were registered below 300 m, representing an MTR of 64,487 birds/km/season. The rest was recorded flying higher than 300 m. The vertical distribution of passerine migrants agrees with the results obtained by Bellebaum et al. (2010). Offshore nocturnal migration averaged from locations at Helgoland (North Sea), Rügen and Fehmarn (both Baltic Sea) indicates 16-25% of the migration occurring below 200 m (Hüppop et al. 2005). The same authors describe lower flight altitudes occurring during daytime and – important with regard to collision risk – during rain and headwinds. For our approach, no further species-specific differences of vertical or geographical distributions are assumed.

3. Results of migration intensity were for practical reasons converted to migration intensity for each m² of air. This facilitates the calculation of the collision area and potential collision rates, as the number of birds per m² must only be multiplied with the collision area of the solid structures of the bridge (see below). To convert a MTR1 of 64,487 birds/km/season at the lower 300 m to a MTR2 per m², the MTR1 is divided by 300,000 (1,000 m x 300 m), resulting in a MTR2 of 0.2150 birds/m²/season.

4. A mean migration direction has been calculated based on the mean migration directions of the four seasons (spring and autumn 2009 and 2010, FEBI 2013, Appendices of Volume III). This overall mean migration direction is 35.5° during spring and 215.5° during autumn. Circular standard deviation of migration directions measured during the baseline is ± 48.5° to both sides (Figure 4.14).

5. Birds migrating at the Fehmarnbelt thus approach the alignment (25°) at a mean angle of 10.5° both during spring and during autumn (Figure 4.14). The collision area is the projection of the solid parts of the proposed cable stayed bridge to this migration direction.

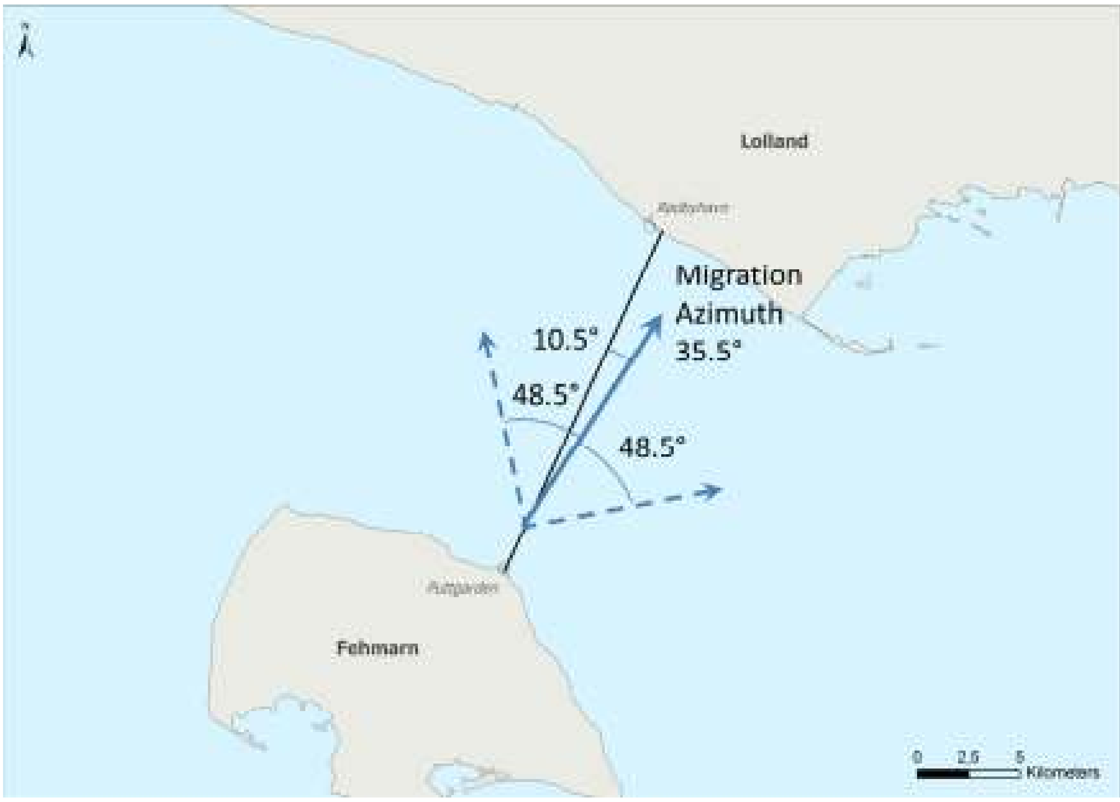


Figure 4.14 Visualisation of mean migration direction ± SE during spring in relation to alignment. During autumn mean migration direction is 215.5°, resulting in the same angles relative to the alignment.

For birds flying along the mean migration direction, the angle to the bridge is 10.5°, and the calculated collision area is 138,327 m².

For birds flying along the N/S axis (48.5° to the left), the angle to the bridge is 38.0°, and the calculated collision area is 259,438 m².

For birds flying along the E/W axis (48.5° to the right), the angle to the bridge is 59.0°, and the calculated collision area is 326,921 m².

6. It is assumed that nocturnally migrating birds exhibit 95% avoidance and 5% attraction to e.g. lightings, which results in an overall assumed avoidance of 85.5% (following Bellebaum et al. 2010).

7. Considering the wingspan of each species, the collision area increases, as a bird flying closer than half of a wingspan length to the structure, would collide as the tip of the wing may hit the structure. For the small passerines of the size of European

Robin (wingspan 22 cm), the increase of the collision area for the maximum projection (326,921 m²) would be 414 m², corresponding to 0.13% more birds colliding. For medium-size passerine birds like Song Thrush (wingspan 35 cm) the increase of the collision area would be 1,581 m² (0.48%). Thus, the additional collision risk accounting for the wingspans of birds is very small, would not affect the estimated collision rates and is therefore not taken into account.

8. A total number of individual birds was estimated based on the relevant populations of nocturnally migrating passerines, from which a proportion is likely to migrate over the Fehmarnbelt region. A list of 33 species of nocturnally migrating passerines, breeding in Scandinavia (within the administrative borders of Sweden and Finland), assumed to migrate SW was identified. Some of those species may also migrate S or even SE (based on ringing results, see also Bellebaum et al. 2010), which potentially lowers the numbers of birds migrating through the Fehmarnbelt. However, birds from Norway (N of the Fehmarnbelt), Russia and the Baltic States (ENE of Fehmarnbelt) also may partly pass over the Southern Baltic Sea, potentially raising the migrating numbers (Table 4.15). Following Bellebaum et al. (2010), the total number of migrants was calculated as the number of breeding pairs in Sweden and Finland (BirdLife International 2004a) multiplied by four (accounting for both breeding adults and assumed two fledglings per pair). If a range of breeding population size is given, the arithmetic mean of the upper and lower limit has been chosen for the calculations. For spring and autumn migration the same numbers were used, which likely overestimates the numbers passing Fehmarnbelt in spring. Species mainly migrating during daytime but with also some proportions during night-time are not included, as the proportion of individuals participating in nocturnal migration is unknown. It must be noted, that these population numbers represent best but only crude estimates, as long as more detailed data are not available.

A theoretical approach is to consider the potential broad front of migrating passerines to be 900 km which represents the distance between the western border of Sweden and the eastern border of Finland perpendicular to the course of migration. If broad front migration applies and thus no concentration or funnelling effect exists, then the numbers crossing over the Lolland coast of some 70 km or any other straight line in the Fehmarnbelt region should be a calculation fraction of the 900 km starting line.

Table 4.15 Estimated population sizes of the nocturnally migrating species that are likely to pass the Fehmarnbelt region; populations from Sweden and Finland (BirdLife International 2004a) multiplied by 4 (two partners, two juveniles).

Species	**Estimate of the relevant reference population**
Wryneck	70,000
Winter Wren	1,660,000
European Robin	24,000,000
Thrush Nightingale	210,000
Black Redstart	3,240
Common Redstart	4,000,000
Whinchat	2,600,000
Common Stonechat	10
Wheatear	1,900,000
Ring Ouzel	26,600
Blackbird	8,500,000
Fieldfare	9,000,000
Song Thrush	12,000,000

Species	Estimate of the relevant reference population
Redwing	12,500,000
Mistle Thrush	870,000
Sedge Warbler	1,700,000
Marsh Warbler	90,000
Reed Warbler	2,300,000
Icterine Warbler	330,000
Lesser Whitethroat	2,100,000
Whitethroat	4,300,000
Garden Warbler	12,000,000
Blackcap	2,960,000
Green Warbler	26,280
Wood Warbler	1,500,000
Chiffchaff	1,500,000
Willow Warbler	88,000,000
Goldcrest	16,400,000
Spotted Flycatcher	9,400,000
Red-breasted Flycatcher	9,000
Pied Flycatcher	7,900,000
Eurasian Treecreeper	3,100,000
Red-backed Shrike	300,000
Sum	**231,255,130**

The total number of birds representing the relevant reference populations of the 33 main night-time migrant passerine species coming through the Fehmarnbelt sums up to 231,255,130 birds (Table 4.15).

Calculation of potential collision rates of nocturnally migrating species depending on weather conditions and relative to the Öresund Bridge collision rates and migration traffic rates

Effects of weather conditions and artificial lights on collision rates of migrating birds were assessed for the Öresund Bridge. These results were related to the proposed Fehmarnbelt Bridge and local weather conditions. Thus, an estimate of night-time collision rates at the proposed Fehmarnbelt Bridge using collision rates found at the Öresund Bridge is presented, by comparing migration rates at the Öresund Bridge and the proposed Fehmarnbelt Bridge and setting them in relation to the bridge measurements.

The effect of weather and lights on bridge structures for collision risk

Following a mass collision event causing an estimated 1,000 casualties of mostly passerine birds at the Öresund Bridge during night of 8 October 2000 (Bengtsson 2000), a monitoring programme for bird collisions with the bridge structure or with traffic on the bridge was initiated (Nilsson et al. 2009). Data were collected by the Öresund Bridge road patrol during the morning hours initially for three years (2001-2003) and repeated again in 2008. The collected birds were later identified to species by staff of Lund University (Nilsson and Green 2002, Nilsson et al. 2009).

To model the weather conditions and the effect of illumination of the bridge when the collisions occurred, data collected at the Öresund Bridge during migration periods of 2001-2003 (1 March – 31 May and 1 August – 15 November) (Figure 4.15) were used, hereby achieving a basic understanding of the impact of weather conditions and identifying which weather parameters were involved in the collision events.

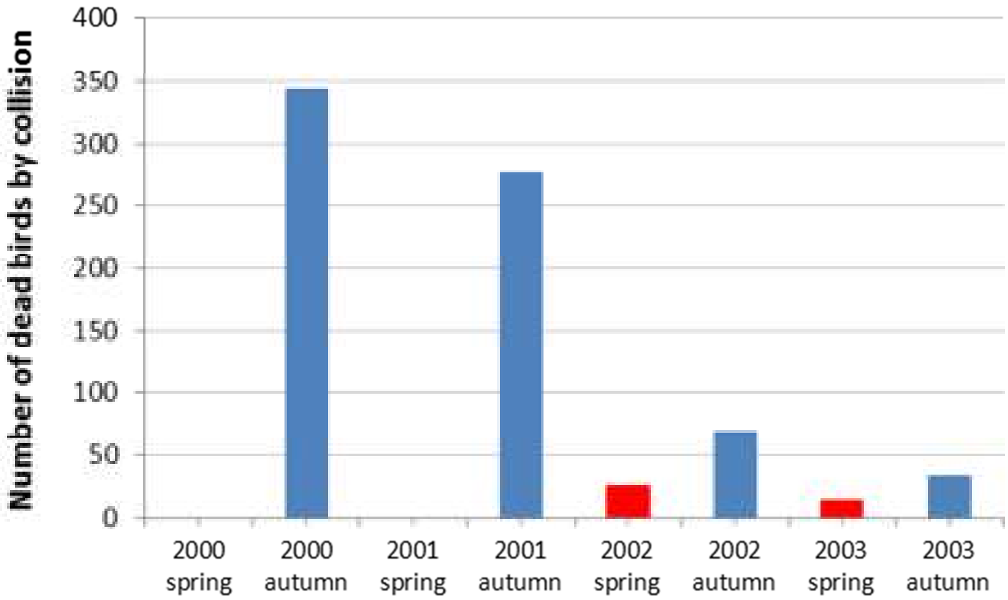


Figure 4.15 Total number of dead birds collected at Öresund Bridge by season and year (Nilsson and Green 2002).

First, a logistic regression analysis (in SAS 9.2) was conducted modelling days with dead birds as dependent variable. Secondly, a generalised linear model was fitted (GENMOD in SAS 9.2) using the number of birds found dead as dependent variable. Weather data were obtained from Kastrup Weather Station 61800 (http://www.tutiempo.net/en/Climate/Koebenhavn_Kastrup/10-2010/61800.htm). Many of the weather variables are highly correlated. Thus, the best single parameters describing temperature, wind, visibility and precipitation based on explanatory power were selected. The variable 'month' was included as a fixed categorical variable because it is known that number of birds and species vary between months. From October 2002 onwards, lights on the bridge pylons were turned off during nights with low visibility to reduce the collision risk (Nilsson and Green 2002, Nilsson et al. 2009). Therefore, 'light' was included as a categorical variable.

Assessment of expected night collision rates at the proposed Fehmarnbelt Bridge in relation to the Öresund Bridge collision rates and migration intensity

From autumn 2002 illumination of the Öresund Bridge was switched off during nights with low visibility and results from the collision studies suggest, that no large collision events have occurred since 2000 (Nilsson and Green 2002).

Furthermore, an estimate of the collision rates for night-time migrating birds at the proposed Fehmarnbelt Bridge relative to the Öresund Bridge is provided, comparing the main parts of these bridges above road level. The Fehmarnbelt Bridge would be operated without street lights but with illuminated pylons (Femern A/S, technical documents and written comm.). In this comparison, the potential attraction of birds by traffic lights (cars, trains) is not accounted for. The number of dead birds found under the main pylons and 1 km on each side on the Öresund Bridge (following Nilsson and Green 2002) is used with a correction for length of the bridge with pylons and cables as well as flight directions and number of birds migrating in the areas to achieve a relative collision rate estimate. Only the calculations on the risk areas (in km^2) of the bridges containing pylons and cables as well as the space in between are conducted. Only statistics on the structures above road level are included. Birds colliding with structures below road level fall into the water and were not sampled by the Öresund surveys and therefore cannot be included in the calculations.

Nilsson and Green (2002) estimated the total number of night-time migrating birds passing the Öresund Bridge to sum up to 4.4-12.7 million birds, which is equal to 372,881-1,076,271 birds per km during autumn (all altitudes included). This estimate is based on known mean traffic rates (MTR) from Falsterbo (Zehnder et al. 2001) corrected to the Öresund Bridge area by use of radar studies (Nilsson and Green 2002). The mean of these two estimates is termed "best estimate" while the upper limit is termed "maximum estimate".

For an estimate of the number of birds passing through the Fehmarnbelt region, two approaches (maximum and best) were applied. The first approach takes all species of nocturnal and partly nocturnal migrants into account, which are based on waterbird population estimates (Wetlands International 2006) and breeding population numbers in Sweden and Finland (BirdLife International 2004a). For this approach it is assumed, that these birds use a 900 km broad front migration corridor towards SW. From the total population numbers a total of 557,792 birds per km are calculated to pass the Fehmarnbelt during autumn at all altitudes. This number is included in the "maximum estimate". For the "best estimate", migration traffic rates from the pencil beam radar during the baseline investigations in 2009 and 2010 were used. In total, it was estimated that 116,141 and 305,068 birds per km pass through the Fehmarnbelt during autumn and spring respectively, or 421,209 birds per km for the entire year (see above; MTR measurements of radar beam directed along the coast, mean value of the two baseline years , all altitudes included).

First, the two "maximum estimates" were converted to an MTR perpendicular to the Öresund Bridge (11.8 km) and Lolland front (70 km), respectively. Second, all estimates were corrected for the orientation of the specific bridges in relation to mean flight direction assuming a flight direction that varied by season only.

Finally, this rate was projected to the length of the bridges with pylons and cables (1 and 2.2 km for Öresund and Fehmarnbelt Bridges, respectively) to achieve a seasonal MTR per length of bridge with pylons and cables ($MTR_{bridge,\ season}$) (Table 4.16).

Equation 1, estimating seasonal MTR for length of bridge with pylons and cables:

$$MTR_{bridge,season} = ((MTR_{region,season} \times \sin(\alpha_{bridge})) / \sin(\alpha_{radar})) \times LENGHT_{bridge,pylon}$$

Where $MTR_{region,season}$ is mean traffic rate (birds per km per season), while α_{bridge} and α_{radar} are mean flying angles to radar and bridge, respectively, used to correct the number of birds facing bridge structures according to the flight angle to the bridge. It must be noted that for the MTR at the Fehmarnbelt the correction for the flight direction angle to the radar has already been incorporated into the calculation of the MTR from the raw radar data (FEBI 2013, Volume III – Appendix). $Length_{bridge,pylon}$ is length of the main bridge with pylons and cables (km). For the Öresund Bridge, all information presented in Table 4.16 was reported by Nilsson and Green (2002) and Nilsson et al. (2009).

Equation 2, the relative collision risk for the Fehmarnbelt Bridge in relation to the Öresund Bridge is then calculated as:

$MTR_{Fehmarnbelt} / MTR_{Öresund} \times AREA_{Fehmarnbelt} / AREA_{Öresund}$

Where $AREA_{Fehmarnbelt / Öresund}$ is the total vertical area of the pylons and cables above the girders in m^2 including areas between pylons and cables. To achieve an estimate of number of birds potentially killed at these parts of the proposed Fehmarnbelt Bridge, the relative collision risk is multiplied with the estimated number of dead birds during autumn 2001 at the Öresund Bridge as reported by Nilsson and Green (2002) and Nilsson et al. (2009).

Total estimates of the MTR for the Öresund Bridge during spring are not available. To achieve a spring estimate for the Fehmarnbelt (FB), we use the known parameters in the equation following this approach:

Equation 3:

$$N_{dead,FB,spring} = N_{dead,FB,autumn} \times (MTR_{FB,spring} \times \sin(\alpha_{radar,spring}) / \sin(\alpha_{bridge,spring})) / (MTR_{FB,autumn} \times \sin(\alpha_{radar,autumn}) / \sin(\alpha_{bridge,autumn}))$$

Table 4.16 Values used in the relative collision rate assessment. "Total migration estimate" for region (birds per region per season) based on different methods (see text). MTR_{sum} are summed hourly MTR data collected by FEBI, N_{max} is a total estimate (see text). MTR_{max} is birds per km per season while α_{radar} and α_{bridge} are mean flying angle to radar and bridge, respectively. $Length_{pylon}$ is length of bridge under pylons (km). MTR_{bridge} is the number of migrating birds corrected for flight direction given for $Length_{pylon}$. $AREA_{bridge}$ is the area above the girder of the pylons including wires and the air in between (m^2).

Bridge	Season		Total migration estimate	MTR_{max}	Mean flight direction	α_{radar}	$\sin(\alpha_{radar})$	α_{bridge}	$\sin(\alpha_{bridge})$	$Length_{pylon}$ (km)	MTR_{bridge}	$AREA_{bridge}$
Öresund	autumn	N_{min}	4,400,000	372,881	215	50	0.77	75	0.97	1	470,176	56,034
Öresund	autumn	N_{max}	12,700,000	1,076,271	215	50	0.77	75	0.97	1	1,357,099	56,034
Fehmarn belt	autumn	MTR_{sum}	NN	116,141	198			7	0.12	2.2	31,139	178,034
Fehmarn belt	autumn	N_{max}	39,045,419	557,792	198	65	0.90	7	0.12	2.2	165,520	178,034
Fehmarn belt	spring	MTR_{sum}	NN	305,068	44			19	0.33	2.2	218,505	178,034

It must be noted, that this comparison and thus collision rate estimates only regard the parts of the main bridges (high bridge) above road level, as for the approach bridges and the areas below road levels, no collision rate data from the Öresund Bridge were available.

4.6.5 Individual-based model for the Common Eider in the Fehmarnbelt

Aim

An individual-based model (IBM) describing the relationships between wintering Common Eiders and their food resources has been developed for baseline conditions in the Fehmarnbelt (FEBI 2013). The aim of developing this model has been to create a base for the assessment of possible impacts of change in food resources caused by the construction or operation of a fixed link across the Fehmarnbelt or birds excluded from the impaired areas. The specific objectives of using the IBM have been the following:

- To predict effects of impact scenarios representing decreased habitat availability and reduced bivalve biomass on fitness of wintering Common Eiders. Fitness was expressed as bird survival and body condition.

- To assess Common Eider habitat carrying capacity in the Fehmarnbelt.

The IBM relates individual behaviours such as feeding activity, rate of food intake or interference to environmental factors and food availability and provides detailed insight into aspects which constrain species fitness and numbers of birds using certain resources. Also, the IBM accounts for already existing human pressures such as shipping traffic and offshore wind farms, by excluding birds from foraging on wind farm areas and shipping lanes (for details see FEBI 2013, Volume II).

The IBM was developed using a specialised software platform MORPH (Stillman 2008) and is presented following a standard protocol for describing individual-based and agent-based models (Grimm et al. 2006) in FEBI baseline report (FEBI 2013). Only changes to the baseline conditions, which have been done to define impact scenarios, are presented below.

Impact scenarios for the Common Eider individual-based model
Three types of impact scenarios were implemented on the baseline IBM developed during FEBI baseline investigations (FEBI 2013):

1. Anticipated impacts from the immersed tunnel construction.

2. Anticipated impacts from the cable stayed bridge construction.

3. Hypothetical impact scenario with maximally reduced food resources due to the tunnel construction and increased number of birds.

For the first impact scenario, the main anticipated impacts from the tunnel construction altering Common Eider food resources were considered. The impacts included:

- The area affected by habitat loss due to the project footprint.

- Bird exclusion due to disturbance expected within 3 km zone around the tunnel trench and land reclamation areas (chapter 9.2.4). In the impact scenario, all food resources were removed from the area affected by disturbance, which in the model design would prevent eiders from using the disturbance zone (Figure 4.16).

- Reductions in Blue Mussel biomass due to sediment spill from the tunnel construction were modelled by FEMA (2013c). Mussel biomass in the IBM impact scenario was reduced accordingly.

- Finally, all birds were excluded from areas where reduced water transparency is assessed as exceeding the defined threshold (see chapter 4.6.1).

The magnitude of the different pressures was predicted to be either equal during the entire construction period or the highest during the first year of the tunnel construction. Therefore, the IBM impact scenario was parameterised to represent the first season of the tunnel construction.

The spatial scale of the IBM model (2×2 km grid) was coarser than some of predicted impacts of the tunnel construction (Figure 4.16). Using a conservative approach a relevant impact was applied on the entire cell of the IBM grid if the overlap exceeded 10% of the grid cell area. Otherwise the change was considered as negligible and therefore not included. As expected, this approach resulted in a higher impact area in the IBM model compared to areas identified in the pressure descriptions. Therefore, the results of individual-based modelling should be considered as conservative.

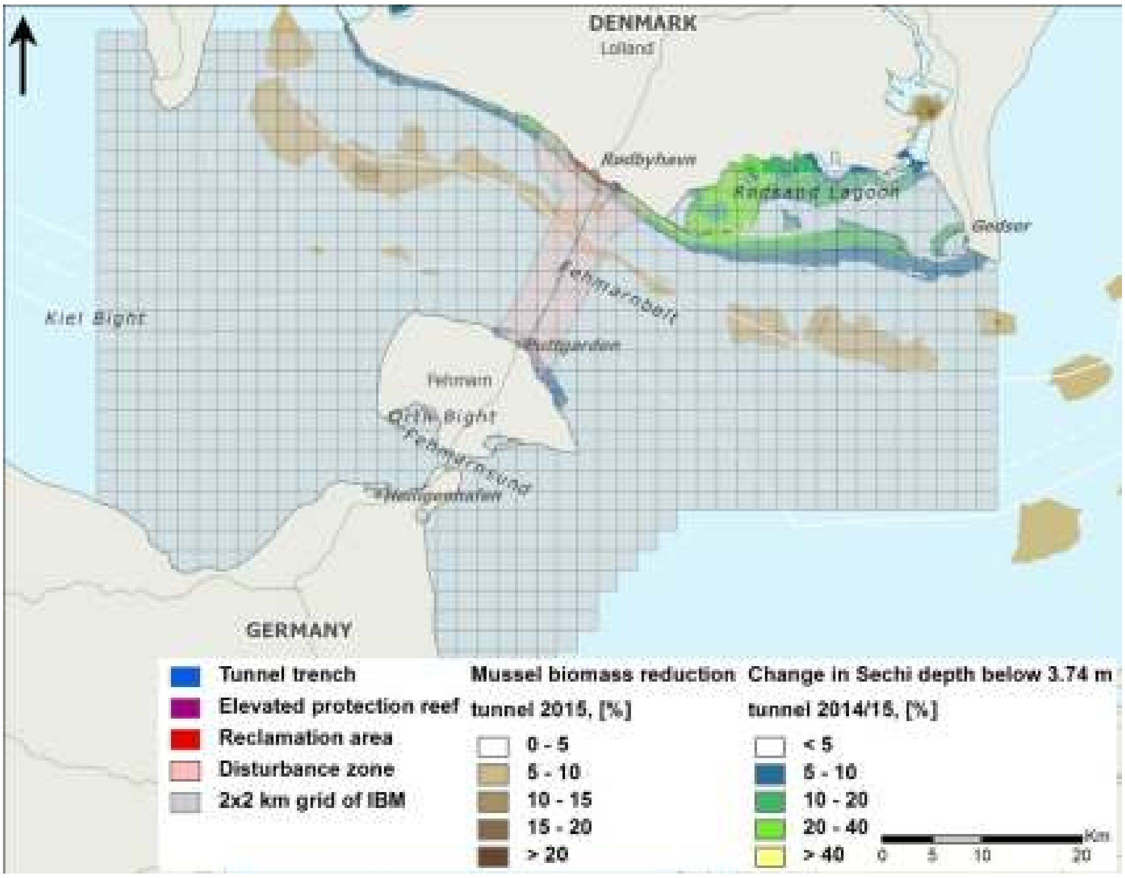


Figure 4.16 Map representing an overlay of 2×2 km grid used in individual-based model for Common Eider and anticipated impacts on bird habitat from the immersed tunnel construction.

The second impact scenario representing anticipated effects of the bridge construction was prepared in an analogous way as for the tunnel (described above), only using relevant specific values for the bridge construction (Figure 4.17).

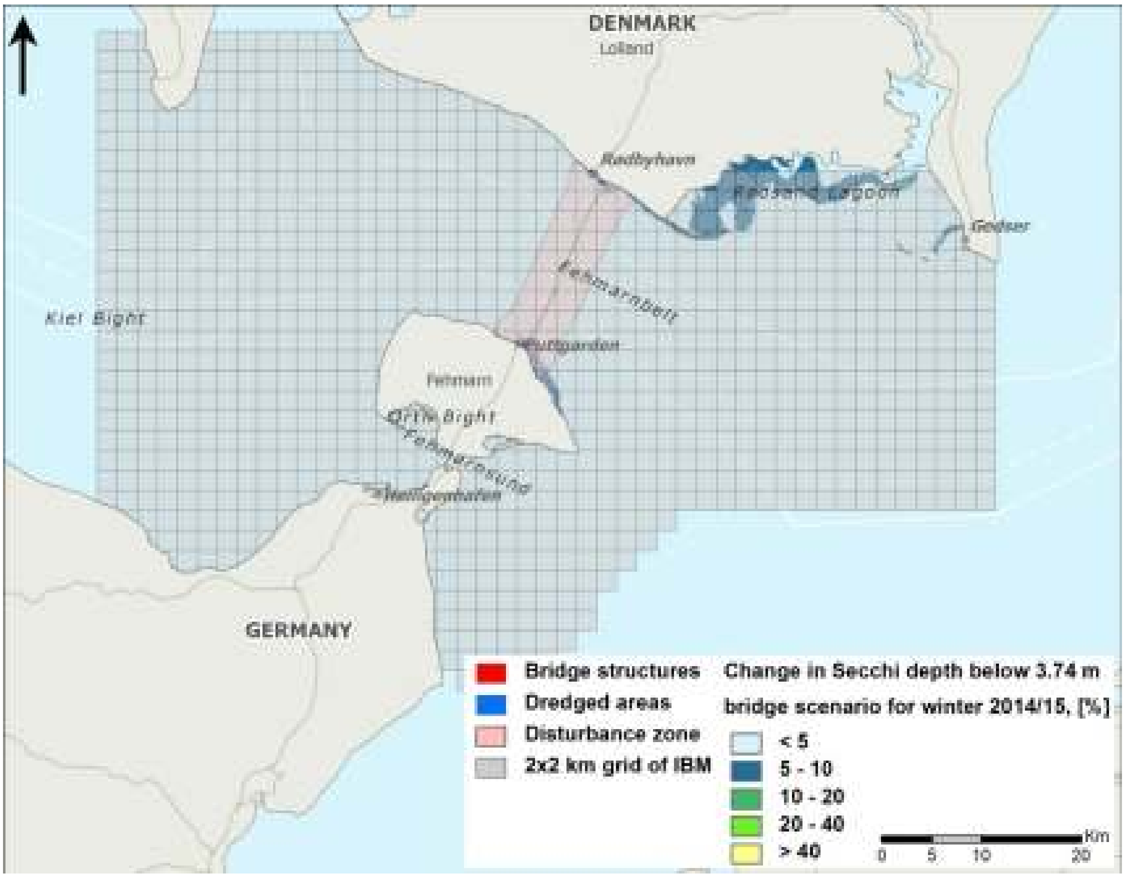


Figure 4.17 Map representing an overlay of 2×2 km grid used in individual-based model for Common Eider and anticipated impacts on bird habitat from the cable stayed bridge construction.

The third impact scenario was designed for measuring the carrying capacity of the remaining habitat after implementing the impact scenario of the tunnel construction. It was here postulated, that disturbance and decreased water transparency resulting from the tunnel construction works may cause wintering eiders to temporarily abandon certain areas, and relocation would be the most probable response of birds. Because location of recipient areas is difficult to predict, the assumption was made that food availability would be the primary factor determining birds' choice of new wintering place. Therefore, a series of simulations were run with gradually increased number of wintering Common Eiders in the IBM with already included impacts of the tunnel construction. The baseline model was parameterised with 250,000 Common Eiders in the simulation. Habitat carrying capacity was measured by allowing the baseline number to double by increasing it at increments of 50,000 birds. Parameters describing bird fitness were assessed following each model run, anticipating a measurable change if habitat carrying capacity was reached. Mass starvation-induced mortality of model birds could be anticipated as an indication of severely exceeded habitat carrying capacity when available food is insufficient to support wintering birds, and decreased body mass and elevated mortality would be interpreted as the first signs of food limitation.

Each impact scenario was simulated 5 times, and the final result was obtained by averaging results of each simulation. There are elements of stochasticity in each model run (e.g., randomly assigned individual dominance and efficiency), therefore it was considered that average results of several simulations are more informative about model predictions than drawing conclusions from a single simulation run.

5 ASSESSMENT OF ZERO-ALTERNATIVE

The Zero-Alternative describes the future situation without the construction of a fixed link. The FEBI baseline study was performed from late 2008 to late 2010. The relatively short time span from the baseline study to the construction phase allows for using the baseline as Zero-Alternative. Exceptions would e.g. be if a new Natura 2000 area was designated. However, at the time of writing no plans to designate new Natura 2000 areas have been identified.

However, the assessment year for the operation phase of the fixed link is considered 2025 and 2030, corresponding to 15 and 20 years after the baseline study was finalised. The reason for choosing 2025 as a reference year for operation is to carry out the assessment, when not only the construction is completed, but the full impacts of the fixed link operation are occurring, and because this year was set in the planning law behind the design of the fixed link.

The year 2030 was chosen as a reference year for operation in order to carry out the assessment, when not only the construction is completed, but the full impacts of the fixed link operation are occurring, and because in Germany it is standard to have a 10 year time span from the project opening to the assessment year.

The Zero-Alternative will be influenced by human-induced changes that will happen within the 15-20 year time span between the baseline study and assessment years of the fixed link operation. Defining the Zero-Alternative involves identifying and quantifying human induced changes that could significantly change the situation described in the baseline studies and thereby influence the outcome of the comparison between Zero-Alternative and preferred alternative in the EIA.

Impacts from climate change are not considered in the Zero-Alternative and are described in chapter 6.

5.1.1 Identification of Changes

Concerning human-caused changes the following preconditions must be met to include a factor in the description of the Zero-Alternative:

1. Very likely to occur

2. Significant enough to influence the results of the EIA

3. Predictable and quantifiable with an adequate level of certainty

If all of these conditions are met, the possible change is included in the description of the Zero-Alternative. The following issues have been identified to fulfil the above mentioned criteria:

- Development of landscape, nature, habitats and species
- Changes due to implementation of new regulations and management practices
- Current spatial planning
- Forecasts on traffic intensity and demography

5.1.2 *Development of landscape, nature, habitats and species*

During the baseline investigations the following human activities were identified as pressures affecting landscape, nature, habitats and thus also birds in the Fehmarnbelt which are also expected to continue affecting birds in the years 2025 to 2030 of the Zero-Alternative:

- Establishment of new offshore wind farms
- Intensive fishing with gillnets and trawls
- Mortality of waterbirds from hunting
- Pollution with contaminants including toxic substances originating from a range of different sources
- Eutrophication

At the time of writing this report, plans for the establishment of four offshore wind farms have been identified in the Fehmarnbelt area: Beltsee (Consent application submitted), Beta Baltic (Consent application submitted), Fairwind (Concept/Early planning) and GEOFReE (Consent Authorised). However, of the proposed projects only one (Fairwind) is situated in the study area. Whether the possible impacts of the planned offshore wind farms are likely to change the baseline conditions and thereby the results of the EIA significantly would be subject of the EIA of this project and cannot be judged at this state.

Fishing is considered to have a significant impact on certain species. However, the development in gillnet and trawl fisheries is considered to be heavily influenced by rules and regulations that cannot be foreseen, and therefore considered as unpredictable and unquantifiable at the present stage.

At present hunting exerts a considerable pressure on certain species. However, hunting is regulated, and any future changes in regulations are unpredictable and unquantifiable at the present stage.

While stricter regulations and improved navigation technology seek to minimise shipping accidents, increasing intensity sea transport may still increase the risk of spills. Any changes are unpredictable and unquantifiable at the present stage.

Eutrophication persists as an important pressure to the ecosystem in the Fehmarnbelt, though loads of nitrogen and phosphorus have been decreasing over the last 15 years (e.g. HELCOM 2009a, b). However, no predictions of any future development in eutrophication levels have been identified. Therefore, no quantifiable changes can be estimated.

5.1.3 *Changes due to implementation of new regulations*

Changes that are predicted to occur e.g. due to implementation of new international legislation are often significant, predictable and quantifiable. Therefore all known relevant EU legislation have been taken into consideration with respect to possible implications for the Zero-Alternative.

Proposals that have not yet become binding regulations are not included in the Zero-Alternative, because it is not known if the proposals will get adopted and realised.

The Water Framework Directive (Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy) is under implementation. Achieving the goals of the Water Framework Directive will mean a significant improvement in the ecological status in the Baltic. However, no assessment systems have yet been developed to quantify and classify the current environmental status and the descriptions of the final good environmental status are currently not finished. Thus, the effect on the environmental status in 2025-2030 is currently unknown.

The Marine Strategy Framework Directive (Directive 2008/56/EC) is expected to be implemented in the EU countries. It will require a considerable effort and time (by the year 2020 at the latest) to implement the Directive. Given the time needed for implementation, and the response time for changes in the ecological state of Baltic Sea it is not possible to quantify the impacts the Directive will have in 2025-2030.

5.1.4 Current spatial planning

The current spatial planning by the municipalities of Lolland and Stadt Fehmarn is not considered to have any significant impacts on marine birds.

5.1.5 Forecasts on traffic intensity and demography

With respect to ferries, the forecast of road traffic predicts a 60% increase in traffic intensity by 2025, if no link is constructed (Fehmern A/S memo on traffic forecast prediction). In 2030 the increase is expected to be even higher. However, it is expected the ferries will increase in size, and have the same time schedule as today (Fehmern A/S memo on traffic forecast prediction). With respect to ships, the yearly number of ships of different sizes passing the Fehmarnbelt in 2018 has been forecasted to increase by 25%. The increase until 2025/2030 is estimated at about 50% (Fehmern A/S memo on traffic forecast prediction). Since the area of the shipping line in the Fehmarnbelt is already highly impaired and most of this increase in shipping is considered to take place within the existing shipping lines, the increase in shipping intensity is expected to result in no relevant additional impairment for birds in the Fehmarnbelt area.

6 ASSESSMENT OF CLIMATE CHANGE

Global climate change is expected to cause species to markedly change their geographical distribution as they follow the local climate to which they are adapted (e.g. Walther et al. 2002, Parmesan and Yohe 2003, Jetz et al. 2007). Recent model studies predict that the potential breeding ranges of many European bird species are likely to move hundreds of kilometres in mainly north-easterly direction (Huntley et al. 2007). In Denmark, climate change is predicted to result in a turnover rate as high as 20% in the breeding bird composition within the next 50 years (Poulsen 2003). Observation of empirical changes in species distributions in recent years are generally in accordance with model predictions (Parmesan 2006).

The distributions of non-breeding waterbirds are, similarly to breeding ranges, affected by climate in addition to food availability and disturbance (e.g. Huntley et al. 2006, 2008, Maclean et al. 2008, Doswald et al. 2009). Henceforth, large-scale changes in climate are expected to cause "cold-weather" adapted waterbirds to move their non-breeding occurrence tracking their climatic niche (e.g. Huntley et al. 2006). These changes may cause significant and largely inverse effects on the suitability of the Fehmarnbelt region to support and sustain the current level of waterbird distributions and populations – with or without a future fixed link.

A large-scale modelling approach has been adapted by FEBI based on an analysis of the large-scale climatic factors, in addition to factors that are important for the current distributions and abundances of waterbirds. By first establishing what factors are important for current distributions and abundances of waterbirds, this knowledge is subsequently used to model the future distribution of waterbirds. This allows a prediction of the relative change in baseline distributions of waterbirds in the Fehmarnbelt due to the large-scale climatic and environmental effects.

The overall aim of the large-scale modelling approach has been to:

- identify important climatic and environmental variables for the distribution of non-breeding waterbirds,
- predict the potential impact of large-scale changes in climate and environment on the future distributions of waterbirds, and
- identify species that may be particularly sensitive to such changes.

6.1 Methods

Species Distribution Models (SDMs; Guisan and Zimmermann 2000, Guisan and Thuiller 2005) have been used to investigate the potential changes in the distribution of the waterbirds in the Fehmarnbelt as a consequence of climate change. SDMs have been subject to intensive evaluation and use in the scientific literature (e.g. Peterson et al. 2002, Elith et al. 2006, Elith and Leathwick 2009, Lawler et al. 2009).

SDMs are statistical models that relate field observations to environmental predictor variables (Guisan and Thuiller 2005, Elith and Leathwick 2009) in order to describe the entire distribution of a species given the records sampled in climatic and environmental space (Figure 6.1).

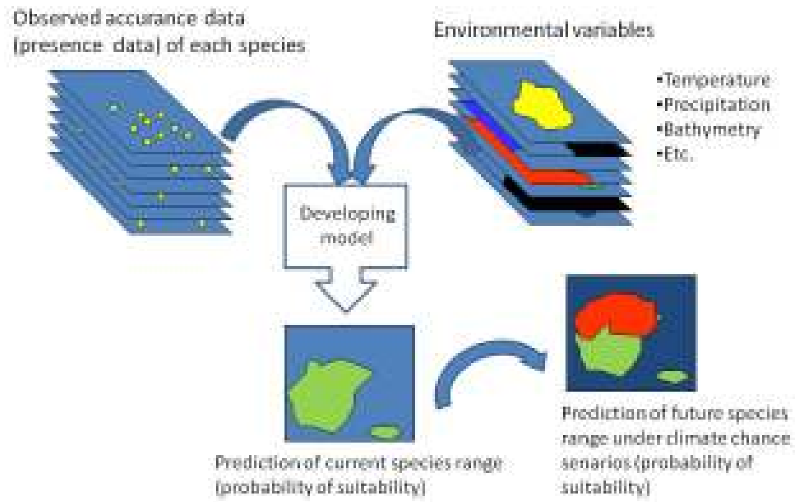


Figure 6.1 Schematic overview of the species distribution modelling approach (following Pearson 2007, Elith and Leathwick 2009).

SDMs predict species-specific distributions by combining known occurrence records with digital layers of environmental variables (Guisan and Zimmermann 2000, Guisan and Thuiller 2005). This information can then be applied to projected future climatic data layers to model future distributions (e.g. Elith and Leathwick 2009). However, climate change analyses in general, have so far mainly been conducted on the distribution of breeding birds in their terrestrial habitats. Hence, there are no current global-change-analyses on the distributions of non-breeding waterbirds.

To describe how a species relates to large-scale climatic and environmental factors, including establishing how the edges of ranges relate to these (i.e. species tolerance), it is essential to include the entire distribution of the species under study (or the range of the biogeographic flyway population) to achieve meaningful results (Guisan and Thuiller 2005, Elith and Leathwick 2009). Hence, to elucidate how large-scale climate change may affect the distribution of waterbirds in the Fehmarnbelt, we conducted our SDM work on the entire region including the North Sea, the waters around the British Isles, the White Sea as well as the inner waters of Denmark and the Baltic Sea.

The SDM was applied using the MaxEnt algorithm (and software) for maximum entropy modelling of species geographic distributions (Phillips et al. 2006, Phillips and Dudik 2008). By use of current species presence data, environmental data layers and topographic/geographic data layers, MaxEnt estimates the current potential species-specific distribution. Using layers of future climate scenarios, MaxEnt estimates the potential future distribution of a species (Figure 6.1).

MaxEnt has, in comparison with other statistical and modelling methods, proven to provide reliable models of species distributions (e.g. Phillips et al. 2006, Elith et al. 2006, Diniz-Filho et al. 2009). A distinguishing feature of MaxEnt is that it can fit more complex models from smaller datasets, using explicit ''regularisation'' mechanisms to prevent model complexity from increasing beyond what is supported by the empirical data. In MaxEnt, several settings affect model accuracy by determining the type and complexity of dependencies on the environment that MaxEnt tries to fit. The dependencies are described by simple functions derived from environmental variables, called ''features''. More complex features allow fitting more complex dependencies, but they may require more data. The complexity of dependencies is controlled by the choice of feature types, and by settings called ''regularisation parameters''. These parameters prevent MaxEnt from matching the input data too closely, which is known as ''overfitting'' and has a detrimental effect on predictive performance (Philips et al. 2006, Phillips and Dudik 2008).

6.1.1 *Species data*

SDMs were carried out on 18 waterbird species for which data were available from the entire region: the Baltic Sea (Skov et al. 1995) and the North Sea (European Seabird At Sea database, ESASd) (Table 6.1). In the Baltic Sea database, Black- and Red-throated Divers (*Gavia arctica/stellata*) were lumped together due to identification problems during fieldwork at sea. Hence, we have treated these species as one species in our modelling work. The species data were treated as presence-only data and cover the period from 1987 to 2000.

Species abundance varies considerably across the study area. To account for this variation, a sensitivity analysis was incorporated with six different abundance thresholds to transfer species abundance data to presences, which were then used in the modelling. Six threshold levels were defined by excluding different percentiles of the grid cells, where the species was present (i.e. all occurrence records, excluding 5%, 10%, 25%, 50% and 75% percentiles). When using the 95% threshold (i.e. excluding the 5% percentile), for example, the 5% of the grid cells with the lowest number of individuals (or, in other words, the lowest abundances) were excluded from the grid cells, where the respective species was present. The remaining 95% were then defined as presence records and were used to run the models.

In Table 6.1 these thresholds are presented and how many individuals were excluded when using each threshold. When the lowest number of individuals defined by the abundance threshold constituted a single bird (which was the case for most species at the 95% threshold, Table 6.1), the respective number of grid cells was randomly selected among those with only a single bird.

Table 6.1 List of species included in the study and AUC (Area under the Receiver Operator Curve) value for the species-specific models. AUC values between 0.7 and 0.9 indicate a reasonable model and above 0.9 that it is a very good model (a value of 0.5 describes a model no better than random; Fielding and Bell 1997). Also included is the number of individual birds in grid cells excluded under the different threshold scenarios (25-95%) i.e. the 95% percentile gives the number of individuals in the 5% of the grid cells with the fewest birds etc.

Species		AUC	95%	90%	75%	50%	25%
Black-throated / Red-throated Diver	*Gavia arctica / stellata*	0.940	1	1	2	8	37
Great Crested Grebe	*Podiceps cristatus*	0.974	1	1	1	2	10
Red-necked Grebe	*Podiceps grisegena*	0.970	1	1	2	4	11
Slavonian Grebe	*Podiceps auritus*	0.972	1	1	2	4	10
Great Cormorant	*Phalacrocorax carbo*	0.955	1	1	2	7	23
Common Eider	*Somateria mollissima*	0.948	1	2	6	34	696
Long-tailed Duck	*Clangula hyemalis*	0.963	1	1	5	100	1,855
Common Scoter	*Melanitta nigra*	0.957	1	1	4	19	333
Velvet Scoter	*Melanitta fusca*	0.948	1	2	4	18	196
Red-breasted Merganser	*Mergus serrator*	0.955	1	1	2	7	22
Little Gull	*Larus minutus*	0.956	1	1	2	6	28

Species		AUC	95%	90%	75%	50%	25%
Common Gull	*Larus canus*	0.932	1	1	3	13	79
Kittiwake	*Rissa tridactyla*	0.904	2	5	17	82	302
Herring Gull	*Larus argentatus*	0.906	1	2	11	48	298
Great Black-backed Gull	*Larus marinus*	0.912	1	2	5	22	90
Common Guillemot	*Uria aalge*	0.905	1	2	6	26	102
Razorbill	*Alca torda*	0.937	1	2	4	17	67
Black Guillemot	*Cepphus grylle*	0.963	1	1	2	7	22

6.1.2 Environmental data layers

The five variables made available by the Intergovernmental Panel on Climate Change (IPCC 2007) were considered most relevant for waterbirds including both present and future projected data, and therefore were selected for both fitting present models and making future projections (Table 6.2). Present day data were calculated as mean values from the time period 1970-2000. For future projection, a standard protocol was followed (Thuiller et al. 2005, 2006, Araújo et al. 2006) and data for two time periods were used: 2005-2034 (named “2020s” from here onwards and 2065-2095 (named “2080s” from here onwards). Of the many different scenarios developed by IPCC, the K-1 coupled GCM (MIROC) at 1.1 degree latitudinal-longitudinal scale for scenarios A1B and B1 was selected. This is a commonly used fine-resolution global general circulation model (GCM) including relevant marine variables (IPCC 2007). Mean or summed measures were used (Table 6.2) for the time period from October to March (both included).

Table 6.2 List of variables used to conduct the species distribution modelling. The climate variables were made available from IPCC from the K-1 coupled GCM (MIROC) for scenarios A1B and B1 and for three time periods (1970-2000, 2035-2065, and 2065-2095, see text for details) (IPCC 2007). Either mean or summed measures were included for the time period from October to March (both months included). Bathymetry was available from NOAA (ETOPO2v2 Global Gridded 2-minute Database). All data were compiled at the spatial resolution of 1.1 latitudinal-longitudinal degrees for the entire region including the North Sea, the waters around the British Isles, the White Sea as well as the inner waters of Denmark and the Baltic Sea (see Figure 6.2 for delimitation of the area).

Variable	Measure	Source
Sea Surface Temperature	Mean	IPCC
Sea Ice Concentration	Summed	IPCC
Precipitation	Summed	IPCC
Zonal Surface Wind Speed	Mean	IPCC
Sea Level Air Pressure	Mean	IPCC
Bathymetry		NOAA

The A1B scenario is a medium to high emission level scenario, while B1 is a low emission level scenario. The A1B storyline and scenario family assumes a future of very rapid economic growth and rapid introduction of more efficient technologies, but low population growth. A major underlying theme is a substantial reduction in regional differences in per capita income and, more specifically, the A1B scenario used here assumes a balanced mix of technologies and supply sources, with technology improvements and resource assumptions, including that no single energy source is overly dominant. The other scenario used herein (B1), also starts from the same low population growth rate, but it differs from A1B in assuming rapid changes in economic structures toward a service and information economy, with reductions in material intensity, and the introduction of clean and resource-efficient technologies. The emphasis is on global solutions to economic, social, and environmental sustainability, including improved equity, but without additional climate initiatives (IPCC 2007).

In addition to the five climatic variables, bathymetry was also included (ETOPO2v2 Global Gridded 2-minute Database) as a topographic data layer assuming that bird distributions are impacted by this factor (Table 6.2). This data layer was likewise included in a 1.1 latitudinal-longitudinal degree resolution. The projected sea-level rise was not included in this SDM, assuming the relatively small changes (0.18-0.38 m (B1) and 0.21-0.48 m (A1B) until 2095; IPCC 2007) will have minor effect on waterbird distributions.

To assess how conditions for waterbirds will change in the Fehmarnbelt region, data were extracted from the island of Rügen in the east to Flensburg Fjord in the west. Values of environmental suitability and of changes in suitability were averaged across 16 grid cells and the 6 abundance thresholds for each of the different scenarios and time periods.

6.1.3 Model validation

Of the sampling records (species data) 25% were set aside allowing for statistical validation of the modelling results (following a standard protocol as outlined in Araújo et al. 2005). An AUC value (area under the receiver operator curve) was calculated for each of the species-specific models run in MaxEnt. A coarse rule of thumb suggests that values below 0.7 indicate that the model is poor, values between 0.7 and 0.9 characterise a reasonable model and values above 0.9 indicate that the model is very good (a value of 0.5 describes a model not better than random) (Fielding and Bell 1997).

6.2 Results

For the two climate scenarios and the environmental variables included in the model, conditions most suitable for wintering waterbirds will shift towards northeast. A large change is seen already by the 2020s, and again from the 2020s to the 2080s. This means that a large change in environmental suitability for waterbirds can be expected to occur already in 2025-2030, the reference period for the zero-alternative (see chapter 5).

Overall, the SDMs for all 18 species performed well including all data. The AUC values revealed that all models performed well with high predictive power (AUC values >0.9; Table 6.1).

Figure 6.2 presents the change in environmental suitability averaged across all 18 species from current conditions to 2020s (climate scenario A1B) for six different abundance thresholds.

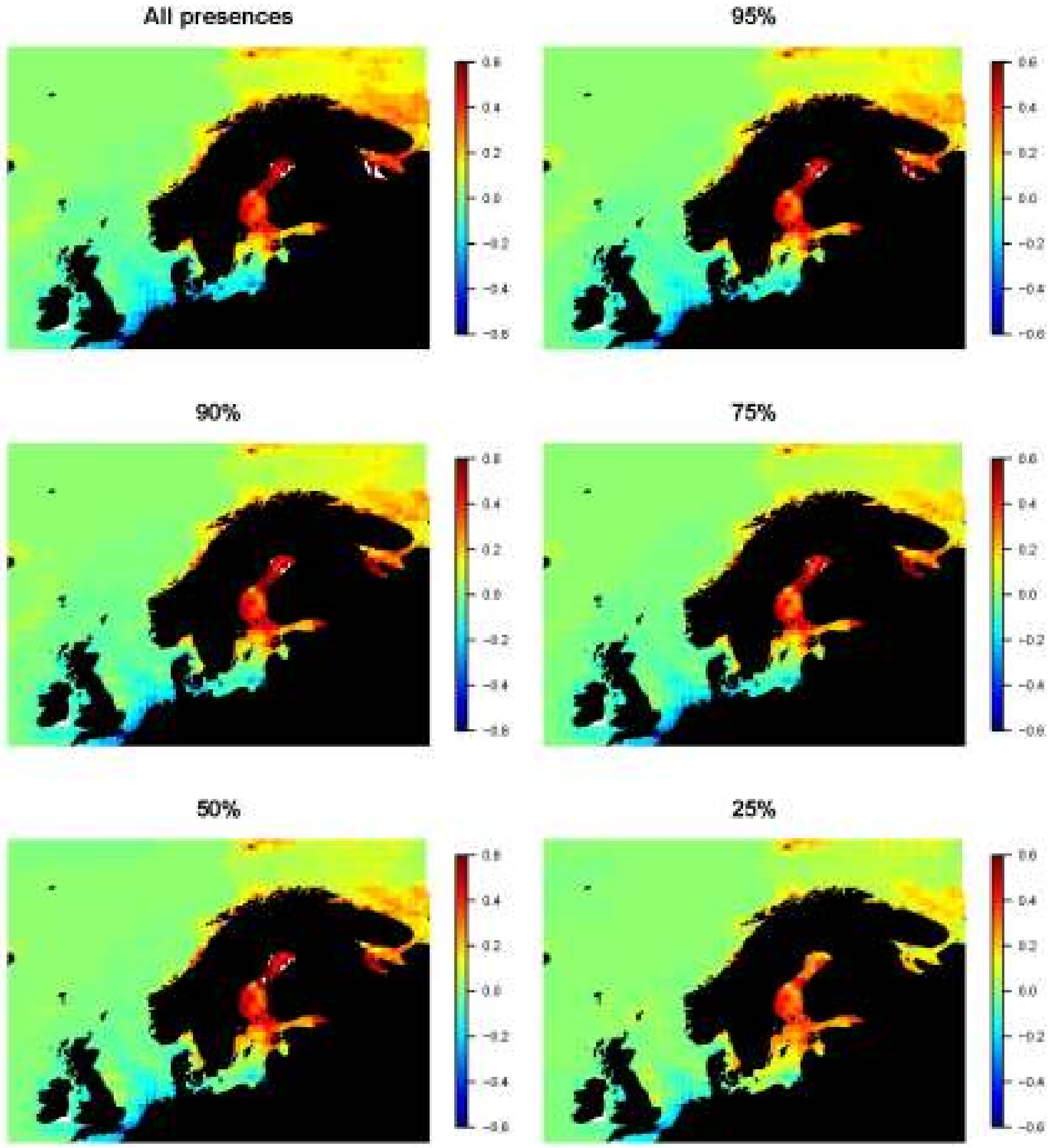


Figure 6.2 *Average change in climatic and environmental suitability across 18 species for six abundance thresholds from current conditions to time period 2020s following IPCC scenario A1B. Red and blue colours indicate decrease and increase in suitability, respectively. Green indicates no change; these are predominately areas with no or low levels of suitability at both present and future conditions.*

Although some variation can be seen, the overall pattern is clearly showing a declining suitability in the North Sea and southern Baltic Sea and an increasing suitability in the northern Baltic Sea and further towards northeast. Very similar patterns for the change were found comparing the current conditions and 2080s, indicating that the largest shift is expected to occur within the next two decades. Averages across the six abundance thresholds confirm the general pattern (Figure 6.3). Similar results were found for the climate scenario B1 (Figure 6.4).

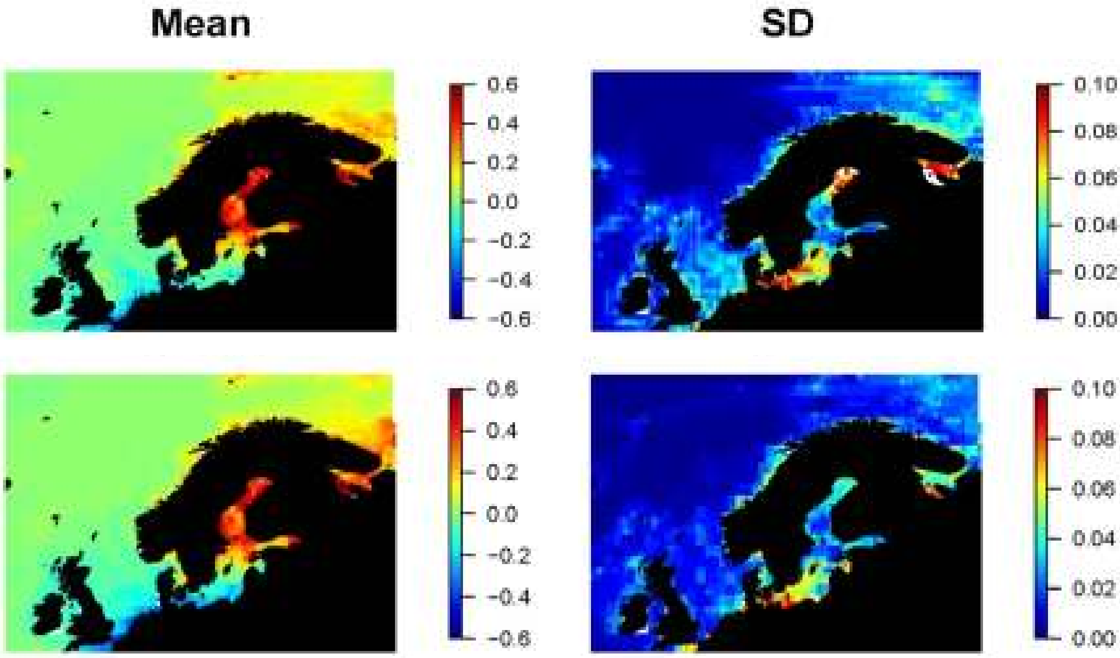


Figure 6.3 *Average change in climatic and environmental suitability for 18 species here shown as the mean (left figures) across six abundance thresholds with standard deviation (SD, right figures) of wintering waterbirds from current conditions to time period 2020s (upper maps) and time period 2080s (lower maps) following IPCC scenario A1B. In left figures: red and blue colours indicate increase and decrease in suitability, respectively. Green indicates no change; these are predominately areas with no or low levels of suitability at both present and future conditions.*

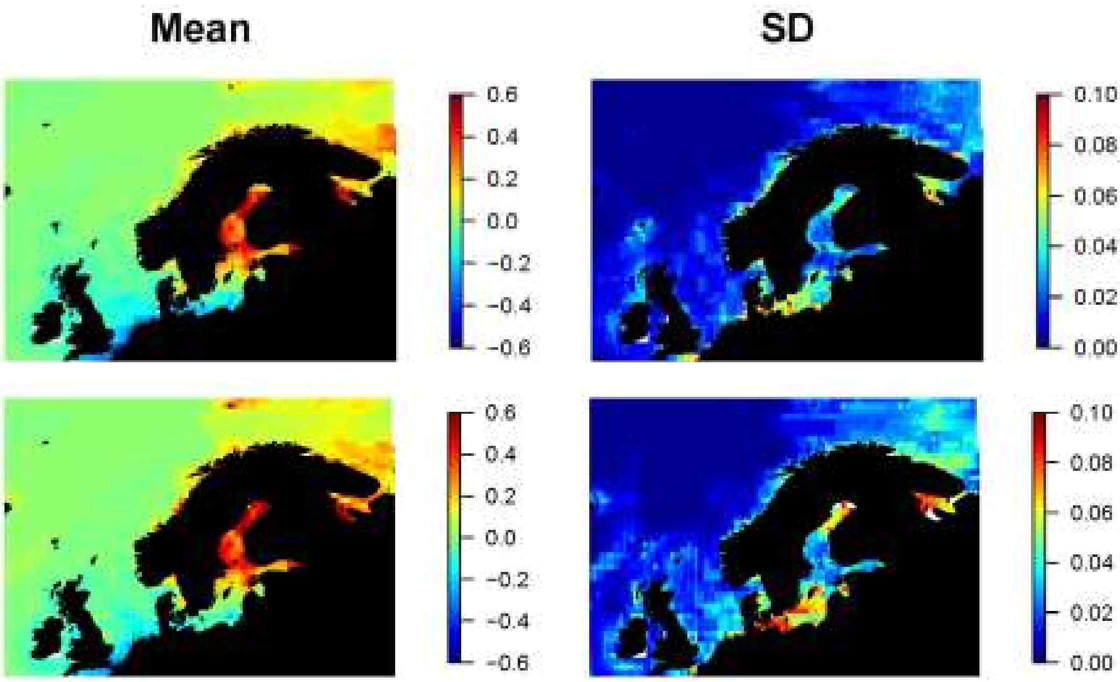


Figure 6.4 *Average change in climatic and environmental suitability for 18 species here shown as the mean (left figures) across six abundance thresholds with standard deviation (SD, right figures) of wintering waterbirds from current conditions to time period 2020s (upper maps) and time period 2080s (lower maps) following IPCC scenario B1. In left figures: red and blue colours indicate increase and decrease in suitability, respectively. Green indicates no change; these are predominately areas with no or low levels of suitability at both present and future conditions.*

For the Fehmarnbelt region, the results show a general and overall decline in suitability for wintering waterbirds. The species-specific change in suitability for the region is presented in Table 6.3 for all analysed species. The results indicate an obvious decrease in suitability across all species, climate scenarios and time periods. All species except Kittiwake (*Rissa tridactyla*) show a similar result of decreasing suitability. For the Kittiwake no change or maybe a small increase in environmental suitability was found. As current suitability is low, this species may – as the only one – increase in numbers according to the model results.

Table 6.3 Species-specific mean environmental suitability for current conditions as well as mean change in suitability from current to 2020s and 2080s conditions, respectively, following climate scenario A1B (IPCC 2007) across six abundance thresholds. All measures are means across 16 grid cells covering the Fehmarnbelt region (from Rügen in the east to Flensburg Fjord in the west) including standard deviation (SD).

Species		Current conditions		A1B			
				2020s		2080s	
		Mean	SD	Mean	SD	Mean	SD
Black/Red-throated Diver	*Gavia arctica / stellata*	0.725	0.022	-0.060	0.078	-0.254	0.081
Great Crested Grebe	*Podiceps cristatus*	0.724	0.023	0.010	0.038	-0.135	0.054
Red-necked Grebe	*Podiceps grisegena*	0.739	0.030	-0.210	0.061	-0.334	0.063
Slavonian Grebe	*Podiceps auritus*	0.729	0.025	-0.170	0.051	-0.283	0.056
Great Cormorant	*Phalacrocorax carbo*	0.709	0.027	-0.050	0.029	-0.175	0.108
Common Eider	*Somateria mollissima*	0.731	0.064	-0.400	0.014	-0.504	0.033
Long-tailed Duck	*Clangula hyemalis*	0.704	0.032	-0.440	0.070	-0.573	0.032
Common Scoter	*Melanitta nigra*	0.6775	0.029	-0.090	0.084	-0.274	0.098
Velvet Scoter	*Melanitta fusca*	0.735	0.037	-0.270	0.072	-0.444	0.059
Red-breasted Merganser	*Mergus serrator*	0.752	0.008	0.010	0.112	-0.298	0.094
Little Gull	*Larus minutus*	0.541	0.063	-0.280	0.022	-0.277	0.045
Common Gull	*Larus canus*	0.632	0.036	-0.220	0.058	-0.347	0.072
Kittiwake	*Rissa tridactyla*	0.220	0.121	0.030	0.109	0.024	0.128
Herring Gull	*Larus argentatus*	0.628	0.042	-0.190	0.034	-0.334	0.076
Great Black-backed Gull	*Larus marinus*	0.500	0.047	-0.110	0.056	-0.182	0.105
Common Guillemot	*Uria aalge*	0.372	0.074	-0.050	0.039	-0.103	0.064
Razorbill	*Alca torda*	0.481	0.079	-0.110	0.070	-0.230	0.068
Black Guillemot	*Cepphus grylle*	0.657	0.046	-0.530	0.034	-0.585	0.034
MEAN		0.625		**-0.174**		**-0.295**	

6.3 Discussion

By modelling the future ranges of 18 species of waterbirds including the entire ranges of the biogeographic populations under two climate change scenarios, it is shown that the environmental suitable area of the majority of analysed species will move towards northeast. Environmental suitability will decrease in most of their current ranges and increase in areas located further towards northeast. Furthermore, the largest changes in suitability will occur during the next few decades while relatively smaller changes are expected during the period between the 2020s and the 2080s. A sensitivity analysis has shown that this overall pattern is robust even after excluding 75% of the grid cells holding the fewest birds.

Within the Fehmarnbelt region, the results show an overall decline in suitability across all wintering waterbirds species except for Kittiwake (*Rissa tridactyla*) with no change or possibly a small increase in suitability. Under the assumption that the current ranges in bird distributions are determined by the climate (or associated) variables, a decrease in numbers of wintering waterbirds (except Kittiwake) is expected within the Fehmarnbelt region over the next 1-2 decades and therefore climate change is expected to have an implication to the zero-alternative (see chapter 5).

It is important to emphasise that the modelling approach is based on the assumptions, that:

1. species are in equilibrium with the current environmental conditions (being present in all suitable areas and absent in unsuitable areas);

2. interactions and levels of disturbance will not change;

3. bird species will follow their climate niche adapted to the new environmental conditions;

4. the available food supply in future suitable areas will be sufficient to meet energy demands of waterbirds.

A suite of important environmental variables are included in the model. However, the model reflects only the environmental niche described by the variables included in the model. This means that variables not included such as food availability, water transparency and salinity may be important in determining the present, as well as affecting future distributions under changed climate conditions.

7 SENSITIVITY ANALYSIS

7.1 Methods

The species-specific sensitivity affects the response of a species to the magnitude of a pressure, thus it is the predictor for general dose-response relationships. If a species shows a strong response to a given pressure it is ranked to be of higher sensitivity compared to a species showing a weak response. If information on a species response is not available, the sensitivity has been subject to expert judgement. The assessment of sensitivity has then been made either on qualitative information about species response to a given pressure or in relation to the degree of specialisation of a species to a resource which might be affected by a pressure of the project. For example, species specialised on a certain food resource (e.g. swans on eelgrass or seaducks on bivalves) have been assessed as being sensitive to impacts on these resources.

In order to select species which are relevant for the Environmental Impact Assessment, a sensitivity screening has been carried out. Species showing a minor sensitivity to a pressure or which were assessed to be of minor importance were assessed to be irrelevant for the EIA and therefore not treated further in the Impact Assessment of a particular pressure (Table 7.1). An exception has been made for the pressure 'Barrier effect'. Here, all species which were identified to exhibit a high or very high sensitivity to this pressure are included irrespective of their importance level, as during the screening process a population effect could not be excluded even for less abundant species (Table 7.1). Because the importance of Natura 2000 areas for breeding waterbirds is assessed to be very high, all waterbirds breeding in these areas were assessed to be of very high importance as well.

Table 7.1 *Combination of importance level and sensitivity of a species to a pressure for the selection of relevance: The table indicates, with a "yes", if a particular pressure is assessed as relevant for a species of breeding waterbirds, non-breeding waterbirds and migrating birds in the Fehmarnbelt.*

Sensitivity of a species to a pressure	Importance level of a species: Very high	High	Medium	Minor
Very high	Yes	Yes	Yes	No/Yes*
High	Yes	Yes	Yes	No/Yes*
Medium	Yes	Yes	Yes	No
Minor	No	No	No	No

* All species showing a high or very high sensitivity to the pressure 'Barrier effect' were considered in the assessment (see text).

In addition, and not reflected in Table 7.1, bird species were excluded from the Impact Assessment if a pressure was judged as being irrelevant considering the distribution of a species. The FEBI baseline investigations on breeding and non-breeding waterbirds cover an investigation area that is larger than the impact zone of identified pressures. Therefore a species may occur in important numbers in the investigation area, but not within the smaller impact zone of a particular pressure. For example the pressure disturbance from construction vessels affects only a certain area around the working area and no impact is expected on birds using areas outside this impact zone (e.g. species mainly using inland parts of SPAs, but rarely occurring in the alignment area, such as Bewick's Swan).

The results of the sensitivity screening for breeding waterbirds, non-breeding waterbirds and migrating birds to the different pressures are presented in chapter 7.3 (Table 7.4 – Table 7.8).

7.2 Sensitivity to different pressures

The following pressures have been identified as being relevant for breeding waterbirds, non-breeding waterbirds and migrating birds during construction and operation of a fixed link in the Fehmarnbelt. In the following the sensitivity of birds to these pressures is described as well.

7.2.1 Habitat loss

Habitat loss from the footprint of a fixed link construction including land reclamation and landfall areas was not subject of the sensitivity screening since every species is per definition sensitive to habitat loss. Whether the habitat loss of the project footprint is relevant for a particular species is assessed in the respective chapters (9.2.1, 9.3.1, 10.2.1, 10.3.1). Habitat changes at the footprint were assessed in the context of habitat loss and were therefore not included in the sensitivity screening.

7.2.2 Habitat change from sediment spill

Habitat change from the construction of a fixed link would primarily affect the foraging habitats of non-breeding waterbirds, though possible changes in roost sites on beaches may occur. The pressure habitat change comprises different pressures related to the construction and operation of a fixed link, which causes indirect changes in availability and quality of the food supply to marine birds. Habitat changes in seabed structure from dredging works, deployment of extra hard bottom layers for scour protection or erection of the bridge structure itself would lead to local changes in benthic communities and thus in food availability for birds. Construction work related sediment spills would result in additional sedimentation and increase of suspended sediments in the water column, also in areas further away from the alignment. These habitat changes can affect survival, productivity and distribution of marine benthic and fish communities and therefore have an indirect effect on birds relying on affected prey organisms. Habitat change resulting from the indirect effect of the sediment spill was identified to be one of the most relevant pressures for birds and therefore addressed independently from other habitat related impacts. Other relevant habitat related impacts such as habitat loss from footprint, habitat change due to provision of artificial reefs, hydrographical changes and direct impact of the sediment spill (water transparency) are addressed in separate pressure chapters and therefore not included in this chapter.

Food is often considered as a critical resource for animal populations. Although bird populations may not necessarily be food-limited in the areas utilised outside the breeding season, their abundance and distribution is dependent on food available in sufficient amount and quality. Human activities have often been shown to substantially reduce marine prey communities resulting in starvation or fitness reductions of the affected seabird species, especially due to exploitation of fish stocks by commercial fisheries (e.g., Tasker et al. 2000, Montevecchi 2002 and references therein). A mass starvation event of Common Eiders in the Wadden Sea in 1999/2000 was related to overfishing of mussels and cockles in the Wadden Sea in the early 1990s (Camphuysen et al. 2002), indicating that food availability might be a limiting factor for wintering birds, and human-caused food reductions can have detrimental effects on seabirds.

In general waterbirds are known to adjust their foraging behaviour in response to variation in food abundance or quality. Declining food availability was described to increase the foraging effort of waterbirds, as e.g. shown for diving ducks (Tufted Duck; Hill and Ellis 1984), seaducks (scoters; Richman and Lovvorn 2003), pursuit diving piscivorous seabirds (Common Guillemot; Monaghan et al. 1994) or herbivorous waterbirds (Brent Geese feeding on eelgrass; Percival and Evans 1997). Birds were also described to adjust their foraging behaviour without increasing the foraging time, when responding to reductions in food availability (dabbling ducks; McKnight 1998). Furthermore, many seabirds show a certain plasticity which allows them switching between preys, e.g. cormorants foraging on the most available fish species (Martucci and Consiglio 1991, Keller 1995, Suter 1997) or Long-tailed Ducks utilising a variety of prey including bivalves, gastropods, crustaceans and fish (Peterson and Ellarson 1977, Goudie and Ankney 1986, Bustnes and Systad 2001, Žydelis and Ruškytė 2005). Literature on Common Scoters in the Baltic Sea indicates the species foraging on a wide range of bivalves, depending on the dominant benthic community (Skov et al. 1998, Žydelis 2002).

The diving behaviour of ducks is strongly influenced by prey (bivalve) density. Dive duration of diving ducks is shorter in areas with high prey densities due to the greater likelihood of encountering prey (Draulans 1982). A similar pattern was described for scoters foraging on clams, which increase their foraging effort at low densities of bivalves (Richman and Lovvorn 2003). At certain minimal bivalve density it is likely that birds leave the foraging area instead of further increasing their foraging effort (Lovvorn and Gillingham 1996). A mass mortality event of Common Eiders in the Wadden Sea indicates that food reductions may also result in starvation incidents (Camphuysen et al. 2002). Percival and Evans (1997) suggest an energetic trigger for Brent Geese, which were described to leave an area, when they were unable to satisfy their basic energy demand after having depleted the food source (eelgrass).

For the Kattegat region Common Eider abundance was shown to fluctuate with benthic food biomass (Blue Mussels) in the shallow water areas between 0-6 m, but such correlation was not found for the deeper areas (Larsen and Guillemette 2000). For Common Eiders, food exploitation rates of 25-69% of Blue Mussel stocks were reported (Guillemette et al. 1996, Larsen and Guillemette 2000), indicating that seaducks are able to exploit a substantial fraction of available food resources in their wintering areas.

In view of these case studies and references, the benthivorous diving duck species occurring in the Fehmarnbelt (seaducks, diving ducks) are considered as being highly sensitive to habitat changes.

Changes in foraging behaviour of piscivorous seabirds are typically explained by bottom-up ecosystem processes (Österblom 2001, Davoren and Montevecchi 2003, Parrish and Zador 2003, Miller and Sydeman 2004, Wanless et al. 2004, 2005, Durant et al. 2009), thus there is no indication that top-down driven depletion of fish by piscivorous seabirds would play an important role in marine systems.

Although fish-eating birds, such as cormorants, have long been blamed by fishers for declining catches (Birt et al. 1987), there is little support that these birds would significantly deplete fish resources in natural conditions (e.g. Žydelis and Kontautas 2008).

Prey selection of piscivorous birds is largely dominated by size selection rather than selection of particular fish species (e.g. Bauer et al. 2005), which is considered to make fish eating birds less susceptible to habitat changes.

It was concluded that piscivorous waterbirds are susceptible to changes in their food supply, but are less sensitive to habitat changes than benthivorous waterbirds due to their typically generalist foraging strategy feeding on a variety of fish species. Thus piscivorous waterbirds, namely divers, grebes, cormorants, mergansers, terns and auks, were assessed to be medium sensitive to habitat changes. Waterbird species foraging on other prey types in addition to fish, such as gulls and White-tailed Eagle, were assessed to be of minor sensitivity to habitat change.

Herbivorous waterbirds are often gregarious and different studies indicate that these birds often deplete their food resources substantially (e.g. van Eerden 1984, Madsen 1988, Percival and Evans 1997, Ganter 2000). This makes these species susceptible to food reductions, but also indicates that herbivorous waterbirds should be behaviourally adapted to encountering food depletion under natural conditions. In general, herbivorous waterbirds relying on habitats in the marine areas of the Fehmarnbelt, e.g. Rødsand Lagoon, were assessed as being medium sensitive to habitat changes. An exception is the case of the moulting Mute Swans, which most likely must rely on local food resources of the Rødsand Lagoon, and were consequently assessed to have a high sensitivity to habitat changes. Herbivorous waterbird species which mainly use inland habitats of e.g. SPAs, such as Bewick’s Swan, Greater White-fronted Goose and Bean Goose, were assessed to be of minor sensitivity to habitat changes in marine areas. A minor sensitivity to habitat changes was also assumed for dabbling ducks foraging on a broad range of vegetation and invertebrate food.

Waders breeding in the SPAs of the Fehmarnbelt study area (mainly SPA Hyllekrog-Rødsand), which normally use habitats on land or the drift line, were assessed to be minor sensitive to habitat change from sediment spill caused by the construction works of a fixed link and were therefore not further considered in this EIA.

7.2.3 Water transparency

During the construction works of a fixed link the amount of suspended sediment in the water column increases, especially close to dredging sites, but depending on hydrographical patterns also in areas further away. Beside the indirect effect of habitat change due to changes in benthic (prey) communities, reduced water transparency could potentially impair foraging conditions of waterbird species.

Waterbird species differ in their foraging strategies and consequently have different tolerance to reduced water transparency. Following Shealer’s (2002) classification of foraging behaviour of seabirds, four main foraging techniques could be distinguished for waterbirds, plus herbivorous birds:

- Surface feeders (gulls)
- Plunge divers (terns)
- Pursuit divers (divers, grebes, mergansers, cormorants, auks)

- Bottom feeders (seaducks, diving ducks)
- Herbivorous species (swans, geese, dabbling ducks, coot)

Surface feeders pick food from the surface of the water and do not engage in diving or pursuit of aquatic prey and, therefore are considered insensitive to changes in water transparency and will not be analysed further with respect to this pressure.

Terns forage by plunge diving into the water from the air, but after submerging several centimetres they resurface without engaging into underwater dive. This group of birds uses vision to locate their prey and changes in water transparency could be an important factor for them (Shealer 2002).

Pursuit diving technique is used by the majority of piscivorous birds, which locate fish and pursue it by swimming underwater. Vision is important for these birds and they are potentially sensitive to changes in water transparency.

Seaducks and diving ducks primarily feed on benthic organisms by diving to depths from 1 to 20 m. These birds likely use vision to locate their prey, at least for some foraging modes and prey types. However, diving ducks of the *Aythya* genus (Tufted Duck, Greater Scaup and Common Pochard) typically forage at night in the Fehmarnbelt. Therefore, they are more likely using tactile sensors rather than vision. Based on their nocturnal foraging habits while in the Fehmarnbelt, it was assumed that *Aythya* ducks are minor sensitive to changes in water transparency and their response to this pressure is not considered further.

Herbivorous birds are not typical inhabitants of marine environments, but a number of species use protected bays and lagoons in the Fehmarnbelt. The majority of these birds forage on submerged vegetation in shallow waters and do not dive. Only Common Coot from all herbivorous species in the Fehmarnbelt is capable of foraging by diving.

Plunge diving terns

Several literature sources analyse sensitivity of terns to water transparency. Haney and Stone (1988) analysed distribution of several plunge-diving seabird species, including six tern species, across water transparency gradient in the Gulf Stream (Secchi depths ranging between 3-20 m) and concluded that water transparency was not influencing the distribution of these birds. Cyrus (1991) studied Little Terns in highly turbid waters off the St Lucia Mouth, South Africa and concluded that not turbid water but other factors influenced tern foraging behaviour at sea. Stienen and Brenninkmeijer (1997, cited in Baptist and Leopold (2010)) did not find a significant linear relationship between the number of foraging Sandwich Terns and the local water transparency in the Wadden Sea. Brenninkmeijer et al. (2002a) studied foraging ecology of wintering terns in Guinea-Bissau and found that the food intake rate of Little Terns and Sandwich Terns was lower in the most turbid waters (visibility <0.5 m) compared to clearer waters (visibility >0.5 m). However, Brenninkmeijer et al. (2002b, cited in Baptist and Leopold (2010)) found no difference in foraging success of these species in waters of different transparency in the Netherlands. In the nearshore waters of Monterey Bay, California, Forster's Terns (*Sterna forsteri*) were more frequent than expected over turbid water (<2.5 m Secchi depth, Henkel 2006). In the most recent study from the Netherlands, Baptist and Leopold (2010) report that foraging success of Sandwich Terns was optimal at waters with transparency of 1.5-2 m and that prey capture success halved at a minimum transparency of 0.4 m and at a maximum transparency of 3.2 m.

In summary, terns' responses to water transparency vary among places and are likely related to local prey abundance and prey behaviour. Terns seem to be generally tolerant to turbid waters and can forage successfully in water with visibility as low as 0.5 m. Therefore, terns were assessed to have minor sensitivity to changes in water transparency in the Fehmarnbelt.

Pursuit divers: divers, grebes, mergansers, cormorants, auks
Published information about responses of pursuit divers to different conditions of water transparency is scarce, except for cormorants.

Although cormorants are often perceived as visually-guided pursuit foragers, recent morphological analysis of cormorant vision revealed that they are only able to detect individual prey underwater at a close range of less than 1 m (White et al. 2007). This explains earlier reports about cormorants being successful hunters in waters with poor visibility (van Eerden and Voslamber 1995, Strod et al. 2008). Therefore, the Great Cormorant is assumed to have a minor sensitivity to changes in water transparency in the Fehmarnbelt.

Van Eerden et al. (1993) suggested that 0.4 m Secchi depth is the lower limit at which large numbers of Great Crested Grebes attend their moulting site in the highly productive Lake Ijsselmeer.

Eriksson (1985) studied fish-eating birds in relation to prey abundance and water transparency in oligotrophic lakes in Sweden and suggested that pursuit-divers (divers and mergansers) compensate for reduced prey densities by foraging in areas with higher water transparency.

Due to a lack of published information about the sensitivity of divers, grebes, mergansers and auks to water transparency, these species were assumed to be affected by changes in water transparency that fall below natural conditions which birds usually experience in the Fehmarnbelt. Thus, these species were attributed to medium category of sensitivity. However, species which predominately aggregate in Rødsand Lagoon were considered as being tolerant to changes in water transparency, as they frequently experience low visibility under natural conditions (water transparency is further described in chapter 4.6.1). Of pursuit diving birds wintering in the Fehmarnbelt, Smew was found being such a species and was therefore attributed minor sensitivity.

Bottom feeding seaducks
No published sources were found, which analyse effects of water transparency on seaduck foraging and habitat choice. Only indirect evidence provides insights into this question.

Typically, seaducks are considered being diurnal foragers (Owen 1990), suggesting that, at least to some extent, they use vision to detect prey or foraging patches. However, e.g. Common Eiders are not obligatory daytime feeders and in some places and/or periods forage nocturnally (Swennen 1976, Nehls 1995, Merkel and Mosbech 2008, Merkel et al. 2009). Also, wintering seaducks might use deep foraging habitats >20 m (Durinck et al. 1994), where light penetration in winter is poor. These birds also frequently forage on infaunal bivalves which cannot be located visually but tactilely. This indicates that seaducks can use foraging techniques that do not rely on vision. However, nocturnal foraging could be prey or habitat-specific.

All seaduck species winter in high latitudes, and some birds occur as far north as north of the polar circle. Considering short daylight periods and often deep foraging habitats, seaducks must be well adapted to forage without any visual clues. However, some species, such as Long-tailed Ducks, were suggested as being obligatory daytime foragers (Systad et al. 2000).

Several literature sources mention seaducks living in highly turbid environment. Kaiser et al. (2006) suggested that Common Scoters are unlikely being visual feeders in the Liverpool Bay where the water is especially turbid due to intensive riverine discharge.

The Wadden Sea and adjacent offshore areas support large numbers of seaducks, Common Eiders and Common Scoters. During winter, Secchi depth in the Wadden Sea is usually less than 0.5 m (Giesen et al. 1990, Brozek and Madsen 2001) and this also applies for parts of the offshore areas (Aarup 2002).

In the Fehmarnbelt, measured Secchi depth varied between 3.7 and 10.1 m during the baseline period and was lowest during the spring algae blooms in February 2009 and March 2010. Very low Secchi depths (between 4 and 6 m) were also measured in January 2010, following a storm which left high concentrations of suspended solids in the water column. Averaged annual measured Secchi depth was 7.3 m in 2009 and 6.8 m in 2010 (FEMA 2013e).

Comparable water transparency as in the Fehmarnbelt is reported for the Kattegat, the most important area for wintering Common Scoters, where average annual Secchi depth values range between 5.4 and 7.7 m (Aarup 2002). Secchi depth in the Pomeranian Bay, an important wintering area for Long-tailed Ducks and Common Scoters, is between 4.0 and 4.8 m (Aarup 2002). For the same area Łysiak-Pastuszak et al. (2009) report slightly higher values of 4.5 m for the Oder mouth section and 5.5 m for the open Pomeranian Bay. Average annual Secchi depths in the Gulf of Gdansk, another site favoured by Long-tailed Ducks and scoters, range between 3.5 and 8.5 m. Secchi depth averages at 8.7 m in shallow waters (up to the isoline of 20 m) along the central Polish coast (Łysiak-Pastuszak et al. 2009). Average annual Secchi depth in the Gulf of Riga, another important area for wintering Long-tailed Ducks, is 5-6 m (HELCOM 2006).

In general, seaducks are probably not very sensitive to changes in water transparency, however, in case of strong gradients, a preference for clearer water might cause areas with poor water transparency to be avoided. Considering a lack of empirical studies analysing this question and using the precautionary principle, it was thus assumed for the purpose of the Fehmarnbelt EIA to consider seaducks as medium sensitive against strong changes in water transparency and that areas of low water transparency that would fall below baseline conditions would be avoided by birds.

During the FEBI baseline investigations it was found that Common Goldeneyes predominately aggregate in the most turbid areas of the Fehmarnbelt such as Rødsand Lagoon and Orth Bight. Therefore, the Common Goldeneye was considered being a species tolerant to changes in water transparency, as they frequently experience low visibility under natural conditions in the Fehmarnbelt (water transparency described in chapter 4.6.1). Subsequently, Common Goldeneye was attributed minor sensitivity to this pressure.

Breeding Common Eiders were also assigned a minor sensitivity to changes in water transparency, as when rearing young, eiders use shallow waters that are continuously affected by resuspending sediments under natural conditions.

Herbivorous species

When foraging on aquatic vegetation, herbivorous waterbirds are typically found in shallow waters where food can be reached without diving. In fact, herbivorous waterbirds do not dive when foraging at all, except for the Common Coot. They also inhabit a variety of habitats when breeding and staging, including highly eutrophic waters with low visibility (Cramp and Simmons 1980). Furthermore, many species of these birds are known to be active not only during the day, but also at night (Jorde and Owen 1998). All this implies that water transparency does not play an important role for herbivorous waterbirds when choosing foraging habitats. Therefore, minor sensitivity to a decrease in water transparency was ascribed to all herbivorous waterbird species.

7.2.4 Provision of artificial reefs

Additional hard substrates from human-built structures under water, such as bridge pillars, embankments or protection layers, result in a loss of the original habitat and associated communities, but provide new habitats for hard-bottom communities and associated flora and fauna. Artificial reefs may also have an effect on the surrounding areas due to the production of organic matter and faecal pellets, which may impair adjacent benthic communities. Additional solid substrates are described to increase the risk of introducing invasive species to an environment (FEMA 2013d).

It is known that reef structures are suitable habitats for different fish species and may aggregate fish from the surrounding area (e.g. Grossman et al. 1997, Inger et al. 2009, Lindeboom et al. 2011). FeBEC (2013b) predicts that artificial reef structures in Fehmarnbelt would have such an effect on fish communities in Fehmarnbelt as well.

Little is published about the use of artificial reefs by waterbirds. Similar to pillars or solid protection layers/reefs of a fixed link structure, offshore wind farms provide artificial reefs in the marine environment. Due to disturbance effects seaducks mostly avoid areas within wind farms, but there are occasional observations of single Common Eiders foraging on epifauna from such artificial reefs (Lindeboom et al. 2011). Higher densities of fish at artificial reefs may attract piscivorous birds. Observations of cormorants are reported for offshore wind farms, where the additional food supply in combination with provision of resting sites (above water structures of wind mills) attract these birds (Petersen et al. 2006, Lindeboom et al. 2011).

The species distribution of benthivorous and piscivorous birds was shown to be shaped by a series of parameters, including water depth, distance to land, distance to shipping lines and others (FEBI 2013). In combination with possible disturbance effects of above-water structures (in the case of a bridge solution) for most waterbird species artificial reefs may only play a minor role as foraging habitat, yet some species or single birds might extensively use the area.

There was no waterbird species identified that would be expected to be impaired by the artificial reefs introduced by either solution of a fixed link. The effect of these additional solid structures is regarded as either non detectable or beneficial for birds, therefore a minor sensitivity to this pressure is assessed for all waterbird species.

7.2.5 *Hydrographical changes*

Hydrodynamic structures which lead to concentrations of piscivorous and planktivorous seabirds are fine-scale frontal structures like those created by eddies, upwellings and tidal fronts (Hunt 1990, Schneider 1990). The general interpretation of these affinities has been the enhancement of the probability of prey encounter, which greatly maximises predators' foraging success (Schneider and Duffy 1985, Fauchald et al. 2011). As small-scale eddies may develop around the bridge pillars (FEHY 2013c), the probability of encountering small prey organisms like zooplankton and small fish may increase locally along the alignment of a cable stayed bridge. The species most likely to benefit from this would be e.g. Little Gull, Black-headed Gull or terns.

There was no waterbird species identified as being sensitive to the predicted hydrographical changes from the structure of a fixed link in terms of expected impairment. The effect of hydrographical changes is regarded to be either non detectable or beneficial, therefore a minor sensitivity to this pressure was attributed for all waterbird species.

7.2.6 *Disturbance from construction vessels*

Waterbirds respond in different ways to on-site or approaching vessels. Some species are attracted to vessels as they expect food (gulls following fishing vessels). Others show a negative response and flee from an approaching vessel at variable distances. The response differs not only between species but also depends on season, function of the area and structure of the waterbird assemblage (Mori et al. 2001). Waterbirds are especially sensitive during moult. Besides, reaction distances are known to be smaller during wintering period (Thiel et al. 1992). Species like the Common Scoter and divers exhibit large fleeing distances of 1-2 km, other species such as Common Eiders of Long-tailed Ducks usually show fleeing distances shorter than 1 km (Bellebaum et al. 2006, Schwemmer et al. 2011). However, initiation of fleeing reactions vary over a broad range of distances and the response distance usually increases with flock size making large aggregations more sensitive to disturbance (Mori et al. 2001, Larsen and Laubek 2005, Schwemmer et al. 2011). Also, repeated disturbances may have a cumulative effect (Merkel et al. 2009). If shipping is channelled within a predictable corridor, some birds may habituate to disturbance and show lower fleeing distances (Schwemmer et al. 2011). Fleeing distances of waterbirds are also described to vary with the hunting pressure. Waterbirds show larger fleeing distances in areas where hunting occurs and hunted species exhibit larger flushing distances than non-hunted species (e.g. Madsen and Fox 1995, Laursen et al. 2005).

Gulls and terns are generally described as being insensitive to disturbance from shipping since they are often observed associated with vessels (Garthe and Hüppop 2004, Mendel et al. 2008). Gulls often scavenge on fish discards and therefore are attracted to ships (e.g. Walter and Becker 1997, Garthe and Scherp 2003, Garthe et al. 2004). Terns are also known to use turbulences caused by ship's propeller for foraging (Garthe et al. 2004, Mendel et al. 2008). Therefore, all gull and tern species were assessed being minor sensitive to disturbance from construction vessels and are not further assessed regarding this pressure.

Divers and both scoter species, which exhibit the largest fleeing distances, were assessed to have a very high sensitivity to disturbance from construction vessels. Grebes, cormorants, diving ducks, seaducks except scoters (see above), mergansers and auks were assessed to have a high sensitivity to this pressure, though disturbance reactions may vary largely among species and with situation (e.g. species composition, flock size, disturbance frequency).

Waterbird species which are rarely observed offshore and for which little information exists about their sensitivity to disturbances in marine habitats, such as swans, geese, dabbling ducks, White-tailed Eagle and Common Coot, were precautionally assessed to be medium sensitive to this pressure.

Breeding waterbirds were assumed to have a high sensitivity to disturbances in the vicinity of their breeding areas, even though disturbance ranges are expected to vary between species. The sensitivity of breeding waterbirds to disturbance in marine foraging habitats distant to the breeding sites was assumed to be similar as for non-breeding waterbirds.

7.2.7 Disturbance from bridge structure and traffic

Little is published about disturbance reactions of waterbirds to existing bridges with car and train traffic. The biological monitoring during the construction and first years of operation of the Great Belt Bridge showed locally significant reductions in numbers of wintering Common Eiders around the island of Sprogø, but no significant effect on numbers in the general Great Belt area (COWI/DHI 2001). Authors of that study identified disturbance from construction vessels (during construction) and from the existing highway and bridge (during operation) being the most important factors affecting bird numbers close to the island of Sprogø and the bridge. However, a later study for an offshore wind farm north of the island of Sprogø indicated that flocks of Common Eiders use areas in the immediate vicinity of the Great Belt Bridge (Orbicon 2008). Thus the disturbance from this bridge seems to be small, at least after some years of operation. Bird observations reported in the online database of the Danish Ornithological Society (Dansk Ornitologisk Forening or DOF) also confirm that Common Eiders use the areas in the close proximity of the Great Belt Bridge (e.g. 4,000 Common Eiders resting close to the western part of the bridge on February 4, 2006; DOF 2011).

FEBI telemetry studies conducted during the baseline investigations revealed Tufted Ducks using areas close to sources of human disturbance for resting and foraging, e.g. birds were frequently observed near the Fehmarnsund Bridge or the Guldborgsund close to Nykøbing, Falster (FEBI 2013). However, disturbance from a larger bridge structure cannot be excluded for this species.

Disturbance effects on birds from car and train traffic, including lighting, are not well studied for marine habitats. Studies on land indicate that traffic would cause only small / minor disturbance to waterbirds with effects only recorded at distances smaller than 250 m (Garniel et al. 2007). In general birds' hearing is less sensitive compared to that of most mammal species and noise is considered to cause little disturbance to birds (Dooling 2002). As car traffic is expected to generate regular noise, it can be assumed that birds habituate. Trains would pass at regular intervals and may cause minor disturbance during each pass, as noise emission is considerable. However, the sensitivity to disturbance from the bridge structure and traffic on breeding and non-breeding waterbirds in the Fehmarnbelt was assumed to be lower than from construction vessels.

Some waterbird species, especially divers and scoters, are known to show strong fleeing or avoidance reactions to human caused disturbances like ships (Bellebaum et al. 2006, Schwemmer et al. 2011) or wind farms (BirdLife International 2004b, Petersen et al. 2006). However, some studies suggest less avoidance of wind farms by sensitive species (Petersen and Fox 2007, Lindeboom et al. 2011), possibly due to habituation. Also, a stationary structure of a bridge might be less disturbing to birds than wind mills or ships, and birds might be able to habituate to the constant pressure (Schwemmer et al. 2011).

Terns and gulls breed on Sprogø in the immediate vicinity of the Great Belt Bridge (Orbicon 2008), which indicates that these species can tolerate the disturbance from the bridge. Furthermore gulls are described to use the wind updrafts over existing bridges (Nilsson et al. 2010). Therefore gulls and terns were assessed to be minor sensitive to disturbance from a bridge in operation in Fehmarnbelt.

Cormorants while not on migration are described to intensively use wind farms as foraging and resting habitats with no indication of general avoidance of these areas (Petersen et al. 2006, Blew et al. 2008, Lindeboom et al. 2011). It is therefore expected that Cormorants are not affected by disturbance from a bridge structure in the Fehmarnbelt and subsequently Great Cormorant was assessed to be minor sensitive to this pressure.

The sensitivity of White-tailed Eagle to disturbance from bridge structure and traffic was also assessed to be minor, as this species as other birds of prey is known to cross bridges without hesitation or to use them as guiding structure across waters (see below: pressure barrier effect and migrating birds).

Disturbance from a cable stayed bridge could not be excluded for all other waterbird species in the Fehmarnbelt. However, according to the available information it is likely that waterbirds would be less sensitive to disturbance from a bridge compared to disturbance from shipping. Divers and scoters, which are known to be very sensitive to disturbances from ships and wind farms (see references above), were thus assessed to have a high sensitivity to a bridge structure.

Having assessed the sensitivity of divers, Great Cormorant, scoters, White-tailed Eagle, gulls and terns, all other waterbird species were assessed to be medium sensitive to disturbance from operation of a cable stayed bridge in the Fehmarnbelt.

7.2.8 Disturbance from channelling of shipping

The structure of a bridge over the Fehmarnbelt would result in channelling of the shipping. In detail, the current shipping on the route T in Fehmarnbelt would be funnelled to a shipping lane of maximal 2 x 724 m between the pylons of the main bridge, also affecting areas which are part of the Natura 2000 site SCI Fehmarnbelt. The sensitivity to this pressure is identical to disturbance from ships as described in chapter 7.2.6. However, restriction of shipping to the narrowed shipping route would make the traffic more predictable to birds. Therefore, it is likely that birds would habituate more to the pressure compared to the baseline situation with wider shipping routes (bird habituation described in IBL 2011, Schwemmer et al. 2011).

The sensitivity of waterbirds to disturbances from ships in general is assessed to be the same as described in chapter 7.2.6. However, the intensification of shipping would occur within an area which is already highly impaired by shipping. It was assumed that the effect of channelling of the shipping would be mainly positive to birds due to the reduction of the impaired area, thus the sensitivity to this pressure was assessed as minor for all waterbird species.

7.2.9 Barrier from bridge structure

Flying birds usually respond to an obstacle by vertical or horizontal changes in their intended flight route. In case of species which migrate or generally fly at low altitudes and tend to pass obstacles by horizontal movements, a long structure like a bridge might pose a barrier.

A barrier effect of a structure is basically meant as a barrier to movement and thus is different from other pressures resulting in displacement or redistribution of birds such as disturbance effects. Barrier effects on wildlife are known for e.g. streets and highways and may lead to habitat fragmentation (Iuell et al. 2003, Böttcher et al. 2005). In the offshore environment, barriers are represented by e.g. large offshore wind farms (Petersen et al. 2006, Blew et al. 2008, Leopold et al. 2010), but also by ships and shipping lanes (Garthe et al. 2004, Bellebaum et al. 2006). Bridges present a barrier simply by being a vertical structure reaching into the air and potentially affecting flying birds. Birds would perceive a bridge structure as a barrier to varying degrees. Up to date little evidence of this is published (Hicklin and Bunker-Popma 2001, Bunker-Popma 2006, MacKinnon and Kennedy 2006, Nilsson et al. 2009, 2010).

If and to which degree birds would perceive a bridge as a barrier and associated behavioural reactions would depend on the status of a bird in its yearly cycle, thus regarding breeding and non-breeding waterbirds and migrating birds. For example a migrating bird may perceive a structure as a barrier, while temporarily resident birds exposed to this barrier more frequently may habituate to some degree. A barrier effect can be either complete or cause weak to strong avoidance reactions and additional flight and therefore energy expenditure, or may not exist.

To assess species-specific sensitivities towards a possible barrier effect, data from the effect studies on the Baltic Sea bridges have been used first of all (see Table 4.11, chapter 4.6.2). These data are supplemented by published information on species-specific sensitivities, such as disturbance or barrier effects from offshore wind farms (Hüppop et al. 2005, 2009, Petersen et al. 2006, Blew et al. 2008, Larsen and Guillemette 2009, Masden et al. 2009, 2010a/b).

In the absence of published data, general conclusions from migration behaviour were used for the sensitivity assessment. Behaviour patterns like flight altitude, flight direction, main migration routes, nocturnal flight activity, known sensitivity against disturbance from e.g. ships, aircrafts, onshore and offshore wind mills were taken into account (Table 7.2). Data was derived from either other studies (Dierschke and Daniels 2003, Garthe and Hüppop 2004, Blew et al. 2008, King et al. 2009) or from FEBI baseline investigations (FEBI 2013). It was assumed that species flying at low altitudes, flying perpendicular to the alignment, preferring to fly over water, being daytime active and being sensitive to anthropogenic disturbances are more likely to perceive a bridge as a barrier than species flying at high altitudes, parallel to the alignment, being nocturnal and being less sensitive to disturbances.

Table 7.2 Bird migration: migration types as defined in FEBI (2013) and generalised flight behaviour.

Migration type	Definition	Generalised flight behaviour
1	Waterbirds preferentially migrating over water – divers, grebes, seaducks, mergansers, auks etc.	flight altitude – low flight direction – perpendicular to alignment
2	Waterbirds less dependent to migrate over water – geese, waders – with migration preferences steered by destination and stop-over sites	flight altitude – high flight direction – perpendicular to and independent of alignment
3	Landbirds migrating during daytime, dependent on updrafts / thermals	flight altitude – mostly low, some high flight direction – parallel to alignment
4	Landbirds migrating in broad-front during night-time	flight altitude – mostly high, 20-30% low flight direction – parallel to alignment

The criteria for assessing the sensitivity to barrier effects for migrating birds of different species correspond closely to the definition of different levels of degree of impairment shown in Table 4.8.

For migrating birds, a species' sensitivity to barrier effect was assessed to be very high, if FEBI baseline investigations or other studies indicate that all birds or a large proportion of the population of a species would not cross a bridge at all or such an effect cannot be excluded based on present state of knowledge.

For migrating birds, a species' sensitivity to barrier effect was assessed to be high, if FEBI baseline investigations or other studies indicate that birds would not cross the bridge, but either fly over land or land on water; in the latter case a crossing or flight over land at a later time may ensue.

For migrating birds, a species' sensitivity to a barrier effect was assessed to be medium if FEBI baseline investigations or other studies indicate that birds show reactions to the bridge, which would include extra energy expenditure. Reactions range from increasing flight height, circling before crossing to changing flight direction, but birds would eventually cross. In the absence of own data, published data were chosen to document similar reaction types. Thus, documented bird behaviour or migration behaviour can lead to an assessment of medium sensitivity if:

- there is strong avoidance of offshore wind farms;
- low flight altitudes in combination with a strong preference to migrate over water; this would apply for most migration type 1 waterbird species;
- flight altitudes are variable, but include low flight altitudes and a preference to fly over water / along coasts; this would apply for most migration type 2 waterbird species.

A minor sensitivity to barrier effects was allocated to those migrating species, which are unlikely to perceive the bridge as a barrier, because those species usually fly at high altitudes and/or their migration route is more or less parallel to the bridge. This would apply for most migration type 3 and 4 species.

Breeding and non-breeding waterbirds
There is only little data available for the assessment of the sensitivity of breeding waterbirds to a barrier. The relevant breeding waterbird species (see Table 7.4, Table 7.5), are considered to be near-coast onshore breeders, which use the near-coast offshore areas for feeding. For breeding waterbirds, a barrier effect is regarded as being caused by the direct disturbance from the bridge (see chapter 7.2.7). Consequently, the sensitivity to a barrier effect from the bridge structure was assessed to be medium for all relevant breeding waterbird species except cormorants, gulls and terns. The sensitivity of White-tailed Eagle to a barrier was also assessed to be minor, as this species is known to cross bridges without hesitation or use them as guiding structure across waters (see below).

Non-breeding waterbirds (wintering or staging), which are not migrating, would be exposed to a bridge more frequently than migrants. FEBI effect studies at Baltic Sea bridges showed, that of birds categorised as not migrating, some proportions even flew under bridges, a behaviour basically not registered for migrating birds. This was recorded for several species such as Great Cormorant, Mute Swan, diving ducks, waders and Common Eiders. Of the latter, local individuals flew under the bridge without hesitation (23 of 135 flocks), or frequently landed on water (109 of 135), which has been interpreted as compensation flights for drifting of resting or foraging ducks (see chapter 4.6.2). On the other hand, not migrating birds did also show reactions suggesting a barrier effect, thus no clear predictions are possible.

In general, the sensitivity to a barrier effect from a bridge for non-breeding waterbirds was assessed being similar to the assessed sensitivity to disturbance from a bridge during operation (see chapter 7.2.7) if there was no additional information which suggests otherwise. This is true for the three auk species, for which a very high sensitivity was assumed, because a complete barrier effect could not be excluded. A high sensitivity to a barrier effect was assumed for divers and scoters. All other non-breeding species were assessed to be medium sensitive to the barrier, except for Great Cormorant, White-tailed Eagle, gulls and terns, which were assessed to be minor sensitive to disturbance from a bridge (see chapter 7.2.7) and were therefore also assessed to have a minor sensitivity to a barrier effect.

Migrating birds

Divers
Divers migrate over water most of the time and were allocated to the migration type 1 waterbirds (Table 7.2). From the FEBI effect studies at bridges (see chapter 4.6.2) only 13 observations of divers are available. Of these, 15% crossed a bridge without hesitation, 69% crossed including an increase in flight altitude and 15% did not cross over the bridge, but over land.

Divers are reported to gain considerable height when crossing e.g. the Öresund Bridge and thus represent the species group with by far the highest flight altitude when crossing. In the same study it was assumed that many diver flocks have been missed due to flight altitude, which could be a hint that this species group may start ascending at long distances from the bridge (Nilsson et al. 2009, 2010).

Presence of a barrier effect from a bridge was assumed, as divers show strongest avoidance reactions to offshore wind farms among all waterbirds (Garthe and Hüppop 2004, Petersen et al. 2006, Mendel et al. 2008, Krijgsveld et al. 2010, Leopold et al. 2010) and are sensitive to disturbance by ships (Bellebaum et al. 2006, Schwemmer et al. 2011; see also chapters 7.2.6 and 7.2.7). Divers are known to fly rather low above the water surface (visual observations: Dierschke

2003, Dierschke and Daniels 2003, FEBI baseline studies). However, FEBI tracking radar results suggest that diver species also fly at high altitudes and may be missed by visual observations, as they are out of sight. Divers are reported to cross over land during autumn migration at several places in Schleswig-Holstein (Flensburg Fjord, Lübeck Bight at Haffkrug), then showing flight altitudes of 200 m and even considerably above that (Koop 2004, 2008b, 2009, 2011).

In the Fehmarnbelt, divers belong to the few species which have been registered in higher numbers in the central Fehmarnbelt than close to the coasts. Therefore, most of these birds would be exposed to the high structures of the main bridge and this barrier may lead to additional reactions (Table 4.8).

Overall, a medium sensitivity to a barrier was assessed for divers.

Grebes
No data are available for grebe species from the FEBI effect studies at the Baltic Sea bridges or the Öresund Bridge. Great Crested and Red-necked Grebes are known to fly at low altitudes over the water, with 100% of the individuals registered below 50 m, and up to 88% below 5 m (Dierschke and Daniels 2003, Hüppop et al. 2005), which is supported by visual observations during the FEBI baseline investigations (FEBI 2013). Besides, a mean flight altitude of 5-10 m was selected for the assessment of the wind farm sensitivity score (Garthe and Hüppop 2004). All grebe species are described as being sensitive towards disturbance (Mendel et al. 2008, Sonntag et al. 2009) and were assessed being medium sensitive to disturbance from a bridge (see chapter 7.2.7).

Therefore, a medium sensitivity to barrier effect was assessed for grebes.

Great Cormorant
Foraging and relocating Cormorants fly over the water at low altitudes and in many different directions. However, a mean flight altitude of 25 m has been recorded for birds on medium- to long-distance movements during the daytime (FEBI 2013). Tracking radar data revealed mean flight altitudes of even up to 411 m, which confirms literature information that Great Cormorant may migrate at relatively high altitudes both over the water and over land (Koop 2002, Herzig and Böhnke 2007, Blew et al. 2008). Cormorants have been recorded during the FEBI effect studies on bridges (n=55 flocks), and 18% of observed flocks crossed bridges without and 73% with little hesitation (climb).

A bridge would represent a barrier for migrating birds travelling along the coasts. However, Cormorants readily migrate over land (Herzig and Böhnke 2007), as it was also confirmed during the baseline studies (FEBI 2013). In summary, this species exhibits a variety of flight directions and altitudes, and shows only light reactions to bridges.

Therefore, the Great Cormorant was assessed to be minor sensitive to barrier effects.

Grey Heron
Grey Herons are day- and night-time active, both when feeding and on migration. As this is a species which was rarely registered during offshore investigations, data on displacement and disturbance do not exist. Migratory movements would be parallel to the alignment (particularly in autumn, FEBI 2013). Flight altitude as measured during night was 580 m for one flock registered by the tracking radar in July 2009.

Due to the flight direction being parallel to a fixed link in the Fehmarnbelt and the high flight altitude, Grey Heron was assessed to be minor sensitive to barrier effects.

White Stork

During FEBI baseline investigations White Storks were observed on six occasions flying at high altitudes (measured by tracking radar, average flight altitude 290 m; FEBI 2013) and migration direction would be parallel to the alignment.

Therefore, the White Stork was assessed to be minor sensitive to barrier effects.

Swans

During the FEBI bridge studies it has been shown that locally living Mute Swans do fly under bridges (e.g. Farøsund Bridge, see chapter 4.6.2). However, there are only a few records of migrating swans at bridges (n=8); of those one Mute Swan did not cross, while of Whooper Swans, 25% crossed over land, 25% crossed with some and 13% with no hesitation. Öresund Bridge studies describe for a few occasions that Mute Swans were climbing for several minutes, before either turning around or passing the Öresund Bridge with some hesitation below or in a few cases above (Nilsson et al. 2010).

In offshore wind farm studies, Mute Swans are described as avoiding to fly into the wind farms, at least when flying at rotor height (Krijgsveld et al. 2010).

Therefore, swans were assessed to be medium sensitive to barrier effects.

Geese

FEBI bridge studies (see chapter 4.6.2) revealed that among the geese flocks that were classified as long-distance migrants (n=120 flocks), 21% passed a bridge with no reaction, 36% showed some reaction but passed, and 37% did not pass a bridge directly, but flew over land.

During the Öresund Bridge studies, Barnacle Goose was the most numerous recorded species in spring 2008 and 2009 (Nilsson et al. 2009, 2010). While many geese passed the motorway overland east of the bridge, the majority of Barnacle Geese was described as not showing any reaction when approaching the bridge or the motorway and just passed without any hesitation. A few Barnacle Geese showed some hesitation when reaching the bridge and a few big flocks even turned back before eventually passing. Many goose flocks changed flight direction before the passage.

Öresund Bridge study in the autumn 2008 revealed that out of in total 480 Brent Geese, 100 individuals passed over land, 291 passed the bridge without and 82 with some hesitation, and 7 individuals turned back but eventually passed (Nilsson et al. 2009). For spring 2009 Brent Geese are reported to generally avoid crossing the Öresund Bridge. However, flight tracks of Brent Geese been parallel to the bridge and birds crossed into land south of the bridge. Also, overall registered numbers of Brent Geese in spring were low compared to e.g. Barnacle Geese (Nilsson et al. 2010).

Greylag Geese are described to often cross just above the freeway of the Öresund Bridge, on their movements between Pepparholm and mainland Sweden (Nilsson et al. 2010). According to the Fehmarnbelt baseline studies (FEBI 2013) it is assumed that among the geese species the Greylag Goose would mainly cross from Lolland to Fehmarn along the alignment, while most other goose species are assumed to migrate in predestined direction more or less independently of the link direction. Consequently, the barrier effect for the Greylag Goose would be small.

In offshore wind farm studies, goose species are described to avoid flying into wind farms, at least when flying at rotor height (Krijgsveld et al. 2010). In general, arctic geese conduct long-distance flights using stop-overs and show some attraction to coastlines (e.g. Alerstam 2001, van der Graaf et al. 2006), but are also considered to be broad-front migrants at other locations (Nilsson et al. 2010). Their flight altitude can be well above 200 m, flight routes not close to the Baltic Sea bridges, and the majority of migrating individuals or flocks may thus not experience a bridge as a barrier at all.

Most goose species, except the Greylag Goose, were assessed to be medium sensitive to barrier effects.

The Greylag Goose was assessed to be minor sensitive to barrier effects.

Common Shelduck
While no data have been collected on this species during the FEBI effect studies on the Baltic Sea bridges (see chapter 4.6.2), during the Öresund Bridge studies Common Shelduck was often recorded flying relatively low close to the bridge or over land at Lernacken, and over Pepparholm (Nilsson et al. 2010).

Shelducks show low sensitivity to disturbance and no dependence on offshore habitats (King et al. 2009). During the FEBI baseline investigations shelducks were recorded flying at low altitudes (FEBI 2013).

Common Shelduck was assessed to be medium sensitive to a barrier effect.

Dabbling ducks
During the effect studies at the Baltic Sea bridges (see chapter 4.6.2), 16 flocks of migrating dabbling ducks have been recorded. Of these, 38% passed the bridge without and 50% with some hesitation. The remaining birds landed on water and thus did not pass during the time of observations. During the Öresund Bridge studies (Nilsson et al. 2010) only Mallard and Eurasian Wigeon were registered and the majority of observed birds passed the bridge without hesitation. Dabbling ducks were also often recorded flying relatively low close to or over land at Lernacken and over Pepparholm at the Öresund Bridge (Nilsson et al. 2010).

Dabbling ducks were registered flying at low mean altitudes (<50 m) during the FEBI baseline studies (FEBI 2013).

In offshore wind farm studies, dabbling ducks are described to show less avoidance of the wind farms than seaducks (Krijgsveld et al. 2010). Most dabbling duck species breed on freshwater habitats and are therefore expected to fly over land without hesitation. Naturally, they also cross land when migrating between the Baltic and the North Sea, for example during autumn, when these migrations are leading either through the bays (Flensburg Fjord, Eckernförde Bight, Kiel Fjord, Lübeck Bight) or along the river Schlei or the Kiel Kanal (Nord-Ostsee-Kanal; Koop 2004, Berndt et al. 2005).

In summary, dabbling ducks cross bridges, fly at low altitudes, prefer flying over water, but do not avoid flying overland. Their avoidance of offshore wind farms is less pronounced than that of e.g. seaducks.

A medium sensitivity to a barrier effect was assessed for dabbling ducks.

Diving ducks
During the effect studies at the Baltic Sea bridges, only few records of diving duck species (Tufted Duck, Common Pochard, Greater Scaup and Common Goldeneye)

have been classified as migration movements (n=21). Five percent of these passed the bridges without reaction, 48% showed some reaction but did pass, and 43%, namely 9 flocks of Common Pochard at the Öland Bridge (Sweden), did not pass. Due to the overall low sample size and thus low confidence, this result - for the Common Pochard in particular – is not to be overemphasised.

During the Öresund Bridge studies, the majority of Tufted Ducks and Common Goldeneye passed the bridge without or with little hesitation, while increasing flight altitude (Nilsson et al. 2009, 2010).

Diving ducks are known to fly at low altitudes, e.g. Common Goldeneye fly mainly below 30 m, Greater Scaup below 50 m, Tufted Duck and Common Pochard mainly below 75 m. Common Goldeneye are mostly daytime active, Greater Scaup are most active at dusk and dawn, Tufted Ducks and Common Pochard – during night-time (Dirksen et al. 2000). Studies on Tufted Ducks reveal that birds are able to avoid wind farms even at night. During dark nights 91% of the birds avoided to cross the wind farm area, compared to 82% during the moonlit nights (Dirksen et al. 2004). In offshore wind farm studies, diving ducks showed less avoidance to the wind farms than seaducks (Krijgsveld et al. 2010).

Greater Scaup is known to be sensitive to disturbance, both from shipping and also from other human near-shore activities (Mendel et al. 2008). As this species conducts nocturnal short- and long-distance movements, it is expected to be less susceptible to a barrier effect than to collision risk (see chapter 7.2.11). No flight behaviour data are available except flight altitudes recorded during the FEBI baseline investigations (FEBI 2013).

Most diving duck species breed on freshwater habitats and are therefore expected to fly over land without hesitation. Naturally, they also cross from the Baltic to the North Sea and vice versa, for example during autumn either through the bays (Flensburg Fjord, Eckernförde Bight, Kiel Fjord, Lübeck Bight) or along the river Schlei or the Kiel Canal (Nord-Ostsee-Kanal) (Koop 2004, Berndt et al. 2005).

Diving ducks were assessed being medium sensitive to a barrier.

Common Eider

The largest dataset of the effect studies at the Baltic Sea bridges (see chapter 4.6.2) consists of Common Eider observations. These data indicate that bridge design and location play a role, as Common Eiders cross the Storstrøms Bridge (Farøsund, DK) without an apparent reaction, but Common Eiders at the Öland Bridge in the Kalmarsund (Sweden) are described reacting by increasing their flight altitude, landing on water or turning in order to follow the bridge alignment. Of those birds crossing the bridges, changes in flight directions are reported to occur at some distance from a bridge (1,000-2,000 m), changes in flight height probably occur even earlier (3,000-4,000 m). Results of the bridge studies conducted in spring 2009 show that considerable proportions avoid bridges by passing over land (38% of the Common Eider flocks at the Öland Bridge, 55% at the Storstrøms Bridge), or do not pass (37% at the Öland Bridge, 11% at the Storstrøms Bridge). For the latter, it must be noted, that flocks may still either come back or cross over land at another place, however, this could not be recorded as flocks have not been followed.

Pooled results from spring 2009 to spring 2010 show, that 27% pass a bridge by increasing flight altitude, 40% either cross over land or land on the water, while 24% did not pass during the registered attempt, most of them at the Öland Bridge.

At the Great Belt Bridge, data have been analysed separately for migrating and local (wintering) Common Eiders. Migrating individuals showed reactions to the bridge in e.g. increasing altitude from some 20 m at 3,000 m distance to the bridge to 90-100 m directly at the bridge while passing (24 of 46 flocks), but also turning back and not passing (9 of 46 flocks). Results from the Öresund Bridge showed, that birds do pass the bridge during spring (Nilsson et al. 2009, 2010). However, it was frequently observed that large flocks more frequently than small flocks turn to fly over land. Some 20% of the registered birds turned back in 2008 and 15% in 2009, of these 40% were not seen making another attempt within five minutes. During autumn very low numbers of Common Eiders were observed. A general remark was, that during hazy and headwind situations Common Eiders landed on water instead of crossing, while most crossings have been registered during moderate to strong tailwinds (Nilsson et al. 2010). For Common Eider it is stated, that the coastal migration corridor along the Swedish coast around Malmö is mainly abandoned due to the bridge. Instead, more birds fly over land (Nilsson et al. 2010).

For Common Eider in the Baltic and North Sea it is well documented, that they show some avoidance of offshore wind farms, both by flying around with reaction distances of up to 4,000 m (Petersen et al. 2006) and generally avoiding offshore wind farm areas (e.g. Krijgsveld et al. 2010). The low numbers entering the area of offshore wind farms prefer higher altitudes (above rotor height; Blew et al. 2008). Additional migration distances and energy expenditures due to these detours have been assessed as trivial (Masden et al. 2009).

It must be noted that results have high variance, as some Common Eiders do not cross, that the reaction varies with location and bridge design and that small flocks show stronger reactions than large flocks.

In summary, Common Eider show a variety of reactions when approaching bridges, but eventually either pass over land or over the bridge after having changed flight direction and increased flight height.

A high sensitivity to a barrier effect was assigned for the Common Eider.

Long-tailed Duck

No data were available on the Long-tailed Duck in the FEBI effect studies at bridges (see chapter 4.6.2) or the Öresund Bridge studies (Nilsson et al. 2009, 2010). Long-tailed Duck is scored as highly sensitive towards offshore wind farms due to e.g. low flight-altitudes and sensitivity to disturbance (Garthe and Hüppop 2004). Danish wind farm studies indicate Long-tailed Ducks avoiding offshore wind farms (Petersen et al. 2006). Large escape distances from moving ships were reported (Bellebaum et al. 2006, Mendel et al. 2008). Baseline visual observations (FEBI 2013) confirm low flight altitudes of this species.

In the absence of observations of Long-tailed Duck reactions to bridges a similar sensitivity as it was assessed for the Common Eider was assumed.

The sensitivity of Long-tailed Ducks to barrier effect was assessed being high.

Common Scoter, Velvet Scoter

Effect studies at the Baltic Sea bridges have shown that of the 26 flocks of Common Scoters registered at the Öland Bridge (Kalmarsund), 21 passed the bridge with and 3 without increasing flight altitude and 2 flocks landed on the water (did not pass). At the Farøsund Bridges, 3 out of 5 flocks of scoters passed the bridge after ascending to higher altitudes, one flock showed strong reaction (disintegrated) but eventually passed, and one flock flew back. Observations indicated that scoters may have reacted at large distances from the bridge. At the Great Belt Bridge, of 194 individuals observed in 14 flocks, only one single scoter crossed the bridge while all the others landed on water some 1,000 m from the bridge. It is assumed that scoters may react so early, i.e. far away from the bridge, that bird reactions could not be recorded from observation point that were used (see chapter 4.6.2).

Öresund Bridge studies (Nilsson et al. 2009, 2010) also report that approaching Common Scoters frequently land on water and do not cross or even turn back. However, observations in 2008 at the Öresund Bridge indicated that in spring the majority of the birds flew over the bridge without hesitation whereas many birds also passed the bridge after some hesitation (Nilsson et al. 2009). Somewhat different results are reported from the spring 2009: rather few Common Scoters were recorded, but on some days large numbers of birds were gathering to the north of the bridge (Nilsson et al. 2010). The results from the small dataset collected in spring 2009 and also visual observations (Olsson unpubl.) indicate that scoters gained considerable height before crossing the bridge. It has also been assumed that probably a large majority of scoters pass the area during night and at high altitudes and probably cross overland to the northeast (Nilsson et al. 2010). When crossing bridges, scoters gain considerable height for crossing, in general three to four times as high as the crossed bridge section, also suggesting that birds perceive a bridge as a barrier.

Scoters are known being sensitive to disturbance (e.g. Bellebaum et al. 2006, Schwemmer et al. 2011; see also chapters 7.2.6 and 7.2.7). Earlier studies reported that e.g. disturbance distances with regard to moving ships are larger during daytime (~2,000 m) than during night-time (~500 m). The same studies reported a tendency of scoters to use higher flight altitudes during night-time (Dirksen et al. 2004). They also avoid offshore wind farms to a high degree than other waterbird species (Leopold et al. 2010, Krijgsveld et al. 2010). However, there is also an indication for some habituation to existing wind farms (Petersen and Fox 2007, Blew et al. 2008).

While it can be assumed that scoters would resume migration during the night-time e.g. by crossing over land, there is a strong barrier effect during the daytime. At least from one other location a considerable barrier effect is reported for scoters (in this case Common, Velvet and Surf Scoters (*M. perspicillata*), namely at the Confederation Bridge between New Brunswick and Prince Edward Island in Eastern Canada (Hicklin and Bunker-Popma 2001). There, monitoring showed that only 13% (n=3,986) of observed birds crossed over the bridge in spring, and 22% (n=1,441) in autumn, while the remaining were assumed to either fly all around the Prince Edward Island, which would represent a detour of more than 180 km or to cross at altitudes outside the detection range of visual observations. Reactions included "landing on water" or "flying along the bridge" or "sharply veering away from the bridge". Authors do not rule out, that scoters may cross over land. A comparison of migration rates before (1990) and after construction of the Confederation Bridge (1997) suggested, that Surf Scoters were affected by showing a lower migration rate after the construction, while migration rates of Common and Velvet Scoters remained the same (Hicklin and Bunker-Popma 2001).

Follow-up studies reported in 2006 suggest that scoters still show considerable reactions to the Confederation Bridge, circling upwards and passing at extremely high altitudes (34% in spring, 53% in autumn) or landing on water for extended time periods or following the bridge towards land (Bunker-Popma 2006). There is no indication of habituation effects after some years of bridge operation. MacKinnon and Kennedy (2006) give an exemplary description of the flight behaviour of a flock of Common Scoters, which have been observed flying parallel to the bridge, making several attempts to cross during which some individuals left the flock and crossed at some 10 m height above the cars, some individuals "disappearing" from the flock (assumed to be landed on water) and the remaining members of the flock eventually also landing on water (MacKinnon and Kennedy 2006).

However, it must be noted that scoters, as other seaducks, dabbling and diving ducks, will inevitably fly over land when e.g. crossing from the Baltic to the North Sea and vice versa. During autumn, these migrations are leading either through the bays (Flensburg Fjord, Eckernförde Bight, Kiel Fjord, Lübeck Bight) or along the river Schlei or the Kiel Kanal (Nord-Ostsee-Kanal) (Koop 2004, Berndt et al. 2005). The same behaviour is reported at other locations such as the Öresund Bridge, where in spring birds also "end up" in bays north from the bridge (Skälderviken, Lommabukten) and scoters were described to ascend to cross over land (Nilsson et al. 2009).

In summary, there is a large variety of behavioural reactions and still there is only little information available about the scoter species. However, both own results and published data suggest that barrier effects can be considerable for these species.

Common Scoter and Velvet Scoter were assessed to have a high sensitivity to a barrier effect.

Mergansers

During the Effect Studies at the Baltic Sea bridges (see chapter 4.6.2), 41% of migrating mergansers showed no reactions while passing, 47% showed reactions but passed and 12% did not pass a bridge (n=17 flocks). During the Öresund Bridge studies, Red-breasted Mergansers were often recorded flying relatively low close to or over land at Lernacken and over Pepparholm (Nilsson et al. 2009, 2010). Red-breasted Merganser and Goosander are known to fly at low altitudes over the water (i.e. mainly below 30 m) (Dirksen et al. 2000), which is supported by visual observations during the FEBI baseline investigations (FEBI 2013). Tracking radar registered a few tracks with a mean flight altitude of 64 m in spring and 137 m in autumn, both low flight altitudes in comparison to other waterbird species.

Some offshore wind farm studies indicate that Red-breasted Mergansers do not show avoidance reactions to wind farm areas (Petersen et al. 2006), other studies do report avoidance behaviours (Mendel et al. 2008). Mergansers are mostly diurnal species and exhibit medium escape distances from approaching ships (Mendel et al. 2008).

In summary, mergansers cross bridges, show low flight altitudes and prefer to fly over water, but show also frequent overland activities; their avoidance of offshore wind farms is less pronounced as for e.g. seaducks.

Therefore, the merganser species were assessed to be medium sensitive to a barrier effect.

Birds of prey

During the Öresund Bridge studies a total of 841 birds of prey were registered in autumn 2008. Among these, a high number (>70%) crossed over land, while low numbers passed over the bridge without hesitation and yet lower numbers followed the bridge structure (in particular Sparrowhawk) (Nilsson et al. 2009). During effect studies on the Baltic Sea bridges, no birds of prey have been registered (see chapter 4.6.2). FEBI baseline studies revealed that if weather conditions allow, birds of prey circle over land to gain height and glide towards the expected migration direction crossing the Belt (see also Baisner et al. 2010, FEBI 2013). Circling over water would also be possible in particular during autumn when water temperature may exceed air temperature (FEBI baseline data). However, during unfavourable weather, in particular during head wind conditions, birds of prey also cross the Fehmarnbelt in active flapping flight, sometimes low over water. Main flight directions of migrating birds of prey were mainly parallel to the alignment during the baseline observations.

For birds of prey, daytime migrants, which preferably cross water bodies at shortest crossing distances (Hake et al. 2003, Thorup et al. 2003, Mebs and Schmidt 2006, Partida 2006), a bridge structure would not be perceived as a barrier, but rather serve as a guiding structure across the alignment.

For the species of birds of prey a minor sensitivity to a barrier effect was assessed.

Common Crane

During the Öresund Bridge studies, a total of 690 Common Cranes in 17 flocks were registered in spring 2008 (Nilsson et al. 2009). A low number crossed over land, while >70% flew over the bridge without or with little hesitation. During autumn 2008, a total of 551 Cranes were registered with 35% crossing over land, 45% flying over the bridge without hesitation and 18% with little hesitation. In spring 2009, all of the 274 registered Cranes passed the bridge without hesitation (Nilsson et al. 2010). It must be noted, that the Öresund Bridge is oriented almost perpendicular to the direction of Common Crane migration, while the Fehmarnbelt bridge would be directed parallel to the main migration route. Flight altitudes of Common Cranes as measured during visual observations of the FEBI baseline investigations (FEBI 2013) are generally around 100 m, however, tracking radar revealed a mean migration altitude of 520 m.

During a dedicated study on the island of Rügen, Germany, Common Crane migration has been tracked from Sweden across some 100 km of the Baltic Sea, resulting in average flight altitudes of 343 m during daytime, and 535 m during night-time, when a migration peak lasted beyond dawn. Common Cranes preferred tailwind situations with flight altitudes around 400 m, while flight altitudes were around 100 m during headwind situations (Wendeln et al. 2008).

Being daytime migrants, Common Cranes, which preferably cross water bodies at shortest crossing distances (e.g. Alerstam 1975, Prange 2010), would not perceive a bridge structure as a barrier, but rather as a leading line across the alignment.

Common Crane was assessed having a minor sensitivity to a barrier effect.

Waders

Waders conduct long-distance, often non-stop flights. While migration strategies of the 10-15 species crossing over Germany and Denmark towards NE are expected to differ among species, studies of single species suggest that birds fly at altitudes well above 300 m and follow coastal topographies which offer potential suitable stop-over sites (e.g. Red Knots: Gudmundsson 1994, Piersma et al. 1990, Leyrer et al. 2009, Dunlin: Meltofte 2008, waders in general: Alerstam and Gudmundsson 1999). It is also reported for some species that long-distance migration would most frequently start around sunset and that waders migrate both during day- and night-time (van den Kam et al. 2004, Leyrer et al. 2009). These findings on flight height and diurnal timing are supported by FEBI baseline investigations of wader migration during the spring 2009 with flight altitudes above 500 m (FEBI 2013, Hedenström and Alerstam 1992).

During the Öresund Bridge studies in 2008, a total of 1,487 waders in 79 flocks were registered (Nilsson et al. 2010). A low number crossed over land, while most birds flew over the bridge without (~60%) or with little hesitation (~25%). During autumn 2009 a total of 314 waders in 56 flocks were registered; of those ~40% crossed over land, and almost the same number flew over the bridge without (~45%) or with little hesitation (<5%), some followed the bridge structure (Nilsson et al. 2009, 2010). It must be assumed, that many waders were not registered due to high flight altitudes. During the effect studies at Baltic Sea bridges, the number of observed waders was too low for analysis (see chapter 4.6.2).

In summary, most wader species migrating across the Fehmarnbelt region, conduct long-distance flights showing some coastal orientation, they also frequently fly above 300-500 m, such that most waders or wader flocks would not come close to any bridge. Of those flocks observed close to the Öresund Bridge, many changed direction and flew over land.

As a conclusion the wader species were assessed to be minor sensitive to barrier effects.

Gulls

Gulls, mostly Herring, Great Black-backed and Lesser Black-backed Gull, observed at the Öresund Bridge use the updrafts along the bridge to perform gliding flight, which sustains the birds well just a few meters above the edges of the bridge. Some birds have been observed gliding continuously for at least one kilometre before they have to flap to avoid getting out of the updraft. This strategy is seen as an energy saving way to travel from breeding sites at the Danish islands of Pepparholm and Saltholm to feeding areas on the Swedish mainland (Nilsson et al. 2009, 2010). From Little, Common and Black-headed Gull, no behavioural data have been sampled during either bridge study (see chapter 4.6.2). Little Gull shows clear avoidance behaviour towards offshore wind farms (Petersen et al. 2006, Leopold et al. 2010), but the same as all other gull species mentioned above, Little Gull exhibits only little sensitivity towards disturbances from ships. Little Gull differs from the other gull species, as it crosses the Fehmarnbelt region mainly on migration with potential short stays for feeding. This species is known to follow rivers when e.g. crossing Schleswig-Holstein and thus tends to follow waterbodies for large parts of its migration (Schwemmer and Garthe 2006). However, with sensitivity to disturbance from ships comparable to the other gull species, it can be assumed that Little Gull will show little to no sensitivity to a barrier effect from a bridge.

Therefore for all gull species, the sensitivity to a barrier effect was assessed to be minor.

Terns

For terns no data from the effect studies at Baltic Sea bridges are available. Other offshore studies document an only medium to weak avoidance of offshore wind farms (e.g. Blew et al. 2008, Krijgsveld et al. 2010, Leopold et al. 2010). For Sandwich Terns no effect of offshore wind farms could be detected (Leopold et al. 2010), while Danish studies show the utilisation of areas in the tidal wake of the outer turbines for feeding (Petersen et al. 2006). As terns combine migration and foraging, their migration is linked to waterbodies. Terns are mostly flying at low altitudes (Dierschke and Daniels 2003, FEBI 2013).

Due to the minor disturbance effect of shipping, which is also anticipated for a bridge (see chapter 7.2.7), a minor sensitivity to a barrier effect was assigned for the tern species.

Auks

While no data on the auk species have been collected during the effect studies on the Baltic Sea bridges (see chapter 4.6.2), results from the studies carried out at the Öresund Bridge (Nilsson et al. 2009, 2010) indicate a complete barrier effect resulting from the bridge.

"In all 63 Guillemots Uria aalgae *and 29 Razorbills* Alca torda *were seen to approach the bridge by the observer on Pepparholm. Not a single individual of these were found to cross (under the bridge), all birds turning and were not seen to come back. The only auk to pass the bridge was a Black Guillemot* Cepphus grylle*, which passed below the bridge."* (Nilsson et al. 2009).

Observation data from Falsterbo, Sweden, located south of the Öresund Bridge, suggest, that the number of auks (Common Guillemot, Razorbill) has considerably decreased in the migration counts. The yearly average for the last ten year period (2000-2009, 253 individuals) is only 47% of the average for the ten year period before the bridge was built or under construction (1985-1994, 540 individuals; N. Kjellen, written comm.; www.skof.se/fbo).

"The bridge [… the Öresund Bridge…] is clearly a barrier for these species and if there ever was an important link between the Baltic Sea and the North Sea, it is now very limited." (Nilsson et al. 2010). Danish studies also report that auks completely avoid offshore wind farms (Petersen et al. 2006), but Dutch surveys found individuals of both species inside the offshore wind farms, however, still in very low numbers (Krijgsveld et al. 2010, Leopold et al. 2010). In general, auks are reported to be sensitive towards ships, and disturbances can lead to changes in foraging behaviour and thus affect the fitness (Mendel et al. 2008).

Based on these few reports and lack of additional data, and using a precautionary approach, bridges must be assumed to represent complete barriers to these species.

Following this, the sensitivity to a barrier effect from a bridge was assessed to be very high for the auk species.

Pigeons

During the Öresund Bridge studies, some 5,000 Wood Pigeons were registered in 76 flocks in autumn 2008, most of them flying rather high and passing the bridge or land without any apparent hesitation (Nilsson et al. 2009). In 2009, Wood Pigeons followed, often in smaller flocks, the bridge alignment flying at high altitudes, using it as a leading line between both landsides. It was not clear if these birds were on migration or on feeding excursions (Nilsson et al. 2010). FEBI baseline results confirmed large flocks frequently flying at altitudes above 500 m, and observed flight directions were mainly directed parallel to the alignment (FEBI 2013).

For the pigeon species a minor sensitivity to a barrier effect was assessed.

Corvids

Corvid species such as the Black-billed Magpies, Eurasian Jay, Carrion Crow, Rook and Eurasian Jackdaw are species, for which no particular data from the effect studies at Baltic Sea bridges exist, but which are considered being minor sensitive to a barrier effect, as they readily approach roads and other structures.

For corvids a minor sensitivity to a barrier effect was assessed.

Passerines – daytime migrants (without corvids)

During the Öresund Bridge studies, 4,181 Blue Tits in 295 flocks, 6,513 finches in 1,018 flocks observed in autumn 2008 serve as an example of daytime passerine migration behaviour (Nilsson et al. 2009). Many of these were registered passing over land. However, lumping all passerines counted during autumn 2008 at Pepparholm (n=11,763), some 65% of them were detected following the bridge. This suggests a leading line effect comparable to a coastline. However, during spring, when most birds migrate NE, there apparently was no such leading-line effect as during autumn (Nilsson et al. 2010). It was concluded, that the cable stayed section (main bridge) would be the only part of this bridge that seems to be a barrier for most, if not all, bird species migrating through the area, both due to its height and the unpredictable wind situations around it (Nilsson et al. 2010). As some flocks of birds have been registered to spread out in escape flights when coming close to the bridge, it is speculated that these birds may be affected by the considerable noise emission of the bridge due to car and train traffic. On the other hand, there is a suggestion that swifts and corvids may benefit from updrafts along the edges of the bridge (Nilsson et al. 2010).

A barrier effect of a bridge at the Fehmarnbelt is not expected for most daytime migrants, as it would be parallel to their main migration direction. This may not be true in situations when wind direction and speed would "force" the birds to follow other directions. As outlined in the FEBI baseline report (FEBI 2013), birds are expected to "decide" to cross the Fehmarnbelt optimising flight time depending on wind direction (blowing onshore or offshore) and migration destination (e.g. Alerstam and Pettersson 1977, Bruderer and Liechti 1998, Erni et al. 2005, Liechti 2006, Jenni-Eiermann et al. 2010). In other terms and supported by results from the FEBI baseline studies, birds would fly along the coast until they "decide" to cross. It can only be speculated how a bridge may influence such a decision and thus the flight paths of these birds. However, observations suggest that a bridge is more likely to represent a leading line for crossing the Fehmarnbelt than a barrier.

Therefore, daytime migrant passerines were assessed to be minor sensitive to a barrier effect.

Passerines – nocturnal migrants

No empirical data exist for the assessment of a barrier effect for nocturnally migrating passerines. Calculations from the nocturnal collision rates (see chapter 10.3.7) show that only small percentages of the respective populations are expected to fly into the risk areas. A barrier effect to these very low proportions would – in theory – not be substantial for any of those species, and would therefore be considered minor.

According to the FEBI baseline studies, it is concluded that nocturnal passerine migrants predominantly migrate at higher altitudes parallel to the link and therefore are not expected to perceive a bridge as a barrier.

Nocturnal (and facultative nocturnal) passerines were assessed to be minor sensitive to a barrier effect.

7.2.10 Barrier from construction vessels

Flying birds usually respond to an obstacle by vertical or horizontal changes in their intended flight route (see also chapter 7.2.9). In case of species which migrate or generally fly at low altitudes the presence of construction vessels might have an effect as a barrier.

Birds flying over water respond in different ways to on-site or approaching vessels. Some species are attracted to vessels such as gulls or terns (e.g. Walter and Becker 1997, Garthe and Scherp 2003, Garthe et al. 2004, Mendel et al. 2008); others show a negative response such as divers or scoters (Bellebaum et al. 2006, Schwemmer et al. 2011) for which it is expected that they avoid flying over vessels and would detour ships at a greater distance. These reactions would result in extra energy expenditures for an individual bird, but the energetic costs of detouring ships are expected to be much smaller than those for a bridge (see also chapters 4.6.2 and 7.2.9).

Construction vessels would operate mostly in defined working areas and would not exhibit a total barrier over the Fehmarnbelt, thus birds are expected to always be able to detour the barrier from construction vessels while passing the area. A spatially small barrier of some construction vessels would not reduce the obstacle-free space in the Fehmarnbelt in a substantial way. Also, the construction of a fixed link over the Fehmarnbelt is planned in an area which is already highly impaired by the existing cargo and ferry traffic. Consequently, the sensitivity to a barrier effect from construction vessels on breeding, non-breeding and migratory birds was assessed to be minor.

In the case of the bridge solution the growing bridge structure would cause an additional barrier effect to birds. The sensitivity to a barrier effect from the bridge structure during the construction period is expected to increase continuously with the progress of the construction works to the level described in chapter 7.2.9.

7.2.11 Collision with bridge structures

Birds may collide under a variety of circumstances with non-moving and moving structures, a fact which is known since long time e.g. due to bird collisions with lighthouses and lit up vessels (Gätke 1900, Hansen 1954). Estimates about the overall number of collisions with structures such as buildings, platforms or wind turbines exist but usually has a high associated uncertainty (e.g. Erickson et al. 2005, Manville 2005). Regarding the non-moving objects, an overview is given by Erickson et al. (2005) and estimates exist for e.g., lighthouses and lit up vessels (Hansen 1954), windows (Klem 2009), communication towers (Gehring et al. 2009), power lines (e.g. Jenkins et al. 2010, Prinsen et al. 2011), ships (e.g. Merkel and Johansen 2011), offshore solid structures (e.g. Hüppop et al. 2009, Aumüller et al. 2011) and recently also bridges (Nilsson et al. 2009, 2010). Studies on collision risk regarding onshore and offshore wind turbines, where the subjects causing collisions are mainly the moving rotor blades, are more comprehensive (e.g. Garthe and Hüppop 2004, Desholm and Kahlert 2005, Manville 2005, Chamberlain et al. 2006, Köller et al. 2006, Petersen et al. 2006, de Lucas et al. 2007, Blew et al. 2008, Drewitt and Langston 2008, Grünkorn et al. 2009, Krijgsveld et al. 2010, Kerlinger et al. 2010). Still, little quantitative information exists on actual collision rates and collision risks (e.g. Band et al. 2007, Bellebaum et al. 2010, May and Bevanger 2011).

Factors that influence collision risk can be divided into three categories: those related to the species, to the environment, and to the configuration and location of structures (Jenkins et al. 2010).

Species-related factors include habitat use, body size, flight behaviour, age, sex, and flocking behaviour. Heavy-bodied, less agile birds or birds within large flocks may lack the ability to quickly negotiate obstacles, making them more likely to collide with e.g. overhead lines or rotating windmill blades (Drewitt and Langston 2008). Likewise, inexperienced birds as well as those distracted by territorial or courtship activities may collide with any solid or moving structure (e.g. Barrios and Rodriguez 2004, de Lucas et al. 2008, Smallwood et al. 2009, Prinsen et al. 2011). From a sensory point of view birds may not be able to foresee objects intruding into the open airspace since they a) do not look ahead and thus being temporarily blind in the direction of travel; b) frontal vision may not be in high resolution as this regards rather the lateral vision, e.g. for species in which the eyes are positioned on the side of the heads; c) are unable to considerably decrease flight speed e.g. when visibility is low (Martin 2011). In general terms, species which are highly sensitive to barrier effects typically have low collision risk and *vice versa*. However, this statement is not true in all cases and depends on other factors as well.

Environmental factors influencing collision risk include the effects of weather and time of day (visibility), surrounding land use practices that may attract birds, and human and other activities that may flush birds into these structures (e.g. May and Bevanger 2011).

Location related factors influencing collision risk include the configuration, location and placement of a structure with respect to other structures or topographic features as well as visibility of the structure parts, e.g. the diameter of the cables (e.g. Richarz and Hormann 1997, APLIC and USFWS 2005, Jenkins et al. 2010). In general, in areas with high waterbird flight activities as well as in any areas with intensive migration, vertical structures may present a risk (Prinsen et al. 2011).

The assessment of the sensitivity to collision follows closely the assessment criteria for degree of impairment defined in Table 4.8.

For assessing the species-specific sensitivity regarding collisions with the structure of a bridge, first of all, results from the collision counts at the Öresund Bridge (Nilsson et al. 2009) were taken into account.

In addition, calculations for three cases have been carried out:

1) Daytime collision risks of selected migrating waterbird species following the effect studies at the Baltic Sea bridges (see chapter 4.6.2). Flight behaviour data from the effect studies at the Baltic Sea bridges were used following selected scenarios. Calculated collision rates were related to numbers observed birds during the baseline investigations at the Fehmarnbelt (FEBI 2013; for methods see chapter 4.6.4).

2) Night-time collision risks of migrating passerine species were based on migration intensity, migration direction, and flight altitude data; (for details see chapter 4.6.4).

3) Night-time collision rates of migrating passerine species were calculated based on collision numbers recorded at the Öresund Bridge (Nilsson and Green 2002, Nilsson et al. 2009), following a relative comparison between the Öresund Bridge and the proposed Fehmarnbelt Bridge (for details see chapter 4.6.4).

For species for which no data were available or no calculations were possible, results from other studies were taken into account, and indirect evidences of a collision risk was inferred from species-specific flight behaviour data from the baseline studies.

Collision study at the Öresund Bridge

The only collision data, which exist with regard to bridges, are from the Öresund Bridge study. After opening of the bridge in 2000, a collision of estimated thousands of birds occurred on the night of the 8 October 2000 (Bengtsson 2000). The day after 344 dead birds have been collected (288 Song Thrushes, 46 Robins and 10 other species (Table 7.3). This collision event was assumed to be an effect of low visibility in combination with illumination of the high pylons – which led to further studies on the bird movements around the bridge and recorded bird collision incidents during autumn 2001, 2002, 2003 and 2008 (Nilsson and Green 2002, 2003, 2004, Nilsson et al. 2009). Results are given in Table 7.3.

Table 7.3 Number of collisions at the Öresund Bridge per species and year (Nilsson and Green 2002, 2003, 2004, Nilsson et al. 2009).

Species	2000	2001	2002	2003	2008	Sum
Great Cormorant				1		**1**
Mute Swan				2	2	**4**
Common Shelduck				1		**1**
Mallard			2	1		**3**
Tufted Duck				1		**1**
European Sparrowhawk			2			**2**
Common Buzzard				1		**1**
Eurasian Kestrel					1	**1**
Merlin		1				**1**
Moorhen		1	1			**2**
Eurasian Woodcock		1	4			**5**
Black-headed Gull					2	**2**
Common Gull			2	1	1	**4**
Lesser Black-backed Gull				1		**1**
Herring Gull		4	13	8	9	**34**
Great Black-backed Gull		1	8	6	2	**17**
Feral Pigeon		1	9	17		**27**
Woodpigeon				6		**6**
Barn Owl					1	**1**
Long-eared Owl		1	1		1	**3**
Short-eared Owl		4		1		**5**
Great Spotted Woodpecker		3				**3**
Woodlark		1				**1**
Skylark		17	3			**20**
Meadow Pipit		10		2		**12**
White Wagtail			2	1		**3**
Winter Wren		3				**3**
European Robin	46	121		1		**168**
Common Redstart			1			**1**
Blackbird		1	1	1		**3**
Fieldfare		1				**1**
Song Thrush	288	37	1	1		**327**
Redwing		4				**4**
Reed Warbler			1	1		**2**
Icterine Warbler			1			**1**
Lesser Whitethroat			1			**1**
Garden Warbler		1				**1**
Blackcap		2				**2**
Chiffchaff		2				**2**
Willow Warbler		2	39			**41**
Goldcrest		28				**28**
Pied Flycatcher			1			**1**
Blue Tit		13				**13**
Black-billed Magpie		1				**1**
Eurasian Jackdaw					1	**1**
Rook					1	**1**

Species	2000	2001	2002	2003	2008	Sum
Carrion Crow		1	1			**2**
Common Starling			5	11		**16**
Chaffinch		10				**10**
Brambling		3	2			**5**
Siskin		1	1			**2**
Common Redpoll		1	1			**2**
Yellowhammer		2				**2**
Little Bunting		1				**1**
Reed Bunting		5				**5**
birds, unidentified	10					**10**
Passerine, unidentified		6				**6**
Sums	**344**	**291**	**103**	**65**	**21**	**824**

The first results from 2001 show that (Nilsson and Green 2002):

- 94% of 291 collision victims were passerines, mainly European Robin, Song Thrush, Goldcrest;
- 96% of the collision victims were migrating birds;
- 73% of the collision victims were nocturnal migrants;
- among the collision victims were also four Long-eared Owls and one Short-eared Owl;
- most of collision victims were collected after two single nights (91%; 14/16 Oct); both these nights had reduced visibility;
- 52% of the collisions occurred within ± 1 km of the main bridge and its pylons;
- it must be noted, that no data exist about collisions with the approach bridges (no pylons above road level) and bridge parts below road levels.

Based on assumptions on migration intensities measured at the Öresund Bridge and at Falsterbo, results from the accompanying radar study, detection rates and altitude distributions, it is estimated that up to 10 million migrants would pass the Öresund Bridge during autumn migration. Based on assumptions on search efficiency, birds falling into the water and birds being removed by predators/scavengers, it is estimated that some 1,000-5,000 birds might have collided with the bridge during the autumn 2001, resulting in an average mortality of 0.01-0.05% of the 10 million migrants passing the bridge. Based on species population numbers, same calculations lead to 0.003-0.007% of e.g. the European Robin population colliding. Considering long-lived larger birds, e.g. 4 Short-eared Owls correspond to 0.04% of the Swedish breeding population (Nilsson and Green 2002).

The studies had been continued in 2002, 2003, 2008 and 2009 (Nilsson 2003, 2004, Nilsson et al. 2009, 2010).

After the year 2001, the number of collected collision victims decreased markedly and species composition changed. Several reasons could have led to this phenomenon:

- From October 2002 onwards, bridge lights at the high pylons were turned off during foggy conditions. This may have reduced the number of night collisions, particularly of passerine species.

- Gulls and crows may have been scavenging on collision victims; thus the proportion of gulls among the collision victims has been increasing (most likely collision with traffic), as scavenging gulls and gulls, which perch on the structures of the bridge, may have a higher risk to collide with traffic (Nilsson et al. 2009).

- Due to the scavenging gulls, numbers of collected passerines have been decreasing.

In the following reports (Nilsson et al. 2009) no new conclusions on collision reasons and effects have been given.

It must be noted, that collision victim search methods that were used in the Öresund Bridge study cannot be compared to other studies of this kind, as methods to assess search efficiency and removal rates have not been applied (e.g. Smallwood 2007, Grünkorn et al. 2009, Huso 2010). However, the main conclusions and the extrapolation to the estimated numbers of collisions are reasonable.

The conclusion from the Öresund Bridge study is that collisions occur at the bridge, they mainly occur during adverse weather conditions and that fewer birds were colliding recently due to the change in lighting regime. The estimated numbers do not represent more than minor effect on any of the species considered (Nilsson et al. 2009).

Behavioural data and published resources

Apart from the field studies at the Baltic Sea bridges, indirect conclusions can be drawn about species-specific collision risk using information about behaviour of migrating birds. Baseline studies at the Fehmarnbelt link provide species-specific data about mean flight altitudes and preferred flight directions in relation to the alignment during daytime. During night-time, flight altitudes and flight directions cannot be associated with species, thus leading to no additional information for a species-specific sensitivity assessment, but assumptions can be made for the species groups.

Waterbirds representing migration type 1 (Table 7.2) would be those flying perpendicular to the bridge and mostly at low altitudes during the daytime. During the daytime, when visibility is usually good, these species are expected to have a low probability to collide with the structures. In case of nocturnal migration of waterbirds, it is assumed that the average flight altitudes are higher (e.g. Common Eider: Alerstam et al. 1974) and most likely birds are less dependent on flying over water, resulting in a low probability of collision with structures of a bridge.

Of the landbird species migrating during the daytime, birds which fly at high speeds and have a low manoeuvrability would be somewhat more at risk to collide with a bridge than others. However, during migration most of these species fly more or less parallel to the alignment, thus sensitivity to collision would be low. This regards most daytime migrating landbirds as e.g. White Stork, birds of prey, Common Crane, daytime migrating waders, pigeons, swifts and daytime migrating passerines. Birds of prey, gulls, swifts and other species may perceive the bridge as a guiding structure across the Fehmarnbelt (Nilsson et al. 2009). The collision risk of nocturnally migrating birds is expected to vary with their flight altitude, which in turn is dependent on a number of environmental parameters like wind speed and direction, precipitation, cloud height and visibility.

In the absence of results of own investigations, data from offshore areas, in most cases offshore wind parks, would be partly comparable to a bridge situation. Studies report species-specific sensitivity indices (Garthe and Hüppop 2004, King et al. 2009) taking into account e.g. flight altitude, manoeuvrability and nocturnal activity. An additional assumption is that species showing strong avoidance behaviour would have lower collision risk and vice versa.

Studies exist for the collision risk with moving wind turbine blades (e.g. Desholm et al. 2006, Drewitt and Langston 2006, 2008, Blew et al. 2008), thin wires from power lines (Richarz and Hormann 1997, Haas and Schürenberg 2008, Prinsen et al. 2011) or guy wires for large structures like communication towers (Gehring et al. 2009). Considering daytime collision risk with solid structures such as a bridge, little direct information is available. Few collisions of waterbirds with bridges are reported from Florida, involving Royal Terns (*Sterna maxima*) and Brown Pelicans (*Pelecanus occidentalis*), due to wind downdrafts in particular when wind direction is perpendicular to a bridge (Bard et al. 2002 in Jacobson 2005). In Texas, avian mortalities at a bridge during certain wind directions included Common Loons (*Gavia immer*), Peregrine Falcons (*Falco peregrinus*), and Brown Pelicans (Owens et al. 1990, Jacobson 2005).

Overviews on bird collisions with power lines show that swans, geese, ducks, waders, gulls and terns – thus most waterbird species groups - are generally among the species found as collision victims. Also daytime migrating landbirds, herons, storks, cranes, birds of prey, bustards and other species are involved (Jenkins et al. 2010, Prinsen et al. 2011). Regarding the sensitivity of species to collision with bridge structures such as cables, it must be noted, that the cables on the proposed Fehmarnbelt Bridge with a diameter of 215 to 285 mm would be much thicker and more visible than power lines with diameters between 6 and 43 mm (http://www.baobab.de/freileitung/3_alustahl/ast_index.html), and thus more visible to birds.

With regard to power lines of the railway on the bridge, it can be assumed, that birds would perceive the entire girder structure with trains running inside as a solid barrier which they would not enter.

Collisions do not occur regularly but happen in separate events, most probably driven by weather conditions (Drewitt and Langston 2006, Hüppop et al. 2009, Ballasus et al. 2010). Bad visibility at night can lead to mass collisions (Hansen 1954, Nilsson et al. 2009, Aumüller et al. 2011). If visibility becomes low due to dense fog or strong rain, it can be assumed for the Fehmarnbelt region that migrating landbirds would cease their migration activity, as coasts are not farther away than 9 km to any side of the alignment. For waterbirds, this cannot be assumed, as flight activities are reported to also occur under foggy and rainy conditions (Day et al. 2003). Thus, daytime collisions are only expected to be relevant in times of very low visibility due to strong rain or dense fog. Notwithstanding, night-time collisions are expected to be influenced by inclement weather, potentially in combination with obstruction lighting attracting disoriented birds.

To conclude, the sensitivity of land bird species to daytime collision is assessed to be minor, as they would not fly during inclement weather conditions. For waterbird species, sensitivity to collision would be – in the absence of other data – medium, as there is some, yet low probability of inclement weather during migration of these species.

Breeding and non-breeding waterbirds

For the majority of waterbird species recorded as resting and breeding in the Fehmarnbelt there is little indication that they would collide with structures during daytime. Since most waterbird species are mainly diurnal when wintering or breeding in the Fehmarnbelt area, in general a minor sensitivity to this pressure is expected. A medium sensitivity to collision was only assumed for species which are night-time active, such as duck species of the genus *Aythya* (Common Pochard, Tufted Duck and Greater Scaup) and could potentially be attracted to bridge structures by illuminations or obstruction lights, or could collide by chance. Other species with a high wing load, which may be more at risk to collide with structures due to their high flight speed (e.g. ducks, divers or auks), were assessed to be minor sensitive as the barrier effect expected for these species (see chapter 7.2.9) would make it unlikely for the temporary resident birds to fly close to the structures and thus collisions are assumed to be unlikely during daytime.

Migrating birds

The list of species groups follows the baseline results, and includes all species groups which were registered during visual daytime and acoustic night-time observations, plus species registered during the morning censuses. Some bird species were not covered by the applied data acquisition methods, but were assessed as being relevant to be discussed in the context of collision risk. These are the owl species of migratory populations, some rail species (Waterrail, Spotted Crake, Corncrake) and some wader species (Jack Snipe, Common Snipe, Woodcock).

Species-specific flight habits and migration patterns relevant for barrier and collision-related pressures in marine habitats are reviewed within chapter 7.2.9. These results of bridge effect studies and literature review are not repeated within this chapter, but taken into account when assessing the sensitivity of birds to the pressure collision with bridge structures.

Divers

Following the general sensitivity to collision for migration type 1 species and flight habits of divers as described above and in chapter 7.2.9, the sensitivity of divers to collision would be low to medium. The sensitivity to a barrier (see chapter 7.2.9) was assumed to be medium due to the mainly daytime activity of these species. However, divers are not exclusively migrating at daytime, but to some extent also during the night-time when higher collision risk is expected.

Therefore, a medium sensitivity to collision with bridge structures was assessed for divers.

Grebes

Great Crested, Red-necked and Slavonian Grebes are known to fly at low altitudes over the water surface and grebes in general were assessed to be medium sensitive to a barrier.

Because grebes are described to migrating during both day and night, they were assessed to be medium sensitive to collision with bridge structures.

Great Cormorant

For migrating Great Cormorants a flight altitude of 25 m has been recorded (FEBI 2013); tracking radar data in spring 2009 recorded mean flight altitude of 83 m, in autumn 2010 even 411 m, which confirms that Great Cormorant may migrate at relatively high altitudes both over water and over land (Koop 2002, Herzig and Böhnke 2007, Blew et al. 2008). Great Cormorant has low flight manoeuvrability

(Garthe and Hüppop 2004), which may be relevant with regard to a collision risk. However, Great Cormorants are mainly daytime active, thus the collision risk is regarded to be low.

Great Cormorant was assessed to be minor sensitive to collision with bridge structures.

Grey Heron

Grey Herons are day- and night-time active, both when feeding and migrating. Their flight altitude varies over a broad range, the flight altitude measured for one flock by tracking radar was 580 m at night of July 2009. As this is a species rarely registered during offshore investigations, there are no data on displacement and disturbance of the species in marine areas. Migratory movements are parallel to the alignment particularly in autumn (FEBI 2013), thus minimising a collision risk. Herons are among those birds frequently found colliding with power lines (Jenkins et al. 2010, Prinsen et al. 2011); it has also been found, that they do react to visual markers and thus collision rates decrease with better visibility of structures (Prinsen et al. 2011). Therefore, it is assumed that collisions with power lines are due to the small diameter of thin cables, structures which would not occur openly on a bridge with risk not being noticed by birds.

Grey Heron is assessed to be minor sensitive to collision with bridge structures.

White Stork

In the two years of FEBI baseline investigations there were 6 observations of White Stork flocks flying at an average altitude of 290 m and a migration direction parallel to the alignment. White Storks are among those birds frequently found dead under power lines, but it is suggested that most of those died of electrocution rather than collision (Prinsen et al. 2011). However, the collision risk with a bridge is regarded to be very low, as all structures are visible and migration direction is parallel to the alignment.

The sensitivity of White Stork to collision with bridge structures was assessed to be minor.

Swans

During the effect studies at the Baltic Sea bridges, Mute Swans showed some avoidance reactions to bridges, suggesting a low collision risk (see chapter 4.6.2). Mute Swans also avoid flying into wind farms, at least when flying at rotor height (Krijgsveld et al. 2010). Swans have low flight manoeuvrability and are nocturnally active to some extent (King et al. 2009). Swans are reported to collide with power lines, but the number of collision incidents varies strongly within Europe (Rees 2006, Hartman et al. 2010 in Prinsen et al. 2011). Migration direction of swans has been registered to be mostly perpendicular to the link.

Therefore, swans were assessed to be medium sensitive to collision with bridge structures.

Geese

It was reported that Greylag Geese often cross just above the freeway of the Öresund Bridge on their movements between Pepparholm and mainland Sweden, and could even have been subjects to collisions with cars (Nilsson et al. 2010).

Arctic geese, when migrating at high altitudes, are considered to have a very low sensitivity to both barrier and collisions (see chapter 7.2.9). However, those migrating at lower altitudes do show some barrier effect, which is assumed to reduce the risk of colliding, but for birds migrating during night-time a certain collision risk is expected.

Geese are reported to collide with power lines less frequently than ducks. Collision rates are described to be site-dependent, and higher collision rates often coincide with large roosting and feeding sites (Prinsen et al. 2011). Migrating geese are also nocturnally active, in particular Arctic geese, which may fly across the Fehmarnbelt on their way from the Wadden Sea to their Arctic breeding grounds (Green et al. 2002, van der Graaf et al. 2006, Drent et al. 2007). All geese species were assessed to be medium sensitive to collision with bridge structures.

Common Shelduck

While no data have been collected on this species during the FEBI effect studies on the Baltic Sea bridges, during the Öresund Bridge studies Common Shelduck was often recorded flying relatively low close to or over land at Lernacken, and over Pepparholm at the Öresund Bridge (Nilsson et al. 2010). During the FEBI baseline studies (FEBI 2013), Common Shelduck showed a diverse migration behaviour including moult migrations during June/July and short- to medium-distance movements between staging places, but mostly coast-parallel flight directions. Shelducks are described to show a low sensitivity to disturbance and no dependence on offshore habitats (King et al. 2009). However, the species is also night-time active and flight altitudes recorded during FEBI baseline investigations were low (FEBI 2013), thus a medium collision risk for this species is expected.

The Common Shelduck was assessed to be medium sensitive to collision with bridge structures.

Dabbling ducks

During the effect studies at the Baltic Sea bridges, only 16 flocks of migrating dabbling ducks were recorded, which showed only little behavioural reactions indicating a low barrier effect (see chapter 4.6.2, Nilsson et al. 2010). With regard to power lines, dabbling ducks and diving ducks are frequently reported as collision victims, more frequently than geese and swans. This may be due to their high abundance, high flight speed and/or frequent nocturnal flying activity, including commuting flights between roosting and feeding sites (Prinsen et al. 2011).

Thus, their low avoidance behaviour towards structures, nocturnal flight activity, predominantly low flight altitude and the expected flight direction that is mostly perpendicular to the bridge in the Fehmarnbelt results in a medium sensitivity to collision with bridge structures for dabbling ducks.

Diving ducks

Diving ducks are known to fly at low altitudes, e.g. Common Goldeneye fly mainly below 30 m, Greater Scaup below 50 m, Tufted Ducks and Common Pochard mainly below 75 m. Common Goldeneye is mainly active during daytime, Greater Scaups during dusk and dawn, and Tufted Ducks and Common Pochards mainly during night-time (Dirksen et al. 2000).

With regard to the bridge studies, no remarkable differences from dabbling ducks were observed, but fewer records than for dabbling ducks exist. In general, the same collision relevant factors apply for both groups, such as low flight altitude, high flight speed and flight direction of migrating birds in the Fehmarnbelt would be mainly perpendicular to the alignment.

Therefore, a medium sensitivity to a collision with bridge structures was assigned to diving ducks.

Seaducks

Following the assessment of sensitivity for barrier effects, Common Eider, Long-tailed Duck and the scoter species were evaluated as being highly sensitive (see chapter 7.2.9 for references and details).

High barrier effect to seaducks during daytime would lower the daytime collisions with the same structure. However, all seaducks may fly during inclement weather and at night, and have flight directions perpendicular to the alignment (bridge) in the Fehmarnbelt.

Thus, overall a medium sensitivity to collision with bridge structures was assigned for the seaduck species.

Mergansers

Mergansers were ranked as being medium sensitive to the barrier from bridge structure (see chapter 7.2.9), they are also mainly active during daytime (Mendel et al. 2008). Both these aspects make it unlikely for mergansers to collide with bridge structures, though the species usually flies at low altitudes.

Thus, Mergansers were assessed to be minor sensitive to collision with bridge structures.

Birds of prey

With regard to power lines, birds of prey are described to be mainly victims to electrocution, and collisions occur less frequently, involving species such as Common Kestrel, Marsh Harrier, Common Buzzard and Eurasian Sparrowhawk (Prinsen et al. 2010).

Birds of prey migrate predominantly during daytime, however, nocturnal migration is reported to occur at places where large water bodies or deserts need to be crossed (DeCandido et al. 2006, Lopez-Lopez et al. 2010, Meyburg et al. 2011). Birds of prey preferably cross water bodies at the shortest crossing distances (Hake et al. 2003, Thorup et al. 2003, Mebs and Schmidt 2006, Partida 2006); this fact and their general migration direction would suggest that a bridge at the Fehmarnbelt would most likely serve as a guiding structure along the alignment (Nilsson et al. 2009, 2010).

Due to mainly daytime activity and migrating parallel to the planned fixed link a minor sensitivity to collision with bridge structures was assessed for the different species of birds of prey.

Common Crane

Several crane species are known to be highly susceptible to collisions with power lines in many regions of the world (Jenkins et al. 2010, Prinsen et al. 2011). For some species of cranes, collision mortality may lead to population decreases (Shaw et al. 2010).

Being predominantly daytime migrant, Common Crane, which preferably cross water bodies at the shortest crossing distances (e.g. Alerstam 1975, Prange 2010), are expected to use a bridge in Fehmarnbelt as a guiding structure. Following the results of the Öresund Bridge studies, the generally high flight altitudes and migration directions parallel to the alignment (FEBI 2013, see also chapter 7.2.9), the likelihood for collisions with bridge structures is low, and in contrast to power lines, bridge structures including cables would be clearly visible during the daytime.

Therefore, Common Crane was assessed to be minor sensitive to collision with bridge structures.

Rails

Several rail species such as Water Rail (*Rallus aquaticus*), Corncrake (*Crex crex*) Common Coot (*Fulica atra*) and Common Moorhen (*Gallinula chloropus*) are partially migratory in Europe (BirdLife International 2004a), but as they predominantly migrate at night, no direct observations have been made during the baseline investigations (FEBI 2013).

Rails are reported as collision victims with power lines in almost every available collision study from Europe. Because of their poor flight abilities, their habit to fly at relatively low heights and the fact that they migrate at night, rails are highly susceptible to collisions. Events at which large numbers of rails were killed e.g. in the Netherlands are regarded as migration events triggered by periods of frost (Prinsen et al. 2011). Main migration direction of rails is expected to be parallel to the Fehmarnbelt fixed link.

Based on the available knowledge rails were assessed to be medium sensitive to collision with bridge structures.

Waders

As waders show some affinity to migrate along coastlines, fly at high altitudes but also nocturnally in a broad front, their sensitivity to a barrier was assessed to be minor (see chapter 7.2.9). Since daytime collisions are considered being unlikely (except during adverse weather conditions), it was assumed that this would be mainly a risk during nocturnal migration. Therefore, wader collision risk was assessed similarly to that of nocturnally migrating passerines (see below) as the same factors driving collision risk are involved, that is potential attraction by light and collision by chance.

Numbers of waders colliding with light-houses and light vessels are low compared to most passerine species. Besides their generally lower numbers, this may also suggest that they either show a different migration behaviour or are less sensitive to attraction to lights. Also, some peculiarities exist, such as Jack Snipe (*Lymnocryptes minimus*) showing higher collision numbers than Common Snipe (*Gallinago gallinago*), even though Common Snipe has a larger population; but this may be related to differences in migration routes or flight behaviour (Hansen 1954, Ballasus et al. 2010, Bellebaum et al. 2010); Common Snipe is a short distance migrant, and migration of this species occurs in short flights with many stop-overs between breeding and wintering grounds (Wlodarczyk et al. 2007). Visual observations do not reveal the tendency of snipes to concentrate along the coasts (Cramp and Simmons 1986), thus a broad-front nocturnal migration is assumed.

In summary, most wader species migrating across the Fehmarnbelt region, conduct long-distance flights showing some coastal affinity. They frequently fly above 300-500 m, thus most waders or wader flocks would not come close to any bridge during normal weather conditions. However, they may fly at lower altitudes during inclement weather.

Therefore, wader species were assessed to be minor sensitive to collision with bridge structures.

Gulls

Gulls (mostly Herring, Great Black-backed and Lesser Black-backed Gull) observed at the Öresund Bridge use the updrafts along the bridge to perform gliding flights, which sustain the birds very well just a few meters above the edges of the bridge. (Nilsson et al. 2010).

Gulls are reported to be highly susceptible to collisions with power lines and are often found as collision victims, frequently representing 5-25% of recorded victims. This could be because they spend relatively long time periods flying, occur often in very dense flocks and also fly during windy conditions (Prinsen et al. 2011). Among the gull species, Black-headed Gull has the highest proportion among the collision numbers. Gulls were also frequently reported as collision victims during the Öresund Bridge studies (Table 7.3). This may be due to a rising number of gulls assumed to be scavenging on collision victims and potentially colliding with traffic (Nilsson et al. 2009). Thus it is expected that gulls are more likely at risk to collide with traffic than with the structure of the bridge itself (see chapter 7.2.13).

As most gull species, except the Common Gull, are reported to also conduct nocturnal movements and migration (Mendel et al. 2008), for those flying perpendicularly to the alignment a collision risk must be assumed according to the results from the power line studies.

Therefore, gull species were assessed to be medium sensitive to collision with bridge structures.

Terns

With regard to power lines, terns appear to be relatively less susceptible to collisions compared to e.g. gulls (Henderson et al. 1996, Prinsen et al. 2011), presumably due to less nocturnal activity and less flocking behaviour. However, Sandwich and Common Tern are reported to be nocturnally active, while the other tern species are almost exclusively daytime active (Mendel et al. 2008).

A medium sensitivity to collision with bridge structures was assessed for Sandwich Tern and Common Tern due to their partly nocturnal activity, and a minor sensitivity to all other tern species.

Auks

For the auk species, a very high barrier effect has been assessed, which means that auks would perceive a bridge as complete barrier (see chapter 7.2.9).

As auks show strong avoidance reactions to offshore wind farms, were assess as having very high sensitivity to a barrier effect and are known to be active exclusively during the daytime and twilight (dusk and dawn), a minor sensitivity to collision with bridge structures was assessed for the different auk species.

Pigeons

Pigeons fly mostly at high altitudes and flight directions are mainly parallel to the alignment (FEBI 2013; see also description in chapter 7.2.9). Pigeons are predominantly daytime active, which makes them less sensitive towards collisions. Their flocking behaviour and flight speed would suggest some sensitivity, but migration direction reduces the risk of colliding with a bridge in the Fehmarnbelt.

Therefore, for the pigeon species a minor sensitivity to collision with bridge structures was assessed.

Owls

Among the owl species, only the Scandinavian populations of the Long-eared Owl (*Asio otus*) and the Short-eared Owl (*Asio flammeus*) are migratory and potentially cross the Fehmarnbelt region. Both species were registered as collision victims at the Öresund Bridge (3 Long-eared and 5 Short-eared Owls); however, it is not known whether those were actually migrating individuals (Nilsson et al. 2009). Owls are known to collide with power lines, however, not in high numbers (Prinsen et al. 2011), with wind mills (also not in high numbers, Dürr 2011) and with traffic

(Eritzoe et al. 2003). The latter includes owls flying and hunting at very low altitudes as well as owls being run over on streets while sitting on their prey.

Based on this information, owls were assessed to be medium sensitive to this pressure.

Corvids
The corvid species are daytime migrants. Black-billed Magpie, Eurasian Jackdaw, Rook and Carrion Crow are registered as single collision victims at the Öresund Bridge; however, it is not known whether these are collision victims with bridge structures or with cars, as the species are known to scavenge on small prey (see also chapter 7.2.13). Very little information is available regarding collisions for these species. However, corvids breed e.g. on power line pylons and these species are not known to be a frequent collision victims.

Therefore, the corvid species were assessed to be minor sensitive to collision with bridge structures.

Passerines – daytime migrants (without corvids)
Based on the Öresund Bridge studies a leading line effect rather than a barrier effect from a bridge was assessed to this group of birds (see chapter 7.2.9 and Nilsson et al. 2010).

Thus, the collision risk for daytime migrating passerines is expected to be very low, as migration direction is parallel to the alignment. Migration altitudes are expected to vary but according to the FEBI baseline investigations (FEBI 2013) would only partially occur below 300 m. Also, passerines are known to manoeuvre very well and under normal weather conditions visibility of bridge structures would be very good during daytime.

Based on available knowledge daytime migrant passerines were assessed to be minor sensitive to collision with bridge structures.

Passerines – nocturnal migrants
Species-specific information on numbers of nocturnal passerines is not directly available. However, both the Öresund Bridge studies (Nilsson et al. 2009, 2010) and FEBI baseline investigations (FEBI 2013) report a high number of passerine species categorised as nocturnal migrants.

At the Öresund Bridge, 80% of the collision victims were nocturnally migrating passerines (see Table 7.3 and Nilsson et al. 2009). At the offshore structure FINO I in the North Sea (research platform), 770 collision victims were found at 36 of 159 visits between October 2003 and December 2007, of those 85% were thrushes and starlings and thus nocturnal migrants; it is assumed, that 50% of these collisions occurred during two nights with headwind conditions, fog and drizzle (Hüppop et al. 2009). A particular collision event during the night of 1/2 November 2010 has been reported from the same platform, with 88 collision victims during one night (93% Redwings and Song Thrushes). It has been shown that a change in wind speed and direction in combination with decreasing visibility most likely caused this collision event, which was also assessed to be rather local, as on FINO 3, another research platform in the German North Sea about 100 km away from FINO I weather parameters and number of collision victims were markedly different (Aumüller et al. 2011).

Generally, it is accepted that bird species that regularly fly at night or in twilight are more susceptible to collision with structures than species that mostly fly during the day. This is particularly true for birds, which fly at critical heights where vertical obstacles are present. A study on power line collisions at the south coast of England, where many migrants enter and leave the mainland, found a high number of nocturnal migrants including rails, thrushes and warblers (Scott et al. 1972 in Prinsen et al. 2011). Reports about collisions at brightly lighted structures, such as light houses, light-vessels, buildings, and oil rigs may not be representative as considerable attraction effects must be taken into account (Hansen 1954, Rich and Longcore 2006, Hill et al. 2008, Ballasus et al. 2010). However, collisions with non-lit structures also occur. In the absence of species-specific information on numbers and flight behaviour, the collision rate in such cases can be considered as a function of migration intensity and migration altitude. These parameters are expected to depend on the location of an obstacle and on weather conditions during the migration. Flight behaviour such as attraction and avoidance reactions should be taken into account, as it can be assumed that birds would not fly absolutely blind but would have some vision.

Nocturnal passerines are assumed to migrate in broad-front across the region; even though Fehmarnbelt waters represent a 20 km barrier of open water, this most likely does not - in contrast to daytime migration (see above) - concentrate night-time migrants at the alignment.

Based on available information it is assumed that collision by chance, potentially including some attraction through illuminations, can take place.

Therefore, nocturnal passerines were assessed medium sensitive to collision with bridge structures.

7.2.12 Collision with construction vessels

Construction works for a fixed link in the Fehmarnbelt would take place in an area of high shipping intensity. However, construction works would take place 24 hours a day with variable number and type of vessels involved. This will increase the overall number of ships in the alignment area, and subsequently the risk of collision with vessels will increase for birds. During daylight hours collisions are highly unlikely. Larger construction vessels are expected to move slowly or be anchored. Birds can easily see the vessels and fly around them.

During the night migrating birds might get attracted by the lights of the construction vessels during certain weather conditions. Night-time collisions of birds (seaducks) with ships have been documented in Southwest Greenland and such events were related to poor visibility (Merkel and Johansen 2011). The impact of the construction vessels would however be limited to a relatively small area at a particular time period, and the number of collisions is expected to be low. The sensitivity to collisions with construction vessels was therefore assessed as minor for all migrating bird species.

Breeding waterbird species are mostly daytime active and therefore assumed to be at low risk of colliding with construction vessels. Therefore, all breeding waterbird species were assessed being minor sensitive to the pressure.

Non-breeding waterbird species foraging, resting and wintering in the Fehmarnbelt area are mostly daytime active apart from the diving duck species Common Pochard, Tufted Duck and Greater Scaup. The overall flight activity of the most abundant waterbird species, such as seaducks, is low in their wintering areas (e.g. Pelletier et al. 2008, Lovvorn et al. 2009, FEBI 2013). Flight activity may also be low during conditions of inclement weather and thus poor visibility. Therefore, the sensitivity to collision with construction vessels was assessed to be minor for all non-breeding waterbird species in the area.

7.2.13 *Collision with traffic*

Collision of birds with traffic is well known and extensively studied for terrestrial habitats (reviewed by Kociolek et al. 2011). Certain species and species groups are particularly susceptible to collision with traffic. A review of road casualties in Europe by Erritzoe et al. (2003) found common species of passerines (e.g. House Sparrow, Tree Sparrow, European Blackbird), breeding within or near human settlements to be the most common victims. The highest numbers of casualties are reported for the breeding and post-breeding period, suggesting that the collision risk for migrating birds is comparably low.

These findings, however, cannot be transferred to the Fehmarnbelt fixed link as there is no breeding habitat along the bridge and also because the road is elevated above the surrounding water. Therefore collisions of local breeding birds are considered negligible while collisions of migrating birds are assumed to be more likely than in terrestrial habitats. There is a lack of data on collision rates with traffic under the specific circumstances of a bridge in the Fehmarnbelt. The studies on collisions at the Öresund Bridge (Nilsson and Green 2002, Nilsson 2003, 2004, Nilsson et al. 2009) do not differentiate between collisions with the structure of the bridge and collisions with traffic on the bridge. Several collisions of gulls and corvids (Table 7.3) have presumably been caused by traffic rather than with bridge structures as these species are mostly daytime active and are often found scavenging along roads. Gulls and corvids might also use bridge structures as a roost. Several species of gulls also show a behaviour of dropping shellfish on hard surface (e.g. roads) to break the shell (Ingolfsson and Estrella 1978, Switzer and Cristol 1999). Due to these considerations Common Gull, Herring Gull, Great Black-backed Gull, Rook, European Jackdaw and Carrion Crow were classified as having a medium sensitivity to collision with traffic; for the gull species in the Fehmarnbelt this regards resident or wintering birds (environmental components breeding waterbirds and non-breeding waterbirds), for the corvids the migrating birds.

Greylag Geese were reported crossing the Öresund Bridge just above the road; it cannot be excluded that this is a site-specific behaviour, however, we assess this species also as medium sensitive to collisions with traffic.

All species found to be sensitive to collision with the structure of a bridge should also be sensitive to collision with vehicles on the bridge. However, collisions with vehicles are expected to be less frequent compared to collisions with the bridge structure itself, as windscreens of 250 cm height will cover both sides of the roadway and the remaining collision area with traffic is considerably smaller compared to the collision area of the bridge structures. Sensitivity to collision with traffic was therefore classified as minor for all other species.

7.3 *Sensitivity screening*

As the first step in the EIA, a sensitivity screening of all encountered species has been conducted aiming to determine whether further assessment is relevant to a species.

The sensitivity screening related to the different pressures during construction and operation of a fixed link in the Fehmarnbelt was conducted separately for the three different environmental components of birds in marine environment:

- breeding waterbirds,
- non-breeding waterbirds and

- migrating birds.

Since different bird species show different sensitivities to different pressures, the sensitivity screening was conducted on the species' level. Only when differentiation between separate species was not possible during the baseline investigations or the Impact Assessment (e.g. divers for the non-breeding waterbirds or night-time migrating passerines for the migrating birds) species groups were assessed instead.

The screening was done considering the species' conservation status and overall abundance in the study area (importance level), its sensitivity to a particular pressure and its distribution in relation to the extent of the impact zone of a pressure. Species, for which the impact from a pressure could be already excluded during the screening process, were not further considered in the EIA.

Species, for which impacts from a particular pressure could not be excluded during the screening process, were further assessed in chapter 9 (Impact Assessment for the main tunnel alternative) and chapter 10 (Impact Assessment for the main bridge alternative). Species which were selected to be relevant during the screening process and therefore get further assessed are marked with a dot '•' in the tables in chapters 7.3.1-7.3.3.

The sensitivity screening was not conducted for the pressure habitat loss since per definition all species are sensitive to habitat loss, and for pressures for which all species were identified as being minor sensitive, such as 'provision of artificial reefs' or 'hydrographical changes' from structures of a fixed link (see chapter 7.2).

7.3.1 Breeding waterbirds

The main breeding areas of waterbirds using the marine areas of the Fehmarnbelt are located within the Natura 2000 areas SPA Hyllekrog-Rødsand, SPA Eastern Kiel Bight and SPA Baltic Sea east of Wagrien. Consequently, the Impact Assessment considers birds breeding in these protected areas only. The Impact Assessment for breeding birds in other areas is conducted as part of the assessment for the Fehmarn and Lolland land areas.

Species were considered as being relevant for the Impact Assessment of the marine areas, either if they breed in marine habitats (gulls and terns nesting on islands of Rødsand Lagoon), rear their offspring in marine habitats (Common Eiders and Red-breasted Mergansers), or use marine habitats as feeding grounds when tending their young (Red-necked Grebe, cormorants, gulls and terns from inland breeding sites / colonies).

The screening has been done based on a species' sensitivity to a pressure and its importance level (Table 7.1). The assessment of species' sensitivity to different pressures (Table 7.4, Table 7.5) follows the description in chapter 7.2.

Table 7.4 Sensitivity assessment of breeding waterbird species to different pressures related to the construction of an immersed tunnel in the Fehmarnbelt (dark green hachures: very high – light green hachures: minor sensitivity). If a particular pressure was assessed to be relevant to a species following the description in chapter 7.1, it was marked with a '•'. The table includes waterbird species, which bred in the SPAs Eastern Kiel Bight, Baltic Sea east of Wagrien and Hyllekrog-Rødsand during the baseline investigations and which were identified as being relevant for the Impact Assessment during the baseline investigations (FEBI 2013). All waterbirds breeding in the SPAs were assessed to be of very high importance. No relevant pressures were identified for the operation phase.

Immersed Tunnel					
Species	**Construction phase**				
	Habitat change	Water transparency	Disturbance from construction vessels	Barrier from construction vessels	Collision with construction vessels
Red-necked Grebe	•	•	•		
Great Cormorant					
Common Heron					
Mute Swan	•				
Greylag Goose					
Common Eider	•				
Red-breasted Merganser	•	•	•		
Goosander					
White-tailed Eagle			•		
Oystercatcher					
Avocet					
Redshank					
Mediterranean Gull					
Black-headed Gull			•		
Common Gull			•		
Herring Gull			•		
Great Black-backed Gull			•		
Sandwich Tern	•		•		
Common Tern	•		•		
Arctic Tern	•		•		
Little Tern	•		•		

Table 7.5 Sensitivity assessment of breeding waterbird species to different pressures related to the construction and operation of a cable stayed bridge in the Fehmarnbelt (dark green hachures: very high – light green hachures: minor sensitivity). If a particular pressure was assessed to be relevant to a species following the description in chapter 7.1, it was marked with a '•'. The table includes waterbird species, which bred in the SPAs Eastern Kiel Bight, Baltic Sea east of Wagrien and Hyllekrog-Rødsand during the baseline investigations and which were identified as being relevant for the Impact Assessment during the baseline investigations (FEBI 2013). All waterbirds breeding in the SPAs were assessed to be of very high importance.

Cable stayed bridge									
Species	Construction phase					Structures and operation			
	Habitat change	Water transparency	Disturbance from construction vessels	Collision with construction vessels	Barrier from construction vessels	Disturbance from bridge structure and traffic	Barrier from bridge structure	Collision with bridge structures	Collision with traffic
Red-necked Grebe	•	•	•			•	•		
Great Cormorant									
Common Heron									
Mute Swan	•								
Greylag Goose									
Common Eider	•								
Red-breasted Merganser	•	•	•			•	•		
Goosander									
White-tailed Eagle			•						
Oystercatcher									
Avocet									
Redshank									
Mediterranean Gull									
Black-headed Gull			•						
Common Gull			•						•
Herring Gull			•						•
Great Black-backed Gull			•						•
Sandwich Tern	•		•						
Common Tern	•		•						
Arctic Tern	•		•						
Little Tern	•		•						

7.3.2 *Non-breeding waterbirds*

The sensitivity screening of non-breeding waterbird species to pressures related to the construction and operation of a fixed link over the Fehmarnbelt (Table 7.6, Table 7.7) was conducted for all waterbird species identified as being potentially relevant for the Environmental Impact Assessment in the FEBI baseline report Volume II (FEBI 2013). The screening was done accounting for the species' sensitivity and importance level (Table 7.1). The importance level refers to the importance level as it is assessed for non-breeding waterbird species in the FEBI baseline report Volume I (FEBI 2013). The sensitivity of a species to a pressure was assessed based on literature or expert judgement when no information was available for a particular species or pressure (see chapter 7.2).

Table 7.6 Sensitivity assessment of non-breeding waterbird species to different pressures related to the construction of an immersed tunnel across the Fehmarnbelt (dark green hachures: very high – light green hachures: minor sensitivity). If the particular pressure was assessed to be relevant to a species (see chapter 7.1), it was marked with a '•'. The table includes all species identified as being relevant for the EIA during the baseline investigations (FEBI 2013). No screening-relevant pressures were identified for the operation phase.

Immersed Tunnel						
Species	**Importance level**	**Construction phase**				
		Habitat change	Water transparency	Disturbance from construction vessels	Barrier from construction vessels	Collision with construction vessels
Divers	Very high	•	•	•		
Great Crested Grebe	Minor					
Red-necked Grebe	Very high	•	•	•		
Slavonian Grebe	Minor					
Great Cormorant	Very high	•		•		
Mute Swan	Very high	•				
Whooper Swan	Very high	•				
Bewick's Swan	Very high					
Bean Goose	Medium					
Greater White-fronted Goose	Minor					
Greylag Goose	Very high	•				
Barnacle Goose	Very high					
Brent Goose	High	•				
Eurasian Wigeon	Very high	•		•		
Gadwall	Very high					
Common Teal	Medium					
Mallard	Minor					
Shoveler	Very high					
Common Pochard	Very high	•		•		
Tufted Duck	Very high	•		•		
Greater Scaup	Very high	•		•		
Common Eider	Very high	•	•	•		
Long-tailed Duck	Very high	•	•	•		
Common Scoter	Very high	•	•	•		
Velvet Scoter	High	•	•	•		
Common Goldeneye	Medium	•		•		
Smew	Very high	•				
Red-breasted Merganser	Very high	•	•	•		
Goosander	Minor					

Immersed Tunnel						
Species	Importance level	Construction phase				
		Habitat change	Water transparency	Disturbance from construction vessels	Barrier from construction vessels	Collision with construction vessels
White-tailed Eagle	High			•		
Common Coot	Medium	•		•		
Little Gull	Very high					
Black-headed Gull	Medium					
Common Gull	High					
Lesser Black-backed Gull	Minor					
Herring Gull	Medium					
Great Black-backed Gull	Medium					
Sandwich Tern	High	•				
Common/Arctic Tern	Minor					
Common Guillemot	Minor					
Razorbill	Medium	•	•	•		
Black Guillemot	High	•	•	•		

Table 7.7 Sensitivity assessment of non-breeding waterbird species to different pressures related to the construction and operation of a cable stayed bridge across the Fehmarnbelt (dark green hachures: very high – light green hachures: minor sensitivity). If the particular pressure was assessed to be relevant to a species (see chapter 7.1), it was marked with a '•'. The table includes all species identified as being relevant for the EIA during the baseline investigations (FEBI 2013).

Cable stayed bridge										
Species	Importance level	Construction phase					Structures and operation			
		Habitat change	Water transparency	Disturbance from construction vessels	Barrier from construction vessels	Collision with construction vessels	Disturbance from bridge structure and traffic	Barrier from bridge structure	Collision with bridge structures	Collision with traffic
Divers		•	•	•			•	•		
Great Crested Grebe										
Red-necked Grebe		•	•	•			•	•		
Slavonian Grebe										
Great Cormorant		•		•						
Mute Swan		•								
Whooper Swan										

Cable stayed bridge										
Species	Importance level	Construction phase					Structures and operation			
		Habitat change	Water transparency	Disturbance from construction vessels	Barrier from construction vessels	Collision with construction vessels	Disturbance from bridge structure and traffic	Barrier from bridge structure	Collision with bridge structures	Collision with traffic
Bewick's Swan										
Bean Goose										
Greater White-fronted Goose										
Greylag Goose		•								
Barnacle Goose										
Brent Goose		•								
Eurasian Wigeon		•		•			•	•		
Gadwall										
Common Teal										
Mallard										
Shoveler										
Common Pochard		•		•			•	•	•	
Tufted Duck		•		•			•	•	•	
Greater Scaup		•		•			•	•	•	
Common Eider		•	•	•			•	•		
Long-tailed Duck		•	•	•			•	•		
Common Scoter		•	•	•			•	•		
Velvet Scoter		•	•	•			•	•		
Common Goldeneye		•		•			•	•		
Smew		•								
Red-breasted Merganser		•	•	•			•	•		
Goosander										
White-tailed Eagle				•						
Common Coot		•		•			•	•		
Little Gull										
Black-headed Gull										
Common Gull										•
Lesser Black-backed Gull										
Herring Gull										•
Great Black-backed Gull										•
Sandwich Tern		•								
Common/Arctic Tern										
Common Guillemot										
Razorbill		•	•	•			•	•		
Black Guillemot		•	•	•			•	•		

7.3.3 Migrating birds

For migrating birds the assessment of sensitivity applies for two types of pressures, the barrier effect (including disturbance from light and other emissions) and collisions. Both impacts were assessed to be relevant for both, the construction period (barrier and collision from/with construction vessels; tunnel and bridge alternative) and the operation period of the bridge solution (barrier from and collision with bridge structures, collision with traffic; Table 7.9).

In the sensitivity screening, initially all bird species were included which were recorded with at least 10 migrating individuals during the FEBI baseline investigations (FEBI 2013). An exception was made for the Black Guillemot, for which at maximum 8 individuals were observed per season. Due to the species very high sensitivity to barrier effect it is regarded as relevant and thus included in the Impact Assessment. As for most passerine species no specific information on the response to a given pressure is available, passerines are assessed in the following groups: obligatory nocturnal migrants, facultative nocturnal migrants and diurnal migrants.

For nocturnal and facultative nocturnal passerines no quantitative data on species have been collected during the baseline investigations and the assessment cannot be done on species level. Migration intensities of passerines were collected using pencil beam radar in a range of 2.5 km for small birds thus a 5 km corridor at the alignment was considered for the assessment. Results indicate that 1,053,023 bird individuals, representing 0.46% of the respective relevant reference populations of nocturnal passerines (i.e. breeding populations of Sweden and Finland, see chapter 4.6.4), would migrate across this corridor each season, considering all altitudes. Below 300 m this would include 322,435 individuals, or 0.14% of the populations. Based on this estimate the importance level of the Fehmarnbelt to nocturnal and facultative nocturnal migrating passerines was assessed to be medium.

For daytime migrating passerines, species-specific information is available from visual observations. However, detection range of visual observations is usually less than 100 m and a high percentage of the small passerine species are expected to have passed the alignment area during baseline investigation without getting noticed. As the available information indicates concentrated migration for many species, daytime migrating passerines (except the corvid species, which are assessed separately) were assessed to be of high importance.

In the Impact Assessment different passerine species are assessed according to the species' migration behaviour: obligatory daytime migrants (d), partly (facultative) nocturnal migrants (d/n) and obligatory nocturnal migrants (n) (Table 7.8). For passerines, the general importance levels as described above and not importance assessment was conducted on species level.

Table 7.8 Passerine species (excluding corvid birds) migrating in the Fehmarnbelt region. Migration behaviour: d = obligatory daytime, d/n = facultative night-time, n = obligatory night-time.

Passerine species	Migration behaviour
Woodlark	d/n
Skylark	d/n
Shorelark	d
Sand Martin	d
Barn Swallow	d
House Martin	d
Tree Pipit	d/n
Meadow Pipit	d
Red-throated Pipit	d

Passerine species	Migration behaviour
Rock Pipit	d
Yellow Wagtail	d
Grey Wagtail	d/n
White Wagtail	d
Waxwing	d
Winter Wren	n
Dunnock	d/n
Robin	n
Thrush Nightingale	n
Black Redstart	n
Common Redstart	n
Whinchat	n
Stonechat	n
Wheatear	n
Ring Ouzel	n
Blackbird	n
Fieldfare	n
Song Thrush	n
Redwing	n
Mistle Thrush	n
Sedge Warbler	n
Marsh Warbler	n
Reed Warbler	n
Icterine Warbler	n
Barred Warbler	n
Lesser Whitethroat	n
Whitethroat	n
Garden Warbler	n
Blackcap	n
Green Warbler	n
Wood Warbler	n
Chiffchaff	n
Willow Warbler	n
Goldcrest	n
Spotted Flycatcher	n
Red-breasted Flycatcher	n
Pied Flycatcher	n
Bearded Tit	d
Long-tailed Tit	d
Marsh Tit	d
Willow Tit	d
Crested Tit	d
Coal Tit	d
Blue Tit	d
Great Tit	d
Nuthatch	d
Eurasian Treecreeper	n
Penduline Tit	d
Eurasian Golden-Oriole	n
Red-backed Shrike	n
Northern Shrike	d
Common Starling	d/n
House Sparrow	d
Tree Sparrow	d/n

Passerine species	Migration behaviour
Chaffinch	d/n
Brambling	d/n
European Serin	d
Greenfinch	d
Goldfinch	d/n
Siskin	d/n
Linnet	d/n
Twite	d/n
Common Redpoll	d/n
Common Crossbill	d/n
Parrot Crossbill	d/n
Common Rosefinch	d/n
Bullfinch	d/n
Hawfinch	d
Lapland Bunting	d/n
Snow Bunting	d/n
Yellowhammer	d/n
Ortolan Bunting	d/n
Reed Bunting	d/n
Corn Bunting	d/n

In the Impact Assessment some non-passerine species were assessed, which were not covered during the baseline investigations (FEBI 2013), but which were most likely missed (non-calling, night-time active species) and which are regarded as relevant (e.g. Water Rail, Corncrake, Moorhen and Coot, Long-eared Owl, Short-eared Owl).

Table 7.9 Sensitivity assessment of migrating birds to different pressures related with the construction and operation of a bridge (construction and operation) or a tunnel (construction phase only) in the Fehmarnbelt. If a particular pressure was assessed to be relevant to a species (see Table 7.1), the cell is marked with a '•'. This table includes all non-passerine and corvid species with more than 10 individuals sighted in total during the bird migration study of FEBI baseline investigations; passerines are only given as groups. The migration type (Table 7.2) and preferred time of migration (day or night) is also indicated.

Species	Migration type	Day-/night-time migrant	Importance level	Sensitivity to pressure				
				Construction phase		Structure and operation		
				Barrier from construction vessels	Collision with construction vessels	Barrier from bridge structure	Collision with bridge structures	Collision with traffic
Red-throated Diver	1	d/n	high			•	•	
Black-throated Diver	1	d/n	high			•	•	
Great Crested Grebe	1	d/n	minor					
Red-necked Grebe	1	d/n	medium			•	•	
Slavonian Grebe	1	d/n	high			•	•	
Northern Gannet	1	d	minor					
Great Cormorant	2	d	very high					
Grey Heron	2	d	minor					

Species	Migration type	Day-/night-time migrant	Importance level	Sensitivity to pressure				
				Construction phase		Structure and operation		
				Barrier from construction vessels	Collision with construction vessels	Barrier from bridge structure	Collision with bridge structures	Collision with traffic
White Stork	3	d	high					
Mute Swan	2	d	medium			•	•	
Bewick's Swan	2	d/n	high			•	•	
Whooper Swan	2	d	high			•	•	
Bean Goose	2	d/n	medium			•	•	
Greater White-fronted Goose	2	d/n	minor					
Greylag Goose	2	d/n	very high				•	•
Barnacle Goose	2	d/n	very high			•	•	
Brent Goose	2	d	very high			•	•	
Common Shelduck	2	d	minor					
Eurasian Wigeon	2	d/n	medium			•	•	
Gadwall	2	d/n	high			•	•	
Common Teal	2	d/n	minor					
Mallard	2	d/n	minor					
Northern Pintail	2	d	very high			•	•	
Garganey	2	d/n	minor					
Northern Shoveler	2	d/n	very high			•	•	
Common Pochard	2	n	minor					
Tufted Duck	2	n	minor					
Greater Scaup	2	n	high			•	•	
Common Eider	1	d/n	very high			•	•	
Long-tailed Duck	1	d/n	minor			•		
Common Scoter	1	d/n	very high			•	•	
Velvet Scoter	1	d/n	minor			•		
Common Goldeneye	2	d/n	minor					
Red-breasted Merganser	1	d	very high			•		
Goosander	1	d	Minor					
Honey-Buzzard	3	d	very high					
Black Kite	3	d	very high					
Red Kite	3	d	very high					
White-tailed Eagle	3	d	very high					
Marsh Harrier	3	d	very high					
Northern (Hen) Harrier	3	d	high					
European Sparrow Hawk	3	d	very high					
Eurasian Buzzard	3	d	very high					
Rough-legged Buzzard	3	d	minor					
Osprey	3	d	very high					
Eurasian Kestrel	3	d	high					
Red-footed Falcon**	3	d	NA					
Merlin	3	d	high					

Species	Migration type	Day-/night-time migrant	Importance level	Sensitivity to pressure				
				Construction phase		Structure and operation		
				Barrier from construction vessels	Collision with construction vessels	Barrier from bridge structure	Collision with bridge structures	Collision with traffic
Hobby	3	d	minor					
Peregrine Falcon	3	d	very high					
Common Crane	3	d	very high					
Waterrail	2/4	n	NA				•	
Corncrake	2/4	n	NA				•	
Moorhen	2/4	n	NA				•	
Common Coot	2/4	n	NA				•	
Oystercatcher	2	d/n	minor					
Avocet	2	d	high					
Little Ringed Plover	2	d/n	minor					
Ringed Plover	2	d/n	minor					
Golden Plover	2	d/n	high					
Grey Plover	2	d/n	medium					
Lapwing	2	d	minor					
Knot	2	d/n	very high					
Sanderling	2	d/n	minor					
Curlew Sandpiper*	2	d/n	NA					
Dunlin	2	d/n	very high					
Ruff	2	d/n	minor					
Common Snipe	2	n	minor					
Bar-tailed Godwit	2	d/n	very high					
Whimbrel	2	d	minor					
Curlew	2	d/n	very high					
Spotted Redshank	2	n	minor					
Redshank	2	n	minor					
Greenshank	2	n	minor					
Green Sandpiper	2	n	minor					
Wood Sandpiper	2	n	minor					
Common Sandpiper	2	n	minor					
Turnstone	2	n	minor					
Arctic Skua*	2	d	NA					
Great Skua*	2	d	NA					
Mediterranean Gull	2	d/n	minor					
Little Gull	2	d/n	very high				•	
Black-headed Gull	2	d/n	medium				•	
Common Gull	2	d/n	high				•	
Lesser Black-backed Gull	2	d/n	minor					
Herring Gull	2	d/n	medium				•	
Great Black-backed Gull	2	d/n	medium				•	
Sandwich Tern	1	d/n	very high				•	
Common Tern	1	d/n	high				•	
Arctic Tern	1	d	high					
Little Tern	1	d	high					

Species	Migration type	Day-/night-time migrant	Importance level	Sensitivity to pressure				
				Construction phase		Structure and operation		
				Barrier from construction vessels	Collision with construction vessels	Barrier from bridge structure	Collision with bridge structures	Collision with traffic
Black Tern	1	d	minor					
Common Guillemot	1	d	minor			•		
Razorbill	1	d	minor			•		
Black Guillemot***	1	d	minor			•		
Stock Dove	3	d	very high					
Woodpigeon	3	d	very high					
Collared Dove	3	d	minor					
Long-eared Owl	4	n	NA				•	
Short-eared Owl	4	n	NA				•	
Cuckoo	4	n	minor					
Swift	3	d/n	minor					
Great Spotted Woodpecker	3	d	minor					
Eurasian Jay	3	d	minor					
Black-billed Magpie	3	d	minor					
Eurasian Jackdaw	3	d	medium					•
Rook	3	d	very high					•
Carrion Crow	3	d	minor					
Passerine groups								
Obligatory daytime migrants	3	d	high					
Facultative night-time migrants	4	d/n	medium				•	
Obligatory night-time migrants	4	n	medium				•	

* These waterbird species are not listed in BirdLife International (2004a) with a SPEC-level, thus no importance level can be assigned.

** Red-footed Falcon: although counted >10 individuals, those are considered vagrants and thus not assessed.

***Black Guillemot: although number of counted individuals is <10, the species is included in the list due to the very high sensitivity to barrier effect, and thus relevance for the Impact Assessment.

8 ESTIMATION OF LEVELS OF POTENTIAL BIOLOGICAL REMOVAL (PBR)

8.1 Concept definition and methodology

8.1.1 The concept of Potential Biological Removal

Bird species differ in their sensitivity to additive mortality, and this depends primarily upon demographic parameters and size of affected populations. While national and international conservation priorities (national red lists, international and European threat statuses, etc.) allow ranking species according to their conservation concern, additional prioritisation according to species-specific sensitivity to additive mortality was deemed relevant to focus the assessment on species for which the Fehmarnbelt is important and for species of conservation concern. Desholm (2009) suggested ranking of bird species based on their relative abundance and demographic sensitivity (elasticity of population growth rate to changes in adult survival). A similar assessment of species sensitivity to additive mortality can be achieved by applying the Potential Biological Removal (PBR) concept (Wade 1998), which in addition to qualitative ranking, allows quantification of additive mortality that can be sustained by a given population.

Originally PBR was developed to calculate limits to the allowable human-caused mortality for marine mammals (Wade 1998) and today PBR constitutes an important tool guiding management of marine mammals (e.g. Taylor et al. 2000, Marsh et al. 2004, Moore et al. 2009). The PBR is a threshold of additional annual mortality, which could be sustained by a population, and is calculated with minimal demographic information. Although simple, PBR is a conservative metric and accounts for potential bias due to density dependence, uncertainty in estimates of the population size and stochasticity (Wade 1998, Taylor et al. 2000, Milner-Gulland and Akçakaya 2001). Additive mortality exceeding PBR would indicate potentially overexploited populations.

Recently, PBR has become increasingly used in studies analysing effects of additive mortality on seabird populations. Niel and Lebreton (2005) demonstrated its use to assess the significance of bycatch in longline fisheries on seabird populations by comparing mortality estimates to PBR levels. Dillingham and Fletcher (2008) analysed PBR applicability for assessing additive mortality on seabirds and geese. Bellebaum et al. (2010) calculated PBR for a number of bird species, including waders and passerines, aiming to assess thresholds of collisions with offshore wind parks in the German Baltic Sea that bird populations can sustain. Žydelis et al. (2009) used PBR to indicate populations where fisheries bycatch was likely unsustainable. (Dillingham and Fletcher 2011) further modified PBR calculation for seabird species where only numbers of breeding pairs are known, and calculated PBR levels for a number of albatross and petrel species. Also, PBR approach was used to assess cumulative impacts of offshore wind farms on seabird population in the Netherlands (Poot et al. 2011).

The main advantage of this approach is that it relies on those demographic parameters which are easiest to obtain for many bird species. However, the PBR concept has been developed and sufficiently tested only for birds with K-strategic life histories, i.e. long-lived and slow reproducing species. Therefore the PBR approach is applied here only to long-lived birds: waterbirds, birds of prey and shorebirds.

For the Fehmarnbelt the PBR is used as a measure for the assessment of the project impact significance in terms of project related additional mortality predicted to be caused from collision incidents (see also chapter 4.5.14). The PBR allows assessing potential impacts on bird populations in more objective biological terms compared to the arbitrarily set conservation targets such as 1% criteria. However, the PBR is not yet recognised as an instrument in managing and protecting seabird or other bird populations. Therefore it is mostly used as a supporting argument when discussing and interpreting the results.

8.1.2 *Calculation of Potential Biological Removal (PBR) thresholds*

PBR is calculated using the following general equation (Wade 1998):

$$PBR = \frac{1}{2} R_{\max} N_{\min} f$$

where R_{max} is maximum recruitment rate, N_{min} is minimum population size, and f is recovery factor used to account for uncertainty in population growth rate and population size. Maximum recruitment rate is calculated considering maximum annual population growth rate:

$$R_{max} = \lambda_{max} - 1$$

where λ_{max} is maximum annual population growth rate, which is solved using the equation suggested by Niel and Lebreton (2005), which requires only adult bird annual survival probability (S_{ad}) and age of first reproduction (α):

$$\lambda_{\max} = \exp\left(\left(\alpha + \frac{S_{ad}}{\lambda_{\max} - S_{ad}}\right)^{-1}\right)$$

For minimum population size (N_{min}) Wade (1998) suggested using the lower bound of the 60% confidence interval of a given population estimate. However, a majority of available bird population estimates lack measures of uncertainty and provide either one figure for population estimate, or the upper and lower bound between which the actual population size is expected to lie. In the latter situation, the lower bound was used as an approximation representing N_{min}. If only one number was provided as population estimate, following Dillingham and Fletcher (2008) we estimated N_{min} as the 20^{th} percentile of the population estimate assuming coefficient of variation $CV_{\bar{N}} = 0.05$.

The population recovery factor f, used to account for uncertainty in population growth rate and population size, ranges between 0.1 and 1. Dillingham and Fletcher (2008) suggested a recovery factor $f = 0.5$ for stable populations, $f = 0.3$ for declining, $f = 0.1$ for rapidly declining. These f values were accepted in our assessment, and we additionally used $f = 0.7$ for species with increasing population trend.

Several key data sources have been used to obtain parameters on bird populations, which were used in calculating PBR thresholds: population sizes and trends for waterbird species were taken from Wetlands International (2006) or BirdLife International (2004a); size of relevant populations of birds of prey were taken from Mebs and Schmidt (2006). Species survival rates and age of first reproduction were mostly extracted from the online database BirdFacts maintained by the British Trust for Ornithology (http://www.bto.org/about-birds/birdfacts). Other literature sources or expert opinion (if no published information was found) were also used in cases where key data sources yielded no necessary input information for PBR estimates.

8.2 Thresholds for sustainable impacts at population level

PBR levels were calculated for waterbird, shorebird and birds of prey species, which were considered as potentially sensitive to impacts from a fixed link construction (Table 8.1). Three birds of prey species, Black Kite, Pallid Harrier and Red-footed Falcon, were not included among species with PBR estimates, as these are assessed to be vagrant individuals of breeding populations mainly south of Fehmarnbelt; therefore, relevant population sizes of these species remain unknown. PBR values indicate levels of additive mortality (from all non-natural sources, not only a fixed link), which could be sustained by bird populations. The lowest additive mortality thresholds in terms of bird individual numbers were estimated for several birds of prey species (Table 8.1). Among waterbirds, the PBR level estimated for Common Eider could be singled out (17,671, Table 8.1), as it suggests a likely unsustainable current exploitation of this species, as the average Danish annual hunting bag alone, consisting of 60,000 – 70,000 individuals (Noer et al. 2009), exceeds the calculated threshold more than three times. It should be noted, however, that exceeded PBR threshold does not necessarily indicate an overexploited population, but it signals a potential conservation issue where more thorough analysis of population demographics is needed.

Table 8.1 Calculated Potential Biological Removal (PBR) levels for waterbirds, shorebirds and birds of prey species, which were considered as potentially susceptible to impacts from a fixed link. Key parameters used to calculate PBR are also provided: size of relevant population, maximum annual population growth rate λ_{max} , and recovery factor f. Full details of input parameters and references are provided in Appendix II.

Species	Population size	λ_{max}	f	PBR
Red-throated Diver	150,000	1.30	0.3	6,705
Black-throated Diver	250,000	1.18	0.3	6,700
Great Crested Grebe	290,000	1.39	0.5	27,956
Red-necked Grebe	42,000	1.33	0.5	3,460
Slavonian Grebe	14,200	1.39	0.3	840
Great Cormorant	380,000	1.19	0.7	24,645
White Stork	483,000	1.18	0.5	14,566
Mute Swan	250,000	1.15	0.5	5,959
Whooper Swan	59,000	1.18	0.5	1,718
Bewick's Swan	20,000	1.17	0.1	112
Greylag Goose	500,000	1.21	0.5	17,552
Bean Goose	600,000	1.25	0.3	14,700
Barnacle Goose	420,000	1.16	0.5	17,230
Brent Goose	200,000	1.24	0.1	1,578
Eurasian Wigeon	1,500,000	2.12	0.5	274,974
Gadwall	60,000	2.05	0.3	6,229
Mallard	4,500,000	1.98	0.5	724,901
Northern Shoveler	40,000	2.05	0.5	6,885
Northern Pintail	60,000	1.93	0.3	5,481
Garganey	2,000,000	2.02	0.3	200,984
Common Teal	500,000	2.12	0.5	91,658
Shelduck	300,000	1.26	0.5	12,575
Common Pochard	350,000	1.95	0.3	32,653
Tufted Duck	1,200,000	1.85	0.3	100,894

Species	Population size	λ_{max}	f	PBR
Greater Scaup	310,000	1.50	0.1	5,102
Common Eider	760,000	1.14	0.5	17,671
Long-tailed Duck	4,600,000	1.29	0.3	133,350
Common Scoter	1,600,000	1.24	0.3	37,117
Velvet Scoter	1,000,000	1.21	0.3	20,554
Common Goldeneye	1,000,000	1.35	0.5	87,354
Smew	40,000	1.33	0.3	1,299
Red-breasted Merganser	170,000	1.31	0.5	8,777
Goosander	266,000	1.31	0.5	13,733
Honey-Buzzard	37,600	1.20	0.5	1,910
Red Kite	3,200	1.44	0.7	495
White-tailed Eagle	2,400	1.10	0.5	38
Marsh Harrier	7,000	1.25	0.7	618
Hen Harrier	9,200	1.32	0.5	741
European Sparrow Hawk	168,000	1.89	0.5	37,173
Eurasian Buzzard	160,000	1.17	0.7	9,611
Rough-legged Buzzard	10,000	1.17	0.5	429
Osprey	17,988	1.20	0.7	1,279
Eurasian Kestrel	18,000	1.89	0.5	3,983
Merlin	24,800	1.99	0.5	6,144
Hobby	16,000	1.36	0.3	874
Peregrine Falcon	820	1.33	0.7	95
Common Coot	1,750,000	1.39	0.5	113,361
Crane	150,000	1.14	0.7	4,718
Oystercatcher	1,020,000	1.15	0.5	24,607
Avocet	73,000	1.24	0.5	2,838
Little Ringed Plover	200,000	1.47	0.5	23,472
Ringed Plover	73,000	1.75	0.3	5,405
Golden Plover	640,000	1.82	0.5	131,231
Grey Plover	247,000	1.28	0.3	6,826
Lapwing	5,100,000	1.39	0.3	297,243
Knot	450,000	1.62	0.3	27,356
Sanderling	123,000	1.31	0.5	6,188
Curlew Sandpiper	1,000,000	1.33	0.7	75,786
Dunlin	1,330,000	1.37	0.5	80,909
Ruff	1,000,000	1.48	0.3	72,357
Snipe	2,500,000	1.50	0.5	204,839
Bar-tailed Godwit	720,000	1.38	0.3	27,151
Whimbrel	190,000	1.25	0.5	11,923
Curlew	700,000	1.37	0.3	38,886
Spotted Redshank	60,000	1.79	0.5	11,794
Redshank	250,000	1.80	0.3	19,794
Greenshank	190,000	1.36	0.5	17,289
Green Sandpiper	1,000,000	1.47	0.5	117,361
Wood Sandpiper	900,000	1.47	0.5	106,609
Common Sandpiper	1,500,000	1.30	0.3	67,048
Turnstone	145,000	1.28	0.3	6,099
Little Gull	72,000	1.29	0.7	7,292
Black-headed Gull	3,700,000	1.24	0.3	133,298
Common Gull	1,200,000	1.20	0.3	35,551
Herring Gull	1,700,000	1.15	0.7	87,385
Lesser Black-backed Gull	55,500	1.13	0.3	717
Great Black-backed Gull	330,000	1.14	0.7	15,796
Sandwich Tern	166,000	1.17	0.3	4,274

Species	Population size	λ_{max}	f	PBR
Common Tern	800,000	1.17	0.5	34,326
Little Tern	42,500	1.17	0.3	1,094
Arctic Tern	1,500,000	1.14	0.5	51,286
Razorbill	500,000	1.14	0.5	11,232
Common Guillemot	4,300,000	1.09	0.5	63,884
Black Guillemot	8,250	1.15	0.3	187

9 ASSESSMENT OF IMPACTS OF IMMERSED TUNNEL (MAIN TUNNEL ALTERNATIVE)

9.1 General description of the project

The alignment for the immersed tunnel passes east of Puttgarden, crosses the Fehmarnbelt in a soft curve and reaches Lolland east of Rødbyhavn as shown in Figure 9.1 along with near-by Natura 2000 sites.

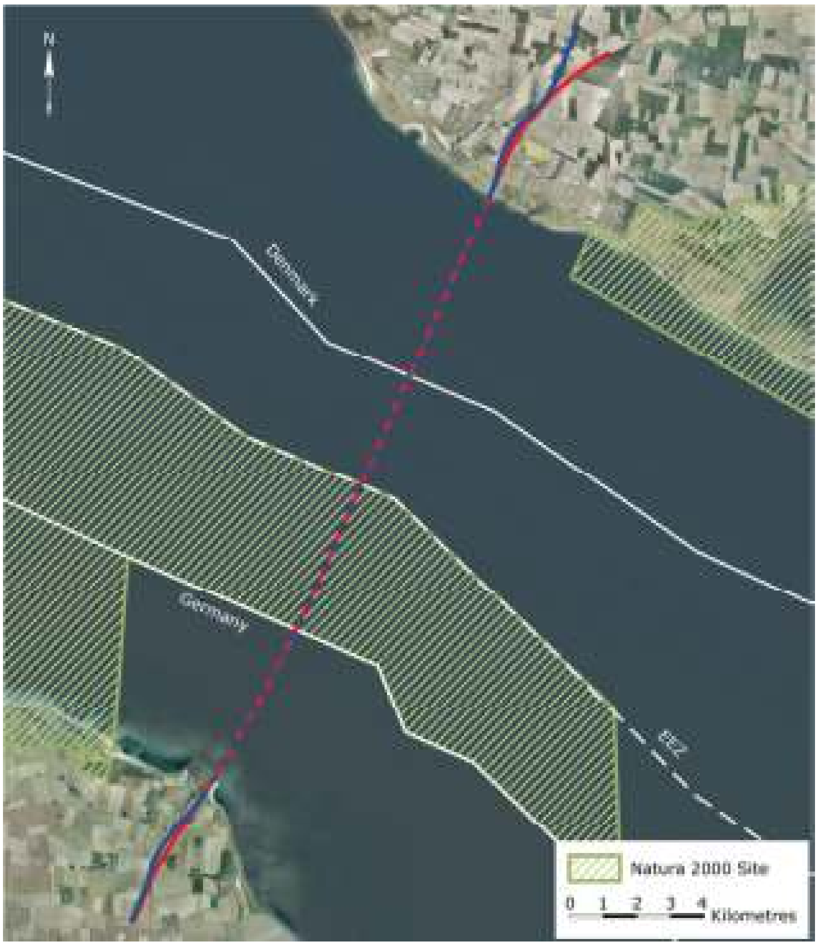


Figure 9.1 Conceptual design alignment.

9.1.1 Tunnel trench

The immersed tunnel is constructed by placing tunnel elements in a trench dredged in the seabed. The proposed methodology for trench dredging comprises mechanical dredging using Backhoe Dredgers (BHD) up to 25 meters and Grab Dredgers (GD) in deeper waters. A Trailing Suction Hopper Dredger (TSHD) will be used to rip the clay before dredging with GD. The material will be loaded into barges and transported to the near-shore reclamation areas where the soil will be unloaded from the barges by small BHDs. A volume of approx. 14.5 mio m^3 sediment is handled.

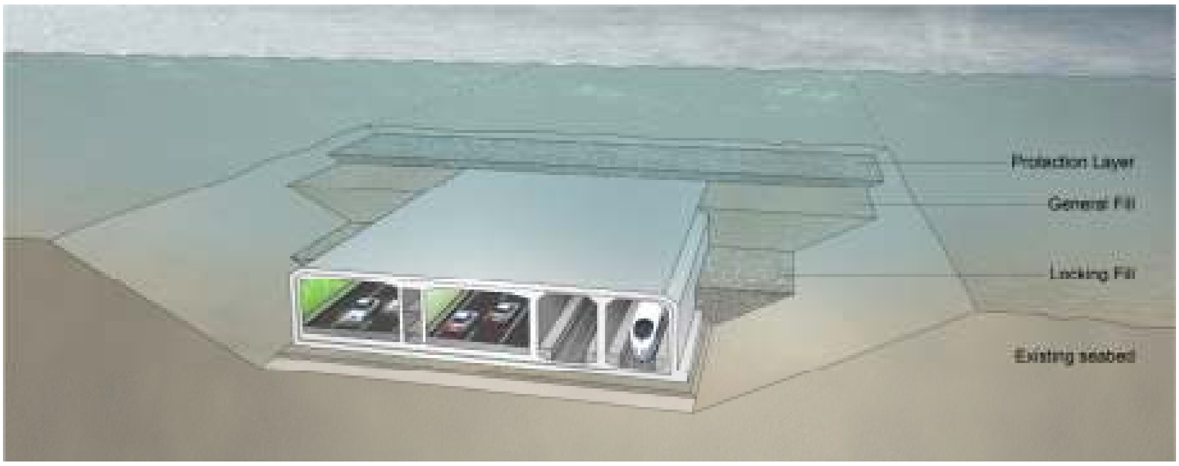


Figure 9.2 Cross section of dredged trench with tunnel element and backfilling.

A bedding layer of gravel forms the foundation for the elements. The element is initially kept in place by placing locking fill followed by general fill, while on top there is a stone layer protecting against damage from grounded ships or dragging anchors. The protection layer and the top of the structure are below the existing seabed level except near the shore. At these locations, the seabed is locally raised to incorporate the protection layer over a distance of approximately 500-700 m from the proposed coastline. Here the protection layer is thinner and made from concrete and a rock layer.

9.1.2 Tunnel elements

There are two types of tunnel elements: standard elements and special elements. There are 79 standard elements. Each standard element is approximately 217 m long, 42 meters wide and 9 meters tall. Special elements are located approximately every 1.8 km providing additional space for technical installations and maintenance access. There are 10 special elements. Each special element is approximately 46 m long, 45 meters wide and 13 meters tall.

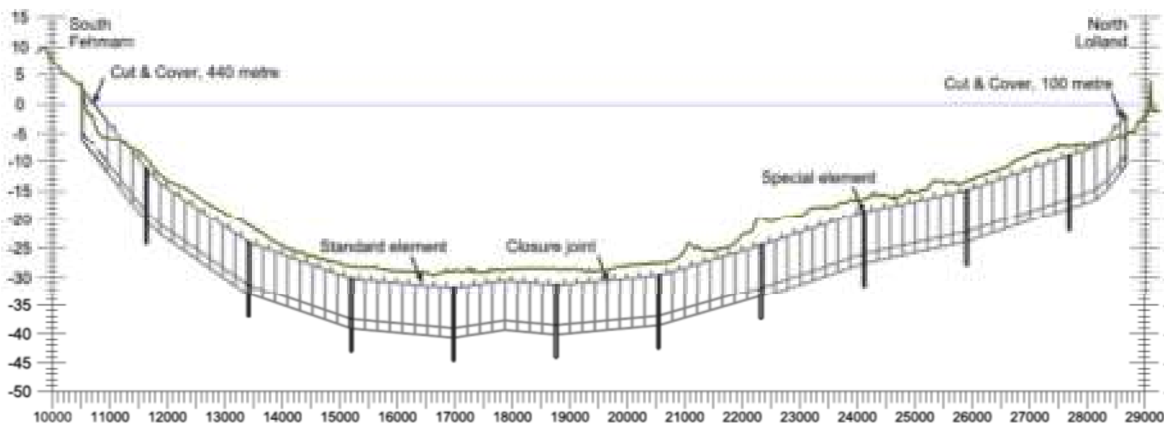


Figure 9.3 Vertical tunnel alignment showing depth below sea level.

The cut and cover tunnel section beyond the light screens is approximately 440 m long on Lolland and 100 m long on Fehmarn. The foundation, walls, and roof are constructed from cast in-situ reinforced concrete.

9.1.3 Tunnel drainage

The tunnel drainage system will remove rainwater and water used for cleaning the tunnel. Rainwater entering the tunnel will be limited by drainage systems on the approach ramps. Fire fighting water can be collected and contained by the system for subsequent handling. A series of pumping stations and sump tanks will transport the water from the tunnel to the portals where it will be treated as required by environmental regulations before being discharged into the Fehmarnbelt.

9.1.4 Reclamation areas

Reclamation areas are planned along both the German and Danish coastlines to accommodate the dredged material from the excavation of the tunnel trench. The size of the reclamation area on the German coastline has been minimized. Two larger reclamations are planned on the Danish coastline. Before the reclamation takes place, containment dikes are to be constructed some 600m out from the coastline.

The landfall of the immersed tunnel passes through the shoreline reclamation areas on both the Danish and German sides.

Fehmarn

The proposed reclamation at the Fehmarn coast does not extend towards north beyond the existing ferry harbour at Puttgarden. The extent of the Fehmarn reclamation is shown in Figure 9.4. The reclamation area is designed as an extension of the existing terrain with the natural hill turning into a plateau behind a coastal protection dike 3.5 m high. The shape of the dike is designed to accommodate a new beach close to the settlement of Marienleuchte.

Figure 9.4 Reclamation area at Fehmarn.

The reclaimed land behind the dike will be landscaped to create an enclosed pasture and grassland habitat. New public paths will be provided through this area leading to a vantage point at the top of the hill, offering views towards the coastline and the sea.

The Fehmarn tunnel portal is located behind the existing coastline. The portal building on Fehmarn houses a limited number of facilities associated with essential equipment for operation and maintenance of the tunnel and is situated below ground level west of the tunnel.

A new dual carriageway is to be constructed on Fehmarn for approximately 3.5 km south of the tunnel portal. This new highway rises out of the tunnel and passes onto an embankment next to the existing harbour railway. The remainder of the route of the highway is approximately at level. A new electrified twin track railway is to be constructed on Fehmarn for approximately 3.5 km south of the tunnel portal. A lay-by is provided on both sides of the proposed highway for use by German customs officials.

Lolland

There are two reclamation areas on Lolland, located either side of the existing harbour. The reclamation areas extend approximately 3.7 km east and 3.4 km west of the harbour and project approximately 500 m beyond the existing coastline into the Fehmarnbelt. The proposed reclamation areas at the Lolland coast do not extend beyond the existing ferry harbour at Rødbyhavn.

The sea dike along the existing coastline will be retained or reconstructed, if temporarily removed. A new dike to a level of +3 m protects the reclamation areas against the sea. To the eastern end of the reclamation, this dike rises as a till cliff to a level of +7 m. Two new beaches will be established within the reclamations. There will also be a lagoon with two openings towards Fehmarnbelt, and revetments at the openings. In its final form the reclamation area will appear as three types of landscapes: recreation area, wetland, and grassland - each with different natural features and use.

The Lolland tunnel portal is located within the reclamation area and contained within protective dikes. The main control centre for the operation and maintenance of the Fehmarnbelt Fixed Link tunnel is housed in a building located over the Danish portal. The areas at the top of the perimeter wall, and above the portal building itself, are covered with large stones as part of the landscape design. A path is provided on the sea-side of the proposed dike to serve as recreation access within the reclamation area.

A new dual carriageway is to be constructed on Lolland for approximately 4.5 km north of the tunnel portal. This new motorway rises out of the tunnel and passes onto an embankment. The remainder of the route of the motorway is approximately at level. A new electrified twin track railway is to be constructed on Lolland for approximately 4.5 km north of the tunnel portal. A lay-by is provided in each direction off the landside highway on the approach to the tunnel for use by Danish customs officials.

A facility for motorway toll collection will be provided on the Danish landside.

Figure 9.5 Reclamation area at Lolland.

9.1.5 Marine construction works

The temporary works comprises the construction of two temporary work harbours, the dredging of the portal area and the construction of the containment dikes. For the harbour on Lolland an access channel is also provided. These harbours will be integrated into the planned reclamation areas and upon completion of the tunnel construction works, they will be dismantled/removed and backfilled.

9.1.6 Production site

The current design envisages the tunnel element production site to be located in the Lolland east area in Denmark. The figure below shows one production facility consisting of two production lines. For the construction of the standard tunnel elements for the Fehmarn tunnel four facilities with in total eight production lines are anticipated.

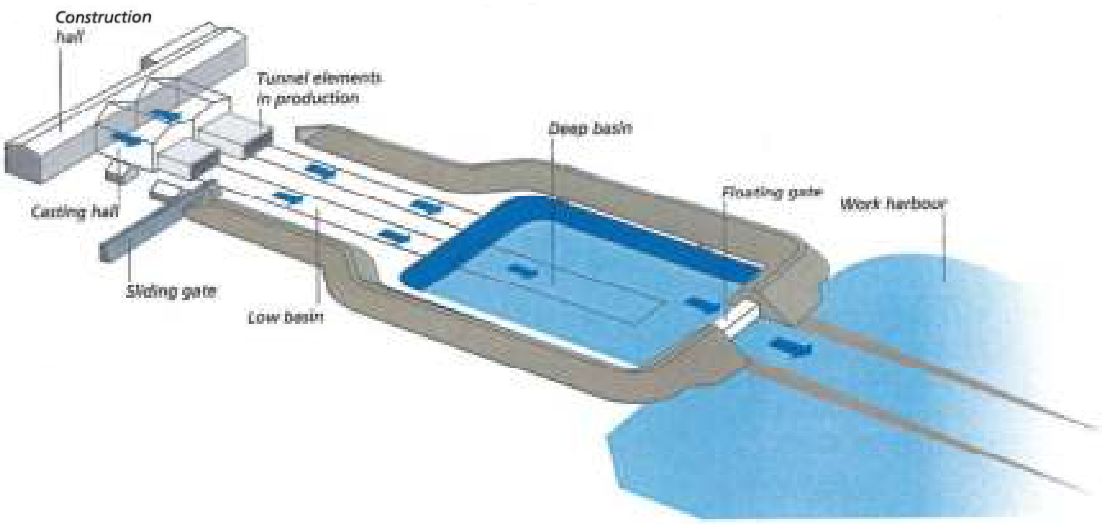


Figure 9.6 Production facility with two production lines.

In the construction hall, which is located behind the casting and curing hall, the reinforcement is handled and put together to a complete reinforcement cage for one tunnel segment. The casting of the concrete for the segments is taking place at a fixed location in the casting and curing hall. After the concrete of the segments is cast and hardened enough the formwork is taken down and the segment is pushed forward to make space for the next segment to be cast. This process continues until one complete tunnel element is cast. After that, the tunnel element is pushed into the launching basin. The launching basin consists of an upper basin, which is located at ground level and a deep basin where the tunnel elements can float. In the upper basin the marine outfitting for the subsequent towing and immersion of the element takes place. When the element is outfitted, the sliding gate and floating gate are closed and sea water is pumped into the launching basin until the elements are floating. When the elements are floating they are transferred from the low basin to the deep basin. Finally, the water level is lowered to normal sea level, the floating gate opened and the element towed to sea. The proposed lay-out of the production site is shown in Figure 9.7.

Dredging of approximately 4 million m^3 of soil is required to create sufficient depth for temporary harbours, access channels and production site basins.

Figure 9.7 Proposed lay-out of the production site.

9.2 Construction phase

9.2.1 Habitat loss from footprint

Description of the pressure

During the construction works of an immersed tunnel the area of the tunnel trench, working harbours and land reclamations would get directly modified by dredging works, deposit of sediments or new backfill layers, which all together are called the project's footprint (Figure 9.8). There is a habitat loss predicted from land reclamations, building protection reefs and the access channel to the Danish working harbour, for which no recovery or recovery times exceeding 10 years are predicted for the seabed (FEHY 2013e).

Recoverable habitat loss is predicted for the tunnel trench area and the working harbours. However, it is expected that almost no recovery will take place during the construction period. Therefore a complete habitat loss was assumed for the entire footprint area. The description of this pressure is based on baseline investigations and Impact Assessment on benthic and fish communities by Fehmarnbelt Fixed Link Marine Biology Services (FEMA 2013a, 2013b, 2013c) and Fehmarnbelt Fish and Fisheries Services (FeBEC 2013a, 2013b).

The tunnel footprint covers 584 ha of marine area, of which the loss from land reclamations holds with 61.4% the largest fraction of this total area (Table 9.1). The reclamation areas are planned outside the breakwater constructions of the ferry harbours in Rødbyhavn (both sides of the harbour) and Puttgarden (only east of the harbour) and would replace mostly shallow water habitats (Figure 9.8). The larger reclamation area at Lolland, extending up to 4 km east and west of the ferry harbour, would affect shallow water areas dominated by macroalgae (mainly *Furcellaria*; FEMA 2013a) and *Mytilus* communities (FEMA 2013b). These coastal areas are important habitats for shallow water fish communities composed of small species like gobies and sandeels, but these areas are also suitable habitats for juvenile stages of other fish species, e.g. cod and flounder (FeBEC 2013a).

For immersion of the tunnel elements an approximately 200 m wide trench would be dredged. In the tunnel trench area mainly habitats of low vegetation cover (0-10%; FEMA 2013a) with mostly *Arctica*, *Corbula* and *Mytilus* communities would be affected (FEMA 2013b).

The habitat loss from the tunnel footprint is predicted to affect different life stages (spawning, egg-larvae drift, nursery, feeding and migration) of the studied fish species (FeBEC 2013b). The impacts on fish are predicted to result in up to 30% reduction in some life stages of different fish species within the near zone (500 m around the footprint; FeBEC 2013b). The highest impact is predicted for juvenile stages of cod and flatfish, and the shallow water fish species, such as sandeels, gobies, and sticklebacks, in the Danish coastal area. There are no impacts on fish predicted to occur from the tunnel footprint beyond the near zone area in the immediate vicinity of the footprint (FeBEC 2013b).

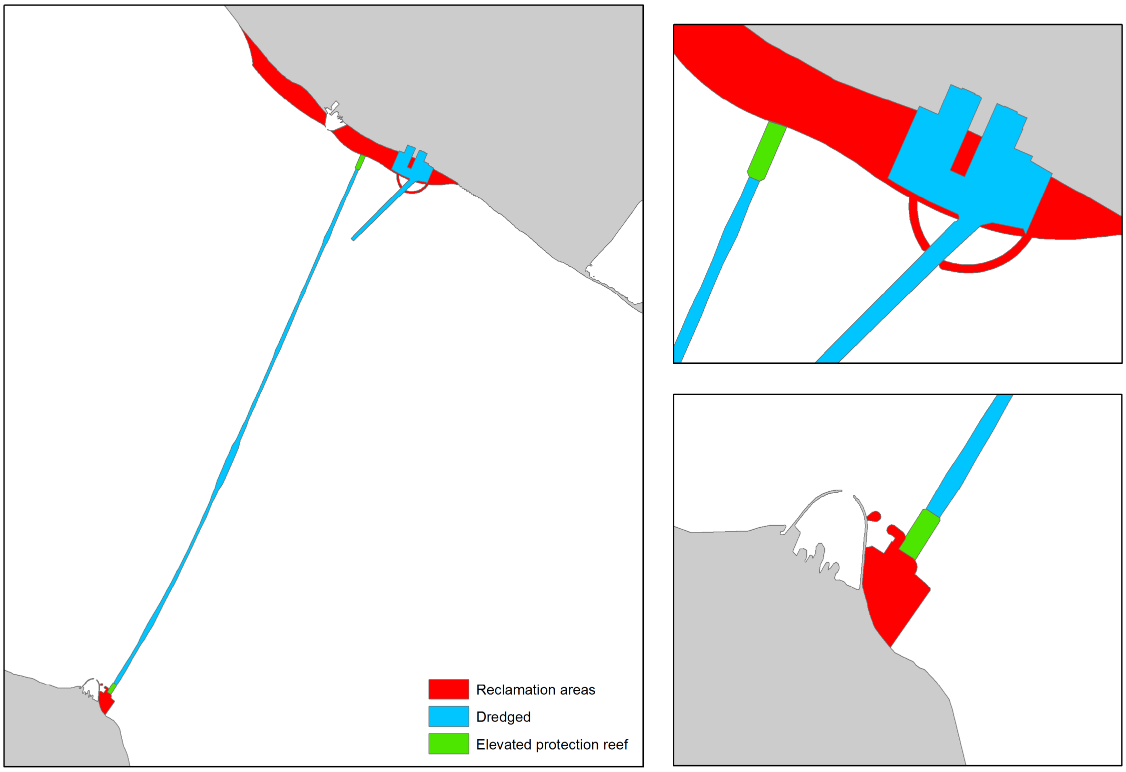


Figure 9.8 Footprint of the immersed tunnel during the construction period.

Table 9.1 Marine areas affected by habitat loss from the footprint of an immersed tunnel during the construction period. Please note: the total marine area lost for the footprint is 584.06 ha; the sum of different areas listed in this table would result in a higher value from double counts of some areas, e.g. protection reefs are built in the tunnel trench area, or parts of the harbour becomes land reclamation later.

Footprint area	**Size, ha**
Dredged areas (tunnel trench, harbour, access channel)	302.10
Elevated protection reefs	12.27
Land reclamation and harbour structures Lolland	336.29
Land reclamation and construction harbour Fehmarn	22.36
TOTAL	584.06

Degree of impairment

The footprint area of the tunnel during the construction period is regarded as an area of complete habitat loss since re-establishment within a short- or long-term period is expected to mostly take place after the completion of the tunnel construction activities. Habitat loss is defined to always result in a complete displacement of all birds from the impact area, so no degree of loss was specified.

Severity of loss

Breeding waterbirds

Only the habitat loss of marine areas has been assessed. Consequently, any possible loss of breeding habitats on land from the tunnel footprint is not part of the present assessment, and will be covered elsewhere. Habitat loss in marine areas is expected to be relevant for breeding bird species which use marine habitats for foraging during the breeding season or rear their offspring in marine areas.

Within the Fehmarnbelt area Red-necked Grebes, Great Cormorants, terns and gulls conduct foraging flights to marine waters. Mute Swans, Red-breasted Mergansers, Common Eiders and partly also other duck species rear their offspring in sheltered coastal areas, but among these only Red-breasted Merganser breeds close to the alignment.

The impact of the habitat loss by the tunnel footprint has been assessed to be only relevant for birds breeding in the northern part of Fehmarn, in the south of Lolland and partly for birds breeding in the western part of Rødsand Lagoon, which might commute between the impact zone and the breeding area (Table 9.2). Cormorants breeding in the west of Fehmarn and birds of other breeding colonies within the German SPAs are expected to mostly use marine areas close to their colonies and not regularly visit the affected alignment area. Therefore, these are not listed in Table 9.2.

Table 9.2 Breeding waterbird species potentially affected by the habitat due to an immersed tunnel in the Fehmarnbelt during the construction phase. Listed are the numbers of breeding pairs, for which use of the impact zone cannot be excluded. Numbers represent breeding pairs in Natura 2000 areas (Fehmarn and Rødsand Lagoon). Numbers from Fehmarn represent birds breeding within the SPA Eastern Kiel Bight between Markelsdorfer Huk and Grüner Brink (data sources: see FEBI 2013). Additionally breeding Red-necked Grebes registered on Lolland outside Natura 2000 sites are listed (data provided by COWI) for information; the assessment on these birds will be conducted as part of the Impact Assessment on Lolland land areas.

Species	Number of breeding pairs		
	Fehmarn north coast (SPA Eastern Kiel Bight)	SPA Hyllekrog-Rødsand	Lolland (outside Natura 2000)
Red-necked Grebe	35	-	20-21
Red-breasted Merganser	26	9*	
White-tailed Eagle	1	2	
Black-headed Gull	15	-	
Common Gull	12	35	
Herring Gull	-	1,066	
Great Black-backed Gull	-	59	
Sandwich Tern	-	2	
Common Tern	33	-	
Arctic Tern	-	14	
Little Tern	10	14	

*Red-breasted Mergansers breeding in Rødsand Lagoon are not expected to use the impact area.

Red-necked Grebe

The habitat loss from the tunnel footprint would affect mostly the shallow coastal areas along the coast of Lolland. Red-necked Grebes breeding at Grüner Brink (30 pairs) or further west on Fehmarn are unlikely to cross the highly disturbed alignment area and the ferry harbour in Puttgarden and thus are not expected to be affected by the footprint area located east of the harbour. Therefore the severity of loss from the tunnel footprint is assessed to be minor for Red-necked Grebes breeding in SPAs.

Red-necked Grebes breeding on small lakes on Lolland outside the Natura 2000 areas (20-21 pairs within the project study area on Lolland; data provided by COWI) were observed regularly commuting between breeding sites and the marine areas of the Fehmarnbelt (Martin Vestergaard, pers. comm.). It is expected that the footprint and especially the land reclamation at Lolland results in a loss of foraging habitats to Red-necked Grebes breeding on Lolland. It cannot be excluded that the longer distance to other foraging sites offshore or to coastal areas not affected by the footprint would have an impact on Red-necked Grebes breeding on Lolland. The severity of loss from the footprint to breeding Red-necked Grebes on Lolland is assessed within the Impact Assessment for the land areas of Lolland.

Red-breasted Merganser

The habitat loss from the tunnel footprint would affect mostly the shallow coastal areas along the coast of Lolland. The breeding birds of Rødsand Lagoon are expected to rear their offspring within the lagoon, and therefore would not be affected by the habitat loss. Red-breasted Mergansers breeding at Grüner Brink or further west on Fehmarn most likely do not cross the highly disturbed ferry harbour in Puttgarden and therefore are not expected to be affected by the footprint area located east of the harbour. There are no records of breeding Red-breasted Mergansers close to the footprint area on Lolland. Therefore the severity of loss from the tunnel footprint is assessed to be minor for Red-breasted Merganser.

White-tailed Eagle

White-tailed Eagles forage on a variety of prey including carrion, birds and fish, and the species uses different inland and coastal habitats for feeding. The coastal areas which are predicted to be lost from land reclamation represent potential foraging habitats of White-tailed Eagle, but are assessed to be of minor importance to the species, since these areas are already highly disturbed by the existing ferry traffic and tourist activities. Therefore the severity of loss from the tunnel footprint is assessed to be minor for White-tailed Eagles breeding in the area.

Gulls

The different gull species breeding in the vicinity of the impact area are assessed as not being sensitive to habitat change due to their opportunistic foraging strategy, which allows them to feed on a variety of prey and use various habitats (see chapter 7.2.2). Therefore the alignment area is assessed to be of minor importance to gulls breeding in the area and therefore the severity of loss is assessed to be minor as well.

Terns

Terns catch by plunge-diving mostly in shallow waters, where small prey fish are abundant. The total loss of such shallow water habitats on the German side would be rather small and therefore the severity of loss from the tunnel footprint for the Common Tern and Little Tern colonies at Grüner Brink and further west are expected to be minor.

The breeding pairs of Arctic Tern and Little Tern in the SPA Hyllekrog-Rødsand could possibly use shallow water areas close to Rødbyhavn which are predicted to be impacted by the land reclamation. However, it is more likely that birds use the shallow waters of Rødsand Lagoon for fishing, since it is closer to their breeding colonies and provides a suitable habitat. Therefore the severity of habitat loss from the footprint to terns breeding in the SPA Hyllekrog-Rødsand has been assessed to be minor. There were no other tern colonies identified on Lolland that would be located close to the alignment (breeding bird surveys on Lolland; COWI 2011).

Other species
For other breeding waterbird species the impact area of the tunnel footprint is assessed to be of minor importance, thus the severity of loss from the tunnel footprint has been assessed to be minor for these species.

Overall assessment of the severity of loss
The overall assessment of the severity of habitat loss from the footprint of the immersed tunnel across the Fehmarnbelt has been assessed to be minor for all waterbird species breeding in SPAs. The severity of loss to Red-necked Grebes breeding on Lolland outside Natura 2000 areas is assessed as part of the Impact Assessment on Lolland land areas.

Non-breeding waterbirds
The severity of loss for non-breeding waterbirds has been assessed by relating the entire tunnel footprint to the importance of the area lost to birds there. The distribution of the most abundant species using offshore habitats was modelled on a resolution of 750x750 m grid cells (Figure 9.9), and such maps were overlaid with the small-scale project footprint map. The relatively small area of the footprint and mismatch in spatial scales provided limited information about the severity of habitat loss to birds. Large proportion of the study area, including the footprint zone has been assessed as being of very high importance for the Common Eider, which was the most abundant species in the Fehmarnbelt. Overlaying Common Eider distribution with the footprint area, the habitat loss corresponds to only a minor severity of loss in terms of number of birds affected (see chapter on Common Eider below). Therefore mapping of the severity of loss has been done only exemplarily for this species (Figure 9.9) and the assessment of the severity of loss for other species has been done in a descriptive way.

The total impact area of the tunnel footprint is relatively small in relation to the Fehmarnbelt study area. The footprint lies within an area of comparably low waterbird densities of most species due to already existing disturbance from the intense shipping, including the ferry traffic. However, some of the coastal waterbird species occur in high numbers in the coastal areas.

Divers (Red-throated/Black-throated Diver)
During the FEBI baseline investigations the Fehmarnbelt was identified as an area of very high importance to divers during the migration and wintering periods. The alignment area was identified to be mostly of minor importance to the species due to the high shipping intensity on the existing ferry route and the ship traffic on the T-Route. Consequently, only single individuals are predicted to use the area of the tunnel footprint during times of maximum abundance. Therefore, the severity of loss is assessed to be minor for the two diver species.

Great Crested Grebe
This species is present in the Fehmarnbelt area all year, but the maximum numbers occur during winter and transitional periods. Especially the coastal areas of Fehmarn were identified as being of very high importance to Great Crested Grebes. However, the tunnel footprint would affect mostly areas of minor importance to this species and only single birds are expected to be affected from direct habitat loss. Therefore, the severity of loss is assessed to be minor for the Great Crested Grebe.

Red-necked Grebe
Red-necked Grebes occur in internationally important numbers in the Fehmarnbelt during winter and transitional periods. The footprint area has been assessed to be mostly of minor importance to the species and the maximum numbers which would get affected by the footprint of an immersed tunnel are predicted to be low (single

to a few tens of birds). Therefore, the severity of loss has been assessed to be minor for Red-necked Grebes wintering in Fehmarnbelt.

Slavonian Grebe
Slavonian Grebes occur regularly, but only in low numbers in the Fehmarnbelt in winter. Since there were no aggregation areas identified during the baseline investigations, only single birds are predicted to get affected by the habitat loss from the tunnel footprint. Therefore, the severity of loss from the tunnel footprint is assessed to be minor for the Slavonian Grebe.

Great Cormorant
The Fehmarnbelt was identified as being of very high importance to Great Cormorants. The species is abundant in the area all year with maximum numbers occurring in autumn. There were no major aggregation areas identified in marine habitats, but cormorants aggregate in high numbers on their roosts. Cormorants roost in the Fehmarnbelt area on undisturbed sandbanks and beaches like Rødsand (Rødsand Lagoon) or Krummsteert (SW Fehmarn), but also on the breakwaters of the ferry harbours in Rødbyhavn and Puttgarden, which are sometimes used by up to 500 Great Cormorants. Due to the land reclamation areas which are planned to border the harbour breakwaters, these structures could become accessible for humans and predators, so cormorants may possibly give up those roosts. Based on the number of possibly affected cormorants and flexibility of this species to change their roosting sites, the severity of loss is assessed to be minor for the Great Cormorant.

Swans
The Fehmarnbelt area is of very high importance to Mute Swans as a moulting and wintering area. Mute Swans prefer sheltered bays and lagoons, such as Rødsand Lagoon, and the numbers occurring in the exposed coastal areas, which would be affected by the tunnel footprint, are low. A maximum count of 100 Mute Swans in the area of Rødbyhavn is expected to be the maximum number of birds which could be affected by the habitat loss.

Internationally important numbers of Whooper and Bewick’s Swan occur in the Fehmarnbelt study area in winter. Whooper Swans and Bewick’s Swans wintering in the Fehmarnbelt area were mostly reported using inland areas or sheltered bays and lagoons. No major concentrations have been observed in the areas of the tunnel footprint. Therefore, the area of concern is predicted to only occasionally hold single individuals of these species and is assessed to be of minor importance to Whooper and Bewick’s Swans.

Based on the minor importance of the footprint area to the different swan species, the severity of loss is assessed to be minor for Mute Swan, Whooper Swan and Bewick’s Swan.

Bean Goose, Greater White-fronted Goose, Greylag Goose
Several thousand of Bean, Greater White-fronted and Greylag Geese use the Fehmarnbelt area during winter and migration periods, but these species mostly use inland habitats and were only occasionally observed in the alignment area. There are no records of the Greater White-fronted Goose from the predicted tunnel footprint area, thus the severity of loss to this species is assessed to be minor.

Bean Goose and Greylag Goose occur in low numbers in the alignment area and occasionally higher numbers of up to a few hundred individuals are reported to use the coastal areas of Lolland for night-time roosting (Thomas W. Johansen, pers. comm.). However, the footprint area is assessed to be of minor importance to both species as it is expected that birds do not rely on that particular area for their night-time roosting. Therefore, the severity of loss is assessed to be minor for Bean Goose and Greylag Goose.

Barnacle Goose, Brent Goose
Barnacle Geese and Brent Geese pass the Fehmarnbelt area in high numbers during migration periods and occasionally high numbers stopover in the area during such periods. The species were mostly observed inland or using sheltered marine habitats, such as Rødsand Lagoon. Due to only occasional sightings of these species in the areas which would be affected by the tunnel footprint, and their primary habitat being further away, the tunnel footprint area is considered as being of minor importance to these birds. Therefore, the severity of loss is assessed to be minor for Barnacle Goose and Brent Goose.

Eurasian Wigeon
Eurasian Wigeon is a common species in the Fehmarnbelt during the non-breeding period, with the highest numbers typically recorded in autumn and the end of the wintering season. During surveys this species is often recorded in sheltered coastal areas such as lagoons and bays, but it also uses inland waterbodies and forages on agricultural fields and pastures. Close to the alignment on Lolland and Fehmarn there are several small lakes and ponds, which are frequently used by dabbling ducks, especially Wigeon. When birds get disturbed on inland habitats they often retreat to the marine areas of Fehmarnbelt, including the area of the planned tunnel footprint (Thomas W. Johansen, pers. comm.). However, numbers observed in the footprint area usually do not exceed a few hundred birds and the area does not represent the foraging habitat, thus the severity of loss is assessed to be minor for Eurasian Wigeon.

Gadwall
Gadwall is a common species in the Fehmarnbelt area during transitional periods in autumn and spring. The species is mostly recorded on inland waterbodies, but also uses sheltered marine habitats. The coastal areas of the alignment usually hold only low numbers of Gadwall, thus the area is assessed to be of minor importance to the species. Therefore the severity of loss from the footprint is assessed to be minor for Gadwall.

Common Teal
Common Teal is a common dabbling duck species in the Fehmarnbelt area, which occurs in highest numbers in autumn. The species is mostly recorded on inland waterbodies, but also uses sheltered marine habitats. The coastal areas of the alignment usually hold only low numbers of Common Teal, thus the area is assessed to be of minor importance to the species. Therefore the severity of loss from footprint is assessed to be minor for Common Teal.

Mallard
Mallard is a very common and abundant species on inland waterbodies and sheltered marine areas of Fehmarnbelt. The species is present in the area all year, but highest numbers are usually observed in winter. The tunnel footprint area holds up to a few hundred Mallards, but due to the high population size and the low conservation status of the species the area was identified to be of minor importance to Mallard. Therefore the severity of loss is assessed to be minor for this species.

Shoveler
Shoveler is a common dabbling duck species in the Fehmarnbelt area, which occurs in highest numbers in autumn. The species is mostly recorded on inland water-bodies, but also uses sheltered marine habitats. In the coastal areas of the alignment Shoveler can be observed only on rare occasions, thus the area is

assessed to be of minor importance to the species. Therefore the severity of loss from the footprint is assessed to be minor for Shoveler.

Common Pochard, Tufted Duck, Greater Scaup

Common Pochard, Tufted Duck and Greater Scaup are common diving ducks which occur in the Fehmarnbelt during the non-breeding period as wintering and migrating birds. Typically, these ducks roost during the day and forage on benthic organisms at night. The nocturnal distribution of the species is not known, but presumably birds are restricted to rather shallow waters (Scott and Rose 1996, Kear 2005, FEBI 2013). The numbers of ducks using the coastal areas affected from the tunnel footprint during nights could therefore be only roughly estimated. Coastal counts indicate up to 710 Common Pochards (0.20% of the biogeographic population), 7,100 Tufted Ducks (0.59% of the biogeographic population) and 130 Greater Scaup (0.04% of the biogeographic population) resting in the vicinity of the ferry harbour in Rødbyhavn during daytime. FEBI baseline telemetry studies on Tufted Ducks indicate this species using foraging habitats close to their daytime roosts (FEBI 2013), so these birds are expected to be affected by the habitat loss from land reclamations, especially on Lolland side.

Due to the high numbers of Common Pochard and Tufted Duck resting and foraging in the immediate vicinity of the planned fixed link this area is assessed to be of high importance to Common Pochard and Tufted Duck. A loss of a relatively large area (343 ha, Table 9.21) of suitable foraging habitats therefore is assessed to result in a high severity of loss for these species. The impacted area is assessed to be of minor importance for the Greater Scaup, therefore the severity of loss is assessed to be minor for this species.

Common Eider

The Fehmarnbelt area has been identified to be a very important wintering area for Common Eiders holding up to 43% of the Baltic population. Consequently, high proportions of the alignment area have also been evaluated as being of very high importance, though clearly not being areas of high density within the Fehmarnbelt (Figure 9.9). It is predicted that a maximum 207 Common Eiders (0.027% of the biogeographic population) would be affected by the tunnel footprint. Therefore the severity of loss is assessed to be minor for Common Eider.

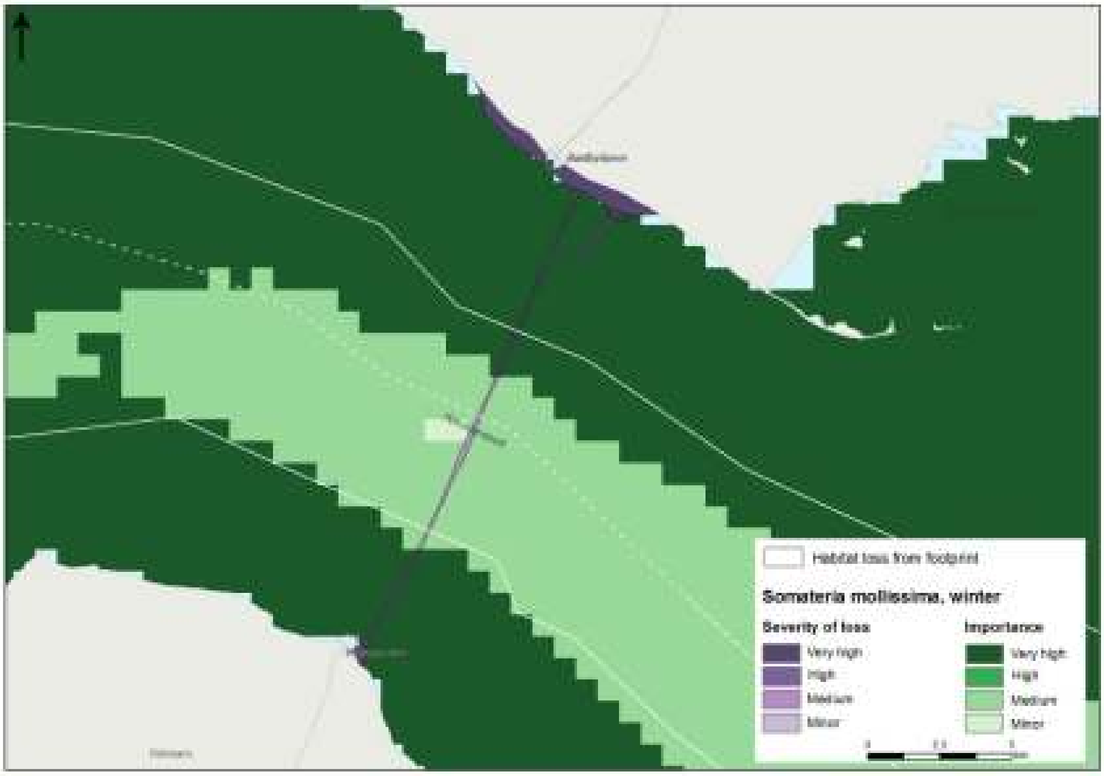


Figure 9.9 Severity of loss from footprint of the immersed tunnel for Common Eiders in winter.

Long-tailed Duck

Long-tailed Duck is an abundant seaduck species with up to 23,000 individuals wintering in the Fehmarnbelt area. The alignment area with the tunnel footprint is assessed to be mostly of minor importance to the species. It is predicted that only single Long-tailed Ducks (predicted mean: 5 birds) would be affected by the habitat loss from the tunnel footprint. Therefore the severity of loss is assessed to be minor for Long-tailed Duck.

Common Scoter, Velvet Scoter

Scoters are common seaducks wintering in high numbers in the Fehmarnbelt area. Baseline investigations indicate numbers of up to 66,000 Common Scoters and 3,000 Velvet Scoters occurring in the study area. The alignment area with the tunnel footprint was identified to be mostly of minor importance to both scoter species. It is predicted that approximately 16 Common Scoters and single Velvet Scoter would get affected by the habitat loss from the tunnel footprint. Therefore the severity of loss is assessed to be minor for both scoter species.

Common Goldeneye

Common Goldeneye is a common wintering duck in the Fehmarnbelt area, which is mostly confined to sheltered coastal areas such as bays or lagoons and only rarely occurs offshore. In the alignment area aggregations of more than 100 individuals were observed in winter. Coastal counts indicate that up to 100 birds would get affected by the habitat loss mainly in the shallow areas of the land reclamations, which is assessed to be a minor severity of loss for Common Goldeneye.

Smew

In some winters Smew occurs in internationally important numbers in the Fehmarnbelt area. However, the species is mostly confined to inland or sheltered marine habitats and can only rarely be observed in the areas that would be affected by the tunnel footprint. Therefore the severity of loss is assessed to be minor for Smew.

Red-breasted Merganser

Red-breasted Mergansers are present in the Fehmarnbelt area all year, but are most abundant during the non-breeding period as wintering and migrating birds. The alignment area is assessed to be mostly of minor importance to the species, but the coastal areas of Lolland and Fehmarn usually hold higher numbers of Red-breasted Mergansers and were therefore assessed to be of very high importance to the species. However, it is predicted that the habitat loss from the tunnel footprint would affect single to a maximum of a few tens of birds (predicted mean: 9 birds) which would be mainly affected from the loss in the coastal areas due to the land reclamations. This impact is assessed to result in a minor severity of loss for Red-breasted Merganser.

Goosander

Goosander is a common wintering bird in the Fehmarnbelt area. The species is mostly confined to inland or sheltered marine habitats and only single birds have been observed in the areas which would be affected by the tunnel footprint. Therefore the severity of loss for this species is assessed to be minor.

White-tailed Eagle

White-tailed Eagles are present in the Fehmarnbelt area all year. The birds use various habitats inland and at the coast. The area of the tunnel footprint was identified to be of minor importance to the species, therefore the severity of loss is assessed to be minor for White-tailed Eagle.

Common Coot

Common Coot is abundant in the Fehmarnbelt area all year with maximum numbers occurring in winter. The species is mostly confined to inland habitats or sheltered marine areas, such as bays and lagoons, thus the area of the tunnel footprint is assessed to be of minor importance to the species. Therefore the severity of loss is assessed to be minor for Common Coot.

Gulls

Different gull species using the Fehmarnbelt area were not observed being confined to certain habitats while foraging. Black-headed Gull, Common Gull, Herring Gull and Great Black-backed Gull are abundant in the study area all year, but occur in maximum abundance in winter. Little Gulls pass the Fehmarnbelt area in internationally important numbers in spring and autumn, but are not confined to any particular habitats in the area; Lesser Black-backed Gull occurs only in low numbers mainly in summer.

The tunnel footprint area was not identified as being of special importance to any of the gull species, although high numbers can be observed using this area for foraging or resting in times. Due to opportunistic and flexible habitat choice, the severity of habitat loss from the footprint is assessed to be minor for all gull species occurring in the Fehmarnbelt.

Terns

It is assumed that most of the observed terns in the Fehmarnbelt area are part of the local breeding population. Thus, the severity of loss for these species is assessed to be the same as described above for terns as breeding birds, which is minor.

Auks

Auks use the Fehmarnbelt area mainly in winter and during migration periods. During this time Common Guillemot and Black Guillemot occur regularly in low numbers in the area. Razorbill is the most abundant auk species in the Fehmarnbelt. The area of the tunnel footprint is assessed as being of minor importance for all three auk species. It is predicted that either none or only single birds could be affected by the footprint; therefore the severity of loss is assessed to be minor for all auk species.

Other species

For other non-breeding waterbird species the impact area of the tunnel footprint is assessed to be of minor importance, thus the severity of loss from the tunnel footprint is assessed to be minor to these species.

Overall assessment of the severity of impact

The severity of loss was determined from the total number of individuals per species which were estimated to be displaced from the entire footprint area of the immersed tunnel. For most of the assessed species the severity of loss is assessed as minor. High severity of loss is predicted for Common Pochard and Tufted Duck (Table 9.3).

Table 9.3 Assessment of the severity of loss from the footprint of an immersed tunnel during the construction period.

Species	Estimated number of displaced individuals	% of the biogeographic population	Severity of loss
Divers	low number	<0.01%	Minor
Great Crested Grebe	low number	<0.01%	Minor
Red-necked Grebe	low number	<0.01%	Minor
Slavonian Grebe	low number	<0.05%	Minor
Great Cormorant	500	0.13%	Minor
Mute Swan	low number	<0.01%	Minor
Bewick's Swan	low number	<0.05%	Minor
Whooper Swan	low number	<0.05%	Minor
Bean Goose	low number	<0.05%	Minor
Greater White-fronted Goose	low number	<0.001%	Minor
Greylag Goose	low number	<0.1%	Minor
Barnacle Goose	low number	<0.001%	Minor
Brent Goose	low number	<0.001%	Minor
Eurasian Wigeon	low number	<0.05%	Minor
Gadwall	low number	<0.05%	Minor
Common Teal	low number	<0.001%	Minor
Mallard	low number	<0.02%	Minor
Shoveler	low number	<0.05%	Minor
Common Pochard	710	0.20%	High
Tufted Duck	7,100	0.59%	High
Greater Scaup	130	0.04%	Minor
Common Eider	207	0.03%	Minor
Long-tailed Duck	low number	<0.001%	Minor
Common Scoter	16	0.002%	Minor

Species	Estimated number of displaced individuals	% of the biogeographic population	Severity of loss
Velvet Scoter	low number	<0.001%	Minor
Common Goldeneye	low number	0.009%	Minor
Smew	low number	<0.01%	Minor
Red-breasted Merganser	low number	<0.05%	Minor
Goosander	low number	<0.001%	Minor
White-tailed Eagle	low number	<0.05%	Minor
Common Coot	low number	0.02%	Minor
Little Gull	low number	<0.01%	Minor
Black-headed Gull	low number	<0.01%	Minor
Common Gull	low number	<0.01%	Minor
Lesser Black-backed Gull	low number	<0.001%	Minor
Herring Gull	low number	<0.01%	Minor
Great Black-backed Gull	low number	<0.01%	Minor
Sandwich Tern	low number	<0.01%	Minor
Common Tern	low number	<0.001%	Minor
Arctic Tern	low number	<0.001%	Minor
Common Guillemot	low number	<0.001%	Minor
Razorbill	low number	<0.01%	Minor
Black Guillemot	low number	<0.1%	Minor
Other species		<0.1%	Minor

During the construction period it is expected that the footprint area would be a part of a greater disturbance zone, which would be highly impaired, resulting in a complete displacement of waterbird species sensitive to this pressure from this area (see chapter 9.2.4). Therefore, it is expected that habitat loss from the footprint would not lead to any additional displacement of birds during the construction period.

Migrating birds

This pressure is assessed to be irrelevant for migrating birds.

Duration of impact

The duration of the pressure 'habitat loss from the footprint' and therefore the impact of the pressure is either permanent (no recovery) or depends on re-establishment of areas of provisional loss (e.g. tunnel trench, working harbours) in terms of recovery times of seabed, benthic flora and fauna and fish communities. In any case the duration of impact exceeds the construction period. Re-established areas offering suitable habitats for waterbirds are considered to be used by birds without relevant additional recovery period.

9.2.2 Habitat change from sediment spill

Description of the pressure

During the construction of an immersed tunnel in total 55.8 million m³ of sediments would be moved while dredging the tunnel trench and the working harbours, backfilling the trench, depositing the material at land reclamation sites and other construction activities (Table 9.4; FEHY 2013a). A certain percentage of the material handled, in total 0.75 million m³, is predicted to get spilled into the open water and the suspended sediments would decrease water transparency and sedimentation processes in certain areas. Details on the predicted sediment spill can be seen in the FEHY report on sediment spill (FEHY 2013a).

Table 9.4 Total amount of dredged sediments, proportion of dredged material getting spilled and the total amount of spilled sediments per activity during the construction of an immersed tunnel (FEHY 2013a).

Activity	Spill [%]	Amount [mill m^3]	Amount spilled [mill m^3]
Dredging for tunnel elements	3.5	15.50	0.540
Containment dikes	0.1-0.8	1.20	0.007
Portal & Ramps Lolland	0.1-0.7	0.36	0.002
Portal & Ramps Fehmarn	0.1-0.7	0.32	0.002
Working harbour Lolland	0.1–0.8	2.87	0.020
Working harbour Fehmarn	0.1-0.8	0.10	0.001
Reclamation	0.5	20.80	0.104
Trench backfilling Lolland	0.1-0.8	3.40	0.015
Trench backfilling Fehmarn	0.1-0.8	3.00	0.013
Restoring seabed Natura 2000*	0.1-1.0	0.48	0.003
Landscaping reclamation area	0.5-2.0	4.31	0.039
Total amount handled/spilled		55.80	0.75

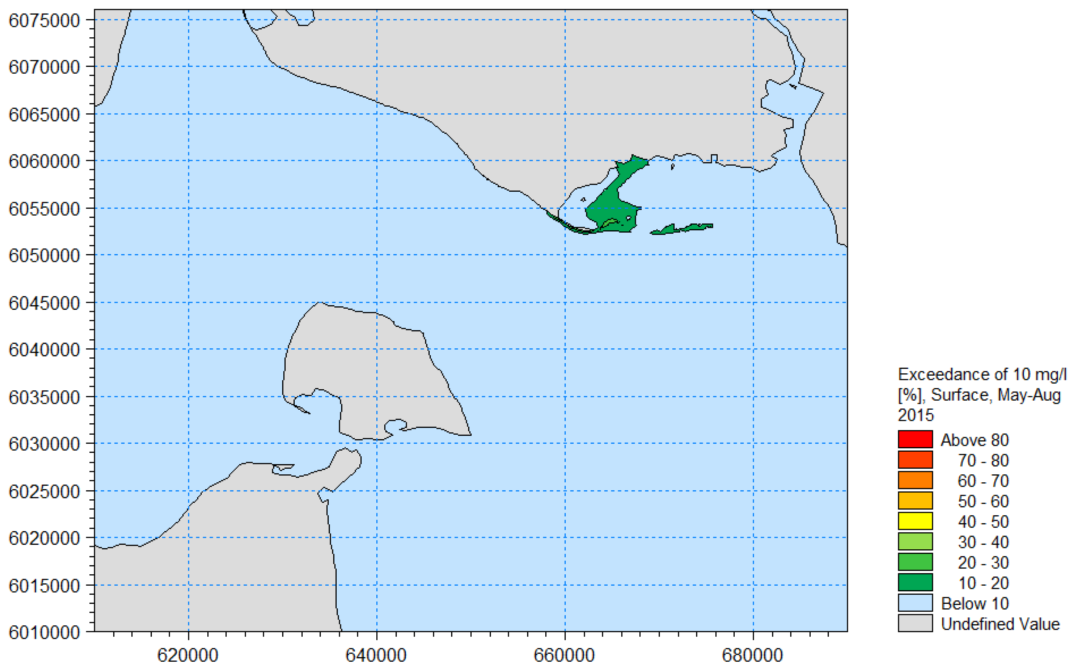
* This activity has been removed from the project in October 2012, but is included here as it was considered in the initial assessment.

The overall construction period is scheduled to last approximately 6 years. The dredging for the construction of the tunnel is planned to start simultaneously at both coasts in October 2014. The construction work is planned to start with the work harbours and associated access channels.

During the tunnel construction the sediment spill would be highest during the first 1.5 years of the construction activities. The largest excess concentrations of suspended sediments are predicted to occur in the last months of 2015 and the first months of 2016. Largest excess concentrations are predicted for Rødsand Lagoon where levels of above 150 mg/l would be reached for short periods of time (FEHY 2013a). For other areas lower values are predicted. In general excess concentrations would be lower at the German side compared to the Danish side. In the course of the construction period the level of excess concentration from dredging would decrease with decreasing dredging activity. Effects of suspended sediments are predicted to be hardly detectable after summer 2019.

Suspended sediment concentrations would be significantly higher near the bottom than at the surface (Figure 9.10; FEHY 2013a). The threshold of 10 mg/l would be exceeded more than 20% of the time along the Lolland coastline from Nakskov

Fjord in the west to Gedser Odde in the east with a maximum along the new reclamation area at Rødbyhavn with an exceedance of this threshold in 60% of the time. Inside the Rødsand Lagoon near bottom concentrations would exceed 10 mg/l for 10-25% of the time. Along the central Fehmarn coasts exceedance times for 10 mg/l are estimated for up to 22% of the time. The higher exceedance times in the nearshore areas are partly due to dredging plumes and partly due to resuspension of spilled sediments (FEHY 2013a).



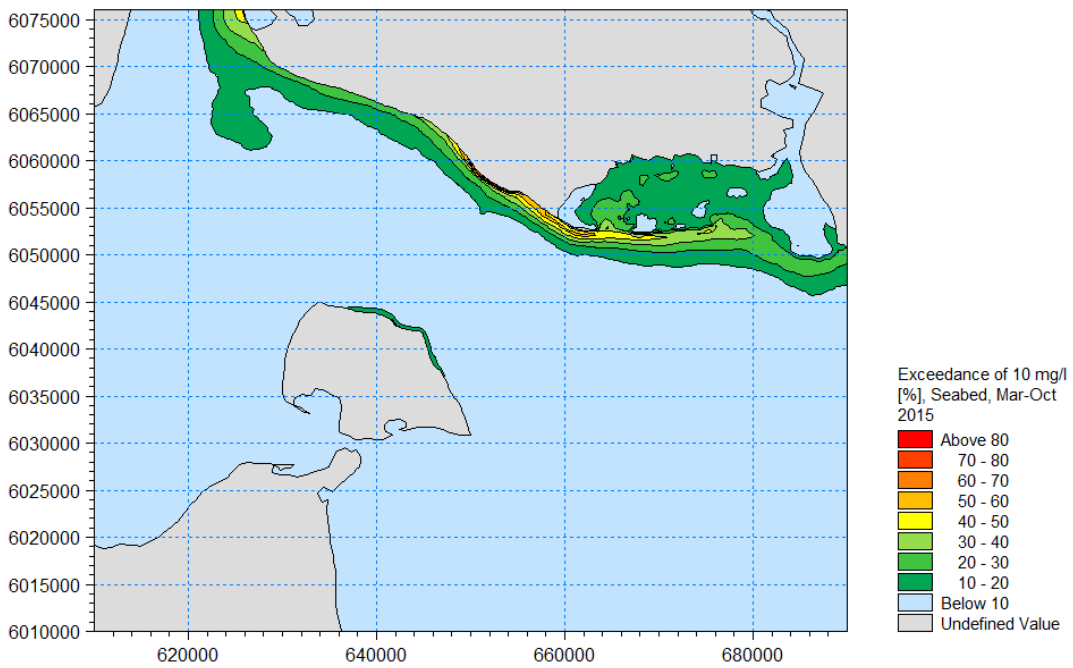


Figure 9.10 Example maps for percentage of time when the value of 10 mg/l of suspended sediment at the water surface (upper map) or just above the seabed (lower map) is exceeded: exceedance time of 10 mg/l spilled sediment concentration for the period May-August 2015 (upper map) and March – October 2015 (lower map). Immersed tunnel E-ME with production facility at Rødbyhavn (maps taken from FEHY (2013a)).

The area of increased concentrations of suspended sediments ranges from the entrance to Nakskov Fjord to Gedser Odde on Danish side, and from the eastern to the western tip of the island of Fehmarn on German side (Figure 9.11; FEHY 2013a).

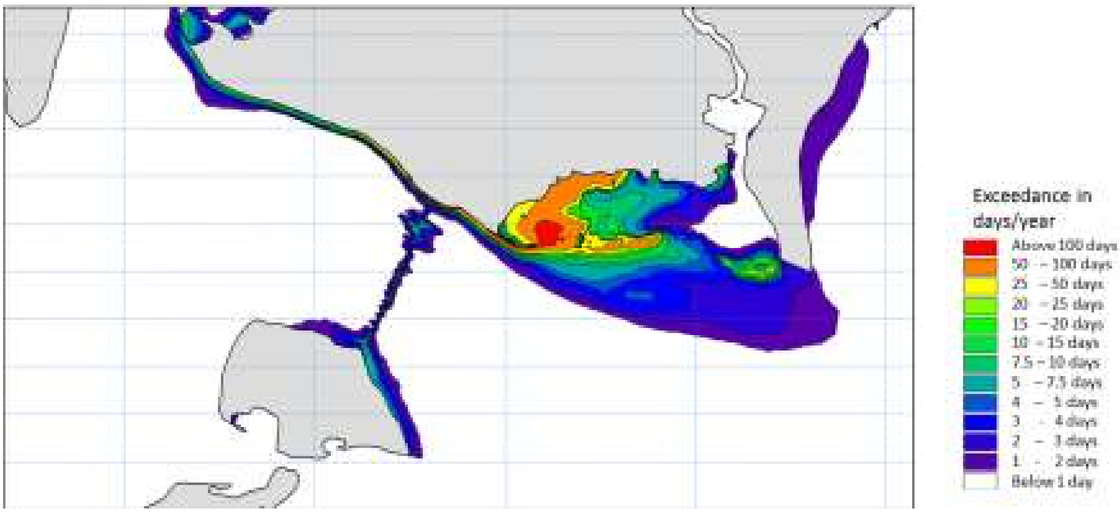


Figure 9.11 Exceedance of 2 mg/l of suspended sediments from construction of an immersed tunnel in days per year for the year 2015 (map taken from FEHY (2013a)).

The sediment spill model predicts little or no sedimentation in the majority of the offshore areas in the Fehmarnbelt away from the alignment at the end of the year 2019 (Figure 9.12; FEHY 2013a). Along the tunnel trench the sedimentation is predicted to be up to 0.5-1.5 cm within a band of about 600 m on each side of the alignment centre line (Figure 9.13). This sedimentation would originate from the coarser fraction of the spill (the sand). Deposition of up to 1 cm is also expected to occur in the sheltered part of Rødsand Lagoon (Figure 9.12; FEHY 2013a).

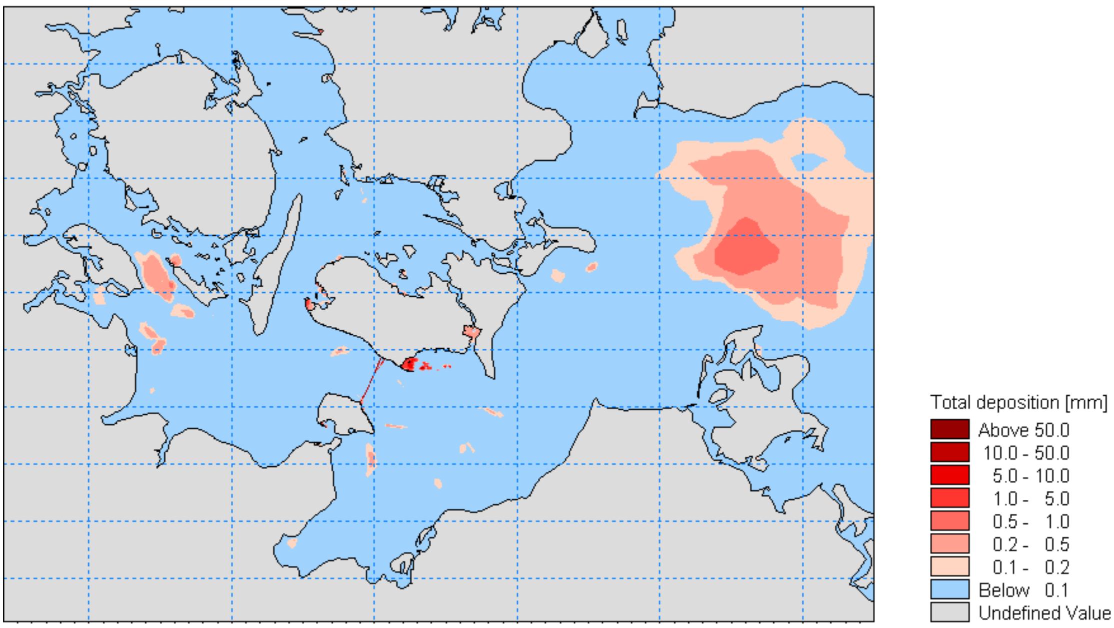


Figure 9.12 Deposition pattern at the end of 2019. E-ME Tunnel solution without local production facility (map taken from FEHY (2013a)).

Figure 9.13 Deposition pattern along the alignment of an immersed tunnel at the end of 2019 (map taken from FEHY (2013a)).

The present chapter focuses on the indirect impacts of the sediment spill on waterbirds resulting from changes in affected benthic flora and fauna, and fish communities. The direct effect of the sediment spill in terms of water transparency on breeding and non-breeding waterbirds is assessed in the chapter 9.2.3.

Changes in benthic flora communities from sediment spill
Sediment spill results in two main pressures impairing benthic vegetation: increased concentration of suspended matter and coverage of the vegetation by sedimentation (FEMA 2013d).

Increased concentration of suspended matter from the construction of an immersed tunnel in the Fehmarnbelt was identified as the pressure which is predicted to have the highest impact and also the larger spatial extent on benthic vegetation among pressures (Figure 9.14–Figure 9.18, Table 9.5; FEMA 2013d).

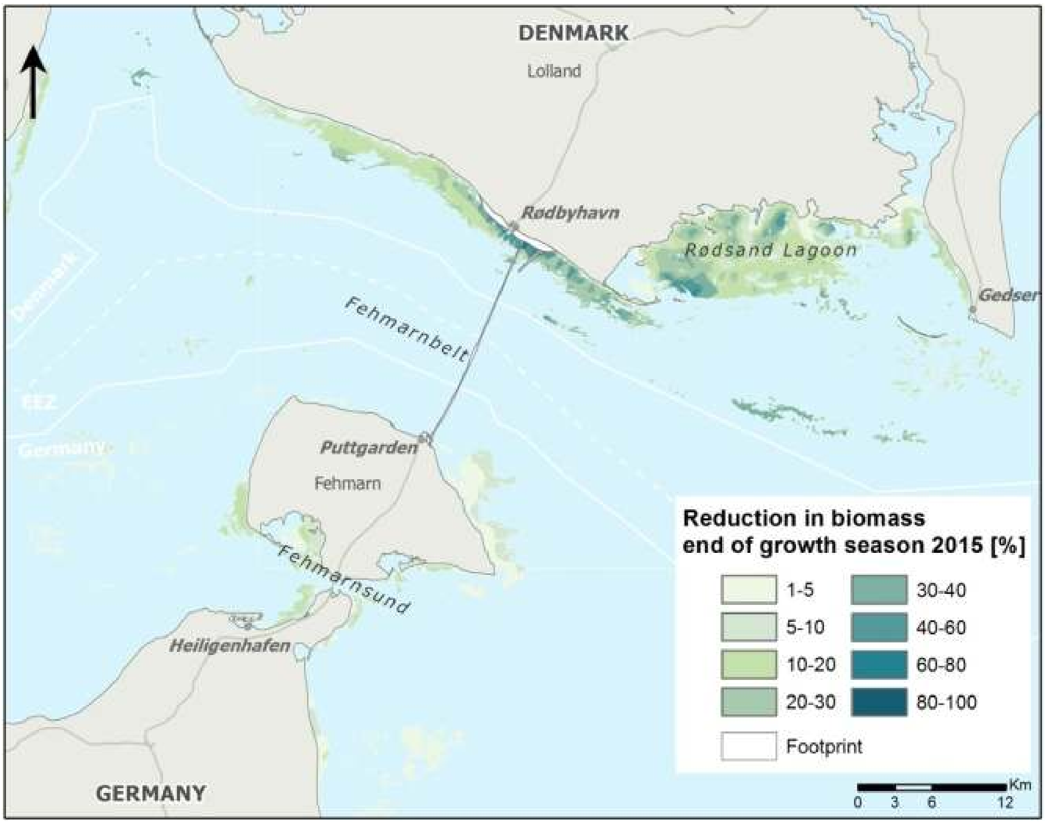


Figure 9.14 *Reduction in benthic flora biomass due to suspended matter at the end of the growth season (1st September) in the year 2015 (map taken from FEMA (2013d)).*

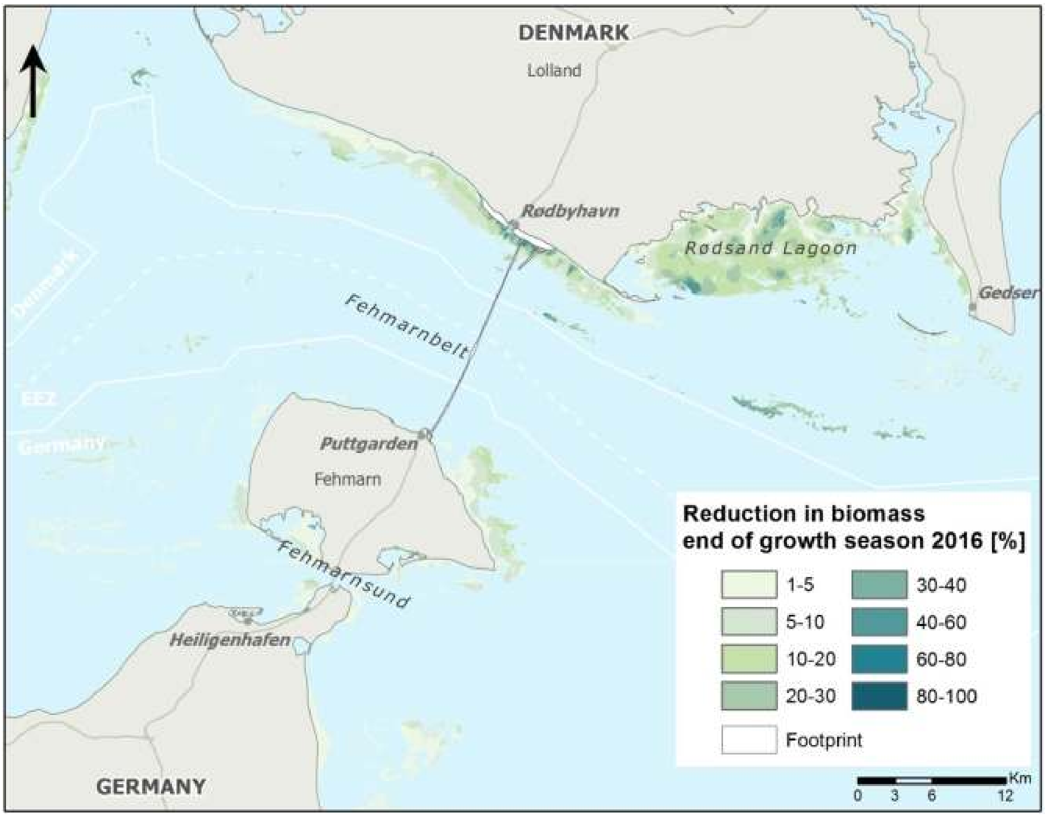


Figure 9.15 *Reduction in benthic flora biomass due to suspended matter at the end of the growth season (1st September) in the year 2016 (map taken from FEMA (2013d)).*

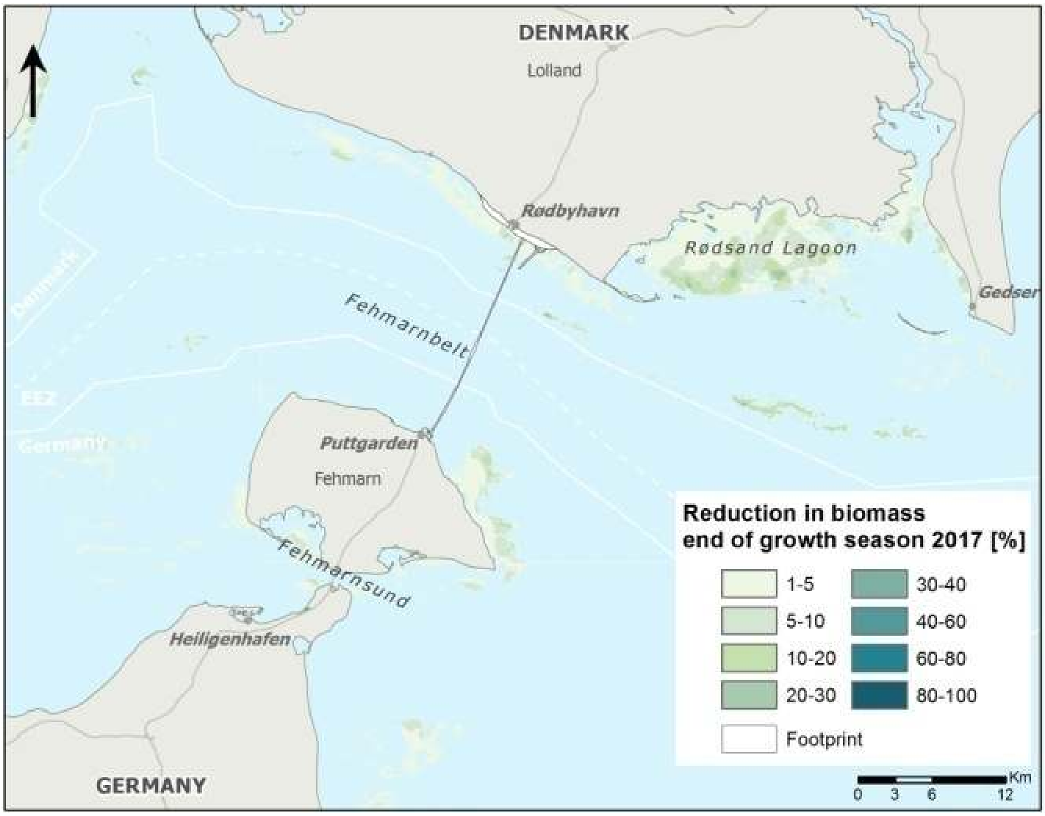


Figure 9.16 Reduction in benthic flora biomass due to suspended matter at the end of the growth season (1st September) in the year 2017 (map taken from FEMA (2013d)).

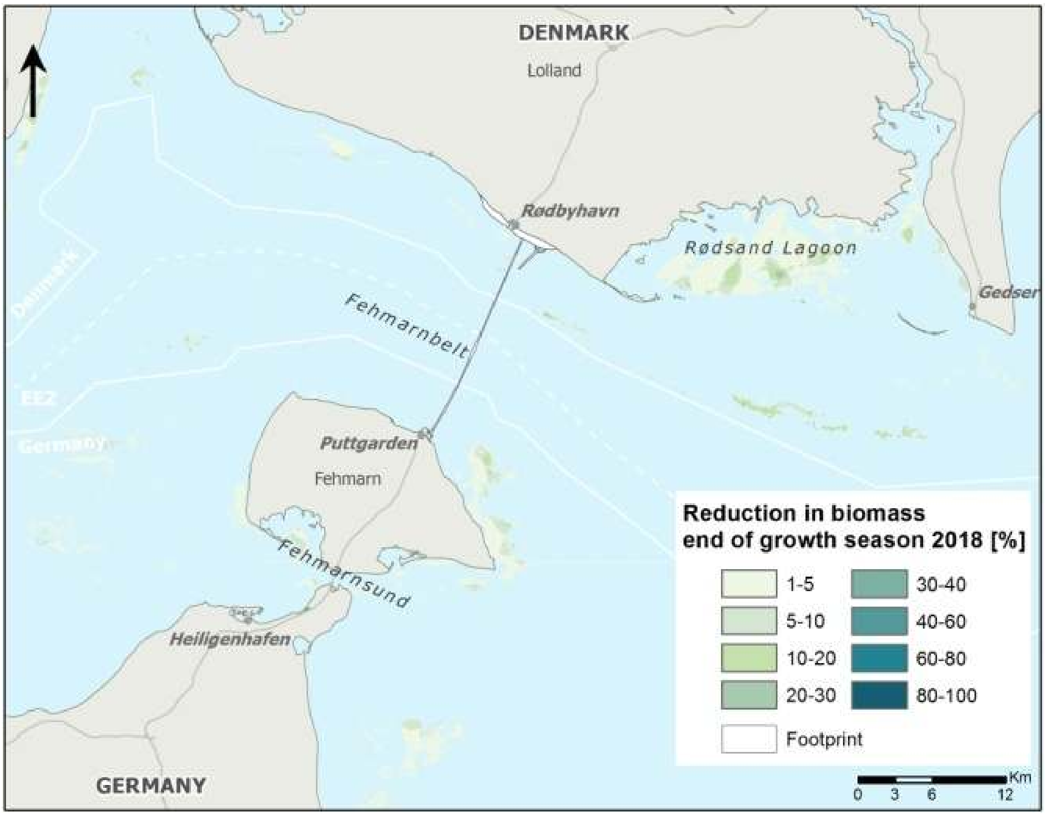


Figure 9.17 Reduction in benthic flora biomass due to suspended matter at the end of the growth season (1st September) in the year 2018 (map taken from FEMA (2013d)).

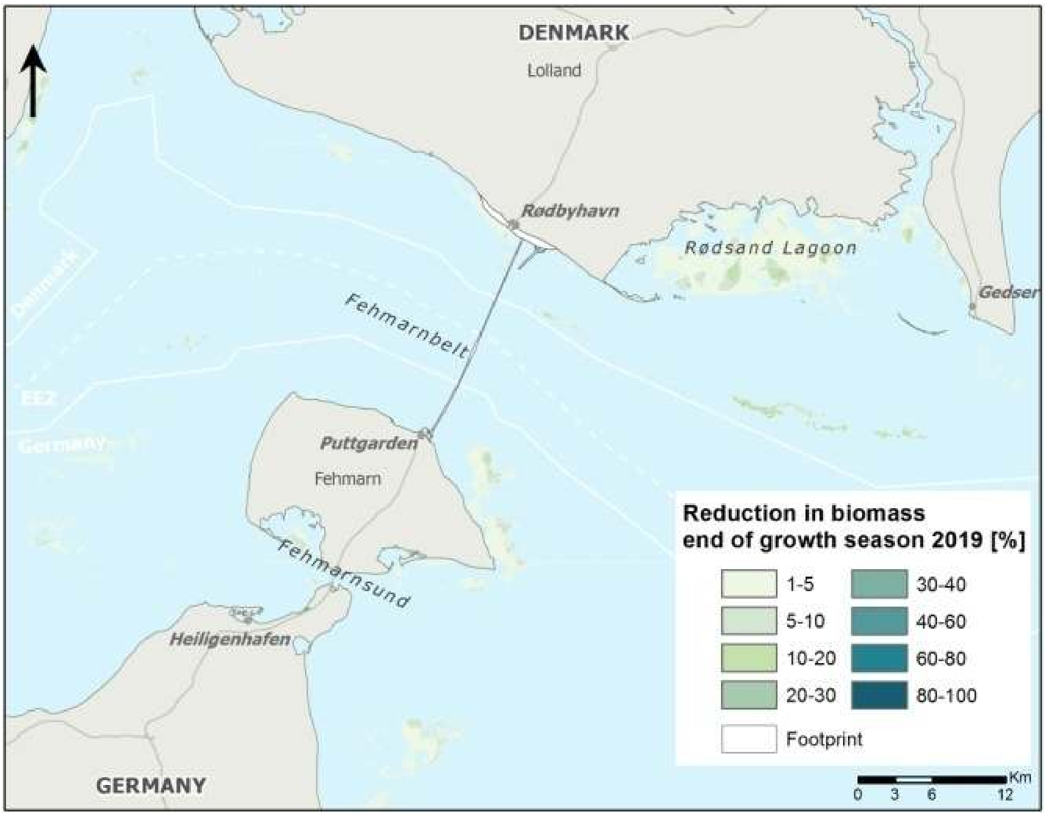


Figure 9.18 Reduction in benthic flora biomass due to suspended matter at the end of the growth season (1st September) in the year 2019 (map taken from FEMA (2013d)).

Table 9.5 Areas of benthic vegetation communities affected with different degree of impairment (very high: 75-100%; minor: 10-25%) caused from suspended sediment from construction of the tunnel alternative. Calculations based on the predicted reductions in biomass at the end of growth season (1st September) of the years 2015-2019 compared to baseline conditions (FEMA 2013d).

Reduction in biomass (%)	Area of communities impacted, ha (% of total community area)						
	Eelgrass	Eelgrass/ Algae	Tassel-weed/ dwarf eelgrass	Filamen-tous species	*Furcellaria*	*Phycodrys/ Delesseria*	*Saccharina*
2015							
75-100	0	0	0	0	0	0	0
50-75	98 (0.8%)	0	0	11 (0.2%)	143 (3.6%)	0	0
25-50	1,922 (15.9%)	0	22 (1.2%)	1,667 (23.2%)	604 (15.3%)	0	0
10-25	7,106 (58.9%)	891 (36.7%)	135 (7.5%)	1,357 (18.9%)	2,127 (54.0%)	487 (15.9%)	122 (10.1%)
2016							
75-100	0	0	0	0	0	0	0
50-75	16 (0.1%)	0	0	3 (0.0%)	33 (0.8%)	0	0
25-50	912 (7.6%)	0	14 (0.8%)	834 (11.6%)	209 (5.3%)	0.8 (0.0%)	0
10-25	5,439 (45.1%)	34 (1.4%)	60 (3.3%)	722 (10.0%)	631 (16.0%)	446 (14.5%)	508 (42.2%)

Reduction in biomass (%)	Area of communities impacted, ha (% of total community area)						
	Eelgrass	Eelgrass/ Algae	Tassel-weed/ dwarf eelgrass	Filamen-tous species	*Furcellaria*	*Phycodrys/ Delesseria*	*Saccharina*
2017							
75-100	0	0	0	0	0	0	0
50-75	0	0	0	0	0	0	0
25-50	62 (0.5%)	0	0	17 (0.2%)	0	0	0
10-25	1,471 (12.2%)	13 (0.5%)	6 (0.3%)	867 (12.1%)	3 (0.7%)	129 (4.2%)	215 (17.9%)
2018							
75-100	0	0	0	0	0	0	0
50-75	0	0	0	0	0	0	0
25-50	18	0	0	3 (0.0%)	0	0	0
10-25	516 (4.3%)	4 (0.2%)	0	595 (8.3%)	0	82 (2.7%)	110 (9.1%)
2019							
75-100	0	0	0	0	0	0	0
50-75	0	0	0	0	0	0	0
25-50	0	0	0	0	0	0	0
10-25	353 (2.9%)	0	0	411 (5.7%)	0	65 (2.1%)	49 (9.1%)

The highest levels of degree of impairment are predicted to occur along the Lolland coast and within Rødsand Lagoon (Figure 9.14–Figure 9.18). For most areas the impact is predicted to be highest after the first year of construction activities (2015) and the area of vegetation impaired and levels of degree of impairment are predicted to be lower the subsequent years (Figure 9.14–Figure 9.18, Table 9.5; FEMA 2013d).

Along the Lolland coast mostly macroalgae are affected from suspended sediments. Within Rødsand Lagoon mostly angiosperms (eelgrass) are affected from reductions. In total an area of 6,518 ha of macroalgae communities and 10,174 ha of eelgrass communities are predicted to be impaired by suspended sediments in 2015 (Table 9.5; FEMA 2013d).

The impact on eelgrass in Rødsand Lagoon would mainly affect the *Zostera* community, which represents the most abundant submerged plant species in the deeper areas of the lagoon. In general the impact of suspended matter on eelgrass in the shallow water areas is predicted to be comparably low, thus also less impact is predicted from reduced light conditions for the tasselweed/dwarf eelgrass community, which mostly occurs in shallow water areas (FEMA 2013d).

Compared to the impact of suspended matter the impact from sedimentation has been assessed to affect only small areas, with impairment predicted to be confined in areas close to the dredging sites, along the northeast coast of Fehmarn and in the southern part of Rødsand Lagoon (Figure 9.19; FEMA 2013d).

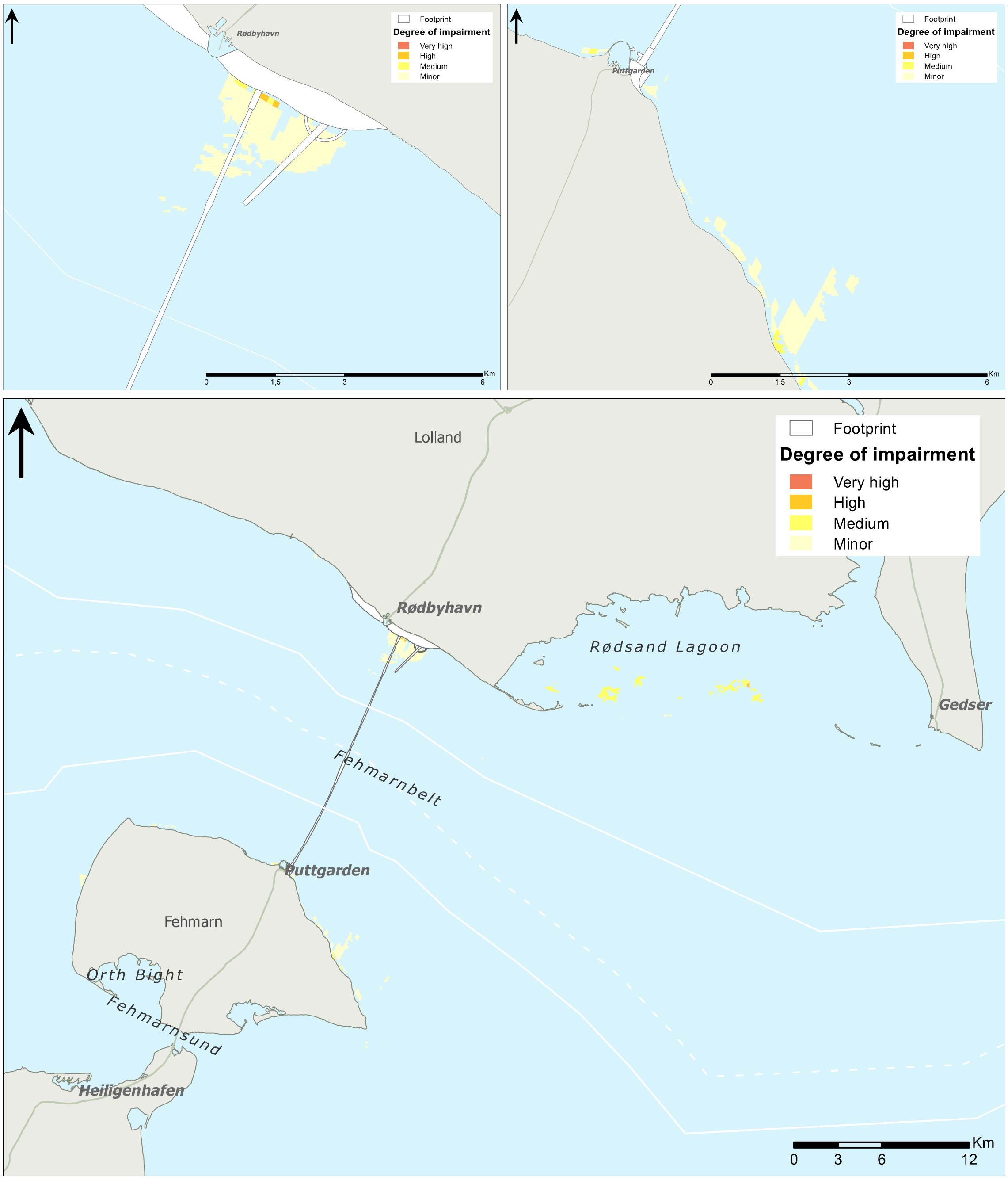


Figure 9.19 Degree of impairment for benthic vegetation from sedimentation due to construction activities of an immersed tunnel (for definitions of different levels of degree of impairment see FEMA (2013d); maps taken from FEMA (2013d)).

Overall 764 ha of vegetation communities are predicted to get impaired by sedimentation from sediment spill, that is 247 ha of eelgrass and eelgrass/algae communities and 517 ha of different macroalgae communities (FEMA 2013d).

Changes in benthic fauna communities from sediment spill

Suspended sediments are predicted to have an impact on benthic fauna only in the first year of tunnel construction (2015). For the year 2016 and thereafter the magnitude of pressure was identified to lie within the range of natural variability (FEMA 2013d). It is predicted that suspended sediments would affect large areas especially along the Lolland coast and Rødsand Lagoon, but also further offshore and along the Fehmarn coast by mostly minor degree of impairment (Figure 9.20; FEMA 2013d).

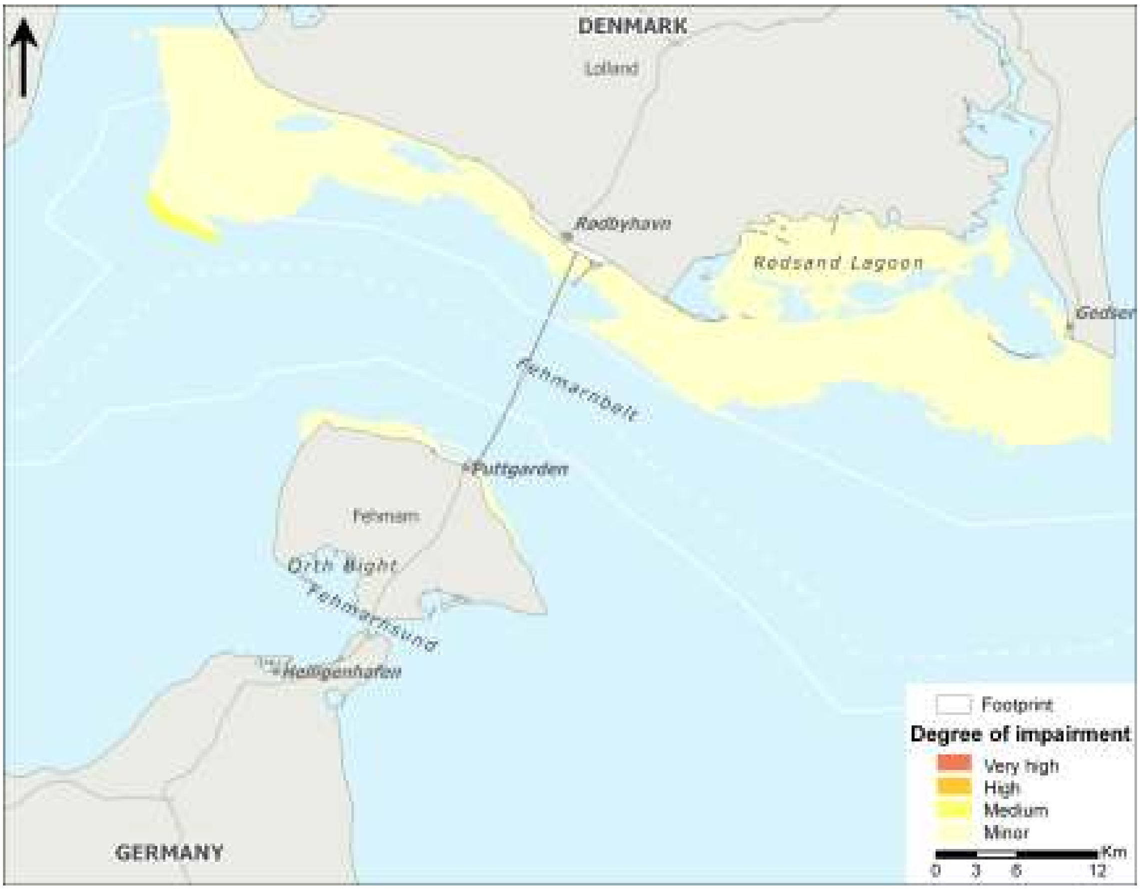


Figure 9.20 Degree of impairment for benthic fauna from suspended sediments due to construction activities of an immersed tunnel in 2015 (for definitions of different levels of degree of impairment see FEMA (2012d); maps taken from FEMA (2013d)).

Reductions caused by minor or medium degree of impairment are predicted to result from lower reproduction, feeding and growth rates of the affected benthic fauna (changes in viability), but not from mortality (FEMA 2013d). Mortality of up to 50% occurs in areas of high degree of impairment. Very high degree of impairment (up to 100% mortality) was not assessed for any area (FEMA 2013d).

Table 9.6 Area of benthic fauna communities affected by different levels of degree of impairment from suspended sediments due to construction activities of an immersed tunnel (data from FEMA (2013d)).

Community	**Area impacted by different levels of degree of impairment, ha (% of total community area)**				
	Very high	**High**	**Medium**	**Minor**	**TOTAL**
Arctica	-	-	-	6 (0.01%)	6 (0.01%)
Bathyporeia	-	-	-	8,830 (56.48%)	8,830 (56.48%)
Cerastoderma	-	-	-	3,029 (27.11%)	3,029 (27.11%)
Corbula	-	-	-	910 (6.87%)	910 (6.87%)
Dendrodoa	-	-	530 (2.45%)	-	530 (2.45%)
Gammarus	-	-	-	12,593 (16.96%)	12,593 (16.96%)
Mytilus	-	-	16 (0.05%)	19,617 (63.41%)	19,633 (63.47%)
Rissoa	-	-	-	8,008 (68.83%)	8,008 (68.83%)
Tanaissus	-	-	-	23 (0.99%)	23 (0.99%)
TOTAL	-	-	546 (0.19%)	57,396 (19.61%)	57,942 (19.79%)

Sedimentation is predicted to result mostly in minor to medium degree of impairment for benthic fauna depending on the thickness and duration of the sediment layer (Figure 9.21; FEMA 2013d). Areas predicted to be affected by the pressure are mainly located next to the dredging sites, but impairment is also predicted for offshore areas, in Rødsand Lagoon and along the Fehmarn and Lolland coasts (Figure 9.21; FEMA 2013d). The affected areas comprise in total 11,871 ha which are mainly predicted to be minor impaired from the pressure sedimentation (Figure 9.21, Table 9.7; FEMA 2013d).

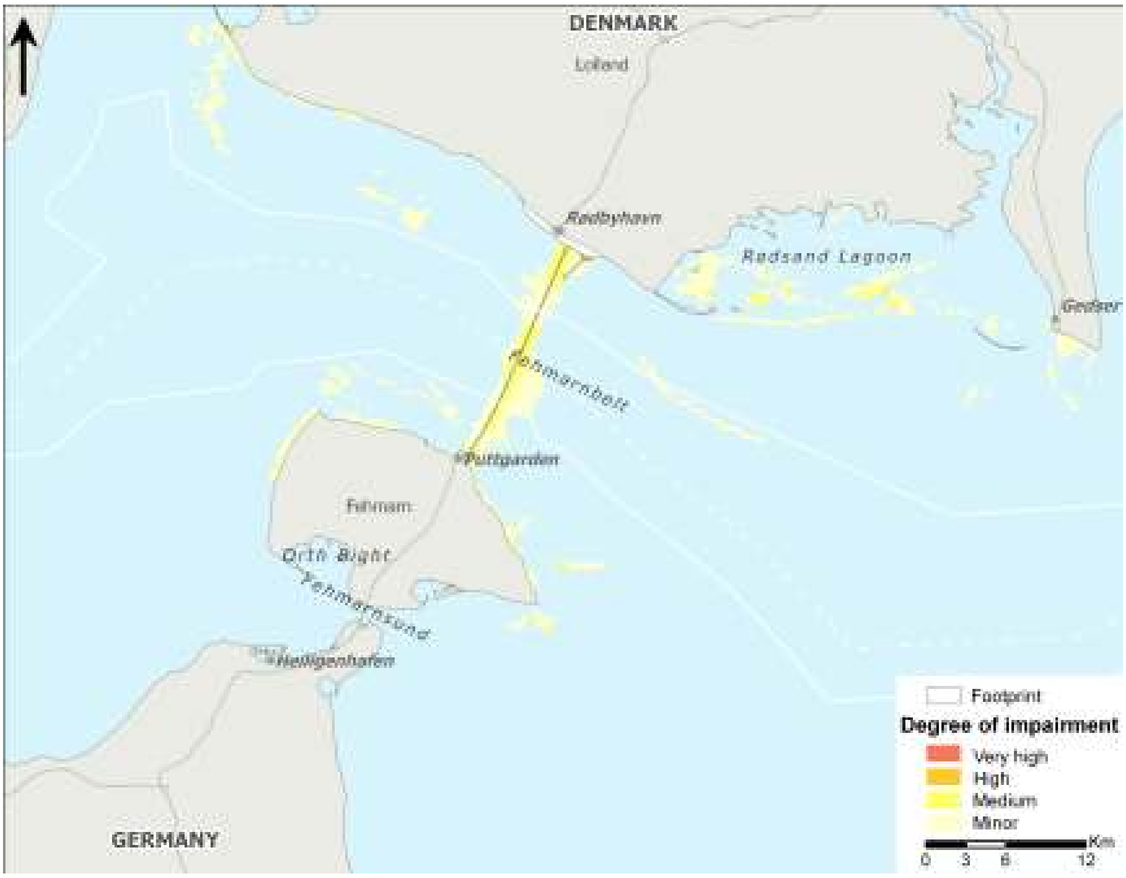


Figure 9.21 Degree of impairment for benthic fauna from sedimentation due to construction activities of an immersed tunnel (for definitions of different levels of degree of impairment see FEMA (2013d); maps taken from FEMA (2013d)).

Table 9.7 Area of benthic fauna communities affected by different levels of degree of impairment from sedimentation due to construction activities of an immersed tunnel (data from FEMA (2013d)).

Community	**Area impacted by different levels of degree of impairment, ha (% of total community area)**				
	Very high	**High**	**Medium**	**Minor**	**TOTAL**
Arctica	-	0.45 (0.00%)	680.24 (0.61%)	1,628.48 (1.45%)	2,309.17 (2.06%)
Bathyporeia	-	-	-	1,187.01 (7.59%)	1,187.01 (7.59%)
Cerastoderma	-	0.17 (0.00%)	126.16 (1.13%)	724.68 (6.49%)	851.01 (7.62%)
Corbula	-	-	13.25 (0.10%)	1,880.32 (14.20%)	1,893.57 (14.30%)
Dendrodoa	-	-	49.72 (0.23%)	-	49.72 (0.23%)
Gammarus	-	1.70 (0.00%)	267.19 (0.36%)	1,703.37 (2.29%)	1,972.26 (2.66%)
Mytilus	-	7.97 (0.03%)	352.63 (1.14%)	1,638.38 (5.30%)	1,998.98 (6.46%)
Rissoa	-	5.57 (0.05%)	246.09 (2.12%)	1,354.45 (11.64%)	1,606.11 (13.80%)
Tanaissus	-	-	1.30 (0.06%)	2.00 (0.09%)	3.30 (0.14%)
TOTAL	-	15.85 (0.01%)	1,736.57 (0.59%)	10,118.68 (3.46%)	11,871.10 (4.06%)

According to the modelling results (FEMA 2013c) it is predicted that due to indirect effects of suspended sediments the overall biomass of Blue Mussels in the study area would be reduced by 0.87%, while locally reductions of up to 10% in biomass are predicted to occur. These changes would only result of changes in viability and not of mortality (FEMA 2013d). Changes in mussel biomass are predicted to mostly occur in the Danish part of the study area south of Rødsand Lagoon and southwest of Lolland (Figure 9.22).

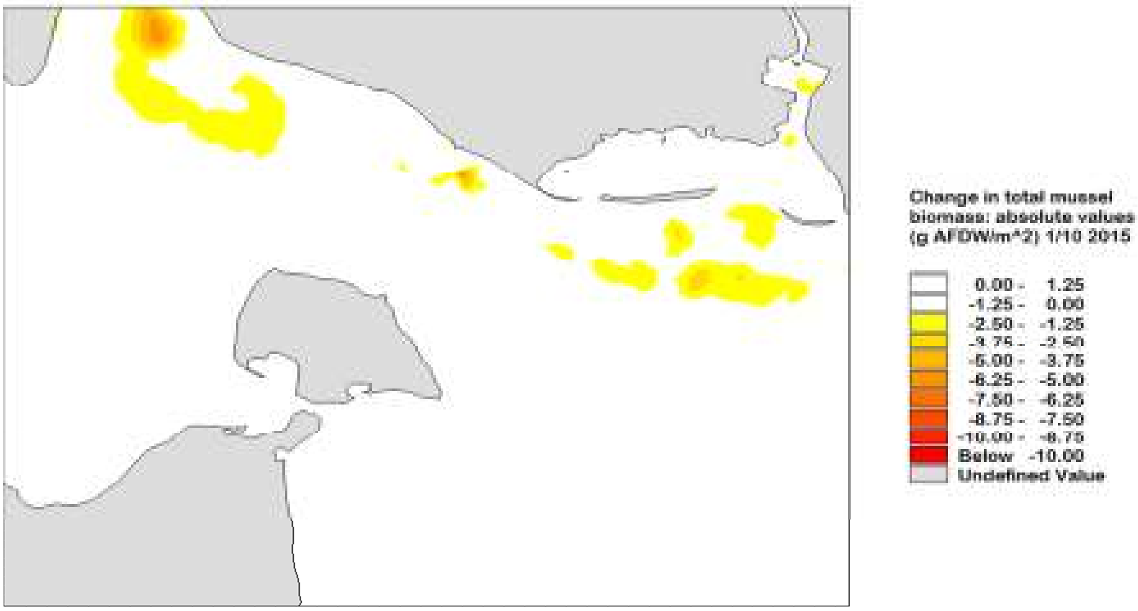


Figure 9.22 Change in total mussel biomass (absolute values of AFDW in g m^{-2}) in Fehmarnbelt caused indirectly by the increased concentration of suspended sediments from the tunnel construction (maps taken from FEMA (2013d)).

Changes in fish communities from sediment spill

There are direct and indirect effects of sediment spill described to be relevant for fish (FeBEC 2013b). Indirect impacts due to changes in benthic communities are predicted to result in no impairment of fish communities in terms of reduced fish biomass in the area, though redistribution of suitable habitats may change local fish distribution (FeBEC 2013b).

Sediment spill is predicted to result in some direct impairment of different life stages of fish communities. It is assumed that impairments leading to reductions in fish biomass below 5% would not result in a detectable effect for fish-eating waterbirds. Impairment levels resulting in fish reductions above this threshold are predicted for juvenile Cod in the Danish near zone ('DK 500 m': 500 m around the footprint in Danish waters) and for adult stages of Cod, Herring and Sprat within Rødsand Lagoon (Table 9.8; FeBEC 2013b). Reductions of fish biomass exceeding 5% are predicted only to occur in the year 2015. No reductions exceeding this threshold were predicted to occur in other areas (FeBEC 2013b).

Table 9.8 Predicted reductions in fish biomass in particular impairment zones from sediment spill of tunnel construction. Displayed are only areas, where the reductions exceed 5% (values in bold letters) at least for one displayed life stage of a species (data: FeBEC 2013b).

Species	**Fish biomass reduction in the year (%)**					
	2014	**2015**	**2016**	**2017**	**2018**	**2019**
Impairment area: **DK 500 m**						
Cod – juveniles	3.0	**7.4**	1.4	0.1	0.4	0.3
Cod – adults	1.7	3.9	0.6	0.1	0.2	0.1
Whiting – juveniles	2.0	4.6	0.9	0.1	0.2	0.2
Herring – juveniles	2.0	4.6	0.9	0.1	0.2	0.2
Herring – adults	1.7	3.9	0.6	0.1	0.2	0.1
Sprat – juveniles	2.0	4.6	0.9	0.1	0.2	0.2
Sprat – adults	1.7	3.9	0.6	0.1	0.2	0.1
Flatfish – juveniles	0.1	0.6	0.0	0.0	0.0	0.0
Flatfish – adults	0.1	0.4	0.0	0.0	0.0	0.0
Shallow water species – juveniles	0.1	0.6	0.0	0.0	0.0	0.0
Shallow water species – adults	0.1	0.6	0.0	0.0	0.0	0.0
Impairment area: **Rødsand Lagoon**						
Cod – juveniles	1.1	4.8	1.8	0.4	0.2	0.2
Cod – adults	0.8	**5.6**	1.0	0.1	0.1	0.0
Whiting – juveniles	1.1	4.8	1.8	0.4	0.2	0.2
Herring – juveniles	1.1	4.8	1.8	0.4	0.2	0.2
Herring – adults	0.8	**5.6**	1.0	0.1	0.1	0.0
Sprat – juveniles	1.1	4.8	1.8	0.4	0.2	0.2
Sprat – adults	0.8	**5.6**	1.0	0.1	0.1	0.0
Flatfish – juveniles	0.1	0.6	0.1	0.0	0.0	0.0
Flatfish – adults	0.1	0.6	0.1	0.0	0.0	0.0
Shallow water species – juveniles	0.1	0.6	0.1	0.0	0.0	0.0
Shallow water species – adults	0.1	0.6	0.1	0.0	0.0	0.0

Degree of impairment

The degree of impairment has been assessed following the criteria described in chapter 4.5.14. Where no other information was available, the reduction in bird numbers in the impairment zone has been defined to correspond closely to the predicted percentage of biomass reduction in benthic communities that were considered as relevant for a bird species. In general predicted changes of up to 5% in prey biomass (benthic communities or fish) were assumed to fall within the range of natural fluctuations and therefore no detectable impact on birds is expected (i.e. the degree of impairment was defined to be minor). Areas where benthic biomass reductions were estimated to be 50% or more were assumed to result in complete displacement of benthivorous birds from the impaired area (Table 9.9). For benthic fauna some assumptions were necessary since no quantitative predictions for changes in benthic communities could be given. Based on impact description of FEMA (2013d) for minor degree of impairment in benthic fauna minor effects on birds were assumed. For medium degree of impairment in benthic fauna it was assumed that this would result in 10% reductions of birds in the affected areas, which is considered a conservative estimate.

Table 9.9 Criteria applied for the assessment of the degree of impairment for bird species, which are sensitive to changes in benthic fauna communities due to sediment spill. Categorisation of degree of impairment of benthic communities taken from FEMA (2013d).

Benthic fauna community		Birds	
Degree of impairment	**Biomass reduction in the impairment zone; predicted impact**	**Degree of impairment**	**Reduction in bird numbers in the impairment zone**
Very high	changes in viability and up to 100% mortality	Very high	100%
High	changes in viability and up to 50% mortality	Very high	100%
Medium	medium changes in viability, no mortality	Medium	10%
Minor	minor changes in viability, no mortality	Minor	0

Table 9.10 Criteria applied for the assessment of the degree of impairment for bird species, which are sensitive to changes in benthic flora communities due to sediment spill. Categorisation of degree of impairment of benthic communities taken from FEMA (2013d).

Benthic community		Birds	
Degree of impairment	**Biomass reduction in the impairment zone; predicted impact**	**Degree of impairment**	**Reduction in bird numbers in the impairment zone**
Benthic flora			
Very high	75-100 %	Very high	100 %
High	50-75 %	Very high	100 %
Medium	25-50 %	High	50 %
Minor	10-25 %	Medium	25 %

The degree of impairment for fish-eating waterbirds is assessed to be minor for areas with a reduction of less than 5% in prey fish and medium for areas with overall reduction in prey fish of 5-10%.

If it could be shown that birds are food limited and the biomass reductions in benthic or fish communities would not result in food limitation (i.e. displacement or additional mortality) to a bird species, the degree of impairment is assessed as minor.

Severity of impairment

In the following the severity of impairment from habitat change from sediment spill is described for all breeding and non-breeding waterbird species, which were identified to be potentially relevant for the EIA during the sensitivity screening (see chapter 7.2.9).

Piscivorous waterbirds occurring in Fehmarnbelt are described as not being specialised on particular fish species, but these birds are considered being generalist foragers and select prey fish mostly by size and abundance (see chapter 7.2.2). Juvenile Cod would be possible prey for various piscivorous birds in the predicted impairment zone close to the construction site (DK 500 m). However, other important prey fish, such as flatfish and shallow water species, are predicted to get less impaired than Cod, so based on these predictions it is likely that birds would encounter less than 5% reduction in total available food. Furthermore, piscivorous bird densities in the highly disturbed area close to the existing ferry line are low and the predicted impairment area generally holds only low numbers of susceptible bird species (see also Impact Assessment of impact from footprint in chapter 9.2.1).

The predicted impact on fish in Rødsand Lagoon affects adult stages of Cod, Herring and Sprat (Table 9.8). Especially for the smaller piscivorous birds, such as terns or Smew, the adult stages of these fish are considered to be too large to be part of their diets. Even larger piscivorous birds, such as cormorants, usually forage on small-sized fish (FEBI 2013), indicating that adult Cod does not play a major role in birds' diets. Based on predictions of minor reductions in prey fish biomass for other life stages and fish communities and that small-sized fish are of higher importance in birds' diets, the overall impairment from reductions in available fish is considered to be minor (<5%) for all breeding and non-breeding waterbird species affected by this pressure in Rødsand Lagoon.

Therefore, the severity of impairment from habitat change from sediment spill has been assessed to be negligible or minor for all piscivorous breeding and non-breeding waterbird species in the Fehmarnbelt. Thus these species are not further considered in the assessment of this pressure.

Breeding waterbirds

Mute Swan and Common Eider are breeding waterbird species identified as being potentially sensitive to the pressure 'habitat change from sediment spill'.

Mute Swan

Estimates suggest that up to 89 pairs of Mute Swans breed within Rødsand Lagoon (Storstrøms Amt – Teknik- og Miljøforvaltningen 2006). Breeding birds comprise a relatively small fraction of all swans present on Rødsand Lagoon in spring and summer, and breeders were not separated from non-breeding individuals when doing surveys during the FEBI baseline investigations. Therefore, breeding birds of this species were accounted for when assessing possible impacts from sediment spill on non-breeding Mute Swans (see further in this chapter), which is assessed to be minor.

Of 43 pairs of Mute Swans breeding within the SPA Eastern Kiel Bight, only 4 pairs possibly use marine areas that are expected to be affected by the sediment spill, while the majority of other pairs nest inland (Koop 2008a). Because biomass reduction of submerged vegetation is expected to be minimal in the Orth Bight and it would be centred in the deepest areas (FEMA 2013d; also see further in this chapter), the severity of impairment from habitat change from sediment spill is assessed to be minor for breeding Mute Swans in the Orth Bight.

Common Eider

Up to 389 pairs of Common Eiders breed within Rødsand Lagoon and 64 on the German side of the Fehmarnbelt (FEBI 2013).

When tending their young, Common Eiders use shallow marine habitats where ducklings can feed on crustaceans and small molluscs (Bauer et al. 2005). It was therefore assumed that all benthic communities found in Rødsand Lagoon could be potentially used by eiders: *Bathyporeia*, *Cerastoderma*, *Gammarus*, *Mytilus* and *Rissoa* (FEMA 2013b). In the absence of specific information about habitat use by breeding Common Eiders, all benthic communities were assumed as being equally important. The degree of impairment on birds is assessed considering a benthic community that was affected by the highest percentage within a particular category of the degree of impairment.

No benthic communities in Rødsand Lagoon were predicted to suffer very high degree of impairment due to suspended sediments and sedimentation, and areas assessed as having high degree of impairment were very small and therefore considered as negligible when assessing affected bird numbers (FEMA 2013d; Table 9.11). Among benthic communities affected by medium degree of impairment, *Rissoa* community was affected to the highest degree accounting for 2.34% of its area, and this figure was used to estimate numbers of affected breeding Common Eiders. It was assumed that medium degree of impairment of a benthic community corresponds to 10% reduction in bird numbers using that community (Table 1.6). Consequently, number of Common Eiders was estimated to be reduced by 0.23%, which corresponds to 1 adult breeding individual and no more than 1 juvenile as average productivity of eiders is low, 0.342 fledglings per female per year (Swennen 1991; Table 9.13). Minor degree of impairment of benthic communities was assumed not to result in any reduction in bird numbers. Therefore, the degree of impairment of habitat change from sediment spill is assessed as minor for Common Eiders breeding on Rødsand Lagoon.

Table 9.11 Degree of impairment of relevant benthic communities due to suspended sediments and sedimentation from the tunnel construction and corresponding numbers of affected Common Eiders breeding in Rødsand Lagoon.

Degree of impairment of benthic communities	Relevant benthic community	% of benthic community affected by suspended sediments in Rødsand Lagoon	% of benthic community affected by sedimentation in Rødsand Lagoon	Corresponding estimated reduction in bird numbers
Very high	*Bathyporeia* *Cerastoderma* *Gammarus* *Mytilus* *Rissoa*	0 0 0 0 0	0 0 0 0 0	0

Degree of impairment of benthic communities	Relevant benthic community	% of benthic community affected by suspended sediments in Rødsand Lagoon	% of benthic community affected by sedimentation in Rødsand Lagoon	Corresponding estimated reduction in bird numbers
High	*Bathyporeia*	0	0	0
	Cerastoderma	0	<0.01%	
	Gammarus	0	0	
	Mytilus	0	0	
	Rissoa	0	0.05%	
Medium	*Bathyporeia*	0	0	2
	Cerastoderma	0	1.33%	
	Gammarus	0	0.48%	
	Mytilus	0	0.09%	
	Rissoa	0	**2.34%**	
Minor	*Bathyporeia*	1.24%	0.48%	No reduction in bird numbers
	Cerastoderma	40.70%	8.86%	
	Gammarus	33.23%	9.07%	
	Mytilus	2.38%	0.34%	
	Rissoa	75.73%	12.82%	

Benthic fauna in the vicinity of Common Eider breeding places on the German side of the Fehmarnbelt (FEBI 2013) would not be affected by the sediment spill (FEMA 2013d). Therefore, it was concluded that severity of impairment on these birds would be minor.

The overall severity of impairment from the sediment spill for all Common Eiders breeding in the Fehmarnbelt is assessed as minor.

Other species

For other breeding waterbird species the impact from habitat change from sediment spill is assessed to be of minor severity of impairment due to either minor importance of the area to the species or birds occurring in the impairment zone are predicted to be of minor sensitivity to this pressure.

Overall assessment of the severity of impairment

The severity of impairment from habitat change from sediment spill is assessed to be minor for all waterbirds breeding in Natura 2000 areas. There is no relevant impact predicted from this pressure for Red-necked Grebes breeding outside Natura 2000 sites on Lolland.

Non-breeding waterbirds

Mute Swan

The Natura 2000 Standard Data Form identifies up to 5,000 Mute Swans staging in Rødsand Lagoon. However, FEBI baseline investigations revealed higher numbers of this species during the moulting period. Over 10,000 individuals were counted in summer 2009 and over 8,000 in summer 2010 (Figure 9.23). The key staging period was identified from May till the end of September when bird numbers are typically the highest in the area and the majority of them represent moulting individuals. Subsequently, swans consume the highest amount of food during summer and could potentially experience food limiting conditions during that period. Therefore the Impact Assessment has mainly been focused on that period.

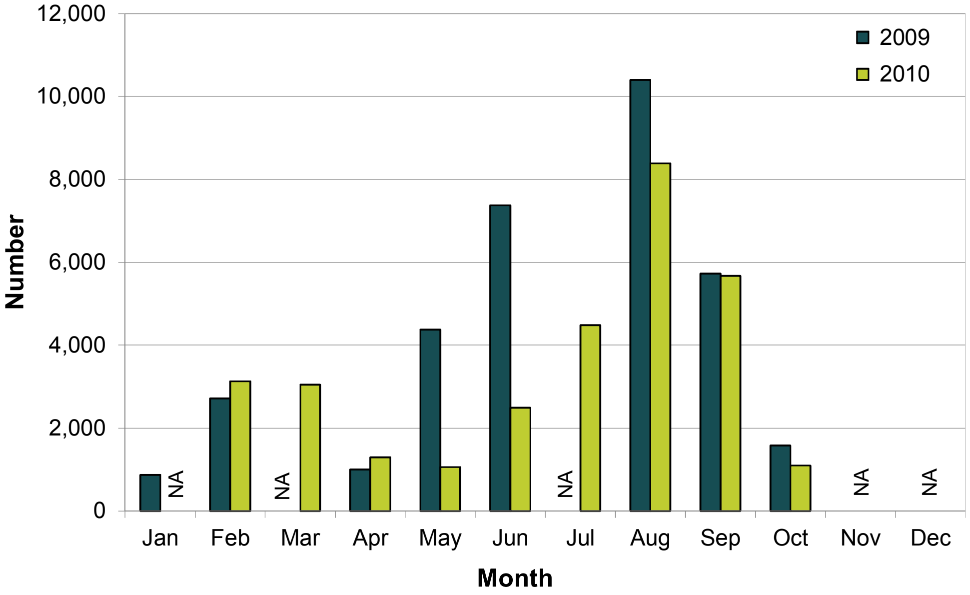


Figure 9.23 *Numbers of swans counted during dedicated search flights in Rødsand Lagoon between January 2009 and September 2010. Swans of genus* Cygnus *were not identified to species level; NA = no data available.*

GPS telemetry and aerial surveys indicated that swans mostly aggregate in the western half of the lagoon during the summer moulting period (Figure 9.24). In addition, telemetry results showed that individual birds, although being flightless when moulting their wing feathers, move extensively within the area of their residence (Figure 9.24).

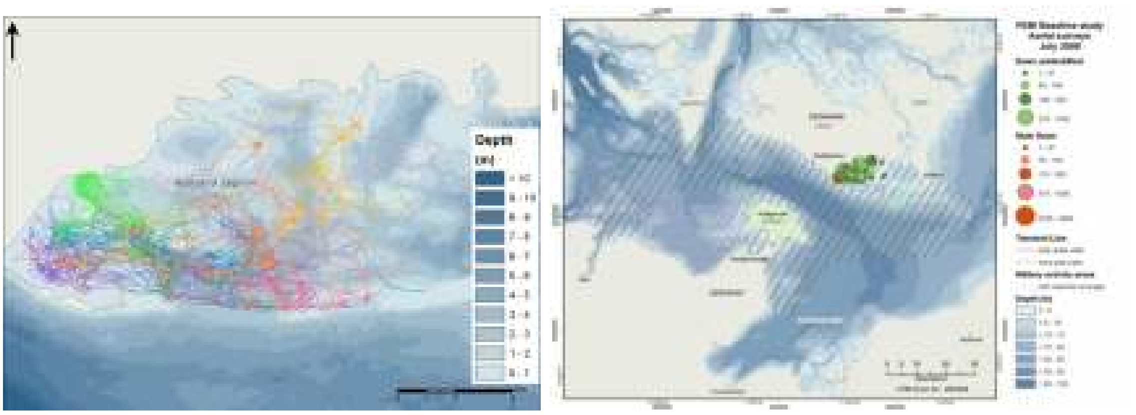


Figure 9.24 *Movements of 6 Mute Swans in Rødsand Lagoon according to GPS telemetry in summer 2010 (left map) and swan distribution recorded during aerial transect survey in July 2009 (right map; maps taken from FEBI 2013).*

A generalised additive model (GAM) with binomial distribution was fitted using Mute Swan GPS telemetry data and simulated pseudo-absence locations, aiming to predict spatial extent of bird foraging habitat accounting for fluctuating water levels. This model represents an update of the model developed during the FEBI baseline investigations (FEBI 2013) and accounts for dynamic water level fluctuations as compared to the static conditions used in the baseline. Predictor variables of the updated model include water depth at a given position and time (from FEHY Fehmarn Belt operational forecast model, 2010, v08), *Zostera* (eelgrass) biomass and submerged vegetation community type (both latter variables prepared by FEMA (2013a)).

The dynamic swan habitat model predicts that the extent of swan habitat is smaller during high water conditions compared to low water (Figure 9.25). The main difference is in the central part of the lagoon, where the predicted foraging habitat becomes unavailable when the water level is high.

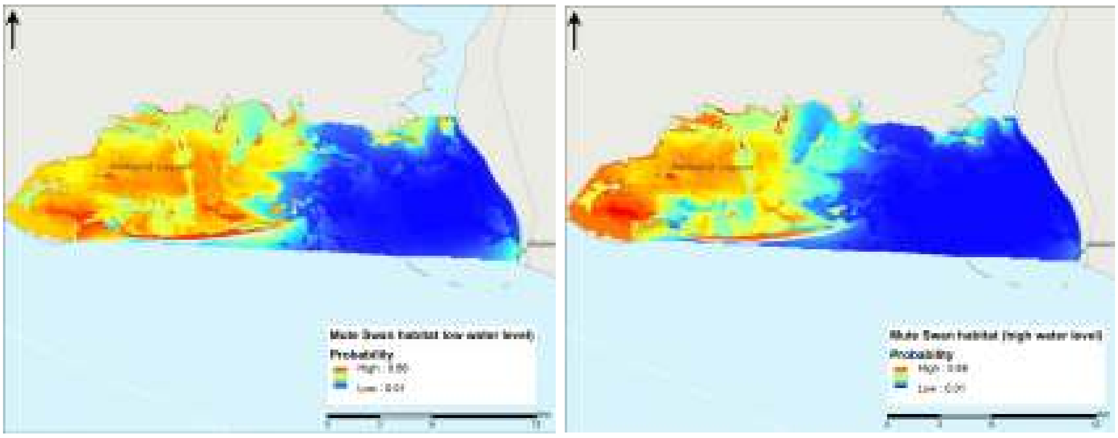


Figure 9.25 Predicted foraging habitat of moulting Mute Swans in Rødsand Lagoon in summer under different water level conditions: low water (left map) and high water (right map; FEBI 2013).

The dynamic habitat model demonstrates that water depth is one of the key factors determining Mute Swan distribution in Rødsand Lagoon. This was also confirmed during aerial surveys (FEBI baseline investigations) of moulting swans, when flocks were clearly located over patches of shallow water (Figure 9.26).

Figure 9.26 A photograph illustrating Mute Swans distributed over the shallow light-coloured water (main concentrations circled in red line) in Rødsand Lagoon in summer 2010.

As found during the FEBI baseline investigations, in Rødsand Lagoon Mute Swans forage on aquatic vegetation, including *Zostera*, *Ruppia*, *Potamogeton* and *Zanichellia*. Common eelgrass *Zostera marina* has the highest biomass among aquatic plants in Rødsand Lagoon and was therefore assumed to be the preferred and most profitable food for swans. FEMA (2013d) predicted that sediments spilled during the construction of the immersed tunnel would inhibit productivity of *Zostera* in Rødsand Lagoon during the five years of the construction (Figure 9.14–Figure 9.18, Figure 9.27). It is predicted that productivity changes would be unevenly distributed and that the highest impact would occur in areas of eelgrass beds with depths over 1.5 m (Figure 9.28).

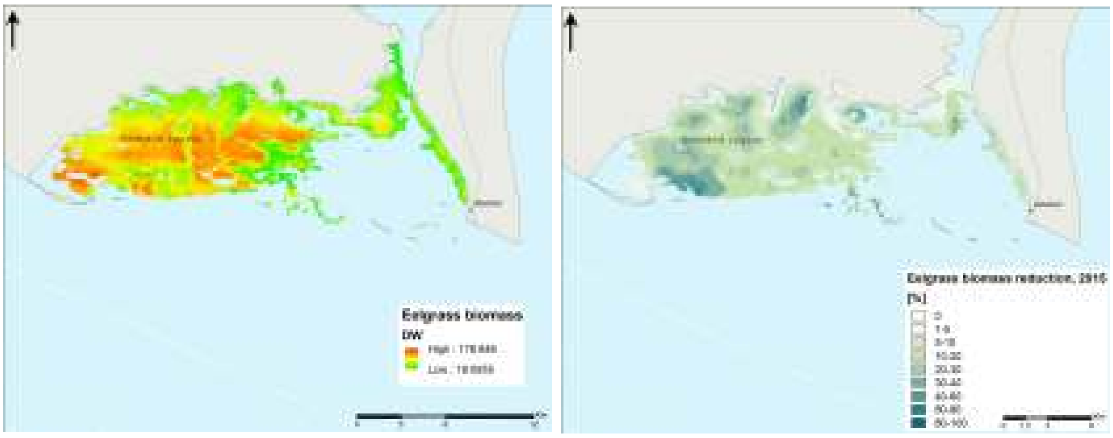


Figure 9.27 *Baseline eelgrass biomass and percent reduction of biomass due to suspended sediment in water column during the first year of construction of the immersed tunnel (estimated for October 1, 2015; FEMA 2013d).*

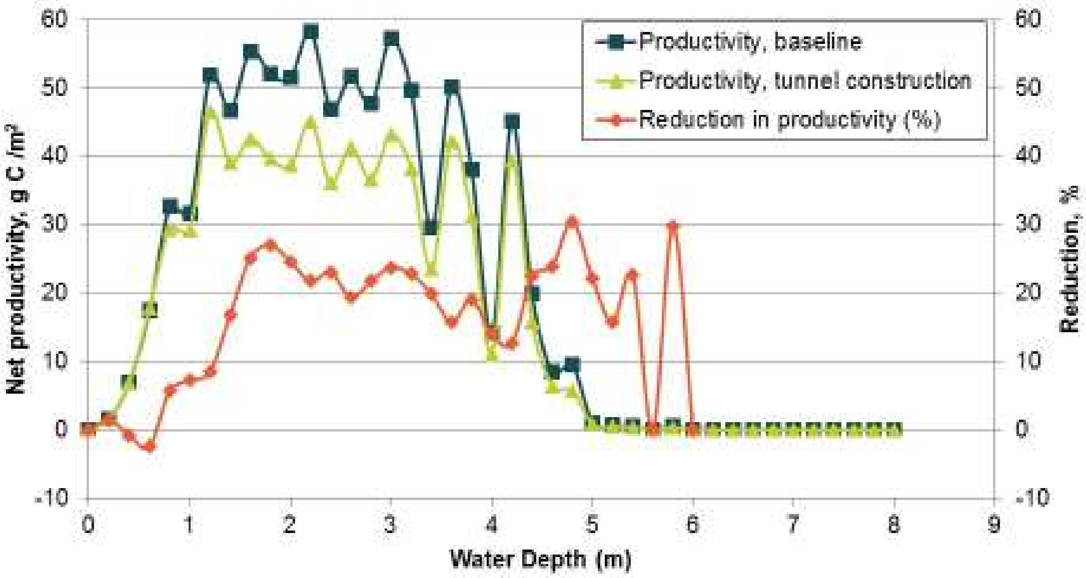


Figure 9.28 *Reduction in* Zostera *productivity (grams of carbon per m^2) in relation to water depth due to suspended sediments in the water column during the first year of construction of the immersed tunnel.*

Further, as mentioned above, the water level is not static in Rødsand Lagoon and, being influenced by astronomical tides and wind, fluctuates up to ±1 m, although typical range (90% of cases) is smaller and restricted to ±0.4 m and even more commonly to just ±0.2 m (70% of cases; Figure 9.29). Because water level determines the availability of forage biomass for Mute Swans, possible impacts on food resources for these birds were analysed considering the full range of possible water level fluctuations. Although typically water level varies frequently around the mean (Figure 9.29), it cannot be excluded that a season with consistently elevated water levels would occur, which would result in reduced availability of forage biomass.

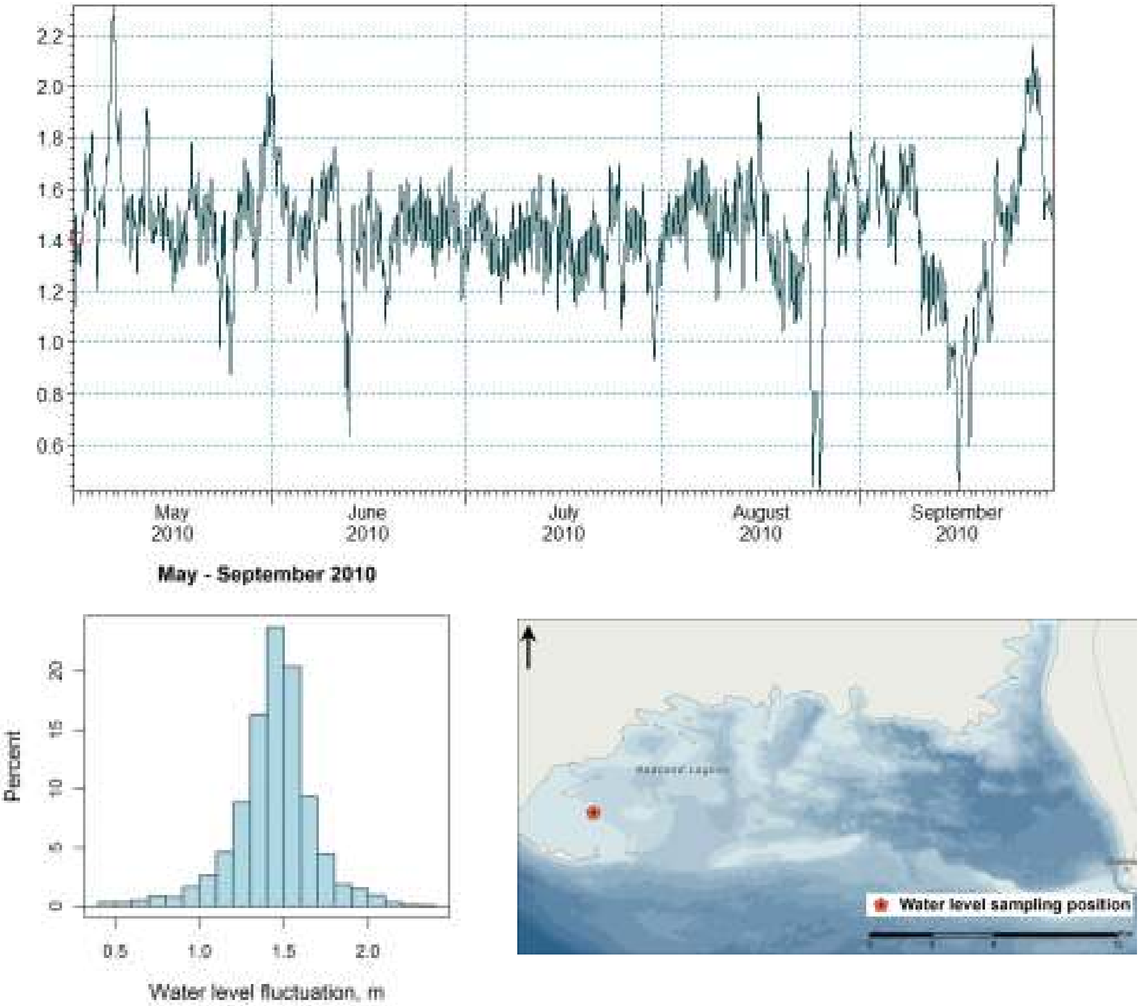


Figure 9.29 Water level fluctuation and distribution of water level variability at a position (average depth 1.4 m) in the western part of Rødsand Lagoon during the main period of Mute Swan presence (extracted from FEHY Fehmarn Belt operational forecast model, 2010, v08).

It was assumed that Mute Swans can forage on *Zostera* until a depth of 1.25 m, as birds can reach down to 1.05 m when foraging by up-ending (Clausen et al. 1995) and *Zostera* leaves were assumed to be available at least 20 cm above the bottom. Following these assumptions *Zostera* availability has been estimated for different water levels under the baseline conditions and impact scenarios with reduced productivity during the five years of the immersed tunnel construction. The *Zostera* crop that is available to Mute Swans has been estimated at 2,000 tonnes dry weight (DW) during the mean water level conditions of the baseline years, and ranges from 1,135 to 3,230 tonnes DW with water level fluctuating within ±0.4 m (Figure 9.30). Following FEMA (2013d) estimates, the predicted reduction of *Zostera* biomass that is available to swans would be the highest during the first (2015) and second years (2016) of the tunnel construction and would constitute reductions of 10% and 7% respectively at mean water level, and 5-12% at water level fluctuating with the range of ±0.4 m (Figure 9.30). The subsequent years would represent smaller reductions, and after the third year from the start of the construction, the reduction would not exceed 1% compared to the baseline (Figure 9.30).

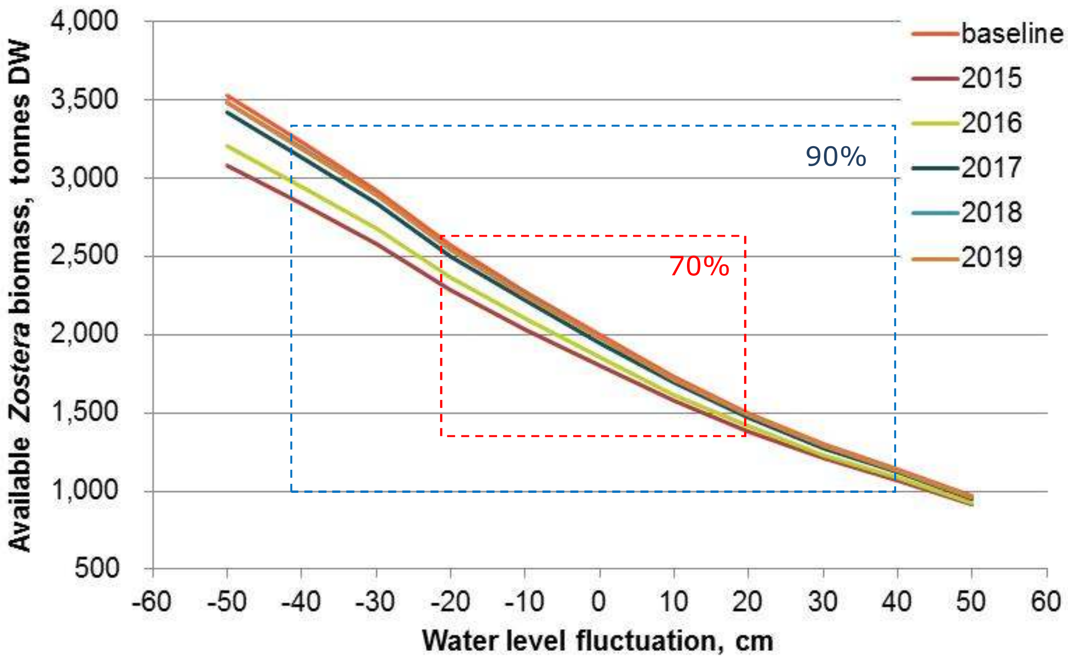


Figure 9.30 Standing biomass of Zostera *available to Mute Swans in Rødsand Lagoon under different water level conditions during the baseline and five seasons of impact scenarios due to construction of the immersed tunnel. Blue and red rectangles indicate typical frequency of range of water level fluctuations in May-September.*

While common eelgrass *Zostera marina* communities are found at depths between 1-5 m, the tasselweed/dwarf eelgrass community is distributed in more shallow areas between 0.25-1.5 m of sheltered bays of Rødsand Lagoon. Key species of this community include tasselweed (*Ruppia cirrhosa/maritima*) and dwarf eelgrass (*Zostera noltii*), accompanied by different characeans (*Chara aspera*, *Chara baltica*, *Tolypella nidifica*) and other angiosperms like the pondweeds *Potamogeton pectinatus* and *Zannichellia palustris*. The standing biomass of the tasselweed/dwarf eelgrass community was estimated at approximately 252.5 tonnes DW in Rødsand Lagoon using values presented by FEMA (2013a). Considering the depth distribution, nearly the entire biomass of the tasselweed/dwarf eelgrass community is accessible to Mute Swans. Because of the shallow distribution, only minor impacts are expected on the tasselweed/dwarf eelgrass community (FEMA 2013d). It was estimated that reduction of the total biomass of this community in Rødsand Lagoon would be 3.5% in 2015, 3.0% in 2016, 1.2% in 2017 and 0.4% in 2018 and 2019.

During the FEBI baseline investigations it was estimated that Mute Swan food requirements were 550 tonnes dry weight (DW) of submerged vegetation between May 1 and October 1, 2009 and 330 tonnes DW during the same period in 2010. This constitutes 24.4% and 14.7%, respectively, of the available standing biomass of the tasselweed/dwarf eelgrass community and *Zostera* biomass under mean water level conditions during the baseline.

However, the overall biomass that is available to birds during the vegetative season is in fact higher than the standing crop. The annual primary production of *Zostera* amounts for 2.4-5.9 times the standing crop (Sand-Jensen 1975, Olesen and Sand-Jensen 1994, Noer et al. 1996). Similarly, the ratio of annual net production to maximum biomass (P/B) of *Ruppia* in the Danish waters has been estimated to range between 1.2 and 2.0 (Kiørboe 1980). Therefore, it is reasonable to assume that the overall biomass available to swans during the vegetative season exceeds the estimated standing crop at least twice.

Assuming the same high number of moulting Mute Swans as observed in summer 2009, and accounting for the estimated reduction of submerged vegetation under scenarios of the immersed tunnel construction, it has been estimated that food consumption by moulting Mute Swans would account for 13.4% of the available standing biomass increased by a factor of 2 (to account for primary production) at the mean water level conditions during summer 2015 (Figure 9.31). The estimated consumption would account for 13% in the following season of 2016 and would be very close to the baseline percentage of 12.4% during the subsequent seasons (Figure 9.31). In general, the percentage of biomass consumed by Mute Swans would increase by 1% at most during the tunnel construction relative to the available biomass of submerged vegetation.

Figure 9.31 Percent consumption of the total available biomass of submerged vegetation (standing biomass increased by the factor of 2 to account for the primary production) by Mute Swans in Rødsand Lagoon during the summer period of May-September. Grey area and grey lines indicate consumption estimated for baseline conditions at mean and ±40 cm water levels; orange lines indicate consumption estimated for the immersed tunnel impact scenario.

For comparison, a study on foraging ecology of moulting Mute Swans around the island of Saltholm in Öresund estimated that bird consumption in typical summer conditions (years 1994 and 1995) corresponded to approximately 10-20% of the available standing crop or less than 10% if to account for a net primary productivity, which is at least twice the peak biomass (Clausen et al. 1996, Noer et al. 1996). In summer of poor production of submerged vegetation and frequently high water level, higher consumption was estimated: equivalent to 50% of the standing crop or less than 25% of the seagrass produced (Clausen et al. 1996, Noer et al. 1996).

When assessing impacts on benthic flora, FEMA (2013d) regarded biomass reductions by 1-10% as representing no impairment, because this level is considerably below the average mean deviation. A biomass reduction by 10-25% was assessed as representing a minor degree of impairment (FEMA 2013d). Considering the reduction of submerged vegetation, overall food requirements by

Mute Swans in Rødsand Lagoon and calculated change in consumed seagrass production relative to the baseline, it is predicted changes in eelgrass availability would not result in a food limitation for Mute Swans in the area. Therefore, neither habitat change related displacement of birds nor increased mortality of swans is predicted and the degree of impairment consequently assessed to be minor. Thus, also the severity of impairment from habitat change due to sediment spill on this species is assessed as minor during all years of the tunnel construction.

Whooper Swan

Whooper Swan occurs as wintering species in the Fehmarnbelt area with peak numbers reaching 590 on the German side and 890 in Rødsand Lagoon on the Danish side. On the German side wintering birds were mostly recorded inland with small numbers in Orther Reede. On the Danish side swans were recorded in Rødsand Lagoon, but foraging birds were also frequently observed on agricultural fields around the lagoon.

Because this species frequently forages inland and only low numbers use coastal waters on the German side, they are not expected to experience negative impacts from the secondary effects of the sediment spill. As presented above for the Mute Swan, resources of submerged vegetation are plentiful in Rødsand Lagoon and numbers of wintering herbivorous birds are relatively low. Even if accessible submerged vegetation is reduced by an estimated maximum 9% in Rødsand Lagoon due to suspended sediments, this should not lead to any negative impacts on wintering Whooper Swans. Therefore, the degree of impairment and severity of impairment are expected to be minor.

Greylag Goose

Non-breeding Greylag Geese occur in the Fehmarnbelt during seasonal migrations and winter period, with the highest numbers being recorded in September-October and March. Recorded peak numbers were 5,000 birds on the German side and 2,700 on the Danish side of the Fehmarnbelt. While some of the observed birds occurred inland, Greylag Geese use marine habitats more than other geese species. As geese are able to use only shallow-growing submerged vegetation, they are not expected to experience reduced food availability due to suspended sediments, as sediments will mostly affects flora productivity in deeper areas (FEMA 2013d). Therefore, the degree of impairment and thus also the severity of impairment on Greylag Goose is assessed as minor.

Brent Goose

Brent Geese use Fehmarnbelt as a stopover site during spring and autumn migrations and were mostly recorded in Rødsand Lagoon. They usually occur in a few hundreds in Rødsand Lagoon and fewer than 20 birds on the German side. The highest record of 1,800 birds was reported for Rødsand Lagoon in May 2007. This species is known to specialise on *Zostera* and seaweed diet, accessibility of which to this small-size goose depends on water level conditions (Clausen 2000). Additionally, Brent Geese can use saltmarshes, cereal and pastures (McKay et al. 1994, Clausen 2000). Since reduction of submerged vegetation is expected to be most pronounced in deeper areas of the lagoon (FEMA 2013d), no impact of suspended sediments is anticipated on staging Brent Geese, and therefore the severity of impairment is assessed as minor.

Eurasian Wigeon

Eurasian Wigeon is a common species in the Fehmarnbelt during the non-breeding period, with highest numbers typically recorded in autumn and late wintering season. During surveys this species was often recorded in sheltered coastal areas such as lagoons and bays, but it also uses inland waterbodies and forages on agricultural fields and pastures. If feeding in lagoons, Eurasian Wigeon can only access submerged vegetation in the shallowest places, which are unlikely to be affected by suspended sediments from the tunnel construction. Therefore, the severity of impairment on this species is assessed as minor.

Common Pochard, Tufted Duck, Greater Scaup

Common Pochard, Tufted Duck and Greater Scaup are considered together as these diving ducks share similar nocturnal foraging habits and would therefore be likely affected in a similar way by the sediment spill. These ducks occur in the Fehmarnbelt during the non-breeding period as wintering and migrating birds. Up to 3,500 Common Pochard, 30,000 Tufted Ducks and 12,000 Greater Scaup have been recorded in the Fehmarnbelt area during the baseline investigations.

These ducks typically roost during the day and forage on benthic organisms at night. The nocturnal distribution is not known, but presumably birds are restricted to rather shallow waters of up to 10 m (Scott and Rose 1996, Kear 2005). The diet composition of Tufted Ducks in the Fehmarnbelt (Skov et al. 1998, FEBI 2013) and diets of Common Pochard and Greater Scaup studied elsewhere (Madsen 1954, Kear 2005) indicate that these ducks rely mostly on small epifaunal bivalves (mussels) and gastropods. This suggests that birds most likely rely on the following benthic communities in marine habitats of the Fehmarnbelt: *Gammarus*, *Mytilus* and *Rissoa* (FEMA 2013b).

As it is not known at what proportion the above listed benthic communities are used by the diving duck species, the degree of impairment on birds has been assessed considering a benthic community that was affected by the highest percentage within a particular category of the degree of impairment. No benthic communities were predicted to suffer very high degree of impairment due to suspended sediments and sedimentation, and areas assessed as having high degree of impairment were very small and therefore considered as negligible when assessing affected bird numbers (FEMA 2013d; Table 9.12). Small percentages of areas covered by relevant benthic communities were affected by medium degree of impairment (Table 9.12). Among these benthic communities, *Rissoa* community was affected to the highest degree accounting for 2.1% of its area, the figure which was used to estimate numbers of affected birds. It was assumed that medium degree of impairment of a benthic community corresponds to 10% reduction in bird numbers using that community (Table 9.9). Consequently, numbers of three diving duck species (*Aythya spp.*) were estimated to be reduced by 0.21% of their maximal number occurring in the Fehmarnbelt: 7 Common Pochard, 63 Tufted Ducks and 25 Greater Scaup (Table 9.12). Further, it was assumed that minor degree of impairment of benthic communities would not result in any reduction in bird numbers.

Considering low numbers of affected individuals, the severity of impairment of habitat change from sediment spill is assessed as minor for Common Pochard, Tufted Duck and Greater Scaup.

Table 9.12 Degree of impairment of relevant benthic communities due to suspended sediments and sedimentation from the tunnel construction and corresponding numbers of affected Common Pochard, Tufted Duck and Greater Scaup.

Degree of impairment of benthic communities	Relevant benthic community	% of benthic community affected by suspended sediments	% of benthic community affected by sedimentation	Corresponding estimated reduction in bird numbers
Very high	*Gammarus* *Mytilus* *Rissoa*	0 0 0	0 0 0	0 0 0
High	*Gammarus* *Mytilus* *Rissoa*	0 0 0	<0.01% <0.01% <0.01%	0 0 0
Medium	*Gammarus* *Mytilus* *Rissoa*	0 <0.01% 0	0.4% 1.1% **2.1%**	7 Common Pochard, 63 Tufted Ducks, 25 Greater Scaup
Minor	*Gammarus* *Mytilus* *Rissoa*	17% 63% 69%	2.3% 5.3% 11.6%	No reduction in bird numbers

Common Eider

Common Eider is the most abundant wintering waterbird species in the Fehmarnbelt and up to 327,505 birds of this species have been estimated to winter in the area (FEBI 2013). Distribution of Common Eiders was modelled over the entire Fehmarnbelt area, therefore no benthic communities were excluded as irrelevant for this species, and the number of affected birds was estimated by overlaying species distribution during the season with highest observations (winter 2009/2010) with maps representing the degree of impairment of benthic communities due to suspended sediments and sedimentation (Figure 9.32).

No benthic communities were impaired at very high degree by suspended sediments or sedimentation and areas affected by high degree of impairment were very small and no Common Eiders were estimated to occur there (FEMA 2013d); Table 9.13). In total 271 Common Eiders were estimated to occur in areas with medium degree of impairment, which, following the assessment criteria (Table 9.9), result in 27 individuals being affected (Table 9.13).

Table 9.13 Degree of impairment of benthic communities due to suspended sediments and sedimentation from the tunnel construction and corresponding numbers of affected Common Eider.

Degree of impairment of benthic communities	Relevant benthic community	Area of benthic communities affected by suspended sediments, km^2	Area of benthic communities affected by sedimentation, km^2	Corresponding estimated reduction in bird numbers
Very high	All benthic communities	0	0	0
High	All benthic communities	0	0.15	0
Medium	All benthic communities	5.46	17.37	27
Minor	All benthic communities	573.96	101.18	No reduction in bird numbers

Further, considering separately assessed decline of Blue Mussel biomass resulting from the tunnel construction activities (FEMA 2013c), the predicted mussel reduction was overlaid with Common Eider distribution in winter 2009/2010 (when the highest numbers were recorded; Figure 9.32). It was assumed that bird abundance would decline at the same rate as Blue Mussels, when reduction exceeds 5% of the initial biomass. Smaller rate of mussel biomass reduction was considered as negligible. Following this approach it was estimated that decline in Blue Mussel biomass would affect 583 Common Eiders.

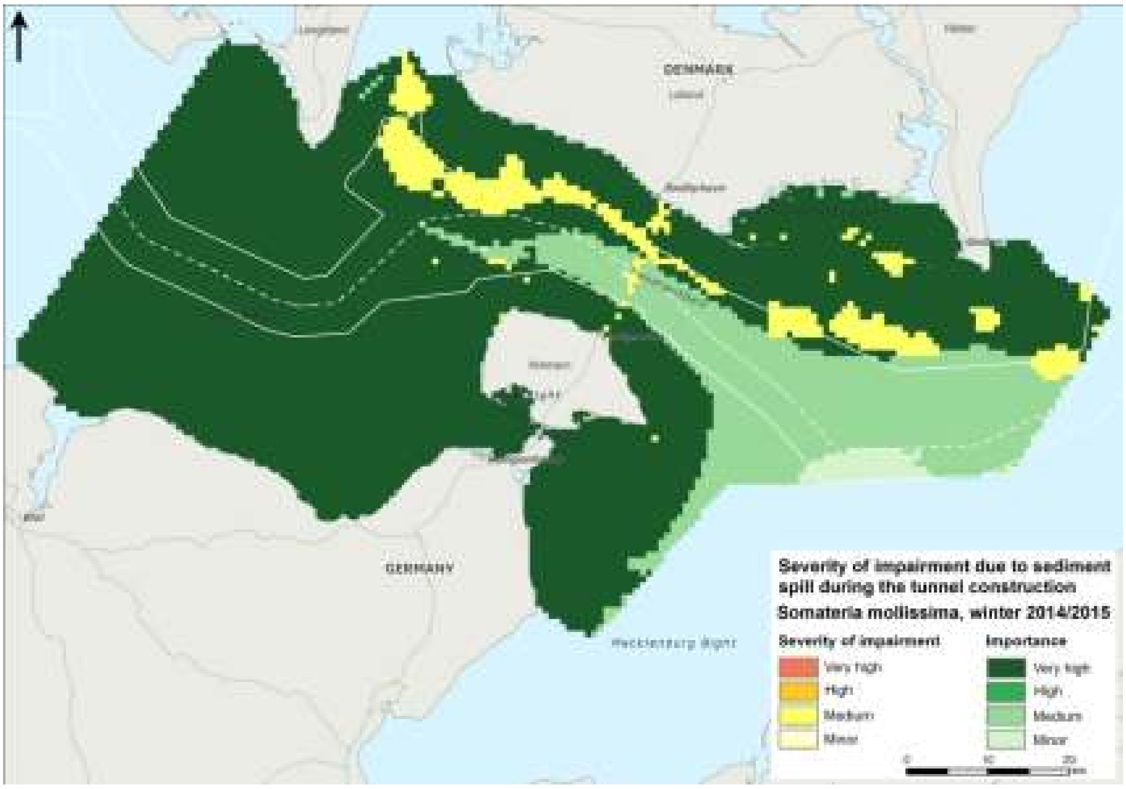


Figure 9.32 Severity of impairment from the pressure 'habitat change from sediment spill' (indirect effect of sedimentation, suspended sediments and reduction in mussel biomass) to Common Eiders in the first winter of the tunnel construction (2014/2015; Common Eider winter distribution).

Considering potentially affected bird numbers (610 individuals or 0.08% of the biogeographic population), the degree of impairment of habitat change from the sediment spill is assessed as minor for Common Eider.

Long-tailed Duck

According to FEBI baseline investigations up to 23,800 Long-tailed Ducks winter in the Fehmarnbelt (FEBI 2013). Because the distribution of Long-tailed Ducks was modelled over the entire Fehmarnbelt area, no benthic communities were excluded as irrelevant for this species, and the number of affected birds was estimated by overlaying bird distribution with maps representing the degree of impairment of benthic communities due to suspended sediments and sedimentation.

No Long-tailed ducks were estimated to occur in small areas of benthic communities which are predicted to suffer high degree of impairment (FEMA 2013d; Table 9.14). Twelve birds were estimated for areas with medium degree of impairment, which, following the assessment criteria (Table 9.9), result in 1 individual being affected.

Table 9.14 Degree of impairment of benthic communities due to suspended sediments and sedimentation from the tunnel construction and corresponding numbers of affected Long-tailed Ducks.

Degree of impairment of benthic communities	Relevant benthic community	Area of benthic communities affected by suspended sediments, km^2	Area of benthic communities affected by sedimentation, km^2	Corresponding estimated reduction in bird numbers
Very high	All benthic communities	0	0	0
High	All benthic communities	0	0.15	0
Medium	All benthic communities	5.46	17.37	1
Minor	All benthic communities	573.96	101.18	No reduction in bird numbers

Further, considering separately assessed decline of Blue Mussel biomass resulting from the tunnel construction activities (FEMA 2013c), the predicted mussel reduction was overlaid with average distribution of wintering Long-tailed Ducks as estimated from ship-based survey data (Figure 9.33). It was assumed that bird abundance would decline at the same rate as Blue Mussels, when reduction exceeds 5% of the initial biomass. Following this approach it was estimated that decline in Blue Mussel biomass would affect 32 Long-tailed Ducks.

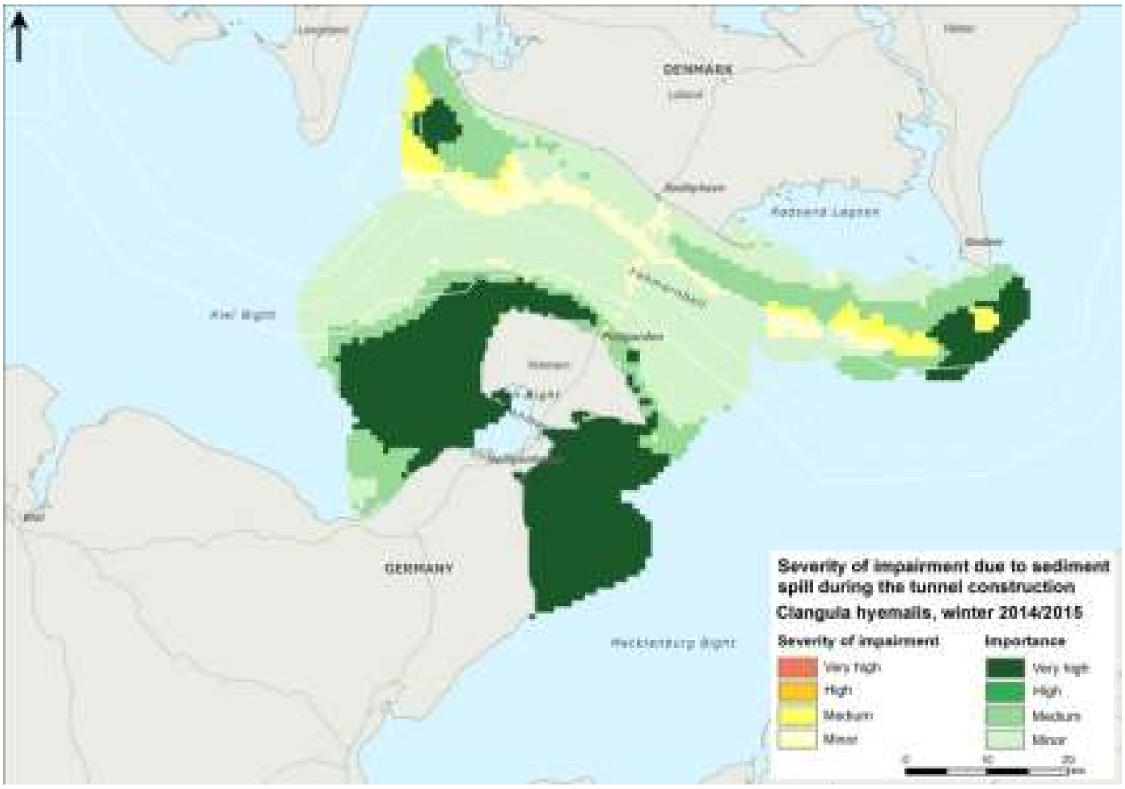


Figure 9.33 Severity of impairment from the pressure 'habitat change from sediment spill' (indirect effect of sedimentation, suspended sediments and reduction in mussel biomass) to Long-tailed Ducks in the first winter of the tunnel construction (2014/2015).

Considering potentially affected bird numbers (33 individuals or less than 0.01% of the biogeographic population), the severity of impairment of habitat change from the sediment spill is assessed as minor for Long-tailed Duck.

Common Scoter

Up to 66,290 Common Scoters were estimated to winter in the Fehmarnbelt during the baseline (FEBI 2013). Distribution of Common Scoters was modelled over the entire Fehmarnbelt area, therefore no benthic communities were excluded as irrelevant for this species, and the number of affected birds was estimated by overlaying bird distribution with maps representing the degree of impairment of benthic communities due to suspended sediments and sedimentation.

No benthic communities were impaired at very high degree by suspended sediments or sedimentation (FEMA 2013d). Areas of benthic communities affected by high degree of impairment were very small and no Common Scoters were estimated to occur there (FEMA 2013d, Table 9.15). Eighteen Common Scoters were estimated to occur in areas with medium degree of impairment, which, following the assessment criteria (Table 9.9), result in 2 individuals being affected.

Table 9.15 Degree of impairment of benthic communities due to suspended sediments and sedimentation from the tunnel construction and corresponding numbers of affected Common Scoters.

Degree of impairment of benthic communities	Relevant benthic community	Area of benthic communities affected by suspended sediments, km^2	Area of benthic communities affected by sedimentation, km^2	Corresponding estimated reduction in bird numbers
Very high	All benthic communities	0	0	0
High	All benthic communities	0	0.15	0
Medium	All benthic communities	5.46	17.37	2
Minor	All benthic communities	573.96	101.18	No reduction in bird numbers

Further, considering a separately assessed decline of Blue Mussel biomass resulting from the tunnel construction activities (FEMA 2013c), the predicted mussel reduction was overlaid with average distribution of wintering Common Scoters as estimated from ship-based survey data. It was assumed that bird abundance would decline at the same rate as Blue Mussels, when reduction exceeds 5% of the initial biomass. Following this approach it was estimated that decline in Blue Mussel biomass would affect 55 Common Scoters.

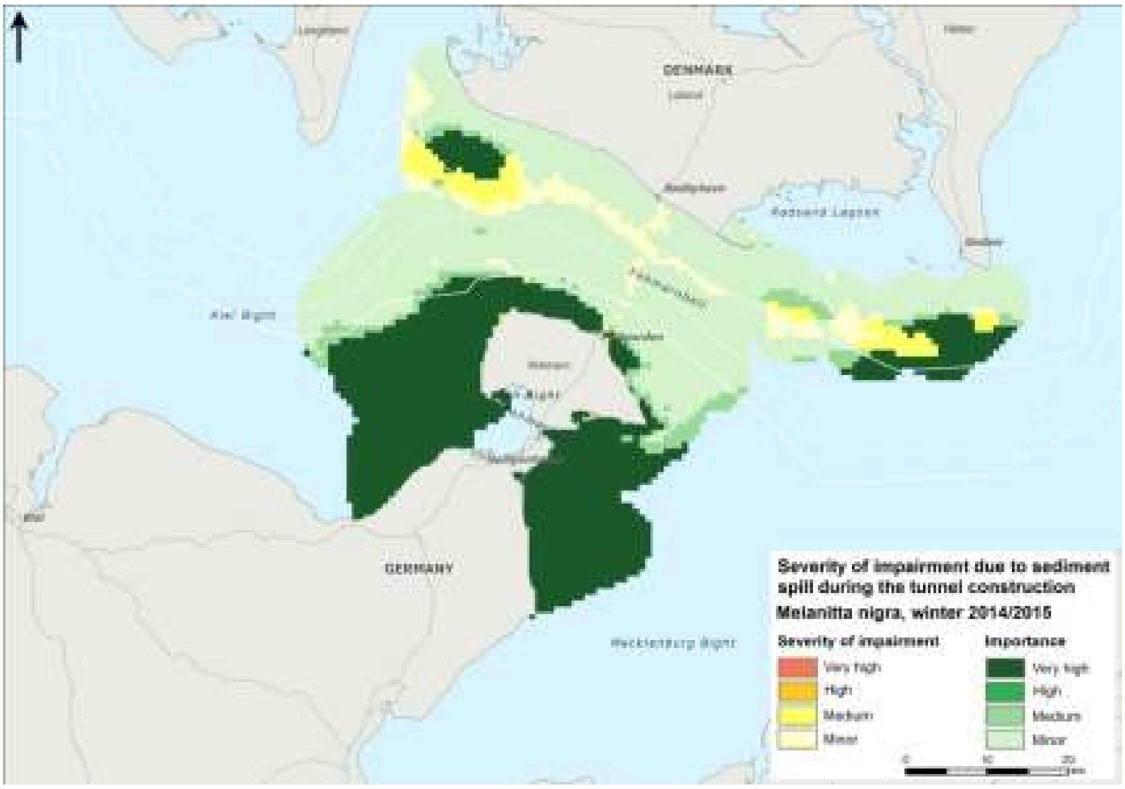


Figure 9.34 Severity of impairment from the pressure 'habitat change from sediment spill' (indirect effect of sedimentation, suspended sediments and reduction in mussel biomass) to Common Scoters in the first winter of the tunnel construction (2014/2015).

Considering potentially affected bird numbers (57 individuals or less than 0.01% of the biogeographic population), the severity of impairment of habitat change from the sediment spill is assessed as minor for Common Scoters.

Velvet Scoter

Velvet Scoter is not an abundant species in the Fehmarnbelt with estimated numbers of up to 3,050 birds (FEBI 2013). Based of mostly offshore distribution of Velvet Scoters and diet predominantly consisting of infaunal bivalves (Durinck et al. 1993, 1994, Žydelis 2002, FEBI 2013) it was assumed that this species relies mostly on the following benthic communities as described in FEMA (2013b) assessment: *Arctica*, *Bathyporeia*, *Cerastoderma*, *Corbula* and *Tanaissus*.

Because it is not known at what proportion the above listed benthic communities are used by the Velvet Scoters, the degree of impairment on birds was assessed considering a benthic community that was affected by the highest percentage within a particular category of the degree of impairment.

No benthic communities were predicted to suffer a very high degree of impairment due to suspended sediments and sedimentation, and areas assessed as having high degree of impairment were very small and therefore considered as negligible when assessing affected bird numbers (FEMA 2013d; Table 9.16). Among benthic communities affected by medium degree of impairment, the *Cerastoderma* community was affected to the highest degree accounting for 1.1% of its area, the figure which was used to estimate numbers of affected Velvet Scoters. It was assumed that medium degree of impairment of a benthic community corresponds to 10% reduction in bird numbers using that community (Table 9.9). Consequently, number of Velvet Scoters was estimated to be reduced by 0.11% of their maximal abundance in the Fehmarnbelt, which corresponds to 3 individuals (Table 9.16). Minor degree of impairment of benthic communities was assumed not to result in any reduction in bird numbers. Therefore, the severity of impairment of habitat change from sediment spill is assessed as minor for the Velvet Scoter.

Table 9.16 Degree of impairment of relevant benthic communities due to suspended sediments and sedimentation from the tunnel construction and corresponding numbers of affected Velvet Scoters.

Degree of impairment of benthic communities	**Relevant benthic community**	**% of benthic community affected by suspended sediments**	**% of benthic community affected by sedimentation**	**Corresponding estimated reduction in bird numbers**
Very high	*Arctica* *Bathyporeia* *Cerastoderma* *Corbula* *Tanaissus*	0 0 0 0 0	0 0 0 0 0	0
High	*Arctica* *Bathyporeia* *Cerastoderma* *Corbula* *Tanaissus*	0 0 0 0 0	<0.01% <0.01% <0.01% <0.01% <0.01%	0
Medium	*Arctica* *Bathyporeia* *Cerastoderma* *Corbula* *Tanaissus*	0 0 0 0 0	0.6% 0 **1.1%** 0.1% 0.1%	3
Minor	*Arctica* *Bathyporeia* *Cerastoderma* *Corbula* *Tanaissus*	<0.01% 56% 27% 7% 1%	1.5% 7.6% 6.5% 14.3% 0.1%	No reduction in bird numbers

Considering the separately assessed decline of Blue Mussel biomass resulting from the tunnel construction activities (FEMA 2013c) it was assumed that bird abundance would decline at the same rate as Blue Mussels, when reduction exceeded 5% of the initial biomass. Since there is no detailed spatial information about Velvet Scoter distribution available, the number of affected birds was estimated to be low (less than 50 birds) based on the assessment of the more abundant Common Scoter (see above). Furthermore, Blue Mussels are rarely important as food for Velvet Scoters, which are considered being infauna specialists (Durinck et al. 1993, 1994, Žydelis 2002).

Common Goldeneye

Up to 6,400 Common Goldeneyes were estimated to winter in the Fehmarnbelt (FEBI 2013). Because the distribution of Common Goldeneyes was modelled over the entire Fehmarnbelt area, no benthic communities were excluded as irrelevant for this species, and the number of affected birds was estimated by overlaying bird distribution with maps representing degree of impairment of benthic communities due to suspended sediments and sedimentation.

Areas of benthic communities affected by high degree of impairment were very small and no Common Goldeneyes were estimated to occur there (FEMA 2013d;

Table 9.17). Thirty three Common Goldeneyes were estimated to occur in areas with medium degree of impairment, which, following the assessment criteria (Table 9.9), result in 3 individuals being affected. Therefore, the severity of impairment of habitat change from sediment spill is assessed as minor for Common Goldeneye.

Table 9.17 Degree of impairment of benthic communities due to suspended sediments and sedimentation from the tunnel construction and corresponding numbers of affected Common Goldeneye.

Degree of impairment of benthic communities	Relevant benthic community	Area of benthic communities affected by suspended sediments, km^2	Area of benthic communities affected by sedimentation, km^2	Corresponding estimated reduction in bird numbers
Very high	All benthic communities	0	0	0
High	All benthic communities	0	0.15	0
Medium	All benthic communities	5.46	17.37	3
Minor	All benthic communities	573.96	101.18	No reduction in bird numbers

Further, considering separately assessed decline of Blue Mussel biomass resulting from the tunnel construction activities (FEMA 2013c), the predicted mussel reduction was overlaid with average distribution of wintering Common Goldeneye as estimated from aerial survey data (Figure 9.35). It was assumed that bird abundance would decline at the same rate as Blue Mussels, when reduction exceeds 5% of the initial biomass. The impairment resulting from habitat changes affects mostly areas of minor importance to Common Goldeneye (Figure 9.35). Following this approach it was estimated that decline in Blue Mussel biomass would affect 2 Common Goldeneye.

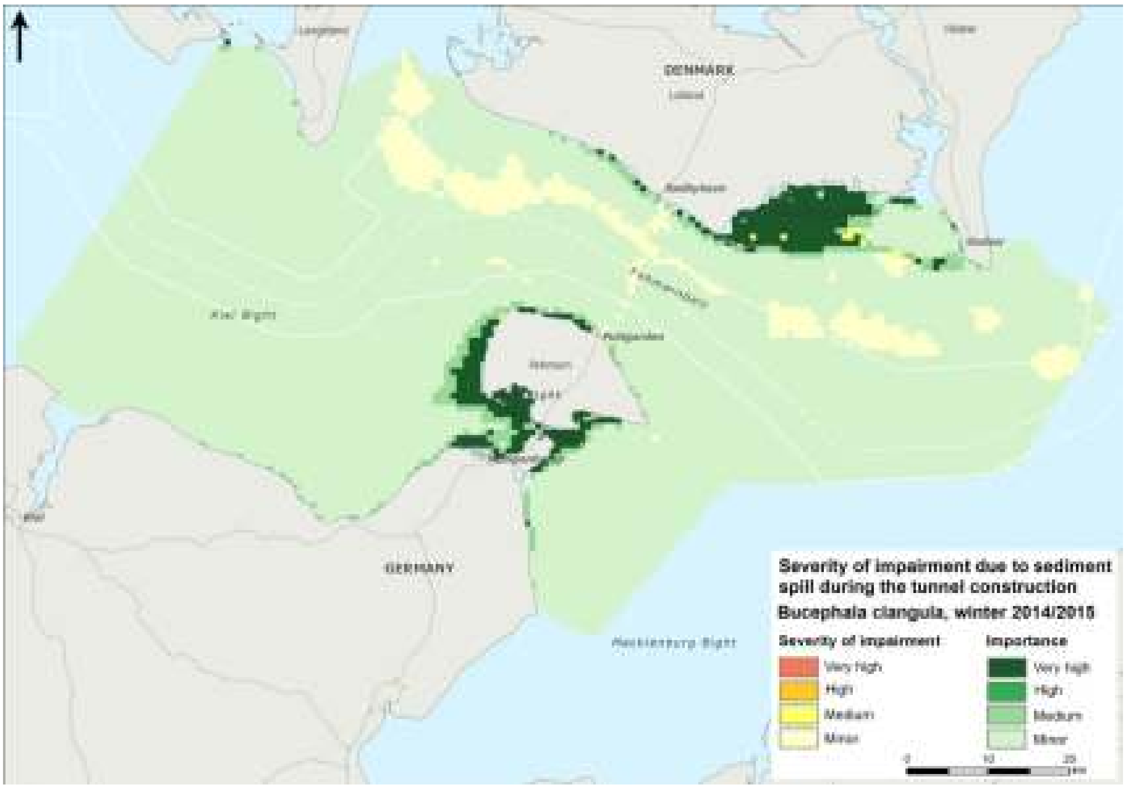


Figure 9.35 Severity of impairment from the pressure 'habitat change from sediment spill' (indirect effect of sedimentation, suspended sediments and reduction in mussel biomass) to Common Goldeneye in the first winter of the tunnel construction (2014/2015.

Considering potentially affected bird numbers (5 individuals or less than 0.01% of the biogeographic population), the severity of impairment of habitat change from the sediment spill is assessed as minor for Common Goldeneye.

Common Coot

Common Coot is frequent in the Fehmarnbelt area with numbers peaking during migration periods and mid-winter. Maximum counts revealed 8,500 birds on the Danish coast, mostly Rødsand Lagoon and Guldborgsund, and 6,500 birds on the German coast of the Fehmarnbelt. This species was mostly observed in sheltered coastal areas and lagoons. The Common Coot is an omnivorous bird, which can forage employing a variety of feeding techniques. However its diet consists primarily of vegetative matter (Cramp and Simmons 1980, Perrow et al. 1997). Common Coot typically feeds in waters less than 2 m deep (Perrow et al. 1997). Considering its diet flexibility and foraging habitat restricted to shallow waters, no negative impact on Common Coot is expected, as FEMA predicts only minimal impact of suspended sediments on aquatic vegetation in shallow areas (Figure 9.28, FEMA 2013d) and only minor impact is predicted for larger and more abundant Mute Swans (see section on Mute Swan above). Therefore, the severity of impairment on Common Coot is assessed as minor.

Other species

For other non-breeding waterbird species the impact from habitat change from sediment spill is assessed to be of minor severity of impairment due to either minor importance of the area to the species or birds occurring in the impairment zone are predicted to be of minor sensitivity to this pressure.

Overall assessment of the severity of impairment

Overall, it is assessed that habitat change from sediment spill during the tunnel construction would cause only minor degree of impairment for non-breeding waterbirds, affecting only very small numbers of a few species (Table 9.18). Therefore, the overall severity of impairment is assessed as minor.

Table 9.18 Assessment of the severity of impairment from sediment spill on non-breeding waterbirds.

Species	Displaced individuals	% of biogeo-graphic pop.	Severity of impairment
Mute Swan	low number	<0.1%	Minor
Whooper Swan	low number	<0.1%	Minor
Greylag Goose	low number	<0.1%	Minor
Brent Goose	low number	<0.1%	Minor
Eurasian Wigeon	low number	<0.1%	Minor
Common Pochard	7	<0.01%	Minor
Tufted Duck	63	<0.01%	Minor
Greater Scaup	25	<0.01%	Minor
Common Eider	610	0.08%	Minor
Long-tailed Duck	33	<0.01%	Minor
Common Scoter	57	<0.01%	Minor
Velvet Scoter	low number	<0.01%	Minor
Common Goldeneye	5	<0.01%	Minor
Common Coot	low number	<0.1%	Minor
Other species	low number	<0.1%	Negligible/Minor

Migrating birds

This pressure is assessed to be irrelevant for migrating birds.

Duration of impact

The duration of the impact of the pressure 'habitat change from sediment spill' depends on recovery times of the prey communities that birds are relying on (benthic flora and fauna, fish communities; see also Table 9.22 in chapter 9.3.1). Re-established areas offering suitable habitats for waterbirds are considered to be used by birds without any additional lag period.

9.2.3 Water transparency

Description of the pressure

The amounts of sediment spilled during the sequence of immersed tunnel construction activities involving the handling of dredged material are described in chapter 9.2.2 (Figure 9.36). The spill material is suspended, settling and under given conditions resuspended from the seabed depending on the grain size of the material and a range of hydrodynamic factors. For a detailed description of the predicted sediment spill and resulting distribution of suspended matter in various grain sizes, reference is made to the FEHY report on sediment spill (FEHY 2013a).

Figure 9.36 Example of sediment plume resulting from dredging works during the construction works of the offshore wind farm Nysted II. Photo: Martin Laczny.

The suspended material increases the light attenuation in the water column thereby reducing the light intensity in the water column. The light attenuation properties of the suspended matter in various grain sizes originating from the bottom materials dredged have been determined based on measurements and laboratory experiments determining the optical properties of the spill material (FEMA 2013c).

The optical properties of the material dredged during the immersed tunnel construction activities have been used to calculate the potential impact of suspended spill material on the light conditions in Fehmarnbelt, quantified as a reduction of the Secchi depths. The baseline Secchi depths and the variation in time and space of the potential effect of spilled material on Secchi depths have been incorporated into the ecological models established for the Fehmarnbelt (FEMA 2013c). A sample result of the calculated reductions in mean Secchi depth during the two first winters of immersed tunnel construction is shown in Figure 9.37.

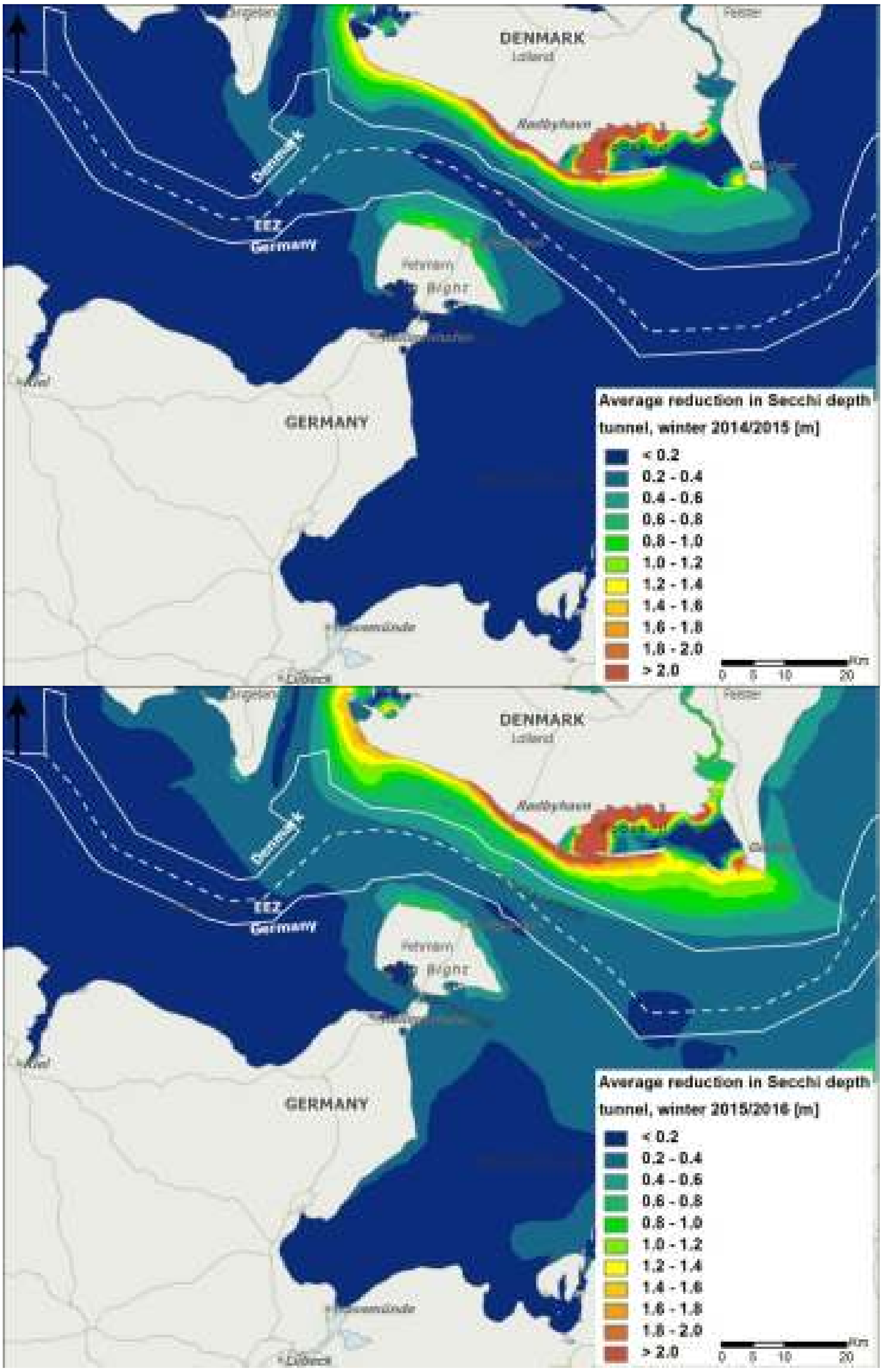


Figure 9.37 Average reduction in Secchi depth during the winter period (November-March) during 1st and 2nd winter of construction of the immersed tunnel (2014/2015 and 2015/2016).

The reductions in Secchi depth during winter periods 2014/2015 and 2015/2016 shown in Figure 9.37 would mainly be caused by resuspension of spilled sediments that have accumulated on the bottom during the construction period. The reductions in average Secchi depths range from no reduction in the deepest areas up to more than 2 meters along the coast of Lolland and parts of Rødsand Lagoon.

Fluctuations in Secchi depth, frequency and duration of different conditions are possibly more important characteristics to wintering waterbirds than simple average seasonal value representing water transparency. As described in chapter 4.6.1, even under natural (baseline) conditions Secchi depth varies within a rather broad range. Occurrence of reduced water transparency is predicted to increase during the period of the tunnel construction (Figure 9.38). Considering the Secchi depth threshold of 3.74 m as defined in chapter 4.6.1, the occurrence of reduced transparency relative to the baseline conditions would be most pronounced during the first and second winters of the tunnel construction (Figure 9.39, Figure 9.40), would be limited to the western end of Rødsand Lagoon during the third and fourth winter seasons (Figure 9.41, Figure 9.42) and would return to conditions similar to the baseline during the last year of the construction (Figure 9.43).

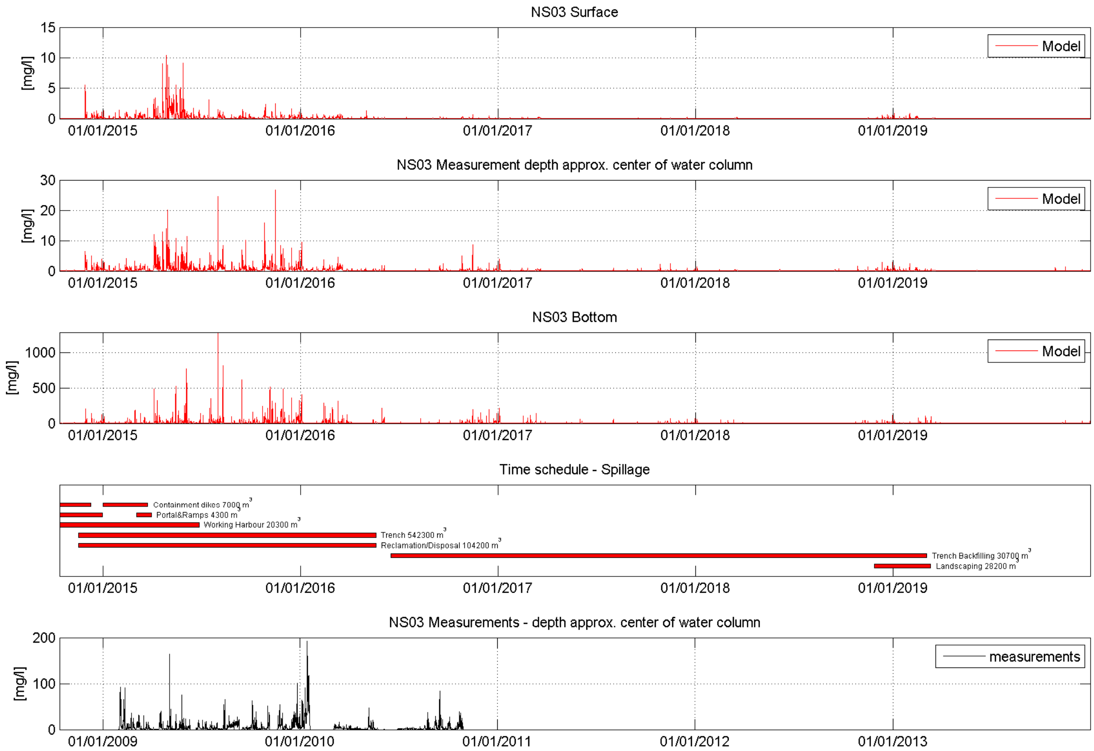


Figure 9.38 Time series of spilled suspended sediment at station NS03 near Rødbyhavn in three depths along with dredging schedule. The bottom panel shows the baseline suspended sediment concentration monitored in 2009-2010 (FEHY 2013a).

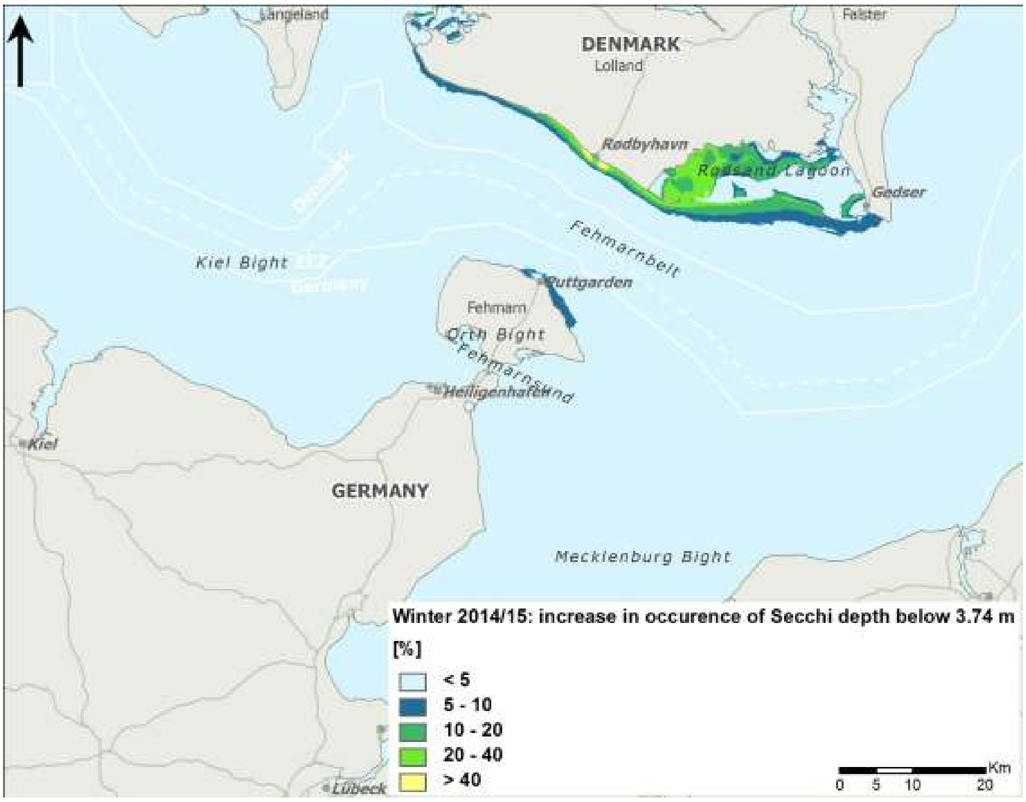


Figure 9.39 Modelled difference in occurrence of Secchi depth below 3.74 m during the first winter (2014/2015) of the immersed tunnel construction relative to the baseline conditions (calculated by subtracting baseline from the tunnel construction scenario).

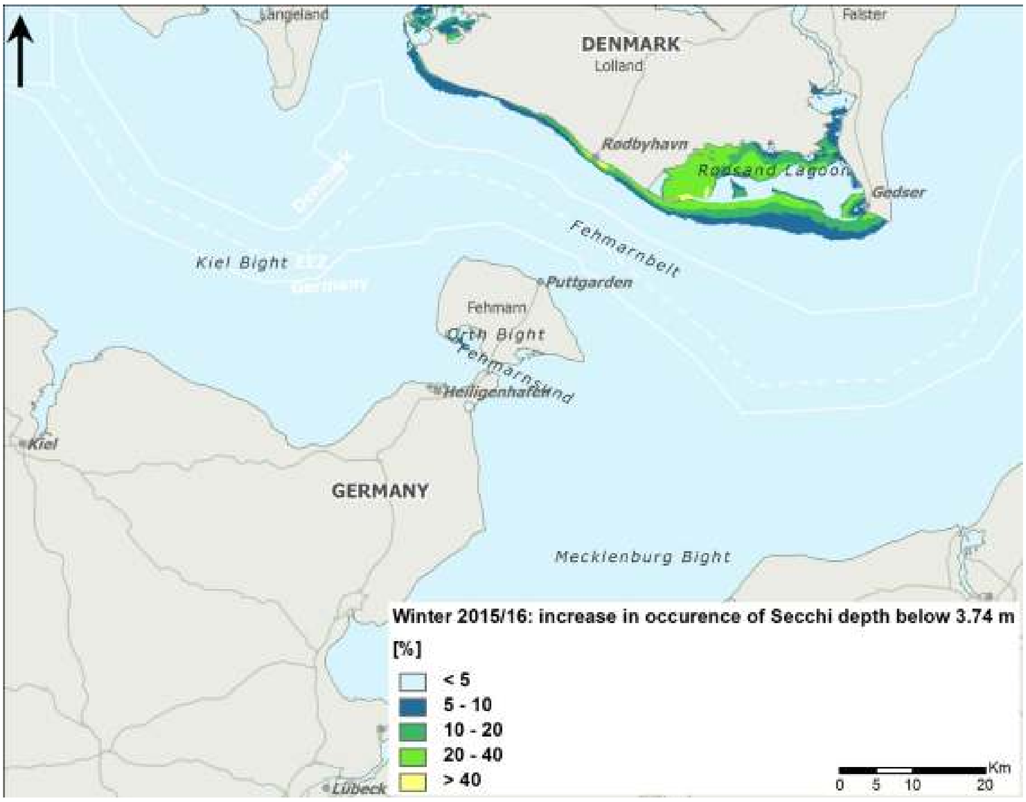


Figure 9.40 Modelled difference in occurrence of Secchi depth below 3.74 m during the second winter (2015/2016) of the immersed tunnel construction relative to the baseline conditions (calculated by subtracting baseline from the tunnel construction scenario).

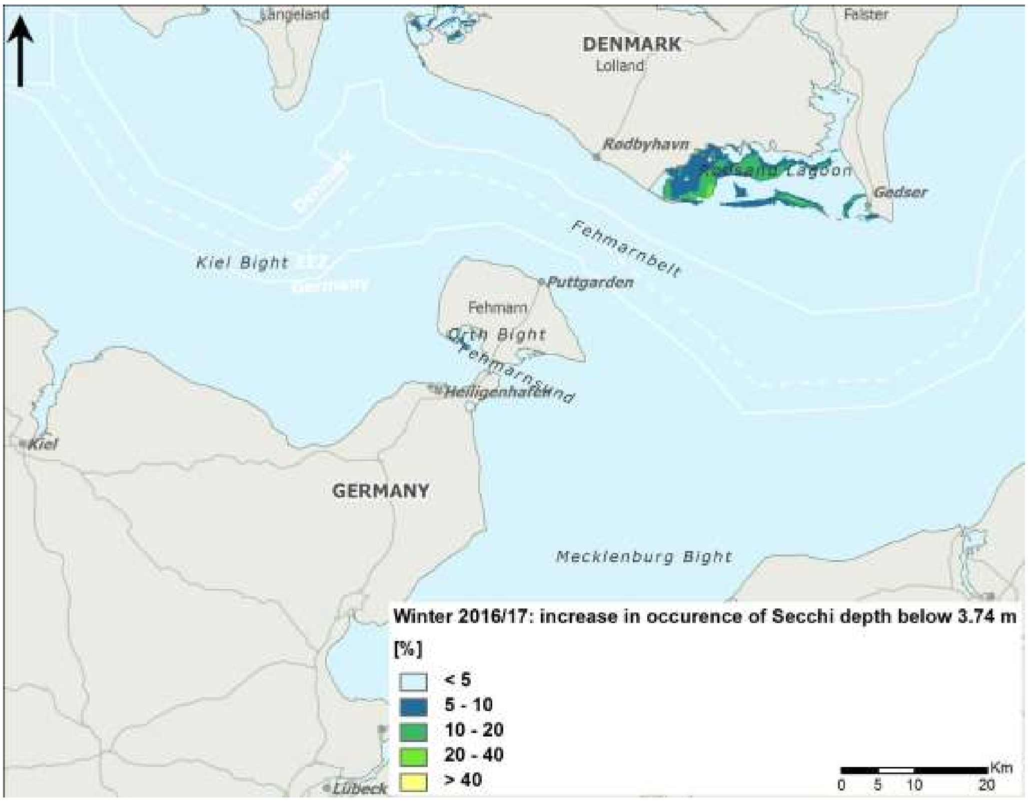


Figure 9.41 Modelled difference in occurrence of Secchi depth below 3.74 m during the third winter (2016/2017) of the immersed tunnel construction relative to the baseline conditions (calculated by subtracting baseline from the tunnel construction scenario).

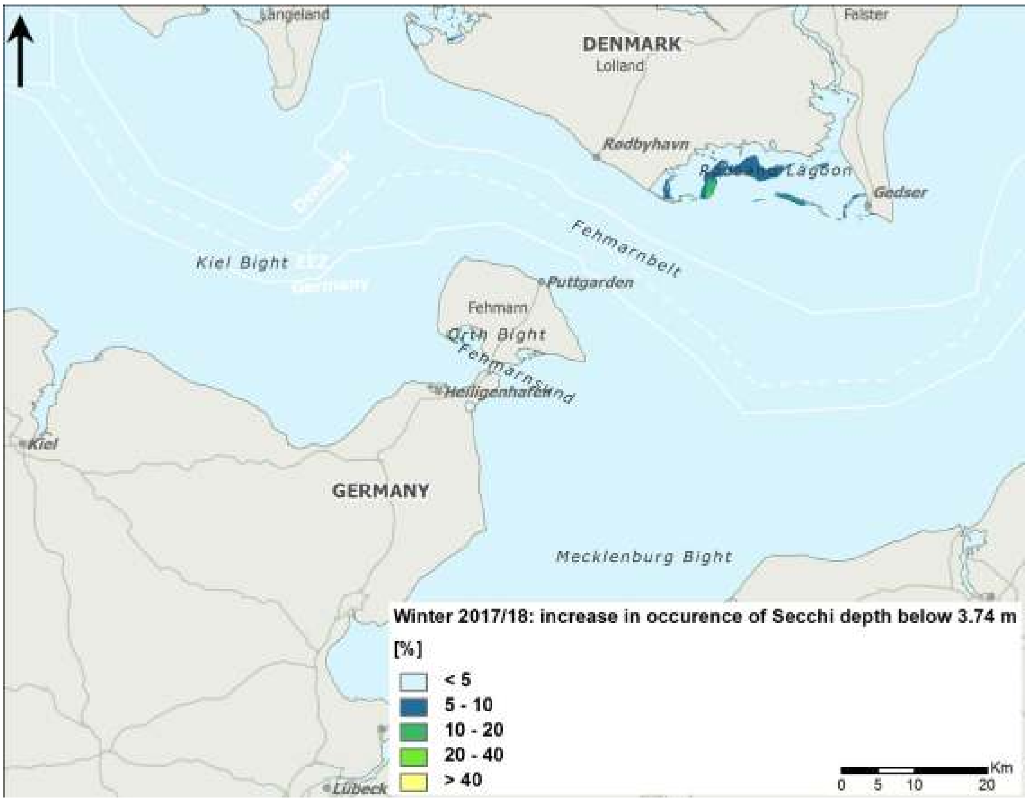


Figure 9.42 Modelled difference in occurrence of Secchi depth below 3.74 m during the fourth winter (2017/2018) of the immersed tunnel construction relative to the baseline conditions (calculated by subtracting baseline from the tunnel construction scenario).

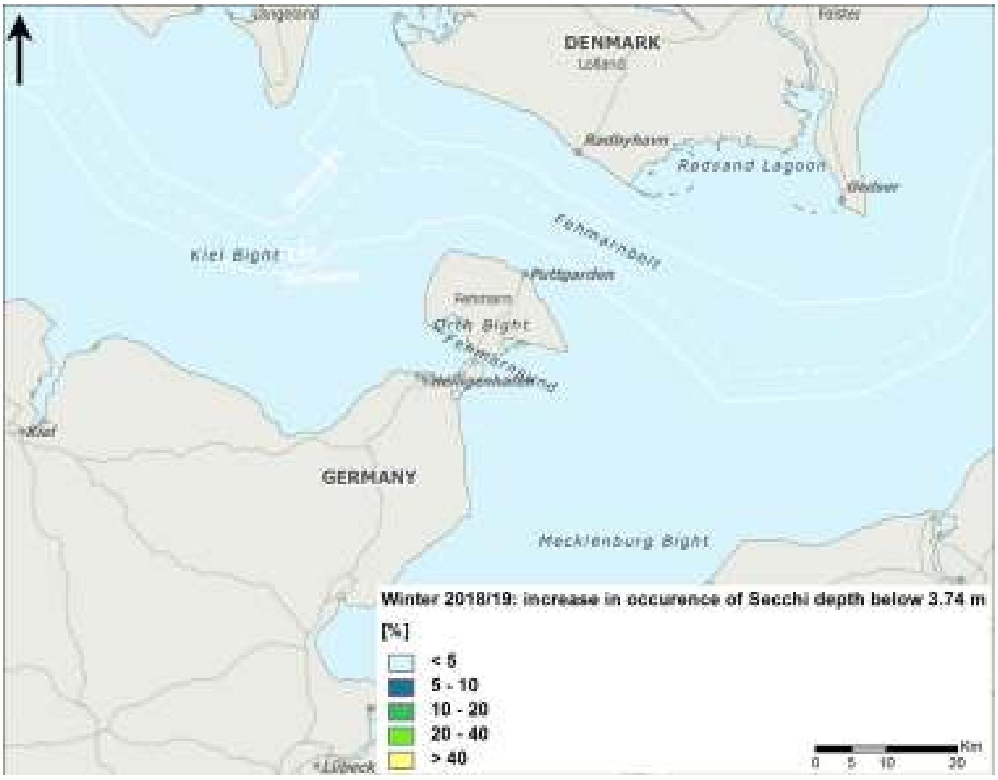


Figure 9.43 Modelled difference in occurrence of Secchi depth below 3.74 m during the fifth winter (2018/2019) of the immersed tunnel construction relative to the baseline conditions (calculated by subtracting baseline from the tunnel construction scenario).

Similarly to the winter period, the occurrence of reduced water transparency relative to the baseline conditions during the summer season would be most pronounced during the first and second summers of the tunnel construction (Figure 9.44, Figure 9.45), would be small and restricted to Rødsand Lagoon during the third summer of 2017 (Figure 9.46) and would return to conditions similar to the baseline during the subsequent years of the construction.

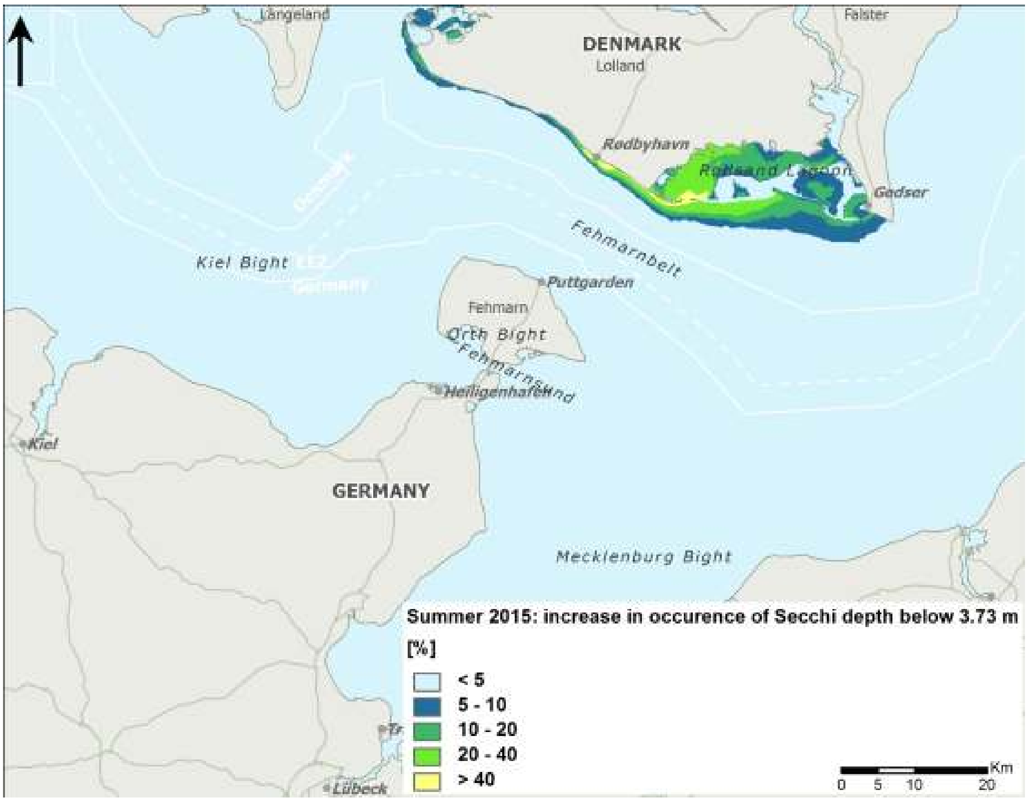


Figure 9.44 Modelled difference in occurrence of Secchi depth below 3.73 m during the first summer (2015) of the immersed tunnel construction relative to the baseline conditions (calculated by subtracting baseline from the tunnel construction scenario).

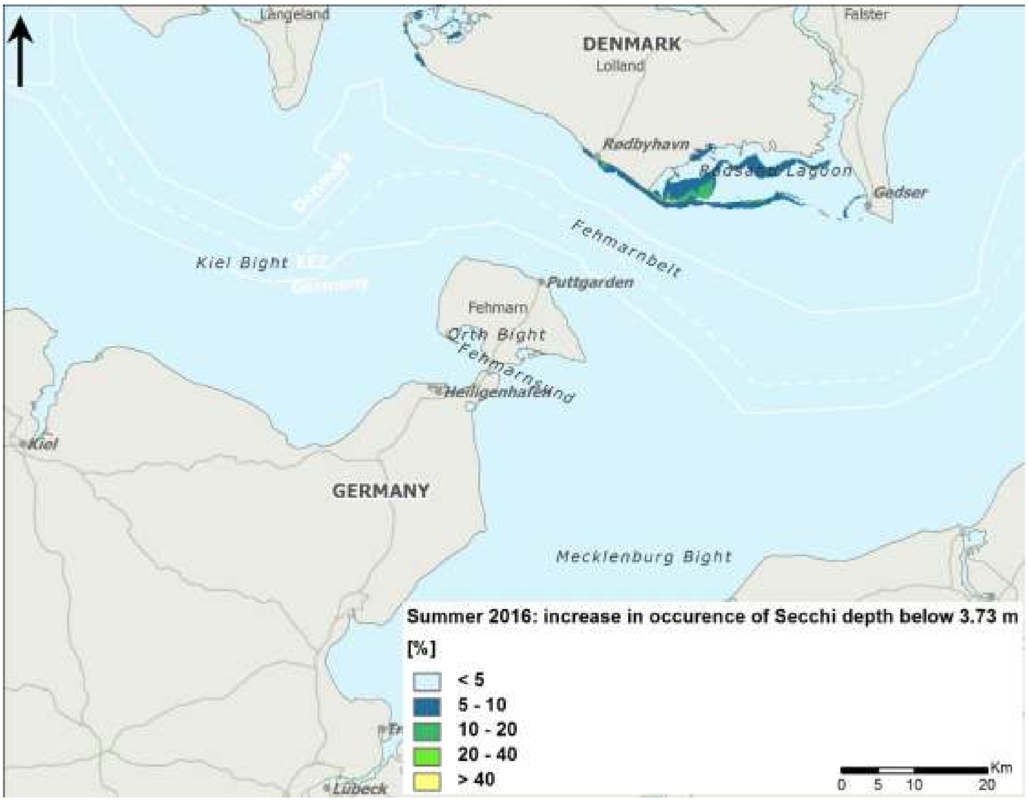


Figure 9.45 Modelled difference in occurrence of Secchi depth below 3.73 m during the second summer (2016) of the immersed tunnel construction relative to the baseline conditions (calculated by subtracting baseline from the tunnel construction scenario).

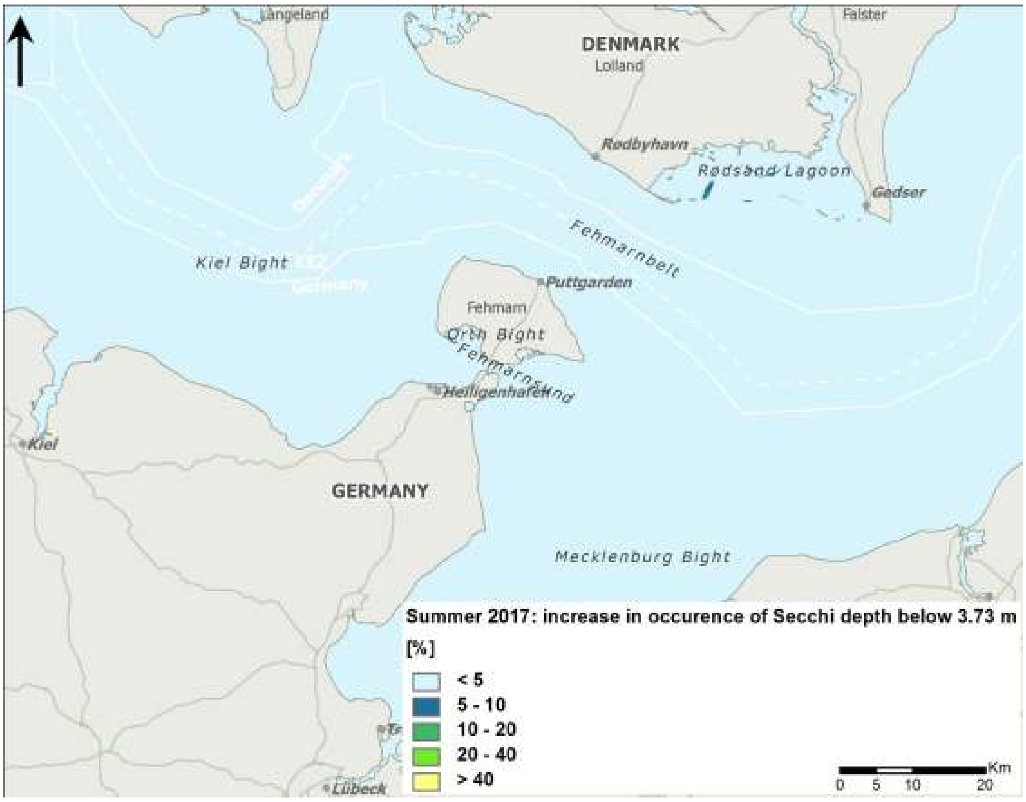


Figure 9.46 Modelled difference in occurrence of Secchi depth below 3.73 m during the third summer (2017) of the immersed tunnel construction relative to the baseline conditions (calculated by subtracting baseline from the tunnel construction scenario).

Degree of impairment

Considering the sensitivity of waterbird species to reduced water transparency and due to uncertainties in predicting the proportion of birds being displaced from this pressure the assessment has been based on an assumed complete displacement of birds from the impairment zone (i.e. very high degree of impairment; see chapter 4.5.14). The determination of threshold levels of water transparency and the resulting range of the pressure (impairment zone) for sensitive species are described in chapter 4.6.1.

Severity of impairment

Breeding waterbirds

Reduced water transparency during the summer period is anticipated only on the Danish side of the Fehmarnbelt and only during the first two years of construction works (Figure 9.44, Figure 9.45). Therefore, reduced transparency impacts on relevant species of breeding waterbirds are assessed only for birds using the Danish part of the Fehmarnbelt.

Red-necked Grebe

There are no Red-necked Grebes breeding within the SPA Hyllekrog-Rødsand, so there is no impact predicted from water transparency changes to be assessed to this species breeding within Natura 2000 areas. The situation is different for breeding pairs on Lolland breeding outside Natura 2000 areas. Although Red-necked Grebes nest on inland lakes and ponds, adult birds often fly to forage in marine coastal waters during the breeding season. Twenty-one pairs of Red-necked Grebes were recorded nesting in the coastal area of Lolland in the vicinity of

Rødbyhavn (COWI 2011). Assuming that all breeding adults would fly the shortest distance to marine waters, all of them (42 individuals) would potentially encounter conditions with decreased water transparency during the first summer (2015) of the tunnel construction. Considering the predicted decrease in water transparency during summers of the tunnel construction, fewer birds would be affected during the second summer (2016), and none during the subsequent years. The assessment of the severity of impairment to Red-necked Grebes breeding on Lolland is part of the Impact Assessment of Lolland land areas.

Red-breasted Merganser
According to Natura 2000 monitoring, 9 pairs of Red-breasted Mergansers bred in the SPA Rødsand-Hyllekrog in 2009 (Miljøcenter 2010), and no breeders of this species were recorded in other areas of Lolland (COWI 2011). After hatching, the adults take their chicks to the sea and stay in shallow water. Because 6 out of 9 breeding pairs were recorded in the northern and eastern part of the lagoon where no major changes in water transparency are predicted (Figure 9.44, Figure 9.45, Figure 9.46) it was assumed that only pairs breeding in the turbid areas would be affected from this pressure, i.e. 3 pairs in the first summer (2015) of the tunnel construction, and 2 pairs during the second summer (2016). No impairment is predicted for the subsequent seasons. Due to low numbers of affected birds, the severity of impairment is assessed as being minor in all breeding seasons during the tunnel construction.

Other species
For other breeding waterbird species breeding in Natura 2000 areas the impact from decreased water transparency is assessed to be of minor severity of impairment due to either minor importance of the area to the species or birds occurring in the disturbance zone are predicted to be of minor sensitivity to this pressure.

Overall assessment of the severity of impairment
The severity of impairment from habitat change from sediment spill is assessed to be minor for all waterbirds breeding in Natura 2000 areas. The Impact Assessment on Red-necked Grebes breeding outside Natura 2000 areas on Lolland is part of the Impact Assessment for land areas on Lolland.

Non-breeding waterbirds

Divers (Red-throated / Black-throated Diver)
Literature information does not suggest water transparency thresholds for divers but infers that it might be an important factor when choosing habitats (see chapter 7.2.3). Therefore, the determined threshold of 3.74 m was used for the Impact Assessment on these species.

By overlaying average distribution of wintering divers with maps representing a decrease in water transparency below the threshold of 3.74 m during different years of the tunnel construction (Figure 9.47, Appendix I), it was predicted that changes in water transparency would result in a displacement of 30 divers from the impairment zone during the first winter of the tunnel construction, 32 birds during the second and lower numbers during subsequent seasons (Figure 9.48). Based on numbers of displaced individuals the severity of impairment for Red-throated and Black-throated Divers is assessed as minor during all years of the tunnel construction (Table 9.19), though for areas within and south of Rødsand Lagoon mostly high severity of impairment is assessed for the first two years of construction (Figure 9.47, Appendix I).

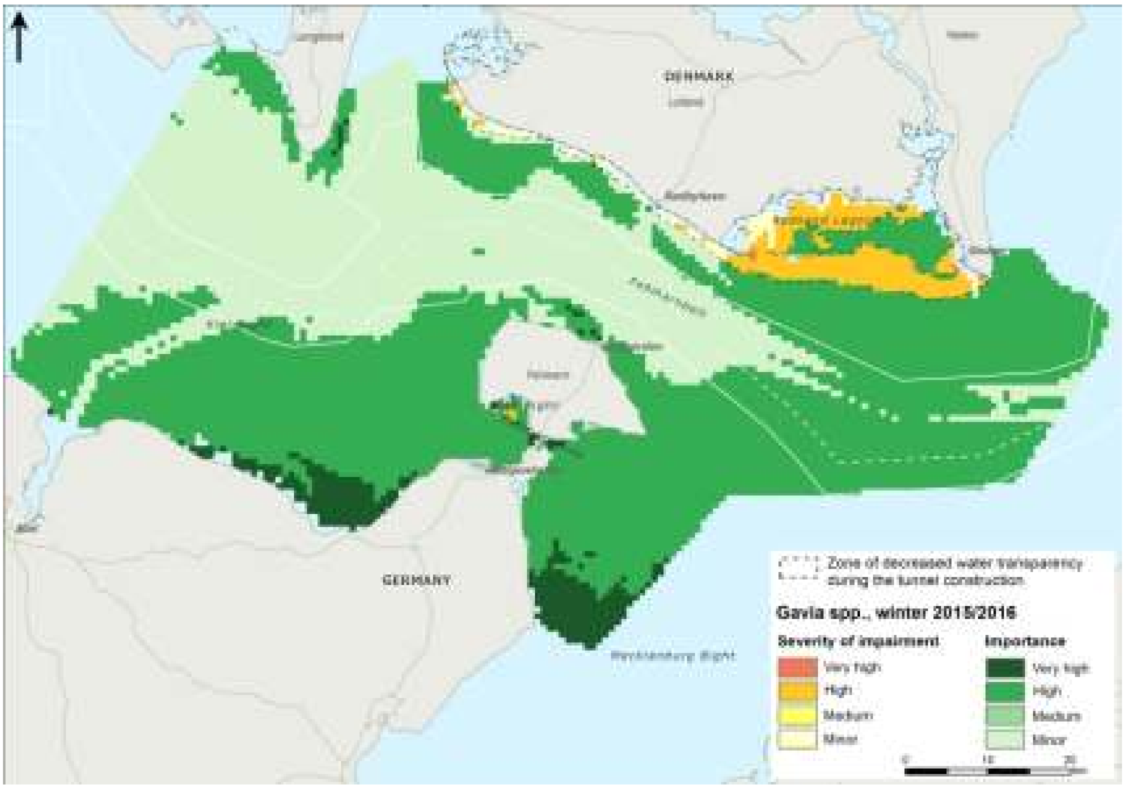


Figure 9.47 *Severity of impairment from the pressure 'decreased water transparency' to divers (Red-throated Diver and Black-throated Diver) from tunnel construction in the winter of the highest impact (second winter of construction 2015/2016).*

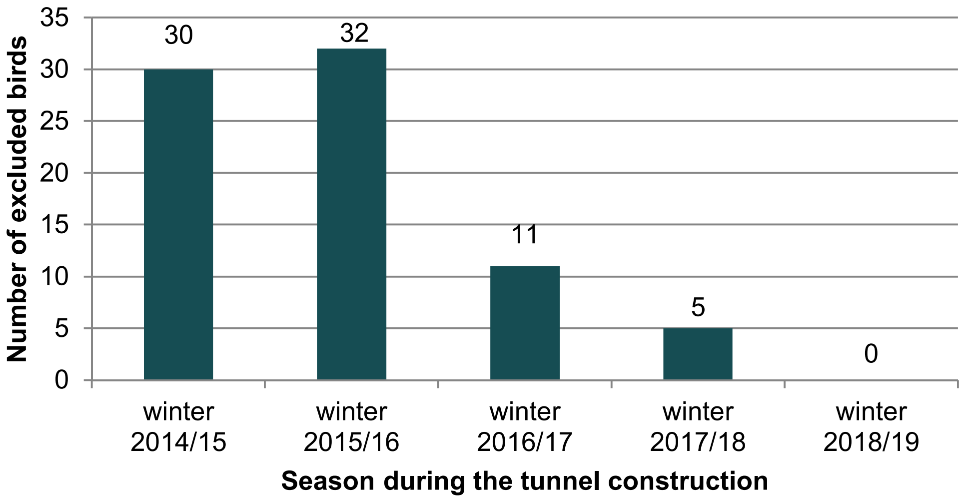


Figure 9.48 *Estimated numbers of Red-throated and Black-throated Divers that would be displaced due to decreased water transparency in different winter seasons during the tunnel construction.*

Red-necked Grebe

Since there are no literature sources analysing the sensitivity of Red-necked Grebes to water transparency, the determined threshold of 3.74 m was used for the Impact Assessment.

The overlaying of modelled distribution of wintering Red-necked Grebes with maps representing a decrease in water transparency below the threshold of 3.74 m during different years of tunnel construction, indicate the coastal areas of Lolland and south of Rødsand Lagoon locally being affected by very high severity of impairment (Figure 9.49, Appendix I). Using the modelled distribution of Red-necked Grebe of winter 2008/2009 (when these birds were substantially more abundant than in the next winter) it is predicted that changes in water transparency would result in a displacement of 60 individuals from impaired areas during the first winter, and 69 birds during the second winter of the tunnel construction (Figure 9.50). The distribution of this species has been modelled using ship-based survey data, which did not cover Rødsand Lagoon, where decrease of water transparency is expected to be the highest. However, supplementary information from DOF database (DOF 2010) suggests that only single individuals of this species occur in the lagoon in winter (FEBI 2013). Therefore, the severity of impairment for Red-necked Grebes is assessed as minor for all years of the tunnel construction (Table 9.19).

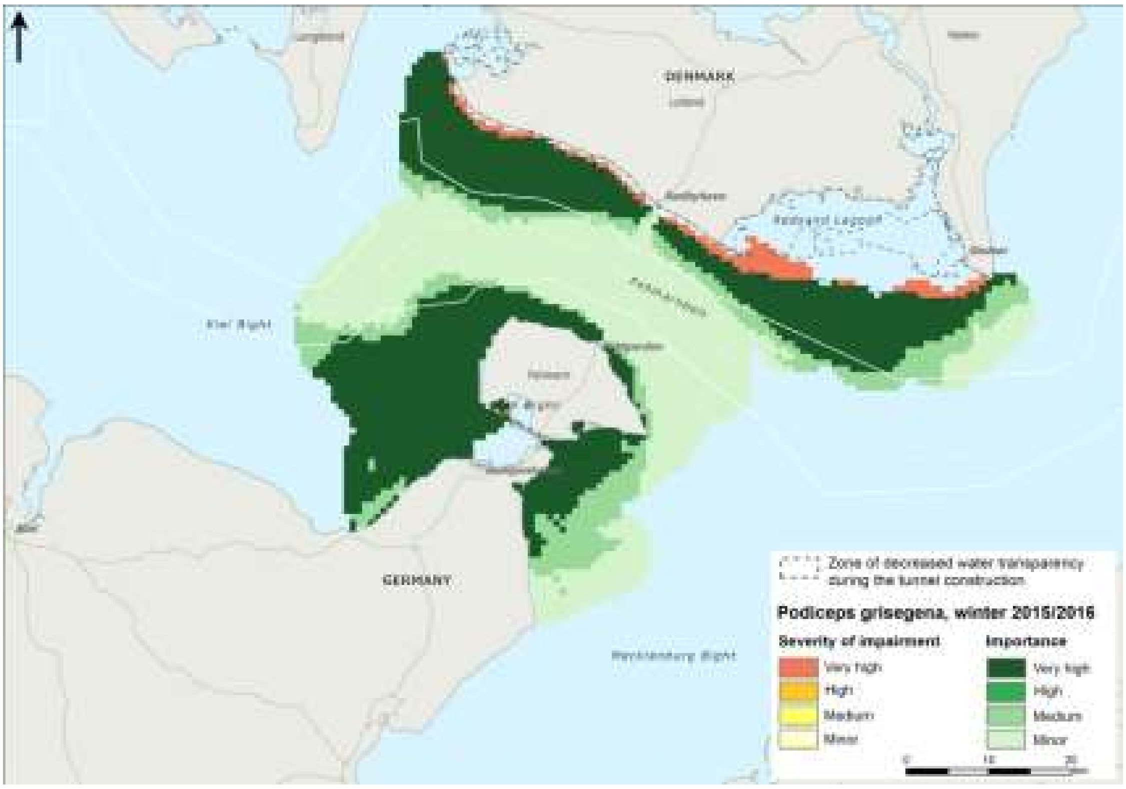


Figure 9.49 Severity of impairment from the pressure 'decreased water transparency' to Red-necked Grebe from tunnel construction in the winter of the highest impact (second winter of construction 2015/2016).

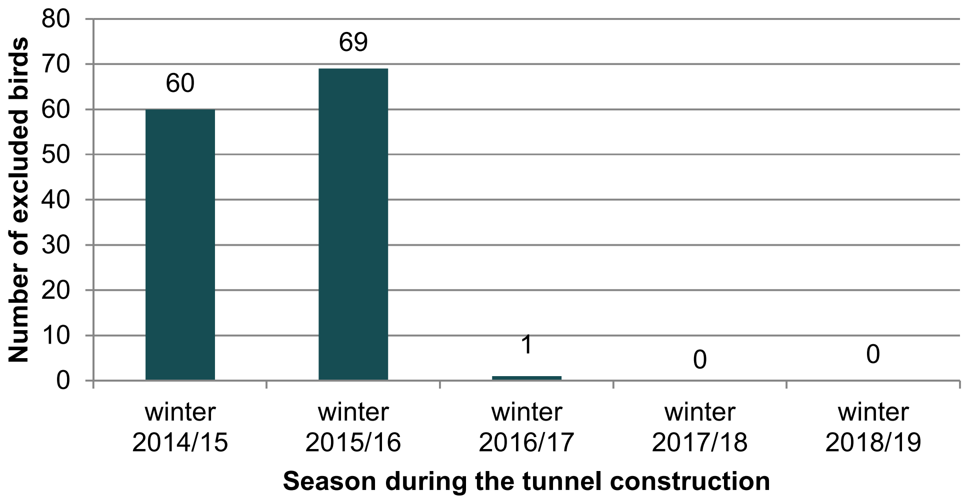


Figure 9.50 Estimated numbers of Red-necked Grebes that would be displaced due to decreased water transparency in different winter seasons during the tunnel construction (in the area covered by ship surveys, i.e. not including Rødsand Lagoon).

Common Eider

There are no literature sources analysing the sensitivity of Common Eiders to water transparency. Therefore, the determined threshold of 3.74 m was used for the Impact Assessment.

The overlaying of modelled distribution of wintering Common Eiders with maps representing a decrease in water transparency below the threshold of 3.74 m during different years of tunnel construction, indicate the coastal areas of Lolland and Rødsand Lagoon being affected by mostly very high severity of impairment (Figure 9.51, Appendix I). Using the modelled distribution of Common Eider of winter 2009/2010, which represents season with substantially higher abundance of this species during the two years of the baseline study, it is predicted that changes in water transparency would result in a displacement of 8,823 Common Eiders from the impairment zone during the first winter of the tunnel construction, 8,325 during the second winter and lower numbers during the subsequent seasons (Figure 9.52). The severity of impairment for Common Eider has been assessed as very high during the first and second winters of the tunnel construction (2014/2015 and 2015/2016 respectively), medium during the third winter (2016/2017) and minor during the following years (Table 9.19).

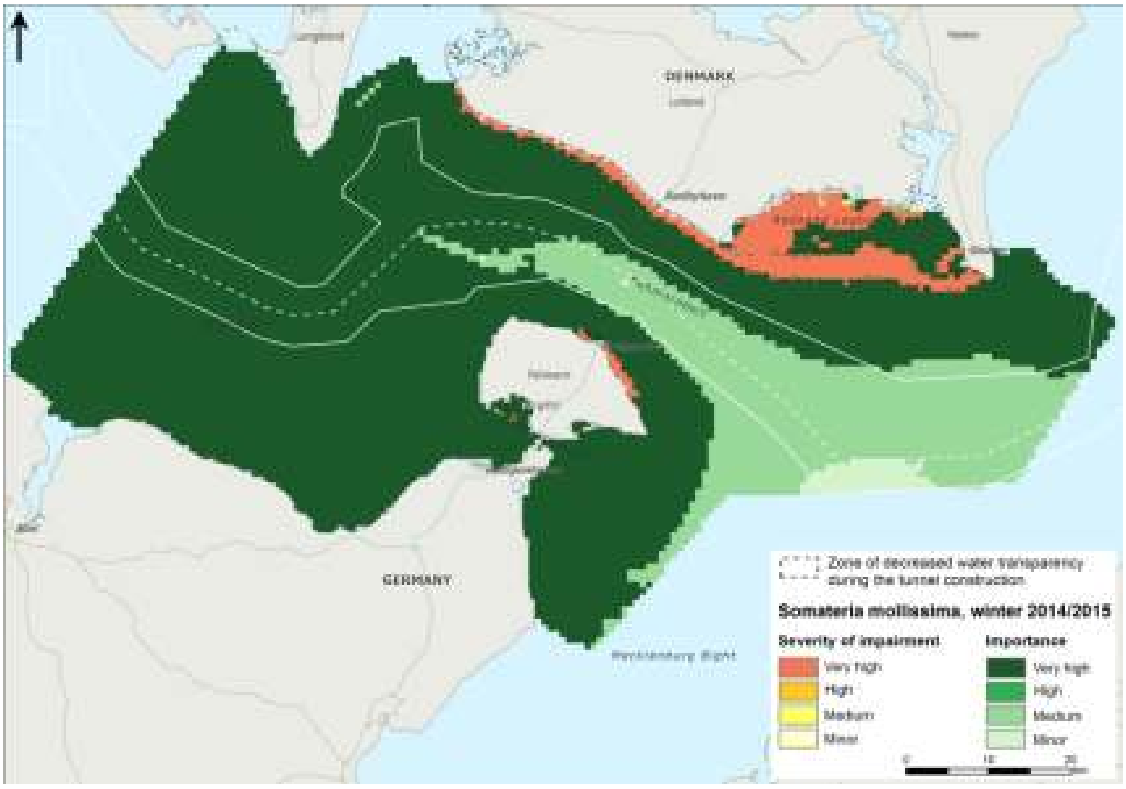


Figure 9.51 Severity of impairment from the pressure 'decreased water transparency' to Common Eider from tunnel construction in the winter of the highest impact (first winter of construction 2014/2015).

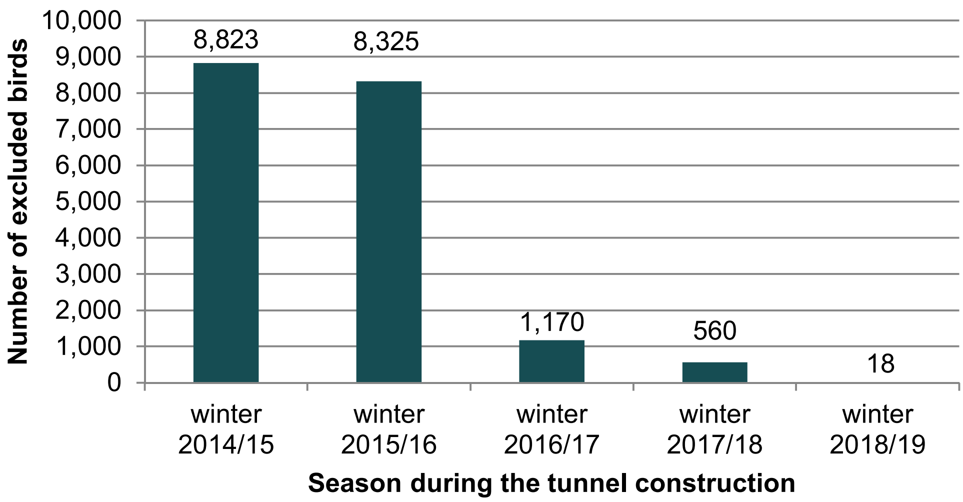


Figure 9.52 Estimated numbers of Common Eiders that would be displaced due to decreased water transparency in different winter seasons during the tunnel construction.

Long-tailed Duck

Since there are no literature sources analysing sensitivity of Long-tailed Ducks to water transparency, the determined threshold of 3.74 m was used for the Impact Assessment.

The overlaying of modelled distribution of wintering Long-tailed Ducks with maps representing a decrease in water transparency below the threshold of 3.74 m during different years of tunnel construction indicates locally minor to medium severity of impairment to Long-tailed Ducks in the coastal areas of Lolland and south of Rødsand Lagoon (Figure 9.53, Appendix I). Long-tailed Duck distribution modelled using ship-based survey data is considered to yield more reliable density estimates than distribution modelled using aerial surveys, however with a smaller spatial coverage not including Rødsand Lagoon (FEBI 2013) where decrease in water transparency is expected to be the highest. Subsequently, numbers of displaced birds in the Fehmarnbelt were estimated using species distribution modelled from ship-based data, and birds displaced in Rødsand Lagoon were estimated using distribution modelled from aerial survey data. It was predicted that changes in water transparency would result in a displacement of 543 Long-tailed Ducks during the first winter, 594 birds during the second winter, 279 birds during the third winter, and 112 birds during the fourth winter of the tunnel construction (Figure 9.54). Based on numbers of birds displaced due to decreased water transparency from the tunnel construction activities the severity of impairment for Long-tailed Duck is assessed as minor (Table 9.19).

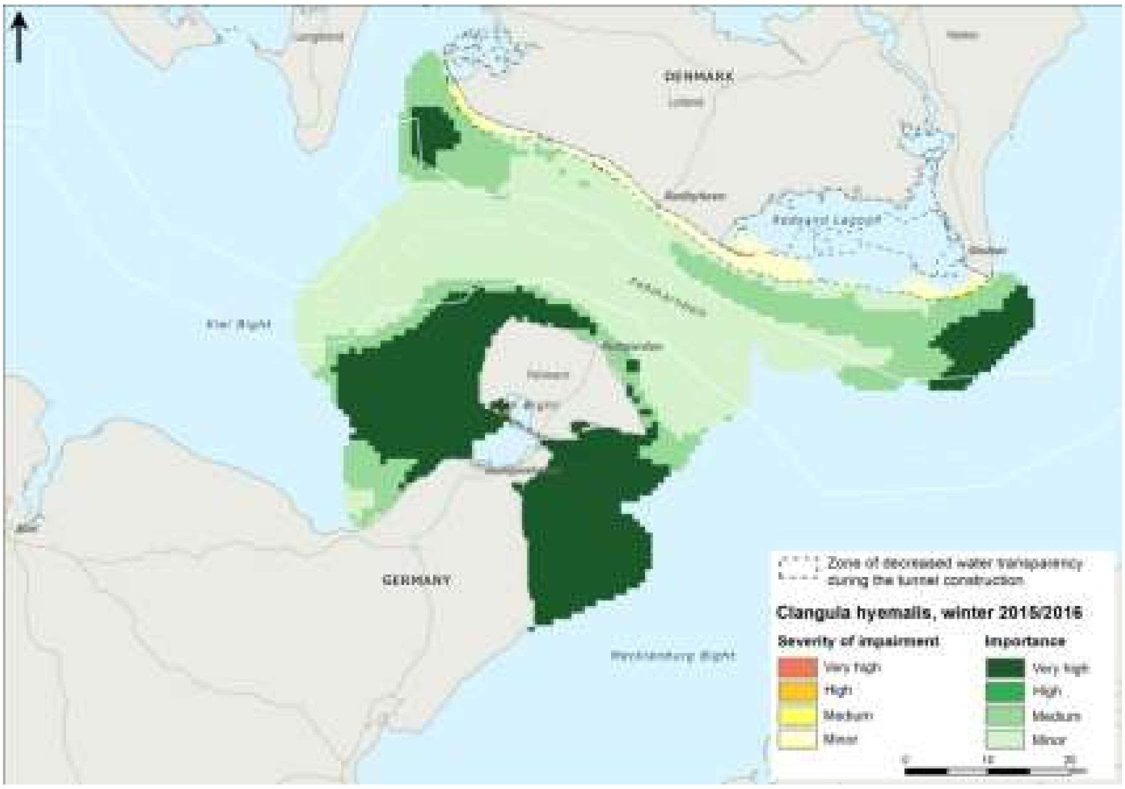


Figure 9.53 Severity of impairment from the pressure 'decreased water transparency' to Long-tailed Duck from tunnel construction in the winter of the highest impact (second winter of construction 2015/2016).

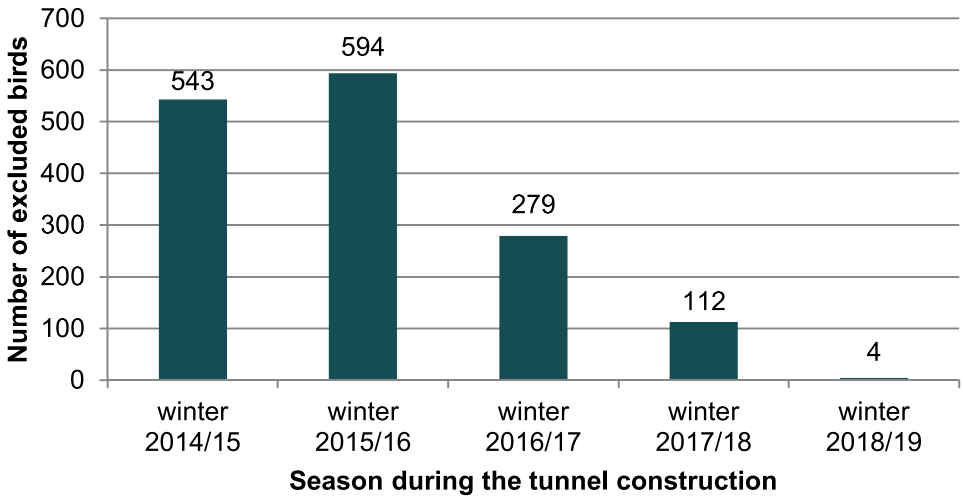


Figure 9.54 Estimated numbers of Long-tailed Ducks that would be displaced due to decreased water transparency in different winter seasons during the tunnel construction.

Common Scoter

No literature sources analysing sensitivity of Common Scoters to water transparency were found, therefore the determined threshold of 3.74 m was used for the Impact Assessment.

The overlaying of modelled distribution of wintering Common Scoter with maps representing a decrease in water transparency below the threshold of 3.74 m during different years of tunnel construction indicates mostly minor severity of impairment to Common Scoters in the coastal areas of Lolland and south of Rødsand Lagoon; a locally medium to very high severity of impairment is assessed for coastal areas of Fehmarn close to the alignment for the second year of construction (Figure 9.55, Appendix I). Common Scoter distribution modelled using ship-based survey data is considered to yield more reliable density estimates than distribution modelled using aerial surveys, however with a smaller spatial coverage not including Rødsand Lagoon (FEBI 2013) where decrease in water transparency is expected to be the highest. Subsequently, the numbers of displaced birds in the major area of the Fehmarnbelt were estimated using species distribution modelled using ship-based data, and birds displaced in Rødsand Lagoon were estimated using distribution modelled from aerial survey data. It was predicted that changes in water transparency would result in a displacement of 512 individuals from the impairment zone during the first winter of the tunnel construction, 173 birds during the second winter, and 118 birds during the third winter and lower numbers during the subsequent years (Figure 9.56). Based on numbers of birds displaced because of decreased water transparency from the tunnel construction, the severity of impairment for Common Scoter is assessed as minor (Table 9.19).

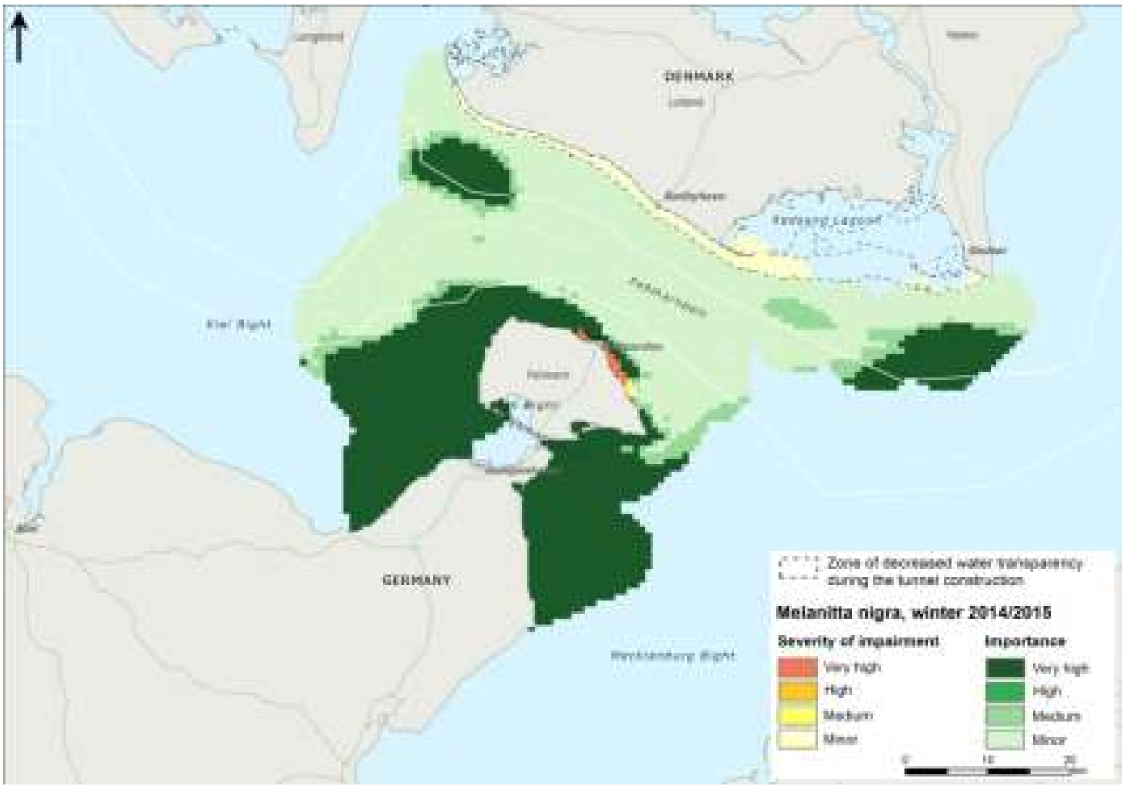


Figure 9.55 Severity of impairment from the pressure 'decreased water transparency' to Common Scoter from tunnel construction in the winter of the highest impact (first winter of construction 2014/2015).

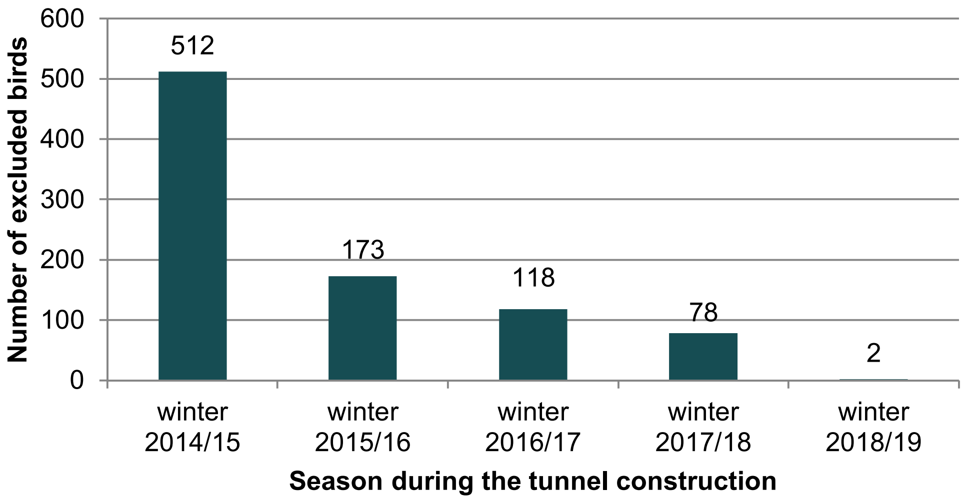


Figure 9.56 Estimated numbers of Common Scoters that would be displaced due to decreased water transparency in different winter seasons during the tunnel construction.

Velvet Scoter

Due to low numbers of this species in the Fehmarnbelt, no modelled spatial distribution maps are available, also no information about Velvet Scoter habitat choice in relation to water transparency was available. However, considering the mostly offshore distribution of this species (FEBI 2013), it is expected that only low numbers of Velvet Scoter would be displaced because of decreased water transparency during the tunnel construction. Therefore, the severity of impairment for this species has been assessed being minor.

Red-breasted Merganser

Since no literature sources analysing sensitivity of Red-breasted Mergansers to water transparency was found, the determined threshold of 3.74 m was used for the Impact Assessment.

The overlaying of modelled distribution of wintering Red-breasted Mergansers with maps representing a decrease in water transparency below the threshold of 3.74 m during different years of tunnel construction indicates locally very high severity of impairment to the species in the coastal areas of Lolland and south of Rødsand Lagoon (Figure 9.59, Appendix I). Red-breasted Merganser distribution modelled using ship-based survey data is considered to yield more reliable density estimates than distribution modelled using aerial surveys, however with a smaller spatial coverage not including Rødsand Lagoon (FEBI 2013) where decrease in water transparency is expected to be the highest. Subsequently, the numbers of displaced birds in the major area of the Fehmarnbelt were estimated using species distribution modelled from ship-based data, and birds displaced in Rødsand Lagoon were estimated using distribution modelled from aerial survey data. It was predicted that changes in water transparency would result in a displacement of 866 individuals from the impairment zone during the first winter, and 892 birds during the second winter, and lower numbers during following winters during the tunnel construction period (Figure 9.60). Based on affected bird numbers the severity of impairment for Red-breasted Merganser has been assessed as medium for the first two winters of the tunnel construction (2014/2015 and 2015/2016) and minor for the subsequent seasons (Table 9.19).

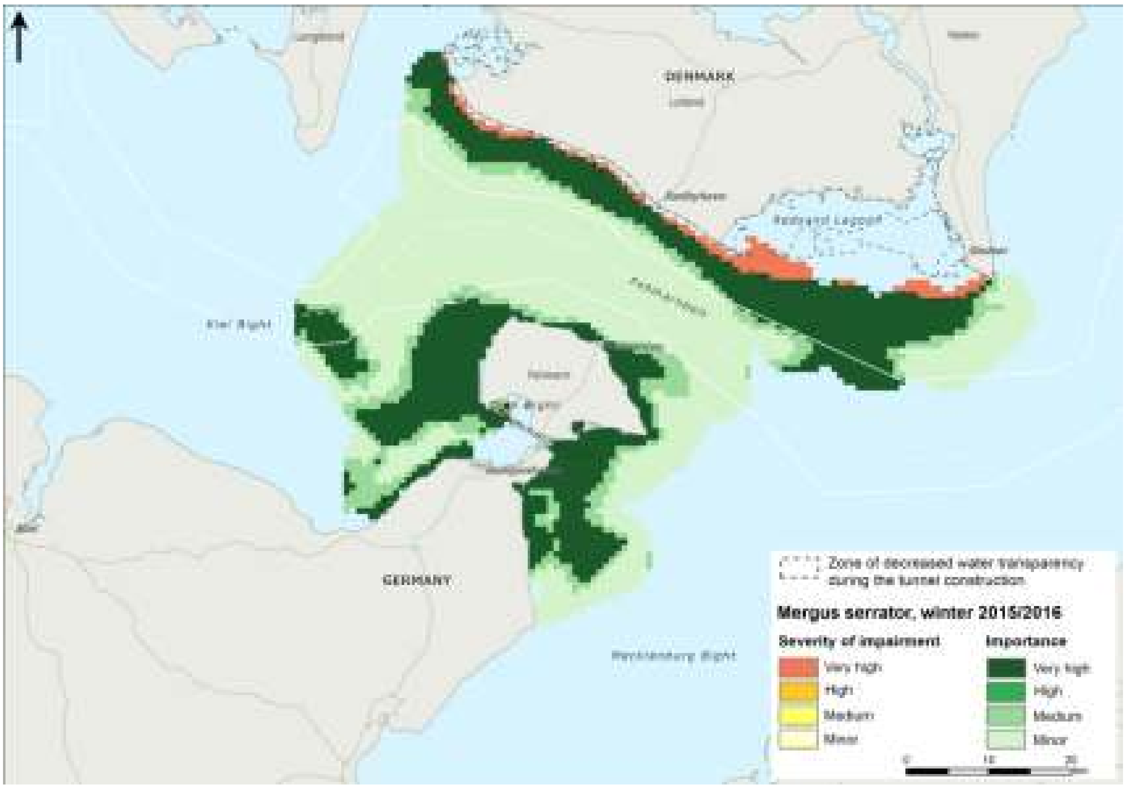


Figure 9.59 Severity of impairment from the pressure 'decreased water transparency' to Red-breasted Merganser from tunnel construction in the winter of the highest impact (second winter of construction 2015/2016).

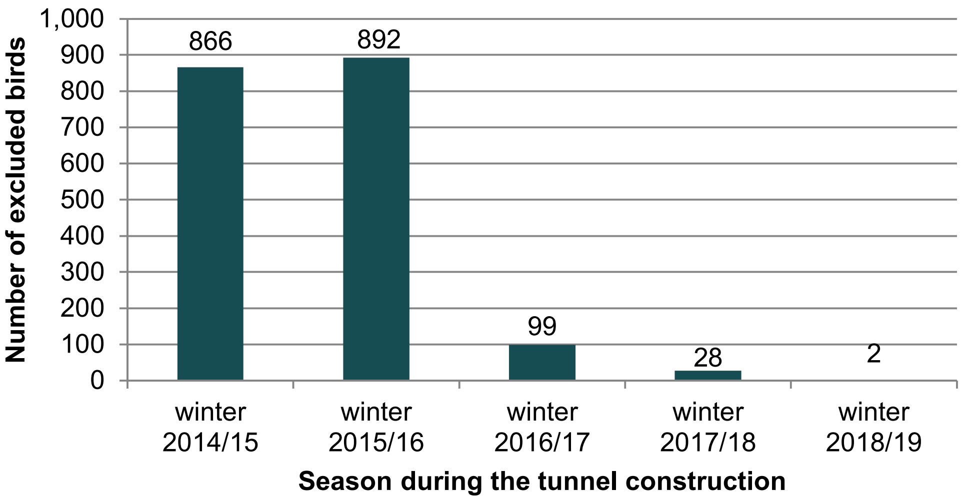


Figure 9.60 Estimated numbers of Red-breasted Mergansers that would be displaced due to decreased water transparency in different winter seasons during the tunnel construction.

Razorbill

The impairment zone, defined by the frequency of exceedance of the Secchi depth threshold of 3.74 m (see chapter 4.6.1), is predicted to affect mostly the coastal areas which are assessed to be of minor importance to Razorbill, resulting in a minor severity of impairment for the species in the respective areas (Figure 9.61, Appendix I). It was estimated that only 3 Razorbills would be displaced due to decreased water transparency during the first and second winters of the tunnel construction (Figure 9.62). The distribution of this species has been modelled using ship-based survey data, which did not cover Rødsand Lagoon, where water transparency decrease is expected to be the highest. However, Razorbill distribution shows this species being confined to offshore areas and only rarely occurring in Rødsand Lagoon (FEBI 2013). Therefore, the severity of impairment is assessed being minor.

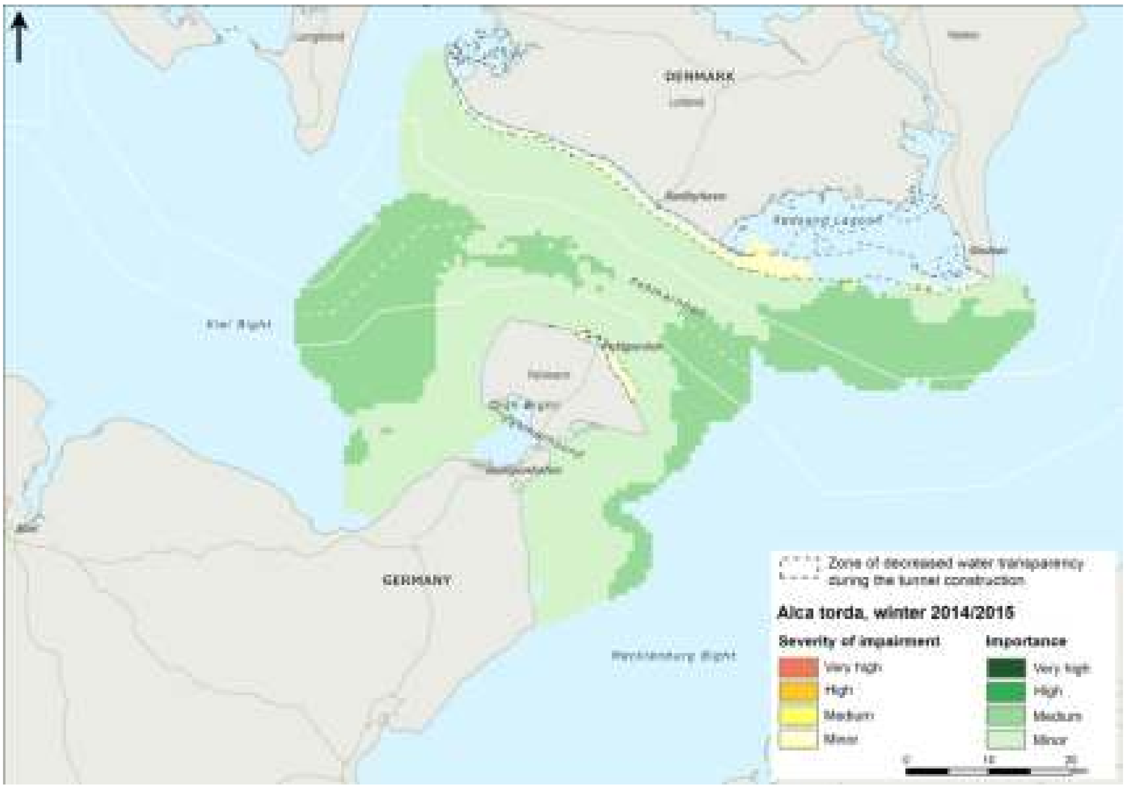


Figure 9.61 *Severity of impairment from the pressure 'decreased water transparency' to Razorbill from tunnel construction in the winter of the highest impact (first winter of construction 2014/2015).*

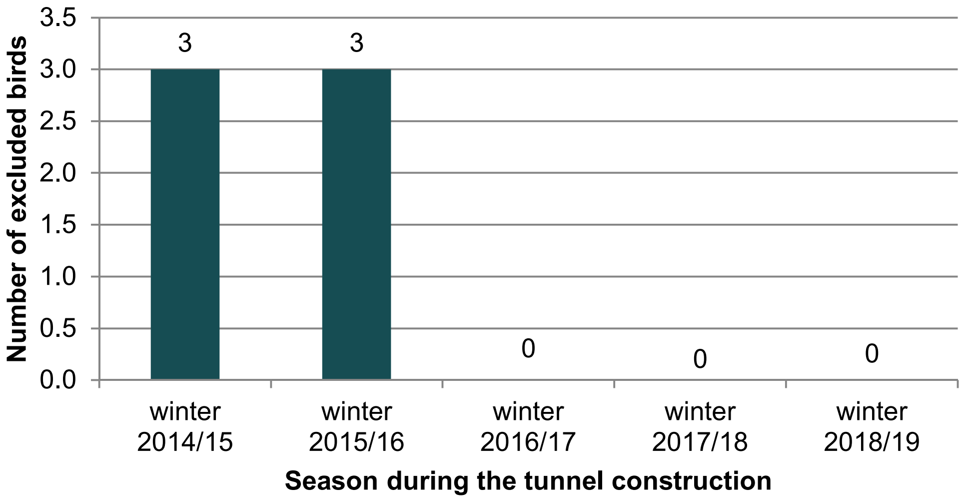


Figure 9.62 *Estimated numbers of Razorbill that would be displaced due to decreased water transparency in different winter seasons during the tunnel construction (in the area covered by ship surveys, i.e. not including Rødsand Lagoon)..*

Black Guillemot

Due to low abundance of this species in the Fehmarnbelt and its offshore distribution, it is not expected that more than single individuals of Black Guillemots would be displaced due to decreased water transparency during the tunnel construction. Therefore, the severity of impairment for this species is assessed as being minor.

Other species
For other non-breeding waterbird species the impact from decreased water transparency is assessed to be of minor severity of impairment due to either minor importance of the area to the species or birds occurring in the disturbance zone are predicted to be of minor sensitivity to this pressure.

Overall assessment of the severity of impairment
The assessment of severity of impairment was based on numbers of birds that are predicted to be displaced from the impairment area during the periods of decreased water transparency (Table 9.19). The severity of impairment from this pressure is assessed to be minor for the majority of non-breeding waterbird species. A very high severity of impairment is assigned for Common Eider for the first two seasons of the construction period, and medium for the third winter. Also, severity of impairment is assessed as medium for Red-breasted Mergansers during the first two winters of the tunnel construction (Table 9.19).

Table 9.19 Assessment of the severity of impairment on non-breeding waterbirds from decreased water transparency in different wintering seasons of tunnel construction.

Species	Season	Displaced individuals	% of biogeo-graphic pop.	Severity of impairment
Divers	2014/2015	30	0.01%	Minor
	2015/2016	32	0.01%	Minor
	2016/2017	11	0.003%	Minor
	2017/2018	5	0.002%	Minor
	2018/2019	0	0%	Minor
Red-necked Grebe	2014/2015	60	0.12%	Minor
	2015/2016	69	0.13%	Minor
	2016/2017	1	0.002%	Minor
	2017/2018	0	0%	Minor
	2018/2019	0	0%	Minor
Common Eider	2014/2015	8,823	1.16%	Very High
	2015/2016	8,325	1.09%	Very High
	2016/2017	1,170	0.15%	Medium
	2017/2018	560	0.07%	Minor
	2018/2019	18	0.002%	Minor
Long-tailed Duck	2014/2015	543	0.012%	Minor
	2015/2016	594	0.013%	Minor
	2016/2017	279	0.006%	Minor
	2017/2018	112	0.002%	Minor
	2018/2019	4	<0.001%	Minor
Common Scoter	2014/2015	512	0.03%	Minor
	2015/2016	173	0.01%	Minor
	2016/2017	118	0.007%	Minor
	2017/2018	78	0.005%	Minor
	2018/2019	2	<0.001%	Minor
Velvet Scoter	all seasons	single birds	<0.01%	Minor

Species	Season	Displaced individuals	% of biogeo-graphic pop.	Severity of impairment
Red-breasted Merganser	2014/2015	866	0.51%	Medium
	2015/2016	892	0.53%	Medium
	2016/2017	99	0.06%	Minor
	2017/2018	28	0.01%	Minor
	2018/2019	2	<0.001%	Minor
Razorbill	2014/2015	3	<0.001%	Minor
	2015/2016	3	<0.001%	Minor
	2016/2017	0	0%	Minor
	2017/2018	0	0%	Minor
	2018/2019	0	0%	Minor
Black Guillemot	all seasons	single birds	<0.1%	Minor
Other species	all seasons		<0.1%	Minor

Migrating birds
This pressure is assessed to be irrelevant for migrating birds.

Duration of impact
The duration of the pressure 'decreased water transparency' depends on duration of decreased transparency below the threshold level. The duration of impact of this pressure is considered to be restricted to the construction period of the tunnel. Suitable habitats for waterbirds would be available without an additional recovery period.

9.2.4 Disturbance from construction vessels

Description of the pressure
The construction of an immersed tunnel will require various shipping activities in the offshore part of the alignment area and between the construction sites and working harbours and reclamation sites at Lolland and Fehmarn. The shipping and other construction activities will cause disturbance to a number of waterbirds species described to be sensitive to these activities (see chapter 7.2.6). The pressure is the physical presence including noise, vibration and light emissions of these ships involved in the construction activities.

Several types of shipping activities will be associated with the construction of an immersed tunnel:

- Dredging: three different types of dredgers will be active along the alignment and other areas in the Fehmarnbelt (Figure 9.63)
- Work harbour constructions at Fehmarn and Lolland
- Transport of sediment to and from the alignment
- Guard vessels to secure the construction works
- Transport of equipment and staff

- Transport and placement of tunnel elements from the construction harbour at Lolland to final location
- Refilling of the tunnel trench
- Construction of land reclamation areas on Lolland and Fehmarn

Figure 9.63 Different types of dredgers planned to be used for the construction of an immersed tunnel (from left to right: BHD "Nordic Giant" (Boskalis), GD "Kanyo" (Taisei), TSHD "Volvox Asia" (Van Oord); pictures taken from Femern A/S Consolidated Technical Report, version June-6, 2011).

The construction activities at the tunnel trench are planned to take place within defined working areas of about 1 km width (Figure 9.64). The construction activities will focus at a given time to parts of the alignment, so parts of the alignment area will be less disturbed than others. However, beside dredging works there will be intense ship traffic between working harbours and working areas with additional disturbance from guard and transport vessels. Also, the ferries operating between the islands of Lolland and Fehmarn may need to change their routes due to the construction activities resulting in a larger disturbance zone for birds.

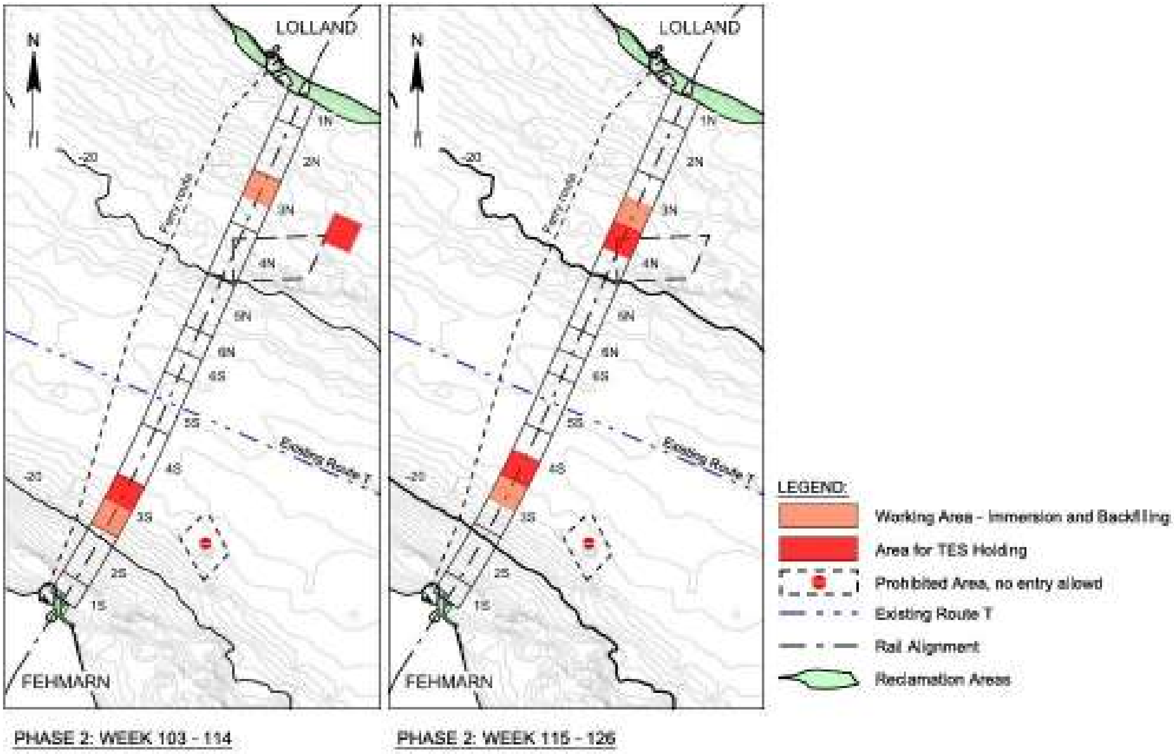


Figure 9.64 Outline of spatial extension of working sequences for an immersed tunnel (excerpt of drawing no. RAT-P-M50-000 (Femern A/S technical data package).

The construction of a fixed link over the Fehmarnbelt is planned in the area which is already highly impaired by existing cargo and ferry traffic. Exact traffic routes of construction and guard vessels are not known and neither is the shift in the existing ferry route due to construction activities. Therefore a relatively broad zone of 3 km on each side of the footprint was defined as a disturbance zone from construction vessels. The buffer of 3 km was chosen using the precautionary principle and aiming to accommodate the largest reported distances over which waterbirds might be disturbed by ships. No impairment from construction vessels is expected to occur beyond that disturbance zone.

Based on the description of the activities during the construction phase of an immersed tunnel, the pressure 'disturbance from construction activities' is defined as follows:

- The entire tunnel footprint (incl. working harbours and reclamation areas) plus a 3 km buffer zone around it was defined as the disturbance zone from construction activities (Figure 9.65).
- The intensity of additional shipping in the area is made up of up to 2,000 vessel passages per week (up to 30 different vessels) in relation to the construction activities, while the existing ferry traffic (770 passages per week) and shipping on the T-Route (approximately 940 ships per week) will be continued.
- The planned duration of the offshore construction phase is 201 weeks (approximately 4 years) and no pressure exists beyond the activity period.

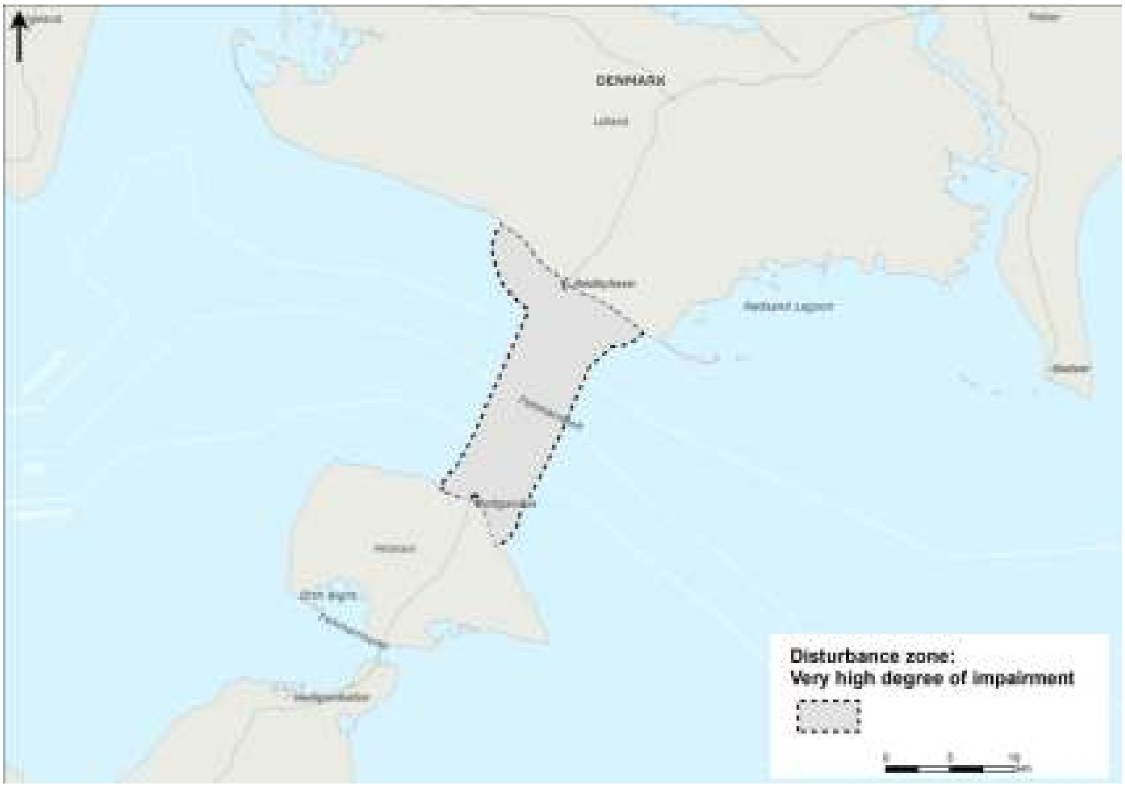


Figure 9.65 Disturbance zone of the construction activities defined as a 3 km buffer around the tunnel footprint.

Degree of impairment

Based on the sensitivity of the relevant waterbird species, the assessment is based on an assumed complete displacement of birds from the impairment zone (i.e. very high degree of impairment). This approach is regarded to be conservative since less sensitive species would likely not get completely displaced from the predicted impairment zone. Also, not the entire construction zone is expected to be continuously impaired by construction vessels. However, due to uncertainties in construction vessel activities and schedules, construction related changes in ferry and shipping routes and also in birds' reaction to a continuous disturbance, according to the precautionary principle, a very high degree of impairment was assumed for all species with medium to very high sensitivity.

Severity of impairment

Breeding waterbirds

In the following the severity of impairment from the pressure 'disturbance from construction vessels' is described for breeding waterbird species, which were identified to be potentially relevant for the EIA during the sensitivity screening (see chapter 7.3.1). Within this report only the impairment on breeding waterbirds in marine areas is assessed. Consequently, any potential disturbance from construction activities on breeding birds on land is not part of the present assessment and will be covered elsewhere. Disturbance of birds in marine areas is expected to be relevant for breeding bird species which use marine habitats for foraging during the breeding season or rear their offspring in marine areas and which were assessed to be sensitive to the pressure.

Among waterbird species which conduct foraging flights to marine areas, the Red-necked Grebe, all breeding gull and tern species were assessed to be relevant for this pressure. Red-breasted Mergansers, Common Eiders and other duck species rear their offspring in sheltered coastal areas, but among these only Red-breasted Merganser breeds close to the alignment. White-tailed Eagle potentially also uses marine areas of the Fehmarnbelt for foraging and was therefore included in this assessment.

The pressure 'disturbance from construction vessels' is assessed to be only relevant for birds breeding in the northern part of Fehmarn, the southern part of Lolland and for those birds breeding in Rødsand Lagoon, which might commute between the impact zone and the breeding area (see Table 9.2, chapter 9.2.1). Cormorants breeding in the west of Fehmarn and birds of other breeding colonies within the German SPAs are expected to mostly use marine areas close to their colonies and not regularly visit the impairment zone at the alignment.

Red-necked Grebe
Red-necked Grebe is an abundant breeding bird on Fehmarn and Lolland with 30 breeding pairs breeding in the reserve Grüner Brink (Fehmarn, SPA Eastern Kiel Bight) alone (Koop 2008a). Outside Natura 2000 areas, baseline investigations on Lolland revealed 20-21 breeding pairs of Red-necked Grebes (data provided by COWI).

Within Natura 2000 areas the nature reserve Grüner Brink is the closest reported breeding site of Red-necked Grebes to the disturbance zone. Birds are known to regularly commute between their inland breeding sites and marine foraging habitats. Since the disturbance zone does not affect the directly adjacent coastal waters of Grüner Brink and the impairment area is already highly impaired by intense ferry traffic, the importance of the disturbance zone to these birds is assessed to be minor. Therefore, the severity of impairment from disturbance from construction vessels is assessed to be minor for Red-necked Grebes breeding in Natura 2000 areas.

COWI breeding bird surveys on Lolland indicate several pairs of Red-necked Grebes breeding outside of Natura 2000 areas close to the alignment and the defined disturbance zone. It cannot be excluded that disturbance effect from construction vessels and longer distances to other foraging sites outside the disturbance zone would have an impact on the breeding Red-necked Grebes. The severity of impairment from this pressure to breeding Red-necked Grebes on Lolland is assessed within the Impact Assessment for the land areas of Lolland.

Red-breasted Merganser
The nature reserve Grüner Brink on Fehmarn is the closest reported breeding site of Red-breasted Mergansers to the affected disturbance zone. Birds breeding in the Rødsand Lagoon are not expected to be affected by the pressure. Red-breasted Mergansers use shallow marine areas to rear their offspring. Since the disturbance zone does not affect the directly adjacent coastal waters of Grüner Brink and the area east of Grüner Brink is already highly disturbed from the ferry traffic between Puttgarden and Rødbyhavn, the importance of the impairment zone to these birds is assessed to be minor. Therefore the severity of impairment from disturbance from construction vessels is assessed to be minor for the Red-breasted Merganser.

White-tailed Eagle
White-tailed Eagles forage on a variety of prey including carrion, birds and fish, and the species uses different inland and coastal habitats for feeding. The coastal areas of the predicted disturbance zone are possible foraging habitats of White-tailed Eagle, but are assessed to be of minor importance to the species, since these areas are already highly disturbed by the existing ferry traffic and tourist activities. Therefore the severity of impairment from disturbance from construction vessels is assessed to be minor for White-tailed Eagles breeding on Fehmarn and Lolland.

Gulls
The different gull species – Black-headed Gull, Common Gull, Herring Gull and Great Black-backed Gull – breeding on Fehmarn or in the Rødsand Lagoon were assessed to be sensitive to disturbances close to their breeding areas. The marine breeding habitats in Rødsand Lagoon and inland breeding areas on Fehmarn are not expected to get directly impaired due to the distance to the construction area. Gulls were assessed as not being sensitive to disturbances from ships while foraging at sea (see chapter 7.2.6), thus the overall severity of impairment from construction vessels is assessed to be minor for all breeding gull species in the area.

Terns
The tern species – Sandwich Tern, Common Tern, Arctic Tern and Little Tern – breeding on Fehmarn or in Rødsand Lagoon were assessed to be sensitive to disturbances close to their breeding areas. The marine breeding habitats in Rødsand Lagoon and inland breeding areas on Fehmarn are not expected to get directly impaired due to the distance to the construction area. Terns were assessed as not being sensitive to disturbances from ships while foraging at sea (see chapter 7.2.6), thus the overall severity of impairment from construction vessels is assessed to be minor for all breeding tern species in the area.

Other species
For other breeding waterbird species the impact from disturbance from construction vessels is assessed to have minor severity of impairment due to either minor importance of the area to the species or birds occurring in the impairment zone are predicted to be of minor sensitivity to this pressure.

Overall assessment of the severity of impairment
The overall assessment of the severity of impairment from construction activities of an immersed tunnel in Fehmarnbelt is assessed to be minor for all waterbirds breeding within Natura 2000 areas. The impact on Red-necked Grebes breeding outside Natura 2000 areas on Lolland is assessed within the Impact Assessment for land areas on Lolland.

Non-breeding waterbirds
In this chapter the severity of impairment from the pressure 'disturbance from construction vessels' is described for all non-breeding waterbird species, which were identified to be potentially relevant for the EIA during the sensitivity screening (see chapter 7.3.2).

Divers (Red-throated/Black-throated Diver)
The disturbance zone is assessed to be mostly of minor importance for the diver species, but in the coastal zone of the islands of Lolland and Fehmarn some areas were identified as being of high importance (Figure 9.66, Figure 9.67). Shipping activities within the disturbance zone will result locally in a high severity of impairment, but in most parts of the disturbance zone the severity of impairment is assessed to be minor (Figure 9.66, Figure 9.67). It is predicted that on average 10 birds (0.003% of the biogeographic population) will be displaced from the impairment zone during winter and 13 birds (0.004% of the biogeographic population) during spring.

Therefore, the disturbance from construction vessels is assessed to result in a minor severity of impairment for divers.

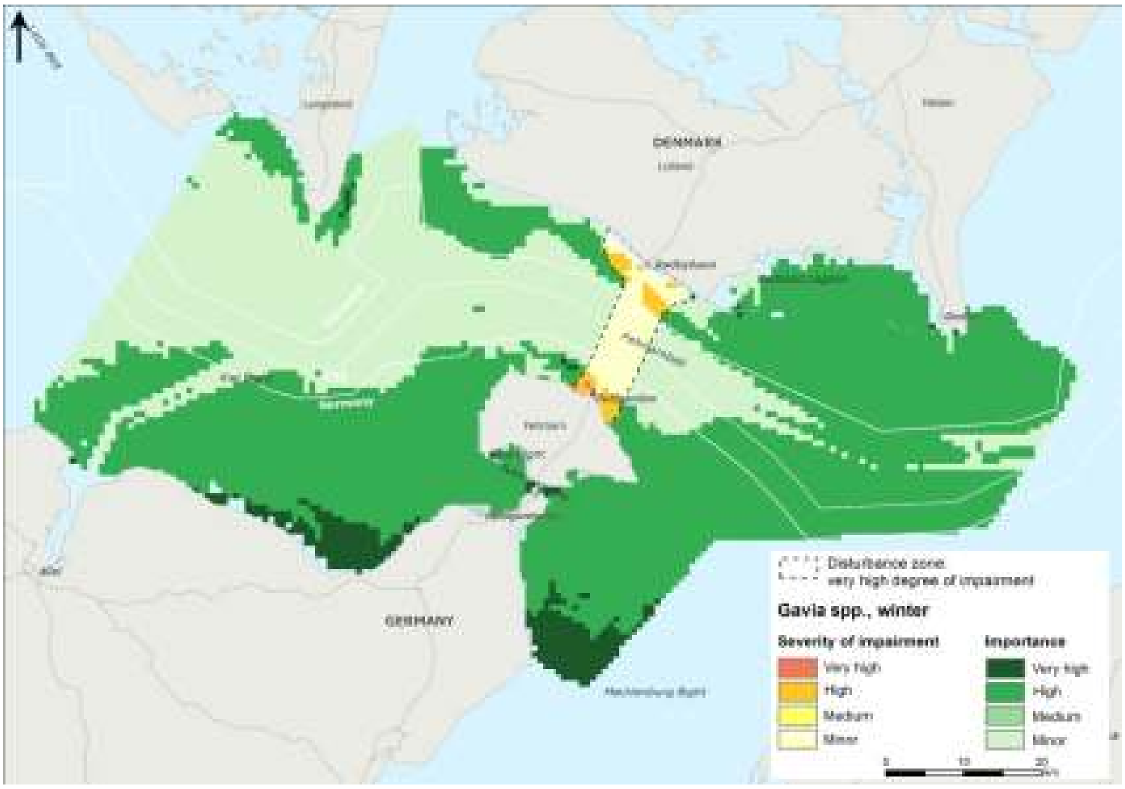


Figure 9.66 *Severity of impairment from the pressure 'disturbance from construction vessels' to divers in winter.*

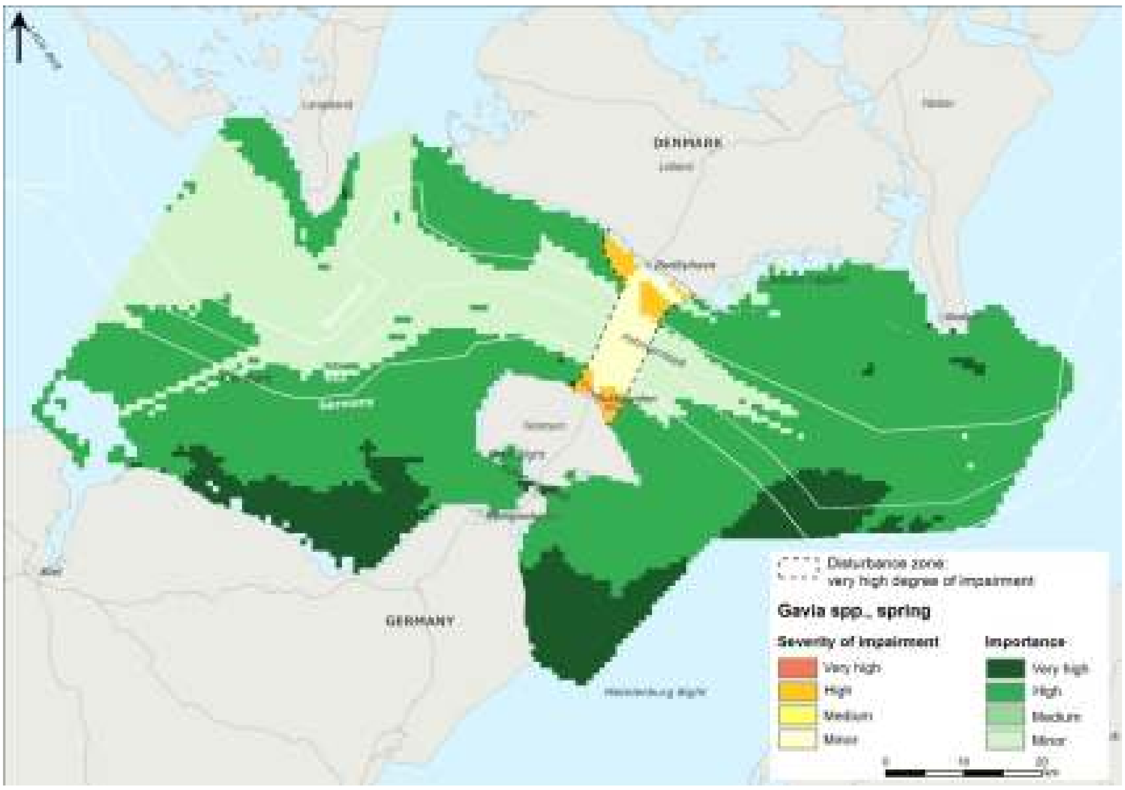


Figure 9.67 *Severity of impairment from the pressure 'disturbance from construction vessels' to divers in spring.*

Red-necked Grebe

The disturbance zone is assessed to be mostly of minor importance to the species, but in the coastal areas of the island of Fehmarn small areas were identified to be of very high importance (Figure 9.68). Construction activities will locally result in a very high severity of impairment, but in most parts of the disturbance zone the severity of impairment is assessed to be minor. It is predicted that on average 18 wintering birds (0.035% of the biogeographic population) will be displaced from the disturbance zone. In winters when abundance of this species is exceptionally high, as it was recorded in winter 2008/2009, 26 birds (0.05% of the biogeographic population) would be excluded from the disturbance zone.

Based on this the disturbance from construction vessels is assessed to result in a minor severity of impairment for the Red-necked Grebe.

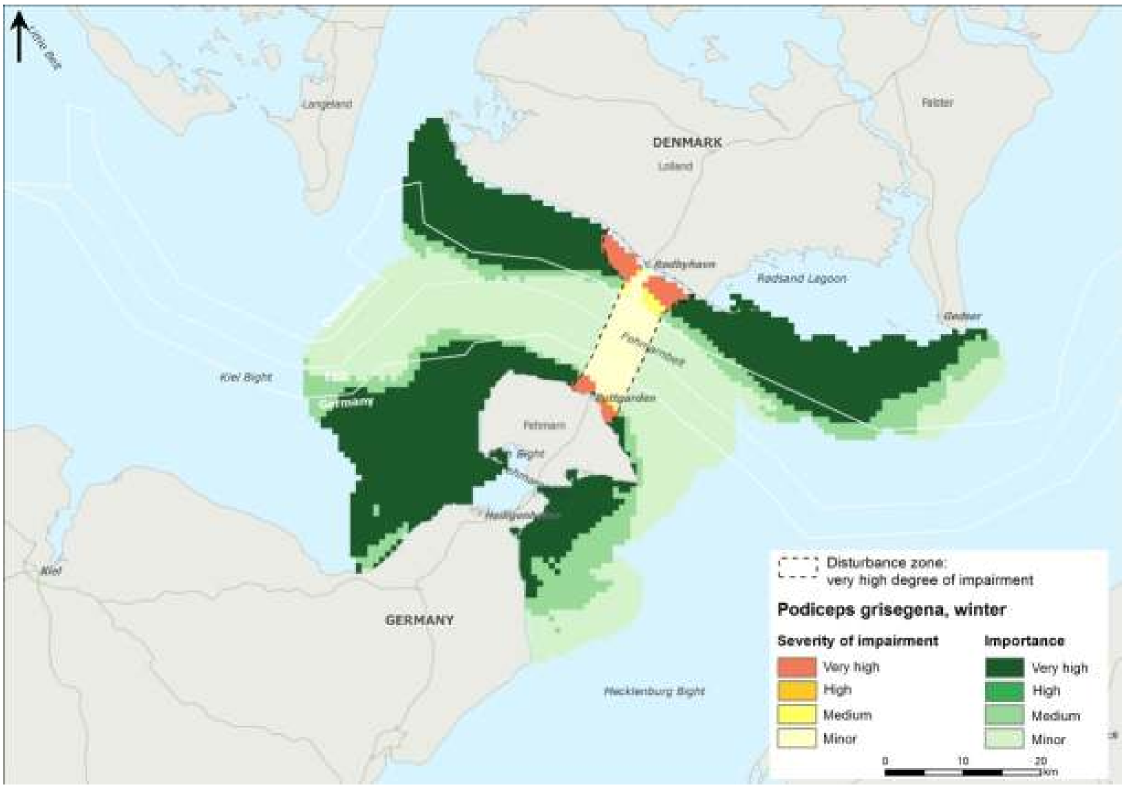


Figure 9.68 Severity of impairment of the pressure 'disturbance from construction vessels' to Red-necked Grebes in winter.

Great Cormorant

Maximum counts in a greater alignment area indicate that up to about 500 Great Cormorants (0.13% of the biogeographic population) use the area of the disturbance zone for roosting (breakwaters of the ferry harbours in Rødbyhavn and Puttgarden).

These birds are expected to be displaced during the time of construction activities, which results in a minor severity of impairment to this species.

Eurasian Wigeon

Maximum counts indicate that, with up to 1,500 birds and more (0.10% of the biogeographic population), medium important numbers of Eurasian Wigeon use the alignment area in winter time. Therefore, it is assumed that similar numbers would be displaced from the disturbance zone.

Thus, the severity of impairment from disturbance from construction vessels for the Eurasian Wigeon is assessed to be medium.

Common Pochard

Maximum daytime counts indicate that, with more than 700 birds (0.20% of the biogeographic population), highly important numbers of Common Pochard use the alignment area in winter time. It is assumed that similar numbers of night-time active Common Pochard would be displaced from the disturbance zone in winter.

Thus, the severity of impairment from disturbance from construction vessels for the Common Pochard is assessed to be high.

Tufted Duck

Maximum daytime counts indicate that, with more than 7,000 birds (0.58% of the biogeographic population) using the area, highly important numbers of Tufted Duck use the alignment area in winter time. It is assumed that similar numbers of night-time active Tufted Ducks would be displaced from the disturbance zone in winter.

Thus, the severity of impairment from disturbance from construction vessels for the Tufted Duck is assessed to be high.

Greater Scaup

Maximum daytime counts of Greater Scaup in the alignment area indicate up to 130 birds (0.04% of the biogeographic population) using the area, which corresponds to a minor importance of this area to the species. Therefore the severity of impairment is assessed to be minor for the Greater Scaup.

Common Eider

The Fehmarnbelt area is a very important wintering area for the species holding up to 40% of the biogeographic population. Consequently, also large proportions of the alignment area have been evaluated as being of very high importance, though clearly not being an area of high densities within the Fehmarnbelt study area. Disturbance from construction activities is assessed to result in a very high severity of impairment in the coastal parts of the disturbance zone and medium severity of impairment for the central deep water parts (Figure 9.69, Figure 9.70). It is predicted that on average 4,117 birds (0.54% of the biogeographic population) will be displaced from the disturbance zone during winter, and 3,213 birds (0.42% of the biogeographic population) during spring.

Considering the maximum estimate for Common Eiders in the Fehmarnbelt study area (as it was recorded in winter 2009/2010), a maximum number of 4,882 birds (0.64% of the biogeographic population) would be displaced from the disturbance zone. Therefore the disturbance from construction vessels is assessed to result in a medium severity of impairment for the Common Eider.

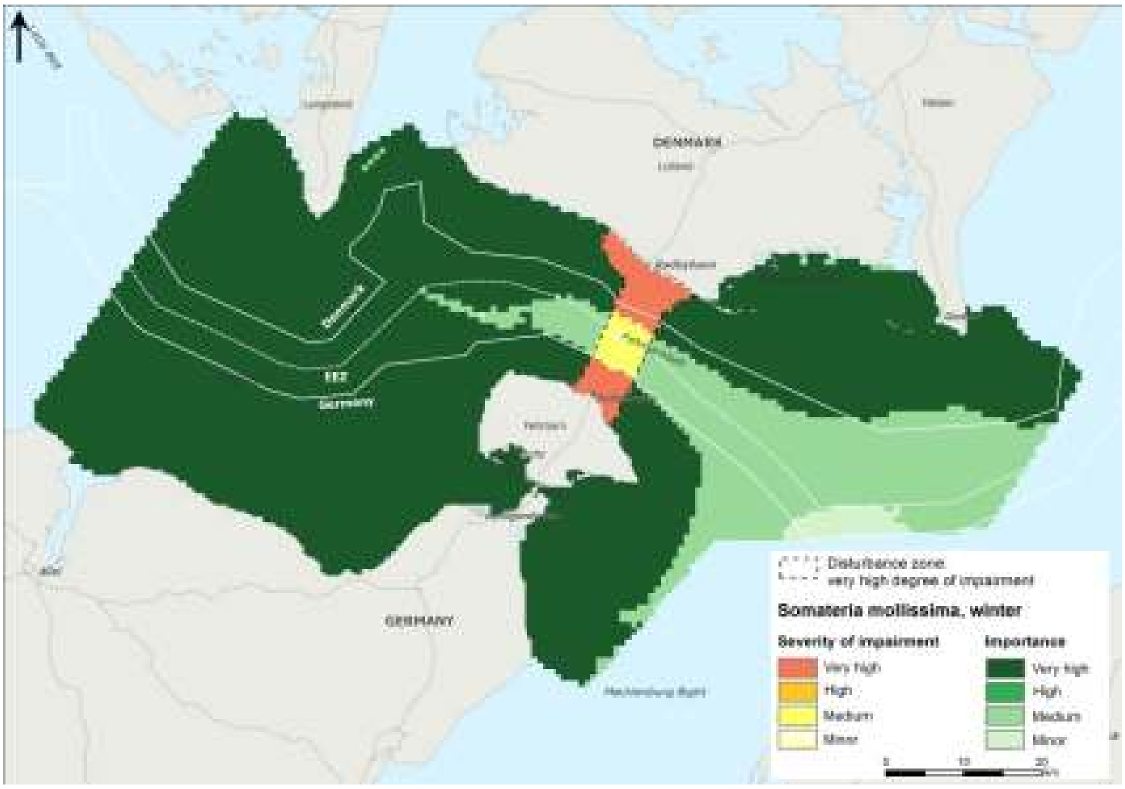


Figure 9.69 Severity of impairment of the pressure 'disturbance from construction vessels' to Common Eiders in winter.

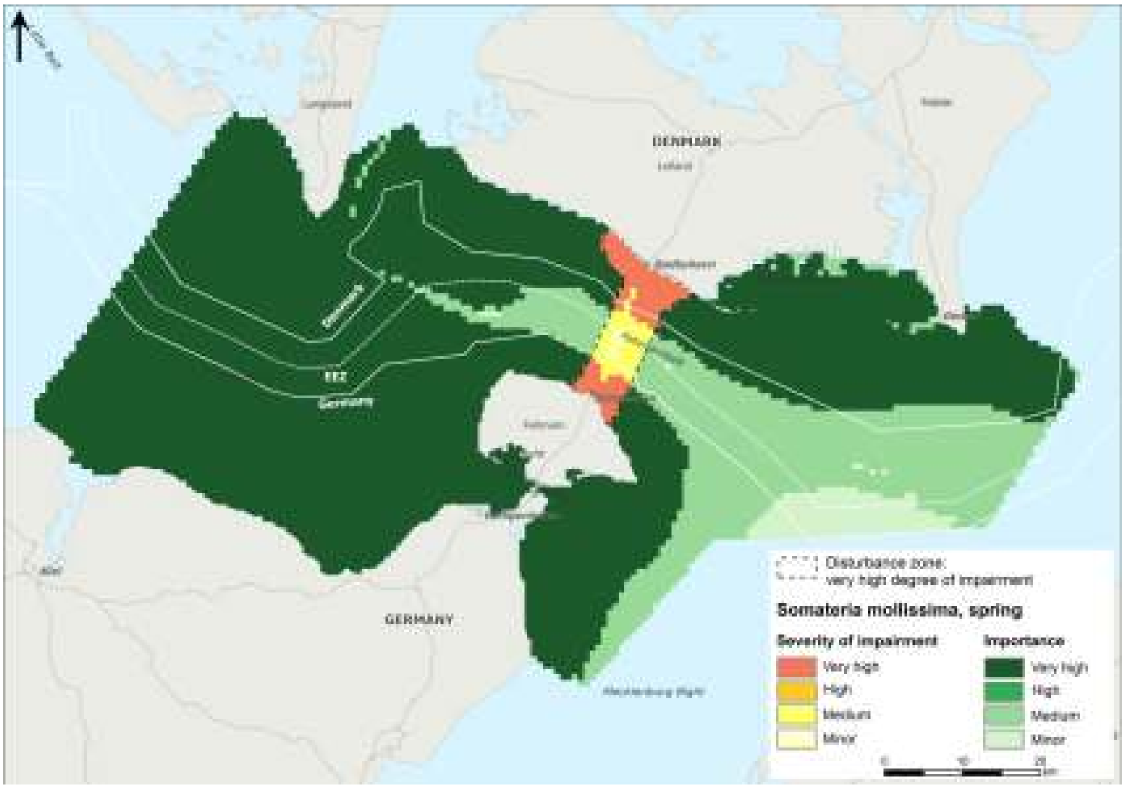


Figure 9.70 Severity of impairment of the pressure 'disturbance from construction vessels' to Common Eiders in spring.

Long-tailed Duck

The predicted disturbance zone is assessed to be mostly of minor importance for the Long-tailed Duck and thus the severity of impairment from construction activities is assessed to be mostly minor as well (Figure 9.71). It is predicted that on average 120 birds (0.003% of the biogeographic population) will be displaced from the disturbance zone in winter.

Based on this the disturbance from construction vessels is assessed to result in a minor severity of impairment for the Long-tailed Duck.

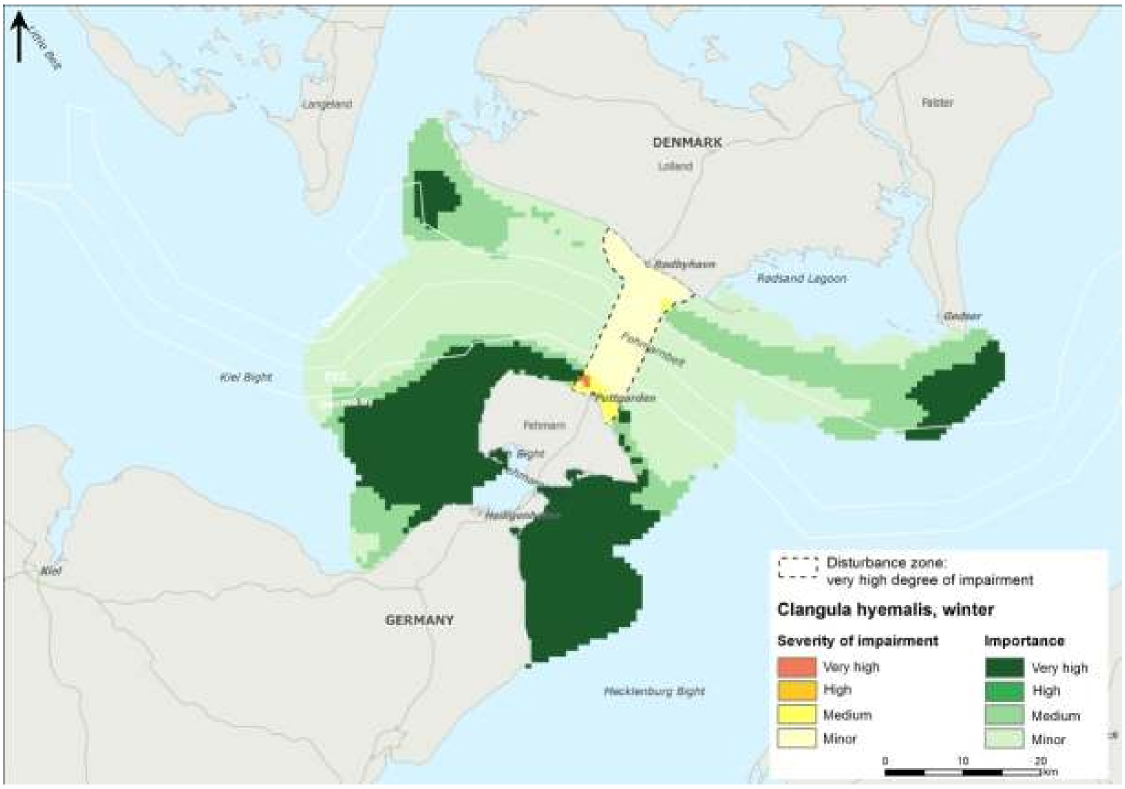


Figure 9.71 Severity of impairment of the pressure 'disturbance from construction vessels' to Long-tailed Ducks in winter.

Common Scoter

The predicted disturbance zone is assessed to be mostly of minor importance to this species, except for the coastal zone of the island of Fehmarn which was assessed to be of very high importance (Figure 9.72). Construction activities are predicted to locally result in a very high severity of impairment, but in most parts of the disturbance zone the severity of impairment is assessed to be minor. It is predicted that on average 391 birds (0.02% of the biogeographic population) will be displaced from the disturbance zone during winter.

Based on this the disturbance from construction vessels is assessed to result in a minor severity of impairment for the Common Scoter.

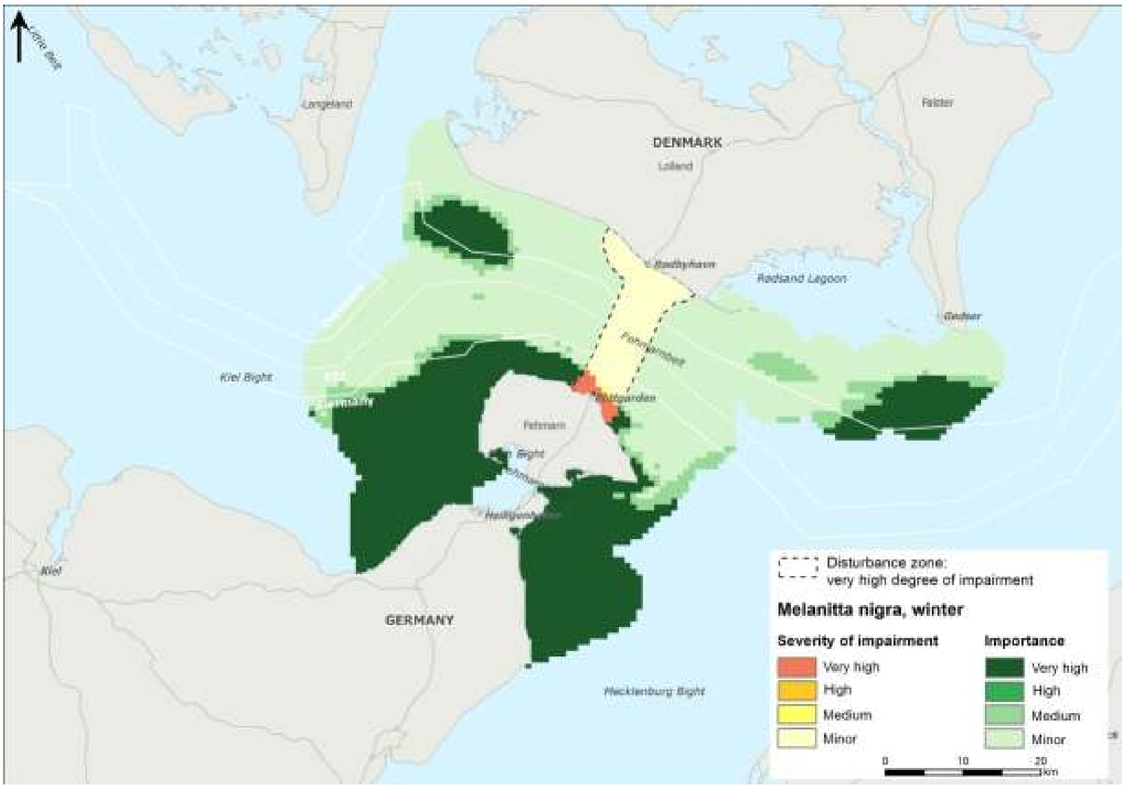


Figure 9.72 Severity of impairment of the pressure 'disturbance from construction vessels' to Common Scoters in winter.

Velvet Scoter

The alignment area is assessed to be of minor importance to Velvet Scoter with usually only low numbers occurring in this area. Similar to Common Scoter (Figure 9.72) higher concentrations of this species have been observed outside of the disturbance zone. Therefore it is assessed that the disturbance zone is mainly of minor importance to the Velvet Scoter and no more than a few tens of birds (<0.01% of the biogeographic population) would be displaced from the disturbance zone during the construction period. This corresponds to a minor severity of impairment from this pressure to the Velvet Scoter.

Common Goldeneye

The predicted disturbance zone is assessed to be mostly of minor importance to the species, but in the coastal zone of the islands of Lolland and Fehmarn some areas are assessed to be of very high importance (Figure 9.73). Construction activities are predicted to locally result in a very high severity of impairment, but in most parts of the disturbance zone the severity of impairment is assessed to be minor. It is predicted that on average 91 birds (0.01% of the biogeographic population) would be displaced from the disturbance zone during winter. German coastal counts indicate up to 160 Common Goldeneye occurring in the greater alignment area of Fehmarnbelt, which still constitutes a very small proportion of the population. Therefore this pressure is assessed to result in a minor severity of impairment for the Common Goldeneye.

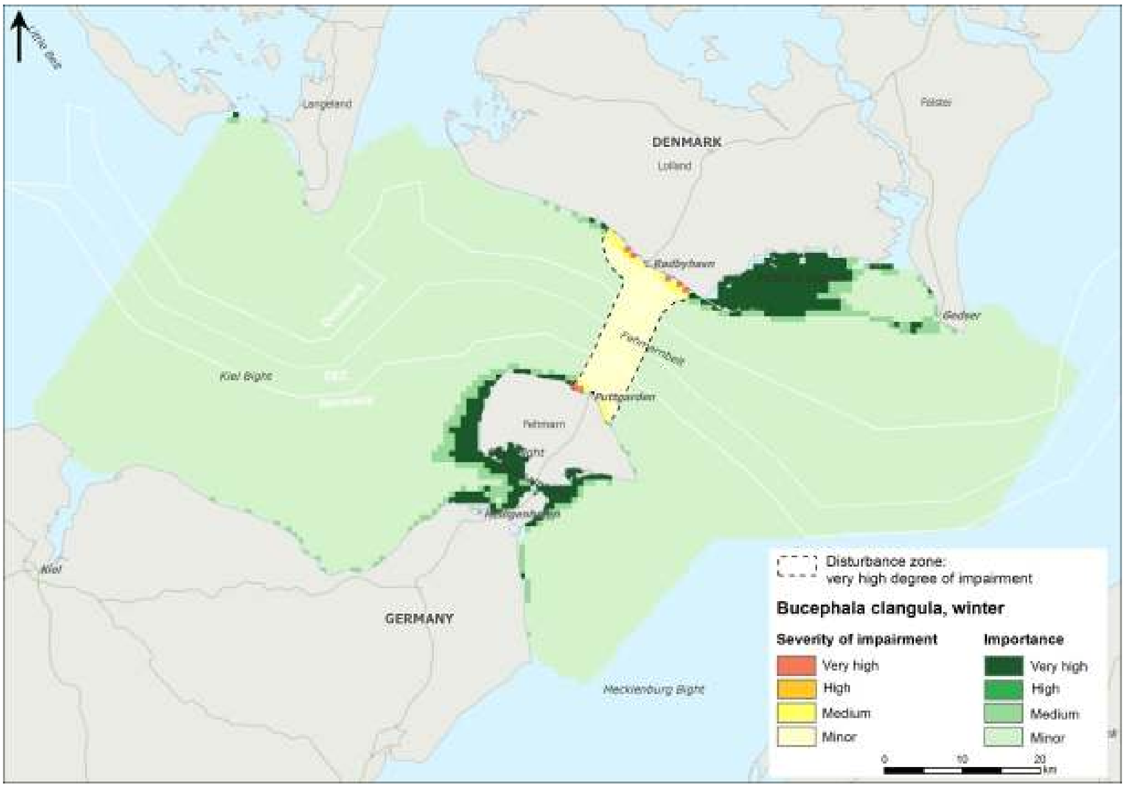


Figure 9.73 Severity of impairment of the pressure 'disturbance from construction vessels' to Common Goldeneye in winter.

Red-breasted Merganser

The predicted disturbance zone is assessed to be of minor importance to the species in offshore areas, but coastal zones of the islands of Lolland and Fehmarn are assessed to be of very high importance (Figure 9.74). Construction activities are predicted to locally result in a very high severity of impairment, but in most parts of the disturbance zone the severity of impairment is assessed to be minor. It is predicted that on average 208 birds (0.12% of the biogeographic population) will be displaced from the disturbance zone during winter.

Based on this the disturbance from construction vessels is assessed to result in a minor severity of impairment for the Red-breasted Merganser.

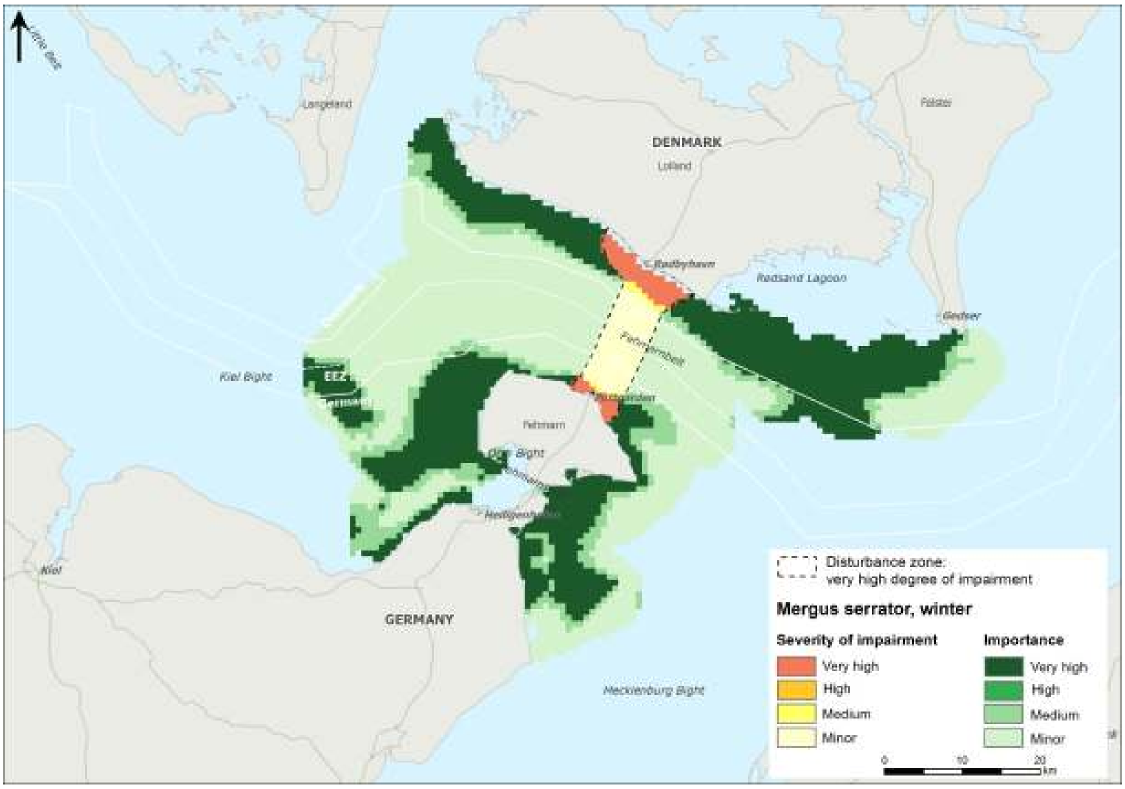


Figure 9.74 Severity of impairment of the pressure 'disturbance from construction vessels' to Red-breasted merganser in winter.

White-tailed Eagle

White-tailed Eagles are present in the Fehmarnbelt area all year round. The birds use various inland and coastal habitats. The predicted disturbance zone from construction vessels lies within an already highly disturbed area with intense shipping, thus the area is assessed to be of minor importance to the species. The severity of impairment from disturbance from construction vessels is assessed to be minor for the White-tailed Eagle.

Common Coot

Common Coot is abundant in the Fehmarnbelt area all year round, but maximum numbers occur in winter. The species is mostly confined to inland habitats or sheltered marine areas, such as bays and lagoons, thus the area of the predicted disturbance zone is assessed to be of minor importance to the species. It is predicted that on average only low numbers of birds would get impaired from this pressure (maximum estimate for the alignment area is 340 birds or 0.02% of the biogeographic population). Consequently, the severity of impairment is assessed to be minor for the Common Coot.

Razorbill

The predicted disturbance zone is assessed to be mostly of minor importance to Razorbill (Figure 9.75) and therefore also the severity of impairment for this area is assessed to be minor. It is predicted that on average 11 birds (0.002% of the biogeographic population) would be displaced from the disturbance zone during winter.

Based on this the disturbance from construction vessels is assessed to result in a minor severity of impairment for the Razorbill.

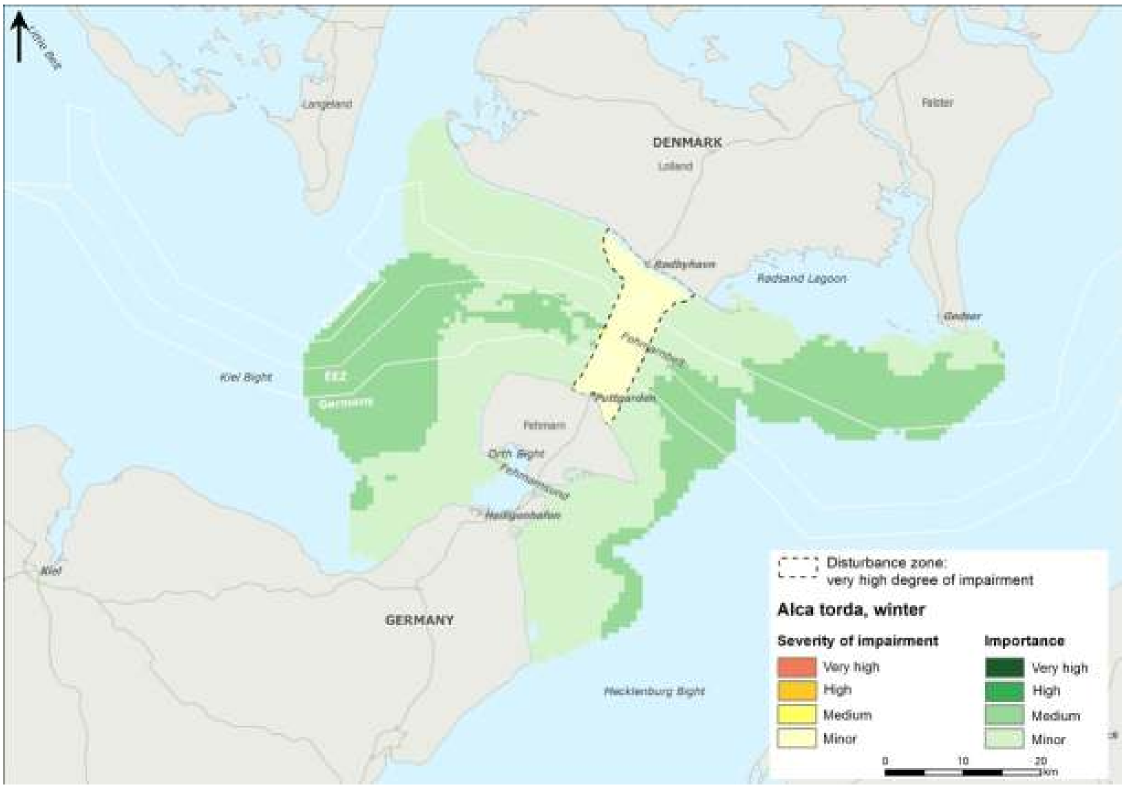


Figure 9.75 Severity of impairment of the pressure 'disturbance from construction vessels' to Razorbills in winter.

Black Guillemot

The greater alignment area is assessed to be of minor importance to Black Guillemot with usually only single birds occurring in this area. Therefore the disturbance from construction vessels is assessed to result in a minor severity of impairment for the Black Guillemot.

Other species

For other non-breeding waterbird species the disturbance zone is assessed to be of minor importance, or birds occurring in the disturbance zone are expected to respond to construction vessels, but the responses would be local and of short duration. Construction activities are not predicted to lead to a relevant reduction of their numbers in the disturbance zone.

Overall assessment of the severity of impairment

The severity of impairment was determined from the total numbers of individuals per species which were estimated to be displaced from the disturbance zone during the construction of an immersed tunnel. Despite locally high to very high severity of impairment, for most of the assessed species the overall severity of impairment is minor. The severity of impairment is assessed to be high for the two diving duck species the Common Pochard and the Tufted Duck, and medium for the Eurasian Wigeon and the Common Eider (Table 9.20).

Table 9.20 Assessment of the severity of impairment from disturbance from construction vessels for non-breeding waterbirds.

Species	Displaced individuals	% of biogeo-graphic pop.	Severity of impairment
Divers	10	0.003%	Minor
Red-necked Grebe	26	0.05%	Minor
Great Cormorant	500	0.12%	Minor
Eurasian Wigeon	1,500	0.10%	Medium
Common Pochard	710	0.20%	High
Tufted Duck	7,100	0.59%	High
Greater Scaup	130	0.04%	Minor
Common Eider	4,882	0.64%	Medium
Long-tailed Duck	120	0.003%	Minor
Common Scoter	391	0.02%	Minor
Velvet Scoter	low number	<0.01%	Minor
Common Goldeneye	91	0.008%	Minor
Red-breasted Merganser	208	0.12%	Minor
White-tailed Eagle	low number	<0.10%	Minor
Common Coot	340	0.02%	Minor
Razorbill	11	0.002%	Minor
Black Guillemot	low number	<0.10%	Minor
Other species		<0.10%	Minor

Migrating birds
The impact of 'disturbance from construction vessels' on migrating birds is assessed as part of the pressure 'barrier from construction vessels' (chapter 9.2.4).

Duration of impact
The duration of the pressure 'disturbance from construction vessels' is restricted to the construction period of the tunnel. It is expected that birds would use the areas offering suitable habitats within a short-term period after finalisation of the construction activities, i.e. within 2 years after end of construction (Construction phase+).

9.2.5 Barrier from construction vessels

Description of the pressure
The construction of an immersed tunnel would require various shipping activities in the offshore part of the alignment area and between the construction sites and working harbours and reclamation sites at Lolland and Fehmarn. The shipping and other construction activities would cause a barrier effect to a number of species of waterbirds in the area described to be sensitive to these activities (see chapter 7.2.9). The pressure is the physical presence including noise, vibration and light emissions of these ships involved in the construction activities.

Several types of shipping activities will be associated with the construction of an immersed tunnel:

- Dredging: three different types of dredgers will be active along the alignment and other areas in the Fehmarnbelt (Figure 9.63)
- Work harbour constructions at Fehmarn and Lolland
- Transport of sediment to and from the alignment
- Guard vessels to secure the construction works
- Transport of equipment and staff
- Transport and placement of tunnel elements from the construction harbour at Lolland to final location
- Refilling of the tunnel trench
- Construction of land reclamation areas on Lolland and Fehmarn

The construction activities at the tunnel trench are planned to take place within defined working areas of about 1 km width (Figure 9.64). The construction activities would focus at a given time to parts of the alignment, so other parts of the alignment area would be less frequented than others. However, beside dredging works there would be intense shipping traffic between working harbours and working areas with additional effects from guard and transport vessels. Also, the ferries operating between the islands of Lolland and Fehmarn may need to change their routes due to the construction activities. All this ship traffic would result in the reduction of barrier free flight paths for breeding and non-breeding waterbirds and migrating birds.

Degree of impairment
Since the magnitude of this pressure is only represented by the construction vessels, and can hardly be quantified concerning the magnitude and frequency, the degree of impairment regarding the pressure barrier effect is defined by the sensitivity of birds to perceive the structure as a barrier. Therefore, the degree of impairment is at first regarded to correspond to the sensitivity level as assessed in chapter 7.2.9. As all considered breeding and non-breeding waterbirds and migrating bird species were assessed being minor sensitive, the degree of impairment is assessed to be minor as well.

Severity of impairment

Breeding waterbirds
All considered breeding waterbird species were assessed to be minor sensitive to a barrier effect from construction vessels. Thus, the severity of impairment is assessed to be minor for all breeding waterbirds in the area.

Non-breeding waterbirds
All considered non-breeding waterbird species were assessed to be minor sensitive to a barrier effect from construction vessels. Thus, the severity of impairment is assessed to be minor or negligible for all non-breeding waterbirds in the area.

Migrating birds
All considered migrating bird species were assessed to be minor sensitive to a barrier effect from construction vessels. Thus, the severity of impairment is assessed to be minor or negligible for all migrating birds in the area.

Duration of impact
The duration of the impact of the pressure 'barrier from construction vessels' is restricted to the construction period. No impact from this pressure is predicted to occur after finalisation of the construction works.

9.2.6 Collision with construction vessels

Description of the pressure
The construction of a tunnel would require various shipping activities in the offshore part of the alignment area and between the construction sites and working harbours and reclamation sites at Lolland and Fehmarn. Birds may collide with the various types of ships used. The pressure is the physical presence of all types of construction vessels including guard vessels, cranes and other working platforms involved in the construction activities. Lights on the ships may attract birds at night during times of bad visibility and might lead to collisions with the construction vessels.

Degree of impairment
The degree of impairment regarding collisions with construction vessels is directly deducted from the sensitivity assessment (see chapter 7.2.12). Based on the minor sensitivity to this pressure assessed for all breeding, non-breeding and migrating bird species, the degree of impairment is assessed to be minor to all affected birds in the area.

Severity of impairment
The severity of impairment from collisions with construction vessels is assessed to be minor or negligible for all breeding and non-breeding waterbird species and migrating birds in the area.

Duration of impact
The duration of the impact of the pressure 'collision with construction vessels' is restricted to the construction period. No impact from this pressure is predicted to occur after completion of the construction works.

9.3 Operation and structures

9.3.1 Habitat loss and habitat change from footprint

Description of the pressure
After completion of the construction works for an immersed tunnel, the different structures of the tunnel footprint result in a permanent loss of marine areas (reclamation sites), other areas will be impaired and will not recover within a longer term period (access channel to working harbour) or the natural seabed gets permanently sealed by protection reef structures. Other areas are predicted to re-establish within a certain period (tunnel trench, working harbours; Figure 9.76, Table 9.21).

The areas affected by the tunnel footprint during operation are the same as described for that pressure during the construction period (see chapter 9.2.1). Different from the construction period, parts of the footprint area are predicted to re-establish depending on project and natural processes (Table 9.21), so the area of loss would become smaller as areas would become suitable for birds again after their food resources have recovered. The recovery times of different benthic communities are predicted to vary between less than 1 year (Filamentous algae) up to more than 10 years (*Arctica,* eelgrass) after re-establishment of the seabed (Table 9.21, Table 9.22).

The loss of shallow water areas from land reclamations is expected to be partly compensated by natural re-establishment of such areas along the reclamation sites over time, though the coastal profile is likely to stay steeper compared to baseline conditions (FEHY 2013c).

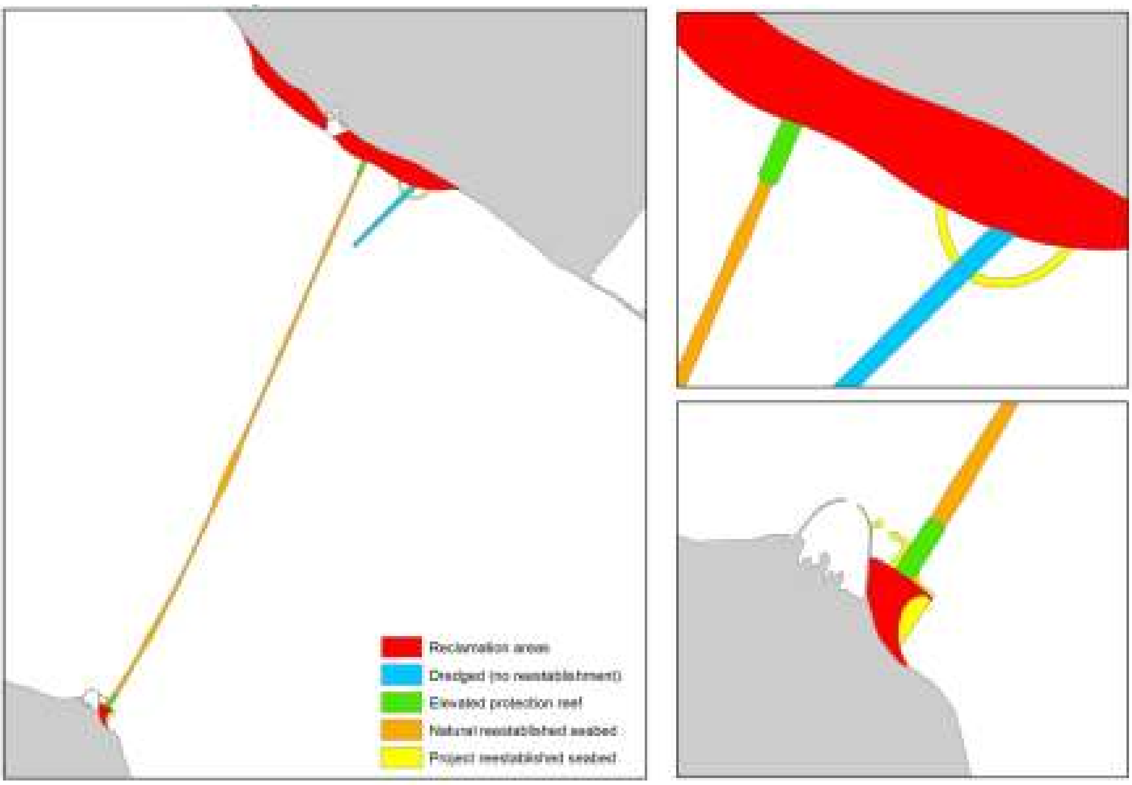


Figure 9.76 Footprint of the immersed tunnel during operation.

Table 9.21 Size of marine areas affected by the permanent footprint of an immersed tunnel with predicted recovery times of the seabed (FEHY 2013c).

Footprint area	Size, ha	Recovery time of seabed
Land reclamation Lolland	329.11	No recovery
Land reclamation Fehmarn	14.31	No recovery
Elevated protection reefs	12.29	No recovery
Dredged areas construction harbour Lolland	32.13	>10 years
Natural re-established seabed (tunnel trench)	181.75	2-10 years
Project re-established seabed (harbours)	14.46	<2 years
TOTAL	584.06	

Table 9.22 Recovery times of benthic fauna and flora communities (FEMA 2013d).

Community	Recovery time	Recovery time category
Benthic fauna		
Arctica	>10 years	Very high
Bathyporeia	<2 years	Low
Cerastoderma	2-5 years	Medium
Corbula	<2 years	Low
Dendrodoa	5-10 years	High
Gammarus	2-5 years	Medium
Mytilus	5-10 years	High
Rissoa	5-10 years	High
Tanaissus	2-5 years	Medium
Benthic flora		
Eelgrass	>10 years	Very high
Eelgrass/algae	>10 years	Very high
Tasselweed/dwarf eelgrass	2-5 years	Medium
Fucus	5-10 years	High
Furcellaria	5-10 years	High
Phycodris/Delesseria	2-5 years	Medium
Saccharina	1-2 years	Low
Filamentous algae	<1 year	Low

The landfall areas of the tunnel elevated protection reefs will change the seabed structure permanently. The impact of such artificial reefs is discussed in chapter 9.3.2. The new structures of an immersed tunnel are predicted to result in local changes in seabed and coastal morphology (FEHY 2013d, FEHY 2013f). No permanent changes in seabed morphology outside the tunnel trench area are predicted. The temporary changes outside the tunnel trench are assessed to be minor or medium and would be local within the near zone of the tunnel trench (FEHY 2013d). Areas west of the reclamation area at the Danish side and east of the reclamation at the German side of the fixed link are predicted to become sediment deposition areas. The coastline east of the reclamation area at Lolland is predicted to be affected by erosion (FEHY 2013f). However, changes in seabed and coastal morphology which would result from the structure of the tunnel alternative (outside the footprint itself) are assessed to have minor impact on the benthic communities (FEMA 2013d). Therefore this issue is not further assessed as relevant pressure component for birds.

As described for the construction period (chapter 9.2.1) the habitat loss from the tunnel footprint is predicted to affect different life stages (spawning, egg-larvae drift, nursery, feeding and migration) of the studied fish species (FeBEC 2013b). The impacts on fish are predicted to result in up to 33% permanent reduction in some life stages of different fish species within the near zone (500 m around the footprint, FeBEC 2013b). The highest impact is predicted for juvenile stages of Cod and flatfish, and the shallow water fish species, such as sandeels, gobies, and sticklebacks, in the Danish coastal area in result of the habitat loss from the large reclamation area. There are no permanent impacts on fish predicted to occur from the tunnel footprint beyond the near zone area of the immediate vicinity of the footprint (FeBEC 2013b).

Degree of impairment

The footprint area of the tunnel is regarded as an area of complete habitat loss for the first years after the end of construction works. Re-establishment of benthic habitats is expected in the areas assigned as recoverable (Table 9.21), which would become suitable for birds again. Since recovery times of benthic communities are uncertain, depending on natural processes, only a complete habitat loss, i.e. the total displacement of all birds within the impact zone, can be assessed. No degree of impairment can be specified for recovering areas at the present stage.

Severity of loss/impairment

The following assessment of the severity of loss represents the worst case scenario for the assessed waterbird species by assuming that the area of the entire footprint would lead to a permanent loss. However, it is expected that for non-benthivorous species, such as pursuit diving piscivorous species (divers, grebes, cormorants and auks) and species collecting food from the water surface (e.g. gulls) or by plunge-diving (terns) the marine areas above the tunnel trench would remain useable.

Breeding waterbirds

During operation of the immersed tunnel the pressure ‘habitat loss and habitat change from footprint’ is predicted to affect the same areas and species as described in chapter 9.2.1 for the construction period of the project. For breeding waterbirds the loss of shallow water habitats from land reclamations would be the most relevant effect. Changes in the seabed morphology and benthic communities at the tunnel trench are of minor relevance for the piscivorous species breeding in the vicinity of the impact zone. No or very few benthivorous birds breed in the area (COWI 2011, FEBI 2013).

The severity of habitat loss from the footprint of an immersed tunnel in the Fehmarnbelt to breeding waterbirds follows the assessment of habitat loss during the construction period of the tunnel (chapter 9.2.1), and has been assessed to be minor for all waterbirds breeding in Natura 2000 areas. The severity of loss to Red-necked Grebes breeding on Lolland outside of Natura 2000 areas is assessed as part of the Impact Assessment on Lolland land areas.

Depending on the development, management and natural succession of the land reclamation sites these areas will likely provide new breeding habitats for different waterbird species.

Non-breeding waterbirds

The habitat loss for non-breeding waterbirds during the operation of the immersed tunnel would affect the same areas and species as described for the construction period (see chapter 9.2.1). Since there are uncertainties about recovery times of benthic communities, the Impact Assessment for the operation phase of the immersed tunnel is expected to be the same as for the construction period, though impact is predicted to decrease with recovering habitats. It is predicted that the tunnel footprint would result in a high severity of loss to the diving duck species Common Pochard, Tufted Duck and Greater Scaup. For all other non-breeding waterbird species the footprint is assessed to result in a minor severity of loss (Table 9.3; chapter 9.2.1).

Migrating birds

This pressure is assessed to be irrelevant for migrating birds.

Duration of impact

The duration of the pressure 'habitat loss from footprint' and therefore the impact of the pressure is either permanent (no recovery) or depends on re-establishment of areas of provisional loss (e.g. tunnel trench, working harbours) in terms of recovery times of seabed, benthic flora and fauna and fish communities. Re-established areas offering suitable habitats for waterbirds are considered to be used by birds without additional lag periods.

9.3.2 Provision of artificial reefs

Description of the pressure

During the construction of an immersed tunnel in the Fehmarnbelt large areas covered by the footprint would provide additional solid substrate to areas lost from the footprint. In total embankments, elevated protection reefs at the landfalls of the tunnel, and the protection layer above the tunnel elements outside the Natura 2000 area will provide an area of 204.59 ha of additional hard substrate (Table 9.23; FEMA 2013d). Artificial reefs from embankments and protection reefs are considered as permanent structures. It is predicted that the hard substrate of the protection layer on top of the tunnel outside of the Natura 2000 area would be covered by sediment eventually due to natural processes of sediment transport, thus would not be available as solid substrate after re-establishment of the seabed (FEMA 2013d).

Table 9.23 Areas of benthic communities destroyed by additional solid hard substrate from the construction of an immersed tunnel in the Fehmarnbelt (data from FEMA (2013d)).

Structure	Community	Area, ha
Embankment Fehmarn	*Cerastoderma*	0.76
	Bathyporeia	0.20
Embankment Lolland	*Mytilus*	9.76
Protection reef Fehmarn	*Gammarus*	5.98
Protection reef Lolland	*Mytilus*	6.26
Protection layer (tunnel trench outside Natura 2000 area)	*Cerastoderma*	3.69
	Gammarus	13.50
	Corbula	49.59
	Arctica	99.00
	Mytilus	15.85
TOTAL		204.59

The areas of additional solid substrate are predicted to be available for the establishment of hard-bottom benthic communities (FEMA 2013d), then called artificial reefs. Hard bottom benthic communities in Fehmarnbelt consist mainly of macroalgae (*Fucus*, *Furcellaria*, *Phycodis*/*Delesseria*, *Saccharina*) and filamentous algae communities (FEMA 2013a). The hard bottom benthic fauna in the area consists of epifaunal species which are confined to hard substrates such as the *Mytilus* community (FEMA 2013b).

Beside the promotion of hard bottom communities there is another aspect related to this pressure, which is the impairment of benthic communities in the vicinity of artificial reefs by material and faecal pellets originating from the hard bottom community. However, for the tunnel alternative this aspect was considered to be irrelevant (FEMA 2013d).

Artificial reef structures are also known to attract different fish species (Keller et al. 2006, Dumke et al. 2007, Lindeboom et al. 2011). Many shallow water fish are substrate-spawners, i.e. they are associated to highly structured habitats. Additional hard substrates from the tunnel construction could also have an attraction effect on many small fish species, for which these areas are considered to serve as additional feeding and nursery grounds (Lindeboom et al. 2011, FeBEC 2013b). The increase in densities of small fish at these artificial reefs would likely also result in an attraction effect on larger fish species (e.g. cod, whiting) (Lindeboom et al. 2011). It is predicted that the additional hard substrates from a tunnel would change the fish communities in the affected areas of the Fehmarnbelt permanently (FeBEC 2013b).

Degree of impairment

Provision of artificial reefs is closely related to habitat loss by deployment of the additional hard substrates, which is assessed in the previous chapter 9.3.1. Some bird species might benefit from provision of artificial reefs and such effects were evaluated descriptively. For others no relevant impact is predicted to result from the artificial reefs. Therefore, the degree of impairment is assessed to be minor for all breeding and non-breeding waterbird species.

Severity of impairment

Breeding waterbirds

The pressure 'provision of artificial reefs' is only relevant for breeding bird species which use marine habitats as foraging sites during the breeding season or to rear their offspring in marine areas. Within the alignment area this would affect mostly fish-eating species (Red-necked Grebes, Red-breasted Mergansers, Great Cormorants, gulls and terns). All these species were assessed as neither being sensitive to any impact on benthic communities close to the artificial reefs nor benefitting directly from the fauna and flora communities associated with artificial reefs. However, new structures with settled benthic communities would provide new habitats for fish and other mobile fauna (crustaceans, echinoderms), which in turn would create potential new foraging habitats for piscivorous birds. Therefore breeding birds are not expected to face impacts from artificial reefs in the Fehmarnbelt. Positive effects are likely for some species. Subsequently, the severity of impairment is assessed to be minor.

Non-breeding waterbirds

There are no negative effects from the provision of artificial reefs expected for non-breeding waterbirds beside habitat loss assessed in chapter 9.3.1. Subsequently, no impairment is further described for any non-breeding waterbird species.

The epiflora and epifauna growing on the new solid substrates of the tunnel structures are expected to provide an additional food source for some benthivorous bird species, such as seaducks and diving ducks. Likewise, new benthic communities on artificial reefs would attract fish and other mobile fauna, which would potentially provide additional food resources for piscivorous birds. There is no disturbance effect from the operation of a tunnel expected which would exclude birds from using available food sources. However, water depth, distance to land and distance to shipping routes were identified as important factors shaping seaduck distributions (FEBI 2013) and may therefore also affect the suitability of these novel habitats to birds.

Migrating birds

This pressure is assessed as being irrelevant for migrating birds.

Duration of impact

The duration of the pressure 'provision of artificial reefs' is either of long-term duration (until seabed of the tunnel trench is re-established) or permanent, thus the impact on waterbirds is predicted to be of long-term or permanent duration too.

9.3.3 Hydrographical changes

Description of the pressure

The hydrographical changes due to the tunnel alternative are assessed in detail in FEHY reports (FEHY 2013b, 2013c). In this section an extract of the reported hydrographical changes relevant to waterbirds is presented. The assessed hydrographical changes include changes to the indicators current, water level, salinity and water temperature, stratification and waves. It is noted that changes associated with sediment spill during the construction process are not included here. It is also noted that water quality related changes are assessed by FEMA, and are not included here.

The main tool for the FEHY hydrography assessment is numerical modelling. The FEHY numerical models (MIKE and GETM) applied to assess the tunnel alternative in Fehmarnbelt and adjacent waters operate at a horizontal grid resolution in the potential tunnel alignment area of 400-700 m offshore and 100 m near the coast. Since only hydrographical changes of similar or larger scales than the grid resolution are captured by the models, it is implied that very localised hydrographical changes with scales that are smaller than the grid resolution are not included in the FEHY hydrography assessment.

FEHY have assessed three scenarios: the 0-alternative ("ferry"), the tunnel only alternative ("tunnel") and the combined ferry and tunnel alternative ("ferry+tunnel"). The results show that the differences in hydrographical changes related to the "tunnel" and "ferry+tunnel" scenarios are very small (FEHY 2013c). Therefore only changes related to the "ferry+tunnel" scenario are further considered.

The change in current conditions due to the tunnel solution is assessed by FEHY in terms of the annual mean surface and bottom current speeds. These are limited to the areas in the vicinity of the two landfalls. In Figure 9.77 the permanent change in annual mean surface current speed as predicted by the MIKE model is shown. The permanent changes amount to a localised reduction in current of 0.02-0.06 m/s (up to 0.1 m/s very locally on the Fehmarn side). At the planned access channel to the production facility at Rødbyhavn, an increase in surface current speed of up to 0.08 m/s very locally is predicted. Outside the vicinity of the reclamations, the effects on current conditions are negligible. In the construction period the temporary work harbour at Fehmarn and the production facility and its breakwaters at Lolland will impose additional local changes to the current conditions. In the lee of the breakwaters of the production facility the current speed is reduced additionally, but elsewhere an effect similar to the permanent effect is predicted.

In order to evaluate the changes in current conditions, it may be useful to compare them to the natural variability in the current conditions in Fehmarnbelt. The natural variability of the current speed in Fehmarnbelt is presented in (FEHY 2013c) in terms of the mean and standard deviation of measured current speed in the FEHY main station 02. The surface and bottom mean current speed 2009-2010 is 0.41 m/s and 0.13 m/s, respectively, and the corresponding surface and bottom standard deviation is 0.23 m/s and 0.09 m/s, respectively. Thus, the estimated changes in currents for the tunnel solution are negligible in comparison to the natural variability found in Fehmarnbelt.

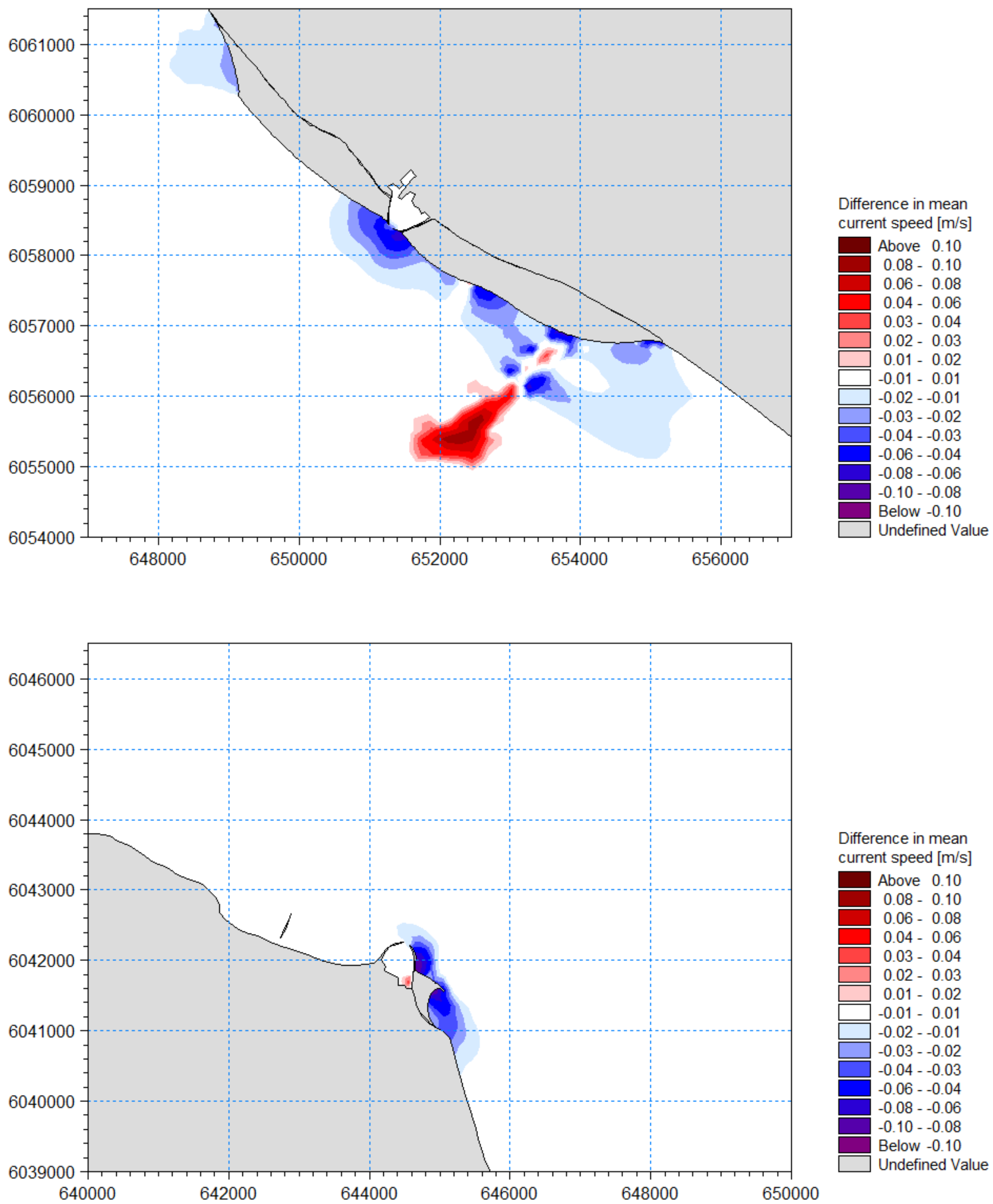


Figure 9.77 Modelled effect of "ferry+tunnel" scenario on annual mean surface current speed at the Lolland side (upper panel) and at the Fehmarn side (lower panel) (FEHY 2013c).

With respect to water level, salinity, water temperature and stratification, the permanent changes and changes during the construction period are predicted by FEHY to be negligible (mean water level change <0.0001 m; mean salinity change <0.2 PSU; mean temperature change <0.05 °C; mean stratification change <0.04 kg/m^3). With respect to waves, permanent changes and changes during construction are only seen in the immediate vicinity of the reclamations and appear mostly as lee effect on the eastern side of the reclamations. At the access channel a slight tendency to increased waves is predicted.

Project related hydrographical changes are assessed as not having a significant impact on benthic and fish communities (FEMA 2013d, FeBEC 2013b), thus no indirect impacts on birds are expected.

Degree of impairment

The degree of impairment is defined as the proportion of birds getting displaced from the impairment zone (zone of hydrographical changes) according to the criteria defined in chapter 4.5.14. There are no relevant negative effects on any bird species predicted to result from the hydrographical changes of the tunnel footprint. Therefore, the degree of impairment is assessed to be minor for all breeding or non-breeding waterbird species.

Severity of impairment

Breeding and non-breeding waterbirds

The changes in hydrographical parameters are so small and locally confined to the vicinity of land reclamation sites that no detectable impairment to breeding and non-breeding waterbirds is expected.

Migrating birds

This pressure is assessed to be irrelevant for migrating birds.

Duration of impact

The duration of the pressure ‘hydrographical changes’ is permanent, but the impact on waterbirds was considered to be negligible.

9.4 Summary and overall assessment of severity and significance of impacts

The overall project impact is assessed by aggregating the impacts of different pressures for each environmental factor (breeding waterbirds, non-breeding waterbirds and migrating birds) separately for the construction period and for structure and operation of the planned immersed tunnel.

Different construction- and operation-related pressures (habitat loss, hydrographical changes, disturbance from construction vessels, changes in water transparency and habitat change from sediment spill) are predicted to result in displacement of birds from impaired areas. For estimating the overall impact as numbers of displaced birds, the spatial and temporal overlap of the different pressures were taken into account (see below). Displacement is assumed to result mostly in a redistribution of birds within the study area and would not necessarily result in mortality. Impairment resulting from a barrier effect can only be assessed qualitatively and therefore cannot be aggregated with disturbance related pressures. Collision with project related structures would result in direct mortality of birds and is not summable with displacement or barrier effects. Therefore, in the overall assessment displacement, barrier effect and collision are presented separately.

The assessment of significance of the project impact was conducted on a species level following the description in chapter 4.5.14. An impact from the construction and operation of the project was considered significant if at least one of the following criteria was met:

- the total number of displaced individuals (resulting from different pressures) corresponds to more than 1% of the biogeographic population, unless it can be excluded that the displacement of >1% of the biogeographic population would result in a population effect for a species;
- the severity of impairment of barrier effect is assessed as being very high and leading to an interruption of migration flyways (migrating birds) or ecologically functional connections between breeding, resting and foraging habitats (breeding and non-breeding waterbirds);
- the number of birds predicted to collide with the project structures (i.e. be killed) exceeds the threshold of Potential Biological Removal (PBR; see chapter 8) or >1% of the biogeographic/relevant reference population, and thus could potentially lead to population effects.

When assessing the significance of the project impact, the duration of different pressures (i.e. duration of significant impacts) was taken into account.

9.4.1 Breeding waterbirds

Construction phase

During the construction period of an immersed tunnel in the Fehmarnbelt, impacts resulting from different pressures are assessed as minor for all waterbird species breeding in Natura 2000 areas (Table 9.24). Therefore, the overall impact on all breeding waterbird species during the tunnel construction period is assessed as being insignificant.

Table 9.24 Summary of the assessment of pressure-specific severity of impact (loss/impairment) and overall significance of impact for breeding waterbirds during the construction phase of an immersed tunnel in the Fehmarnbelt. 'Overall impact of displacement' indicates the aggregated impact in terms of bird displacement from the pressures habitat loss, habitat change, water transparency and disturbance. This assessment was conducted for waterbirds breeding in Natura 2000 areas only.

Species	Loss	Impairment			Overall impact of displacement	Impairment		Significance
	Habitat loss from footprint	Habitat change from sediment spill	Water transparency	Disturbance from construction vessels		Barrier from construction vessels	Collision with construction vessels	
Red-necked Grebe	Minor	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Great Cormorant	Minor	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Common Heron	Minor	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Mute Swan	Minor	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Greylag Goose	Minor	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Common Eider	Minor	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Red-breasted Merganser	Minor	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Goosander	Minor	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
White-tailed Eagle	Minor	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Oystercatcher	Minor	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Avocet	Minor	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Redshank	Minor	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Mediterranean Gull	Minor	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Black-headed Gull	Minor	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Common Gull	Minor	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Herring Gull	Minor	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Great Black-backed Gull	Minor	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Sandwich Tern	Minor	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Common Tern	Minor	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Arctic Tern	Minor	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Little Tern	Minor	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Other species	Minor	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant

Structure and operation

Impacts from structure and operation of an immersed tunnel in the Fehmarnbelt are assessed to result in minor severity of impact for all waterbird species breeding in Natura 2000 areas (Table 9.25). Therefore, the overall impact is assessed as being insignificant for all breeding waterbird species in the area.

Table 9.25 Summary of the assessment of pressure-specific severity of impact (loss/impairment) and overall significance of impact for breeding waterbirds from structure and operation of an immersed tunnel in Fehmarnbelt. 'Overall impact of displacement' indicates the aggregated impact in terms of bird displacement from the pressures habitat loss and hydrographical changes. This assessment was conducted for waterbirds breeding in Natura 2000 areas only.

Species	Loss	Impairment		Overall impact of displacement	Significance
	Habitat loss from footprint	Provision of artificial reefs	Hydro-graphical changes		
Red-necked Grebe	Minor	No impact	No impact	Minor	Insignificant
Great Cormorant	Minor	No impact	No impact	Minor	Insignificant
Common Heron	Minor	No impact	No impact	Minor	Insignificant
Mute Swan	Minor	No impact	No impact	Minor	Insignificant
Greylag Goose	Minor	No impact	No impact	Minor	Insignificant
Common Eider	Minor	No impact	No impact	Minor	Insignificant
Red-breasted Merganser	Minor	No impact	No impact	Minor	Insignificant
Goosander	Minor	No impact	No impact	Minor	Insignificant
White-tailed Eagle	Minor	No impact	No impact	Minor	Insignificant
Oystercatcher	Minor	No impact	No impact	Minor	Insignificant
Avocet	Minor	No impact	No impact	Minor	Insignificant
Redshank	Minor	No impact	No impact	Minor	Insignificant
Mediterranean Gull	Minor	No impact	No impact	Minor	Insignificant
Black-headed Gull	Minor	No impact	No impact	Minor	Insignificant
Common Gull	Minor	No impact	No impact	Minor	Insignificant
Herring Gull	Minor	No impact	No impact	Minor	Insignificant
Great Black-backed Gull	Minor	No impact	No impact	Minor	Insignificant
Sandwich Tern	Minor	No impact	No impact	Minor	Insignificant
Common Tern	Minor	No impact	No impact	Minor	Insignificant
Arctic Tern	Minor	No impact	No impact	Minor	Insignificant
Little Tern	Minor	No impact	No impact	Minor	Insignificant
Other species	Minor	No impact	No impact	Minor	Insignificant

9.4.2 Non-breeding waterbirds

Construction phase

During the construction of an immersed tunnel separate pressures are assessed to result in different severity of loss or impairment to non-breeding waterbirds in the area (Table 9.26). Habitat loss from the project footprint is predicted to result in minor severity of loss to most non-breeding waterbird species in the area. For the two diving duck species, the Common Pochard and the Tufted Duck, habitat loss from the Danish land reclamation is predicted to result in a high severity of loss.

Habitat change from sediment spill, i.e. the indirect effect of changes in benthic or fish communities on birds, is assessed to result in negligible to minor severity of impairment to all non-breeding waterbird species in the area.

Decreased water transparency resulting from sediment spill during the construction period is predicted to result in a very high severity of impairment for the Common Eider during the first two years of the construction period and in a medium severity of impairment during the third year of the construction period. A medium severity of impairment from this pressure is assessed for the Red-breasted Merganser during the first two construction years. For other species the severity of impairment is assessed to be minor for the entire construction period.

Disturbance from construction vessels is assessed to be of high severity of impairment for the Common Pochard and the Tufted Duck; a medium severity of impairment is assessed for the Common Eider and the Eurasian Wigeon. Displacement from the disturbance zone is assessed to result in negligible to minor severity of impairment to all other non-breeding waterbird species.

The severity of impairment from barrier from construction vessels and collision with construction vessels is assessed to be minor for all non-breeding waterbird species in the area.

Table 9.26 Summary of the assessment of pressure-specific severity of impact (loss/impairment) for non-breeding waterbirds during the construction phase of an immersed tunnel in the Fehmarnbelt. Superscript numbers indicate that severity level changes during the construction period and that number indicates the number of seasons the severity level is assessed to be higher than minor. The highest degree of impairment assessed for any of the construction years is indicated in the cell.

Species	**Loss**	**Impairment**				
	Habitat loss from footprint	**Habitat change from sediment spill**	**Water transparency**	**Disturbance from construction vessels**	**Barrier from construction vessels**	**Collision with construction vessels**
Divers	Minor	Minor	Minor	Minor	Minor	Minor
Great Crested Grebe	Minor	Negligible	Minor	Minor	Negligible	Negligible
Red-necked Grebe	Minor	Minor	Minor	Minor	Minor	Minor
Slavonian Grebe	Minor	Negligible	Minor	Minor	Negligible	Negligible
Great Cormorant	Minor	Minor	Minor	Minor	Minor	Minor
Mute Swan	Minor	Minor	Minor	Minor	Minor	Minor
Bewick's Swan	Minor	Minor	Minor	Minor	Minor	Minor
Whooper Swan	Minor	Minor	Minor	Minor	Minor	Minor
Bean Goose	Minor	Minor	Minor	Minor	Minor	Minor
Greater White-fronted Goose	Minor	Negligible	Negligible	Minor	Negligible	Negligible
Greylag Goose	Minor	Minor	Minor	Minor	Minor	Minor
Barnacle Goose	Minor	Minor	Minor	Minor	Minor	Minor
Brent Goose	Minor	Minor	Minor	Minor	Minor	Minor
Eurasian Wigeon	Minor	Minor	Minor	Medium	Minor	Minor
Gadwall	Minor	Minor	Minor	Minor	Minor	Minor
Common Teal	Minor	Minor	Minor	Minor	Minor	Minor
Mallard	Minor	Negligible	Negligible	Minor	Negligible	Negligible
Shoveler	Minor	Minor	Minor	Minor	Minor	Minor
Common Pochard	High	Minor	Minor	High	Minor	Minor
Tufted Duck	High	Minor	Minor	High	Minor	Minor
Greater Scaup	Minor	Minor	Minor	Minor	Minor	Minor

Species	Loss	Impairment				
	Habitat loss from footprint	**Habitat change from sediment spill**	**Water transparency**	**Disturbance from construction vessels**	**Barrier from construction vessels**	**Collision with construction vessels**
Common Eider	Minor	Minor	Very High[3]	Medium	Minor	Minor
Long-tailed Duck	Minor	Minor	Minor	Minor	Minor	Minor
Common Scoter	Minor	Minor	Minor	Minor	Minor	Minor
Velvet Scoter	Minor	Minor	Minor	Minor	Minor	Minor
Common Goldeneye	Minor	Minor	Minor	Minor	Minor	Minor
Smew	Minor	Minor	Minor	Minor	Minor	Minor
Red-breasted Merganser	Minor	Minor	Medium[2]	Minor	Minor	Minor
Goosander	Minor	Negligible	Minor	Minor	Negligible	Negligible
White-tailed Eagle	Minor	Minor	Minor	Minor	Minor	Minor
Common Coot	Minor	Minor	Minor	Minor	Minor	Minor
Little Gull	Minor	Minor	Minor	Minor	Minor	Minor
Black-headed Gull	Minor	Minor	Minor	Minor	Minor	Minor
Common Gull	Minor	Minor	Minor	Minor	Minor	Minor
Lesser Black-backed Gull	Minor	Negligible	Negligible	Negligible	Negligible	Negligible
Herring Gull	Minor	Minor	Minor	Minor	Minor	Minor
Great Black-backed Gull	Minor	Minor	Minor	Minor	Minor	Minor
Sandwich Tern	Minor	Minor	Minor	Minor	Minor	Minor
Common Tern	Minor	Negligible	Negligible	Negligible	Negligible	Negligible
Arctic Tern	Minor	Negligible	Negligible	Negligible	Negligible	Negligible
Common Guillemot	Minor	Negligible	Minor	Minor	Negligible	Negligible
Razorbill	Minor	Minor	Minor	Minor	Minor	Minor
Black Guillemot	Minor	Minor	Minor	Minor	Minor	Minor
Other species	Minor	Negligible/ Minor	Negligible/ Minor	Negligible/ Minor	Negligible/ Minor	Negligible/ Minor

Separate pressures anticipated during the tunnel construction partly or fully overlap (Figure 9.78), therefore their impacts cannot be simply summed without accounting for spatial correspondence. When overlapping, a pressure which is assessed as having higher impact on birds was used in the overall assessment.

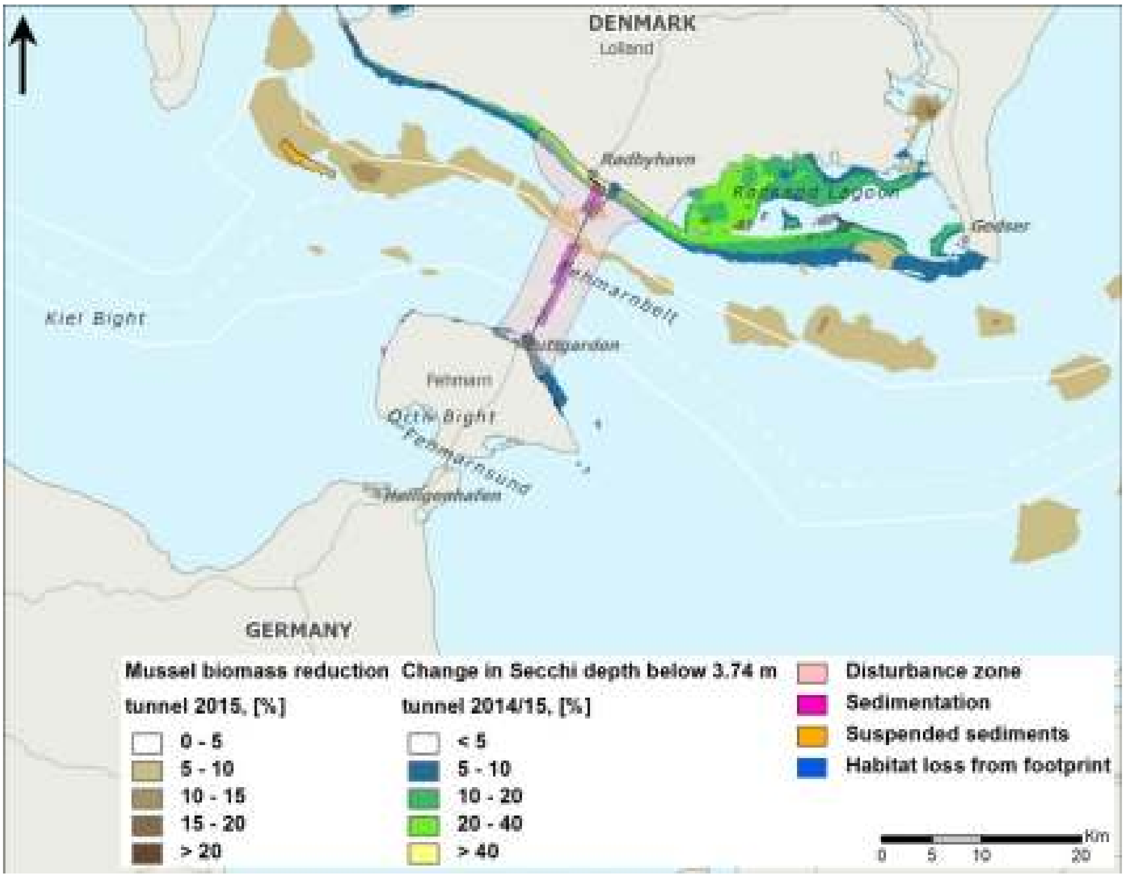


Figure 9.78 Pressures and their spatial overlap in the Fehmarnbelt during the tunnel construction.

The following set of rules applied when making the overall assessment:

- Footprint structures would fall completely within the disturbance zone, and since both pressures were assumed to result in a complete exclusion of birds, only the disturbance zone was considered in the overall assessment.
- Decreased water transparency was the other pressure, which was assumed to result in a complete exclusion of birds. Because it partly overlaps with the disturbance zone, the overlapping area was excluded from the overall assessment (i.e. no double displacement of birds of that area).
- Impacts of the pressure sediment spill, consisting of three sub-pressures (reduction of Blue Mussel biomass, sedimentation and suspended sediments) were added to the overall assessment after excluding areas overlapping with the disturbance zone and areas of decreased water transparency.

Cumulative assessment for species, for which continuous spatial distribution maps were not available, was done by simple summing of all separate pressures despite their partial overlap. (The footprint structures, which completely fall within the disturbance zone, were not included.)

For no species the aggregation of the pressures causing a displacement of birds led to a higher overall severity level than already reached by one of the pressures alone (Table 9.28).

The assessment of significance was conducted following the description in chapter 4.5.14 and the introduction to this chapter. In the first two years of the construction period internationally important numbers of Common Eiders (up to 12,114 birds or 1.59% of the biogeographic population) are predicted to be displaced from the overall impact zone. Additionally, a medium severity of impairment is assessed to result from the barrier caused by construction vessels. Based on the number of displaced birds this impact would be significant for the Common Eider (>1% of the biogeographic population displaced). However, it is assumed that excluding birds from the impaired areas would result in a redistribution of birds, which would not result in population impacts if the displaced birds find suitable (foraging and resting) habitats elsewhere and the carrying capacity of these habitats is sufficient to accommodate them. To analyse this question further, an individual-based model (IBM) for the Common Eider was run to predict the effect of bird exclusion from the impaired areas and allowing them to redistribute within the study area (see below).

Individual-based model for the Common Eider

An individual-based model (IBM) for Common Eider has been used for simulations referring to the tunnel impact scenario using the baseline IBM (FEBI 2013) with modified food resources and restricted bird access to areas that were predicted to be affected by disturbance and decreased water transparency (see chapter 4.6.2). By allowing 250,000 eiders into the IBM system and without forcing bird spatial distribution, the model predicted that eiders would distribute in a pattern resembling closely observed eider distribution in the study area (see chapter 4.6.2; Figure 9.79).

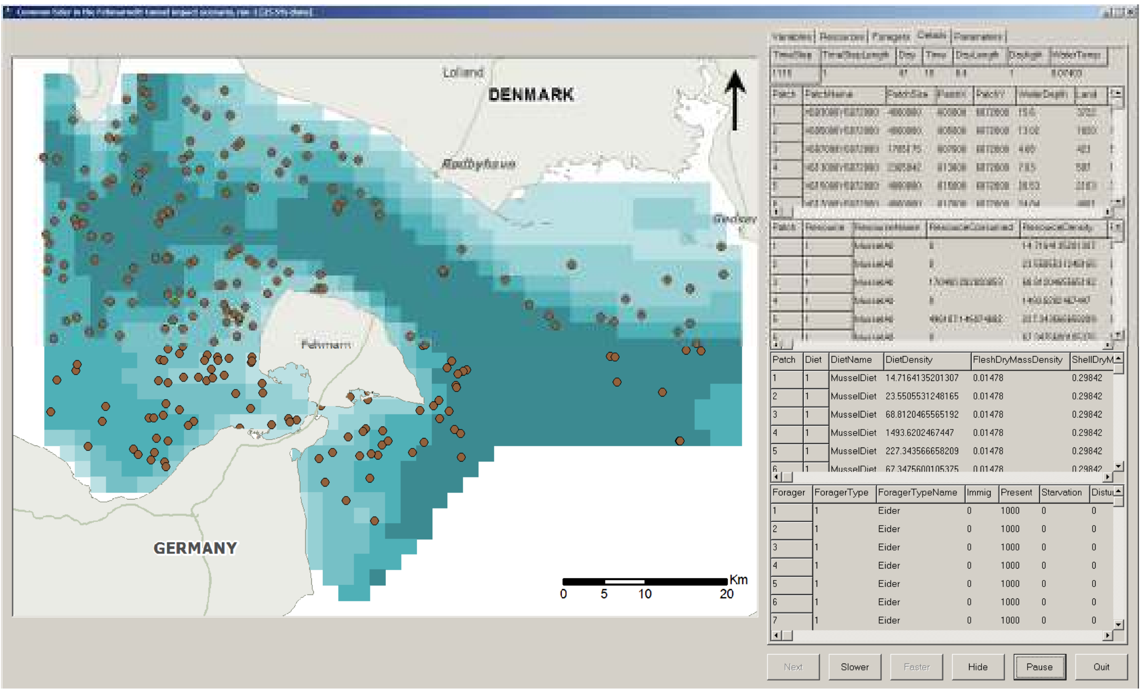


Figure 9.79 Screen shot of MORPH running individual-based model for Common Eiders in the Fehmarnbelt under the impact scenario representing the construction of the immersed tunnel. Each dot represents a 'super-individual' consisting of 1,000 model birds.

The IBM results representing simulations of the tunnel scenario indicated that model eiders consumed a similar amount of food per day as during the baseline – approximately 5,000 of 14 mm mussels per day (Figure 9.80). This amount is about 30% lower than consumption estimates according to eider energy budget if birds relied exclusively on blue mussels (FEBI 2013). However, there is no discrepancy from the actual Blue Mussel intake as these bivalves contribute about 70-80% of the total energy intake for Common Eiders in the Fehmarnbelt, as it was established by the diet analysis (FEBI 2013). Mussel consumption by Common Eiders according to the IBM simulations was on average 1.5% lower during the tunnel impact scenario compared to the baseline. The difference was statistically significant when comparing mussel intake rate at selected time steps during the winter period (paired t test: $t = 3.47$, $P < 0.01$, $df = 74$).

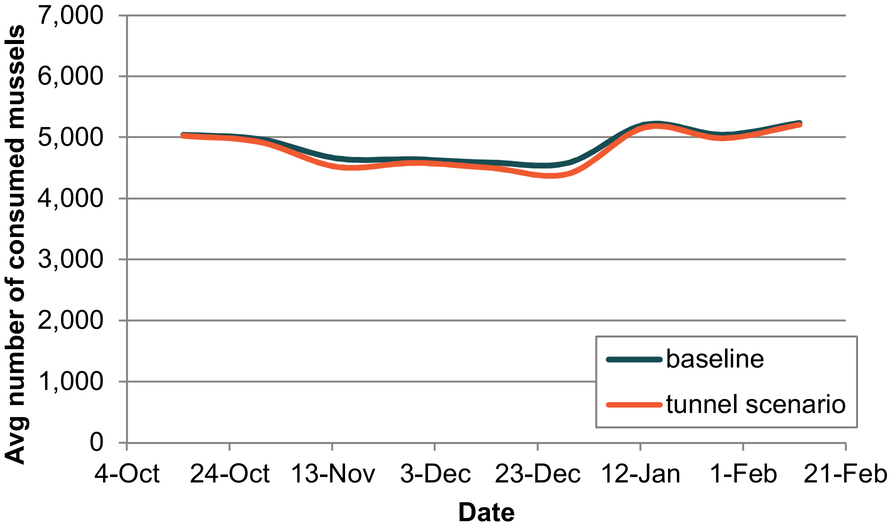


Figure 9.80 IBM-predicted daily consumption of 14 mm size Blue Mussels of by an individual Common Eider during the wintering season under the baseline conditions and tunnel impact scenario.

The survival of modelled Common Eiders was slightly lower for the tunnel scenario than that predicted for the baseline conditions. Simulations predicted that 600 birds would die due to starvation during the baseline conditions and 1,200 during the immersed tunnel impact scenario. Such levels of mortality account for 0.2% and 0.5% respectively of the total number of birds used in the simulations (250,000) lasting the entire wintering period of 6 months. Natural mortality of adult Common Eiders is at least 7% per annum (Balmer and Peach 1997). Therefore predicted starvation-induced mortality comprises only a small fraction of overall natural mortality.

Further, dynamics of body mass of model birds was compared between the baseline and tunnel impact scenarios. The simulations predicted similar body mass development in both cases (Figure 9.81). Pairwise comparison of the mean body mass of all individuals during selected time steps of simulations showed that birds were on average 14 g (95% CI = 12.54-15.37) lighter in the tunnel impact scenario, the difference being significant (paired t test, $t = 19.35$, $P < 0.01$, $df = 287$). Although statistically significant, the difference comprises only 0.6% of average adult Common Eider body mass, and model individuals under both simulation scenarios (baseline and tunnel) reached target body by the end of the wintering season.

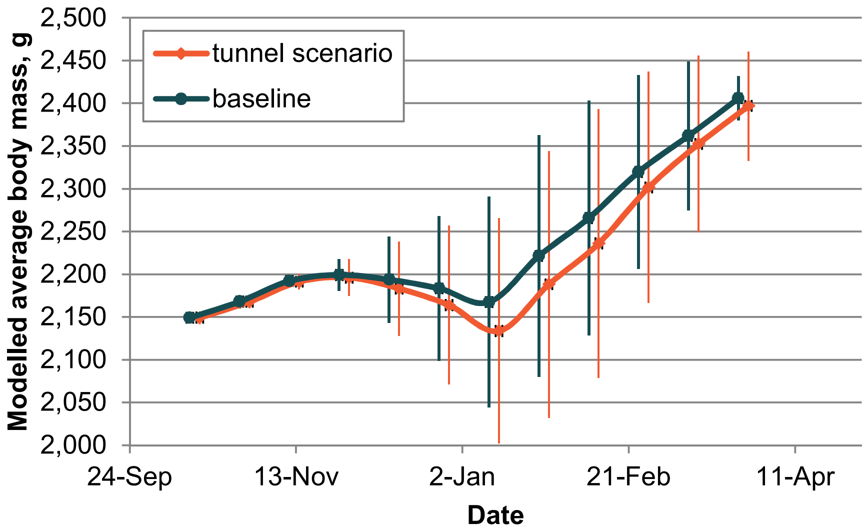


Figure 9.81 Mean body mass of Common Eiders (with bars indicating standard deviation) as predicted by the IBM for baseline conditions and immersed tunnel impact scenario when 250,000 birds were allowed to enter the model system.

Assessment of Common Eider habitat carrying capacity

It was assumed, that decreased Blue Mussel resources, disturbance and decreased water transparency resulting from the tunnel construction works may cause wintering eiders to temporarily abandon some areas and relocate elsewhere. Considering that displaced birds would redistribute locally within the Fehmarnbelt area, a series of simulations were run with gradually increasing numbers of wintering Common Eiders in the IBM with already included impacts of the tunnel construction.

The model predicted that under the tunnel impact scenario, bird mortality due to starvation would be slightly higher compared to the baseline conditions (Figure 9.82). However, the mortality would not become massive what would indicate widespread resource depletion, but would comprise just 1.5% even when number of birds in the model system was doubled and reached 500,000. Such a number of birds in the Fehmarnbelt represents an unlikely scenario and has never been recorded there. This simulation exercise suggests that predicted higher mortality does not necessarily indicate general resource depletion beyond profitable levels, but that factors, such as bird density dependence and number of sub-dominant individuals, increase with increasing number of birds in the model system and also play a role. The predicted eider mortality in the simulations did not follow the increasing bird numbers in a strictly linear way (e.g., it predicted slightly lower mortality of birds for the tunnel scenario with 400,000 individuals compared to the scenario with 350,000 birds), which is another indication that stochastic factors built into the model were driving some of the mortalities and therefore bird survival was not depending exclusively on food resource availability.

Finally, dynamics of body mass development of the model birds indicated that average body mass of wintering individuals had a tendency to be lower when their numbers were artificially increased, but by the end of the wintering season birds reached or approached the target weight under all scenarios (Figure 9.83).

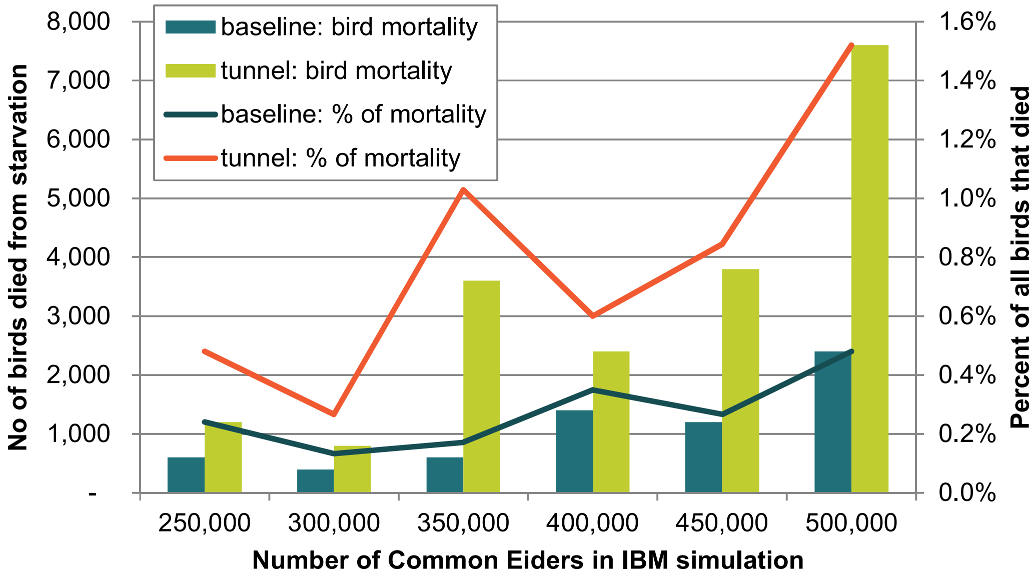


Figure 9.82 IBM-predicted Common Eider mortality due to starvation during the wintering season depending on the number of birds allowed into the model system under the baseline conditions and immersed tunnel scenario.

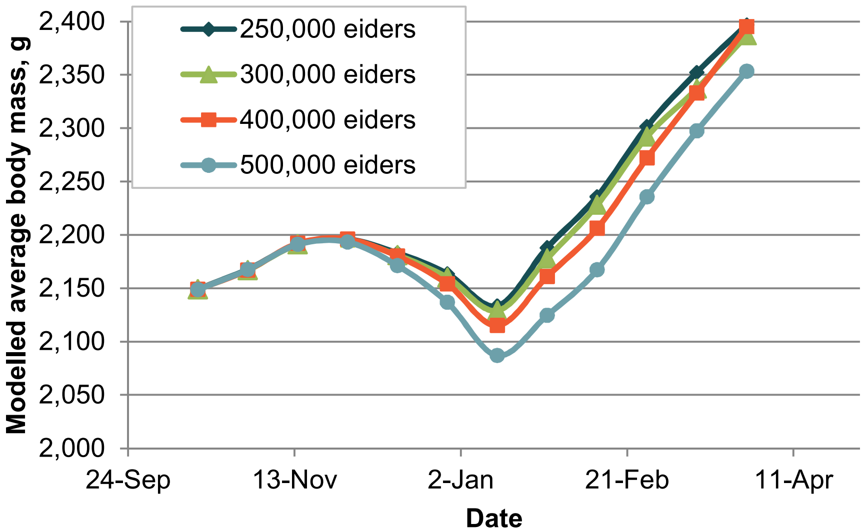


Figure 9.83 Measuring habitat carrying capacity for Common Eiders: simulations with increasing number of birds (250 – 500 thousands) in the model system indicated that higher numbers of birds have led to slightly lower mean body mass.

The IBM predicted that 250,000 Common Eiders would consume a total of about 3,000 tonnes of AFDW of Blue Mussels per wintering season in order to satisfy their energetic requirements. It was estimated that during the baseline scenario Common Eiders consume about 10.7% of the initial standing stock of Blue Mussels per wintering season. During the scenario representing possible impacts of the immersed tunnel, the initial standing stock of Blue Mussels that is potentially available for birds would be about 18.6% lower (22,800 tonnes AFWD) and therefore Common Eider consumption would account for 13.2% of the total potentially available biomass (Table 9.27).

Table 9.27 Initial biomass of Blue Mussels and their consumption by wintering Common Eiders during the baseline and immersed tunnel impact scenario.

	Baseline	Immersed tunnel impact scenario
Number of birds	250,000	250,000
Biomass of Blue Mussels, t AFDW	28,000	22,800
Mussel consumption by eiders, t AFDW	3,000	3,000
Mussel consumption by eiders, %	10.7%	13.2%

Opinions vary about the amount of food that wintering seaducks need for satisfying their energetic demands. Laursen et al. (2010) suggested that Common Eiders wintering in the Danish Wadden Sea need a standing stock of Blue Mussels that exceed the birds' physiological needs at least 2.5 times. Camphuysen et al. (2002) reported mass mortality of starving Common Eider in the Dutch Wadden Sea even though estimated stock of bivalves 4.7 times exceeded bird physiological demands.

The individual-based model indicate that possible impacts on wintering Common Eiders arising from the construction of the immersed tunnel (habitat loss, reduction of food resources, complete displacement from areas affected by construction-related disturbance and decreased water transparency), would cause an additional mortality of about 600 individuals (0.24% of birds in the model, 0.08% of the biogeographic population) and small reduction in mean body mass during mid-winter. Furthermore, according to the IBM simulations, the carrying capacity of the Fehmarnbelt as Common Eider habitat is well above the number of birds that are actually using this ecosystem.

Based on IBM predictions the overall impact of the tunnel construction on the Common Eider wintering in Fehmarnbelt would not result in a population effect for the species and is therefore assessed as being insignificant (Table 9.28).

Table 9.28 Cumulative assessment of separate pressures after accounting for their spatial overlap and assessment of significance of the project impact to non-breeding waterbird species. Please note: total number of displaced birds accounts for spatial overlap of different pressures, thus total number can be smaller than the sum of separate pressures. Number of displaced birds 'Minor' means that low numbers corresponding to less than 0.1% of the biogeographic population would be affected.

Species	Number of displaced birds due to			Total number of displaced birds	Severity of impair-ment		Significance
	Distur-bance*	Water transpare ncy	Sediment spill		Barrier from constr. vessels	Collision with constr. vessels	
Divers	10	32	Minor	42	Minor	Minor	Insignificant
Great Crested Grebe	Minor	Minor	Negligible	Minor	Negligible	Negligible	Insignificant
Red-necked Grebe	26	69	Minor	91	Minor	Minor	Insignificant
Slavonian Grebe	Minor	Minor	Negligible	Minor	Negligible	Negligible	Insignificant
Great Cormorant	500	Minor	Minor	500	Minor	Minor	Insignificant
Mute Swan	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Whooper Swan	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Bewick's Swan	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Bean Goose	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant

Species	Number of displaced birds due to			Total number of displaced birds	Severity of impairment		Significance
	Disturbance*	Water transparency	Sediment spill		Barrier from constr. vessels	Collision with constr. vessels	
Greater White-fronted Goose	Minor	Negligible	Negligible	Minor	Negligible	Negligible	Insignificant
Greylag Goose	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Barnacle Goose	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Brent Goose	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Eurasian Wigeon	1,500	Minor	Minor	1,500	Minor	Minor	Insignificant
Gadwall	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Common Teal	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Mallard	Minor	Minor	Minor	Minor	Negligible	Negligible	Insignificant
Shoveler	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Common Pochard	710	Minor	7	717	Minor	Minor	Insignificant
Tufted Duck	7,100	Minor	63	7,163	Minor	Minor	Insignificant
Greater Scaup	130	Minor	25	155	Minor	Minor	Insignificant
Common Eider	4,882	8,823	576	12,114	Minor	Minor	Insignificant**
Long-tailed Duck	120	594	33	745	Minor	Minor	Insignificant
Common Scoter	391	512	58	726	Minor	Minor	Insignificant
Velvet Scoter	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Common Goldeneye	91	Minor	1	92	Minor	Minor	Insignificant
Smew	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Red-breasted Merganser	208	892	Minor	1,026	Minor	Minor	Insignificant
Goosander	Minor	Minor	Negligible	Minor	Negligible	Negligible	Insignificant
White-tailed Eagle	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Common Coot	340	Minor	Minor	Minor	Minor	Minor	Insignificant
Little Gull	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Black-headed Gull	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Common Gull	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Lesser Black-backed Gull	Minor	Negligible	Negligible	Minor	Negligible	Negligible	Insignificant
Herring Gull	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Great Black-backed Gull	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Sandwich Tern	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Common Tern	Minor	Negligible	Negligible	Minor	Negligible	Negligible	Insignificant
Arctic Tern	Minor	Negligible	Negligible	Minor	Negligible	Negligible	Insignificant
Common Guillemot	Minor	Minor	Negligible	Minor	Negligible	Negligible	Insignificant
Razorbill	11	3	Minor	13	Minor	Minor	Insignificant
Black Guillemot	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Other species	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant

** bird exclusion due to footprint structures is included in Disturbance due to complete overlap.*
*** The number of displaced birds (>1% of the biogeographic population) would correspond to a significant impact for the Common Eider. However, the impact is assessed being insignificant based on the results of the individual-based model, based on which a population effect could be excluded.*

Structure and operation

Two pressures were identified as being relevant for birds from structure and operation of an immersed tunnel in the Fehmarnbelt: habitat loss from footprint and hydrographical changes (Table 9.29). Corresponding to the assessment of the habitat loss of the tunnel footprint during the construction phase a high severity of loss is assessed to result from habitat loss from Danish land reclamation to the Common Pochard and the Tufted Duck. For all other non-breeding waterbird species in the area a minor severity of loss is assessed to result from the tunnel footprint.

On the other hand, new structures would likely create similar conditions that are currently used by Common Pochard and Tufted Ducks around existing harbour structures at Rødbyhavn. These species currently aggregate in the alignment area using shelter provided by the harbour structures. Thus, it is likely that Common Pochard and Tufted Ducks will habituate and utilise changed habitats.

Hydrographical changes resulting from the tunnel footprint are assessed to not result in any relevant changes in bird numbers and distribution in the area, thus the severity of impairment is assessed to be minor for all non-breeding waterbirds in Fehmarnbelt.

The assessment of significance was conducted following the description in chapter 4.5.14 and the introduction to this chapter. No significant impact was identified to result from structure and operation of an immersed tunnel in the Fehmarnbelt for any non-breeding waterbird species in the area (Table 9.29). Permanent displacement of highly important numbers of the Common Pochard and the Tufted Duck were regarded to result mostly in redistribution of birds and no population impacts are expected to occur. Therefore, the impact on the Common Pochard and the Tufted Duck is assessed being insignificant.

Table 9.29 Summary of the assessment of pressure-specific severity of impact (loss/impairment) and overall significance of impact for non-breeding waterbirds from structure and operation of an immersed tunnel in the Fehmarnbelt. 'Total number of displaced birds' indicates the aggregated impact in terms of bird displacement from the pressures habitat loss and hydrographical changes.

Species	Loss	Impairment		Total number of displaced birds	Significance
	Habitat loss from footprint	Provision of artificial reefs	Hydro-graphical changes		
Divers	Minor	No impact	No impact	Low number	Insignificant
Great Crested Grebe	Minor	No impact	No impact	Low number	Insignificant
Red-necked Grebe	Minor	No impact	No impact	Low number	Insignificant
Slavonian Grebe	Minor	No impact	No impact	Low number	Insignificant
Great Cormorant	Minor	No impact	No impact	500	Insignificant
Mute Swan	Minor	No impact	No impact	Low number	Insignificant
Bewick's Swan	Minor	No impact	No impact	Low number	Insignificant
Whooper Swan	Minor	No impact	No impact	Low number	Insignificant
Bean Goose	Minor	No impact	No impact	Low number	Insignificant
Greater White-fronted Goose	Minor	No impact	No impact	Low number	Insignificant
Greylag Goose	Minor	No impact	No impact	Low number	Insignificant
Barnacle Goose	Minor	No impact	No impact	Low number	Insignificant
Brent Goose	Minor	No impact	No impact	Low number	Insignificant
Eurasian Wigeon	Minor	No impact	No impact	Low number	Insignificant
Gadwall	Minor	No impact	No impact	Low number	Insignificant

Species	Loss	Impairment		Total number of displaced birds	Significance
	Habitat loss from footprint	Provision of artificial reefs	Hydro-graphical changes		
Common Teal	Minor	No impact	No impact	Low number	Insignificant
Mallard	Minor	No impact	No impact	Low number	Insignificant
Shoveler	Minor	No impact	No impact	Low number	Insignificant
Common Pochard	High	No impact	No impact	710	Insignificant
Tufted Duck	High	No impact	No impact	7,100	Insignificant
Greater Scaup	Minor	No impact	No impact	130	Insignificant
Common Eider	Minor	No impact	No impact	207	Insignificant
Long-tailed Duck	Minor	No impact	No impact	Low number	Insignificant
Common Scoter	Minor	No impact	No impact	16	Insignificant
Velvet Scoter	Minor	No impact	No impact	Low number	Insignificant
Common Goldeneye	Minor	No impact	No impact	Low number	Insignificant
Smew	Minor	No impact	No impact	Low number	Insignificant
Red-breasted Merganser	Minor	No impact	No impact	Low number	Insignificant
Goosander	Minor	No impact	No impact	Low number	Insignificant
White-tailed Eagle	Minor	No impact	No impact	Low number	Insignificant
Common Coot	Minor	No impact	No impact	Low number	Insignificant
Little Gull	Minor	No impact	No impact	Low number	Insignificant
Black-headed Gull	Minor	No impact	No impact	Low number	Insignificant
Common Gull	Minor	No impact	No impact	Low number	Insignificant
Lesser Black-backed Gull	Minor	No impact	No impact	Low number	Insignificant
Herring Gull	Minor	No impact	No impact	Low number	Insignificant
Great Black-backed Gull	Minor	No impact	No impact	Low number	Insignificant
Sandwich Tern	Minor	No impact	No impact	Low number	Insignificant
Common Tern	Minor	No impact	No impact	Low number	Insignificant
Arctic Tern	Minor	No impact	No impact	Low number	Insignificant
Common Guillemot	Minor	No impact	No impact	Low number	Insignificant
Razorbill	Minor	No impact	No impact	Low number	Insignificant
Black Guillemot	Minor	No impact	No impact	Low number	Insignificant
Other species	Minor	No impact	No impact	Low number	Insignificant

9.4.3 *Migrating birds*

Construction phase

Two pressures were identified to be relevant for migrating birds during the construction of an immersed tunnel in the Fehmarnbelt: barrier from construction vessels and collision with construction vessels (Table 9.30). Both pressures are assessed to result in negligible or minor severity of impairment to the migrating bird species in the area; therefore, the significance of the project impact during the construction phase is assessed to be insignificant for all migrating bird species passing the Fehmarnbelt.

Table 9.30 Summary of the assessment of pressure-specific severity of impairment for migrating birds during the construction phase of an immersed tunnel in Fehmarnbelt.

Species	Impairment		Significance
	Barrier from construction vessels	Collision with construction vessels	
Red-throated Diver	Minor	Minor	Insignificant
Black-throated Diver	Minor	Minor	Insignificant
Great Crested Grebe	Minor	Minor	Insignificant
Red-necked Grebe	Minor	Minor	Insignificant
Slavonian Grebe	Minor	Minor	Insignificant
Northern Gannet	Minor	Minor	Insignificant
Great Cormorant	Minor	Minor	Insignificant
Grey Heron	Negligible	Negligible	Insignificant
White Stork	Minor	Minor	Insignificant
Mute Swan	Minor	Minor	Insignificant
Bewick's Swan	Minor	Minor	Insignificant
Whooper Swan	Minor	Minor	Insignificant
Bean Goose	Minor	Minor	Insignificant
Greater White-fronted Goose	Negligible	Negligible	Insignificant
Greylag Goose	Minor	Minor	Insignificant
Barnacle Goose	Minor	Minor	Insignificant
Brent Goose	Minor	Minor	Insignificant
Common Shelduck	Negligible	Negligible	Insignificant
Eurasian Wigeon	Minor	Minor	Insignificant
Gadwall	Minor	Minor	Insignificant
Common Teal	Negligible	Negligible	Insignificant
Mallard	Negligible	Negligible	Insignificant
Northern Pintail	Minor	Minor	Insignificant
Garganey	Negligible	Negligible	Insignificant
Northern Shoveler	Minor	Minor	Insignificant
Common Pochard	Negligible	Negligible	Insignificant
Tufted Duck	Negligible	Negligible	Insignificant
Greater Scaup	Minor	Minor	Insignificant
Common Eider	Minor	Minor	Insignificant
Long-tailed Duck	Negligible	Negligible	Insignificant
Common Scoter	Minor	Minor	Insignificant
Velvet Scoter	Negligible	Negligible	Insignificant
Common Goldeneye	Negligible	Negligible	Insignificant
Red-breasted Merganser	Minor	Minor	Insignificant
Goosander	Negligible	Negligible	Insignificant
Honey-Buzzard	Minor	Minor	Insignificant
Black Kite	Minor	Minor	Insignificant
Red Kite	Minor	Minor	Insignificant
White-tailed Eagle	Minor	Minor	Insignificant
Marsh Harrier	Minor	Minor	Insignificant
Northern (Hen) Harrier	Minor	Minor	Insignificant
European Sparrow Hawk	Minor	Minor	Insignificant

Species	Impairment		Significance
	Barrier from construction vessels	Collision with construction vessels	
Eurasian Buzzard	Minor	Minor	Insignificant
Rough-legged Buzzard	Negligible	Negligible	Insignificant
Osprey	Minor	Minor	Insignificant
Eurasian Kestrel	Minor	Minor	Insignificant
Red-footed Falcon	Minor	Minor	Insignificant
Merlin	Minor	Minor	Insignificant
Hobby	Negligible	Negligible	Insignificant
Peregrine Falcon	Minor	Minor	Insignificant
Common Crane	Minor	Minor	Insignificant
Waterrail	Minor	Minor	Insignificant
Corncrake	Minor	Minor	Insignificant
Moorhen	Minor	Minor	Insignificant
Common Coot	Minor	Minor	Insignificant
Oystercatcher	Negligible	Negligible	Insignificant
Avocet	Minor	Minor	Insignificant
Little Ringed Plover	Negligible	Negligible	Insignificant
Ringed Plover	Negligible	Negligible	Insignificant
Golden Plover	Minor	Minor	Insignificant
Grey Plover	Minor	Minor	Insignificant
Lapwing	Negligible	Negligible	Insignificant
Knot	Minor	Minor	Insignificant
Sanderling	Negligible	Negligible	Insignificant
Curlew Sandpiper	Minor	Minor	Insignificant
Dunlin	Minor	Minor	Insignificant
Ruff	Negligible	Negligible	Insignificant
Common Snipe	Negligible	Negligible	Insignificant
Bar-tailed Godwit	Minor	Minor	Insignificant
Whimbrel	Negligible	Negligible	Insignificant
Curlew	Minor	Minor	Insignificant
Spotted Redshank	Negligible	Negligible	Insignificant
Redshank	Negligible	Negligible	Insignificant
Greenshank	Negligible	Negligible	Insignificant
Green Sandpiper	Negligible	Negligible	Insignificant
Wood Sandpiper	Negligible	Negligible	Insignificant
Common Sandpiper	Negligible	Negligible	Insignificant
Turnstone	Negligible	Negligible	Insignificant
Arctic Skua	Minor	Minor	Insignificant
Great Skua	Minor	Minor	Insignificant
Mediterranean Gull	Negligible	Negligible	Insignificant
Little Gull	Minor	Minor	Insignificant
Black-headed Gull	Minor	Minor	Insignificant
Common Gull	Minor	Minor	Insignificant
Lesser Black-backed Gull	Negligible	Negligible	Insignificant
Herring Gull	Minor	Minor	Insignificant

Species	Impairment		Significance
	Barrier from construction vessels	Collision with construction vessels	
Great Black-backed Gull	Minor	Minor	Insignificant
Sandwich Tern	Minor	Minor	Insignificant
Common Tern	Minor	Minor	Insignificant
Arctic Tern	Minor	Minor	Insignificant
Little Tern	Minor	Minor	Insignificant
Black Tern	Negligible	Negligible	Insignificant
Common Guillemot	Negligible	Negligible	Insignificant
Razorbill	Negligible	Negligible	Insignificant
Black Guillemot	Negligible	Negligible	Insignificant
Stock Dove	Minor	Minor	Insignificant
Woodpigeon	Minor	Minor	Insignificant
Collared Dove	Negligible	Negligible	Insignificant
Long-eared Owl	Minor	Minor	Insignificant
Short-eared Owl	Minor	Minor	Insignificant
Cuckoo	Negligible	Negligible	Insignificant
Swift	Negligible	Negligible	Insignificant
Great Spotted Woodpecker	Negligible	Negligible	Insignificant
Eurasian Jay	Negligible	Negligible	Insignificant
Black-billed Magpie	Negligible	Negligible	Insignificant
Eurasian Jackdaw	Minor	Minor	Insignificant
Rook	Minor	Minor	Insignificant
Carrion Crow	Negligible	Negligible	Insignificant
Obligatory daytime migrating passerines	Minor	Minor	Insignificant
Facultative night-time migrating passerines	Minor	Minor	Insignificant
Obligatory night-time migrating passerines	Minor	Minor	Insignificant
Other species	Minor/Negligible	Minor/Negligible	Insignificant

Structure and operation

There was no pressure from structure or operation of the tunnel solution identified which could have a relevant effect on migrating birds. Therefore, there is no impact on migrating birds predicted to result from structure and operation of an immersed tunnel in the Fehmarnbelt.

9.5 Cumulative impacts

This section describes the probable and significant cumulative impacts of the fixed link in conjunction with other projects.

9.5.1 Included projects and possible interactions

When more projects within the same region affect the same environmental conditions at the same time, there are cumulative impacts. For a project to be relevant to include, it requires that the project:

- is within the same geographic area
- has some of the same impacts as the fixed link
- affects some of the same environmental conditions, habitats or components
- creates new environmental impacts during the period from the environmental investigations were completed to the fixed link is in operation.

The following projects at sea are considered relevant to include in the assessment of cumulative impacts on different environmental conditions. All of them are offshore wind farms:

Project	Placement	Phase	Possible interactions
Arkona Becken Südost	Northeast of Rügen	Construction	Sediment spill, displacement, collision risk, barrier effect
EnBW Windpark Baltic II	Southeast of Kriegers Flak	Construction	Sediment spill, displacement, collision risk, barrier effect
Wikinger	Northeast of Rügen	Construction	Sediment spill, displacement, collision risk, barrier effect
Rødsand II	In front of Lolland's southern coast	Operation	Coastal morphology, collision risk, barrier effect
Kriegers Flak II	Kriegers Flak	Construction	Sediment spill, displacement, collision risk, barrier effect
GEOFReE	Lübeck Bay	Construction	Sediment spill, displacement, collision risk

Rødsand II (Figure 9.84) is specifically included, as this is a project that went into operation, while Femern A/S conducted its environmental investigations, whereby a cumulative effect in principle cannot be excluded.

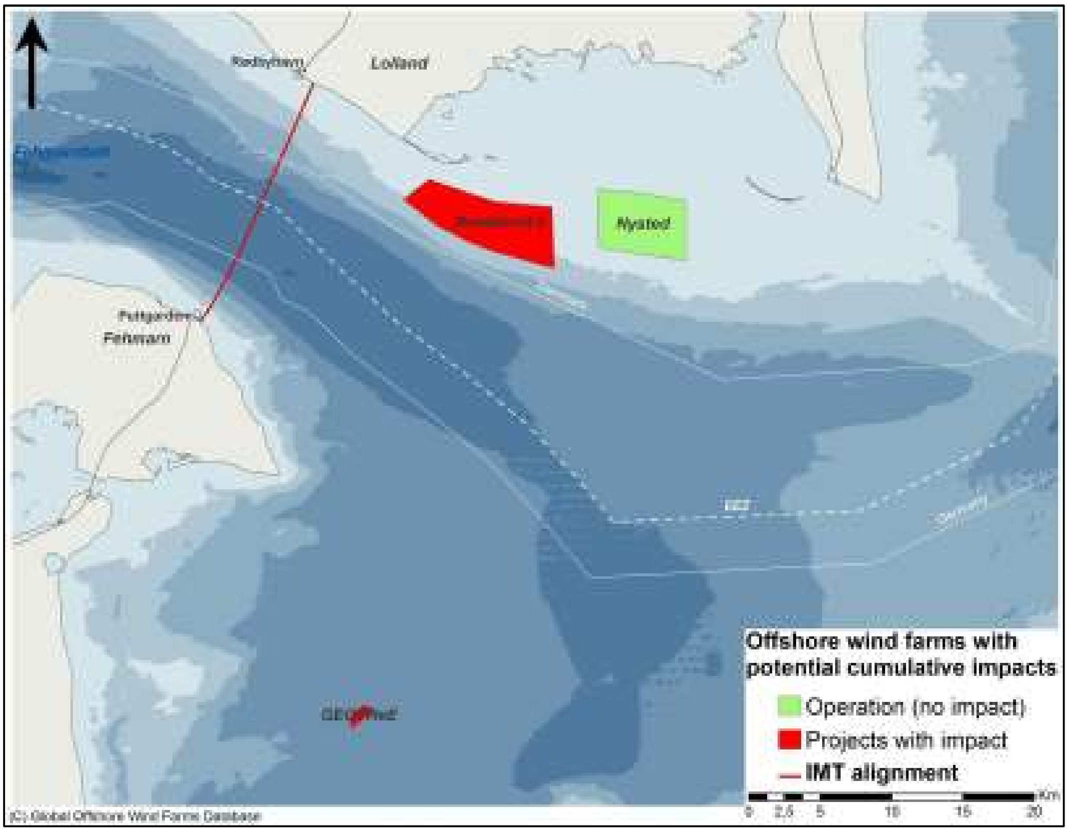


Figure 9.84 Locations of Rødsand II, Nysted and GEOFreE.

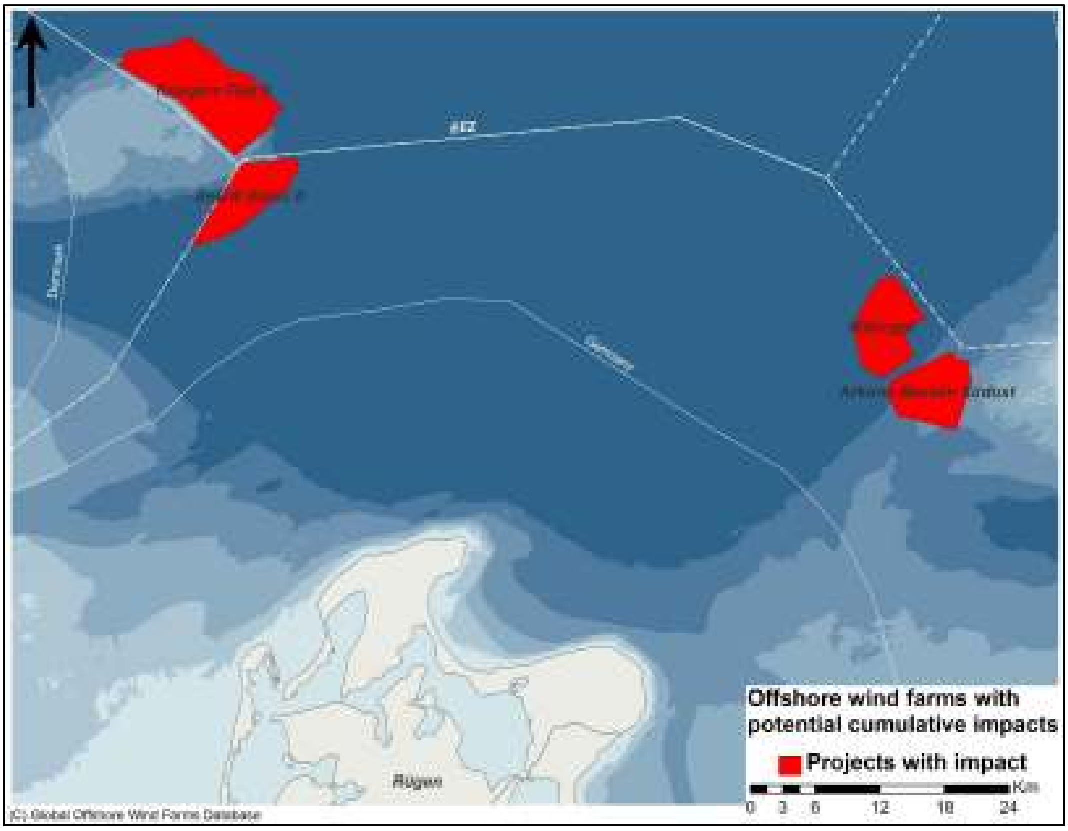


Figure 9.85 Locations of Kriegers Flak, EnBW Baltic II, Wikinger and Arkona Becken Südost.

9.5.2 Assessment and significance of impact

Breeding waterbirds
For a tunnel solution, no cumulative impacts on breeding birds are assumed.

Non-breeding waterbirds
Cumulative effects for non-breeding waterbirds need to be assessed with respect to habitat loss and displacement for the Rødsand II wind farm. The other wind farms at Kriegers Flak and north of Rügen are situated in a rather large distance to the Fehmarnbelt and due to higher water depth and different sediments it is of low importance for seaducks and other birds for which Fehmarnbelt is important (Vattenfall undat., BSH 2005, 2006, 2007b), thus only Rødsand II is considered for cumulative impacts with respect to a fixed link across Fehmarnbelt.

The Rødsand II wind farm, which has been erected in the years 2009 and 2010, is situated east of the alignment of a fixed link and covers an area of 35 km^2. It borders to the existing wind farm Nysted. Based on studies on previously constructed offshore wind farms the EIA report on birds expects high displacement of sensitive waterbird species as seaducks and divers from the wind farm area and a 2 km zone around it (Kahlert et al. 2007) and provides calculations for two scenarios of the number of Long-tailed Ducks. For other species, it is only concluded that no impacts on population level are expected and no numbers are presented.

The tunnel solution leads during the construction period to higher than minor severity of impairment for the following species: Eurasian Wigeon (medium), Common Pochard (high), Tufted Duck (high), Common Eider (very high), Red-breasted Merganser (medium). During operation, impacts on non-breeding waterbirds are higher than minor for Common Pochard (high) and Tufted Duck (high). Of these species, Common Eider and Red-breasted Merganser occur in some numbers in the Rødsand II offshore wind farm area. Red-breasted Merganser occur in low numbers in the wind farm area and it is assumed that the species will tolerate the presence of the wind farm as it is not mentioned to be affected by it in the EIA report (Kahlert et al. 2007). For Common Eider at least some displacement by the wind farm is expected. The displacement of Common Eider through construction of a tunnel is partly caused by decreased water transparency as a result of the sediment spill. As this will affect the wind farm area the displacement effects are only partly cumulative and as the effect of the tunnel construction is only relevant in three years, cumulative impacts are considered to be small and insignificant.

Based on the FEBI baseline investigations and assuming a complete displacement of Common Eider from the wind farm area and the surrounding 2 km around it, up to 5,800 Eider would be displaced. Impacts from construction and operation of an immersed tunnel would add to this, though during construction only partly, as impacts overlap. The displacement effect from the wind farm has been fully incorporated in the Individual-based model (IBM, see chapter 9.4.2) and is thus included in the assessment of significance. The conclusion of the assessment is that the combined effects of the tunnel and the offshore wind farm Rødsand II wind farm are insignificant.

Bird migration
Cumulative effects for migrating birds need to be assessed with respect to barrier effect and collisions. Due to long distances covered by migratory birds all offshore wind farms as listed above will be considered. With regard to a planned fixed link across the Fehmarnbelt only the bridge solution is considered to be relevant as the impacts of a tunnel on bird migration is minor for all species.

9.6 Assessment of impacts of decommissioning of tunnel constructions

Decommissioning is foreseen to take place in the year 2140, when the fixed link has been in operation for the design lifetime of 120 years. It is likely that methods for removing structures and reuse of materials will evolve over a time span of more than 100 years. Also it is likely that new methods will be less polluting as a result of development of green technologies. However, it is not possible to predict these changes, and therefore it is assumed that decommissioning will be carried out using methods similar to the ones available today. This is expected to result in a conservative estimate of the environmental impacts.

Any structure on the seabed will be levelled with the seabed in order to allow then undisturbed ship traffic, fishery and similar activities at sea. There is no navigational requirement to remove structures below seabed level.

Demolition of the elements of the immersed tunnel will mainly take place in-situ and can be done by usual methods. De-commissioning of the different elements will happen as follows:

- The tunnel tubes will be stripped of all technical equipment. The tunnel elements themselves along with fill over the elements remain in the ground. This process may take several years and proceed at a pace determined by the availability of the materials.

- Portal buildings will not be demolished. They will be sold as premises for viewpoint, restaurant, museum, local (water-)sports clubs or other similar uses.

- The reclaimed areas are expected to constitute various habitats for flora and fauna. The decommissioning will leave the reclaimed areas and these habitats undisturbed.

- Roadway surfacing asphalt outside the tunnel will be removed and reused as raw material for new asphalt. Roadbases will be removed and reused for new roads or for filling the tunnel elements and tunnel mouth.

- In industrial areas, no further activities are carried out and the area is sold as industrial site. In farming areas, the remaining embankment will be levelled to a slope of no more than 6% and covered with topsoil, in order to be sold as farm-land.

- Railway tracks will be recycled as scrap metal and ballast material will be cleaned and reused. In industrial areas, no further activities are carried out and the area is sold as industrial site.

- In farming areas, the remaining embankment will be levelled to a slope of no more than 6% and covered with topsoil, in order to be sold as farmland.

- The area for customs control will remain in operation as the need for authority control will remain as long as a traffic connection with Germany is maintained, whether fixed or ferry based. The toll plaza is continued as battery changing station for electrical vehicles or other transport related services.

9.6.1 Impacts during decommissioning of immersed tunnel

All activities related to decommissioning of the immersed tunnel are foreseen to be carried out on land.

The local disturbance from the decommissioning activities, such as stripping of technical equipment and filling the tunnel elements are not expected to have any significant impacts on marine birds.

9.6.2 Impacts after decommissioning of immersed tunnel

No impacts on marine birds are foreseen after completion of the decommissioning work for the immersed tunnel.

10 ASSESSMENT OF IMPACTS OF CABLE STAYED BRIDGE (MAIN BRIDGE ALTERNATIVE)

10.1 General description of the project

The alignment for the marine section passes east of Puttgarden harbour, crosses the belt in a soft S-curve and reaches Lolland east of Rødbyhavn.

10.1.1 Bridge concept

The main bridge is a twin cable stayed bridge with three pylons and two main spans of 724 m each. The superstructure of the cable stayed bridge consists of a double deck girder with the dual carriageway road traffic running on the upper deck and the dual track railway traffic running on the lower deck. The pylons have a height of 272 m above sea level and are V-shaped in transverse direction. The main bridge girders are made up of 20 m long sections with a weight of 500 to 600 t. The standard approach bridge girders are 200 m long and their weight is estimated to ~8,000 t.

Caissons provide the foundation for the pylons and piers of the bridge. Caissons are prefabricated placed 4 m below the seabed. If necessary, soils are improved with 15 m long bored concrete piles. The caissons in their final positions end 4 m above sea level. Prefabricated pier shafts are placed on top of the approach bridge caissons. The pylons are cast in situ on top of the pylon caissons Pier Protection Works are prefabricated and installed around the pylons and around two piers on both sides of the pylons. These works protrudes above the water surface. The main bridge is connected to the coasts by two approach bridges. The southern approach bridge is 5,748 m long and consists of 29 spans and 28 piers. The northern approach bridge is 9,412 m long and has 47 spans and 46 piers.

Figure 10.1 Cable stayed bridge.

10.1.2 Land works

A peninsula is constructed both at Fehmarn and at Lolland to use the shallow waters east of the ferry harbours breakwater to shorten the Fixed Link Bridge between its abutments. The peninsulas consist partly of a quarry run bund and partly of dredged material and are protected towards the sea by revetments of armour stones.

Fehmarn

The peninsula on Fehmarn is approximately 580 m long, measured from the coastline. The gallery structure on Fehmarn is 320 m long and enables a separation of the road and railway alignments. A 400 m long ramp viaduct bridge connects the road from the end of the gallery section to the motorway embankment. The embankments for the motorway are 490 m long. The motorway passes over the existing railway tracks to Puttgarden Harbour on a bridge. The profile of the railway and motorway then descend to the existing terrain surface.

Lolland

The peninsula on Lolland is approximately 480 m long, measured from the coastline. The gallery structure on Lolland is 320 m long. The existing railway tracks to Rødbyhavn will be decommissioned, so no overpass will be required. The viaduct bridge for the road is 400 m long, the embankments for the motorway are 465 m long and for the railway 680 m long. The profile of the railway and motorway descend to the natural terrain surface.

Figure 10.2 Peninsula of a cable stayed bridge at Lolland.

10.1.3 Drainage on main and approach bridges

On the approach bridges the roadway deck is furnished with gullies leading the drain water down to combined oil separators and sand traps located inside the pier head before discharge into the sea.

On the main bridge the roadway deck is furnished with gullies with sand traps. The drain water passes an oil separator before it is discharged into the sea through the railway deck.

10.1.4 Marine construction work

The marine works comprises soil improvement with bored concrete piles, excavation for and the placing of backfill around caissons, grouting as well as scour protection. The marine works also include the placing of crushed stone filling below and inside the Pier Protection Works at the main bridge.

Soil improvement will be required for the foundations for the main bridge and for most of the foundations for the Fehmarn approach bridge. A steel pile or reinforcement cage could be placed in the bored holes and thereafter filled with concrete.

The dredging works are one of the most important construction operations with respect to the environment, due to the spill of fine sediments. It is recommended that a grab hopper dredger with a hydraulic grab be employed to excavate for the caissons both for practical reasons and because such a dredger minimises the sediment spill. If the dredged soil cannot be backfilled, it must be relocated or disposed of.

10.1.5 Production sites

The temporary works comprises the construction of two temporary work harbours with access channels. A work yard will be established in the immediate vicinity of the harbours, with facilities such as concrete mixing plant, stockpile of materials, storage of equipment, preassembly areas, work shops, offices and labour camps.

The proposed lay-out of the production site is shown in Figure 10.3.

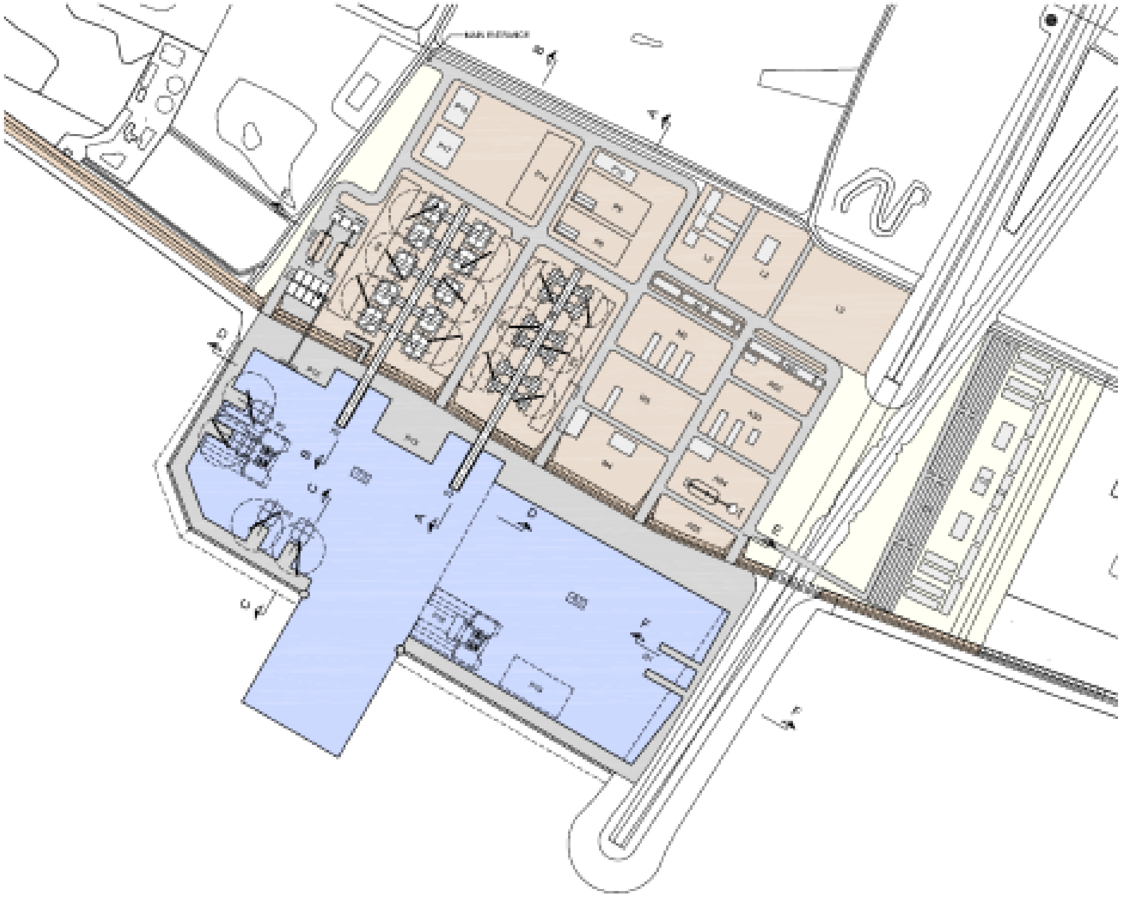


Figure 10.3 Proposed lay-out of the production site.

10.2 Construction phase

10.2.1 Habitat loss from footprint

Description of the pressure

During the construction of a cable stayed bridge in the Fehmarnbelt, marine habitats would be directly lost due to dredging works, building working harbours, land reclamations or the bridge structure itself (Figure 10.4). The largest areas which would be affected by the footprint are the coastal areas east of Rødbyhavn from bridge peninsula and the working harbour, and east of the breakwater of the ferry harbour of Puttgarden with bridge peninsula and the working harbour (Table 10.1). The footprint in the offshore areas of the Fehmarnbelt consists of the footprints of 74 piers of the two approach bridges, and the 4 piers and 3 pylons of the main bridge (Figure 10.4).

The benthic habitats affected by the bridge footprint would be mostly macroalgae (*Furcellaria*) and *Mytilus* communities in the coastal areas and *Arctica* and *Corbula* communities in the deeper areas (FEMA 2013a, FEMA 2013b).

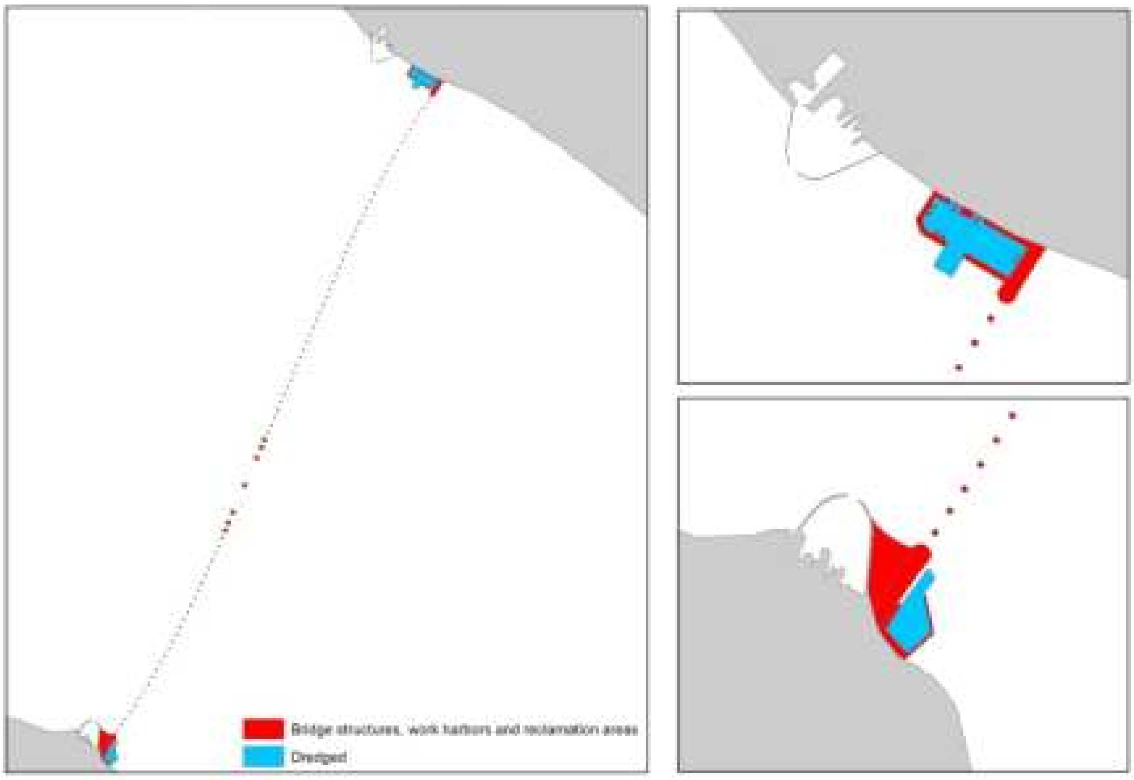


Figure 10.4 Footprint of the cable stayed bridge during the construction period.

Table 10.1 Marine areas affected by habitat loss from the footprint of a cable stayed bridge during the construction period.

Footprint area	Size, ha
Dredged area Fehmarn (working harbour)	9.09
Dredged areas Lolland (working harbour)	19.80
Bridge pylons and piers	19.88
Bridge peninsula Lolland	4.99
Bridge peninsula Fehmarn	7.43
Working harbour Lolland	5.62
Working harbour Fehmarn	2.82
Reclamation area Fehmarn	8.95
TOTAL	78.59

Degree of impairment

The footprint area of the cable stayed bridge during the construction period is regarded as an area of complete habitat loss since re-establishment of construction harbours is expected to mostly take place after the construction period. Habitat loss is defined to always result in a complete displacement of all birds from the impact area, so no degree of loss can be specified.

Severity of loss

Breeding waterbirds

The habitat loss in marine areas is expected to be relevant for breeding bird species which use marine habitats as foraging sites during the breeding season or rear their offspring in marine areas. It is predicted that the same species could get affected by the habitat loss from the construction of a cable stayed bridge as described in chapter 9.2.1 for the tunnel alternative.

The loss of coastal habitats of the cable stayed bridge would be about 85% smaller compared to the tunnel footprint. Therefore the severity of loss from the bridge footprint is assessed to be generally lower than for the tunnel alternative.

Based on the Impact Assessment of the tunnel alternative and the substantially smaller areas affected by the bridge alternative, the severity of loss is assessed to be minor for all waterbird species breeding in Natura 2000 areas. There is no relevant impact predicted from this pressure for Red-necked Grebes breeding outside Natura 2000 sites on Lolland.

Non-breeding waterbirds

The total impact area of the cable stayed bridge footprint is relatively small in relation to the Fehmarnbelt study area that was investigated during the baseline investigations. The footprint lies within an area of comparably low waterbird densities due to existing disturbance from the intensive shipping, including the ferry traffic in this area. Since in the Impact Assessment for the footprint of the tunnel alternative the severity of loss is assessed to be minor to all species, except for the three diving ducks Common Pochard, Tufted Duck and Greater Scaup (see chapter 9.2.1), no detailed assessment for the bridge footprint covering a smaller fraction of the same area that was already assessed is given here.

The severity of loss for Common Pochard, Tufted Duck and Greater Scaup, for the tunnel alternative is assessed as high, but for the bridge alternative it is expected to be lower. It is predicted that in total about 58.7 ha of coastal habitats would be lost from the bridge footprint (Table 10.1), which is expected to result in a loss of foraging habitats of the diving ducks. Due to the size of the area lost in relation to the remaining foraging habitats it is estimated that fewer than 350 Common Pochard, fewer than 1,200 Tufted Ducks and fewer than 310 Greater Scaup (<0.1% of each particular biogeographic population) would be affected by the habitat loss of the cable stayed bridge footprint.

Therefore the severity of loss from the cable stayed bridge footprint is assessed to be minor for all non-breeding waterbird species in the Fehmarnbelt (Table 10.2).

Table 10.2 Assessment of the severity of loss from the footprint of a cable stayed bridge.

Species	Estimated number of displaced ind.	% of biogeo-graphic pop.	Severity of loss
Divers	single birds	<0.01%	Minor
Great Crested Grebe	single birds	<0.01%	Minor
Red-necked Grebe	single birds	<0.01%	Minor
Slavonian Grebe	single birds	<0.05%	Minor
Great Cormorant	500	0.13%	Minor
Mute Swan	single birds	<0.01%	Minor
Bewick's Swan	single birds	<0.05%	Minor
Whooper Swan	single birds	<0.05%	Minor
Bean Goose	single birds	<0.05%	Minor
Greater White-fronted Goose	single birds	<0.01%	Minor
Greylag Goose	few hundred birds	<0.1%	Minor
Barnacle Goose	single birds	<0.1%	Minor
Brent Goose	single birds	<0.01%	Minor
Eurasian Wigeon	few hundred birds	0.013%	Minor
Gadwall	single birds	<0.05%	Minor
Common Teal	single birds	<0.01%	Minor
Mallard	few hundred birds	<0.02%	Minor
Shoveler	single birds	<0.05%	Minor
Common Pochard	<350	<0.1%	Minor
Tufted Duck	<1,200	<0.1%	Minor
Greater Scaup	<130	<0.04%	Minor
Common Eider	a few tens of birds	<0.01%	Minor
Long-tailed Duck	single birds	<0.01%	Minor
Common Scoter	single birds	<0.01%	Minor
Velvet Scoter	single birds	<0.01%	Minor
Common Goldeneye	a few tens of birds	<0.01%	Minor
Smew	single birds	<0.01%	Minor
Red-breasted Merganser	single birds	<0.01%	Minor
Goosander	single birds	<0.01%	Minor
White-tailed Eagle	single birds	<0.05%	Minor
Common Coot	a few tens of birds	<0.01%	Minor

Species	Estimated number of displaced ind.	% of biogeo-graphic pop.	Severity of loss
Little Gull	single birds	<0.01%	Minor
Black-headed Gull	a few tens of birds	<0.01%	Minor
Common Gull	a few tens of birds	<0.01%	Minor
Lesser Black-backed Gull	single birds	<0.01%	Minor
Herring Gull	a few tens of birds	<0.01%	Minor
Great Black-backed Gull	a few tens of birds	<0.01%	Minor
Sandwich Tern	single birds	<0.01%	Minor
Common Tern	single birds	<0.01%	Minor
Arctic Tern	single birds	<0.01%	Minor
Common Guillemot	single birds	<0.01%	Minor
Razorbill	single birds	<0.01%	Minor
Black Guillemot	single birds	<0.1%	Minor
Other species		<0.1%	Minor

During the construction period, it is expected that the footprint area would be a part of a greater disturbance zone that would be highly impaired, resulting in a complete displacement of sensitive waterbird species from this area (see chapter 10.2.4). Therefore, it is expected that the habitat loss from the footprint would not lead to additional displacement of birds during the construction period.

Migrating birds
This pressure is assessed as being irrelevant for migrating birds.

Duration of impact
The duration of the pressure 'habitat loss from footprint' and therefore the impact of the pressure is either permanent (no recovery) or depends on re-establishment of areas of provisional loss (e.g. working harbours) in terms of recovery times of seabed, benthic flora and fauna and fish communities. In any case, the duration of impact exceeds the construction period. Re-established areas offering suitable habitats for waterbirds are considered to be used by birds without relevant additional recovery period.

10.2.2 Habitat change from sediment spill

Description of the pressure
During the construction of a cable stayed bridge in total 3.20 million m³ of sediments would be moved while dredging for bridge piers and working harbour, or backfilling processes and other construction activities (Table 10.3; FEHY 2013a). A certain percentage of the material handled, in total 0.11 million m³, is predicted to get spilled in the water and the suspended sediments would increase the amount of suspended sediments and sedimentation processes in certain areas. However, most recent calculations on sediment spill indicate that the scenario applied for predictions overestimates the actual spill by 43%, so the assessment of the impact in considered to be very conservative (FEHY 2013a). The dredging works associated with the construction of a cable stayed bridge are predicted to last 3 years.

Table 10.3 Total amount of dredged sediments, proportion of dredged material getting spilled and the total amount of spilled sediments per activity during the construction of a cable stayed bridge. The spill calculations are expected to be conservative by about factor 2 (FEHY 2013a).

Activity	Spill [%]	Amount [mill m^3]	Amount spilled [mill m^3]
Dredging for piers	12	0.54	0.07
Backfilling at piers (sand)	1	0.18	0.002
Dredging of access channels	5	0.35	0.02
Backfilling of access channels	5	0.35	0.02
Scour protection etc.	1	0.05	0.0005
Working harbour at Rødby	1	1.19	0.01
Total amount handled/spilled		3.20	0.11

Suspended sediment concentrations from the construction works of a cable stayed bridge are predicted to results in very small excess concentrations. Sediment would only be visible at the surface for less than 4% of the time in 2014 and even less when averaged for the entire construction period. At the sea bed level sediment concentrations are predicted to rarely exceed 10 mg/l (Figure 10.5; FEHY 2013a).

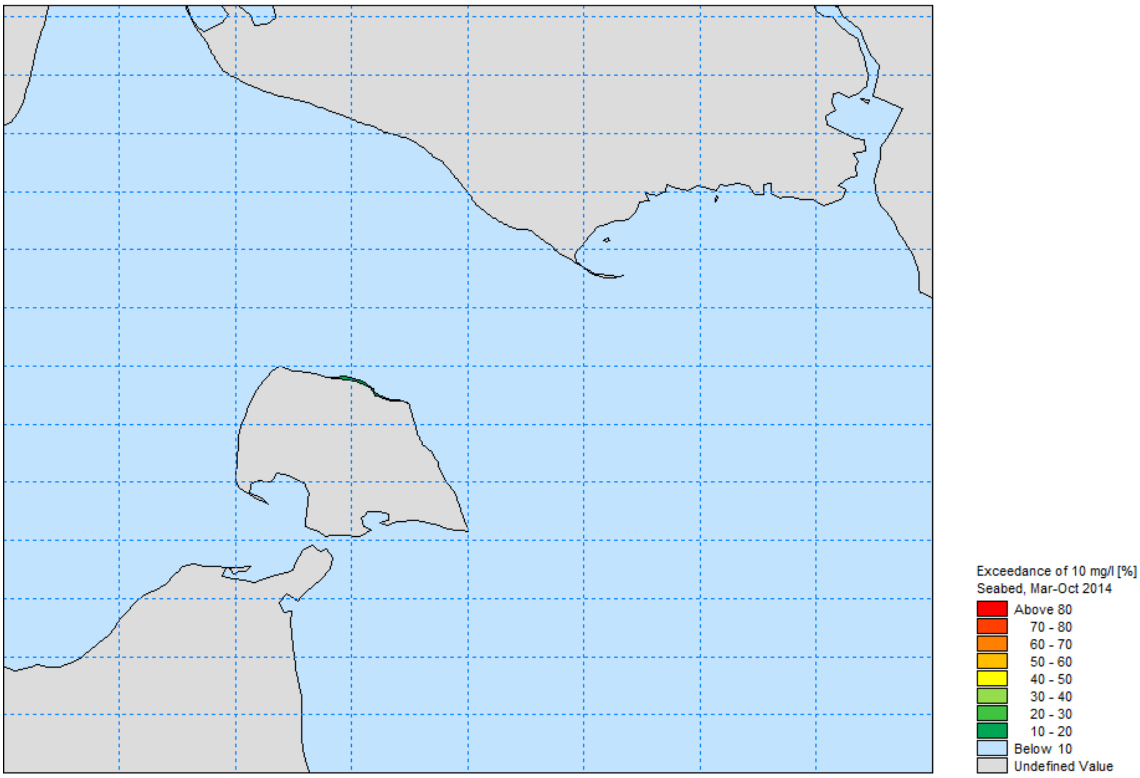


Figure 10.5 Example maps for percentage of time when the value of 10 mg/l of suspended sediment in the lower part of the water column is exceeded: exceedance time of 10 mg/l spilled sediment concentration for the period March – October 2014 (summer, first year) for the construction of a cable stayed bridge. Dredging is planned to occur at different piers both nearshore and offshore. Most dredging activities located at the German end of the link (maps taken from FEHY (2013a)).

With respect to deposition it is predicted that the coarsest sand fraction would get deposited close to the alignment and the finer fractions would spread over a larger area. Final deposition areas would be the Arkona basin, the edge of Mecklenburg Bight and the sheltered parts of the Rødsand Lagoon. The layers spread to a larger area are predicted to be are very thin; generally maximum deposition heights are predicted to be below 1 mm. However, close to the alignment 1-5 cm thick layers of sand would be deposited (Figure 10.6; FEHY 2013a).

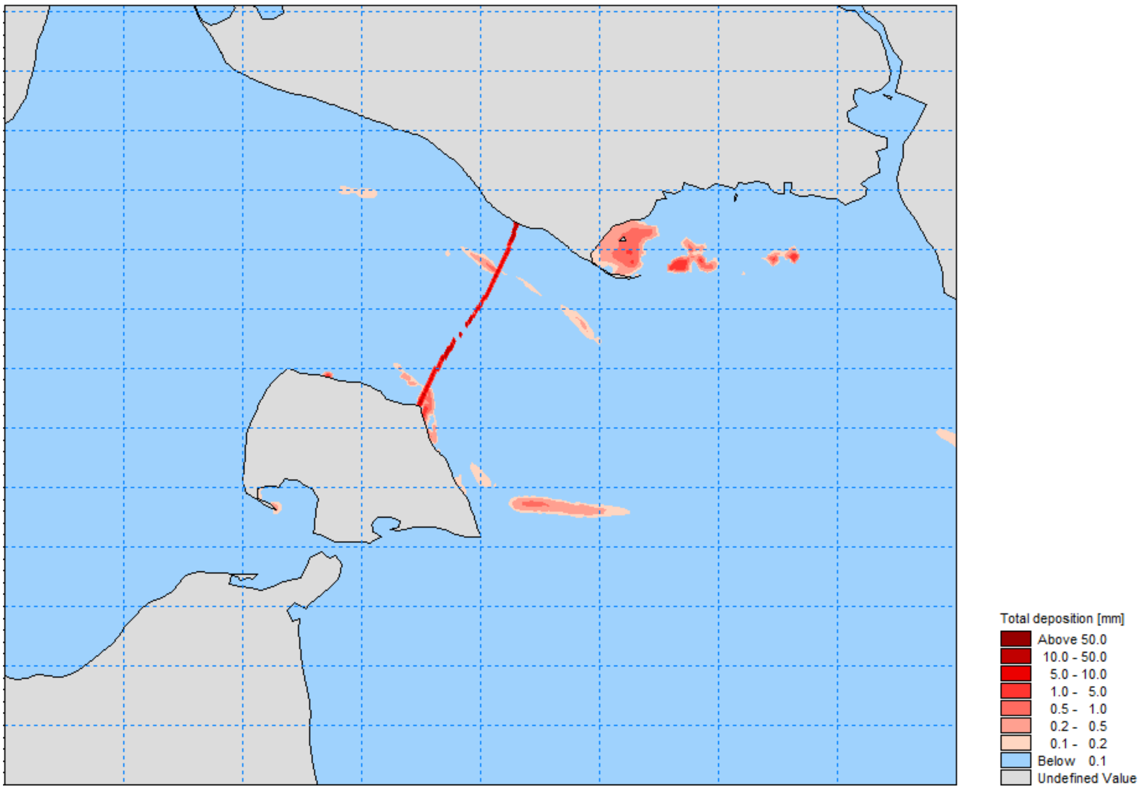


Figure 10.6 Deposition pattern from the construction of a cable stayed bridge in Fehmarnbelt at the end of 2016 (map taken from FEHY (2013a)).

The present chapter focuses on the indirect impacts of the sediment spill on waterbirds resulting from changes in affected benthic flora and fauna, and fish communities. The direct effect of the sediment spill in terms of changes in water transparency on breeding and non-breeding waterbirds is assessed in chapter 10.2.3.

Changes in benthic flora communities from sediment spill

Sediment spill results in two main pressures relevant for benthic vegetation: increased concentration of suspended matter and coverage of the vegetation by sediments (FEMA 2013d).

Suspended sediments are predicted to result in minor reductions of macroalgae and eelgrass biomass of mostly less than 5-10% in all areas (Figure 10.7–Figure 10.9; FEMA 2013d). For macroalgae it is predicted that no biomass reductions exceeding 10% (FEMA threshold for minor degree of impairment) would occur in the area in 2015 and 2017 (first and third year of construction period). For the second year of construction (2016) reductions of 10-20% are predicted to occur in a small area of 0.25 ha (FEMA 2013d). For eelgrass no reductions exceeding 10% are predicted for the first year; in 2016 and 2017, minor degree of impairment (biomass reductions of 10-25%) would occur in a relatively small area of 12 and 32 ha, respectively (Figure 10.7–Figure 10.9; FEMA 2013d).

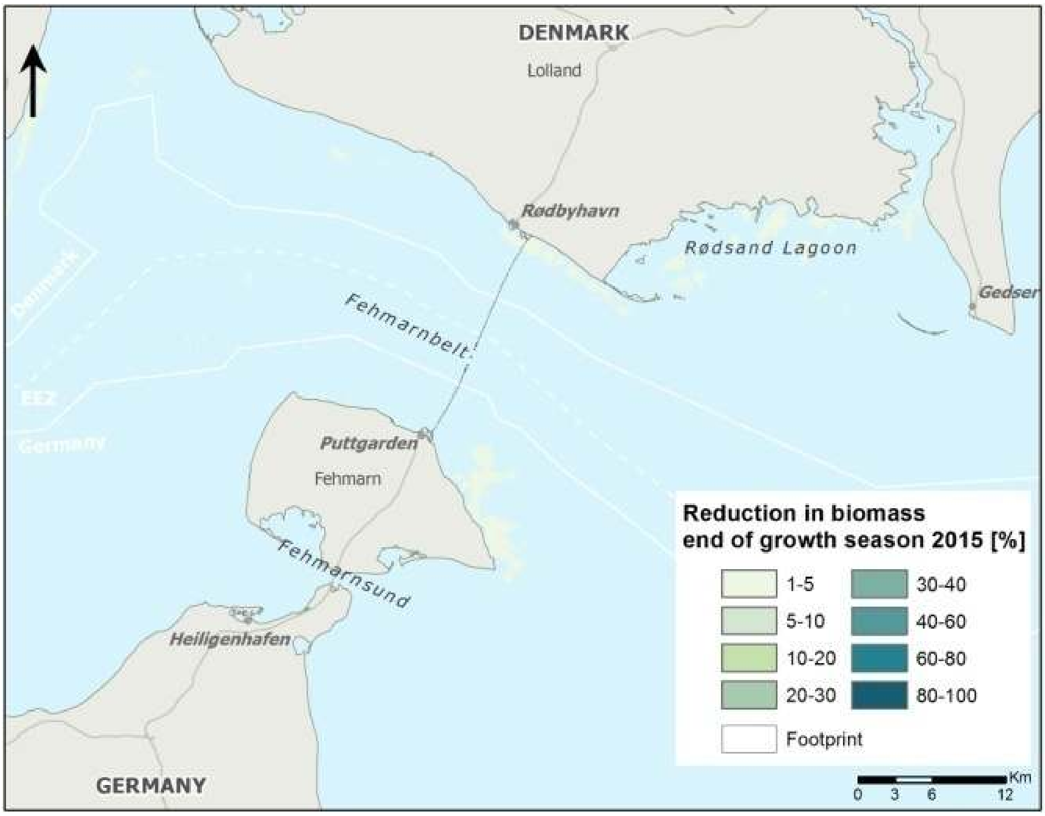


Figure 10.7 *Reduction in benthic flora biomass due to suspended matter at the end of the growth season (1st September) in the year 2015 (map taken from FEMA (2013d)).*

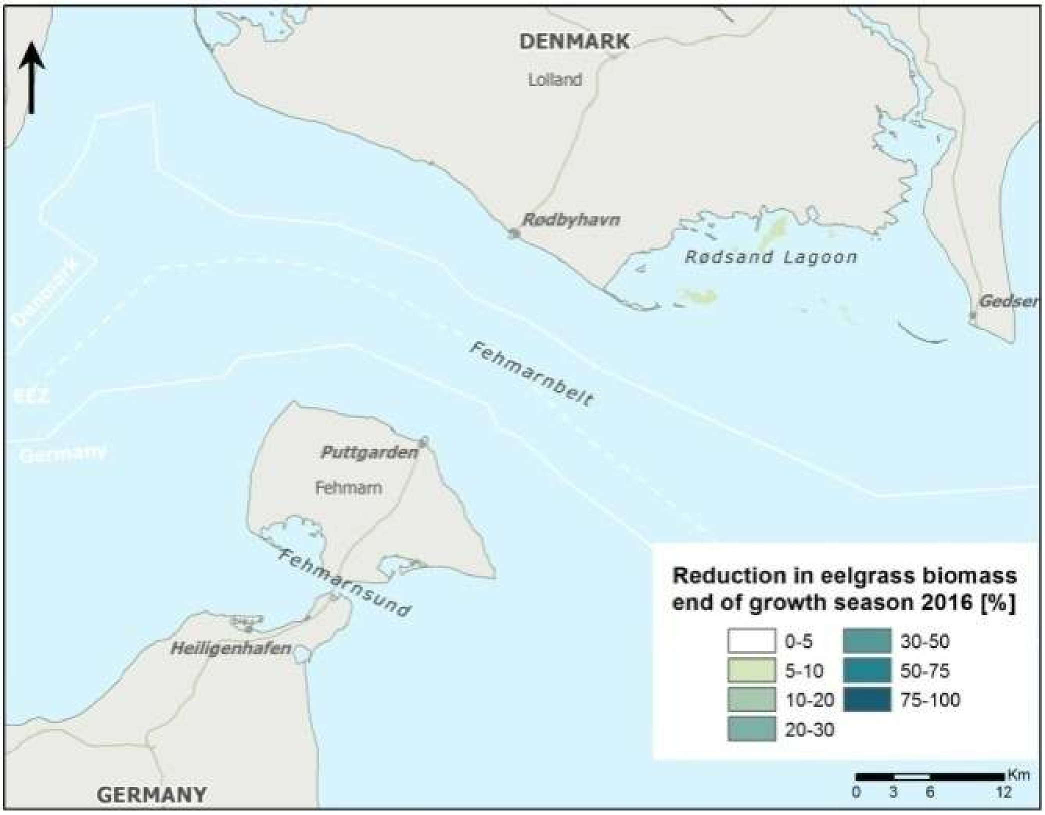


Figure 10.8 *Reduction in benthic flora biomass due to suspended matter at the end of the growth season (1st September) in the year 2016 (map taken from FEMA (2013d)).*

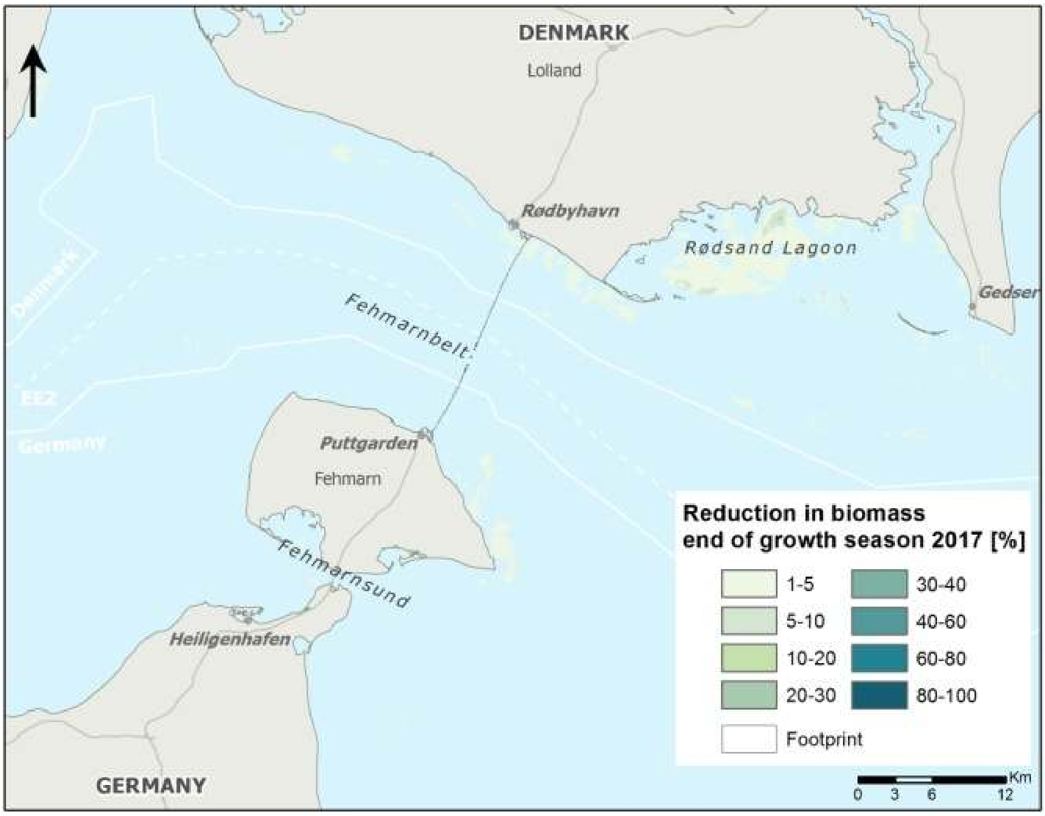


Figure 10.9 Reduction in benthic flora biomass due to suspended matter at the end of the growth season (1st September) in the year 2017 (map taken from FEMA (2013d)).

Sedimentation from construction works is predicted to impair the benthic vegetation locally. Minor to medium degree of impairment is predicted for small areas close to the construction harbour in Rødbyhavn and along the northeast coast of Fehmarn (Figure 10.10; FEMA 2013d). Overall 83 ha of vegetation communities are predicted to get affected by minor to medium degree of impairment from sedimentation (FEMA 2013d).

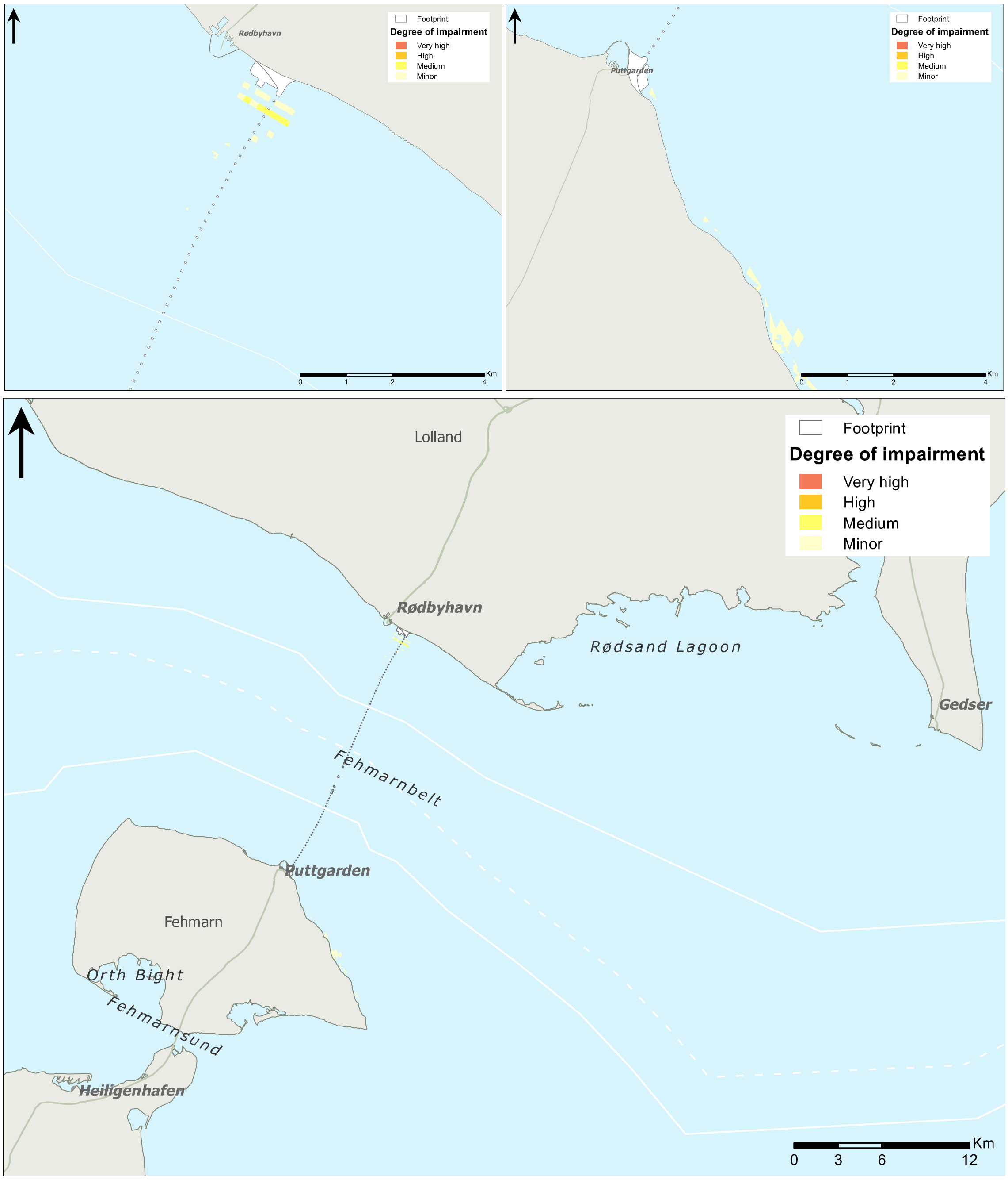


Figure 10.10 Degree of impairment for benthic vegetation from sedimentation due to construction activities for a cable stayed bridge (for definitions of different levels of degree of impairment see FEMA (2012d); maps taken from FEMA (2013d)).

Changes in benthic fauna communities from sediment spill

Sediment spill results in two different pressures for benthic fauna – suspended sediments and sedimentation. It is predicted that the impact from suspended sediments from bridge construction would be negligible for benthic fauna (FEMA 2013d).

Sedimentation is predicted to have locally minor to medium impact on benthic fauna depending on the thickness and duration of the sediment layer (Figure 10.11; FEMA 2013d). Areas predicted to be affected by the pressure are mainly located next to the dredging sites and along the Fehmarn coast. The affected areas comprise in total 1,525 ha which are mainly predicted to be minor impaired from the pressure sedimentation (Figure 10.11, Table 10.4; FEMA 2013d).

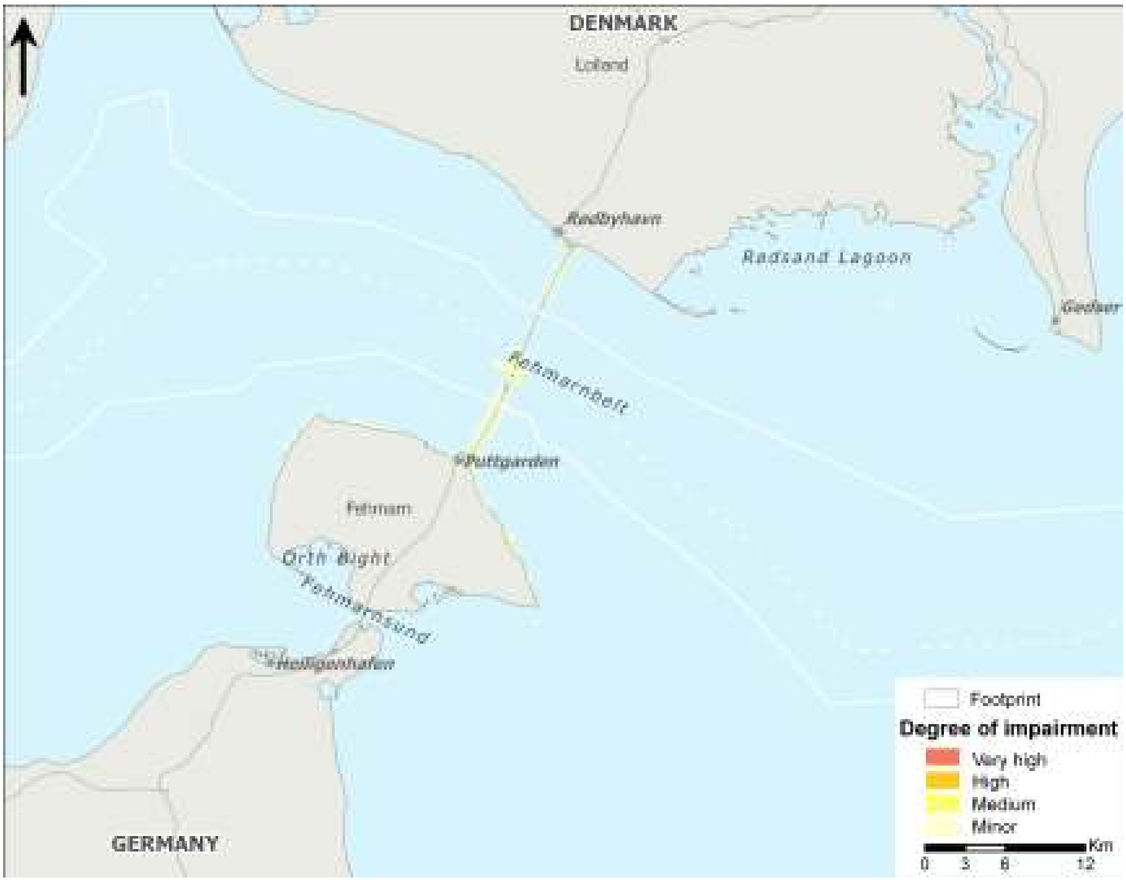


Figure 10.11 Degree of impairment for benthic fauna from sedimentation due to construction activities of a cable stayed bridge (for definitions of different levels of degree of impairment see FEMA (2012d); maps taken from FEMA (2013d)).

FEMA (2013d) estimated that the biomass of impaired communities would generally be reduced by 10% in areas of medium degree of impairment, and by 5% in areas of minor degree of impairment. Reductions caused by minor or medium degree of impairment are predicted to result from lower reproduction, feeding and growth rates of the affected benthic fauna, but not from mortality (FEMA 2013d). The impact is predicted for the construction period only.

Table 10.4 Area of benthic fauna communities affected by different levels of degree of impairment from sedimentation due to construction activities of a cable stayed bridge (data from FEMA (2013d)).

Community	Area impacted by different levels of degree of impairment, ha (% of total community area)				
	Very high	High	Medium	Minor	TOTAL
Arctica	-	-	92.10 (0.08%)	498.36 (0.44%)	590.46 (0.53%)
Bathyporeia	-	-	-	241.84 (1.55%)	241.84 (1.55%)
Cerastoderma	-	-	22.89 (0.20%)	35.96 (0.32%)	58.85 (0.53%)
Corbula	-	-	-	241.63 (1.82%)	241.63 (1.82%)
Dendrodoa	-	-	-	-	-
Gammarus	-	-	25.97 (0.03%)	232.29 (0.31%)	258.26 (0.35%)
Mytilus	-	-	37.27 (0.12%)	72.20 (0.23%)	109.47 (0.35%)
Rissoa	-	-	-	23.11 (0.20%)	23.11 (0.20%)
Tanaissus	-	-	-	1.08 (0.05%)	1.08 (0.05%)
TOTAL	-	-	178.23 (0.06%)	1,346.46 (0.46%)	1,524.70 (0.52%)

Changes in fish communities from sediment spill
There are direct and indirect effects of sediment spill described to be potentially relevant for fish (FeBEC 2013b). It is assumed that impairments leading to reductions of fish below 5% would not result in a detectable effect in fish-eating waterbirds. For the direct effects of suspended matter and sedimentation on different life stages of fish it is predicted that the impact from construction of a bridge in Fehmarnbelt would result in no or less than 1% for different life stages of fish within a 500 m zone around the construction site (near zone). No direct effects are predicted for areas beyond this zone (FeBEC 2013b). Indirect effects from changes in benthic vegetation are predicted to result in up to 3.1% reductions for shallow water fish species in the Danish near zone in 2015 and no or lower reductions for other fish species and areas (FeBEC 2013b).

Degree of impairment
The degree of impairment is assessed following the criteria described in chapter 4.5.14 and applied in chapter 9.2.2 for the same pressure for the tunnel alternative.

The predicted changes in benthic flora of up to 20% would result in local minor to medium impairment for herbivorous waterbirds in Rødsand Lagoon.

The predicted changes in benthic fauna of 5-10% in areas mostly close to the dredging sites would result in locally medium degree of impairment to benthivorous waterbirds.

The predicted changes in fish communities are assessed to result in minor degree of impairment of piscivorous birds (i.e. no or no detectable reductions in bird numbers due to this pressure).

Severity of impairment

In this chapter the severity of impairment from habitat change due to sediment spill is described for all breeding and non-breeding waterbird species, which were identified to be potentially relevant for the EIA during the sensitivity screening (see chapter 6).

Due to the small-scale impacts on benthic vegetation and following the assessment conducted for the impact of sediment spill from the tunnel alternative, where much larger areas are predicted to be impaired (see chapter 9.2.2), the severity of impairment is assessed to be minor for all herbivorous breeding and non-breeding waterbirds.

Changes in benthic fauna are predicted to affect mainly areas located close to the construction site. Due to intense shipping and ferry traffic in this area it was identified to hold comparably low numbers of benthivorous waterbirds during the baseline investigations (FEBI 2013). Based on the size of the impairment zone and the medium degree of impairment it is assessed that changes in benthic fauna would affect only minor important numbers of sensitive waterbird species. Additionally, the largest fraction of the impairment zone lies within the disturbance zone from construction vessels (see chapter 10.2.4), thus no relevant additional impairment is expected to result from habitat changes in benthic fauna due to sediment spill. Therefore, the severity of impairment is assessed to be minor for all benthivorous breeding and non-breeding waterbirds.

Due to the low predicted impact of sediment spill on fish communities (FeBEC 2013b), which is assessed to result in a minor degree of impairment for piscivorous birds from this pressure, a minor severity of impairment is assessed for all piscivorous breeding and non-breeding waterbirds from construction-related sediment spill.

Breeding waterbirds

The severity of impairment from habitat changes due to sediment spill from construction of a cable stayed bridge is assessed to be minor for all affected breeding waterbird species in the area.

Non-breeding waterbirds

The severity of impairment from habitat changes due to sediment spill from construction of a cable stayed bridge is assessed to be negligible or minor for all affected non-breeding waterbird species in the area.

Migrating birds

This pressure is assessed to be irrelevant for migrating birds.

Duration of impact

The duration of the impact of the pressure 'habitat change from sediment spill' depends on recovery times of prey communities birds are relying on (benthic flora and fauna, fish communities; see also Table 9.22 in chapter 9.3.1). Re-established areas offering suitable habitats for waterbirds are considered to be used by birds without additional recovery period.

10.2.3 Water transparency

Description of the pressure

The amounts of sediment spilled during construction activities of a cable stayed bridge involving the handling of dredged material are described in chapter 10.2.2. The spill material is suspended, settling and under given conditions resuspended from the seabed depending on the grain size of the material and a range of hydrodynamic factors. For a detailed description of the predicted sediment spill and resulting distribution of suspended matter in various grain sizes, reference is made to the FEHY report on sediment spill (FEHY 2013a).

The suspended material increases the light attenuation in the water column thereby reducing the light intensity in the water column. The light attenuation properties of the suspended matter in various grain sizes originating from the bottom materials dredged have been determined based on measurements and laboratory experiments determining the optical properties of the spill material (FEMA 2013c).

The optical properties of the material dredged during the bridge construction activities have been used to calculate the potential impact of suspended spill material on the light conditions in Fehmarnbelt, quantified as a reduction of the Secchi depths. The baseline Secchi depths and the variation in time and space of the potential effect of spilled material on Secchi depths have been incorporated into the ecological models established for the Fehmarnbelt (FEMA 2013c).

Fluctuations in Secchi depth, frequency and length of different conditions are possibly more important characteristics to wintering waterbirds than simple average seasonal value representing water transparency. As described in chapter 4.6.1, even under natural (baseline) conditions Secchi depth varies within a rather broad range. Occurrence of decreased visibility is predicted to increase during the period of the bridge construction (Figure 10.12). Considering the Secchi depth threshold of 3.74 m as defined in chapter 4.6.1, the occurrence of decreased visibility relative to the baseline conditions would be most pronounced during the first and second winters of the bridge construction (Figure 10.13, Figure 10.14), would be barely detectable during the third winter season (Figure 10.15) and would return to conditions similar to the baseline later.

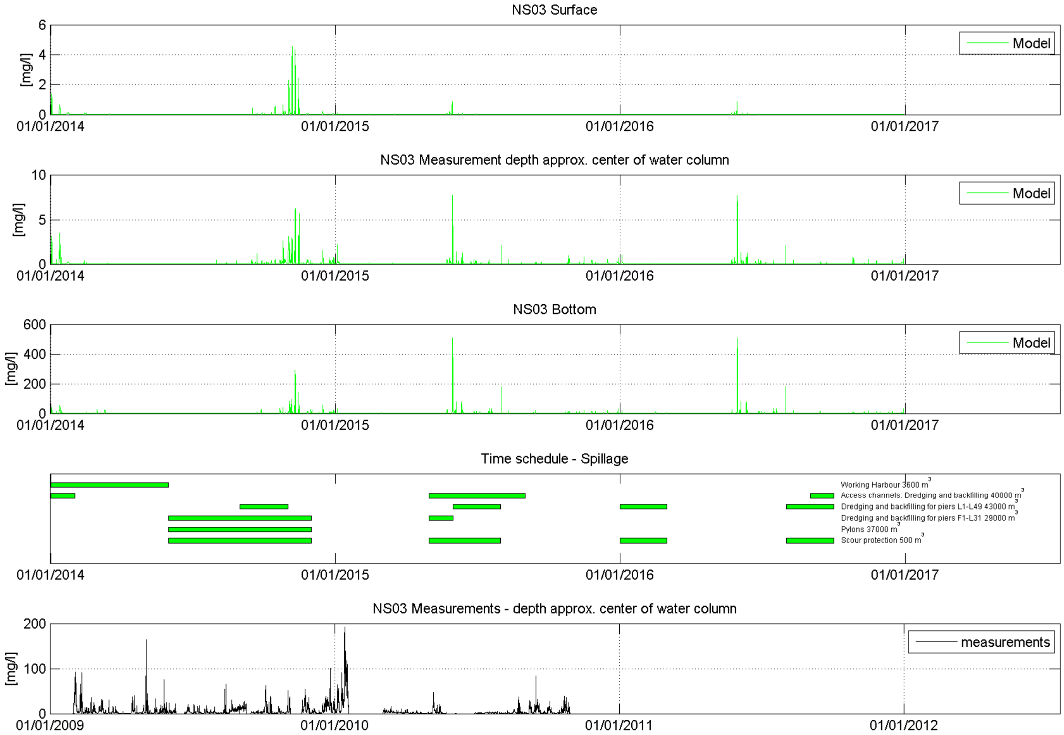


Figure 10.12 Time series of spilled suspended sediment at station NS03 near Rødbyhavn in three depths along with dredging schedule. The bottom panel shows the baseline suspended concentration monitored in 2009-2010 (FEHY 2013a).

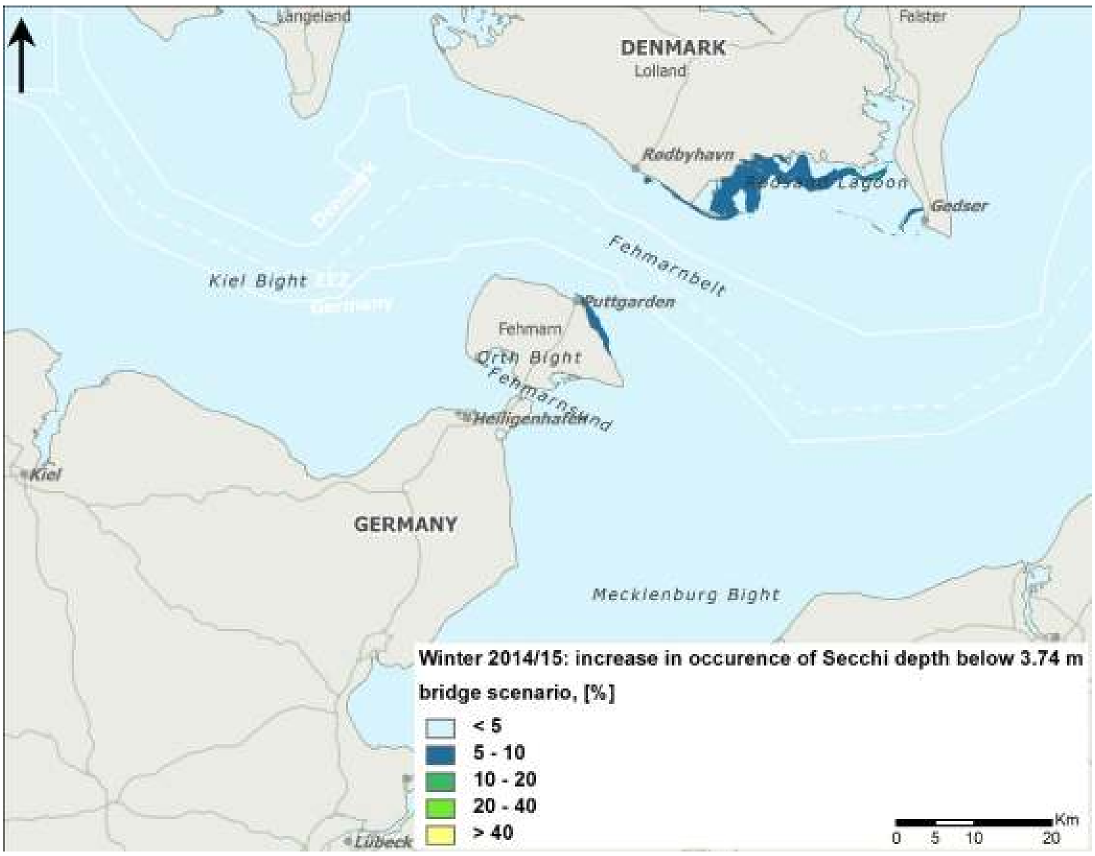


Figure 10.13 Modelled difference in occurrence of Secchi depth below 3.74 m during the first winter (2014/2015) of the cable stayed bridge construction relative to the baseline conditions (calculated by subtracting baseline from the bridge construction scenario).

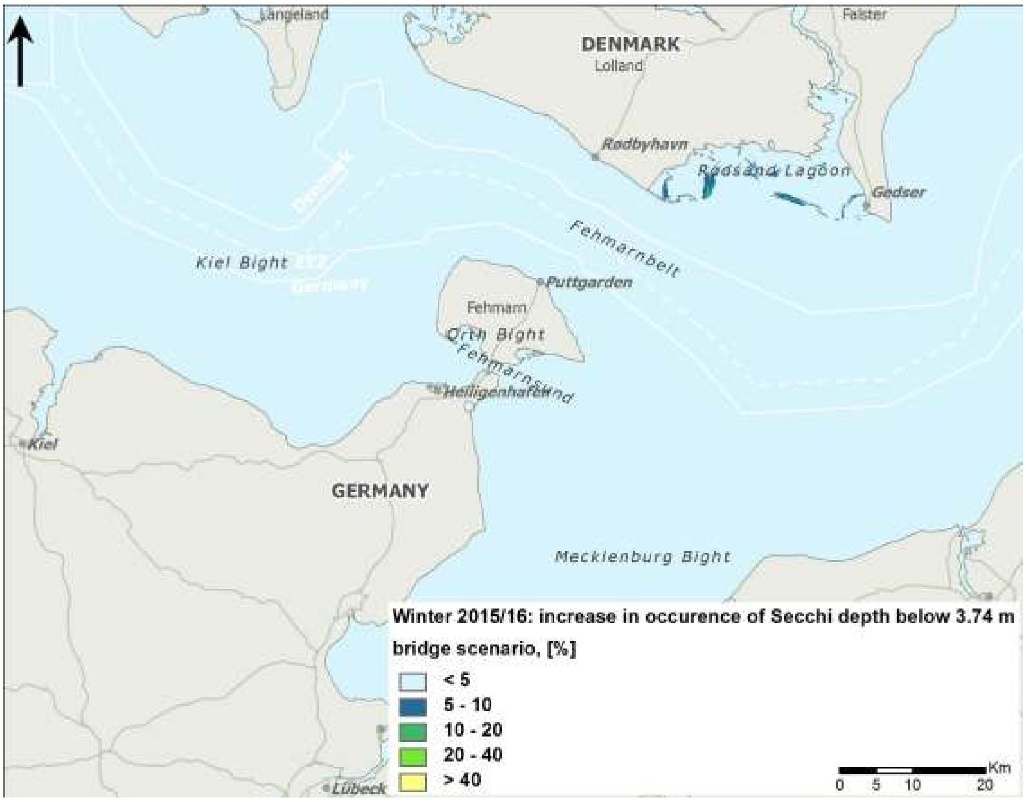


Figure 10.14 Modelled difference in occurrence of Secchi depth below 3.74 m during the second winter (2015/2016) of the cable stayed bridge construction relative to the baseline conditions (calculated by subtracting baseline from the bridge construction scenario).

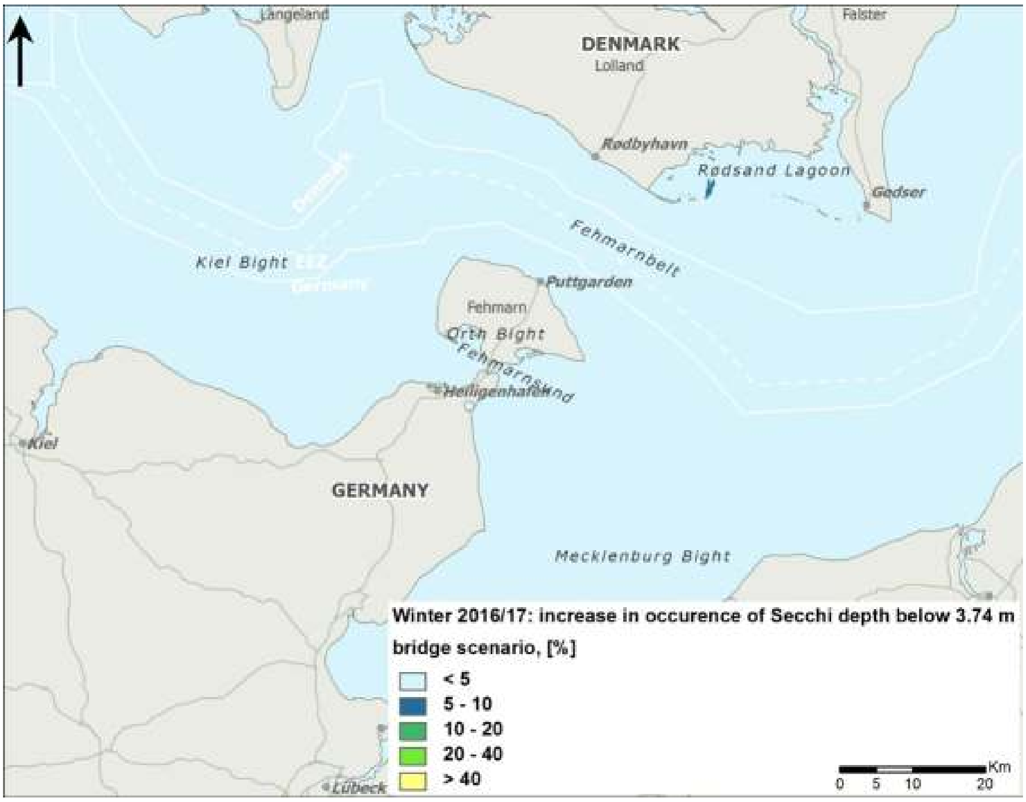


Figure 10.15 Modelled difference in occurrence of Secchi depth below 3.74 m during the third winter (2016/2017) of the cable stayed bridge construction relative to the baseline conditions (calculated by subtracting baseline from the bridge construction scenario).

The predicted occurrence of decreased water transparency relative to the baseline conditions during summer seasons would be undetectable for the first summer of 2015 and would be limited to small areas in Rødsand Lagoon during the second and third summers of the bridge construction (Figure 10.16, Figure 10.17) and would return to the baseline conditions during the subsequent years.

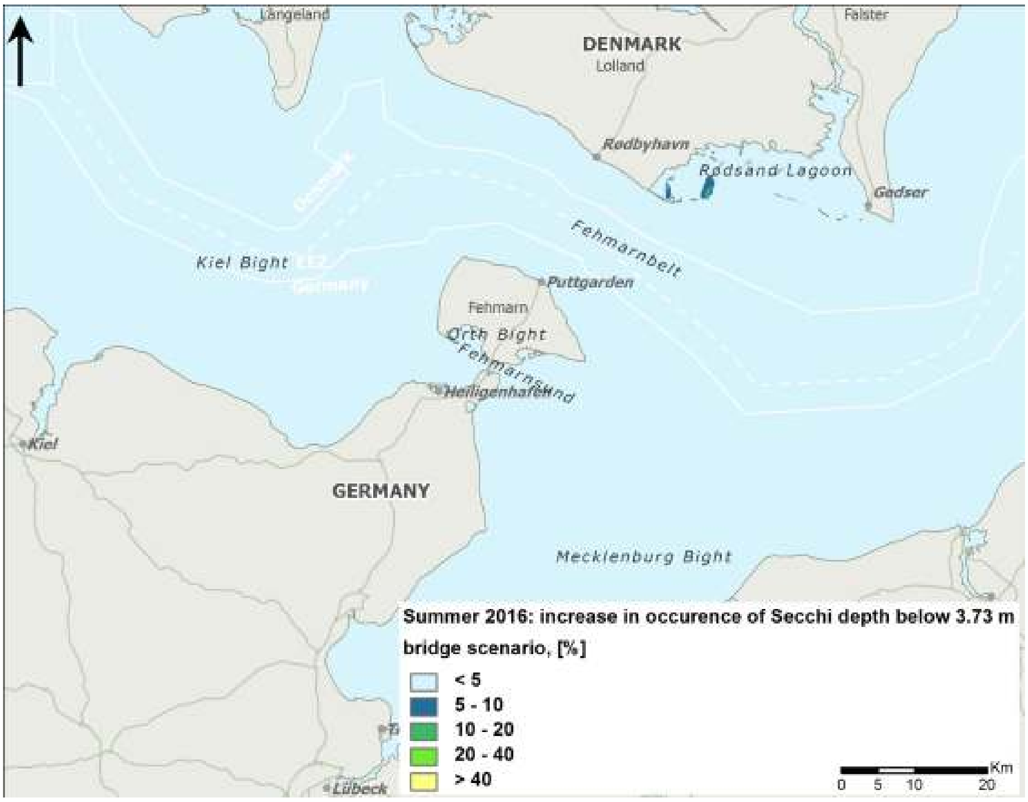


Figure 10.16 Modelled difference in occurrence of Secchi depth below 3.73 m during the second summer (2016) of the cable stayed bridge construction relative to the baseline conditions (calculated by subtracting baseline from the bridge construction scenario).

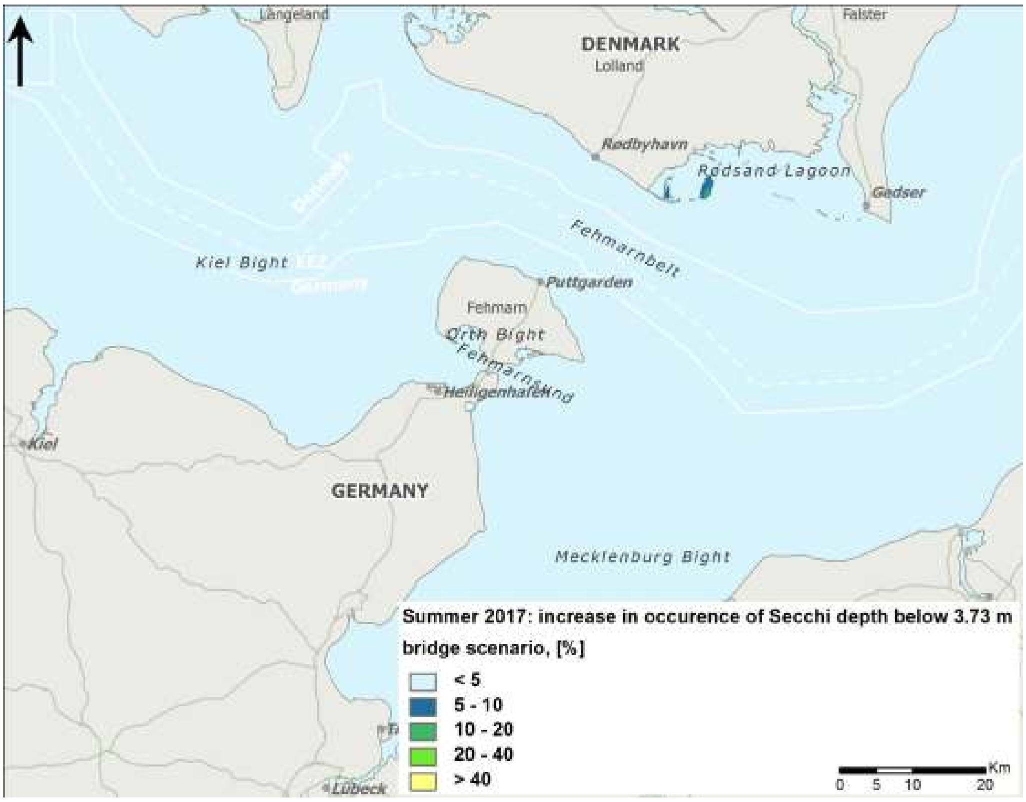


Figure 10.17 Modelled difference in occurrence of Secchi depth below 3.73 m during the third summer (2017) of the cable stayed bridge construction relative to the baseline conditions (calculated by subtracting baseline from the bridge construction scenario).

Degree of impairment

The degree of impairment is assessed following the criteria described in chapter 4.5.14 and applied in chapter 9.2.3 for the same pressure for the tunnel alternative.

Severity of impairment

Breeding waterbirds

Due to the relatively smaller areas of decreased water transparency due to sediment spill from construction of a cable stayed bridge construction compared to the tunnel alternative and the results of the tunnel assessment (see chapter 9.2.3), the severity of impairment of this pressure is assessed to be minor for all waterbird species breeding in Natura 2000 areas. There is no relevant impact predicted from this pressure for Red-necked Grebes breeding outside Natura 2000 sites on Lolland.

Non-breeding waterbirds

Divers (Red-throated/Black-throated Diver)

By overlaying average distribution of wintering divers with maps representing a decrease in water transparency below the threshold of 3.74 m during different years of the bridge construction, it is assessed that small areas of Rødsand Lagoon and along the north-east coast of Fehmarn would get affected by high severity of impairment (Figure 10.18, Appendix I). It is predicted that changes in water transparency would result in a displacement of 10 divers from the impairment zone during the first winter of the bridge construction, 3 birds during the second and 1 during the third season (Figure 10.19). Based on numbers of displaced individuals the severity of impairment for Red-throated and Black-throated Divers is assessed as minor during all years of the bridge construction (Table 10.5).

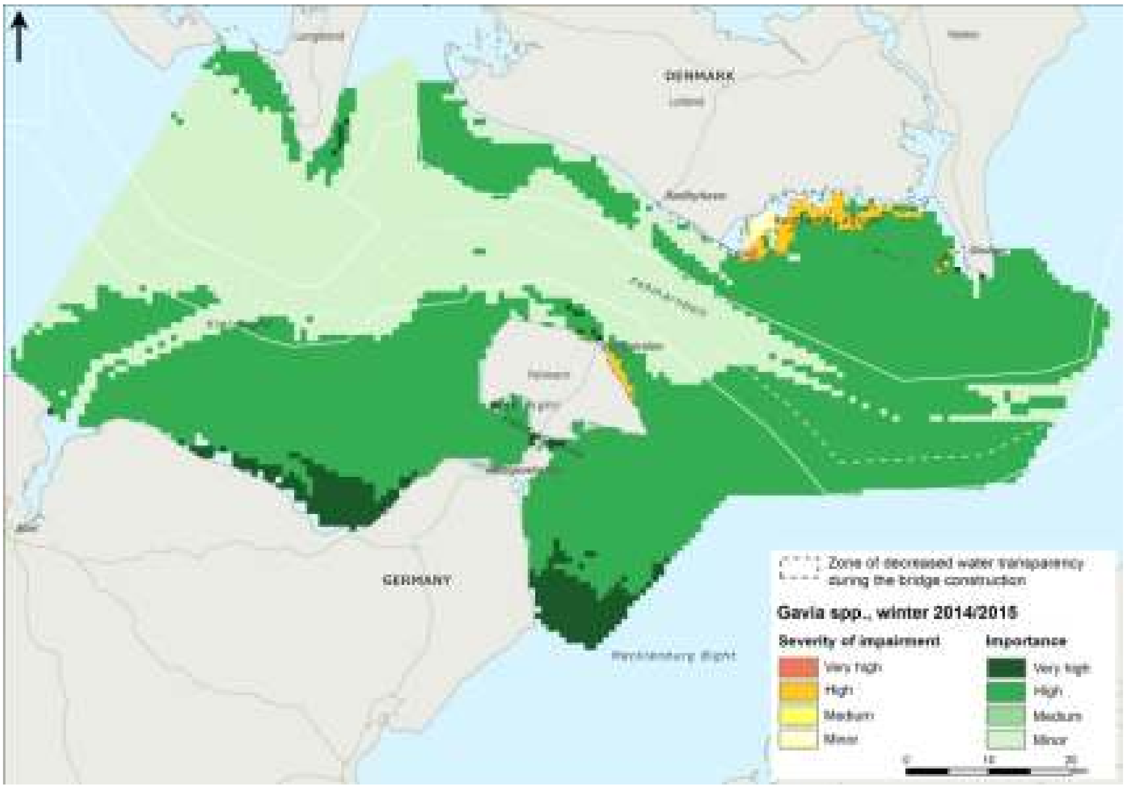


Figure 10.18 Severity of impairment from the pressure 'decreased water transparency' to Red-throated and Black-throated Diver from bridge construction in the first construction winter (2014/2015).

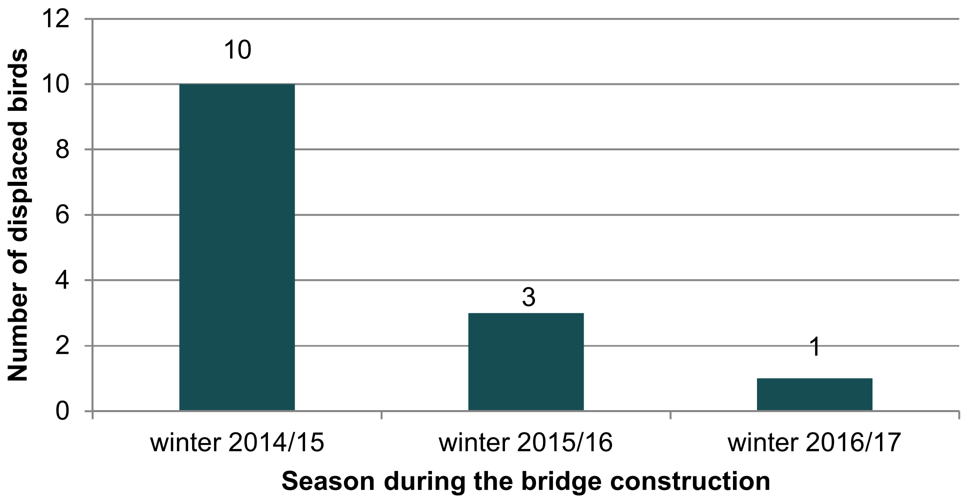


Figure 10.19 Estimated numbers of Red-throated and Black-throated Divers that would be displaced due to decreased water transparency in different winter seasons during the bridge construction.

Red-necked Grebe

The overlaying of modelled distribution of wintering Red-necked Grebes with maps representing a decrease in water transparency below the threshold of 3.74 m during different years of the bridge construction results in a locally very high severity of impairment in the south-west of Rødsand Lagoon and along the north-east coast of Fehmarn (Figure 10.20, Appendix I). Using the modelled distribution of Red-necked Grebe of winter 2008/2009 (when these birds were substantially more abundant than in the next winter) it is predicted that changes in water transparency would result in a displacement of 6 individuals during the first winter, and no displaced birds during the following winter seasons (Figure 10.21). The distribution of this species has been modelled using ship-based survey data, which did not cover Rødsand Lagoon, where decrease of water transparency is expected to be the highest. However, supplementary information from the DOF database (DOF 2010) suggests that only single individuals of this species occur in the lagoon in winter (FEBI 2013). Therefore, the severity of impairment for Red-necked Grebes is assessed as minor due to decreased water transparency from the bridge construction activities (Table 10.5).

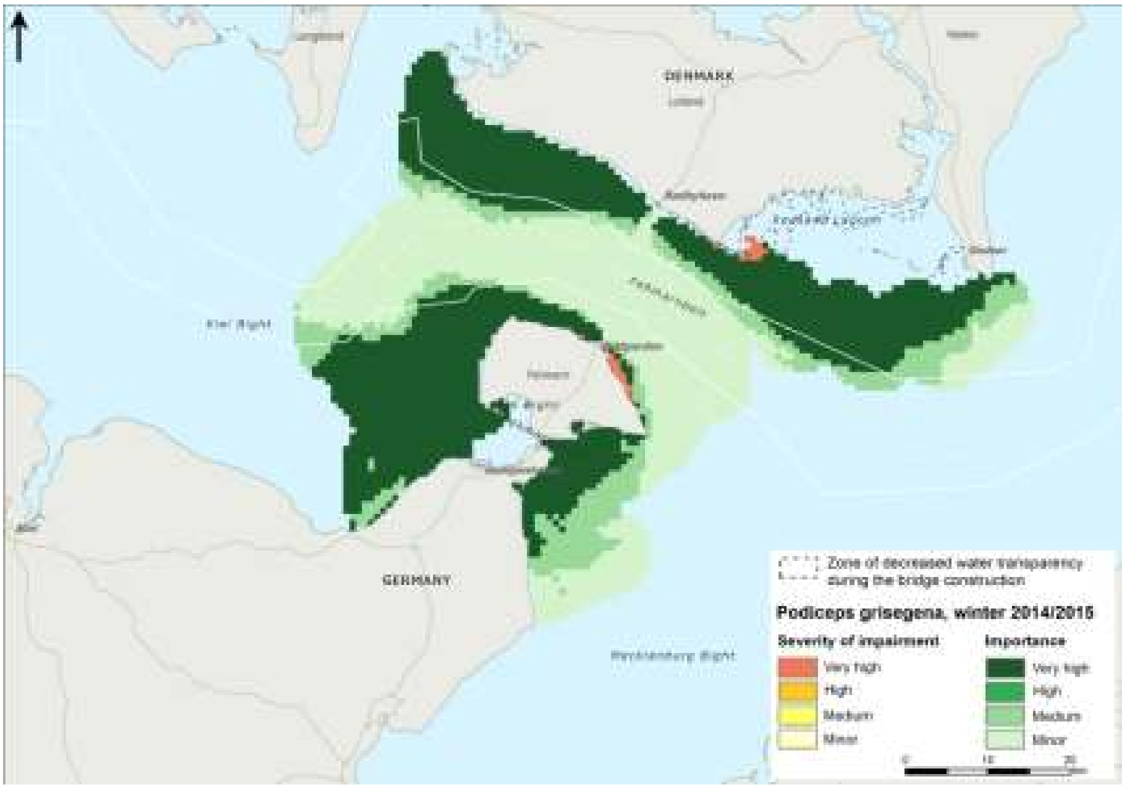


Figure 10.20 Severity of impairment from the pressure 'decreased water transparency' to Red-necked Grebe from bridge construction in the first construction winter (2014/2015).

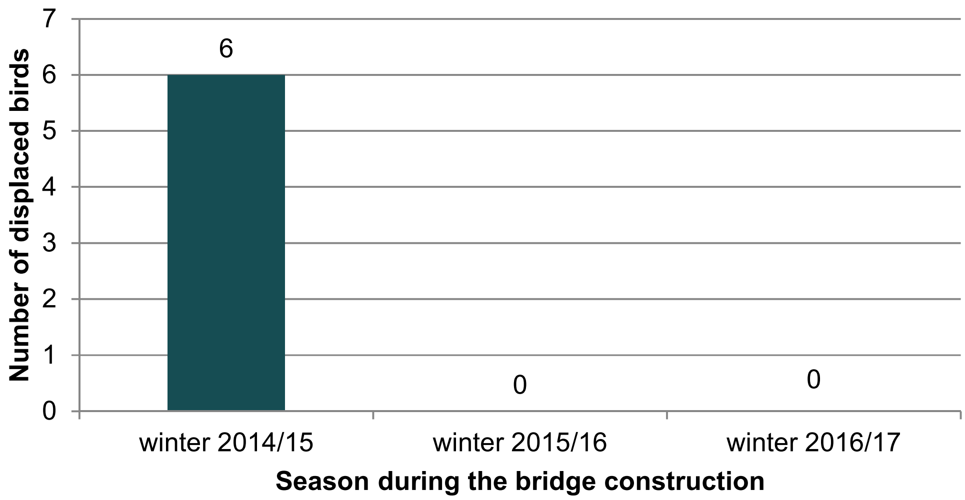


Figure 10.21 Estimated numbers of Red-necked Grebes that would be displaced due to decreased water transparency in different winter seasons during the bridge construction (in the area covered by ship surveys, i.e. not including Rødsand Lagoon).

Common Eider

The overlaying of modelled distribution of wintering Common Eiders with maps representing a decrease in water transparency below the threshold of 3.74 m during different years of the bridge construction results in a locally very high severity of impairment in the south-west of Rødsand Lagoon and along the north-east coast of Fehmarn (Figure 10.22, Appendix I). Using the modelled distribution of Common Eiders estimated for the winter 2009/2010, which represents season with higher abundance of this species during the two years of the baseline study, it is predicted that changes in water transparency would result in a displacement of 2,029 Common Eiders from the impairment zone during the first winter of the bridge construction, 184 during the second winter and 50 birds during the third winter (Figure 10.23). Severity of impairment for the Common Eider is assessed as medium during the first winter and minor during the subsequent winters of the bridge construction (Table 10.5).

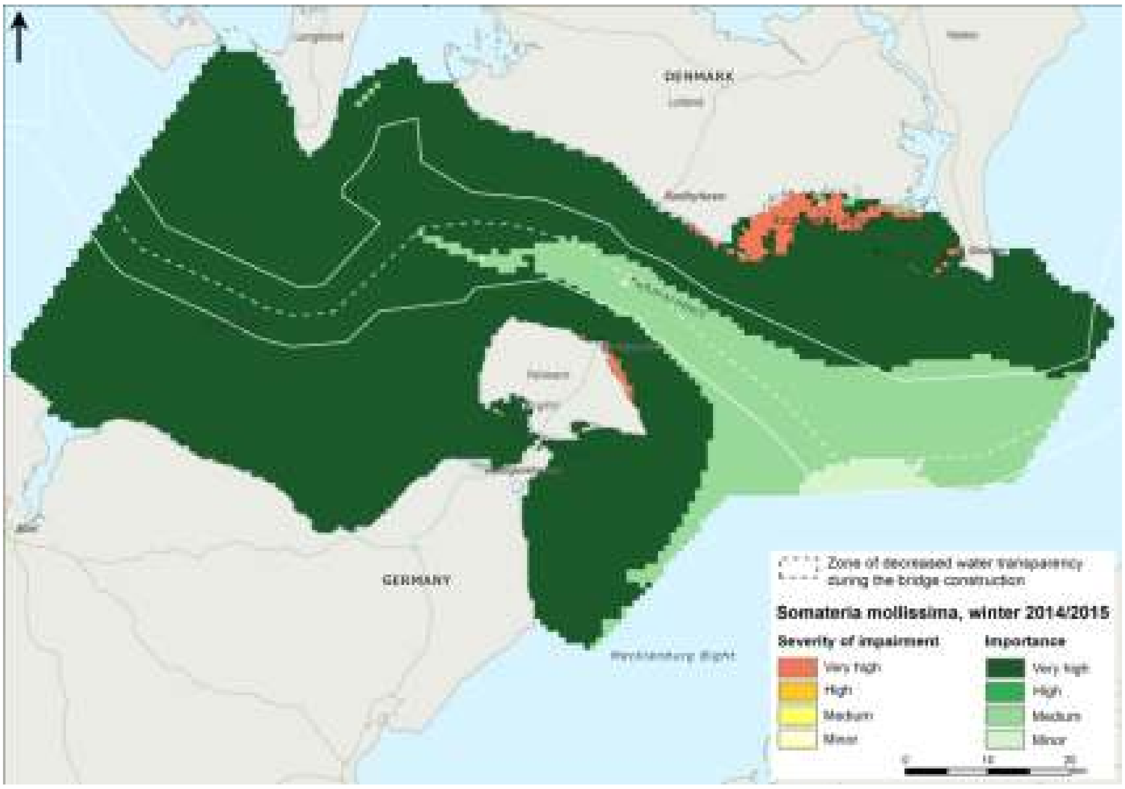


Figure 10.22 Severity of impairment from the pressure 'decreased water transparency' to Common Eider from bridge construction in the first construction winter (2014/2015).

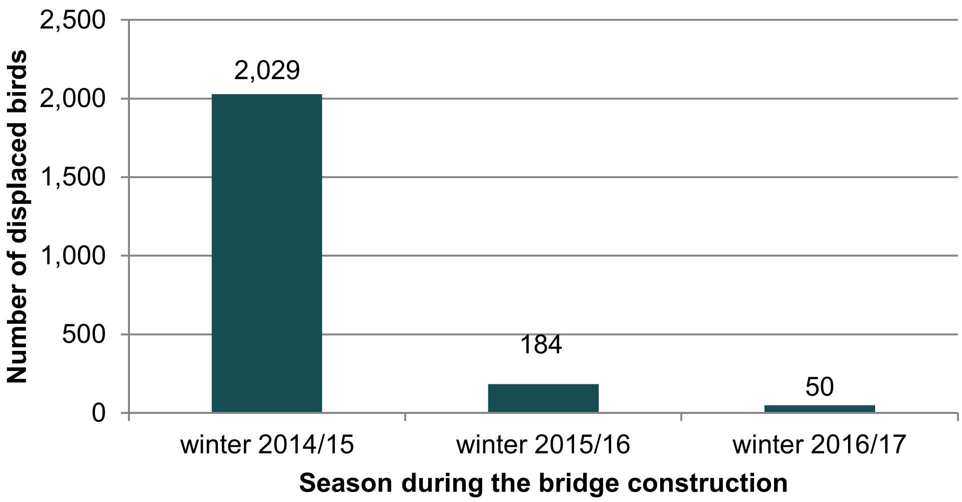


Figure 10.23 Estimated numbers of Common Eiders that would be displaced due to decreased water transparency in different winter seasons during the bridge construction.

Long-tailed Duck

To assess the severity of impairment from decreased water transparency, modelled distribution of wintering Long-tailed Ducks was overlaid with maps representing a decrease in water transparency below the threshold of 3.74 m during different years of the bridge construction. It is predicted that the pressure would affect areas of mostly minor to medium importance to the species, thus resulting in minor to medium severity of impairment in impaired areas (Figure 10.24, Appendix I). Long-tailed Duck distribution modelled using ship-based survey data yielded more reliable density estimates but had smaller spatial coverage than that of aerial surveys and did not include Rødsand Lagoon (FEBI 2013) where decrease in water transparency is expected to be the highest. Subsequently, numbers of displaced birds in the Fehmarnbelt were estimated using species distribution modelled from ship-based data, and birds displaced in Rødsand Lagoon were estimated using distribution modelled from aerial survey data. It is predicted that changes in water transparency would result in a displacement of 174 Long-tailed Ducks during the first winter, 63 birds during the second winter and 13 during the third winter of the bridge construction (Figure 10.25). Based on numbers of birds displaced due to decreased water transparency from the bridge construction activities the severity of impairment for the Long-tailed Duck is assessed as minor (Table 10.5).

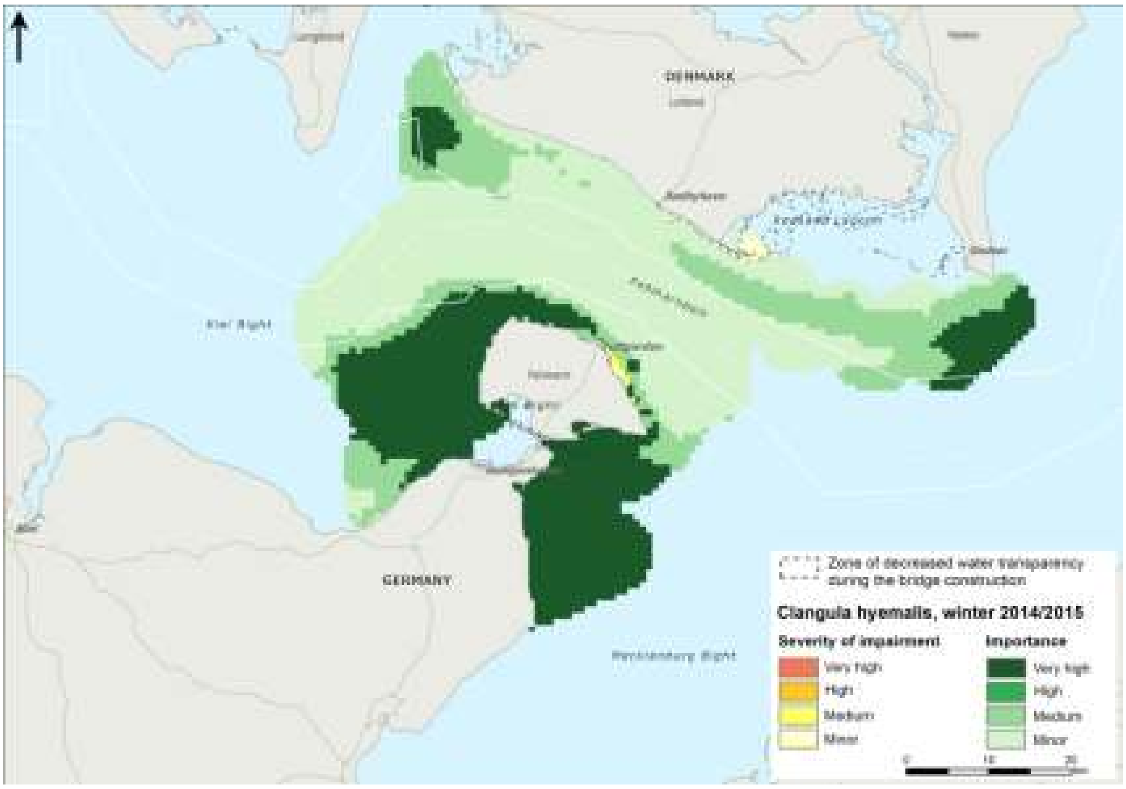


Figure 10.24 Severity of impairment from the pressure 'decreased water transparency' to Long-tailed Duck from bridge construction in the first construction winter (2014/2015).

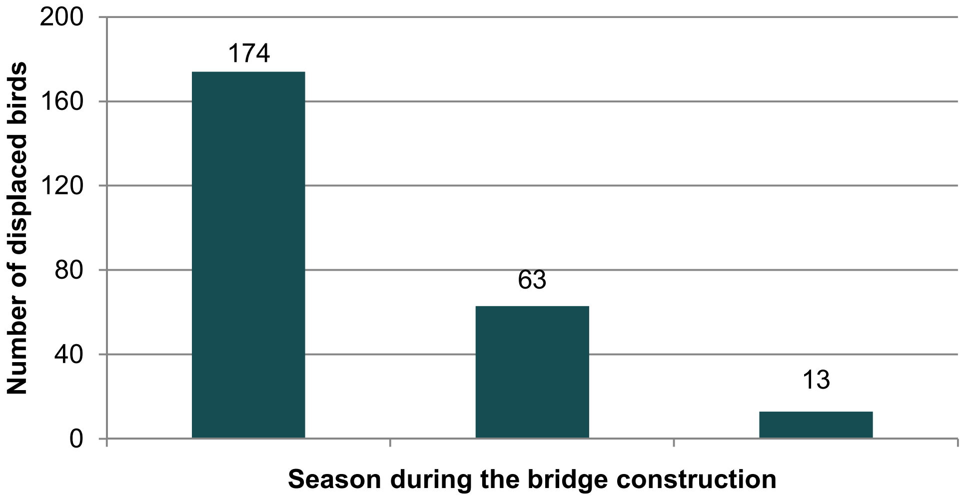


Figure 10.25 Estimated numbers of Long-tailed Ducks that would be displaced due to decreased water transparency in different winter seasons during the bridge construction.

Common Scoter

To assess the severity of impairment from decreased water transparency, modelled distribution of wintering Common Scoters was overlaid with maps representing a decrease in water transparency below the threshold of 3.74 m during different years of the bridge construction. It is predicted that the pressure would result locally in a high to very high severity of impairment along the north-east coast of Fehmarn (Figure 10.26, Appendix I). Common Scoter distribution modelled using ship-based survey data yielded more reliable density estimates but had smaller spatial coverage than that of aerial surveys and did not include Rødsand Lagoon (FEBI 2013) where decrease in water transparency is expected to be the highest. Subsequently, numbers of displaced birds in the Fehmarnbelt were estimated using species distribution modelled using ship-based data, and birds displaced in Rødsand Lagoon were estimated using distribution modelled from aerial survey data. It was predicted that changes in water transparency would result in a displacement of 183 individuals from the impairment zone during the first winter of the bridge construction, 13 birds during the second winter, and 3 birds during the third winter (Figure 10.27). Based on numbers of displaced birds because of decreased water transparency from the bridge construction, the severity of impairment for the Common Scoter is assessed as minor (Table 10.5).

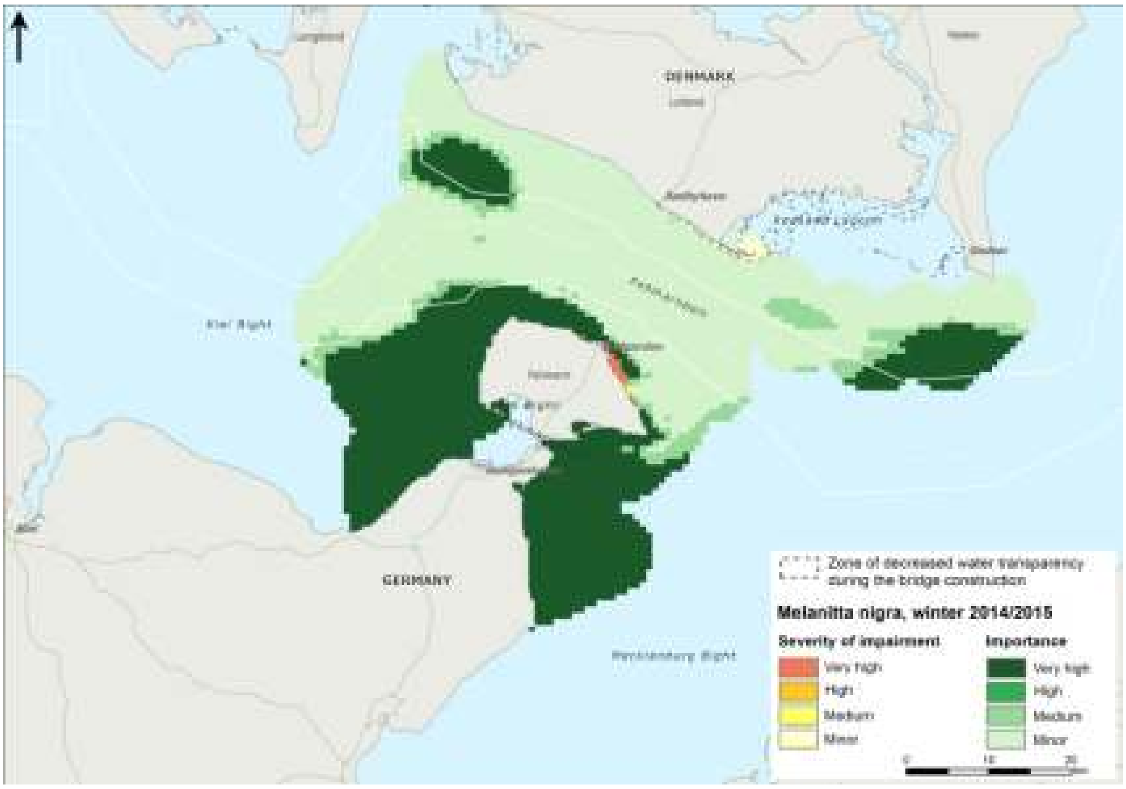


Figure 10.26 Severity of impairment from the pressure 'decreased water transparency' to Common Scoter from bridge construction in the first construction winter (2014/2015).

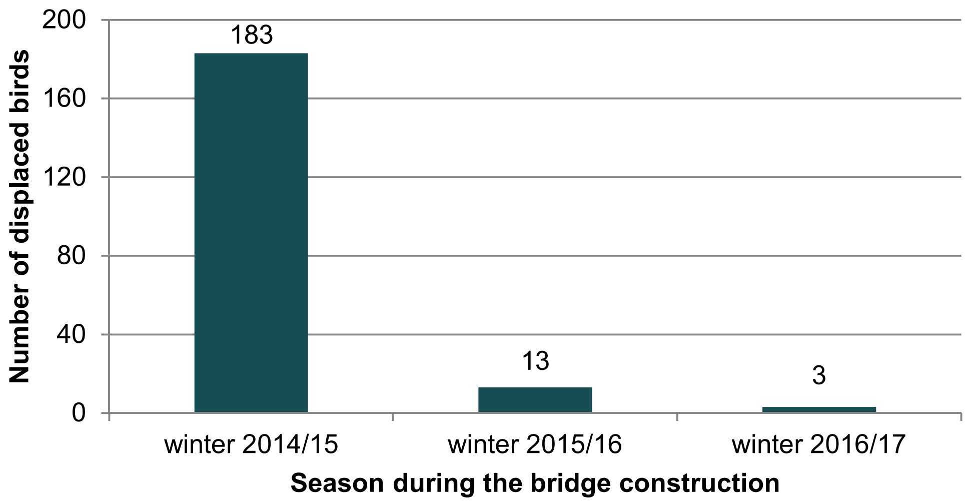


Figure 10.27 Estimated numbers of Common Scoters that would be displaced due to decreased water transparency in different winter seasons during the bridge construction.

Velvet Scoter

Due to low numbers of this species in the Fehmarnbelt, no modelled spatial distribution maps are available, also no information about Velvet Scoter habitat choice in relation to water transparency was available. However, considering the mostly offshore distribution of this species (FEBI 2013), it is not expected that more than single individuals of Velvet Scoter would be displaced because of decreased water transparency during the bridge construction. Therefore, the severity of impairment for this species is assessed being minor.

Red-breasted Merganser

To assess the severity of impairment from decreased water transparency, modelled distribution of wintering Red-breasted Mergansers was overlaid with maps representing a decrease in water transparency below the threshold of 3.74 m during different years of the bridge construction. It is predicted that the pressure would result locally in a very high severity of impairment in parts of Rødsand Lagoon and along the north-east coast of Fehmarn (Figure 10.30, Appendix I). Red-breasted Merganser distribution modelled using ship-based survey data yielded more reliable density estimates but had smaller spatial coverage than that of aerial surveys and did not include Rødsand Lagoon (FEBI 2013) where decrease in water transparency is expected to be the highest. Subsequently, numbers of displaced birds in the major area of the Fehmarnbelt were estimated using species distribution modelled from ship-based data, and birds displaced in Rødsand Lagoon were estimated using distribution modelled from aerial survey data. It was predicted that changes in water transparency would result in a displacement of 158 individuals from the impairment zone during the first winter, 17 birds during the second winter, and 4 during third winters of the bridge construction period (Figure 10.31). Based on affected bird numbers the severity of impairment for the Red-breasted Merganser is assessed as minor during the bridge construction period (Table 10.5).

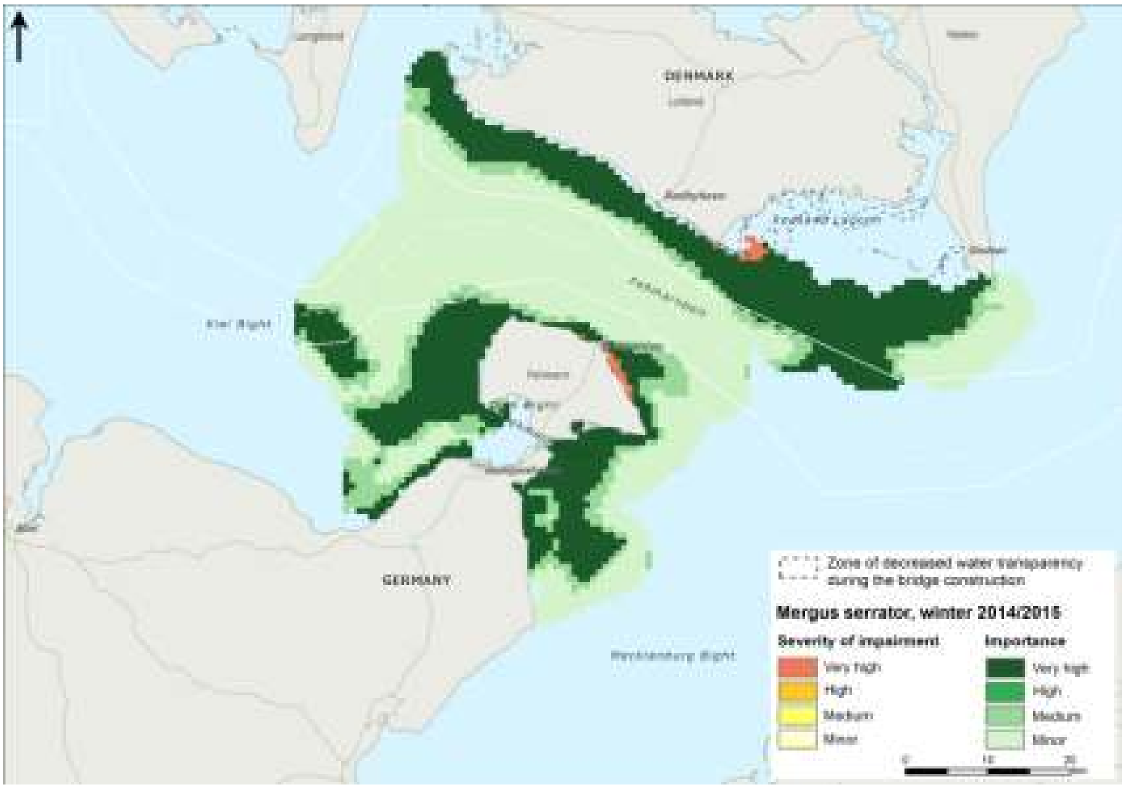


Figure 10.30 Severity of impairment from the pressure 'decreased water transparency' to Red-breasted Merganser from bridge construction in the first construction winter (2014/2015).

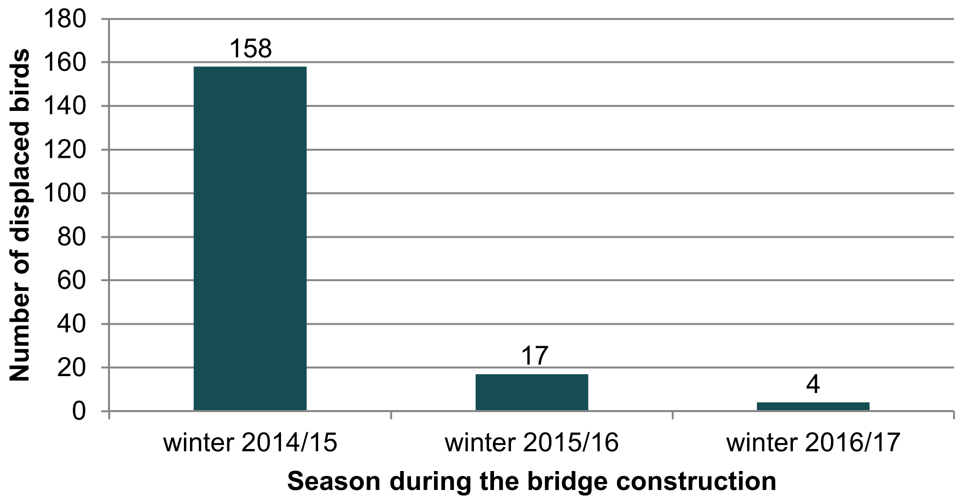


Figure 10.31 Estimated numbers of Red-breasted Mergansers that would be displaced due to decreased water transparency in different winter seasons during the bridge construction.

Razorbill

Using spatial overlays of bird distribution and predicted water transparency levels (Figure 10.32, Appendix I) it was concluded that no Razorbills would be displaced due to changes in water transparency during the bridge construction. The distribution of this species has been modelled using ship-based survey data, which did not cover Rødsand Lagoon, where water transparency decrease is expected to be the highest. However, Razorbill distribution shows this species being confined to offshore areas and only rarely occurring in Rødsand Lagoon (FEBI 2013). Therefore, the severity of impairment is assessed being minor.

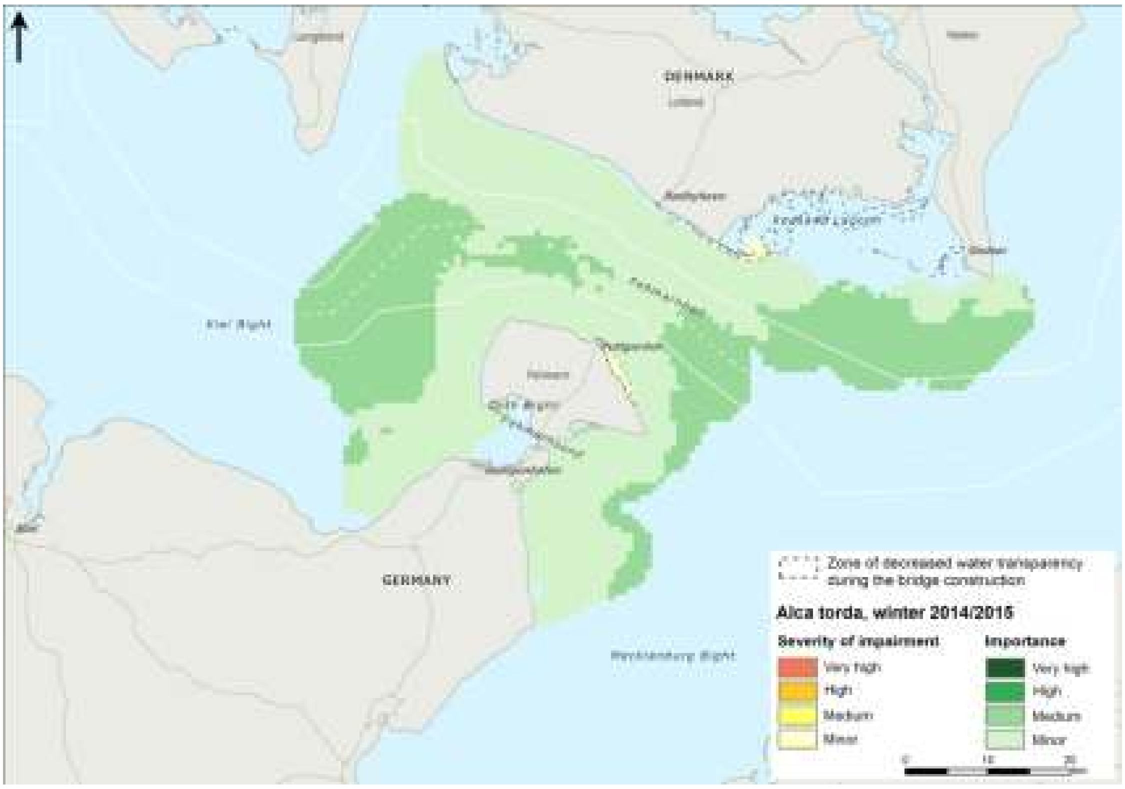


Figure 10.32 Severity of impairment from the pressure 'decreased water transparency' to Razorbill from bridge construction in the first construction winter (2014/2015).

Black Guillemot

Due to low abundance of this species in the Fehmarnbelt and its offshore distribution, it is not expected that more than single individuals of Black Guillemots would be displaced due to water transparency changes during the bridge construction. Therefore, the severity of impairment for this species is assessed as being minor.

Other species

For other non-breeding waterbird species the impact from decreased water transparency is assessed to be of minor severity of impairment due to either minor importance of the area to the species or birds occurring in the disturbance zone are predicted to be of minor sensitivity to this pressure.

Overall assessment of the severity of impairment

The assessment of severity of impairment was based on numbers of birds that are predicted to be displaced from the impairment area during the periods of decreased water transparency (Table 10.5). The severity of impairment from this pressure is assessed to be minor for the majority of non-breeding waterbird species. Only for the Common Eider a medium severity of impairment is assigned for the first winter season of the construction period (Table 10.5).

Table 10.5 Assessment of the severity of impairment on non-breeding waterbirds from decreased water transparency in different wintering seasons of bridge construction.

Species	Season	Displaced individuals	% of biogeo-graphic pop.	Severity of impairment
Divers	2014/2015	10	<0.01%	Minor
	2015/2016	3	<0.01%	Minor

Species	Season	Displaced individuals	% of biogeo-graphic pop.	Severity of impairment
	2016/2017	1	<0.01%	Minor
Red-necked Grebe	2014/2015	6	<0.01%	Minor
	2015/2016	0	0%	Minor
	2016/2017	0	0%	Minor
Common Eider	2014/2015	2,029	0.27%	Medium
	2015/2016	184	0.02%	Minor
	2016/2017	50	<0.01%	Minor
Long-tailed Duck	2014/2015	174	<0.01%	Minor
	2015/2016	63	<0.01%	Minor
	2016/2017	13	<0.01%	Minor
Common Scoter	2014/2015	183	0.01%	Minor
	2015/2016	13	<0.01%	Minor
	2016/2017	3	<0.01%	Minor
Velvet Scoter	all seasons	single birds	<0.01%	Minor
Red-breasted Merganser	2014/2015	158	0.09%	Minor
	2015/2016	17	0.01%	Minor
	2016/2017	4	<0.01%	Minor
Razorbill	2014/2015	0	0%	Minor
	2015/2016	0	0%	Minor
	2016/2017	0	0%	Minor
Black Guillemot	all seasons	single birds	<0.1%	Minor
Other species	all seasons		<0.1%	Minor

Migrating birds
This pressure is assessed to be irrelevant for migrating birds.

Duration of impact
The duration of the pressure 'decreased water transparency' depends on duration of lower transparency below the threshold level. The duration of impact of this pressure is considered to be restricted to the construction period of the bridge. Suitable habitats for waterbirds would be available without an additional recovery period.

10.2.4 Disturbance from construction vessels

Description of the pressure
The construction of a cable stayed bridge will require various shipping activities in the offshore part of the alignment area and between the construction sites and working harbours and reclamation sites at Lolland and Fehmarn. The shipping and other construction activities will cause disturbance to those species of waterbirds in the area which are sensitive to human activities (see chapter 7.2.6). The pressure is the physical presence including noise, vibration and lighting of all types of construction vessels including cranes and other working platforms involved in the

construction activities. Additionally, in the course of the construction period the growing structure of the bridge itself will have a disturbance effect on birds as well.

Several types of shipping and construction activities will be associated with the construction of a cable stayed bridge:

- Dredging for working harbours, access channels and for piers
- Work harbour constructions at Fehmarn and Lolland
- Transport of sediment to and from the alignment
- Guard vessels to secure the construction works
- Transport of equipment and staff
- Transport and placement of pre-constructed bridge elements to final location
- Soil improvement works
- Excavation and placing of the scour protection
- Foundation and erection of the pylons, piers and anchor elements and ship impact protection structures (caissons)
- Commissioning of the bridge superstructure (girder elements)
- Construction of land reclamation areas on Lolland and Fehmarn
- Construction of the bridge peninsulas (embankments)

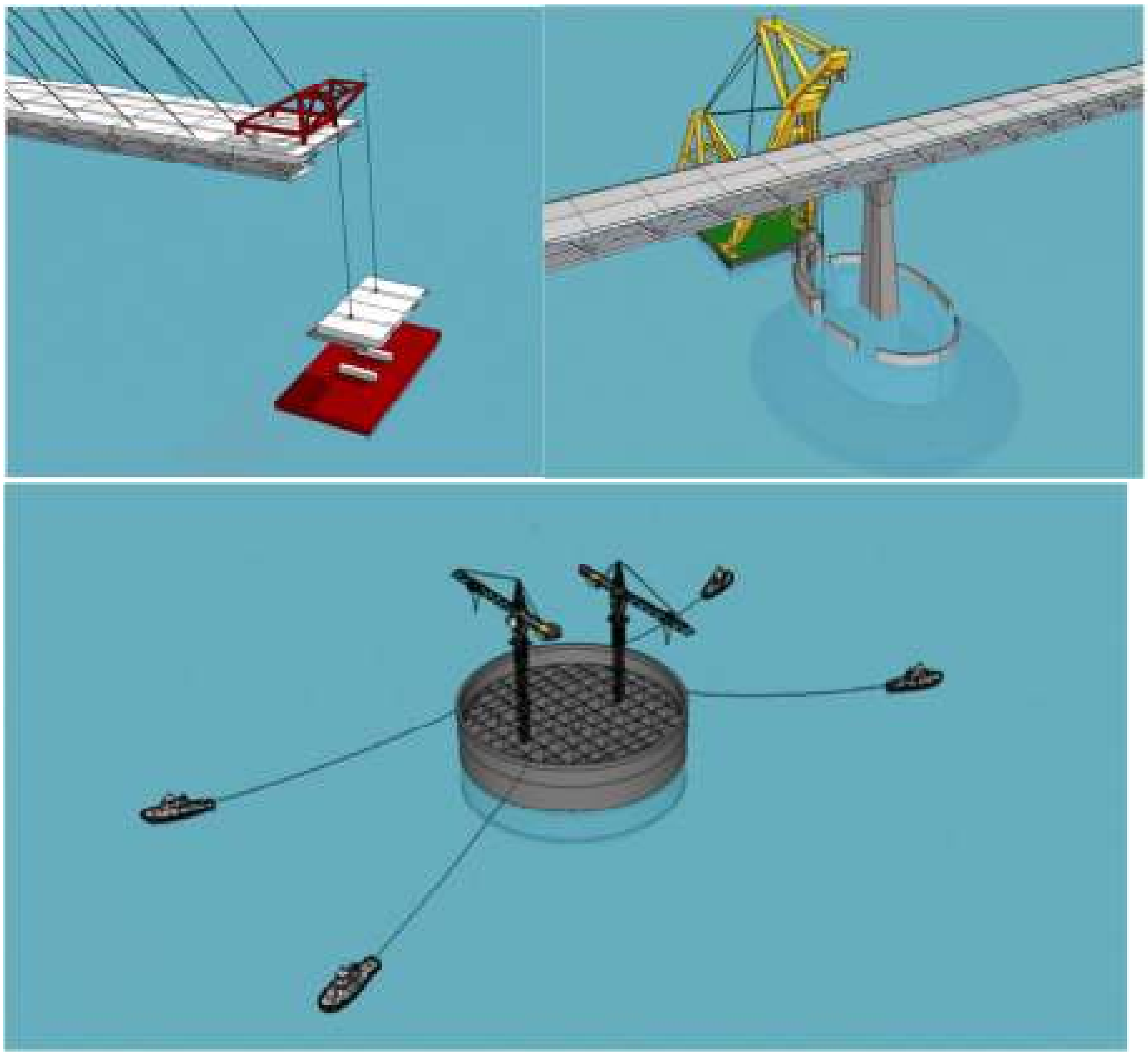


Figure 10.33 Examples of construction activities during the construction period of a cable stayed bridge: erection of a girder section (upper left picture), erection of ship impact protection ring with sheer leg crane (upper right picture), transport, positioning and placing of the caisson for the centre pylon (lower picture; pictures taken from Femern A/S Consolidated Technical Report, version June-6, 2011).

There are no detailed descriptions about shipping intensity and dimensions of working areas presently available. Therefore, similar to the description for the tunnel construction (chapter 9.2.4) the entire bridge footprint (incl. working harbours and reclamation areas) plus a 3 km buffer zone around it was defined as the disturbance zone from construction activities of a cable stayed bridge (Figure 10.34).

According to the construction schedule for the cable stayed bridge the disturbance intensive dredging, construction and backfilling works will be conducted within a time period of 3 years. After this period the disturbance from the bridge is assumed to be the same as described in chapter 10.3.4 for the operation phase.

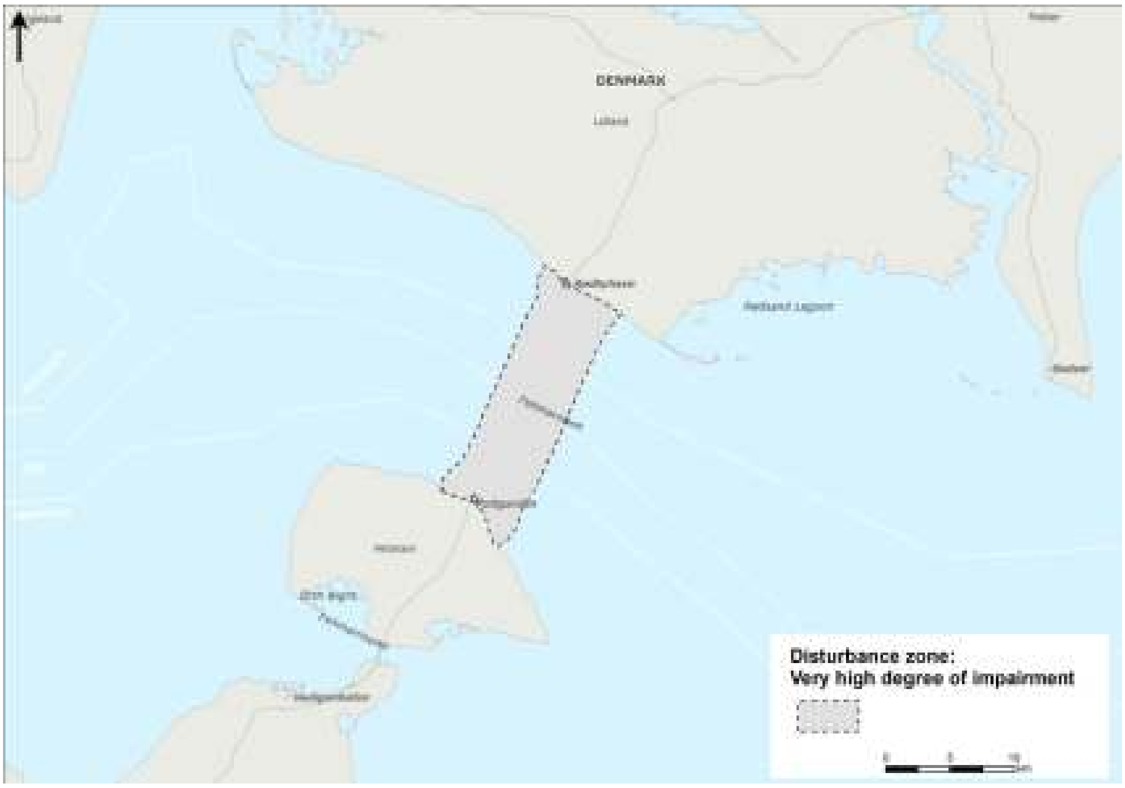


Figure 10.34 Disturbance zone of the construction activities defined as a 3 km buffer around the cable stayed bridge footprint.

Degree of impairment

Based on the sensitivity of the relevant waterbird species the assessment is based on an assumed complete displacement of birds from the impairment zone (i.e. very high degree of impairment).

Severity of loss/impairment

Breeding waterbirds

The pressure 'disturbance from construction vessels' during the construction of a cable stayed bridge in Fehmarnbelt is assessed to have a similar impact on breeding waterbirds as the same pressure for the tunnel solution (see chapter 9.2.4). Due to the smaller area disturbed from construction activities of the bridge solution along the Lolland coast the impairment on Red-necked Grebes breeding on Lolland is expected to be less severe than from the tunnel solution. However, an impact on breeding Red-necked Grebes breeding in the immediate vicinity of the disturbance zone cannot be excluded.

Corresponding to the Impact Assessment for the pressure 'disturbance from construction vessels' for the tunnel alternative (chapter 9.2.4) the severity of impairment is assessed to be minor for all waterbird species breeding in Natura 2000 areas. The severity of impairment from this pressure to breeding Red-necked Grebes on Lolland is assessed within the Impact Assessment for the land areas of Lolland.

Non-breeding waterbirds

In the following the severity of impairment from the pressure 'disturbance from construction vessels' will be described for all non-breeding waterbird species, which were identified to be potentially relevant for the EIA during the sensitivity screening (see chapter 7.3.2).

Divers (Red-throated/Black-throated Diver)
The disturbance zone was identified to be mostly of minor importance to divers, but in the coastal zone of the islands of Lolland and Fehmarn some areas are assigned to be of high importance (Figure 10.35 and Figure 10.36). Construction activities are predicted to locally result in a high severity of impairment, but in most parts of the disturbance zone the severity of impairment is assessed to be minor (Figure 10.35 and Figure 10.36). It is predicted that on average 8 birds (0.003% of the biogeographic population) will be displaced from the disturbance zone during winter and 11 birds (0.004% of the biogeographic population) during spring.

Based on this the disturbance from construction vessels is assessed to result in a minor severity of impairment for divers.

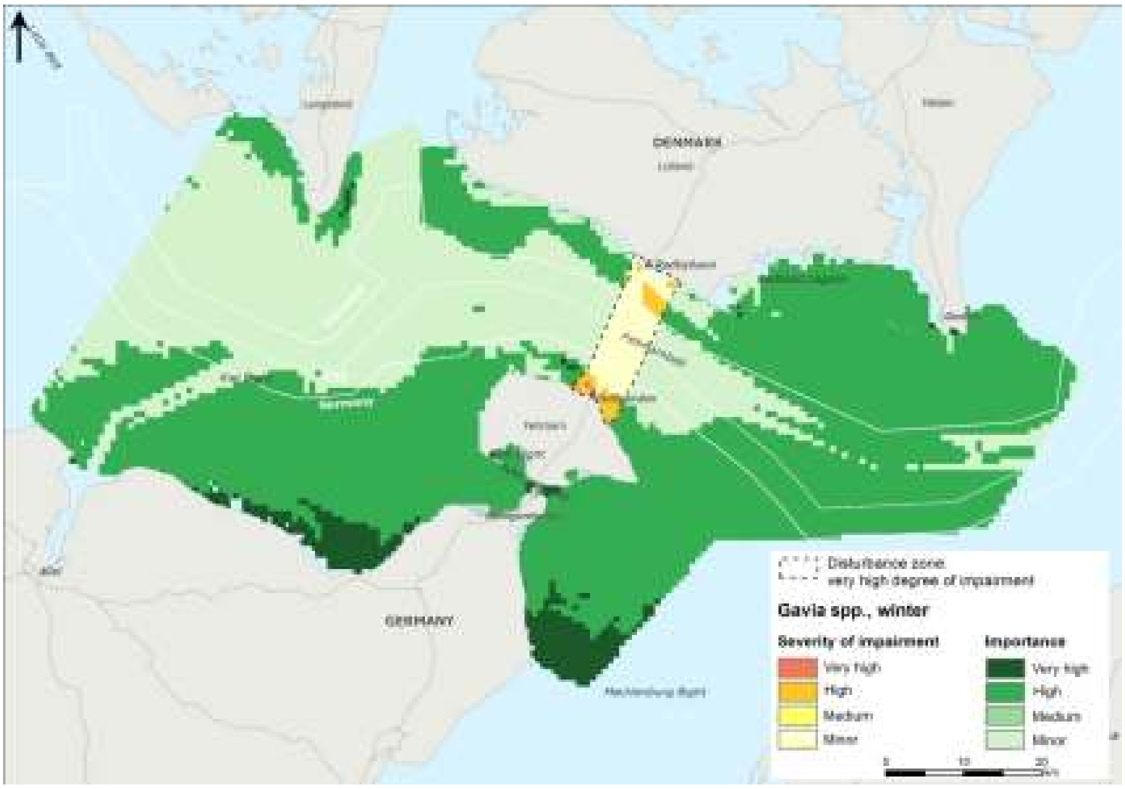


Figure 10.35 Severity of impairment from the pressure 'disturbance from construction vessels' to divers in winter.

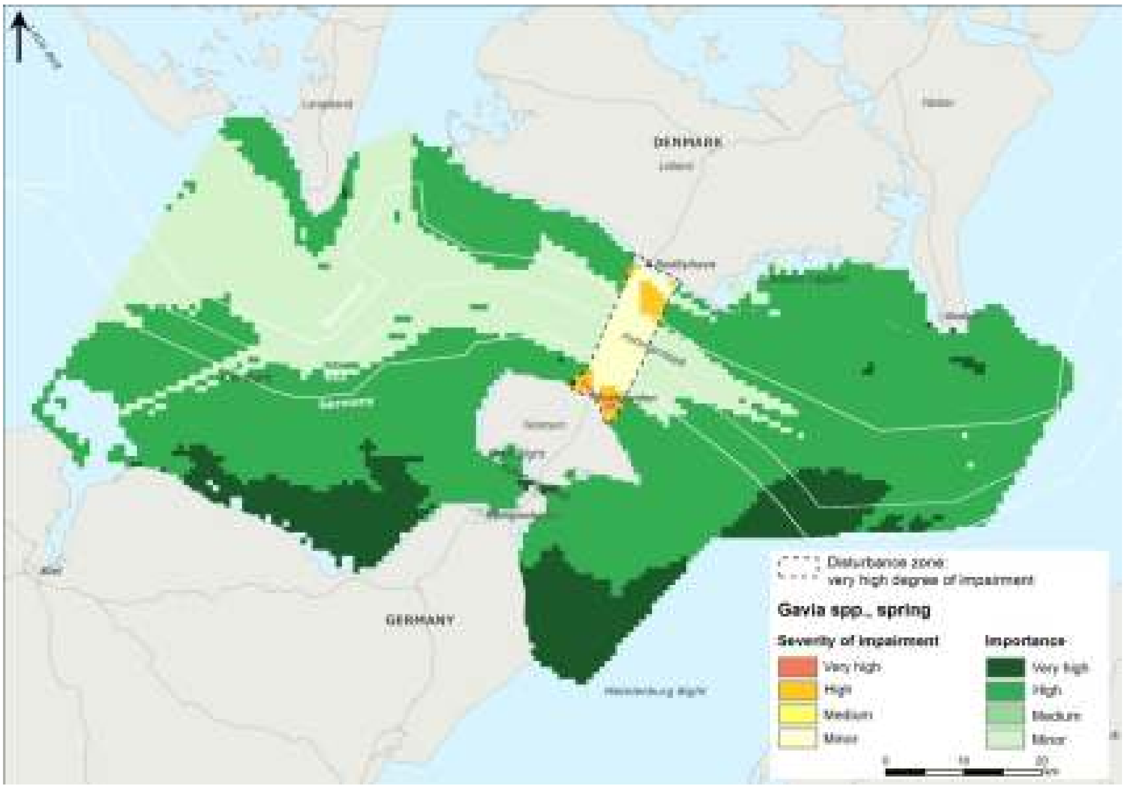


Figure 10.36 Severity of impairment from the pressure 'disturbance from construction vessels' to divers in spring.

Red-necked Grebe

The disturbance zone is assessed to be mostly of minor importance to the species, but in the coastal zone of the islands of Fehmarn and Lolland some areas are assessed to be of very high importance (Figure 10.37). Construction activities are predicted to locally result in a very high severity of impairment, but in most parts of the disturbance zone the severity of impairment is assessed to be minor. It is predicted that on average 13 birds (0.025% of the biogeographic population) will be displaced from the disturbance zone during winter. In winters when abundance of this species is high, as it was recorded in winter 2008/2009, 19 birds (0.037% of the biogeographic population) would be excluded from the disturbance zone.

Based on this the disturbance from construction vessels is assessed to result in a minor severity of impairment for Red-necked Grebe.

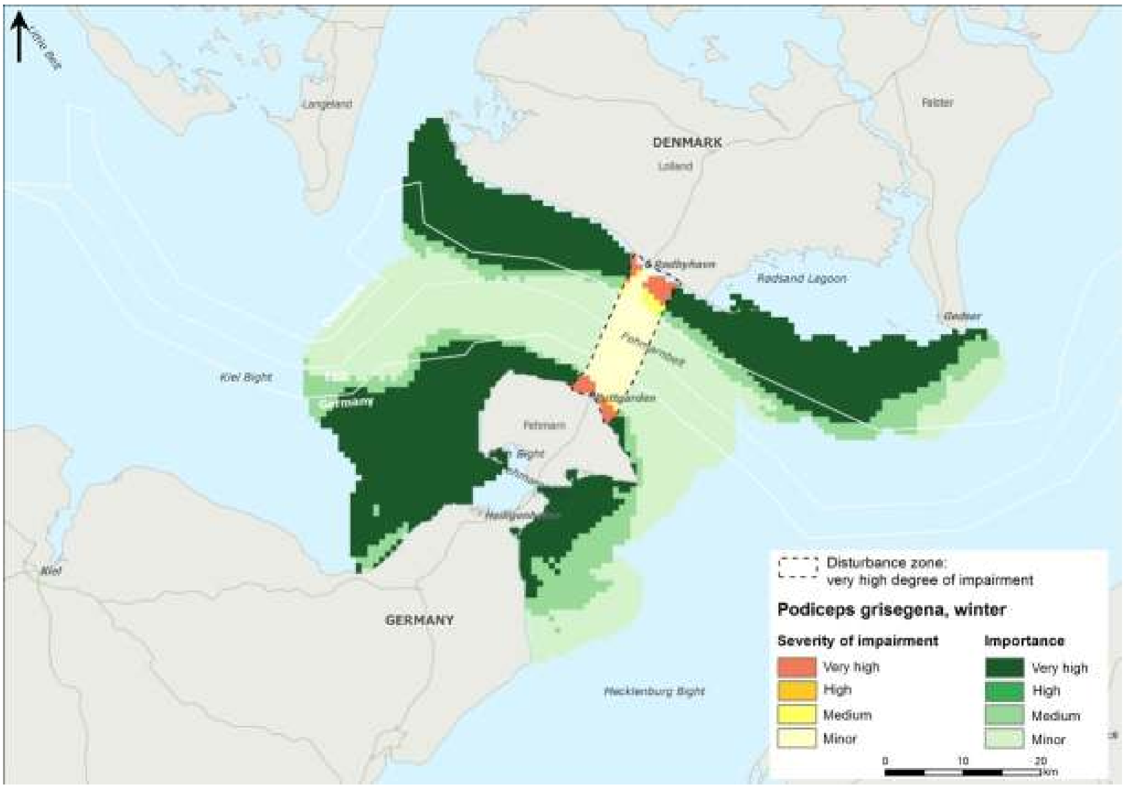


Figure 10.37 Severity of impairment of the pressure 'disturbance from construction vessels' to Red-necked Grebes in winter.

Great Cormorant

Maximum counts in the alignment area indicate that up to about 500 Great Cormorants use the area of the disturbance zone especially for roosting (breakwaters of the ferry harbours in Rødbyhavn and Puttgarden).

These birds are expected to be displaced during the time of construction activities, which results in a minor severity of impairment to this species.

Eurasian Wigeon

Maximum counts indicate that, with up to 1,500 birds and more, medium important numbers of Eurasian Wigeon use the alignment area in winter time. It is assumed that similar numbers would be displaced from the disturbance zone in winter.

Thus, the severity of impairment from disturbance from construction vessels for the Eurasian Wigeon is assessed to be medium.

Common Pochard

Maximum daytime counts indicate that, with more than 700 birds, highly important numbers of Common Pochard use the alignment area in winter time. It is assumed that similar numbers of night-time active Common Pochard would be displaced from the disturbance zone in winter.

Thus, the severity of impairment from disturbance from construction vessels for the Common Pochard is assessed to be high.

Tufted Duck
Maximum daytime counts indicate that, with more than 7,000 birds using the area, highly important numbers of Tufted Ducks use the alignment area in winter time. It is assumed that similar numbers of night-time active Tufted Ducks would be displaced from the disturbance zone in winter.

Thus, the severity of impairment from disturbance from construction vessels for the Tufted Duck is assessed to be high.

Greater Scaup
Maximum daytime counts of Greater Scaup in the alignment area are up to 130 birds, which corresponds to a minor importance of this area to the species. Therefore the severity of impairment is assessed to be minor for the Greater Scaup.

Common Eider
The Fehmarnbelt area has been identified as being a very important wintering area for the species holding up to 40% of the Baltic population. Consequently, also high proportions of the disturbance zone have been evaluated as being of very high importance, though clearly not being a high density area within the Fehmarnbelt (Figure 10.38, Figure 10.39). Disturbance from construction activities is assessed to lead to a very high severity of impairment in the coastal parts of the disturbance zone, and to a medium or minor severity of impairment in the central deep water parts of the disturbance zone. It is predicted that on average 3,316 birds (0.436% of the biogeographic population) will be displaced from the disturbance zone during winter and 2,570 birds (0.338% of the biogeographic population) during spring.

Based on the maximum estimate of Common Eiders in the Fehmarnbelt, a maximum number of 3,919 birds would be displaced from the disturbance zone. Therefore the disturbance from construction vessels is assessed to result in a medium severity of impairment for the Common Eider.

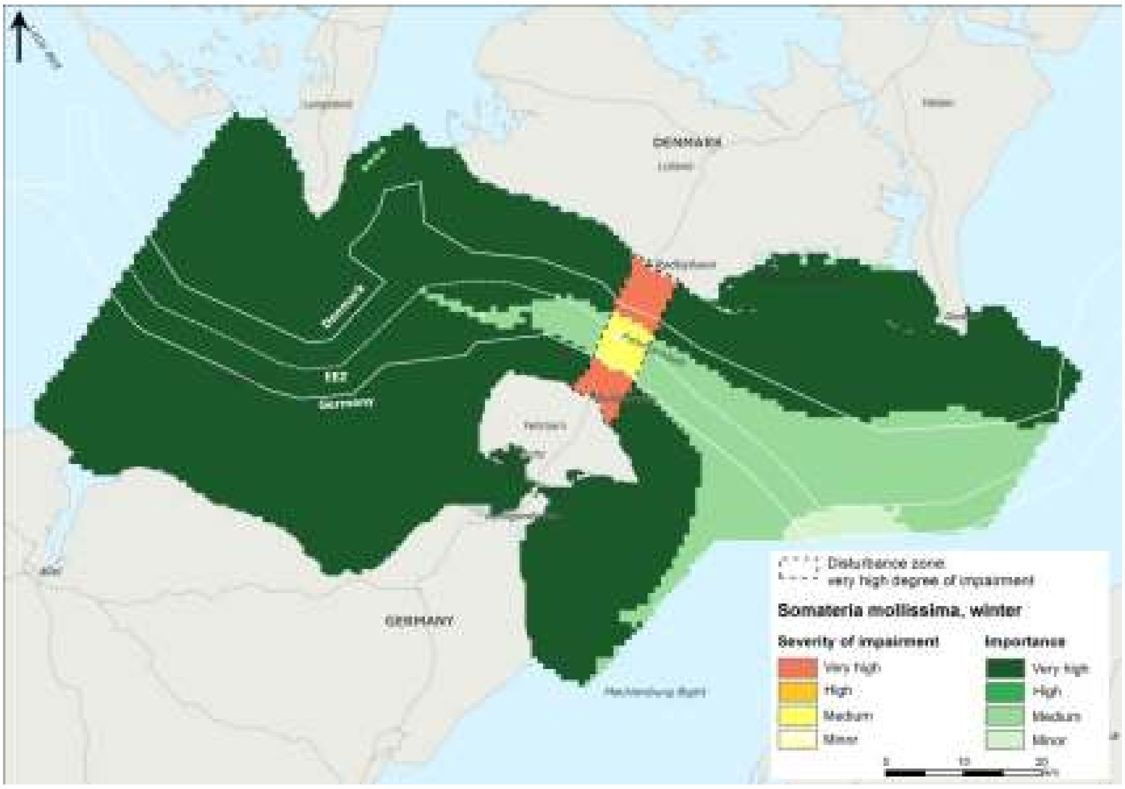


Figure 10.38 Severity of impairment of the pressure 'disturbance from construction vessels' to Common Eiders in winter.

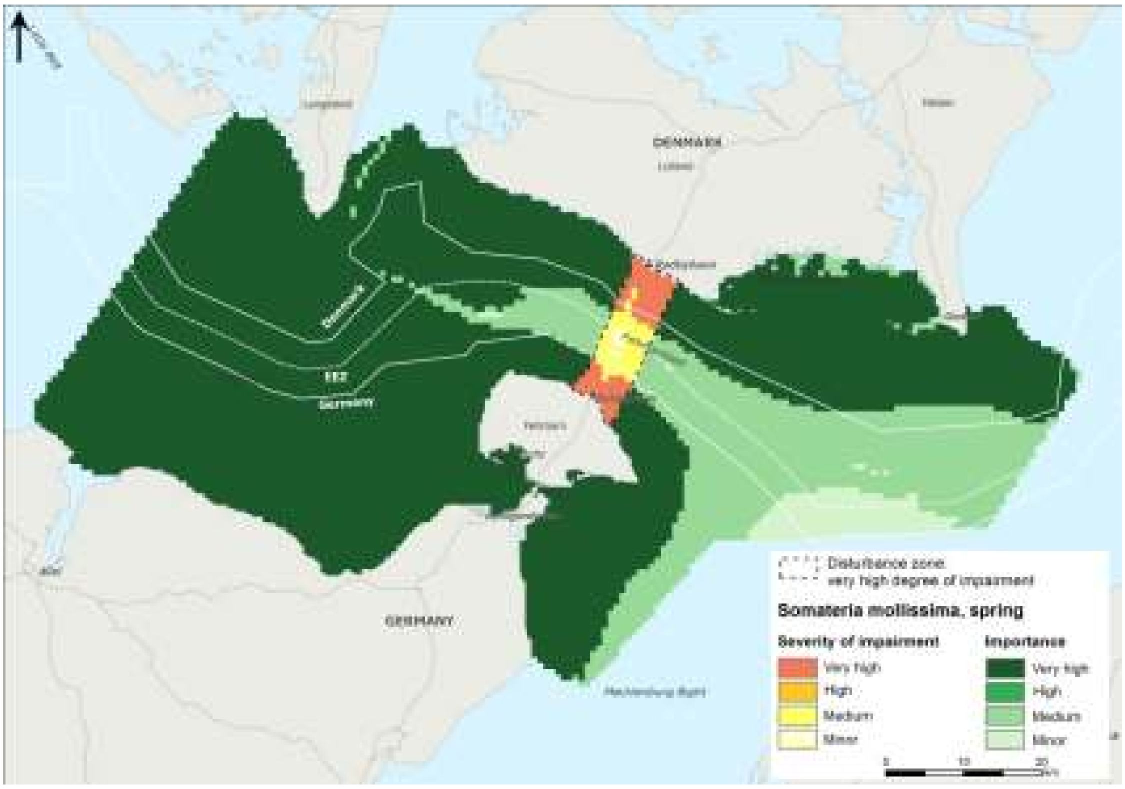


Figure 10.39 Severity of impairment of the pressure 'disturbance from construction vessels' to Common Eiders in spring.

Long-tailed Duck

The disturbance zone is assessed to be of mostly minor importance to Long-tailed Ducks and therefore the severity of impairment from construction activities is assessed to be mostly minor as well (Figure 10.40). It is predicted that on average 110 birds (0.002% of the biogeographic population) will be displaced from the disturbance zone during winter.

Based on this the disturbance from construction vessels is assessed to result in a minor severity of impairment for the Long-tailed Duck.

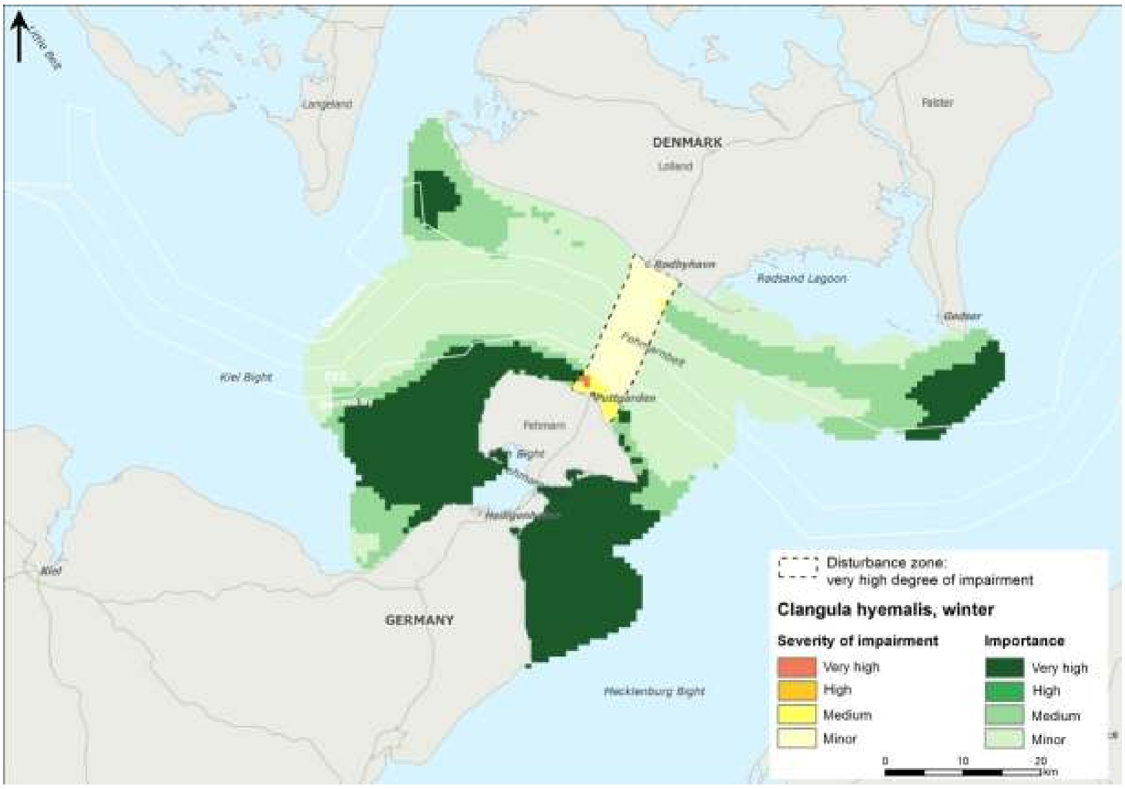


Figure 10.40 Severity of impairment of the pressure 'disturbance from construction vessels' to Long-tailed Ducks in winter.

Common Scoter

The disturbance zone is assessed to be mostly of minor importance to the species, but the coastal zone of the island of Fehmarn is assessed to be of very high importance (Figure 10.41). Shipping activities are predicted to lead locally to a very high severity of impairment, but in most parts of the disturbance zone the severity of impairment is assessed to be minor. It is predicted that on average 383 birds (0.024% of the biogeographic population) will be displaced from the disturbance zone during winter.

Based on this the disturbance from construction vessels is assessed to result in a minor severity of impairment for the Common Scoter.

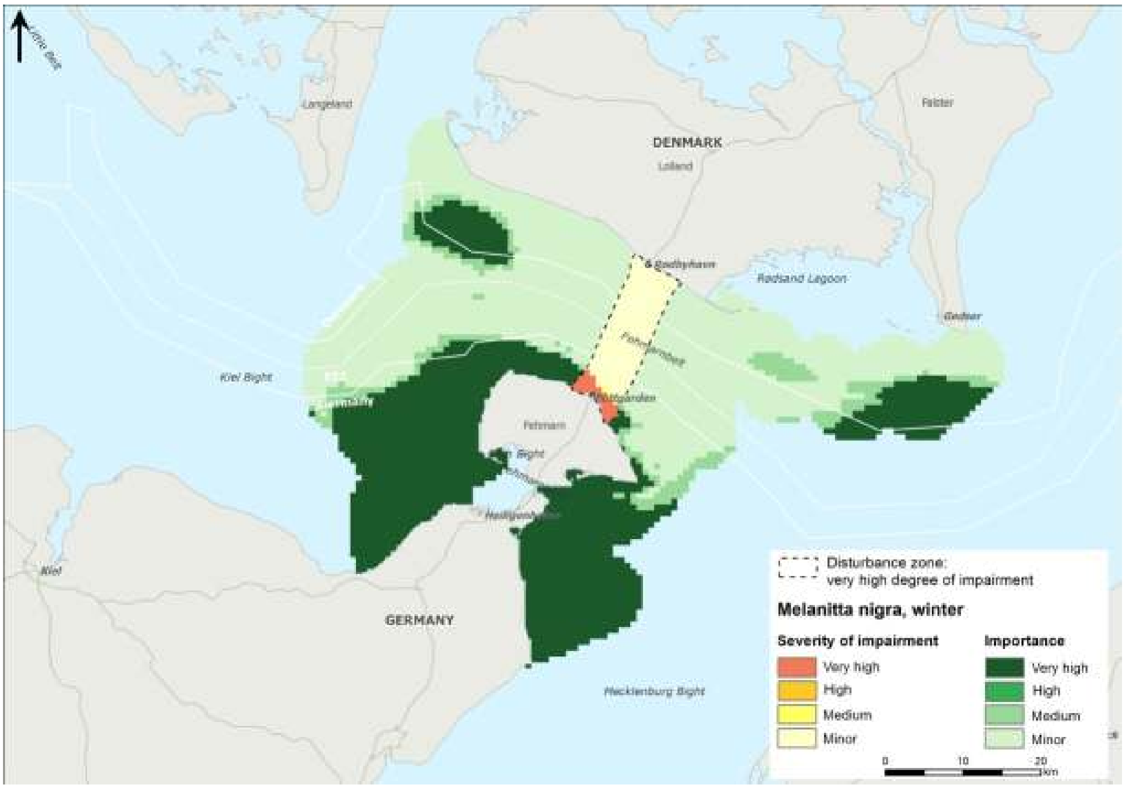


Figure 10.41 Severity of impairment of the pressure 'disturbance from construction vessels' to Common Scoters in winter.

Velvet Scoter

The greater alignment area is assessed to be of minor importance to Velvet Scoters with usually low numbers occurring in this area. Similar to Common Scoter (Figure 10.41), higher concentrations of this species have been observed outside of the disturbance zone. Therefore it is assessed that the disturbance zone is mainly of minor importance to Velvet Scoters and not more than a few tens of birds would be displaced from the disturbance zone during the construction period. This corresponds to a minor severity of impairment from this pressure to the Velvet Scoter.

Common Goldeneye

The disturbance zone is assessed to be mostly of minor importance to the species, but in the coastal zone of the islands of Lolland and Fehmarn some areas are assessed to be of very high importance (Figure 10.42). Shipping activities are predicted to lead locally to a very high severity of impairment, but in most parts of the disturbance zone the severity of impairment is assessed to be minor. It is predicted that on average 54 birds (0.004% of the biogeographic population) will be displaced from the disturbance zone during winter, 57 birds for the winter of maximum abundance (2008/2009). German coastal counts indicate up to 160 Common Goldeneyes occurring in the greater alignment area of the Fehmarnbelt. This pressure is assessed to result in a minor severity of impairment for the Common Goldeneye.

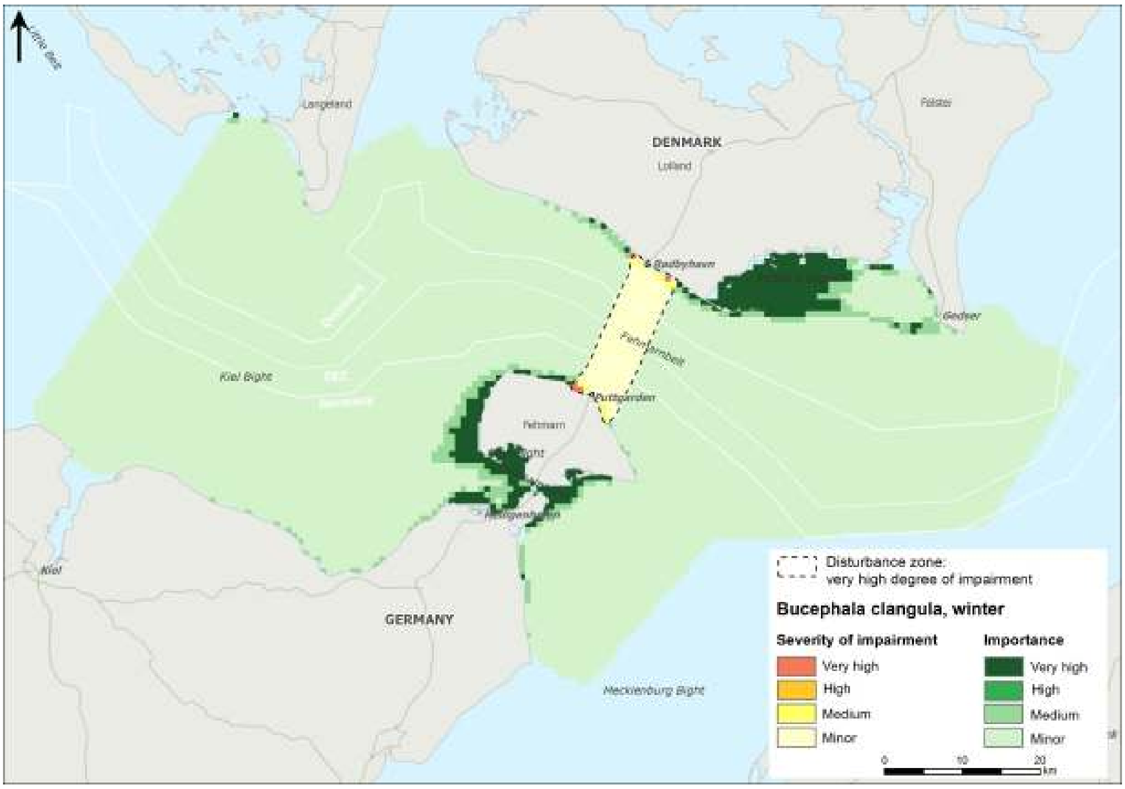


Figure 10.42 Severity of impairment of the pressure 'disturbance from construction vessels' to Common Goldeneye in winter.

Red-breasted Merganser

The disturbance zone is assessed to be mostly of minor importance to the species, except for the coastal zones of the islands of Lolland and Fehmarn which are assessed to be of very high importance (Figure 10.43). Shipping activities are predicted to lead locally to a very high severity of impairment, but in most parts of the disturbance zone the severity of impairment is assessed to be minor. It is predicted that on average 115 birds (0.068% of the biogeographic population) will be displaced from the disturbance zone during winter.

Based on this the disturbance from construction vessels is assessed to result in a minor severity of impairment for the Red-breasted Merganser.

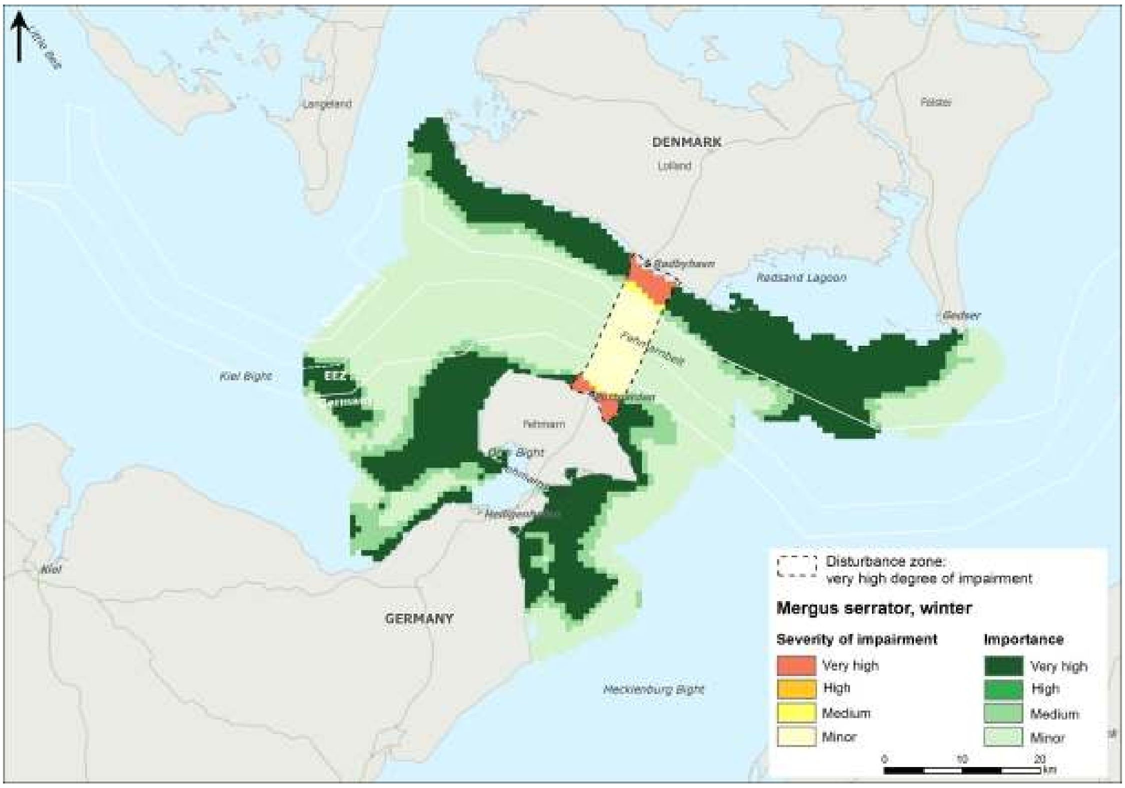


Figure 10.43 Severity of impairment of the pressure 'disturbance from construction vessels' to Red-breasted merganser in winter.

White-tailed Eagle

White-tailed Eagles are present in the Fehmarnbelt area all year. The birds use various inland and coastal habitats. The predicted disturbance zone from construction vessels lies within an already highly disturbed area with intensive shipping, thus the area is assessed to be of minor importance to the species. Therefore severity of impairment is assessed to be minor for the White-tailed Eagle.

Common Coot

Common Coot is abundant in the Fehmarnbelt area all year, but maximum numbers occur in winter. The species is mostly confined to inland habitats or sheltered marine areas, such as bays and lagoons, thus the area of the predicted disturbance zone is assessed to be of minor importance to the species. It is predicted that on average not more than a few tens of birds would get impaired from this pressure (maximum estimate for the alignment area: 340 birds, 0.02% of the biogeographic population). Consequently, severity of impairment is assessed to be minor for the Common Coot.

Razorbill

The disturbance zone is assessed to be mostly of minor importance to the species and therefore the severity of impairment from construction activities is assessed to be mostly minor as well (Figure 10.44). It is predicted that on average 10 birds (0.002% of the biogeographic population) will be displaced from the disturbance zone during winter.

Based on this the disturbance from construction vessels is assessed to result in a minor severity of impairment for the Razorbill.

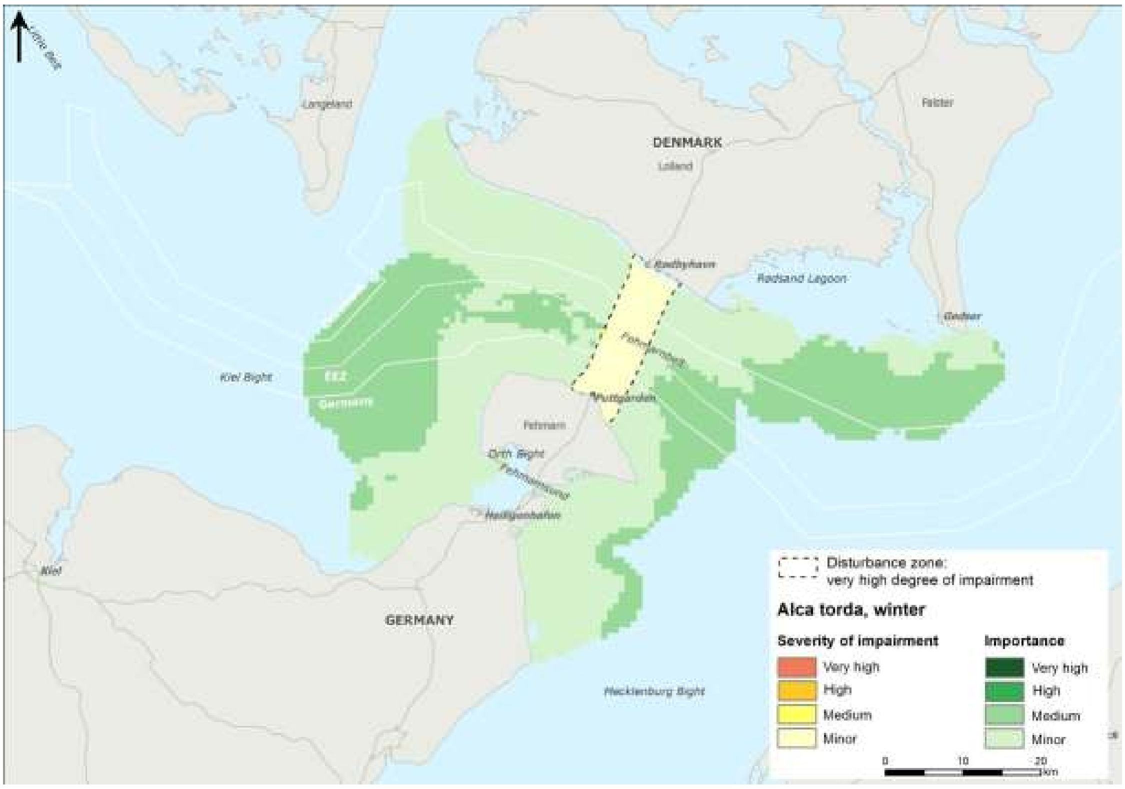


Figure 10.44 Severity of impairment of the pressure 'disturbance from construction vessels' to Razorbills in winter.

Black Guillemot

The alignment area is assessed to be of minor importance to the Black Guillemot with only single birds occurring there. Therefore the disturbance from construction vessels is assessed to result in a minor severity of impairment for the Black Guillemot.

Other species

For other non-breeding waterbird species the disturbance zone is assessed to be of minor importance, or birds occurring in the disturbance zone would respond to construction vessels, but the responses would be local and of short duration. Construction activities would not lead to a relevant reduction of their numbers in the disturbance zone, thus the severity of impairment is assessed to be minor for all other non-breeding waterbird species.

Overall assessment of the severity of impairment

The severity of impairment was determined from the total number of individuals per species which was estimated to be displaced from the disturbance zone during the construction of a cable stayed bridge. Despite locally high to very high severity of impairment, for most of the assessed species the overall severity of impairment is minor. A high level of severity of impairment is assessed for Common Pochard and Tufted Duck, and for Common Eider and Eurasian Wigeon the severity of impairment is assessed to be medium (Table 10.6).

Table 10.6 Assessment of the severity of impairment from disturbance of construction activities on non-breeding waterbirds.

Species	Displaced individuals	% of biogeo-graphic pop.	Severity of impairment
Divers	8	0.003%	Minor
Red-necked Grebe	19	0.04%	Minor
Great Cormorant	500	0.12%	Minor
Eurasian Wigeon	1,500	0.10%	Medium
Common Pochard	710	0.20%	High
Tufted Duck	7,100	0.59%	High
Greater Scaup	130	0.04%	Minor
Common Eider	3,919	0.52%	Medium
Long-tailed Duck	110	0.002%	Minor
Common Scoter	383	0.02%	Minor
Velvet Scoter	a few tens of birds	<0.01%	Minor
Common Goldeneye	57	0.004%	Minor
Red-breasted Merganser	115	0.068%	Minor
White-tailed Eagle	single birds	<0.1%	Minor
Common Coot	340	0.02%	Minor
Razorbill	10	0.002%	Minor
Black Guillemot	single birds	<0.1%	Minor
Other species		<0.1%	Negligible/ Minor

Migrating birds
The impact of disturbance from construction vessels on migrating birds is assessed as part of the pressure 'barrier from construction vessels' (chapter 10.2.5).

Duration of impact
The duration of the pressure 'disturbance from construction vessels' is restricted to the construction period of the bridge. It is expected that birds use the areas offering suitable habitats within a short-term period after finalisation of the construction activities, i.e. within 2 years after end of construction (Construction phase+).

10.2.5 Barrier from construction vessels

Description of the pressure
The construction of a cable stayed bridge will require various shipping activities in the offshore part of the alignment area and between the construction sites and working harbours and reclamation sites at Lolland and Fehmarn. The shipping and other construction activities will cause a barrier effect to those species of waterbirds in the area which are sensitive to human activities (see chapter 7.2.9). The pressure is the physical presence including noise, vibration and lighting of all types of construction vessels including cranes and other working platforms involved in the construction activities. Additionally, in the course of the construction period the growing structure of the bridge itself would have a barrier effect on birds as well.

Several types of shipping and construction activities would be associated with the construction of a cable stayed bridge:

- Dredging for working harbours, access channels and for piers
- Work harbour constructions at Fehmarn and Lolland
- Transport of sediment to and from the alignment
- Guard vessels to secure the construction works
- Transport of equipment and staff
- Transport and placement of pre-constructed bridge elements to final location
- Soil improvement works
- Excavation and placing of the scour protection
- Foundation and erection of the pylons, piers and anchor elements and ship impact protection structures (caissons)
- Commissioning of the bridge superstructure (girder elements)
- Construction of land reclamation areas on Lolland and Fehmarn
- Construction of the bridge peninsulas (embankments)

All this ship traffic would result in the reduction of barrier free flight paths for staging and migratory waterbirds. According to the construction schedule for the cable stayed bridge the disturbance from intensive dredging, construction and backfilling works will be conducted within a time period of 3 years. After this period the barrier effect from the bridge is assumed to be the same as described in chapter 10.3.6 for the operation phase.

Degree of impairment

Since the magnitude of pressure is only represented by the construction vessels, and can hardly be quantified concerning magnitude and frequency, the degree of impairment regarding the pressure barrier effect is defined by the sensitivity of birds to perceive the structure as a barrier. Therefore, the degree of impairment is at first regarded to correspond to the sensitivity level as assessed in chapter 7.2.9. As all considered bird species were assessed as being minor sensitive, the degree of impairment is assessed to be minor as well.

Severity of impairment

All considered breeding and non-breeding waterbird species and migrating birds were assessed to be minor sensitive to a barrier effect from construction vessels. Thus, the severity of impairment is assessed to be minor or negligible for all birds in the area.

Duration of impact
The duration of the impact of the pressure 'barrier from construction vessels' is restricted to the construction period. No impact from this pressure is predicted to occur after finalisation of the construction works.

10.2.6 Collision with construction vessels

Description of the pressure
The construction of a cable stayed bridge would require various shipping activities in the offshore part of the alignment area and between the construction sites and working harbours and reclamation sites at Lolland and Fehmarn. Birds may collide with the various types of ships used. The pressure is the physical presence of all types of construction vessels including guard vessels, cranes and other working platforms involved in the construction activities. Lights on the ships may attract birds at night during times of bad visibility and might lead to collisions with the vessels. There are no detailed descriptions about shipping intensity and dimensions of working areas available. In the course of the construction period additionally to the construction vessels the growing structure of a bridge would cause a risk for bird collisions which would need to be considered differently to the described collision with construction vessels (see chapter 10.3.7).

Degree of impairment
The degree of impairment regarding the collision risk with construction vessels is a deducted from the sensitivity assessment (see chapter 7.2.12). Based on the minor sensitivity to this pressure assessed for all breeding, non-breeding and migrating bird species, the degree of impairment is assessed to be minor to all affected birds in the area.

Severity of impairment

The severity of impairment from collisions with construction vessels is assessed to be minor or negligible for all breeding and non-breeding waterbirds and migrating bird species in the area.

Duration of impact
The duration of the impact of the pressure 'collision with construction vessels' is restricted to the construction period. No impact from this pressure is predicted to occur after completion of the construction works.

10.3 Operation and structures

10.3.1 Habitat loss and habitat change from footprint

Description of the pressure
During the operation of the cable stayed bridge in the Fehmarnbelt, marine areas would be directly lost due to land reclamations or the bridge structure itself (Figure 10.45). The largest areas affected by the footprint would be the coastal areas east of Rødbyhavn and Puttgarden due to the bridge peninsulas, reclamation areas and re-established seabed (Figure 10.45). The footprint in the offshore areas of the Fehmarnbelt would include the 74 piers of the two approach bridges, and the 4 piers and 3 pylons of the main bridge (Figure 10.45).

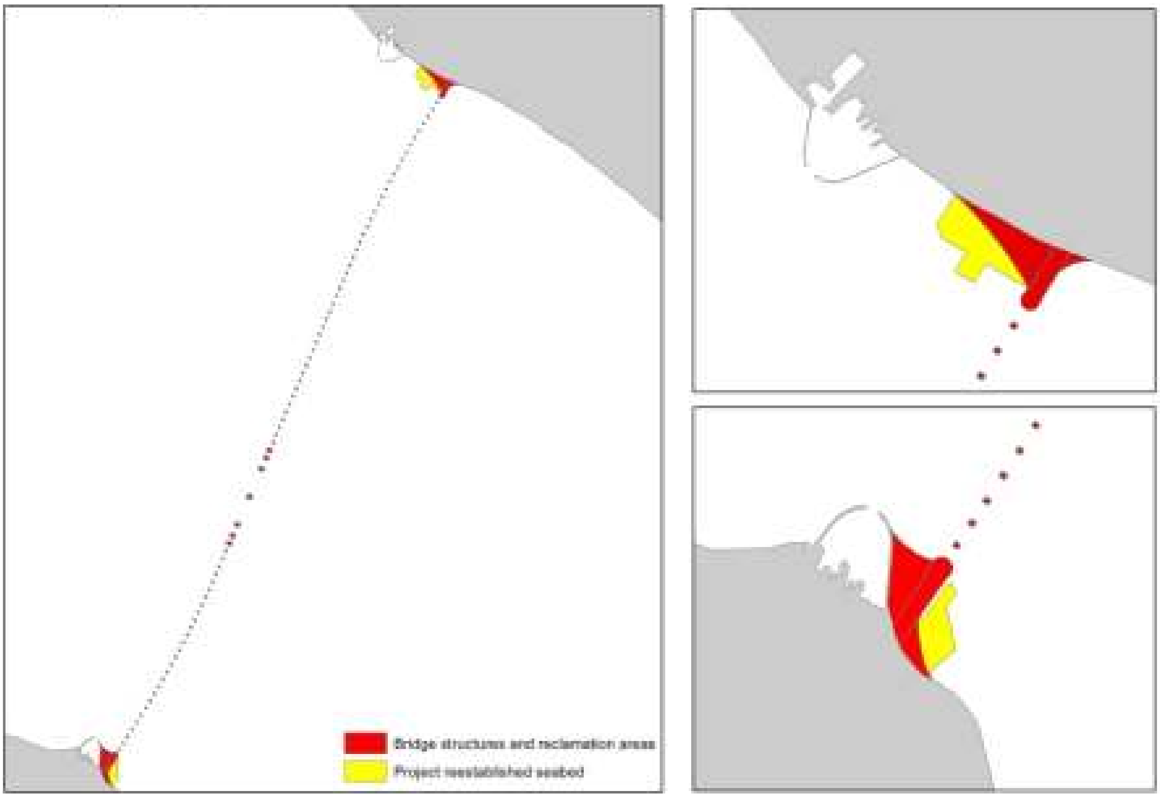


Figure 10.45 Footprint of the cable stayed bridge during operation.

The total habitat loss from the bridge footprint would affect an area of 79.4 ha. Among this, the greater area of 55.87 ha would be affected from permanent habitat loss (no recovery: land reclamations, bridge pylons and piers), and 23.53 ha are predicted to recover (Table 10.7). Seabed recovery is predicted to happen within a 2 year period, the recovery time of benthic flora and fauna depends on the particular affected community (see Table 9.22 in chapter 9.3.1).

Table 10.7 Size of marine areas affected by the permanent footprint of a cable stayed bridge and predicted recovery times of the seabed in different areas (FEHY 2013c).

Footprint area	Size, ha	Recovery time
Land reclamation and bridge peninsula Lolland	16.26	No recovery
Land reclamation and bridge peninsula Fehmarn	19.73	No recovery
Bridge pylons and piers	19.88	No recovery
Project re-established seabed (harbour Lolland)	14.67	<2 years
Project re-established seabed (harbour Fehmarn)	8.86	<2 years
TOTAL	79.40	

The structures of a cable stayed bridge are predicted to result in local changes in seabed and coastal morphology (FEHY 2013d, FEHY 2013f). The assessment of the impacts on the seabed morphology predict that the seabed would get flattened in the near zone area around the bridge pylons and piers due to increased turbulence and bottom current speed, which would result in loss of lunar and sand wave bed forms in these areas (FEHY 2013d). However, changes in seabed and coastal morphology from the bridge alternative were assessed to result in a negligible impact on the benthic communities (FEMA 2013d). Therefore this issue is not further assessed as relevant pressure component for birds.

Degree of impairment

The footprint area of the cable stayed bridge is regarded as an area of complete habitat loss during the first years after the completion of the bridge construction. Re-establishment of benthic communities is expected, so areas of the dredged working harbours would become suitable for birds again. Re-establishment of benthic habitats is expected to recover the areas assigned as recoverable (Table 9.21) into useable for birds again. Since there are uncertainties in recovery times of benthic communities in affected areas depending on natural processes, only complete habitat loss, i.e. the total displacement of all birds within the impact zone, can be assessed. No degree of impairment can be specified for recovering areas at the present stage.

Severity of loss/impairment

Breeding waterbirds

During the operation of a cable stayed bridge in the Fehmarnbelt the pressure ‘habitat loss and habitat change from the footprint’ would affect the same areas and species as described in chapter 9.2.1 for the construction phase.

The footprint of the cable stayed bridge is assessed to result in a minor severity of loss to all waterbirds breeding in Natura 2000 areas. There is no relevant impact predicted from this pressure for Red-necked Grebes breeding outside Natura 2000 sites on Lolland.

Non-breeding waterbirds

The habitat loss for non-breeding waterbirds during the operation of the cable stayed bridge would affect the same areas and species as described for the construction period (see chapter 10.2.1). Since there are no predictions about recovery times of benthic communities available the Impact Assessment for the operation phase of a cable stayed bridge is expected to be the same as for the construction period.

It is predicted that the bridge footprint would result in a minor severity of loss to all non-breeding waterbird species in the Fehmarnbelt area (Table 10.2; chapter 10.2.1).

Migrating birds
This pressure is assessed to be irrelevant for migrating birds.

Duration of impact
The duration of the pressure 'habitat loss from footprint' and therefore the impact of the pressure is either permanent (no recovery) or depends on re-establishment of areas of provisional loss (e.g. working harbours) in terms of recovery times of seabed, benthic flora and fauna and fish communities. Re-established areas offering suitable habitats for waterbirds are considered to be used by birds without relevant additional recovery period.

10.3.2 Provision of artificial reefs

Description of the pressure
During the construction of a cable stayed bridge a large amount of additional hard substrates would be added to the marine environment. Scour protections, embankments and the bridge pylons and piers themselves provide suitable habitats for hard bottom communities, which benefit from these additional human-made underwater hard substrates called artificial reefs. Hard bottom benthic communities in Fehmarnbelt consist mainly of macroalgae (*Fucus*, *Furcellaria*, *Phycodis/ Delesseria*, *Saccharina*) and filamentous algae communities (FEMA 2013a). The hard bottom benthic fauna consists on epifaunal species which are confined to hard substrates such as the *Mytilus* community (FEMA 2013b).

Beside the promotion of hard bottom communities there is another aspect related to this pressure. The benthic communities in the vicinity of artificial reefs get impaired by material and faecal pellets originating from the hard bottom community. It is predicted that this secondary effect is very local affecting areas only within a distance of 100 m from the artificial reef (FEMA 2013d).

The areas of additionally deployed solid substrates from a cable stayed bridge in the Fehmarnbelt would cover large areas of different benthic communities (Table 10.8). There are no estimates about the additional biomass from artificial reefs available. The areas listed in Table 10.8 do not account for three-dimensional structures that is caused by the material itself (e.g. boulders), but only give the two-dimensional area that is occupied.

Table 10.8 *Areas of additional hard substrate from the structures of a cable stayed bridge in Fehmarnbelt. The benthic communities listed are the communities which are predicted to get lost by deployment of additional solid hard substrate, not communities predicted to grow on the new substrate (FEMA 2013d).*

Structure	Community	Area, ha
Embankment Fehmarn	*Cerastoderma*	0.92 ha
Embankment Lolland	*Mytilus*	0.84 ha
Bridge pylons and piers	*Mytilus*	1.32 ha
	Gammarus	0.58 ha
	Corbula	5.58 ha
	Arctica	15.78 ha
	Cerastoderma	0.36 ha
TOTAL		25.38 ha

Artificial reef structures are also known to attract different fish species (Keller et al. 2006, Dumke et al. 2007, Lindeboom et al. 2011). Many shallow water fish species are substrate-spawners, i.e. they are associated to highly structured habitats. Additional hard substrates from bridge construction would also have an attraction effect on many small fish species, for which these areas are considered to serve as additional feeding and nursery grounds (Lindeboom et al. 2011, FeBEC 2013b). The increase in densities of small fish at these artificial reefs would likely also result in an attraction effect on larger fish species (e.g. Cod, Whiting) (Lindeboom et al. 2011). It is predicted that the additional hard substrates from a bridge would change the fish communities in the affected areas of Fehmarnbelt permanently (FeBEC 2013b).

Degree of impairment

Provision of artificial reefs is closely related to habitat loss by deployment of the additional hard substrates, which is assessed in the previous chapter 10.3.1. Some bird species might benefit from provision of artificial reefs and such effects were evaluated descriptively. For others no relevant impact is predicted to result from the artificial reefs. Therefore, the degree of impairment is assessed to be minor for all breeding and non-breeding waterbird species.

Severity of impairment

Breeding waterbirds

The pressure 'provision of artificial reefs' is only relevant for breeding bird species which use marine habitats as foraging sites during the breeding season or to rear their offspring in marine areas. Within the alignment area this would affect mostly fish-eating species (Red-necked Grebes, Red-breasted Mergansers, Great Cormorants, gulls and terns). All these species were assessed as neither being sensitive to any impact on benthic communities close to the artificial reefs nor benefitting directly from the fauna and flora communities growing at the artificial reefs. However, new structures with settled benthic communities would provide new habitats for fish and other mobile fauna (crustaceans, echinoderms), which in turn would create potential new foraging habitats for piscivorous birds. Therefore breeding waterbirds are not expected to face impacts from artificial reefs in the Fehmarnbelt, and positive effects are likely for some species. Subsequently, the severity of impairment is assessed to be minor.

Non-breeding waterbirds
The predicted impact on benthic communities close to the artificial reefs are expected to be local and small, so that no negative effect on any non-breeding waterbird species is predicted to result from the impairment of the benthic communities close to the additional solid substrates. The severity of impairment is assessed to be minor to all non-breeding waterbird species.

The epiflora and epifauna growing on the new solid substrates of a bridge are expected to provide an additional food source for some benthivorous bird species, such as seaducks or diving ducks. Likewise, new benthic communities on artificial reefs would attract fish and other mobile fauna, which would provide additional food resources for piscivorous birds. Whether new food can be exploited by the different bird species depends on bird behavioural reaction to the structures. If birds are sensitive to disturbance and avoid resting and foraging close to a bridge (see chapter 10.3.4) the food sources available on the underwater structures of the bridge may not be used. Distance to land and distance to shipping routes were identified as important factors shaping seaduck distributions (FEBI 2013) and may therefore also affect bird willingness to use novel habitats.

Migrating birds
This pressure is assessed as being irrelevant for migrating birds.

Duration of impact
The duration of the pressure 'provision of artificial reefs' is permanent, thus the impact on waterbirds is predicted to be permanent too.

10.3.3 Hydrographical changes

Description of the pressure
The hydrographical changes due to the bridge alternative are assessed in detail in FEHY reports (FEHY 2013b, 2013c). The assessed hydrographical changes include changes to the indicators current, water level, salinity and water temperature, stratification and waves. It is noted that changes associated with sediment spill during the construction process are not included here. It is also noted that water quality related changes are assessed by FEMA and are not included here.

The main tool for the FEHY hydrography assessment is numerical modelling. The FEHY numerical models (MIKE and GETM) applied to assess the bridge alternative in Fehmarnbelt and adjacent waters operate at a horizontal grid resolution of 400-700 m in the potential bridge alignment area, and the effect of bridge piers and pylons are included by means of a sub-grid parameterisation. Since only hydrographical changes of similar or larger scales than the grid resolution are captured by the models, it is implied that very localised hydrographical changes with scales of less than a few hundred meters are not included in the FEHY hydrography assessment.

FEHY have assessed three scenarios: the 0-alternative ("ferry"), the bridge alternative only ("bridge") and the combined ferry and bridge alternative ("ferry+bridge"). The results show that the differences in hydrographical changes related to the "bridge" and "ferry+bridge" scenarios are very limited (FEHY 2013c). Therefore only changes related to the "ferry+bridge" scenario are described here.

The change in current conditions due to the bridge solution is assessed by FEHY in terms of the annual mean surface and bottom current speeds. In Figure 10.46 the permanent change in annual mean surface current speed as calculated using the MIKE model is shown. The permanent changes amount to a reduction in surface current of up to 0.03 m/s at 5 km distance from the main bridge structures and decreasing with distance from the bridge. Off the Fehmarn coast an increase up to 0.02 m/s is predicted. At the bottom the modelled effect in annual mean current speed is of the same order of magnitude or lower. In the construction period the temporary work harbour and the production facility and its breakwaters will impose additional local changes to the current conditions. FEHY has not quantified these changes, but state that there will be considerable reduction in the current speed between the Lolland production facility and the Rødbyhavn breakwater.

In order to evaluate the changes in current conditions, it may be useful to compare them to the natural variability in the current conditions. The natural variability of the current speed in Fehmarnbelt is presented in terms of the mean and standard deviation of measured current speed in the FEHY main station 02 (FEHY 2013c). The surface and bottom mean current speed 2009-2010 is 0.41 m/s and 0.13 m/s, respectively, and the corresponding surface and bottom standard deviation is 0.23 m/s and 0.09 m/s, respectively. Thus, the estimated changes in currents for the bridge solution are negligible in comparison to the natural variability found in Fehmarnbelt.

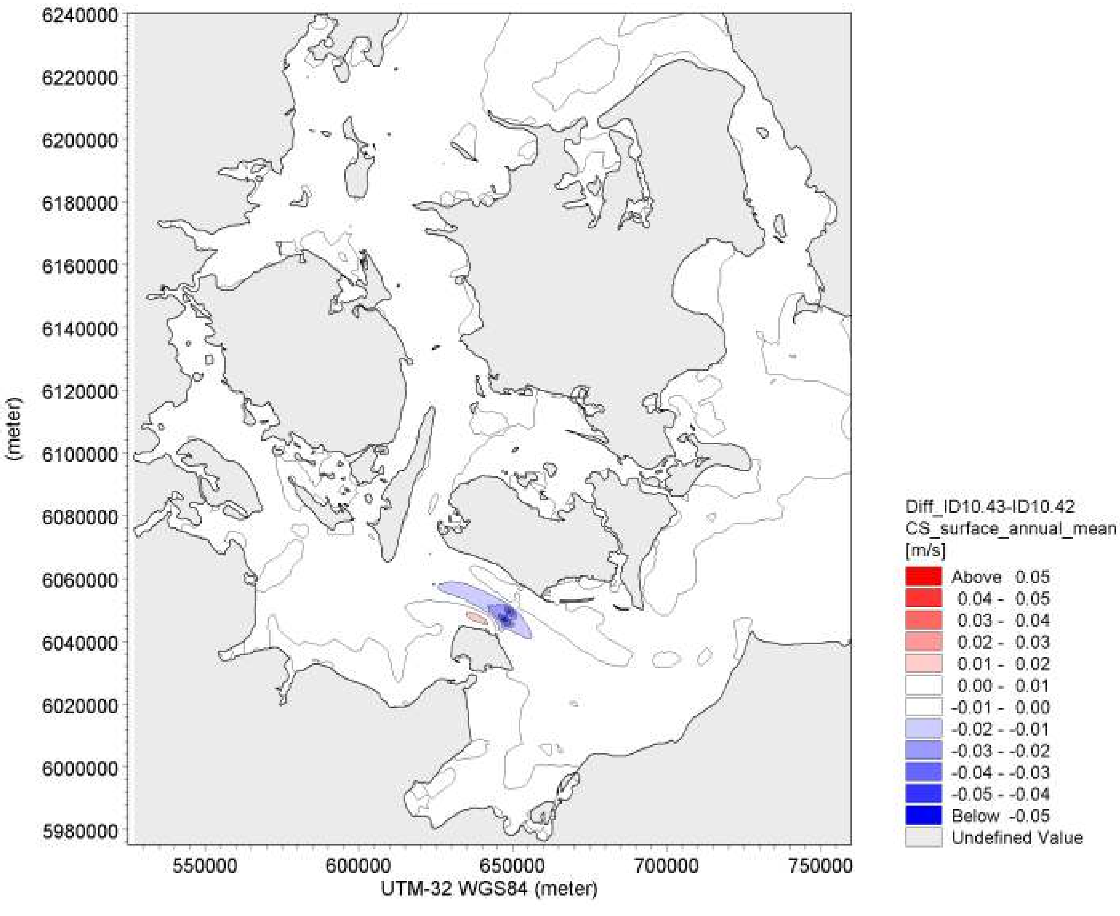


Figure 10.46 Modelled effect of "ferry+bridge" scenario on annual mean surface current speed (FEHY 2013c).

With respect to water level, salinity, water temperature and stratification, the permanent changes and changes during the construction period are predicted to be limited (mean water level change <0.01 m; mean salinity change <0.25 PSU; mean temperature change <0.25 °C; mean stratification change <0.25 kg/m^3). With respect to waves, permanent changes and changes during construction are mainly seen on the eastern side of the bridge alignment. The changes predicted are reductions of 0.15-0.30 m of the significant wave height exceeded 5% of the time within about 8 km of the bridge.

Project related hydrographical changes are assessed to have minor impact on benthic communities or changes are within the natural variability of the area (FEMA 2013d), thus no relevant indirect impact on birds is expected.

Degree of impairment

The degree of impairment is defined as the proportion of birds getting displaced from the impairment zone (zone of hydrographical changes) according to the criteria defined in chapter 4.5.14.

Severity of impairment

Breeding and non-breeding waterbirds

Relevant changes in hydrographical parameters are locally confined to areas close to bridge pylons and pillars, where small-scale eddies and upwelling events may enhance the foraging situation for some breeding and non-breeding waterbird species, such as terns and gulls. Breeding and non-breeding waterbird species are not expected to get impaired by hydrographical changes; therefore the severity of impairment for all waterbird species in the Fehmarnbelt is assessed to be minor or negligible.

Migrating birds

This pressure is assessed to be irrelevant for migrating birds.

Duration of impact

The duration of the pressure 'hydrographical changes' would be permanent, but the impact on waterbirds was considered to be negligible.

10.3.4 Disturbance from bridge structure and traffic

A detailed description of the structure and dimensions of the planned cable stayed bridge in Fehmarnbelt is given in chapter 10.1.

The presence of a cable stayed bridge is expected to result in disturbance of sensitive birds using the area. The bridge structure itself, noise and light emissions from cars and trains and illumination of the bridge structure are considered to result in avoidance reactions of sensitive breeding and non-breeding waterbirds. The disturbance effect of a bridge can result in a barrier effect for migrating birds, and breeding and non-breeding waterbirds can perceive a bridge as a barrier when the bridge lies between roosting sites, breeding places or feeding grounds by this affecting or disrupting functional connections between these areas. The barrier effect of the planned bridge to breeding waterbirds, non-breeding waterbirds and migrating birds is assessed in chapter 10.3.6 and is not subject of this chapter.

Based on the sensitivity analysis of waterbirds to the pressure 'disturbance from bridge structure and traffic' during operation of a bridge, an impairment zone (called 'disturbance zone' further on) of 2 km around the bridge structure was defined (Figure 10.47), similar to the use in Environmental Impact Assessments for offshore wind farms (Petersen et al. 2006, BioConsult SH 2008, Mendel and Garthe

2010). This disturbance zone was applied for all species identified as being medium to highly sensitive to this pressure. The disturbance zone of 2 km is regarded as a conservative approach because disturbance ranges often are smaller (see chapter 7.2.7).

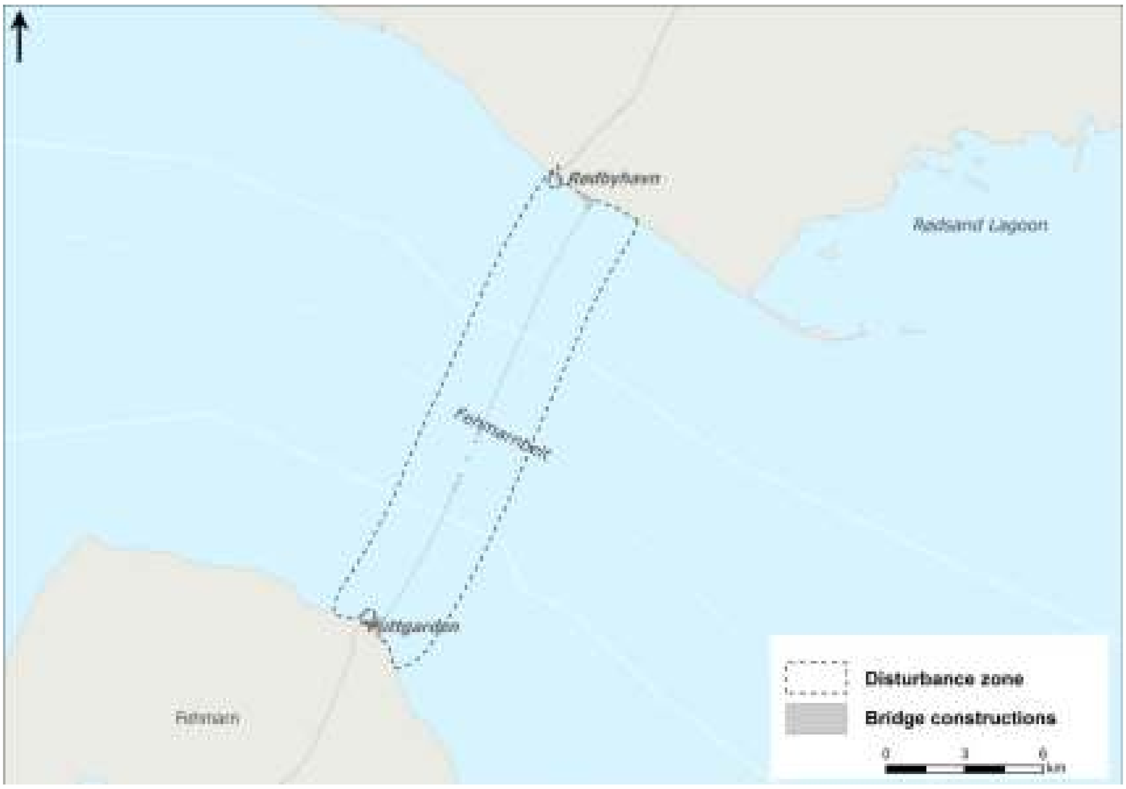


Figure 10.47 Disturbance zone of the cable stayed bridge defined as a 2 km buffer around the bridge structure during operation.

Degree of impairment

The degree of impairment is assessed following the criteria described in chapter 4.5.14. According to the precautionary principle for all species which were assessed to be medium to very high sensitive to the pressure (see chapter 7.2.9), a complete displacement of birds from the disturbance zone was assumed (i.e. very high degree of impairment). However, complete displacement of all medium to very high sensitive birds from the disturbance zone is regarded as very unlikely scenario and thus a very conservative approach. Medium sensitive species are expected to show avoidance reactions, and numbers of resting and foraging birds are likely to be reduced within this area, but a complete displacement of all birds from the disturbance zone is unlikely. Also, habituation might reduce the impact on birds over time. However, the degree of displacement is not quantifiable for these species. Therefore, according to the precautionary principle a complete displacement of all birds from the disturbance zone is assumed, i.e. a very high degree of impairment for medium to very high sensitive species. Species with attributed minor sensitivity are not expected to show avoidance reactions to the bridge in operation, thus not resulting in reductions of bird numbers in the disturbance zone and are therefore not assessed in this chapter.

Severity of impairment

Breeding waterbirds

In this chapter the severity of impairment from the pressure 'disturbance from bridge structure and traffic' is described for breeding waterbird species, which were identified to be potentially relevant for the EIA during the sensitivity screening (see chapter 7.3.1). Within this report only the impairment on breeding birds in marine areas is assessed. Consequently, any possible disturbance from bridge and traffic on breeding birds on land is not part of the present assessment and is covered elsewhere. Disturbance of birds in marine areas is expected to be relevant for breeding bird species which use marine habitats for foraging during the breeding season or rear their offspring in marine areas and which are assessed to be sensitive to the pressure.

Among waterbird species which conduct foraging flights to marine areas, the Red-necked Grebe is assessed to be relevant for this pressure. Red-breasted Mergansers, Common Eiders and partly also other duck species rear their offspring in sheltered coastal areas, but among these only Red-breasted Merganser breeds close to the alignment.

The pressure 'disturbance from bridge structure and traffic' is assessed to be only relevant for birds breeding in the northern part of Fehmarn, in the south of Lolland and partly for birds breeding in the Rødsand Lagoon, which might commute between the impact zone and the breeding area (Table 9.2). Cormorants breeding in the west of Fehmarn and birds of other breeding colonies within the German SPAs are expected to mostly use marine areas close to their colonies and not regularly visit the impairment zone at the alignment. Therefore, these have not been considered to be relevant.

Table 10.9 *Breeding waterbird species potentially affected from bridge structure and traffic during operation of a cable stayed bridge in Fehmarnbelt. Listed are the numbers of breeding pairs, for which use of the disturbance zone cannot be excluded. Numbers represent breeding pairs in Natura 2000 areas (Fehmarn and Rødsand Lagoon). Numbers from Fehmarn represent birds breeding within the SPA Eastern Kiel Bight between Markelsdorfer Huk and Grüner Brink (data sources: see FEBI 2013). Additionally breeding Red-necked Grebes registered on Lolland outside Natura 2000 sites are listed (data provided by COWI) for information; the assessment on these birds is part of the Impact Assessment of Lolland land areas.*

Species	Number of breeding pairs		
	Fehmarn north coast (SPA Eastern Kiel Bight)	SPA Hyllekrog-Rødsand	Lolland (outside Natura 2000)
Red-necked Grebe	35	-	20-21
Red-breasted Merganser	26	9*	

*Red-breasted Mergansers breeding in Rødsand Lagoon are not expected to use the impact area.

Red-necked Grebe

Red-necked Grebe is a typical breeding bird on Fehmarn and Lolland with 30 breeding pairs breeding in the reserve Grüner Brink (Fehmarn, SPA Eastern Kiel Bight) alone (Koop 2008a). Outside Natura 2000 areas, baseline investigations on Lolland revealed 20-21 breeding pairs of Red-necked Grebes (COWI 2011).

The nature reserve Grüner Brink is the closest reported breeding site of Red-necked Grebes to the disturbance zone within Natura 2000 areas. Birds are known to regularly commute between their inland breeding sites and marine foraging habitats. Since the disturbance zone does not affect the adjacent coastal waters of Grüner Brink and the area is already highly impaired by intense ferry traffic, the importance of the disturbance zone to these birds is assessed to be minor, though the area might partly be used by Red-necked Grebes. The severity of impairment from disturbance from bridge structure and traffic is assessed to be minor for Red-necked Grebes breeding in Natura 2000 areas.

COWI breeding bird surveys on Lolland indicate some Red-necked Grebes breeding close to the planned bridge alignment and the defined disturbance zone. It cannot be excluded that disturbance effects from the bridge structure and traffic and longer distances to other foraging sites outside the disturbance zone would have an impact on Red-necked Grebes breeding in the immediate vicinity of the disturbance zone. However, Red-necked Grebes are expected to habituate to a certain degree to this disturbance. The severity of impairment from this pressure to breeding Red-necked Grebes outside Natura 2000 areas on Lolland is assessed within the Impact Assessment for the land areas of Lolland.

Red-breasted Merganser
The nature reserve Grüner Brink on Fehmarn is the closest reported breeding site of Red-breasted Mergansers to the affected disturbance zone of a bridge across the Fehmarnbelt. Birds breeding in Rødsand Lagoon are not expected to be affected by the pressure. Red-breasted Mergansers use shallow marine areas to rear their offspring. Since the disturbance zone does not affect the coastal waters directly adjacent to Grüner Brink and the area east of Grüner Brink is already highly disturbed by the existing ferry traffic between Puttgarden and Rødbyhavn, the importance of the impairment zone to these birds is assessed to be minor. Therefore the severity of impairment from disturbance from bridge structure and traffic is assessed to be minor for the Red-breasted Merganser.

Other species
For other breeding waterbird species the disturbance zone is assessed to be of minor importance or birds are assessed to be insensitive or minor sensitive to the pressure, thus the severity of impairment from disturbance from bridge structure and traffic is assessed to be minor to these species.

Overall assessment of the severity of impairment
The overall assessment of the severity of impairment from disturbance from bridge structure and traffic during operation is assessed to be minor for all waterbirds breeding within Natura 2000 areas. The severity of impairment to Red-necked Grebes breeding outside Natura 2000 areas on Lolland is assessed as part of the Impact Assessment on Lolland land areas.

Non-breeding waterbirds
In this chapter the severity of impairment from the pressure 'disturbance from bridge structure and traffic' is described for all non-breeding waterbird species, which were identified to be potentially relevant for the EIA during the sensitivity screening (see chapter 7.3.2).

Divers (Red-throated/Black-throated Diver)
During FEBI baseline investigations the Fehmarnbelt was identified as an area of very high importance to divers during migrations and wintering period. The alignment area was identified as being mostly of minor importance to the species due to the high shipping intensity on the existing ferry route and the ship traffic on the route T. It is predicted that from the pressure 'disturbance from bridge structure and traffic' on average 4 birds (0.001% of the biogeographic population) would be displaced from the disturbance zone during winter and 6 birds (0.002% of the biogeographic population) during spring.

Based on this the disturbance from bridge structure and traffic is assessed to result in a minor severity of impairment for divers.

Red-necked Grebe

Red-necked Grebes occur in internationally important numbers in the Fehmarnbelt area during winter and transitional periods. The predicted disturbance zone is assessed to be mostly of minor importance to the species, but in the coastal zone of the island of Fehmarn some areas are assessed to be of very high importance (FEBI 2013). It is predicted that on average 6 birds (0.011% of the biogeographic population) would be displaced from the disturbance zone during winter. In winters when abundance of this species is exceptionally high, as it was recorded in winter 2008/2009, 8 birds (0.016% of the biogeographic population) would be excluded from the disturbance zone.

Based on this the disturbance from construction vessels is assessed to result in a minor severity of impairment for the Red-necked Grebe.

Eurasian Wigeon

Maximum counts indicate that, with up to 1,500 birds and more, medium important numbers of Eurasian Wigeon use the alignment area at times and these birds therefore assumed to be potentially affected in the disturbance zone of the planned bridge over the Fehmarnbelt. Based on the assumption that all these birds would be displaced from the disturbance zone, medium important numbers would be affected from this pressure in times of peak abundance, resulting in a medium severity of impairment for Eurasian Wigeon.

However, Eurasian Wigeon is known to also occur in highly disturbed areas, such as the ferry harbours in Puttgarden and Rødbyhavn (AKVSW 2010, DOF 2010, FEBI 2013) and the species was regularly observed occurring within the 1 km range of the Fehmarnsund Bridge during FEBI field investigations (unpublished observations from FEBI telemetry studies), thus it is likely that this species would not be completely displaced from the defined disturbance zone. Since medium important numbers are expected to occur in the disturbance zone only occasionally and it is predicted that at least some proportion of Eurasian Wigeon would use the disturbance zone anyway, the severity of impairment is assessed to be minor for the Eurasian Wigeon.

Common Pochard, Tufted Duck, Greater Scaup

Common Pochard, Tufted Duck and Greater Scaup are common diving ducks which occur in the Fehmarnbelt during the non-breeding period as wintering and migrating birds. These ducks typically roost during the day and forage on benthic organisms at night. The nocturnal distribution of these species is not known, but FEBI baseline telemetry studies on Tufted Duck indicate this species using foraging habitats close at sea to its daytime roosts (FEBI 2013). However, telemetry studies also revealed this species being highly mobile, thus the numbers of ducks using the coastal areas of the predicted disturbance zone can only be roughly estimated.

Maximum daytime counts indicate that, with more than 700 Common Pochard (>0.20% of the biogeographic population) and more than 7,000 Tufted Ducks (>0.58% of the biogeographic population), highly important numbers of these two species use the alignment area at times. Therefore the coastal areas in the alignment area are assessed to be of high importance to Common Pochard and Tufted Duck. Maximum daytime counts of Greater Scaup indicate up to 130 birds using the alignment area, which corresponds to a minor importance of this area to the species. Therefore the area is assessed to be of minor importance to Greater Scaup.

Based on the assumption that all birds would be displaced from the disturbance zone, the disturbance from bridge would result in a high severity of impairment for Common Pochard and Tufted Duck. The pressure would result in a minor severity of impairment for the Greater Scaup.

However, based on the sensitivity analysis and literature review presented in chapter 7.2.7 and own observations during FEBI baseline, small numbers of both species use the Puttgarden harbour basin, therefore it is very likely that not all birds would avoid the defined disturbance zone and some flocks of diving ducks would use areas closer to the bridge structure within the disturbance zone. Due to uncertainties about the proportion of birds which would be displaced from the areas around a bridge and the fact that even 50% displacement of birds within the area (instead of 100% assumed above) would result in displacement of highly important numbers of Common Pochard and Tufted Duck, a high severity of impairment from disturbance from bridge structure and traffic during operation of a cable stayed bridge is assessed for the Common Pochard and the Tufted Duck wintering in the Fehmarnbelt. Due to low numbers of Greater Scaup using the disturbance zone, the severity of impairment is assessed to be minor to this species.

Common Eider

The Fehmarnbelt area has been identified to be a very important wintering area for the species holding up to 43% of the Baltic population. Consequently, also high proportions of the disturbance zone have been evaluated as being of very high importance, though clearly not being a high density area within the Fehmarnbelt (FEBI 2013). It is predicted that possibly up to 1,889 birds (0.249% of the biogeographic population) would be displaced from the disturbance zone during winter and 1,251 birds (0.165% of the biogeographic population) during spring, assuming a complete displacement of all birds from the disturbance zone.

However, based on the sensitivity analysis and literature review in chapter 7.2.7 it is very likely that not all birds would avoid the defined disturbance zone and some flocks of eiders would use areas closer to the bridge structure within the disturbance zone. Due to uncertainties about proportion of birds which would be displaced from the areas around a bridge and the fact that even 50% displacement of birds within the area (instead of 100% assumed above) would result in a displacement of medium important numbers of Common Eiders, a medium severity of impairment from disturbance from bridge structure and traffic during operation of a cable stayed bridge is assessed for the Common Eider wintering in the Fehmarnbelt.

Long-tailed Duck

Long-tailed Duck is an abundant seaduck species with up to 23,000 individuals wintering in the Fehmarnbelt area. The disturbance zone is assessed to be of mostly minor importance to Long-tailed Ducks (FEBI 2013). It is predicted that on average 61 birds (0.001% of the biogeographic population) would be displaced from the disturbance zone during winter.

Based on this the disturbance from structure and traffic during operation of a cable stayed bridge is assessed to result in a minor severity of impairment for the Long-tailed Duck.

Common Scoter, Velvet Scoter

Scoters are common seaducks wintering in high numbers in the Fehmarnbelt area. Baseline investigations indicate numbers of up to 66,000 Common Scoters and 3,000 Velvet Scoters occurring in the study area. The alignment area with the predicted disturbance zone of a bridge was identified to be mostly of minor importance to both scoter species. It is predicted that on average 118 Common

Scoters (0.007% of the biogeographic population) and not more than a few tens of Velvet Scoters (<0.005% of the biogeographic population) would be displaced from the disturbance zone during winter.

Based on this the disturbance from structure and traffic during operation of a cable stayed bridge is assessed to result in a minor severity of impairment for Common Scoter and Velvet Scoter.

Common Goldeneye
Common Goldeneye is a common wintering duck in the Fehmarnbelt area, which is mostly confined to sheltered coastal areas such as bays or lagoons and only rarely occurs offshore. The disturbance zone is assessed to be mostly of minor importance to the species, but in the coastal zone of the islands of Lolland and Fehmarn some areas are assessed to be of very high importance (FEBI 2013). It is predicted that on average 23 birds (0.002% of the biogeographic population) would be displaced from the disturbance zone during winter. Consequently, the pressure is assessed to result in a minor severity of impairment for the Common Goldeneye.

Red-breasted Merganser
Red-breasted Mergansers are present in the Fehmarnbelt area all year round, but are most abundant during the non-breeding period as wintering and migrating birds. The disturbance zone is assessed to be mostly of minor importance to the species, but in the coastal zone of the islands of Lolland and Fehmarn some areas are assessed to be of very high importance (FEBI 2013). It is predicted that on average 53 birds (0.031% of the biogeographic population) would be displaced from the disturbance zone during winter.

Based on this the disturbance from structure and traffic during operation of a cable stayed bridge is assessed to result in a minor severity of impairment for the Red-breasted Merganser.

Common Coot
Common Coot is abundant in the Fehmarnbelt area all year round, but maximum numbers occur in winter. The species is mostly confined to inland habitats or sheltered marine areas, such as bays and lagoons, thus the area of the predicted disturbance zone is assessed to be of minor importance to the species. It is predicted that on average not more than a few tens of birds would be impaired by this pressure (maximum estimate for the alignment area: 340 birds, 0.02% of the biogeographic population). Consequently, the severity of impairment is assessed to be minor for the Common Coot.

Razorbill
Razorbill uses the Fehmarnbelt area mainly in winter and during migration periods. The disturbance zone is assessed to be mostly of minor importance to the species (FEBI 2013). It is predicted that on average 6 birds (0.001% of the biogeographic population) would be displaced from the disturbance zone during winter.

Based on this the disturbance from structure and traffic during operation of a cable stayed bridge is assessed to result in a minor severity of impairment for the Razorbill.

Black Guillemot
The greater alignment area is assessed to be of minor importance to Black Guillemot with only single birds occurring in this area. Therefore the disturbance from structure and traffic during operation of a cable stayed bridge is assessed to result in a minor severity of impairment for the Black Guillemot.

Other species
For other non-breeding waterbird species the disturbance zone is assessed to be of minor importance, or birds occurring in the disturbance zone would respond to the bridge structure, but the responses would be local and of short duration (no or minor sensitivity to the pressure). Disturbance effects from bridge structure and traffic are not predicted to result in a relevant reduction of their numbers in the defined disturbance zone.

Overall assessment of the severity of impairment
The severity of impairment was determined from the total number of individuals per species which was estimated to be displaced from the disturbance zone of a cable stayed bridge. For most of the assessed species the overall severity of impairment is assessed to be minor. The severity of impairment is assessed to be high for the two diving duck species Common Pochard and Tufted Duck; and a medium severity of impairment is assessed for the Common Eider (Table 10.10).

Table 10.10 Assessment of the severity of impairment from disturbance of bridge structure and traffic activities on non-breeding waterbirds.

Species	Displaced individuals	% of biogeo-graphic pop.	Severity of impairment
Divers	6	0.002%	Minor
Red-necked Grebe	8	0.016%	Minor
Eurasian Wigeon	<1,500	<0.10%	Minor
Common Pochard	710	0.20%	High
Tufted Duck	7,100	0.59%	High
Greater Scaup	130	0.04%	Minor
Common Eider	1,889	0.25%	Medium
Long-tailed Duck	61	0.001%	Minor
Common Scoter	118	0.01%	Minor
Velvet Scoter	low number	<0.001%	Minor
Common Goldeneye	23	0.002%	Minor
Red-breasted Merganser	53	0.03%	Minor
Common Coot	low number	<0.01%	Minor
Razorbill	6	0.001%	Minor
Black Guillemot	low number	<0.1%	Minor
Other species	low number	<0.1%	Negligible/ Minor

Migrating birds
The impact of disturbance from the bridge structure on migrating birds is assessed as part of the pressure 'barrier from bridge structure' (chapter 10.3.6).

Duration of impact
The duration of the pressure 'disturbance from bridge structure and traffic' would be permanent, thus the impact on waterbirds is predicted to be permanent too. Habituation might reduce the impact on some waterbird species over the years, but the pressure would persist for all sensitive species permanently.

10.3.5 *Disturbance from channelling of shipping*

Description of the pressure

The Fehmarnbelt is an area of high shipping intensity with a main navigational route passing the area (route T; Figure 10.48; Femern A/S 2011). AIS data analysis revealed in total 46,200 vessels passing the alignment area of a fixed link in Fehmarnbelt in east-west and west-east direction per year (analysed dataset 2006/2007) in addition to the existing ferry traffic between Rødbyhavn and Puttgarden with approximately 38,400 ferry crossings per year (Femern A/S 2011). The structure of a cable stayed bridge would funnel the main vessel traffic from an area covering a third to half of the width of Fehmarnbelt (Figure 10.48) to the two openings of the main bridge, each spanning 724 m (see chapter 10.1). This would result in an increase of vessel traffic in the Natura 2000 site SCI Fehmarnbelt, where the main bridge would be located.

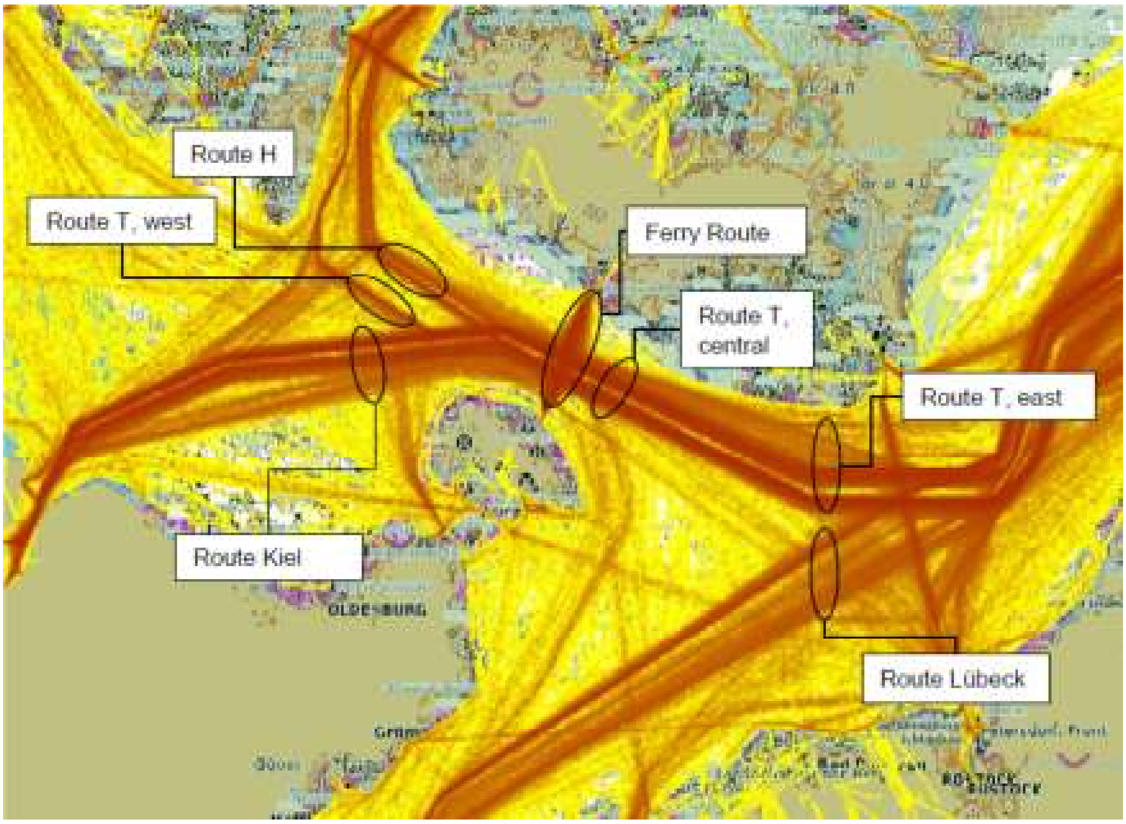


Figure 10.48 Intensity plot of the Fehmarnbelt area based on registered AIS data with main navigation routes marked (map (excerpt) taken from (Femern A/S 2011).

Degree of impairment

The degree of impairment from the channelling of shipping resulting in reductions of bird numbers in the impairment zone is assessed following the description for the degree of impairment from habitat change in chapter 4.5.14. Some bird species might benefit from this pressure and such effects were evaluated descriptively.

Severity of impairment

Breeding waterbirds
The pressure 'channelling of shipping' is only relevant for breeding bird species using the offshore marine areas impaired by the shipping traffic at the main shipping route in Fehmarnbelt (route T). Among breeding waterbirds it is mostly gulls and terns which are expected to use the offshore areas of Fehmarnbelt and which would get affected from the pressure. Since gulls and terns were assessed as not being sensitive to disturbance from shipping (see chapter 7.2.6), there is no impact on these species expected from this pressure, though distribution of ship associated gulls might change with distribution of ship traffic.

Other species which were assessed to be sensitive to disturbance from shipping are expected to benefit from the channelling effect of a bridge, since the impairment zone from the shipping likely gets reduced and with more predictable traffic distribution the probability of habituation of sensitive waterbird species increases (see chapters 7.2.6 and 7.2.7). Therefore breeding birds are not expected to face impacts from channelling of shipping in the Fehmarnbelt. Positive effects could occur for species which are sensitive to disturbance from shipping and also use the affected offshore area (possibly Red-necked Grebe). Subsequently, the severity of impairment is assessed to be minor.

Non-breeding waterbirds
The pressure 'disturbance from channelling of shipping' is mainly relevant for species occurring in the offshore areas of the Fehmarnbelt, which are mostly regarded to be sensitive to disturbance from shipping (see chapter 7.2.6). The area where shipping intensity is expected to increase due to the channelling effect of a bridge lies within the area of main shipping route during the baseline conditions. Therefore this area is considered to be already highly impaired for sensitive bird species, which is also reflected in bird distribution of e.g. divers observed during FEBI baseline investigations (FEBI 2013). Thus, an intensification of shipping traffic in the already highly impaired area of the shipping route is assessed to have minor additional effect on non-breeding waterbirds. On the contrary it is predicted that the channelling of ship traffic to a more predictable smaller area would reduce the disturbance effect on sensitive non-breeding waterbirds due to reduction of the impaired area and the greater likelihood of habituation (e.g. Schwemmer et al. 2011). Therefore the severity of impairment is assessed to be minor for all non-breeding waterbird species.

Migrating birds
This pressure is assessed to be irrelevant for migrating birds.

Duration of impact

The duration of the pressure 'disturbance from channelling of shipping' would be permanent, thus the impact on waterbirds is predicted to be permanent too. Habituation might reduce the impact on some waterbird species over the years, but the pressure would persist for all sensitive species permanently.

10.3.6 Barrier from bridge structure

Description of the pressure

The structure itself and the operation-related disturbances like light and noise emissions of a cable stayed bridge over the Fehmarnbelt are expected to result in a barrier effect for birds being sensitive to this pressure. The pressure results on one hand from the technical structure and operation features of the bridge (see chapter 10.1) and on the other hand from the sensitivity of birds to perceive the bridge as a barrier (see chapter 7.2.9).

Degree of impairment

Since the magnitude of pressure is defined by the structure of the bridge, the degree of impairment regarding barrier effect is defined by the sensitivity of birds to the structure. Therefore, the degree of impairment is at first regarded to correspond to the sensitivity as assessed in chapter 7.2.9.

In order to account for extra energy expenditures as a result from avoidance reactions to a barrier, the degree of impairment is further assessed as energy expenditures for different detour flight scenarios for a selected number of species (see below).

Species, for which results from the effect studies at the Baltic Sea bridges suggest strong behavioural reactions (see chapter 4.6.2), are considered to invest more energy for crossing the bridge than birds passing the area without any behavioural response. To assess the extra energy expenditure for migrating individuals, it was set into relation to the estimated species-specific total migration costs. To assess the extra energy expenditure for the non-breeding (staging/wintering) waterbirds, it was estimated in relation of the daily energy expenditure. To calculate the extra costs for crossing the barrier bridge, four different scenarios of avoidance reactions (increasing flight height by 120 or 250 m, flying an 18 km detour over land, 10 min circling and crossing at 120 m) were defined (see chapter 4.6.2) and the respective energetic costs were calculated by using the program FLIGHT (Table 10.12, see also methods chapter 0).

Table 10.11 gives the species-specific input parameters used for energy calculations of the selected waterbird species, which are characterised by a high wing load and thus represent bird species with the highest relative flight costs. Only species with at least medium sensitivity to the barrier effect were included in the calculations.

Table 10.11 Energy expenditure: species-specific parameters used in the calculations. For details see text. Bold print: species considered both as migrating and resting / wintering (non-breeding waterbird) species; non-bold print: species relevant as migratory species only. Mass represents body mass taken from Wings database of the program Flight (see chapter 0) and thus can deviate from actual body weights of birds migrating or staging in the Fehmarnbelt.

Species	Mass (kg)	True air speed at 1.3 Vmp (m/s)	Chemical power (W) at minimum power speed (Vmp) and 20% fat gain	Total migration distance (km)	Costs of total migration (kJ)
Red-throated Diver	2.66	24.1	225	1,500	12,700
Red-necked Grebe	0.98	20.5	78	1,500	5,170
Mute Swan	12.00	27.8	1,020	700	25,800
Whooper Swan	11.2	27.2	887	2,000	59,900
Barnacle Goose ($)	2.04	20.2	121	5,000	28,400
Brent Goose ($)	1.66	20.8	114	4,500	22,600
Eurasian Wigeon	0.92	19.8	68	1,000	3,300
Northern Pintail*	0.91	19.0	63	2,500	6,720
Tufted Duck ($)**	0.91	21.3	83	2,500	9,420
Common Eider	1.66	22.1	146	1,400	9,120
Long-tailed Duck ($)	0.88	21.2	80	3,000	10,200
Common Scoter	1.20	21.3	114	2,500	13,700
Common Goldeneye**	0.90	20.9	77	1,500	7,260
Red-breasted Merganser	1.30	16.3	103	1,400	6,150

($) Calculation of the entire energy expenditure using 50% fat load
* Modified physiological data from male Mallard used
** Modified physiological data from Long-tailed Duck used.

For migrating species, the highest additional energy expenditures were estimated for the scenario 3 and were highest for heavy species (Table 10.12). Considering costs of the entire migration route the relative additional costs are highest for species with short migration distances (Table 10.12). The highest relative increase calculated for scenario 3 would be 2.6% for the Mute Swan (migration distance 700 km). For the maximum detour distance to fly around the bridge (scenario 2) a maximum additional cost of 2% was also estimated for the Mute Swan. For the scenarios 1 and 4, additional energy expenditures correspond to less than 0.5% of the total migration flight costs for all species. Thus, for long-distance migrants additional energetic costs would rarely exceed values of 1% of total migration costs, even when assuming the most conservative scenario 3 (Table 10.12).

Table 10.12 Energy expenditure (costs) for selected waterbird species: results of different scenarios in kJ and in % of total migration costs. Bold print: species considered both as migrating and resting / wintering (non-breeding waterbirds) species; non-bold print: species relevant as migrating bird only. For details see text and methods in chapter 4.6.2. For species parameters see Table 10.11.

Species	Scenario 1 – flying over bridge (climb of 120 m)		Scenario 2 – flying around the bridge (detour of 18 km)		Scenario 3 – circling for 10 min and flying over bridge (climb of 120 m)		Scenario 4 – flying over bridge (climb of 250 m)	
	Costs (kJ)	% of migration costs	Costs (kJ)	% of migration costs	Costs (kJ)	% of migration costs	Costs (kJ)	% of migration costs
Red-throated Diver	13.6	0.1	99.7	0.8	148.6	1.2	28.4	0.2
Red-necked Grebe	5.0	0.1	29.8	0.6	52.1	1.0	10.5	0.2
Mute Swan	61.4	0.2	521.0	2.0	673.4	2.6	128.0	0.5
Whooper Swan	57.3	0.1	443.4	0.7	589.5	1.0	119.4	0.2
Barnacle Goose ($)	10.4	0.0	45.6	0.2	83.0	0.3	21.8	0.1
Brent Goose ($)	8.5	0.0	44.1	0.2	76.9	0.3	17.7	0.1
Eurasian Wigeon	4.7	0.1	25.0	0.8	45.5	1.4	9.9	0.3
Northern Pintail*	4.6	0.1	22.1	0.3	42.1	0.6	9.7	0.1
Tufted Duck ($)**	4.7	0.0	32.6	0.3	54.5	0.6	9.7	0.1
Common Eider	8.5	0.1	59.5	0.7	96.1	1.1	17.7	0.2
Long-tailed Duck ($)	4.5	0.0	31.2	0.3	52.4	0.5	9.3	0.1
Common Scoter	6.1	0.0	44.8	0.3	74.5	0.5	12.8	0.1
Common Goldeneye**	4.6	0.1	29.6	0.4	50.6	0.7	9.6	0.1
Red-breasted Merganser	6.7	0.1	31.2	0.5	68.5	1.1	13.9	0.2

($) Calculation of the entire energy expenditure using 50% fat load
* Modified physiological data from male Mallard used
** Modified physiological data from Long-tailed Duck used.

There is limited information available from baseline visual observations and telemetry studies available on local movements of non-breeding waterbirds in the area (FEBI 2013). Results of telemetry studies of Common Eider and Long-tailed Duck in the Fehmarnbelt show generally low flight activity of these species and give no indication for regular flight activities between different resting and foraging grounds on different sides of the alignment (FEBI 2013). Occasional crossings of the alignment area are anticipated, but it is not expected that sensitive species regularly commute between different areas on both sides of the alignment.

For wintering waterbirds the additional costs of crossing the barrier are assessed in relation to the daily energy expenditure (DEE). Daily energy budget of the Common Eider was calculated within the FEBI baseline investigations (FEBI 2013). Relating the maximum estimate of additional flight costs calculated for migrating Common Eiders in Table 10.12 (scenario 3) to the daily energy expenditures calculated based on winter data 2009/2010 (1,670-1,870 kJ), flight costs of 10 min circling plus gaining height to cross the bridge (one time) would result in additional expenses corresponding to 5.1-5.8% of the daily energy expenditure (DEE). Scenario 2 applied for migrating birds is assumed to be unlikely for resting birds since wintering eiders and other waterbird species are not expected to detour a barrier by flying over land. The other two scenarios would correspond to 0.5% (scenario 1) or 0.9-1.1% (scenario 4) of DEE, respectively. However, the body weight for Common Eider as measured during FEBI baseline investigations (2,290 g; FEBI 2013) is considerably higher than the value used for the calculations above. For the Common Eider energy budget (FEBI 2013) flight costs of 98 W kg^{-1} were assumed. According to this, flying for 10 minutes, as assumed for the scenario 3, would result in extra energy expenditures of 127.8 kJ, corresponding to 6.8-7.7% of the calculated daily energy expenditure of Common Eiders in Fehmarnbelt. Therefore, values calculated for the Common Eider in Table 10.12 likely underestimate actual costs of Common Eiders wintering in Fehmarnbelt.

For non-breeding waterbirds wintering in the Fehmarnbelt area the worst case scenario (scenario 3) of 10 min circling is assumed to be a very conservative estimate since it is unlikely that local birds would react in this way to a persistent barrier like a bridge. It is more likely that birds would either cross the barrier directly or decide not to cross it at all. Therefore, it is assumed that extra energy expenditures for crossing the barrier bridge would usually result in additional costs corresponding to less than 5% of the daily energy expenditure of wintering Common Eiders. Since the wing load of Common Eiders is one of the highest of birds that are capable to fly (Guillemette 1994), the calculations of extra energy expenditures are considered representative and surely conservative for other waterbird species for which no detailed information is available. Therefore, the degree of impairment of non-breeding waterbirds to a barrier effect is assessed to correspond to the sensitivity level presented in chapter 7.3.2.

Severity of impairment

Breeding waterbirds

In the following the severity of impairment from the pressure ‘barrier from bridge structure’ is described for breeding waterbird species, which were identified as being potentially relevant for the EIA during the sensitivity screening (see chapter 7.3.1).

Red-necked Grebe

The nature reserve Grüner Brink is the closest breeding site of Red-necked Grebes within SPAs near to the zone of a proposed bridge. Birds are known to regularly commute between their inland breeding sites and marine foraging habitats. Since the potential barrier is within 3 km distance from Grüner Brink the severity of impairment from a barrier of a bridge structure is assessed to be minor for Red-necked Grebes breeding in the SPAs. Red-necked Grebes breeding outside Natura 2000 areas close to the bridge on Lolland could perceive the bridge as a barrier. However, the height of the bridge close to the land is rather low. Also habituation of local birds to the structure is expected. The Impact Assessment on waterbirds breeding outside Natura 2000 areas is part of the assessment on land areas of Lolland and Fehmarn.

Red-breasted Merganser

The nature reserve Grüner Brink on Fehmarn is the closest reported breeding site of Red-breasted Mergansers to the alignment. Birds breeding in Rødsand Lagoon are not expected to be affected by the pressure. Red-breasted Mergansers use shallow marine areas to rear their offspring, such as e.g. the coastal waters directly adjacent to Grüner Brink. Therefore impairment from a barrier effect for these birds is very unlikely, thus the severity of impairment is assessed to be minor for the Red-breasted Merganser.

Other species
Other breeding waterbird species were assessed to be minor sensitive to the pressure 'barrier from bridge structure' or the area affected is assessed to be of minor importance to the species, thus the severity of impairment is assessed to be minor to these species.

Overall assessment of the severity of impairment
The overall assessment of the severity of impairment from barrier from a bridge structure during operation is assessed to be minor for all waterbirds breeding in the SPAs. The Impact Assessment on birds breeding outside Natura 2000 areas is part of the assessment on land areas of Lolland and Fehmarn.

Non-breeding waterbirds
In the following the severity of impairment from the pressure 'barrier from bridge structure' is assessed for non-breeding waterbird species, which were identified to be potentially relevant for the EIA during the sensitivity screening (see chapter 7.3.2).

Divers (Red-throated / Black-throated Diver)
Divers wintering in the Fehmarnbelt area are assumed to show little flight activity as no intensive and regular movements were recorded by FEBI surveys and visual observation, thus regular commuting between different resting or foraging habitats is considered unlikely. However, if birds stay on either side of the alignment the effect of the barrier would be a potential constraint on resource utilisation. Due to the species' high sensitivity to disturbances in general a high degree of impairment to a barrier effect from the bridge structure is assessed.

Based on the very high importance of the area to divers and high degree of impairment from this pressure, the severity of impairment is assessed to be high for the diver species.

Red-necked Grebe
Grebes wintering in the Fehmarnbelt area are assumed to show little flight activity, thus regular commuting between different resting or foraging habitats is unlikely. However, if birds stay on either side of the alignment the barrier would result in a potential constraint on resource utilisation.

Based on the very high importance level and medium degree of impairment, the severity of impairment is assessed to be medium for the Red-necked Grebe.

Eurasian Wigeon
Eurasian Wigeon have roosting sites separate from feeding sites (Berndt et al. 2005) and are also known to be nocturnally active. The locations of such sites are variable throughout the season (Berndt et al. 2005) and it is assumed that flight paths between those may occasionally cross the alignment. It has been registered that wintering Eurasian Wigeon occasionally fly below bridges, as observed at the Fehmarnsund in one case. If birds stay on either side of the alignment the barrier effect would result in a potential constraint for resource utilisation.

Based on the very high importance of the area to the species and medium degree of impairment, the severity of impairment is assessed to be medium for the Eurasian Wigeon.

Common Pochard, Tufted Duck, Greater Scaup

The diving duck species Common Pochard, Tufted Duck and Greater Scaup use different habitats for daytime roost and night-time foraging. It is assumed that while commuting between resting and foraging areas the alignment would be crossed occasionally. Birds may occasionally, but not regularly fly below a bridge or above with no or little hesitation, which has been observed for the Tufted Duck during the FEBI bridge effect studies (see chapter 4.6.2). If birds stay on either side of the alignment the barrier effect would result in a potential constraint for resource utilisation.

Based on the very high importance and medium degree of impairment for all three species, the severity of impairment is assessed to be medium for Common Pochard, Tufted Duck and Greater Scaup.

Common Eider

Common Eider is an abundant seaduck species wintering in the Fehmarnbelt and it also uses areas close to the planned fixed link. Results from effect studies at the Baltic Sea bridges show that wintering Common Eiders may occasionally fly under bridges and also occur close to bridges (see chapter 4.6.2). If birds stay on either side of the alignment the barrier effect would result in a potential constraint on resource utilisation. Based on the species' sensitivity and assessment of the extra energetic costs for crossing a bridge the degree of impairment is assessed to be medium for wintering Common Eiders.

Based on the very high importance and medium degree of impairment, the severity of impairment is assessed to be medium for the Common Eider.

Long-tailed Duck

No data from effect studies at the Baltic Sea bridges are available for this species (see chapter 4.6.2). Based on the assessed sensitivity of this species towards disturbances a medium degree of impairment from this pressure was assumed. If birds stay on either side of the alignment the barrier effect would result in a potential constraint on resource utilisation. However, the high-density areas of Long-tailed Duck within the study area are located further away from the alignment and telemetry studies did not indicate that birds are commuting between distinct wintering grounds (FEBI 2013), thus it is unlikely that high numbers of Long-tailed Ducks would regularly cross the alignment.

Based on the very high importance of the Fehmarnbelt area to the species and medium degree of impairment the severity of impairment is assessed being medium for the Long-tailed Duck.

Common Scoter, Velvet Scoter

Scoters are abundant seaducks wintering in the Fehmarnbelt area. During the effect studies at the Baltic Sea bridges only a few individuals of Common Scoter were registered, but none of them was categorised as local wintering bird (see chapter 4.6.2). Scoters are more sensitive towards disturbances from e.g. boats than other waterbird species (Schwemmer et al. 2011) and are described to avoid crossing bridges (Hicklin and Bunker-Popma 2001, Bunker-Popma 2006, MacKinnon and Kennedy 2006, Nilsson et al. 2009, 2010). It cannot be excluded that the disturbance effect from the bridge would either result in significant energy expenditures while trying to cross the barrier or birds would be impaired by not crossing the bridge. If birds stay on either side of the alignment, the barrier effect would result in a potential constraint on resource utilisation. Consequently, the sensitivity and degree of impairment towards a barrier effect is assessed to be high for the two scoter species.

Based on importance levels (Common Scoter: very high, Velvet Scoter: high) and high degree of impairment, the severity of impairment is assessed to be high for the Common Scoter and the Velvet Scoter.

Common Goldeneye
Common Goldeneye may use different areas for resting and foraging (Berndt et al. 2005), thus commuting flights between these areas are expected to occur and these flights might possibly also cross the alignment. It is assumed, that Common Goldeneye, similar to other diving ducks, occasionally cross under bridges or cross above without hesitation and apparent reaction, but no direct results on the species exist (see chapter 4.6.2). If birds stay on either side of the alignment the barrier effect would result in a potential constraint on resource utilisation.

Based on the medium importance of the Fehmarnbelt area to the species and medium degree of impairment, the severity of impairment is assessed to be medium for the Common Goldeneye.

Red-breasted Merganser
Red-breasted Mergansers wintering in the Fehmarnbelt area are assumed to show little flight activity, thus regular commuting between different resting or foraging habitats is unlikely. However, due to the species' medium sensitivity to disturbances a medium degree of impairment to a barrier effect from the bridge structure is assessed. If birds stay on either side of the alignment the barrier effect would result in a potential constraint on resource utilisation.

Based on the very high importance of the area to the species and medium degree of impairment from this pressure the severity of impairment is assessed to be medium for the Red-breasted Merganser.

Common Guillemot
Due to lack of information about reactions of migrating auks to bridges, and because other studies suggest that barrier effect from a bridge could result in a complete barrier to auks (Nilsson et al. 2009, 2010), an impact on local auk populations due this effect cannot be excluded. Therefore, the degree of impairment is assessed to be very high to auk species. However, numbers of Common Guillemot using the Fehmarnbelt are low, thus no detrimental effect is expected to result from a barrier effect to this species wintering in the area.

Therefore, the severity of impairment is assessed to be minor for non-breeding Common Guillemots.

Razorbill
Based on the same reasons given for the Common Guillemot above, the degree of impairment is assessed to be very high for the Razorbill. The offshore areas of the Fehmarnbelt are assessed to be of medium importance to the species (FEBI 2013); therefore, the severity of impairment is assessed to be medium to the Razorbill.

Black Guillemot
Based on the same reasons given for the Common Guillemot above, the degree of impairment is assessed to be very high for the Black Guillemot. The offshore areas of Fehmarnbelt are assessed to be of high importance to the species (FEBI 2013); therefore, the severity of impairment is assessed to be high to the Black Guillemot.

Other species
Other non-breeding waterbird species are assessed to be minor sensitive to the pressure 'barrier from bridge structure', or the importance level is assessed to be

minor; thus, the severity of impairment is assessed to be minor or negligible to these species.

Overall assessment of the severity of impairment

The overall assessment of the severity of impairment from barrier of the bridge structure on non-breeding waterbirds results in a high severity of impairment for divers, scoters and the Black Guillemot. For ten non-breeding waterbird species the severity of impairment is assessed to be medium (Table 10.13). For all other non-breeding waterbird species the severity of impairment is assessed to be either minor or negligible, resulting in no relevant barrier effect to these species.

Table 10.13 Assessment of the severity of impairment, regarding non-breeding waterbirds and the pressure 'barrier from bridge structure' during operation of a bridge in the Fehmarnbelt. The table includes all bird species, for which this pressure has been assessed to be relevant following Table 7.9.

Species	Importance level	Sensitivity / degree of impairment	Severity of impairment
Divers	Very High	High	High
Red-necked Grebe	Very High	Medium	Medium
Eurasian Wigeon	Very High	Medium	Medium
Common Pochard	Very High	Medium	Medium
Tufted Duck	Very High	Medium	Medium
Greater Scaup	Very High	Medium	Medium
Common Eider	Very High	Medium	Medium
Long-tailed Duck	Very High	Medium	Medium
Common Scoter	Very High	High	High
Velvet Scoter	High	High	High
Common Goldeneye	Medium	Medium	Medium
Red-breasted Merganser	Very High	Medium	Medium
Common Guillemot	Minor	Very high	Minor
Razorbill	Medium	Very high	Medium
Black Guillemot	High	Very high	High
Other species			Minor / Negligible

Migrating birds

The severity of impairment is assessed based on the degree of impairment (in this case equalling the species' sensitivity) and the species' importance level according to the scheme displayed in Table 4.10 (Methods chapter 4.5.14). The Impact Assessment on species' level was conducted on bird species which were assessed being relevant with regard to barrier effect in the sensitivity screening (chapter 7.2.9). For species not listed in the summary table (Table 10.14) or treated in separate species accounts the severity of impairment is assessed to be either minor or negligible.

Divers (Red-throated/Black-throated Diver)

According to results from the effect studies at Baltic Sea bridges (see chapter 4.6.2) it is expected, that some 10-20% of birds migrating through the Fehmarnbelt would not cross the bridge directly, but would detour the barrier. According to the energy expenditure calculations for these species, a detour of 18 km would represent about 1.2% of the total migration cost (assuming migration distance of 1,500 km; Table 10.12). As the majority of the birds are registered in spring, their migration destination would lie NE of the Fehmarnbelt (Bønløkke et al. 2006, FEBI 2013).

The majority of the migrating birds would pass the bridge by increasing their altitude to 100-300 m or even more, as it is reported that divers increase their flight altitudes beyond a climb necessary to cross a bridge. According to the energy expenditure calculations for these species, a climb of 120 m or 250 m would represent an additional 0.1% or 0.2% of their total migration cost.

Therefore, the degree of impairment and thus the severity of impairment are assessed to be medium for the diver species.

Grebes

It is expected that Red-necked Grebes would pass the bridge showing medium reactions by e.g. increasing flight altitude. Red-necked Grebes migrating through the Fehmarnbelt region may breed close to the study area (there are breeding pairs on Fehmarn and Lolland) or further away. The relative increase in migration cost could be higher for those birds breeding within short distance. However, additional costs due to the barrier effect are still considered to be small and thus the degree of impairment is assessed as medium for the different grebe species.

Accounting for the species' importance level, the severity of impairment is assessed to be medium for the Red-necked Grebe and the Slavonian Grebe. Due to the minor importance level of the Great Crested Grebe, the severity of impairment is assessed as minor for this species.

Swans

The Mute Swan occurs in the Fehmarnbelt region as resting, moulting and migrating bird, and the species was recorded to conduct long-distance movements through the area of the planned fixed link. These birds mainly originate from NE Germany, Poland, the Baltic countries, Sweden and sometimes Norway (Bønløkke et al. 2006, FEBI 2013). Baseline investigations revealed medium important numbers of Mute Swans migrating through the Fehmarnbelt (FEBI 2013). It is assumed that Mute Swans would cross a bridge including additional energy expenditure of up to 2.6% of the total migration costs (Table 10.12). Based on this information and species sensitivity the degree of impairment is assessed to be medium. Accounting for the species' importance level the severity of impairment is assessed as medium for the Mute Swan.

Bewick's Swans may migrate during night at heights above 200 m, larger flocks even above 800 m (A. Degen, pers. comm., Koop 2002). A barrier effect is thus expected mainly for the proportion of daytime migrating birds. Daily maximum records of daytime migration at Fehmarn, but at locations other than the link, are 210 individuals in 1971 and 122 in 1996 (Berndt et al. 2005), and registered numbers have been lower during the last decade (FEBI 2013). It is assumed that Bewick's Swans would pass the bridge by increasing flight altitude. Based on calculations for the Whooper Swan (see below), the energy cost for this climb would range between 0.1% and 1.0% of their total migration cost (assuming 2,000 km migration distance). Based on this information and species sensitivity, the degree of impairment is assessed to be medium for this species. Accounting for the species' importance level, the severity of impairment is assessed as medium for the Bewick's Swan.

The Whooper Swan is expected to exhibit similar flight behaviour as the Bewick's Swan, migrating in differing altitudes during day and night (A. Degen, pers. comm.). It is assumed that Whooper Swans would pass a barrier by increasing their flight altitude and the extra energy for this climb was estimated to range between

0.1% and 1% of their total migration cost (assuming 2,000 km migration distance). Based on this information and species sensitivity, the degree of impairment is assessed to be medium for this species. Accounting for the species' importance level, the severity of impairment is assessed as medium for the Whooper Swan.

Geese

Geese migrate at medium to high altitudes (e.g. Koop 2002) and would only perceive a bridge as a barrier if their migration path directly crosses the bridge. Most goose species migrate both during day- and night-time.

Bean, Barnacle and Brent Geese mainly follow a predestined migration route with some orientation along coast lines or other topographic features. For individuals flying over water at low altitude, an expected reaction to a bridge would be crossing over land or increasing flight altitude. Circling in front of the bridge has not been observed. Crossing by detouring or increasing their flight altitude was calculated to add 0.0–0.3% of the total migration costs (Table 10.12).

Based on this information and species sensitivity, the degree of impairment is assessed to be medium for these goose species. Accounting for the species' importance level, the severity of impairment is assessed as medium for Bean, Barnacle and Brent Goose.

Dabbling ducks

For the dabbling ducks, differences between the species regarding flight and migration behaviour (altitude, direction) as well as reaction to barriers are considered to be small, or not known due to a lack of specific data (Koop 2002). The species considered relevant for the severity of impairment assessment, Eurasian Wigeon, Gadwall, Northern Pintail and Northern Shoveler migrate during both day- and night-time (Koop 2002, King et al. 2009). Autumn migration in the region may take place over water using coastline as a leading line, while spring migration frequently occurs broad front at higher altitudes (Koop 2002). Consequently, higher numbers of migrating dabbling ducks are registered in the Fehmarnbelt during autumn. The island of Fehmarn is a stop-over and resting site for a number of dabbling duck species (Berndt et al. 2005). While it cannot be excluded that some of the birds registered as migrating during the baseline studies might have been locally staging birds, the island of Fehmarn and most likely staging sites on Lolland host high numbers of these species and thus the area represents an end or starting point for migration. However, other individuals would pass Fehmarn on their way to resting sites farther away (Koop 2002). Due to their general migration behaviour, a bridge might not pose a substantial barrier to dabbling ducks, since migrating individuals may readily veer off over land to their resting places or increase altitude to continue in migration direction. Thus, the degree of impairment is assessed as medium to these species.

According to species' importance level and assessed degree of impairment, the severity of impairment is assessed to be medium for Eurasian Wigeon, Gadwall, Northern Pintail and Northern Shoveler.

Greater Scaup

Among diving ducks, differences between the species regarding flight behaviour (altitude, direction) as well as reaction to barriers are considered to be small, or not known due to a lack of specific data. However, of these only the Greater Scaup is considered relevant according to the sensitivity screening due to the highly important numbers passing the area of the link (FEBI 2013). The waters around Fehmarn represent one of the important stop-over and resting places for this species (Berndt et al. 2005). Similar to the assessment of dabbling ducks (see above) it is assumed that the Fehmarnbelt region serves both as wintering area (i.e. starting/ending point of migration) and stop-over site on migration to wintering areas further away. Taking this and the assessed species sensitivity into account, the degree of impairment is assessed to be medium for diving ducks.

Based on the assessed degree of impairment and the importance level of the species, the severity of impairment from barrier effect of a bridge in the Fehmarnbelt is assessed to be medium for the Greater Scaup.

Common Eider

During spring migration, Eiders flying close to the Lolland coast may cross over Lolland once they encounter a bridge in the Fehmarnbelt, and it can be assumed that they either return to their path over the Baltic Sea east of Hyllekrog or at the eastern coast of Falster. During autumn migration Common Eiders flying near the Fehmarn coast would most likely circumvent the bridge over the northwest part of Fehmarn. Extra energy expenditures calculated for the different scenarios predict not to exceed 1.1% of the total estimated migration costs (Table 10.12). It must be noted, that the body weight of Common Eider, 1.66 kg, taken from the Wings database from the FLIGHT software (see chapter 0) is lower than body weights of Common Eiders in the Fehmarnbelt (FEBI 2013). However, it is assumed that using higher body weights for the calculations would not result in considerably different relative costs of circumventing a bridge (see also Masden et al. 2009). The calculated extra energy expenditures would not include changes of overall migration routes. However, alternative routes described above would rather shorten the overall migration distance, as is it was suggested e.g. for the Öresund Bridge (Nilsson et al. 2010). Due to the sensitivity assessment of Common Eiders, the degree of impairment is assessed being high for this species.

According to species' importance level and assessed degree of impairment, the severity of impairment is assessed to be high for the Common Eider migrating through the Fehmarnbelt.

Long-tailed Duck

Long-tailed Ducks were observed in relatively low numbers migrating through the Fehmarnbelt and therefore the area is assessed to be of minor importance to migrating Long-tailed Ducks (FEBI 2013). Based on the assessment of the Common Eider, Long-tailed Duck is also assessed to be highly sensitive to the barrier effect of a bridge resulting in a high degree of impairment to the species. However, the Fehmarnbelt is assessed to be of minor importance to migrating Long-tailed Ducks and there is no additional population effect expected to occur from deterring individuals not crossing a bridge in the Fehmarnbelt (most individuals are assumed to cross a bridge eventually).

Thus, the severity of impairment is assessed as minor for the Long-tailed Duck.

Common Scoter

For the Common Scoter, own results of behavioural reactions are comparable to those observed for the Common Eider. Extra energy expenditures calculated to result from different reaction scenarios to the barrier of a bridge are assessed to be relatively low with the most costly scenario resulting in additional costs corresponding to 0.5% of total estimated migration costs (Table 10.12). Due to uncertainties in predictions of how scoters would actually react to a bridge in the Fehmarnbelt and the sensitivity assessment of the Common Scoter, the degree of impairment is assessed as high for this species.

Based on the high barrier effect which cannot be excluded for this species and the very high importance of the Fehmarnbelt to Common Scoter migration, the severity of impairment is assessed to be high for the species.

Velvet Scoter
Velvet Scoters were observed in relatively low numbers migrating through Fehmarnbelt and therefore the area is assessed to be of minor importance to migrating Velvet Scoters (FEBI 2013). Based on the sensitivity assessment of the Common Scoter, Velvet Scoter is also assessed to be highly sensitive to the barrier effect of a bridge resulting in a high degree of impairment to the species. However, the Fehmarnbelt is assessed to be of minor importance to migrating Velvet Scoters and there is no additional population effect anticipated from deterring individuals not crossing a bridge in the Fehmarnbelt (most individuals are assumed to cross a bridge eventually).

Thus, the severity of impairment is assessed as minor for the Velvet Scoter.

Red-breasted Merganser
It is expected that Red-breasted Mergansers would pass the bridge showing medium reactions by e.g. increasing the flight altitude. Red-breasted Mergansers migrating through the Fehmarnbelt region may breed close to the study area or further away. The relative increase in migration cost could be higher for those birds breeding within short distance. However, overall additional energetic costs due to the barrier effect are still considered to be small. Taking this and the assessed species sensitivity into account, the degree of impairment is assessed to be medium for the Red-breasted Merganser.

Therefore, the severity of impairment is assessed also to be medium for the Red-breasted Merganser.

Auks
The Fehmarnbelt area was assessed to be of minor importance to migrating Common Guillemot, Razorbill and Black Guillemot due to the low numbers of birds recorded during visual observations (FEBI 2013). However, the sensitivity towards a barrier effect from a bridge and therefore the degree of impairment is assessed to be very high for these species, thus these birds were assessed to be relevant to be included in this chapter.

A complete barrier from a bridge to auks would result in an exclusion of these species from a large wintering area beyond the bridge. Since it cannot be excluded that this could have an effect on a larger proportion of the populations than actually observed during the baseline observations, the severity of impairment assessed to be very high for the auk species Common Guillemot, Razorbill and Black Guillemot (see also chapter 7.1).

Other species
Other migrating bird species are either assessed to be minor sensitive to the pressure ‘barrier from bridge structure’, or the importance is assessed to be minor. Thus the severity of impairment is assessed to be minor or negligible to these species.

Overall assessment of the severity of impairment
Regarding the barrier effect of a bridge in the Fehmarnbelt it is assessed that the pressure would result in a very high severity of impairment to the three migrating auk species Common Guillemot, Razorbill and Black Guillemot. A high severity of impairment is assessed for migrating Common Eiders and Common Scoters, and in total 16 species are assessed to be affected by medium severity of impairment from a barrier effect of a bridge (see Table 10.14). For all other species the severity of impairment is assessed to be either minor or negligible, resulting in no relevant barrier effect.

Table 10.14 Assessment of the severity of impairment, regarding migrating birds and the pressure "barrier from bridge structure" during operation of a bridge in the Fehmarnbelt. The table includes all bird species, for which this pressure has been assessed to be relevant following Table 7.1 and Table 7.8.

Species	Importance level	Sensitivity / degree of impairment	Severity of impairment
Red-throated Diver	High	Medium	Medium
Black-throated Diver	High	Medium	Medium
Red-necked Grebe	Medium	Medium	Medium
Slavonian Grebe	High	Medium	Medium
Mute Swan	Medium	Medium	Medium
Bewick's Swan	High	Medium	Medium
Whooper Swan	High	Medium	Medium
Bean Goose	Medium	Medium	Medium
Barnacle Goose	Very high	Medium	Medium
Brent Goose	Very high	Medium	Medium
Eurasian Wigeon	Medium	Medium	Medium
Gadwall	High	Medium	Medium
Northern Pintail	Very high	Medium	Medium
Northern Shoveler	Very high	Medium	Medium
Greater Scaup	High	Medium	Medium
Common Eider	Very high	High	High
Long-tailed Duck	Minor	High	Minor
Common Scoter	Very high	High	High
Velvet Scoter	Minor	High	Minor
Red-breasted Merganser	Very high	Medium	Medium
Common Guillemot	Minor	Very high	Very high
Razorbill	Minor	Very high	Very high
Black Guillemot	Minor	Very high	Very high
Other species			Minor/Negligible

Duration of impact
The duration of the pressure 'barrier from bridge structure' would be permanent, thus the impact on birds is predicted to be permanent as well. Habituation might reduce the impact on some local breeding or resting waterbird species over the years, but no habituation is predicted for migrating birds. The pressure would persist for all sensitive species permanently.

10.3.7 Collision with bridge structures

Description of the pressure
A general overview description of the bridge and its structures are given in chapter 10.1. The bridge would represent a structure across the Fehmarnbelt reaching from above the water level into the airspace. As such, it would present a risk of collision for flying birds, both migrating and those conducting short distance movements.

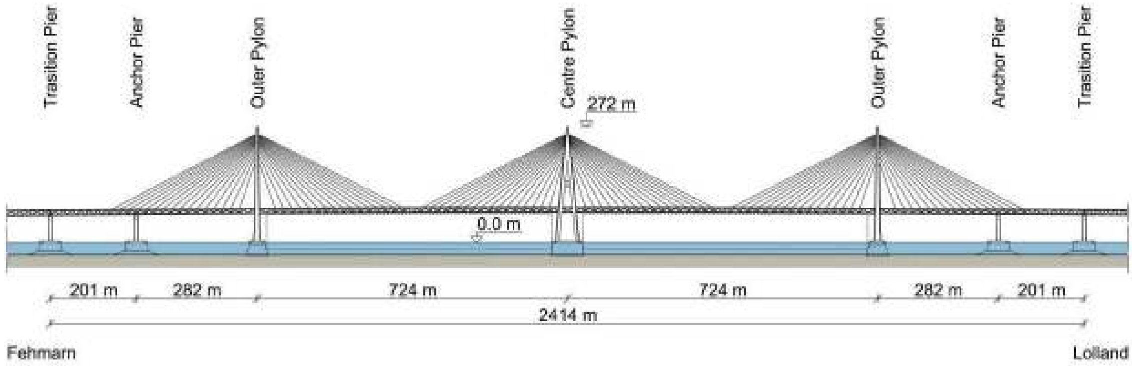


Figure 10.49 Main bridge – drawing and dimensions.

The bridge would cover a total length of about 18 km between the two abutments. Starting from Fehmarn and here from the abutment (bridge segment on peninsula), the southern approach bridge would be 5,748 m in length, including 28 piers and thus 29 spans of 201 m each. The main bridge including two transition piers, two anchor piers and three pylons, stretches 2,414 m with spans of 724 m between the three tall pylons (Figure 10.49). The northern approach bridge towards Lolland would be 9,412 m, including 46 piers and 47 spans of 201 m each and would arrive at the abutment (bridge segment on peninsular) on the Lolland side. At each landing / end would be a reclaimed peninsula ranging to marine areas of 5-6 m water depth. The approach bridges would continuously rise towards the centre main bridge.

The structure of the entire bridge would be a double-deck with the four-lane road on the upper level and a two-track railway on the lower level. Considering a cross-section (Figure 10.50), the upper width would be 24.1 m, the lower width 12.2 m. The height of the structure itself would be 12.9 m. The wind screens at both sides of the road would consist of perforated metallic plates with an expected perforation percentage of approximately 50% and would reach to 2.50 m above road level, thus adding to the height of the cross-section.

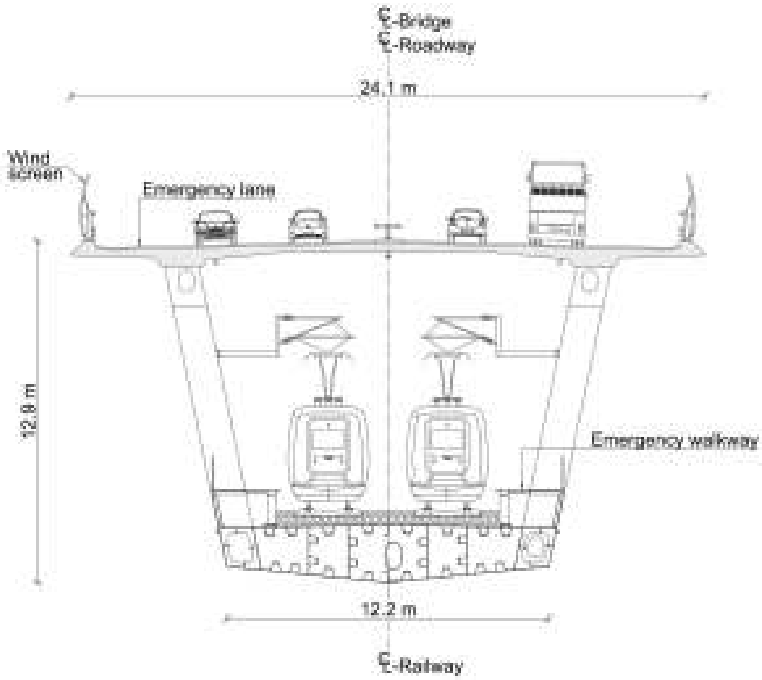


Figure 10.50 Cross-section of the bridge including horizontal and vertical measurements (Consolidated Technical Report Draft 3.3.docx).

For the pressure 'collision with bridge structures', important technical features of the planned cable stayed bridge are:

1. Height of the bridge girders.

   Measured from the underside of the bridge girder to the upper rim of the wind screens: 15.4 m. (Figure 10.50).

2. Height of the bridge structure on ramp, peninsula and abutment.

   Fehmarn: starting at the coastline, a peninsula of 580 m length would be built with a gallery structure bridge on top. The bridge structure dimensions would be comparable to the bridge girder dimensions; thus, from bottom to the upper road level it would be about 15.9 m. The ramp itself would rise from mainland level to some 12 m at the position of the abutment. Here the upper rim of the wind screens would be already 27.40 m high.

   Lolland: as on Fehmarn, bridge structure would be built on a 450 m long peninsula. The ramp would rise to 8 m at the abutment, corresponding to an overall height including wind screens of 23.4 m.

Figure 10.51 Bridge on peninsula leaving Fehmarn: visualisation.

Figure 10.52 Bridge on peninsula leaving Lolland: visualisation.

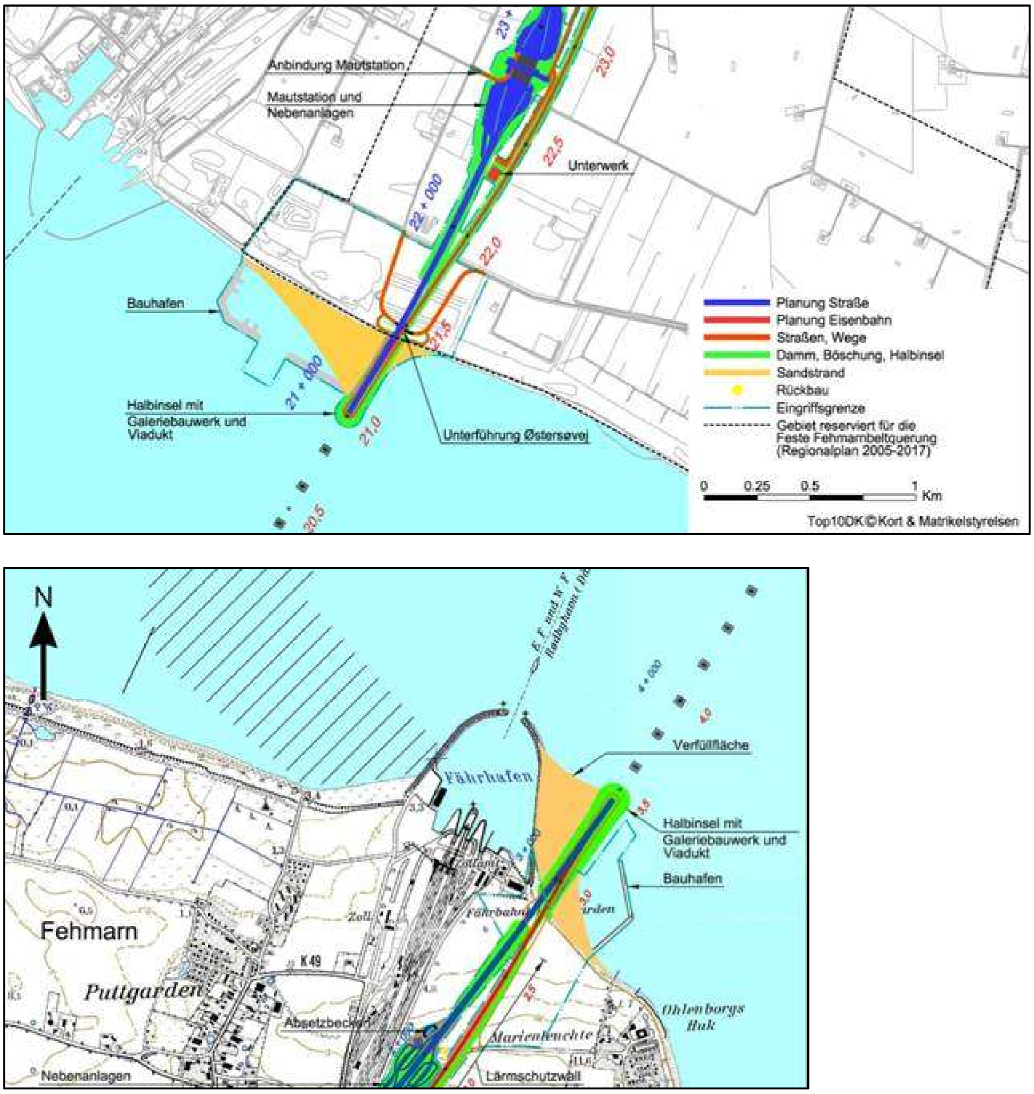


Figure 10.53 Peninsulas on Fehmarn (bottom) and Lolland (top): drawings.

3. Measurements of the approach bridges.

   Starting from the Fehmarn abutment (bridge segment on peninsula), the southern approach bridge would be 5,748 km long, including 28 piers and 29 spans of 180 to 201 m each. The clearing of the bridge leaving the peninsula at Fehmarn would be 12 m, with an overall height of the structure of 27.4 m; up to the main bridge (see below) the clearing height would rise to 62.1 m, with the upper rim of the wind screens at 80.5 m.

   Starting from the Lolland abutment, the northern approach bridge would be 9,412 km in length, including 46 piers and 47 spans of 200 to 201 m each. The clearing of the bridge leaving the peninsula at Lolland would be 8 m, while the overall height would be 23.4 m; up to the main bridge (see below) the clearing height would rise to 63.4 m, with the upper rim of the wind screens at 81.8 m.

4. Measurements of the main bridge (Figure 10.1 and Figure 10.49).

   The main part of the bridge in the centre of the Fehmarnbelt would start at each end with a transition pier, followed after 201 m by an anchor pier, which both are planned to have a 282 m distance to the centre pylons. Spacing between the three centre pylons would be 724 m. The clearance below the main span would be at least 66.2 m, but rising in the middle up to 68.8 m, with the road levels plus wind screens from the southern anchor pier of 79.8 m, the centre pylon at 84.7 m and the northern anchor pier at 80.5 m.

The three pylons would be 272 m high, and would be held by 16 cables on each side; the lowest cable would attach at a height of 187 m (some 80 m above road level) to the pylons, while the highest cable would attach at 252 m.

5. 2-dimensional area covered by the bridge structures (viewed from a perspective perpendicular to the bridge alignment).

   The side-projection of the area of the bridge including the girder, the piers and pylons as well as the triangular areas where the cables run would be:
   1,159,919 m²;
   Of this area solid structures comprise 317,132 m², corresponding to 27.3% of the projection (the remaining is the open areas between the solid structures).

6. Construction details:
   - the cables of the main bridge would have a diameter between 210 and 285 mm and would be steel-coloured or grey;
   - the colour of the piers, the pylons and the road deck would be grey concrete; the steel structures would be white or grey;
   - the wind screens would be 2.50 m high, running the full length of the bridge and would be perforated metallic plates with an expected perforation percentage of approximately 50% to enable the motorists to view through the screens when driving on the bridge;

7. Lighting of the bridge and architectural lighting.

   Illumination would indirectly illuminate the structures of the bridge with white coloured floodlighting with average luminance of 5-10 cd/m². These lights would be designed to only mark the respective areas and not radiate beyond. It is planned to decrease light intensity during times of inclement weather in order to decrease collision risk for birds.

   The obstruction lighting would follow the rules of the IALA (International Association of Marine Aids to Navigation and Lighthouse Authorities) and ICAO (International Civil Aviation Organization). Navigational lighting would include red and green light at the underpasses under the main bridge. According to rules stated in the ICAO regulations annex 14, white flashing lights would be positioned at the top of the pylons and at two lower levels dividing the full height of the pylons into three sections of the same height. These lights have to be visible from all sides. The light intensity is 200,000 cd at daytime, 20,000 cd at twilight and 2,000 cd at night. The flashing is 40 flashes per minute. There would be no street lights on the bridge.

Degree of impairment
For assessing the degree of impairment, in a first step the results of the different collision rate calculations were taken into account. Based on bird migration data of FEBI baseline investigations and the effect studies at the Baltic Sea bridges, plus applying a number of assumptions, the collision rates of day- and night-time migrating birds were calculated (see methods chapter 4.6.4). Additionally, possible collision rates were calculated based on collision data from the Öresund Bridge (see methods chapter 4.6.4). In a second step, the species sensitivity levels were considered in the assessment of the degree of impairment.

Potential collision rates of selected daytime migrating bird

Results from the effect studies at the Baltic Sea bridges have been used to calculate potential collision rates for selected species of daytime migrating waterbirds. Birds are regarded as potentially colliding with bridge structures if they approach a bridge structure closer than 10 m. It must be noted that relevant studies to assess collision risks were carried out during favourable weather conditions and that during those studies no collisions have been observed. Three scenarios for calculating the potential daytime collision rates were applied for 14 waterbird species resulting in potential annual collision numbers, also giving the 95% confidence intervals of these estimates (Table 10.15). For details and calculation methods see chapter 4.6.4. It must be noted that calculated collision rates must be considered with caution, as true collision rates are not known.

Table 10.15 Number of estimated daytime collisions at the proposed Fehmarnbelt Bridge for 14 waterbird species. Data indicate the bridges from which the data on each species were collected. N_{flock} is total number of flocks included, $N_{flock10m}$ is number of flocks recorded closer than 10 m from the bridge, $N_{Annual\ max}$ is the seasonal maximum number of birds counted during FEBI baseline investigations of birds passing through Fehmarnbelt during either migration season. Collision numbers are estimated using 0.01% ($N_{0.01\%,\ year}$) and 1% ($N_{1\%,\ year}$) strike rates for birds moving closer than 10 m of a bridge during migration as registered during the effect studies. N_{Obs} gives number of collisions recorded during bridge effects studies. Binominal 95% confidence intervals of the estimates are presented based on individual species for scenario 1 and 2 and based on species groups for scenario 3 (see chapter 4.6.4 for further details).

					Scenario 1	Scenario 2	Scenario 3
Species	**Data**	**N_{flock}**	**$N_{flock\ 10m}$**	**$N_{Annual\ max}$**	**$N_{0.01\%,year}$ [95%CI]**	**$N_{1\%,year}$ [95%CI]**	**N_{obs} [95%CI]**
Divers	Kalmarsund, Öresund, Mon	43	0	3,588	0.0 [0 ; 0.02]	0 [0 ; 2]	0 [0 ; 1]
Great Cormorant	All bridges	63	3	26,454	0.1 [0 ; 0.4]	13 [3 ; 35]	0 [0 ; 8]
Greylag Goose	Great Belt	11	1	15,734	0.1 [0 ; 0.5]	11 [0 ; 50]	0 [0 ; 4]
Barnacle Goose	Öresund, Kalmarsund, Great Belt	138	3	81,918	0.1 [0.02 ; 0.3]	11 [2 ; 32]	0 [0 ; 25]
Brent Goose	Storstrøm	13	1	41,947	0.6 [0.1 ; 3]	65 [2 ; 302]	0 [0 ; 15]
Eurasian Wigeon	Kalmarsund	21	0	13,650	0.0 [0 ; 0.2]	0 [0 ; 22]	0 [0 ; 0]
Northern Pintail	Kalmarsund, Storstrøm	11	0	1,058	0.0 [0 ; 0.02]	0 [0 ; 2]	0 [0 ; 1]
Tufted Duck	Fehmarnsund, Farø, Kalmarsund	102	0	404	0.0 [0 ; 0.002]	0 [0 ; 0.3]	0 [0 ; 0]
Common Eider	All bridges	1,340	82	323,729	2.0 [1.6 ; 2.4]	198 [159 ; 244]	0 [0 ; 15]
Long-tailed Duck	Kalmarsund	18	0	2,484	0.0 [0 ; 0.03]	0 [0 ; 3]	0 [0 ; 2]
Common Scoter	Öresund, Kalmarsund, Great Belt, Storstrøm	65	0	49,458	0.0 [0 ; 0.3]	0 [0 ; 0]	0 [0 ; 0]
Goldeneye	Kalmarsund	52	0	562	0.0 [0 ; 20]	0 [0 ; 0.2]	0 [0 ; 0]
Red-breasted Merganser	Farø, Fehmarnsund, Kalmarsund	34	1	3,794	0.0 [0 ; 0.1]	1 [0 ; 6]	0 [0 ; 0]

					Scenario 1	Scenario 2	Scenario 3
Species	Data	N_{flock}	$N_{flock\ 10m}$	$N_{Annual\ max}$	$N_{0.01\%,year}$ [95%CI]	$N_{1\%,year}$ [95%CI]	N_{obs} [95%CI]
Goosander	Farø, Fehmarnsund, Kalmarsund	61	1	137	0.0 [0 ; 0.001]	0 [0 ; 0.1]	0 [0 ; 0]

Results for scenario 1 (assumption: 0.01% of birds flying closer than 10 m of bridge structures would collide) predict very low collision numbers (≤ 2 individuals per species and migration season corresponding to very low collision rates (< 0.002%), expressed as proportion of numbers migrating through the Fehmarnbelt ($N_{Annual\ max}$).

Results for scenario 2 (assumption: 1% of birds flying closer than 10 m of bridge structures would collide) still predict relatively low collision numbers for most of the species. However, with 198 Common Eider, 65 Brent Goose and 11 Greylag Goose, relating to collision rates of 0.061%, 0.155% and 0.070%, respectively, these are quite high (Table 10.15).

For scenario 3 (based on actual observed bird collisions during FEBI bridge effect studies), it must be noted, that no incidences of actual collisions were detected by the observers. Thus, in all cases the best estimate of bird collisions is zero. After having lumped numbers into two species groups (see methods in chapter 4.6.4), the upper limits of the 95% confidence interval give low numbers corresponding to a collision rate well below estimates of the scenario 2 (Table 10.15).

It must be noted, that the values of the upper 95% confidence interval for scenario 2 reveal rather high numbers, e.g. in the case of the Brent Goose. However, this is based on the observation on 1 out of 13 flocks at the Storstrøm Bridge, while no data exist for this species at the other Baltic Sea bridges. Consequently, the dimension of the upper 95% confidence interval is mainly a consequence of the low sample size. It is assessed that in the case of the Brent Goose this will not lead to an increase in the degree of impairment, which is medium based on the sensitivity of this species to collisions, as sample size is too low for such a conclusion.

Potential collision rates of nocturnally migrating passerine species based on migration traffic rates (migration intensity)

Compared to the daytime migration, the situation is different for night-time periods. Different bird species migrate at night and different orientation and navigation skills are used (Alerstam 1990, Berthold 2001). In addition, obstruction and architectural lighting may attract birds, disorient them or lead to circling and exhaustion (e.g. Ballasus et al. 2010).

As explained in the method chapter 4.6.4, the basic parameter to calculate bird numbers which potentially fly into the possible collision area is the migration traffic rate (MTR) registered by pencil beam radar during the FEBI baseline investigations. Then the number of birds crossing 1 m² of air was used estimated to 0.2150 birds/m²/season in the Fehmarnbelt region.

Regarding the number of birds potentially colliding, the resulting numbers were multiplied by 0.145 to account for the considered avoidance rate of 85.5% (see methods, chapter 4.6.4).

As also explained in chapter 4.6.4, the relevant number of nocturnal passerine migrants flying through the Fehmarnbelt region is 1,053,023 birds along a 5 km line in all altitudes.

Considering the mean migration direction, it is estimated that in total 29,734 nocturnally migrating passerines would fly into the collision risk area of a bridge, resulting in a collision estimate of 4,311 birds per season (Table 10.16). Accounting for the deviation of migration directions from the mean within the ± SD of 48.5°, estimated numbers are higher, yet less likely, as it is assumed, that mean migration direction applies for most of the time.

Table 10.16 Calculated numbers of birds estimated to fly into the collision risk area for the mean migration direction (see Figure 4.14) and corresponding bird numbers potentially colliding with bridge structures per season (for details see text).

	Number of birds	**% of nocturnal passerines passing Fehmarnbelt (1,053,023)**
Mean migration direction 35.5°; angle to the bridge 10.5°		
Numbers crossing the collision risk area (138,327 m²)	29,734	2.8237
Numbers potentially colliding (including avoidance)	4,311	0.4094
Migration direction 35.5° + 48.5° = 84.0°; angle to the bridge 59.0°		
Numbers crossing into risk area (326,921 m²)	70,274	6.6735
Numbers potentially colliding (including avoidance)	10,190	0.9677
Migration direction 35.5° - 48.5° = 347.0°; angle to the bridge 38.0°		
Numbers crossing into risk area (259,438 m²)	55,768	5.2960
Numbers potentially colliding (including avoidance)	8,086	0.7679

It must be noted, that calculations and considerations are based on a number of assumptions in the absence of empirical data. In general it must be assumed that the calculations for the mean migration directions, yielding the lowest collision rates, are most likely representative of the situation during mass migration days and nights. The migration directions deviating from the main migration direction, resulting in larger collision areas (bridge projections) and thus larger collision numbers, would only occur during wind directions that are less favourable to bird migration and thus less frequent in combination with mass migration events.

Factors which could increase collision numbers are: a) attraction due to e.g. light, thus resulting in attraction rate of >5%; b) inclement weather conditions, which would lead to higher migration intensities at low altitudes and limited visibility. A factor potentially decreasing the collision numbers is mainly the avoidance. If the avoidance is higher, collision numbers would be lower (see also Chamberlain et al. 2006, Bellebaum et al. 2010).

Regarding the degree of impairment, the potential collision rates of 0.41% to 0.97% for those birds flying within 2.5 km of the alignment would result in a high degree of impairment, as these results suggest that small proportions of the nocturnally migrating passerines in the region would regularly collide with the structures.

Potential collision rates of nocturnally migrating species in dependence of weather and relative to Öresund Bridge collision rates and migration traffic rates

The effect of weather and lights on bridge structures for collision risk

The effect of illumination of bridges and different weather conditions on collision numbers of night-migrating birds was modelled using data on actual collisions from the Öresund Bridge during 2001-2003 (see chapter 4.6.4).

Applying logistic regression, minimum temperature came out as the only significant weather factor explaining collision events at the Öresund Bridge (Table 10.17). Applying generalised linear modelling to analyse occurrence and magnitude of bird collisions at the Öresund Bridge, all variables were significant – weather factors and light (Table 10.18). Nights with collisions were generally associated with higher temperatures, low wind speeds, less precipitation and poor visibility. Temperature is expected to affect spring (higher migration intensities with higher temperatures) and autumn (higher migration intensities with lower temperatures) migration differently. The effect of wind and precipitation likely reflects lower migration intensities during nights with strong wind and rain. Month is most likely explaining differences in number of birds passing during the migration seasons. Furthermore, turning off the lights on the bridge seems to decrease collision numbers, as those were higher before the initiation of this practice.

Table 10.17 Results of logistic regression, which was applied for explaining occurrence of bird collision events at the Öresund Bridge.

		Parameter Estimates		***Type 3 analyses***	
Parameter	**DF**	**Estimate**	**Standard error**	**F**	**P**
Intercept	1	-2.735	0.999	-	-
Month	6	-	-	21.9	0.0013
Minimum temperature	1	0.128	0.063	4.07	0.0438
Maximum wind speed	1	-0.039	0.022	3.10	0.0782
Visibility	1	0.048	0.080	0.353	0.5524
Precipitation	1	-0.259	0.160	2.61	0.1061
Light (0)	1	0.113	0.182	0.387	0.534

Table 10.18 Results of generalised linear model, which was applied for explaining occurrence and magnitude of bird collision events at the Öresund Bridge.

		Parameter Estimates		***Type 3 analyses***	
Parameter	**DF**	**Estimate**	**Standard error**	**F**	**P**
Intercept	1	-0.135	0.662	-	-
Month	6	-	-	24.6	<0.0001
Minimum temperature	1	0.296	0.047	48.0	<0.0001
Maximum wind speed	1	-0.040	0.014	8.7	0.0034
Visibility	1	-0.219	0.032	47.9	<0.0001
Precipitation	1	-0.220	0.086	20.2	<0.0001
Light (0)	1	0.836	0.263	11.6	0.0007

As the road patrols found fewer birds in general but more dead gulls over time, it has been argued by Nilsson et al. (2009) that the data from the Öresund Bridge are biased by gulls having adapted to scavenge on the dead or injured birds after collision with the bridge structure. It was not possible to control for this potential effect in the analysis. However, as only the early years of the Öresund Bridge study were analysed, gull predation may have not been a big issue (Nilsson et al. 2009, Nilsson pers. comm.). Furthermore, when the approach was limited to only model days with dead birds versus days with no dead birds as dependent variable (logistic regression), very similar results were found, further supporting the patterns found.

To conclude, the analysis shows that lights on the bridge structures as well as bad visibility cause higher numbers of night-time migrating birds to collide with the bridge.

Assessment of expected night-time collision rates at the proposed Fehmarnbelt Bridge in relation to bird collision rates and migration intensity at the Öresund Bridge

Using the estimated MTRs for the Öresund and Fehmarnbelt, the relative collision risk at the proposed Fehmarnbelt Bridge was found to be 0.11 when using “best estimate” and 0.39 when using “maximum estimate” (Table 10.19, for methods see chapter 4.6.4).

Table 10.19 Relative collision risk and estimated numbers of dead birds. Low and high numbers follow the low and high collision number estimates at the Öresund Bridge, on which comparisons are based.

	Best estimate		**Maximum estimate**	
Relative collision risk	0.11		0.39	
	low	high	low	high
Spring (number of dead birds)	395	1,976	1,414	7,070
Autumn (number of dead birds)	56	282	202	1,008

For the entire length of the Öresund Bridge, Nilsson and Green (2002) estimated that 1,000-5,000 birds may have collided during autumn 2001. The numbers estimated for the bridge part above the road level including pylons and cables comprise 52% of the total estimate (Nilsson and Green 2002), resulting in 520–2,600 birds colliding during autumn. Using best estimates and the assumption that similar weather conditions occur in the Fehmarnbelt region, it was calculated that 56–282 and 395–1,976 birds would collide with the Fehmarnbelt Bridge during autumn and spring, respectively, considering only the parts above road level of the main bridge. Using maximum estimates, 202–1,008 and 1,414–7,070 birds would collide during autumn and spring (Table 10.19).

In conclusion, calculated collision numbers for the main bridge part under the high pylons and cables are relatively low. The highest estimate of 7,070 bird casualties in spring would comprise only 0.6714% of the nocturnal migrants crossing a 5 km line in the Fehmarnbelt region.

As collision risk is weather-dependent, the number of birds colliding with the bridge is expected to be underestimated for the Fehmarnbelt if days with low visibility are more common in the Fehmarnbelt region compared to the period of collision studies at the Öresund Bridge.

The following conclusions could be drawn from the results of the different collision rate calculations:

- For daytime collision estimates the scenario resulting in the highest collision numbers (scenario 2) is considered as being a very conservative approach, since collisions of 1% of all birds getting closer than 10 m to a bridge structure are regarded as very unlikely. Also, for some species, such as the Brent Goose, the small sample size resulted in a high uncertainty of the collision estimates. Thus, following the sensitivity assessment, the degree of impairment is assessed to be minor for daytime migrating birds (see chapters on sensitivity assessment 7.2.11, 7.3.3).

- It was estimated that low but presumably regular proportions of nocturnally migrating passerines would collide with the structures of the bridge in the Fehmarnbelt. It cannot be excluded, however, that occasionally (very rarely though) higher collision rates would occur, when inclement weather conditions would coincide with a night of intensive migration. Thus, the degree of impairment was assessed being high for nocturnal or facultative nocturnal migrating species (following definitions in Table 4.8).

Severity of impairment

Breeding waterbirds

The bird species breeding in the Natura 2000 areas are considered daytime active when utilising the offshore areas (Table 7.4). Consequently, their sensitivity to collision and thus the degree of impairment is assessed to be minor, leading to a minor severity of impairment for all species.

All considered breeding bird species are assessed to have a minor severity of impairment to the pressure 'collision with bridge structures'.

Non-breeding waterbirds

Most of the non-breeding waterbird species, which are staging and wintering and therefore are temporarily resident in the area, are mainly daytime active and thus assessed to be minor sensitive to collisions with the bridge structure. Calculations of daytime collision risks with daytime avoidance rates of 99% and 99.99% (see above and Table 10.15) result in very low potential collision rates for migrating individuals. It must be noted that birds temporarily resident in the area would be more accustomed to the presence of the bridge and most likely would have an even lower collision risk. The severity of impairment for these species is minor.

Common Pochard, Tufted Duck, Greater Scaup

Common Pochard, Tufted Duck and Greater Scaup are night-time active species, conducting regularly flights between their daytime roosts and night-time feeding sites. Consequently their sensitivity to collide with the bridge structure is assessed to be medium. No empirical data on nocturnal collision rates exist for these species. Calculations for migrating birds (see above, Table 10.16, Table 10.19) give low potential collision rates, but cannot be easily applied to temporarily resident species, as these on one hand are expected to be accustomed to the presence of the bridge, on the other hand may cross the alignment and thus the bridge several times during a wintering season. Therefore the degree of impairment is assessed to be medium for these three diving duck species. Consequently, the severity of impairment from the pressure 'collision with bridge structures' for Common Pochard, Tufted Duck and Greater Scaup is assessed as medium as well.

Overall assessment of the severity of impairment

For Common Pochard, Tufted Duck and Greater Scaup a medium severity of impairment from the pressure 'collision with bridge structures' is assessed. For all other non-breeding waterbirds a minor severity of impairment is assessed.

Migrating birds
The severity of impairment formally follows the combination of the degree of impairment with the importance of the species (see chapter 4.5.14). Where empirical data exist for estimating collision numbers, these are given and included in the assessment as well.

As it turns out from the three approaches that were used to estimate collision rates and numbers for migrating birds (see paragraph on degree of impairment of this chapter), the predictions for the different scenarios result in usually low proportions of the respective bird populations being affected.

Daytime collision rates under the maximum (most severe) scenario were estimated to correspond 0.033% of the biogeographic/relevant reference population of the Brent Goose (65 birds), 0.026% of the Common Eider (198 birds) and less than <0.01% of all other species. Therefore, the numerical assessment of daytime bird collisions agrees with the assessment of the sensitivity and degree of impairment (minor for obligatory daytime migrants) resulting in a minor severity of impairment for obligatory daytime migrating birds (see sensitivity assessment in chapter 7.2.11).

The severity of impairment to species at least partly migrating at nights and identified as being relevant in the sensitivity screening (see chapter 7.3.3) are assessed below.

Divers (Red-throated/Black-throated Diver)
Potential daytime collision rate, following scenario 2, is estimated to be 0.0 (Table 10.15).

Divers typically migrate over water. During the Öresund Bridge studies this species group showed by far the highest flight altitude when crossing the bridge (Nilsson et al. 2009, 2010). Divers also show strongest avoidance reactions to offshore wind farms and are ranked highest regarding sensitivity scores (Garthe and Hüppop 2004). Therefore, the collision risk for daytime migrating divers is regarded to be very low, which is also confirmed by collision estimates following different scenarios (Table 10.15). Nocturnal flight activity occurs, most likely perpendicular to the alignment, thus a collision risk exists during the night-time. Due to this and uncertainties about collision risks for the species at night, the precautionary principle is followed and the degree of impairment is assessed as medium for the diver species.

Accounting for the high importance of the Fehmarnbelt to migrating Red-throated and Black-throated Divers, the severity of impairment is assessed to be medium.

Grebes
Grebes are active during both day and night-time and typically migrate perpendicularly to the alignment.

Due to uncertainties about the collision risk of grebe species at night, the precautionary principle is followed and the degree of impairment is assessed as medium for the three grebe species occurring in the area: Great Crested Grebe, Red-necked Grebe and Slavonian Grebe.

Accounting for the medium importance of the Fehmarnbelt to migrating Red-necked Grebes and high importance to Slavonian Grebes, the severity of impairment is assessed to be medium for these two species. Due to the minor importance level, the severity of impairment is assessed as minor for the Great Crested Grebe.

Swans

During the effect studies at Baltic Sea bridges Mute Swans showed some avoidance reactions to bridges, suggesting a low collision risk and they are known to avoid wind farms. Due to the low flight manoeuvrability, high flight activity, some nocturnal activity and the lack of empirical data, the degree of impairment is assessed following the sensitivity assessment as medium for the three swan species Mute Swan, Bewick's Swan and Whooper Swan.

For the Bewick's Swan, a low PBR threshold of 0.56% of the population (112 individuals; see chapter 8) was calculated, mainly on account of a low population size and a decreasing trend (this aspect is further discussed in chapter 10.4). A medium sensitivity to collision means, that collisions are unlikely, but may occur during inclement weather. No such collision events with bridges or other non-moving structures have been reported for Bewick's Swan. Therefore, collisions will most likely involve, if at all, only single individuals.

Whooper Swan will exhibit more or less the same flight behaviour as Bewick's Swan, migrating day and night at differing altitudes (A. Degen, pers. comm.).

Thus, the severity of impairment is assessed to be medium for Mute Swan, Whooper Swan and Bewick's Swan.

Geese

The Fehmarnbelt is of very high importance for migrating geese with up to 20% of the Barnacle and Brent Goose populations passing the area and up to 3% of the Greylag Goose population using the area (FEBI 2013). For the Bean Goose a medium importance of the area was assessed (0.2% of the population observed; FEBI 2013). Other goose species were recorded in minor important numbers and are therefore not further assessed in this chapter (see chapter 7.3.3).

Calculated daytime collision rates of some goose species indicate the assessed goose species being of relatively high collision risk compared to other daytime migrating birds (Table 10.15). It is estimated that 11 individuals of Greylag and Barnacle Goose and 65 of Brent Goose could collide with a bridge in the Fehmarnbelt per year (scenario 2). Geese in general migrate at medium to high altitudes and show some avoidance against bridge structures in cases when their migration path directly crosses the bridge. Most goose species migrate both during day- and night-time. They are known to collide with power lines when large roosting or feeding sites are close-by. Thus, the degree of impairment is assessed following the sensitivity assessment as medium.

Following a numerical approach the calculated collision numbers are assessed as representing minor severity of impairment (<0.1% of the biogeographic populations affected). However, there are uncertainties about collision risks at night and the degree of impairment is assessed as medium, thus the severity of impairment for these goose species is assessed to be medium as well. The severity of impairment for other goose species is assessed as minor due to the minor importance of the area to them.

Dabbling ducks

For the dabbling ducks, differences between the species regarding flight and migration behaviour (altitude, direction) as well as risk of collision are considered to be small, or not known due to a lack of specific data. The relevant species Eurasian Wigeon, Gadwall, Northern Shoveler and Northern Pintail also migrate during night-time (Koop 2002, King et al. 2009). Autumn migration in the region may take place over water using leading line effects, while spring migration frequently occurs in a broad-front and at higher altitudes (Koop 2002).

Potential daytime collision scenarios estimated for Wigeon and Pintail indicate that collisions of dabbling ducks during daytime would be very unlikely (0 collisions; Table 10.15).

However, there are uncertainties about collision risk at night-time and the degree of impairment is assessed as medium. Therefore, the severity of impairment for these dabbling duck species (Eurasian Wigeon, Gadwall, Northern Shoveler and Northern Pintail) is assessed to be medium as well. The severity of impairment for other dabbling duck species is assessed as minor due to the minor importance of the area to these species.

Greater Scaup
There are no calculations on potential daytime collisions available for the Greater Scaup, but the potential daytime collision scenarios for Tufted Duck and Common Goldeneye indicate that collisions of diving ducks during daytime would be very unlikely (0 collisions; Table 10.15).

However, there are uncertainties about collision risk at night-time and the degree of impairment is assessed as medium for diving ducks, thus the severity of impairment for the Greater Scaup is assessed to be medium as well. The severity of impairment for other diving duck species is assessed as minor due to the minor importance of the area to these species.

Common Eider
Common Eider is the most abundant migrating waterbird species in the Fehmarnbelt area with more than 40% of the biogeographic population passing the area twice a year during migration. Thus, absolute numbers of potential daytime collisions predicted with 198 collisions for the most conservative scenario 2 are comparably high (Table 10.15). However, this number represents just 0.026% of the biogeographic population which would, in a quantitative assessment, result in a minor severity of impairment.

However, there are uncertainties about collision risks at night and therefore the degree of impairment is assessed as medium for the Common Eider. Thus, the severity of impairment is assessed to be medium as well.

Common Scoter
Common Scoters are known to show strong avoidance reactions to structures due to barrier effect, which makes it unlikely for this species to collide with the same structures during daytime (see also chapter 7.2.9). This is also confirmed by daytime collision estimates for the Common Scoter following different scenarios (0 collisions; Table 10.15).

However, there are uncertainties about collision risks at night-time and due to that the degree of impairment is assessed as medium for the Common Scoter. Thus, the severity of impairment is assessed to be medium as well.

Gulls
Of the gull species, Black-headed Gulls are inland the most common victims of collisions with power lines, Common Gulls are reported as well (Prinsen et al. 2010). All gull species frequently fly in dense flocks, are active under windy conditions and can be attracted to structures. Great Black-backed Gull was observed at the Öresund Bridge using the updrafts along the bridge to perform gliding flights, which sustain the birds very well just a few meters above the edges of the bridge. Therefore, the sensitivity and thus the degree of impairment are assessed as medium for the gull species.

Accounting for the species' importance level and the assessed degree of impairment the severity of impairment is assessed as medium for Little Gull, Black-headed Gull, Common Gull, Herring Gull and Great Black-backed Gull, and minor for other gull species.

Terns
Terns mainly fly at low altitudes and show little to no avoidance reactions to wind farms. Sandwich Terns and Common Terns are in contrast to other tern species nocturnally active to a small degree. Thus, the sensitivity and the degree of impairment are assessed as medium for these two tern species.

Accounting for the species' importance level and the assessed degree of impairment the severity of impairment is assessed as medium for Sandwich Tern and Common Tern, and minor for the other tern species.

Nocturnal and facultative nocturnal migrating passerines
Regarding night-time collision of nocturnally migrating passerines, the maximum seasonal collision estimate is some 10,000 individuals (or 20,000 individuals annually). While this maximum value would present some 0.97% of the birds passing the Fehmarnbelt across a 5 km line per season, such collision rate would represent just 0.0088% of the relevant reference populations per year. This numerical assessment would result in a minor severity of impairment based on the low proportion of the respective birds populations affected, while the degree of impairment was assessed to be high. However, due to uncertainties in the calculations as outlined above, the severity of impairment from collisions with bridge structures is assessed to be medium for nocturnal and facultative nocturnal migrating passerines.

Rails
Several rails species such as Water Rail (*Rallus aquaticus*), Corncrake (*Crex crex*), Common Coot (*Fulica atra*) and Common Moorhen (*Gallinula chloropus*) are partially migratory in Europe (BirdLife International 2004a). However, as they predominantly migrate at night, no direct observations of these species are available from the baseline investigations (FEBI 2013). Migration directions are assumed to be mostly parallel to the link. Based on these assumptions, rails are assessed to be medium sensitive to collision with bridge structures and the degree of impairment is assessed to be medium as well.

For the severity of impairment assessment the assumptions applied for nocturnally migrating passerines are considered also to be valid for these rail species (see above), thus broad front nocturnal migration at varying altitudes is assumed. Accordingly, estimated collision numbers resulting from these calculations would account for less than 0.01% of the respective populations and the impact is assessed, following a numerical approach, as minor severity of impairment.

However, due to uncertainties in the calculations and uncertainties about whether the same criteria can be applied for nocturnal rail species, the assessment of the severity of impairment follows the assessment of the sensitivity and degree of impairment.

The severity of impairment of collisions with bridge structures is assessed to be medium for the above mentioned nocturnal migrating rail species.

Long-eared and Short-eared Owls
Due to their night-time activity and their known sensitivity to collisions the degree of impairment for the pressure 'collision with bridge structures' is assessed as medium for Long-eared and Short-eared Owls.

Following the assessment of the degree of impairment and due to the lack of observation data from FEBI baseline investigations (FEBI 2013), the severity of impairment to collision with bridge structures is assessed as medium for these two species.

Other species

Other migrating bird species are assessed to be minor sensitive to the pressure, or importance of the area is assessed to be minor. Thus the severity of impairment is assessed to be minor or negligible to these species.

Overall assessment of the severity of impairment

The severity of impairment for 31 species and two species groups is assessed as medium regarding the collision with bridge structures (Table 10.20). This is a precautionary assessment, as applied collision scenarios result in collision rates and numbers corresponding to less than 0.1% of the respective migrating bird populations, for which a minor severity of impairment would be concluded. However, there are substantial uncertainties within these calculations and assuming that these calculations present 'normal' migration conditions, rare incidents with higher collision numbers cannot be excluded (e.g. due to adverse weather conditions). This was taken into account when assigning a medium severity of impairment for several species. For other species the severity of impairment is assessed to be negligible or minor (Table 10.20).

Table 10.20 Assessment of the severity of impairment, regarding migrating birds and the pressure 'collision with bridge structures' during operation of a bridge in the Fehmarnbelt. The table includes all bird species, for which this pressure has been assessed to be relevant following Table 7.9.

Species	Importance level	Sensitivity / degree of impairment	Severity of impairment
Red-throated Diver	High	Medium	Medium
Black-throated Diver	High	Medium	Medium
Red-necked Grebe	Medium	Medium	Medium
Slavonian Grebe	High	Medium	Medium
Mute Swan	Medium	Medium	Medium
Bewick's Swan	High	Medium	Medium
Whooper Swan	High	Medium	Medium
Bean Goose	Medium	Medium	Medium
Greylag Goose	Very High	Medium	Medium
Barnacle Goose	Very High	Medium	Medium
Brent Goose	Very High	Medium	Medium
Eurasian Wigeon	Medium	Medium	Medium
Gadwall	High	Medium	Medium
Northern Pintail	Very High	Medium	Medium
Northern Shoveler	Very High	Medium	Medium
Greater Scaup	High	Medium	Medium
Common Eider	Very High	Medium	Medium
Common Scoter	Very High	Medium	Medium
Little Gull	Very High	Medium	Medium
Black-headed Gull	Medium	Medium	Medium
Waterrail	NA	Medium	Medium
Corncrake	NA	Medium	Medium
Moorhen	NA	Medium	Medium
Common Coot	NA	Medium	Medium
Common Gull	High	Medium	Medium
Herring Gull	Medium	Medium	Medium

Species	Importance level	Sensitivity / degree of impairment	Severity of impairment
Great Black-backed Gull	Medium	Medium	Medium
Sandwich Tern	Very High	Medium	Medium
Common Tern	High	Medium	Medium
Long-eared Owl	NA	Medium	Medium
Short-eared Owl	NA	Medium	Medium
Obligatory nocturnal migrating passerines	Medium	Medium/High	Medium
Facultative nocturnal migrating passerines	Medium	Medium/High	Medium
Other species			Minor/Negligible

Duration of impact
The duration of the pressure 'collision with bridge structures' would be permanent, thus the impact on birds is predicted to be permanent too.

10.3.8 Collision with traffic

Description of the pressure
Beside the collision risk with the bridge structure itself (see previous chapter 10.3.7) birds may collide with trains and vehicles crossing the bridge.

The traffic would run on two levels with a four-lane road on the upper level and a two-track railway on the lower level. A 2.5 m high wind screen of perforated metal is planned to partially cover the four-lane road from the side (see Figure 10.50). This structure would force the birds to cross the road at higher altitudes and therefore probably reduces the risk of traffic kills for birds.

Traffic rates for road and rail traffic have been predicted for the operation years 2025 and 2030 assuming different scenarios (Table 10.21, Table 10.22): a) operation of the Fixed Link solely (without continued ferry traffic) and b) operation of the Fixed Link parallel with ferry service with an assumed share of 50% each).

Table 10.21 Road traffic rates (in number of vehicles per day) predicted for the planned bridge over Fehmarnbelt for the year 2025 and 2030 without and with continued ferry traffic (source: Fehmern A/S memo on traffic forecast prediction).

	All traffic over bridge (without ferry), n/24 h		Shared traffic over bridge and ferry, n/24 h		Max. speed (km/h)
	2025	2030	2025	2030	
Passenger cars	9,819	10,956	4,910	5,478	110
Busses	153	167	77	83	80
Lorries	1,751	2,132	876	1,066	80
Total vehicles	11,723	13,256	5,862	6,628	

Table 10.22 Rail traffic rates (in number of trains per day or night) predicted for the planned bridge over Fehmarnbelt for the year 2025 and 2030. Rail traffic would only use the existing bridge, thus scenarios with and without continued ferry traffic are the same (source: Fehmern A/S memo on traffic forecast prediction).

Train type	2025		2030		Max. speed (km/h)
	day	night	Day	night	
ICE	16	4	16	4	200
Night train	0	4	0	4	200
Local train	12	4	12	4	160
Freight train	39	39	48	48	140

Degree of impairment

Different from the pressure ‘collision with bridge structures’, the degree of impairment regarding collision with traffic was not directly deducted from the sensitivity assessment (see chapter 7.2.13). Although some species are assessed to have a medium sensitivity to colliding with traffic the overall proportion of birds affected by such collision incidents is regarded to be low. Therefore the degree of impairment is assessed to be minor for all breeding, non-breeding and migrating bird species.

Severity of impairment

Breeding waterbirds

Three species of breeding waterbirds have been identified as medium sensitive to collision with traffic (Common Gull, Herring Gull and Great Black-backed Gull; chapter 7.2.13). It cannot be excluded that single birds of these species would collide with the traffic on a cable stayed bridge. However, the numbers of birds which would get killed are expected to be low, though no quantitative collision rate estimates can be given. The severity of impairment is assessed to be minor for all breeding waterbirds in the area.

Non-breeding waterbirds

Three species of non-breeding waterbirds have been identified as medium sensitive to collision with traffic (Common Gull, Herring Gull and Great Black-backed Gull; chapter 7.2.13). It cannot be excluded that some birds of these species would collide with the traffic on a cable stayed bridge. However, the numbers of birds which would get killed are expected to be low, though no quantitative collision rate estimates can be given. The severity of impairment is assessed to be minor for all non-breeding waterbirds in the area.

Migrating birds

Three species of migrating birds have been identified as medium sensitive to collision with traffic (Greylag Goose, Eurasian Jackdaw and Rook; chapter 7.2.13). It cannot be excluded that some birds of these species would collide with the traffic on a cable stayed bridge. However, the numbers of birds which would get killed are expected to be low, though no quantitative collision rate estimates can be given. The severity of impairment is assessed to be minor for all migrating birds in the area.

Duration of impact

The duration of the pressure 'collision with traffic' would be permanent, thus the impact on birds is predicted to be permanent too.

10.4 Summary and overall assessment of severity and significance of impacts

The overall project impact is assessed by aggregating the impacts of different pressures for each environmental component (breeding waterbirds, non-breeding waterbirds and migrating birds) separately for the construction period and for structure and operation of the cable stayed bridge.

Different construction- and operation-related pressures (habitat loss, disturbance effects, water transparency and habitat change from sediment spill) are predicted to result in displacement of birds from impaired areas, the barrier effect must be considered separately and effects of potential collisions would result in direct mortality.

For estimating the overall impact as numbers of displaced birds, the spatial and temporal overlap of the different pressures was taken into account (see below). Displacement is assumed to result mostly in a redistribution of birds within the study area and would not necessarily result in mortality. Impairment resulting from barrier effect can only be assessed qualitatively and therefore cannot be aggregated with pressures leading to displacements. Collision with project related structures would result in direct mortality of birds and is not summable with displacement or barrier effects. Therefore, displacement, barrier effect and collisions are presented separately in the overall assessment.

The assessment of the significance of the project impact was conducted on a species level following the description in chapter 4.5.14. An impact from the construction and operation of the project was considered significant if at least one of the following criteria was met:

- the total number of displaced individuals (resulting from different pressures) corresponds to more than 1% of the biogeographic population, unless it can be excluded that the displacement of >1% of the biogeographic population would result in a population effect for a species;
- the severity of impairment of barrier effect is assessed as being very high and leading to an interruption of migration flyways (migrating birds) or ecologically functional connections between breeding, resting and foraging habitats (breeding and non-breeding waterbirds);
- the number of birds predicted to collide with the project structures (i.e. be killed) exceeds the threshold of Potential Biological Removal (PBR; see chapter 8) or >1% of the biogeographic/relevant reference population, and thus could potentially lead to population effects.

When assessing the significance of the project impact, the duration of different pressures (i.e. duration of significant impacts) was taken into account.

10.4.1 Breeding waterbirds

Construction phase

During the construction period of a cable stayed bridge in the Fehmarnbelt, impacts resulting from different pressures are assessed as minor for all waterbird species breeding in Natura 2000 areas (Table 10.23). Therefore, the overall impact on all breeding waterbird species during the bridge construction period is assessed as being insignificant.

Table 10.23 Summary of the assessment of pressure-specific severity of impact (loss/impairment) and overall significance of impact for breeding waterbirds during the construction phase of a cable stayed bridge in the Fehmarnbelt. 'Overall impact of displacement' indicates the aggregated impact in terms of bird displacement from the pressures habitat loss, habitat change, water transparency and disturbance. This assessment was conducted for waterbirds breeding in Natura 2000 areas only.

Species	Loss	Impairment			Overall impact of displacement	Impairment		Significance
	Habitat loss from footprint	Habitat change from sediment spill	Water transparency	Disturbance from construction vessels		Barrier from construction vessels	Collision with construction vessels	
Red-necked Grebe	Minor	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Great Cormorant	Minor	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Common Heron	Minor	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Mute Swan	Minor	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Greylag Goose	Minor	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Common Eider	Minor	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Red-breasted Merganser	Minor	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Goosander	Minor	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
White-tailed Eagle	Minor	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Oystercatcher	Minor	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Avocet	Minor	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Redshank	Minor	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Mediterranean Gull	Minor	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Black-headed Gull	Minor	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Common Gull	Minor	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Herring Gull	Minor	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Great Black-backed Gull	Minor	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Sandwich Tern	Minor	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Common Tern	Minor	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Arctic Tern	Minor	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Little Tern	Minor	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Other species	Minor	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant

Structure and operation

Impacts from structure and operation of a cable stayed bridge in the Fehmarnbelt are assessed to result in minor severity of impact for all waterbird species breeding in Natura 2000 areas (Table 10.24). Therefore, the overall impact is assessed as being insignificant for all breeding waterbird species in the area.

Table 10.24 Summary of the assessment of pressure-specific severity of impact (loss/impairment) and overall significance of impact for breeding waterbirds from structure and operation of a cable stayed bridge in Fehmarnbelt. 'Overall impact of displacement' indicates the aggregated impact in terms of bird displacement from the pressures habitat loss and hydrographical changes. This assessment was conducted for waterbirds breeding in Natura 2000 areas only.

Species	Loss	Impairment					Impairment			Significance
	Footprint	Provision of artificial reefs	Hydrographical changes from bridge pillars	Disturbance from bridge structure and traffic	Disturbance from channelling of shipping	Overall impact of displacement	Barrier from bridge structure	Collision with bridge structures	Collision with traffic	
Red-necked Grebe	Minor	No impact	No impact	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Great Cormorant	Minor	No impact	No impact	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Common Heron	Minor	No impact	No impact	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Mute Swan	Minor	No impact	No impact	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Greylag Goose	Minor	No impact	No impact	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Common Eider	Minor	No impact	No impact	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Red-breasted Merganser	Minor	No impact	No impact	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Goosander	Minor	No impact	No impact	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
White-tailed Eagle	Minor	No impact	No impact	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Oystercatcher	Minor	No impact	No impact	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Avocet	Minor	No impact	No impact	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Redshank	Minor	No impact	No impact	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Mediterranean Gull	Minor	No impact	No impact	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Black-headed Gull	Minor	No impact	No impact	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Common Gull	Minor	No impact	No impact	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Herring Gull	Minor	No impact	No impact	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Great Black-backed Gull	Minor	No impact	No impact	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Sandwich Tern	Minor	No impact	No impact	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Common Tern	Minor	No impact	No impact	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Arctic Tern	Minor	No impact	No impact	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Little Tern	Minor	No impact	No impact	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Other species	Minor	No impact	No impact	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant

10.4.2 Non-breeding waterbirds

Construction phase

During the construction of a cable stayed bridge different pressures were identified to result in severity of loss or impairment for non-breeding waterbirds in the area (Table 10.25). Habitat loss from the project footprint is predicted to result in minor severity of loss to all non-breeding waterbird species in the area.

Habitat change from sediment spill, i.e. the indirect effect of changes in benthic or fish communities on birds, is assessed to result in negligible to minor severity of impairment to all non-breeding waterbird species in the area.

Changes in water transparency resulting from sediment spill during the construction period are predicted to result in a medium severity of impairment for the Common Eider during the first year of the construction period. For other species the severity of impairment is assessed to be minor for the entire construction period.

Disturbance from construction vessels is assessed to be of high severity of impairment for the Common Pochard and the Tufted Duck. A medium severity of impairment is assessed for the Common Eider and the Eurasian Wigeon. Displacement from the disturbance zone is assessed to result in negligible to minor severity of impairment to all other non-breeding waterbird species.

The severity of impairment from barrier from construction vessels and collision with construction vessels is assessed to be minor for all non-breeding waterbird species in the area.

Table 10.25 Summary of the assessment of pressure-specific severity of impairment for non-breeding waterbirds during the construction phase of a cable stayed bridge in the Fehmarnbelt. Superscript numbers indicate that severity level changes during the construction period and that number indicates the number of seasons the severity level is assessed to be higher than minor. The highest degree of impairment assessed for any of the construction years is indicated in the cell.

Species	Loss	Impairment				
	Habitat loss from footprint	Habitat change from sediment spill	Water transparency	Disturbance from construction vessels	Barrier from construction vessels	Collision with construction vessels
Divers	Minor	Minor	Minor	Minor	Minor	Minor
Great Crested Grebe	Minor	Negligible	Minor	Minor	Negligible	Negligible
Red-necked Grebe	Minor	Minor	Minor	Minor	Minor	Minor
Slavonian Grebe	Minor	Negligible	Minor	Minor	Negligible	Negligible
Great Cormorant	Minor	Minor	Minor	Minor	Minor	Minor
Mute Swan	Minor	Minor	Minor	Minor	Minor	Minor
Bewick's Swan	Minor	Minor	Minor	Minor	Minor	Minor
Whooper Swan	Minor	Minor	Minor	Minor	Minor	Minor

Species	Loss	Impairment				
	Habitat loss from footprint	Habitat change from sediment spill	Water transparency	Disturbance from construction vessels	Barrier from construction vessels	Collision with construction vessels
Bean Goose	Minor	Minor	Minor	Minor	Minor	Minor
Greater White-fronted Goose	Minor	Negligible	Negligible	Minor	Negligible	Negligible
Greylag Goose	Minor	Minor	Minor	Minor	Minor	Minor
Barnacle Goose	Minor	Minor	Minor	Minor	Minor	Minor
Brent Goose	Minor	Minor	Minor	Minor	Minor	Minor
Eurasian Wigeon	Minor	Minor	Minor	Medium	Minor	Minor
Gadwall	Minor	Minor	Minor	Minor	Minor	Minor
Common Teal	Minor	Minor	Minor	Minor	Minor	Minor
Mallard	Minor	Negligible	Negligible	Minor	Negligible	Negligible
Shoveler	Minor	Minor	Minor	Minor	Minor	Minor
Common Pochard	Minor	Minor	Minor	High	Minor	Minor
Tufted Duck	Minor	Minor	Minor	High	Minor	Minor
Greater Scaup	Minor	Minor	Minor	Minor	Minor	Minor
Common Eider	Minor	Minor	Medium[1]	Medium	Minor	Minor
Long-tailed Duck	Minor	Minor	Minor	Minor	Minor	Minor
Common Scoter	Minor	Minor	Minor	Minor	Minor	Minor
Velvet Scoter	Minor	Minor	Minor	Minor	Minor	Minor
Common Goldeneye	Minor	Minor	Minor	Minor	Minor	Minor
Smew	Minor	Minor	Minor	Minor	Minor	Minor
Red-breasted Merganser	Minor	Minor	Minor	Minor	Minor	Minor
Goosander	Minor	Negligible	Minor	Minor	Negligible	Negligible
White-tailed Eagle	Minor	Minor	Minor	Minor	Minor	Minor
Common Coot	Minor	Minor	Minor	Minor	Minor	Minor
Little Gull	Minor	Minor	Minor	Minor	Minor	Minor
Black-headed Gull	Minor	Minor	Minor	Minor	Minor	Minor
Common Gull	Minor	Minor	Minor	Minor	Minor	Minor
Lesser Black-backed Gull	Minor	Negligible	Negligible	Negligible	Negligible	Negligible
Herring Gull	Minor	Minor	Minor	Minor	Minor	Minor
Great Black-backed Gull	Minor	Minor	Minor	Minor	Minor	Minor
Sandwich Tern	Minor	Minor	Minor	Minor	Minor	Minor
Common Tern	Minor	Negligible	Negligible	Negligible	Negligible	Negligible
Arctic Tern	Minor	Negligible	Negligible	Negligible	Negligible	Negligible
Common Guillemot	Minor	Negligible	Negligible	Minor	Negligible	Negligible
Razorbill	Minor	Minor	Minor	Minor	Minor	Minor
Black Guillemot	Minor	Minor	Minor	Minor	Minor	Minor
Other species	Minor	Negligible/ Minor	Negligible/ Minor	Negligible/ Minor	Negligible/ Minor	Negligible/ Minor

Separate pressures anticipated during the bridge construction partly or fully overlap (Figure 10.54). Therefore their impacts cannot be simply summed without accounting for spatial correspondence. When overlapping, a pressure which is assessed as having higher impact on birds was used in the overall assessment. The pressures related to barrier and collision could not be numerically aggregated with the pressures causing bird displacement and redistribution and are therefore presented separately.

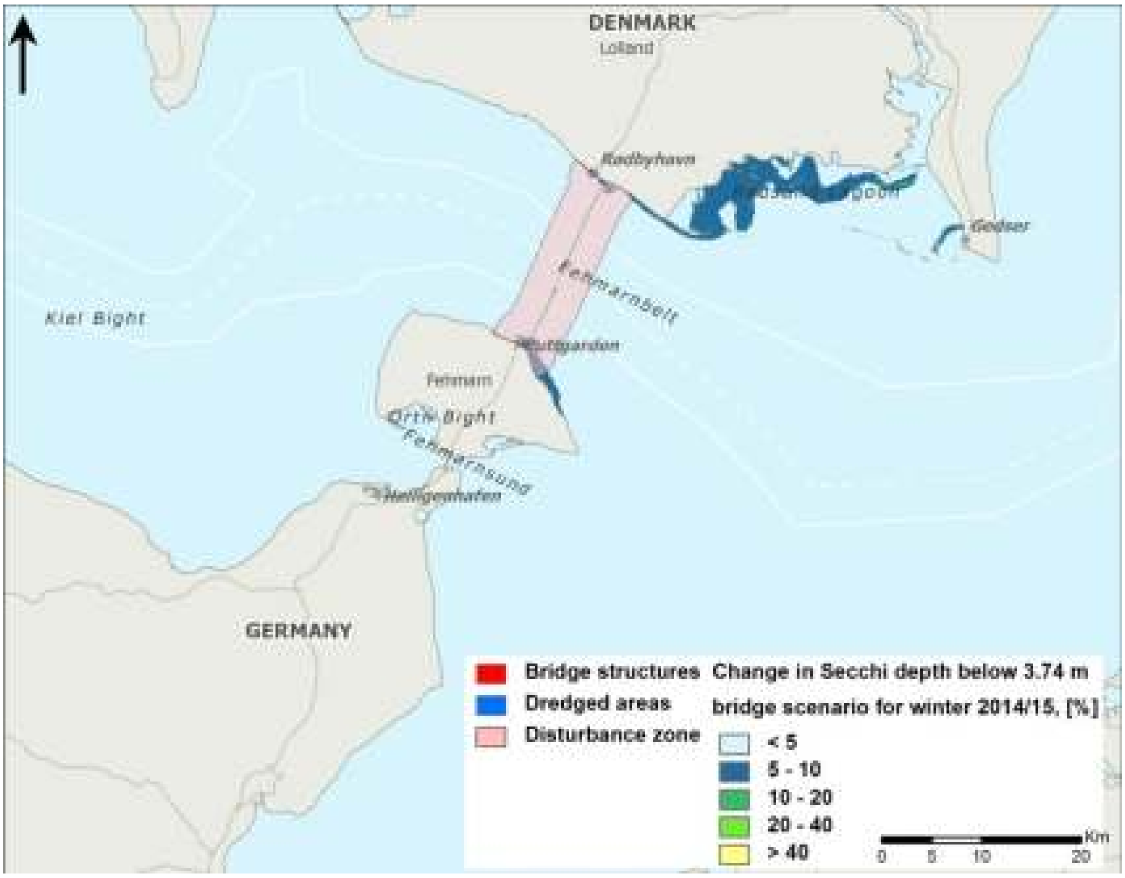


Figure 10.54 Pressures and their spatial overlap in the Fehmarnbelt during the bridge construction.

The following set of rules was applied when making the overall assessment:

- Footprint structures would fall completely within the disturbance zone, and since both pressures were assumed to result in a complete exclusion of birds, only the disturbance zone was considered in the overall assessment.

- Decreased water transparency was the other pressure, which was assumed to result in a complete exclusion of birds. Because it partly overlaps with the disturbance zone, the overlapping area was excluded from the overall assessment (i.e. no double displacement of birds of that area).

Cumulative assessment for species, for which continuous spatial distribution maps were not available, was done by simple summing of all separate pressures despite their partial overlap. (The footprint structures, which completely fall within the disturbance zone, were not included.)

For none of the species the aggregation of the pressures causing a displacement of birds led to a higher overall severity level than already reached by one of the pressures alone (Table 10.26).

The assessment of significance was conducted following the description in chapter 4.5.14 and the introduction to this chapter. No significant impact was identified to result during the construction period of a cable stayed bridge in the Fehmarnbelt for any non-breeding waterbird species in the area (Table 10.26). Displacement of highly important numbers of Common Pochard and Tufted Duck were regarded to result mostly in redistribution of birds and no population effect resulting from the impact is expected to occur. Therefore, the impact on the Common Pochard and the Tufted Duck is assessed being insignificant.

Table 10.26 Cumulative assessment of separate pressures during the bridge construction after accounting for their spatial overlap and assessment of project significance to non-breeding waterbird species. Number of displaced birds 'Minor' means that low numbers corresponding to less than 0.1% of the biogeographic population would be affected.

Species	Number of displaced birds due to			Total number of displaced birds	Severity of impairment		Significance
	Disturbance*	Water transparency	Sediment spill		Barrier from constr. vessels	Collision with constr. vessels	
Divers	8	10	Minor	17	Minor	Minor	Insignificant
Great Crested Grebe	Minor	Minor	Negligible	Minor	Negligible	Negligible	Insignificant
Red-necked Grebe	19	6	Minor	23	Minor	Minor	Insignificant
Slavonian Grebe	Minor	Minor	Negligible	Minor	Negligible	Negligible	Insignificant
Great Cormorant	500	Minor	Minor	500	Minor	Minor	Insignificant
Mute Swan	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Whooper Swan	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Bewick's Swan	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Bean Goose	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Greater White-fronted Goose	Minor	Negligible	Negligible	Minor	Negligible	Negligible	Insignificant
Greylag Goose	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Barnacle Goose	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Brent Goose	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Eurasian Wigeon	1,500	Minor	Minor	1,500	Minor	Minor	Insignificant
Gadwall	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Common Teal	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Mallard	Minor	Minor	Minor	Minor	Negligible	Negligible	Insignificant
Shoveler	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Common Pochard	710	Minor	Minor	710	Minor	Minor	Insignificant
Tufted Duck	7,100	Minor	Minor	7,100	Minor	Minor	Insignificant
Greater Scaup	130	Minor	Minor	130	Minor	Minor	Insignificant
Common Eider	3,919	2,029	Minor	4,969	Minor	Minor	Insignificant
Long-tailed Duck	110	174	Minor	273	Minor	Minor	Insignificant
Common Scoter	383	183	Minor	566	Minor	Minor	Insignificant
Velvet Scoter	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Common Goldeneye	54	Minor	Minor	54	Minor	Minor	Insignificant
Smew	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Red-breasted Merganser	115	158	Minor	230	Minor	Minor	Insignificant
Goosander	Minor	Minor	Negligible	Minor	Negligible	Negligible	Insignificant
White-tailed Eagle	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Common Coot	340	Minor	Minor	Minor	Minor	Minor	Insignificant

Species	Number of displaced birds due to			Total number of displaced birds	Severity of impairment		Significance
	Disturbance*	Water transparency	Sediment spill		Barrier from constr. vessels	Collision with constr. vessels	
Little Gull	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Black-headed Gull	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Common Gull	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Lesser Black-backed Gull	Minor	Negligible	Negligible	Minor	Negligible	Negligible	Insignificant
Herring Gull	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Great Black-backed Gull	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Sandwich Tern	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Common Tern	Minor	Negligible	Negligible	Minor	Negligible	Negligible	Insignificant
Arctic Tern	Minor	Negligible	Negligible	Minor	Negligible	Negligible	Insignificant
Common Guillemot	Minor	Minor	Negligible	Minor	Negligible	Negligible	Insignificant
Razorbill	10	0	Minor	10	Minor	Minor	Insignificant
Black Guillemot	Minor	Minor	Minor	Minor	Minor	Minor	Insignificant
Other species	Minor	Minor/ Negligible	Minor/ Negligible	Minor	Minor/ Negligible	Minor/ Negligible	Insignificant

** bird exclusion due to footprint structures is included in Disturbance due to complete overlap.*

Individual-based model for Common Eider

An individual-based model (IBM) for Common Eider has been used for simulations referring to the bridge impact scenario using the baseline IBM (FEBI 2013) with restricted bird access to areas that were predicted to be affected by disturbance and decreased water transparency (see chapter 4.6.2).

The IBM results representing simulations of the bridge scenario indicated that model eiders consumed a similar amount of food per day as during the baseline – approximately 5,000 of 14 mm mussels per day (Figure 9.80). This amount is about 30% lower than consumption estimates according to eider energy budget if birds relied exclusively on Blue Mussels (FEBI 2013). However, there is no discrepancy from actual Blue Mussel intake as these bivalves actually contribute about 70-80% of the total energy intake for Common Eiders in the Fehmarnbelt, as it was established by the diet analysis (FEBI 2013). Mussel consumption by Common Eiders according to the IBM simulations was on average 0.6% lower during the bridge impact scenario compared to the baseline. The difference was marginally statistically significant when comparing mussel intake rate at selected time steps during the winter period (paired t test: $t = 2.01$, $P = 0.048$, $df = 74$).

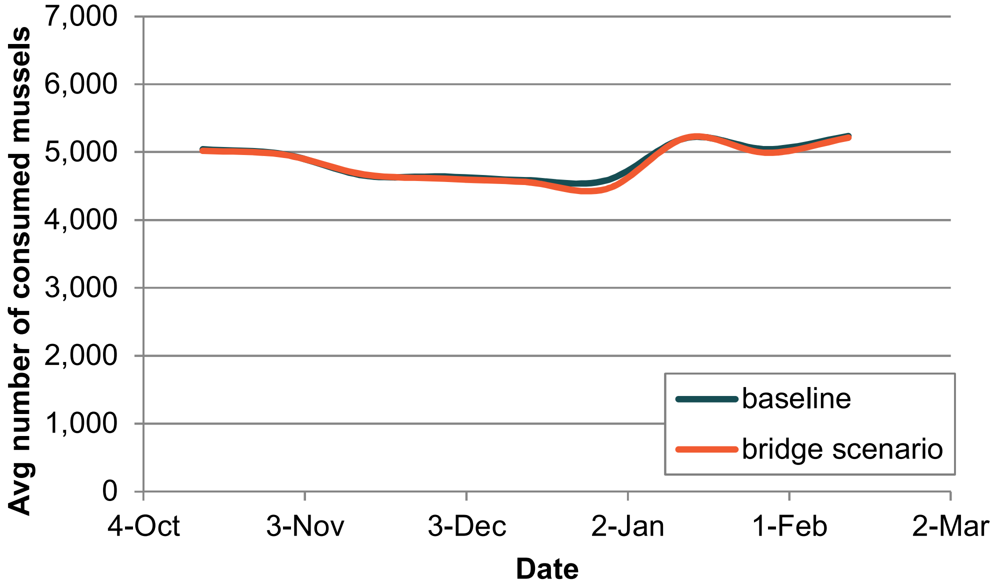


Figure 10.55 IBM-predicted daily consumption of 14 mm size Blue Mussels of by an individual Common Eider during the wintering season under the baseline conditions and bridge impact scenario.

The survival of modelled Common Eiders was slightly higher for the bridge scenario than that predicted for the baseline conditions. Simulations predicted that 600 birds would die due to starvation during the baseline conditions and 200 during the cable stayed bridge impact scenario. Such levels of mortality account for 0.2% and 0.08% respectively of the total number of birds used in the simulations (250,000) lasting the entire wintering period of 6 months. Natural mortality of adult Common Eiders is at least 7% per annum (Balmer and Peach 1997). Therefore predicted starvation-induced mortality comprises only a small fraction of overall natural mortality. It is likely that mortality levels predicted by the baseline and bridge impact scenarios reflect variability of individual fitness as built in the IBM design.

Further, dynamics of body mass of model birds was compared between the baseline and bridge impact scenarios. The simulations predicted very similar body mass development in both cases (Figure 9.81). Pairwise comparison of the mean body mass of all individuals during selected time steps of simulations showed that birds were on average 1.55 g (95% CI = 1.29-1.80) lighter in the bridge impact scenario, the difference being significant (paired t test, $t = 12.05$, $P < 0.01$, $df = 287$). Although statistically significant, the difference comprises less than 0.1% of average adult Common Eider body mass, and model individuals under both simulation scenarios (baseline and bridge) reach target body mass by the end of the wintering season.

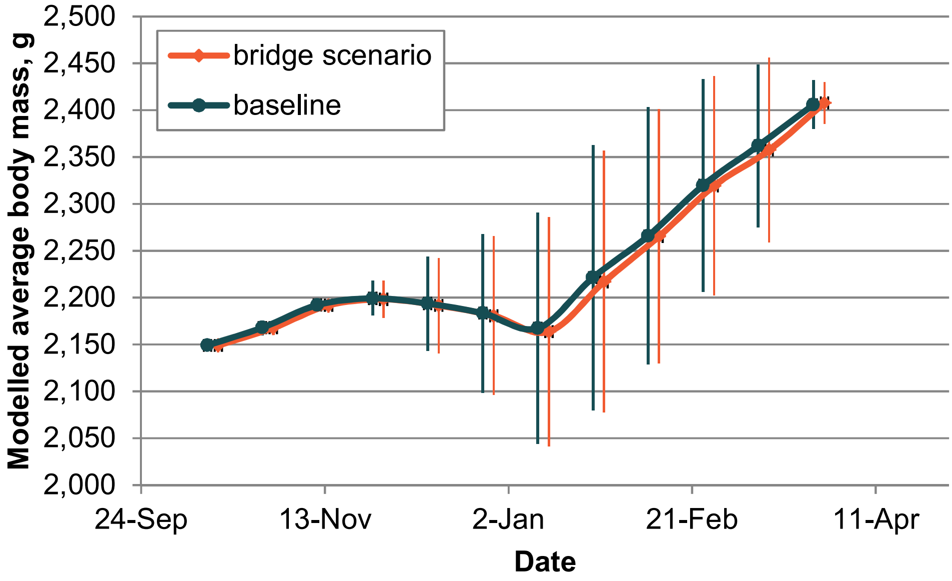


Figure 10.56 Mean body mass of Common Eiders (with bars indicating standard deviation) as predicted by the IBM for baseline conditions and cable stayed bridge impact scenario when 250,000 birds were allowed to enter the model system.

Assessment of Common Eider habitat carrying capacity

It was assumed, that disturbance and decreased water transparency resulting from the bridge construction works may cause wintering eiders to temporarily abandon some areas and relocate elsewhere. Considering that displaced birds would redistribute locally within the Fehmarnbelt area, a series of simulations were run with gradually increasing numbers of wintering Common Eiders in the IBM with already included impacts of the bridge construction.

The model predicted that under the bridge impact scenario, bird mortality due to starvation would be slightly higher compared to the baseline conditions (Figure 9.82). However, the mortality would not become massive what would indicate widespread resource depletion, but would comprise at most 1.0% of all birds. Number of Common Eiders reaching 500,000 individuals in the Fehmarnbelt represents an unlikely scenario and has never been recorded there. This simulation exercise suggests that predicted higher mortality does not necessarily indicate general resource depletion beyond profitable levels, but that factors, such as bird density dependence and number of sub-dominant individuals, increase with increasing number of birds in the model system and also play a role. The predicted eider mortality in the simulations did not follow the increasing bird numbers in a strictly linear way (e.g., it predicted slightly lower mortality of birds for the bridge scenario with 500,000 individuals compared to the scenario with 450,000 birds), which is another indication that stochastic factors built into the model were driving some of the mortalities and therefore bird survival was not depending exclusively on food resource availability.

Finally, dynamics of body mass development of the model birds indicated that average body mass of wintering individuals had a tendency to be slightly lower when their numbers were artificially increased, but by the end of the wintering season birds reached the target weight under all scenarios (Figure 9.83).

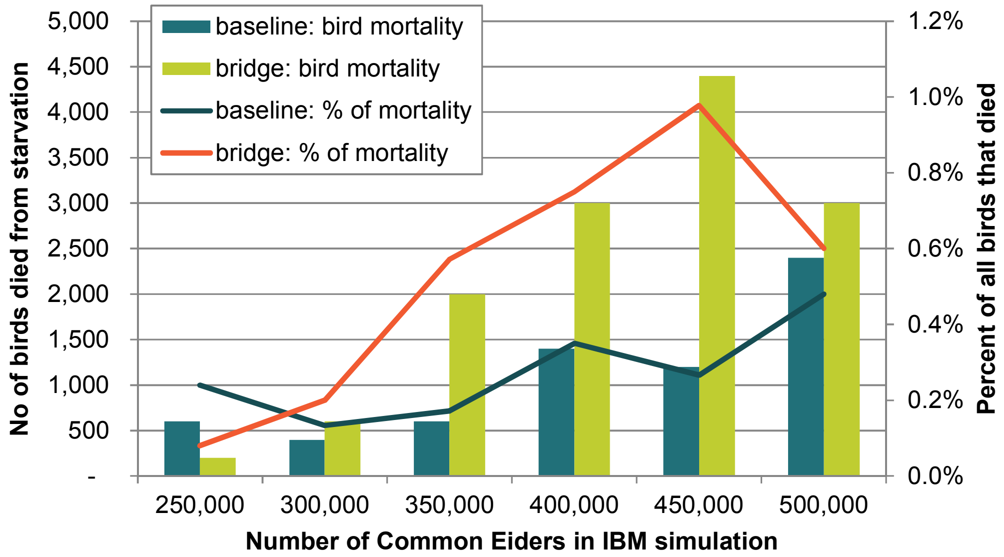


Figure 10.57 IBM-predicted Common Eider mortality due to starvation during the wintering season depending on the number of birds allowed into the model system under the baseline conditions and cable stayed bridge scenario.

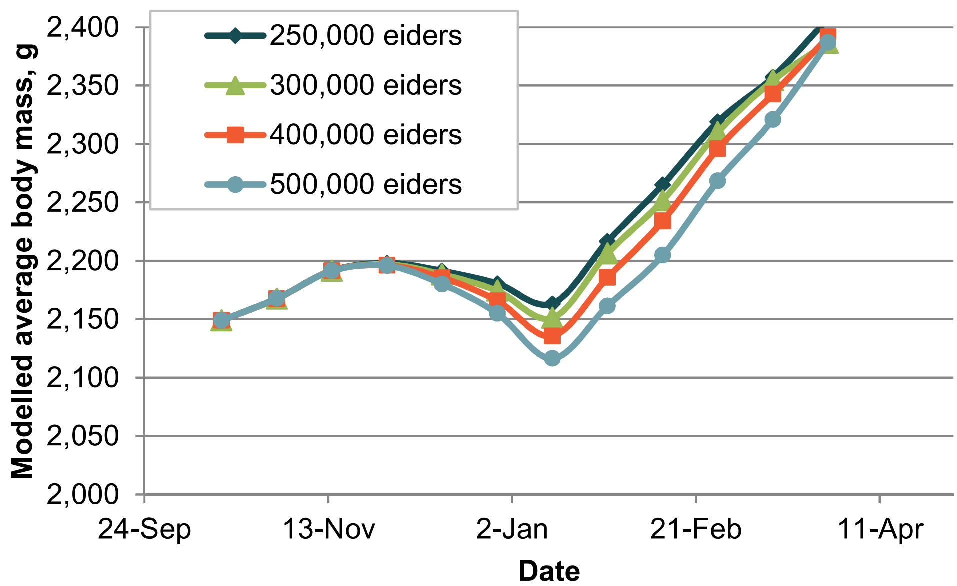


Figure 10.58 Measuring habitat carrying capacity for Common Eiders under the cable stayed bridge scenario: simulations with increasing number of birds (250 – 500 thousands) in the model system indicated that higher numbers of birds have led to slightly lower mean body mass.

The IBM predicted that 250,000 Common Eiders would consume a total of about 3,000 tonnes of AFDW of Blue Mussels per wintering season in order to satisfy their energetic requirements. It was estimated that during the baseline scenario Common Eiders consume about 10.7% of the initial standing stock of Blue Mussels per wintering season. During the scenario representing possible impacts of the cable stayed bridge, the initial standing stock of Blue Mussels that is potentially available for birds would be about 6% lower (26,300 tonnes AFWD) and therefore Common Eider consumption would account for 11.4% of the total potentially available biomass (Table 9.27).

Table 10.27 Initial biomass of Blue Mussels and their consumption by wintering Common Eiders during the baseline and cable stayed bridge impact scenario.

	Baseline	Cable stayed bridge impact scenario
Number of birds	250,000	250,000
Biomass of Blue Mussels, t AFDW	28,000	26,300
Mussel consumption by eiders, t AFDW	3,000	3,000
Mussel consumption by eiders, %	10.7%	11.4%

Opinions vary about the amount of food that wintering seaducks need for satisfying their energetic demands. Laursen et al. (2010) suggested that Common Eiders wintering in the Danish Wadden Sea need a standing stock of Blue Mussels that exceed the birds' physiological needs at least 2.5 times. Camphuysen et al. (2002) reported mass mortality of starving Common Eider in the Dutch Wadden Sea even though estimated stock of bivalves 4.7 times exceeded bird physiological demands.

The individual-based model indicates that possible impacts on wintering Common Eiders arising from the construction of the cable stayed bridge (habitat loss, complete displacement from areas affected by construction-related disturbance and decreased water transparency), would cause a minor severity of impairment on the species and there would be no measureable additional mortality, but small reduction in mean body mass could be detected during mid-winter. Furthermore, according to the IBM simulations, the carrying capacity of the Fehmarnbelt as Common Eider habitat is well above the number of birds that are actually using this ecosystem, even when accounting for the potential impacts of the bridge construction scenario.

Structure and operation

Several pressures from structure and operation of a cable stayed bridge were assessed for their impacts on non-breeding waterbirds (Table 10.28). Habitat loss from the permanent bridge footprint is predicted to result in a minor severity of loss to all non-breeding waterbird species in the area.

The pressures 'provision of artificial reefs' and 'hydrographical changes' are assessed not to result in any displacement of non-breeding waterbirds from the area. Therefore, the severity of impairment from both pressures is assessed as being negligible to minor to all non-breeding waterbirds in the area.

Disturbance from bridge structure is assessed to be of high severity of impairment for the Common Pochard and the Tufted Duck. A medium severity of impairment is assessed for the Common Eider. Displacement from the disturbance zone is assessed to result in negligible to minor severity of impairment to all other non-breeding waterbird species. There is no additional displacement resulting from disturbance from channelling of shipping predicted for any non-breeding waterbird species. Therefore, the severity of impairment to this pressure is assessed to be negligible to minor.

A barrier effect from a bridge structure is assessed qualitatively based on the sensitivity of the different species to disturbance from the bridge and results of effect studies on other Baltic Sea bridges. The severity of impairment is assessed to be high for divers (Red-throated Diver and Black-throated Diver), scoters (Common Scoter and Velvet Scoter) and Black Guillemot. A medium severity of impairment is assessed for Red-necked Grebe, Eurasian Wigeon, diving ducks, other seaducks than scoters, Red-breasted Merganser and Razorbill. For all other non-breeding waterbird species occurring in the Fehmarnbelt area the severity of impairment from a barrier effect from a bridge structure is assessed to be negligible to minor.

The severity of impairment from collision with bridge structures is assessed to be medium for the nocturnal diving duck species Common Pochard, Tufted Duck and Greater Scaup. For all other non-breeding waterbird species the severity of impairment is assessed to be negligible to minor.

Collision with traffic is assessed to result in negligible to minor severity of impairment to all non-breeding waterbird species in the area.

Table 10.28 Summary of the assessment of pressure-specific severity of impact (loss/impairment) for non-breeding waterbirds from the structure and during operation of a cable stayed bridge in Fehmarnbelt.

Species	Loss	Impairment						
	Habitat loss from footprint	Provision of artificial reefs	Hydrographical changes from bridge pillars	Disturbance from bridge structure and traffic	Disturbance from channelling of shipping	Barrier from bridge structure	Collision with bridge structures	Collision with traffic
Divers	Minor	No impact	No impact	Minor	Minor	High	Minor	Minor
Great Crested Grebe	Minor	No impact	No impact	Minor	Minor	Minor	Negligible	Negligible
Red-necked Grebe	Minor	No impact	No impact	Minor	Minor	Medium	Minor	Minor
Slavonian Grebe	Minor	No impact	No impact	Minor	Minor	Minor	Negligible	Negligible
Great Cormorant	Minor	No impact	No impact	Minor	Minor	Minor	Minor	Minor
Mute Swan	Minor	No impact	No impact	Minor	Minor	Minor	Minor	Minor
Bewick's Swan	Minor	No impact	No impact	Minor	Minor	Minor	Minor	Minor
Whooper Swan	Minor	No impact	No impact	Minor	Minor	Minor	Minor	Minor
Bean Goose	Minor	No impact	No impact	Minor	Minor	Minor	Minor	Minor
Greater White-fronted Goose	Minor	No impact	No impact	Minor	Minor	Minor	Negligible	Negligible
Greylag Goose	Minor	No impact	No impact	Minor	Minor	Minor	Minor	Minor
Barnacle Goose	Minor	No impact	No impact	Minor	Minor	Minor	Minor	Minor
Brent Goose	Minor	No impact	No impact	Minor	Minor	Minor	Minor	Minor
Eurasian Wigeon	Minor	No impact	No impact	Minor	Minor	Medium	Minor	Minor
Gadwall	Minor	No impact	No impact	Minor	Minor	Minor	Minor	Minor
Common Teal	Minor	No impact	No impact	Minor	Minor	Minor	Minor	Minor
Mallard	Minor	No impact	No impact	Minor	Negligible	Minor	Negligible	Negligible
Shoveler	Minor	No impact	No impact	Minor	Minor	Minor	Minor	Minor
Common Pochard	Minor	No impact	No impact	High	Minor	Medium	Medium	Minor
Tufted Duck	Minor	No impact	No impact	High	Minor	Medium	Medium	Minor
Greater Scaup	Minor	No impact	No impact	Minor	Minor	Medium	Medium	Minor
Common Eider	Minor	No impact	No impact	Medium	Minor	Medium	Minor	Minor
Long-tailed Duck	Minor	No impact	No impact	Minor	Minor	Medium	Minor	Minor
Common Scoter	Minor	No impact	No impact	Minor	Minor	High	Minor	Minor
Velvet Scoter	Minor	No impact	No impact	Minor	Minor	High	Minor	Minor
Common Goldeneye	Minor	No impact	No impact	Minor	Minor	Medium	Minor	Minor

Species	Loss	Impairment						
	Habitat loss from footprint	Provision of artificial reefs	Hydrographical changes from bridge pillars	Disturbance from bridge structure and traffic	Disturbance from channelling of shipping	Barrier from bridge structure	Collision with bridge structures	Collision with traffic
Smew	Minor	No impact	No impact	Minor	Minor	Minor	Minor	Minor
Red-breasted Merganser	Minor	No impact	No impact	Minor	Minor	Medium	Minor	Minor
Goosander	Minor	No impact	No impact	Minor	Negligible	Minor	Negligible	Negligible
White-tailed Eagle	Minor	No impact	No impact	Minor	Minor	Minor	Minor	Minor
Common Coot	Minor	No impact	No impact	Minor	Minor	Minor	Minor	Minor
Little Gull	Minor	No impact	No impact	Minor	Minor	Minor	Minor	Minor
Black-headed Gull	Minor	No impact	No impact	Minor	Minor	Minor	Minor	Minor
Common Gull	Minor	No impact	No impact	Minor	Minor	Minor	Minor	Minor
Lesser Black-backed Gull	Minor	No impact	No impact	Negligible	Negligible	Negligible	Negligible	Minor
Herring Gull	Minor	No impact	No impact	Minor	Minor	Minor	Minor	Minor
Great Black-backed Gull	Minor	No impact	No impact	Minor	Minor	Minor	Minor	Minor
Sandwich Tern	Minor	No impact	No impact	Minor	Minor	Minor	Minor	Minor
Common Tern	Minor	No impact	No impact	Negligible	Negligible	Negligible	Negligible	Negligible
Arctic Tern	Minor	No impact	No impact	Negligible	Negligible	Negligible	Negligible	Negligible
Common Guillemot	Minor	No impact	No impact	Minor	Minor	Minor	Negligible	Negligible
Razorbill	Minor	No impact	No impact	Minor	Minor	Medium	Minor	Minor
Black Guillemot	Minor	No impact	No impact	Minor	Minor	High	Minor	Minor
Other species	Minor	No impact	No impact	Minor/ Negligible	Minor/ Negligible	Minor/ Negligible	Minor/ Negligible	Minor/ Negligible

Separate pressures from structures during operation of a cable stayed bridge partly or fully overlap. The bridge footprint structures would fall completely within the anticipated disturbance zone from bridge structure and traffic. Since both pressures were assumed to result in a complete exclusion of birds, only the disturbance zone was considered in the overall assessment (Table 10.29). The pressures 'provision of artificial reefs', 'hydrographical changes' and 'disturbance from channelling of shipping' are assessed to not result in detectable displacement of birds. Thus, the overall number of displaced birds from the structure during operation of a bridge in Fehmarnbelt was assumed to correspond with the number of birds assessed to be displaced by disturbance from bridge structure and traffic. Therefore, no spatial analysis was conducted for the cumulative assessment of separate pressures.

The assessment of significance was conducted following the description in chapter 4.5.14 and the introduction to this chapter. No significant impact was identified to result from structure during operation of a cable stayed bridge in Fehmarnbelt for any non-breeding waterbird species in the area (Table 10.29). Displacement of highly important numbers of Common Pochard and Tufted Duck were regarded to result mostly in a redistribution of birds and no population effects resulting from the impact are expected to occur. Therefore, the impact on Common Pochard and Tufted Duck is assessed being insignificant. High and medium barrier effects assessed for different waterbird species are regarded to affect local movements and increase energy expenditures of individual birds in the area, but no impact on population level is predicted. Therefore, the impact from barrier from bridge and traffic is assessed to be insignificant to all non-breeding waterbird species in the Fehmarnbelt. Expected collision numbers with either construction vessels or the bridge structures and traffic during operation are assessed to stay well below the calculated thresholds of the Potential Biological Removal for non-breeding waterbird species (see chapter 8). Therefore, there is no significant impact predicted to result from additional mortality caused by the project.

Table 10.29 Cumulative assessment of separate pressures from structure and during operation of a cable stayed bridge in Fehmarnbelt after accounting for their spatial overlap and assessment of project significance to non-breeding waterbird species. 'Total number of displaced birds' equals to the estimate of number of displaced birds from disturbance from bridge structure and traffic (bird exclusion due to footprint structures is included due to complete overlap of impact areas; no additional displacement from other pressures). Number of displaced birds 'Minor' means that low numbers corresponding to less than 0.1% of the biogeographic population would be affected.

Species	Total number of displaced birds	Impairment			Overall impair-ment from collision	Significance
		Barrier from bridge structure	Collision with bridge structures	Collision with traffic		
Divers	6	High	Minor	Minor	Minor	Insignificant
Great Crested Grebe	Minor	Minor	Negligible	Negligible	Negligible	Insignificant
Red-necked Grebe	8	Medium	Minor	Minor	Minor	Insignificant
Slavonian Grebe	Minor	Minor	Negligible	Negligible	Negligible	Insignificant
Great Cormorant	500	Minor	Minor	Minor	Minor	Insignificant
Mute Swan	Minor	Minor	Minor	Minor	Minor	Insignificant
Whooper Swan	Minor	Minor	Minor	Minor	Minor	Insignificant
Bewick's Swan	Minor	Minor	Minor	Minor	Minor	Insignificant
Bean Goose	Minor	Minor	Minor	Minor	Minor	Insignificant
Greater White-fronted Goose	Minor	Minor	Negligible	Negligible	Negligible	Insignificant
Greylag Goose	Minor	Minor	Minor	Minor	Minor	Insignificant
Barnacle Goose	Minor	Minor	Minor	Minor	Minor	Insignificant
Brent Goose	Minor	Minor	Minor	Minor	Minor	Insignificant
Eurasian Wigeon	Minor	Minor	Minor	Minor	Minor	Insignificant
Gadwall	Minor	Minor	Minor	Minor	Minor	Insignificant
Common Teal	Minor	Minor	Minor	Minor	Minor	Insignificant
Mallard	Minor	Minor	Negligible	Negligible	Negligible	Insignificant
Shoveler	Minor	Minor	Minor	Minor	Minor	Insignificant
Common Pochard	710	Medium	Medium	Minor	Medium	Insignificant
Tufted Duck	7,100	Medium	Medium	Minor	Medium	Insignificant
Greater Scaup	130	Medium	Medium	Minor	Medium	Insignificant
Common Eider	1,889	Medium	Minor	Minor	Minor	Insignificant
Long-tailed Duck	61	Medium	Minor	Minor	Minor	Insignificant
Common Scoter	118	High	Minor	Minor	Minor	Insignificant
Velvet Scoter	Minor	High	Minor	Minor	Minor	Insignificant
Common Goldeneye	23	Medium	Minor	Minor	Minor	Insignificant
Smew	Minor	Minor	Minor	Minor	Minor	Insignificant
Red-breasted Merganser	53	Medium	Minor	Minor	Minor	Insignificant
Goosander	Minor	Minor	Negligible	Negligible	Negligible	Insignificant

Species	Total number of displaced birds	Impairment			Overall impair-ment from collision	Significance
		Barrier from bridge structure	Collision with bridge structures	Collision with traffic		
White-tailed Eagle	Minor	Minor	Minor	Minor	Minor	Insignificant
Common Coot	Minor	Minor	Minor	Minor	Minor	Insignificant
Little Gull	Minor	Minor	Minor	Minor	Minor	Insignificant
Black-headed Gull	Minor	Minor	Minor	Minor	Minor	Insignificant
Common Gull	Minor	Minor	Minor	Minor	Minor	Insignificant
Lesser Black-backed Gull	Minor	Negligible	Negligible	Minor	Negligible	Insignificant
Herring Gull	Minor	Minor	Minor	Minor	Minor	Insignificant
Great Black-backed Gull	Minor	Minor	Minor	Minor	Minor	Insignificant
Sandwich Tern	Minor	Minor	Minor	Minor	Minor	Insignificant
Common Tern	Minor	Negligible	Negligible	Negligible	Negligible	Insignificant
Arctic Tern	Minor	Negligible	Negligible	Negligible	Negligible	Insignificant
Common Guillemot	Minor	Minor	Negligible	Negligible	Negligible	Insignificant
Razorbill	6	Medium	Minor	Minor	Minor	Insignificant
Black Guillemot	Minor	High	Minor	Minor	Minor	Insignificant
Other species	Minor	Minor/ Negligible	Minor/ Negligible	Minor/ Negligible	Minor/ Negligible	Insignificant

10.4.3 Migrating birds

Construction phase

Similar to the immersed tunnel, two pressures were identified to be relevant for migrating birds during the construction of a cable stayed bridge in the Fehmarnbelt: barrier from construction vessels and collision with construction vessels (Table 10.30). Both pressures are assessed to result in negligible or minor severity of impairment to the migrating birds in the area. Therefore, the significance of the project impact during the construction phase is assessed to be insignificant for all migrating bird species passing the Fehmarnbelt.

Table 10.30 Summary of the assessment of pressure-specific severity of impairment and overall significance of impairment for migrating birds during the construction phase of a cable stayed bridge in Fehmarnbelt.

Species	Impairment		Significance
	Barrier from construction vessels	Collision with construction vessels	
Red-throated Diver	Minor	Minor	Insignificant
Black-throated Diver	Minor	Minor	Insignificant
Great Crested Grebe	Minor	Minor	Insignificant
Red-necked Grebe	Minor	Minor	Insignificant
Slavonian Grebe	Minor	Minor	Insignificant
Northern Gannet	Minor	Minor	Insignificant
Great Cormorant	Minor	Minor	Insignificant
Grey Heron	Negligible	Negligible	Insignificant

Species	Impairment		Significance
	Barrier from construction vessels	Collision with construction vessels	
White Stork	Minor	Minor	Insignificant
Mute Swan	Minor	Minor	Insignificant
Bewick's Swan	Minor	Minor	Insignificant
Whooper Swan	Minor	Minor	Insignificant
Bean Goose	Minor	Minor	Insignificant
Greater White-fronted Goose	Negligible	Negligible	Insignificant
Greylag Goose	Minor	Minor	Insignificant
Barnacle Goose	Minor	Minor	Insignificant
Brent Goose	Minor	Minor	Insignificant
Common Shelduck	Negligible	Negligible	Insignificant
Eurasian Wigeon	Minor	Minor	Insignificant
Gadwall	Minor	Minor	Insignificant
Common Teal	Negligible	Negligible	Insignificant
Mallard	Negligible	Negligible	Insignificant
Northern Pintail	Minor	Minor	Insignificant
Garganey	Negligible	Negligible	Insignificant
Northern Shoveler	Minor	Minor	Insignificant
Common Pochard	Negligible	Negligible	Insignificant
Tufted Duck	Negligible	Negligible	Insignificant
Greater Scaup	Minor	Minor	Insignificant
Common Eider	Minor	Minor	Insignificant
Long-tailed Duck	Negligible	Negligible	Insignificant
Common Scoter	Minor	Minor	Insignificant
Velvet Scoter	Negligible	Negligible	Insignificant
Common Goldeneye	Negligible	Negligible	Insignificant
Red-breasted Merganser	Minor	Minor	Insignificant
Goosander	Negligible	Negligible	Insignificant
Honey-Buzzard	Minor	Minor	Insignificant
Black Kite	Minor	Minor	Insignificant
Red Kite	Minor	Minor	Insignificant
White-tailed Eagle	Minor	Minor	Insignificant
Marsh Harrier	Minor	Minor	Insignificant
Northern (Hen) Harrier	Minor	Minor	Insignificant
European Sparrow Hawk	Minor	Minor	Insignificant
Eurasian Buzzard	Minor	Minor	Insignificant
Rough-legged Buzzard	Negligible	Negligible	Insignificant
Osprey	Minor	Minor	Insignificant
Eurasian Kestrel	Minor	Minor	Insignificant
Red-footed Falcon	Minor	Minor	Insignificant
Merlin	Minor	Minor	Insignificant
Hobby	Negligible	Negligible	Insignificant
Peregrine Falcon	Minor	Minor	Insignificant
Common Crane	Minor	Minor	Insignificant
Waterrail	Minor	Minor	Insignificant

Species	Impairment		Significance
	Barrier from construction vessels	Collision with construction vessels	
Corncrake	Minor	Minor	Insignificant
Moorhen	Minor	Minor	Insignificant
Common Coot	Minor	Minor	Insignificant
Oystercatcher	Negligible	Negligible	Insignificant
Avocet	Minor	Minor	Insignificant
Little Ringed Plover	Negligible	Negligible	Insignificant
Ringed Plover	Negligible	Negligible	Insignificant
Golden Plover	Minor	Minor	Insignificant
Grey Plover	Minor	Minor	Insignificant
Lapwing	Negligible	Negligible	Insignificant
Knot	Minor	Minor	Insignificant
Sanderling	Negligible	Negligible	Insignificant
Curlew Sandpiper	Minor	Minor	Insignificant
Dunlin	Minor	Minor	Insignificant
Ruff	Negligible	Negligible	Insignificant
Common Snipe	Negligible	Negligible	Insignificant
Bar-tailed Godwit	Minor	Minor	Insignificant
Whimbrel	Negligible	Negligible	Insignificant
Curlew	Minor	Minor	Insignificant
Spotted Redshank	Negligible	Negligible	Insignificant
Redshank	Negligible	Negligible	Insignificant
Greenshank	Negligible	Negligible	Insignificant
Green Sandpiper	Negligible	Negligible	Insignificant
Wood Sandpiper	Negligible	Negligible	Insignificant
Common Sandpiper	Negligible	Negligible	Insignificant
Turnstone	Negligible	Negligible	Insignificant
Arctic Skua	Minor	Minor	Insignificant
Great Skua	Minor	Minor	Insignificant
Mediterranean Gull	Negligible	Negligible	Insignificant
Little Gull	Minor	Minor	Insignificant
Black-headed Gull	Minor	Minor	Insignificant
Common Gull	Minor	Minor	Insignificant
Lesser Black-backed Gull	Negligible	Negligible	Insignificant
Herring Gull	Minor	Minor	Insignificant
Great Black-backed Gull	Minor	Minor	Insignificant
Sandwich Tern	Minor	Minor	Insignificant
Common Tern	Minor	Minor	Insignificant
Arctic Tern	Minor	Minor	Insignificant
Little Tern	Minor	Minor	Insignificant
Black Tern	Negligible	Negligible	Insignificant
Common Guillemot	Negligible	Negligible	Insignificant
Razorbill	Negligible	Negligible	Insignificant
Black Guillemot	Negligible	Negligible	Insignificant
Stock Dove	Minor	Minor	Insignificant

Species	Impairment		Significance
	Barrier from construction vessels	Collision with construction vessels	
Woodpigeon	Minor	Minor	Insignificant
Collared Dove	Negligible	Negligible	Insignificant
Long-eared Owl	Minor	Minor	Insignificant
Short-eared Owl	Minor	Minor	Insignificant
Cuckoo	Negligible	Negligible	Insignificant
Swift	Negligible	Negligible	Insignificant
Great Spotted Woodpecker	Negligible	Negligible	Insignificant
Eurasian Jay	Negligible	Negligible	Insignificant
Black-billed Magpie	Negligible	Negligible	Insignificant
Eurasian Jackdaw	Minor	Minor	Insignificant
Rook	Minor	Minor	Insignificant
Carrion Crow	Negligible	Negligible	Insignificant
Obligatory daytime migrating passerines	Minor	Minor	Insignificant
Facultative night-time migrating passerines	Minor	Minor	Insignificant
Obligatory night-time migrating passerines	Minor	Minor	Insignificant
Other species	Minor/Negligible	Minor/Negligible	Insignificant

Structure and operation
Only pressures regarding barrier or collision are considered relevant for migrating bird species.

Barrier from bridge structure is assessed qualitatively based on the sensitivity of the different species to a barrier effect from the bridge and results of effect studies on other Baltic Sea bridges. The severity of impairment is assessed to be very high for the auk species Common Guillemot, Razorbill and Black Guillemot, and high for the Common Scoter. A medium severity of impairment is assessed for Red-necked and Slavonian Grebe, all swan species, some goose species, some dabbling duck species, seaducks other than scoters and Red-breasted Merganser. For all other migrating species occurring in the Fehmarnbelt area the severity of impairment from barrier from bridge structure is assessed to be negligible or minor.

The severity of impairment from collision with bridge structures is assessed to be medium for the nocturnally active waterbird species with a migration direction most likely perpendicular to the alignment. The severity of impairment is also assessed to be medium for the rail species (Waterrail, Corncrake, Moorhen, Common Coot), some gull and tern species and two owl species. Passerine species which are facultative or obligatory nocturnal migrants are also assessed medium. For all other migrating species the severity of impairment is assessed to be negligible or minor. Estimated collision numbers with either construction vessels or the bridge structures and traffic during operation are assessed to be well below thresholds of Potential Biological Removal for all migrating bird species for which PBR calculations are available (see chapter 8). Therefore, no significant impact is predicted on migrating birds from additional mortality caused by the project.

Collision with traffic is assessed to result in negligible to minor severity of impairment to all non-breeding waterbird species in the area.

For the three auk species the very high barrier effect leading to a significant impact is assessed. It had to be assumed that the barrier effect from a bridge would preclude auks from crossing the fixed link at all. This is assessed as a significant impact, since this could affect a greater part of the auk populations than actually using the Fehmarnbelt study area and thus result in a population effect to these species. For the Common Scoter, although high severity of impairment from barrier effect was assessed, the impact is evaluated as insignificant, because it is assumed that Common Scoters would be able to migrate on alternative routes, e.g. during night-time over land and therefore would be able to reach both their breeding and wintering grounds.

Table 10.31 Summary of the assessment of pressure-specific severity of impairment and overall significance of impairment for migrating birds from the structure and during operation of a cable stayed bridge in the Fehmarnbelt.

Species	**Impairment**			**Overall impairment from collision**	**Significance**
	Barrier from bridge structure	**Collision with bridge structures**	**Collision with traffic**		
Red-throated Diver	Medium	Medium	Minor	Medium	Insignificant
Black-throated Diver	Medium	Medium	Minor	Medium	Insignificant
Great Crested Grebe	Minor	Minor	Minor	Minor	Insignificant
Red-necked Grebe	Medium	Medium	Minor	Medium	Insignificant
Slavonian Grebe	Medium	Medium	Minor	Medium	Insignificant
Northern Gannet	Minor	Negligible	Negligible	Negligible	Insignificant
Great Cormorant	Minor	Minor	Minor	Minor	Insignificant
Grey Heron	Negligible	Negligible	Negligible	Negligible	Insignificant
White Stork	Minor	Negligible	Minor	Negligible	Insignificant
Mute Swan	Medium	Medium	Minor	Medium	Insignificant
Bewick's Swan	Medium	Medium	Minor	Medium	Insignificant
Whooper Swan	Medium	Medium	Minor	Medium	Insignificant
Bean Goose	Medium	Medium	Minor	Medium	Insignificant
Greater White-fronted Goose	Minor	Minor	Negligible	Minor	Insignificant
Greylag Goose	Minor	Medium	Minor	Medium	Insignificant
Barnacle Goose	Medium	Medium	Minor	Medium	Insignificant
Brent Goose	Medium	Medium	Minor	Medium	Insignificant
Common Shelduck	Minor	Minor	Negligible	Minor	Insignificant
Eurasian Wigeon	Medium	Medium	Minor	Medium	Insignificant
Gadwall	Medium	Medium	Minor	Medium	Insignificant
Common Teal	Minor	Minor	Negligible	Minor	Insignificant
Mallard	Minor	Minor	Negligible	Minor	Insignificant
Northern Pintail	Medium	Medium	Minor	Medium	Insignificant
Garganey	Minor	Minor	Negligible	Minor	Insignificant
Northern Shoveler	Medium	Medium	Minor	Medium	Insignificant
Common Pochard	Minor	Minor	Negligible	Minor	Insignificant
Tufted Duck	Minor	Minor	Negligible	Minor	Insignificant
Greater Scaup	Medium	Medium	Minor	Medium	Insignificant
Common Eider	High	Medium	Minor	Medium	Insignificant

Species	Impairment			Overall impairment from collision	Significance
	Barrier from bridge structure	Collision with bridge structures	Collision with traffic		
Long-tailed Duck	Minor	Minor	Negligible	Minor	Insignificant
Common Scoter	High	Medium	Minor	Medium	Insignificant
Velvet Scoter	Minor	Minor	Negligible	Minor	Insignificant
Common Goldeneye	Minor	Minor	Negligible	Minor	Insignificant
Red-breasted Merganser	Medium	Minor	Minor	Minor	Insignificant
Goosander	Minor	Negligible	Negligible	Negligible	Insignificant
Honey-Buzzard	Minor	Minor	Minor	Minor	Insignificant
Black Kite	Minor	Minor	Minor	Minor	Insignificant
Red Kite	Minor	Minor	Minor	Minor	Insignificant
White-tailed Eagle	Minor	Minor	Minor	Minor	Insignificant
Marsh Harrier	Minor	Minor	Minor	Minor	Insignificant
Northern (Hen) Harrier	Minor	Minor	Minor	Minor	Insignificant
European Sparrow Hawk	Minor	Minor	Minor	Minor	Insignificant
Eurasian Buzzard	Minor	Minor	Minor	Minor	Insignificant
Rough-legged Buzzard	Negligible	Negligible	Negligible	Negligible	Insignificant
Osprey	Minor	Minor	Minor	Minor	Insignificant
Eurasian Kestrel	Minor	Minor	Minor	Minor	Insignificant
Red-footed Falcon	Minor	Minor	Minor	Minor	Insignificant
Merlin	Minor	Minor	Minor	Minor	Insignificant
Hobby	Negligible	Negligible	Negligible	Negligible	Insignificant
Peregrine Falcon	Minor	Minor	Minor	Minor	Insignificant
Common Crane	Minor	Minor	Minor	Minor	Insignificant
Waterrail	Minor	Medium	Minor	Medium	Insignificant
Corncrake	Minor	Medium	Minor	Medium	Insignificant
Moorhen	Minor	Medium	Minor	Medium	Insignificant
Common Coot	Minor	Medium	Minor	Medium	Insignificant
Oystercatcher	Negligible	Negligible	Negligible	Negligible	Insignificant
Avocet	Minor	Minor	Minor	Minor	Insignificant
Little Ringed Plover	Negligible	Negligible	Negligible	Negligible	Insignificant
Ringed Plover	Negligible	Negligible	Negligible	Negligible	Insignificant
Golden Plover	Minor	Minor	Minor	Minor	Insignificant
Grey Plover	Minor	Minor	Minor	Minor	Insignificant
Lapwing	Negligible	Negligible	Negligible	Negligible	Insignificant
Knot	Minor	Minor	Minor	Minor	Insignificant
Sanderling	Negligible	Negligible	Negligible	Negligible	Insignificant
Curlew Sandpiper	Minor	Minor	Minor	Minor	Insignificant
Dunlin	Minor	Minor	Minor	Minor	Insignificant
Ruff	Negligible	Negligible	Negligible	Negligible	Insignificant
Common Snipe	Negligible	Negligible	Negligible	Negligible	Insignificant
Bar-tailed Godwit	Minor	Minor	Minor	Minor	Insignificant
Whimbrel	Negligible	Negligible	Negligible	Negligible	Insignificant
Curlew	Minor	Minor	Minor	Minor	Insignificant
Spotted Redshank	Negligible	Negligible	Negligible	Negligible	Insignificant
Redshank	Negligible	Negligible	Negligible	Negligible	Insignificant

Species	Impairment			Overall impairment from collision	Significance
	Barrier from bridge structure	Collision with bridge structures	Collision with traffic		
Greenshank	Negligible	Negligible	Negligible	Negligible	Insignificant
Green Sandpiper	Negligible	Negligible	Negligible	Negligible	Insignificant
Wood Sandpiper	Negligible	Negligible	Negligible	Negligible	Insignificant
Common Sandpiper	Negligible	Negligible	Negligible	Negligible	Insignificant
Turnstone	Negligible	Negligible	Negligible	Negligible	Insignificant
Arctic Skua	Minor	Minor	Minor	Minor	Insignificant
Great Skua	Minor	Minor	Minor	Minor	Insignificant
Mediterranean Gull	Negligible	Minor	Negligible	Minor	Insignificant
Little Gull	Minor	Medium	Minor	Medium	Insignificant
Black-headed Gull	Minor	Medium	Minor	Medium	Insignificant
Common Gull	Minor	Medium	Minor	Medium	Insignificant
Lesser Black-backed Gull	Negligible	Minor	Minor	Minor	Insignificant
Herring Gull	Minor	Medium	Minor	Medium	Insignificant
Great Black-backed Gull	Minor	Medium	Minor	Medium	Insignificant
Sandwich Tern	Minor	Medium	Minor	Medium	Insignificant
Common Tern	Minor	Medium	Minor	Medium	Insignificant
Arctic Tern	Minor	Minor	Minor	Minor	Insignificant
Little Tern	Minor	Minor	Minor	Minor	Insignificant
Black Tern	Negligible	Negligible	Negligible	Negligible	Insignificant
Common Guillemot	Very high	Negligible	Negligible	Negligible	Significant
Razorbill	Very high	Negligible	Negligible	Negligible	Significant
Black Guillemot	Very high	Negligible	Negligible	Negligible	Significant
Stock Dove	Minor	Minor	Minor	Minor	Insignificant
Woodpigeon	Minor	Minor	Minor	Minor	Insignificant
Collared Dove	Negligible	Negligible	Negligible	Negligible	Insignificant
Long-eared Owl	Minor	Medium	Minor	Medium	Insignificant
Short-eared Owl	Minor	Medium	Minor	Medium	Insignificant
Cuckoo	Negligible	Minor	Negligible	Minor	Insignificant
Swift	Negligible	Negligible	Negligible	Negligible	Insignificant
Great Spotted Woodpecker	Negligible	Negligible	Negligible	Negligible	Insignificant
Eurasian Jay	Negligible	Negligible	Negligible	Negligible	Insignificant
Black-billed Magpie	Negligible	Negligible	Negligible	Negligible	Insignificant
Eurasian Jackdaw	Minor	Minor	Minor	Minor	Insignificant
Rook	Minor	Minor	Minor	Minor	Insignificant
Carrion Crow	Negligible	Negligible	Minor	Negligible	Insignificant
Obligatory daytime migrating passerines	Minor	Minor	Minor	Minor	Insignificant
Facultative night-time migrating passerines	Minor	Medium	Minor	Medium	Insignificant
Obligatory night-time migrating passerines	Minor	Medium	Minor	Medium	Insignificant
Other species	Minor/ Negligible	Minor/ Negligible	Minor/ Negligible	Minor/ Negligible	Insignificant

10.5 Cumulative impacts

This section describes the probable and significant cumulative impacts of the fixed link in conjunction with other projects.

10.5.1 Included projects and possible interactions

When more projects within the same region affect the same environmental conditions at the same time, there are cumulative impacts. For a project to be relevant to include, it requires that the project:

- is within the same geographic area
- has some of the same impacts as the fixed link
- affects some of the same environmental conditions, habitats or components
- creates new environmental impacts during the period from the environmental investigations were completed to the fixed link is in operation.

The following projects at sea are considered relevant to include in the assessment of cumulative impacts on different environmental conditions. All of them are offshore wind farms:

Project	Placement	Phase	Possible interactions
Arkona Becken Südost	Northeast of Rügen	Construction	Sediment spill, displacement, collision risk, barrier effect
EnBW Windpark Baltic II	Southeast of Kriegers Flak	Construction	Sediment spill, displacement, collision risk, barrier effect
Wikinger	Northeast of Rügen	Construction	Sediment spill, displacement, collision risk, barrier effect
Rødsand II	In front of Lolland's southern coast	Operation	Coastal morphology, collision risk, barrier effect
Kriegers Flak II	Kriegers Flak	Construction	Sediment spill, displacement, collision risk, barrier effect
GEOFReE	Lübeck Bay	Construction	Sediment spill, displacement, collision risk

Rødsand II (Figure 10.59) is specifically included, as this is a project that went into operation, while Femern A/S conducted its environmental investigations, whereby a cumulative effect in principle cannot be excluded.

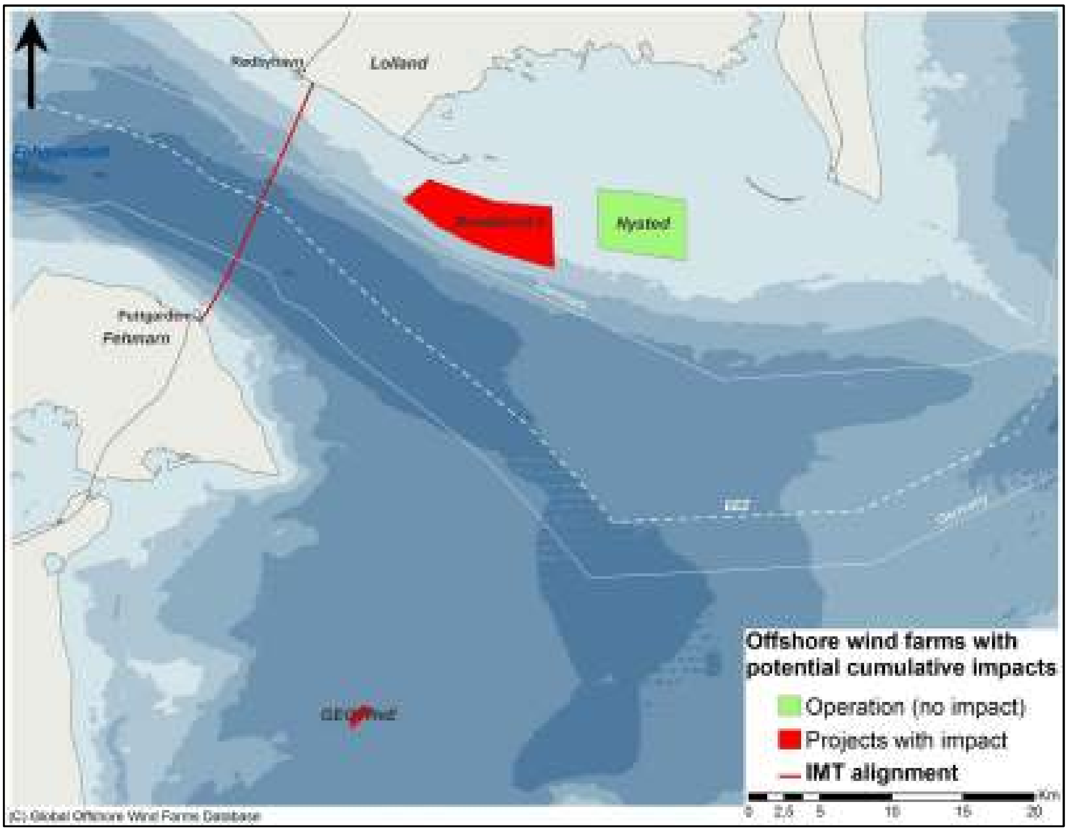


Figure 10.59 Locations of Rødsand II, Nysted and GEOFreE.

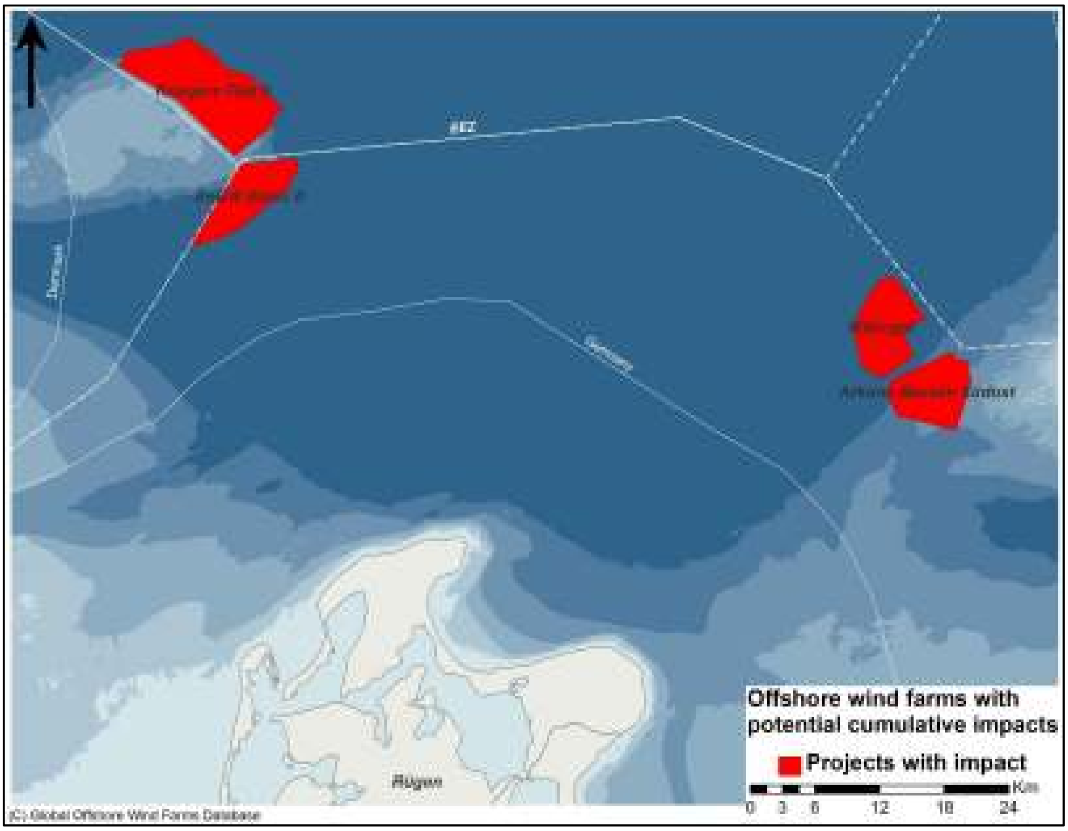


Figure 10.60 Locations of Kriegers Flak, EnBW Baltic II, Wikinger and Arkona Becken Südost.

10.5.2 Assessment and significance of impact

Breeding waterbirds

Breeding waterbirds of the Rødsand Lagoon might be affected by the presence of the Rødsand II wind farm, while the other projects are not relevant in this respect due to the large distance to Fehmarnbelt. Of the breeding bird community of the area only gulls and terns may use the open sea area of the wind farm for foraging flights. Both species groups are assumed to be of low sensitivity against disturbance and barrier effects and no relevant impact are assumed (e.g. Kahlert et al. 2007). Gulls do collide with wind turbines on land and thus they might be sensitive towards collisions with offshore turbines especially at coastal sites and this would add to collisions with traffic on a bridge. As the EIA for the Rødsand II wind farm (Kahlert et al. 2007) does not conclude this being a relevant impact, it is considered that no relevant cumulative impacts occur.

Non-breeding waterbirds

Cumulative effects for non-breeding waterbirds need to be assessed with respect to habitat loss and displacement for the Rødsand II wind farm, as well as for the pressure collision. The other wind farms at Kriegers Flak and north of Rügen are situated in a rather large distance to the Fehmarnbelt and due to higher water depth and different sediments it is of low importance for seaducks and other birds for which Fehmarnbelt is important (Vattenfall undat., BSH 2005, 2006, 2007b). Therefore only Rødsand II is considered for cumulative impacts with respect to a fixed link across Fehmarnbelt. The pressure barrier leads to higher than minor severity of impairment for some species. However, for resident birds the pressure from the wind farm is considered to be less relevant and sufficiently covered under displacement from the wind farm area.

The Rødsand II wind farm, which has been erected in the years 2009 and 2010, is situated east of the alignment of a fixed link and covers an area of 35 km^2. It borders to the existing wind farm Nysted. Based on studies on previously constructed offshore wind farms the EIA report on birds expects high displacement of sensitive waterbird species as seaducks and divers from the wind farm area and a 2 km zone around it (Kahlert et al. 2007) and provides calculations for two scenarios of the number of Long-tailed Ducks. For other species, it is concluded that no impacts on population level are expected. However, no numbers are presented.

The bridge solution leads during the construction period to higher than minor severity of impairment from habitat loss and displacement for the following species: Eurasian Wigeon (medium), Common Pochard (high), Tufted Duck (high) and Common Eider (medium). During operation, impacts on non-breeding waterbirds are higher than minor for Common Pochard (high), Tufted Duck (high) and Common Eider (medium).

For the Common Eider, during construction the same applies as for the tunnel solution. Impacts partly overlap and are thus only partly cumulative. Further, the impacts from the bridge construction are lower than for the tunnel alternative, thus no significant cumulative impacts are expected.

Based on the FEBI baseline investigations and assuming a complete displacement of Common Eider from the wind farm area and the surrounding, up to 5,800 Eider would be displaced. Impacts from construction and operation of a bridge solution would add to this, though during construction only partly as impacts overlap. The displacement effect from the wind farm has been fully incorporated in the

Individual-based model (see chapter 10.4.2) and is thus included in the assessment of significance. The conclusion of the assessment is that the combined effects of the tunnel and the offshore wind farm Rødsand II wind farm are insignificant.

The pressure collision leads to higher than minor severity of impairment for Pochard, Tufted Duck and Scaup (all medium). There may be some collision risk for these species in the wind farm but according to the assessment of impacts on birds (Kahlert et al. 2007) collision risk of waterbirds at the Rødsand II offshore wind farm is considered to be low and thus cumulative impacts are assessed to be insignificant.

Bird migration

Cumulative effects for migrating birds need to be assessed with respect to barrier effect and collisions. Due to long distances covered by migratory birds all offshore wind farms as listed above will be considered.

Of the planned offshore wind farms, the projects at Kriegers Flak and north of Rügen are located outside important bird migration areas (Vattenfall undat., BSH 2005, 2006, 2007b). Those species which pass in high numbers through the Fehmarnbelt occur in much lower numbers in these wind farm areas. The wind farm GEOFReE in the Lübeck Bay is also not in the migration flyways of those birds migrating through or across the Fehmarnbelt. However, the Danish wind farm Rødsand II, is in close vicinity to the alignment, and for birds migrating over water it lies on the same migration route.

The bridge solution leads during operation to higher than minor severity of impairment from the pressure 'barrier from bridge structure' for the species listed in Table 10.14.

Table 10.14 Assessment of the severity of impairment, regarding migrating birds and the pressure 'barrier from bridge structure' during operation of a bridge in the Fehmarnbelt.

Species	Importance level	Sensitivity / degree of impairment	Severity of impairment
Red-throated Diver	High	Medium	Medium
Black-throated Diver	High	Medium	Medium
Red-necked Grebe	Medium	Medium	Medium
Slavonian Grebe	High	Medium	Medium
Mute Swan	Medium	Medium	Medium
Bewick's Swan	High	Medium	Medium
Whooper Swan	High	Medium	Medium
Bean Goose	Medium	Medium	Medium
Barnacle Goose	Very high	Medium	Medium
Brent Goose	Very high	Medium	Medium
Eurasian Wigeon	Medium	Medium	Medium
Gadwall	High	Medium	Medium
Northern Pintail	Very high	Medium	Medium
Northern Shoveler	Very high	Medium	Medium
Greater Scaup	High	Medium	Medium
Common Eider	Very high	High	High

Species	Importance level	Sensitivity / degree of impairment	Severity of impairment
Common Scoter	Very high	High	High
Red-breasted Merganser	Very high	Medium	Medium
Common Guillemot	Minor	Very high	Very high
Razorbill	Minor	Very high	Very high
Black Guillemot	Minor	Very high	Very high
Other species			Minor/Negligible

The species, for which a medium to very high severity of impairment was assessed, prefer to migrate over water or may fly during night-time perpendicular to the alignment. The more pelagic species such as divers, grebes, mergansers and auks will preferably migrate in the middle of the Fehmarnbelt, while all other species (swans, geese, ducks) will migrate closer to the coast, which is close to the Lolland coast in spring and close to the Fehmarn coast in autumn.

For species mainly migrating close to the coast, the wind farm Rødsand II will be located in the migration routes, but is assessed to represent a limited barrier, as birds can fly around and detours were assessed to be insignificant compared to the total distance flown during their entire migration (Kahlert et al. 2007). The presence of the wind farm may lead to some changes in the spatial distribution of birds in the Fehmarnbelt, especially in autumn but no changes on numbers of birds migrating through Fehmarnbelt are expected. The pelagic species, divers, grebes, mergansers and auks, will be little affected, as they already prefer the middle of the Fehmarnbelt for their migration. For the other swan, geese and duck species, FEBI investigations showed, that a large proportion is migrating close to the Fehmarn coast, such that no change for these birds are to be expected. Thus, cumulative effects from the Rødsand II wind farm regarding the barrier effect are assessed to be insignificant. Cumulative effects regarding the other wind farms close to Rügen are also assessed to be insignificant, as those are not within the same migratory route.

Regarding collision risk, three cases have to be considered:

1. Birds migrating over water may be exposed to repeated collision risk along their migration route.

2. Night-time migrants migrating at broad-front across the Baltic Sea will have a statistical collision risk at each of the projects on population level, though individuals are unlikely to pass the fixed link and an offshore wind farm in the Baltic during the same migration season; effects would be additive on population level.

3. Daytime migrants preferring the shortest crossing distance across the Baltic Sea for their migration. These species are unlikely to come into contact with offshore wind farms and have also been assessed a minor severity of impairment for the collision risk with a bridge. For these species, no cumulative impacts with offshore wind farms will occur.

For the operation of a bridge the collision risk has been assessed as higher than minor severity from the pressure 'collision with bridge structures' for species listed in Table 10.20.

Table 10.20 Assessment of the severity of impairment, regarding migrating birds and the pressure 'collision with bridge structures' during operation of a bridge in the Fehmarnbelt.

Species	Importance level	Sensitivity / degree of impairment	Severity of impairment
Red-throated Diver	High	Medium	Medium
Black-throated Diver	High	Medium	Medium
Red-necked Grebe	Medium	Medium	Medium
Slavonian Grebe	High	Medium	Medium
Mute Swan	Medium	Medium	Medium
Bewick's Swan	High	Medium	Medium
Whooper Swan	High	Medium	Medium
Bean Goose	Medium	Medium	Medium
Greylag Goose	Very High	Medium	Medium
Barnacle Goose	Very High	Medium	Medium
Brent Goose	Very High	Medium	Medium
Eurasian Wigeon	Medium	Medium	Medium
Gadwall	High	Medium	Medium
Northern Pintail	Very High	Medium	Medium
Northern Shoveler	Very High	Medium	Medium
Greater Scaup	High	Medium	Medium
Common Eider	Very High	Medium	Medium
Common Scoter	Very High	Medium	Medium
Little Gull	Very High	Medium	Medium
Black-headed Gull	Medium	Medium	Medium
Rails spp.	NA	Medium	Medium
Common Gull	High	Medium	Medium
Herring Gull	Medium	Medium	Medium
Great Black-backed Gull	Medium	Medium	Medium
Sandwich Tern	Very High	Medium	Medium
Common Tern	High	Medium	Medium
Long-eared Owl	NA	Medium	Medium
Short-eared Owl	NA	Medium	Medium
Obligatory nocturnal migrating passerines	Medium	Medium/High	Medium
Facultative nocturnal migrating passerines	Medium	Medium/High	Medium
Other species			Minor/Negligible

It must be noted, that the assessments of the severity of impairment for these species and species groups listed in Table 10.20 are precautionary, as applied collision scenarios result in collision rates and numbers corresponding to less than 0.1% of the respective migrating bird populations, for which a minor severity of impairment would be concluded. Collision risk has been assessed as being insignificant, thus no impacts on population level are concluded.

Collision risk at offshore wind farms is assumed to be driven by similar factors as described for the bridge: as long as birds are not attracted by light, collisions will be stochastic events. Available data suggest potentially very small collision rates, and population effects are not expected. However, scenarios of a situation in which all proposed offshore wind farms are erected in the Baltic Sea show, that for some species collision rates close to the calculated PBR values could possibly be reached, but is has been stated, that considerable uncertainties do not yet allow for a full assessment (Bellebaum et al. 2010). It is concluded, that the considered offshore wind farms Rødsand II and those at Kriegers Flak and north of Rügen will increase the collision rates of each of these species, but that the cumulative effect – based on current knowledge – is still insignificant.

10.6 Assessment of impacts of decommissioning of bridge constructions

Decommissioning is foreseen to take place in the year 2140, when the fixed link has been in operation for the design lifetime of 120 years. It is likely that methods for removing structures and reuse of materials will evolve over a time span of more than 100 years. Also it is likely that new methods will be less polluting as a result of development of green technologies. However, it is not possible to predict these changes, and therefore it is assumed that decommissioning will be carried out using methods similar to the ones available today. This is expected to result in a conservative estimate of the environmental impacts.

Any structure on the seabed will be levelled with the seabed in order to allow then undisturbed ship traffic, fishery and similar activities at sea. There is no navigational requirement to remove structures below seabed level.

The majority of bridge components are foreseen to be transported to shore for further dis-mantling. This will require a designated facility, possibly a shipyard, harbour area or a purpose-built installation. A significant part of the environmental impacts will arise at this location.

The decommissioning and removal of the Fehmarnbelt Bridge structures and installations is considered to comprise the following:

- Stripping the bridge superstructure of all technical equipment
- Dismantling of the bridge superstructure by reversal of the construction methods and transportation of the bridge girder components to shore for further demolition and scrapping.
- The pylons to be cut in-situ into elements with a reasonable weight that can be handled by cranes. The elements are transported to shore for further demolition.
- The pylon caissons to be removed by in-situ demolition of the plinth, de-ballasting and re-floating of the caisson and towing it to a near shore location for further demolition. Demolition of the base plate and lower parts of the walls will require a dry dock or earth basin.
- The pier caissons to be removed by removal of internal ballast material, removal of scour protection and backfill material around the caisson and lifting of the caissons with a Heavy Lift Vessel and transportation to shore for further demolition. Pile inclusions for soil improvement are situated below the natural seabed. Removal is therefore not required.
- Piers to be cut from their caissons and transported to shore with a Heavy Lift Vessel for further demolition.

- Ship collision protection structures to be removed by reversing the construction method. This involves emptying the crushed stone from the central compartment and in-situ cutting the outer ring into the four original sections. The gravel in the outer ring is grouted and therefore re-floating the elements is not possible. The elements are lifted with a Heavy Lift Vessel and towed to a near shore location for further demolition.

- The gallery is constructed as an in-situ cast concrete element supported by piers. The gallery to be cut into elements with a reasonable weight that can be handled by cranes.

- For ramp viaduct and embankment the roadway surfacing asphalt to be removed. Roadbases to be removed. Railway tracks to be removed. In industrial areas, no further activities to be carried out and the area to be sold as industrial site. In farming areas, the remaining embankment to be levelled to a slope of no more than 6% and covered with topsoil, in order to be sold as farmland.

- The peninsulas to be removed by reversing the construction method. After removing the gallery, the high quality sand core and stone revetments to be removed and reused. Finally the quarry run dikes on either side to be excavated and reused.

- No demolition of the motorway overpass on Fehmarn is foreseen.

- The area for customs control will remain in operation as the need for authority control will remain as long as a traffic connection with Germany is maintained, whether fixed or ferry based. The toll plaza is continued as battery changing station for electrical vehicles or other transport related services.

10.6.1 Impacts during decommissioning of cable stayed bridge

Generally, the activities related to decommissioning of the cable stayed bridge are foreseen to be carried out in reverse order of the construction.

The impacts on marine birds during decommissioning of the cable stayed bridge are considered to be at the same level as for the construction regarding disturbance related pressures, barrier effect and collision risk, or lower regarding pressures related to sediment spill (habitat change, water transparency).

No significant impacts have been identified for the construction of the cable stayed bridge.

10.6.2 Impacts after decommissioning of cable stayed bridge

No impacts on marine birds are foreseen after completion of the decommissioning work for the cable stayed bridge.

The seabed areas from where the collision protection structures/pylons and the peninsulas will after completion reverse as a habitat for marine flora and fauna.

11 COMPARISON OF BRIDGE AND TUNNEL MAIN ALTERNATIVES

For the comparison of bridge and tunnel main alternatives the three different environmental components – breeding waterbirds, non-breeding waterbirds and migrating birds – are considered separately. Due to the different impact predictions for different bird species (groups) the comparison of the main alternatives for each environmental component is conducted on the species (group) level. The comparison of the main alternatives is based on the results of the cumulative assessment of the tunnel and bridge alternatives (see chapter 9.4 and 10.4), where the impact of different pressures was aggregated to three impact categories according to the effect of the impact: displacement (from the pressures habitat loss, disturbance, water transparency, habitat change), barrier effect and collisions (collision with construction vessels, structures and traffic, i.e. mortality).

Pressures resulting in displacement of non-breeding waterbirds from lost/impaired areas are assessed quantitatively based on the numbers of displaced birds (see pressure chapters in chapter 9 and 10). Therefore, it was possible to also assess the aggregated impact resulting in displacement based on the total number of birds predicted to be displaced after accounting for overlays of different pressures. For differentiation between assessment results for particular pressures (severity of loss/severity of impairment) and the result of the assessment of the overall impact, the latter is called 'overall severity of impact'.

Firstly, the severity levels assessed for the different species for either alternative are compared separately for the construction and the operation phase. If there is no difference in the severity levels of a particular pressure between the alternatives, zeros (0) indicate a comparable assessment for both alternatives. If the assessment of severity level for a pressure is the same (or minor severity *versus* no impact), but a slight advantage of one of the alternatives is predicted, this is indicated by '(+)'. The number of '+' signs indicate the degree of advantage in severity levels (+ one level difference – advantage (e.g. minor severity *versus* medium severity); ++ two levels difference - strong advantage; +++ three levels difference - very strong advantage). Secondly, it is compared if a significant project impact is predicted to result from either alternative during construction or from structure during operation. Finally, for each environmental component a concluding statement comparing both main alternatives is given.

11.1 Breeding waterbirds

11.1.1 Construction phase

All pressures relevant for waterbirds breeding in Natura 2000 sites in the Fehmarnbelt area are assessed to result in a minor severity of impairment to the different species (Table 11.1). Pressures resulting in displacement of birds, such as habitat loss from footprint, disturbance from construction vessels, decreased water transparency and habitat change, affect different areas for the tunnel and bridge alternatives. However, for none of the main alternatives a detectable reduction in bird numbers is predicted to occur.

For the pressures barrier from and collision with construction vessels for both main alternatives, a minor severity of impairment was assessed for breeding waterbirds (Table 11.1).

Table 11.1 Comparison of overall assessment of bridge and tunnel main alternatives during the construction phase to breeding waterbird species. This assessment was conducted for waterbirds breeding in Natura 2000 areas only.

Species	**Construction phase**					
	TUNNEL			**BRIDGE**		
	Displace-ment	**Barrier from constr. vessels**	**Collision with constr. vessels**	**Displace-ment**	**Barrier from constr. vessels**	**Collision with constr. vessels**
Red-necked Grebe	Minor	Minor	Minor	Minor	Minor	Minor
Great Cormorant	Minor	Minor	Minor	Minor	Minor	Minor
Common Heron	Minor	Minor	Minor	Minor	Minor	Minor
Mute Swan	Minor	Minor	Minor	Minor	Minor	Minor
Greylag Goose	Minor	Minor	Minor	Minor	Minor	Minor
Common Eider	Minor	Minor	Minor	Minor	Minor	Minor
Red-breasted Merganser	Minor	Minor	Minor	Minor	Minor	Minor
Goosander	Minor	Minor	Minor	Minor	Minor	Minor
White-tailed Eagle	Minor	Minor	Minor	Minor	Minor	Minor
Oystercatcher	Minor	Minor	Minor	Minor	Minor	Minor
Avocet	Minor	Minor	Minor	Minor	Minor	Minor
Redshank	Minor	Minor	Minor	Minor	Minor	Minor
Mediterranean Gull	Minor	Minor	Minor	Minor	Minor	Minor
Black-headed Gull	Minor	Minor	Minor	Minor	Minor	Minor
Common Gull	Minor	Minor	Minor	Minor	Minor	Minor
Herring Gull	Minor	Minor	Minor	Minor	Minor	Minor
Great Black-backed Gull	Minor	Minor	Minor	Minor	Minor	Minor
Sandwich Tern	Minor	Minor	Minor	Minor	Minor	Minor
Common Tern	Minor	Minor	Minor	Minor	Minor	Minor
Arctic Tern	Minor	Minor	Minor	Minor	Minor	Minor
Little Tern	Minor	Minor	Minor	Minor	Minor	Minor
Other species	Minor	Minor	Minor	Minor	Minor	Minor

Due to the smaller footprint and smaller areas predicted to be impaired from disturbance and sediment spill (reduced water transparency and habitat change), the bridge construction is regarded to have a slight advantage in comparison to the tunnel construction (Table 11.2).

No detectable differences between the impact from barrier and collision risk from construction vessels on breeding waterbirds are predicted between the two main alternatives, though construction vessel activities would vary between the project alternatives (Table 11.2).

Table 11.2 Comparison of overall assessment of bridge and tunnel main alternatives during the construction phase to breeding waterbird species. This assessment was conducted for waterbirds breeding in Natura 2000 areas only. Zeros (0) in cells mean: no difference between alternatives; no differences in severity of impairment levels; (+): slight advantage; detectable difference in numbers of birds affected, but difference within the same level of severity of impairment; +: advantage results in one level difference between severity of impairment levels; ++: strong advantage results in two levels of difference between severity of impairment levels; +++: very strong advantage results in three levels of difference between severity of impairment levels.

Species	Construction phase					
	TUNNEL			BRIDGE		
	Displace-ment	Barrier from constr. vessels	Collision with constr. vessels	Displace-ment	Barrier from constr. vessels	Collision with constr. vessels
Red-necked Grebe		0	0	(+)	0	0
Great Cormorant		0	0	(+)	0	0
Common Heron		0	0	(+)	0	0
Mute Swan		0	0	(+)	0	0
Greylag Goose		0	0	(+)	0	0
Common Eider		0	0	(+)	0	0
Red-breasted Merganser		0	0	(+)	0	0
Goosander		0	0	(+)	0	0
White-tailed Eagle		0	0	(+)	0	0
Oystercatcher		0	0	(+)	0	0
Avocet		0	0	(+)	0	0
Redshank		0	0	(+)	0	0
Mediterranean Gull		0	0	(+)	0	0
Black-headed Gull		0	0	(+)	0	0
Common Gull		0	0	(+)	0	0
Herring Gull		0	0	(+)	0	0
Great Black-backed Gull		0	0	(+)	0	0
Sandwich Tern		0	0	(+)	0	0
Common Tern		0	0	(+)	0	0
Arctic Tern		0	0	(+)	0	0
Little Tern		0	0	(+)	0	0
Other species		0	0	(+)	0	0

Significance

The project impact is assessed to be insignificant for all waterbird species breeding in Natura 2000 areas during the construction period of both, tunnel and bridge main alternatives.

11.1.2 Operation and structures

During operation of a fixed link, displacement of birds due to habitat loss (both alternatives) and disturbance from structure and traffic (only bridge alternative) is predicted to have a minor overall severity of impact on breeding waterbirds in the area for either of the main alternatives (Table 11.3). The pressures barrier effect and collision with structure and traffic are not relevant for the tunnel alternative (no impact), but these are assessed to result in minor severity of impairment for the different breeding waterbird species for the bridge alternative (Table 11.3).

Table 11.3 Comparison of overall assessment of bridge and tunnel main alternatives from structure and during the operation to breeding waterbird species. This assessment was conducted for waterbirds breeding in Natura 2000 areas only.

Species	Operation and structures					
	TUNNEL			BRIDGE		
	Displace-ment	Barrier from structure	Collision with structure	Displace-ment	Barrier from structure	Collision with structure and traffic
Red-necked Grebe	Minor	No impact	No impact	Minor	Minor	Minor
Great Cormorant	Minor	No impact	No impact	Minor	Minor	Minor
Common Heron	Minor	No impact	No impact	Minor	Minor	Minor
Mute Swan	Minor	No impact	No impact	Minor	Minor	Minor
Greylag Goose	Minor	No impact	No impact	Minor	Minor	Minor
Common Eider	Minor	No impact	No impact	Minor	Minor	Minor
Red-breasted Merganser	Minor	No impact	No impact	Minor	Minor	Minor
Goosander	Minor	No impact	No impact	Minor	Minor	Minor
White-tailed Eagle	Minor	No impact	No impact	Minor	Minor	Minor
Oystercatcher	Minor	No impact	No impact	Minor	Minor	Minor
Avocet	Minor	No impact	No impact	Minor	Minor	Minor
Redshank	Minor	No impact	No impact	Minor	Minor	Minor
Mediterranean Gull	Minor	No impact	No impact	Minor	Minor	Minor
Black-headed Gull	Minor	No impact	No impact	Minor	Minor	Minor
Common Gull	Minor	No impact	No impact	Minor	Minor	Minor
Herring Gull	Minor	No impact	No impact	Minor	Minor	Minor
Great Black-backed Gull	Minor	No impact	No impact	Minor	Minor	Minor
Sandwich Tern	Minor	No impact	No impact	Minor	Minor	Minor
Common Tern	Minor	No impact	No impact	Minor	Minor	Minor
Arctic Tern	Minor	No impact	No impact	Minor	Minor	Minor
Little Tern	Minor	No impact	No impact	Minor	Minor	Minor
Other species	Minor	No impact	No impact	Minor	Minor	Minor

Comparing the two main alternatives regarding displacement effects, both of them are assessed equally. Though different areas would be affected from habitat loss (tunnel footprint larger than bridge footprint) or disturbance (only from bridge with traffic) from either alternative no relevant difference in displaced numbers of birds from the affected areas is expected between tunnel and bridge alternatives (Table 11.4). The slight advantage of the smaller footprint of the bridge alternative is regarded to be compensated by the slight advantage of the tunnel alternative regarding the disturbance from structure and traffic during operation.

For the tunnel alternative there is no impact from barrier and collisions predicted for the operation phase. For the bridge alternative a minor severity of impairment is assessed to result from each of these pressures (Table 11.3). Therefore, regarding these pressures a slight advantage of the tunnel alternative is assessed (Table 11.4).

Table 11.4 Comparison of overall assessment of bridge and tunnel main alternatives from structure and during operation to breeding waterbird species. This assessment was conducted for waterbirds breeding in Natura 2000 areas only. Zeros (0) in cells mean: no difference between alternatives, no differences in severity of impairment levels; (+): slight advantage, detectable differences in numbers of birds affected, but within the same level of severity of impairment; +: advantage results in one level difference between severity of impairment levels; ++: strong advantage results in two levels of difference between severity of impairment levels; +++: very strong advantage results in three levels of difference between severity of impairment levels.

Species	Structure and operation					
	TUNNEL			BRIDGE		
	Displace-ment	Barrier from structure	Collision with structure and traffic	Displace-ment	Barrier from structure	Collision with structure and traffic
Red-necked Grebe	0	(+)	(+)	0		
Great Cormorant	0	(+)	(+)	0		
Common Heron	0	(+)	(+)	0		
Mute Swan	0	(+)	(+)	0		
Greylag Goose	0	(+)	(+)	0		
Common Eider	0	(+)	(+)	0		
Red-breasted Merganser	0	(+)	(+)	0		
Goosander	0	(+)	(+)	0		
White-tailed Eagle	0	(+)	(+)	0		
Oystercatcher	0	(+)	(+)	0		
Avocet	0	(+)	(+)	0		
Redshank	0	(+)	(+)	0		
Mediterranean Gull	0	(+)	(+)	0		
Black-headed Gull	0	(+)	(+)	0		
Common Gull	0	(+)	(+)	0		
Herring Gull	0	(+)	(+)	0		
Great Black-backed Gull	0	(+)	(+)	0		
Sandwich Tern	0	(+)	(+)	0		
Common Tern	0	(+)	(+)	0		
Arctic Tern	0	(+)	(+)	0		
Little Tern	0	(+)	(+)	0		
Other species	0	(+)	(+)	0		

Significance

The project impact from structure and during operation of both main alternatives is assessed to be insignificant for all waterbird species breeding in Natura 2000 sites of the Fehmarnbelt area.

11.1.3 Conclusion

Regarding breeding waterbirds for none of the main alternatives a significant impact is predicted and the severity of impairment levels of breeding waterbird species do not exceed minor for any pressure and fixed link alternative. During the construction phase a slight advantage is given for the bridge alternative. During the operation phase a slight advantage is predicted for the tunnel alternative. Regarding both, construction and operation, and taking the duration of impact into account a slight overall advantage is assigned to the tunnel alternative since this option has a slight advantage during the permanent operation phase.

11.2 Non-breeding waterbirds

11.2.1 Construction phase

During the construction phase of a fixed link across the Fehmarnbelt, different pressures are predicted to impair waterbirds resting, foraging and wintering in the area. Habitat loss from footprint, disturbance from construction vessels and direct and indirect impairments resulting from the sediment spill (direct: changes in Secchi depth; indirect: habitat change in terms of impairment of benthic prey communities due to sedimentation, suspended sediments and changes in mussel biomass due to reductions in marine phytoplankton) are predicted to result in displacement of non-breeding waterbirds from the respective lost/impaired areas. For both main alternatives the first construction year (2014/2015) is predicted to have the greatest impact on non-breeding waterbirds and is therefore chosen for the comparison of the main alternatives (Figure 11.1, Figure 11.2).

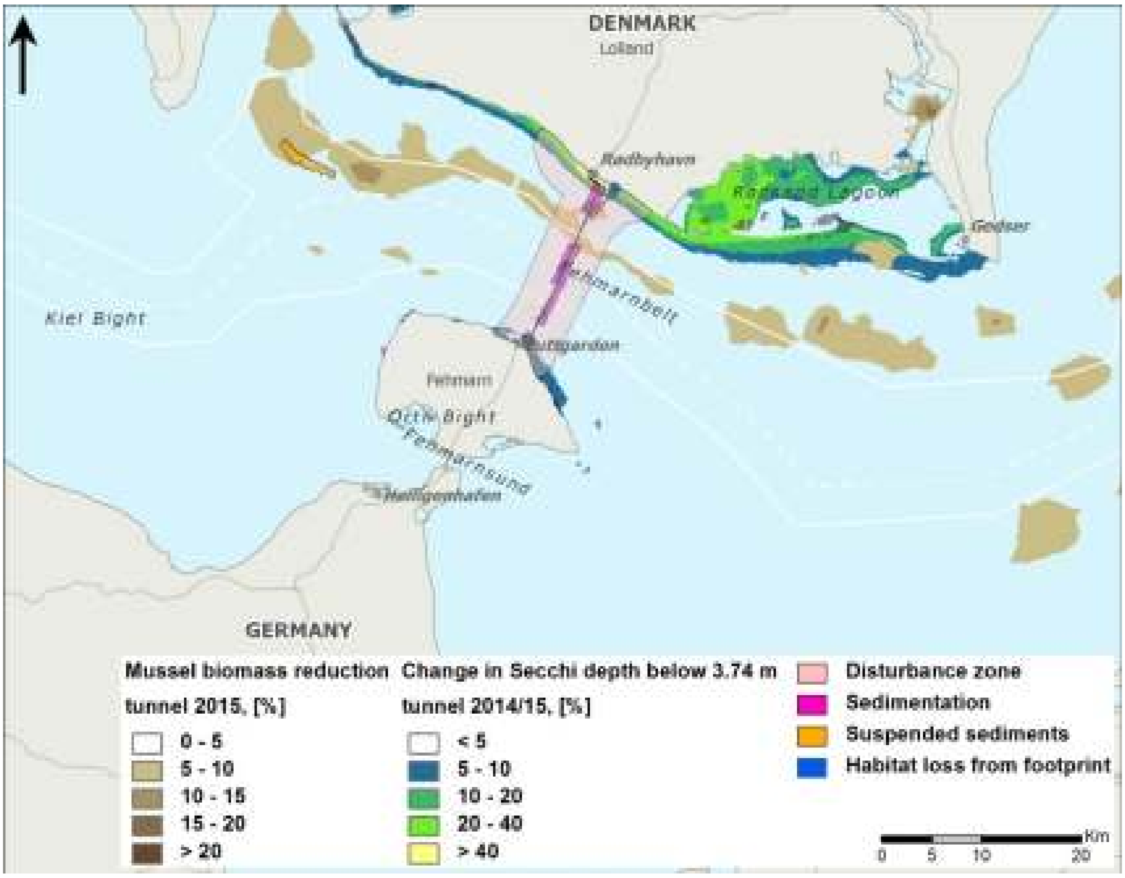


Figure 11.1 Pressures resulting in displacement of birds and their spatial extent in the Fehmarnbelt during the first year of the tunnel construction.

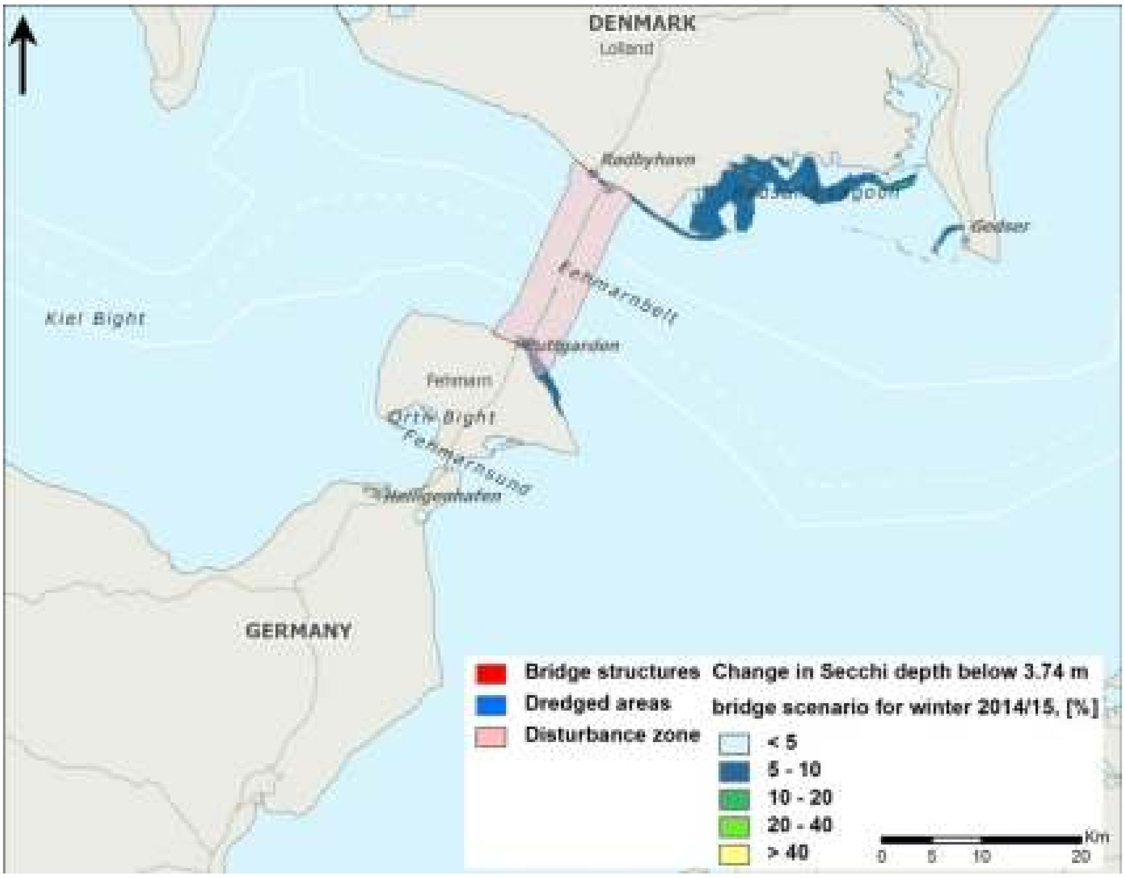


Figure 11.2 Pressures resulting in displacement of birds and their spatial extent in the Fehmarnbelt during the first year of the bridge construction.

For the tunnel alternative habitat loss from footprint, disturbance from construction vessels and direct and indirect impact from construction related sediment spill are pressures resulting in displacement of birds (Figure 11.1). For the bridge alternative bird displacement is predicted to result from habitat loss from footprint, disturbance from construction vessels and from the direct impairment of the sediment spill. For the bridge solution there is no bird displacement predicted from indirect effects of the sediment spill (Figure 11.2).

The areas impaired or lost from the different pressures during the construction period of the bridge alternative are predicted to be smaller than for the tunnel alternative (Figure 11.1, Figure 11.2), which is also reflected in the numbers of waterbirds predicted to be displaced from impaired or lost areas. Affected numbers differ mostly due to different impacts from changes in water transparency. Predictions of displaced bird numbers lead to assessments ranging from minor to very high overall severity of impact for the tunnel alternative and between minor and high overall severity of impact for the bridge alternative (Table 11.5).

The severity of impairment from barrier from construction vessels and collision with construction vessels assessed for the different non-breeding waterbird species range between negligible and minor for both main alternatives (Table 11.5).

Table 11.5 Comparison of overall assessment of bridge and tunnel main alternatives during the construction phase to non-breeding waterbird species.

Species	Construction phase					
	TUNNEL			BRIDGE		
	Displace-ment	Barrier from constr. vessels	Collision with constr. vessels	Displace-ment	Barrier from constr. vessels	Collision with constr. vessels
Divers	42	Minor	Minor	17	Minor	Minor
Great Crested Grebe	Minor	Negligible	Negligible	Minor	Negligible	Negligible
Red-necked Grebe	91	Minor	Minor	23	Minor	Minor
Slavonian Grebe	Minor	Negligible	Negligible	Minor	Negligible	Negligible
Great Cormorant	500	Minor	Minor	500	Minor	Minor
Mute Swan	Minor	Minor	Minor	Minor	Minor	Minor
Whooper Swan	Minor	Minor	Minor	Minor	Minor	Minor
Bewick's Swan	Minor	Minor	Minor	Minor	Minor	Minor
Bean Goose	Minor	Minor	Minor	Minor	Minor	Minor
Greater White-fronted Goose	Minor	Negligible	Negligible	Minor	Negligible	Negligible
Greylag Goose	Minor	Minor	Minor	Minor	Minor	Minor
Barnacle Goose	Minor	Minor	Minor	Minor	Minor	Minor
Brent Goose	Minor	Minor	Minor	Minor	Minor	Minor
Eurasian Wigeon	1,500	Minor	Minor	1,500	Minor	Minor
Gadwall	Minor	Minor	Minor	Minor	Minor	Minor
Common Teal	Minor	Minor	Minor	Minor	Minor	Minor
Mallard	Minor	Negligible	Negligible	Minor	Negligible	Negligible
Shoveler	Minor	Minor	Minor	Minor	Minor	Minor
Common Pochard	717	Minor	Minor	710	Minor	Minor
Tufted Duck	7,163	Minor	Minor	7,100	Minor	Minor
Greater Scaup	155	Minor	Minor	130	Minor	Minor
Common Eider	12,114	Minor	Minor	4,969	Minor	Minor
Long-tailed Duck	745	Minor	Minor	273	Minor	Minor
Common Scoter	726	Minor	Minor	566	Minor	Minor
Velvet Scoter	Minor	Minor	Minor	Minor	Minor	Minor
Common Goldeneye	92	Minor	Minor	54	Minor	Minor
Smew	Minor	Minor	Minor	Minor	Minor	Minor
Red-breasted Merganser	1,026	Minor	Minor	230	Minor	Minor
Goosander	Minor	Negligible	Negligible	Minor	Negligible	Negligible
White-tailed Eagle	Minor	Minor	Minor	Minor	Minor	Minor
Common Coot	Minor	Minor	Minor	Minor	Minor	Minor
Little Gull	Minor	Minor	Minor	Minor	Minor	Minor
Black-headed Gull	Minor	Minor	Minor	Minor	Minor	Minor
Common Gull	Minor	Minor	Minor	Minor	Minor	Minor
Lesser Black-backed Gull	Minor	Negligible	Negligible	Minor	Negligible	Negligible
Herring Gull	Minor	Minor	Minor	Minor	Minor	Minor
Great Black-backed Gull	Minor	Minor	Minor	Minor	Minor	Minor
Sandwich Tern	Minor	Minor	Minor	Minor	Minor	Minor

Species	Construction phase					
	TUNNEL			BRIDGE		
	Displace-ment	Barrier from constr. vessels	Collision with constr. vessels	Displace-ment	Barrier from constr. vessels	Collision with constr. vessels
Common Tern	Minor	Negligible	Negligible	Minor	Negligible	Negligible
Arctic Tern	Minor	Negligible	Negligible	Minor	Negligible	Negligible
Common Guillemot	Minor	Negligible	Negligible	Minor	Negligible	Negligible
Razorbill	13	Minor	Minor	10	Minor	Minor
Black Guillemot	Minor	Minor	Minor	Minor	Minor	Minor
Other species	Minor	Minor	Minor	Minor	Minor	Minor

Comparing the tunnel and bridge main alternatives with regard to predicted bird displacement from lost/impaired areas, a strong advantage is predicted for the bridge alternative regarding the Common Eider and an advantage for the Red-breasted Merganser (Table 11.6). Differences in footprint and impairment areas between the main alternatives result in a slight advantage for the bridge alternative for several waterbird species. However, for most species the difference in terms of numbers of displaced birds between tunnel and bridge alternative is regarded to be undetectable (Table 11.6).

No detectable differences between the impact from barrier effect and collision risk from construction vessels on non-breeding waterbirds are predicted between the two main alternatives, though construction vessel activities would vary between the project alternatives (Table 11.6).

Table 11.6 *Comparison of overall assessment of bridge and tunnel main alternatives during the construction phase to non-breeding waterbird species. Zeros (0) in cells mean: no difference between alternatives; no differences in severity of impairment levels (negligible and minor severity of impairments are assumed to be the same level); (+): slight advantage; detectable difference in numbers of birds affected, but within the same level of severity of impairment; +: advantage results in one level difference between severity of impairment levels; ++: strong advantage results in two levels of difference between severity of impairment levels; +++: very strong advantage results in three levels of difference between severity of impairment levels.*

Species	Construction phase					
	TUNNEL			BRIDGE		
	Displace-ment	Barrier from constr. vessels	Collision with constr. vessels	Displace-ment	Barrier from constr. vessels	Collision with constr. vessels
Divers		0	0	(+)	0	0
Great Crested Grebe	0	0	0	0	0	0
Red-necked Grebe		0	0	(+)	0	0
Slavonian Grebe	0	0	0	0	0	0
Great Cormorant	0	0	0	0	0	0
Mute Swan	0	0	0	0	0	0
Whooper Swan	0	0	0	0	0	0
Bewick's Swan	0	0	0	0	0	0
Bean Goose	0	0	0	0	0	0
Greater White-fronted Goose	0	0	0	0	0	0

Species	Construction phase					
	TUNNEL			BRIDGE		
	Displace-ment	Barrier from constr. vessels	Collision with constr. vessels	Displace-ment	Barrier from constr. vessels	Collision with constr. vessels
Greylag Goose	0	0	0	0	0	0
Barnacle Goose	0	0	0	0	0	0
Brent Goose	0	0	0	0	0	0
Eurasian Wigeon	0	0	0	0	0	0
Gadwall	0	0	0	0	0	0
Common Teal	0	0	0	0	0	0
Mallard	0	0	0	0	0	0
Shoveler	0	0	0	0	0	0
Common Pochard	0	0	0	0	0	0
Tufted Duck	0	0	0	0	0	0
Greater Scaup	0	0	0	0	0	0
Common Eider		0	0	++	0	0
Long-tailed Duck		0	0	(+)	0	0
Common Scoter		0	0	(+)	0	0
Velvet Scoter	0	0	0	0	0	0
Common Goldeneye		0	0	(+)	0	0
Smew	0	0	0	0	0	0
Red-breasted Merganser		0	0	+	0	0
Goosander	0	0	0	0	0	0
White-tailed Eagle	0	0	0	0	0	0
Common Coot	0	0	0	0	0	0
Little Gull	0	0	0	0	0	0
Black-headed Gull	0	0	0	0	0	0
Common Gull	0	0	0	0	0	0
Lesser Black-backed Gull	0	0	0	0	0	0
Herring Gull	0	0	0	0	0	0
Great Black-backed Gull	0	0	0	0	0	0
Sandwich Tern	0	0	0	0	0	0
Common Tern	0	0	0	0	0	0
Arctic Tern	0	0	0	0	0	0
Common Guillemot	0	0	0	0	0	0
Razorbill	0	0	0	0	0	0
Black Guillemot	0	0	0	0	0	0
Other species	0	0	0	0	0	0

Significance

The project impact is assessed to be insignificant for all non-breeding waterbirds in the Fehmarnbelt during the construction period of both, tunnel and bridge main alternatives.

However, for the tunnel construction in the year of maximum impact (winter 2014/2015), more than 12,000 Common Eiders are predicted to be displaced from the impaired/lost areas. Though this prediction of affected birds corresponds to 1.59% of the biogeographic population, the project impact of the tunnel alternative is regarded to be insignificant since no population-level effects are expected to result from excluding this number of birds from impaired areas. This was concluded following the results of the individual-based model (IBM; see chapter 9.4.2). The IBM predicts an additional mortality of 600 birds compared to baseline conditions and a slight decrease in mean body weight for Common Eiders in the first winter of the tunnel construction. This is regarded not to result in population-level effects for Common Eiders and therefore the impact is assessed as insignificant.

For the bridge solution, numbers of displaced birds are predicted to be generally lower and for the Common Eider also no detectable additional mortality is predicted from the construction related-redistribution (see IBM results in chapter 10.4.2), i.e. the impact during bridge construction is assessed as insignificant.

11.2.2 Operation and structures

During operation of a fixed link the predicted impacts differ with regards to the number of relevant pressures and with regards to the area lost or impaired by the different pressures. For the tunnel alternative the only relevant pressure is the habitat loss from the project footprint which results in a displacement of birds from the affected area (Figure 11.3).

For the bridge alternative a smaller footprint area would be lost for non-breeding waterbirds, but a larger disturbance zone around the bridge would result in an additional impairment of non-breeding waterbirds (Figure 11.3). Thus, the areas impaired or lost from the different pressures during operation of the tunnel and bridge alternatives differ, which is also reflected in the numbers of waterbirds predicted to be displaced from impaired or lost areas (Table 11.7).

Predictions of displaced bird numbers lead to assessments ranging from minor to high overall severity of impact for both main alternatives (Table 11.5). However, for non-breeding waterbirds, which are sensitive to disturbance, the number of birds predicted to be displaced is higher for the bridge alternative due to the larger area impaired by disturbance (Table 11.7).

The pressures ‘barrier from structures’ and ‘collision with structures and traffic’ are not relevant for the tunnel alternative (no impact), but these pressures are assessed to result in a minor to high severity of impairment for non-breeding waterbirds for the bridge alternative (Table 11.7).

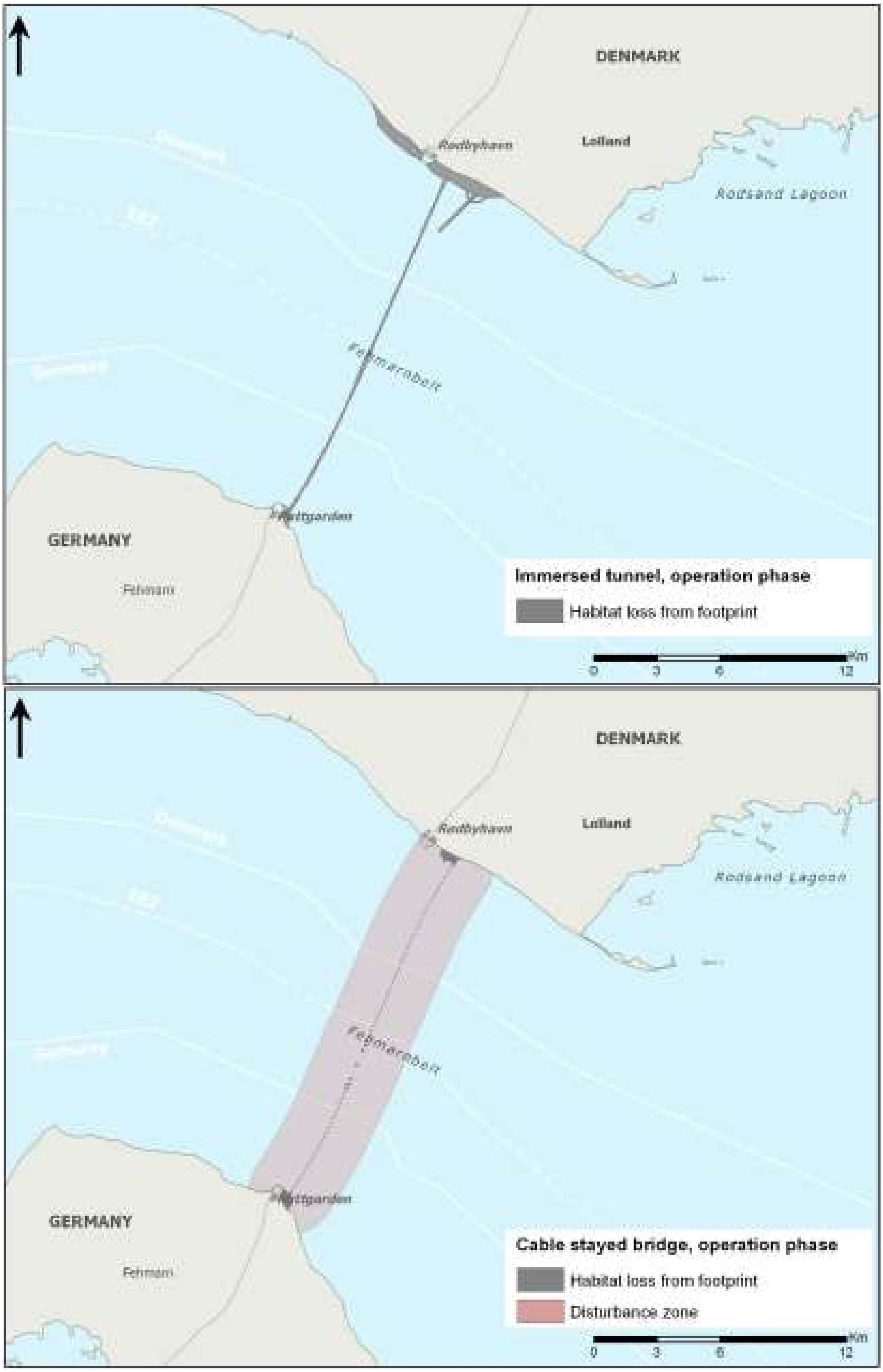


Figure 11.3 Pressures resulting in displacement of birds and their spatial extent in the Fehmarnbelt during operation of an immersed tunnel (upper map) and a cable stayed bridge (lower map).

Table 11.7 Comparison of overall assessment of bridge and tunnel main alternatives from structure and during the operation to non-breeding waterbird species.

Species	**Operation and structures**					
	TUNNEL			**BRIDGE**		
	Displace-ment	**Barrier from structure**	**Collision with structure and traffic**	**Displace-ment**	**Barrier from structure**	**Collision with structure and traffic**
Divers	Minor	No impact	No impact	6	High	Minor
Great Crested Grebe	Minor	No impact	No impact	Minor	Minor	Negligible
Red-necked Grebe	Minor	No impact	No impact	8	Medium	Minor
Slavonian Grebe	Minor	No impact	No impact	Minor	Minor	Negligible
Great Cormorant	500	No impact	No impact	500	Minor	Minor
Mute Swan	Minor	No impact	No impact	Minor	Minor	Minor
Whooper Swan	Minor	No impact	No impact	Minor	Minor	Minor
Bewick's Swan	Minor	No impact	No impact	Minor	Minor	Minor
Bean Goose	Minor	No impact	No impact	Minor	Minor	Minor
Greater White-fronted Goose	Minor	No impact	No impact	Minor	Minor	Negligible
Greylag Goose	Minor	No impact	No impact	Minor	Minor	Minor
Barnacle Goose	Minor	No impact	No impact	Minor	Minor	Minor
Brent Goose	Minor	No impact	No impact	Minor	Minor	Minor
Eurasian Wigeon	Minor	No impact	No impact	Minor	Minor	Minor
Gadwall	Minor	No impact	No impact	Minor	Minor	Minor
Common Teal	Minor	No impact	No impact	Minor	Minor	Minor
Mallard	Minor	No impact	No impact	Minor	Minor	Negligible
Shoveler	Minor	No impact	No impact	Minor	Minor	Minor
Common Pochard	710	No impact	No impact	710	Medium	Medium
Tufted Duck	7,100	No impact	No impact	7,100	Medium	Medium
Greater Scaup	130	No impact	No impact	130	Medium	Medium
Common Eider	207	No impact	No impact	1,889	Medium	Minor
Long-tailed Duck	Minor	No impact	No impact	61	Medium	Minor
Common Scoter	16	No impact	No impact	118	High	Minor
Velvet Scoter	Minor	No impact	No impact	Minor	High	Minor
Common Goldeneye	Minor	No impact	No impact	23	Medium	Minor
Smew	Minor	No impact	No impact	Minor	Minor	Minor
Red-breasted Merganser	Minor	No impact	No impact	53	Medium	Minor
Goosander	Minor	No impact	No impact	Minor	Minor	Negligible
White-tailed Eagle	Minor	No impact	No impact	Minor	Minor	Minor
Common Coot	Minor	No impact	No impact	Minor	Minor	Minor
Little Gull	Minor	No impact	No impact	Minor	Minor	Minor
Black-headed Gull	Minor	No impact	No impact	Minor	Minor	Minor
Common Gull	Minor	No impact	No impact	Minor	Minor	Minor
Lesser Black-backed Gull	Minor	No impact	No impact	Minor	Negligible	Negligible
Herring Gull	Minor	No impact	No impact	Minor	Minor	Minor
Great Black-backed Gull	Minor	No impact	No impact	Minor	Minor	Minor
Sandwich Tern	Minor	No impact	No impact	Minor	Minor	Minor

Species	Operation and structures					
	TUNNEL			BRIDGE		
	Displace-ment	Barrier from structure	Collision with structure and traffic	Displace-ment	Barrier from structure	Collision with structure and traffic
Common Tern	Minor	No impact	No impact	Minor	Negligible	Negligible
Arctic Tern	Minor	No impact	No impact	Minor	Negligible	Negligible
Common Guillemot	Minor	No impact	No impact	Minor	Minor	Negligible
Razorbill	Minor	No impact	No impact	6	Medium	Minor
Black Guillemot	Minor	No impact	No impact	Minor	High	Minor
Other species	Minor	No impact	No impact	Minor	Minor/ Negligible	Minor/ Negligible

Displacement from the larger tunnel footprint is regarded to have a comparable effect to some non-breeding waterbird species as it is predicted to result from disturbance and (smaller) footprint of the bridge alternative. However, there is an advantage of the tunnel alternative predicted for the Common Eider and a slight advantage is expected for several other waterbird species in terms of numbers of displaced birds (Table 11.8).

Regarding the pressures barrier effect and collision, there is no impact predicted for the tunnel alternative, but non-breeding waterbirds are predicted to get impaired by these pressures in case of the bridge alternative (Table 11.7). Consequently, with regards to barrier effect, the tunnel alternative is assessed to have a strong advantage for divers, scoters and Black Guillemot and an advantage or slight advantage to all other non-breeding waterbird species in the area (Table 11.8). Concerning collision with structures, the tunnel alternative is assessed to have an advantage for nocturnal ducks, such as Common Pochard, Tufted Duck and Greater Scaup, and a slight advantage for all other non-breeding waterbirds in the area (Table 11.8).

Table 11.8 Comparison of overall assessment of bridge and tunnel main alternatives from structure and during operation to non-breeding waterbird species. Zeros (0) in cells mean: no difference between alternatives; no differences in severity of impairment levels (negligible and minor severity of impairments are assumed to be the same level); (+): slight advantage; detectable difference in numbers of birds affected, but within the same level of severity of impairment; +: advantage results in one level difference between severity of impairment levels; ++: strong advantage results in two levels of difference between severity of impairment levels; +++: very strong advantage results in three levels of difference between severity of impairment levels.

Species	Structure and operation					
	TUNNEL			BRIDGE		
	Displace-ment	Barrier from structure	Collision with structure and traffic	Displace-ment	Barrier from structure	Collision with structure and traffic
Divers	(+)	++	(+)			
Great Crested Grebe	(+)	(+)	(+)			
Red-necked Grebe	(+)	+	(+)			
Slavonian Grebe	(+)	(+)	(+)			
Great Cormorant	0	(+)	(+)	0		
Mute Swan	0	(+)	(+)	0		
Whooper Swan	0	(+)	(+)	0		
Bewick's Swan	0	(+)	(+)	0		

Species	Structure and operation					
	TUNNEL			BRIDGE		
	Displace-ment	Barrier from structure	Collision with structure and traffic	Displace-ment	Barrier from structure	Collision with structure and traffic
Bean Goose	0	(+)	(+)	0		
Greater White-fronted Goose	0	(+)	(+)	0		
Greylag Goose	0	(+)	(+)	0		
Barnacle Goose	0	(+)	(+)	0		
Brent Goose	0	(+)	(+)	0		
Eurasian Wigeon	0	(+)	(+)	0		
Gadwall	0	(+)	(+)	0		
Common Teal	0	(+)	(+)	0		
Mallard	0	(+)	(+)	0		
Shoveler	0	(+)	(+)	0		
Common Pochard	0	+	+	0		
Tufted Duck	0	+	+	0		
Greater Scaup	0	+	+	0		
Common Eider	+	+	(+)			
Long-tailed Duck	(+)	+	(+)			
Common Scoter	(+)	++	(+)			
Velvet Scoter	(+)	++	(+)			
Common Goldeneye	(+)	+	(+)			
Smew	0	(+)	(+)	0		
Red-breasted Merganser	(+)	+	(+)			
Goosander	0	(+)	(+)	0		
White-tailed Eagle	0	(+)	(+)	0		
Common Coot	0	(+)	(+)	0		
Little Gull	0	(+)	(+)	0		
Black-headed Gull	0	(+)	(+)	0		
Common Gull	0	(+)	(+)	0		
Lesser Black-backed Gull	0	(+)	(+)	0		
Herring Gull	0	(+)	(+)	0		
Great Black-backed Gull	0	(+)	(+)	0		
Sandwich Tern	0	(+)	(+)	0		
Common Tern	0	(+)	(+)	0		
Arctic Tern	0	(+)	(+)	0		
Common Guillemot	(+)	(+)	(+)			
Razorbill	(+)	+	(+)			
Black Guillemot	(+)	++	(+)			
Other species	0	(+)	(+)	0		

Significance
The project impact is assessed to be insignificant for all non-breeding waterbirds in the Fehmarnbelt from structure and during operation of both, tunnel and bridge main alternatives.

11.2.3 *Conclusion*

Regarding non-breeding waterbirds there is no clear overall advantage for one of the main alternatives.

With regards to the construction phase, a clear overall advantage for the bridge alternative is given. Numbers of waterbirds getting displaced from impaired and lost areas are in general lower for the bridge alternative.

Regarding the operation phase of a fixed link in the Fehmarnbelt there is a clear overall advantage for the tunnel solution. Fewer birds are predicted to be displaced due to habitat loss and disturbance, and the absence of a barrier effect and collision risk from the project structure is an advantage for the tunnel solution.

Taking the duration of impact into account, regarding both, construction and operation, a slight overall advantage is assigned to the immersed tunnel alternative since this alternative has an advantage during the permanent operation phase.

11.3 *Migrating birds*

11.3.1 *Construction phase*

During the construction period of a fixed link across the Fehmarnbelt for both main alternatives, the two pressures 'barrier from construction vessels' and 'collision with construction vessels' are relevant. For both the tunnel and bridge main alternatives these pressures are assessed to result in minor or negligible severity of impairment to all migrating bird species (Table 11.9).

Table 11.9 Comparison of overall assessment of bridge and tunnel main alternatives during the construction phase to migrating birds.

Species	**Construction phase**			
	TUNNEL		**BRIDGE**	
	Barrier from constr. vessels	**Collision with constr. vessels**	**Barrier from constr. vessels**	**Collision with constr. vessels**
All migrating bird species	Minor/Negligible	Minor/Negligible	Minor/Negligible	Minor/Negligible

No detectable differences between the impact from barrier effect and collision risk from construction vessels on migrating birds are predicted between the two main alternatives, though construction vessel activities would vary between tunnel and bridge construction (Table 11.10). Therefore, no clear advantage for one of the main alternatives can be given based on the impact on migrating birds during the construction period.

Table 11.10 Comparison of overall assessment of bridge and tunnel main alternatives during the construction phase to migrating birds. Zeros (0) in cells mean: no difference between alternatives; no differences in severity of impairment levels; (+): slight advantage; detectable differences in numbers of birds affected, but within the same level of severity of impairment; +: advantage results in one level difference between severity of impairment levels; ++: strong advantage results in two levels of difference between severity of impairment levels; +++: very strong advantage results in three levels of difference between severity of impairment levels.

Species	Construction phase			
	TUNNEL		BRIDGE	
	Barrier from constr. vessels	Collision with constr. vessels	Barrier from constr. vessels	Collision with constr. vessels
All migrating bird species	0	0	0	0

Significance

The project impact is assessed to be insignificant for all migrating bird species crossing the Fehmarnbelt during the construction period of both, tunnel and bridge main alternatives.

11.3.2 *Operation and structures*

There is no impact on migrating birds predicted to result from structure and operation of an immersed tunnel in the Fehmarnbelt. During operation of a cable stayed bridge, a minor to very high severity of impairment is predicted to result from the barrier effect of the structure (Table 11.11). This includes the prediction that a bridge over the Fehmarnbelt would serve as a complete barrier to the three auk species assumed not to cross this barrier at all (very high severity of impairment). Collisions with bridge structure and traffic are assessed to result in negligible to medium severity of impairment for the different migrating bird species (Table 11.11).

Table 11.11 Comparison of overall assessment of bridge and tunnel main alternatives from structure and during operation to migrating birds.

Species	Operation and structures			
	TUNNEL		BRIDGE	
	Barrier from structure	Collisions with structure and traffic	Barrier from structure	Collisions with structure and traffic
Red-throated Diver	No impact	No impact	Medium	Medium
Black-throated Diver	No impact	No impact	Medium	Medium
Great Crested Grebe	No impact	No impact	Minor	Minor
Red-necked Grebe	No impact	No impact	Medium	Medium
Slavonian Grebe	No impact	No impact	Medium	Medium
Northern Gannet	No impact	No impact	Minor	Negligible
Great Cormorant	No impact	No impact	Minor	Minor
Grey Heron	No impact	No impact	Negligible	Negligible
White Stork	No impact	No impact	Minor	Negligible
Mute Swan	No impact	No impact	Medium	Medium
Bewick's Swan	No impact	No impact	Medium	Medium
Whooper Swan	No impact	No impact	Medium	Medium
Bean Goose	No impact	No impact	Medium	Medium

Species	Operation and structures			
	TUNNEL		BRIDGE	
	Barrier from structure	Collisions with structure and traffic	Barrier from structure	Collisions with structure and traffic
Greater White-fronted Goose	No impact	No impact	Minor	Minor
Greylag Goose	No impact	No impact	Minor	Medium
Barnacle Goose	No impact	No impact	Medium	Medium
Brent Goose	No impact	No impact	Medium	Medium
Common Shelduck	No impact	No impact	Minor	Minor
Eurasian Wigeon	No impact	No impact	Medium	Medium
Gadwall	No impact	No impact	Medium	Medium
Common Teal	No impact	No impact	Minor	Minor
Mallard	No impact	No impact	Minor	Minor
Northern Pintail	No impact	No impact	Medium	Medium
Garganey	No impact	No impact	Minor	Minor
Northern Shoveler	No impact	No impact	Medium	Medium
Common Pochard	No impact	No impact	Minor	Minor
Tufted Duck	No impact	No impact	Minor	Minor
Greater Scaup	No impact	No impact	Medium	Medium
Common Eider	No impact	No impact	High	Medium
Long-tailed Duck	No impact	No impact	Minor	Minor
Common Scoter	No impact	No impact	High	Medium
Velvet Scoter	No impact	No impact	Minor	Minor
Common Goldeneye	No impact	No impact	Minor	Minor
Red-breasted Merganser	No impact	No impact	Medium	Minor
Goosander	No impact	No impact	Minor	Negligible
Honey-Buzzard	No impact	No impact	Minor	Minor
Black Kite	No impact	No impact	Minor	Minor
Red Kite	No impact	No impact	Minor	Minor
White-tailed Eagle	No impact	No impact	Minor	Minor
Marsh Harrier	No impact	No impact	Minor	Minor
Northern (Hen) Harrier	No impact	No impact	Minor	Minor
European Sparrow Hawk	No impact	No impact	Minor	Minor
Eurasian Buzzard	No impact	No impact	Minor	Minor
Rough-legged Buzzard	No impact	No impact	Negligible	Negligible
Osprey	No impact	No impact	Minor	Minor
Eurasian Kestrel	No impact	No impact	Minor	Minor
Red-footed Falcon	No impact	No impact	Minor	Minor
Merlin	No impact	No impact	Minor	Minor
Hobby	No impact	No impact	Negligible	Negligible
Peregrine Falcon	No impact	No impact	Minor	Minor
Common Crane	No impact	No impact	Minor	Minor
Waterrail	No impact	No impact	Minor	Medium
Corncrake	No impact	No impact	Minor	Medium
Moorhen	No impact	No impact	Minor	Medium
Common Coot	No impact	No impact	Minor	Medium

Species	Operation and structures			
	TUNNEL		BRIDGE	
	Barrier from structure	Collisions with structure and traffic	Barrier from structure	Collisions with structure and traffic
Oystercatcher	No impact	No impact	Negligible	Negligible
Avocet	No impact	No impact	Minor	Minor
Little Ringed Plover	No impact	No impact	Negligible	Negligible
Ringed Plover	No impact	No impact	Negligible	Negligible
Golden Plover	No impact	No impact	Minor	Minor
Grey Plover	No impact	No impact	Minor	Minor
Lapwing	No impact	No impact	Negligible	Negligible
Knot	No impact	No impact	Minor	Minor
Sanderling	No impact	No impact	Negligible	Negligible
Curlew Sandpiper	No impact	No impact	Minor	Minor
Dunlin	No impact	No impact	Minor	Minor
Ruff	No impact	No impact	Negligible	Negligible
Common Snipe	No impact	No impact	Negligible	Negligible
Bar-tailed Godwit	No impact	No impact	Minor	Minor
Whimbrel	No impact	No impact	Negligible	Negligible
Curlew	No impact	No impact	Minor	Minor
Spotted Redshank	No impact	No impact	Negligible	Negligible
Redshank	No impact	No impact	Negligible	Negligible
Greenshank	No impact	No impact	Negligible	Negligible
Green Sandpiper	No impact	No impact	Negligible	Negligible
Wood Sandpiper	No impact	No impact	Negligible	Negligible
Common Sandpiper	No impact	No impact	Negligible	Negligible
Turnstone	No impact	No impact	Negligible	Negligible
Arctic Skua	No impact	No impact	Minor	Minor
Great Skua	No impact	No impact	Minor	Minor
Mediterranean Gull	No impact	No impact	Negligible	Minor
Little Gull	No impact	No impact	Minor	Medium
Black-headed Gull	No impact	No impact	Minor	Medium
Common Gull	No impact	No impact	Minor	Medium
Lesser Black-backed Gull	No impact	No impact	Negligible	Minor
Herring Gull	No impact	No impact	Minor	Medium
Great Black-backed Gull	No impact	No impact	Minor	Medium
Sandwich Tern	No impact	No impact	Minor	Medium
Common Tern	No impact	No impact	Minor	Medium
Arctic Tern	No impact	No impact	Minor	Minor
Little Tern	No impact	No impact	Minor	Minor
Black Tern	No impact	No impact	Negligible	Negligible
Common Guillemot	No impact	No impact	Very high	Negligible
Razorbill	No impact	No impact	Very high	Negligible
Black Guillemot	No impact	No impact	Very high	Negligible
Stock Dove	No impact	No impact	Minor	Minor
Woodpigeon	No impact	No impact	Minor	Minor

Species	Operation and structures			
	TUNNEL		BRIDGE	
	Barrier from structure	Collisions with structure and traffic	Barrier from structure	Collisions with structure and traffic
Collared Dove	No impact	No impact	Negligible	Negligible
Long-eared Owl	No impact	No impact	Minor	Medium
Short-eared Owl	No impact	No impact	Minor	Medium
Cuckoo	No impact	No impact	Negligible	Minor
Swift	No impact	No impact	Negligible	Negligible
Great Spotted Woodpecker	No impact	No impact	Negligible	Negligible
Eurasian Jay	No impact	No impact	Negligible	Negligible
Black-billed Magpie	No impact	No impact	Negligible	Negligible
Eurasian Jackdaw	No impact	No impact	Minor	Minor
Rook	No impact	No impact	Minor	Minor
Carrion Crow	No impact	No impact	Negligible	Negligible
Obligatory daytime migrating passerines	No impact	No impact	Minor	Minor
Facultative night-time migrating passerines	No impact	No impact	Minor	Medium
Obligatory night-time migrating passerines	No impact	No impact	Minor	Medium
All other migrating bird species	No impact	No impact	Minor/Negligible	Minor/Negligible

Comparing the two main alternatives during the operation phase with regards to migrating birds, the tunnel alternative is clearly more advantageous, because there are no impacts predicted to occur from structure and operation of an immersed tunnel in the Fehmarnbelt (Table 11.12).

Regarding the barrier effect, a strong advantage of the tunnel alternative is predicted for Common Eider and Common Scoter and even a very strong advantage for the auk species Common Guillemot, Razorbill and Black Guillemot. For all other migrating birds an advantage or slight advantage is predicted of the tunnel solution with regards to the pressure barrier effect. Concerning the impact from collisions, the tunnel alternative with no predicted impact from this pressure is assessed to have an advantage or slight advantage for the various species compared to the bridge alternative (Table 11.12).

Table 11.12 Comparison of overall assessment of bridge and tunnel main alternatives from structure and during operation to migrating birds. Zeros (0) in cells mean: no difference between alternatives; no differences in severity of impairment levels; (+): slight advantage; detectable difference in numbers of birds affected, but within the same level of severity of impairment; +: advantage results in one level difference between severity of impairment levels; ++: strong advantage results in two levels of difference between severity of impairment levels; +++: very strong advantage results in three levels of difference between severity of impairment levels.

Species	Structure and operation			
	TUNNEL		BRIDGE	
	Barrier from structure	Collisions with structure and traffic	Barrier from structure	Collisions with structure and traffic
Red-throated Diver	+	+		
Black-throated Diver	+	+		
Great Crested Grebe	(+)	(+)		
Red-necked Grebe	+	+		
Slavonian Grebe	+	+		
Northern Gannet	(+)	(+)		
Great Cormorant	(+)	(+)		
Grey Heron	(+)	(+)		
White Stork	(+)	(+)		
Mute Swan	+	+		
Bewick's Swan	+	+		
Whooper Swan	+	+		
Bean Goose	+	+		
Greater White-fronted Goose	(+)	(+)		
Greylag Goose	(+)	+		
Barnacle Goose	+	+		
Brent Goose	+	+		
Common Shelduck	(+)	(+)		
Eurasian Wigeon	+	+		
Gadwall	+	+		
Common Teal	(+)	(+)		
Mallard	(+)	(+)		
Northern Pintail	+	+		
Garganey	(+)	(+)		
Northern Shoveler	+	+		
Common Pochard	(+)	(+)		
Tufted Duck	(+)	(+)		
Greater Scaup	+	+		
Common Eider	++	+		
Long-tailed Duck	(+)	(+)		
Common Scoter	++	+		
Velvet Scoter	(+)	(+)		
Common Goldeneye	(+)	(+)		
Red-breasted Merganser	+	(+)		
Goosander	(+)	(+)		
Honey-Buzzard	(+)	(+)		

Species	Structure and operation			
	TUNNEL		BRIDGE	
	Barrier from structure	Collisions with structure and traffic	Barrier from structure	Collisions with structure and traffic
Black Kite	(+)	(+)		
Red Kite	(+)	(+)		
White-tailed Eagle	(+)	(+)		
Marsh Harrier	(+)	(+)		
Northern (Hen) Harrier	(+)	(+)		
European Sparrow Hawk	(+)	(+)		
Eurasian Buzzard	(+)	(+)		
Rough-legged Buzzard	(+)	(+)		
Osprey	(+)	(+)		
Eurasian Kestrel	(+)	(+)		
Red-footed Falcon	(+)	(+)		
Merlin	(+)	(+)		
Hobby	(+)	(+)		
Peregrine Falcon	(+)	(+)		
Common Crane	(+)	(+)		
Waterrail	(+)	+		
Corncrake	(+)	+		
Moorhen	(+)	+		
Common Coot	(+)	+		
Oystercatcher	(+)	(+)		
Avocet	(+)	(+)		
Little Ringed Plover	(+)	(+)		
Ringed Plover	(+)	(+)		
Golden Plover	(+)	(+)		
Grey Plover	(+)	(+)		
Lapwing	(+)	(+)		
Knot	(+)	(+)		
Sanderling	(+)	(+)		
Curlew Sandpiper	(+)	(+)		
Dunlin	(+)	(+)		
Ruff	(+)	(+)		
Common Snipe	(+)	(+)		
Bar-tailed Godwit	(+)	(+)		
Whimbrel	(+)	(+)		
Curlew	(+)	(+)		
Spotted Redshank	(+)	(+)		
Redshank	(+)	(+)		
Greenshank	(+)	(+)		
Green Sandpiper	(+)	(+)		
Wood Sandpiper	(+)	(+)		
Common Sandpiper	(+)	(+)		
Turnstone	(+)	(+)		
Arctic Skua	(+)	(+)		

Species	Structure and operation			
	TUNNEL		BRIDGE	
	Barrier from structure	Collisions with structure and traffic	Barrier from structure	Collisions with structure and traffic
Great Skua	(+)	(+)		
Mediterranean Gull	(+)	(+)		
Little Gull	(+)	+		
Black-headed Gull	(+)	+		
Common Gull	(+)	+		
Lesser Black-backed Gull	(+)	(+)		
Herring Gull	(+)	+		
Great Black-backed Gull	(+)	+		
Sandwich Tern	(+)	+		
Common Tern	(+)	+		
Arctic Tern	(+)	(+)		
Little Tern	(+)	(+)		
Black Tern	(+)	(+)		
Common Guillemot	+++	(+)		
Razorbill	+++	(+)		
Black Guillemot	+++	(+)		
Stock Dove	(+)	(+)		
Woodpigeon	(+)	(+)		
Collared Dove	(+)	(+)		
Long-eared Owl	(+)	+		
Short-eared Owl	(+)	+		
Cuckoo	(+)	(+)		
Swift	(+)	(+)		
Great Spotted Woodpecker	(+)	(+)		
Eurasian Jay	(+)	(+)		
Black-billed Magpie	(+)	(+)		
Eurasian Jackdaw	(+)	(+)		
Rook	(+)	(+)		
Carrion Crow	(+)	(+)		
Obligatory daytime migrating passerines	(+)	(+)		
Facultative night-time migrating passerines	(+)	+		
Obligatory night-time migrating passerines	(+)	+		
All other migrating bird species	(+)	(+)		

Significance

For the three auk species, Common Guillemot, Razorbill and Black Guillemot, there is a significant impact predicted to result from the operation of a bridge in the Fehmarnbelt. It has to be assumed that the barrier effect from a bridge would preclude auks from crossing the fixed link at all. This is assessed as a significant impact, since this could affect a greater part of the auk populations than actually using the Fehmarnbelt study area and thus result in population-level effects to these species.

For all other migrating bird species the project impact is assessed to be insignificant during operation of a cable stayed bridge in the Fehmarnbelt. For operation of the tunnel alternative, the project impact is assessed to be insignificant for all migrating bird species, including auks.

11.3.3 Conclusion

For the construction period both alternatives are predicted to have a comparable (minor) impact on migrating birds. However, there is a significant impact predicted on migrating auks from operation of a bridge in the Fehmarnbelt due to the barrier effect, whereas no impact on migrating birds is predicted from operating a tunnel in this area. Therefore, with regards to migrating birds there is a strong overall advantage for the tunnel alternative.

12 ASSESSMENT OF STRICTLY PROTECTED SPECIES

12.1 Methodology

The protection of species is regulated by the Habitats Directive (Article 12) and the Birds Directive (Article 5). For bird species Article 5 Birds Directive has to be applied, but general prohibitions of Article 12 of the Habitats Directive have to be considered as well. In German law both articles are integrated in the German Federal Nature Conservation Act (§44 Bundesnaturschutzgesetz, BNatSchG) and account for Annex IV species as well as all European bird species.

Article 12 of the Habitats Directive on the protection of species states that:

1. Member States shall take the requisite measures to establish a system of strict protection for the animal species listed in Annex IV (a) in their natural range, prohibiting:

    a) all forms of deliberate capture or killing of specimens of these species in the wild;

    b) deliberate disturbance of these species, particularly during the period of breeding, rearing, hibernation and migration;

    c) deterioration or destruction of breeding sites or resting places.

2. For these species, Member States shall prohibit the keeping, transport and sale or exchange, and offering for sale or exchange, of specimens taken from the wild, except for those taken legally before this Directive is implemented.

3. The prohibition referred to in paragraph 1 (a) and (b) and paragraph 2 shall apply to all stages of life of the animals to which this Article applies.

Article 5 of the Birds Directive on the conservation of wild birds states that:

Member States shall take the requisite measures to establish a general system of protection for all species of birds referred to in Article 1 (all European Bird Species), prohibiting in particular:

a) deliberate killing or capture by any method;

b) deliberate destruction of, or damage to, their nests and eggs or removal of their nests;

c) taking their eggs in the wild and keeping these eggs even if empty;

d) deliberate disturbance of these birds particularly during the period of breeding and rearing, in so far as disturbance would be significant having regard to the objectives of this Directive;

e) keeping birds of species the hunting and capture of which is prohibited.

Member States may derogate from the provisions of Article 5, where there is no other satisfactory solution, for the following reasons:

a) - in the interests of public health and safety,

- in the interests of air safety,

- to prevent serious damage to crops, livestock, forests, fisheries and water,

- for the protection of flora and fauna;

b) for the purposes of research and teaching, of re-population, of re-introduction and for the breeding necessary for these purposes;

c) to permit, under strictly supervised conditions and on a selective basis, the capture, keeping or other judicious use of certain birds in small numbers.

Article 12 of the Habitats Directive covers additionally the prohibition of deterioration and destruction of resting places. As in the Fehmarnbelt area extraordinary important resting areas for wintering waterbirds exist, the prohibition of deterioration and destruction of resting places is also considered for birds here. The German Federal Nature Conservation Act (§44 Bundesnaturschutzgesetz, BNatSchG) contains this prohibition for Annex IV species and all European bird species as well.

The demands from the Birds Directive and the Habitats Directive concerning the strictly protected species have been transposed into national law in Germany (German Federal Nature Conservation Act §44 Bundesnaturschutzgesetz, BNatSchG) and in Denmark (Naturbeskyttelsesloven). Further guidance on the application of the regulation of Article 12 of the Habitats Directive is provided by the EU (http://ec.europa.eu/environment/nature/conservation/species/guidance/index_en.htm). It is legal opinion and common sense to use this guidance document for European bird species as well. In Germany, the states have frequently drafted guidelines for structuring assessments of strictly protected species in a special report (Artenschutzrechtlicher Fachbeitrag) and the guideline from the state of Schleswig-Holstein (LBV 2009) is also considered.

Approach and methodology of the assessment

The strict protection obligations under Article 5 must be interpreted in terms of the overall aim of a favourable conservation status of the species. The aim of the assessment of strictly protected species is to provide a contribution to the formal assessments in Germany and Denmark which are organised in different steps of the application documents:

- In Denmark the assessment of strictly protected species is part of the EIA (VVM) and covers both main alternatives of the project, which are the immersed tunnel and the cable stayed bridge including all pressures during construction and operation.

- In Germany, the assessment of strictly protected species is associated with the landscape management plan (Landschaftspflegerischer Begleitplan) and only covers the preferred alternative, which is the immersed tunnel.

The approach and methodology to this part of the assessment is thus restricted to specific requirements of birds. All European bird species are covered by Article 2 of the Birds Directive and shall thus be treated in the assessment of strictly protected species. It is possible to treat not endangered and widely distributed species together in ecological guilds. This approach is recommended by the LBV Schleswig-Holstein (LBV 2009).

As part of the Environmental Impact Assessment for a fixed link across the Fehmarnbelt, it needs to be assessed whether any pressure, or the sum of all pressures of the project, might lead to a violation of these demands from the Birds Directive.

The pressures, which might be relevant for the assessment, are described in chapters 9 and 10.

A potential barrier of a bridge would be regarded as disturbance in this assessment.

The used threshold for a violation of Article 5 was set to 1% by FEBI. That means, deliberate disturbances according to German §44 (1) Nr. 2 BNatschG are significant in terms of strictly protected species, if 1% or more of the local population will get impaired and the state of preservation will deteriorate. For the German plan approval procedure a guideline published by the LBV Kiel (LBV-SH 2009) is decisive. Here, a threshold of 2% of the Schleswig-Holstein population of the particular species is used for assessing a violation of §44 (1) Nr. 2 BNatschG. These 2% of the Schleswig-Holstein population seemed not to be useful for FEBI assessments as many of the relevant species use transboundary operation ranges and are thus not restricted to Schleswig-Holstein waters. Further, many species use depending on season or forage habitat different parts of the Fehmarnbelt area and cannot be related to a particular administration unit.

The FEBI criterion of 1% of the local (breeding and resting birds) and biogeographic/relevant reference (migrating birds) population is often used for assessments, e.g. for Natura 2000 appropriate assessments (Lambrecht et al. 2004) or for designations of important waterbird areas according to Ramsar convention. Furthermore, the use of 1% instead of 2% as recommended by the LBV Kiel (LBV-SH 2009) is in accordance with the precautionary principle as a minor number of impaired individuals is sufficient for a violation of Article 5.

1. Deliberate killing or capture by any method

Deliberate killing is not restricted to intentional killing of individuals, for example, by hunting: 'The term "deliberate" has to be interpreted as going beyond "direct intention". A person who is reasonably expected to know that his action will most likely lead to an offence against a species, but intends the offence or, if not, at least accepts the results of his action, commits an offence' (EU guidance document). According to recent court cases it is generally accepted that a significant increase in the risk that an animal may be killed by a certain activity has to be regarded as violation of the regulations under Article 5. Although Article 5 is directed towards the conservation of species and populations, the prohibition of deliberate killing refers to the individuals of European bird species. In addition to killing, the German Federal Nature Conservation Act (BNatschG) is also prohibiting injuring protected animals, irrespective of whether or not this leads to death.

A violation of the demands of Article 5 is stated if a project increases the risk of mortality of a European bird species above normal risk levels (LBV 2009). As normal risk levels single collisions with cars are regarded whereas a systematic increase in collision risk by constructing roads, power lines or wind farms in important migration corridors might be assessed as significantly increasing the risk of mortality. In this sense the construction of a bridge in an important bird migration area has to be regarded as a systematic threat (LBV 2009). However, collision modelling in the EIA gives a more detailed assessment of the risk of killings and might be useful to differ between incidental and systematic killings. Further, traffic intensity plays a role in the assessment and collision risk is supposed to increase with the daily number of cars using a road (LBV 2009).

2. Deliberate destruction of, or damage to, their nests and eggs or removal of their nests

3. Deliberate disturbance of these birds particularly during the period of breeding and rearing

With respect to deliberate disturbance, the term deliberate has to be understood in the same way as described above and is going beyond direct intention. In addition, unlike deliberate killing, deliberate disturbance does not refer to the individual and Article 5 does not prohibit any disturbance, but considers impacts on species and their populations: 'The intensity, duration and frequency of repetition of disturbances are important parameters when assessing their impact on a species' (EU guidance document). There is no definition of disturbance provided and the degree of disturbance which is regarded as a violation of the Directive is not defined. In general, disturbance is regarded as any effect which leads to the displacement of animals out of a natural habitat. This includes barriers for migrating animals (LBV 2009). The EU provides some additional guidance: 'The disturbance under Article 12(1)(b) must be deliberate (see therein chapter II.3.1) and not accidental. On the other hand, whilst "disturbance" under Article 6(2) must be significant, this is not the case in Article 12(1), where the legislator did not explicitly add this qualification'. According to the EU guidance document 'Disturbance does not need to affect the physical integrity of a species but can nevertheless have a direct negative effect. Disturbance is detrimental for a protected species e.g. by reducing survival chances, breeding success or reproductive ability. A species-by-species approach needs to be taken as different species will react differently to potentially disturbing activities'.

The German Federal Nature Conservation Act (BNatschG) provides further definition in Article 44 by specifying that a disturbance shall be deemed significant if it causes the conservation status of the local population of a species to decline. In the practice of Impact Assessments, local populations are sometimes defined by administrative rather than biological borders. Following KIEL (2005) the latter is also recommended by the state of Schleswig-Holstein (LBV 2009). Though the assessment of strictly protected species will feed into different stages of the assessment procedure in Germany and Denmark, it is not considered practical to separate local populations of birds for both countries as the project of a fixed link should, in any case, be assessed as one unit. For migratory species the term 'local population' has to be interpreted in a wide sense, because for these species the biogeographic/relevant reference population has to be considered.

4. Deterioration and destruction of breeding sites and resting places

According to Article 12 a deterioration or destruction of breeding sites and resting places is not allowed. Due to disturbance a resting place of birds can lose its function. Furthermore the footprint of a structure can destroy such protected sites.

12.2 Assessment of relevant species

The assessment of relevant species aims to identify those European bird species, for which a species-wise approach is necessary and for which an assessment in ecological guilds is possible.

For all endangered or protected species (e.g. Annex I of the Birds Directive, SPEC), and for species with special requirements concerning the breeding habitats or occur in high abundance an assessment at species level will be conducted. For common and widely distributed species it is possible to treat them in ecological guilds (e.g. reed breeding species).

For those species, where suitable habitats are existent in the impairment area or in adjacent areas, but which are not expected to occur there due to already existing pressures or due to reasons of their distribution, there will be no assessment. The same applies for species, where no negative impacts are expected.

There might be some species, which are relevant, but not covered by the baseline investigations. These species have been added as potentially occurring and were assessed additionally.

Table 12.1 *List of all species recorded as breeding birds in the SPAs Eastern Kiel Bight, Baltic Sea east of Wagrien, Hyllekrog-Rødsand and Maribo Lakes for the year 2005 or 2008 (FEBI 2013). It is listed if the species is listed in Annex I of the EU Birds Directive and its SPEC (Species of European Conservation Concern) status (BirdLife International 2004a).*

Species		EU Birds Directive	SPEC status	Number of breeding pairs in SPA			
				Eastern Kiel Bight	Baltic Sea east of Wagrien	Hyllekrog-Rødsand	Maribo Lakes
Little Grebe	*Tachybaptus ruficollis*		Non-SPEC	36			105
Great Crested Grebe	*Podiceps cristatus*		Non-SPEC	24			387
Red-necked Grebe	*Podiceps grisegena*		Non-SPEC	84			62
Black-necked Grebe	*Podiceps nigricollis*		Non-SPEC				7
Great Cormorant	*Phalacrocorax carbo*		Non-SPEC	120			1,806
Eurasian Bittern	*Botaurus stellaris*	Annex I	SPEC 3	30	1		35
Common Heron	*Ardea cinerea*		Non-SPEC	14	12		124
Mute Swan	*Cygnus olor*		Non-SPEC E	43	4	89	28
Greylag Goose	*Anser anser*		Non-SPEC	444	45	61	550
Canada Goose	*Branta canadensis*		Non-SPEC	17	1		
Shelduck	*Tadorna tadorna*		Non-SPEC	168	15	14	23
Eurasian Wigeon	*Anas penelope*		Non-SPEC E W	1			
Gadwall	*Anas strepera*		SPEC 3	68	10	15	65
Common Teal	*Anas crecca*		Non-SPEC	1			
Mallard	*Anas platyrhynchos*		Non-SPEC			33	105
Garganey	*Anas querquedula*		SPEC 3	17			5
Northern Shoveler	*Anas clypeata*		SPEC 3	14		10	64
Red-crested Pochard	*Netta rufina*		Non-SPEC	9			12
Common Pochard	*Aythya ferina*		SPEC 2	13			254
Tufted Duck	*Aythya fuligula*		SPEC 3	43		1	276
Greater Scaup	*Aythya marila*		SPEC 3W				
Common Eider	*Somateria mollissima*		Non-SPEC E	56	8	398	
Red-breasted Merganser	*Mergus serrator*		Non-SPEC	116	28	9	

Species		EU Birds Directive	SPEC status	Number of breeding pairs in SPA			
				Eastern Kiel Bight	Baltic Sea east of Wagrien	Hylle-krog-Rødsand	Maribo Lakes
Goosander	*Mergus merganser*		Non-SPEC	10			
White-tailed Eagle	*Haliaeetus albicilla*	Annex I	SPEC 1	2		2	1
Marsh Harrier	*Circus aeruginosus*	Annex I	Non-SPEC	30	3		34
Eurasian Kestrel	*Falco tinnunculus*		SPEC 3			1	
Hobby	*Falco subbeteo*		Non-SPEC	2			
Quail	*Coturnix coturnix*		SPEC 3	1			
Water Rail	*Rallus aquaticus*		Non-SPEC	190	10		145
Spotted Crake	*Porzana porzana*	Annex I	Non-SPEC E	10			
Corncrake	*Crex crex*		SPEC 1	2			
Moorhen	*Gallinula chloropus*		Non-SPEC	45			210
Common Coot	*Fulica atra*		Non-SPEC	86			1,255
Crane	*Grus grus*	Annex I	SPEC 2	2			
Oystercatcher	*Haematopus ostralegus*		Non-SPEC E	76	7	31	
Avocet	*Recurvirostra avosetta*	Annex I	Non-SPEC	62	6	41	
Little Ringed Plover	*Charadrius dubius*		Non-SPEC			5	
Ringed Plover	*Charadrius hiaticula*		Non-SPEC E	114	9	15	
Lapwing	*Vanellus vanellus*		SPEC 2	146	12	8	
Dunlin	*Calidris alpina*		SPEC 3			2	
Snipe	*Gallinago gallinago*		SPEC 3	12	2		
Redshank	*Tringa totanus*		SPEC 2	102	10	19	
Mediterranean Gull	*Larus melanocephalus*	Annex I	Non-SPEC E	2			
Black-headed Gull	*Larus ridibundus*		Non-SPEC E	60			215
Common Gull	*Larus canus*		SPEC 2	1,251	44	35	
Herring Gull	*Larus argentatus*		Non-SPEC E	771	2	1,066	
Great Black-backed Gull	*Larus marinus*		Non-SPEC E	8		59	
Sandwich Tern	*Sterna sandvicensis*	Annex I	SPEC 2			2	
Common Tern	*Sterna hirundo*	Annex I	Non-SPEC	84	1		30
Arctic Tern	*Sterna paradisaea*	Annex I	Non-SPEC	36		14	
Little Tern	*Sterna albifrons*	Annex I	SPEC 3	56	44	14	
Black Tern	*Chlidonias niger*	Annex I	SPEC 3	2			
Stock Dove	*Columba oenas*		Non-SPEC E	3			
Woodpigeon	*Columba palumbus*		Non-SPEC E			3	
Cuckoo	*Cuculus canorus*		Non-SPEC	19	3		
Eagle Owl	*Bubo bubo*	Annex I	SPEC 3	1			
Long-eared Owl	*Asio otus*		Non-SPEC	6			
Short-eared Owl	*Asio flammeus*	Annex I	SPEC 3	1			
Kingfisher	*Alcedo atthis*	Annex I	SPEC 3	3			

Species		EU Birds Directive	SPEC status	Number of breeding pairs in SPA			
				Eastern Kiel Bight	Baltic Sea east of Wagrien	Hyllekrog-Rødsand	Maribo Lakes
Black Woodpecker	*Dryocopus martius*	Annex I	Non-SPEC	1			
Middle Spotted Woodpecker	*Dendrocopos medius*	Annex I	Non-SPEC E	2			
Skylark	*Alauda arvensis*		SPEC 3	278	10	1	
Sand Martin	*Riparia riparia*		SPEC 3	230			
Barn Swallow	*Hirundo rustica*		SPEC 3			13	
Meadow Pipit	*Anthus pratensis*		Non-SPEC E	231	17	6	
Yellow Wagtail	*Motacilla flava*		Non-SPEC	48	4	1	
Thrush Nightingale	*Luscinia luscinia*		Non-SPEC E	9			
Bluethroat	*Luscinia svecica*	Annex I	Non-SPEC	25			
Whinchat	*Saxicola rubetra*		Non-SPEC E	13			
Stonechat	*Saxicola torquata*		Non-SPEC	4			
Grasshopper Warbler	*Locustella naevia*		Non-SPEC E	58	1		
Savi's Warbler	*Locustella luscinoides*		Non-SPEC E	21			
Sedge Warbler	*Acrocephalus schoenobaenus*	-	Non-SPEC E	446	23		
Marsh Warbler	*Acrocephalus palustris*		Non-SPEC E	24	4		
Reed Warbler	*Acrocephalus scirpaceus*		Non-SPEC E	811	53		
Whitethroat	*Sylvia communis*		Non-SPEC E	145	14		
Bearded Tit	*Panurus biarmicus*		Non-SPEC	120	8		
Penduline Tit	*Remiz pendulinus*		Non-SPEC	2	1		
Golden Oriole	*Oriolus Oriolus*		Non-SPEC	2			
Red-backed Shrike	*Lanius collurio*	Annex I	SPEC 3	11	1		
Hooded Crow	*Corvus corone cornix*		Non-SPEC			3	
Common Raven	*Corvus corax*		Non-SPEC	5			
Siskin	*Carduelis spinus*		Non-SPEC E	3			
Linnet	*Carduelis cannabina*		SPEC 2	48			
Common Rosefinch	*Carpodacus erythrinus*		Non-SPEC	10	7		
Reed Bunting	*Emberiza schoeniclus*		Non-SPEC	1,043	105	3	
Corn Bunting	*Miliaria calandra*		SPEC 2	2			

Table 12.2 *Species list of all species recorded during aerial and ship-based surveys during FEBI baseline investigation (FEBI 2013). It is listed whether the species is listed in Annex I of the EU Birds Directive and the species' SPEC (Species of European Conservation Concern) status is given (BirdLife International 2004a); maximum estimate indicates the maximum abundance estimate for the Fehmarnbelt study area (Total; 'X' species has been recorded), for German coastal areas (DE) and for Danish coastal areas (DK) from FEBI baseline investigations; importance level is given for assessed non-breeding waterbird species (FEBI 2013).*

Species		EU Birds Directive	SPEC status	Maximum estimate			Importance level
				Total	DE	DK	
Red-throated Diver	*Gavia stellata*	Annex I	SPEC 3	X			very high
Black-throated Diver	*Gavia arctica*	Annex I	SPEC 3	X			very high
Diver spp.	*Gaviidae indet.*			1,711			
Little Grebe	*Tachybaptus ruficollis*		Non-SPEC	X			
Great Crested Grebe	*Podiceps cristatus*		Non-SPEC	1,540			minor
Red-necked Grebe	*Podiceps grisegena*		Non-SPEC	1,100			very high
Slavonian Grebe	*Podiceps auritus*	Annex I	SPEC 3	10			minor
Black-necked Grebe	*Podiceps nigricollis*		Non-SPEC	X			
Fulmar	*Fulmarus glacialis*		Non-SPEC	X			
Manx Shearwater	*Puffinus puffinus*		SPEC 2	X			
Northern Gannet	*Sula bassana*		Non-SPEC E	X			
Great Cormorant	*Phalacrocorax carbo*		Non-SPEC		6,500	3,900	very high
Common Heron	*Ardea cinerea*		Non-SPEC	X			
Mute Swan	*Cygnus olor*		Non-SPEC E	10,400			very high
Bewick's Swan	*Cygnus columbianus bewickii*	Annex I	SPEC 3W		138	61	very high
Whooper Swan	*Cygnus cygnus*	Annex I	Non-SPEC E W		890	590	very high
Bean Goose	*Anser fabalis*		Non-SPEC E W		2,100	102	medium
Greater White-fronted Goose	*Anser albifrons*		Non-SPEC		1,700	200	minor
Greylag Goose	*Anser anser*		Non-SPEC		5,000	2,700	very high
Canada Goose	*Branta canadensis*		Non-SPEC	X			
Barnacle Goose	*Branta leucopsis*	Annex I	Non-SPEC E		5,350	3,000	very high
Brent Goose	*Branta bernicla*		SPEC 3W			1,800	high
Egyptian Goose	*Alopochen aegyptiacus*			X			
Shelduck	*Tadorna tadorna*		Non-SPEC	X			
Eurasian Wigeon	*Anas penelope*		Non-SPEC E W		15,000	1,900	very high
Gadwall	*Anas strepera*		SPEC 3		720	60	very high
Common Teal	*Anas crecca*		Non-SPEC		2,500	520	medium
Mallard	*Anas platyrhynchos*		Non-SPEC		7,400	3,250	minor
Northern Pintail	*Anas acuta*		SPEC 3	X			

Species		EU Birds Direc-tive	SPEC status	Maximum estimate			Importance level
				Total	DE	DK	
Garganey	*Anas querquedula*		SPEC 3	X			
Northern Shoveler	*Anas clypeata*		SPEC 3		990	90	very high
Red-crested Pochard	*Netta rufina*		Non-SPEC	X			
Common Pochard	*Aythya ferina*		SPEC 2		1,720	1,800	very high
Tufted Duck	*Aythya fuligula*		SPEC 3		17,500	14,000	very high
Greater Scaup	*Aythya marila*		SPEC 3W		12,000	450	very high
Common Eider	*Somateria mollissima*		Non-SPEC E	327,505			very high
King Eider	*Somateria spectabilis*		Non-SPEC	X			
Long-tailed Duck	*Clangula hyemalis*		Non-SPEC	23,800			very high
Common Scoter	*Melanitta nigra*		Non-SPEC	66,290			very high
Velvet Scoter	*Melanitta fusca*		SPEC 3	3,050			high
Common Goldeneye	*Bucephala clangula*		Non-SPEC	6,400			medium
Smew (merganser)	*Mergus albellus*	Annex I	SPEC 3		60	1,300	very high
Red-breasted Merganser	*Mergus serrator*		Non-SPEC	7,800			very high
Goosander	*Mergus merganser*		Non-SPEC		325	284	minor
Honey-Buzzard	*Pernis apivorus*	Annex I	Non-SPEC E	X			
Red Kite	*Milvus milvus*	Annex I	SPEC 2	X			
White-tailed Eagle	*Haliaeetus albicilla*	Annex I	SPEC 1		21	6	
Marsh Harrier	*Circus aeruginosus*	Annex I	Non-SPEC	X			
Northern (Hen) Harrier	*Circus cyaneus*	Annex I	SPEC 3	X			
European Sparrow Hawk	*Accipiter nisus*		Non-SPEC	X			
Eurasian Buzzard	*Buteo buteo*		Non-SPEC	X			
Rough-legged Buzzard	*Buteo lagopus*		Non-SPEC	X			
Osprey	*Pandion haliaetus*	Annex I	SPEC 3	X			
Eurasian Kestrel	*Falco tinnunculus*		SPEC 3	X			
Merlin	*Falco columbarius*	Annex I	Non-SPEC	X			
Hobby	*Falco subbeteo*		Non-SPEC	X			
Peregrine Falcon	*Falco peregrinus*	Annex I	Non-SPEC	X			
Common Coot	*Fulica atra*		Non-SPEC		8,500	6,520	minor
Oystercatcher	*Haematopus ostralegus*		Non-SPEC E	X			
Golden Plover	*Pluvialis apricaria*	Annex I	Non-SPEC E	X			
Grey Plover	*Pluvialis squatarola*		Non-SPEC	X			
Sanderling	*Calidris alba*		Non-SPEC	X			
Purple Sandpiper	*Calidris maritima*		Non-SPEC E	X			
Dunlin	*Calidris alpina*		SPEC 3	X			
Snipe	*Gallinago gallinago*		SPEC 3	X			

Species		EU Birds Direc-tive	SPEC status	Maximum estimate			Importance level
				Total	DE	DK	
Bar-tailed Godwit	*Limosa lapponica*	Annex I	Non-SPEC	X			
Whimbrel	*Numenius phaeopus*		Non-SPEC E	X			
Curlew	*Numenius arquata*		SPEC 2	X			
Redshank	*Tringa totanus*		SPEC 2				
Grey Phalarope	*Phalaropus fulicarius*		Non-SPEC	X			
Pomarine Skua	*Stercorarius pomarinus*		Non-SPEC	X			
Arctic Skua	*Stercorarius parasiticus*		Non-SPEC	X			
Mediterranean Gull	*Larus melanocephalus*	Annex I	Non-SPEC E	X			
Little Gull	*Larus minutus*	Annex I	SPEC 3	5,720			very high
Sabine's Gull	*Larus sabini*		Non-SPEC	X			
Black-headed Gull	*Larus ridibundus*		Non-SPEC E	8,250			medium
Common Gull	*Larus canus*		SPEC 2	6,700			high
Lesser Black-backed Gull	*Larus fuscus*		Non-SPEC E	9			minor
Herring Gull	*Larus argentatus*		Non-SPEC E	10,600			medium
Yellow-legged Gull	*Larus cachinnans michahellis*		Non-SPEC E	X			
Caspian Gull	*Larus cachinnans*		Non-SPEC E	X			
Great Black-backed Gull	*Larus marinus*		Non-SPEC E	1,200			medium
Kittiwake	*Rissa tridactyla*		Non-SPEC	X			
Caspian Tern	*Sterna caspia*		SPEC 3	X			
Sandwich Tern	*Sterna sandvicensis*	Annex I	SPEC 2	350			high
Common Tern	*Sterna hirundo*	Annex I	Non-SPEC	255			minor
Arctic Tern	*Sterna paradisaea*	Annex I	Non-SPEC	150			minor
Little Tern	*Sterna albifrons*	Annex I	SPEC 3	X			
Black Tern	*Chlidonias niger*	Annex I	SPEC 3	X			
Common Guillemot	*Uria aalge*		Non-SPEC	10			minor
Razorbill	*Alca torda*		Non-SPEC E	1,184			medium
Black Guillemot	*Cepphus grylle*		SPEC 2	X			high
Little Auk	*Alle alle*		Non-SPEC	X			
Puffin	*Fratercula arctica*		SPEC 2	X			
Stock Dove	*Columba oenas*		Non-SPEC E	X			
Woodpigeon	*Columba palumbus*		Non-SPEC E	X			
Long-eared Owl	*Asio otus*		Non-SPEC	X			
Swift	*Apus apus*		Non-SPEC	X			
Woodlark	*Lullula arborea*	Annex I	SPEC 2	X			
Skylark	*Alauda arvensis*		SPEC 3	X			
Sand Martin	*Riparia riparia*		SPEC 3	X			

Species		EU Birds Directive	SPEC status	Maximum estimate			Importance level
				Total	DE	DK	
Barn Swallow	*Hirundo rustica*		SPEC 3	X			
House Martin	*Delichon urbica*		SPEC 3	X			
Meadow Pipit	*Anthus pratensis*		Non-SPEC E	X			
Yellow Wagtail	*Motacilla flava*		Non-SPEC	X			
Grey Wagtail	*Motacilla cinerea*		Non-SPEC	X			
White Wagtail	*Motacilla alba*		Non-SPEC	X			
Robin	*Erithacus rubecula*		Non-SPEC E	X			
Fieldfare	*Turdus pilaris*		Non-SPEC E W	X			
Redwing	*Turdus iliacus*		Non-SPEC E W	X			
Chiffchaff	*Phylloscopus collybita*		Non-SPEC	X			
Willow Warbler	*Phylloscopus trochilus*		Non-SPEC	X			
Coal Tit	*Parus ater*		Non-SPEC	X			
Blue Tit	*Parus caeruleus*		Non-SPEC E	X			
Great Tit	*Parus major*		Non-SPEC	X			
Black-billed Magpie	*Pica pica*		Non-SPEC	X			
Eurasian Jackdaw	*Corvus monedula*		Non-SPEC E	X			
Rook	*Corvus frugilegus*		Non-SPEC	X			
Carrion Crow	*Corvus corone corone*		Non-SPEC	X			
Common Raven	*Corvus corax*		Non-SPEC	X			
Common Starling	*Sturnus vulgaris*		SPEC 3	X			
Chaffinch	*Fringilla coelebs*		Non-SPEC E	X			
Brambling	*Fringilla montifringilla*		Non-SPEC	X			
Goldfinch	*Carduelis carduelis*		Non-SPEC	X			
Siskin	*Carduelis spinus*		Non-SPEC E	X			
Linnet	*Carduelis cannabina*		SPEC 2	X			
Reed Bunting	*Emberiza schoeniclus*		Non-SPEC	X			

Table 12.3 *List of all species recorded as migrating bird during FEBI baseline investigation (FEBI 2013). It is listed whether the species is listed in Annex I of the EU Birds Directive and the species' SPEC (Species of European Conservation Concern) status is given (BirdLife International 2004); maximum number indicates the maximum number obtained from visual observations from both baseline years for spring and autumn season; importance indicates the importance level derived from maximum number of visual observations and species' conservation status (FEBI 2013).*

Species		EU Birds Directive	SPEC status	Maximum number		Importance level
				spring	autumn	
Red-throated Diver	*Gavia stellata*	Annex I	SPEC 3	602	192	high
Black-throated Diver	*Gavia arctica*	Annex I	SPEC 3	586	200	high
Great Northern Diver	*Gavia immer*	Annex I	Non-SPEC	8	0	minor
Diver sp.	*Gaviidae indet.*			2,400	392	high
Little Grebe	*Tachybaptus ruficollis*		Non-SPEC	0	0	
Great Crested Grebe	*Podiceps cristatus*		Non-SPEC	1,046	296	minor
Red-necked Grebe	*Podiceps grisegena*		Non-SPEC	222	450	medium
Slavonian Grebe	*Podiceps auritus*	Annex I	SPEC 3	40	6	high
Sooty Shearwater	*Puffinus griseus*		SPEC 1	8	2	minor
Northern Gannet	*Sula bassana*		Non-SPEC E	24	0	minor
Great Cormorant	*Phalacrocorax carbo*		Non-SPEC	6,950	26,454	very high
Eurasian Bittern	*Botaurus stellaris*	Annex I	SPEC 3	2	0	minor
Great White Egret	*Egretta alba*	Annex I	Non-SPEC	16	2	minor
Common Heron	*Ardea cinerea*		Non-SPEC	188	428	minor
White Stork	*Ciconia ciconia*	Annex I	SPEC 2	6	106	very high
Mute Swan	*Cygnus olor*		Non-SPEC E	1,785	2,194	medium
Bewick's Swan	*Cygnus columbianus bewickii*	Annex I	SPEC 3W	80	96	high
Whooper Swan	*Cygnus cygnus*	Annex I	Non-SPEC E W	224	78	high
Bean Goose	*Anser fabalis*		Non-SPEC E W	234	1,142	medium
Pink-footed Goose	*Anser brachyrhynchus*		Non-SPEC E	0	2	minor
Greater White-fronted Goose	*Anser albifrons*		Non-SPEC	2,050	1,936	minor
Greylag Goose	*Anser anser*		Non-SPEC	4,038	15,734	very high
Canada Goose	*Branta canadensis*		Non-SPEC	136	104	
Barnacle Goose	*Branta leucopsis*	Annex I	Non-SPEC E	50,939	81,918	very high
Brent Goose	*Branta bernicla*		SPEC 3W	41,947	5,670	very high
Egyptian Goose	*Alopochen aegyptiacus*			6	0	
Shelduck	*Tadorna tadorna*		Non-SPEC	752	706	minor
Eurasian Wigeon	*Anas penelope*		Non-SPEC E W	2,556	13,650	medium
Gadwall	*Anas strepera*		SPEC 3	83	184	high
Common Teal	*Anas crecca*		Non-SPEC	474	1,838	minor
Mallard	*Anas platyrhynchos*		Non-SPEC	343	2,760	minor
Northern Pintail	*Anas acuta*		SPEC 3	128	1,058	very high
Garganey	*Anas querquedula*		SPEC 3	11	6	minor
Northern Shoveler	*Anas clypeata*		SPEC 3	294	354	medium
Red-crested Pochard	*Netta rufina*		Non-SPEC	2	0	minor
Common Pochard	*Aythya ferina*		SPEC 2	90	62	minor
Tufted Duck	*Aythya fuligula*		SPEC 3	404	342	minor
Greater Scaup	*Aythya marila*		SPEC 3W	936	788	high
Common Eider	*Somateria mollissima*		Non-SPEC E	323,729	311,774	very high
King Eider	*Somateria spectabilis*		Non-SPEC	5	0	minor
Long-tailed Duck	*Clangula hyemalis*		Non-SPEC	2,484	674	minor

Species		EU Birds Directive	SPEC status	Maximum number		Importance level
				spring	autumn	
Common Scoter	*Melanitta nigra*		Non-SPEC	48,052	49,458	very high
Black/Velvet Scoter	*Melanitta indet.*			24	0	
Velvet Scoter	*Melanitta fusca*		SPEC 3	192	328	minor
Common Goldeneye	*Bucephala clangula*		Non-SPEC	562	426	minor
Smew (merganser)	*Mergus albellus*	Annex I	SPEC 3	4	2	minor
Red-breasted Merganser	*Mergus serrator*		Non-SPEC	3,794	2,264	very high
Goosander	*Mergus merganser*		Non-SPEC	137	106	minor
Merganser sp.	*Mergus indet.*			8	4	
Honey-Buzzard	*Pernis apivorus*	Annex I	Non-SPEC E	790	4,080	very high
Black Kite	*Milvus migrans*	Annex I	SPEC 3	10	6	very high
Red Kite	*Milvus milvus*	Annex I	SPEC 2	112	812	very high
White-tailed Eagle	*Haliaeetus albicilla*	Annex I	SPEC 1	26	44	very high
Marsh Harrier	*Circus aeruginosus*	Annex I	Non-SPEC	132	372	very high
Northern (Hen) Harrier	*Circus cyaneus*	Annex I	SPEC 3	18	48	high
Pallid Harrier	*Circus macrourus*		SPEC 1	0	4	minor
Montagu's Harrier	*Circus pygargus*	Annex I	Non-SPEC E	4	4	minor
Harrier sp.	*Circus indet.*			0	8	
Northern Goshawk	*Accipiter gentilis*		Non-SPEC	2	2	minor
European Sparrow Hawk	*Accipiter nisus*		Non-SPEC	645	2,432	very high
Eurasian Buzzard	*Buteo buteo*		Non-SPEC	1,954	6,236	very high
Rough-legged Buzzard	*Buteo lagopus*		Non-SPEC	14	40	minor
Lesser Spotted Eagle	*Aquila pomarina*	Annex I	SPEC 2	2	2	minor
Greater Spotted Eagle	*Aquila clanga*	Annex I	SPEC 1	0	2	minor
Osprey	*Pandion haliaetus*	Annex I	SPEC 3	18	98	very high
Eurasian Kestrel	*Falco tinnunculus*		SPEC 3	69	174	high
Red-footed Falcon	*Falco vespertinus*		SPEC 3	0	12	
Merlin	*Falco columbarius*	Annex I	Non-SPEC	37	58	high
Hobby	*Falco subbeteo*		Non-SPEC	70	32	minor
Peregrine Falcon	*Falco peregrinus*	Annex I	Non-SPEC	20	18	very high
Falcon sp.	*Falco indet.*			4	8	
Grey Partridge	*Perdix perdix*		SPEC 3	0	0	
Quail	*Coturnix coturnix*		SPEC 3	0	0	
Pheasant	*Phasianus colchicus*		Non-SPEC	0	26	minor
Water Rail	*Rallus aquaticus*		Non-SPEC	0	0	
Spotted Crake	*Porzana porzana*	Annex I	Non-SPEC E	0	0	
Corncrake	*Crex crex*		SPEC 1			
Moorhen	*Gallinula chloropus*		Non-SPEC	0	0	
Common Coot	*Fulica atra*		Non-SPEC	0	0	
Crane	*Grus grus*	Annex I	SPEC 2	1,916	328	very high
Oystercatcher	*Haematopus ostralegus*		Non-SPEC E	187	426	minor
Avocet	*Recurvirostra avosetta*	Annex I	Non-SPEC	62	82	high
Little Ringed Plover	*Charadrius dubius*		Non-SPEC	2	18	minor
Ringed Plover	*Charadrius hiaticula*		Non-SPEC E	120	334	minor
Dotterel	*Charadrius morinellus*	Annex I	Non-SPEC	0	2	minor
Golden Plover	*Pluvialis apricaria*	Annex I	Non-SPEC E	632	1,930	high
Grey Plover	*Pluvialis squatarola*		Non-SPEC	2,190	446	medium

Species		EU Birds Directive	SPEC status	Maximum number		Importance level
				spring	autumn	
Golden / Grey Plover	*Pluvialis apricaria / squatarola*			0	6	
Lapwing	*Vanellus vanellus*		SPEC 2	458	1,878	minor
Knot	*Calidris canutus*		SPEC 3W	14,020	450	very high
Sanderling	*Calidris alba*		Non-SPEC	50	106	minor
Little Stint	*Calidris minuta*		Non-SPEC	0	6	minor
Temmincks Stint	*Calidris temminckii*		Non-SPEC	8	2	minor
Curlew Sandpiper	*Calidris ferruginea*		NA	0	28	minor
Purple Sandpiper	*Calidris maritima*		Non-SPEC E	6	4	minor
Dunlin	*Calidris alpina*		SPEC 3	23,042	2,390	very high
Broad-billed Sandpiper	*Limicola falcinellus*		SPEC 3	0	0	
Ruff	*Philomachus pugnax*	Annex I	SPEC 2	28	54	minor
Jack Snipe	*Lymnocryptes minimus*	-	SPEC 3	0	0	
Snipe	*Gallinago gallinago*		SPEC 3	18	392	minor
Woodcock	*Scolopax rusticola*		SPEC 3	6	0	
Black-tailed Godwit	*Limosa limosa*		SPEC 2	4	0	minor
Bar-tailed Godwit	*Limosa lapponica*	Annex I	Non-SPEC	31,262	898	very high
Whimbrel	*Numenius phaeopus*		Non-SPEC E	62	104	minor
Curlew	*Numenius arquata*		SPEC 2	13,232	2,268	very high
Spotted Redshank	*Tringa erythropus*		SPEC 3	8	38	minor
Redshank	*Tringa totanus*		SPEC 2	34	96	minor
Marsh Sandpiper	*Tringa stagnatilis*		Non-SPEC	0	2	minor
Greenshank	*Tringa nebularia*		Non-SPEC	14	152	minor
Green Sandpiper	*Tringa ochropus*		Non-SPEC	18	82	minor
Wood Sandpiper	*Tringa glareola*	Annex I	SPEC 3	14	74	minor
Common Sandpiper	*Actitis hypoleucos*		SPEC 3	16	68	minor
Turnstone	*Arenaria interpres*		Non-SPEC	4	120	minor
Pomarine Skua	*Stercorarius pomarinus*		Non-SPEC	8	4	minor
Arctic Skua	*Stercorarius parasiticus*		Non-SPEC	60	52	
Long-tailed Skua	*Stercorarius longicaudus*		Non-SPEC	0	8	
Great Skua	*Stercorarius skua*		Non-SPEC E	0	10	
Arctic/Pomarine Skua	*Stercorarius longicaudus/ parasiticus*			8	4	
Arctic / Pomarine Skua	*Stercorarius parasiticus / pomarinus*			2	2	
Mediterranean Gull	*Larus melanocephalus*	Annex I	Non-SPEC E	18	4	minor
Little Gull	*Larus minutus*	Annex I	SPEC 3	7,707	4,564	very high
Black-headed Gull	*Larus ridibundus*		Non-SPEC E	7,549	8,792	medium
Common Gull	*Larus canus*		SPEC 2	1,809	4,522	high
Lesser Black-backed Gull	*Larus fuscus*		Non-SPEC E	43	22	minor
Herring Gull	*Larus argentatus*		Non-SPEC E	4,569	4,943	medium
Yellow-legged Gull	*Larus cachinnans michahellis*		Non-SPEC E	0	4	minor
Glaucous Gull	*Larus hyperboreus*		Non-SPEC	4	0	minor
Great Black-backed Gull	*Larus marinus*		Non-SPEC E	627	676	medium
Kittiwake	*Rissa tridactyla*		Non-SPEC	3	0	minor
Caspian Tern	*Sterna caspia*		SPEC 3	0	2	minor

Species		EU Birds Direc-tive	SPEC status	Maximum number		Importance level
				spring	autumn	
Sandwich Tern	*Sterna sandvicensis*	Annex I	SPEC 2	538	3,638	very high
Common Tern	*Sterna hirundo*	Annex I	Non-SPEC	770	1,606	high
Arctic Tern	*Sterna paradisaea*	Annex I	Non-SPEC	2,401	198	high
Common/Arctic Tern	*Sterna hirundo / paradisaea*	Annex I	Non-SPEC	2,346	1,668	
Little Tern	*Sterna albifrons*	Annex I	SPEC 3	132	108	high
Black Tern	*Chlidonias niger*	Annex I	SPEC 3	60	100	minor
Common Guillemot	*Uria aalge*		Non-SPEC	32	40	minor
Common Guillemot/Razorbill	*Alca torda / Uria aalge*			62	70	
Razorbill	*Alca torda*		Non-SPEC E	172	92	minor
Black Guillemot	*Cepphus grylle*		SPEC 2	8	8	minor
Little Auk	*Alle alle*		Non-SPEC			
Puffin	*Fratercula arctica*		SPEC 2	2	0	minor
Stock Dove	*Columba oenas*		Non-SPEC E	1,500	4,356	very high
Woodpigeon	*Columba palumbus*		Non-SPEC E	40,920	289,884	very high
Collared Dove	*Streptopelia decaocto*		Non-SPEC	52	16	minor
Cuckoo	*Cuculus canorus*		Non-SPEC	10	4	minor
Tawny Owl	*Strix aluco*		Non-SPEC E	0	0	
Long-eared Owl	*Asio otus*		Non-SPEC	0	0	
Short-eared Owl	*Asio flammeus*	Annex I	SPEC 3	2	0	
Swift	*Apus apus*		Non-SPEC	6,052	1,318	minor
Kingfisher	*Alcedo atthis*	Annex I	SPEC 3	0	2	minor
Beeeater	*Merops apiaster*		SPEC 3	0	2	minor
Wryneck	*Jynx torquilla*	-	SPEC 3	0	0	
Great Spotted Woodpecker	*Dendrocopos major*		Non-SPEC	6	56	minor
Middle Spotted Woodpecker	*Dendrocopos medius*	Annex I	Non-SPEC E	0	2	minor
Lesser Spotted Woodpecker	*Dendrocopos minor*	Annex I	Non-SPEC	0	2	minor
Woodlark	*Lullula arborea*	Annex I	SPEC 2	46	370	
Skylark	*Alauda arvensis*		SPEC 3	1,699	7,062	
Shorelark	*Eremophila alpestris*		Non-SPEC	0	6	
Sand Martin	*Riparia riparia*		SPEC 3	282	574	
Barn Swallow	*Hirundo rustica*		SPEC 3	4,710	12,580	
House Martin	*Delichon urbica*		SPEC 3	1,990	1,864	
Tawny Pipit	*Anthus campestris*	Annex I	SPEC 3	2	6	
Tree Pipit	*Anthus trivialis*		Non-SPEC	238	15,802	
Meadow Pipit	*Anthus pratensis*		Non-SPEC E	1,888	14,500	
Red-throated Pipit	*Anthus cervinus*		Non-SPEC	0	8	
Scandinavian Rock Pipit	*Anthus petrosus littoralis*		Non-SPEC E	10	84	
Yellow Wagtail	*Motacilla flava*		Non-SPEC	1,387	13,806	
Grey Wagtail	*Motacilla cinerea*		Non-SPEC	12	238	
White Wagtail	*Motacilla alba*		Non-SPEC	981	2,286	
Waxwing	*Bombycilla garrulus*		Non-SPEC	2	710	
Winter Wren	*Troglodytes troglodytes*		Non-SPEC	2	0	
Dunnock	*Prunella modularis*		Non-SPEC E	91	392	
Robin	*Erithacus rubecula*		Non-SPEC E	66	0	
Thrush Nightingale	*Luscinia luscinia*		Non-SPEC E	0	0	
Bluethroat	*Luscinia svecica*	Annex I	Non-SPEC			

Species		EU Birds Directive	SPEC status	Maximum number		Importance level
				spring	autumn	
Black Redstart	*Phoenicurus ochruros*		Non-SPEC	14	2	
Redstart	*Phoenicurus phoenicurus*		SPEC 2	0	2	
Whinchat	*Saxicola rubetra*		Non-SPEC E	2	0	
Stonechat	*Saxicola torquata*		Non-SPEC	10	0	
Wheatear	*Oenanthe oenanthe*		3	2	14	
Ring Ouzel	*Turdus torquatus*		Non-SPEC E	2	2	
Blackbird	*Turdus merula*		Non-SPEC E	51	54	
Fieldfare	*Turdus pilaris*		Non-SPEC E W	28	2,140	
Song Thrush	*Turdus philomelos*		Non-SPEC E	44	1,102	
Redwing	*Turdus iliacus*		Non-SPEC E W	18	308	
Mistle Thrush	*Turdus viscivorus*		Non-SPEC E	114	534	
Sedge Warbler	*Acrocephalus schoenobaenus*	-	Non-SPEC E	0	0	
Marsh Warbler	*Acrocephalus palustris*		Non-SPEC E	0	0	
Reed Warbler	*Acrocephalus scirpaceus*		Non-SPEC E	0	0	
Reed-warblers	*Acrocephalus indet.*			0	0	
Icterine Warbler	*Hippolais icterina*		Non-SPEC E	2	0	
Lesser Whitethroat	*Sylvia curruca*		Non-SPEC	0	0	
Whitethroat	*Sylvia communis*		Non-SPEC E	0	4	
Garden Warbler	*Sylvia borin*		Non-SPEC E	0	24	
Blackcap	*Sylvia atricapilla*		Non-SPEC E			
Green Warbler	*Phylloscopus trochiloides*		Non-SPEC	0	0	
Wood Warbler	*Phylloscopus sibilatrix*		SPEC 2	2	0	
Chiffchaff	*Phylloscopus collybita*		Non-SPEC	9	24	
Willow Warbler	*Phylloscopus trochilus*		Non-SPEC	2	22	
Warbler sp.	*Phylloscopus indet.*			0	4	
Goldcrest	*Regulus regulus*		Non-SPEC E	0	10	
Firecrest	*Regulus ignicapillus*		Non-SPEC E	0	0	
Spotted Flycatcher	*Muscicapa striata*		SPEC 3	2	4	
Red-breasted Flycatcher	*Ficedula parva*	Annex I	Non-SPEC	0	0	
Pied Flycatcher	*Ficedula hypoleuca*		Non-SPEC E	4	4	
Bearded Tit	*Panurus biarmicus*		Non-SPEC	0	12	
Long-tailed Tit	*Aegithalos caudatus*		Non-SPEC	0	34	
Marsh Tit	*Parus palustris*		SPEC 3	2	0	
Coal Tit	*Parus ater*		Non-SPEC	80	12	
Blue Tit	*Parus caeruleus*		Non-SPEC E	1,296	4,330	
Great Tit	*Parus major*		Non-SPEC	386	386	
Nuthatch	*Sitta europaea*		Non-SPEC	0	2	
Treecreeper	*Certhia familiaris*		Non-SPEC	0	0	
Short-toed Treecreeper	*Certhia brachydactyla*	-	Non-SPEC E	0	0	
Penduline Tit	*Remiz pendulinus*		Non-SPEC	8	10	
Red-backed Shrike	*Lanius collurio*	Annex I	SPEC 3	0	0	
Northern Shrike	*Lanius excubitor*		SPEC 3	0	2	
Eurasian Jay	*Garrulus glandarius*		Non-SPEC	0	240	minor
Black-billed Magpie	*Pica pica*		Non-SPEC	92	140	minor
Eurasian Jackdaw	*Corvus monedula*		Non-SPEC E	5,532	5,616	medium

Species		EU Birds Directive	SPEC status	Maximum number		Importance level
				spring	autumn	
Rook	*Corvus frugilegus*		Non-SPEC	376	4,320	very high
Carrion Crow	*Corvus corone corone*		Non-SPEC	228	36	minor
Common Raven	*Corvus corax*		Non-SPEC	4	0	minor
Common Starling	*Sturnus vulgaris*		SPEC 3	6,336	18,060	
House Sparrow	*Passer domesticus*		SPEC 3	4	82	
Tree Sparrow	*Passer montanus*		SPEC 3	136	558	
Chaffinch	*Fringilla coelebs*		Non-SPEC E	17,438	43,588	
Brambling	*Fringilla montifringilla*		Non-SPEC	228	246	
Chaffinch sp.	*Fringilla indet.*		Non-SPEC E	1,104	301,472	
European Serin	*Serinus serinus*		Non-SPEC E	37	2	
Greenfinch	*Carduelis chloris*		Non-SPEC E	2,591	6,708	
Goldfinch	*Carduelis carduelis*		Non-SPEC	215	2,286	
Siskin	*Carduelis spinus*		Non-SPEC E	742	65,416	
Linnet	*Carduelis cannabina*		SPEC 2	2,973	4,506	
Twite	*Carduelis flavirostris*		Non-SPEC	64	758	
Common Redpoll	*Carduelis cabaret*		Non-SPEC	554	5,972	
Common Crossbill	*Loxia curvirostra*		Non-SPEC	130	1,258	
Parrot Crossbill	*Loxia pytyopsittacus*		Non-SPEC E	0	30	
Common Rosefinch	*Carpodacus erythrinus*		Non-SPEC	2	4	
Bullfinch	*Pyrrhula pyrrhula*		Non-SPEC	4	312	
Hawfinch	*Coccothraustes coccothraustes*		Non-SPEC	12	44	
Lapland Bunting	*Calcarius lapponicus*	-	Non-SPEC	2	6	
Snow Bunting	*Plectrophenax nivalis*		Non-SPEC	2	6	
Yellowhammer	*Emberiza citrinella*		Non-SPEC E	53	484	
Ortolan Bunting	*Emberiza hortulana*	-	SPEC 2	0	2	
Reed Bunting	*Emberiza schoeniclus*		Non-SPEC	356	3,826	
Corn Bunting	*Miliaria calandra*		SPEC 2	2	0	
Passerines grouped by migration behaviour						
Obligatory night-time migrants						medium
Facultative night-time migrants						medium
Obligatory daytime migrants						high

Most of the observed bird species use the impairment zone during migration or as resting and foraging habitat. Breeding sites are not located within the impairment zone, thus breeding birds are only indirectly affected in the marine area. Deliberate destruction or damage of nests and eggs are thus not discussed here, but in the land approach reports. Article 5 b) is therefore irrelevant in this assessment.

As all European bird species are covered by Article 5, all species, which are present in the impact area, have to be discussed here. During the baseline investigations 261 bird species were recorded in the area (Table 12.1). Of these, 50 species are listed in Annex I of the Birds Directive and 78 have one of the SPEC Status 1-3W. All species having such a protection status and occurring at a relevant abundance in the impact area (Table 12.1) are described below. All other species are combined into ecological guilds.

12.3 Assessment of Strictly Protected Species for the tunnel alternative

The assessment of Strictly Protected Species is conducted assessing the following impact categories:

1. Deliberate killing

a) caused during construction

Deliberate killings of birds during construction works may occur due to collision with construction vessels or due to starvation, e.g. if a food resource declines in abundance and/or mass or decreased water transparency makes searching for food for birds inefficient.

b) caused by structure and operation

Deliberate killings due to the structure and operation of an immersed tunnel are not expected for bird species as the structure will be under water and the airspace will be free of barriers.

2. Deliberate destruction of, or damage to, their nests and eggs or removal of their nests

As there are no breeding sites in the marine environment of the Fehmarnbelt, this prohibition does not apply here. The assessment of strictly protected species of the land approach will cover the affected species.

3. Deliberate disturbance

a) caused during construction

Deliberate disturbance caused during construction of a tunnel may occur from construction vessels and decreased water transparency and will result in a displacement of individuals. Barrier effects have, according to German guidelines (LBV-SH 2007), also be treated as disturbances, if local populations are seriously impaired by habitat limitations.

b) caused by structure and operation

Deliberate disturbance caused by structure and operation of a tunnel may not occur. Barrier effects have, according to German guidelines (LBV-SH 2007), also be treated as disturbances, if local populations are seriously impaired by habitat limitations.

4. Deterioration or destruction of resting places

a) caused during construction

Deterioration or destruction of resting places during construction may occur from the footprint area of the tunnel.

b) caused by structure and operation

Deterioration or destruction of resting places by structure and operation may not occur.

Thus, in the following only deliberate killing and deliberate disturbance caused during construction as well as disturbance of resting places will be considered for the assessment of the tunnel alternative.

12.3.1 Breeding waterbirds

Introduction

Breeding waterbirds are not directly affected, as breeding sites are not located within the impairment zone. Therefore, only such species that are connected to marine habitats (as foraging or rearing sites) are discussed here. These species face in principle the same pressures and risks as non-breeding waterbird species.

Deliberate killing caused during construction

Deliberate killings due to collisions with construction vessels are not expected to be of relevance for breeding waterbirds. Construction works for a fixed link in the Fehmarnbelt would take place in an area of already existing high shipping intensity. So, construction vessels are expected to contribute to the total amount of ship traffic in the area.

During daylight hours collisions are highly unlikely. Larger construction vessels are expected to move rather slowly or be anchored. Birds can easily see the vessels and can fly around them.

During the night birds might be attracted by the lights of the construction vessels during certain weather conditions. Collisions of birds with ships at night have been documented in Southwest Greenland and were significantly related to bad visibility (Merkel and Johansen 2011). The impact of the construction vessels would however be limited to a small area at any time and the number of collisions is expected to be very low. Thus, it is not expected, that deliberate killings by collisions will commit an offence of Article 5 for any breeding bird species.

Deliberate disturbance caused during construction

Deliberate disturbance due to barrier effects from construction vessels have according to the EIA no impact on the local populations of breeding waterbirds. Thus, barrier effects will not commit an offence of Article 5.

Red-necked Grebe

Deliberate killing caused during construction

Assuming that all breeding adults would fly the shortest distance to marine waters, all of them (42 individuals) would potentially encounter conditions with decreased water transparency during the first summer (2015) of the tunnel construction. Considering predicted decrease in water transparency during summers of the tunnel construction, fewer birds would be affected during the second summer (2016), and none during the subsequent years. As there are no impacts on small fish species according to the EIA, deliberate killings due to starvation will not commit an offence of Article 5 for breeding Red-necked Grebes.

Deliberate disturbance caused during construction

According to the EIA the nature reserve Grüner Brink is the closest reported German breeding site of Red-necked Grebes to the affected disturbance zone. Birds are known to regularly commute between their inland breeding sites and marine foraging habitats. Since the disturbance zone does not affect the directly adjacent coastal waters of Grüner Brink and the area is already highly impaired by intense ferry traffic, the impairment of breeding Red-necked Grebes at Grüner Brink will be low.

In contrast, on the Danish side on Lolland some Red-necked Grebes breed close to the planned alignment and the defined disturbance zone. It cannot be excluded that disturbance effect from construction vessels, decreased water transparency and longer distances to other foraging sites outside the disturbance zone would have an impact on Red-necked Grebes breeding in the immediate vicinity of the disturbance zone. The assessment of strictly protected species for the land areas of Lolland is part of the EIA on Lolland land areas.

Thus, for the marine environment there will be no deliberate disturbance and therefore no offence of Article 5 for Red-necked Grebes.

Deterioration or destruction of resting places during construction
Resting places of breeding Red-necked Grebes will be near the breeding sites. According to the EIA it is expected that the footprint and especially the land reclamation at Lolland will result in a loss of foraging habitats to Red-necked Grebes breeding on Lolland outside the SPAs. A deterioration or loss of resting habitats might only have small effects and will thus not commit an offence of Article 5 for breeding Red-necked Grebes.

Mute Swan

Deliberate killing caused during construction
Estimates suggest that up to 89 pairs of Mute Swans breed within Rødsand Lagoon (Storstrøms Amt – Teknik- og Miljøforvaltningen 2006). Breeding birds comprise a relatively small fraction of all swans present on Rødsand Lagoon in spring and summer. Resources of submerged vegetation are plentiful in Rødsand Lagoon. Even if accessible submerged vegetation is reduced by an estimated maximum of 9% in Rødsand Lagoon due to suspended sediments (FEMA 2013b), this should not lead to any negative impacts.

Of 43 pairs of Mute Swans breeding within the SPA Eastern Kiel Bight, only 4 pairs possibly use marine areas that are expected to be affected by the sediment spill, while the majority of birds are found inland (Koop 2008a). Because biomass reduction of submerged vegetation is expected to be minimal in the Orth Bight and it would be centred in the deepest areas (FEMA 2013d; also see further in this chapter), this should also not lead to any negative impacts.

Thus, there will be no deliberate killing of breeding Mute Swans that occur in the area.

Deliberate disturbance caused during construction
Breeding Mute Swans occur, according to the baseline investigations, only in the sheltered areas of Rødsand Lagoon and Orth Bight and in some inland areas. These species are thus not impaired by disturbances caused during construction works due to their spatial distribution. Therefore, deliberate disturbance of swan species will not occur.

Deterioration or destruction of resting places during construction
The impacts on resting places in the Rødsand Lagoon and Orth Bight for breeding Mute Swans will be small. Disturbances will not occur and the submerged

vegetation will not be impaired in a detrimental way for Mute Swans. Thus, deterioration or destruction of resting places will not occur for breeding Mute Swans.

Common Eider

Deliberate killing caused during construction

The results of the EIA conclude that 1 adult breeding individual and no more than 1 juvenile will be impaired by the secondary effects of spilled sediments. As the local breeding population in the area is 462 breeding pairs (=924 adult individuals) a proportion of 0.1% of the local population will be impaired. This will not be an offence of Article 5 for breeding Common Eiders.

Deliberate disturbance caused during construction

Breeding Common Eiders are restricted to the Rødsand Lagoon and Orther Bight. Thus, this species is not impaired by disturbances caused during construction works due to the spatial distribution. Therefore, deliberate disturbance of breeding Common Eiders will not occur.

Deterioration or destruction of resting places during construction

Resting places of breeding Common Eiders are, as well as the breeding sites, restricted to the Rødsand Lagoon and Orth Bight. Thus, this species is not impaired by disturbances caused during construction works due to their spatial distribution. Therefore, deliberate disturbance of breeding Common Eiders will not occur.

Red-breasted Merganser

Deliberate killing caused during construction

Because 6 out of 9 breeding pairs were recorded in the northern and eastern part of Rødsand Lagoon where no major changes in water transparency are predicted by the EIA, it was assumed that only pairs breeding in the turbid areas would be affected from this pressure, i.e. 3 pairs in the first summer (2015) of the tunnel construction, and 2 pairs during the second summer (2016). No impairment is predicted for the subsequent seasons. As there are no impacts on small fish species according to the EIA, deliberate killings due to starvation will not commit an offence of Article 5 for breeding Red-breasted Mergansers.

Deliberate disturbance caused during construction

The nature reserve Grüner Brink on Fehmarn is the closest reported breeding site of Red-breasted Mergansers to the affected disturbance zone. Red-breasted Mergansers use shallow marine areas to rear their offspring. Since the disturbance zone does not affect the directly adjacent coastal waters of Grüner Brink there will be no impact on breeding Red-breasted Mergansers.

Considering decrease of water transparency in Rødsand Lagoon the results of the EIA show that only pairs breeding in the turbid areas would be affected from this pressure, i.e. 3 pairs (1.7% of the local population) in the first summer (2015) of the tunnel construction, and 2 pairs during the second summer (2016).

Deterioration or destruction of resting places during construction

The habitat loss from the tunnel footprint would affect mostly the shallow coastal areas along the coast of Lolland. The breeding birds of Rødsand Lagoon are expected to rear their offspring within the lagoon, and therefore would not be affected by the habitat loss. Red-breasted Mergansers breeding at Grüner Brink or further west on Fehmarn most likely do not cross the highly disturbed ferry harbour in Puttgarden anyway and therefore are not expected to be affected by the footprint area located east of the harbour. Thus, there will be no offence of Article 5 for breeding Red-breasted Mergansers.

White-tailed Eagle

Deliberate killing caused during construction
White-tailed Eagles forage on a variety of prey including carrion, birds and fish, and the species uses different inland and coastal habitats for feeding. According to the EIA it is not expected that food resources of White-tailed Eagle will be impaired in a way that White-tailed Eagles face a risk of starvation. Thus, there will be no deliberate killing of White-tailed Eagles.

Deliberate disturbance caused during construction
The EIA concludes that possible foraging habitats in the coastal areas of the predicted disturbance zone are of minor importance for White-tailed Eagles, since the areas are already highly disturbed by the existing ferry traffic and tourist activities. Therefore, there will be no additional disturbance due to construction activities and thus no offence of Article 5.

Deterioration or destruction of resting places during construction
There are according to the EIA no known important resting places which will be deteriorated or destroyed. The coastal areas which are predicted to be lost from land reclamation represent potential foraging habitats of White-tailed Eagle, but are assessed to be of minor importance to the species, since the areas are already highly disturbed by the existing ferry traffic and tourist activities. Therefore, there will be no impact on resting places due to the tunnel construction and thus no offence of Article 5.

Gulls

Deliberate killing caused during construction
As generalist feeders gulls are foraging on fish and marine and terrestrial invertebrates. Thus, it is not expected that deliberate killings due to starvation will occur and will commit an offence of Article 5.

Deliberate disturbance caused during construction
Gull species breeding on Fehmarn or in the Rødsand Lagoon were assessed as being sensitive to disturbances close to their breeding areas. The marine breeding habitats in Rødsand Lagoon and inland breeding areas on Fehmarn are not expected to get directly impaired due to the distance to the construction area. Gulls are assessed not to be sensitive to disturbances from ships while foraging at sea, thus there will be no deliberate disturbance caused by tunnel construction.

Deterioration or destruction of resting places
There are according to the EIA no known important resting places of breeding gulls which will be deteriorated or destroyed. The whole alignment area is assessed to be of minor importance to gulls breeding in the area and thus, no deterioration or destruction of resting sites is expected.

Terns

Deliberate killing caused during construction
The EIA conclude that small fish species are not impaired by the effects of spilled sediment. Thus, deliberate killings due to starvation will not commit an offence of Article 5 for Sandwich Terns.

Deliberate disturbance caused during construction
Terns breeding on Fehmarn or in Rødsand Lagoon are assessed to be sensitive to disturbances close to their breeding areas. The marine breeding habitats in Rødsand Lagoon and inland breeding areas on Fehmarn are not expected to get directly impaired due to the distance to the construction area. Terns were assessed not to be sensitive to disturbances from ships while foraging at sea, thus the impairment from construction vessels will be low and thus will not commit an offence of Article 5.

Deterioration or destruction of resting places during construction
There are no important resting places of breeding terns known in the area. The total loss of shallow water habitats on the German side would be rather small. The breeding pairs of Arctic Tern and Little Tern in the SPA Hyllekrog-Rødsand could possibly use shallow water areas close to Rødbyhavn which are predicted to be impacted by the land reclamation. However, it is more likely that birds use the shallow waters of Rødsand Lagoon for fishing, since these is closer to their breeding colonies and provide suitable habitats. Thus, there will be no deterioration or destruction of resting places of breeding terns.

12.3.2 Non-breeding waterbirds

Introduction

Deliberate killing caused during construction
Non-breeding waterbirds use the Fehmarnbelt area as staging or wintering ground and some species occur in high proportions of their biogeographic populations. These species stay for long periods in the area and are dependent on sufficient food resources. Furthermore they may conduct short-distance movements within the region and are therefore at risk of collisions with construction vessels.

Deliberate killings due to collisions with construction vessels are not expected to be of relevance for non-breeding waterbirds. Construction works for a fixed link in the Fehmarnbelt would take place in an area of high shipping intensity. So, construction vessels are expected to contribute to the total amount of ship traffic in the area.

During daylight hours collisions are highly unlikely. Larger construction vessels are expected to move rather slowly or be anchored. Birds can easily see the vessels and can fly around them.

During the night birds might get attracted by the lights of the construction vessels during certain weather conditions. Collisions of birds with ships at night have been documented in Southwest Greenland and were significantly related to bad visibility (Merkel and Johansen 2011). The impact of the construction vessels would however be limited to a small area at any time and the number of collisions is expected to be very low. Thus, it is not expected, that deliberate killings by collisions will commit an offence of Article 5 for any non-breeding bird species.

Deliberate killings due to decreased water transparency resulting in an impairment of the quality of the foraging habitats are expected only on the Danish side of the Fehmarnbelt and only during the first two years of construction works (Figure 9.36, Figure 9.37).

Deliberate disturbance caused during construction
Deliberate disturbance due to barrier effect from construction vessels has, according to the EIA, no impact on local populations of non-breeding waterbirds. Thus, barrier effects will not commit an offence of Article 5.

Red-throated Diver and Black-throated Diver

Deliberate killing caused during construction
The results of the EIA conclude that small fish species are not impaired by the effects of spilled sediment and that diver abundance in the highly disturbed area is already low due to the existing ferry line. Thus, deliberate killings due to starvation will not commit an offence of Article 5 for Red-throated and Black-throated Divers.

Deliberate disturbance caused during construction
According to the EIA it is predicted that on average 42 divers (0.014% of the biogeographic population, 2,5% of the local population) will be displaced from the impairment zone due to disturbance, decreased water transparency and indirect effects of sediment spill. Thus, more than 1% of the local population will be impaired by disturbance. So, there will be an offence of Article 5 due to disturbance for Red-throated and Black-throated Divers. Affected proportions in administrative subareas are given in Table 12.4.

Deterioration or destruction of resting places
The footprint of the tunnel alternative can cause deterioration or destruction of resting places. But the results of the EIA conclude, that only single individuals are predicted to use the area of the tunnel footprint during times of maximum abundance. Normally, this area is already avoided due to the high shipping intensity. Thus, there will be no additional pressure on the resting places caused by the footprint of the tunnel and therewith no offence of Article 5 Birds Directive will occur.

Whooper Swan and Bewick's Swan

Deliberate killing caused during construction
Results of the EIA indicate that these species frequently forage inland and only low numbers use coastal waters on the German side, so they are not expected to experience negative impacts from the secondary effects of the sediment spill. Resources of submerged vegetation are plentiful in Rødsand Lagoon and numbers of wintering herbivorous birds are relatively low. Even if accessible submerged vegetation is reduced by an estimated maximum of 9% in Rødsand Lagoon due to suspended sediments (FEMA 2013b), this should not lead to any negative impacts on wintering Whooper and Bewick's Swans. Therefore, deliberate killings due to starvation will not commit an offence of Article 5 for Whooper and Bewick's Swans.

Deliberate disturbance caused during construction
Bewick's Swans and Whooper Swans occur according to the baseline investigations only in the sheltered areas of Rødsand Lagoon and Orth Bight and in some inland areas. These species are thus not impaired by disturbances caused during construction works due to their spatial distribution. Therefore, deliberate disturbance of swan species will not occur.

Deterioration or destruction of resting places

The results of the EIA indicate that these species frequently forage inland and only low numbers use coastal waters on the German side, so they are not expected to experience negative impacts from the secondary effects of the sediment spill. Resources of submerged vegetation are plentiful in Rødsand Lagoon and numbers of wintering herbivorous birds are relatively low. Even if accessible submerged vegetation is reduced by an estimated maximum of 9% in Rødsand Lagoon due to suspended sediments (FEMA 2013b), this should not lead to any negative impacts on wintering Whooper and Bewick's Swans. The inland areas will not be impaired at all. Therefore, deliberate deterioration and disturbance of resting places will not commit an offence of Article 5 for Whooper and Bewick's Swans.

Barnacle Goose

Deliberate killing caused during construction

Since reduction of submerged vegetation is, according to the results of the EIA, expected to be most pronounced in deeper areas of Rødsand Lagoon (FEMA 2013b), no impact of suspended sediments is anticipated on staging Barnacle Geese, and therefore deliberate killings due to starvation will not commit an offence of Article 5 for Barnacle Geese.

Deliberate disturbance caused during construction

Barnacle Geese pass the Fehmarnbelt area in high numbers during migration periods and occasionally high numbers stopover in the area during such periods. The species is mostly observed inland or using sheltered marine habitats, such as Rødsand Lagoon. They are thus not impaired by disturbances caused during construction works due to their spatial distribution. Therefore, deliberate disturbance of Barnacle Geese will not occur.

Deterioration or destruction of resting places

Barnacle Geese pass the Fehmarnbelt area in high numbers during migration periods and occasionally high numbers stopover in the area during such periods. The species is mostly observed inland or using sheltered marine habitats, such as Rødsand Lagoon. The reduction of submerged vegetation in the Rødsand Lagoon is, according to the results of the EIA, expected to be most pronounced in deeper areas (FEMA 2013b), thus, no impact of suspended sediments is anticipated on staging Barnacle Geese. Therefore deliberate disturbance or destruction of resting places will not commit an offence of Article 5 for Barnacle Geese.

Common Pochard

Deliberate killing caused during construction

The conclusion of the EIA suggests that no benthic communities of relevance for Common Pochard are predicted to suffer at very high degree of impairment due to suspended sediments and sedimentation, and areas assessed as having high degree of impairment were very small and therefore considered as negligible when assessing affected bird numbers. As a result numbers Common Pochard were estimated to be displaced by 0.21% of their maximal number occurring in the Fehmarnbelt, that means 7 individuals of Common Pochard, but individuals will not get killed.

Considering low numbers of affected individuals, there will be no deliberate killings due to starvation for Common Pochard.

Deliberate disturbance caused during construction

Maximum daytime counts indicate that, with more than 700 birds (0.20% of the biogeographic population, ca. 20% of the local population), highly important numbers of Common Pochard use the alignment area in winter time. It is assumed that similar numbers of night-time active Common Pochard get displaced from the disturbance zone during construction in winter. Affected proportions in administrative subareas are given in Table 12.4.

Thus, the disturbance caused during construction will commit an offence of Article 5 for Common Pochard. It must be noted, that resting places in marine habitats are not stable or linked to geographical sites. In fact, such sites depend on particular habitat features as for example sheltered bays. Thus, such resting sites can re-establish after construction of a tunnel e.g. in sheltered areas of the land reclamation sites. So it has to be noted, that these marine resting sites might not be unrecoverable destroyed or deteriorated.

Deterioration or destruction of resting places

According to the EIA Common Pochard is described to mainly use inland freshwater habitats for daytime resting in spring and autumn. Coastal areas are more frequently used in winter due to freezing over of inland habitats. Up to 710 Common Pochard (0.20% of the biogeographic population; ca. 20% of the local population) rest in the vicinity of the ferry harbour in Rødbyhavn during daytime. A loss of a relatively large area (343 ha) of suitable foraging and resting habitats due to the footprint will thus commit an offence of Article 5.

It must be noted, that resting places in marine habitats are not stable or linked to specific geographical sites. In fact, such sites depend on particular habitat features as for example sheltered bays. Thus, such resting sites can re-establish after construction of a tunnel e.g. in sheltered areas of the land reclamation sites. So it has to be noted, that these marine resting sites might not be unrecoverable destroyed or deteriorated.

Smew

Deliberate killing caused during construction

The results of the EIA conclude that small fish species will not be impaired by the effects of spilled sediment and that Smew abundance in the highly disturbed area is already low as this species occurs not only in the sheltered marine parts of the area, but also on inland lakes. Thus, deliberate killings due to starvation will not commit an offence of Article 5 for Smew.

Deliberate disturbance caused during construction

As Smew abundance is already low in the area of the planned fixed link, which is highly disturbed by the high shipping intensity, there will be no deliberate disturbance and thus no offence of Article 5 for Smew.

Deterioration or destruction of resting places

There are no resting places of Smew in the direct vicinity of the planned fixed link, therefore there will be no deterioration or disturbance of resting places and thus no offence of Article 5 for Smew.

Little Gull

Deliberate killing caused during construction

Little Gull is a generalist species foraging on insects, fish and marine invertebrates. Thus, it is not expected that deliberate killings due to starvation will occur and will commit an offence of Article 5.

Deliberate disturbance caused during construction

The results of the EIA conclude that Little Gulls pass the Fehmarnbelt area in internationally important numbers in spring and autumn, but are not confined to certain habitats in the area. The species is not sensitive to disturbances from construction works due to opportunistic and flexible habitat choice. Thus deliberate disturbance caused during the construction will not commit an offence of Article 5.

Deterioration or destruction of resting places

The results of the EIA conclude that Little Gulls pass the Fehmarnbelt area in internationally important numbers in spring and autumn, but are not confined to certain habitats in the area. The tunnel footprint area was not identified as being of special importance to Little Gulls, although high numbers can be observed using this area for foraging or resting in times. Due to opportunistic and flexible habitat choice, a deterioration or destruction of resting places will not occur.

Common Gull

Deliberate killing caused during construction

Common Gull is also a generalist species foraging on fish and marine and terrestrial invertebrates. Thus, it is not expected that deliberate killings due to starvation will occur and will commit an offence of Article 5.

Deliberate disturbance caused during construction

Common Gulls are abundant in the study area all year, but occur in maximum abundance in winter. They were not observed being confined to certain habitats while foraging. The area of the fixed link was not identified as being of special importance to Common Gulls, although high numbers can be observed using this area for foraging or resting in times. The species is not sensitive to disturbances from construction works, due to opportunistic and flexible habitat choice. Thus deliberate disturbance caused during construction will not commit an offence of Article 5.

Deterioration or destruction of resting places

Common Gulls are abundant in the study area all year, but occur in maximum abundance in winter. They were not observed being confined to certain habitats while foraging. The tunnel footprint area was not identified as being of special importance to Common Gulls, although high numbers can be observed using this area for foraging or resting in times. Due to opportunistic and flexible habitat choice, a deterioration or destruction of resting places will not occur.

Sandwich Tern

Deliberate killing caused during construction

The results of the EIA conclude that small fish species will not be impaired by the effects of spilled sediment. Thus, deliberate killings due to starvation will not commit an offence of Article 5 for Sandwich Terns.

Deliberate disturbance caused during construction
It is assumed that most of the observed terns in the Fehmarnbelt area are part of the local breeding population. Sandwich Terns, breeding on Fehmarn or in Rødsand Lagoon, were assessed to be sensitive to disturbances close to their breeding areas. The marine breeding habitats in Rødsand Lagoon and inland breeding areas on Fehmarn are not expected to get directly impaired due to the distance to the construction area. Terns were assessed not to be sensitive to disturbances from ships while foraging at sea, thus the impairment from construction vessels will be low and thus will not commit an offence of Article 5.

Deterioration or destruction of resting places
It is assumed that most of the observed terns in the Fehmarnbelt area are part of the local breeding population. Thus, resting places of Sandwich Terns do not occur in the impaired area of the tunnel footprint and so there will be no offence of Article 5 for Sandwich Terns.

Black Guillemot

Deliberate killing caused during construction
During baseline investigations only single birds of Black Guillemot were observed in the Fehmarnbelt area. As numbers of this species are low and the main prey is fish, of which only the large adult stages will be impaired, it is expected that deliberate killings due to starvation will not commit an offence of Article 5 for Black Guillemot.

Deliberate disturbance caused during construction
According to the EIA the greater alignment area is assessed to be of minor importance to Black Guillemot with usually only single birds occurring in this area. Therefore the disturbance from construction vessels is assessed to be low and will not commit an offence of Article 5.

Deterioration or destruction of resting places
According to the EIA the greater alignment area is assessed to be of minor importance to Black Guillemot with usually only single birds occurring in this area. Thus, no important resting places occur in the area and there will be no offence of Article 5.

Diving ducks and seaducks

Deliberate killing caused during construction
Main food sources of these species are molluscs, which are captured by diving. Benthic communities are assessed to be affected in minor or medium degrees (FEMA 2013). Large impacts on seaduck species resulting in starvation are thus not expected. The Impact Assessment resulted in 576 affected Common Eiders, 33 affected Long-tailed Duck, 58 affected Common Scoters, 3 affected Velvet Scoters and 1 affected Common Goldeneye, which are predicted to be displaced but not killed. Therefore, deliberate killings due to starvation will not commit an offence of Article 5 for any seaduck species occurring in the Fehmarnbelt.

Deliberate disturbance caused during construction
According to the EIA for diving ducks, 7,163 Tufted Ducks (0.60% of the biogeographic population; 22.7% of the local population) and 155 Greater Scaup (0.05% of the biogeographic population; 1.2% of the local population) will be displaced during construction works.

According to the EIA for seaducks, up to 12,114 Common Eiders (1.6% of the biogeographic population; 3.7% of the local population), 745 Long-tailed Ducks (0.02% of the biogeographic population; 3.1% of the local population), 726 Common Scoters (0.05% of the biogeographic population; 1.1% of the local population), a few tens of Velvet Scoters (<0.01% of the biogeographic population; ca. 1% of the local population) and 92 Common Goldeneyes (<0.01% of the biogeographic population; 1.4% of the local population) will be displaced during construction works. Affected proportions in administrative subareas are given in Table 12.4.

Thus, for all seaduck and diving duck species (Tufted Duck, Greater Scaup, Common Eider, Long-tailed Duck, Common Scoter, Velvet Scoter and Common Goldeneye) more than 1% of the local population will be impaired by deliberate disturbance and thus there will be an offence of Article 5 for these species. Especially the Tufted Duck will be affected with substantial proportions of their local population.

The individual-based model for Common Eiders indicate that possible impacts arising from the construction of the immersed tunnel (habitat loss, reduction of food resources, complete displacement from areas affected by construction-related disturbance and decreased water transparency), would cause for the 12,114 individuals an additional mortality of about 600 individuals (0.18% of the local population, 0.08% of the biogeographic population) and small reduction in mean body mass during mid-winter (see chapter 9.4.2). Furthermore, according to the IBM simulations, the carrying capacity of the Fehmarnbelt as Common Eider habitat is well above the number of birds that are actually using this ecosystem.

Deterioration or destruction of resting places

According to the EIA diving ducks are described to mainly use inland freshwater habitats for daytime resting in spring and autumn. Coastal areas are more frequently used in winter due to freezing over of inland habitats. Thus, in winter the deterioration of resting places is anticipated for Tufted Ducks and Greater Scaup of the same magnitude as the disturbance during construction works (see above). A loss of a relatively large area (343 ha) of suitable foraging and resting habitats therefore would result in an offence of Article 5.

For seaduck species the habitat loss from tunnel footprint will displace 207 Common Eiders, 5 Long-tailed Ducks, 16 Common Scoters, single Velvet Scoters and up to 100 Common Goldeneye. Thus, only for Common Goldeneye there will be more than 1% of the local population impaired and thus, for this species an offence of Article 5 would occur.

It must be noted, that resting places in marine habitats are not stable or linked to specific geographical sites. In fact, such sites are dependent on particular habitat features as for example sheltered bays. Thus, such resting sites can re-establish after construction of a tunnel e.g. in sheltered areas of the land reclamation sites. So it has to be noted, that these marine resting sites might not be unrecoverable destroyed or deteriorated.

Piscivorous species

Deliberate killing caused during construction

The results of the EIA conclude that small fish species will not be impaired by the effects of spilled sediment. Thus, deliberate killings due to starvation will not commit an offence of Article 5 for piscivorous species.

Deliberate disturbance caused during construction

It is assumed that most of the observed terns in the Fehmarnbelt area are part of the local breeding population. The tern species breeding on Fehmarn or in Rødsand Lagoon were assessed to be sensitive to disturbances close to their breeding areas. The marine breeding habitats in Rødsand Lagoon and inland breeding areas on Fehmarn are not expected to get directly impaired due to the distance to the construction area. Terns were assessed not to be sensitive to disturbances from ships while foraging at sea, thus the impairment from construction vessels will be low and thus will not commit an offence of Article 5.

The results of the EIA show that 91 Red-necked Grebes (0.018% of the biogeographic population; 8.3% of the local population), 1.026 Red-breasted Mergansers (0.60% of the biogeographic population; 13.2% of the local population) and 13 Razorbills (<0.01% of the biogeographic population; 1.1% of the local population) will get displaced due to disturbances caused by construction works. For Great Cormorant the Fehmarnbelt was identified as being of very high importance and up to 500 individuals (0.1% of the biogeographic population, 4.8% of the local population) will be displaced during construction. Thus, for these four species (Red-necked Grebe, Red-breasted Merganser, Razorbill and Great Cormorant) the impairment from construction vessels will be high and thus will commit an offence of Article 5. Affected proportions in administrative subareas are given in Table 12.4.

Deterioration or destruction of resting places

For grebes, mergansers, terns and auks the results of the EIA show, that none or only single birds will be affected by deterioration or destruction of resting places within the tunnel footprint area. For Great Cormorant the Fehmarnbelt area was identified as being of very high importance. The species is abundant in the area all year with maximum numbers occurring in autumn. There were no major aggregation areas identified in marine habitats, but cormorants aggregate in high numbers on their roosts. Cormorants roost in the Fehmarnbelt area on undisturbed sandbanks and beaches like Rødsand (Rødsand Lagoon) or Krummsteert (SW Fehmarn), but also on the breakwaters of the ferry harbours in Rødbyhavn and Puttgarden, which are sometimes used by up to 500 Great Cormorants (0.1% of the biogeographic population, 4.8% of the local population). Due to the land reclamation areas which are planned to border the harbour breakwaters, these structures could become accessible for humans and predators, so cormorants may possibly give up those roosts. Based on the number of possibly affected cormorants there will be an offence of Article 5 for this species concerning the proportion of the local population.

Herbivorous waterbirds

Deliberate killing caused during construction

Herbivorous waterbirds can be impaired by spilled sediment resulting in reduction of submerged vegetation. But many herbivorous species (especially geese) feed also inland on agricultural farmland and are not restricted to marine habitats. Furthermore, resources of submerged vegetation are plentiful in Rødsand Lagoon and numbers of wintering herbivorous birds are relatively low. Results of the EIA show that even if accessible submerged vegetation is reduced by an estimated maximum of 9% in Rødsand Lagoon due to suspended sediments, this should not lead to any negative impacts on wintering herbivorous waterbirds. Since reduction of submerged vegetation is expected to be most pronounced in deeper areas of the lagoon (FEMA 2013d), no impact of suspended sediments is anticipated on staging herbivorous waterbirds, even not on moulting Mute Swans, and therefore deliberate killings due to starvation will not commit an offence of Article 5.

Deliberate disturbance caused during construction
According to the baseline investigations most herbivorous waterbirds occur mostly in sheltered marine habitats or at inland waters. Therefore they will not be impaired by disturbances caused during construction works due to their spatial distribution. Only the Eurasian Wigeon is, according to the EIA with up to 1,500 birds (0.1% of the biogeographic population; 8.9% of the local population), impaired by disturbance. Therefore, deliberate disturbance of herbivorous waterbirds will occur at least for the Eurasian Wigeon in a magnitude, that there will be an offence of Article 5. Affected proportions in administrative subareas are given in Table 12.4.

Deterioration or destruction of resting places
According to the baseline investigations herbivorous waterbirds occur mostly in sheltered marine habitats or at inland waters. Occasionally higher numbers of up to a few hundred individuals are reported using the coastal areas within the tunnel footprint area. But there are no important resting places for herbivorous waterbirds, thus, deliberate disturbance of herbivorous waterbirds will not occur.

Gulls

Deliberate killing caused during construction
As generalist feeders they are foraging on fish and marine and terrestrial invertebrates. Thus, it is not expected that deliberate killings due to starvation will occur and will commit an offence of Article 5.

Deliberate disturbance caused during construction
Gulls breeding on Fehmarn or in the Rødsand Lagoon were assessed to be sensitive to disturbances close to their breeding areas. The marine breeding habitats in Rødsand Lagoon and inland breeding areas on Fehmarn are not expected to get directly impaired due to the distance to the construction area. Gulls were assessed not to be sensitive to disturbances from ships while foraging at sea, thus the impairment from construction vessels will be low and thus will not commit an offence of Article 5.

Deterioration or destruction of resting places
The different gull species were assessed as not being sensitive to habitat loss due to their opportunistic behaviour, which allows them to use various habitats. Thus, there will be no deterioration or destruction of resting places and therewith no offence of Article 5 for gulls.

Table 12.4 *Number of displaced birds during tunnel construction due to disturbance, decreased water transparency and sediment spill in the Fehmarnbelt study area and administrative subareas.*

Species	Number of displaced birds due to															Total number of displaced birds
	Disturbance					Decreased water transparency					Sediment spill					
		thereof in					thereof in					thereof in				
	Study area	German coastal waters	German EEZ	Danish EEZ	Danish coastal waters	Study area	German coastal waters	German EEZ	Danish EEZ	Danish coastal waters	Study area	German coastal waters	German EEZ	Danish EEZ	Danish coastal waters	
Divers	10	5	0	1	4	32	0	0	0	32						42
Great Crested Grebe	44	40	0	1	3	51	37	0	0	14						
Red-necked Grebe	26	11	0	1	15	69	13	0	0	46						91
Great Cormorant	500	~250			~250											500
Eurasian Wigeon	1,500	1,500														1,500
Common Pochard	710				710						7					717
Tufted Duck	7,100				7,100						63					7,163
Greater Scaup	130				130						25					155
Common Eider	4,882	2,808	21	72	1,980	8,823	375	0	0	7,950	576	1	1	276	304	12,114
Long-tailed Duck	120	75	5	11	29	594	13	0	0	581	33	0	0	8	24	745
Common Scoter	391	362	5	2	23	512	402	0	0	110	58	0	0	22	33	726
Common Goldeneye	91	25	0	0	66						1	0	0	0	1	92
Red-breasted Merganser	208	49	0	1	157	892	0	0	0	892						1,026
Common Coot	340	~170			~170											340
Razorbill	11	2	4	2	4	3	0	0	0	3						13

12.3.3 Migrating birds

Introduction

Migrating birds fly over the Fehmarnbelt in different altitudes and directions. This is often determined by weather conditions during migration. For the tunnel alternative two pressures have been identified, which might affect migrating birds and might commit offences of Article 5 of the Birds Directive: collision with construction vessels (deliberate killing) and barrier effect from construction vessels (deliberate disturbance).

Deliberate killing caused during construction

Birds migrating in low altitudes may collide with construction vessels, especially in bad weather situations with poor visibility and high wind speed. But deliberate killings due to collisions with construction vessels are not expected to be of relevance for migrating birds. Construction works for a fixed link in the Fehmarnbelt would take place in an area of already high shipping intensity. So, construction vessels are expected to contribute to the total amount of ship traffic in the area.

During daylight hours collisions are highly unlikely. Larger construction vessels are expected to move rather slowly or be anchored. Birds can easily see the vessels and can fly around them.

During the night birds might get attracted by the lights of the construction vessels during certain weather conditions. Collisions of birds with ships at night have been documented in Southwest Greenland and were significantly related to bad visibility (Merkel and Johansen 2011). The impact of the construction vessels would however be limited to a small area at any time and the number of collisions is expected to be very low. Thus, it is not expected, that deliberate killings by collisions will commit an offence of Article 5 for any migrating bird species.

Deliberate disturbance caused during construction
Flying birds usually respond to an obstacle by vertical or horizontal changes in their intended flight route. In case of species which migrate or generally fly at low altitudes the presence of construction vessels might have an effect as a barrier.

Birds flying over water respond in different ways to on-site or approaching vessels. Some species are attracted to vessels such as gulls or terns; others show a negative response such as divers or scoters, for which it is expected that they avoid flying over vessels and would detour ships at a greater distance. These reactions would result in extra energy expenditures for an individual bird.

Construction vessels would operate mostly in defined working areas and would not exhibit a total barrier over the Fehmarnbelt, therefore birds are expected to always be able to detour the barrier from construction vessels while passing the area. A spatially small barrier caused by construction vessels would not reduce the obstacle-free space in the Fehmarnbelt in a substantial way. Thus, it is not expected, that deliberate disturbance will commit an offence of Article 5 for any migrating species.

Deliberate disturbance due to barrier effects from construction vessels has, according to the EIA (see chapter 9.2.5), no impact on the local population of migrating birds.

As none of these pressures will commit an offence of Article 5 for any migrating species, the species-wise description is skipped here.

12.4 Assessment of Strictly Protected Species for the bridge alternative

1. Deliberate killing

a) caused during construction

Deliberate killings during construction works may occur due to collision with construction vessels or due to starvation, if a food resource declines in abundance and/or mass or decreased water transparency makes searching for food for birds inefficient.

b) caused by structure and operation

Deliberate killings caused by structure and operation of a cable stayed bridge may occur due to collision with bridge structures and traffic.

2. Deliberate destruction of, or damage to, their nests and eggs or removal of their nests

As there are no breeding sites in the marine environment of the Fehmarnbelt, this prohibition do not apply here. The assessment of strictly protected species of the land approach will cover the affected species.

3. Deliberate disturbance

a) caused during construction

Deliberate disturbance caused during construction of a tunnel may occur from construction vessels and decreased water transparency and will result in a displacement of individuals. Barrier effects have, according to German guidelines (LBV-SH 2007), also be treated as disturbances, if local populations are seriously impaired by habitat limitations.

b) caused by structure and operation

Deliberate disturbance caused by structure and operation may occur from bridge structure and traffic as well as from channelling of shipping and will result in a displacement of individuals. Barrier effects have, according to German guidelines (LBV-SH 2007), also be treated as disturbances, if local populations are seriously impaired by habitat limitations.

4. Deterioration or destruction of resting places

a) caused during construction

Deterioration or destruction of resting places during construction may occur from the footprint area of the bridge.

b) caused by structure and operation

Deterioration or destruction of resting places during construction may occur from the footprint area of the bridge.

Thus, in the following deliberate killing and deliberate disturbance caused during construction and operation as well as disturbance of resting places caused during construction and operation will be considered for the assessment of the tunnel alternative.

12.4.1 Breeding waterbirds

Breeding waterbirds are not directly affected, as breeding sites are not placed within the impairment zone. Therefore, only such species that are connected to marine habitats (as foraging or rearing sites) are discussed here. These species face in principle the same pressures and risks as non-breeding waterbird species.

Deliberate killing caused during construction

Deliberate killings due to collisions with construction vessels are not expected to be of relevance for breeding waterbirds. Construction works for a fixed link in the

Fehmarnbelt would take place in an area of high shipping intensity. So, construction vessels are expected to contribute to the total amount of ship traffic in the area.

During daylight hours collisions are highly unlikely. Larger construction vessels are expected to move rather slowly or be anchored. Birds can easily see the vessels and can fly around them.

During the night birds might get attracted by the lights of the construction vessels during certain weather conditions. Collisions of birds with ships at night have been documented in Southwest Greenland and were significantly related to bad visibility (Merkel and Johansen 2011). The impact of the construction vessels would however be limited to a small area at any time and the number of collisions is expected to be very low. Thus, it is not expected, that deliberate killings by collisions will commit an offence of Article 5 for any breeding bird species.

The effects of spilled sediment are considerably lower for the bridge alternative than for the tunnel (see chapter 12.3). Effects on the benthic vegetation by suspended sediments are predicted to result in minor reductions of macroalgae and eelgrass biomass of mostly less than 5-10% in all areas, effects on benthic fauna by sedimentation are predicted to have locally minor to medium impact depending on the thickness and duration of the sediment layer and effects on fish will be small as well with no detectable effects on bird species. As even for the tunnel alternative with larger amounts of spilled sediment no offence of Article 5 was predicted (see chapter 13.3), it is not expected for the bridge alternative as well.

Deliberate disturbance caused during construction
Deliberate disturbance due to barrier effects from construction vessels has, according to the EIA, no impact on the local population of breeding waterbirds. Thus, barrier effects will not commit an offence of Article 5.

Deliberate disturbance caused by structure and operation
Deliberate disturbance due to barrier effects from structure and operation has, according to the EIA, no impact on the local population of breeding waterbirds. Thus, barrier effects will not commit an offence of Article 5.

Red-necked Grebe

Deliberate killing caused during construction
See introduction of chapter 12.4.1.

Deliberate killing caused by structure and operation
According to the EIA bird species breeding in the Natura 2000 areas are considered daytime active when utilising the offshore areas. Consequently, a very low collision risk with the structures of a bridge was predicted for breeding waterbirds. Thus there will be no offence of Article 5 for Red-necked Grebes.

According to the EIA collision with traffic is unlikely to occur for Red-necked Grebes. Thus there will be no offence of Article 5.

Deliberate disturbance caused during construction
According to the EIA the nature reserve Grüner Brink is the closest reported German breeding site of Red-necked Grebes to the affected disturbance zone. Birds are known to regularly commute between their inland breeding sites and marine foraging habitats. Since the disturbance zone does not affect the directly adjacent coastal waters of Grüner Brink and the area is already highly impaired by intense

ferry traffic, the impairment of breeding Red-necked Grebes at Grüner Brink will be low.

In contrast, on the Danish side on Lolland few pairs of Red-necked Grebes breed close to the planned alignment and the defined disturbance zone. Due to the smaller area disturbed from construction activities of the bridge solution along the Lolland coast, the impairment on Red-necked Grebes breeding on Lolland is expected to be less severe than from the tunnel solution. However, an impact on breeding Red-necked Grebes breeding in the immediate vicinity of the disturbance zone cannot be excluded. The assessment of strictly protected species for the land areas of Lolland is part of the EIA on Lolland land areas.

Thus, for the marine environment there will be no deliberate disturbance and therefore no offence of Article 5 for Red-necked Grebes.

Deliberate disturbance caused by structure and operation
According to the EIA it cannot be excluded that disturbance effects from the bridge structure and traffic and longer flight distances to other foraging sites outside the disturbance zone would have an impact on Red-necked Grebes breeding in the immediate vicinity of the disturbance zone. The assessment of strictly protected species for the land areas of Lolland is part of the EIA on Lolland land areas.

Deterioration or destruction of resting places during construction
Resting places of breeding Red-necked Grebes will be near the breeding sites. According to the EIA it is expected that the footprint results in a loss of foraging habitats to Red-necked Grebes breeding on Lolland outside the SPAs. The loss of coastal habitats of the cable stayed bridge would be about 85% smaller compared to the tunnel footprint. A deterioration or loss of resting habitats might only have small effects and will thus not commit an offence of Article 5 for breeding Red-necked Grebes.

Deterioration or destruction caused by structure and operation
See deterioration or destruction of resting places during the construction (see above).

Mute Swan

Deliberate killing caused during construction
See introduction of chapter 12.4.1.

Deliberate killing caused by structure and operation
According to the EIA bird species breeding in the Natura 2000 areas are considered daytime active when utilising the offshore areas. Consequently, a very low collision risk with the structures of a bridge was predicted for breeding waterbirds. Thus there will be no offence of Article 5 for Mute Swans.

According to the EIA collision with traffic is unlikely to occur for Mute Swans. Thus there will be no offence of Article 5.

Deliberate disturbance caused during construction
Breeding Mute Swans occur, according to the baseline investigations, only in the sheltered areas of Rødsand Lagoon and Orth Bight and in some inland areas. These species are thus not impaired by disturbances caused during construction works due to their spatial distribution. Therefore, deliberate disturbance of swan species will not occur.

Deliberate disturbance caused by structure and operation
See deliberate disturbance caused during construction.

Deterioration or destruction of resting places during construction
The impacts on resting places in the Rødsand Lagoon and Orther Bight for breeding Mute Swans will be small: disturbances will not occur and the submerged vegetation will not be impaired in a problematic way for Mute Swans. Thus, deterioration or destruction of resting places will not occur for breeding Mute Swans.

Deterioration or destruction caused by structure and operation
See deterioration or destruction of resting places during construction (see above).

Common Eider

Deliberate killing caused during construction
See introduction of chapter 12.4.1.

Deliberate killing caused by structure and operation
According to the EIA bird species breeding in the Natura 2000 areas are considered daytime active when utilising the offshore areas. Consequently, a very low collision risk was predicted for breeding waterbirds. Thus there will be no offence of Article 5 for Common Eiders.

According to the EIA collision with traffic is unlikely to occur for Common Eiders. Thus there will be no offence of Article 5.

Deliberate disturbance caused during construction
Breeding Common Eiders are restricted to the Rødsand Lagoon and Orth Bight. Thus, this species is not impaired by disturbances caused during construction works due to the spatial distribution. Therefore, deliberate disturbance of breeding Common Eiders will not occur.

Deliberate disturbance caused by structure and operation
See deliberate disturbance caused during construction (see above).

Deterioration or destruction of resting places during construction
Resting places of breeding Common Eiders are, as well as the breeding sites, restricted to the Rødsand Lagoon and Orth Bight. Thus, this species is not impaired by disturbances caused during construction works due to the spatial distribution. Therefore, deliberate disturbance of breeding Common Eiders will not occur.

Deterioration or destruction caused by structure and operation
See deterioration or destruction of resting places during construction (see above).

Red-breasted Merganser

Deliberate killing caused during construction
See introduction of chapter 12.4.1.

Deliberate killing caused by structure and operation
According to the EIA bird species breeding in the Natura 2000 areas are considered daytime active when utilising the offshore areas. Consequently, a very low collision risk with the structures of a bridge was predicted for breeding waterbirds. Thus there will be no offence of Article 5 for Red-breasted Mergansers.

According to the EIA collision with traffic is unlikely to occur for Red-breasted Mergansers. Thus there will be no offence of Article 5.

Deliberate disturbance caused during construction
The nature reserve Grüner Brink on Fehmarn is the closest reported breeding site of Red-breasted Mergansers to the affected disturbance zone. Red-breasted Mergansers use shallow marine areas to rear their offspring. Since the disturbance zone does not affect the directly adjacent coastal waters of Grüner Brink there will be no impact on breeding Red-breasted Mergansers.

Deliberate disturbance caused by structure and operation
See deliberate disturbance caused during construction (see above).

Deterioration or destruction of resting places during construction
The habitat loss from the bridge footprint would affect mostly the shallow coastal areas along the coast of Lolland. The breeding waterbirds of Rødsand Lagoon are expected to rear their offspring within the lagoon, and therefore would not be affected by the habitat loss. Red-breasted Mergansers breeding at Grüner Brink or further west on Fehmarn most likely do not cross the highly disturbed ferry harbour in Puttgarden anyway and therefore are not expected to be affected by the footprint area located east of the harbour. Thus, there will be no offence of Article 5 for breeding Red-breasted Mergansers.

Deterioration or destruction caused by structure and operation
See deterioration or destruction of resting places during construction (see above).

White-tailed Eagle

Deliberate killing caused during construction
See introduction of chapter 12.4.1.

Deliberate killing caused by structure and operation
According to the EIA bird species breeding in the Natura 2000 areas are considered daytime active when utilising the offshore areas. Consequently, a very low collision risk with the structures of a bridge was predicted for breeding waterbirds. Thus there will be no offence of Article 5 for White-tailed Eagles.

According to the EIA collision with traffic is unlikely to occur for White-tailed Eagles. Thus there will be no offence of Article 5.

Deliberate disturbance caused during construction
The EIA concludes that possible foraging habitats in the coastal areas of the predicted disturbance zone are of minor importance for White-tailed Eagles, since these areas are already highly disturbed by the existing ferry traffic and tourist activities. Therefore, there will be no additional disturbance due to construction activities and thus no offence of Article 5.

Deliberate disturbance caused by structure and operation
See deliberate disturbance caused during construction (see above).

Deterioration or destruction of resting places during construction
According to the EIA there are no known important resting places which will be deteriorated or destroyed. Therefore, there will be no impact on resting places due to the bridge construction and thus no offence of Article 5.

Deterioration or destruction caused by structure and operation
See deterioration or destruction of resting places during construction (see above).

Gulls

Deliberate killing caused during construction
See introduction of chapter 12.4.1.

Deliberate killing caused by structure and operation
According to the EIA bird species breeding in the Natura 2000 areas are considered daytime active when utilising the offshore areas. Consequently, a very low collision risk with the structures of a bridge was predicted for breeding waterbirds. Thus there will be no offence of Article 5 for gulls.

Gulls are, according to the EIA, at risk of collision with traffic. This can occur as scavenging gull species (mostly Common, Herring and Great Black-backed) can be attracted by collision victims on the traffic lane and then collide with the traffic themselves. Even though no quantitative traffic collision rate estimates can be given, the numbers of birds which would get killed are expected to be low and will not have an effect on the local population. Thus, deliberate killings due to collision with traffic will not commit an offence of Article 5 for gull species.

Deliberate disturbance caused during construction
Gull species breeding on Fehmarn or in Rødsand Lagoon were assessed to be sensitive to disturbances close to their breeding areas. The marine breeding habitats in Rødsand Lagoon and inland breeding areas on Fehmarn are not expected to get directly impaired due to the distance to the construction area. Gulls were assessed not to be sensitive to disturbances from ships while foraging at sea, thus there will be no deliberate disturbance caused by tunnel construction.

Deliberate disturbance caused by structure and operation
See deliberate disturbance caused during construction (see above).

Deterioration or destruction of resting places during construction
There are according to the EIA no known resting places of importance for breeding gulls which will be deteriorated or destroyed. The whole alignment area is assessed to be of minor importance to gulls breeding in the area and thus, no deterioration or destruction of resting sites is expected.

Deterioration or destruction caused by structure and operation
See deterioration or destruction of resting places during construction (see above).

Terns

Deliberate killing caused during construction
See introduction of chapter 12.4.1.

Deliberate killing caused by structure and operation
According to the EIA bird species breeding in the Natura 2000 areas are considered daytime active when utilising the offshore areas. Consequently, a very low collision risk with the structures of a bridge was predicted for breeding waterbirds. Thus there will be no offence of Article 5 for Terns.

According to the EIA collision with traffic is unlikely to occur for terns. Thus there will be no offence of Article 5.

Deliberate disturbance caused during construction
Terns breeding on Fehmarn or in Rødsand Lagoon were assessed to be sensitive to disturbances close to their breeding areas. The marine breeding habitats in Rødsand Lagoon and inland breeding areas on Fehmarn are not expected to get directly impaired due to the distance to the construction area. Terns were assessed as not being sensitive to disturbances from ships while foraging at sea, thus the impairment from construction vessels will be low and thus will not commit an offence of Article 5.

Deliberate disturbance caused by structure and operation
See deliberate disturbance caused during construction (see above).

Deterioration or destruction of resting places during construction
There are no important resting places of breeding terns known in the area. The total loss of shallow water habitats would be rather small. Thus, there will be no deterioration or destruction of resting places of breeding terns.

Deterioration or destruction caused by structure and operation
See deterioration or destruction of resting places during construction (see above).

12.4.2 Non-breeding waterbirds

Introduction
Non-breeding waterbirds use the Fehmarnbelt area as staging or wintering ground and some species occur in high proportions of their biogeographic population. These species stay for long periods in the area and are dependent on sufficient food resources. Furthermore they may conduct short-distance movements within the region and are therefore at risk for collisions with construction vessels.

Deliberate killing caused during construction
Deliberate killings due to collisions with construction vessels are not expected to be of relevance for non-breeding waterbirds. Construction works for a fixed link in the Fehmarnbelt would take place in an area of high shipping intensity. So, construction vessels are expected to contribute to the total amount of ship traffic in the area.

During daylight hours collisions are highly unlikely. Larger construction vessels are expected to move rather slowly or be anchored. Birds can easily see the vessels and can fly around them.

During the night birds might get attracted by the lights of the construction vessels during certain weather conditions. Collisions of birds with ships at night have been documented in Southwest Greenland and were significantly related to bad visibility (Merkel and Johansen 2011). The impact of the construction vessels would however be limited to a small area at any time and the number of collisions is expected to be very low. Thus, it is not expected, that deliberate killings by collisions will commit an offence of Article 5 for any non-breeding bird species.

The effects of spilled sediment are for the bridge alternative considerably lower than for the tunnel (see chapter 12.3). Effects on the benthic vegetation by suspended sediments are predicted to result in minor reductions of macroalgae and eelgrass biomass of mostly less than 5-10% in all areas. Effects on benthic fauna by sedimentation are predicted to have locally minor to medium impact depending on the thickness and duration of the sediment layer and effects on fish will be small as well with no detectable effects on bird species. As even for the tunnel alternative with larger amounts of spilled sediment deliberate killings due to starvation will not occur in such degree, that an offence of Article 5 was predicted (see chapter 12.3), it is not predicted for the bridge alternative as well.

Deliberate disturbance caused during construction
Deliberate disturbance due to barrier effects from construction vessels has, according to the EIA, no impact on local populations of non-breeding waterbirds. Thus, barrier effects will not commit an offence of Article 5.

Deliberate disturbance caused by structure and operation
Deliberate disturbance due to barrier effects from structure and operation of the bridge has, according to the EIA, no impact on most local populations of non-breeding waterbirds. For seaducks and diving ducks, especially scoter species, as well as auks an offence of Article 5 due to impacts on local populations cannot be excluded (see below).

Red-throated Diver and Black-throated Diver

Deliberate killing caused during construction
See introduction of chapter12.4.2.

Deliberate killing caused by structure and operation
According to the EIA the potential collision rates are very low as birds are mainly daytime active and being temporary residents in the area birds will be accustomed to the presence of the bridge. Thus, deliberate killings caused by collision with bridge structures will not commit an offence of Article 5 for diver species.

Collisions with traffic are not likely to occur as flight altitudes of resting divers are generally low and the high avoidance of the structure by divers reduce the risk of a collision. Thus, deliberate killings due to collision with traffic will not commit an offence of Article 5 for Red-throated and Black-throated Divers.

Deliberate disturbance caused during construction
According to the EIA it is predicted that on average 17 divers (<0.01% of the biogeographic population, 1.0% of the local population) will be displaced from the impairment zone due to disturbance from construction vessels and decreased water transparency caused by spilled sediment. Thus, more than 1% of the local population will be impaired by disturbance during construction. So, there will be an offence of Article 5 due to disturbance for Red-throated and Black-throated Divers. Affected proportions in administrative subareas are given in Table 12.5 and Table 12.6.

Deliberate disturbance caused by structure and operation
According to the EIA it is predicted that on average 6 divers (<0.01% of the biogeographic population, 0.35% of the local population) will be displaced from the impairment zone due to disturbance caused by structure and operation of a bridge. Thus, there will be no offence of Article 5 due to disturbance for Red-throated and Black-throated Divers.

Deterioration or destruction caused during construction
The footprint of the tunnel alternative can cause deterioration or destruction of resting places. But the results of the EIA conclude, that only single individuals of divers are predicted to use the area of the bridge footprint during times of maximum abundance. Normally, this area is already avoided due to the high shipping intensity. Thus, there will be no additional pressure on the resting places caused by the footprint of the tunnel and therewith no offence of Article 5 Birds Directive will occur.

Deterioration or destruction caused by structure and operation
See deterioration or destruction caused during construction (see above).

Whooper Swan and Bewick's Swan

Deliberate killing caused during construction
See introduction of chapter 12.4.2.

Deliberate killing caused by structure and operation
According to the EIA the potential collision rates are very low as birds are mainly daytime active and being temporary residents in the area will be accustomed to the presence of the bridge. Thus, deliberate killings caused by collision with bridge structures will not commit an offence of Article 5 for Whooper and Bewick's Swans.

Collisions with traffic are unlikely to occur as the usage of inland areas and the avoidance of the structure would reduce the risk of a collision. Thus, deliberate killings due to collision with traffic will not commit an offence of Article 5 for Whooper Swan and Bewick's Swan.

Deliberate disturbance caused during construction
Bewick's Swans and Whooper Swans occur, according to the baseline investigations, only in the sheltered areas of Rødsand Lagoon and Orth Bight and in some inland areas. These species will thus not be impaired by disturbances caused during construction works due to their spatial distribution. Therefore, deliberate disturbance of swan species will not occur.

Deliberate disturbance caused by structure and operation
See deliberate disturbance caused during construction (see above).

Deterioration or destruction caused during construction
The results of the EIA indicate that these species frequently forage inland and only low numbers use coastal waters on the German side, so they are not expected to experience negative impacts from the secondary effects of the sediment spill. Resources of submerged vegetation are plentiful in Rødsand Lagoon and numbers of wintering herbivorous birds are relatively low. Even if accessible submerged vegetation is reduced by an estimated maximum of 9% in Rødsand Lagoon due to suspended sediments (FEMA 2013b), this should not lead to any negative impacts on wintering Whooper and Bewick's Swans. The inland areas will not be impaired at all. Therefore, deliberate deterioration and disturbance of resting places will not commit an offence of Article 5 for Whooper and Bewick's Swans.

Deterioration or destruction caused by structure and operation
See deterioration or destruction caused during construction (see above).

Barnacle Goose

Deliberate killing caused during construction
See introduction of chapter 12.4.2.

Deliberate killing caused by structure and operation
According to the EIA the potential collision rates are very low as birds are mainly daytime active and being temporary residents in the area will be accustomed to the presence of the bridge. Thus, deliberate killings caused by collision with bridge structures will not commit an offence of Article 5 for Barnacle Geese.

Collisions with traffic are not likely to occur as the usage of inland areas and the avoidance of the structure will reduce the risk of a collision. Thus, deliberate killings due to collision with traffic will not commit an offence of Article 5 for Barnacle Geese.

Deliberate disturbance caused during construction
Barnacle Geese pass the Fehmarnbelt area in high numbers during migration periods and occasionally high numbers stopover in the area during such periods. The species was mostly observed inland or using sheltered marine habitats, such as Rødsand Lagoon. Birds are thus not impaired by disturbances caused during construction works due to their spatial distribution. Therefore, deliberate disturbance of Barnacle Geese will not occur.

Deliberate disturbance caused by structure and operation
See deliberate disturbance caused during construction (see above).

Deterioration or destruction caused during construction
Barnacle Geese pass the Fehmarnbelt area in high numbers during migration periods and occasionally high numbers stopover in the area during such periods. The species was mostly observed inland or using sheltered marine habitats, such as Rødsand Lagoon. The reduction of submerged vegetation in the Rødsand Lagoon is according to the results of the EIA expected to be most pronounced in deeper areas (FEMA 2013b), thus, no impact of suspended sediments is anticipated on staging Barnacle Geese. Therefore deliberate disturbance or destruction of resting places will not commit an offence of Article 5 for Barnacle Geese.

Deterioration or destruction caused by structure and operation
See deterioration or destruction caused during construction (see above).

Common Pochard

Deliberate killing caused during construction
See introduction of chapter 12.4.2.

Deliberate killing caused by structure and operation
Common Pochard is active during day- and night-time, flying from their roosts to the feeding sites and between feeding sites. Conducting night-time flights can increase the risk of collisions. According to the EIA no empirical data on nocturnal collision rates exist for this species. Calculations for migrating birds gave low potential collision rates, but cannot be easily applied to temporarily resident species, as those on one hand will be accustomed to the presence of the bridge, on the other hand may cross the alignment and thus the bridge more than once during a wintering season. Thus, incidental killings of Common Pochard cannot be excluded, but it is not expected, that there will be an effect on the local population. Thus, there will be no offence of Article 5.

Collisions with traffic can occur as night-time flying Common Pochard can be disoriented by traffic lights. However, the proportion will be very small and will stay in the field of incidental killings. Thus, incidental killings due to collision with traffic will not commit an offence of Article 5 for Common Pochard.

Deliberate disturbance caused during construction
According to the EIA it is predicted that on average 710 Common Pochard (0.2% of the biogeographic population, 20.2% of the local population) will be displaced from the impairment zone due to disturbance from construction vessels. Thus, a large proportion of the local population will be impaired by disturbance during

construction. So, there will be an offence of Article 5 due to disturbance of Common Pochard. Affected proportions in administrative subareas are given in Table 12.5 and Table 12.6.

It must be noted, that resting places in marine habitats are not stable and linked to particular geographical locations. In fact, such sites are dependent on particular habitat features as for example sheltered bays. Thus, such resting sites can re-establish after construction of a tunnel e.g. in sheltered areas of the land reclamation sites. So it has to be noted, that these marine resting sites might not be unrecoverable destroyed or deteriorated.

Deliberate disturbance caused by structure and operation
See deliberate disturbance caused during construction (see above).

Deterioration or destruction caused during construction
According to the EIA Common Pochard is described to mainly use inland freshwater habitats for daytime resting in spring and autumn. Coastal areas are more frequently used in winter due to freezing over of inland habitats. Less than 350 Common Pochard (<0.1% of the biogeographic population; less than 10% of the local population) rest in the vicinity of the ferry harbour in Rødbyhavn during daytime. A loss of suitable foraging and resting habitats due to the bridge footprint area (58.7 ha) will thus commit an offence of Article 5.

Deterioration or destruction caused by structure and operation
See deterioration or destruction caused during construction (see above).

Smew

Deliberate killing caused during construction
See introduction of chapter 12.4.2.

Deliberate killing caused by structure and operation
According to the EIA the potential collision rates are very low as birds are mainly daytime active and birds, which are temporarily resident in the area would be accustomed to the presence of the bridge. Thus, deliberate killings caused by collision with bridge structures will not commit an offence of Article 5 for Smew.

Collisions with traffic are unlikely to occur as the usage of inland areas and the low flight altitude would reduce the risk of a collision. Thus, killings due to collision with traffic will not commit an offence of Article 5 for Smew.

Deliberate disturbance caused during construction
As Smew abundance is already low in the area of the planned fixed link, which is highly disturbed by the high shipping intensity, there will be no deliberate disturbance and thus no offence of Article 5 for Smew.

Deliberate disturbance caused by structure and operation
See deliberate disturbance caused during construction (see above).

Deterioration or destruction caused during construction
As there are no resting places of Smew in the direct vicinity of the planned fixed link, there will be no deterioration or disturbance of resting places and thus no offence of Article 5 for Smew.

Deterioration or destruction caused by structure and operation
See deterioration or destruction caused during construction (see above).

Little Gull

Deliberate killing caused during construction
See introduction of chapter 12.4.2.

Deliberate killing caused by structure and operation
According to the EIA the potential collision rates are very low as birds are mainly daytime active and birds, which are temporary residents in the area will be accustomed to the presence of the bridge. Thus, deliberate killings caused by collision with bridge structures will not commit an offence of Article 5 for Little Gull.

Collisions with traffic are unlikely to occur as Little Gull is not, in contrast to other gull species, attracted by bridge structures and do not scavenge on collision victims. Thus, the collision risk with traffic is very low and killings due to collision with traffic will not commit an offence of Article 5 for Little Gull.

Deliberate disturbance caused during construction
The results of the EIA conclude that Little Gulls pass the Fehmarnbelt area in internationally important numbers in spring and autumn, but they are not confined to certain habitats in the area. The species is not sensitive to disturbances from construction works due to opportunistic and flexible habitat choice. Thus deliberate disturbance caused during construction will not commit an offence of Article 5.

Deliberate disturbance caused by structure and operation
See deliberate disturbance caused during construction (see above).

Deterioration or destruction caused during construction
The results of the EIA conclude that Little Gulls pass the Fehmarnbelt area in internationally important numbers in spring and autumn, but are not confined to certain habitats in the area. The bridge footprint area was not identified as being of special importance to Little Gulls, although high numbers can be observed using this area for foraging or resting in times. Due to opportunistic and flexible habitat choice, a deterioration or destruction of resting places will not occur.

Deterioration or destruction caused by structure and operation
See deterioration or destruction caused during construction (see above).

Common Gull

Deliberate killing caused during construction
See introduction of chapter 12.4.2.

Deliberate killing caused by structure and operation
Gulls use the updrafts along the bridge to perform gliding flights, which sustain the birds very well just a few meters above the edges of the bridge. They are reported to be highly susceptible to collisions with power lines, bridges and traffic. This may be due to a rising number of gulls assumed to scavenge on collision victims and potentially be exposed to collisions with traffic. Thus it is expected that gulls are more likely at risk to collide with traffic than with the structure of the bridge itself.

According to the EIA, the potential collision rates are very low as birds are mainly daytime active and birds, which are temporarily residents in the area will be accustomed to the presence of the bridge. Thus, deliberate killings caused by collision with bridge structures will not commit an offence of Article 5 for Common Gull.

Even though no quantitative collision rate estimates for collisions with traffic can be given, the numbers of birds which would get killed are expected to be low. Thus, deliberate killings due to collision with traffic will not commit an offence of Article 5 for Common Gull.

Deliberate disturbance caused during construction
Common Gulls are abundant in the study area all year, but occur in maximum abundance in winter. They were not observed being confined to certain habitats while foraging. The area of the fixed link was not identified as being of special importance to Common Gulls, although high numbers can be observed using this area for foraging or resting in times. The species is not sensitive to disturbances from construction works, due to opportunistic and flexible habitat choice. Thus deliberate disturbance caused during construction will not commit an offence of Article 5.

Deliberate disturbance caused by structure and operation
See deliberate disturbance caused during construction (see above).

Deterioration or destruction caused during construction
Common Gulls are abundant in the study area all year, but occur in maximum abundance in winter; they were not observed being confined to certain habitats while foraging. The bridge footprint area was not identified as being of special importance to Common Gulls, although high numbers can be observed using this area for foraging or resting in times. Due to opportunistic and flexible habitat choice, a deterioration or destruction of resting places will not occur.

Deterioration or destruction caused by structure and operation
See deterioration or destruction caused during construction (see above).

Sandwich Tern

Deliberate killing caused during construction
See introduction of chapter 12.4.2.

Deliberate killing caused by structure and operation
According to the EIA the potential collision rates are very low as birds are mainly daytime active and birds, which are temporary residents in the area will be accustomed to the presence of the bridge. Thus, deliberate killings caused by collision with bridge structures will not commit an offence of Article 5 for Sandwich Tern.

Collisions with traffic are unlikely to occur as terns mainly fly at low altitudes and are not at risk of reaching the traffic part of the bridge. Thus, deliberate killings due to collision with traffic will not commit an offence of Article 5 for Sandwich Tern.

Deliberate disturbance caused during construction
It is assumed that most of the observed terns in the Fehmarnbelt area are part of the local breeding population. Sandwich Terns, breeding on Fehmarn or in Rødsand Lagoon, were assessed to be sensitive to disturbances close to their breeding areas. The marine breeding habitats in Rødsand Lagoon and inland breeding areas on Fehmarn are expected not to get directly impaired due to the distance to the construction area. Terns were assessed not to be sensitive to disturbances from ships while foraging at sea, thus the impairment from construction vessels will be low and thus will not commit an offence of Article 5.

Deliberate disturbance caused by structure and operation
See deliberate disturbance caused during construction (see above).

Deterioration or destruction caused during construction
It is assumed that most of the observed terns in the Fehmarnbelt area are part of the local breeding population. Thus, resting places of Sandwich Tern do not occur in the impaired area of the bridge footprint area and so there will be no offence of Article 5 for Sandwich Terns.

Deterioration or destruction caused by structure and operation
See deterioration or destruction caused during construction (see above).

Black Guillemot

Deliberate killing caused during construction
See introduction of chapter 12.4.2.

Deliberate killing caused by structure and operation
According to the EIA the potential collision rates are very low as birds are mainly daytime active and birds, which are temporary residents in the area will be accustomed to the presence of the bridge. Thus, deliberate killings caused by collision with bridge structures will not commit an offence of Article 5 for Black Guillemots.

Collisions with traffic are unlikely to occur, as flight altitudes of resting auks are generally low and the high avoidance of the structure by auks reduces the risk of a collision. Thus, deliberate killings due to collision with traffic will not commit an offence of Article 5 for Black Guillemot.

Deliberate disturbance caused during construction
According to the EIA the greater alignment area is assessed to be of minor importance to Black Guillemot with usually only single birds occurring in this area. Therefore the disturbance from construction vessels is assessed to be low and will not commit an offence of Article 5.

Deliberate disturbance caused by structure and operation
The EIA predicts significant barrier effect for Black Guillemots. Other studies indicate that barrier effect from a bridge could result in a complete barrier to auks (Nilsson et al. 2009, 2010). As the maximum number of recorded Black Guillemots during the baseline investigations was only 18 birds, the local population seems to be only marginal. For this small population a significant effect is excluded. Thus, there will be no offence of Article 5 due the barrier effect.

Deterioration or destruction caused during construction
According to the EIA the greater alignment area is assessed to be of minor importance to Black Guillemot with usually only single birds occurring in this area. Thus, no important resting places occur in the area and there will be no offence of Article 5.

Deterioration or destruction caused by structure and operation
See deterioration or destruction caused during construction (see above).

Diving ducks and seaducks

Deliberate killing caused during construction
See introduction of chapter 12.4.2.

Deliberate killing caused by structure and operation
It is well documented, that seaducks show some avoidance to offshore wind farms; these high barrier effects already suggest a low collision risk. For diving ducks avoidance reactions to wind farms are reported as well. For some of these species night-time flights can increase the risk of collisions.

Diving ducks are active during both day- and night-time, flying from their roosts to the feeding sites and between feeding sites. According to the EIA no empirical data on nocturnal collision rates exist for these species. Calculations for migrating birds gave low potential collision rates, but cannot be easily applied to temporarily resident species, as those on one hand will be accustomed to the presence of the bridge, on the other hand may cross the alignment and thus the bridge more than once during a wintering season. Thus, incidental killings of diving ducks cannot be excluded, but an effect on the population is not expected. Thus, there will be no offence of Article 5.

According to the EIA the potential collision rates of seaducks are very low as birds are mainly daytime active and birds, which are temporary residents in the area will be accustomed to the presence of the bridge. Thus, deliberate killings caused by collision with bridge structures will not commit an offence of Article 5 for seaduck species.

Collisions with traffic can occur as night-time flying species can be disoriented by traffic lights. However, the proportion will be very small and will stay in the field of incidental killings. Thus, deliberate killings due to collision with traffic will not commit an offence of Article 5 for seaduck and diving duck species.

Deliberate disturbance caused during construction
According to the EIA for diving ducks, up to 7,100 Tufted Ducks (0.60% of the biogeographic population; 22.5% of the local population) and 130 Greater Scaup (0.04% of the biogeographic population; 1.0% of the local population) will be displaced during construction works.

According to the EIA for seaducks up to 4,969 Common Eiders (0.65% of the biogeographic population; 1.5% of the local population), 273 Long-tailed Ducks (0.005% of the biogeographic population; 1.1% of the local population), 566 Common Scoters (0.04% of the biogeographic population; 0.9% of the local population), a few tens of Velvet Scoters (<0.01% of the biogeographic population; ca. 1% of the local population) and 54 Common Goldeneyes (<0.01% of the biogeographic population; 0.9% of the local population) will be displaced during construction works. Affected proportions in administrative subareas are given in Table 12.5 and Table 12.6.

Thus, for nearly all seaduck and diving duck species (Tufted Duck, Greater Scaup, Common Eider, Long-tailed Duck and Velvet Scoter) more than 1% of the local population will be impaired by deliberate disturbance and thus there will be an offence of Article 5 for these species. Especially the Tufted Duck will be affected with a substantial proportion of their local populations.

Deliberate disturbance caused by structure and operation
According to the EIA for diving ducks up to 7,100 Tufted Ducks (0.60% of the biogeographic population; 22.5% of the local population) and 130 Greater Scaup

(0.04% of the biogeographic population; 1.0% of the local population) will be displaced due to structure and operation.

According to the EIA for seaducks up to 1,889 Common Eiders (0.2% of the biogeographic population; 0.6% of the local population), 61 Long-tailed Ducks (<0.01% of the biogeographic population; 0.3% of the local population), 118 Common Scoters (<0.01% of the biogeographic population; 0.2% of the local population), a few tens of Velvet Scoters (<0.01% of the biogeographic population; ca. 1% of the local population) and 23 Common Goldeneye (<0.01% of the biogeographic population; 0.4% of the local population) will be displaced due to structure and operation.

Thus, for Tufted Duck, Greater Scaup and Velvet Scoter more than 1% of the local population will be impaired by deliberate disturbance and thus there will be an offence of Article 5 for these species.

Additionally staging seaducks and diving ducks can be affected by barrier effects, if birds stay on either side of the alignment. The barrier effect would then be a potential constraint for resource utilisation. Numbers of affected seaducks and diving ducks cannot be estimated, but deliberate disturbance due to barrier effects cannot be excluded. Especially scoter species are assessed as being sensitive to barrier effects, therefore effects on the local populations might occur.

Deterioration or destruction caused during construction

According to the EIA diving ducks are described to mainly use inland freshwater habitats for daytime resting in spring and autumn. Coastal areas are more frequently used in winter due to freezing over of inland habitats. Less than 1,200 Tufted Ducks (<0.1% of the biogeographic population; less than 3.8% of the local population) and 130 Greater Scaup (<0.04% of the biogeographic population; less than 1.0% of the local population) rest in the vicinity of the ferry harbour in Rødbyhavn during daytime. A loss of suitable foraging and resting habitats to the bridge footprint area (58.7 ha) will thus commit an offence of Article 5 at least for Tufted Ducks. Affected proportions in administrative subareas are given in Table 12.5 and Table 12.6.

It must be noted, that resting places in marine habitats are not stable and linked to specific geographical sites. In fact, such sites are dependent on particular habitat features as for example sheltered bays. Thus, such resting sites can re-establish after construction of a tunnel e.g. in sheltered areas of the land reclamation sites. So it has to be noted, that these marine resting sites might not be unrecoverable destroyed or deteriorated.

For seaduck species the habitat loss from bridge footprint amounts to maximum of a few tens of birds; thus less than 1% of the local population will be impaired and no offence of Article 5 will occur.

Deterioration or destruction caused by structure and operation

See deterioration or destruction caused during construction (see above).

Piscivorous waterbirds

Deliberate killing caused during construction

See introduction of chapter 12.4.2.

Deliberate killing caused by structure and operation
Grebes and mergansers are low flying species, whereof grebes are partly nocturnal. Great Cormorant was registered during radar observations flying at altitudes of up to 400 m and has low flight manoeuvrability. Terns fly very agile, but show less flocking behaviour as e.g. gulls and some species are partly night-time active. Auks show strong avoidance reactions to offshore wind farms and bridges and are thus, not at risk of collisions.

According to the EIA, the potential collision rates are very low as birds are mainly daytime active and birds, which are temporary residents in the area will be accustomed to the presence of the bridge. Thus, deliberate killings caused by collision with bridge structures will not commit an offence of Article 5 for piscivorous waterbird species.

Collisions with traffic can occur as night-time active species (grebes, terns) can be disoriented by traffic lights. However, the proportion will be very small and will stay in the field of incidental killings. Thus, deliberate killings due to collision with traffic will not commit an offence of Article 5 for piscivorous species.

Deliberate disturbance caused during construction
It is assumed that most of the observed terns in the Fehmarnbelt area are part of the local breeding population. The tern species breeding on Fehmarn or in Rødsand Lagoon were assessed to be sensitive to disturbances close to their breeding areas. The marine breeding habitats in Rødsand Lagoon and inland breeding areas on Fehmarn are not expected to get directly impaired due to the distance to the construction area. Terns were assessed not to be sensitive to disturbances from ships while foraging at sea, thus the impairment from construction vessels will be low and thus will not commit an offence of Article 5.

The EIA shows, that 23 Red-necked Grebes (0.04% of the biogeographic population; 2.1% of the local population) 230 Red-breasted Mergansers (0.13% of the biogeographic population; 2.9% of the local population) and 10 Razorbills (<0.01% of the biogeographic population; 0.8% of the local population) will get displaced due to disturbances caused by construction works. Up to 500 Great Cormorants (0.1% of the biogeographic population, 4.8% of the local population) will be displaced during construction. Thus, for three species (Red-necked Grebe, Red-breasted Merganser and Great Cormorant) the impairment from construction vessels will be high and thus will commit an offence of Article 5. Affected proportions in administrative subareas are given in Table 12.5 and Table 12.6.

Deliberate disturbance caused by structure and operation
The EIA shows, that 8 Red-necked Grebes (0.02% of the biogeographic population; 0.7% of the local population), 53 Red-breasted Mergansers (0.03% of the biogeographic population; 0.7% of the local population) and 6 Razorbills (<0.01% of the biogeographic population; 0.5% of the local population) will get displaced due to disturbances caused by structure and operation. Up to 500 Great Cormorants (0.1% of the biogeographic population, 4.8% of the local population) will be displaced during operation. Thus, for at least Great Cormorant the impairment from disturbance caused by structure and operation will be high and thus will commit an offence of Article 5. Affected proportions in administrative subareas are given in Table 12.5 and Table 12.6.

Additionally the EIA predicts substantial effects of barrier effect for auks. Other studies indicate that barrier effect from a bridge could result in a complete barrier to auks (Nilsson et al. 2009, 2010). As the maximum numbers of recorded auks during baseline investigations were small, the local populations seem to be only marginal. For these small populations a significant effect is excluded. Thus, there will be no offence of Article 5 due the barrier effect.

Deterioration or destruction caused during construction
For grebes, mergansers, terns and auks the results of the EIA show that none or only single birds will be affected by deterioration or destruction of resting places within the bridge footprint area. For Great Cormorant the Fehmarnbelt was identified as being of very high importance. There were no major aggregation areas identified in marine habitats, but cormorants aggregate in high numbers on their roosts. Cormorants roost in the Fehmarnbelt area on undisturbed sandbanks and beaches like Rødsand (Rødsand Lagoon) or Krummsteert (SW Fehmarn), but also on the breakwaters of the ferry harbours in Rødbyhavn and Puttgarden, which are sometimes used by up to 500 Great Cormorants (0.1% of the biogeographic population, 4.8% of the local population). Cormorants may possibly give up those roosts, due to construction works. Based on the number of possibly affected Cormorants there will be an offence of Article 5 for this species concerning the proportion of the local population.

Deterioration or destruction caused by structure and operation
See deterioration or destruction caused during construction (see above).

Herbivorous waterbirds

Deliberate killing caused during construction
See introduction of chapter 12.4.2.

Deliberate killing caused by structure and operation
During the FEBI bridge studies Mute Swans showed some avoidance reactions to bridges, suggesting a low collision risk and these birds are known to avoid wind farms. Swans have low flight manoeuvrability, high flight activity and are sometime active at night.

Geese in general fly at medium to high altitudes and show some avoidance against bridge structures in cases when their migration path directly crosses a bridge. Most goose species migrate both during day- and night-time.

For Greylag Geese it is reported that they often crossed just above the freeway of the Öresund Bridge, on their movements between Pepparholm and mainland Sweden, and could even have been subjects for collisions with cars (Nilsson et al. 2010).

Dabbling ducks show low avoidance rates, nocturnal flight activity, predominant low flight altitude and flight directions perpendicular to the bridge and are more often reported being victims of power lines than geese and swans.

According to the EIA, the potential collision rates are very low for all herbivorous waterbird species as birds are mainly daytime active and birds, which are temporary residents in the area, will be accustomed to the presence of the bridge. Thus, deliberate killings caused by collision with bridge structures will not commit an offence of Article 5 for herbivorous waterbird species.

Collisions with traffic can occur as night-time flying species can be disoriented by traffic lights. However, the proportion will be very small and will stay in the field of incidental killings. Thus, deliberate killings due to collision with traffic will not commit an offence of Article 5 for seaduck and diving duck species.

Deliberate disturbance caused during construction
According to the baseline investigations most herbivorous waterbirds occur mostly in sheltered marine habitats or at inland waters. They are thus not impaired by disturbances caused during construction works due to their spatial distribution. Only the Eurasian Wigeon is with up to 1,500 birds (0.1% of the biogeographic population; 8.9% of the local population) impaired by disturbance. Therefore, deliberate disturbance of herbivorous waterbirds will occur at least for the Eurasian Wigeon in a magnitude that will be an offence of Article 5. Affected proportions in administrative subareas are given in Table 12.5 and Table 12.6.

Deliberate disturbance caused by structure and operation
According to the baseline investigations most herbivorous waterbirds occur mostly in sheltered marine habitats or at inland waters. They are thus not impaired by disturbances caused during construction works due to their spatial distribution. As Eurasian Wigeon is known to also occur in highly disturbed areas, such as the ferry harbours in Puttgarden and Rødbyhavn it is expected that the species will adapt to the bridge and will thus not be impaired by the bridge structure. Affected proportions in administrative subareas are given in Table 12.5 and Table 12.6.

Deterioration or destruction caused during construction
According to the baseline investigations herbivorous waterbirds occur mostly in sheltered marine habitats or at inland waters. Occasionally higher numbers of up to a few hundred individuals are reported to use the coastal areas within the bridge footprint area. But there are no important resting places for herbivorous waterbirds, thus, deliberate disturbance of herbivorous waterbirds will not occur.

Deterioration or destruction caused by structure and operation
See deterioration or destruction caused during construction (see above).

Gulls

Deliberate killing caused during construction
See introduction of chapter 12.4.2.

Deliberate killing caused by structure and operation
Gulls (mostly Herring, Great Black-backed and Lesser Black-backed Gull) observed at the Öresund Bridge use the updrafts along the bridge to perform gliding flights, which sustain the birds very well just a few meters above the edges of the bridge. (Nilsson et al. 2010).

Gulls are reported to be highly susceptible to collisions with power lines and are often found as collision victims. This could be because they spend relatively long time periods flying, occur often in very dense flocks and also fly during windy conditions (Prinsen et al. 2011). Among the gull species, Black-headed Gull has the highest proportion among the collision numbers. Gulls are also frequently reported as collision victims during the Öresund Bridge studies. This may be due to a rising number of gulls assumed to be scavenging on collision victims and potentially colliding with traffic (Nilsson et al. 2009). Thus it is expected that gulls are more likely at risk to collide with traffic than with the structure of the bridge itself.

As most gull species, except the Common Gull, are reported to also conduct nocturnal movements and migration (Mendel et al. 2008), for those flying perpendicularly to the alignment a collision risk must be assumed according to the results from the power line studies.

According to the EIA the potential collision rates are very low as birds are mainly daytime active and birds, which are temporary residents in the area will be accustomed to the presence of the bridge. Thus, deliberate killings caused by collision with bridge structures will not commit an offence of Article 5 for gull species.

Collisions with traffic can occur as scavenging gull species (mostly Herring, Great Black-backed and Lesser Black-backed Gull) can be attracted by collision victims on the traffic lane and then collide with traffic. Even though no quantitative collision rate estimates for collisions with traffic can be given, the numbers of birds which would get killed are expected to be low and have no effect on the local population. Thus, deliberate killings due to collision with traffic will not commit an offence of Article 5 for gull species.

Deliberate disturbance caused during construction

Gulls breeding on Fehmarn or in Rødsand Lagoon were assessed to be sensitive to disturbances close to their breeding areas. The marine breeding habitats in Rødsand Lagoon and inland breeding areas on Fehmarn are not expected to get directly impaired due to the distance to the construction area. Gulls were assessed not to be sensitive to disturbances from ships while foraging at sea, thus the impairment from construction vessels will be low and thus will not commit an offence of Article 5.

Deliberate disturbance caused by structure and operation

Gulls breeding on Fehmarn or in Rødsand Lagoon were assessed to be sensitive to disturbances close to their breeding areas. The marine breeding habitats in Rødsand Lagoon and inland breeding areas on Fehmarn are expected not to get directly impaired due to the distance to a fixed link. Gulls were assessed not to be sensitive to disturbances while foraging at sea, thus the impairment from disturbance caused by structure and operation will be low and thus will not commit an offence of Article 5.

Deterioration or destruction caused during construction

The different gull species were assessed as not being sensitive to habitat loss due to their opportunistic behaviour, which allows them to use various habitats. Thus, there will be no deterioration or destruction of resting places and therewith no offence of Article 5 for gulls.

Deterioration or destruction caused by structure and operation

See deterioration or destruction caused during construction (see above).

Table 12.5 *Number of displaced birds during bridge construction due to disturbance, decreased water transparency and sediment spill in the Fehmarnbelt study area and administrative subareas.*

Species	Number of displaced birds due to															Total number of displaced birds
	Disturbance					Decreased water transparency					Sediment spill					
	Study area	thereof in				Study area	thereof in				Study area	thereof in				
		German coastal waters	German EEZ	Danish EEZ	Danish coastal waters		German coastal waters	German EEZ	Danish EEZ	Danish coastal waters		German coastal waters	German EEZ	Danish EEZ	Danish coastal waters	
Divers	8	5	0	1	2	10	2	0	0	8						17
Great Crested Grebe	42	39	0	1	2	24	23	0	0	1						
Red-necked Grebe	19	11	0	1	7	6	7	0	0	2						23
Great Cormorant	500	~250			~250											500
Eurasian Wigeon	1,500	1,500														1,500
Common Pochard	710				710											710
Tufted Duck	7,100				7,100											7,100
Greater Scaup	130				130											130
Common Eider	3,919	2,798	22	72	1,027	2,029	1,429	0	0	601						4,969
Long-tailed Duck	110	74	5	11	20	174	27	0	0	147						273
Common Scoter	383	360	5	2	16	183	129	0	0	53						566
Common Goldeneye	54	25	0	0	29											54
Red-breasted Merganser	115	49	0	1	65	158	46	0	0	96						230
Common Coot	340	~170			~170											340
Razorbill	10	1	4	2	3	3	0	2	1	0						10

Table 12.6 *Number of displaced birds during operation of a bridge due to disturbance in the Fehmarnbelt study area and administrative subareas.*

Species	Total number of displaced birds	thereof in			
		German coastal waters	German EEZ	Danish EEZ	Danish coastal waters
Divers	3	2	0	0	1
Great Crested Grebe	20	18	0	0	1

Species	Total number of displaced birds	thereof in			
		German coastal waters	German EEZ	Danish EEZ	Danish coastal waters
Red-necked Grebe	8	4	0	0	4
Great Cormorant	500	~250			~250
Common Pochard	710				710
Tufted Duck	7,100				7,100
Greater Scaup	130				130
Common Eider	1,889	1,204	14	46	626
Long-tailed Duck	61	37	3	7	13
Common Scoter	118	104	3	7	13
Common Goldeneye	23	6	0	0	17
Red-breasted Merganser	53	17	0	1	35
Razorbill	6	1	2	1	2

12.4.3 Migrating birds

Introduction

Migrating birds fly over the Fehmarnbelt in different altitudes and directions; this is often determined by weather conditions and also depends on species-specific migration behaviour.

Deliberate killing caused during construction

Birds migrating at low altitudes may collide with construction vessels, especially in bad weather situations with poor visibility and high wind speeds. But deliberate killings due to collisions with construction vessels are not expected to be of relevance for migrating birds. Construction works for a fixed link in the Fehmarnbelt would take place in an area of already high shipping intensity. So, construction vessels are expected to contribute to the total amount of ship traffic in the area.

During daylight hours collisions are highly unlikely. Larger construction vessels are expected to move rather slowly or be anchored. Birds can easily see the vessels and fly around them.

During the night birds might get attracted by the lights of the construction vessels during certain weather conditions. Collisions of birds with ships at night have been documented in Southwest Greenland and were significantly related to bad visibility (Merkel and Johansen 2011). The impact of the construction vessels would however be limited to a small area at any time and the number of collisions is expected to be very low. Thus, it is not expected, that deliberate killings by collisions will commit an offence of Article 5 for any migrating species.

Deliberate killing caused by structure and operation

Deliberate killings due to the structure and operation of a bridge over the Fehmarnbelt will be caused by collision with bridge structures and collision with traffic running over the bridge.

Deliberate disturbance caused during construction

Flying birds usually respond to an obstacle by vertical or horizontal changes in their intended flight route. In case of species which migrate or generally fly at low altitudes the presence of construction vessels might have an effect as a barrier.

Birds flying over water respond in different ways to on-site or approaching vessels. Some species are attracted to vessels such as gulls or terns; others show a negative response such as divers or scoters, for which it is expected that they avoid flying over vessels and would detour ships at a greater distance. These reactions would result in extra energy expenditures for an individual bird.

Construction vessels would operate mostly in defined working areas and would not exhibit a total barrier over the Fehmarnbelt, thus birds are expected to always be able to detour the barrier from construction vessels while passing the area. A spatially small barrier caused by construction vessels would not reduce the obstacle-free space in the Fehmarnbelt in a substantial way. Thus, it is not expected, that deliberate disturbance will commit an offence of Article 5 for any migrating species.

Deliberate disturbance due to barrier effects from construction vessels has, according to the EIA (see chapter 10.2.5), no impact on the local population of migrating birds.

As none of these pressures will commit an offence of Article 5 for any migrating species, the species-wise description is skipped here.

Deliberate disturbance caused by structure and operation

Deliberate disturbance caused by structure and operation of a bridge will, according to the EIA, result from barrier effects. These barrier effects result for many species in extra energy expenditure for gaining height or making detours. Few species (auks) are expected to perceive the bridge as a total barrier that will not be crossed. For more details see species/species group accounts.

Deterioration or destruction of resting places caused during construction

Not applicable for migrating birds.

Deterioration or destruction of resting places caused by structure and operation

Not applicable for migrating birds.

Red-throated Diver/Black-throated Diver

Deliberate killing caused during construction

See introduction of chapter 12.4.3.

Deliberate killing caused by structure and operation

According to the EIA, the potential daytime collision rate is estimated to be 0.0, (<0.001% of the biogeographic population) per year. Thus, there will be no offence of Article 5 for diver species caused by collisions with bridge structure. For more details see chapter 10.3.7.

Deliberate disturbance caused during construction
See introduction of chapter 12.4.3.

Deliberate disturbance caused by structure and operation
The EIA concludes that diver species are expected to detour the bridge with an extra energy expenditure of 1.2% of the total migration cost or gain height with an extra energy expenditure of 0.1 or 0.2%. This will not have an effect on the population and thus, there will be no offence of Article 5.

Slavonian Grebe

Deliberate killing caused during construction
See introduction of chapter 12.4.3.

Deliberate killing caused by structure and operation
No potential collision risks have been estimated for Slavonian Grebes. Nevertheless, the EIA concludes that less than 0.01% of the biogeographic population may be potentially colliding. Incidental killings cannot be excluded, but there will be no offence of Article 5 for Slavonian Grebes.

Deliberate disturbance caused during construction
See introduction of chapter 12.4.3.

Deliberate disturbance caused by structure and operation
The EIA concludes that Slavonian Grebes will pass the bridge showing medium reactions without effects on the population. Thus, there will be no offence of Article 5.

White Stork

Deliberate killing caused during construction
See introduction of chapter 12.4.3.

Deliberate killing caused by structure and operation
According to the EIA, the collision risk of White Storks will be very low, as all structures are visible and migration direction will be parallel to the alignment. White Storks are among those birds frequently found dead under power lines, but it is suggested that most of those died of electrocution rather than collision. Thus, there will be no offence of Article 5 for White Storks.

Deliberate disturbance caused during construction
See introduction of chapter 12.4.3.

Deliberate disturbance caused by structure and operation
According to the EIA, the barrier effects will not occur for White Storks due to the migration altitude and direction. Thus, there will be no offence of Article 5 for White Storks.

Bewick's Swan

Swans have low flight manoeuvrability, high flight activity and can be active at night, but also show avoidance reactions to structures.

Deliberate killing caused during construction
See introduction of chapter 12.4.3.

Deliberate killing caused by structure and operation
The EIA concluded that for Bewick's Swan collisions are very unlikely to occur; thus, collisions will most likely involve, if at all, only single individuals. Therefore an offence of Article 5 is not expected.

Deliberate disturbance caused during construction
See introduction of chapter 12.4.3.

Deliberate disturbance caused by structure and operation
The EIA concludes that Bewick's Swans are expected to increase height to cross the bridge. The energy cost for this climb would range between 0.1% and 1.0% of their total migration cost. This will not have an effect on the population and thus, there will be no offence of Article 5.

Whooper Swan

Swans show a low flight manoeuvrability, high flight activity and some nocturnal activity, but show also avoidance reactions to structures.

Deliberate killing caused during construction
See introduction of chapter 12.4.3.

Deliberate killing caused by structure and operation
For Whooper Swans the EIA conducted that collisions are very unlikely to occur; thus, collisions will most likely involve, if at all, only single individuals. Therefore an offence of Article 5 is not expected.

Deliberate disturbance caused during construction
See introduction of chapter 12.4.3.

Deliberate disturbance caused by structure and operation
The EIA concludes that Whooper Swans are expected to increase height to cross the bridge. The energy cost for this climb would range between 0.1% and 1.0% of their total migration cost. This will not have an effect on the population and thus, there will be no offence of Article 5.

Barnacle Goose

Deliberate killing caused during construction
See introduction of chapter 12.4.3.

Deliberate killing caused by structure and operation
According to the EIA, 11 Barnacle Geese (0.003% of the biogeographic population) will collide with the bridge structures per year. This collision estimate will not have an effect on the population as comparison with the PBR shows (see chapter 10.3.7). Thus, there will be no offence of Article 5.

Deliberate disturbance caused during construction
See introduction of chapter 12.4.3.

Deliberate disturbance caused by structure and operation
The EIA concludes that Barnacle Geese are expected to increase height to cross the bridge or to detour overland with an extra energy expenditure of up to 0.3% of the total migration costs. This will not have an effect on the population and thus, there will be no offence of Article 5.

Birds of prey

Deliberate killing caused during construction
See introduction of chapter 12.4.3.

Deliberate killing caused by structure and operation
The EIA concluded that all birds of prey migrate predominantly during daytime and cross water bodies at shortest crossing distances, thus a bridge structure would more likely serve as a guiding structure across the alignment than a barrier causing collisions. Therefore there will be no offence of Article 5 for any migrating bird of prey.

Deliberate disturbance caused during construction
See introduction of chapter 12.4.3.

Deliberate disturbance caused by structure and operation
According to the EIA all birds of prey will, as daytime migrants, cross water bodies preferably at shortest crossing distances, a bridge structure would not be perceived as a barrier, but rather serve as a guiding structure across the alignment. Thus, there will be no offence of Article 5.

Crane

Deliberate killing caused during construction
See introduction of chapter 12.4.3.

Deliberate killing caused by structure and operation
Even though several crane species are known to be highly susceptible to collisions with power lines in many regions of the world, the EIA concluded that collision risk with bridge structure will be low for Common Crane. As this species migrate predominantly during daytime and cross water bodies at shortest crossing distances, a bridge structure would more likely serve as a guiding structure across the alignment than a barrier causing collisions. Flight directions and altitudes make the probability for collisions with bridge structures low, and therefore no offence of Article 5 will occur for Common Crane.

Deliberate disturbance caused during construction
See introduction of chapter 12.4.3.

Deliberate disturbance caused by structure and operation
According to the EIA, Common Crane will, as daytime migrant, cross water bodies preferably at shortest crossing distances. A bridge structure would not be perceived as a barrier, but rather serve as a guiding structure across the alignment. Thus, there will be no offence of Article 5.

Waders

Deliberate killing caused during construction
See introduction of chapter 12.4.3.

Deliberate killing caused by structure and operation
The EIA concluded that all wader species show some affinity to migrate along coastlines, fly at high altitudes but also migrate in broad front at night. Regarding collision, since daytime collisions were considered being unlikely (except during

adverse weather conditions), it is assumed that this would be mainly a risk during nocturnal migration (attraction by light).

In summary, most wader species migrating across the Fehmarnbelt region, conduct long-distance flights showing some coastal orientation. They frequently fly above 300-500 m, thus most waders or wader flocks would not come close to any bridge during normal weather conditions. However, they may fly at lower altitudes during inclement weather. Thus, there will be no offence of Article 5 for waders, only during inclement weather conditions incidental killings may occur, but these are not predictable.

Deliberate disturbance caused during construction
See introduction of chapter 12.4.3.

Deliberate disturbance caused by structure and operation
According to the EIA, most wader species migrating across the Fehmarnbelt region, conduct long-distance flights showing some coastal orientation, they also frequently fly above 300-500 m, such that most waders or wader flocks would not come close to any bridge. Of those flocks close to the Öresund Bridge, many changed direction and flew over land. This might cost some extra energy, but there will be no offence of Article 5.

Little Gull

Deliberate killing caused during construction
See introduction of chapter 12.4.3.

Deliberate killing caused by structure and operation
According to the EIA all gull species frequently fly in dense flocks and under windy conditions, furthermore gulls are reported to be highly susceptible to collisions with power lines and are often found as collision victims, frequently representing 5-25% of recorded victims. As the EIA gives no potential collision risk for Little Gulls, incidental killings cannot be excluded, but there will be no offence of Article 5 for Little Gull colliding with bridge structures.

Collisions with traffic are not likely to occur as Little Gull in contrast to other gull species is not attracted by bridge structures and do not scavenge on collision victims. Thus, the collision risk with traffic is very low and killings due to collision with traffic will not commit an offence of Article 5 for Little Gull.

Deliberate disturbance caused during construction
See introduction of chapter 12.4.3.

Deliberate disturbance caused by structure and operation
The EIA concludes that all gull species are not disturbed by ships and show flexible flight and migration behaviour. Therefore, barrier effects are assessed to be small for these species. Thus, there will be no offence of Article 5 for Little Gull.

Common Gull

Deliberate killing caused during construction
See introduction of chapter 12.4.3.

Deliberate killing caused by structure and operation
According to the EIA all gull species frequently fly in dense flocks and under windy conditions, furthermore gulls are reported to be highly susceptible to collisions with power lines and are often found as collision victims, frequently representing 5-25% of recorded victims. As the EIA gives no potential collision risk for Common Gulls, incidental killings cannot be excluded, but there will be no offence of Article 5 for Common Gull colliding with bridge structures.

Even though no quantitative collision rate estimates for collisions with traffic can be given, the numbers of birds which would get killed are expected to be low. Thus, deliberate killings due to collision with traffic will not commit an offence of Article 5 for Common Gull.

Deliberate disturbance caused during construction
See introduction of chapter 12.4.3.

Deliberate disturbance caused by structure and operation
The EIA concludes that all gull species are not disturbed by ships and show flexible flight and migration behaviour. Therefore, barrier effects are assessed to be small for these species. Common Gull is even known to use the updrafts of a bridge to perform gliding flights. Thus, there will be no offence of Article 5 for Common Gull.

Sandwich Tern

Deliberate killing caused during construction
See introduction of chapter 12.4.3.

Deliberate killing caused by structure and operation
The EIA gives no potential collision risk for tern species, but shows that with regard to power lines, terns appear to be relatively less susceptible to collisions compared to e.g. gulls, assumedly due to less nocturnal activity and less flocking behaviour. As Sandwich Tern is reported to be nocturnally active, the collision risk is assessed higher than for other tern species. Thus, incidental killings cannot be excluded, but there will be no offence of Article 5 for Sandwich Tern.

Deliberate disturbance caused during construction
See introduction of chapter 12.4.3.

Deliberate disturbance caused by structure and operation
The EIA concludes that tern species show no avoidance behaviour to offshore wind farms. Thus, it is expected, that there will be no barrier effect for tern species and therewith no offence of Article 5.

Arctic Tern

Deliberate killing caused during construction
See introduction of chapter 12.4.3.

Deliberate killing caused by structure and operation
The EIA gives no potential collision risk for tern species, but shows that with regard to power lines, terns appear to be relatively less susceptible to collisions compared to e.g. gulls, assumedly due to less nocturnal activity and less flocking behaviour. As Arctic Tern is reported to be almost exclusively daytime active, the collision risk is assessed lower than for Sandwich Tern and Common Tern. Thus, an offence of Article 5 will not occur for Arctic Tern.

Deliberate disturbance caused during construction
See introduction of chapter 12.4.3.

Deliberate disturbance caused by structure and operation
The EIA concludes that tern species show no avoidance behaviour to offshore wind farms. Thus, it is expected, that there will be no barrier effect for tern species and therewith no offence of Article 5.

Common Tern

Deliberate killing caused during construction
See introduction of chapter 12.4.3.

Deliberate killing caused by structure and operation
The EIA gives no potential collision risk for tern species, but shows that with regard to power lines, terns appear to be relatively less susceptible to collisions compared to e.g. gulls, assumedly due to less nocturnal activity and less flocking behaviour. As Common Tern is reported to be nocturnally active, the collision risk is assessed higher than for other tern species. Thus, incidental killings cannot be excluded, but there will be no offence of Article 5 for Common Tern.

Deliberate disturbance caused during construction
See introduction of chapter 12.4.3.

Deliberate disturbance caused by structure and operation
The EIA concludes that tern species show no avoidance behaviour to offshore wind farms. Thus, it is expected, that there will be no barrier effect for tern species and therewith no offence of Article 5.

Little Tern

Deliberate killing caused during construction
See introduction of chapter 12.4.3.

Deliberate killing caused by structure and operation
The EIA gives no potential collision risk for tern species, but shows that with regard to power lines, terns appear to be relatively less susceptible to collisions compared to e.g. gulls, assumedly due to less nocturnal activity and less flocking behaviour. As Little Tern is reported to be almost exclusively daytime active, the collision risk is assessed lower than for Sandwich Tern and Common Tern. Thus, an offence of Article 5 will not occur for Little Tern.

Deliberate disturbance caused during construction
See introduction of chapter 12.4.3.

Deliberate disturbance caused by structure and operation
The EIA concludes that tern species show no avoidance behaviour to offshore wind farms. Thus, it is expected, that there will be no barrier effect for tern species and therewith no offence of Article 5.

Short-eared Owl

Deliberate killing caused during construction
See introduction of chapter 12.4.3.

Deliberate killing caused by structure and operation
The EIA gives no potential collision risk for Short-eared Owls. The species was registered as collision victim at the Öresund Bridge (5 individuals); however, it is not known whether those were actually migrating individuals. Owls are known to collide with power lines, wind mills and with traffic. Thus, incidental killings cannot be excluded, but there will be no offence of Article 5 for Short-eared Owl.

Deliberate disturbance caused during construction
See introduction of chapter 12.4.3.

Deliberate disturbance caused by structure and operation
The EIA gives no assessment for owl species concerning barrier effects, but as migration direction of owls will be parallel to the bridge, it is not expected, that there will be a barrier effect with an impact on the population. Thus, there will be no offence of Article 5.

Day-time migrating passerines

Deliberate killing caused during construction
See introduction of chapter 12.4.3.

Deliberate killing caused by structure and operation
According to the EIA, the bridge structure will likely have a leading line effect and the collision risk for daytime migrating passerines is expected to be very low. Rook (and corvids in general) and Eurasian Jackdaw are, according to the EIA, at higher risk of colliding with traffic, but it is assessed not to have impacts on the populations. Incidental killings cannot be excluded, but there will be no offence of Article 5 for day-time migrating passerines.

Deliberate disturbance caused during construction
See introduction of chapter 12.4.3.

Deliberate disturbance caused by structure and operation
The EIA concludes that there will be no barrier effect of a bridge for most daytime migrants, as it would be parallel to their main migration direction and thus rather represent a leading line for crossing the Belt than a barrier. Thus, there will be no offence of Article 5.

Obligatory and facultative night-time migrating species

Deliberate killing caused during construction
See introduction of chapter 12.4.3.

Deliberate killing caused by structure and operation
According to the EIA, night-time migrants are assumed to migrate in a broad-front across the region. Depending on weather conditions collision events may occur. But estimated potential collision numbers for night-time migrating passerines are 10,000 individuals per season. While this maximum value would present some 0.97% of the birds passing the Fehmarnbelt across a 5 km line per season, this collision rate would represent just 0.0088% of the relevant biogeographic/relevant reference populations per year and thus, stay below any proportions leading to population effect. Thus, incidental killings cannot be excluded, but there will be no offence of Article 5 for night-time migrating species.

Deliberate disturbance caused during construction
See introduction of chapter 12.4.3.

Deliberate disturbance caused by structure and operation
According to the EIA, nocturnal passerine migrants migrate predominantly at higher altitudes parallel to the link and therefore are not expected to perceive a bridge as a barrier. Thus, for nocturnal (and facultative nocturnal) passerines there will be no offence of Article 5.

Geese and swans

Deliberate killing caused during construction
See introduction of chapter 12.4.3.

Deliberate killing caused by structure and operation
According to the EIA, 11 Greylag Geese (0.002% of the biogeographic population) and 65 Brent Geese (0.03% of the biogeographic population) might collide with the bridge structures per year. This collision estimate will not have an effect on populations of these species according to the PBR threshold. For all other species no potential collision risk was estimated, but it is assessed to be small. Additionally for Greylag Geese the collision risk with traffic is assessed to be higher than for other species, as Greylag Geese have been observed crossing the Öresund Bridge just above the road. Therefore, incidental collisions with traffic cannot be excluded, but in sum there will be no offence of Article 5 for geese and swans.

Deliberate disturbance caused during construction
See introduction of chapter 12.4.3.

Deliberate disturbance caused by structure and operation
The EIA concludes that Mute Swans are expected to increase flight altitude to cross the bridge with an extra energy expenditure of up to 2.6% of the total migration costs; for geese the maximum extra energy expenditure was estimated being up to 0.3% of the total migration costs. These extra energy expenditures will not have an effect on the populations of Mute Swan and geese and thus, there will be no offence of Article 5.

Dabbling ducks

Deliberate killing caused during construction
See introduction of chapter 12.4.3.

Deliberate killing caused by structure and operation
According to the EIA 22 Eurasian Wigeon (0.001% of the biogeographic population) and 2 Northern Pintail (0.003% of the biogeographic population) will collide per year. This collision estimate will not have an effect on the population as comparison with PBR show. For all other species no potential collision risk was estimated, but is assessed to be small. Thus, there will be no offence of Article 5 for dabbling ducks.

Deliberate disturbance caused during construction
See introduction of chapter 12.4.3.

Deliberate disturbance caused by structure and operation
According to the EIA, a barrier effect might not play a large role to dabbling ducks, since migrating individuals may readily veer off over land to their resting places or increase altitude and continue in migration direction. Extra energy expenditures will

not have an effect on the populations of dabbling ducks and thus, there will be no offence of Article 5.

Diving ducks and seaducks

Deliberate killing caused during construction
See introduction of chapter 12.4.3.

Deliberate killing caused by structure and operation
According to the EIA collisions of diving ducks with the bridge structure will be very unlikely. Numbers of potentially colliding Common Eiders are higher – up to 198 birds (0.026% of the flyway population) per year. Estimates for day time migrating Common Scoters show no collisions. For all other species no potential collision risk was estimated, but it is assessed to be small. Thus, there will be no effects on populations. Incidental killings cannot be excluded, but there will be no offence of Article 5 for diving ducks and seaducks.

Deliberate disturbance caused during construction
See introduction of chapter 12.4.3.

Deliberate disturbance caused by structure and operation
According to the EIA, a barrier effect might not play a large role to diving ducks, since migrating individuals may readily veer off over land to their resting places or increase altitude to continue in migration direction. For seaducks, the EIA concludes that Common Eiders are expected avoid the bridge by making detours with an extra energy expenditure of up to 1.1% of the total migration costs, for Common Scoter the maximum extra energy expenditure was estimated up to 0.5% of the total migration costs.

For Common and Velvet Scoters barrier effect can be considerable, more than described for other duck species, as scoters have been observed avoiding crossing bridges with some flocks even flying back. Based on the high barrier effect and the very high important numbers of Common Scoter potentially being affected, an effect on the population cannot completely be excluded. Thus, there will be an offence of Article 5 for scoter species. For other diving and seaduck species extra energy expenditures will not have an effect on the populations and thus, there will be no offence of Article 5.

Other waterbirds (grebes, mergansers, rails, auks etc.)

Deliberate killing caused during construction
See introduction of chapter 12.4.3.

Deliberate killing caused by structure and operation
No potential collision risks have been estimated for other waterbirds. Nevertheless, the EIA concludes, that less than 0.01% of the biogeographic population may be potentially colliding. Incidental killings cannot be excluded, but there will be no offence of Article 5 for grebes, mergansers and rails.

Deliberate disturbance caused during construction
See introduction of chapter 12.4.3.

Deliberate disturbance caused by structure and operation
For grebes, mergansers, rails and Great Cormorant the EIA shows no to little extra energy expenditures due to the bridge effect. For auks the EIA concludes

substantial effects of barrier effect. Other studies indicate that barrier effect from a bridge could result in a complete barrier to auks (Nilsson et al. 2009, 2010). This would result in excluding auks from a large wintering area between the planned fixed link and the bridges at Great Belt and Little Belt, which is an offence of Article 5.

Gulls

Deliberate killing caused during construction
See introduction of chapter 12.4.3.

Deliberate killing caused by structure and operation
According to the EIA, all gull species frequently fly in dense flocks and under windy conditions, furthermore gulls are reported to be highly susceptible to collisions with power lines and are often found as collision victims, frequently representing 5-25% of recorded victims. As the EIA gives no potential collision risk for gulls, incidental killings cannot be excluded, but there will be no offence of Article 5 for gulls colliding with bridge structures.

Even though no quantitative collision rate estimates for collisions with traffic can be given, the numbers of birds which would get killed are expected to be low. There will be no deliberate killings due to collision with traffic and thus, no offence of Article 5 will occur.

Deliberate disturbance caused during construction
See introduction of chapter 12.4.3.

Deliberate disturbance caused by structure and operation
The EIA concludes that all gull species are not disturbed by ships and show flexible flight and migration behaviour. Therefore, barrier effects are assessed to be small for these species. Some gull species are even known to use the updrafts of a bridge to perform gliding flights. Thus, there will be no offence of Article 5 for gulls.

12.5 Conclusion

12.5.1 Tunnel main alternative

The assessment of strictly protected species of the tunnel alternative leads to the conclusion that an offence of Article 5 might occur for a number of non-breeding waterbird species (Table 12.7). This results mainly from direct disturbance from construction vessels and decreased water transparency from sediment spill. Though these impacts are temporary and predicted to occur at significant levels only for two years, the total number of affected individuals exceeds 1% of the local population for some species and this is regarded as an offence of Article 5 of the Birds Directive.

Estimated additional mortality of Common Eiders is with 600 individuals relatively small and thus stays well below 1% of the local population (Table 12.7).

For migrating birds no offence of Article 5 is assessed for the tunnel alternative.

Table 12.7 Overview table for species, for which an offence of Article 5 is assessed for the tunnel alternative.

Species	Deliberate killing (% of local population)		Deliberate disturbance (% of local population)		Deterioration or destruction of resting places (x = will occur)	
	Con-struction	Operation/ structure	Con-struction	Operation/ structure	Con-struction	Operation/ structure
Non-breeding waterbirds						
Divers			2.5			
Common Pochard			20.2		x*	x*
Tufted Duck			22.7		x*	x*
Greater Scaup			1.2		x*	x*
Common Eider	0.18		3.7			
Long-tailed Duck			3.1			
Common Scoter			1.1			
Velvet Scoter			ca. 1.0			
Common Goldeneye			1.4	1.6	x*	x*
Red-necked Grebe			8.3			
Red-breasted Merganser			13.2			
Razorbill			1.1			
Great Cormorant			4.8		x	x
Eurasian Wigeon			8.9			
Breeding waterbirds						
Red-breasted Merganser			1.7 (3 BP)			

*It must be noted, that resting places in marine habitats are not stable and linked to geographical sites. In fact, such sites are dependent on particular habitat features as for example sheltered bays. Thus, such resting sites can re-establish after construction of a tunnel e.g. in sheltered areas of the land reclamation sites. So it has to be noted, that these marine resting sites might not be unrecoverable destroyed or deteriorated.

12.5.2 Bridge main alternative

The assessment of strictly protected species of the bridge alternative leads to the conclusion that significant impacts might occur for a number of non-breeding waterbird species (Table 12.8). This results mainly from direct disturbance from construction vessels and decreased water transparency from sediment spill. These impacts are temporary and predicted to occur at significant levels only for two years, the total number of affected individuals exceeds 1% of the local population for some species and this is regarded as an offence of Article 5 Birds Directive. Impacts from habitat loss due to land reclamation areas causing a deterioration or destruction of resting habitats are permanent. For migrating birds it is concluded that the barrier results in significant disturbance for the three auk species, where studies indicate a complete barrier effect for Common and Velvet Scoter (Table 12.8). This is regarded as an offence of Article 5 of the Birds Directive.

For breeding waterbirds no offence of Article 5 is assessed for the bridge alternative.

Table 12.8 Overview table over species, for which an offence of Article 5 for the bridge alternative is assessed.

Species	Deliberate killing (% of local population)		Deliberate disturbance (% of local population)		Deterioration or destruction of resting places (x = will occur)	
	Con-struction	Operation/structure	Con-struction	Operation/structure	Con-struction	Operation/structure
Non-breeding waterbirds						
Diver spp.			1.0			
Common Pochard			20.2		x*	x*
Tufted Duck			22.5	22.5	x*	x*
Greater Scaup			1.0	1.0		
Common Eider			1.5			
Long-tailed Duck			1.1			
Velvet Scoter			ca. 1.0	1.0		
Red-necked Grebe			2.1			
Red-breasted Merganser			2.9			
Razorbill			0.8			
Great Cormorant			4.8	4.8	x	x
Eurasian Wigeon			8.9			
Migrating birds						
Common Scoter				Complete barrier, population effect		
Velvet Scoter				Complete barrier, population effect		
Black Guillemot and other auks				Complete barrier, population effect		

*It must be noted, that resting places in marine habitats are not stable and linked to geographical sites. In fact, such sites are dependent on particular habitat features as for example sheltered bays. Thus, such resting sites can re-establish after construction of a tunnel e.g. in sheltered areas of the land reclamation sites. So it has to be noted, that these marine resting sites might not be unrecoverable destroyed or deteriorated.

12.5.3 Mitigation (CEF and FCS activities)

The strict protection obligations under Article 5 must be interpreted in terms of the overall aim of a favourable conservation status of the species. The aim of the assessment of strictly protected species is to provide a contribution to the formal assessments in Germany and Denmark which are organised in different steps of the application documents:

- In Denmark the assessment of strictly protected species is part of the EIA (VVM) and covers both main alternatives of the project, which are the immersed tunnel and the cable stayed bridge including all pressures during construction and operation.

- In Germany, the assessment of strictly protected species is associated with the landscape management plan (Landschaftspflegerischer Begleitplan) and only covers the preferred alternative, which is the immersed tunnel.

As the assessment of strictly protected species has to be carried out according to national law, no conclusion on the requirement of CEF (Continuous Ecological Functionality) and FCS (Favourable Conservation Status) activities can be given in the EIA. Therefore it has to be decided in the national assessments whether within national borders an offence of §44 BNatSchG or §1 "Bekendtgørelse om fredning af visse dyre- og plantearter mv., indfangning af og handel med vildt og pleje af tilskadekommet vildt" can be excluded or not. For those species for which an offence of these obligations cannot be excluded, specific mitigation activities have to be developed.

For the barrier effect of the bridge structure no CEF measures seem to be possible which could compensate for this impact. As a consequence, these effects will remain as an offence of Article 5 Birds Directive and thus, as an offence of national law as well.

13 MITIGATION

Mitigation is defined as actions taken to minimise or eliminate impacts on protected species during design, construction and/or operation of a fixed link. In the project design substantial measures have been taken to avoid impacts on birds, both for the tunnel and bridge alternatives, such as selection of visible, 2.5 m high wind screens reducing the collision risk of birds or cables designed with dimensions clearly visible to birds in order to reduce collision risk.

In addition to the mitigation measures already included in the planning and design of the project, it is recommended to reduce and control light emissions during construction activities as long as this is not in conflict with safety requirements. Light emissions may attract birds during bad weather conditions and consequently enhance collision risk, or act as a barrier during other situations, when birds would avoid intensively lit areas.

During operation of the bridge alternative, the recommendations with respect to light reductions are similar to the recommendations during construction.

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