Final Report

FEHMARNBELT FIXED LINK
BAT SERVICES

Fauna and Flora - Impact Assessment

Bats of the Fehmarnbelt Area

E3TR0017

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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).

SUMMARY

The present report assesses potential effects on bat migration related to construction, operation and structure of a fixed link structure between Rødby and Puttgarden based on the results of a study on bat migration (FEBI 2013) carried out by FEBI. The before mentioned study detected six bat species during the offshore investigations. Out of these three species (Soprano Pipistrelle *Pipistrellus pygmaeus*, Nathusius' Pipistrelle *Pipistrellus nathusii*, and Noctule *Nyctalus noctula*) were assessed to be relevant for the EIA of the fixed link.

Tunnel option
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 extremities of the immersed tunnel. The new dual carriageway and electrified twin track railway are to be constructed on Fehmarn for approximately 3.5 km south of the tunnel landfall, while they will extend for approximately 4.5 km north of the tunnel landfall at Lolland.

Bridge option
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.

Migratory bat sensitivity and project pressures
The following potential pressures induced by construction, operation and structure of a fixed link were inspected with regard to their impact on migrating Soprano Pipistrelles, Nathusius' Pipistrelles and Noctules during an initial screening (Chapter 6):

Construction

1. Disturbance (restricted working areas, equipment, facilities and physical structures of the fixed link incl. land approaches)
2. Collision with construction vessels
3. Barrier from construction vessels
4. Habitat change or loss at restricted working areas

Operation and structure

1. Barrier effects (only bridge)
2. Collision risk with structures

3. Habitat change (from footprint and at restricted working areas of the fixed link structures incl. land approaches and sea areas)

4. Traffic related collision risk

With the exception of the pressure 'Traffic related collision risk' (operation phase of tunnel and bridge alternative) the sensitivity of migrating bats to all other construction and operation related pressures was assessed to be minor. Therefore, the impacts of these pressures were not further described in detail. The pressure 'Traffic related collision risk' was assessed to be relevant for migrating bats, the sensitivity to this pressure was assessed to be medium. Thus, the impact assessment for this pressure was assessed in detail regarding the degree of impairment and severity of impairment.

Assessment of degree of impairment and severity of impairment
With the exception of the pressure 'Traffic related collision risk' (operation phase of tunnel and bridge alternative) the degree of impairment and severity of impairment of all other construction and operation related pressures were assessed to be minor for all migrating bat species. The pressure 'Traffic related collision risk' was assessed to result in a medium degree of impairment and thus a medium severity of impairment to both assessed migratory Pipistrelle species (Nathusius' Pipistrelle and Soprano Pipistrelle). For the tunnel alternative the illuminated tunnel entrances and ramp areas are relevant regarding this pressure. Regarding the bridge solution illuminated traffic space of ramp areas, approach bridges and the main bridge are affected by a medium degree of impairment and thus medium severity of impairment regarding the two Pipistrelle species. Thus, for the bridge alternative a larger area is predicted to be impaired by medium degree of impairment due to the pressure 'Traffic related collision risk' compared to the immersed tunnel alternative.

Traffic related collision risk was assessed to include a medium severity of impairment to migratory *Pipistrelle* species in the area of the illuminated tunnel entrances and ramps. However, regarding the bridge solution the collision risk in the area of the main bridge was assessed to include a minor severity of impairment, while illuminated traffic space in ramp areas, approach bridges and main bridge include a medium severity of impairment regarding *Pipistrelle* species.

Assessment of significance and conclusion
In a final step the significance of impact was assessed for both fixed link alternatives.

The impact assessment undertaken by FEBI concludes that any predicted impacts are insignificant at the local (Fehmarnbelt) and population level of migrating bats. For the tunnel solution, however, smaller areas are predicted to be affected by impairments regarding bat migration.

1 INTRODUCTION

1.1 Environmental theme

The theme of the present report is to assess to the impacts of a fixed link between Rødby and Puttgarden on bat migration. For this, potential effects on bats from the different possible solutions for a fixed link arising from construction, physical structures and operation of the link are assessed.

It is well known that bats from some European populations migrate between their summer and winter areas (Vauk 1974, Gerell 1987, Ahlén 1997, Skiba 2007). The present knowledge about bat species which are supposed to be migratory, their flyways, flight altitudes and flight distances is very limited. Although some species, such as the Nathusius' Pipistrelle and the Noctule have been studied for years no reliable flyways or population sizes could be examined. The current state of research lacks detailed information on migration corridors, flight altitudes during migration and total population sizes resulting in uncertainties when assessing impacts on bat migration.

Overall ten bat species have been detected in the area of investigation including both coastal and offshore investigation areas (Table 1.1). In total six species (Nathusius' Pipistrelle *Pipistrellus nathusii*, Soprano Pipistrelle *Pipistrellus pygmaeus*, Noctule *Nyctalus noctula,* Serotine *Eptesicus serotinus*, Common Pipistrelle *Pipistrellus pipistrellus* and Pond Bat *Myotis dasycneme* have been detected in the Fehmarnbelt during migration periods. The species composition during the migration phases is dominated by Nathusius' Pipistrelle, Soprano Pipistrelle and Noctule which are proven to conduct seasonal migration comparable to migratory birds. Some of them also breed in coastal areas.

The baseline report (FEBI 2013) states that bats do regularly occur in the Fehmarnbelt coastal areas and some species have been proven to migrate across the Fehmarnbelt. In particular during autumn bats were observed crossing the Fehmarnbelt. There are no indications that bats were using specific migration corridors, there are no records giving information about specific migration directions.. It is assumed that bats are crossing the Fehmarnbelt at broad front and that the alignment area of a planned fixed link does not play a special role in bat migration. The Fehmarnbelt has thus been considered to be of general importance to bat migration.

Table 1.1 Species abbreviations, protection status according to the EU Habitats Directive, offshore occurrence in the Fehmarnbelt and migration status according to Hutterer et al. (2005) of bat species recorded in the Fehmarnbelt during baseline investigations. LDM: Long-distance migrant; RM: regional migrant; NC: non-classifiable). Species listed in bold letters were assessed as being relevant for the EIA of a fixed link according to the baseline report (FEBI 2013).

Species	**Scientific name**	**Abbre-viation**	**Annex IV (FFH)**	**Annex II (FFH)**	**Offshore registration**	**Status**
Barbastelle	*Barbastella barbastellus*	Bbar	+	+	-	RM
Serotine	*Eptesicus serotinus*	Eser	+	-	+	RM
Noctule	*Nyctalus noctula*	Nnoc	+	-	+	LDM
Leisler´s Bat	*Nyctalus leisleri*	Nlei	+	-	-	LDM
Parti-coloured Bat	*Vespertilio murinus*	Vmur	+	-	-	LDM

Species	Scientific name	Abbre-viation	Annex IV (FFH)	Annex II (FFH)	Offshore registration	Status
Nathusius' Pipistrelle	*Pipistrellus nathusii*	Pnat	+	-	+	LDM
Common Pipistrelle	*Pipistrellus pipistrellus*	Ppip	+	-	+	RM
Soprano Pipistrelle	*Pipistrellus pygmaeus*	Ppyg	+	-	+	NC
Pond Bat	*Myotis dasycneme*	Mdas	+	+	+	RM
Daubenton's Bat	*Myotis daubentonii*	Mdau	+	-	-	RM

1.2 Environmental Components assessed

The FEBI baseline bat studies in coastal and marine areas obtained a total of ten different species among which three have been shown to migrate across Fehmarnbelt and thus are considered as relevant for the impact assessment. These are defined as the environmental components for the impact assessment (Table 1.2).

Table 1.2 Environmental Components assessed

Factor	Sub-factor	Components
Fauna and flora (including biodiversity)	Bat migration	Nathusius' Pipistrelle Soprano Pipistrelle Noctule

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).

2 THE FEHMARNBELT FIXED LINK PROJECT

The Fehmarnbelt Fixed Link between Germany and Denmark is planned to comprise of a four-lane motorway and a double-track electrified railway. The link will run from Rødbyhavn on the Danish side of the Fehmarnbelt to Puttgarden on the island of Fehmarn on the German side over a distance of about 19 km. The three main scenarios being considered for the fixed link are:

- • A cable-stayed bridge
- • An immersed tunnel
- • A zero alternative (do nothing)

2.1 Relevant Project pressures

The present report describes the pressures and the assessment of the potential effects on migratory bats from the different possible solutions for a fixed link during construction, pressures caused by the permanent physical structures, and the pressures due to the operation of the link.

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

- Restricted working areas, equipment, facilities and physical structures of the fixed link structures incl. land approaches and sea areas may disturb bats*.
- Collision with construction vessels
- Barrier from construction vessels
- Habitat change at tunnel entrances/land approaches

* Noise excluded because no passive listening species were detected during survey.

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

- Barrier effects (only bridge)
- Collision risk with structures
- Habitat loss and/or change

*Habitat loss excluded because irrelevant for migrating bats since no roosts were found during the survey.

Environmental pressures related to the operation of the fixed link:

- Traffic related collision risk

3 DATA AND METHODS

3.1 Area of investigation

The area of investigation for the bat studies covers the coastal areas of Fehmarn and Lolland and the Fehmarnbelt (Figure 3.1). The demarcation of the area of investigation ensures that all relevant Natura 2000 sites and adjacent areas are covered.

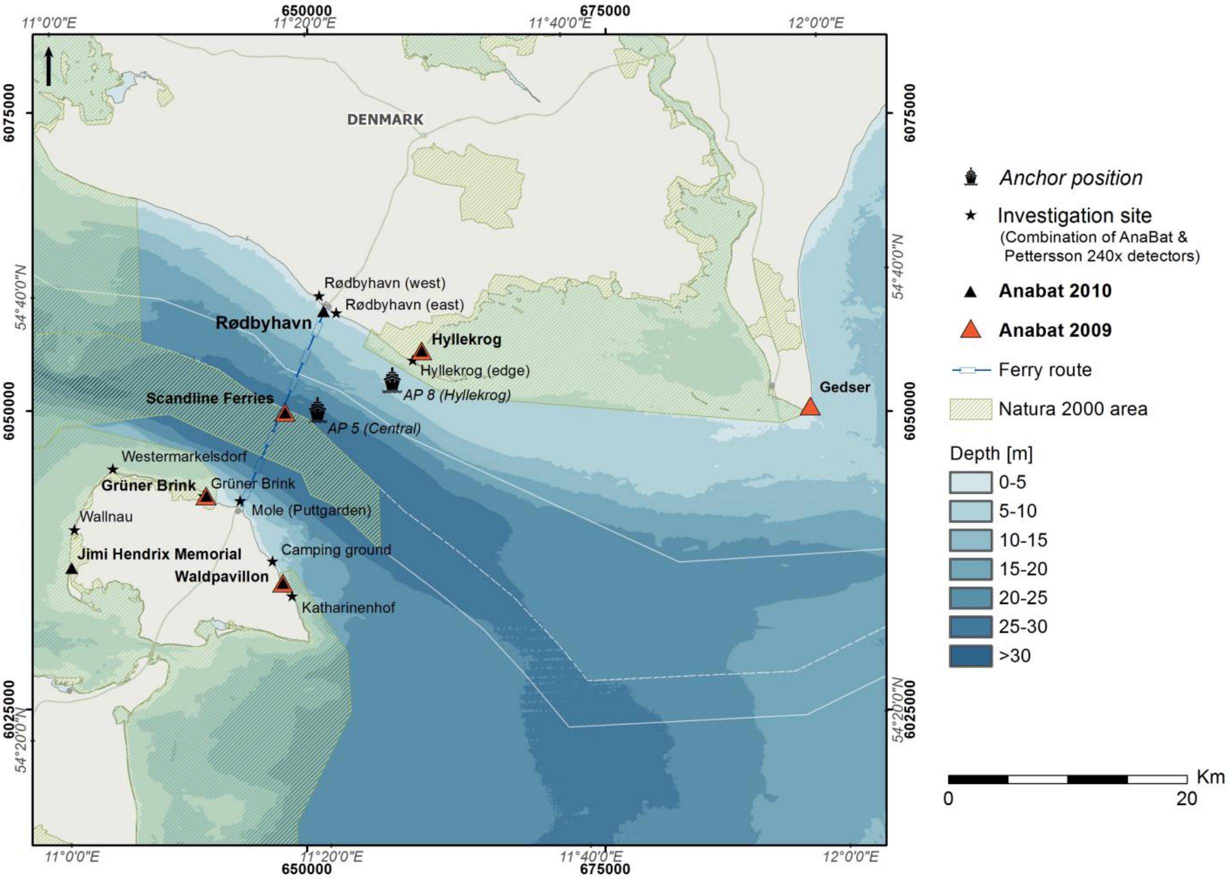

Figure 3.1 Area of investigation.

3.2 Content of the investigations and methodological approach

The scope of investigations during autumn 2009 and the year 2010 was to examine which bat species, if any, use the Fehmarnbelt for spring and/or autumn migration and to which extent they use it (FEBI 2013). Furthermore, flight patterns, seasonal variation in occurrence and intensity of migration were examined at different locations along the Fehmarn and Lolland coasts and offshore during the studies.

The baseline provides detailed information on activity, distribution and habitat use of bats in the study area, as well as description of the current state of research concerning bat migration and bats' flight patterns during migration at the location of the Fehmarn link. Different investigation methods were developed and tested in coastal and offshore areas of the Fehmarnbelt during the autumn migration period in 2009 (August 13 – October 19, 2009) in the Fehmarnbelt area. The survey was continued in 2010 covering the period from spring to autumn (April 1 – November

1, 2010). Up to now no international standard for bat studies in offshore areas exists and only few studies have been conducted in offshore areas of the Baltic Sea.

The baseline investigations focused on the following items:

- Activity, distribution and patterns of bats in the offshore areas and the surroundings on Fehmarn and Lolland
- Local flight patterns of bats
- Migration of bats

Overall, the baseline investigations about bats included the following:

- Quantitative survey of activity with analysing, distribution and seasonal variation in observed activity over the year
- Survey of migratory behaviour of bats by visual and detector observations

3.3 Marine area/Fehmarnbelt

The Fehmarnbelt (and the Belt Sea) is seen as part of the transition area between Scandinavia and Europe, which is also passed by migrating bats. A wide range of shallow marine and freshwater habitats provide suitable habitats with rich food supply for insectivorous bats. The activity of bats is clustered within areas of vertical structures, such as hedgerows and wood patches. In the Fehmarnbelt bat migration activity was observed during spring and autumn, with species such as Soprano Pipistrelle (*Pipistrellus pygmaeus*), Nathusius´ Pipistrelle (*Pipistrellus nathusii*) and Noctules` (*Nyctalus noctula*) being the most common species in the area. These species were regularly detected during the offshore surveys. The Fehmarnbelt area is less important for non- migrating species like Brown long-eared Bat (*Plecotus auritus*) or several *Myotis*-species. No nationally or internationally important colonies or roosts of bats were recorded in the investigation area.

3.4 Impact 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 below) has been prepared. The methodology is defined by the impact forecast methods described in the scoping report (Femern 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 bats and relatively stationary marine bottom fauna are not identical). The necessary modifications are explained in chapter 3.5. The specification of methods and tools used in the present report are given in the following sections of this chapter.

3.4.1 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
Environmental 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-factor: 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 a 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	Betriebsphase
Permanent	Pressure and impacts lasting for the life time of the Project (until decommissioning).	Permanent	Permanent
Provisional (temporary)	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	Wirkfaktoren
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	Wirkintensität

Term	*Explanation*	*Term DK*	*Term DE*
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.	Arealinddragelse	Flächeninanspruch 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.	Følsomhed/ Sårbarhed	Empfindlichkeit
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	Flächenverlust
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 Auswirkungen bei Flächenverlust
Impairment	An impairment is a change in the function of an environmental factor.	Forringelse	Funktionsbe-einträchtigung
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/grad af forringelser	Schwere der Funktionsbe-einträchtigung
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.	Virkningens væsentlighed	Erheblichkeit
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.

3.4.2 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 3.2 - Figure 3.4. 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.

3.4.3 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 3.1 and Table 3.2, respectively.

Table 3.1 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 3.2 (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 Chapter 3.

Table 3.2 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 3.3.

Table 3.3 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**

3.4.4 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 Chapter 3 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, 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.

3.4.5 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).

3.4.6 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 3.2.4). 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.

3.4.7 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.

3.4.8 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 3.2. 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 3.1).

The loss is estimated as hectares of lost area. As far as possible the spatial distribution of the importance classes is shown on maps.

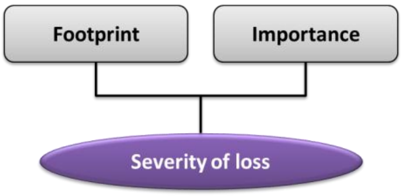

Figure 3.2 The assessment scheme for severity of loss

3.4.9 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 (Figure 3.3). 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.

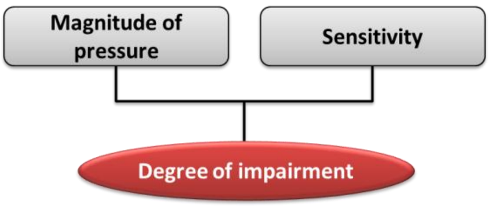

Figure 3.3 The assessment scheme for degree of impairment

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.

3.4.10 Severity of Impairment

Severity of impairment is assessed from the grading's of degree of impairment and of importance of the environmental factor (Figure 3.4) using the matrix in Table 3.3. If it is not possible to grade degree of impairment and/or importance an assessment is given based on expert judgment.

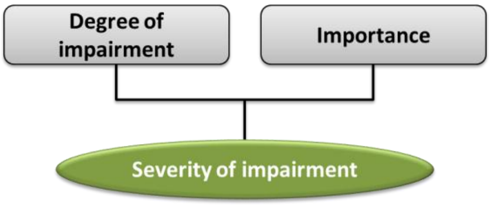

Figure 3.4 The assessment scheme for severity of impairment

In the UVS and the VVM, the results of the assessment of severity of impairment support the significance assessment. The UVS and VVM do not present the results as such.

3.4.11 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 3.5. In addition the size of the impacted areas located in the German national waters and the German EEZ zone, respectively, as well as in the Danish national plus EEZ waters (no differentiation) are calculated. If relevant the area of transboundary impacts are also estimated.

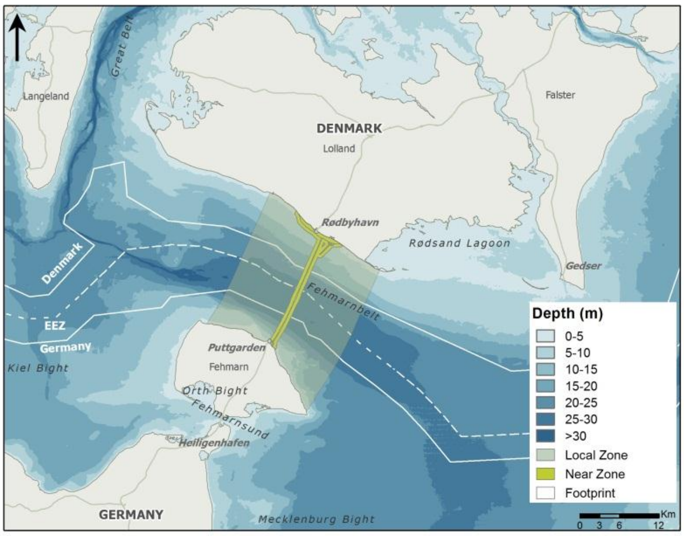

Figure 3.5 The assessment zones applied for description of the spatial distribution of the impacts. The near zone illustrated is valid for the tunnel alternative. It comprises the footprint and a surrounding 500 m band. The local zone is identical for the two alternatives. The eastern and western borders are approximately 10 km from the centre of the alignment.

3.4.12 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 3.4 as a framework.

Table 3.4 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

It should be noted that in the background reports, the construction phase has been indicated by exact years (very late 2014-2020 (tunnel) and early 2014-2020 (bridge). As the results are generic and not dependent on the periodization of the construction phase, the years are in the VVM and the UVS indicated as calendar year 0, year 1, etc. This means that the construction of the tunnel starts in Year 0 (only some initial activities) and the bridge construction commence in year 1.

3.4.13 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.

3.4.14 Comparison of environmental impacts from project alternatives

Femern A/S will prepare a final recommendation of the project alternative, which from a technical, financial and environmental point of view can meet the goal of a Fehmarnbelt Fixed Link from Denmark to Germany. As an important input to the background for this recommendation, the consortia have been requested to compare the two alternatives, immersed tunnel and cable-stayed bridge, with the aim to identify the alternative having the least environmental impacts on the environment. The bored tunnel alternative is discussed in a separate report. In order to make the comparison as uniform as possible the ranking is done using a ranking system comprising the ranks: 0 meaning that it is not possible to rank the alternatives, + meaning that the alternative compared to the other alternative has a minor environmental advantage and ++ meaning that the alternative has a noticeable advantage. The ranking is made for the environmental factor or sub-factor included in the individual report (e.g. for the marine area: hydrography, benthic fauna, birds, etc.). To support the overall assessment similar analyses are sometimes made for individual pressures or components/subcomponents. It should be noticed that the ranking addresses only the differences/similarities between the two alternatives and not the degree of impacts.

3.4.15 Cumulative impacts

The aim of the assessment of cumulative impacts is to evaluate the extent of the environmental impact of the project in terms of intensity and geographic extent compared with the other projects in the area and the vulnerability of the area. The assessment of the cumulative conditions does not only take into account existing conditions, but also land use and activities associated with existing utilized and unutilized permits or approved plans for projects in the pipe.

When more projects within the same region affect the same environmental conditions at the same time, they are defined to have cumulative impacts. A project is relevant to include, if the project meets one or more of the following requirements:

- The project and its impacts are within the same geographical area as the fixed link
- The project affects some of the same or related environmental conditions as the fixed link
- The project results in new environmental impacts during the period from the environmental baseline studies for the fixed link were completed, which thus not is included in the baseline description
- The project has permanent impacts in its operation phase interfering with impacts from the fixed link

Based on the criteria above 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	Present Phase	Possible interactions
Arkona-Becken Südost	North East of Rügen	Construction	Sediment spill, habitat displacement, collision risk, barrier effect
EnBW Windpark Baltic 2	South east off Kriegers Flak	Construction	Sediment spill, habitat displacement, collision risk, , barrier effect
Wikinger	North East of Rügen	Construction	Sediment spill, habitat displacement, collision risk, , barrier effect
Kriegers Flak II	Krieger's Flak	Construction	Sediment spill, habitat displacement, collision risk, barrier effect
GEOFReE	Lübeck Bay	Construction	Sediment spill, habitat displacement, collision risk
Rødsand II	In front of Lolland's southern coast	Operation	Coastal morphology, collision risk, barrier risk

Rødsand II is included, as this project went into operation while the baseline investigations for the Fixed Link were conducted, for which reason in principle a cumulative impact cannot be excluded.

On land, the following projects are considered relevant to include:

Project	Placement	Phase	Possible cumulative impact
Extension of railway	Orehoved to Holeby	Construction	Area loss, noise and dust
		Operation	Landscape, barrier effect
Construction of emergency lane	Guldborgsund to Rødbyhavn	Construction	Area loss, noise and dust
		Operation	Landscape, barrier effect
Extension of railway	Puttgarden to Lübeck	Construction	Area loss, noise and dust
		Operation	Landscape, barrier effect
Upgrading of road to highway	Oldenburg to Puttgarden	Construction	Area loss, noise and dust
		Operation	Landscape, barrier effect

The increased traffic and resultant environmental impacts are taken into account for the environmental assessment of the fixed link in the operational phase and is thus not included in the cumulative impacts. In the event that one or more of the included projects are delayed, the environmental impact will be less than the environmental assessment shows.

For each environmental subject it has been considered if cumulative impact with the projects above is relevant.

3.4.16 Impacts related to climate change

The following themes are addressed in the EIA for the fixed link across Fehmarnbelt:

- Assessment of the project impact on the climate, defined with the emission of greenhouse gasses (GHG) during construction and operation
- Assessment of expected climate change impact on the project
- Assessment of the expected climate changes impact on the baseline conditions
- Assessment of cumulative effect between expected climate changes and possible project impacts on the environment
- Assessment of climate change impacts on nature which have to be compensated and on the compensated nature.

Changes in the global climate can be driven by natural variability and as a response to anthropogenic forcing. The most important anthropogenic force is proposed to be the emission of greenhouse gases, and hence an increasing of the concentration of greenhouse gases in the atmosphere.

Even though the lack of regulations on this issue has made the process of incorporating the climate change into the EIA difficult, Femern A/S has defined the following framework for assessment of importance of climate change to the environmental assessments made:

- The importance of climate change is considered in relation to possible impacts caused by the permanent physical structures and by the operation of the fixed link.

- The assessment of project related impacts on the marine hydrodynamics, including the water flow through the Fehmarnbelt and thus the water exchange of the Baltic Sea, is based on numerical model simulations, for baseline and the project case, combined with general model results for the Baltic Sea and climate change.

- Possible consequences of climate change for water birds are analysed through climatic niche models. A large-scale statistical modelling approach is applied using available data on the climatic and environmental factors determining the non-breeding distributions at sea of the relevant waterbirds in Northern European waters.

- The possible implications of climate change for marine benthic flora and fauna, fish, marine mammals, terrestrial and freshwater flora and fauna, coastal morphology and surface and ground water are addressed in a more qualitative manner based on literature and the outcome of the hydrodynamic and ecological modelling.

- Concerning human beings, soil (apart from coastal morphology), air, landscape, material assets and the cultural heritage, the implications of climate changes for the project related impacts are considered less relevant and are therefore not specifically addressed in the EIA.

The specific issues have been addressed in the relevant background reports.

3.4.17 How to handle mitigation and compensation issues

A significant part of the purpose of an EIA is to optimize the environmental aspects of the project applied for, within the legal, technical and economic framework. The optimization occurs even before the environmental assessment has been finalized and the project, which forms the basis for the present environmental assessment, is improved environmentally compared to the original design. The environmental impacts, which are assessed in the final environmental assessment, are therefore the residual environmental impacts that have already been substantially reduced.

Similarly, a statement of the compensation measures that will be needed to compensate for the loss and degradation of nature that cannot be averted shall be prepared. Compensating measures shall not be described in the impact assessment of the individual components and are therefore not treated in the background reports, but will be clarified in the Danish EIA and the German LBP (Landschaftspflegerischer Begleitplan), respectively.

In the background reports, the most important remediation measures which are included in the final project and are of relevance to the assessed subject are mentioned. In addition additional proposals that are simple to implement are presented.

3.5 Assessment methodology for bats

The impact assessment has been conducted based on literature, other projects and mainly on expert judgement. A four scale assessment matrix is not appropriate for the assessment of bats because the knowledge gaps concerning bat migration and lack of assessment standards do not allow for a detailed categorisation. By analysing the pressures and the expected impacts depending on the single species the assessment presents detailed descriptions of the possible impairments concerning bat migration. Wherever possible, statements are backed up by literature or information from other projects.

3.5.1 Importance

The importance of the Fehmarnbelt area has been determined on the species level by accounting for the detected offshore activity of a species in the area (offshore surveys from Scandlines ferries and radar vessel) and the conservation status of the species (all bats are listed in Annex IV of EU Habitat Directive). Species detected less than five times during the offshore surveys are not considered.

A four scale assessment matrix regarding the importance of the Fehmarnbelt to bat migration was not appropriate, because present knowledge about the species is lacking basic information about the species, such as population sizes and migration patterns. There are no assessment standards established for bats, thus it was decided to only apply a two-scale assessment of special and general importance for these (FEBI 2013).

Due to the high conservation status of bat species and uncertainties about numerical abundance and species' population parameters all commonly in offshore areas detected bat species were assessed to be of general importance to the area. However, most bat species only were only rarely detected in the offshore areas of the Fehmarnbelt. For the three most common species (Nathusius´ Pipistrelle, Soprano Pipistrelle and Noctule) with comparably high observed activity in the offshore areas the importance was assessed as general. Due to their more common activity offshore these species were assessed as relevant species for the EIA, though the observed activity still was assessed as general with no special importance of the area to the species. Due to the rare records of other species (Serotine, Common Pipistrelle and Pond Bat) these species were assessed to not being relevant for the impact assessment of a fixed link in the marine areas and therefore not considered further.

3.5.2 Assessment of magnitude of pressures

The magnitude of pressure is inferred from 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 bat 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. Thus, the sensitivity (the qualitative response) to a given pressure is used to identify if a species may be subject to relevant impacts from a pressure and thus require a detailed assessment. For example the pressure barrier effect of a structure is only determined by the species response to a structure and the magnitude of pressure cannot be described independently. Therefore, the magnitude of pressure and sensitivity are incorporated separately in the EIA for bats: the magnitude of pressure for bats is defined solely as a (quantitative) technical description of a pressure without incorporating the response of a species in the description.

3.5.3 Sensitivity

For the assessment of the environmental sub-factor 'migrating bats' the assessment is made on a species level (environmental component). The sensitivity (the qualitative response) to a given pressure has been used in an initial assessment step to identify which pressures may be subject to relevant impacts to migrating bats requiring a detailed assessment. The sensitivity of a species is also reflected in the degree of impairment and takes the range and duration of a pressure into account.

It has to be mentioned that in most cases the assessment is based on expert judgements and presents the expected behaviour schemes of bats. Guidelines, literature and experiences with comparable projects are considered in the assessment.

The following guidelines were predominantly used during the sensitivity analyses to assess the sensitivity of the relevant bat species:

- FÖA Landschaftsplanung (2009). Leitfaden Fledermausschutz. Draft 10/2010. Project report for FE 02.0256/2004/LR des Bundesministeriums für Verkehr, Bau und Stadtentwicklung „Quantifizierung und Bewältigung verkehrsbedingter Trennwirkungen auf Fledermauspopulationen als Arten des Anhangs der FFH-Richtlinie". Trier/Bonn

- Landesbetrieb Straßenbau und Verkehr Schleswig-Holstein (LBV) (2011). Fledermäuse und Straßenbau – Arbeitshilfe zur Beachtung der artenschutzrechtlichen Belange bei Straßenbauvorhaben in Schleswig-Holstein. Kiel. 63 pp.

3.5.4 *Degree of impairment*

The degree of impairment (the suspected impairment of bats within the impairment zone getting impaired by a pressure) is directly assessed by available information of a species response (sensitivity) to a pressure. The different levels of degree of impairment are defined separately for the different pressure types (Table 3.5). In general a very high degree of impairment corresponds to a loss of function of the impairment zone for an environmental component.

Table 3.5 Criteria for assessing the degree of impairment affecting the environmental components ' 'migrating bats' 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 Construction vessels/ Link structure	Very high	Barrier is complete concerning bat migration. There are no alternative flight routes.
	High	Barrier is not complete, but migratory bats are supposed show strong additional reactions when approaching the barrier, e.g. modification of migration routes.
	Medium	Barrier results in additional reactions, but will be crossed anyway.
	Minor	Minor barrier effect expected; migratory bats show minor reactions and fly above or below the structure.
Collision risk Link structure/ Traffic	Very high	A high proportion of migratory bats collide with the structure / traffic on a regular basis.
	High	A small proportion of bats migrating through collide with the structure or traffic on a regular basis.
	Medium	Collisions are unlikely, but in some areas higher proportions of migratory bats are expected to collide with the structure or traffic.
	Minor	Collisions between migrating bats and link structure or traffic are unlikely. Only single bats collide with the link structure or traffic.

Construction-, structure- or operation-related pressures of the project	Degree of impairment	Description of the degree of impairment
Disturbance Construction phase	Very high	Very high proportions of migratory bats are expected to get displaced from the impairment zone.
	High	High proportions of migratory bats get displaced from the impairment zone.
	Medium	Medium proportions of migratory bats get displaced from the impairment zone.
	Minor	Disturbance does not lead to a detectable displacement of migratory bats.
Habitat change	Very high	Habitat changes result in a very high reduction of migratory bat activity within the impairment zone.
	High	Habitat changes result in a high reduction of migratory bat activity within the impairment zone.
	Medium	Habitat changes result in a medium reduction of bat activity in the impairment zone.
	Minor	Habitat changes will not result in a detectable reduction of activity of migratory bats.

3.5.5 *Severity of impact*

The severity of impairment is assessed by combining the degree of impairment with the importance of a species (Table 3.6). This is done based on the importance of the estimated proportion of bats of a species in relation to the affected area impaired by a pressure. A quantitative approach is not possible due to insufficient knowledge concerning the total population sizes and because it is only possible to deal with bat activity and it is not possible to calculate bat abundances.

Table 3.6 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 or the importance level of the estimated proportion of bats in relation to the affected area impaired by the pressure collision risk (in a qualitative assessment).

	Importance level	
Degree of impairment	**Special**	**General**
Very high (loss of function)	Very High	Medium
High	High	Medium
Medium	Medium	Medium
Minor	Minor	Minor

For the pressure collision risk a qualitative estimation of severity of impairment has been carried out. Here, the severity of impairment is defined to correspond with the importance of the estimated proportion of bats predicted to get removed from the impairment zone due to mortality. The importance level is assessed for each species according to the bat activity and conservation status following the method described above.

3.5.6 Assessment of significance

Assessment of significance[1]: As an overall conclusion in a final step the significance is assessed based on expert judgement. The objective of this step is to give an evaluation of the overall impact on the ecosystem – if pressures from the Project pose an overall risk to the ecosystem.

3.5.7 Assessment of strictly protected species

Article 12 of the Council Directive 92/43/EEC 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.

1. 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.

2. 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.

Member states are further requested to establish a system to monitor the deliberate capture or killing of species listed in Annex IV (a) and to make sure that this will not impair the conservation status of these species. The demands from 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 is provided by the EU[2]. 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, as well as a special guideline on bats and road construction (LBV 2011).

Approach and methodology of the assessment

The strict protection obligations under Article 12 must be interpreted in terms of the overall aim of the Directive described in Article 2, to which they contribute. The aim of the assessment of strictly protected species as part of the level 2 EIA 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 specially protected species is part of the EIA (VVM) and will cover both main alternatives of the project, which are the

[1] Femern, Sund & Bælt: "EIA for the Fehmarnbelt Fixed Link: Assessment method and assessment criteria. Working Paper, Volume 1. June 24th, 2011.

[2] (http://ec.europa.eu/environment/nature/conservation/species/guidance/index_en.htm)

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 will only cover 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 migrating bats. All bat species are listed in annex IV of the directive and shall thus be treated in the assessment of strictly protected species.

As part of the Environmental Impact Assessment for a fixed link across Fehmarnbelt, it needs to be assessed whether any pressure, or the sum of all pressures of the project, might lead to a violation of the demands from the Habitats Directive, especially regarding the clauses under Paragraph 1, Article 12.

The pressures, which might be relevant for the assessment, are described in Chapter 2.1. Due to the lack of structures, migrating bats do not use any breeding or resting places in the marine areas of the Fehmarnbelt. The assessment is thus carried out in relation to the first two objectives of Article 12.1 (deliberate capture or killing and deliberate disturbance) but the third objective (deterioration or destruction of breeding sites or resting places) is not assessed separately. A potential barrier of a bridge would be regarded as disturbance in this assessment.

1. Deliberate capture or killing of specimens

Deliberate killing is not restricted to intentional killing of individuals, for example, by hunting: 'Article 12(1)(a) prohibits all forms of deliberate capture or killing of specimens of Annex IV(a) species in the wild. 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 12. Although Article 12 is directed towards the conservation of species and populations, the prohibition of deliberate killing refers to the individuals of strictly protected 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 12 is stated if a project increases the risk of mortality of a protected species above normal risk levels (LBV 2009). Single collisions with cars are regarded as normal risk levels, whereas a systematic increase in collision risk by constructing roads, power line or wind farms in important migration corridors might be assessed as significantly increasing the risk of mortality. 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 2011)

2. Deliberate disturbance, particularly during the period of breeding, rearing, hibernation and migration

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 12 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 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. There is no definition of a local population which can be applied to migratory bats in the context of the planned fixed link across Fehmarnbelt. The biological definition of populations is not applicable and the term 'local population' refers to management units based on distinct centres of a distribution of a species and is mostly applicable to breeding or specific resting areas. In the practice, when carrying out impact assessments, local population 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 migratory bats for both countries as the project of a fixed link should, in any case, be assessed as one unit.

4 ASSESSMENT OF 0-ALTERNATIVE

The Zero-Alternative describes the future situation without the establishment of a fixed link. The FEBI baseline study was carried out from autumn 2009 to late 2010. The relatively short time-span from the baseline study to the construction phase allows for using the baseline as Zero Alternative for the construction phase. Exceptions would e.g. be if a new NATURA 2000 area is appointed. However, at the time of writing no appointment of new NATURA 2000 areas have been identified.

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

Year 2030 is chosen as a reference year for operation in order to carry out the assessment, when not only 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 opening to the assessment year.

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 can 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.

Impact from climate change is not considered in the Zero-Alternative. Impacts from climate change are dealt with in a separate chapter 5.

4.1.1 Identification of changes

For a change to be included in the Zero- Alternative, the following preconditions must be met. The change is:

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 Zero-Alternative. As a result, the following issues have been included:

- Development of landscape, nature, habitats and species.
- Changes due to new regulation
- Current spatial planning
- Forecasts on traffic intensity and demography

4.1.2 Development of landscape, nature, habitats and species

In the baseline the following major human activities in the Fehmarnbelt that could lead to pressures affecting landscape, nature, habitats and thereby migratory bat species in the Fehmarnbelt and which may influence the year 2025 to 2030 Zero-Solution:

- Establishment of new offshore wind farms.

At the time of writing plans for the establishment of offshore wind farms in the Fehmarnbelt area have been identified, including Beltsee (Consent application submitted), Fairwind (Concept/Early planning), Beta Baltic (Consent application submitted) and GEOFReE (Consent Authorised). Of the proposed projects only one (Fairwind) is situated in the study area. However, the possible changes of the planned offshore wind farms are not considered to change the baseline conditions and thereby the results of the EIA significantly.

4.1.3 Changes due to implementation of new regulation

Changes that are predicted to occur e.g. due to implementation of new international legislation etc. 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 regulation are not included in the Zero-Alternative, because it is not known if the proposals will get adopted and realised.

4.1.4 Current spatial planning

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

4.1.5 Forecasts on traffic intensity and demography

With respect to ferries, the forecast of road traffic predicts a 60% increase in traffic in 2025, if no link is constructed. 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 (Femern A/S memo on traffic forecast prediction). With respect to ships, the yearly number of ships in different sizes passing Fehmarnbelt in 2018 has been forecasted to increase by 25%. The increase until 2025/2030 is estimated to about 50%. The impact on migratory bats from disturbance of ships is considered to be minor, and is not considered to influence the EIA significantly.

5 ASSESSMENT OF CLIMATE CHANGE

Current state of research does not provide information on response of migrating bat species to climate change.

Popa-Lisseanu & Voigt (2009) hypothesise that migratory bat species would react comparably to migratory bird species. Furthermore, recent studies on migratory birds show changes in "timing and speed of migration, number of successful broods, proportion of residents and migrants of a species, and even overall patterns in species richness and composition of communities" (Marra et al. 2005; Hedenström et al. 2007; Lemoine et al. 2007; Rivalan et al. 2007) quoted in (Popa-Lisseanu & Voigt 2009).

Meinig (2010) interprets current findings for some bat species in Middle Europe but none of the detected species in the Fehmarnbelt was described. In general Meinig (2010) describes problematic effects like higher temperatures in hibernation roost, lower reproduction rate and higher interspecies competition concerning food resources and roosts caused by climate change.

Rebelo et al. (2010) predict changes in distribution regarding Noctule as a boreal species and Nathusius´ Pipistrelle as a species of the temperate zone. However, Rebelo et al. (2010) do not describe whether migration patterns of bats will be influenced by climate change.

Finally, a detailed prospect of changes due to climate change concerning bat migration is not possible based on current state of knowledge.

6 SENSITIVITY ANALYSIS

The response to a given pressure differs between species and wherever possible the impact assessment is based on species-specific information. In this chapter, the sensitivity of the selected species to different pressures is assessed. The sensitivity describes the response of a species to the intensity or magnitude of a pressure, generating general dose-response relationships. If a species shows a strong response to a given pressure it is ranked to be more sensitive than a species showing a lower response. If information on a species response is not available, the sensitivity is subject to expert judgement. The assessment of sensitivity is either based on qualitative information of a species response to a given pressure or on the degree of specialisation of a species on a resource which might be affected by a pressure of the project. For example, species which are flying close to the water surface are assessed not to be sensitive to collisions with the structure of the bridge alternative.

Species expected not being sensitive to a pressure are assessed to be not relevant for the EIA and are therefore not considered further.

Assessing the impacts of a cable-stayed bridge to bat migration is difficult, because there are only a few bat migration studies in Europe available which deal with netting (Petersons 1990, 2004) or detector surveys (e.g. Bach et al. 2009, Furmankiewicz 2009, Ciechanowski et al. 2010), especially on sea (Ahlén et al. 2009, Hüppop 2009), but none with regard to a comparable bridge structure.

6.1 Main pressures during construction (temporary):

6.1.1 Disturbance

It is supposed that the most predictable response towards construction activities will be that light emission during construction phase might attract insects which result in a benefit for foraging bats. All of the regarded species are known to hunt in the surroundings of street lamps as described by Baagøe & Rydell (1996) and Dietz et al. (2007) implying that light emissions do not have a negative impact on the bat species of concern. Furthermore, a guidance paper edited by FÖA Landschaftsplanung (2009) also describes that the detected species are not sensitive to light emission. Though, L. Bach (pers. comm.) describes the Nathusius' Pipistrelle to avoid illuminated areas. Ahlén et al. (2009) describe that migrating bats forage over sea in areas with sources of insects giving evidence that bats might also hunt in the surroundings of onshore/offshore working areas during migration flights. Furthermore, the species of concern are described not being sensitive to noise emission (FÖA Landschaftsplanung 2009, LBV 2011). Since Nicholls & Racy (2009) proofed that rotating marine radars do not reduce bat activity no impairments are supposed to arise from radars on service vessels.

To conclude, the sensitivity to this pressure is assessed to be minor and no 'disturbance' from the restricted working areas is expected.

This pressure will not be considered further.

6.1.2 Barrier from construction vessels

The fact that all of the regarded species are known to hunt in the surroundings of street lamps described by Baagøe & Rydell (1996), Dietz et al. (2007) or other illuminated structures implies that light emission does not have a negative impact on bat behaviour (FÖA Landschaftsplanung 2009) and will not cause a barrier effect. Ahlén et al (1997) as well as the baseline study (FEBI 2013) showed that bats hunt around vessels. Additionally, at sea and at the coastlines there are ample possibilities for bats to pass a potential barrier caused by construction vessels. Due to the echolocation bats have the opportunity to avoid obstacles (Bat Conservation Trust 2008) like construction vessels in horizontal and vertical axis by flying over or aside the vessels. Also, the Fehmarnbelt area is already highly frequented by ferry and cargo shipping, thus the additional traffic by construction vessels would only slightly increase shipping intensity in the area.

To conclude, the sensitivity to this pressure is assessed to be minor and therefore will not be considered further.

6.1.3 Collision with construction vessels

Current literature does not indicate a collision risk for bats with vessels. Bats in offshore areas were observed using echolocation (Ahlén et al. 2009, FEBI 2013), thus it is expected that bats are able to detect obstacles such as stationary or slowly moving construction vessels and therefore would avoid collisions.

The sensitivity to this pressure is assessed to be minor and therefore will not be considered further.

6.1.4 Habitat change

The habitat change due to the working areas, land approaches of bridge or tunnel entrances depends on the present habitat characteristics, functionality with regard to bats and the intensity (dimension) of change and duration. The worst possible impacts arise when important hunting habitats, flyways or existing frequently used roosts of migratory bats would be impaired. However, with respect to bat migration, habitat change is generally of low relevance because the area is used for transition. Additionally the baseline investigations indicated that bat migration occurs in a broad front (FEBI 2013) which implies that only a small proportion of the bats migrating across the Fehmarnbelt area may be affected. The largest part of the planning area consists of water surface and is of minor importance for migratory bats. Observations of hunting activity are scarce and only single bats were observed hunting in the offshore areas indicating the minor importance of the offshore areas regarding hunting activity. The affected onshore/coastal areas at Rødby and Puttgarden do not include important habitats or roosts of migratory bats (COWI 2011, Leguan 2011), therefore habitat loss though the coastlines are expected to function as guideline features which bats would follow during migration.

To conclude, the sensitivity to this pressure is assessed to be minor and therefore will not be considered further.

6.1.5 Conclusion

The sensitivity analysis has shown that all potential pressures arising during the construction phase could be identified to not result in any relevant impairment for migratory bats. Therefore these pressures will not be further discussed in the impact assessment.

6.2 Potential effects induced by the presence of the (permanent) physical structures and operation of the fixed link

Observations of bats hunting around off-shore wind turbines in Kalmarsund (Ahlén et al. 2009) and the fact that bats were observed as regularly colliding with on-shore wind turbines lead to the suggestion that migrating bats that cross large open waters could get in conflict with off-shore wind farms (Bach & Rahmel 2007,Ahlén et al. 2009). Until now only anecdotal reports exist of bat behaviour along large bridges crossing open waters. From land it is known that bats can roost in large numbers in bridge structures (AGFH 1994, Keeley & Tuttle 1999).

Roads and bridges can affect bats in different ways: collision with traffic or structure, loss of hunting habitat, interruption of flight routes (Richards 2000, Bach et al. 2004, Lesinski 2007, 2008, Brinkmann et al. 2008, Gaisler et al. 2009, Medinas 2010). With regard to species protection and the Habitats- Directive collision is the most important factor.

6.2.1 *Barrier effects*

Since the main part of the tunnel will be immersed in the ground and thus out of the range of bats, no barrier effects are predicted to occur. The tunnel entrances and portals are not expected to cause a barrier effect regarding bat migration.

A barrier effect from a structure – in this case the structure of a bridge – would occur if bats either do not cross the structure at all, less frequently or do show reactions to the structure, including a change in flight direction or flight altitude. Reactions due to a barrier effect result in additional energy expenditures for detour flights, if bats cross the structure by altering their flight route. For bat species which would be very sensitive to obstacles in the flight area a structure would potentially result in a reduced connectivity between areas or even in a complete exclusion of bats from areas beyond the structure if the barrier would not be crossed at all.

During operation the structure of a bridge, the carriageways and railways will be partly illuminated. Additionally, the cars and trains that pass the bridge at night will emit light.

Baagøe & Rydell (1996) describe that light emissions from streetlamps attract insects which results in a food resource for bats. High abundances of insects might occur in the areas of illuminated land approaches or illuminated tunnel entrances and could not be excluded for illuminated parts of main bridge. Also, the bats' hunting activity might increase in areas of permanent light emission (Baagøe & Rydell 1996) which will finally result in an elevated collision risk of bats with traffic. Attraction of bats from illuminated structures in the areas of land approaches or tunnel entrances, and the main part of the bridge in offshore areas are expected.

Current literature does not provide any indication that migratory bats might perceive a bridge structure as a barrier or perform directional changes during their flight. Furthermore, common literature explains that bats are known to follow linear landscape features like hedges or alleys (Ahlén 1997, Bach et al. 2005, Bach & Limpens 2008, Bach & Rahmel 2008, Furmankiewicz & Kucharska 2009). Bats might perceive the structure of a bridge as a linear landscape feature. Since the bridge is directed into the main migration direction (NE/SW) it might be used by bats as a guidance structure over the Baltic Sea during migration (Hutterer et al. 2005). Chistiakov (2011) observed migration streams of Noctules and Nathusius' Pipistrelles following an artificial levee in the Finish gulf showing that bats use man-made structures as linear landscape features during migration. The same was observed at the 'Afsluitdijk' (closure dike) at Lake Ijssel (The Netherlands) (H. Limpens, notice in writing). Baagøe observed Northern Bats under the Öresund Bridge between Denmark and Sweden (H. Baagøe, pers. comm.) which indicates that bats do not avoid a bridge structure. Moreover these findings indicate that a bridge structure might be used by bats as a guidance or hunting habitat.

In case bats avoid the structure of a bridge they have the opportunity to elude the structure by flying above/underneath or aside the bridge.

It is concluded that overall bats have a minor sensitivity to barrier effects from structures, such as a bridge and therefore this pressure is not further considered in detail the impact assessment.

6.2.2 *Collision risk with structures*

Since the main part of the tunnel will be immersed in the ground and thus out of the range of bats regarding migrating bats a collision risk with structures of the tunnel can be ruled out.

The Fehmarnbelt Bridge will be high above the sea surface (Puttgarden 12 m; Rødbyhavn 8 m; main bridge 66.2 m) and the centre pylon will reach a height of 272 m (Conceptual design; Cowi-Obermeyer 2010). Although little data are available about the flight height of bats crossing large open waters (Ahlén et al. 2009, FEBI 2013) it is expected that most bats will fly in altitudes below 40-50 m. An exception might be the Noctule which is known to fly in heights of up to 500 m (Schober & Grimmberger 1998, Dietz et al 2007).

Previous studies have documented bats colliding with several man-made structures. The first report by Saunders (1930) reported that five bats of three species were killed at a light house in Ontario, Canada. Later, Van Gelder (1956) reported bats colliding with television towers, and Crawford and Baker (1981) report 54 bat fatalities of seven species colliding with television towers during a 25-year monitoring in Florida. Over an eight-year period 79 bats of four species were found underneath large windows at a convention centre in Chicago (Timm 1989) cited in (Johnson et al. 2003) and other studies have documented fatalities at tall buildings (Mumford & Whitaker 1982) or fences (Fenton 2001). Van Gelder (1956) described that bat collisions were found during nights with low cloud ceiling, fog and in nights when also bird collisions were observed. Additionally most collisions were observed during autumn migration period. Bat collision mortality is also known for wind farms (Arnett et al. 2008, Rydell et al. 2010) but these collisions likely represent bats killed by moving rotor blades rather than active collision with the structure.

These data show that there might be some collision risk with the structure of the bridge itself, especially nights with low cloud ceiling and fog during the migration phase in autumn seem to include some collision risk. However, the risk of collision is considered to be a weather-related exception. Because the bridge will be illuminated it is possible that some bat species, like Noctules and *Pipistrelle* bats can be attracted and possibly collide with the bridge (Lighthouse effect). On the other hand main bat migration, except Noctule, is expected to be in altitudes lower than the height of the bridge. And as already mentioned bats are able to detect obstacles e.g. bridge structure incl. pylons and pillars and avoid collision. Furthermore, a lighthouse effect from the illuminated parts of the bridge is not suspected to pose a risk of collision of bats with the bridge itself.

It is concluded that overall there is a minor sensitivity of bats to collisions with stationary structures, such as a bridge. Therefore, this pressure is not further considered in detail the impact assessment.

6.2.3 *Traffic related collision risks of bats*

From land it is well known, that bats collide with cars and trains while crossing roads/rails or forage in the area of traffic (Brinkmann et al. 2008). The main collision risk occurs when roads interrupt flight paths as hedges, coastlines etc. (Bach et al. 2005, Lesinski 2007, 2008, Medinas 2010). Thus it is assumed that there would be a higher collision risk in the area of land approaches and tunnel entrances, because bats are used to follow coastlines. Bats often use manmade structures like bridges (Koettnitz. & Heuser 1994, Keeley & Tuttle 1997,1999, Hendricks et al. 2005), houses or comparable structures as day-, mating- or hibernation roost (Dietz 2000).

If bats use structures next to the traffic for roosting the collision risk will increase in this area. However, it is unlikely that structures in the tunnel entrances would be used for roosting, because these areas will be illuminated during night-time and there is indication that bats avoid illuminated roosts and roost entrances (Bat Conservation Trust 2008).

Regarding roosting possibilities in bridge structure especially the Noctule and the Soprano Pipistrelle might set up roosts. Examples of bat roosts in bridges show that these would be set up in less exposed areas regarding collision risk as in counter bearings outside the traffic space.

Usually bats collide with cars because cars move too fast for a bat to estimate the actual speed (Richarz 2000). From onshore areas it is well known, that bats of the genus *Myotis* avoid crossing open areas, such as wide roads if possible or fly so low that they risk a collision with traffic (see also Zurcher et al. 2010). Bats from the genera *Pipistrellus* and *Nyctalus* have fewer problems with crossing open areas, because they use different echolocation calls that allow them to detect structures in larger distances (Skiba 2003). Mainly these so called CF-species occur as migrating species in the Fehmarnbelt area.

The *Pipistrelle* species were observed flying mainly in altitudes between 2 and 5 m above sea level. Thus these species are regarded to exhibit a higher risk of collision with traffic (Gaisler et al. 2009, Medinas 2010). Compared to these, for *Nyctalus* species the risk of collision is regarded to be much lower (Lesinski 2007, 2008, Brinkmann et al. 2008, Gaisler et al. 2009, Medinas 2010), using a very different flight behaviour in higher altitudes. It has to be mentioned that bridge structure and traffic space strongly vary in height regarding the different sections of the bridge between land approaches and the main bridge. The collision risk is mainly dependent on traffic volume (vehicles/night), width of the street, driving speed and the bats' flight speed while crossing the street (Mader 1981). Furthermore, number of crossings per year, number of crossing individuals and time of crossings are of interest. A traffic volume between 5,000 – 30,000 vehicles/day was rated by Landesbetrieb Straßenbau und Verkehr Schleswig-Holstein (LBV) (2011) to cause a high general risk of collision when important flyways are affected. The estimated traffic volume with regard to operation of a fixed link is estimated to comprise about 11,720 vehicles on an average day. Furthermore Landesbetrieb Straßenbau und Verkehr Schleswig-Holstein (2011) suggests that bats are not being able to actively elude vehicles driving with speeds above 50 km/h. However, the ramps will ascend towards the approach bridges and the traffic space will be elevated compared to the surrounding area which leads to an increased risk of collision (LBV 2011) for some species such as the Noctule. There might be two situations under which bats might collide with traffic during migration:

1. Passing the bridge while crossing the Fehmarnbelt on their regular flight route.

Since most bats (e.g. Nathusius' Pipistrelle and Soprano Pipistrelle) are expected to fly below the height of the bridge the risk to collide with the traffic usually should be very low in the area of the main bridge. Since Ahlèn et al. (2009) detected bats hunting around offshore windmills it can be expected that these species would also occur in areas close to the bridge.. Bats passing the link structures at the land approaches or tunnel entrances would have a larger risk of collision especially for *Pipistrellus* species because these species are expected to cross the structure at the height of traffic space.

Noctules are known to fly in altitudes between 10–50 m and are categorised as aerial hawkers which to some extent also use flight altitudes between 300-500 m (Dietz 2007) and show a flight pattern of open hunting habitats. Since the traffic space is bordered by structures (wind screens, cables etc.) the Noctule is not supposed to hunt in the traffic space. Usually, they fly in altitudes above the traffic and therefore are regarded to be of much lower risk to collide than the *Pipistrellus* species (Lesinski 2007, 2008, Brinkmann et al. 2008, Gaisler et al. 2009).

2. Following the bridge as a landscape feature (see above).

There are indications that bats will use the bridge as a guiding structure leading across the Fehmarnbelt, especially for bats that start their migration close to the bridge. It is also possible that bats from local populations and bats on migration might forage along the bridge, especially when the bridge is illuminated with lights attracting insects. That may lead to fatalities due to collision with traffic; although the general flight direction of bats is expected to be parallel to the traffic, since the bridge is aligned in the same direction as the main supposed bat migration direction. The main risk for collision appears when roads interrupt main flight paths of bats, such as the coast line (Lesinski 2007, Zurcher et al. 2010), where bats have to cross roads regularly. This cannot be ruled out in the areas of land approaches. Therefore the sensitivity to collision with traffic for the Pipistrelle species is assessed as minor for the offshore parts of the bridge (traffic space not extra illuminated), but as medium for the land approach areas of the bridge, where the traffic space is illuminated by road lighting.

To conclude, a minor sensitivity to traffic related collisions is assessed for the Noctule and a medium sensitivity to this pressure for Nathusius' Pipistrelle and Soprano Pipistrelle regarding the illuminated areas of the land approaches and the bridge .

6.2.4 Loss and/or habitat change

See Chapter 6.1.4.

6.2.5 Conclusion

The sensitivity analysis has shown that most potential pressures arising from the construction, the physical structures and operation of the fixed link could be identified to pose no relevant impairments to migratory bats. Finally, the pressure traffic related collision risk is the only one which according to the sensitivity analysis is relevant for a further detailed impact assessment.

7 ASSESSMENT OF IMPACTS OF MAIN TUNNEL ALTERNATIVE

7.1 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 7.1 along with near-by NATURA2000 sites.

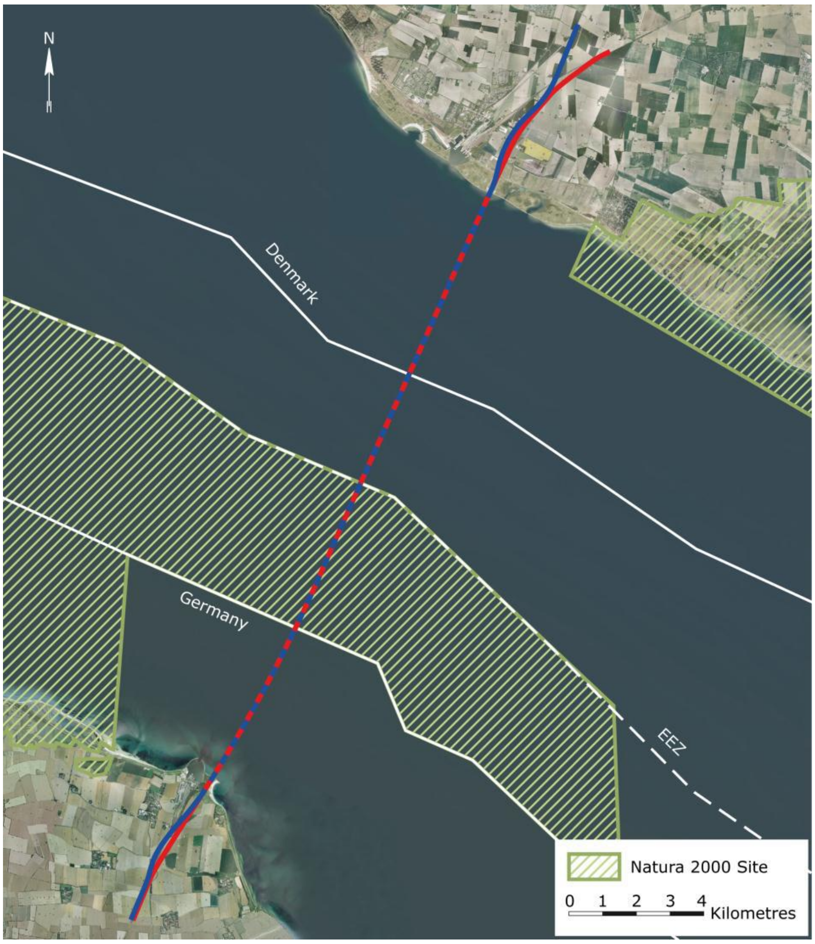

Figure 7.1 Conceptual design alignment

7.1.1 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 m 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 million m^3 sediment is handled.

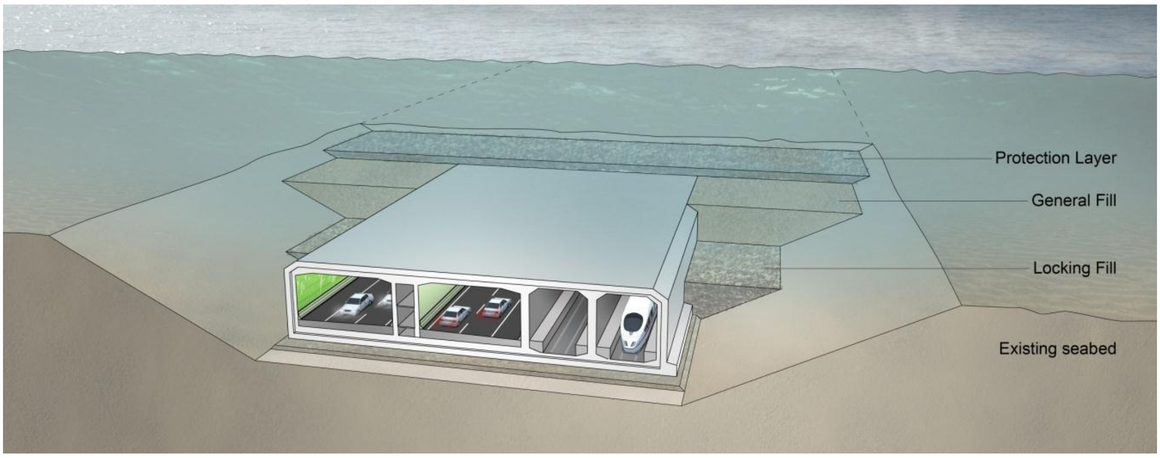

Figure 7.2 Cross section of dredged trench with tunnel element and backfilling.

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.

7.1.2 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.

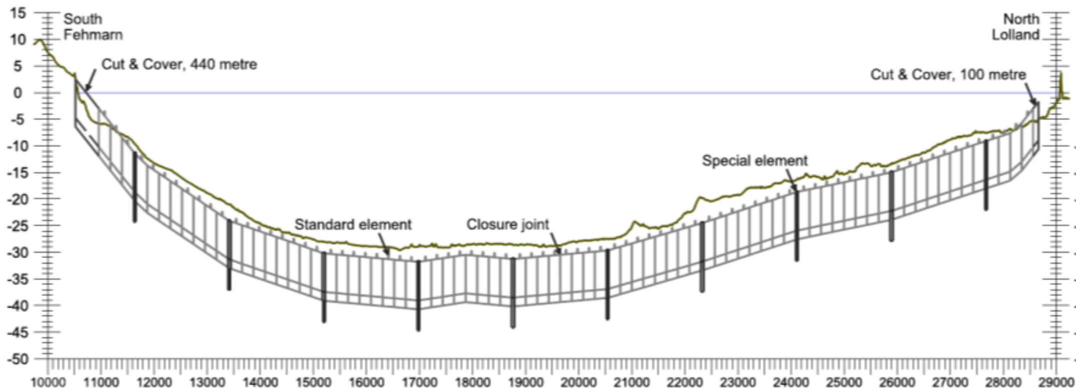

Figure 7.3 Vertical tunnel alignment showing depth below sea level

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.

7.1.3 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.

7.1.4 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 500 m 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 7.4. 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 7.4 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 shown in Figure 7.5. 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 7.5 Reclamation area at Lolland.

7.1.5 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.

7.1.6 Production site

The current design envisages the tunnel element production site to be located in the Lolland east area in Denmark. The Figure 7.6 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.

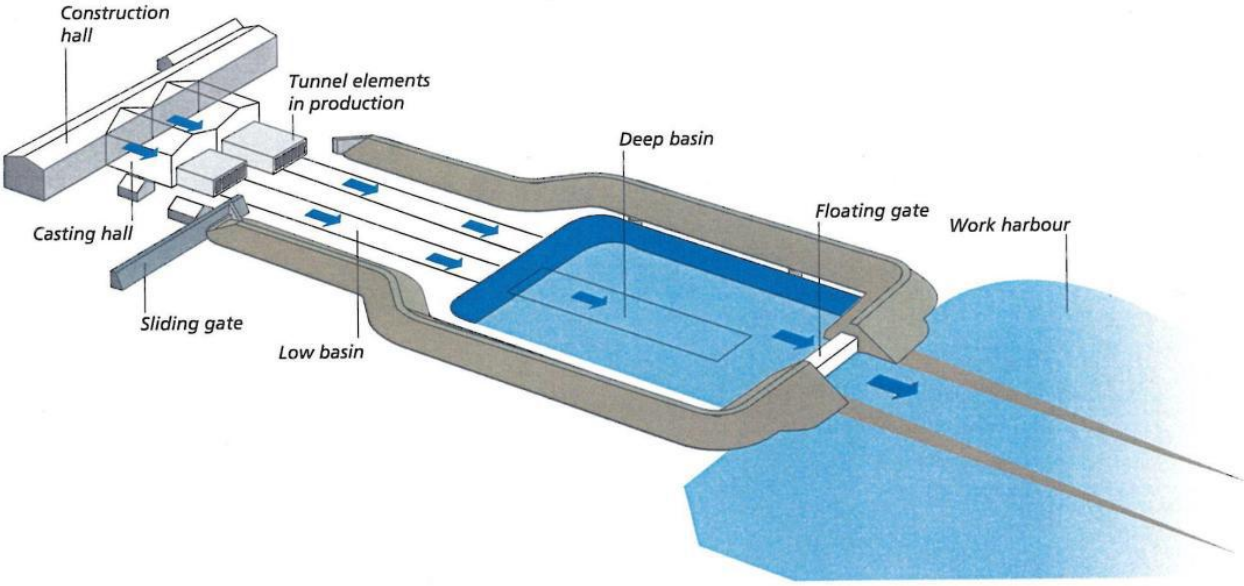

Figure 7.6 Production facility with two production lines.

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 7.7.

Dredging of approx. 4 million m^3 soil is required to create sufficient depth for temporary harbours, access channels and production site basins.

Figure 7.7 Proposed lay-out of the production site.

7.2 Construction phase

The sensitivity analysis shows that all of the potential pressures arising during the construction phase will not cause any relevant impairments/impacts to migratory bats. See Chapter 6.1.1, Chapter 6.1.2, Chapter 6.1.3 & Chapter 6.1.4. For all construction related pressures it was assessed that migrating bat species would be only minor sensitive. Based on the sensitivity analysis the degree of impairment is assessed as minor for all pressures and bat species. Consequently, also the severity of impairment, accounting for the importance level of the migrating bat species, is assessed as minor

7.3 Operation and structures

The sensitivity analysis (chapter 6.2) identified among all potential with structures and operation related pressures one being relevant for further description in the Impact Assessment. For all other pressures the sensitivity of the different bat species was assessed being minor, resulting in a minor degree of impairment. Consequently, also the severity of impairment is assessed as minor for all pressures and bat species except for the pressure 'traffic related collision risk'.

7.3.1 Traffic related collision risk

The operation of an immersed tunnel will include traffic of vehicles e.g. cars, motor trucks and trains. In the area of the tunnel ramps and portals the traffic volume causes permanent collision risk of bats with traffic (Figure 7.8). This risk is strengthened by the illumination of tunnel entrances and indirectly due to attraction of insects leading to an attraction of bats exploiting the food resource. The pressure is the physical presence of vehicles including volume of traffic, speed, and light emission during operation conditions causing collision risk to bats.

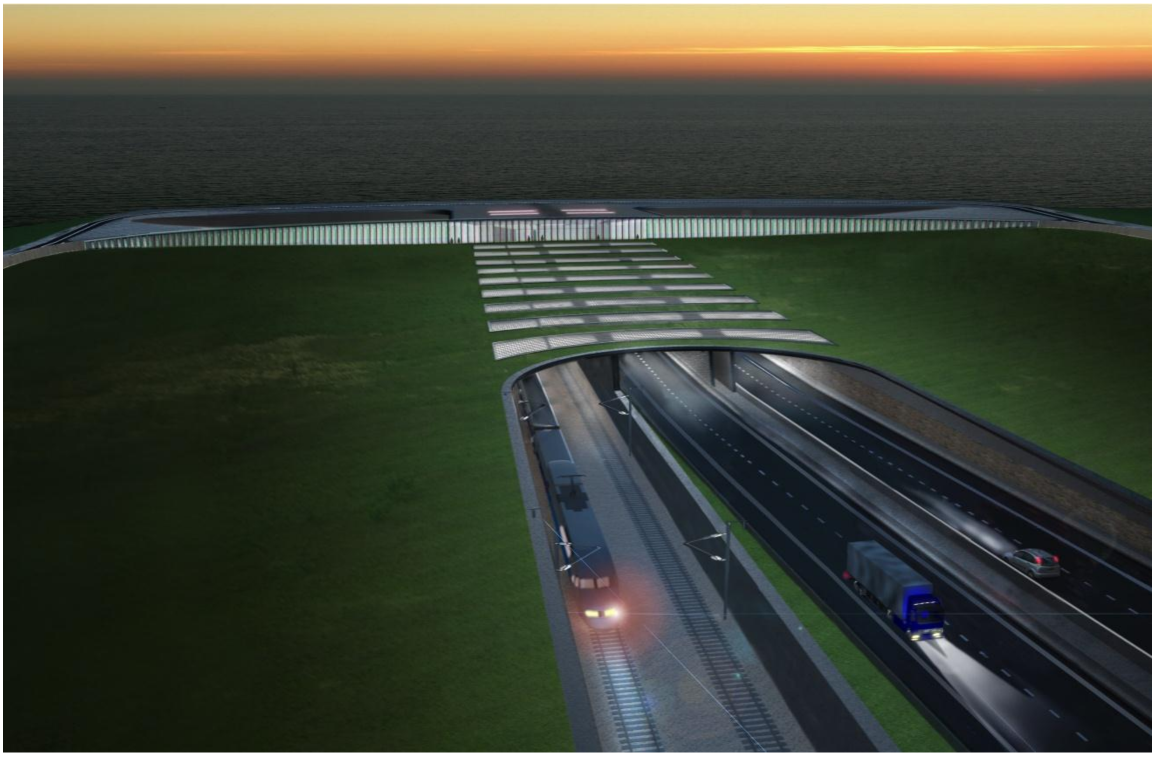

Figure 7.8 Night view of Portal Building, Lolland.

Description of pressure
Several types of traffic will be associated with the operation of an immersed tunnel. The total road traffic consisting of cars, buses and trucks includes about 11,720 vehicles a day. While traffic during night-time was estimated to include 2,110 vehicles and 30 trains (Germany, 22:00 – 06:00). Regarding traffic related collision risk of migratory bats only traffic during phases of twilight and dark are of interest.

Light emission (constant road tunnel lighting level combined with light attenuation screens at both entry and exit portals to ensure good visibility throughout.)

Degree of impairment
Based on the sensitivity of the relevant bat species the assessment of degree of impairment for traffic related collisions is based on the assumed proportion of migratory bats colliding with traffic in the traffic space.

Nathusius' Pipistrelle
The Nathusius' Pipistrelle is known to hunt next to illuminated areas (Baagøe & Rydell 1996; Dietz et al. 2007) and might use these areas for foraging. Since the tunnel portals and ramps would be illuminated it is expected that this species would adopt these areas as hunting habitat, which includes hunting next to or even within traffic space which would result in a certain risk of collision with traffic and might cause bat fatalities.

Because of this expected collision risk a medium degree of impairment is assessed for the areas of illuminated tunnel portals and ramps.

Soprano Pipistrelle
The Soprano Pipistrelle is known to hunt next to illuminated areas (Baagøe & Rydell 1996; Dietz et al. 2007) and might use these areas for foraging . Since the tunnel portals and ramps would be illuminated it is expected that this species would adopt

these areas as hunting habitat, which includes hunting next to or even within the traffic space which will would result in a certain risk of collision with traffic and might cause bat fatalities.

Therefore, as for the Nathusius' Pipistrelle, a medium degree of impairment is assessed for the areas of illuminated tunnel portals and ramps.

Noctule
On land the Noctule is known to fly high above the traffic space, which implies a minor risk to collide with vehicles during hunting or migration flights. The probability to get in conflict with vehicles in traffic space is low because of the species' flight and hunting behaviour in, using mainly altitudes between 10-50 m and to some extent even between 300-500m (Dietz et al 2007, Schober & Grimmberger 1998). Additionally the altitude of the traffic space of the tunnel entrances will decrease compared to the ground level of the surrounding area which will reduce the risk of collision of the generally high flying Noctule.

Therefore, a minor degree of impairment is assessed for the species, even in the area of illuminated tunnel portals and ramps.

Assessment of the severity of impact
The area of interest is assessed to be of general importance for migratory bats as it does not provide a special migration corridor. The degree of impairment for the pressures traffic related collision risk of migrating bats is assessed to be medium for Soprano Pipistrelle and Nathusius' Pipistrelle and minor for Noctule. Consequently, the severity of impact regarding traffic related collision risk is assessed to be minor for Noctule and medium for Nathusius' Pipistrelle and Soprano Pipistrelle in the area of illuminated tunnel ramps and tunnel portals.

7.4 Summary of impacts and assessment of severity

Construction phase
Based on the sensitivity analysis (chapter 6.1) all pressures related to the construction of an immersed tunnel are assessed to result in minor degree of impairment and minor severity of impairment (Table 7.1).

Table 7.1 Summary of the assessment of pressure specific severity of impairment for migrating bats during the construction phase of an immersed tunnel in Fehmarnbelt.

Species	**Severity of impairment of the pressure**			
	Habitat change	**Disturbance**	**Barrier from construction vessels**	**Collision risk with construction vessels**
Nathusius' Pipistrelle	Minor	Minor	Minor	Minor
Soprano Pipistrelle	Minor	Minor	Minor	Minor
Noctule	Minor	Minor	Minor	Minor

Structure and operation

Based on the sensitivity analysis (chapter 6.2) the pressure 'habitat changes / loss' related to structure and operation of an immersed tunnel is assessed to result in minor degree of impairment and minor severity of impairment (Table 7.2). The severity of impairment due to the pressure 'traffic related collision risk' for the tunnel ramp and portal areas a medium severity of impairment is assessed for the Nathusius' Pipistrelle and the Soprano Pipistrelle, and a minor severity of impairment for the Noctule (Table 7.2).

Table 7.2 Summary of the assessment of pressure specific severity of impairment for migrating bats from the structure and during operation of an immersed tunnel in Fehmarnbelt.

Species	**Severity of impairment of the pressure**	
	Habitat change	**Traffic related collision risk (Tunnel entrances)**
Nathusius' Pipistrelle	Minor	Medium
Soprano Pipistrelle	Minor	Medium
Noctule	Minor	Minor

7.4.1 Conclusion and significance of impact

The construction and operation of an immersed tunnel would result in mostly minor impairments to migrating bats. A medium severity of impairment regarding traffic related collisions at the illuminated tunnel portals and ramps is assessed for the Nathusius' Pipistrelle and Soprano Pipistrelle. Bat migration is supposed to occur in broad front which implies that a small proportion of the bats migrating across the Fehmarnbelt might be affected. The estimated traffic volume with regard to operation of a fixed link during night time (22:00-06:00, Germany) was estimated to include 2,110 vehicles and 30 trains. Due to flight behaviour of bat species of concern, the fact that bat migration in the Fehmarnbelt area occurs in broad front, no important flyways were identified during the baseline investigations and, accounting for the comparably small area affected, the impact from collisions is assessed to be insignificant for the population migrating through the Fehmarnbelt area. To conclude, the impacts from construction, structure and operation of an immersed tunnel are assessed as being insignificant for migrating bats.

7.5 Assessment of strictly protected species

It is required to determine whether any of the pressures described in the chapters above may lead to a violation of the objectives of Article 12 of the Habitats Directive as outlined in section 3.5.7.

7.5.1 Deliberate capture or killing of specimens, including injury

Possible incidents will be restricted to the entrances of the tunnel while bat migration is not affected in the marine areas. The impacts assessment concludes no significant impacts on the three species regularly migrating through the area. Due to the restricted area which is of no special importance to bat migration it is concluded that the project would not lead to a systematic increase in the risk or mortality.

It is thus concluded that construction and operation of a tunnel solution will not lead to significant killing or injuring of migratory bats and that the obligations of Article 12 of the Habitats Directive are not violated by the project.

7.5.2 Deliberate disturbance

Possible disturbance will be restricted to the entrances of the tunnel while bat migration is not affected in the marine areas. The impacts assessment concludes no significant impacts on the three species regularly migrating through the area. Due to the restricted area which is of no special importance to bat migration it is concluded that the project would not lead to significant disturbance.

It is thus concluded that construction and operation of a tunnel solution will not lead to significant disturbance of bat migration in the Fehmarnbelt area and that the obligations of Article 12 of the Habitats Directive are not violated by the project.

7.6 Cumulative impacts

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
Krieger's Flak II	Kriegers Flak	Construction	Sediment spill, displacement, collision risk, barrier effect
GEOFReE	Lübeck Bay	Construction	Sediment spill, displacement, collision risk

Rødsand II (Figure 7.9) 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.

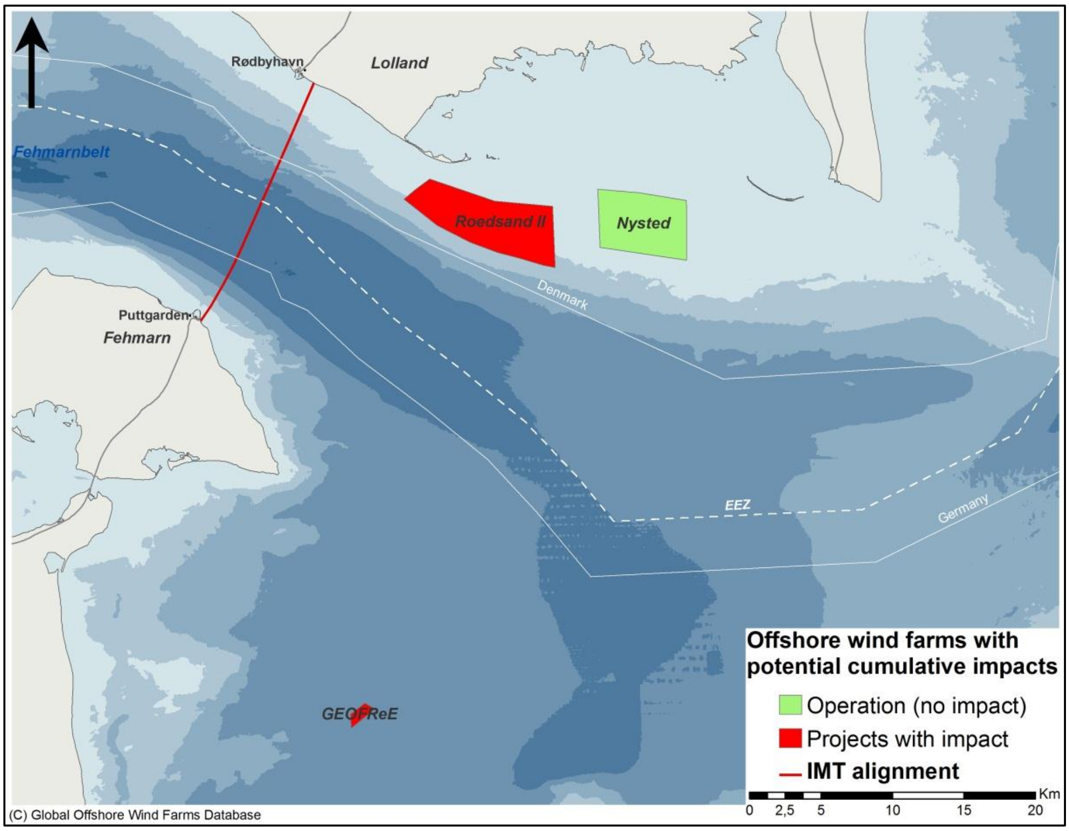

Figure 7.9 Locations of Rødsand II, Nysted and GEOFreE.

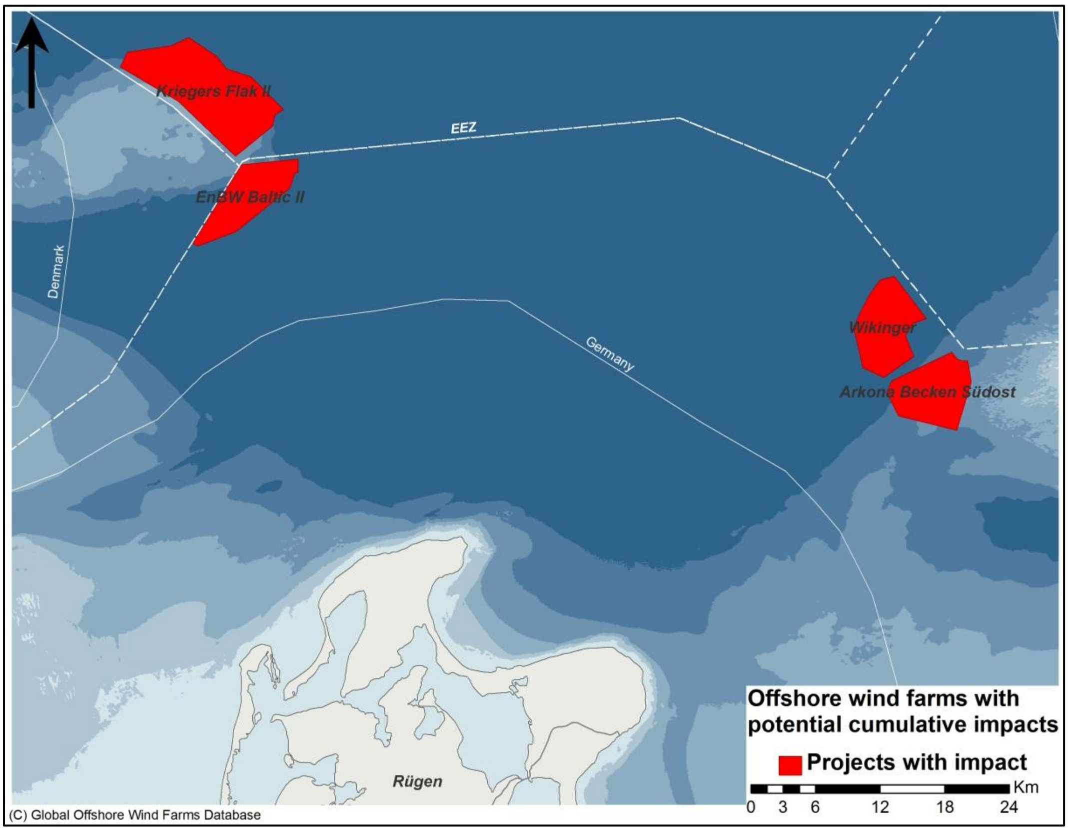

Figure 7.10 Locations of Kriegers Flak, EnBW Baltic II, Wikinger and Arkona Becken Südost.

7.6.1 Assessment and significance of impact

Observations of bats hunting around offshore wind turbines in Kalmarsund (Ahlén et al. 2009) and the fact that bats collide regularly with on-shore wind turbines lead to the suggestion that migrating bats that cross large open waters get in conflict with offshore wind farms (Bach & Rahmel 2007, Ahlén et al. 2009). Furthermore, this assessment shows an impact on migratory bats from collision risk. This might lead to cumulative impacts on migratory bats. However, it is unknown where the bat specimens detected in the Fehmarnbelt originate from and on which flight route they cross the Fehmarnbelt area. Moreover, collision rate of migratory bats when passing offshore wind energy farms is also unknown.

Therefore, a reliable assessment of cumulative impacts is impossible on the basis of current research.

7.7 Decommissioning – immersed tunnel

Since work from decommissioning of an immersed tunnel are similar to construction works and the sensitivity analyses showed no impairments from construction activities regarding migratory bats, it is finally assessed that the decommissioning works will also cause no impairments on migratory bats.

8 ASSESSMENT OF IMPACTS OF CABLE STAYED BRIDGE (MAIN BRIDGE ALTERNATIVE)

8.1 General description of the project

8.1.1 Bridge concept

The main bridge is a twin cable stayed bridge with three pylons and two main spans of 724 m each (Figure 8.1). 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. 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 8.1 Main bridge (visualisation).

8.1.2 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 480m 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 railway 680 m long. The profile of the railway and motorway descend to the natural terrain surface.

8.1.3 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.

8.1.4 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 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.

8.1.5 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 8.2.

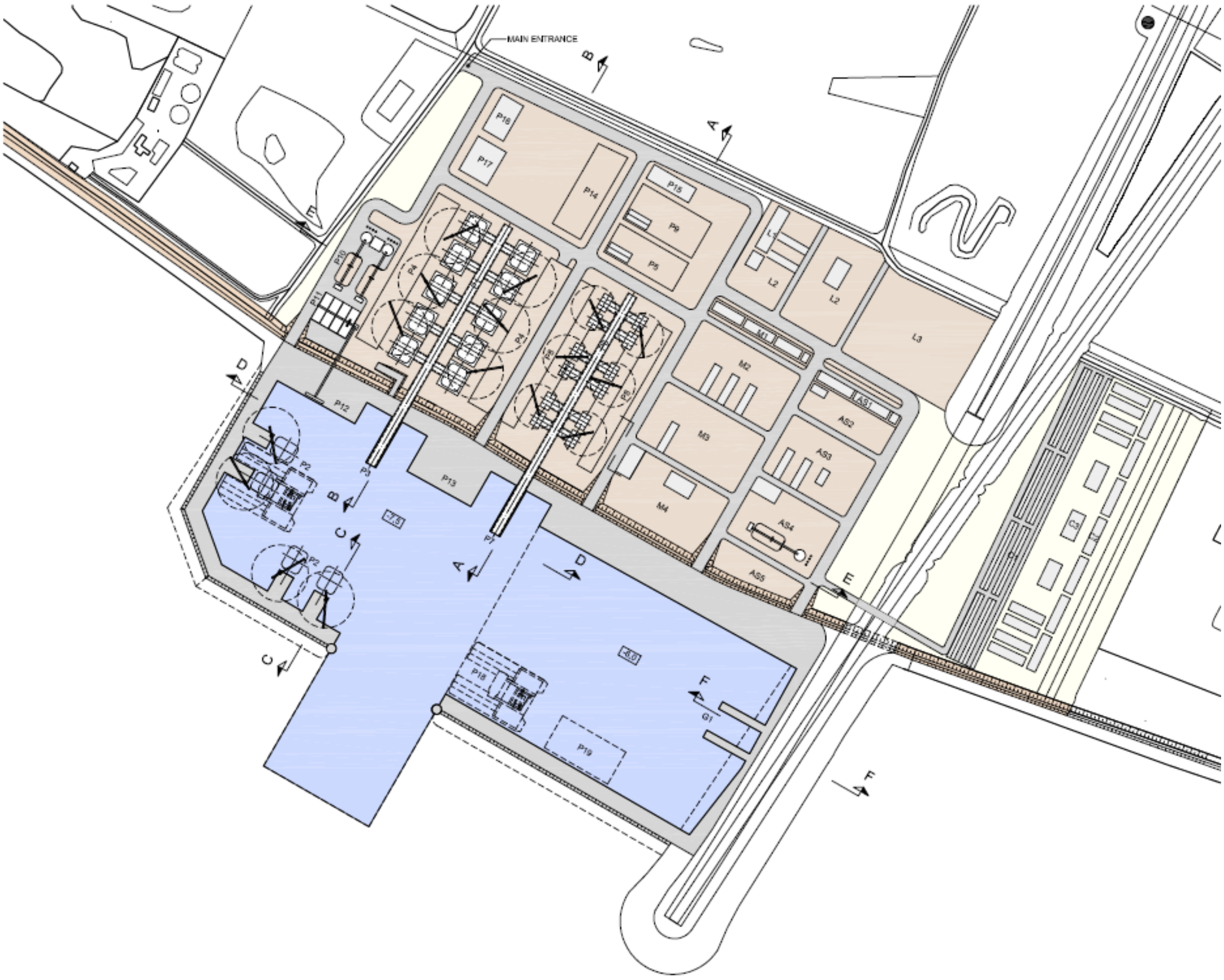

Figure 8.2 Proposed lay-out of the production site.

8.2 Construction phase

The sensitivity analysis shows that all of the potential pressures arising during the construction phase will not cause any relevant impairments/impacts to migratory bats. See Chapter 6.1.1, Chapter 6.1.2, Chapter 6.1.3 & Chapter 6.1.4. For all construction related pressures it was assessed that migrating bat species would be only minor sensitive. Based on the sensitivity analysis the degree of impairment is assessed as minor for all pressures and bat species. Consequently, also the severity of impairment, accounting for the importance level of the migrating bat species, is assessed as minor

8.3 Operation and structures

The sensitivity analysis (Chapter 6.2) identified among all potential with structures and operation related pressures one being relevant for further description in the Impact Assessment. For all other pressures the sensitivity of the different bat species was assessed being minor, resulting in a minor degree of impairment. Consequently, also the severity of impairment is assessed as minor for all pressures and bat species except for the pressure 'traffic related collision risk'.Traffic related collision risk

The operation of a cable-stayed bridge will include traffic of vehicles e.g. cars, motor trucks and trains. In the whole area of the traffic space the traffic volume causes potential collision risk between bats and traffic (Figure 8.3). This risk is enhanced by the illumination of bridge structures and the indirectly due to attraction of insects leading to an attraction of bats adopting the food resource (Baagøe & Rydell 1996; Dietz et al. 2007). The pressure is the physical presence of vehicles including volume of traffic, speed, and light emission during operation conditions causing collision risk to bats.

Description of pressure

The bridge will cover a total length of some 18 km between the two abutments. At each landing / end will be a reclaimed peninsula up to a water depth of 5-6 m, some 580 m from the shore (Figure 8.4 & Figure 8.5). The approach bridges will continuously rise towards the centre main bridge.

The structure of the entire bridge will 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 8.3), the upper width will be 24.1 m, the lower width 12.2 m; the height of the structure itself will be 12.9 m, plus an additional windscreen of 2.5 m at both sides of the road.

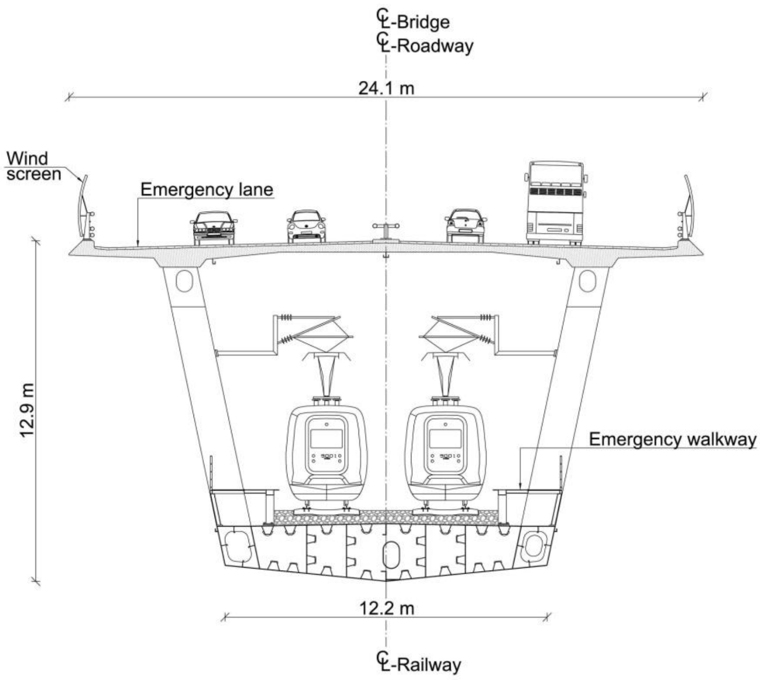

Figure 8.3 Cross-section of the bridge including horizontal and vertical measurements (Consolidated Technical Report Draft 3.3.docx).

Figure 8.4 Bridge on peninsula leaving Fehmarn: visualisation.

Figure 8.5 Bridge on peninsula leaving Lolland: visualisation.

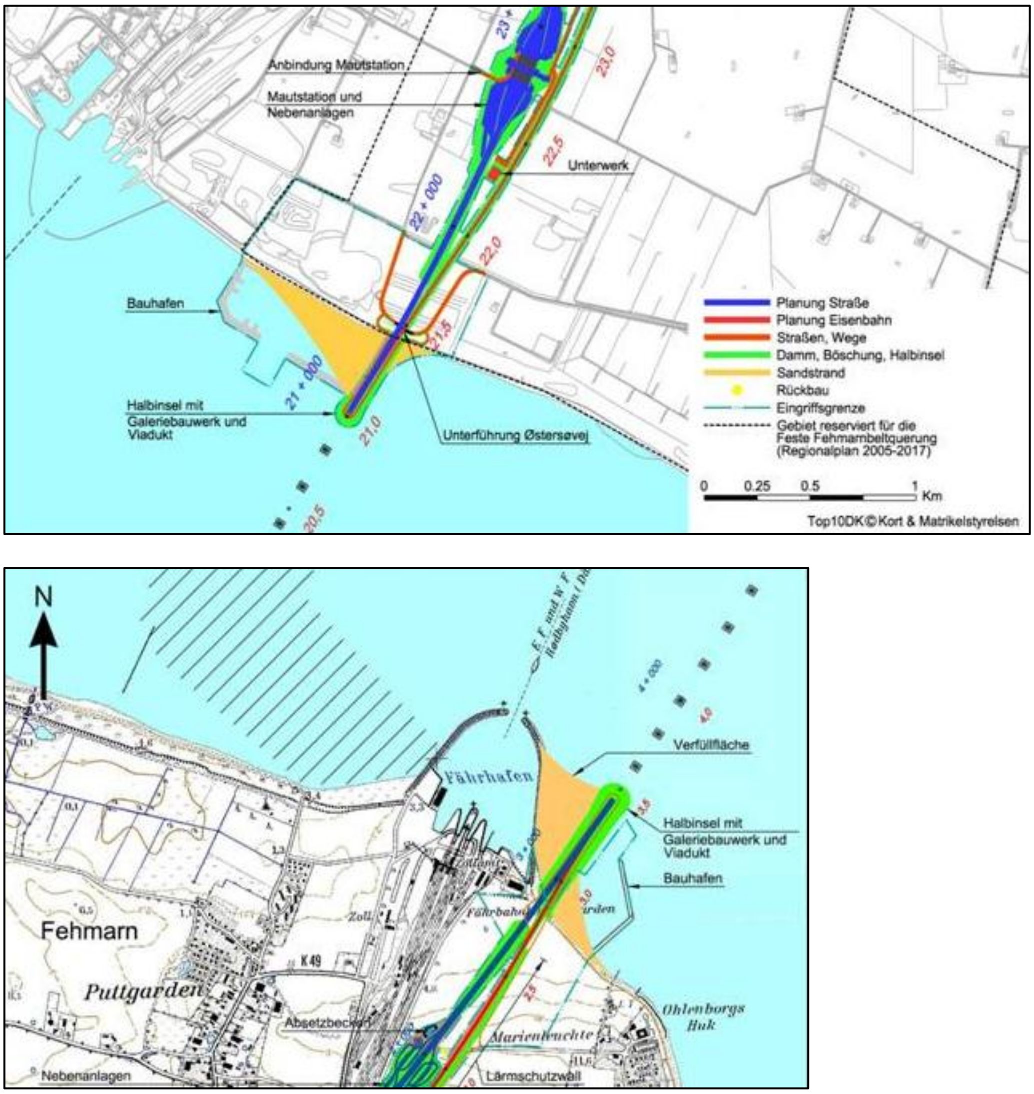

Figure 8.6 Peninsulas on Fehmarn (bottom) and Lolland (top): drawings.

For the traffic related collision risk important features of the cable-stayed bridge are:

1. **Dimension** covered by four-lane road on the upper level and a two-track railway on the lower level (Figure 8.3)

2. Several types of traffic will be associated with the operation of a cable-stayed bridge. The total road traffic consisting of cars, buses and trucks includes about 11,720 vehicles a day. While traffic during night time was estimated to include 2,110 vehicles and 30 trains.

3. **Lighting of the bridge** the architectural lighting / illumination will indirectly illuminate the structures of the bridge; with white coloured floodlighting with average luminance of 5-10 cd/m². The obstruction lighting will follow the rules of the IALA (marine) and ICAO (aviation). For flight safety white flashing lights will 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; those lights have to be visible from all sides. Navigational lighting will most likely include red and green light at the underpasses under the main bridge.

Degree of impairment
Based on the sensitivity of the relevant bat species the assessment of degree of impairment is based on the collision risk assessment within the sensitivity analysis (chapter 6.2.3).. The ramps will ascend towards the approach bridges and the traffic space will be elevated compared to the surrounding area which leads to an increased risk of collision (LBV 2011) for some species such as the Noctule. In this respect it has to be noted, however, that the traffic space is shielded by a 2.5 m windscreen reducing the risk of migrating bats to directly approach the traffic area. Collision risk is considered to be a relevant factor for roads with traffic intensities between 5,000 and 50,000 cars/24 h (LBV 2011), a medium collision risk is assumed due to the windscreen.

Nathusius' Pipistrelle
The Nathusius' Pipistrelle is known to hunt next to illuminated areas (Baagøe & Rydell 1996; Dietz et al. 2007) and possibly would use these areas for foraging because of higher abundances of insects. In combination with the windscreen, which is 2.5 m while literature (LBV 2011) demands for 4 m to mitigate traffic related collision risk the collision risk of migrating Nathusius' Pipistrelle is considered to be medium.

Therefore, a minor degree of impairment is considered in the unlighted traffic space areas of the bridge.

A medium degree of impairment is considered in the illuminated traffic space of ramps, approach bridges and bridge.

Soprano Pipistrelle
The Soprano Pipistrelle is known to hunt next to illuminated areas (Baagøe & Rydell 1996; Dietz et al. 2007) and might start foraging abundances of attracted insects in these areas. Thus, a medium degree of impairment is assessed in the illuminated areas of main bridge.

The species is known to follow guidance of landscape features as coastlines during migration. Leading to the conflict that bats have to cross the traffic space of the four-lane road or the two-track railway to continue their flight along the coastline of Lolland or Fehmarn. In combination with the windscreen, which is 2.5 m while literature (LBV 2011) demands for 4 m to mitigate traffic related collision risk the collision risk of migrating Soprano Pipistrelle is considered to be medium.

Therefore, a minor degree of impairment is considered in the unlighted traffic space areas of the bridge.

A medium degree of impairment is considered in the illuminated traffic space of ramps, approach bridges and bridge.

Noctule
The Noctule is known to fly and hunt in altitudes above traffic. However it is also known to hunt next to illuminated areas and might start foraging in areas of higher abundances of attracted insects as illuminated ramp areas, approach bridges and main bridge. In the area of the main bridge the flight height could lead to an elevated collision risk, however, due to the windscreen there is a alleviated risk of migrating Noctules to directly approach the traffic area though traffic space and flight height overlap. Based on the knowledge that Noctules generally fly in altitudes above traffic and that the species appears being less sensitive to collision risk than other species a minor degree of impairment is considered in the traffic space situated in the offshore areas.

A minor degree of impairment is considered in the area of ramps, approach bridges and main bridge.

Assessment of the severity of impact
The area of interest is of only general importance for migratory bats. It does not provide a special importance as migration corridor. The collision risk of migrating Pipistrelles (Nathusius' and Soprano Pipistrelle) is assessed to be medium. Consequently, the severity of impact regarding traffic related collision risk is assessed to be medium for Nathusius' Pipistrelle and Soprano Pipistrelle in the illuminated traffic space of ramps, approach bridges and main bridge. However, the unlighted traffic space of main bridge was assessed to result in a minor severity of impairment. The severity of impact regarding Noctule was assessed to be minor.

8.4 *Summary of impacts and assessment of significance*

Construction phase
Based on the sensitivity analysis (chapter 6.1) all pressures related to the construction of an immersed tunnel are assessed to result in minor degree of impairment and minor severity of impairment (Table 8.1).

Table 8.1 Summary of the assessment of pressure specific severity of impairment for migrating bats during the construction phase of a cable-stayed bridge in Fehmarnbelt.

Species	**Severity of impairment of the pressure**			
	Habitat change	**Disturbance**	**Barrier from construction vessels**	**Collision risk with construction vessels**
Nathusius' Pipistrelle	Minor	Minor	Minor	Minor
Soprano Pipistrelle	Minor	Minor	Minor	Minor
Noctule	Minor	Minor	Minor	Minor

Structure and operation

Table 8.2 Summary of the assessment of pressure specific severity of impairment for migrating bats from the structure and during operation of a cable-stayed bridge in Fehmarnbelt.

Species	Severity of impairment of the pressure			
	Habitat change	**Barrier effect**	**Traffic related collision risk at unlighted traffic space of main bridge**	**Traffic related collision risk in illuminated traffic space of land approaches and main bridge**
Nathusius' Pipistrelle	Minor	Minor	Minor	Medium
Soprano Pipistrelle	Minor	Minor	Minor	Medium
Noctule	Minor	Minor	Minor	Minor

8.4.1 *Conclusion and significance of impact*

The main pressure of a cable-stayed bridge between Rødby and Puttgarden for migrating bats is the traffic related collision risk. The complete carriageways and rail tracks in the whole length of a bridge potentially pose a collision risk for bats. This risk is increased by attraction of bats caused by abundances of insects attracted by lighting in these areas. The estimated traffic volume with regard to the operation of a fixed link was estimated to include about 11,720 vehicles per day which incorporates a generally increased risk of collision (LBV 2011). Due to fight behaviour of bat species of concern and the fact that bat migration in the Fehmarnbelt area occurs in broad front and no important flyways were identified during the baseline investigations, the severity of impairment regarding collision risk was assessed to be medium regarding Nathusius' Pipistrelle and Soprano Pipistrelle, while the severity regarding Noctule was assessed to be minor.

Impairments including bat fatalities due to collision with traffic are expected to not having a relevant effect to any of the studied bat populations.

Therefore, the impacts from construction, structure and operation of a cable-stayed bridge in the Fehmarnbelt are assessed as insignificant regarding migratory bat species.

8.5 *Assessment of strictly protected species*

It needs to be determined whether any of the pressures described in the chapters above may lead to a violation of the objectives of Article 12 of the Habitats Directive as outlined in section 3.5.7.

8.5.1 *Deliberate capture or killing of specimens, including injury*

The impacts assessment concludes no significant impacts on the three species regularly migrating through the area. Due to the general importance to bat migration and the absence of migration corridors it is concluded that the project would not lead to a systematic increase in the risk or mortality.

It is thus concluded that construction and operation of a bridge solution will not lead to killing or injuring of migratory bats and that the obligations of Article 12 of the Habitats Directive are not violated by the project.

8.5.2 Deliberate disturbance

The impacts assessment concludes no significant disturbance on the three species regularly migrating through the area. Due to the general importance to bat migration and the absence of migration corridors it is concluded that the project would not lead to significant disturbance.

It is thus concluded that construction and operation of a bridge solution will not lead to significant disturbance of bat migration in the Fehmarnbelt area and that the obligations of Article 12 Habitats Directive are not violated by the project.

8.6 Cumulative and transboundary impacts

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
Krieger’s Flak II	Kriegers Flak	Construction	Sediment spill, displacement, collision risk, barrier effect
GEOFReE	Lübeck Bay	Construction	Sediment spill, displacement, collision risk

Rødsand II (Figure 8.7) 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.

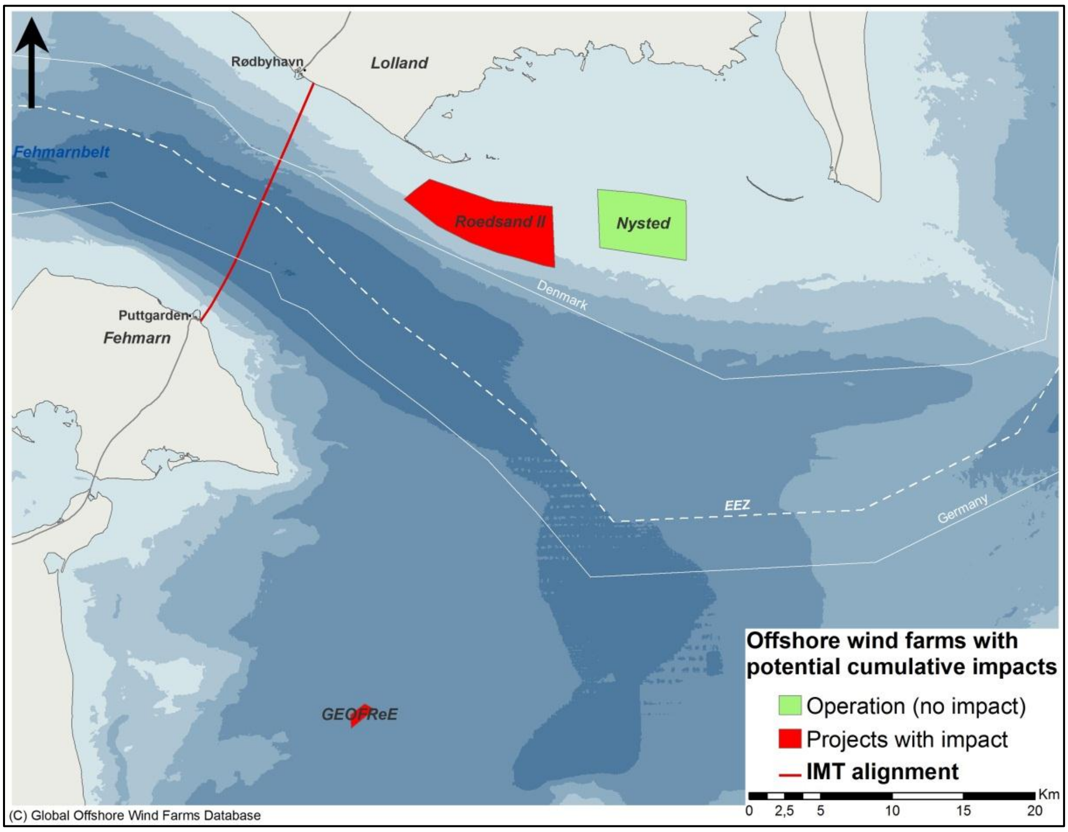

Figure 8.7 Locations of Rødsand II, Nysted and GEOFreE.

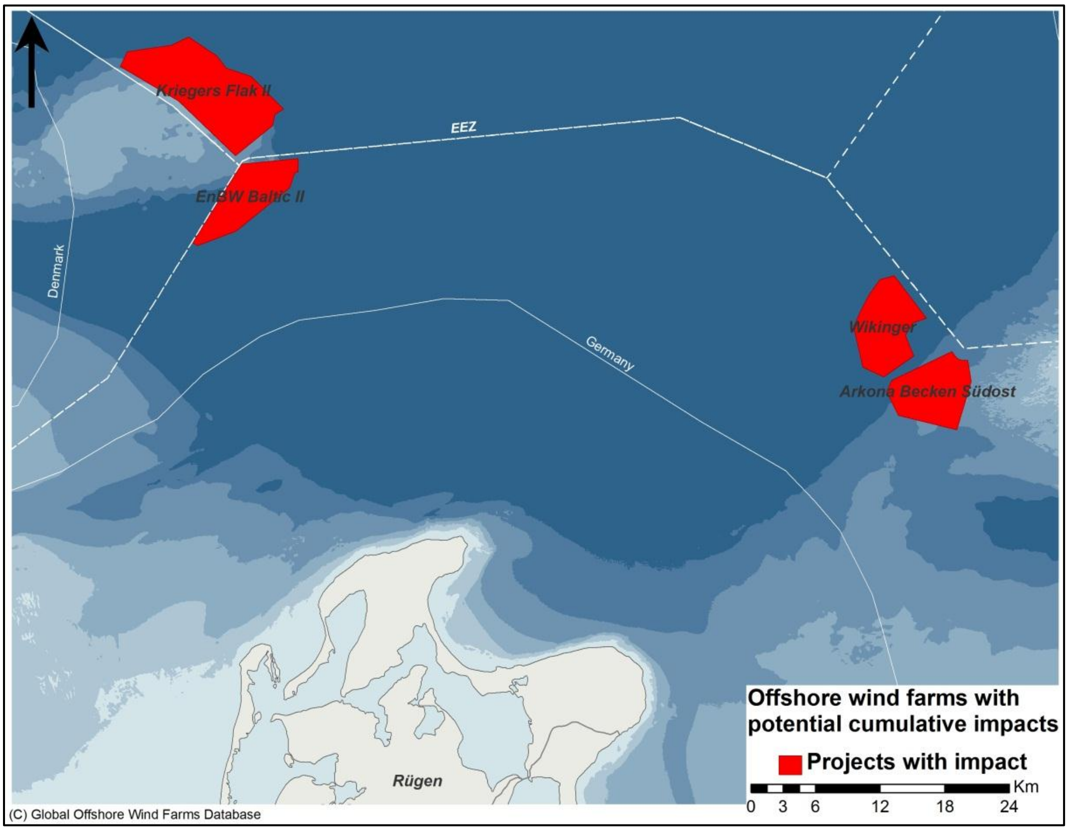

Figure 8.8 Locations of Krieger's Flak, EnBW Baltic II, Wikinger and Arkona Becken Südost.

8.6.1 *Assessment and significance of impact*

Observations of bats hunting around offshore wind turbines in Kalmarsund (Ahlén et al. 2009) and the fact that bats collide regularly with on-shore wind turbines lead to the suggestion that migrating bats that cross large open waters get in conflict with offshore wind farms (Bach & Rahmel 2007, Ahlén et al. 2009). Furthermore, this assessment shows an impact on migratory bats from collision risk. This might lead to cumulative impacts on migratory bats. However, it is unknown where the bat specimens detected in the Fehmarnbelt originate from and on which flight route they cross the Fehmarnbelt area. Moreover, collision rate of migratory bats when passing offshore wind energy farms is also unknown.

Therefore, a reliable assessment of cumulative impacts is impossible on the basis of current research.

8.7 *Decommissioning - cable-stayed bridge*

Since work from decommissioning of a cable-stayed bridge are similar to construction works and the sensitivity analyses showed no impairments from construction activities regarding migratory bats, it is finally assessed that the decommissioning works will also cause no impairments on migratory bats.

9 COMPARISON OF BRIDGE AND TUNNEL MAIN ALTERNATIVES

The impairment of migratory bats from construction, structure and operation of a fixed link in the Fehmarnbelt depends on the chosen alternative (bridge/tunnel). While the immersed tunnel solution offers comparably small impact areas at the tunnel portals and ramp areas, the bridge solution affects a larger impact area based on the fact that the carriageways and rail tracks in the whole length of a bridge including ramp areas and approach bridges potentially pose traffic related collision risk to migratory bats. All other pressures were identified to result in only minor effects according to the results of the sensitivity analysis.

The severity of impairment levels of different pressures range from minor to medium for both alternatives of a fixed link.

Regarding significance of impact both solutions are assessed to result in insignificant effects for migratory bats. No population effects are predicted.

When comparing the two alternatives it is concluded that both alternatives result in comparable impairment levels (Table 9.1). However, for the immersed tunnel solution the impaired areas (risk areas) are much smaller than for the bridge alternative (tunnel: only ramps and portal areas, bridge: entire traffic space of bridge structure).

Table 9.1 Summary of severity of impairment for Bridge and Tunnel construction and operation phases on migratory bats.

PRESSURES	**TUNNEL - severity of impairment**			**BRIDGE - severity of impairment**		
	Nathusius' Pipistrelle	**Soprano Pipistrelle**	**Noctule**	**Nathusius' Pipistrelle**	**Soprano Pipistrelle**	**Noctule**
Construction						
Disturbance	Minor	Minor	Minor	Minor	Minor	Minor
Barrier effect	Minor	Minor	Minor	Minor	Minor	Minor
Collision	Minor	Minor	Minor	Minor	Minor	Minor
Habitat change/loss	Minor	Minor	Minor	Minor	Minor	Minor
Operation						
Barrier effect	Minor	Minor	Minor	Minor	Minor	Minor
Collision (structure)	Minor	Minor	Minor	Minor	Minor	Minor
Collision (traffic)	Medium	Medium	Minor	Medium	Medium	Minor
Habitat change	Minor	Minor	Minor	Minor	Minor	Minor

In the comparison of the tunnel and bridge (Table 9.2), the severity of impairment and the dimension of the impaired areas are taken into account. If there were no relevant differences between the two options identified, this is ranked as 0. If severity levels for a given pressure are equal but there are obvious differences, e.g. in the spatial extent of the footprint area, a slight advantage (ranked as +) is noted for the option with the smaller impact. If strong differences with respect to severity and significance occur, a ++ ranking is given.

Table 9.2 Comparison of impacts on migratory bats from the two main alternatives of a fixed link across Fehmarnbelt. Values assigned to Rank differences: (0) no difference and (+) slight advantage, + advantage, ++ strong advantage.

Environmental sub-factor: Migratory bats	Result of comparison of main alternatives	
	Bridge	**Tunnel**
Assessment criteria: occurrence		
Habitat change	0	0
Disturbance	0	0
Collision risk		+
Assessment criteria: migration corridor		
Barrier effect during construction	0	0
Barrier effect from structure	0	0

9.1 Aggregation of impacts of main tunnel alternative

The aggregation of impacts of the main tunnel alternative showed an impact on bat migration in the area of tunnel portals and ramps. In these areas a medium traffic related collision risk for Nathusius' Pipistrelle and Soprano Pipistrelle was assessed. All other pressures were assessed having no or only minor impacts to migrating bats. The severity of impairment with regard to the pressure traffic related collision risk was assessed to be medium for the Nathusius' Pipistrelle and Soprano Pipistrelle, while severity of impairment was assessed as minor for the Noctule.

According to the findings of the baseline study that bat migration occurs in broad front only a small proportion of migrating Pipistrelles would be exposed to traffic related collision risk

Therefore, the impacts from construction and operation of main tunnel alternative are assessed to be **insignificant** regarding bat migration.

9.2 Aggregation of impacts of main bridge alternative

The aggregation of impacts of main bridge alternative was assessed to have an impact on bat migration in the area of the carriageways and rail tracks. The bridge was assessed to pose a medium traffic related risk of collision for Nathusius' Pipistrelle and Soprano Pipistrelle. While the collision risk regarding Noctule was assessed to be minor. All other pressures were identified to only having no or minor impacts on migrating bats.

According to the findings of the baseline study that bat migration occurs in broad front only a small proportion of migrating Pipistrelles would be exposed to traffic related collision risk. Though, the traffic space is shielded by a 2.5 m windscreen reducing the risk of migrating bats to directly approach the traffic area, while current literature (LBV 2011) demands for mitigation of traffic related collision risk a height of 4 m for collision hindering walls.

To conclude, the impacts from construction and operation of main bridge alternative are assessed to be **insignificant** regarding bat migration.

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