Seaduck Assessment

Omø Syd and Jammerland Bugt
Offshore Windfarms

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1 Introduction

The Danish Energy Agency has asked NIRAS to undertake a revised assessment on the effect of common eider (*Somateria mollissima*), common scoter (*Melanitta nigra*) and velvet scoter (*Melanitta fusca*) for Omø Syd and Jammerland Bugt Offshore Wind Farms (OWF). It is specifically the potential displacement of common eider that is a focus given the periodic large numbers of this species within and around the two project areas. This revised assessment includes an assessment of the individual project's effects on seaducks as well as cumulative effects with other relevant present or planned offshore plans and projects.

Omø Syd and Jammerland Bugt OWF are projects under the open-door procedure, where a project developer takes the initiative to establish an offshore wind farm. The Environmental Impact Assessment (EIA) for Omø Syd OWF was first submitted by European Energy A/S via Omø South Nearshore A/S to the Danish Energy Agency in March 2015 (Orbicon, 2016). As part of the EIA an Appropriate Assessment considering the impact on birds, including common eider was conducted (Orbicon, 2016). The EIA for Jammerland Bugt OWF was first submitted by European Energy A/S via Jammerland Bugt Nearshore A/S to the Danish Energy Agency in June 2015 (Orbicon, 2018).

1.1 Windfarm designs and locations

1.1.1 Omø Syd OWF

The production capacity of Omø Syd OWF will be 200 to 320 MW distributed across 66-80 turbines of 3 MW or 25-40 turbines of 6-8 MW. The project area for Omø Syd covers a 24,5 km^2 area located in Great Belt west of Omø Stålgrunde and adjacent to Smålandsfarvandet. The project area is in close proximity to several Special Protected Areas (SPA), with it located 3 km from the nearest SPA. The project area is part of an important area for staging seaducks and is of international importance for several species, especially common eider (Orbicon, 2016).

The original study area covered 44 km^2, however after the initial assessment of impact on birds was conducted, it was decided by the project developer to reduce the project area to 24,5 km^2 and avoid turbines in the western part of the study area to increase the distance between the windfarms and shipping lanes (Orbicon, 2016). It was also decided to avoid turbines in the northern part of the study area and new calculations for the impact on seaducks has been conducted. The reason to exclude the northern part is to reduce the impact on common eider, common scoter and velvet scoter that use the area as a staging area in a large number. Furthermore, the reduction will also cause a smaller impact on the migratory birds (Orbicon, 2016). The reduced project area is not given in the EIA (Orbicon, 2016) but in the technical background report for birds (Orbicon, 2016) a footprint of 22 km^2 is given and use for calculations. The area of the GIS-files provided by Orbicon for data analyses is 24.5 km^2, though, and this area is the baseline used for this revised assessment.

1.1.2 Jammerland Bugt OWF

The production capacity of Jammerland Bugt OWF will be 180 MW distributed across 60 turbines of 3 MW or 240 MW distributed across 34 turbines of 7 MW. The project area for Jammerland Bugt covers a 31 km^2 area located in the central part of Jammerland Bugt with the peninsulas Asnæs and Reersø located to North and South, respectively. The project area is located 7 km from the nearest SPA, however the project area is an important area for staging seaducks and is of international importance for several species, especially common eider but also common scoter can reside in large numbers (Orbicon, 2018).

The original study area covered 65 km^2, however to reduce the visual impact and the impact on staging birds (especially common eider) the project area has been reduced, by excluding the northern and eastern part of the study area, and new calculation on the impact of common eider, common scoter and velvet scoter has been conducted. The reduced project area is now at least 6 km from the coast. Thus, the area 3-6 km from the coast, with the highest estimates and densities of seaducks observed during the aerial surveys (2014-2015) are excluded (Orbicon, 2018). The reduced project area has a footprint of 31 km^2 and is the baseline used for this revised assessment.

1.2 Structure of the report

The report provides a basic structure of methodology, assessment of common eider, common scoter and velvet scoter displacement at each of the two projects alone, cumulative assessment and conclusions. Key aspects of the assessment that are subject to re-analysis and assumptions tested are as follows:

- Geographical extent of common eider, common scoter and velvet scoter displacement
- Impact of displacement through the annual cycle
- Fate of displaced birds following displacement
- Re-visit of projects included in cumulative assessment
- Re-visit of SPAs included in the appropriate assessment

The report also clarifies an appropriate presentation of the population modelling through Potential Biological Removal (PBR) as implemented in the EIA of each of the two Windfarms. While the use of PBR is doubtful the results provided here compared against PBR outputs combined with a more holistic, qualitative discussion on the potential impacts on the common eider, common scoter and velvet scoter populations provide the best available current evidence.

This entire assessment calculates levels of displacement and the predicted mortality arising (through assessments against 1% population thresholds and PBR) and is wholly dependent on the density surface estimates provided by the technical background report on birds for Omø Syd and Jammerland Bugt Offshore Windfarms (Orbicon, 2018; Orbicon, 2016). This report has not attempted to revisit this baseline modelling. For a further discussion of this and potential caution that should be exercised in the use of the assessments of displacement levels presented here please see section 10.2.1.

2 Public hearing

2.1 Process and issues raised from the public hearing

As part of the EIA process, public hearings are required in order to obtain a license to develop windfarms. The objective of this consultation and hearing process is to enable the public to submit information or concerns to the EIA and potential appropriate assessment.

The EIA and background reports for Jammerland Bugt OWF were published on the 27th December 2018 through the Energy Agency webpage with the public consultation lasting until the 28th February 2019. The EIA, appropriate assessment and background reports for Omø Syd OWF were published on the 10th February 2017 through the Energy Agency webpage with the public consultation lasting until the 22nd April 2017. In addition public meetings were held at locations where interest in these proposed developments would be highest. The public hearings complied with the appropriate regulations and guidelines.

Several responses were submitted during the public hearing in relation to issues on common eider, velvet scoter and common scoter for both windfarms. Specifically five of the 20 received responses for Omø Syd OWF where related to the effects on seabirds and waterfowl and cumulative effects from other present or proposed Offshore Wind Farms. The letters were received from the Danish Environmental Protection Agency, Dansk Ornitologisk Forening, Agersø Naturcenter, Danmarks Naturfredningsforening and the last letter from a citizen.

For Jammerland Bugt OWF 440 response were received during the public hearing period of which the main focus of four were of issues relating to birds. These hearing responses was delivered from the Danish Environmental Protection Agency, the NGO: "Protection of Jammerland Bugt" and a citizen. The Danish Environmental Protection Agency and the other responses expressed concern about the impact on staging seaducks. It is especially the impact on common eider when Jammerland Bugt is assessed cumulatively with Omø Syd OWF as well as other existing Danish windfarms that has caused concern.

2.2 Implications for the current assessment

Following the public hearing the project areas for both windfarms have been reduced partly to reduce the impact on staging birds. Furthermore it was decided by the Danish Energy Agency, that a revised assessment on the potential displacement of common eider, common scoter and velvet scoter should be conducted for Omø Syd and Jammerland Bugt OWFs. This report presents this assessment. Specific concerns raised in the public hearing about cumulative impacts (see section 8), Appropriate Assessment (section 9) and survey effort (section 10.2.1) are also included in the present report.

3 Methodology

3.1 Summary of methods applied in EIAs for Jammerland Bugt and Omø Syd OWF

The summary of the methods applied in the bird assessment conducted in preparation of EIAs for the two offshore windfarms is based on the following reports:

- Omø Syd kystnær Havmøllepark. VVM – Vurdering af virkninger på miljøet og miljørapport, December 2016.
- Omø Syd kystnær havmøllepark: Teknisk baggrundsrapport. Påvirkninger på trækkende, rastende og ynglende fugle. December 2016.
- Omø Syd kystnær havmøllepark. Natura 2000-konsekvensvurdering. December 2016.
- Jammerland Bugt Kystnær Havmøllepark. VVM – Vurdering af virkninger på miljøet og miljørapport, November 2018.
- Jammerland Bugt kystnær havmøllepark: Teknisk baggrundsrapport. Påvirkninger på trækkende, rastende og ynglende fugle. May 2018.
- Jammerland Bugt kystnær havmøllepark: Fortrængning of tæthedsbetinget dødelighed for reduceret projektområde. January 2018.

3.1.1 Survey method

The assessment of staging birds in the Environmental Impact Assessment and Appropriate Assessment for Omø Syd OWF and the Environmental Impact Assessment for Jammerland Bugt OWF are both informed by project-specific baseline visual aerial surveys. For Omø Syd OWF, the survey area covered approximately 530 km^2 including the western part of Smålandsfarvandet between the coastline of Sjælland and the coastline of Lolland. For Jammerland Bugt OWF, the survey area covered approximately 442 km^2 and included Jammerland Bugt between the coast of Asnæs and a southern transect line between the coast of Sjælland and a point north of Kerteminde on the Fyn side.

The survey protocol adopted for both windfarms follows a standard line transect methodology for surveying offshore birds to provide data for calculation of population estimates. For Omø Syd OWF baseline surveys, a total of 13 parallel east-west oriented transects were flown with a 2 km distance between individual flight paths. For Jammerland Bugt a total of 11 parallel east-west oriented transects were flown with 2 km distance between individual flight paths. For both project specific baseline surveys a standard methodology were followed in accordance e.g. the Buckland et al. 2001. The line transect survey technique consisted of five perpendicular distance bands following the distance sampling approach of Buckland et al. 2001. The five standard bands used were: 0-44 m, 44-91 m, 91-163 m, 163-431 m, 431-1000 m. Data were then analysed with the distance sampling software "Distance" (Distance v.6. r2, http://www.ruwpa.st-and.ac.uk, Thomas, et al., 2010) to generate densities of staging birds within and around the project areas for each of the individual aerial surveys.

Five aerial surveys were conducted within the Omø Syd study area, two in autumn 2014 (30th October 2014 and 21st November 2014), one in winter 2014 (28th December 2014) and two in spring 2015 (9th March 2015 and 9th April 2015). Four aerial surveys were conducted within the Jammerland Bugt study area, two in autumn 2014 (30th October 2014 and 21st November 2014) and two in spring 2015 (9th March 2015 and 9th April 2015).

3.1.2 Displacement and displacement-dependent mortality

Two different methods are used to calculate the displacement estimates and displacement-dependent mortalities: 1) Orbicon's calculation method and 2) A statistic predictive distribution model developed by DHI (following the method used in the EIAs for Sejerø Bugt and Smålandsfarvandet OWF and described in details in Skov and Heinänen 2015). A summary of the two methods (as used by Orbicon) are provided in the following sections.

3.1.2.1 Descriptions of Orbicon's calculation method

Bird abundance and densities

Orbicon's calculation method of bird abundances and densities are merely based on the aerial surveys conducted as part of the preparation of the two EIAs. More specific it include five aerial surveys for Omø Syd conducted in 2014-2015 and four aerial surveys for Jammerland Bugt also conducted in 2014-2015. Abundance of staging birds were estimated for each of the aerial surveys and the distance sampling methodology was applied to calculate densities of staging birds for the entire survey area as well as for the two project areas including species specific buffer zones of 0,5 km for common eider, 1 km for velvet scoter and 2 km for common scoter. The method did not include density surface modelling.

Displacement and density-dependent mortality

Displacement calculation for each seaduck species is based on the one aerial survey with the highest total abundance estimate of all bird species. Based on the population densities, the number of expected displaced birds within the project area and the species specific buffer are calculated. As a conservative assumption it is expected that 90% of the birds (same rate for common eider, common scoter and velvet scoter) within the project area and the species specific buffer are displaced.

It is further assumed (following recommendation by Natural England 2014) that 10% of the displaced birds will die or becomes so weakened that they are unable to reproduce during the subsequent breeding season due to higher densities in the nearby areas and thereby higher competition for food etc.

3.1.2.2 *Descriptions of DHI's predictive distribution model*

Modelling of bird densities and distributions

Based on the aerial survey data (corrected for distance detection bias), estimations of the distributions and densities of target species of birds were conducted using a predictive distribution model.

Data included in the predictive distribution modelling for Omø Syd OWF includes data from the aerial surveys used in the bird assessment conducted by Skov & Heinänen (2015) in relation to another offshore windfarm project "Smålandsfarvandet" as well as data from the five aerial surveys conducted as part of the preparation of Orbicon's EIA for "Omø Syd Kystnær Havmøllepark". Thus data included in the modelling for Omø Syd OWF is based on 19 aerial surveys conducted in the time period 1999-2015.

Data included in the predictive distribution modelling for Jammerland Bugt OWF is identical with the data used in Orbicon's calculation method and include four aerial surveys conducted as part of the preparation of Orbicon's EIA for "Jammerland Bugt Kystnær Havmøllepark" in 2014-2015.

Four potentially important environmental predictors/variables were included in the model:

- Water depth
- Bottom slope
- Distance to land
- Bottom current speed

Data from the modelling for each bird species were extrapolated to cover a larger area than the surveyed area. The result of the modelling is a series of density maps for each bird species into 1x1 km^2 grids. Thus, the maps are based on bird counts along transects fed into a model, that extrapolate data, so the distributions and densities are shown for the an area (larger than the survey area) taking the potentially important environmental factors into account.

For each individual bird species predicted mean density maps for autumn, winter and spring is provided along with a map where predicted densities are classified into four "suitability" classes based on the number of birds within each of the 1x1 km^2 grid:

- Class 1: <25% of the birds are within this class
- Class 2: 25-75% of the birds are within this class
- Class 3: 75-90% of the birds are within this class
- Class 4: <90% of birds are within this class.

The season with highest abundance estimates of a specific bird species are used in the further calculation of displacement and density related mortality.

<u>Displacement and faith of displaced birds</u>
The modeled densities were used to estimate the numbers of displaced birds by calculating amount of birds within the wind farm area and within the species specific buffer around the wind farm (2 km for common eider and 3 km for common scoter and velvet scoter). It was assumed that 75% of the birds were displaced from the wind farm area and that 50% of the birds were displaced from the species specific buffer (same displacement rates for all species). The final step of the analysis was to restrict the relocation of the birds. It was assumed that displaced birds from each suitability class would only relocated into areas of similar habitat quality (based on the suitability class) outside the displacement zone associated with the wind farm.

<u>Density-dependent mortality</u>
Estimation of density-dependent mortalities caused by increases in densities in the areas outside the displacement zone associated with the wind farm were conducted following the method described in (Skov & Heinänen, 2015). It was assumed that a 1% increase in density would lead to a 2,5% increase in mortality. The rates are based on the Oystercatcher studies of (Durell, Goss-Custard, & McGrorty, 2000; Durell S. E., Goss-Custard, Stillman, & West, 2001; Goss-Custard & Durell, 1984) as Oystercatcher is one of the few species in which the density-dependence of overwintering mortality has been quantified.

3.2 Applied method in the present assessment

3.2.1 Population data

The current assessment was dependent on the density surface estimates provided by the EIA for Omø Syd and Jammerland Bugt Offshore Windfarms. These density surfaces estimates was supplemented by density surface estimates from the EIA for Smålandsfarvandet OWF. Orbicon modelled their density surfaces using the method developed by DHI for the EIA of Smålandsfarvandet OWF (see 3.1.2.2) and therefor the density surfaces were comparable. The modelled density surfaces of common eider, common scoter and velvet scoter for each survey were made available to the current assessment by Orbicon for Omø Syd and Jammerland Bugt OWF and by DHI for Smålandsfarvandet OWF, as estimated densities for each grid cell of 1x1 km.

To assess the possible impact from Jammerland Bugt and Omø Syd OWF on a national scale and related to the Danish jurisdictional territory national wintering populations estimates were identified. The national wintering population estimate for common eider, common scoter and velvet scoter used in the analysis was taken from a recent report published by the Danish Centre for Environment and Energy (DCE) (Clausen, Petersen, Bregnballe, & Nielsen, 2019). Data used in the DCE report is mainly based on National Monitoring and Assessment Program for the Aquatic and Terrestrial Environment (NOVANA) avian monitoring results from the years 2004-2017. The most recent national wintering population estimates are 586,900 for common eider, 387,300 for common scoter and 31,300 for velvet scoter (Clausen, Petersen, Bregnballe, & Nielsen, 2019).

The assessment of possible impacts related to the internationally protected populations of affected seaduck species was related to the flyway population estimates. The most recent revision of the flyway population estimates for common eider is, 980,000 for common scoter 1,200,000 and for Velvet scoter 400,000 (Wetlands International, 2019).

3.2.2 Population trends

The following section provides a brief narrative of recent population trends for common eider, common scoter and velvet scoter nationally and for the biogeographic migratory flyway as predicted to interact with the projects. This appraisal is later used as a guide in the selection of the recovery factor *f* for common eider, common scoter and velvet scoter to be used in the PBR analysis.

3.2.2.1 Common eider

Within Europe, common eider has experienced moderate declines which have not been compensated for by increases elsewhere in the species' range. Declines are thought to be driven by a range of threats including overharvesting of aquatic resources, pollution, disturbance and hunting. In Denmark, estimates for wintering birds show an decreasing trend (BirdLife International, 2020).

3.2.2.2 Common scoter

The overall trend emerging from international trend estimates for wintering birds in Europe shows a decline in long-term, whereas a stable trend in short-term. In Denmark, estimates for wintering birds show an increasing trend in the short-term and fluctuations in the long-term (BirdLife International, 2020).

3.2.2.3 Velvet scoter

The international population of velvet scoter is estimated to have undergone a population decline of 30-49% over the last three generations (estimated at 23 years based on a generation length of 7.5 years). It was previously estimated to be undergoing very rapid population declines; however the rate of decline has apparently slowed. The national trend estimates show a similar trend with a decreasing/fluctuation population estimate (BirdLife International, 2020).

3.3 Assessment methodology

3.3.1 The 1% threshold

The assessment of impact on national and international population estimates was held up against a threshold level criteria of 1% of the populations estimates. The 1% criteria is a generally accepted threshold to distinguish between non-significant and possible significant effects on a population level (NIRAS, 2015; NIRAS, 2015; Clausen, Petersen, Bregnballe, & Nielsen, 2019; Energinet.dk, 2014).

3.3.2 Potential Biological Removal (PBR) method

Potential Biological Removal (PBR) is defined as the maximum number of animals, not including in natural mortalities that may be removed annually from a population while allowing that population to reach or maintain its optimal sustainable population level. This is most often used on marine mammal populations, but have also been used in several EIAs including Omø Syd and Jammerland Bugt. It gives an easy limit to assess against but has often been criticised for being difficult to use, as many factors included in the method is hard to assess (Green, 2014; Cook & Robinson, 2016). How to use PBR is described in detail in section 4.2.

4 Overview of analysis

4.1 Displacement

The approach to displacement analysis used in this report has followed the published guidance for displacement analysis in the UK (JNCC, 2017). Displacement effects are calculated and presented using a range of displacement and mortality rates. For the assessment, it has been possible to define a worse case displacement scenario using the empirical data on displacement effects from a number of studies (see Section 4.1.3).

4.1.1 Seasonal extents

The following seasonal extents have been applied for all species, with these consistent with the seasonal extents used in previous assessments in this area (e.g. NIRAS, 2016):

- Summer: May to August
- Autumn: September and October
- Winter: November to February
- Spring: March and April

These seasons approximate respectively to post-breeding moult of males/immatures, post-breeding moult of adult females, winter and spring passage for all three species.

4.1.2 Population estimates

It is recommended that displacement analysis be conducted using seasonal mean-peak population estimates and that these estimates should be calculated using at least two years of data in order to capture the inherent variability in bird populations within assessments (JNCC, 2017).

For both projects, site-specific baseline aerial surveys were undertaken. Five aerial surveys were conducted within the Omø Syd study area, two in autumn 2014 (30th October 2014 and 21st November 2014), one in winter 2014 (28th December 2014) and two in spring 2015 (9th March 2015 and 9th April 2015). Four aerial surveys were conducted within the Jammerland Bugt study area, two in autumn 2014 (30th October 2014 and 21st November 2014) and two in spring 2015 (9th March 2015 and 9th April 2015).

In addition to these data, aerial surveys have been previously conducted across a wider geographical area at Smålandsfarvandet which incorporates the Omø Syd project area (the Smålandsfarvandet dataset). There are data from sixteen surveys for common scoter and four for velvet scoter and common eider.

The data is for both Omø Syd, Jammerland Bugt and Smålandsfarvandet OWF present as modelled density surface estimates.

To include all surveys covering areas with potential displacement from the wind farms a buffer was included around the OWFs. JNCC *et al.* (2017) recommends that a 4 km buffer is used for seaducks to account for the increased sensitivity to displacement impacts exhibited by these species. Petersen *et al.* (2014) indicates that displacement effects on common scoter, within Danish waters may occur out to 5 km. This study did however indicate that there was a linear decrease in effect across this area (see Section 4.1.3) whereas the advice in the UK would generally be to apply a constant 100% displacement rate across the entire wind farm and 4 km buffer, accepting that displacement effects may occur over a larger area but the use of a 100% displacement rate would account for this in terms of the effect predicted. In this report the information in Petersen *et al.* (2014) is applied to provide a displacement effect that is based upon empirical evidence.

The densities from those surveys in the Smålandsfarvandet dataset that overlap with Omø Syd plus a 5 km buffer area have been extracted. From these densities the mean value has been calculated and used for displacement analysis for each month. The data from Smålandsfarvandet for common scoter consists of aerial surveys undertaken between February 1999 and April 2014 (Table 4.1). These data are, in some cases, more than five years old. It is considered that data more than five years old is not contemporaneous and may therefore not reflect current conditions with this supported by the changes in the national populations of the three key species as reported in Clausen *et al.* (2019) and the trends evident in the data extracted from the Smålandsfarvandet dataset. In order to balance this against the data needs for displacement analysis to provide a measure of inter-annual variability, only data from 2013 and 2014 in the Smålandsfarvandet dataset have been included in the analyses presented in this report with these years consistent with those during which site-specific surveys for Omø Syd were undertaken (in 2014 and 2015).

It is therefore possible to calculate seasonal mean-peak population estimates for Omø Syd after including the relevant data from the Smålandsfarvandet dataset, however note that the datasets available do not cover every month in the defined seasons and do not provide data for the breeding season.

It is not possible to calculate seasonal mean-peak population estimates for Jammerland Bugt as only one year of data is available. The maximum population within a season is therefore used for displacement analyses as this population would be incorporated into the calculation of a mean-peak population if another year of data were available. It is however important to note that it is not possible to know if this represents an over- or under-estimation of the likely impact and hence must be interpreted in that context.

Further discussion on the limitations of the datasets used for the displacement analyses presented in this report for both Omø Syd and Jammerland Bugt is provided in Section 10.2.1.

Table 4.1: Timing of aerial surveys undertaken covering Jammerland Bugt (JB) and Omø Syd (OS) with density surface modelled data available to this assessment.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1999		OS	OS						OS		OS	OS
2000		OS	OS	OS								
2004	OS											
2008	OS											
2012								OS				
2013	OS									OS	OS	
2014			OS	OS						OS JB	OS JB	OS
2015			OS JB	OS JB								

4.1.3 Displacement rates

JNCC *et al*. (2017) indicates that UK Statutory Nature Conservation Bodies (SNCBs) intend to use 'Disturbance Susceptibility' scores from Bradbury *et al*. (2014) (which have been updated by Wade *et al.* (2016) as a general guide to the appropriate displacement levels to apply for a species. JNCC *et al.* (2017) suggests that a displacement rate range of 90-100% should be used for species with a high vulnerability, 30-70% should be used for species with a moderate vulnerability and 10% should be used for species with a low vulnerability. Wade *et al.* (2016) identifies common scoter and velvet scoter as species of high vulnerability to displacement which would therefore suggest a displacement rate range of 90-100%. Common eider is identified as a species with moderate vulnerability to displacement and therefore a displacement rate range of 30-70% may be appropriate.

Although concentrating on birds in flight, the study of the operational Egmond aan Zee wind farm by Krijgsveld *et al*. (2011) is one of the more in-depth studies determining the effect of the presence of operational turbines on birds. Based on radar and panorama scans, macro-avoidance rates (i.e. birds avoiding the wind farm as a whole) were assessed for the majority of species groups present, and this behaviour is likely to be indicative of displacement risks. For scoters an average macro-avoidance rate of 68% was estimated with a 71% avoidance rate for seaducks combined.

Petersen & Fox (2007) showed that common scoter avoided both the Horns Rev 1 and Nysted offshore wind farms. At Horns Rev common scoters responded to the presence of the wind farm by general avoidance to the wind farm area but with aggregations of birds within a few hundred metres of the wind farm. At Nysted fewer birds were recorded but there was a general indication that birds were avoiding the wind farm. Further studies at Horns Rev 1 showed that during operation encounter rates of common scoter within and outside the wind farm did not differ and showed that gradually higher percentages of birds within the study area were found both in the wind farm and at distances out to 6 km. These studies suggest that common scoters will habituate to the presence of an offshore wind farm and that offshore wind farms may actually create conditions preferable to the species.

Petersen *et al.* (2014) recorded significant decreases in the abundance of common scoter in and around the Horns Rev 2 offshore wind farm strongly suggested a behavioural response of birds to turbine presence post-construction. However, birds were also frequently seen foraging between the turbines. Petersen *et al.* (2014) calculated displacement rates for each 500 m buffer surrounding Horns Rev 2 showing a decreasing displacement effect as distance from the wind farm increased, however no displacement rate is presented for the wind farm area. Previous assessments based upon the information presented in Petersen *et al.* (2014) have however used a 70% displacement rate for the wind farm area (NIRAS, 2016).

Studies at the Robin Rigg wind farm in the Solway Firth, Scotland recorded increases in the population of common scoter post-construction of the wind farm with birds also observed in the wind farm (Nelson & Caryl, 2015).

It is therefore considered that an initial displacement rate of 70% is appropriate, with this consistent with the rate used in the assessments for other offshore wind farms in this area (e.g. NIRAS, 2016). However, assessments should take into account the apparent habituation behaviour of common scoter once a project is operational and thereby a potential decrease in displacement from the OWF (Petersen *et al.,* 2014). There is more limited empirical information available for velvet scoter and therefore given the similarities between the two species, it is proposed that a 70% displacement rate is also applied for this species.

Common eider is described as 'consistently indifferent' to the presence of offshore wind farms by Vanerman and Stienen (2019) with a number of studies supporting this. Such a response has been observed at the Tunø Knob offshore wind farm where, although there was a significant decline in the number of eider at the wind farm between pre- and post-construction, such changes were identified as being due to natural variability (Guillemette, Larsen, & Clausager, 1999). Similar behaviour has been observed at both Horns Rev 1 and Nysted (Petersen, Christensen, Kahlert, Desholm, & Fox, 2006) and Lillgrund (Nilsson & Green, 2011). Common eider may therefore not be sensitive to displacement impacts however, on a precautionary basis the displacement rate range as derived by applying the JNCC *et al.* (2017) is used in this report (i.e. 30-70%). The displacement rates applied for each species (and justification) for each of the projects are presented in Table 4.2

Table 4.2: Precautionary displacement rates and justification applied for common scoter, velvet scoter and common eider.

Species	Displacement rate (%)	Justification
Common scoter	70	Multiple studies suggest displacement rates of approximately 70% (e.g. Petersen *et al.,* 2014; Krijsveld *et al.,* 2011). Some studies have also suggested a decrease in displacement as distance from a wind farm increases (e.g. Petersen *et al.,* 2014) or habituation after a number of years (e.g. Petersen *et al.,* 2006).
Velvet scoter	70	Limited empirical evidence available for velvet scoter however, it is considered appropriate to apply the same displacement rate as used for common scoter due to the similarities between the two species
Common eider	30-70	A number of studies suggest common eider is 'consistently indifferent' to the presence of wind farms although others have suggested strong avoidance responses. A displacement rate range based on the guidance provided in JNCC *et al.* (2017) has therefore been used

4.1.4 Mortality rates

When assessing the resultant effects of displacement on a population, it is recognised that a worst-case scenario of 100% mortality for displaced birds is unrealistic and over-precautionary (e.g. Wind, 2014, Natural England 2014). It is predicted, in the first instance, that birds displaced from the windfarm and adjacent buffers, will relocate to other areas of suitable habitat where the mortality of birds would increase as density increases (density-dependent mortality). The assumption is that as bird density increases, pressure on prey resources also increases. Limitations on prey availability and the consequent competition for resources will lead to reduced fitness of individuals that will be expressed in terms of reduced reproduction rates and in consequence, a reduced population size supported year on year by suitable habitats.

There is little or no evidence on what displacement impacts may be for any of the three species. In the absence of such empirical data, a generic range (i.e. not species-specific) of 1-10% has been recommended for use in the assessments for project in UK waters. A range of 1-10% has previously been recommended by Natural England when considering impacts on auk (Alcidae) species, diver species and gannet (*Morus bassanus*) as the potential upper limit of mortality effects following displacement (e.g. see documentation associated with the planning application for Hornsea Project One (Smart Wind, 2014) and Hornsea Project Two (Natural England, 2014) and Norfolk Vanguard (Natural England, 2018) .

For the purposes of this assessment, a range of mortality rates from 1 to 20% has therefore been assumed for displaced birds to account for uncertainty and that the actual value is likely to vary with season. For example, the additional constraints that moult imposes upon a bird (NIRAS, 2015), may have the potential for displacement to lead to greater mortality or carry-over effect on population size during the moulting period than at other times, though the study area population is smaller in total size. Therefore a single displacement scenario with a range of mortality level effects is taken through to the assessment stage for each of the two scenarios for the design of the two windfarms.

4.2 Potential Biological Removal

4.2.1 Overview

PBR has however been included in this report to allow for comparison to the EIA reports. There are issues associated with the use of PBR for the assessment of impacts on bird populations arising from offshore wind farms and these are discussed in Section 10.4.

4.2.2 Methodology

PBR has been calculated replicating the methodology applied in Zydelis & Heinänen (2014) and Žydelis et al. (2015). However, NIRAS (2015) highlights a number of important considerations that have been taken into account within the approach to PBR presented here:

- Improved clarity required when outlining methodology and the use of population trends
- The limitations of PBR should be discussed in terms of the application of PBR for assessment purposes

The PBR approach used here takes no account of anthropogenic mortality sources, as previously considered in Zydelis & Heinänen (2014) and Žydelis et al. (2015). The inclusion of such mortality sources and the effect these have on PBR is considered to be purely conjecture and therefore unhelpful in terms of focusing any assessment.

The application of PBR in windfarm assessments has been criticized by some authors (e.g. Green, 2014; Cook & Robinson, 2016) and is no longer recommended for use as part of the assessments for projects in UK waters. A population incurring additional mortality caused by an intervention such as a wind energy project which is below the level defined by a PBR may still be likely to decline substantially below the population size that would have occurred in the absence of the project. PBR calculations do not themselves provide an estimate of how large this difference between the population with and without the intervention is expected to be. It is therefore recommended that the assessment does not rely solely on PBR and provides a comprehensive summary of potential impacts. However, there is no agreed population modelling method to apply for the populations of interest in this report and it is outside the scope of this report to provide an alternative method.

PBR provides a means of estimating the number of additional mortalities that a given population can sustain. Wade (1998) and others have defined a simple formula for PBR:

$$PBR = \frac{1}{2} r_{max} N_{min} f$$

Where:

r_{max} is the maximum annual recruitment rate

N_{min} is a conservative estimate of the population size

f is a "recovery factor" applied to depleted populations where the management goal may be to facilitate growth back to a target population size

Wade (1998) showed that PBR can be used to identify sustainable harvest rates that would maintain populations at, or above, maximum net productivity level (MNPL or maximum sustained yield). Based on a generalized logistic model of population growth and assuming that the density dependency in the population growth is linear (θ =

1.0) then MNPL is equivalent to 0.5K (where K is the notion-al carrying capacity) and the net recruitment rate at MNPL (RMNPL) is 0.5 r_{max}.

Wade (1998) also showed that PBR is conservative for populations with θ > 1.0 (i.e. a convex density-dependent growth curve) where RMNPL will be > 0.5 r_{max} (see Figure 1 in Wade 1998).

4.2.3 Estimating r_{max}

The maximum annual recruitment rate (r_{max}) is equivalent to λ_{max} – 1, therefore:

$$r_{max} = \lambda_{max} - 1$$

Where:

λ_{max} is the maximum discrete rate of population growth.

Niel & Lebreton (2005) show two methods for calculating λ_{max}:

- A quadratic solution (equation 15 of Niel & Lebreton 2005) also used by Watts (2010):

$$\lambda_{max} \approx \frac{(s\alpha - s + \alpha + 1) + \sqrt{(s - s\alpha - \alpha - 1)^2 - 4s\alpha^2}}{2a}$$

- And a relationship based on mean optimal generation length (equation 17 of Niel & Lebreton 2005):

$$\lambda_{max} = exp\left[\left(\alpha + \frac{s}{\lambda_{max} - s}\right)^{-1}\right]$$

Where:

s is annual adult survival

ɑ is age of first breeding

Niel & Lebreton (2005) suggest that the second method is most suitable for short-lived species. A comparison of the results of both methods indicated that the first generated slightly more precautionary PBRs for the relatively long-lived species considered in this report. Consequently λ_{max} has been estimated using the first method for all species below.

4.2.4 Estimating N_{min}

N_{min} is a conservative estimate of the population size. For the purposes of this assessment, N_{min} is taken as the lower population estimate for each of the species from Wetlands International (2019). Zydelis & Heinänen (2014) and Žydelis *et al.* (2014) uses the 20th percentile of the population estimate, this approach has not been applied here due to a lack of clarity as to the application of this approach in Zydelis & Heinänen (2014) and Žydelis *et al*. (2015).

4.2.5 Selecting *f*

The recovery factor *f* is an arbitrary value set between 0.1 and 1.0 and its purpose is to increase conservatism in the calculation of PBR or to identify a value for PBR that is intended to achieve a specific outcome for nature conservation (e.g. population recovery).

Dillingham & Fletcher (2008) link the value of *f* to conservation status and (following IUCN status criteria) suggest that *f* = 0.1 is adopted for 'threatened' species; *f* = 0.3 for 'near threatened' species and *f* = 0.5 for species of 'least concern'. They further argue that a value of *f* = 1.0 may be suitable for species of 'least concern' that are known to be increasing or stable.

A similar scheme could be used for individual populations and their status in relation to specific conservation objectives.

4.2.6 Sensitivity of PBR estimate

Dillingham & Fletcher (2008) discuss the sensitivity of the PBR estimate in relation to variability in survival rates and age of first breeding. It is generally the case that survival estimates are derived in non-optimal conditions or estimates have not been adjusted for possible emigration from the study area. When so, consideration of the impact of changes in different survival estimates on the PBR by Dillingham & Fletcher (2008) has led to the recommendation that conservative (i.e. high) survival estimates should be used to avoid over-estimation of λ_{max} and PBR. As such, it is not considered inappropriate to use the survival estimates as published by Waterbird population estimates – Conservation Status Report 7 Edition (CSR7) in the current analysis.

For seabirds and -ducks with delayed fecundity and high survival, Dillingham & Fletcher (2008) stated changes in ɑ lead to only small changes in λ_{max} Fecundity and age-specific breeding success of seaducks increases in the initial two or three years of breeding. Mid-point values for ɑ are usually appropriate, while high values lead to conservative estimates of λ_{max} and PBR (Dillingham & Fletcher 2008). The current analysis uses the typical age of first breeding (ɑ) as published by Horswill & Robinson (2015).

5 Displacement analyses for Omø Syd OWF

5.1 Assessment against the national and flyway populations

As presented in section 3.2 the assessments are done with reference to the national populations estimates and the international population estimates presented by the estimated flyway population. In the analysis presented below density dependent mortality in a range of 1 – 20 % of displaced birds are held up against a 1% criteria of the national and the international populations estimates respectively (see section 3.3.1).

5.1.1 Common eider

Monthly population estimates of common eider for Omø Syd plus 2 km buffer area as derived from modelled densities from the two density datasets from Omø Syd and Smålandsfarvandet are presented in Table 5.1.

Table 5.1: Population estimates (number of birds) of common eider for Omø Syd + 2 km buffer as derived from site-specific surveys and Smålandsfarvandet dataset

Month	Season	Site-specific surveys 2014-2015	Smålandsfarvandet surveys 2013-2014	Seasonal mean-peak
October	Autumn	48,439	9,038	28,739
November	Winter	45,070	9,285	27,178
December		9,982	-	
March	Spring	3,351	22,926	13,139
April		0	11,504	

Seasonal displacement mortality for common eider, assuming a 30-70% displacement rate is calculated in Table 6.5. Full displacement matrices for common eider at Omø Syd incorporating a full range of displacement and mortality rates are presented in Appendix 1.

Table 5.2:Predicted common eider mortality (number of birds) as a result of displacement from Omø Syd + 2 km buffer during different seasons

Season	Displacement rate (%)	Mortality rate (%)				
		1	2	5	10	20
Autumn	30	86	172	431	862	1,724
	70	201	402	1,006	2,012	4,023
Winter	30	82	163	408	815	1,631
	70	190	380	951	1,902	3,805
Spring	30	39	79	197	394	788
	70	92	184	460	920	1839

<1% national population	>1% national population/<1% international population	>1% international population

All possible effects on both national as international population level of common eider are assessed to be below the 1% threshold.

5.1.2 Common scoter

Monthly population estimates of common scoter for Omø Syd plus 5 km buffer area as derived from modelled densities from the two density datasets from Omø Syd and Smålandsfarvandet are presented in Table 5.3.

Table 5.3: Population estimates (number of birds) of common scoter for Omø Syd + 5 km buffer as derived from site-specific surveys and Smålandsfarvandet dataset

Month	Season	Site-specific surveys 2014-2015	Smålandsfarvandet surveys 2013-2014	Seasonal mean-peak
October	Autumn	2,831	1,286	2,059
November	Winter	2,465	1,546	4,739
December		805		
January			7,013	
March	Spring	3,128	7,486	22,011
April		6,298	37,724	

Seasonal displacement mortality for common scoter, assuming a 70% displacement rate in the wind farm area and a linear decline in displacement out to 5 km based on the results presented in Petersen *et al.* (2014) is calculated in Table 5.4.

Table 5.4: Predicted common scoter displacement (number of birds) from Omø Syd + 5 km buffer during different seasons when using a 70% displacement

Season	Population estimate	Displaced population
Autumn	2,059	387
Winter	4,739	786
Spring	22,011	4,310

Displacement mortality for common scoter is calculated in Table 5.5 using a range of mortality rates (1-20%). Full displacement matrices for common scoter at Omø Syd incorporating a wider range of mortality rates are presented in Appendix 1.

Table 5.5: Predicted common scoter mortality (number of birds) as a result of displacement from Omø Syd and 5 km buffer during different seasons

Season	Mortality rate (%)				
	1	2	5	10	20
Autumn	4	8	19	39	77
Winter	8	16	39	79	157
Spring	43	86	215	431	862
<1% national population		>1% national population/<1% international population		>1% international population	

All possible effects on both national as international population level of common scoter are assessed to be below the 1% threshold.

5.1.3 Velvet scoter

Monthly population estimates of velvet scoter for Omø Syd plus 5 km buffer area as derived from modelled densities from the two density datasets from Omø Syd and Smålandsfarvandet are presented in Table 5.6.

Table 5.6; Population estimates (number of birds) of velvet scoter for Omø Syd + 5 km buffer as derived from site-specific surveys and Smålandsfarvandet dataset

Month	Season	Site-specific surveys 2014-2015	Smålandsfarvandet surveys 2013-2014	Seasonal average
October	Autumn	302	375	338
November	Winter	2,516	847	1,682
December		654		
March	Spring	552	2,717	2,109
April		1,473	2,744	

Seasonal displacement mortality for velvet scoter, assuming a 70% displacement rate in the wind farm area and a linear decline in displacement out to 5 km based on the results presented in Petersen *et al.* (2014) for common scoter is calculated in Table 5.7.

Table 5.7: Predicted velvet scoter displacement (number of birds) from Omø Syd + 5 km buffer during different seasons when using a 70% displacement

Season	Population estimate	Displaced population
Autumn	338	54
Winter	1,682	248
Spring	2,109	395

Displacement mortality for velvet scoter is calculated in Table 5.8 using a range of mortality rates (1-20%). Full displacement matrices for velvet scoter at Omø Syd incorporating a wider range of mortality rates are presented in Appendix 1.

Table 5.8: Predicted velvet scoter mortality (number of birds) as a result of displacement from Omø Syd + 5 km buffer during different seasons

Season	Mortality rate (%)				
	1	2	5	10	20
Autumn	1	1	3	5	11
Winter	2	5	12	25	50
Spring	4	8	20	39	79
<1% national population		>1% national population/<1% international population		>1% international population	

All possible effects on both national as international population level of velvet scoter are assessed to be below the 1% threshold.

5.2 Summary

In summary all possible calculated effects on a population level based on estimated mortality rates from 1 – 20% of displaced birds and for all species of seaducks results in no significant impact when compared to the 1% threshold of the national and international population estimates respectively.

6 Displacement analyses for Jammerland Bugt OWF

6.1 Assessment against the national and flyway populations

As presented in section 3.2 the assessments are done with reference to the national populations estimates and the international population estimates presented by the estimated flyway population. In the analysis presented below density dependent mortality in a range of 1 – 20 % of displaced birds are held up against a 1% criteria of the national and the international populations estimates respectively (see section 3.3.1).

6.1.1 Common eider

Monthly population estimates of common eider for Jammerland Bugt plus 2 km buffer area as derived from modelled densities from the density dataset from Jammerland Bugt are presented in Table 6.1.

Table 6.1: Population estimates (number of birds) of common eider for Jammerland Bugt + 2 km buffer as derived from site-specific surveys 2014-2015

Month	Season	Population estimate	Seasonal maximum
October	Autumn	2,118	2,118
November	Winter	16,821	16,821
March	Spring	3,580	3,580
April		66	

Seasonal displacement mortality for common eider, assuming a 30-70% displacement rate range is calculated in Table 6.5. Full displacement matrices for common eider at Jammerland Bugt incorporating a full range of displacement and mortality rates are presented in Appendix 1.

Table 6.2: Predicted common eider mortality (number of birds) as a result of displacement from Jammerland Bugt + 2 km buffer during different seasons

Season	Displacement rate (%)	Mortality rate (%)				
		1	2	5	10	20
Autumn	30	6	13	32	64	127
	70	15	30	74	148	297
Winter	30	50	101	252	505	1,009
	70	118	235	589	1,177	2,355
Spring	30	11	21	54	107	215
	70	25	50	125	251	501

<1% national population	>1% national population/<1% international population	>1% international population

All possible effects on both national as international population level of common eider are assessed to be below the 1% threshold.

6.1.2 Common scoter

Monthly population estimates of common scoter for Jammerland Bugt plus 5 km buffer area as derived from modelled densities from the density dataset from Jammerland Bugt are presented in Table 6.3.

Table 6.3: Population estimates (number of birds) of common scoter for Jammerland Bugt + 5 km buffer as derived from site-specific surveys 2014-2015

Month	Season	Population estimate	Seasonal maximum
October	Autumn	588	588
November	Winter	6,266	6,266
March	Spring	805	805
April		229	

Seasonal displacement mortality for common scoter, assuming a 70% displacement rate in the wind farm area and a linear decline in displacement out to 5 km based on the results presented in Petersen *et al.* (2014) is calculated in Table 6.4.

Table 6.4: Predicted common scoter displacement (number of birds) from Jammerland Bugt + 5 km buffer during different seasons when using a 70% displacement

Season	Population estimate	Displaced population
Autumn	588	38
Winter	6,266	852
Spring	805	169

Displacement mortality for common scoter is calculated in Table 6.5 using a range of mortality rates (1-20%). Full displacement matrices for common scoter at Jammerland Bugt incorporating a wider range of mortality rates are presented in Appendix 1.

Table 6.5: Predicted common scoter mortality (number of birds) as a result of displacement from Jammerland Bugt + 5 km buffer during different seasons

Season	Mortality rate (%)				
	1	2	5	10	20
Autumn	0	1	2	4	8
Winter	9	17	43	85	170
Spring	2	3	8	17	34
<1% national population		>1% national population/<1% international population		>1% international population	

All possible effects on both national as international population level of common scoter are assessed to be below the 1% threshold.

6.1.3 Velvet scoter

Monthly population estimates of velvet scoter for Jammerland Bugt plus 5 km buffer area as derived from modelled densities from the density dataset from Jammerland Bugt are presented in Table 6.6.

Table 6.6: Population estimates (number of birds) of velvet scoter for Jammerland Bugt + 5 km buffer as derived from site-specific surveys 2014-2015

Month	Season	Population estimate	Seasonal maximum
October	Autumn	15	15
November	Winter	1,564	1,564
March	Spring	482	482
April		62	

Seasonal displacement mortality for velvet scoter, assuming a 70% displacement rate in the wind farm area and a linear decline in displacement out to 5 km based on the results presented in Petersen *et al.* (2014) is calculated in Table 6.7.

Table 6.7: Predicted common scoter displacement (number of birds) from Jammerland Bugt + 5 km buffer during different seasons when using a 70% displacement

Season	Population estimate	Displaced population
Autumn	15	11
Winter	1,564	380
Spring	482	282

Displacement mortality for velvet scoter is calculated in Table 6.8 using a range of mortality rates (1-20%). Full displacement matrices for velvet scoter at Jammerland Bugt incorporating a wider range of mortality rates are presented in Appendix 1.

Table 6.8: Predicted velvet scoter mortality (number of birds) as a result of displacement from Jammerland Bugt + 5 km buffer during different seasons

Season	Mortality rate (%)				
	1	2	5	10	20
Autumn	0	0	1	1	2
Winter	4	8	19	38	76
Spring	3	6	14	28	56

<1% national population	>1% national population/<1% international population	>1% international population

All possible effects on both national as international population level of velvet scoter are assessed to be below the 1% threshold.

6.2 Summary

In summary all possible calculated effects on a population level based on estimated mortality rates from 1 – 20% of displaced birds and for all species of seaducks results in no significant impact when compared to the 1% threshold of the national and international population estimates respectively.

7 Potential Biological Removal

7.1 Overview

PBR is generally no longer recommended as an approach for assessing impacts from offshore wind farms on bird populations. PBR has however been included in this report to allow for comparison to the EIA reports. Further discussion on the use of PBR in assessments for ornithological receptors at offshore wind farms is provided in Section 10.4. The PBR method are describes in summary in section 3.3.2.

7.2 Selecting the recovery factor *f*

Clausen *et al.* (2019) presents the most recent international population counts for common scoter, velvet scoter and common eider.

For common scoter, the population declined between 2004-09 and 2010-15 but has remained stable since (to 2016). If it is assumed that the international population of common scoter is currently stable then a recovery factor of 0.5 is considered appropriate. This species is classified under the IUCN Red List Criteria as of Least Concern (BirdLife International, 2020) reports that the population trend for the European breeding population is unknown whereas the trend for the European wintering population is increasing.

For velvet scoter, Clausen *et al.* (2019) indicates that the international population has decreased between 2004-09 and 2010-15 and continued to decrease into 2016-21. A similar trend is also evident for the European population (BirdLife International, 2020) although the wintering population is classed as ‘fluctuating’. This species is classified under the IUCN Red List Criteria as Vulnerable (BirdLife International, 2020). A decreasing population trend would support the use of a recovery factor of 0.1-0.3.

For common eider, Clausen *et al.* (2019) suggests that the international population increased between 2004-09 and 2010-15 and has remained stable since. However, Birdlife International (2020) suggests that the European population has decreased. The international population has shown recent increases, suggesting that a recovery factor of 0.5-1.0 may be appropriate. A decreasing European population would suggest that a recovery factor of 0.1-0.3 would be appropriate.

7.3 Potential Biological Removal

Table 7.1 presents the PBR values for the national and biogeographic migratory flyway populations of results for the three species predicted to interact with the two projects for a range of recovery factors.

Table 7.1:Potential Biological Removal for national and international migratory flyway population for the three species for a range of recovery factors.

Species	Popula-tion	Population size[1]	Age of First Breeding (α)[2]	Annual Adult Sur-vival (s)[3]	Growth Rate (λmax)	Population Trend	*f= 0.1*	*f=0.2*	*f=0.3*	*f= 0.4*	*f= 0.5*	*f= 1.0*
Common eider	Interna-tional	980000	3	0.886	1.16061	Increasing	7,870	15,739	23,609	31,479	39,348	78,697
	National	568900				Decreasing	4,568	9,137	13,705	18,274	22,842	45,684
Common scoter	Interna-tional	1200000	3	0.783	1.20617	Long-tern decline, short-tern stable	12,370	24,741	37,111	49,481	61,852	123,703
	National	387300				Increasing	3,993	7,985	11,978	15,970	19,963	39,925
Velvet scoter	Interna-tional	400000	2	0.773	1.28489	Decreasing	5,698	11,396	17,094	22,792	28,489	56,979
	National	31300				Decreas-ing/fluctu-ating	446	892	1,338	1,783	2,229	4,459

[1] Clausen *et al.* (2019)
[2] Horswill and Robinson (2015)
[3] Horswill and Robinson (2015)

7.4 Predicted mortality rates from displacement in terms of PBR

7.4.1 Omø Syd OWF

The following tables present the predicted seasonal mortality for each of the key species arising from displacement at Omø Syd with respect to the Danish wintering population estimate as represented by the equivalent PBR recovery factor (f) value. Recovery factors are presented for a range of displacement and mortality rates using the mean/mean-maximum and maximum population estimates for each species.

Table 7.2: Common eider predicted mortality arising from displacement at Omø Syd OWF for each season with respect to the Danish wintering population estimate as represented by the equivalent PBR recovery factor (f) value.

Season	Displace-ment rate (%)	Mortality rate (%)				
		1	2	5	10	20
Autumn	30	0.0	0.0	0.0	0.0	0.1
	70	0.0	0.0	0.1	0.1	0.2
Winter	30	0.0	0.0	0.0	0.0	0.1
	70	0.0	0.0	0.0	0.1	0.2
Spring	30	0.0	0.0	0.0	0.0	0.1
	70	0.0	0.0	0.0	0.1	0.1

Table 7.3: Common scoter predicted mortality arising from displacement at Omø Syd OWF for each season with respect to the Danish wintering population estimate as represented by the equivalent PBR recovery factor (f) value.

Season	Mortality rate (%)				
	1	2	5	10	20
Autumn	0.0	0.0	0.0	0.0	0.0
Winter	0.0	0.0	0.0	0.0	0.0
Spring	0.0	0.0	0.0	0.0	0.1

Table 7.4: Velvet scoter predicted mortality arising from displacement at Omø Syd OWF for each season with respect to the Danish wintering population estimate as represented by the equivalent PBR recovery factor (f) value.

Season	Mortality rate (%)				
	1	2	5	10	20
Autumn	0.0	0.0	0.0	0.0	0.0
Winter	0.0	0.0	0.0	0.0	0.1
Spring	0.0	0.0	0.0	0.0	0.1

7.4.2 Jammerland Bugt OWF

The following tables present the predicted seasonal mortality for each of the key species arising from displacement at Jammerland Bugt with respect to the Danish wintering population estimate as represented by the equivalent PBR recovery factor (f) value. Recovery factors are presented for a range of displacement and mortality rates using the mean/mean-maximum and maximum population estimates for each species.

Table 7.5: Common eider predicted mortality arising from displacement at Jammerland Bugt OWF for each season with respect to the Danish wintering population estimate as represented by the equivalent PBR recovery factor (f) value.

Season	Displacement rate (%)	Mortality rate (%)				
		1	2	5	10	20
Autumn	30	0.0	0.0	0.0	0.0	0.0
	70	0.0	0.0	0.0	0.0	0.1
Winter	30	0.0	0.0	0.0	0.0	0.1
	70	0.0	0.0	0.0	0.1	0.2
Spring	30	0.0	0.0	0.0	0.0	0.0
	70	0.0	0.0	0.0	0.0	0.0

Table 7.6: Common scoter predicted mortality arising from displacement at Jammerland Bugt OWF for each season with respect to the Danish wintering population estimate as represented by the equivalent PBR recovery factor (f) value.

Season	Mortality rate (%)				
	1	2	5	10	20
Autumn	0.0	0.0	0.0	0.0	0.0
Winter	0.0	0.0	0.0	0.0	0.0
Spring	0.0	0.0	0.0	0.0	0.0

Table 7.7: Velvet scoter predicted mortality arising from displacement at Jammerland Bugt OWF for each season with respect to the Danish wintering population estimate as represented by the equivalent PBR recovery factor (f) value.

Season	Mortality rate (%)				
	1	2	5	10	20
Autumn	0.0	0.0	0.0	0.0	0.0
Winter	0.0	0.0	0.0	0.0	0.1
Spring	0.0	0.0	0.0	0.0	0.0

8 Cumulative displacement analysis

8.1 Selection of projects for cumulative assessment

A screening review has been conducted of projects in Danish, German and Swedish waters. Scoping of projects for inclusion within the in-combination assessment was based upon:

- Geographical location (i.e. all operational, consented or planned projects in Danish, German or Swedish waters); and

- Consenting status (i.e. how the project identified relate to the two nearshore projects in the consenting process).

A tiered approach to the consideration of plans and projects has been adopted, based upon the consenting stage at which each windfarm currently sits within the planning and consenting process. Therefore, the windfarm projects have been categorised into the following tiers:

- Tier 1- Projects operational or under construction;
- Tier 2- Projects with consent authorised;
- Tier 3- Projects with planning application submitted;
- Tier 4 - Projects with planning application in preparation and/or status uncertain.

This tiered approach provides a straightforward way of presenting the assessment with particular focus on the confidence that can be drawn from various mortality estimates. Where a project is in initial stages of planning, there may be some uncertainty over whether the project will lead to consent and subsequent construction /operation of turbines. Furthermore, where no site specific ornithological data has been published lower levels of confidence can be drawn over final in combination displacement or mortality estimates.

Table 8.1 presents the results of initial screening of Projects to be considered cumulatively. These are also shown in Figure 8.1. In addition to the presentation of the projects into one of the four tiers as detailed above, the size (in MW) of the project is detailed and most critically, whether data on common eider, common scoter and velvet scoter displacement is available from the EIA documents submitted or from other sources. All information regarding the geographical location and consenting status of projects was retrieved from the online 4C Offshore 'Offshore Windfarms Database'[4] information resource.

Where no data exists on common eider, common scoter and velvet scoter displacement for a given assessment, no attempt has been made to model displacement impacts from these projects and the project is not considered further. While it is anticipated that some of these projects are located in areas where common eider, common scoter and velvet scoter are not abundant and there is no likelihood of a material contribution to any cumulative impact, this may not be the case for all. It is notable, for instance that few data exists on displacement for German projects no matter their status in the consenting process.

[4] http://www.4coffshore.com/offshorewind/

The next step taken in the screening process is to summarise cumulative displacement impacts where the data is given and also mortality predictions. These are summarized in Table 8.2. Very few projects attempted to quantify the effects of displacement by estimating resultant mortality. Whilst it is recognized that significant data sets exist for some projects from post-consent monitoring, where data on displacement and/or mortality of common eider, common scoter and velvet scoter exists which a project was consented or from data forming primary application information, this is given priority to inform the cumulative assessment. The source documents on which the data was derived is indicated in Table 8.2.

Also provided in Table 8.2 are details on the assessment method used to calculate displacement – no attempt is made to turn this data into a 'common currency' and methods applied are highly variable in terms of many parameters. Finally, the survey method used for the baseline data collection are detailed; these are predominantly aerial surveys although boat-based surveys were applied to a small number of projects.

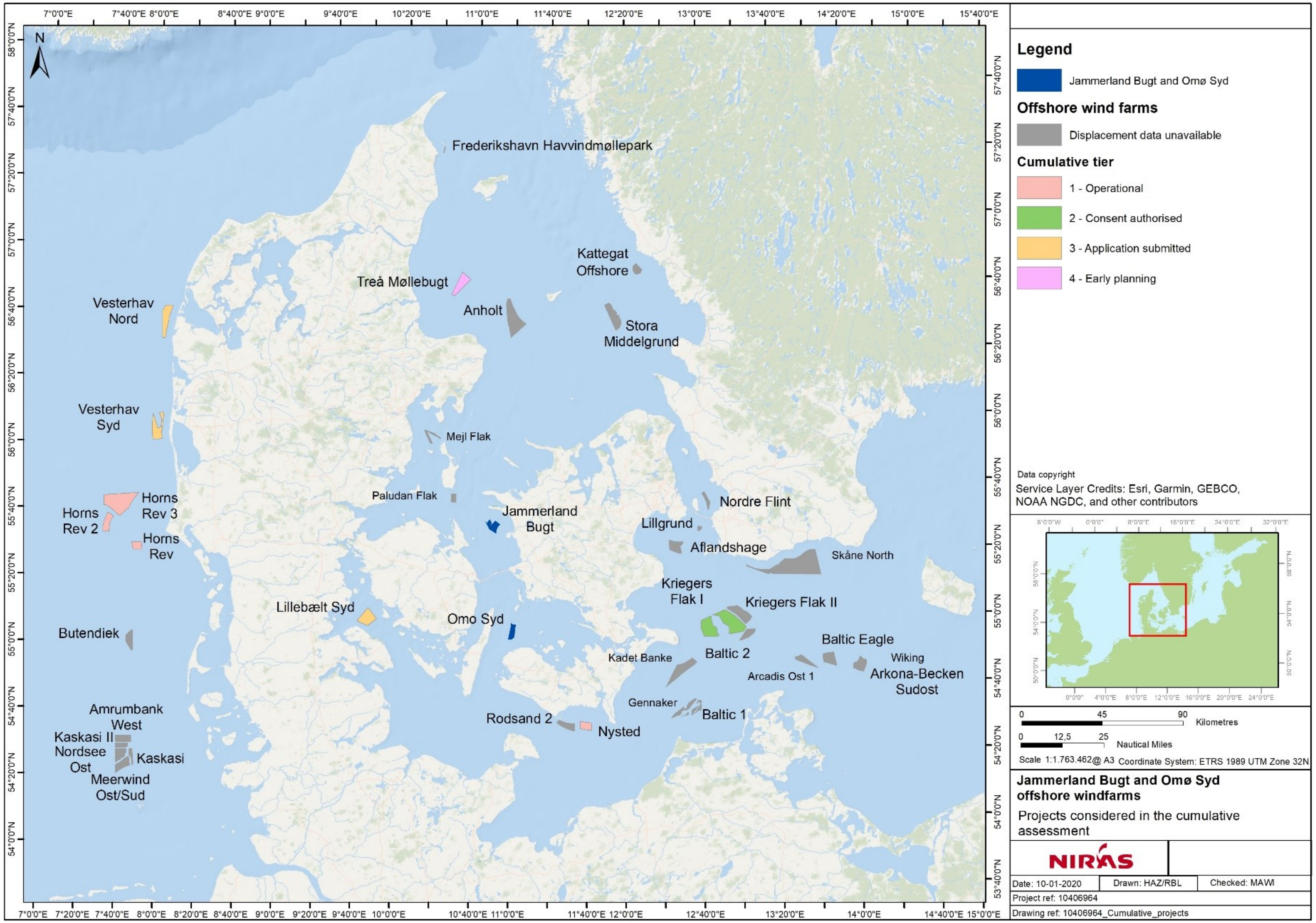

Figure 8.1 Projects considered for cumulative assessment

Table 8.1 Projects considered for cumulative assessment and their displacement data availability

Consenting phase	Windfarm (Year of first power)	Country	Assessment tier	Total planned MW	Displacement data availability?
Tier 1					
Operational	Horns Rev 1 (2002)	Denmark	1	160	Y
Operational	Horns Rev 2 (2009)	Denmark	1	209.3	Y
Operational	Horns Rev 3 (2019)	Denmark	1	406.7	Y
Operational	Anholt (2013)	Denmark	1	399.6	N
Operational	Rødsand 2 (2010)	Denmark	1	207	N
Operational	Nysted (2003)	Denmark	1	165.6	Y
Operational	Butendiek (2015)	Germany	1	288	N
Operational	Amrumbank West (2015)	Germany	1	302	N
Operational	Nordsee Ost (2014)	Germany	1	295.2	N
Operational	Meerwind Ost/Süd (2014)	Germany	1	288	N
Operational	EnBW Baltic 2 (2015)	Germany	1	288	N
Operational	EnBW Baltic 1 (2011)	Germany	1	48.3	N

Consenting phase	Windfarm (Year of first power)	Country	Assessment tier	Total planned MW	Displacement data availability?
Operational	Lillgrund (2007)	Sweden	1	110.4	N
Operational	Arkona (2019)	Germany	1	385	N
Operational	Wikinger (2017)	Germany	1	350	N
Tier 2					
Consent authorised	Kattegat Offshore	Sweden	2	282	N
Consent authorised	Stora Middelgrund	Sweden	2	864	N
Consent authorised	Kreigers Flak	Denmark	2	610	Y
Consent authorised	Kriegers Flak II	Sweden	2	640	N
Consent authorised	Kaskasi II	Germany	2	325	N
Consent authorised	Arcadis Ost 1	Germany	2	247.25	N
Consent authorised	Baltic Eagle	Germany	2	476	N
Consent authorised	Gennaker	Germany	2	865.2	N
Tier 3					
Application submitted	Vesterhav Nord	Denmark	3	200	Y
Application submitted	Vesterhav Syd	Denmark	3	200	Y
Application submitted	Lillebælt Syd	Denmark	3	50	Y

Consenting phase	Windfarm (Year of first power)	Country	Assessment tier	Total planned MW	Displacement data availability?
Application submitted	Mejlfalk	Denmark	3	120	N
Tier 4					
Early planning	Frederikshavn Havvindmøllepark	Denmark	4	72	N
Early planning	Nordre Flint	Denmark	4	160	N
Early planning	Aflandshage	Denmark	4	250	N
Early planning	Thor Havvindmøllepark	Denmark	4	1,000	N
Early planning	Kadet Banke	Denmark	4	864	N
Early planning	Paludan Flak	Denmark	4	228	N
Early planning	Treå Møllebugt	Denmark	4	720	Y
Early planning	Skåne North	Sweden	4	500	N

Table 8.2 Common eider, common scoter and velvet scoter displacement estimates from projects considered for cumulative assessment. Bold text indicates the number used in the assessment

Windfarm	Country	Displaced Common Eider	Displaced Common Scoter	Displaced Velvet Scoters	Assessment method	Survey method	Mortality given	Reference
Tier 1								
Horns Rev 1	Denmark	**0**	**0**	**0**	Density maps (result from original EIA report)	Aerial surveys	No (acc to Orbicon: Com. scoter:1000)	(Noer, Christensen, Clausager, & Petersen, 2000)
Horns Rev 2	Denmark	**0**	29,135 (main) **10,996**	**0**	100% in the two layouts + a linear effect up to 2km. Gives modelled displacement maps **Petersen *et al.* 2014 gives this as the significant reduction (table 8)**	Aerial surveys from HR1+2	No (acc to Orbicon: Com. scoter 5310)	(Dong Energy, 2006; Petersen, Nielsen, & Mackenzie, 2014)
Horns Rev 3	Denmark	**0**	**2,808 (cons)** 1,404 (opp.) 1,750	**0**	**100% in worst case windfarm layout + 500m** 50% in worst case windfarm layout + 500m Given in cumulative assessment	10 Aerial surveys, 12 transects, 4 km spacing	No (acc to Orbicon: Com. scoter 843)	(Energinet.dk, 2014)

Windfarm	**Coun-try**	**Displaced Common Eider**	**Displaced Common Scoter**	**Dis-placed Velvet Scoters**	**Assessment method**	**Survey method**	**Mortality given**	**Reference**
Nysted (Rødsand I)	Den-mark	**Few**	**309**	**Few**	**Indirectly given as OWF+4km** Common scoter: 70 % displaced (not stated - assumption by au-thors)	Aerial surveys	No	(Kahlert, Desholm, Clausager, & Petersen, 2000)
Rødsand II	Den-mark	**Few**	**47**	**Few**	**Indirectly given as max. for OWF+4km (modelled max. 5,957 eiders in OWF+4km)** Common scoter: 70 % displaced (not stated - assumption by au-thors)	Aerial surveys	No	(Kahlert, Petersen, & Desholm, 2007)
Butendiek	Ger-many	**0**	503 715 953 1,497 **2,873**	**0**	OWF area OWF + 500m OWF + 1000m OWF + 2000m **OWF + 4000m** This is density data –displacement data is not specifically given. Common scoter: 70 % displaced (not stated - assumption by au-thors)	Aerial and boat surveys They use the aerial sur-vey data in assessment	No	(Dorch & Nehls, 2012)

Windfarm	Coun-try	Displaced Common Eider	Displaced Common Scoter	Dis-placed Velvet Scoters	Assessment method	Survey method	Mortality given	Reference
Tier 1 total		**0**	**17,033**	**0**				
Tier 2								
Kreigers Flak	Den-mark	2 **5**	**34**	**0**	Common scoter: 70% displaced (not stated- assumption by author) Common eider: 30 and 70% dis-placed (not stated- assumption by author)	Model distribution from historic boat and aerial surveys	No	(Energinet.dk, 2015)
Tier 1 & 2 total		**5**	**17,064**	**0**				
Tier 3								
Vesterhav Nord	Denmark	**0**	0 **(8)**	**0**	100% in windfarm area + 500m (+ 2 km)	6 aerial surveys, 20 tran-sects, 2 km space.	No	(NIRAS, 2015)
Vesterhav Syd	Denmark	**0**	**674**	**60**	100% up to 2 km.	6 aerial surveys, 18 tran-sects, 2 km space.	No	(NIRAS, 2015)
Lillebælt Syd	Denmark	**403** 235	**10**	**0**	4 MW 50% in windfarm area (+ 1km) 8 MW 30% in windfarm area (+ 1km) Common scoter: 70% displaced (not stated - assumption by authors)	Aerial surveys	No	(COWI, 2019)

Windfarm	Coun-try	Displaced Common Eider	Displaced Common Scoter	Dis-placed Velvet Scoters	Assessment method	Survey method	Mortality given	Reference
Mejlflak	Denmark	**few**	**few**	**-**	1,500-2,000 eiders within windfarm area + 2 km og 500-600 common scoter	Aerial surveys	No	(Rambøll, 2012)
Tier 1 - 3 total		**408**	**17,756**	**60**				
Tier 4								
Frederik-shavn OWF	Denmark	**Few**	**87**	**32**	Common scoter and velvet scoter: 70 % displaced (not stated – as-sumption by authors)	Surveys from station-ary boats at 4 stations + observations from lighthouse (May to June 2008)	No	(Orbicon, 2008)
Treå	Denmark	**-**	**2,177**	**-**	65% within the wind farm area and a linear decline to 5,5 km from wind farm.	Based on modelled data from mid-winter aerial counts 2008	No (10% assumed)	(Wind Estate, 2019)
Tier 1 - 4 total		**408**	**20,020**	**92**				

Omø Syd and Jammerland Bugt are themselves categorized as Tier 4 projects, however they are both expected to be consented / constructed concurrently. Therefore, the estimated displacement from both projects are added to the totals under each tier in Table 8.2.

Table 8.3 Common eider, common scoter and velvet scoter displacement estimates from project tiers cumulatively with Omø Syd and Jammerland Bugt

Windfarm	Worst case displacement	Total with Tier 1	Total with Tiers 1-2	Total with Tiers 1-3	Total with Tiers 1-4
Common eider	31,892	31,892	31,897	32,300	32,300
Common scoter	5,162	22,195	22,226	22,918	25,182
Velvet scoter	775	775	775	835	867

Table 8.3 above presents the worst case scenarios for Omø Syd and Jammerland. A total of 32,300 common eiders, 25,182 common scoters and 867 velvet scoters are predicted to be displaced when projects in all tiers are considered. When considering only those projects that are operational or have gained consent (i.e. Tiers 1 -2), up to 31,897 common eiders, 22,226 common scoters and 775 velvet scoters are predicted to be displaced cumulatively with the construction of Omø Syd and Jammerland Bugt.

As with the assessments of Omø Syd and Jammerland Bugt alone, a range of mortality rates are applied to the displacement predictions (Tables Table 8.4,Table 8.5 and Table 8.6).

Table 8.4 Cumulative common eider predicted mortality as a result of displacement from Omø Syd and Jammerland Bugt combined with projects in tiers 1-4

Season	% mortality				
	1	5	10	15	20
Tier 1	319	1,595	3,189	4,784	6,378
Tiers 1-2	319	1,595	3,190	4,785	6,379
Tiers 1-3	323	1,615	3,230	4,845	6,460
Tiers 1-4	323	1,615	3,230	4,845	6,460

Table 8.5 Cumulative common scoter predicted mortality as a result of displacement from Omø Syd and Jammerland Bugt combined with projects in tiers 1-4

Season	% mortality				
	1	5	10	15	20
Tier 1	222	1,180	2,220	3,329	4,439
Tiers 1-2	222	1,111	2,223	3,224	4,445
Tiers 1-3	229	1,146	2,292	3,438	4,584
Tiers 1-4	252	1,259	2,518	3,777	5,036

Table 8.6 Cumulative velvet scoter predicted mortality as a result of displacement from Omø Syd and Jammerland Bugt combined with projects in tiers 1-4

Season	% mortality				
	1	5	10	15	20
Tier 1	8	39	78	116	155
Tiers 1-2	8	39	78	116	155
Tiers 1-3	8	42	84	125	167
Tiers 1-4	9	43	87	130	173

8.2 Assessment against biogeographical population

At the highly precautionary worst case, when all projects are considered and the upper level of mortality considered in this Report (20%) is applied, then 6,460 common eiders, 5,036 common scoters and 173 velvet scoters will die as a result of displacement with the construction of Omø Syd and Jammerland Bugt. This represents an *f* value of just under 0.2 for Common eider and common scoter and below 0.1 for velvet scoter compared to their respectively Danish national population and less than 0.1 of the flyway populations. The mortality also represents c. 1.1, 1.3 and 0.6 % of the national population for common eider, common scoter and velvet scoter respectively. Looking at the flyway populations it represents c. 0.7, 0.4 and 0.04 % of the national population for common eider, common scoter and velvet scoter respectively.

This is apparently sustainable (notwithstanding limitations regarding the application of PBR and the absence of data from some projects within the search area) due to the currently stability of the populations of common eider, common scoter and velvet scoter which may lead to a *f* value of 0.5 being deemed appropriate. If though looking only at the counted numbers for the latest National surveys there is an indication that common scoter is declining giving an appropriate *f* factor of 0.1-0.3. These estimates are though not taking into account differences in survey effort leading to important wintering areas for common scoter in the North Sea being covered. When a mortality rate of 10% is applied (i.e. the maximum rate recommended by Natural England) 3,230 common eiders, 2,518 common scoter and 87 velvet scoters are predicted to suffer mortality with the construction Omø Syd an Jammerland Bugt. This represents an *f* value of less than 0.1 of the flyway / Danish national population.

When considering only those projects that are operational or have gained consent (i.e. Tiers 1 -2), 6,379 common eiders, 4,445 common scoters and 155 velvet scoters are predicted to suffer mortality cumulatively with Omø Syd and Jammerland Bugt at 20% mortality rate of displaced birds. These represents an *f* value of 0.13 for both construction at Omø Syd and Jammerland Bugt (and 1.1% of the biogeographical population). When a lower mortality rate of 10% is applied (i.e. the maximum rate recommended by Natural England) 3,190 common eiders, 2,223 common scoters and 78 velvet scoters are predicted to suffer mortality which both represent an *f* value of less than 0.1.

9 Appropriate Assessment of nearest SPAs

9.1 Identification of Likely Significant Effect (LSE)

While this report does not present a complete, standalone revised Appropriate Assessment for either windfarm, considering the extensive re-assessment of seaduck displacement earlier in this report, those re-assessments are the baseline for identification of Likely Significant Effects (LSE) to investigate potential implications for the SPAs.

9.1.1 Previous assessments

There are a number of SPAs on the west coast of Zealand and in the Great Belt that support populations of common scoter, velvet scoter and common eider (Table 9.1).

Table 9.1: SPAs in the Great Belt region that is designated for the tree key species with designated populations and reference to the national population. OS = Omø Syd and JB = Jammerland Bugt.

SPA	Designated features (limited to the three key species)	Designated wintering population	Percentage of national wintering population	Relevant to:
73 Vresen og havet mellem Fyn og Langeland	Common eider (M)	6,846	0.70	OS
94 Sejerø Bugt og Nekselø	Common eider (M) Common scoter (M) Velvet scoter (M)	12,400 15,517 2,460	1.29 4.01 7.86	JB
96 Farvandet mellem Skælskør Fjord og Glænø	Common eider (M) Velvet scoter (M)	6,400 3,500	0.65 11.18	OS
98 Sprogø og Halsskov Rev	Common eider (M)	3,000	0.31	JB OS
31 Stavns Fjord	Common eider (M) Common scoter (M) Velvet scoter (M)	8,010 1,114 155	0.82 0.29 0.50	JB
36 Horsens Fjord og Endelave	Common eider (M) Velvet scoter (M)	18,159 19	1.85 0.06	JB
71 Sydfynske Øhav	Common eider (M)	27,037	2.76	OS
72 Marstal Bugt og den sydlige del af Langeland	Common eider (M)	29,690	3.03	OS

Of these SPAs, the previous assessments for Jammerland Bugt and Omø Syd identified the potential for LSE for Natura 2000 area 162 which includes SPA 95 (Skælskør Nor, Skælskør Fjord and Gammelsø) (which is not designated for populations of any of the three key species) and SPA 96 (Farvandet mellem Skælskør Fjord og Glænø) which is designated for a wintering population of common eider and velvet scoter. Further SPAs, including some of those identified in Table 9.1, were considered in the previous assessments for Omø Syd and Jammerland Bugt but these were screened out due to the distance between the SPAs and the project sites.

The proposed windfarms lies, with the exception of Farvandet mellem Skælskør Fjord and Glænø SPA, more than 10 km from the SPA boundaries and is therefore not expected to displace birds directly to the SPA designated areas.

All of the species included in this report are each associated with more than one of the SPAs included in Table 9.1. It is not known, though, whether the populations at each of these SPAs are independent or form part of a larger meta-population that moves between these SPAs across an unknown temporal scale (e.g. daily, monthly, etc.). The population of seaducks within the region is highly mobile, with notable shifts in distribution between both seasons and years. Therefore, some connectivity would be expected to occur between these adjacent sites. If the population of birds in this area is transient then there is potential for birds from a number of SPAs to occur at Jammerland Bugt and Omø Syd throughout the non-breeding period.

Farvandet mellem Skælskør Fjord og Glænø SPA are placed only 3 km from Omø Syd and therefore birds are likely to be displace within the SPA. The is true for common and velvet scoter but not for common eider, as the latter species is only displaced up to 2 km from the wind farm (precautionary approach by Natural England is followed in this report). Looking at the distributions of common eider, common scoter and velvet scoter it is most likely that the majority, if not all of the birds, will be displaced closed to both Omø Syd and Jammerland Bugt Offshore Windfarms. From the distribution maps given in the EIAs for Omø Syd and Jammerland Bugt OWF and survey data from DCE it is evident that common eider, common scoter and velvet scoter are mainly distributed to the east and north of Omø Syd project area and to the north of Jammerland Bugt project area near the reefs around Asnæs, but also to the east along the cost of Sealand. It is likely that most of the displaced birds will be dispersed locally within 10 km of the wind farms and therefore less than 10% are likely to be displaced to any SPA, with the exception of the Farvandet mellem Skælskør Fjord og Glænø SPA that is within 5 km from Omø Syd.

The assessments conducted in this report therefore attempt to define the magnitude of effects on each SPA by either assuming that the whole impact predicted for a species at either Jammerland Bugt or Omø Syd affects each SPA in isolation or by assuming that the SPAs form part of a larger population that impacts can be attributed to. Impacts can then be apportioned to each SPA based on the proportion of the total population represented by each SPA.

In the following, displacement matrices are presented for each designated feature (limited to the three key species) in the SPAs listed in Table 9.1 and associated seasons identified in Section 4.1.1. Potential displacement impacts for each species are presented here based on a wide range of potential displacement (10-100%) and mortality rates (1-20%) for Farvandet mellem Skælskør Fjord og Glænø SPA. For the rest of the SPAs mortality rates (1-20%) are given for a more realistic displacement of up to 10% apportioned to the SPAs. Consideration of the appropriate displacement and mortality rates to apply for assessment is provided in Section 4.1. As indicated in Table 9.1, only SPA 98 Sprogø og Halsskov Rev are considered to be affected by birds displaced from both wind farms. For each SPA, the increased mortality has been related to a 1% increase in background mortality and related to calculations of PBR based on the designated population of the individual SPA. Each matrix, in the following SPA specific sections, is shaded to indicate where the predicted displacement mortality surpasses the 1% threshold of background mortality of the population for each species. In addition, each matrix is shaded to indicate where the PBR at f = 0.3 (or 0.4 for common scoter) and f = 0.5 has been exceeded for respectively a slightly declining population and a stable population.

9.1.2 Vresen og havet mellem Fyn og Langeland SPA

9.1.2.1 Overview

Vresen og havet mellem Fyn og Langeland SPA is located in the Great Belt between the islands of Zealand and Funen covering an area south of Nyborg into the strait separating Funen and Langeland. The SPA is located approximately 30 km to the south of Jammerland Bugt and 15 km to the north-west of Omø Syd. The only qualifying feature at the SPA is common eider (42-6.846 individuals).

9.1.2.2 Common eider

The maximum displacement effects from Omø Syd on the Vresen og Havet mellem Fyn og Langeland SPA population and the increase in baseline mortality of that population that they represent are presented in Table 9.2 and Table 9.3. Displacement effects are presented using the higher and lower range of displacement and mortality rates as presented in Table 5.2 and Table 6.2.

Table 9.2 Common eider predicted mortality arising from 30% displacement at Omø Syd OWF in autumn with respect to the birds apportioned to Vresen og havet mellem Fyn og Langeland SPA designated population

		% mortality				
		1	5	10	15	20
Proportion of displaced birds apportioned to Vresen og havet mellem Fyn og Langeland SPA	1	1	4	9	13	17
	2	2	9	17	26	34
	3	3	13	26	39	52
	4	3	17	34	52	69
	5	4	22	43	65	86
	6	5	26	52	78	103
	7	6	30	60	91	121
	8	7	34	69	103	138
	9	8	39	78	116	155
	10	9	43	86	129	172

Input data: Estimated number of birds displaced for the Autumn period (8,622) at 30% displacement		>1% increase in background mortality
Reference population: Vresen og havet mellem Fyn og Langeland SPA = 6,846 individuals		exceeds PBR threshold value when *f* =0.3
		exceeds PBR threshold value when *f* =0.5

Table 9.3 Common eider predicted mortality arising from 70% displacement at Omø Syd OWF in winter with respect to the birds apportioned to Vresen og havet mellem Fyn og Langeland SPA designated population

		% mortality				
		1	5	10	15	20
Proportion of displaced birds apportioned to Vresen og havet mellem Fyn og Langeland SPA	1	2	10	20	30	40
	2	4	20	40	60	80
	3	6	30	60	91	121
	4	8	40	80	121	161
	5	10	50	101	151	201
	6	12	60	121	181	241

	7	14	70	141	211	282
	8	16	80	161	241	322
	9	18	91	181	272	362
	10	20	101	201	302	402
Input data: Estimated number of birds displaced for the Winter period (20,117) at 70% displacement					>1% increase in background mortality	
Reference population: Vresen og havet mellem Fyn og Langeland SPA = 6,846 individuals					exceeds PBR threshold value when *f* =0.3	
					exceeds PBR threshold value when *f* =0.5	

9.1.2.3 Summary for Vresen og havet mellem Fyn og Langeland SPA

Table 9.2 and Table 9.3 indicate that PBR at *f*=0.5 is only exceeded under relatively extreme circumstances for common eider. It is considered that such scenarios are unlikely bearing in mind the regional distribution of common eider and also the maximum mortality rates applied by regulators in other windfarm determinations (e.g. Natural England, 2014).

Arbitrary thresholds of 1% on background mortality have also been applied in other windfarm determinations to guide the level of impact. A scenario where an increase in 1% background mortality occur is found to be realistic. Both in regard to PBR and 1% threshold adverse effects on designated common eider and the integrity of the SPA can be rejected.

9.1.3 Sejerø Bugt og Nekselø SPA

9.1.3.1 Overview

Sejerø Bugt og Nekselø SPA is located on the north-western coast of Zealand and covers the sea area between Svenstrup Overdrev in the south-west to Sjællands Odde in the north-west via Sejerø island. The SPA is located approximately 18 km from Jammerland Bugt and 74 km from Omø Syd. The designation for the SPA comprises nine species including, of relevance to this report, common eider (1000-12400 individuals), common scoter (200-15517 individuals) and velvet scoter (50-2460 individuals).

9.1.3.2 Common eider

The maximum displacement effects from Jammerland Bugt on the Sejerø Bugt og Nekselø SPA population and the increase in baseline mortality of that population that they represent are presented in Table 9.4 and Table 9.5. Displacement effects are presented using the higher and lower range of displacement and mortality rates as presented in Table 5.2 and Table 6.2.

Table 9.4 Common eider predicted mortality arising from 30% displacement at Jammerland Bugt OWF in winter with respect to the birds apportioned to Sejerø Bugt og Nekselø SPA designated population

		% mortality				
		1	5	10	15	20
Proportion of displaced birds apportioned to Sejerø Bugt og Nekselø SPA	1	1	3	5	8	10
	2	1	5	10	15	20
	3	2	8	15	23	30
	4	2	10	20	30	40
	5	3	13	25	38	50
	6	3	15	30	45	61
	7	4	18	35	53	71
	8	4	20	40	61	81

	9	5	23	45	68	91
	10	5	25	50	76	101
Input data: Estimated number of birds displaced for the Winter period (5,049) at 30% displacement					>1% increase in background mortality	
Reference population: Sejerø Bugt og Nekselø SPA = 12,400 individuals					exceeds PBR threshold value when *f* =0.3	
					exceeds PBR threshold value when *f* =0.5	

Table 9.5 Common eider predicted mortality arising from 70% displacement at Jammerland Bugt OWF in winter with respect to the birds apportioned to Sejerø Bugt og Nekselø SPA designated population

Proportion of displaced birds apportioned to Sejerø Bugt og Nekselø SPA		% mortality				
		1	5	10	15	20
	1	1	6	12	18	24
	2	2	12	24	35	47
	3	4	18	35	53	71
	4	5	24	47	71	94
	5	6	29	59	88	118
	6	7	35	71	106	141
	7	8	41	82	124	165
	8	9	47	94	141	188
	9	11	53	106	159	212
	10	12	59	118	177	236
Input data: Estimated number of birds displaced for the Winter period (11,775) at 70% displacement					>1% increase in background mortality	
Reference population: Sejerø Bugt og Nekselø SPA = 12,400 individuals					exceeds PBR threshold value when *f* =0.3	
					exceeds PBR threshold value when *f* =0.5	

9.1.3.3 *Common scoter*

The maximum displacement effects from Jammerland Bugt on the Sejerø Bugt og Nekselø SPA population and the increase in baseline mortality of that population that they represent are presented in Table 9.6. Displacement effects and mortality rates as presented in Table 5.2 and Table 6.5.

Table 9.6 Common scoter predicted mortality arising from displacement at Jammerland Bugt OWF in winter with respect to the birds apportioned to Sejerø Bugt og Nekselø SPA designated population

Proportion of displaced birds apportioned to Sejerø Bugt og Nekselø SPA		% mortality				
		1	5	10	15	20
	1	0	0	1	1	2
	2	0	1	2	3	3
	3	0	1	3	4	5
	4	0	2	3	5	7
	5	0	2	4	6	9
	6	1	3	5	8	10
	7	1	3	6	9	12
	8	1	3	7	10	14
	9	1	4	8	12	15
	10	1	4	9	13	17

Input data: Estimated number of birds displaced for the winter period (852) from Jammerland Bugt		>1% increase in background mortality
Reference population: Sejerø Bugt og Nekselø SPA = 15,517 individuals		exceeds PBR threshold value when *f* =0.4
		exceeds PBR threshold value when *f* =0.5

9.1.3.4 *Velvet scoter*

The maximum displacement effects from Jammerland Bugt on the Sejerø Bugt og Nekselø SPA population and the increase in baseline mortality of that population that they represent are presented in Table 9.7. Displacement effects and mortality rates as presented in Table 5.8 and Table 6.8.

Table 9.7 Velvet scoter predicted mortality arising from displacement at Jammerland Bugt OWF in winter with respect to the birds apportioned to Sejerø Bugt og Nekselø SPA designated population

Proportion of displaced birds apportioned to Sejerø Bugt og Nekselø SPA		% mortality				
		1	5	10	15	20
	1	0	0	0	1	1
	2	0	0	1	1	2
	3	0	1	1	2	2
	4	0	1	2	2	3
	5	0	1	2	3	4
	6	0	1	2	3	5
	7	0	1	3	4	5
	8	0	2	3	5	6
	9	0	2	3	5	7
	10	0	2	4	6	8

Input data: Estimated number of birds displaced for the Winter period (380)		>1% increase in background mortality
Reference population: Sejerø Bugt og Nekselø SPA = 2,460 individuals		exceeds PBR threshold value when *f* =0.3
		exceeds PBR threshold value when *f* =0.5

9.1.3.5 *Summary for Sejerø Bugt og Nekselø SPA*

Table 9.4, Table 9.5, Table 9.6 and Table 9.7 indicate that PBR at *f*=0.3 and *f*=0.4 is only exceeded under relatively extreme circumstances for common eider, common scoter and velvet scoter. It is considered that such scenarios are unlikely bearing in mind the regional distribution of the three species and also the maximum mortality rates applied by regulators in other windfarm determinations (e.g. Natural England, 2014).

Arbitrary thresholds of 1% on background mortality have also been applied in other windfarm determinations to guide the level of impact. A scenario where an increase in 1% background mortality occur is found to be realistic only for common eider. Both in regard to PBR and 1% threshold adverse effects on designated common eider, common and velvet scoter and the integrity of the SPA can be rejected.

9.1.4 Farvandet mellem Skælskør Fjord og Glænø SPA

9.1.4.1 Overview

Farvandet mellem Skælskør Fjord og Glænø SPA is located adjacent to the south-western coast of Zealand encompassing the sea area between the coast to the east of Bisserup and the sea area offshore of Egerup encompassing the sea areas around the islands of Agersø and Omø. The SPA is located approximately 31 km to the south of Jammerland Bugt and 3 km to the north of Omø Syd. The designation for the SPA consists of seventeen qualifying features including, of relevance to this report, velvet scoter (2 individuals) and common eider (50-6,400 individuals).

9.1.4.2 Common eider

The maximum displacement effects from Omø Syd on the Farvandet mellem Skælskør Fjord og Glænø SPA population and the increase in baseline mortality of that population that they represent are presented in Table 9.8 and

Table 9.9. Displacement effects are presented using the higher and lower range of displacement and mortality rates as presented in Table 5.2 and Table 6.2.

Table 9.8 Common eider predicted mortality arising from 30% displacement at Omø Syd OWF in autumn with respect to the birds apportioned to Farvandet mellem Skælskør Fjord og Glænø SPA designated population

Proportion of displaced birds apportioned to Farvandet mellem Skælskør Fjord og Glænø SPA		% mortality				
		1	5	10	15	20
	10	9	43	86	129	172
	20	17	86	172	259	345
	30	26	129	259	388	517
	40	34	172	345	517	690
	50	43	216	431	647	862
	60	52	259	517	776	1,035
	70	60	302	604	905	1,207
	80	69	345	690	1,035	1,380
	90	78	388	776	1,164	1,552
	100	86	431	862	1,293	1,724

Input data: Estimated number of birds displaced for the Autumn period (8,622) at 30% displacement		>1% increase in background mortality
Reference population: Farvandet mellem Skælskør Fjord og Glænø SPA = 6,400 individuals		exceeds PBR threshold value when *f* =0.3
		exceeds PBR threshold value when *f* =0.5

Table 9.9 Common eider predicted mortality arising from 70% displacement at Omø Syd OWF in autumn with respect to the birds apportioned to Farvandet mellem Skælskør Fjord og Glænø SPA designated population

Proportion of displaced birds apportioned to Farvandet mellem Skælskør		% mortality				
		1	5	10	15	20
	10	20	101	201	302	402
	20	40	201	402	604	805
	30	60	302	604	905	1,207
	40	80	402	805	1,207	1,609

	50	101	503	1,006	1,509	2,012
	60	121	604	1,207	1,811	2,414
	70	141	704	1,408	2,112	2,816
	80	161	805	1,609	2,414	3,219
	90	181	905	1,811	2,716	3,621
	100	201	1,006	2,012	3,018	4,023
Input data: Estimated number of birds displaced for the Autumn period (20,117) at 70% displacement					>1% increase in background mortality	
Reference population: Farvandet mellem Skælskør Fjord og Glænø SPA = 6,400 individuals					exceeds PBR threshold value when *f* =0.3	
					exceeds PBR threshold value when *f* =0.5	

9.1.4.3 Velvet scoter

Table 9.10 Velvet scoter predicted mortality arising from displacement at Omø Syd OWF in spring with respect to the birds apportioned to Farvandet mellem Skælskør Fjord og Glænø SPA designated population

Proportion of displaced birds apportioned to Farvandet mellem Skælskør Fjord og Glænø SPA		% mortality				
		1	5	10	15	20
	10	0	2	4	5	7
	20	1	4	7	11	14
	30	1	5	11	16	22
	40	1	7	14	22	29
	50	2	9	18	27	36
	60	2	11	22	32	43
	70	3	13	25	38	50
	80	3	14	29	43	57
	90	3	16	32	48	65
	100	4	18	36	54	72
Input data: Estimated number of birds displaced for the Spring period (359)					>1% increase in background mortality	
Reference population: Farvandet mellem Skælskør Fjord og Glænø SPA = 2 individuals					exceeds PBR threshold value when *f* =0.3	
					exceeds PBR threshold value when *f* =0.5	

9.1.4.4 Summary for Farvandet mellem Skælskør Fjord og Glænø SPA

Table 9.8, Table 9.9 and Table 9.10 indicate that PBR at *f*=0.5 is exceeded for common eider and velvet scoter at relatively low apportioning and mortality. It is considered that the scenarios for velvet scoter are unlikely and an artefact of the very low reference population in the SPA. For common eider the scenarios with 10% mortality is not unrealistic.

For Farvandet mellem Skælskør Fjord og Glænø SPA the distribution of common eider in Smålandsfarvandet is mainly within or adjacent to Omø Syd OWF and near Omø and Agersø, therefore a large proportion maybe apportioned to the SPA. With regard to PBR the limit would be breached at 10% mortality and 30% apportioning. This might be realistic given the proximity between Omø Syd OWF and the SPA. In situations with high numbers of common eider in the region numbers of common eider might be higher in Farvandet mellem Skælskør Fjord og Glænø SPA as indicated by estimated numbers of common eider from aerial counts in 2016 of 21,826 common eiders (Clausen, Petersen, Bregnballe, & Nielsen, 2019). This would lead to a breach of the PBR limit at 10% mortality and 50% apportioning. It is unlikely that half the displaced birds will be apportioned to the

Farvandet mellem Skælskør Fjord og Glænø SPA and therefore the displacement and increased mortality is unlikely to have an adverse effect on the integrity of Farvandet mellem Skælskør Fjord og Glænø SPA.

Arbitrary thresholds of 1% on background mortality have also been applied in other windfarm determinations to guide the level of impact. A scenario where an increase in 1% background mortality occur is found to be realistic only for common eider. Both in regard to PBR and 1% threshold adverse effects on designated common eide and velvet scoter and the integrity of the SPA can be rejected.

9.1.5 Sprogø og Halsskov Rev SPA

9.1.5.1 Overview

Sprogø og Halsskov Rev SPA is located in the Great Belt adjacent to the west coast of Zealand between Halsskov, Zealand and the island of Sprogø. The SPA is located approximately 19 km to the south of Jammerland Bugt and 26 km to the north of Omø Syd. The designation for the SPA includes breeding populations of Sandwich tern and little tern and, of relevance to this report, common eider (500-3000 individuals).

9.1.5.2 Common eider

The maximum displacement effects from Omø Syd and Jammerland Bugt on the Sprogø og Halsskov Rev SPA population and the increase in baseline mortality of that population that they represent are presented in Table 9.11 and Table 9.12. Displacement effects are presented using the higher and lower range of displacement and mortality rates as presented in Table 5.2 and Table 6.2.

Table 9.11 Common eider predicted mortality arising from 30% displacement at Jammerland Bugt and Omø Syd OWF in winter with respect to the birds apportioned to Sprogø og Halsskov Rev SPA designated population

Proportion of displaced birds apportioned to Sprogø og Halsskov Rev SPA		% mortality				
		1	5	10	15	20
	1	1	7	13	20	26
	2	3	13	26	40	53
	3	4	20	40	59	79
	4	5	26	53	79	106
	5	7	33	66	99	132
	6	8	40	79	119	158
	7	9	46	92	139	185
	8	11	53	106	158	211
	9	12	59	119	178	238
	10	13	66	132	198	264
Input data: Estimated number of birds displaced for the Winter period (13,200) at 30% displacement					>1% increase in background mortality	
Reference population: Sprogø og Halsskov Rev SPA = 3,000 individuals					exceeds PBR threshold value when *f* =0.3	
					exceeds PBR threshold value when *f* =0.5	

Table 9.12 Common eider predicted mortality arising from 70% displacement at Jammerland Bugt and Omø Syd OWF in winter with respect to the birds apportioned to Sprogø og Halsskov Rev SPA designated population

Proportion of displaced birds apportioned to Sprogø og Halsskov Rev SPA		% mortality				
		1	5	10	15	20
	1	3	15	31	46	62
	2	6	31	62	92	123
	3	9	46	92	139	185
	4	12	62	123	185	246
	5	15	77	154	231	308
	6	18	92	185	277	370
	7	22	108	216	323	431
	8	25	123	246	370	493
	9	28	139	277	416	554
	10	31	154	308	462	616

Input data: Estimated number of birds displaced for the Winter period (30,799) at 70% displacement		>1% increase in background mortality
Reference population: Sprogø og Halsskov Rev SPA = 3,000 individuals		exceeds PBR threshold value when *f* =0.3
		exceeds PBR threshold value when *f* =0.5

9.1.5.3 *Summary for Sprogø og Halsskov Rev SPA*

Table 9.11 and Table 9.12 indicate that PBR at *f*=0.5 is only exceeded under relatively extreme circumstances for common eider at 30% displacement. For 70% displacement it is exceeded at 4% apportioning and 10% mortality or 8% apportioning and 5% mortality. It is considered that such scenarios are unlikely bearing in mind the regional distribution of common eider and also the maximum mortality rates applied by regulators in other windfarm determinations (e.g. Natural England, 2014).

Arbitrary thresholds of 1% on background mortality have also been applied in other windfarm determinations to guide the level of impact. A scenario where an increase in 1% background mortality occur is found to be realistic. Both in regard to PBR and 1% threshold adverse effects on designated common eider and the integrity of the SPA can be rejected.

9.1.6 Stavns Fjord

9.1.6.1 *Overview*

Stavns Fjord SPA is located to the north-east of the island of Samsø on the northern edge of the Great Belt. The SPA is located approximately 34 km from Jammerland Bugt and 91 km from Omø Syd. The designation for the SPA comprises nine species including, of relevance to this report, common eider (1,225-8,010 individuals), common scoter (8-1,114 individuals) and velvet scoter (2-155 individuals).

9.1.6.2 *Common eider*

The maximum displacement effects from Jammerland Bugt on the Stavns Fjord SPA population and the increase in baseline mortality of that population that they represent are presented in Table 9.13 and Table 9.14. Displacement effects are presented using the higher and lower range of displacement and mortality rates as presented in Table 5.2 and Table 6.2.

Table 9.13 Common eider predicted mortality arising from 30% displacement at Jammerland Bugt OWF in winter with respect to the birds apportioned to Stavns Fjord SPA designated population

Proportion of displaced birds apportioned to Stavns Fjord SPA		% mortality				
		1	5	10	15	20
	1	1	3	5	8	10
	2	1	5	10	15	20
	3	2	8	15	23	30
	4	2	10	20	30	40
	5	3	13	25	38	50
	6	3	15	30	45	61
	7	4	18	35	53	71
	8	4	20	40	61	81
	9	5	23	45	68	91
	10	5	25	50	76	101

Input data: Estimated number of birds displaced for the Winter period (5,046) at 30% displacement		>1% increase in background mortality
Reference population: Stavns Fjord SPA = 8,010 individuals		exceeds PBR threshold value when *f* =0.3
		exceeds PBR threshold value when *f* =0.5

Table 9.14 Common eider predicted mortality arising from 70% displacement at Jammerland Bugt OWF in winter with respect to the birds apportioned to Stavns Fjord SPA designated population

Proportion of displaced birds apportioned to Stavns Fjord SPA		% mortality				
		1	5	10	15	20
	1	1	6	12	18	24
	2	2	12	24	35	47
	3	4	18	35	53	71
	4	5	24	47	71	94
	5	6	29	59	88	118
	6	7	35	71	106	141
	7	8	41	82	124	165
	8	9	47	94	141	188
	9	11	53	106	159	212
	10	12	59	118	177	236

Input data: Estimated number of birds displaced for the Winter period (11,775) at 70% displacement		>1% increase in background mortality
Reference population: Stavns Fjord SPA = 8,010 individuals		exceeds PBR threshold value when *f* =0.3
		exceeds PBR threshold value when *f* =0.5

9.1.6.3 *Common scoter*

The maximum displacement effects from Jammerland Bugt on the Stavns Fjord SPA population and the increase in baseline mortality of that population that they represent are presented in Table 9.15. Displacement effects and mortality rates as presented in Table 5.2 and Table 6.5.

Table 9.15 Common scoter predicted mortality arising from displacement at Jammerland Bugt OWF in winter with respect to the birds apportioned to Stavns Fjord SPA designated population

Proportion of displaced birds apportioned to Stavns Fjord SPA		% mortality				
		1	5	10	15	20
	1	0	0	1	1	2
	2	0	1	2	3	3
	3	0	1	3	4	5
	4	0	2	3	5	7
	5	0	2	4	6	9
	6	1	3	5	8	10
	7	1	3	6	9	12
	8	1	3	7	10	14
	9	1	4	8	12	15
	10	1	4	9	13	17
Input data: Estimated number of birds displaced for the winter period (852) from Jammerland Bugt					>1% increase in background mortality	
Reference population: Stavns Fjord SPA = 1,114 individuals					exceeds PBR threshold value when *f* =0.4	
					exceeds PBR threshold value when *f* =0.5	

9.1.6.4 *Velvet scoter*

The maximum displacement effects from Jammerland Bugt on the Stavns Fjord SPA population and the increase in baseline mortality of that population that they represent are presented in Table 9.16. Displacement effects and mortality rates as presented in Table 5.8 and Table 6.8.

Table 9.16 Velvet scoter predicted mortality arising from displacement at Jammerland Bugt OWF in winter with respect to the birds apportioned to Stavns Fjord SPA designated population

Proportion of displaced birds apportioned to Stavns Fjord SPA		% mortality				
		1	5	10	15	20
	1	0	0	0	1	1
	2	0	0	1	1	2
	3	0	1	1	2	2
	4	0	1	2	2	3
	5	0	1	2	3	4
	6	0	1	2	3	5
	7	0	1	3	4	5
	8	0	2	3	5	6
	9	0	2	3	5	7
	10	0	2	4	6	8
Input data: Estimated number of birds displaced for the Winter period (380)					>1% increase in background mortality	
Reference population: Stavns Fjord SPA = 155 individuals					exceeds PBR threshold value when *f* =0.3	
					exceeds PBR threshold value when *f* =0.5	

9.1.6.5 Summary for Stavns Fjord SPA

Table 9.13, Table 9.14, Table 9.15 and Table 9.16 indicate that PBR at *f*=0.3 and *f*=0.4 is only exceeded under relatively extreme circumstances for common eider, common scoter and velvet scoter. It is considered that such scenarios are unlikely bearing in mind the regional distribution of the three species and also the maximum mortality rates applied by regulators in other windfarm determinations (e.g. Natural England, 2014).

Arbitrary thresholds of 1% on background mortality have also been applied in other windfarm determinations to guide the level of impact. A scenario where an increase in 1% background mortality occur is found to be realistic for all species due to the low reference populations for scoters. Both in regard to PBR and 1% threshold adverse effects on designated common eider, common and velvet scoter and the integrity of the SPA can be rejected.

9.1.7 Horsens Fjord og Endelave

9.1.7.1 Overview

Horsens Fjord og Endelave SPA is located to the east coast of Jutland, spanning large shallow waters around the island of Endelave to the west of Samsø. The SPA is located approximately 38 km from Jammerland Bugt and 97 km from Omø Syd. The designation for the SPA comprises eleven species including, of relevance to this report, common eider (1,241-18,159 individuals) and velvet scoter (0-19 individuals).

9.1.7.2 Common eider

The maximum displacement effects from Jammerland Bugt on the Horsens Fjord og Endelave SPA population and the increase in baseline mortality of that population that they represent are presented in Table 9.17 and Table 9.18. Displacement effects are presented using the higher and lower range of displacement and mortality rates as presented in Table 5.2 and Table 6.2.

Table 9.17 Common eider predicted mortality arising from 30% displacement at Jammerland Bugt OWF in winter with respect to the birds apportioned to Horsens Fjord og Endelave SPA designated population

Proportion of displaced birds apportioned to Horsens Fjord og Endelave SPA		% mortality				
		1	5	10	15	20
	1	1	3	5	8	10
	2	1	5	10	15	20
	3	2	8	15	23	30
	4	2	10	20	30	40
	5	3	13	25	38	50
	6	3	15	30	45	61
	7	4	18	35	53	71
	8	4	20	40	61	81
	9	5	23	45	68	91
	10	5	25	50	76	101
Input data: Estimated number of birds displaced for the Winter period (5,046) at 30% displacement					>1% increase in background mortality	
Reference population: Horsens Fjord og Endelave SPA = 18,159 individuals					exceeds PBR threshold value when *f* =0.3	
					exceeds PBR threshold value when *f* =0.5	

Table 9.18 Common eider predicted mortality arising from 70% displacement at Jammerland Bugt OWF in winter with respect to the birds apportioned to Horsens Fjord og Endelave SPA designated population

Proportion of displaced birds apportioned to Horsens Fjord og Endelave SPA		% mortality				
		1	5	10	15	20
	1	1	6	12	18	24
	2	2	12	24	35	47
	3	4	18	35	53	71
	4	5	24	47	71	94
	5	6	29	59	88	118
	6	7	35	71	106	141
	7	8	41	82	124	165
	8	9	47	94	141	188
	9	11	53	106	159	212
	10	12	59	118	177	236

Input data: Estimated number of birds displaced for the Winter period (11,775) at 70% displacement		>1% increase in background mortality
Reference population: Horsens Fjord og Endelave SPA = 18,159 individuals		exceeds PBR threshold value when *f* =0.3
		exceeds PBR threshold value when *f* =0.5

9.1.7.3 *Velvet scoter*

The maximum displacement effects from Jammerland Bugt on the Horsens Fjord og Endelave SPA population and the increase in baseline mortality of that population that they represent are presented in Table 9.19. Displacement effects and mortality rates as presented in Table 5.8 and Table 6.8

Table 9.19 Velvet scoter predicted mortality arising from displacement at Jammerland Bugt OWF in winter with respect to the birds apportioned to Horsens Fjord og Endelave SPA designated population

Proportion of displaced birds apportioned to Horsens Fjord og Endelave SPA		% mortality				
		1	5	10	15	20
	1	0	0	0	1	1
	2	0	0	1	1	2
	3	0	1	1	2	2
	4	0	1	2	2	3
	5	0	1	2	3	4
	6	0	1	2	3	5
	7	0	1	3	4	5
	8	0	2	3	5	6
	9	0	2	3	5	7
	10	0	2	4	6	8

Input data: Estimated number of birds displaced for the Winter period (380)		>1% increase in background mortality
Reference population: Horsens Fjord og Endelave SPA = 19 individuals		exceeds PBR threshold value when *f* =0.3
		exceeds PBR threshold value when *f* =0.5

9.1.7.4 Summary for Horsens Fjord og Endelave SPA

Table 9.17, Table 9.18 and Table 9.19 indicate that PBR at *f*=0.3 is only exceeded under relatively extreme circumstances for common eider. It is considered that the scenarios for velvet scoter are unlikely and an artefact of the very low reference population in the SPA. It is therefore considered that such scenarios are unlikely bearing in mind the regional distribution of the two species and also the maximum mortality rates applied by regulators in other windfarm determinations (e.g. Natural England, 2014).

Arbitrary thresholds of 1% on background mortality have also been applied in other windfarm determinations to guide the level of impact. A scenario where an increase in 1% background mortality occur is found to be realistic only for common eider. Both in regard to PBR and 1% threshold adverse effects on designated common eider, velvet scoter and the integrity of the SPA can be rejected.

9.1.8 Sydfynske Øhav

9.1.8.1 Overview

Sydfynske Øhav SPA is located to the south of Funen, spanning the large archipelago between the islands Ærø, Tåsinge, Funen, Langeland and Averknakø. The SPA is located approximately 67 km from Jammerland Bugt and 23 km from Omø Syd. The designation for the SPA comprises eleven species including, of relevance to this report, common eider (8,917-27,037 individuals).

9.1.8.2 Common eider

The maximum displacement effects from Omø Syd on the Sydfynske Øhav SPA population and the increase in baseline mortality of that population that they represent are presented in Table 9.20 and Table 9.21. Displacement effects are presented using the higher and lower range of displacement and mortality rates as presented in Table 5.2 and Table 6.2.

Table 9.20 Common eider predicted mortality arising from 30% displacement at Omø Syd OWF in winter with respect to the birds apportioned to Sydfynske Øhav SPA designated population

Proportion of displaced birds apportioned to Sydfynske Øhav SPA		% mortality				
		1	5	10	15	20
	1	1	4	9	13	17
	2	2	9	17	26	34
	3	3	13	26	39	52
	4	3	17	34	52	69
	5	4	22	43	65	86
	6	5	26	52	78	103
	7	6	30	60	91	121
	8	7	34	69	103	138
	9	8	39	78	116	155
	10	9	43	86	129	172
Input data: Estimated number of birds displaced for the Autumn period (8,622) at 30% displacement					>1% increase in background mortality	
Reference population: Sydfynske Øhav SPA = 27,037 individuals					exceeds PBR threshold value when *f* =0.3	
					exceeds PBR threshold value when *f* =0.5	

Table 9.21 Common eider predicted mortality arising from 70% displacement at Omø Syd OWF in winter with respect to the birds apportioned to Sydfynske Øhav SPA designated population

Proportion of displaced birds apportioned to Sydfynske Øhav SPA		% mortality				
		1	5	10	15	20
	1	2	10	20	30	40
	2	4	20	40	60	80
	3	6	30	60	91	121
	4	8	40	80	121	161
	5	10	50	101	151	201
	6	12	60	121	181	241
	7	14	70	141	211	282
	8	16	80	161	241	322
	9	18	91	181	272	362
	10	20	101	201	302	402
Input data: Estimated number of birds displaced for the Winter period (20,117) at 70% displacement					>1% increase in background mortality	
Reference population: Sydfynske Øhav SPA = 27,037 individuals					exceeds PBR threshold value when *f* =0.3	
					exceeds PBR threshold value when *f* =0.5	

9.1.8.3 Summary for Sydfynske Øhav SPA

Table 9.20 and Table 9.21 indicate that PBR at *f*=0.3 is only exceeded under relatively extreme circumstances for common eider. It is considered that such scenarios are unlikely bearing in mind the regional distribution of the two species and also the maximum mortality rates applied by regulators in other windfarm determinations (e.g. Natural England, 2014).

Arbitrary thresholds of 1% on background mortality have also been applied in other windfarm determinations to guide the level of impact. A scenario where an increase in 1% background mortality occur is found to be unrealistic. Both in regard to PBR and 1% threshold adverse effects on designated common eider and the integrity of the SPA can be rejected.

9.1.9 Marstal Bugt og den sydlige del af Langeland

9.1.9.1 Overview

Marstal Bugt og den sydlige del af Langeland SPA is located along the southwest coast of Langeland both covering the coastal waters with bays and reefs and the lagoons along the coast. The SPA is located approximately 87 km from Jammerland Bugt and 33 km from Omø Syd. The designation for the SPA comprises eleven species including, of relevance to this report, common eider (3,200-29,690 individuals).

9.1.9.2 Common eider

The maximum displacement effects from Omø Syd on the Marstal Bugt og den sydlige del af Langeland SPA population and the increase in baseline mortality of that population that they represent are presented in Table 9.22 and

Table 9.23. Displacement effects are presented using the higher and lower range of displacement and mortality rates as presented in Table 5.2 and Table 6.2.

Table 9.22 Common eider predicted mortality arising from 30% displacement at Omø Syd OWF in autumn with respect to the birds apportioned to Marstal Bugt og den sydlige del af Langeland SPA designated population

Proportion of displaced birds apportioned to Marstal Bugt og den sydlige del af Langeland SPA		% mortality				
		1	5	10	15	20
	1	1	4	9	13	17
	2	2	9	17	26	34
	3	3	13	26	39	52
	4	3	17	34	52	69
	5	4	22	43	65	86
	6	5	26	52	78	103
	7	6	30	60	91	121
	8	7	34	69	103	138
	9	8	39	78	116	155
	10	9	43	86	129	172
Input data: Estimated number of birds displaced for the Autumn period (8,622) at 30% displacement					>1% increase in background mortality	
Reference population: Marstal Bugt og den sydlige del af Langeland SPA = 29,690 individuals					exceeds PBR threshold value when *f* =0.3	
					exceeds PBR threshold value when *f* =0.5	

Table 9.23 Common eider predicted mortality arising from 70% displacement at Omø Syd OWF in winter with respect to the birds apportioned to Marstal Bugt og den sydlige del af Langeland SPA designated population

Proportion of displaced birds apportioned to Marstal Bugt og den sydlige del af Langeland SPA		% mortality				
		1	5	10	15	20
	1	2	10	20	30	40
	2	4	20	40	60	80
	3	6	30	60	91	121
	4	8	40	80	121	161
	5	10	50	101	151	201
	6	12	60	121	181	241
	7	14	70	141	211	282
	8	16	80	161	241	322
	9	18	91	181	272	362
	10	20	101	201	302	402
Input data: Estimated number of birds displaced for the Winter period (20,117) at 70% displacement					>1% increase in background mortality	
Reference population: Marstal Bugt og den sydlige del af Langeland SPA = 29,690 individuals					exceeds PBR threshold value when *f* =0.3	
					exceeds PBR threshold value when *f* =0.5	

9.1.9.3 *Summary for Marstal Bugt og den sydlige del af Langeland SPA*

Table 9.22 and Table 9.23 indicate that PBR at *f*=0.3 is only exceeded under relatively extreme circumstances for common eider. It is considered that such scenarios are unlikely bearing in mind the regional distribution of the two species and also the maximum mortality rates applied by regulators in other windfarm determinations (e.g. Natural England, 2014).

Arbitrary thresholds of 1% on background mortality have also been applied in other windfarm determinations to guide the level of impact. A scenario where an increase in 1% background mortality occur is found to be unrealistic. Both in regard to PBR and 1% threshold adverse effects on designated common eider and the integrity of the SPA can be rejected.

10 Discussion and conclusions

10.1 Introduction to the discussion

The assessment of common eider, common scoter and velvet scoter displacement in this report has focused on impacts from Omø Syd and Jammerland Bugt Offshore Windfarms alone and cumulatively with other projects and has also provided an update to the Appropriate Assessment of nearby SPA. This section includes a holistic approach to the discussion and conclusions of the main findings in this report.

This assessment include stages of the analysis, with which there are variance in the degree of certainty or confidence that can be drawn in the data or technique applied. These discussions and conclusions are structured in decreasing levels of certainty. Uncertainty is described for two key areas of the assessment:

(1) The fate (mortality) of displaced common eiders, common scoters and velvet scoters
(2) The appropriate metric to apply to test significance of the impact (i.e. PBR or 1% thresholds)

There is considered to be a notable degree of confidence in determining the number (and worst case) of common scoter likely to be displaced from the proposed windfarms applying data from Petersen *et al*. (2014). Though for both common eider and velvet scoter there is little knowledge about displacement. Therefore a precautionary displacement have been assumed. For eider, the displacement might be less than stated here given some surveys finding indifference to wind farms when on the sea. Flying though they show avoidance and therefore recommendations from JNCC have been followed. This Report has also defined a useful seasonal approach to determining the worst case scenario for the EIA assessment. Further, a precautionary approach has been applied to identify a theoretical worst case of displacement using the defined footprint of the windfarms within the original development boundary extent. Whilst this theoretical worst case is unlikely to represent a scenario economically appropriate for development, it provides an upper ceiling of potential impacts on common eider, common scoter and velvet scoter from which interpretation can be made.

The key conclusions that can be drawn from investigating the number of eider and scoter displaced (without further stages of the analysis i.e. mortality) against 1% population thresholds are shown in section 10.2.

As discussed elsewhere in this Report, there is little or no published information on the likely fate of displaced seabirds and -ducks from windfarm footprints and none specifically pertaining to common scoter. In order to apply reliable mortality rates (and PBR values as detailed below), in a fully robust manner, more solid knowledge of population size, sub-population delineation and population dynamics than currently available is sought. However, certain authorities (e.g. Natural England in the UK) have proposed a range of mortality rates that they deem to be reasonably precautionary. Section 10.2.3 explores the conclusions that can be drawn in terms of assessment against the flyway population thresholds when a range of mortality rates are applied to the estimation of displacement.

Thirdly, Section 10.4 explores conclusions that may be drawn if PBR is applied to the estimates of common eider, common scoter and velvet scoter mortality. The limitations of PBR have been highlighted in NIRAS (2015) as well as in this Report. The challenges in using PBR to estimate the removal potential of the Western Palaearctic flyway population of common eider, common scoter and velvet scoter led to the suggestion of considering a more holistic approach to inform the assessment of common eider, common scoter and velvet scoter displacement.

When calculating a 'removal' potential of a flyway population, the calculated amount will ideally describe the amount of extra anthropogenic take from the flyway population as a whole, including mortality from sources other than offshore windfarms and along the entire flyway. It has not been possible to include such data in the calculations made in this report.

While recognising the shortcomings in the use of PBR values and the estimation of mortality from displaced birds, this report provides a re-assessment of displacement of common eider, common scoter and velvet scoter from Omø Syd and Jammerland Bugt Offshore Windfarms.

10.2 Displacement estimates and assessment against flyway populations

10.2.1 Jammerland Bugt and Omø Syd separate assessment

The approach to displacement analysis used in Sections 5 and 6 and the associated displacement outputs used for subsequent assessments has, where possible, attempted to follow the guidance for the assessment of displacement presented in JNCC *et al.* (2017). However, it has not been possible to follow this guidance in relation to the calculation of seasonal mean-peak population estimates.

JNCC *et al.* (2017) provides the joint advice of UK Statutory Nature Conservation Bodies (SNCBs) (JNCC, Natural England, Natural Resources Wales, Department of Agriculture, Environment and Rural Affairs and Scottish Natural Heritage) in relation to the assessment of displacement effects. For the calculation of displacement effects, the guidance states that displacement impacts should be assessed based on the "*overall mean seasonal peak numbers of birds (averaged over the years of survey) in the development footprint and appropriate buffer"*. The guidance advises that at least two full years of monthly survey data should be considered to be the bare minimum for assessment purposes. Seasonal mean-peak populations can then be calculated from multiple years of data.

The data available for use in the assessments for Jammerland Bugt come from a programme of aerial surveys undertaken between October 2014 and April 2015. This level of coverage does not provide the minimum two years of baseline data as recommended by JNCC *et al.* (2017). In addition, the survey programme only provides data for a restricted period within the wider non-breeding period not covering the full extent of the autumn, winter and spring seasons for all three key species as defined in Section 4.1.2. Finally, within the period covered, the survey programme did not cover every month, with surveys not conducted in January or February and it is not known if the abundance of the key species during these months would be higher than the populations in the months available. Registrations from the NOVANA program do though indicate the January distributions are similar to the October and November. These data is not modelled or corrected for detection functions and are hard to compare directly. Therefore these limitations significantly limit the resulting assessments meaning that variability in the abundance of the key species at Jammerland Bugt is not captured in the populations used for displacement analysis.

The data available for use in the assessments for Omø Syd come from two datasets. The first was obtained through a programme of site-specific aerial surveys undertaken in the non-breeding period of 2014/15 with the other from surveys covering a wider area undertaken in 1999/2000, 2004, 2008, 2012 and 2013/14 (the Smålandsfarvandet dataset). Seasonal mean-peak populations have been calculated for some seasons for use in the displacement analysis for Omø Syd, however there are still issues associated with the underlying data supporting these populations. Although the latter of the aforementioned datasets (the Smålandsfarvandet dataset) covers a longer time period than the dataset supporting the Jammerland Bugt assessments, it was not considered appropriate to incorporate much of the data from this dataset due to changes in the populations of the three key species, over the time period covered by the Smålandsfarvandet dataset. To ensure the displacement analyses provided effects relevant to the current populations of the key species associated with the areas in which Omø Syd is located only data collected within five years of assessments being conducted were used in displacement analyses. The use of data within five years of the assessment is consistent with the approach generally applied for offshore wind farm projects elsewhere (e.g. in the UK). This approach ensures that the assessments are using data on bird populations that is relevant to the populations under consideration and avoids using data that may have changed significantly since being collected. For assessments for Omø Syd this means that the only data that can be utilised from the Smålandsfarvandet dataset are those collected in the non-breeding period of 2013/14.

Despite the exclusion of data prior to 2013 from the Smålandsfarvandet dataset, if the site-specific data and the Smålandsfarvandet dataset are combined this provides a dataset that includes data collected in two years. However, there are gaps in both datasets meaning that the entire period during which key species may be present at Omø Syd was not covered in either of the two survey programmes. It is not known if the abundance of the key species during these months would be higher than the populations in the months available and this significantly limits the resulting assessments meaning that variability in the abundance of the key species at Omø Syd is not captured in the populations used for displacement analysis.
To account for the limitations in the datasets for both projects, displacement analyses using maximum populations have been presented alongside analyses using mean-peak or average populations. This has been conducted in an attempt to address the limitations in the available data however, it is not known which population, if either, provide an accurate reflection of the likely displacement effect on the key species.

In general each of the two wind farms affect a large proportion of the common eiders in Denmark. Omø Syd and Jammerland Bugt displaces 3.5% and 2.0% of the estimated Danish wintering population respectively. Both areas are most important for common eider in autumn, with the highest counts in October and November. When compared to the flyway population the displacements potentially account for 2.0% and 1.2% of the flyway population respectively. These numbers are high and the two wind farms potentially displace more than 3% of the flyway population together.

Also common and velvet scoter have high numbers of birds present in the two wind farm areas. The seasons with potentially most displaced birds are though different for the two areas. At Jammerland Bugt it is potentially autumn when most birds are affected by the wind farms whereas the spring is most important for Omø Syd.

10.2.2 Comparison to Assessments in the EIA reports

Apart from the overall shortcomings in the survey periods, the use of the data in the EIAs give different results when using the two methods described in them. The Orbicon method uses displacement for only one survey with a fixed displacement of 90% from the wind farm plus a buffer. As the chosen survey (month) for the displacement calculation is not specific to species or bird distribution the result varies from the results in the DHI method. The latter is more consistent with the method for displacement in the present report.

The results of the Orbicon approach in Omø Syd EIA gives result that are more in line with the DHI and present approaches as the survey chosen (November) contains the highest numbers of the three species except common eider. November is thought the month with most eiders within the survey area and therefore most displaced birds for Omø Syd.

For Jammerland Bugt the same month (November) is used giving the same problems with common eider that is most numerous in October. For the other species, November is the survey with the highest number of birds but at the same time the distribution of common and velvet scoter is so that most birds are displaced during other surveys. Especially for velvet scoter, the number of displaced birds are greatly underestimated in the Orbicon method compared to both the DHI method and the method used in section 6.

As both the DHI method and this report's method uses averages for each season the results are more comparable than the results from the Orbicon method. The actual numbers displaced in the different methods vary from method to method. The displaced numbers in the present reassessment is comparable to Orbicon's method for common eider and velvet scoter and to DHI's method for common scoter. For Jammerland Bugt the displaced numbers of common eider is higher than calculated with both Orbicon's and DHI's methods by a factor 3-4. For common scoter and velvet scoter the numbers are roughly the same as when calculated with the DHI method. Orbicon's calculations displaces more common scoters by a factor 2 and underestimates the displaced numbers of velvet scoter as described above.

The differences in displaced birds do also affect the assessments in section 10.3 and 10.4 in a similar manner. Therefore if there is no deviations from the overall comparison it is not discussed further in these sections.

10.2.3 Comparison to flyway population

Both Omø Syd and Jammerland Bugt Offshore Windfarm are situated in an area with a high density of common eiders and scoters, particularly during autumn, winter and spring. The calculated number of displaced common eiders from the windfarm site and the 2 km buffer were highest in autumn and winter. For common and velvet scoter, the displaced numbers were high during the winter and especially for Omø Syd in the spring.

For Omø Syd, the mean number of displaced common eiders in autumn represented between 1.5 and 3.5 % of the national population and 0.9-2.0 % of the flyway population. The comparable statistics for common scoter and velvet scoter were 1.1 % and 1.3 % of the national population and 0.4% and 0.1% of the flyway populations with the highest numbers during spring. For the Jammerland Bugt Offshore Windfarm, the mean number of displaced common eiders peaked in winter, with 0.9-2.0 % of the national and 0.5-1.2 % the flyway population displaced. For both species of scoter, the mean number of displaced birds also peaked during winter, representing nationally 0.2 and 1.2 % for common scoter and velvet scoter respectively and less than 0.1 % of the flyway population for both species.

10.2.4 Cumulative

When considering the amount of displaced common eiders, common scoters and velvet scoters from the Omø Syd and Jammerland Bugt Offshore Windfarms, in combination with windfarms in the German, Danish, Swedish offshore windfarms that hold concentrations of common eider, common scoters and velvet scoters, a total estimated number of more than 31,000 common eiders, 22.000 common scoters and 700 velvet scoters is reached when considering projects ahead in the planning process (i.e. Tiers 1-2). This is equivalent to ca. 3% of the common eider flyway population, ca. 2% common scoter flyway population and ca. 0.2 % of the velvet scoter flyway populations.

10.2.5 Conclusions

Over 1% of the flyway population of common eider are potentially being displaced from each of the two windfarms, as calculated on mean seasonal densities. The 1% is considered to be a relatively high number of displaced individuals.

With an estimated displacement of approximately 2% of the common scoter flyway population across offshore windfarms in Germany, Denmark and Sweden that are considered cumulatively (projects in Tiers 1 - 2), the current level of displacement of the population is considerable. A majority of the estimated displacement has been or is occurring in Danish offshore windfarm sites. Since it is known that offshore windfarms displace common scoters, but the actual impact from the displacement on the population is unknown, it can be considered precautionary to reduce the displacement impact to a minimum where possible. This is true on a lesser extent for common eider due to the likely lower displacement from wind farms.

10.3 Mortality estimations of displaced seaducks and assessment against flyway population

10.3.1 Jammerland Bugt and Omø Syd separate assessment

There is little or no evidence on what displacement impacts may be for common eider, common scoter and velvet scoter. Guided by the advice from a statutory nature conservation advisor in the UK (Natural England who propose generic rates of 1-10%), a range of mortality rates from 1 to 20% has been assumed for displaced birds in this assessment. This is considered to account for uncertainty regarding the notably sensitive common scoter and the variation in vulnerability through the annual cycle. Considering the uncertainty over species specific mortality as a result of displacement, this range is considered suitably precautionary for EIA requirements including the assumption that will cover the different periods of the eider and scoter lifecycle (e.g. moulting periods). The range of 1-20% therefore includes higher mortality rates than the generic range promoted by Natural England (1-10%). Where, appropriate the discussion and conclusions in this section focus on the (likely) highly precautionary maximum 20% mortality rate applied in this Report and also the maximum 10% rate advocated by Natural England.

The numbers of common eider, common scoter and velvet scoter at risk of mortality do not surpass a 1% threshold of the national population for any period of the annual cycle irrespective of the selected level of up to and including 20% mortality. This holds true at the predicted levels of displacement and extreme worst case of 20% mortality when summing (1) the predicted displacement mortality across each season and (2) both windfarms are considered. These observations are equally applicable to a 1% threshold of the biogeographic migratory flyway population at its lower limit. It should be noted that calculating a total annual mortality by summing the predicted displacement mortality across each season is considered overly precautionary with a more realistic expectation being to only consider the displacement impact in the “worst case” season.

10.3.2 Cumulative

The worst case scenarios for Omø Syd and Jammerland Bugt are compared with projects that are operational or have gained consent (i.e. Tiers 1 - 2). All projects are considered irrespective of the consenting stage at which each windfarm currently sits within the planning and consenting process.

When considering only those projects that are operational or have gained consent (i.e. Tiers 1 -2), mortality of 6,379 common eiders, 4,445 common scoters and 155 velvet scoters is predicted to occur cumulatively with Omø Syd and Jammerland Bugt when applying the maximum mortality rate presented (20%). This represents c. 0.7%, 0.4% and 0.04% of the flyway population of common eider, common scoter and velvet scoter respectively for both construction at Omø Syd and Jammerland Bugt. When the maximum level of mortality advocated by Natural England (10%) is applied then the proportion of common eider, common scoter and velvet scoter predicted to die is well below the 1% threshold for the population (0.3%, 0.2% and 0,02% respectively). Calculated against the national populations the percentages are much higher as the population numbers are lower. Against the Danish national population mortality represents c. 1.1%, 1.1% and 0.5% for common eider, common scoter and velvet scoter respectively for construction at both Omø Syd and Jammerland Bugt when applying the maximum mortality rate presented (20%). With the recommended maximum mortality of 10% (Natural England, 2014) the mortality represents c. 0.6%, 0.6% and 0.01% for common eider, common scoter and velvet scoter respectively.

At the highly precautionary worst case, when all projects are considered and the upper level of mortality considered in this Report (20%) is applied, then 6,460 common eiders, 5,036 common scoters and 173 velvet scoters will die as a result of displacement from the construction of Omø Syd and Jammerland bugt. This represents c. 0.7%, 0.4% and 0.04% of the flyway population of common eider, common scoter and velvet scoter respectively for both construction at Omø Syd and Jammerland Bugt. When the maximum level of mortality advocated by Natural England (10%) is applied then the proportion of common eider, common scoter and velvet scoter predicted to die is well below the 1% threshold for the population (0.3%, 0.2% and 0,02% respectively). Calculated against the national populations the percentages are much higher as the population numbers are lower. Against the Danish national population mortality represents c. 1.1%, 1.3% and 0.6% for common eider, common scoter and velvet scoter respectively for construction at both Omø Syd and Jammerland Bugt when applying the maximum mortality rate presented (20%). With the recommended maximum mortality of 10% (Natural England, 2014) the mortality represents c. 0.6%, 0.7% and 0.3% for common eider, common scoter and velvet scoter respectively.

10.3.3 Conclusions

(1) The numbers of common eider, common scoter and velvet scoter at risk of mortality following displacement at both windfarms alone does not surpass a 1% threshold of the national/flyway population for any period of the annual cycle irrespective of the selected level of up to and including a highly precautionary 20% mortality rate.

(2) For Omø Syd and using the highest predicted mortality based on the most precautionary mortality rate (20%), the predicted mortality arising from displacement in this analysis is 4,023 common eiders, 862 common scoters and 79 velvet scoters.

(3) For Jammerland Bugt and using the highest predicted mortality based on the most precautionary mortality rate (20%), the predicted mortality arising from displacement in this analysis is 2,355 common eiders, 170 common scoters and 76 velvet scoters.

(4) At the worst case, when all projects considered cumulatively are included and mortality is assumed to be a highly precautionary 20%, then then 6,460 common eiders, 5,036 common scoters and 173 velvet scoters will die as a result of displacement from the construction of Omø Syd and Jammerland bugt. This represents c. 0.7%, 0.4% and 0.04% of the flyway population of common eider, common scoter and velvet scoter respectively.

(5) When considering only those projects that are operational or have gained consent (i.e. Tiers 1 - 2) and mortality is assumed to be a highly precautionary 20%, then, 6,379 common eiders, 4,445 common scoters and 155 velvet scoters is predicted to die cumulatively with Omø Syd and Jammerland Bugt. This represents c. 0.7%, 0.4% and 0.04% of the flyway population of common eider, common scoter and velvet scoter respectively.

(6) When the maximum level of mortality advocated by Natural England (10%) is applied then the proportion of common eider, common scoter and velvet scoter predicted to die cumulatively is below the 1% threshold for the population (0.3%, 0.2% and 0.02% respectively for projects in Tiers 1-2 and in Tiers 1-4).

10.4 Potential Biological Removal

10.4.1 Jammerland Bugt and Omø Syd separate assessment

To allow for comparisons with the EIA reports, PBR has been presented in this report for the three seaduck species. The use of PBR for understanding the implications for seabird and -duck populations arising from predicted offshore wind farm effects in the UK has been reviewed in some detail (see Green, 2014 and Cook and Robinson, 2015). The main criticisms of PBR for this purpose are:

- PBR fails to incorporate additional sources of anthropogenic mortality and as PBR focusses on determining whether a certain level of mortality is exceeded or not this is a significant issue;
- The recovery factors (*f*) used in PBR are not based on empirical evidence;
- PBR is not suitable for quantifying the impact of additional mortality on population size; and
- PBR has not been adequately validated by empirical studies with studies that have been conducted providing inconsistent results.

The overall conclusion of Cook and Robinson (2016) was:

"…that PBR generally cannot be used to assess whether the population-level effects of offshore wind farms mean that the conservation objectives (whatever they may be) of protected sites are (or are not) being met. This is because PBR considers only whether a predetermined level of mortality is exceeded, rather than the biological impact of any additional mortality at a population level."

The use of PBR as part of the assessments for ornithological receptors at offshore wind farms is therefore no longer advised.

For Omø Syd and Jammerland Bugt using the highest predicted mortality based on the most precautionary mortality rate (20%) and the maximum advocated rate by Natural England (10%), the predicted mortality arising from displacement in this analysis for the worst case construction scenario has been compared with the PBR of the biogeographical / national population.

At Omø Syd for the worst case scenario of the spring season and based on the most precautionary mortality rate (20%), the predicted mortality arising from displacement in this analysis is 4,023 common eiders, 862 common scoters and 79 velvet scoters which is equivalent to a PBR with *f* less than 0.1 even at the national level. At the maximum advocated mortality rate by Natural England (10%), mortality is predicted to be 2,011 common eiders, 431 common scoters and 39 velvet scoters birds.

At Jammerland Bugt for the worst case scenario based on the most precautionary mortality rate (20%), the predicted mortality arising from displacement in this analysis is 2,355 common eiders, 170 common scoters and 76 velvet scoters which is equivalent to a PBR with *f* less than 0.1. At the maximum advocated mortality rate by Natural England (10%), mortality is predicted to be 1,178 common eiders, 85 common scoters and 38 velvet scoters.

10.4.2 Cumulative

The PBR of the biogeographical / national population is compared with the highest predicted mortality of worst case scenarios for Omø Syd and Jammerland Bugt cumulatively with projects that are operational or have gained consent (i.e. Tiers 1 - 2). All projects are considered irrespective of the consenting stage at which each windfarm currently sits within the planning and consenting process.

The currently stability of the biogeographical / national population may lead to a recovery factor (*f*) value of 0.5 being deemed appropriate for common scoter. For common eider it will be similar considering the flyway population though it nationally might be lower. It is likely around 0.3 but can be as low as 0.1. The flyway population of velvet scoter is declining and therefor the recovery factor (*f*) is likely 0.1-0.3 thought the national population is likely to be increasing.

10.4.3 Conclusions

(1) For Omø Syd and using the highest predicted mortality based on the most precautionary mortality rate (20%), the predicted mortality arising from displacement in this analysis is equivalent to a PBR with *f* less than 0.1 all species with respect to the biogeographical / national population. Therefore, during no season is the species predicted to suffer mortality from displacement exceeding the PBR for the national and biogeographic migratory flyway populations at such a high mortality rate.

(2) For Jammerland Bugt and using the highest predicted mortality based on the most precautionary mortality rate (20%), the predicted mortality arising from displacement in this analysis is equivalent to a PBR with *f* less than 0.1 with respect to the biogeographical/national population. Therefore, during no season is the species predicted to suffer mortality from displacement exceeding the PBR for the national and biogeographic migratory flyway populations even at such a high mortality rate.

(3) For the cumulative assessment, using the worst case, when considering only those projects that are operational or have gained consent (i.e. Tiers 1 - 2), and mortality is assumed to be the highly precautionary 20%, the predicted mortality of all analysed species as a result of displacement from construction at Omø Syd and Jammerland Bugt OWF is equivalent to a PBR with *f* less than 0.1 with respect to the biogeographical population. For common eider and common scoter the mortality compared to the national population is equivalent to a BPR with *f* between 0.1 and 0.2. The value is, though, considerably below *f* = 0.5 which is appropriate for a stable population. Even with a drastically declining population the maximum advocated mortality rate by Natural England (10%), leads to a mortality equivalent to a recovery factor less than 0.1. Therefore, if PBR was to be considered appropriate to make judgements on the sustainability of the population no significant effect on the national or biogeographic migratory flyway population would be concluded on this basis (even if applying the highest recommended mortality rates).

(4) For the cumulative assessment, using the worst case, when all projects are considered (i.e. Tiers 1 - 4) and mortality is assumed to be the highly precautionary 20%, the predicted mortality will give the same result as for Tiers 1-2, as the displacements are similar.
(5) The above conclusions are similar to the conclusions from Omø Syd and Jammerland Bugt EIAs even though most of the mortality estimates are slightly higher; there are no breach of the PBR limit from displacement and increased mortality of Omø Syd and Jammerland Bugt OWFs.

10.5 Appropriate Assessment of SPAs

10.5.1 Displaced birds from Omø Syd and Jammerland Bugt Offshore Windfarm

The worst case scenario for Omø Syd and Jammerland Bugt Offshore Windfarm has been defined for each of the three species with a potential for 8,621-20,117 common eiders, 4,310 common scoter and 395 velvet scoters from Omø Syd and 5,046-11,775 common eiders, 852 common scoters and 380 velvet scoters from Jammerland Bugt to be displaced. These numbers represent a significant part of the SPAs populations, especially for common eider, if all birds was displaced directly into any one of the SPAs. However, the proposed windfarms lies, with the exception of Farvandet mellem Skælskør Fjord og Glænø SPA, more than 10 km from the SPA boundaries and is therefore not expected to displace birds directly within the SPA. Farvandet mellem Skælskør Fjord og Glænø SPA are though placed only 3 km from Omø Syd and therefore birds are likely to be displace within the SPA. The is true for common and velvet scoter but not common eider, as the latter species is only displaced up to 2 km from the wind farm (precautionary approach by Natural England is followed in this report). The population of seaducks within the region is highly mobile, with notable shifts in distribution between both seasons and years. Therefore, some connectivity would be expected to occur between these adjacent sites. The proportion, though, of the displaced birds that is displaced into the SPAs remains speculative as is the proportion displaced to the individual SPA. Two areas of key uncertainty have been investigated in terms of determining the extent of the impact on the integrity of the SPA, namely the fate of the displaced birds (i.e. mortality rate as discussed above) and the number of birds that can be directly apportioned to the SPA. These are both discussed further below.

10.5.2 Mortality, apportioning and PBR

At 20% mortality the worst case displacement from both Omø Syd and Jammerland Bugt (30,799 common eiders in winter) represents 6,160 individuals, which would represent a large proportion of the SPA populations (should all displaced birds in a worst case scenario be considered to be representatives of the SPA). For Sprogø og Halsskov Rev SPA, the only SPA likely to be affected by both wind farms, the displaced eiders would represent more than twice SPA population of 3,000 common eiders. At 10% mortality (the maximum rate advocated by Natural England) it would represent 3,080 individuals (or 103% of the SPA). It is though only for this SPA that the mortality at 20% will exceed the population of the SPA for common eider.

There are also two SPAs for which the increase in velvet scoter mortality is likely to exceed the population of the SPA, but this is due to the designated populations being very low (2 and 19 individuals). Therefore any increase in the mortality will affect the population. It is though unlikely that the low population in those cases will lead to an actual increase in mortality for the SPA population as suitable habitat will be present within the SPA unless the designation was inaccurate.

It is clear that with respect to common eider (and scoters), the SPAs supports a proportion of the habitat suitable for the species in the region and hence a proportion of a wider common eider population. Therefore, it is very unlikely that the total amount of eiders displaced from the windfarm will relate to the same SPA, although there are limited opportunities to apply any meaningful ‘apportioning’ technique. For common eider less than 10% of the displaced birds will have to be apportioned when regarding an mortality of 10% before the increased mortality exceeds the 1% value of the SPA population when using peak winter displacement estimates.

Further analysis is presented on PBR of the SPAs where both a recovery factor of f =0.5 (representing a stable population) is presented alongside an recovery factor of f = 0.3 (representing a declining population). For the peak level of displacement the lowest breaches of the PBR would either involve mortality of 10% and a combined apportioning from the two windfarms of as low as 3-10% (70-30% displacement respectably) for the Sprogø and Halskov Rev SPA. It is considered that such scenarios are unlikely bearing in mind the extensive regional distribution of common eiders, most realistic displacement being low and also the maximum mortality rates applied by regulators in other windfarm determinations (e.g. Natural England, 2014). Looking at the distributions of common eiders it is most likely the majority if not all of the common eiders that will be displaced closed to both Omø Syd and Jammerland Bugt Offshore Windfarms. From the distribution maps given in the EIAs for Omø Syd and Jammerland Bugt OWF and survey data from DCE it is evident that common eiders are mainly distributed to the east and north of Omø Syd project area and to the north of Jammerland Bugt project area near on the reefs around Asnæs. It is likely that most of the displaced birds will be dispersed locally within 10 km of the wind farms and therefore less than 10% are likely to be displaced to any SPA, with the exception of the Farvandet mellem Skælskør Fjord og Glænø SPA that is within 5 km from Omø Syd.

For Farvandet mellem Skælskør Fjord og Glænø SPA the distribution of common eider in Smålandsfarvandet is mainly within or adjacent to Omø Syd OWF and near Omø and Agersø, therefore a large proportion maybe apportioned to the SPA. With regard to PBR the limit would be breached at 10% mortality and 30% apportioning. This might be realistic given the proximity between Omø Syd OWF and the SPA. In situations with high numbers of common eider in the region numbers of common eider might be higher in Farvandet mellem Skælskør Fjord og Glænø SPA as indicated by estimated numbers of common eider from aerial counts in 2016 of 21,826 common eiders (Clausen, Petersen, Bregnballe, & Nielsen, 2019). This would lead to a breach of the PBR limit at 10% mortality and 50% apportioning. It is unlikely that half the displaced birds will be apportioned to the Farvandet mellem Skælskør Fjord og Glænø SPA and therefore the displacement and increased mortality can be rejected to have an adverse effect on the designated common eider and the integrity of Farvandet mellem Skælskør Fjord og Glænø SPA.

10.5.3 Conclusions

(1) The worst case displacement scenario for Omø Syd and Jammerland Bugt OWFs represents a significant proportion of the SPAs populations before considering mortality and apportioning.

(2) The apportioning of all SPAs except Farvandet mellem Skælskør Fjord and Glænø SPA are assessed to be less than 10% leading to impact below the PBR thresholds at 10% mortality.

(3) For Farvandet mellem Skælskør Fjord og Glænø SPA the PBR limit for common eider would be breached at 10% mortality and 30% apportioning or at 10% mortality and 50% apportioning when using the highest estimates of birds in the SPA from DCE (Clausen, Petersen, Bregnballe, & Nielsen, 2019) leading to an assessment of the SPA close to the PBR but not compromising the integrity of the SPA and thus adverse effect on the designation of the SPA can be rejected.

(4) This assessment on the SPAs is overall the same as the assessment in the EIAs for Omø Syd and Jammerland Bugt OWFs.

10.6 Summary and key conclusions

On the basis of either a 1% threshold of the Danish national / biogeographical flyway population or a PBR threshold, there is no likelihood of a significant impact from either Omø Syd or Jammerland Bugt Offshore Windfarms alone on common eider, common scoter and velvet scoter, even when accounting for a precautionary mortality rate of up to 20%.

On the basis of either a 1% threshold of the Danish national / biogeographical flyway population or a PBR threshold, there is for common eider, common scoter and velvet scoter no indication of a significant impacts from projects in Tiers 1 and 2 considered cumulatively with Omø Syd or Jammerland Bugt Windfarms alone, when applying high mortality rate of up to 20%. The total quantity of common scoter and common eider displaced cumulatively does however remain at a high and concerning level (22,226 and 31,897 respectively for Tiers 1-2), so if a higher mortality rate is maintained, little ‘headroom’ remains subsequent to the development of Omø Syd and Jammerland Bugt OWF.

It is unlikely that more than 10% of the displaced bird will be apportioned to the to any of the SPAs except for Farvandet mellem Skælskør Fjord og Glænø SPA. Therefore the designated species populations and the integrity of all SPAs cannot be compromised. For Farvandet mellem Skælskør Fjord og Glænø SPA the displacement of common eider will likely lead to an increased mortality close to the PBR of the SPA. When the population in the region is high and therefore many birds are displaced it is likely the population of common eider within the Farvandet mellem Skælskør Fjord og Glænø SPA will be higher than given in the designation. It is unlikely, though, that half the displaced birds will be apportioned to the Farvandet mellem Skælskør Fjord og Glænø SPA and therefore the displacement and increased mortality can be rejected to have an adverse effect on the designated common eider and the integrity of Farvandet mellem Skælskør Fjord og Glænø SPA The ‘headroom’ for further cumulative impacts are though very little.

The overall conclusions of this reassessment is the same as in the EIAs for Omø Syd and Jammerland Bugt even though the displacement and increased mortality might be higher in some aspects.

11 Perspectivation

Further to the assessment the following may be considered by the Danish regulators.

In some western European countries decisions on OWFs in relation to displacements of birds have been based on estimated percentage of a flyway population or in some cases in relation to national population levels. In Germany for instance, Baltic offshore windfarms have been rejected because more than 1% of the national German population of a given bird species was assumed to be displaced by the windfarm. Regulators in the UK, on the other hand, have applied 1% of populations (or 1% change in baseline mortality) to define the sensitivity or importance of a given number of a seabird or -duck species such as eiders and scoter. A generic mortality rate between 1 and 10% has then been recommended to be applied when estimating the displacement rate. As no species specific rate has been presented for common scoter (a particularly vulnerable species) and no consideration was given to sensitive periods of the life cycle such as moulting, a widened range of up to 20% mortality have been referred to in this report.

No set accepted limit for displacement of marine birds has been defined in Denmark. It is a broad recommendation by the authors that national guidelines, if possible, will be developed to address seabird and -duck displacement and protection of important concentrations of moulting seaducks.

The identified cumulative effect of displacement of the common eider and common scoter flyway population across offshore windfarms in Germany, Denmark and Sweden (i.e. before mortality rates are applied), potentially leaving little headroom for future development of additional offshore windfarms along the flyway distribution of the species if future windfarms holding concentrations of common eiders and common scoters. When 100% of the removal potential is taken from the flyway population (e.g. from offshore windfarm developments), there will in principle be no space available for further development of offshore activities in areas with common eider or common scoter populations belonging to the flyway population. Thus it’s considered important to maximize offshore wind power capacity with minimal impact on sensitive species before a level of 100% removal potential has been reached.

The potential impact from the Omø Syd and the Jammerland Bugt Offshore Windfarms could potentially be mitigated by means of altering other anthropogenic impacts on the population. These impacts could be either direct or indirect effects on the population. Direct impacts are for instance hunting pressure on the common eider, common scoter and velvet scoter population or by-catch of birds in gill nets fishery. Indirect effects could be human disturbances in the form of boat traffic. These effects could potentially mitigate for undesired effects from the presence of the two windfarms. Regulation of human activities in specific areas and periods could be one way of mitigation, while regulations in fishery and hunting activity could be a more direct way of mitigation. The national Danish hunting bag of common eider, common scoter and velvet scoter were 43,579, 8,400 and 2,656 birds respectively in 2014/2015 (Asferg, et al., 2018). The majority of common eiders are shoot around Funen and in the Great Belt area, whereas the majority of common and velvet scoter being short more northern in the Great Belt and in the southern part of Kattegat (Asferg, et al., 2018).

It is recommended that the authorities consider initiatives with the aim to achieve more information about for instance the common eider, common scoter and velvet scoter population sizes and dynamic features (e.g. age-specific mortality, survival rates and reproduction rates) and moulting ducks that allow for more exact evaluations of the potential impact from offshore windfarms in the future. Likewise, strategic assessment of future offshore windfarm developments and thorough screening processes under a spatial planning framework is also considered helpful for the process.

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Appendix 1: Displacement matrices

Omø Syd

Common eider

Table 12.1: Predicted displacement of common eider from Omø Syd plus a 2 km buffer area during the autumn using a range of displacement and mortality rates

	Mortality (%)												
Displacement (%)	**1**	**2**	**5**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
10	29	57	144	287	575	862	1,150	1,437	1,724	2,012	2,299	2,586	2,874
20	57	115	287	575	1,150	1,724	2,299	2,874	3,449	4,023	4,598	5,173	5,748
30	86	172	431	862	1,724	2,586	3,449	4,311	5,173	6,035	6,897	7,759	8,622
40	115	230	575	1,150	2,299	3,449	4,598	5,748	6,897	8,047	9,196	10,346	11,495
50	144	287	718	1,437	2,874	4,311	5,748	7,185	8,622	10,059	11,495	12,932	14,369
60	172	345	862	1,724	3,449	5,173	6,897	8,622	10,346	12,070	13,795	15,519	17,243
70	201	402	1,006	2,012	4,023	6,035	8,047	10,059	12,070	14,082	16,094	18,105	20,117
80	230	460	1,150	2,299	4,598	6,897	9,196	11,495	13,795	16,094	18,393	20,692	22,991
90	259	517	1,293	2,586	5,173	7,759	10,346	12,932	15,519	18,105	20,692	23,278	25,865
100	287	575	1,437	2,874	5,748	8,622	11,495	14,369	17,243	20,117	22,991	25,865	28,739

Table 12.2: Predicted displacement of common eider from Omø Syd plus a 2 km buffer area during the winter using a range of displacement and mortality rates

	Mortality (%)												
Displacement (%)	**1**	**2**	**5**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
10	27	54	136	272	544	815	1,087	1,359	1,631	1,902	2,174	2,446	2,718
20	54	109	272	544	1,087	1,631	2,174	2,718	3,261	3,805	4,348	4,892	5,436
30	82	163	408	815	1,631	2,446	3,261	4,077	4,892	5,707	6,523	7,338	8,153
40	109	217	544	1,087	2,174	3,261	4,348	5,436	6,523	7,610	8,697	9,784	10,871
50	136	272	679	1,359	2,718	4,077	5,436	6,794	8,153	9,512	10,871	12,230	13,589
60	163	326	815	1,631	3,261	4,892	6,523	8,153	9,784	11,415	13,045	14,676	16,307
70	190	380	951	1,902	3,805	5,707	7,610	9,512	11,415	13,317	15,220	17,122	19,024
80	217	435	1,087	2,174	4,348	6,523	8,697	10,871	13,045	15,220	17,394	19,568	21,742
90	245	489	1,223	2,446	4,892	7,338	9,784	12,230	14,676	17,122	19,568	22,014	24,460
100	272	544	1,359	2,718	5,436	8,153	10,871	13,589	16,307	19,024	21,742	24,460	27,178

Table 12.3: Predicted displacement of common eider from Omø Syd plus a 2 km buffer area during the spring using a range of displacement and mortality rates

	Mortality (%)												
Dis	**1**	**2**	**5**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**

10	13	26	66	131	263	394	526	657	788	920	1,051	1,182	1,314
20	26	53	131	263	526	788	1,051	1,314	1,577	1,839	2,102	2,365	2,628
30	39	79	197	394	788	1,182	1,577	1,971	2,365	2,759	3,153	3,547	3,942
40	53	105	263	526	1,051	1,577	2,102	2,628	3,153	3,679	4,204	4,730	5,255
50	66	131	328	657	1,314	1,971	2,628	3,285	3,942	4,598	5,255	5,912	6,569
60	79	158	394	788	1,577	2,365	3,153	3,942	4,730	5,518	6,306	7,095	7,883
70	92	184	460	920	1,839	2,759	3,679	4,598	5,518	6,438	7,358	8,277	9,197
80	105	210	526	1,051	2,102	3,153	4,204	5,255	6,306	7,358	8,409	9,460	10,511
90	118	236	591	1,182	2,365	3,547	4,730	5,912	7,095	8,277	9,460	10,642	11,825
100	131	263	657	1,314	2,628	3,942	5,255	6,569	7,883	9,197	10,511	11,825	13,139

Common scoter

Table 12.4: Predicted displacement of common scoter from Omø Syd plus a 5 km buffer area all the autumn, winter and spring

		Mortality (%)												
		1	**2**	**5**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
Season	**Autumn**	4	8	19	39	77	116	155	194	232	271	310	348	387
	Winter	8	16	39	79	157	236	314	393	472	550	629	707	786
	Spring	43	86	215	431	862	1,293	1,724	2,155	2,586	3,017	3,448	3,879	4,310

Velvet scoter

Table 12.5: Predicted displacement of velvet scoter from Omø Syd plus a 5 km buffer area all the autumn, winter and spring

		Mortality (%)												
		1	**2**	**5**	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
Season	**Autumn**	1	1	3	5	11	16	22	27	33	38	43	49	54
	Winter	2	5	12	25	50	74	99	124	149	173	198	223	248
	Spring	4	8	20	39	79	118	158	197	237	276	316	355	395

Jammerland Bugt

Common eider

Table 12.6: Predicted displacement of common eider from Jammerland Bugt plus a 2 km buffer area during the autumn using a range of displacement and mortality rates

Displacement (%)	Mortality (%) 1	2	5	10	20	30	40	50	60	70	80	90	100
10	2	4	11	21	42	64	85	106	127	148	169	191	212
20	4	8	21	42	85	127	169	212	254	297	339	381	424
30	6	13	32	64	127	191	254	318	381	445	508	572	636
40	8	17	42	85	169	254	339	424	508	593	678	763	847
50	11	21	53	106	212	318	424	530	636	741	847	953	1,059
60	13	25	64	127	254	381	508	636	763	890	1,017	1,144	1,271
70	15	30	74	148	297	445	593	741	890	1,038	1,186	1,335	1,483
80	17	34	85	169	339	508	678	847	1,017	1,186	1,356	1,525	1,695
90	19	38	95	191	381	572	763	953	1,144	1,335	1,525	1,716	1,907
100	21	42	106	212	424	636	847	1,059	1,271	1,483	1,695	1,907	2,118

Table 12.7: Predicted displacement of common eider from Jammerland Bugt plus a 2 km buffer area during the winter using a range of displacement and mortality rates

Displacement (%)	Mortality (%) 1	2	5	10	20	30	40	50	60	70	80	90	100
10	17	34	84	168	336	505	673	841	1,009	1,177	1,346	1,514	1,682
20	34	67	168	336	673	1,009	1,346	1,682	2,018	2,355	2,691	3,028	3,364
30	50	101	252	505	1,009	1,514	2,018	2,523	3,028	3,532	4,037	4,542	5,046
40	67	135	336	673	1,346	2,018	2,691	3,364	4,037	4,710	5,383	6,055	6,728
50	84	168	421	841	1,682	2,523	3,364	4,205	5,046	5,887	6,728	7,569	8,410
60	101	202	505	1,009	2,018	3,028	4,037	5,046	6,055	7,065	8,074	9,083	10,092
70	118	235	589	1,177	2,355	3,532	4,710	5,887	7,065	8,242	9,420	10,597	11,775
80	135	269	673	1,346	2,691	4,037	5,383	6,728	8,074	9,420	10,765	12,111	13,457
90	151	303	757	1,514	3,028	4,542	6,055	7,569	9,083	10,597	12,111	13,625	15,139
100	168	336	841	1,682	3,364	5,046	6,728	8,410	10,092	11,775	13,457	15,139	16,821

Table 12.8: Predicted displacement of common eider from Jammerland Bugt plus a 2 km buffer area during the spring using a range of displacement and mortality rates

Displacement (%)	Mortality (%) 1	2	5	10	20	30	40	50	60	70	80	90	100
10	4	7	18	36	72	107	143	179	215	251	286	322	358
20	7	14	36	72	143	215	286	358	430	501	573	644	716
30	11	21	54	107	215	322	430	537	644	752	859	967	1,074
40	14	29	72	143	286	430	573	716	859	1,003	1,146	1,289	1,432
50	18	36	90	179	358	537	716	895	1,074	1,253	1,432	1,611	1,790
60	21	43	107	215	430	644	859	1,074	1,289	1,504	1,719	1,933	2,148
70	25	50	125	251	501	752	1,003	1,253	1,504	1,754	2,005	2,256	2,506
80	29	57	143	286	573	859	1,146	1,432	1,719	2,005	2,291	2,578	2,864
90	32	64	161	322	644	967	1,289	1,611	1,933	2,256	2,578	2,900	3,222

	100	36	72	179	358	716	1,074	1,432	1,790	2,148	2,506	2,864	3,222	3,580

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Common scoter

Table 12.9: Predicted displacement of common scoter from Jammerland Bugt plus a 5 km buffer area all the autumn, winter and spring

	Mortality (%)													
		1	2	5	10	20	30	40	50	60	70	80	90	100
Season	Autumn	0	1	2	4	8	12	15	19	23	27	31	35	38
	Winter	9	17	43	85	170	256	341	426	511	596	682	767	852
	Spring	2	3	8	17	34	51	68	84	101	118	135	152	169

Velvet scoter

Table 12.10: Predicted displacement of velvet scoter from Jammerland Bugt plus a 5 km buffer area all the autumn, winter and spring

	Mortality (%)													
		1	2	5	10	20	30	40	50	60	70	80	90	100
Season	Autumn	0	0	1	1	2	3	4	5	6	8	9	10	11
	Winter	4	8	19	38	76	114	152	190	228	266	304	342	380
	Spring	3	6	14	28	56	84	113	141	169	197	225	253	282