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Anholt Offshore Wind Farm

Birds

December 2009

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1. Summaries

1.1 Dansk resumé

Udbredelsen og antallet af vandfugle i regionen omkring Anholt Møllepark (AM) projektområde blev undersøgt ved baseline surveys fra fly og skib og analyser af eksisterende historiske fly- og skibsbaserede surveys. Anholt Havmøllepark's betydning for vandfugle i forhold til resten af regionen, der huser de største koncentrationer af vandfugle i danske farvande, blev demonstreret ved detaljeret modellering af udbredelsen af en bred vifte af vandfugle, der forekommer regelmæssigt i den nordlige og centrale del af Kattegat. Modellerne dokumenterer at vandfuglefaunaen udenfor yngletiden dækker både bundfouragerende fugle (især havdykænder), dykkende fiskespisende fugle som alke, der fouragerer på stimer af pelagiske fisk, og overfladefouragerende arter som ride og generalisters som måger. Dette konglomerat af fugle-økotyper er unikt på internationalt niveau, idet det repræsenterer kombinationen af det største sammenhængende område med vandybder under 15 m i dennne del af Europa, og vandmasser af Atlantisk oprindelse, som er rige på dyreplankton og fisk, som dominerer de dybere områder med mere end 20 m vanddybde.

Vigtigst i forhold til vurderingen af Anholt Havmøllepark's betydning for vandfugle er områdets placering udenfor disse to miljøer. Området med høj bæreevne for muslingevækst strækker sig fra nord for Anholt og Djursland til en afstand på mellem 8 og 12 km fra mølleområdet. Denne afstand matcher præcist afstanden til de internationalt vigtige koncentrationer af vandfugle i det nordlige Kattegat. På trods af variationen i de estimerede mønstre i væksten af muslinger så viser de mange surveydata som baselyne er baseret på, at havdykænder kun udnytter den planlagte møllepark og omgivende havområder i mindre grad. Eftersom mølleparken vil blive placeret udenfor de to større biologisk-ocenanografiske områder i det centrale Kattegat kan den vurderes som placeret på økotonen mellem disse to zoner. Økotonen er karakteriseret ved relativt kraftig frontaktivitet og saltgradienter, - strukturer som har en markant indflydelse på fuglenes brug af mølleområdet, især Rødstrubet og Sortstrubet Lom.

På trods af områdets betydning for de to lomarter har mølleområdet et relativt lavt antal af andre fuglarter. Vurderingen af mølleområdets kumulative betydning for de regionale fuglebestande, målt i relation til de totale bio-geografiske bestande viser tre områder af international betydning placeret i en vis afstand til mølleområdet: et område nordvest for Anholt, et nordøst for Djursland og et syd for Læsø. De to førstnævnte områder har en minimumsafstand til Anholt Havmøllepark på 5 km.

Baselineundersøgelserne inkluderede et detaljeret studie af fugletrækket ved integreret brug af radar og visuelle observationer fra Djursland (Gjerrild Klint) og Anholt (Anholt Havn). Studiet blev designet med henblik på at indhente detaljerede data på artssammensætning og analyser af profiler i fugletrækkets relative intensitet og højde langs forskellige dele af den potentielle trækkorridor mellem Djursland og Anholt. Resultaterne peger entydigt på eksistensen af en trækkorridor af landfugle mellem

Djursland og Anholt i foråret 2009. 'Ø-effekten' fra Anholt blev tydeligt reflekteret af de indsamlede data, og øen synes at fungere som en magnet på trækfugle om foråret. Selvom Anholt Havmøllepark er placeret på trækkorridoren vurderes intensiteten af fugletrækket ved mølleparken at være lavere end registreret ved Djursland og Anholt. Højdefordelingen af fugletrækket i foråret 2009 indikerede, at de fleste trækfugle passerer Anholt i lav højde (< 100 m), hvorimod mellem 25 % og 40 % af trækket ved Djursland fandt sted ved højder under 200 m om natten, og mellem 40 % og 60 % om dagen. Det er sandsynligt, at trækhøjden ved Anholt Havmøllepark generelt vil være lavere end ved Djursland.

Effekter af habitatfortrængning på lommer på grund af Anholt Havmøllepark blev vurderet ved anvendelse af en påvirkningsafstand på 2 km. Andelen af det tilgængelige høj-tæthedsområde (> 0.66 fugle/km^2) indenfor regionen, som lommerne kan fortrænges fra blev estimeret til 24.7 %, svarende til 260 km^2. Det fortrængte antal af lommer svarer til 150 fugle, - et antal der ikke vil have betydning på bestandsniveau. De fysiske ændringer af habiten forårsaget af mølleparken vurderes at have ubetydelige påvirkninger på fuglene i området. Specifikt, vurderes der ingen effekter som følge af direkte habitattab ved placeringen af de 88-174 turbiner, på grund af det begrænsede areal, der berøres.

På baggrund af den dokumenterede eksistens af en trækkorridor for vandfugle vurderes risikoen for collision for denne gruppe af fugle som moderat. Hyppige kollisioner forekommer sjældent, og er kun rapporteret fra et fåtal eksponerede mølleparker karakteriseret ved høje trækintensiteter og høje antal af for eksempel lokale rovfugle. Ved disse 'worst-case' scenarier har dødeligheden hos rovfugle som direkte følge af collision med rortorblade været relativt høj set i forhold til størrelsen af de brørte bestande. Kendskabet til de adfærdsmæssige reaktioner hos rovfugle på langdistancetræk på havmøller er meget begrænset, idet havmølleparker indtil nu ikke har været placeret i egentlige trækkorridorer for disse arter. Kun overvågningsaktiviteter vil vise hvorvidt de forskellige rovfuglearter, der anvender korridoren mellem Djursland og Anholt vil ændre deres trækrute når de nærmer sig møllerne eller tiltrækkes til mølleparken på grund af deres aversion mod at flyve over åben hav. Rovfuglene der udnytter trækkorridoren inkluderer arter med små bestande, der er listet på Anneks I i EF Fulebeskyttelsesdirektivet såsom Kongeørn, Fiskeørn og Vandrefalk, og kollision og dermed forhøjet dødelighed vil formordentlig være i strid med Direktivet og kan være signifikante for de berørte bestande.

Kollisionsrisikoen for vandfugle vurderes som minimal. Afhængig af det valgte design vil mølleparkens diameter dække 10-12 % af bredden af farvandet mellem Djursland og Anholt. Vandfugle vil formodentlig undgå mølleparken ved afstande på 3-5 km; en mindre justering, og en mindre kollisionsrisiko til følge for de bestande, der bevæger sig gennem farvandet. Selvom frekvensen af kollisioner vil blive mindre end vurderet for havmølleparken ved Nysted vil antallet af kollisioner pr. sæson sandsynligvis være højere som følge af at antallet af dykænder, der passerer farvandet, er langt større end andefugletrækket der passerer Nysted.

Den kumulative habitatfortrængning af lommer forventes at overstige den estimerede fortrængning på grund af mølleparken. Den samlede habitatfortrængning som følge af fiskeri, vindmøller, færger og Anholt Havmøllepark vil potentielt kunne påvirke lommer fra en stor del af den tilgængelige habitat i området. Antal af fortrængte fugle vil dog være ubetydelig i forhold til størrelsen af de berørte bio-geografiske bestande.

Rekommandationer omkring afværgeforanstaltninger i forhold til risikoen for kollision for trækkende landfugle begrænsis af de manglende data på de adfærdmæssige reaktioner hos store arter som rovfugle og traner på havmølleparker.

1.2 Summary

The distribution and abundance of waterbirds in the region around the Anholt Offshore Wind Farm (OWF) Project Area have been analysed using baseline surveys from aircraft and ship and all available historic aerial and ship-based surveys in the region. By modelling the fine-scale distribution of the wide range of waterbird species occurring regularly in the northern and central Kattegat the importance of the Anholt OWF to waterbirds could be demonstrated relative to the rest of this region, which houses the largest concentrations of waterbirds in Danish waters. The models document that during the non-breeding season the waterbird fauna ranges from benthivorous birds (chiefly seaducks), across pursuit-diving piscivores like razorbills targeting schooling pelagic fish, to surface foragers like kittiwakes and generalists like gulls. This conglomerate of avian ecotypes is quite unique at an international level, as it represents a combination of the largest continuous area of shallow offshore waters below 15 m water depth found in this part of Europe and water masses of Atlantic origin rich in animal plankton and fish dominating the areas deeper than 20 m.

Importantly, in relation to establishing the significance of the Anholt OWF to waterbirds the site is actually located outside both of these environments. The area of high carrying capacity for mussel growth stretches north of Anholt and Djursland at distances of approximately 8 and 12 km, respectively, from the wind farm site. This matches exactly the distance to the major and, in international perspective, most sensitive elements of the bird fauna in the Northern Kattegat; the extensive concentrations of seaducks. Despite variability in these mean patterns of mussel growth, the large amount of survey data on which the baseline has been established clearly show that the seaducks do not use the wind farm and associated areas to any great extent. As the wind farm site is located outside the major marine environments as found in the central Kattegat it may be regarded as being embedded in the ecotone marking the transition between the two zones. The ecotone is characterised by relatively strong frontal activity and salinity gradients, - structures which have a profound influence on the birds using the site most frequently, notably Red-throated and Black-throated divers.

The wind farm, despite being important to divers, has relatively lower cumulative abundance when evaluated across the entire bird fauna. Evaluation of the cumulative

importance of the wind farm to regional bird populations, measured in relation to total bio-geographic populations showed three areas of international significance located at some distance from the wind farm – one located northwest of Anholt, one northeast of Djursland and one south of Læsø. The two former areas have a minimum distance to the Anholt OWF of 5 km.

An extensive bird migration study was undertaken by integrated radar and visual surveys from Djursland (Gjerrild Klint) and Anholt (Anholt Harbour). The study was designed to enable descriptions of species compositions, and analyses of profiles in relative migration intensity and altitude along different parts of the potential migration corridor between Djursland and Anholt. The results unambiguously indicate the existence of a migration pathway or corridor of landbirds between Djursland and Anholt in spring 2009. Clearly, the 'island effect' of Anholt was reflected, and the island seems to function as a magnet on migrants during spring. Although the Anholt OWF is located on this migration corridor the densities of bird migration at the OWF site can be safely assessed to be below the densities recorded close to Djursland and Anholt. At Gjerrild, between 25% and 40 % of the migration took place at altitudes below 200 m during the night, while during the day between 40% and 60% of the migration was recorded below 200 m altitude, *Figure 3-55.* Intensities at Gjerrild were lower below 100 m altitude than between 100 and 600 m altitude during all 5-day periods and parts of the day.

Habitat displacement impacts on divers due to Anholt OWF were investigated using a displacement range of 2 km. The proportion of the available high-density areas (> 0.66 birds/km^2) within the region from which divers could be displaced was estimated at 24.7 %, equivalent of 260 km^2. The displaced population of divers was estimated at 150 birds, thus the number of displaced birds does not have any significant impact at the population level. The physical changes imposed by constructing the Anholt OWF are assessed to have insignificant, if any, impacts on birds in the area. Specifically, no impact is expected in relation to 'direct habitat loss' as a result of the physical presence of 88-174 turbines because of the very little area that is actually affected.

Due to the documented presence of a migration corridor to landbirds collision risks were assessed as moderate to this group of birds. Frequent collisions are rare events and have been reported from only a few exposed sites with high migration densities and large numbers of, for example, soaring resident raptors. In such worst-case scenarios mortality rates of raptors as a direct result of collisions with the rotor blades are relatively high in comparison with the size of the affected populations. There is an almost complete lack of experience regarding the behavioural responses of large birds on long-distance migration like raptors and cranes around offshore wind farms, as wind farms have not yet been erected in migration corridors for these species groups. Only monitoring will tell us to what extent the different species of raptors using the Djursland-Anholt corridor will change their flight route on approach to the structures or get attracted to the wind farm due to their aversion to migrate over open sea. As the raptor migration along the Djursland-Anholt corridor includes raptor species with small population sizes listed in the Annex I of EU Birds Directive like Golden Eagle, Osprey and Peregrine Falcon impacts due to collisions (extra mortality) may not be in line with the Directive and may be significant at the level of the affected populations.

Collision risks to waterbirds were assessed as minor. Depending on the lay-out chosen, the cross-sectional diameter of the wind farm will span 10-12% of the width of the strait between Djursland and Anholt. Waterbirds will probably deflect the wind farm at distances of 3-5 km; a minor adjustment and collision risks to migrating waterbirds should be expected to be at a low level with no or minor consequences for the populations passing the strait. Yet, even if the collision frequencies will be smaller than at the Nysted wind farm the number of collisions per season may be higher, as the number of seaducks passing the strait might be several times larger than the number passing Nysted.

The cumulative displacement of divers is expected to exceed the estimated displacement on account of the Anholt OWF. Thus, the joint impact of fisheries, ferry services and the Anholt OWF will potentially be displacing divers from a large proportion of the available habitat in the region. The total number displaced, however, is likely to be well below levels which are significant in comparison to the size of the bio-geographic populations involved.

Recommendations regarding mitigation of collision risks to migrating landbirds are limited by the lack of data on behavioural reactions of large species of migrating landbirds (raptors and cranes) on offshore wind farms.

Long-tailed ducks in display

2. Introduction

2.1 Background

In 1998 the Ministry of Environment and Energy empowered the Danish energy companies to build offshore wind farms of a total capacity of 750 MW, as part of fulfilling the national action plan for energy, Energy 21. One aim of the action plan, which was elaborated in the wake of Denmark's commitment to the Kyoto agreement, is to increase the production of energy from wind power to 5.500 MW in the year 2030. Hereof 4.000 MW has to be produced in offshore wind farms.

In the years 2002-2003 the two first wind farms was established at Horns Rev west of Esbjerg and Rødsand south of Lolland, consisting of 80 and 72 wind turbines, respectively, producing a total of 325,6 MW. In 2004 it was furthermore decided to construct two new wind farms in proximity of the two existing parks at Horns rev and Rødsand. The two new parks, Horns rev 2 and Rødsand 2, are going to produce 215 MW each and are expected to be fully operational by the end 2010.

The 400 MW Anholt Offshore Wind Farm constitutes the next step of the fulfilment of aim of the action plan. The wind farm will be constructed in 2012, and the expected production of electricity will cover the yearly consumption of approximately 400.000 households. Energinet.dk on behalf of the Ministry of Climate and Energy is responsible for the construction of the electrical connection to the shore and for development of the wind farm site, including the organization of the impact assessment which will result in the identification of the best suitable site for constructing the wind farm. Rambøll with DHI and other sub consultants are undertaking the site development including a full-scale Environmental Impact Assessment for the wind farm.

The present report is a part of a number of technical reports forming the base for the Environmental Impact Assessment for Anholt Offshore Wind Farm.

The Environmental Impact Assessment of the Anholt Offshore Wind Farm is based on the following technical reports:

- Technical Description
- Geotechnical Investigations
- Geophysical Investigations
- Metocean data for design and operational conditions
- Hydrography including sediment spill, water quality, geomorphology and coastal morphology
- Benthic Fauna
- Birds
- Marine mammals
- Fish
- Substrates and benthic communities
- Benthic habitat
- Maritime archaeology

- Visualization
- Commercial fishery
- Tourism and Recreational Activities
- Risk to ship traffic
- Noise calculations
- Air emissions

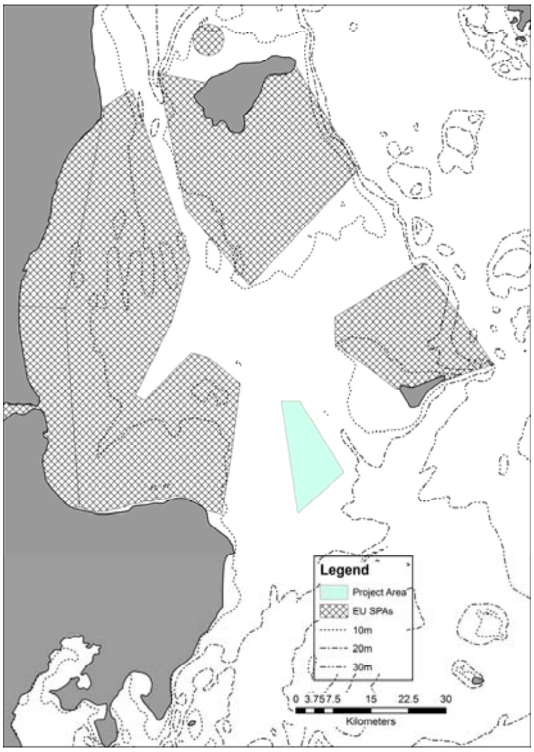
2.2 Content of specific memo

This memo describes the results of the baseline investigations and the impact assessment on birds. The Project Area for the Anholt OWF is located in close proximity to the most important area to wintering waterbirds in Denmark; the Northwestern Kattegat, Ref. 21, and marks the boundary between two distinct ecosystems, harbouring distinct and highly different waterbird communities:

- the benthivorous community of the large shallow area between Anholt, Læsø and Jutland and
- the piscivorous community found around the offshore banks in the eastern and central Kattegat.

In addition, the Project Area is located midway between eastern Djursland and Anholt in a region which is considered strategically important for landbird migration during spring. Thus, baseline investigations and impact assessment on wintering waterbirds cover a wide range of waterbird species and the spring migration of landbirds. The memo is divided into chapters describing methods and results for the baseline study and environmental impact assessment. Separate chapters are covering mitigation measures, cumulative impacts and potential impacts connected to decommissioning, as well the assessment of impacts due to the sub-station and offshore cable.

Factors which may affect wintering waterbirds include habitat displacement due to disturbance, barrier effects and collision risks to migrating birds. The impact assessment will combine existing knowledge of the sensitivity of the wide range of species to habitat displacement, barrier effects and collision risks, and largely follow the methods developed and applied during the assessments of the impact of the Horns Rev1, Horns Rev 2, Nysted and Rødsand 2 offshore wind farms, Ref. 13, Ref. 24, Ref. 28. In addition, the assessment will draw upon the experiences from the monitoring activities related to the construction and operation of the above mentioned wind farms. Compared to the environment of the planned Anholt OWF, the OWFs at Horns Rev and Nysted have slightly shallower depth, and roughly the same dimensions as Anholt. The sediment conditions of Horns Rev and Nysted, however, differ slightly from those at Anholt by larger grain sizes. Compared to Nysted and Horns Rev the Anholt OWF will be located in a region of significantly higher bird conservation interests, both in relation to wintering birds and in relation to bird migration.



2-1. Map showing EU Special Protection Areas (SPAs) in the region, designated on the basis of internationally important concentrations of waterbirds.

In the baseline description as well as in the assessment of impact two geographical entities are referred to:

- Project area – area of 144 km inside which the wind farm site of approximately 88 km^2 will be located

- Region – the investigated region for staging and wintering waterbirds (the area covered by the map in Figure 2-1.

3. Offshore wind farm

3.1 Project description

This chapter describes the technical aspects of the Anholt Offshore Wind Farm. For a full project description reference is made to Ref. 47. The following description is based on expected conditions for the technical project; however, the detailed design will not be done until a developer of the Anholt Offshore Wind Farm has been awarded.

3.1.1 Site location

The designated investigation area for the Anholt Offshore Wind Farm is located in Kattegat between the headland Djursland of Jutland and the island Anholt - see Figure 3-1. The investigation area is 144 km^2, but the planned wind turbines must not cover an area of more than 88 km^2. The distance from Djursland and Anholt to the project area is 15 and 20 km, respectively. The area is characterised by fairly uniform seabed conditions and water depths between 15 and 20 m.

3.1.2 Offshore components

3.1.2.1 Foundations

The wind turbines will be supported on foundations fixed to the seabed. The foundations will be one of two types; either driven steel monopiles or concrete gravity based structures. Both concepts have successfully been used for operating offshore wind farms in Denmark.

The monopile solution comprises driving a hollow steel pile into the seabed. A steel transition piece is attached to the pile head using grout to make the connection with the wind turbine tower.

The gravity based solution comprises a concrete base that stands on the seabed and thus relies on its mass including ballast to withstand the loads generated by the offshore environment and the wind turbine.

3.1.2.2 Wind turbines

The maximum rated capacity of the wind farm is by the authorities limited to 400 MW 0. The farm will feature from 80 to 174 turbines depending on the rated energy of the selected turbines corresponding to the range of 2.3 to 5.0 MW.

Preliminary dimensions of the turbines are not expected to exceed a maximum tip height of 160 m above mean sea level for the largest turbine size (5.0 MW) and a minimum air gap of approximately 23 m above mean sea level. An operational sound power level is expected in the order of 110 dB(A), but will depend on the selected type of turbine.

The wind turbines will exhibit distinguishing markings visible for vessels and aircrafts in accordance with recommendations by the Danish Maritime Safety Administration and the Danish Civil Aviation Administration. Safety zones will be applied for the wind farm area or parts hereof.

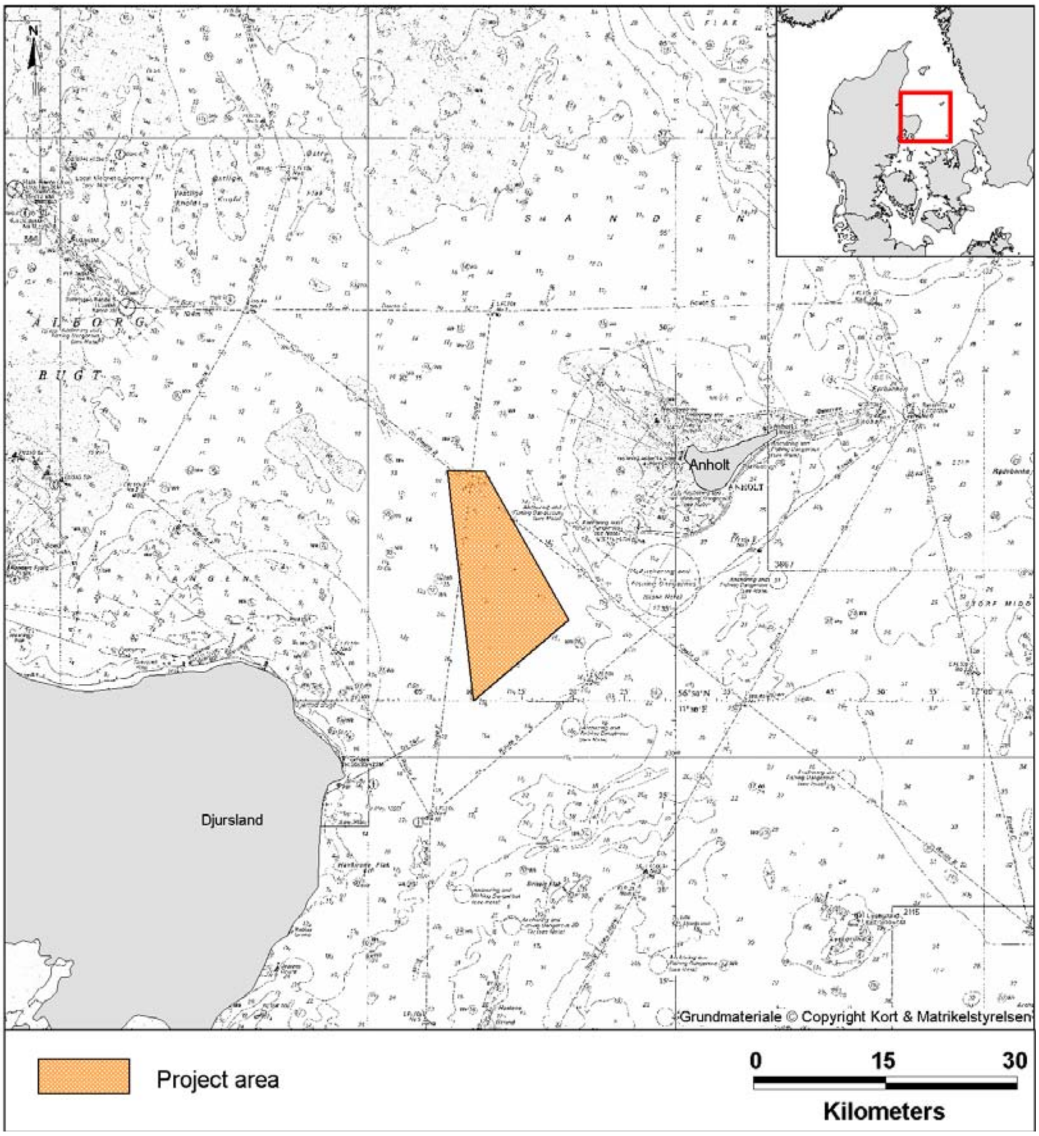


Figure 3-1 Location of the Anholt Offshore Wind Farm project area.

3.1.3 Installation

The foundations and the wind turbine components will either be stored at an adjacent port and transported to site by support barge or the installation vessel itself, or transported directly from the manufacturer to the wind farm site by barge or by the installation vessel.

The installation will be performed by jack-up barges or floating crane barges depending on the foundation design. A number of support barges, tugs, safety vessels and personnel transfer vessels will also be required.

Construction activity is expected for 24 hours per day until construction is complete. Following installation and grid connection, the wind turbines are commissioned and are available to generate electricity.

A safety zone of 500 m will be established to protect the project plant and personnel, and the safety of third parties during the construction and commissioning phases of the wind farm. The extent of the safety zone at any one time will be dependent on the locations of construction activity. However the safety zone may include the entire construction area or a rolling safety zone may be selected.

3.1.3.1 Wind turbines

The installation of the wind turbines will typically require one or more jack-up barges. These vessels stand on the seabed and create a stable lifting platform by lifting themselves out of the water. The area of seabed taken by a vessels feet is approximately 350 m^2 (in total), with leg penetrations of up to 2 to 15 m (depending on seabed properties). These holes will be left to in-fill naturally.

3.1.3.2 Foundations

The monopile concept is not expected to require any seabed preparation.

The installation of the driven monopiles will take place from either a jack-up platform or an anchored vessel. In addition, a small drilling spread may be adopted if driving difficulties are experienced. After transportation to the site the pile is transferred from the barge to the jack-up and then lifted into a vertical position. The pile is then driven until target penetration is achieved, the hammer is removed and the transition piece is installed.

For the gravity based foundations the seabed needs most often to be prepared prior to installation, i.e. the top layer of material is removed and replaced by a stone bed. The material excavated during the seabed preparation works will be loaded onto split-hopper barges for disposal. There is likely to be some discharge to water from the material excavation process. A conservative estimate is 5% material spill, i.e. up to 200 m^3 for each base, over a period of 3 days per excavation.

The installation of the concrete gravity base will likely take place using a floating crane barge, with attendant tugs and support craft. The bases will either be floated and towed to site or transported to site on a flat-top barge. The bases will then be lowered from the barge onto the prepared stone bed and filled with ballast.

After the structure is placed on the seabed, the base is filled with a suitable ballast material, usually sand. A steel 'skirt' may be installed around the base to penetrate into the seabed and to constrain the seabed underneath the base.

3.1.4 Protection systems

3.1.4.1 Corrosion

Corrosion protection on the steel structure will be achieved by a combination of a protective paint coating and installation of sacrificial anodes on the subsea structure. The anodes are standard products for offshore structures and are welded onto the steel structures.

3.1.4.2 Scour

If the seabed is erodible and the water flow is sufficient high a scour hole will form around the structure. The protection system normally adopted for scour consists of rock placement in a ring around the in-situ structure. The rock will be deployed from the host vessel either directly onto the seabed from the barge, via a bucket grab or via a telescopic tube.

For the monopile solution the total diameter of the scour protection is assumed to be 5 times the pile diameter. The total volume of cover stones will be around 850-1,000 m³ per foundation. For the gravity based solution the quantities are assessed to be 800–1100 m³ per foundation.

3.2 Baseline study

3.2.1 Methods

In order to cover the wide range of waterbird species potentially using the planned wind farm area the baseline description has been based on earlier observations and literature, Ref. 15, Ref. 17, **Error! Reference source not found.**, Ref. 33, as well as targeted field campaigns during winter and spring 2009. In order to get information on waterbirds's use of the area during the summer and autumn seasons and over a longer time span historic data has been made available by NERI, who has covered the shallower parts of the region by aerial monitoring surveys regularly since the late 1980'es. In order to obtain better coverage of the parts of the region, incl. the construction site of the OWF, at medium depth and in order to cover all important species an extensive survey campaign was undertaken during winter 2009. Due to the lack of knowledge on the volume of birds passing the area on spring migration én route between Djursland and Anholt a targeted bird migration study was carried out in spring 2009. Thus, the methods used for the field surveys included:

- Aerial surveys
- Ship-based observations
- Combined visual and radar observations of migrating birds

3.2.1.1 Determination of spatial gradients in waterbird densities

The major gradients in the average density of various parts of the region to the key species of waterbirds were estimated on the basis of the aerial and ship-based survey data from winter 2009, the aerial survey data made available by NERI and historic ship-based data on Razorbill *Alca torda*.

3.2.1.2 **Application of spatial prediction models**

Spatial prediction models have been applied for the target waterbird species using landscape, topographic, hydrographic and prey data available for the entire survey area. The response parameter is spatially resolved distance corrected densities at each segment of the aerial and ship-based line transects. The statistical models have been established through an iterative process, which was initiated by an analysis of the spatial structure of the transect data as a means for selecting the scale of controlling parameters. The spatial structure was analysed by means of geo-statistical analysis and variography which determined the scale and structure of autocorrelations in the sampled data.

The spatial prediction models were developed using a step-wise approach. First, the probability of detection of birds in the transect was estimated. The probability of detecting birds along a line transect declines with perpendicular distance from the line. The decline is typically non-linear with a high detection from the line to a deflection point in the transect from where the detection gradually drops to low values in the more distant parts of the transect. This distance bias can be corrected using key functions, adjustment terms and variance estimators. Even with relatively low sample sizes the application of line transect theory allows for precise estimation of p – the probability of observation within the transect, and the correction factor 1/p. The analysis of the survey data based on the three innermost perpendicular distance bands from the aircrafts and the four distance bands from ships and using exact sizes of clusters. Key functions were evaluated with cosines and simple polynomials for ad-justment terms: uniform, half-normal and hazard rate, and the best function was chosen on the basis of minimum *AIC* values. The data were not post-stratified by wave height. In order to minimise the impact of increasing wave heights on the detectability of the birds only data collected in wave heights lower than Beaufort 3 were retained for estimation of detection probabilities (equivalent to 82.3 % of the effort).

The distance-corrected densities then formed the basis for estimating the local density of birds in the whole region for which data on physical and biological habitat drivers were available in high resolution. Statistical models were developed using Generalized Linear Modelling. Generalized Linear Models are well suited to estimate the combination of linear and nonlinear response in waterbird densities to physical oceanographical variables, including two-way interactions and comparisons of gradually fewer and more important parameters before deciding on the final model. In addition, the generalized linear models can be used to predict responses for samples of waterbirds with discrete distributions. The GLM models were designed for estimation of bird densities using a poisson distribution and a log link function on log-transformed and distance-corrected densities.

The adequacy and fit of the prediction models were tested by goodness-of-fit (Pearson Chi^2) and by inspection of residuals, Ref. 29. The significance of individual predictor variables was determined using an α-level of 0.05. The predicted density values were validated against observed densities by visual inspection of observed values plotted on the density surfaces. The final maps for each species were selected on the basis of the results of these tests.

Line transect survey data like the data collected in the central Kattegat display a high degree of spatial autocorrelation, which limits the usefulness of multivariate methods like GLM due to the introduction of inflated significance values and hence unreliable explanatory and predictive power. The autocorrelation effects were reduced by aggregating data in 3000*3000 m squares before analysis.

The following physical oceanographical variables were included in the statistical analyses, of which the dynamic data were averaged over the entire 3-dimensional hydrodynamic model data available from 2005:

1. V = Long-shore current vector at the surface (m/s);
2. S = Salinity at the surface (psu);
3. Gradient in V, measured as the slope of each grid cell based on the cell resolution and the values of the immediate neighbouring cells to the top, bottom, left and right of the cell in question using the following formula:

$$Tangent = \sqrt{\left(\left(\left(right - left\right)/\left(res \bullet 2\right)\right)^2 + \left(\left(top - bottom\right)\left(res \bullet 2\right)\right)^2\right)}$$

which measures the tangent of the angle that has the maximum downhill slope; left, right, top, bottom are the attributes of the neighbouring cells and res is the cell resolution;

4. Potential filter-feeder carrying capacity index for *Mytilus edulis*. The potential growth of *Mytilus* has been modelled using DHI filter-feeder model in high resolution (see details of the model set-up in Møhlenberg 2009). The index values were averaged for the years 2000 to 2007.
5. Gradient in S, same GIS method as 3;
6. Bathymetry: negative values;
7. Bottom relief: slope same GIS method as 3;
8. Bottom complexity (F) calculated for 5x5 kernel: F = (n-1)/(c-1) Where n = number of different classes present in the kernel, c = number of cells;
9. Distance to shallow areas (< 6 m water depth): Euclidean distance in m from each cell.

3.2.1.3 Analyses of radar and visual data on bird migration

3.2.1.4 Echo detection

The echo received by the applied Furuno radar was extracted directly from the receiver circuit before any of the traditional marine radar processing was done. This raw signal was sampled at 20 MHz at 10 bit resolution (1023 levels) and collected in "bins" each covering a radial distance of 120 m and 1 degree tangentially. The sample time for one image was one minute at 24 rpm (each location sampled 24 times). For further processing the mean, peak and variance of the radar signals (named L, M, V) were calculated for each bin every minute. This processing was performed "on-the-fly" at the data collection computer at each radar station. The scanning was performed continuously. For each time step three files were generated (the L, M and V files). All radar data were stored in polar format.

3.2.1.5 Correction for distance and volume bias

The Volume- and en-route correction of the echo, i.e. compensation for a larger scan volume as a function of distance and attenuation of the signal as a result of other echoes like rain, was handled using the standard correction scheme used on the DHI Local Area Weather Radar (LAWR) system during the last 10 years. The correction follows the following equations that are applied to each raw scan line.

Volume correction:

$$Z_{rv} = \frac{1}{C_2 \cdot \exp(r \cdot C_3)} \quad (1)$$

Where:

Zrv: Volume-corrected reflectivity at range r

r: range

C2, C3: Empirical constants that are location dependent.

En-route correction:

$$Z_r = Z_{g,r}\left(1 + \frac{\alpha \sum_{i=0}^{r-1} Z_i}{C_1 \cdot 8000}\right) \quad (2)$$

Where:

Zr: Adjusted reflectivity value at range r

Zg,r: Uncorrected reflectivity at range r

α, C1: Empirical Constants where typical values are 1.5 and 200 respectively

The actual setting of these parameters was stored in each radar image.

3.2.1.6 Echo identification and mapping of flight trajectories

The tracking algorithm operates on 120 successive radar images where each pixel is tagged for potential track content (corresponding to 2 hrs recording). Starting from the oldest image each tagged pixel forms the starting point for a volume search +/- two cells in the same and succeeding images. The candidates for continued track are ranked according to shortest Euclidean distance from the track-start candidate in the L, M, V space described in below. The selected candidates are tagged "used" and cannot appear in another track. For each step along the track, track-length and track-time are updated. When no more continuation candidates are found, the track is recorded. From the recorded wind-speed and wind-direction and the corresponding data for the track (speed and direction over ground), the object (bird) heading and velocity (speed through air) is calculated.

3.2.1.7 Dual radar installation

In order to estimate the flight height of the migration the horizontal scanning radar has been supplemented with a vertical. By changing the orientation of this radar to a vertical rotation a 20 degree fan beam starting from one horizon going via zenith to the other has been established. The post-processing of these data is following the same classification as used on the horizontal scanning radar. The results are track heights with corresponding distance from the radar.

3.2.1.8 Filtering, incl. removal of noise

Based on visual and statistical analyses of the recorded M, L and V values of each pixel in the polar image, a set of threshold values has been identified that will help distinguish echoes from potential birds from other echoes. The following parameters for this filtering process have been identified:

- M values in the interval   0 <= M <= 1024
- L values in the interval   5 <= L <= 1024
- V values in the interval   0 <= V <= 7000

A physical way to interpret the data is for example that the echo from a large object like a ship will display similar (and high) average (L) and peak (M) values and small variance (V) values, while a bird will display much larger M than L values, and a bigger variance V. These threshold values have been determined during radar calibration observations in earlier studies.

In order to further remaining ship tracks, rain and wind-induced clutter from the data the following exclusion filters were applied to the radar data:

- Bird speed < 18 km/h
- Rain level > 100
- Wind velocity > 50 km/h.

3.2.1.9 Estimation of relative flight intensities

The classified tracks were transferred from vector to raster using a grid with the resolution of 1 km. The gridded track data, which were total frequencies, were split into bird classes. They were subsequently used to profile the time series of relative flight intensities (frequency of tracks) for each class and period in five 4*4 km statistical boxes, *Figure 3-2*, located along the potential pathway between Gjerrild Klint and Anholt. Migration altitudes were profiled by analysing the distribution of echoes from 0 to 1500 m altitude within a distance of 500-2000 m from the radars. Absolute flight intensities, based on aspect- and species-specific detection ranges, were not estimated.

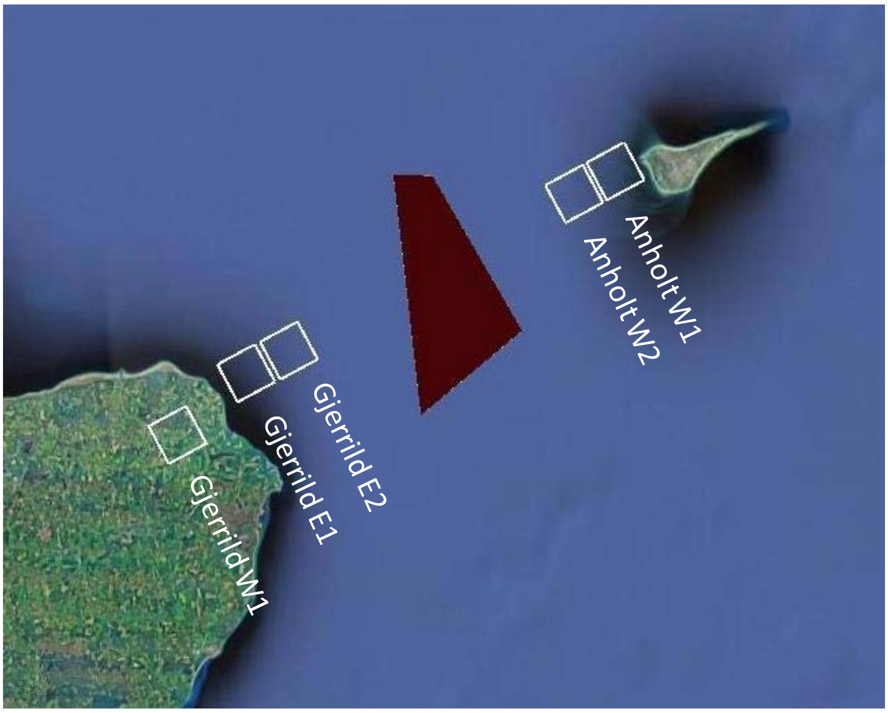


Figure 3-2. Five zones used for analyses of the time series of bird migration (Source: Google Earth).

3.2.1.10 **Aerial surveys**

The aim of the aerial surveys was to get an overview of the distribution of wintering waterbirds, especially of seaducks, in the in the direct vicinity of the proposed wind farm as well in the adjoining shallower areas of expected high abundance of seaducks. The surveys were undertaken monthly between December 2008 and August 2009. Aerial surveys were carried out using the standard methods developed during the Nysted and Horns Rev monitoring programmes. The survey methodology followed line transect survey techniques using a high-winged, twin-engine air-craft (e.g. Partenavia P-68), equipped with "bubble windows", at an altitude of 250 feet (76 m) and with a cruising speed of ca. 100 knots (ca. 185 km/h). Each survey was carried out by two experienced observers. Data were collected only during good or moderate survey conditions (seastate < 3 bft, visibility > 5 km, moderate glare). Further details of the aerial survey techniques are given in Ref. 13.

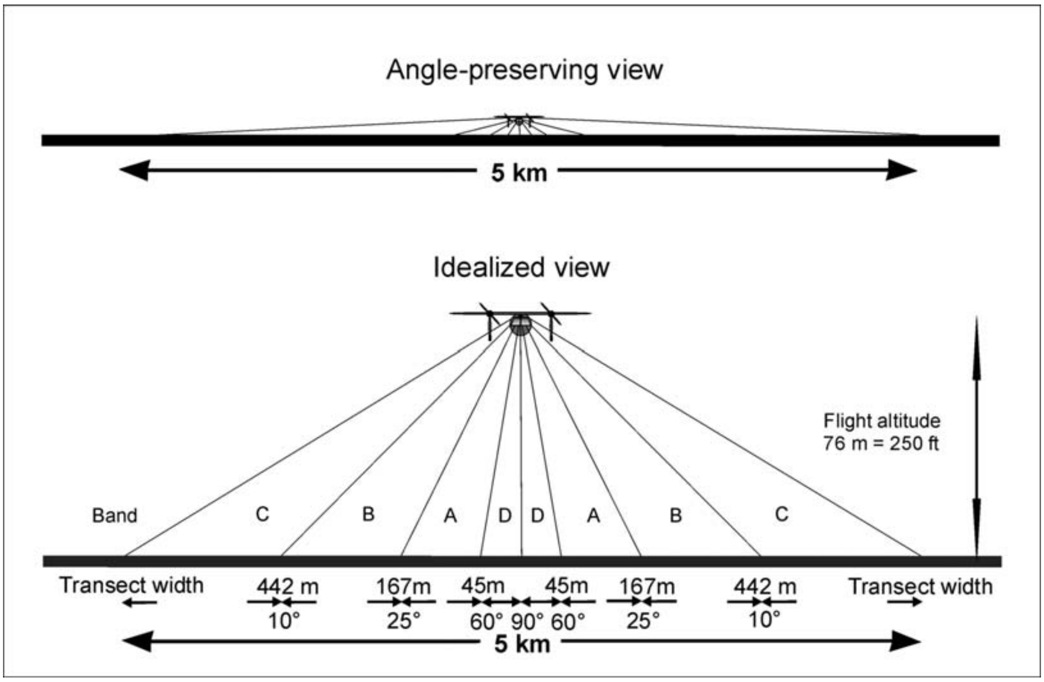


Figure 3-3. Aerial survey method for counting birds, angles and corresponding band widths. Band C extends to 1000 m perpendicular distance.

All observations were recorded by using a dictaphone. Sightings were recorded to the nearest second (in UTC, watches were synchronised with an on-board GPS before every flight) and positions were logged by a GPS every 3 sec. Positions and observation data were stored in SQL/Access databases linked to ArcGIS. Determination of species, behaviour and registration of numbers were made, but are much more difficult to carry out from an aircraft than from a ship because the birds can be seen for a short period of time only and because it is not possible to work with binoculars. Numbers of groups of more than 50 individuals can only be estimated.

The transect design consisted of 17 n-s oriented transects covering the entire region from east of Anholt to north of Djursland. The distance between the transect lines was 5 km. Before and after each aerial survey a check of equipment was carried out following an approved checklist. After the flight the GPS-track was downloaded to a computer and checked for completeness. As soon as possible after the flight the tapes were transcribed by one of the observers directly into a special developed database (FULMAR). Unusual data were marked, commented and the observers were asked for clarification or confirmation of the observations. Later on the data sets were run through different routines to detect mistyping and other errors. Finally, a senior scientist evaluated the data.

The survey effort given as flight km and observed area (km^2) as well as dates is given in Table 3-1.

Table 3-1 Effort in km and km^2 in the study area, with voyage dates

Transect no.	effort sum km	effort sum km^2	Trip dates		
1	108.84	32.65	29-12-2008		
2	330.78	99.23	19-2-2009	20-2-2009	21-2-2009
3	303.28	90.98	28-3-2009	29-3-2009	
4	174.42	52.32	2-4-2009		
5	338.68	101.60	20-4-2009	21-4-2009	
6	121.51	36.45	14-5-2009		

Migrating Barnacle Geese

Figure 3-4 Survey plane Partenavia P68.

Figure 3-5 Aerial survey: measuring the angle to the birds by clinometer.

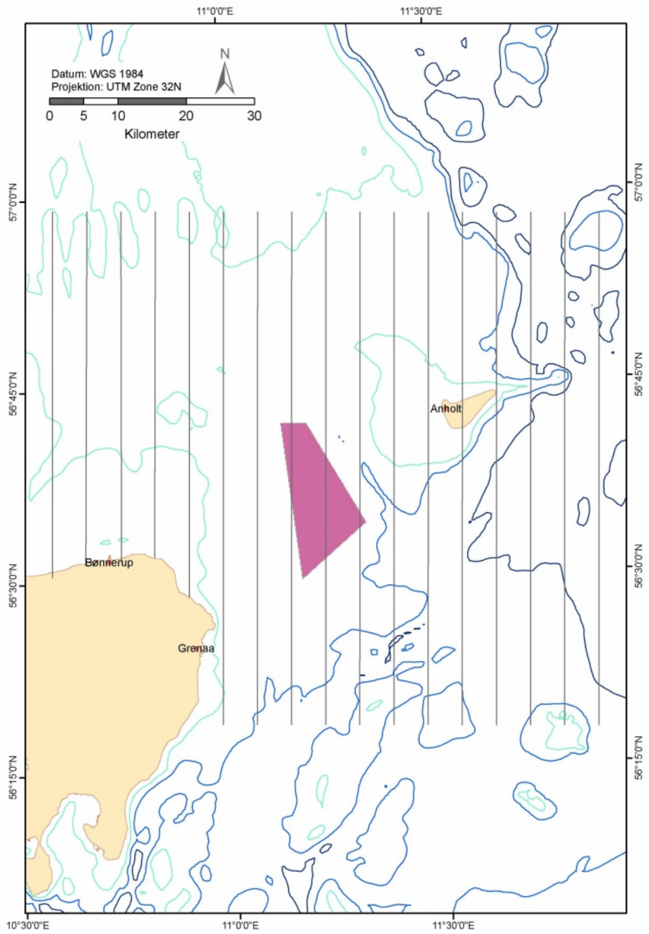


Figure 3-6 Aerial survey design.

The aerial transect surveys undertaken by NERI in the region during 2000-2008 closely followed the same methodology as described for the baseline surveys Ref. 13. During 2000-2001 seasonal surveys were made in relation to the impact assessment of a planned offshore wind farm south of Læsø, and during 2004 and 2008 winter surveys were undertaken as part of the national monitoring scheme Ref. 33. During 2006, aerial surveys were made during the moult period of seaducks in June and July. The standard grid of line transects operated by NERI is indicated in Figure 3-7.

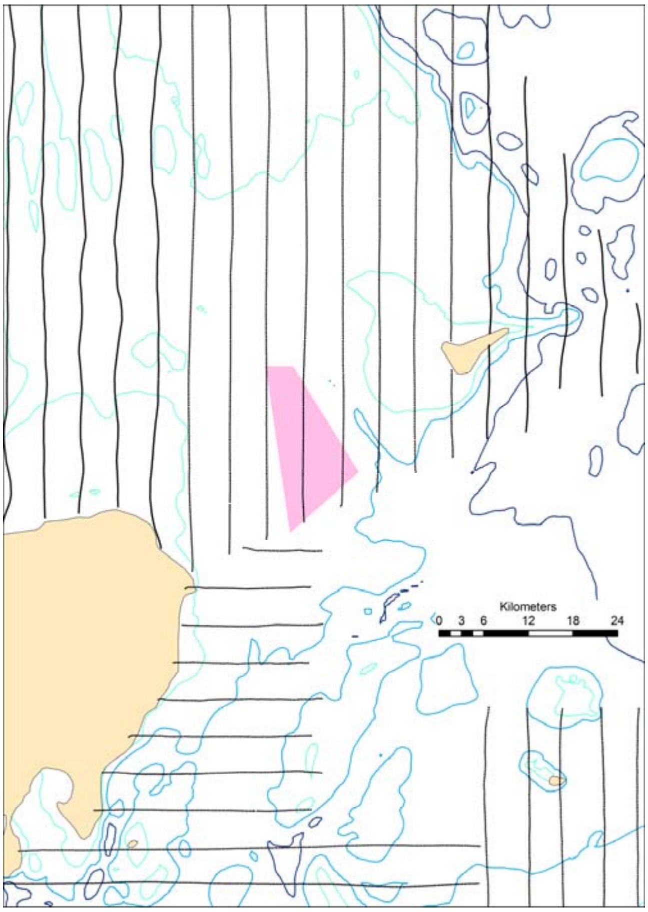


Figure 3-7 Example grid of aerial survey transects operated by NERI (January-February 2004).

3.2.1.11 **Ship-based surveys**

Ship-based surveys were undertaken to complement the aerial surveys with respect to the more difficult species, which occur regularly and in relatively large numbers in the region. This is especially the case with large divers Gaviidae, grebes Podicepedidae, velvet scoter Melanitta fusca and auks Alcidae, - species which are typically underestimated by aerial surveys. The strip-transect method proposed by Tasker et al. 1984, slightly revised to a line-transect technique, is still the backbone of modern ship-based surveys of seabirds at sea in NW European waters. The standard strip-transect technique is often called strip-transect technique although it conceptually is identical to what is described as line-transect technique in the description of aerial surveys. The method involves a 300m wide band or strip-transect operated on one side and ahead of the ship and short time-intervals (1, 5, or 10-minute periods) in a continuous series to sample short stretches of water with a known surface area, a known location and any other biological, geographical, or physical factors that could be associated by that area. To evaluate the bias caused by specific differences in detection probability with distance away from the observer, the transect is subdivided into narrower distance strata (A= 0-50m away from the ship, B = 50-100m, C = 100-200m, D = 200-300m, and E > 300m).

A species-specific frequency distribution over these strata would indicate how many individuals were likely to have been missed in the furthest strata (Distance Sampling). All birds on water within 300m perpendicular to the trackline of the ship are counted as 'in transect'. To avoid an overestimate of bird numbers in flight, a regular snapshot of flying birds over the transect and within 300m distance ahead of the ship is performed (frequency of snapshots depending on ship's speed). Distance techniques, used to correct numbers of birds observed swimming to numbers believed to have been present on the water, cannot be deployed on birds in flight. Birds 'outside transect' are recorded either in a 90° or 180° scan ahead of the ship. Birds recorded in the scan are not used to calculate densities, and recording them has therefore a lower priority than recording birds in transect when abundance estimates are the main objective of a survey. Scan results may enhance assessments of age and sex composition of certain populations or directions of flight by migrants and birds travelling to and from colonies simply by enlarging sample sizes and the scan accommodates sightings of rarer, highly mobile seabirds such as shearwaters, skuas, terns and migratory birds that would otherwise remain unrecorded, or flushed birds, e.g. divers and scoters.

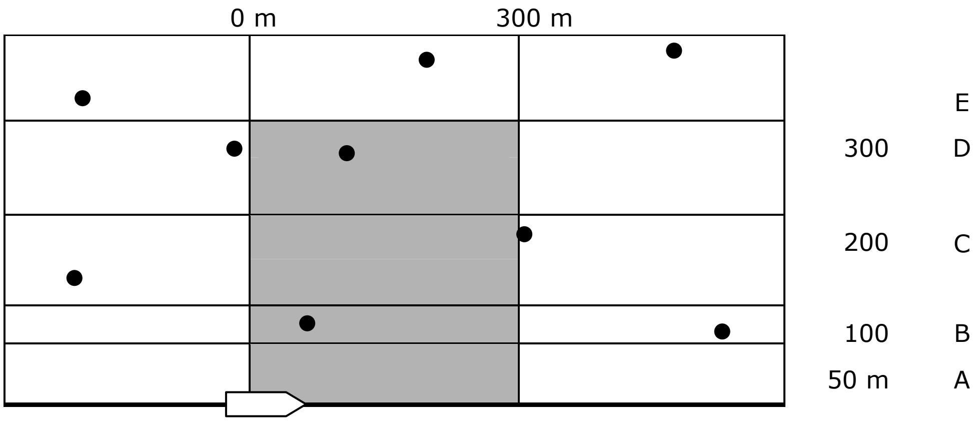


Figure 3-8 Scheme of a strip transect survey by ship speed of 10 kn (flying birds in grey areas at the time of the snapshot are counted as 'in transect', all other flying birds are counted as 'not in transect')

The surveys were performed from a ship, equipped with a stable observer platform (usually a box, in which the observers are sitting, sheltered against the wind), and with a cruising speed of ca. 10 knots (ca. 18.5 km/h). Data were collected only during good or moderate survey conditions (sea state not higher than 4 bft, visibility > 3 km, moderate glare). From the onset of the survey, the observers searched continuously for birds. Bird detection was done by naked eye as a default but scanning ahead with binoculars is necessary and done by the second observer, for example to detect flushed divers or low flying common scoters. Identification of species, recording of behaviour and registration of numbers was done following a modified ESAS-standard, Ref. 40.

Sightings were noted in 1 min intervals on form sheets (in UTC, watches will be synchronised with an on-board GPS before every survey). The ship-track was logged and stored continuously in 10 s intervals by a GPS (Garmin GPS 48 with external antennae). Positions and observation data were stored in SQL/Access data-bases linked to ArcGIS.

The ship-based surveys were conducted with a speed of ca. 10 Kn. Following ziczac lines focused on the Anholt OWF site (Figure 3-9).

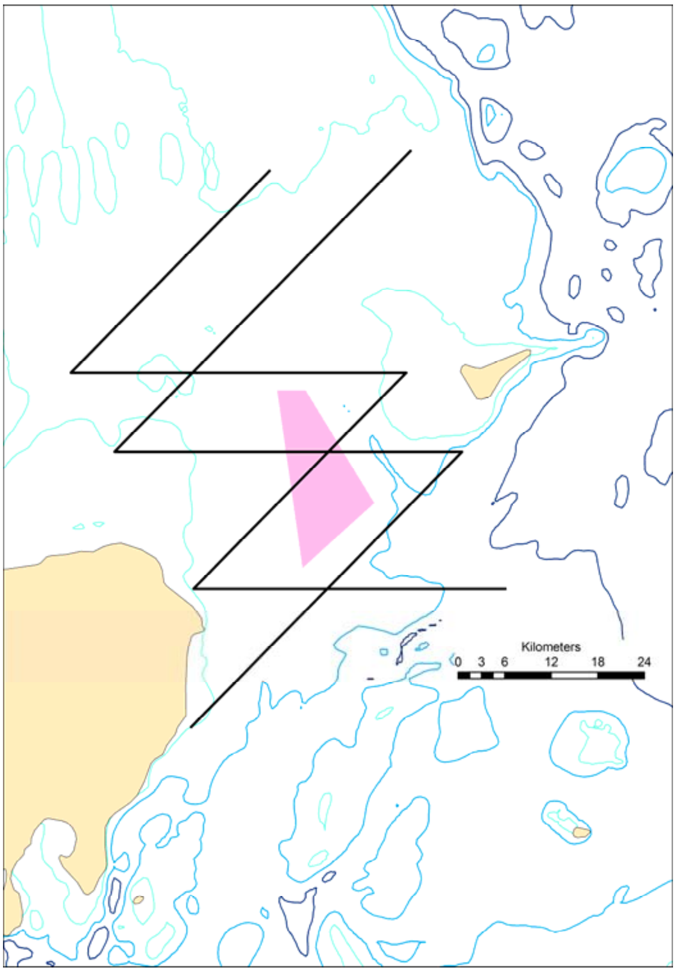


Figure 3-9. Ship-based survey design.

3.2.1.12 **Bird migration study**

Due to the location of the Anholt OWF site midway between Djursland and Anholt a relatively large volume of landbirds on spring migration was anticipated to cross the site regularly. For this reason a bird migration study was designed to describe the spring migration between Djursland and Anholt, - a design which included the application of radar installations on fixed platforms on shore at Gjerrild and Anholt harbour. Migration observations started in late March, and combined visual and radar observations were undertaken throughout April and May 2009. This design was chosen due to the methodological constraints and limitations using visual observations and radar screen analyses for quantifying bird migration and the inherently low samples obtainable from ship-based radar installations. The application of automated registration by surveillance radars with horizontal and vertical antennas allowed for continuous collection of data on flight intensities and altitudes at the two sites. The operation included radar signal processing with enhanced clutter suppression capacities and a number of further analysis options including distance corrections, corrections for clutter and disturbances as well as synoptic calibration observations.

The location of the radar station is depicted in Figure 3-10, and the installation design is shown in Figure 3-11.

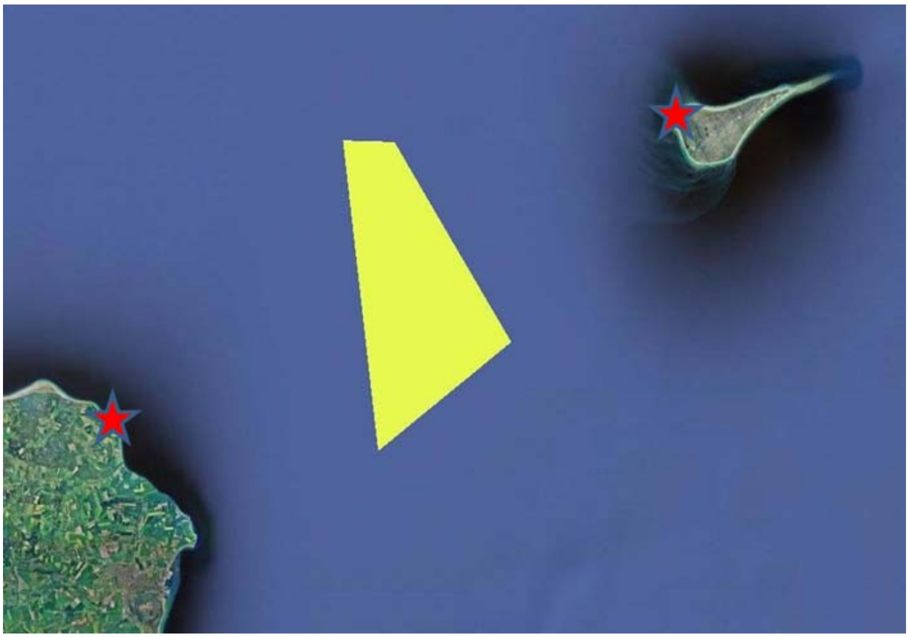


Figure 3-10 The location of the two radar stations (Source: Google Earth).


Figure 3-11 The radar installation at Anholt Harbour and Gjerrild Klint

The potential detection range (birds of prey, pigeons, flocks of passerines) of the surveillance radar was 10 km, although the detection range for individual passerines in most cases would be much smaller, e.g. 3 km. For safety reasons a 45 degree 'blind sector' was applied at both radars. Due to the large amount of data recorded analyses of profiles of flight intensities have been made by analysing mean values for five statistical zones measuring 4x4 kms and oriented along the major axis of bird migration from Gjerrild to Anholt. One statistical zone was located southwest of Gjerrild, two northeast of Gjerrild and two southwest of Anholt harbour which were selected to obtain tempo-spatial information on migration intensities of landbirds within a maximum range of 5 km from the radar.

The visual observations were carried out close to the radar stations, and provided counts of migrating birds crossing transects in a north-easterly and easterly direction as well as calibration data for classification of the radar data into bird species groups.

Visual observations of flying birds with a focus on migration took place during day-light hours from before sunrise until after sunset. The focus of the visual observa-tions was set on recording long-distance flight movements of landbirds. Optics used by the observers were binoculars with 10x magnification and telescopes 25x magnifi-cation. Birds were counted along one long-shore and one cross-shore transect, both 1 km in length – see example from Gjerrild Klint in Figure 3-12. The distribution of observation hours at the two radar stations is shown in Figure 3-13.

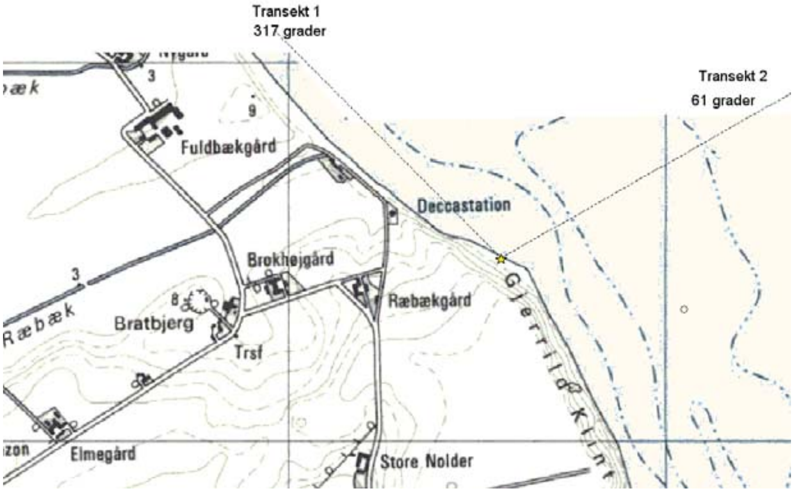
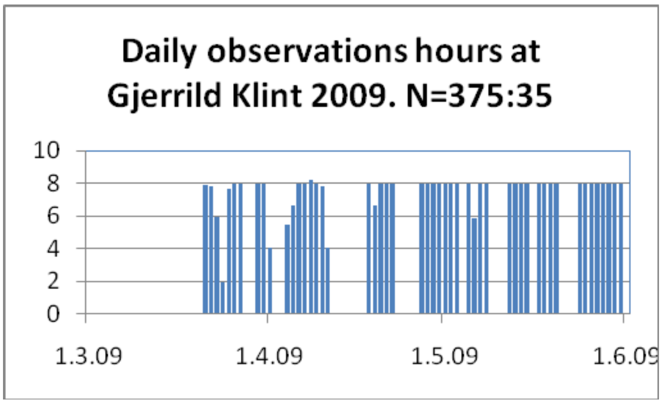


Figure 3-12 Example of cross- and long-shore transect used for the visual observations – here at Gjerrild Klint.



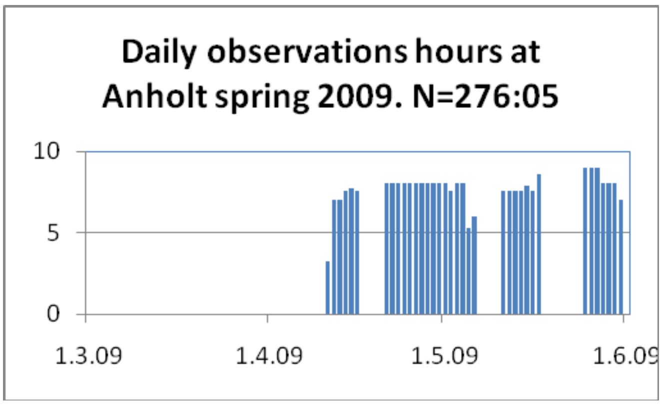


Figure 3-13 Number of daily observation hours at Gjerrild Klint and Anholt.

3.2.1.13 **The LAWR system design**

The two installations were based on the LAWR (Local Area Weather Radar) system design, which uses software developed by DHI for high-resolution LAWR signal processing, data extraction, automatic classification and GIS-interfacing. The LAWR is based on X-band technology, using a standard marine radar, type FR2127 from Furuno designed for 24/7 operation under harsh conditions (Table 3-2). The data acquisition hardware developed by DHI allows sampling of up to 24 images per minute, which facilitates object tracking. All radar equipment includes ancillary hardware linked to the systems, allowing 24 hour operation and remote control.

A mechanical clutter fence was used at the radar installation to eliminate problems related to clutter (undesired echoes from waves, structures etc.). A major benefit is a well-defined scan area allowing beams to come close to sea surface without picking up sea-clutter. Dependent on the elevation of the radar antenna and the clutter-fence it is expected that reasonable data can be collected up to Beaufort sea state 4.

Table 3-2 Specifications of radar devices used.

Brand	**Furuno**
Type	**FAR2127**
Power output [kW]	25kW
Frequency [MHz]/wavelength [mm]	9.4 GHz (X-band)
Horizontal angle of radar beam [°]	1 degree
Vertical angle of radar beam [°]	10 degree
Rotational speed [min^{-1}]	24 rpm
Antenna length [mm]	2400

The radar software was subdivided into 3 parts:

1. RadCtrl2/PolScan. Radar control and acquisition software;
2. BirdWatch/BirdWatchShow. On-line ground truth data collection system;
3. BirdTrack. Software for classification and extraction of bird tracks.

Apart from the PolScan software which is DOS based, the rest of the software runs under the WINDOWS-XP operating system.

RadCtrl2 - PolScan

RadCtrl2 is the radar site software and PolScan is the control radar hardware. This software is responsible for archiving the collected data and for automatic restart of the radar system, in case of e.g. power failure. The software can be operated remotely via its internet connection. All sites were connected using wireless 3G internet. This software are modified versions of the well-proven software that has been used on DHI LAWR radars during the last 10 years.

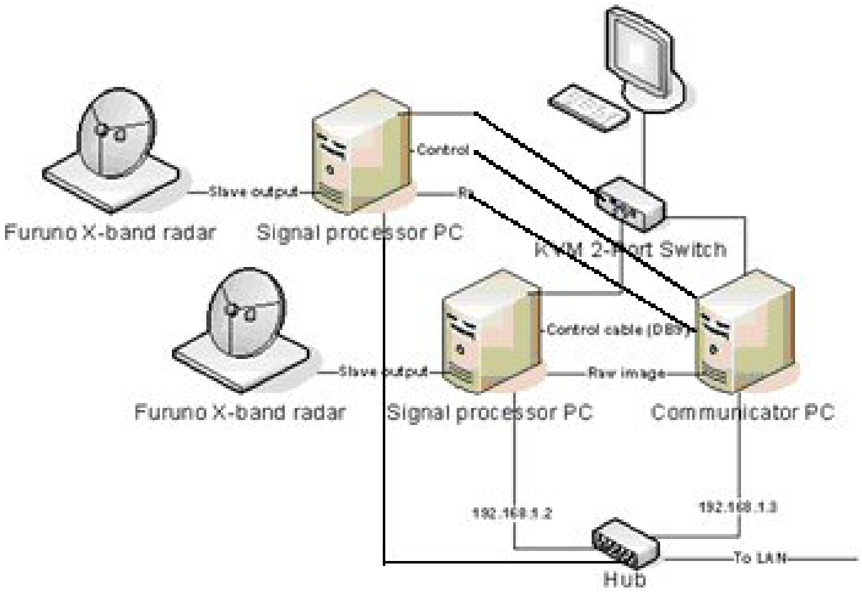


Figure 3-14 LAWR system hardware design.

BirdWatch - BirdWatchShow
BirdWatch is data entry software package that allows visual observations to be entered directly on top of a live radar image simply by clicking on the echo identified as birds. This approach guarantees accurate positioning of the observation when both visual and radar detection is present. The BirdWatchShow is a tool that allows easy access to data and the corresponding bitmap dump of the radar image. Based on the radar site coordinates and the orientation of the radar, the observations can be extracted with UTM coordinates. With the use of wireless Internet/wireless LAN, the software can be used away from radar site. Data are stored comma separated in a ASCII file, and the radar images are stored as BMP files.

BirdTrack
The BirdTrack software is used to classify the data in the radar images followed by a tracking system that extracts tracks from a set of images. The software is a post-processing software and is not available at the radar site.

Collation and integration of weather data
Wind direction, wind velocity and air pressure at the three radar stations has been collected from model at a temporal resolution of hour. This information was used together with the radar-extracted flight tracks "over ground" to calculate the corresponding bird heading and flight speed through air.

In addition to the wind information, the presence of rainfall in the radar coverage area has been estimated as the average reflectivity over the entire radar image.

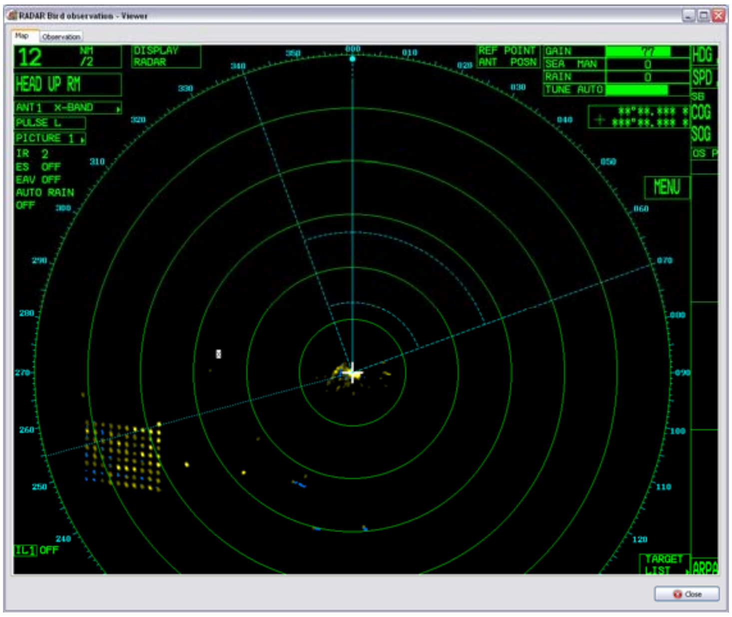


Figure 3-15 Visual observation marked on radar image in BirdWatchShow.

3.2.2 Waterbirds

3.2.2.1 Importance of the region

The inner Danish waters, including the central parts of Kattegat, constitute major staging and wintering grounds for huge numbers of migratory waterbirds. At least 5-7 million individuals of more than 30 bird species winter in these areas, and much greater numbers exploit them for staging on migration, Ref. 28. In some cases, these concentrations constitute the entire breeding- or flyway populations of north-west Palearctic species and are of major international importance, Ref. 28, Ref. 39. As a consequence, Denmark has obligations under international legislation and as a signatory to international conventions, such as the African – Eurasian Migratory Waterbird Agreement under the Bonn Convention, the Ramsar Convention and the EU Bird Directive.

The shallow north-western parts of Kattegat are important as wintering area for thirteen species of waterbirds, Ref. 17. In the north-west Europe, the northern Kattegat is the most important wintering area for Razorbill, Red-necked Grebe, Common Scoter and Common Eider. As regard to Razorbill, the area is probably the most important in the world during the mid-winter period. Up to 930,000 Common Scoter, 120,000 Velvet Scoter and 320,000 Eiders have been counted here in winter. Common Scoter and Eider were representing 54% and 37% respectively of the total number of observed birds, Ref. 31.

Several large Ramsar and EU Special Protection Areas exist in the Northern Kattegat, which in concert make approximately 45% protected on account for waterbirds the region a flagship area for marine conservation in Denmark. The closest Ramsar site to the area assigned for the planned wind farm is the EU site No.32/Ramsar site No. 12 covering the waters north of Anholt approximately 20 km north-east of the assigned wind farm. The wind farm is planned to be located in an area of relatively-shallow (12-18 m deep) waters south-west of Anholt between Anholt and Jutland.

Several of the bird species occurring in Kattegat are listed on the Danish red-list and yellow-list. The red-list includes breeding species that are uncommon, or immediately threatened, Ref. 42 and , while the yellow-list includes breeding and non-breeding species, which are potentially threatened. Razorbill is found on the red-list. It is, however, not known to which degree birds from the Danish breeding colony at Græsholmen visit the waters of the central Kattegat. Red-necked Grebe *Podiceps griseigena*, Red-throated Diver, Eider, Common Scoter and Guillemot occur on the yellow-list, Ref. 43.

Below is given a description of the baseline situation with respect to the most abundant species as well as the species regarded as the most important seen in relation to the size of the reference populations. The baseline has been described according to both the surveys undertaken in 2008 and 2009 and the historic surveys undertaken by NERI between 2000 and 2008. In addition, due to lack of recent data on the early winter concentration of Razorbills (baseline 2008-09 started in December 2008) historic ship-based data collected during countrywide and international ship-based surveys between 1987 and 1993 Ref. 17 and Ref. 28, were included for this species.

3.2.2.2 Red-throated / Black-throated Diver (Gavia stella / arctica)

Both species are listed in the Annex I to the EU Birds Directive. Historical data from 1987-1993 Ref. 28 / show that the northern Kattegat is of international importance for Red-throated/Black-throated Divers both in spring and autumn. The number increase from 900-4500 in autumn up to 5300 in spring before they move towards the Baltic Sea. Approximately one quarter of the birds were observed at water depth less than 20 meter. The entire combined population of both species in NW European waters has been estimated to 400,000-950,000 (Red-throated 150,000-450,000, Black-throated 250,000-500,000), Ref. 15.

Based on the observations during the surveys 1999-2000, Ref. 31/ totally 4065 divers was reported. According to reference Ref. 31/ a relative high concentration of divers occurred in the most north-western part of the assigned wind farm area, although the majority of the observed population was registered in more shallow waters in the central and northern parts, Figure 3-16.

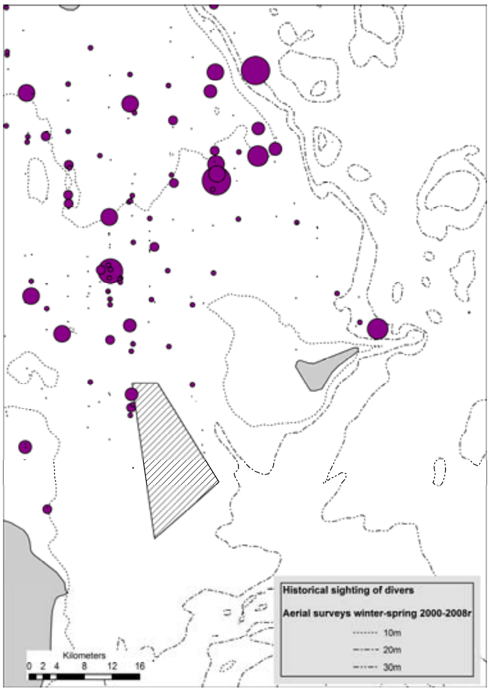


Figure 3-16 Historical sightings of Red-throated/Black-throated Diver during the aerial surveys carried out by NERI 2000-2008 (scale is arbitrary).

The 2009 aerial and ship-based survey data (Figure 3-17) show that divers in general (unidentified sp.) were widespread in the survey area, but with a higher frequency of elevated densities occurring in a zone between Djursland and Anholt, including the wind farm and adjacent areas. The spatial model based on the aerial baseline data provided the most significant overall model of the mean densities of divers in the area of the wind farm, Figure 3-18, estimating medium-high densities of divers within a well-defined continuous area from the central part of the wind farm to east of Anholt, - a zone overlapping the mean position of the hydrographical front between coastal waters with high current velocities and offshore waters with lower velocities in the Central Kattegat. The mean densities within this zone area were between 0.75 and 1.5 birds/km^2. The estimated mean population size within the wind farm area is 150 birds. Smaller patches of elevated densities were estimated north of the zone.

The available data indicate that the wind farm area is more important to the two diver species than other species. Total estimated numbers, however, were well below levels of international significance for both Red-throated (≅3000) and Black-throated Diver (≅3750), Ref. 1.

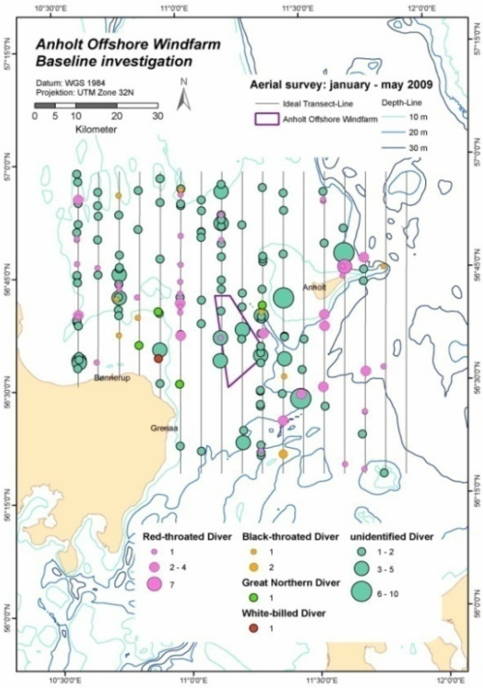


Figure 3-17 Aerial baseline observations of Red-throated, Black-throated, White-billed and Great Northern Diver.

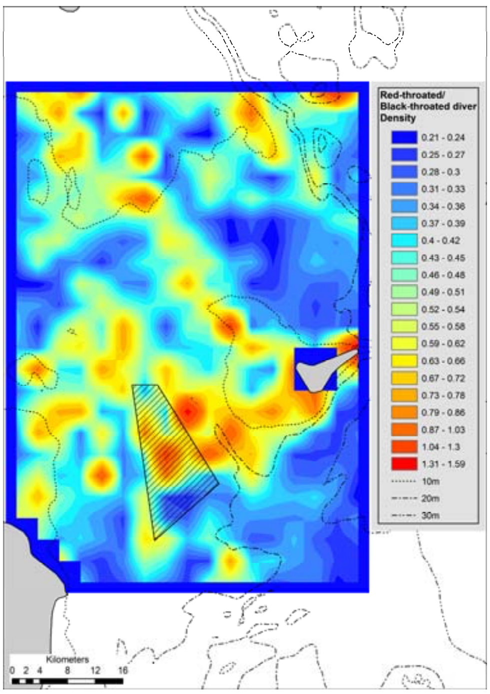


Figure 3-18 Modelled average densities (number of birds/km^2) of Red-throated/Black-throated Diver based on Aerial baseline observations.

3.2.2.3 **White-billed/Great Northern Diver (Gavia adamsii/immer)**

Both species are listed in the Annex I to the EU Birds Directive. Although the White-billed Diver (Gavia adamsii) and Great Northern Diver (Gavia immer) are considered rare visitors to Danish waters the baseline surveys undertaken this winter documented that both species occur in the surveyed region in low densities. The observation of 17 Great Northern Divers from ship is in line with isolated previous observations from the region during late winter and early spring Ref. 35. However, the observation of 30 White-billed divers during the ship-based surveys is without precedence in Danish waters as well as in the Baltic as a whole.

These observations indicate that the region may be of higher importance to the populations of both species than previously known. The origin of these birds is uncertain – Great Northern Divers breed chiefly in North America, while White-billed divers breed both in eastern Siberia and North America. The birds observed from ship were all seen within a small area located 20-30 km NNE from the Anholt OWF, while the birds observed from aircraft were seen just north of Gjerrild both on Djursland and a few kms east of the Anholt OWF (one bird), Figure 3-17 and Figure 3-19.

Given the distribution of these sightings it seems likely that both species may turn up regularly in the planned wind farm area.

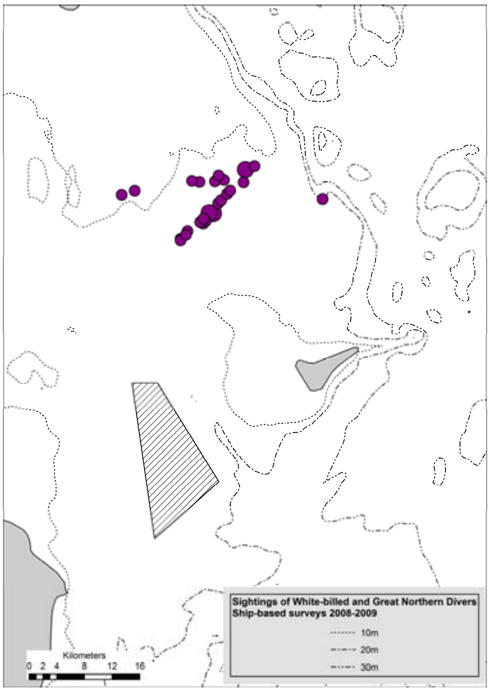


Figure 3-19 Sightings of White-billed/Great Northern Diver during the ship-based baseline surveys 2008-2009.

3.2.2.4 **Red-necked Grebe (Podiceps grisegena)**

Up to approx 3,600 Red-necked Grebe have been estimated to winter in Denmark

Ref. 28/. The majority of these birds have been observed in northern Kattegat within an area of up to 30 km from the coast Ref. 31/. The estimated number in the northern Kattegat constitutes between 16 and 24 % of the fly-away population according to Ref. 17 and Ref. 24.More than 80 % have been observed at water depths of less than 20 meter.

From the ship-based surveys undertaken this winter it seems that Red-necked Grebes occur widespread in low densities within a region to the north and west of the the Anholt OWF area, Figure 3-20.

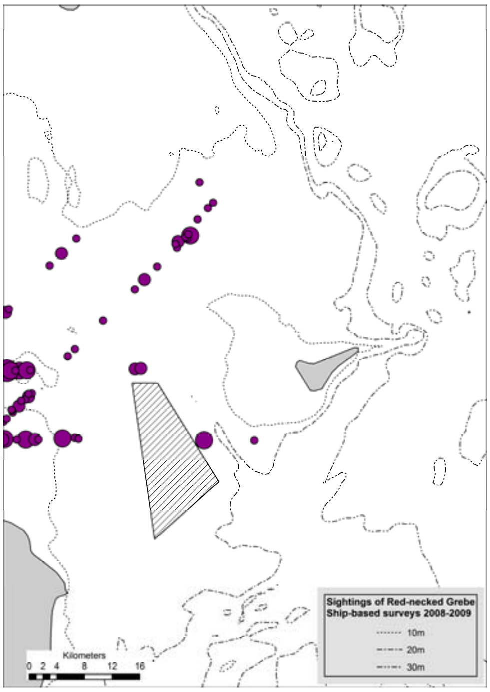


Figure 3-20 Ship-based survey data 2009 for Red-necked Grebe

The spatial model of the mean density of wintering Red-necked Grebes during these surveys corroborates this, and show patches associated with the lower slopes of the shallow areas north Djursland, south of Læsø and northwest of Anholt, Figure 3-21.

The model results indicate that areas deeper than 15 m, including the wind farm area, support very few grebes during winter.

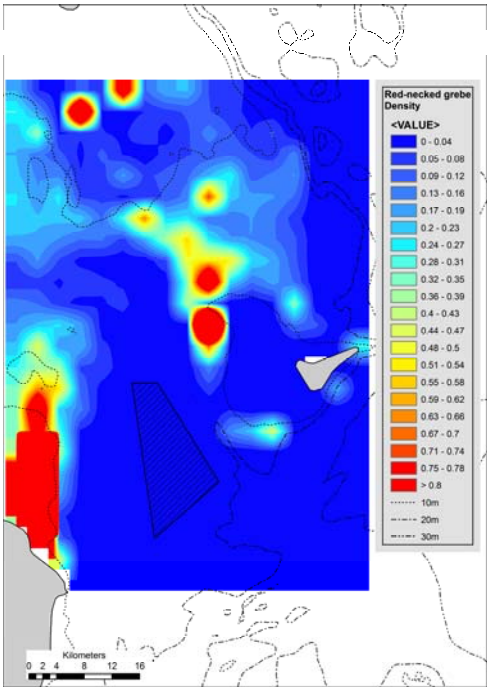


Figure 3-21 Modelled average densities (number of birds/km^2) of wintering Red-necked Grebe based on ship-based baseline observations.

3.2.2.5 **Cormorant (Phalacrocorax carbo)**

The Danish population of Cormorants increased from 300-400 pairs in 1970 to approx. 37,000 pair in 2002 Ref. 19/. Outside the breeding season most Cormorants live in the coastal areas where they favour beaches, sandbanks etc.. Although single cormorants were observed during the baseline surveys the historic data provide a more comprehensive picture of the distribution of the species. Up to 1,600 Cormorants have been observed in the northern Kattegat in the winter season and up to 3,700 in other periods of the year. In general the Cormorants have been observed within 10 km from the coastline of Eastern Jutland and Læsø Ref. 31/, Figure 3-22.

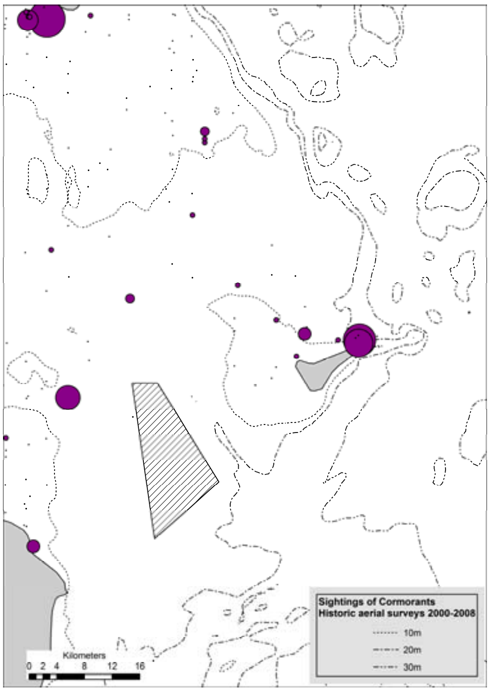


Figure 3-22 Historical sightings of Cormorant during the aerial surveys carried out by NERI 2000-2008 (scale is arbitrary).

3.2.2.6 **Common Eider (Somateria mollissima)**

The Common Eider is the most numerous seaduck in Denmark. In the late 1980s up to 80.000 moulting eiders were found in the northern Kattegat with a large concentration around Læsø in late summer,

Ref. 28/, Ref. 31/. In the winter 1999/2000 the population decreased with more than 90 % compared to the late 1980s Ref. 31/. The main concentrations were found south of Læsø, at the NW Rev, Anholt and along the east coast of Jutland, Figure 3-23. The observations during the baseline aerial surveys in winter 2008-2009 follow these trends rather accurately, Figure 3-24. During the moulting season, medio June – late July, the historical data indicate that the Eiders were using the area south of Læsø more than the other two areas.

Based on the historical aerial survey data the average winter density was estimated, Figure 3-25. The spatial trend in the densities indicate strong patchiness in the distribution of the species with concentrations of more than 10 birds per km^2 occurring regularly in the three above-mentioned areas.

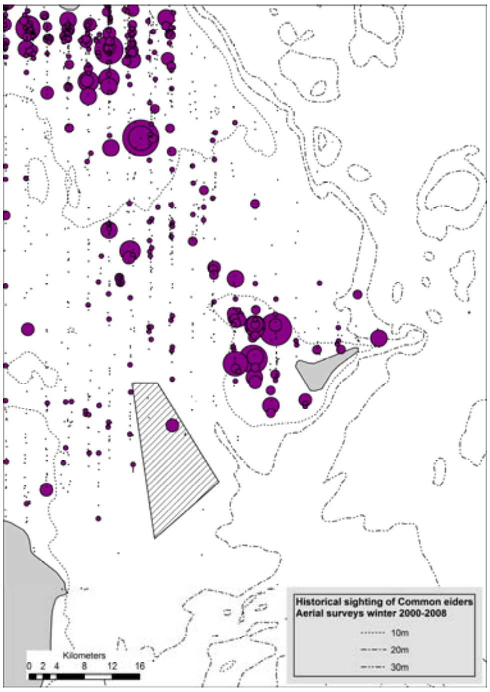


Figure 3-23 Historical sightings of Common Eider during the aerial surveys carried out by NERI 2000-2008 (scale is arbitrary).

Eiders were only estimated to occur occasionally and with relative low mean density (< 1 bird/km^2) within the assigned area for the wind farm. There is a correspondence between the highest observed Eider densities and the high carrying capacity for blue mussels estimated for the three high-density areas.

In the wind farm area and in the southern part of the survey area where low density of Eiders has been observed low carrying capacity for mussels were estimated. The parameters, mytilus index and the interaction between the index, shallow areas and distance from the coastline, all had a significant influence on Eider densities ($p<0.005$).

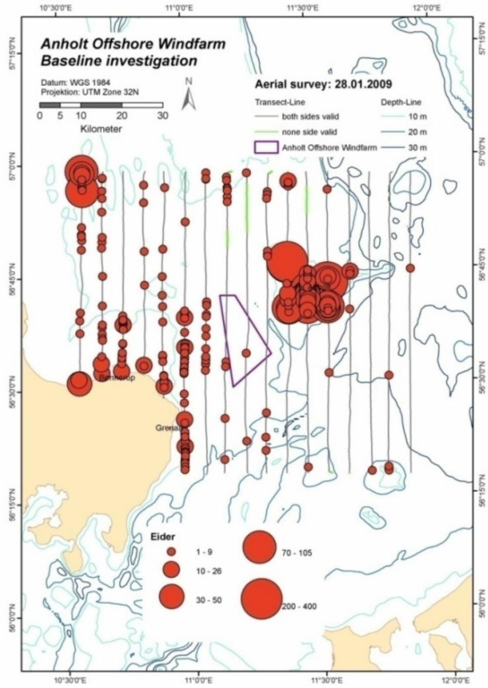


Figure 3-24 Observations of Common Eider from baseline aerial survey undertaken 28 January, 2009.

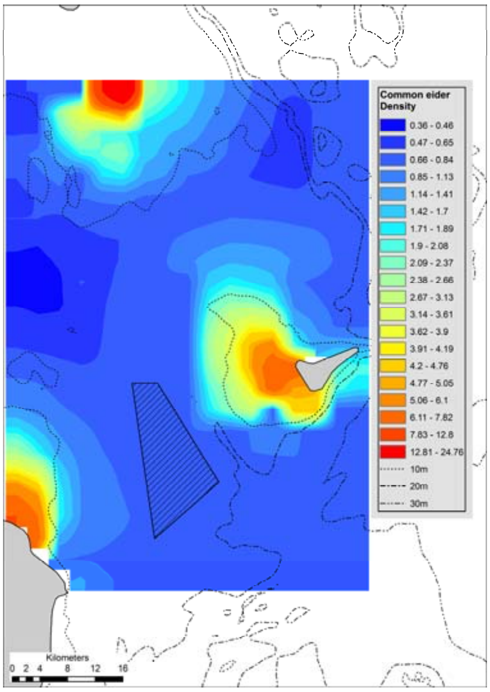


Figure 3-25 Modelled average densities (number of birds/km^2) of wintering Common Eider based on historical aerial survey data 2000-2008.

3.2.2.7 Common Scoter (Melanitta nigra)

Within the region the winter concentration of Common Scoters found in shallower areas represents the single most spectacular and important occurrence of birds with mean estimates in winter at 495,000 or equivalent to 38% of the NW European winter population, Ref. 17. This is also the largest known concentration of the species in Europe. The species is found all year round in the northern Kattegat. In late 1980s approx. 50,000 moulting Common Scoter were recorded in late summer Ref. 31/, and moulting birds were also recorded in 2000-01 and in 2006 (Petersen et al. 2006b) Ref. 33 .

As the observations depicted in Figure 3-26 and Figure 3-28 show, Common Scoters may occur irregularly in small numbers within the Anholt OWF. Common scoters exploit bivalves like common mussel and *Spisula* within areas shallower than 15 m, and in general birds are staying in offshore waters throughout the year. Despite seasonal dynamics, most sightings of large concentrations have been observed in the large shallows south of Læsø, NW-revet Anholt and off the east coast of Jutland. This is true both for historical surveys and for the baseline surveys. Despite the fact that most of the historic surveys were undertaken north of the Anholt OWF the spatial density models for both the historic and baseline aerial surveys, and the baseline ship-based surveys display parallel trends, Figure 3-27, Figure 3-29 and Figure 3-30. All three models estimated strong decreasing trends in the mean densities of scoters from more than 10 birds/km^2 in the concentrations at Anholt and Jutland and towards the Anholt OWF site, where densities were generally below 1 bird/km^2.

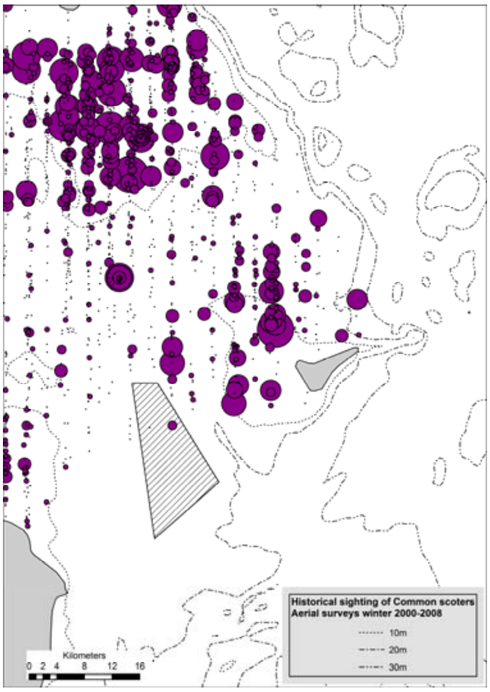


Figure 3-26 Historical sightings of Common Scoter during the aerial surveys carried out by NERI 2000-2008 (scale is arbitrary).

All three models were highly significant, and indicated interactions between water depth, distance from coastline and mussel index as the main habitat drivers.

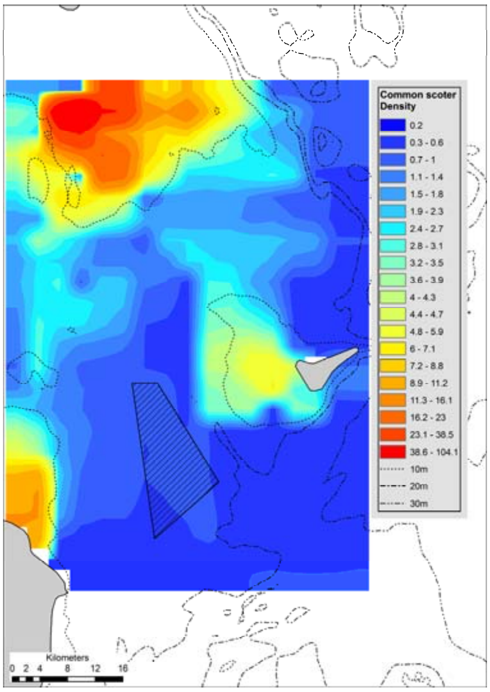


Figure 3-27 Modelled average densities (number of birds/km^2) of wintering Common Scoter based on historical aerial survey data 2000-2008.

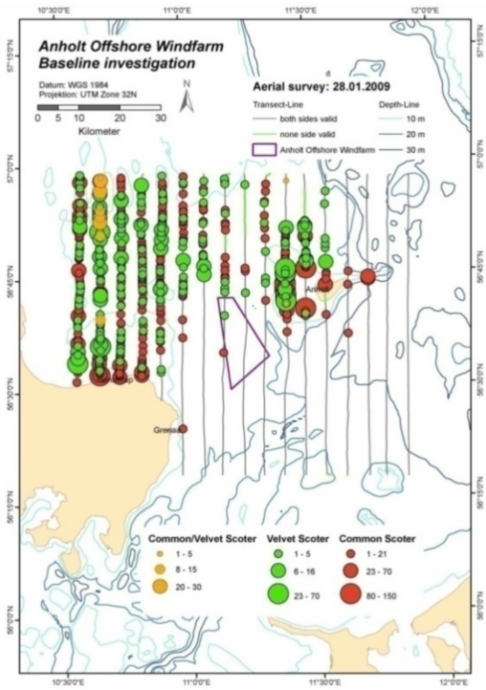


Figure 3-28. Observations of Common and Velvet Scoter during the baseline aerial surveys 2008-09.

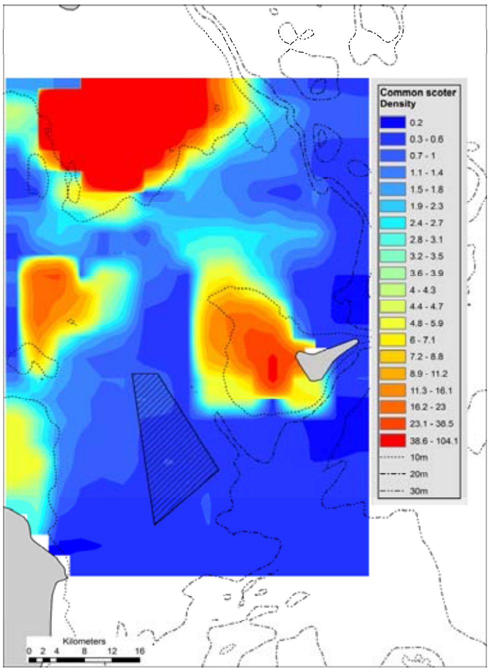


Figure 3-29 Modelled average densities (number of birds/km^2) of wintering Common Scoter based on aerial baseline survey data 2008-09.

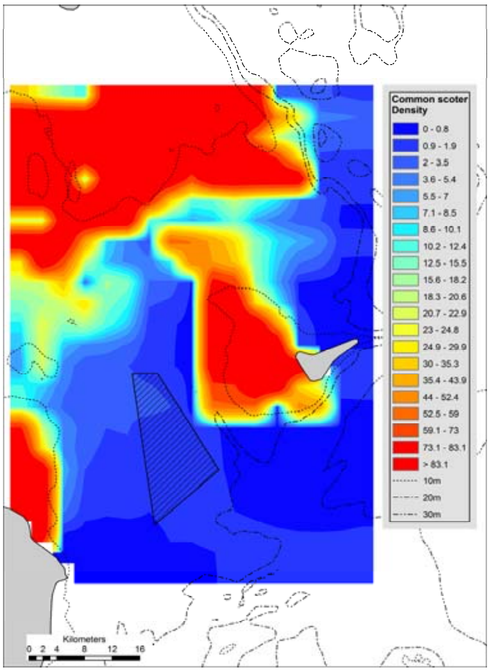


Figure 3-30 Modelled average densities (number of birds/km^2) of wintering Common Scoter based on ship-based baseline survey data 2008-09.

3.2.2.8 **Velvet Scoter (Melanitta fusca)**

The Velvet Scoter is common in Danish water all year around with the Northern Kattegat as one of the more important areas for the species where mean winter abundance has been estimated at 82,000 birds, equivalent of 8.2% of the NW European winter population. In the late 1980's up to 7,000 moulting individuals were recorded in late summer primarily scattered over an areas south of Læsø Ref. 31/. In autumn, winter and spring it is more widespread in the Northern Kattegat and occurs in high densities in many of the same areas as the Common Scoter Ref. 31/,

Ref. 28/, Ref. 35/.

During the 2009 surveys most Velvet Scoters were observed in the western part of the survey area and north-west and west of Anholt – more or less together with the Common Scoters, Figure 3-28. The most significant spatial model was computed on the basis of the baseline aerial surveys showing the mussel index and interactions between the index and distance to the coastline as main habitat drivers. The resulting density model mimicked the patterns and gradients depicted for Common Scoter with densities dropping from above 5 birds/km^2 in the major shallows to less than 0.2 in the area associated with the Anholt OWF, Figure 3-31. The available data indicate that the wind farm area and the area south-west hereof are only irregularly used by the Velvet Scoters.

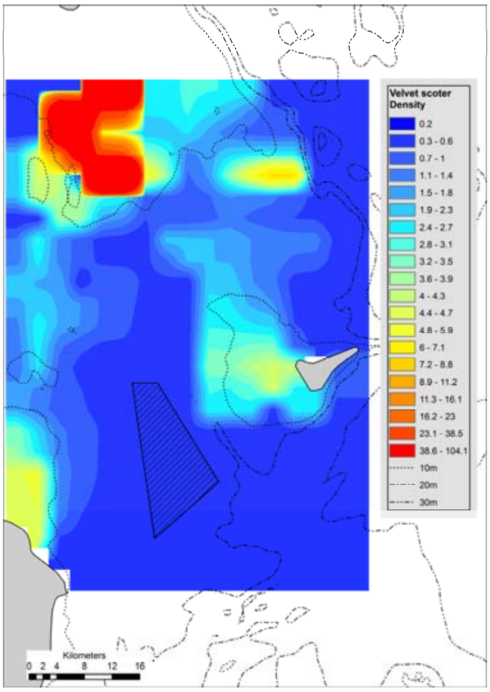


Figure 3-31 Modelled average densities (number of birds/km^2) of wintering Velvet Scoter based on aerial baseline survey data 2008-09.

3.2.2.9 **Long-tailed Duck (Clangula hyemalis)**

The Long-tailed Duck winters in variable numbers in primarily the south-eastern part of the Danish waters. The numbers are depending on the severity of the winter. The Long-tailed Duck does winter in northern Kattegat in moderate numbers. In the late 1980s and early 1990s, up to 1,100 individuals were recorded Ref. 31, Ref. 24, Ref. 35, yet numbers of up to 4,800 have been estimated. The species was more or less evenly distributed over northern Kattegat south of Læsø in areas with a water depth less than 15 m, Ref. 17, Figure 3-32.

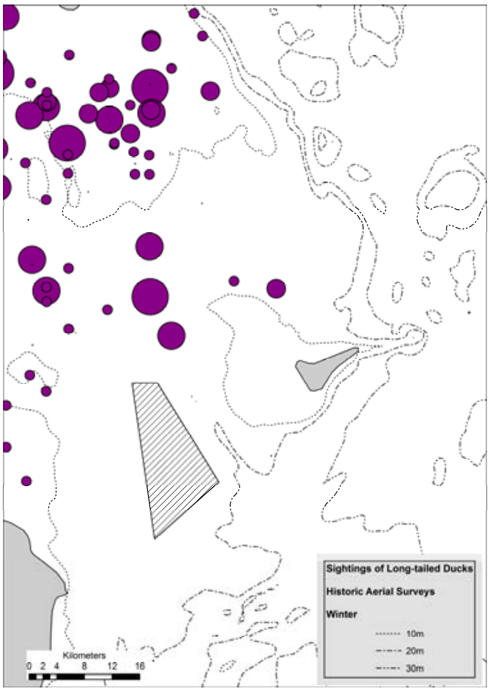


Figure 3-32 Historical sightings of Long-tailed Ducks during the aerial surveys carried out by NERI 2000-2008 (scale is arbitrary).

From the aerial 2009 surveys it was possible to make a significant prediction model of the fine-scale distribution of the species, Figure 3-33. The model, which indicated the mussel index as main explanatory variable, displayed rather low mean densities over most of the region, but with a tendency to elevated densities in the same areas as Common and Velvet Scoters.

Consequently, the mean density estimated for the wind farm areas was very low. No or only very few individuals should be expected at the site for the OWF.

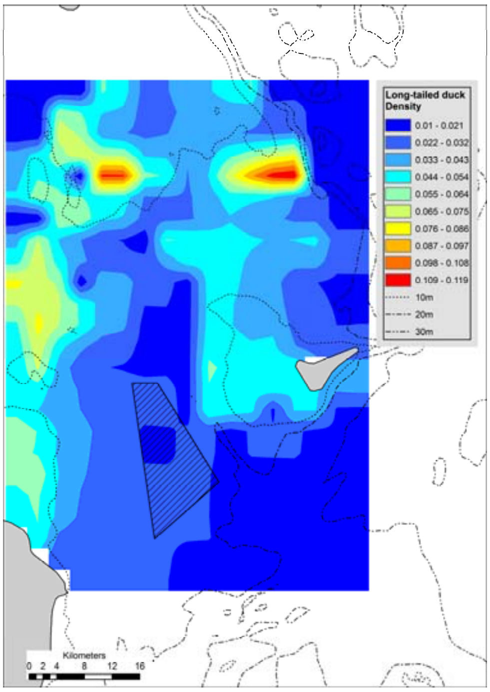


Figure 3-33 Modelled average densities (number of birds/km^2) of wintering Long-tailed Ducks based on aerial baseline survey data 2008-09.

3.2.2.10 **Gulls (Larus ssp.)**

In general the different species of gulls are all widespread, occur in numbers well below international significance and are difficult to determine to species during most aerial surveys. Consequently, the species are dealt with in short, and the results from the aerial surveys are presented as cumulative plots. Although none of the spatial models obtained for the gull species recorded during the baseline surveys were significant, the predicted densities are shown to illustrate the general tendency for a higher densities of Common Gull (Larus canus), Herring Gull (Larus argentatus) and Great Black-backed Gull (Larus marinus) in the region of strong currents found south of the planned wind farm, Figure 3-34, Figure 3-35, Figure 3-36 and Figure 3-37.

In the wind farm area low or very low densities of gulls were estimated.

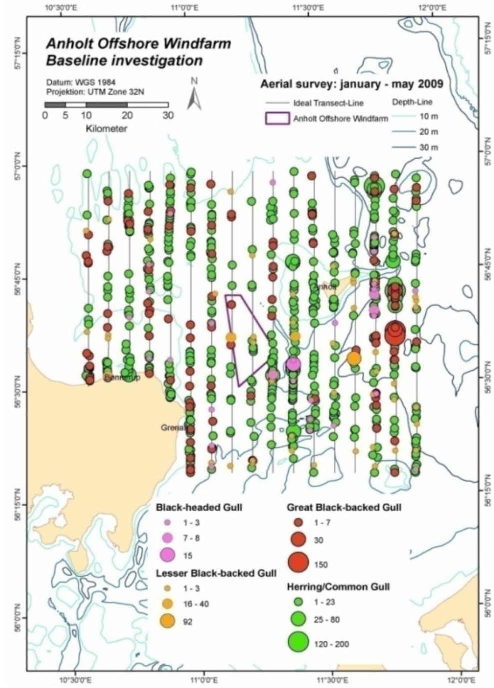


Figure 3-34 Observations of Black-heded Gull, Common Gull, Herring Gull, Lesser Black-backed Gull and Great Black-backed Gull during the baseline aerial surveys 2008-09.

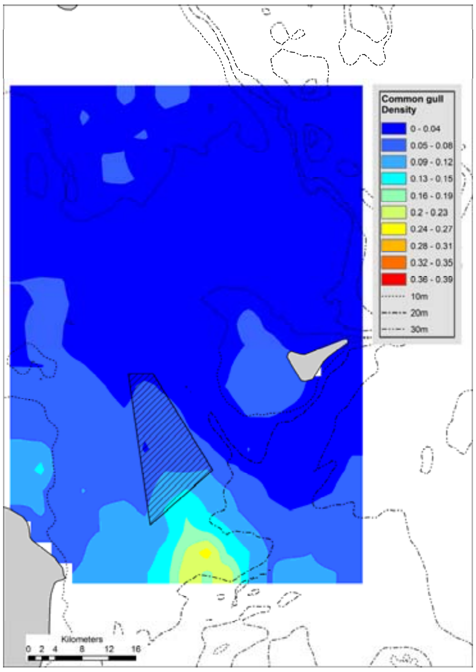


Figure 3-35 Modelled average densities (number of birds/km2) of wintering Common Gull based on ship-based baseline survey data 2008-09.

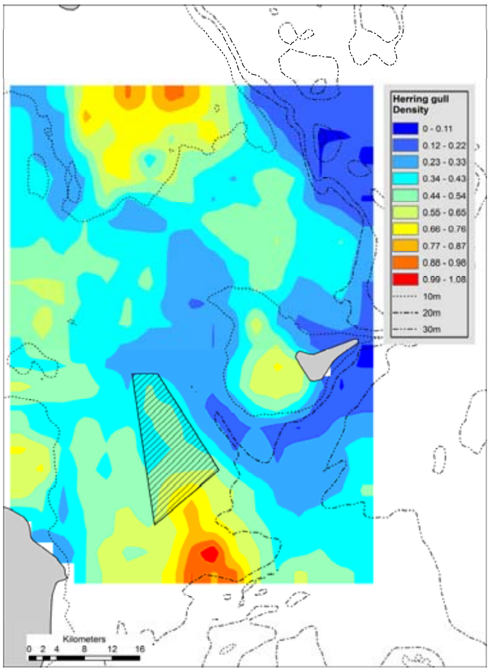


Figure 3-36 Modelled average densities (number of birds/km2) of wintering Herring Gull based on ship-based baseline survey data 2008-09.

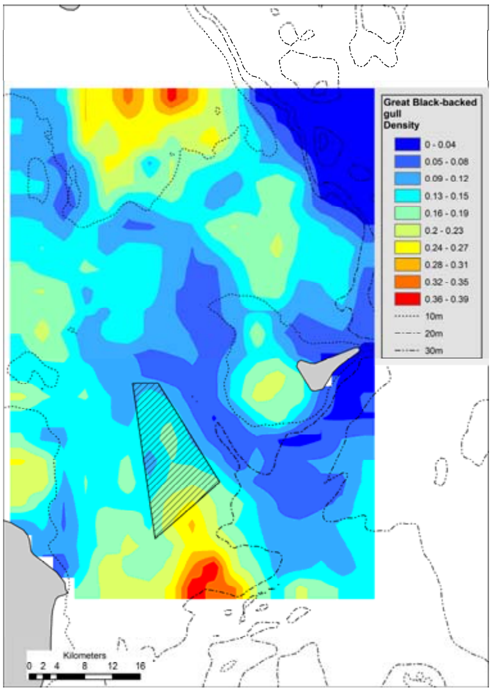


Figure 3-37 Modelled average densities (number of birds/km2) of wintering Great Black-backed Gull based on ship-based baseline survey data 2008-09.

3.2.2.11 **Kittiwake (Rissa tridactyla)**

The kittiwake is a pelagic species which primarily occurs in the northeastern Kattegat in winter Ref. 31. The 1999-2001 survey showed highest density in the most eastern and northern part of the survey area and only very few observations were made within the wind farm area. These general characteristics could be corroborated by the observations during 2009 and the historic observations, Figure 3-38.

The species probably occur in small numbers in the Anholt OWF during mid winter.

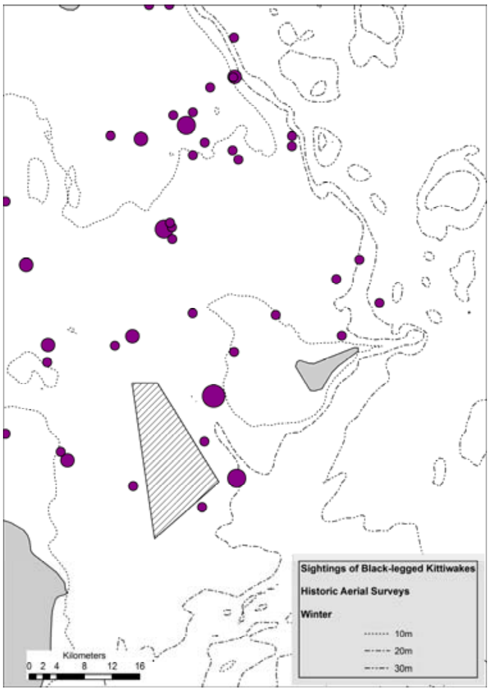


Figure 3-38 Historical sightings of Black-legged Kittiwake during the aerial surveys carried out by NERI 2000-2008 (scale is arbitrary).

3.2.2.12 Guillemot (Uria aalge)

The Guillemots winter gregariously in Danish waters, where they can be encountered in large flocks, especially in the eastern and northern Kattegat in winter. Data from ship-based surveys 1987-89

Ref. 28 showed 110,000 wintering Guillemots mainly occurring in the eastern part. The estimates for Guillemots in autumn and spring did not exceed 15,000 individuals. Nearly 80% Guillemots were estimated in waters deeper than 20 m Ref. 17/.

The ship-based and aerial survey data from the 2009 winter underlined that Guillemots mainly use the eastern-most and pelagic part of the survey area, and confirms that the eastern part of the region is of importance for Guillemots, Figure 3-39. The few data obtained did, however, not allow for estimating the densities through spatial modelling.

Only single observations of few individuals have been observed within or near the Anholt OWF.

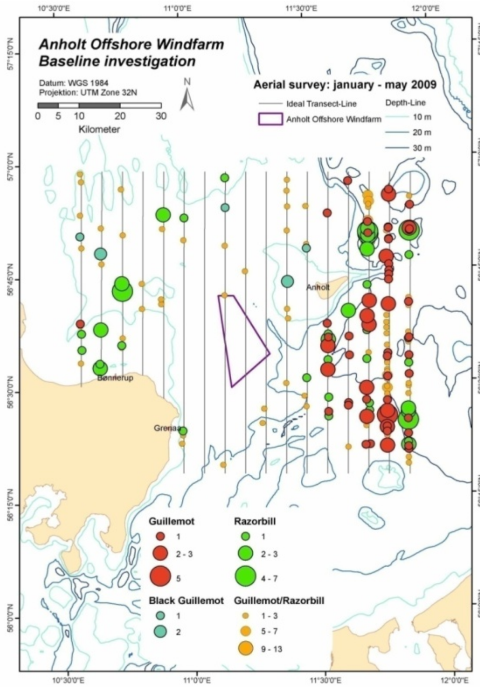


Figure 3-39 Observations of Common Guillemot, Black Guillemot and Razorbill during the baseline aerial surveys 2008-09.

3.2.2.13 Razorbill (Alca torda)

The Razorbill is as the Guillemot a common winter visitor to Danish waters where it occurs gregariously with numbers approaching 200,000, - the largest known winter concentration of the species. In the autumn, when the birds arrive in late October and early November, most birds are found off the NE coast of Djursland and at Anholt, while in mid winter most birds concentrate in the eastern Kattegat.

In winter approximately 70% were recorded in waters deeper than 20 meter Ref. 17. During the 1999-2001 surveys Ref. 31/ the highest density of Razorbill occurred in the areas north of Anholt although significant number of Razorbill in December 1999 and January 2001 also occurred close to and within the area assigned for the wind farm.

The 2009 surveys confirm these findings. Unfortunately, the timing of the surveys did not allow for covering the wind farm and adjacent areas during the peak period of Razorbill abundance in late autumn, and relatively low densities were observed from ship, mainly close to Djursland and in the eastern-most sector. No birds were observed in the wind farm area or adjacent to it.

The estimated densities during late autumn based on historic ship-based surveys obtained during 1987-1993 indicated extreme patchiness, and the presence of high densities west of Anholt and east of Djursland approaching the wind farm area,

Figure 3-40. The model is insignificant, however, as it’s based on few sightings of relatively large flocks. However, the model indicated the gradient in bottom salinity and current velocity as the main habitat drivers

Updated information on the use of the species of the area between Djursland and Anholt in late autumn is needed to resolve the importance of the Anholt OWF to this species. Based on the circumstantial evidence from the historic data and the indications of the spatial model it cannot be ruled out that the site may house larger numbers of the species during this time of the year.

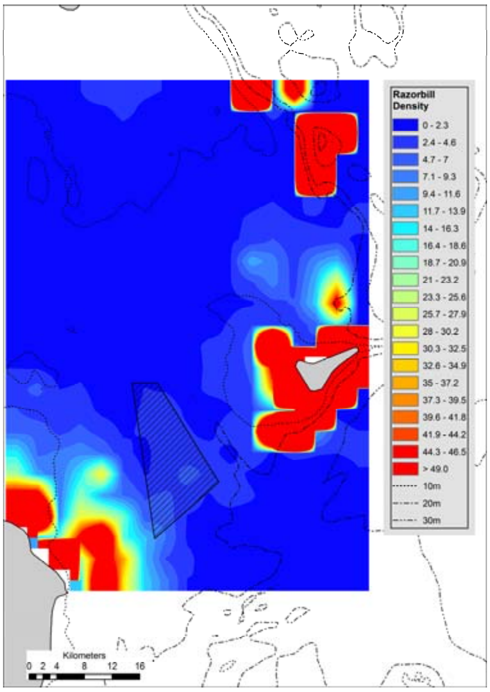


Figure 3-40 Modelled average densities (number of birds/km^2) of wintering Razorbill based on historic ship-based survey data 1987-1993.

3.2.2.14 **Black Guillemot (Cepphus grylle)**

The Danish breeding population of Black Guillemot is exclusively confined to the islands and islets in Kattegat and the northern part of the Great Belt. In 1996 1,100 pairs were counted, of which 75% were found just north of Læsø, Ref. 21/, and Ref. 31/.

The Danish population is largely sedentary with local movements only within the Kattegat area. There is no measurable influx of birds from other populations into the Kattegat Ref. 31/. During the breeding season, Black Guillemots occur close to the colonies whereas the species disperse over a larger area outside the breeding season. In the winters of the late 1980s, up to just over 2,000 birds were estimated in northern Kattegat, of which 60% occurred north of Læsø and 40% south of the island. During autumn, 75-100% of the estimated 1,000 individuals were recorded from waters south of Læsø,

Ref. 28/. Approximately 80% of all Black Guillemots were recorded in water with depths of 10-30 m, Ref. 17. During the 1999-2001 aerial surveys the Black Guillemot was rarely encountered in the study area Ref. 31/.

The 2009 aerial surveys showed few observations of black Guillemot north-west of Anholt and in the north-western part of the survey area. However, higher densities were observed during the ship-based surveys in the same areas, and the significant density model based on these recordings show a trend toward fine-scale patchiness at the salinity front at the edges of the shallows and off the east Djursland coast, Figure 3-41. Medium or low densities are indicated for the Anholt OWF, which is corroborated by the paucity of sightings made within the site during the baseline.

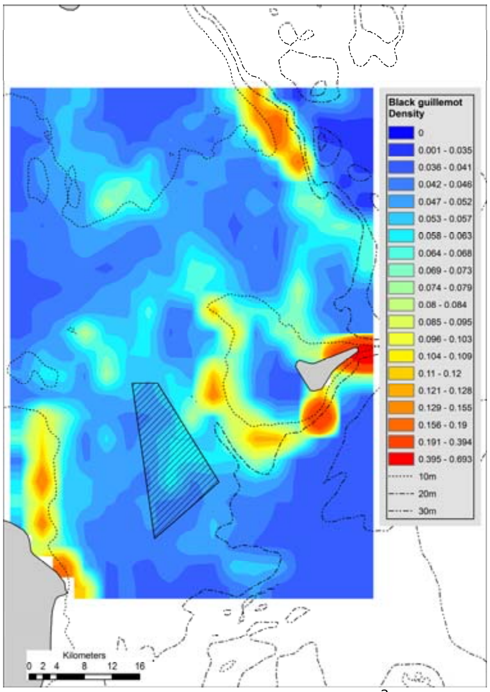


Figure 3-41 Modelled average densities (number of birds/km^2) of wintering Black Guillemot based on ship-based baseline survey data 2008-09.

3.2.2.15 **Synthesis – benthic and pelagic habitats to waterbirds**

The series of maps showing the distribution of observations or the results of the prediction models of waterbird densities in the region around the planned Anholt OWF have clearly demonstrated that the site is located in a region of high diversity and abundance of waterbirds, especially during the winter season. The diversity of waterbirds and seabirds found in the region in significant numbers during the non-breeding season ranges from benthivorous birds (chiefly seaducks), across pursuit diving piscivores like razorbills targeting schooling pelagic fish, to surface foragers like kittiwakes and generalists like gulls.

This conglomerate of avian ecotypes is quite unique at an international level, as it represents a combination of the largest continuous area of shallow offshore waters below 15 m water depth found in this part Europe and water masses of Atlantic origin rich in animal plankton and fish dominating the areas deeper than 20 m. Importantly, in relation to establishing the importance of the Anholt OWF to waterbirds the site is actually located outside both of these environments. The area of high carrying capacity for mussel growth (> 0.15) is depicted in Figure 3-42, and stretches, north of Anholt and Djursland at distances of approximately 8 and 12 km, respectively, from the wind farm site. This matches exactly the distance to the major and, in international perspective, most sensitive elements of the bird fauna in the Northern Kattegat; the extensive concentrations of seaducks.

Despite variability in these mean patterns of mussel growth, the large amount of survey data on which the baseline has been established unambiguously point at the fact that the seaducks do not use the wind farm and associated areas to any great extent.

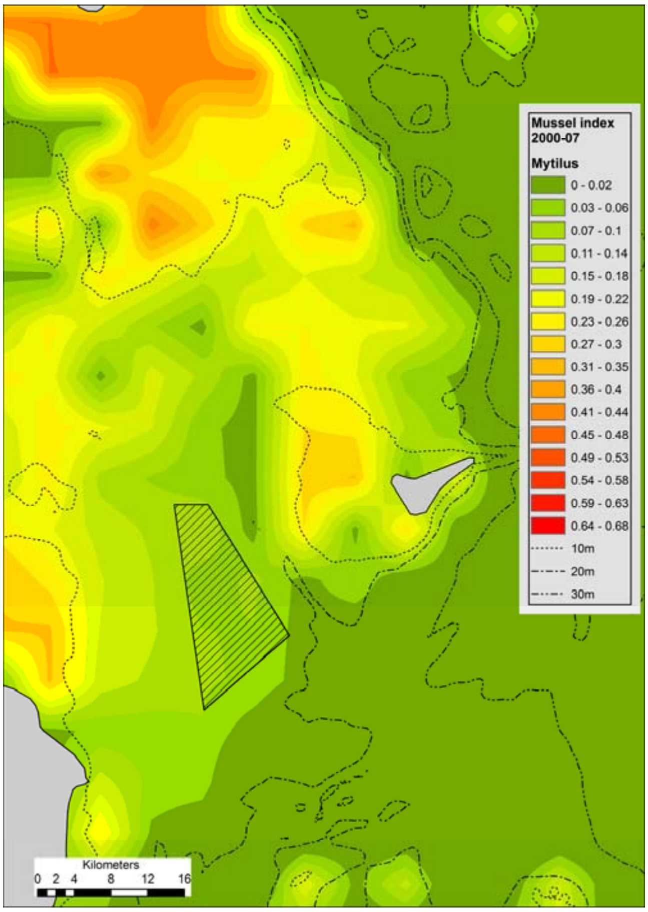


Figure 3-42 Modelled mean mussel carrying capacity index for Mytilus edulis between 2000 and 2007.

As the wind farm site is located outside the major marine environments as found in the central Kattegat it may be regarded as being embedded in the ecotone marking the transition between the two zones. The ecotone is characterised by relatively strong frontal activity and salinity gradients, Figure 3-43 and Figure 3-44. These structures have a profound influence on the birds using the site most frequently, most notably Red-throated and Black-throated divers. The divers are known to utilise hydrographic fronts as feeding habitats, as prey concentrate at these fronts during prolonged periods, and hence increase the bird's probability to encounter prey. Divers are heavy birds, and have relatively high costs associated with flying, thus high densities of these birds have been reported at hydrographic structures supporting predictable food sources.

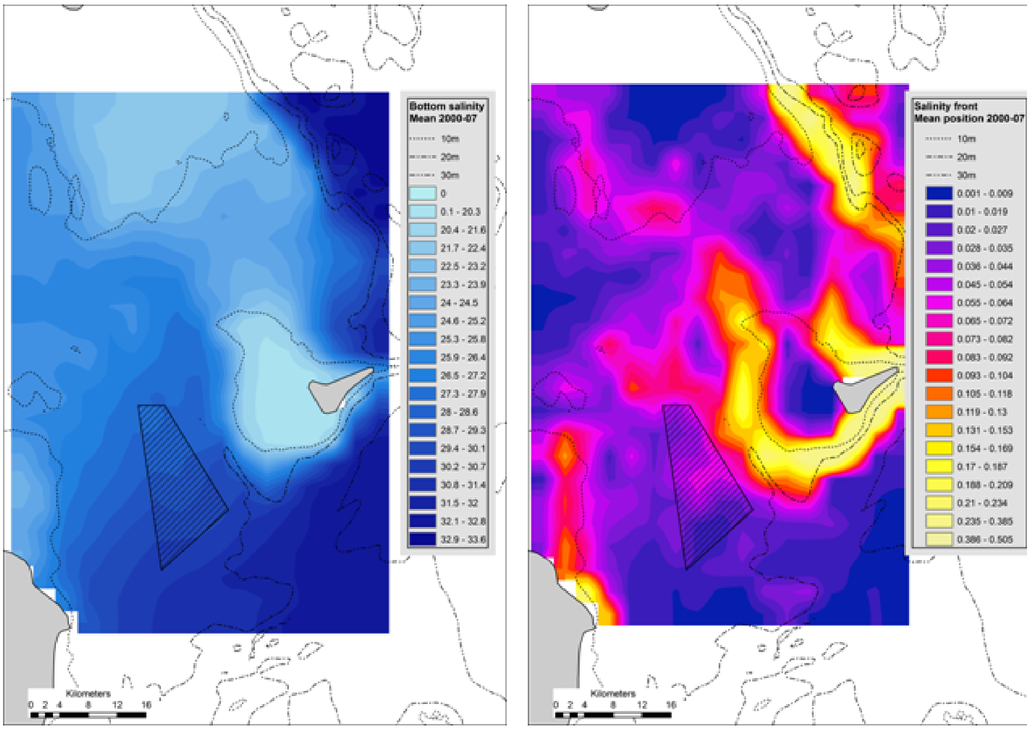


Figure 3-43 Modelled mean bottom salinity and salinity gradient at the bottom between 2000 and 2007.

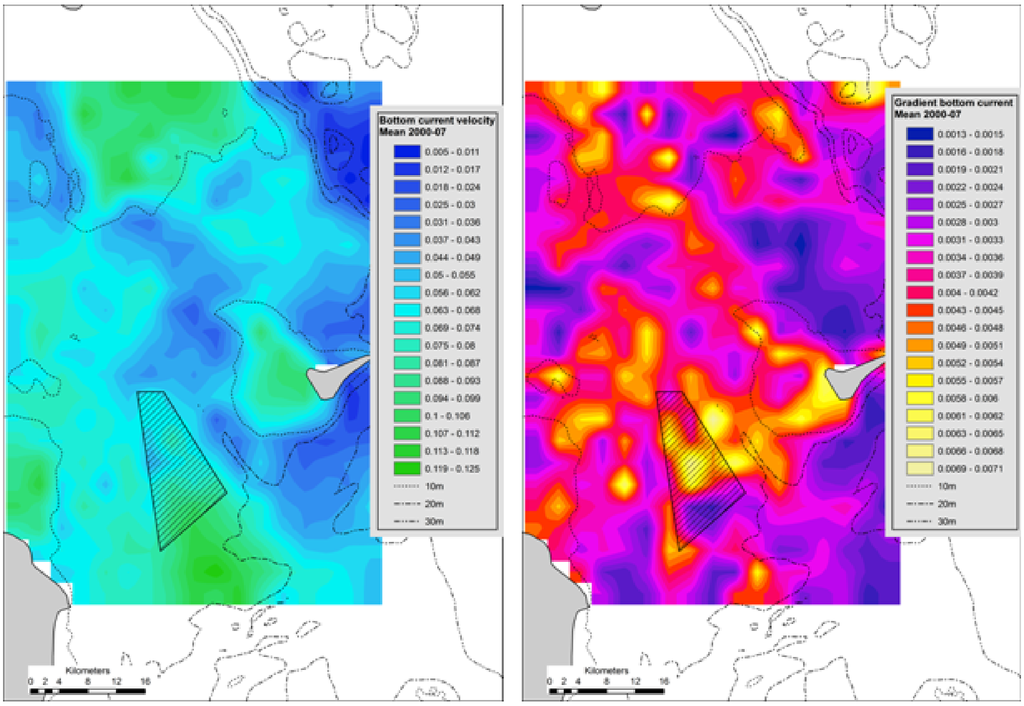


Figure 3-44 Modelled mean bottom current velocity and gradient in velocity at the bottom between 2000 and 2007.

To get a summarised spatially explicit index of the total importance of the region to all key waterbird species an index of total standardised abundance was calculated. The index is a simple summary of the densities per grid point across all species occurring with more than 1% of the European winter population (Red-necked grebe, Common eider, Common scoter, Velvet scoter, Razorbill). The densities of all species were standardised to a scale from 0 to 1 before calculating the index. The standardised total index of bird abundance discloses 5 areas of high abundance overlapping with the habitats mentioned above, Figure 3-45. The wind farm, despite being important to divers, has relatively lower cumulative abundance when evaluated across the entire bird fauna.

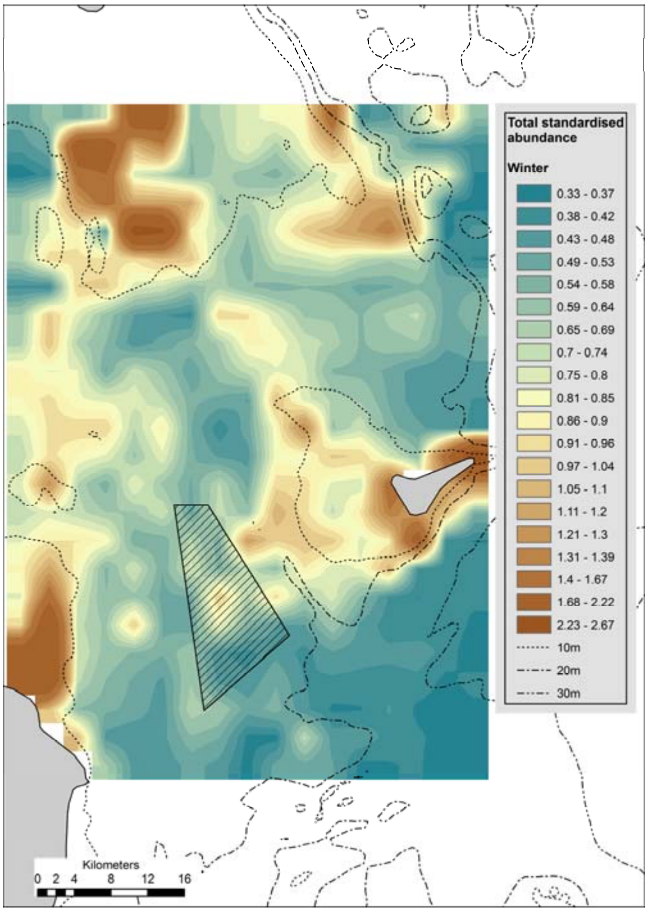


Figure *3-45* Modelled total (standardised) abundance of waterbirds during winter (species occurring in internationally important concentrations) based on species spatial density models. The scale is arbitrary (see Methods for details).

3.2.3 **Bird Migration**

3.2.3.1 **Migration Corridor**

The vast majority of landbirds (such as raptors, pigeons, and songbirds) passing through Jutland on spring migration is heading towards northeast. As they don't like to cross over sea, the migrants will follow the coastline until they reach the sea on both sides. The tendency to concentrate at certain bottlenecks, or 'hot spots' is biggest during the day, while nocturnal migration seem to occur over a much broader front. In this way large numbers of diurnal migrants are being concentrated at Gjerrild Klint, the tip of the Djursland peninsula, before they cross the waters to Sweden. Along with Skagen, Gjerrild Klint and the associated coastline represent the most important diurnal bird migration point in Jutland during spring. Summaries of ornithological observations were received from ornithologists at Gjerrild over the last 25 years (Hans Christophersen and Anders Rasmussen pers. comm.). In Table 3-3 the numbers of raptors recorded at Gjerrild during spring 1985, 1986 and 1987 are compared with the numbers recorded at Skagen, and it's apparent that for a wide number of species migration intensities are at the same level at the two locations. Consequently, the migration of raptors at Gjerrild may be regarded as of international importance, and it includes species with small population sizes listed in the Annex I of EU Birds Directive (EU Birds Directive 1989) like Golden Eagle (Aquila chrysaetos), Osprey (Pandion haliaetus), Honey Buzzard (Pernis apivorus) and Peregrine Falcon (Falco peregrines). The diurnal migration at Gjerrild during autumn is much less well-known. Recent observations, however, indicate the large numbers of raptors, pigeons and passerines may pass Gjerrild regularly in autumn (Hans Christophersen and Anders Rasmussen pers. comm.).

The intensity and direction of the landbird migration at Gjerrild Klint is very much dependent on the weather conditions. The greatest number of migrants will cross the sea during clear days and mild winds between South and West. When the wind is coming from the eastern sector the migrants will only be able to fly relatively low typically below 100 meters in the headwind. When reaching the coast at Gjerrild Klint the migrants will either fly out to sea or continue along the coast. On days with low visibility the migrants will hesitate to leave the coast and the intensity of the northeast-ward migration will drop even more.

During adverse weather conditions the migrants will pause and wait for the weather to clear. Fog at sea (a common phenomenon in spring) represents a potentially critical situation to a migrant crossing the Kattegat. In the fog the bird will get wet from the moist and lose the ability the fly. During fog exhausted migrants will often land on ships. The spring of 2009 was characterized by mostly westerly winds in March, easterly winds in April and again westerly winds in May. There were also periods of low (<5km) visibility during April with fog on a few occasions. The visual migration of landbirds recorded at several locations, including Gjerrild and Skagen, during spring 2009 was at an extraordinarily low level. Accordingly, unusually low numbers were seen of species typically abundant at Gjerrild like Common Buzzard (Buteo buteo), Wood Pigeon (Columba palumbus) and (Fringilla coelebs).

Table 3-3. Numbers of raptor species recorded on spring migration at Gjerrild (G) during 1985-1987 as compared to numbers recorded at Skagen (S). Observations at both locations were carried out daily during the entire spring periods (Hans Christophersen and Anders Rasmussen pers. Comm.).

	1985 G	**1985 S**	**1986 G**	**1986 S**	**1987 G**	**1987 S**
Honey Buzzard	322	1721	211	121	162	734
Black Kite	3	6	2	2	3	10
Red Kite	23	15	19	10	33	10
White-tailed Eagle	7	7	0	3	3	3
Marsh Harrier	48	73	125	181	129	186
Hen Harrier	105	251	125	205	88	121
Montagu's Harrier	4	16	4	18	5	10
Goshawk	16	20	8	20	16	30
Sparrowhawk	2170	2653	809	1941	2323	3794

Buzzard	4890	1262	3038	1025	3637	1980
Rough-legged Buzzard	140	788	237	1798	368	933
Golden Eagle	1	1	1	1	0	2
Osprey	101	274	120	204	86	158
Kestrel	116	409	61	266	74	250
Red-footed Falcon	13	24	1	14	2	2
Merlin	67	218	96	291	113	160
Hobby	59	148	25	53	16	47
Peregrine Falcon	5	15	4	18	5	22

In Figure 3-46 the theoretical pathways of landbirds on diurnal spring migration from Djursland are depicted. One of these potential pathways entails birds using Anholt as a 'stepping stone' before crossing the eastern part of Kattegat. The level of potential barrier effects and collision risks for diurnal migrants will depend on the importance of this pathway. Both migration intensities and directions at Gjerrild Klint and Anholt would provide data which could help in determining the frequency of use of the migration pathway by the different species of landbirds.

Figure 3-46. Theoretical pathways of diurnal landbird migration between Djursland and Scandinavia, of which one using Anholt as a 'stepping stone' will cross the Anholt OWF.

3.2.3.2 Temporal distribution

The early spring (March and first half April) is the main migration season for the short- and medium-distance migrants from wintering quarters on the European continent. During this time of the year great numbers of Wood Pigeon, Eurasian Skylarks (Alauda arvensis), and a variety of thrushes and Corvids pass Gjerrild Klint. Birds of Prey, notably Common Buzzard, are making a strong appearance at this time of the year too. Also Finches are passing through in large numbers. Later in the season the insectivores and species from tropical wintering quarters such as Swifts (Apus apus), swallows and pipits arrive on migration.

Below, a series of phenology graphs displays these patterns of landbird migration as deduced by the visual transect observations on Gjerrild Klint during spring 2009, Figure 3-47, Figure 3-48.

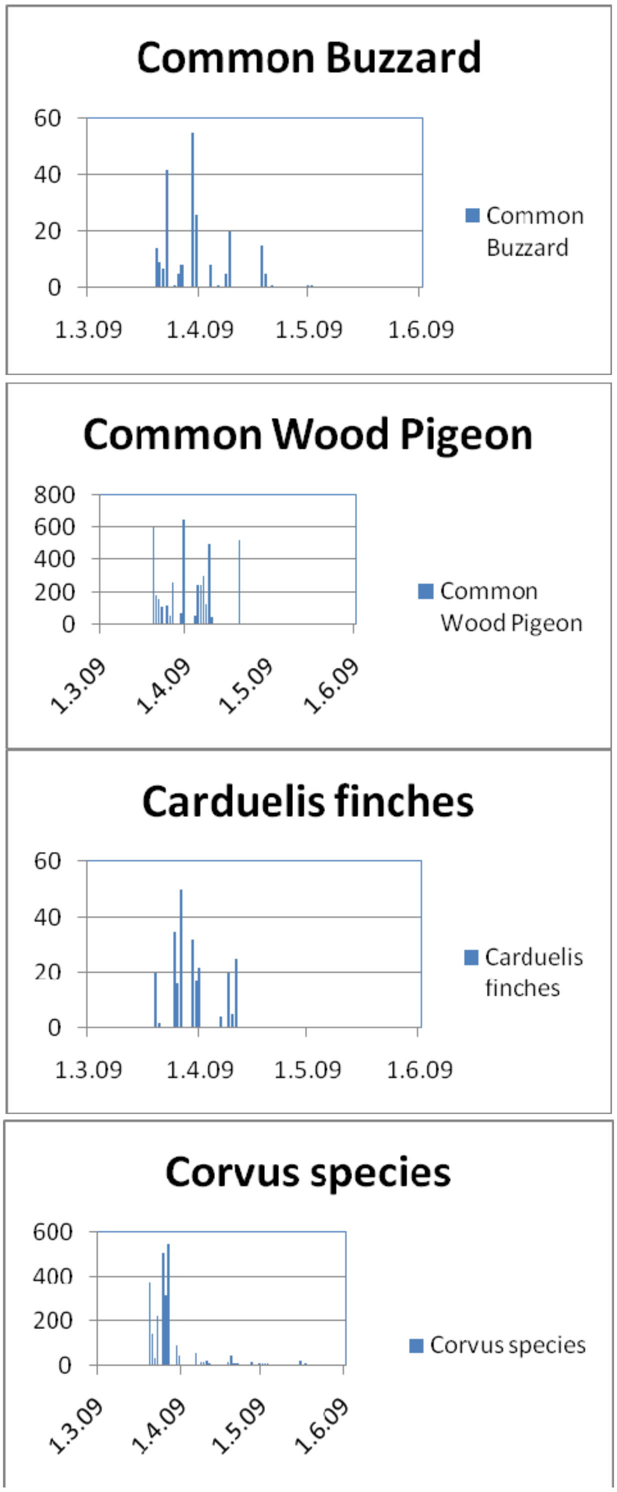


Figure 3-47 Temporal destribution (daily totals) of (a) Common Buzzards, (b) Wood Pigeon, (c) all Carduelis spesies and (d) all Corvid species observed during the transect observation at Gjerrild Klint in spring 2009.

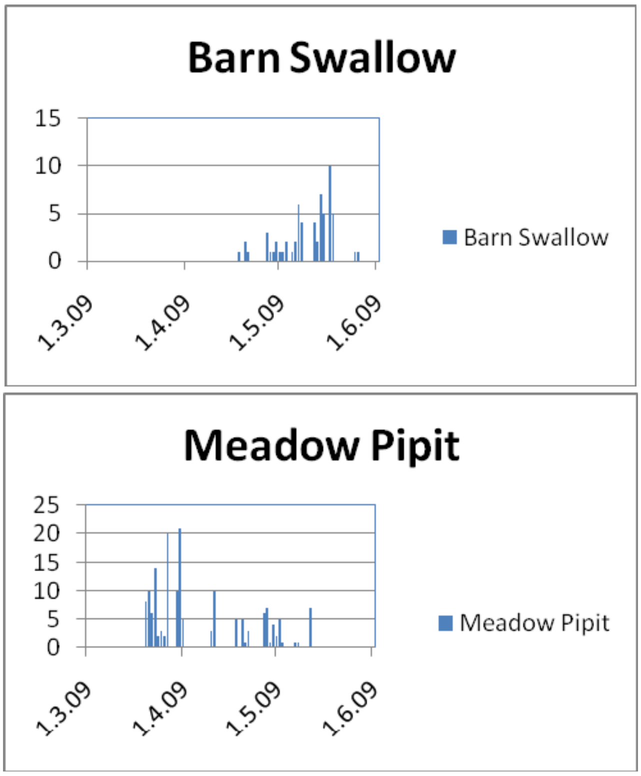


Figure 3-48 Temporal destribution (daily totals) of (a) Barn Swallow (Hirundo hirundo) and (b) Meadow Pipit (Anthus pratensis) observed during the transect observation at Gjerrild Klint in spring 2009.

Barnacle geese on migration

During spring large number of seabirds, especially Common Eider and Common Scoter, pass by along the coastline at Gjerril Klint. Movements may represent short distances relating to wintering and staging birds. During 2009, however, the

Common Eider showed a peak in numbers around late March corresponding to the spring migration period, and again late May at the onset of the moult migration, Figure 3-49. The movement of Common Scoters in early May was also noted at Anholt, and probably relates to the exodus of the large concentrations of birds wintering in the Northern Kattegat. Both the late March miration of Eiders and the May migration of Scoters were heading in southeasterly direction, Figure 3-50.

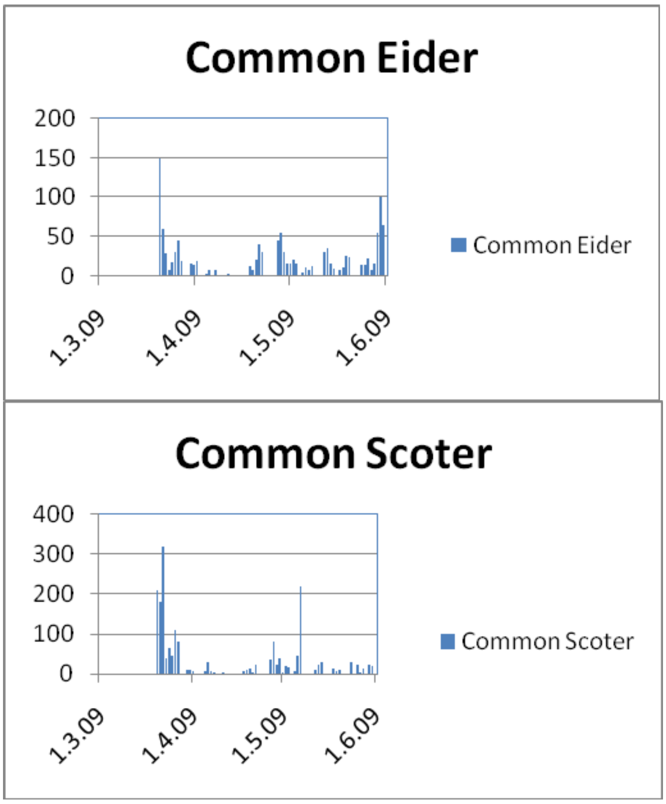


Figure 3-49 Temporal destribution (daily totals) of a) Common Eider and (b) Common Scoter observed during the transect observation at Gjerrild Klint in spring 2009.

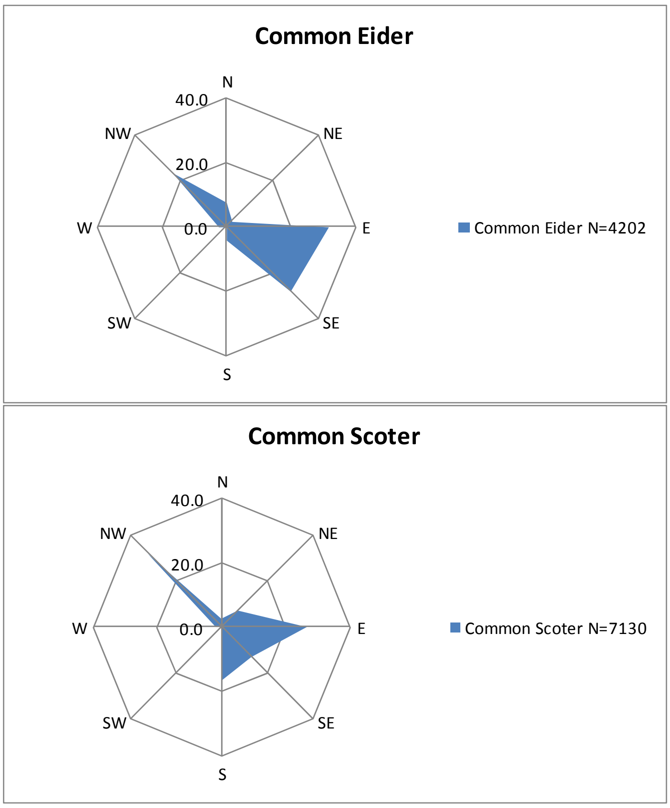


Figure 3-50 Flight directions at Gjerild Klint of Common Eider and Common Scoter.

3.2.3.3 **The landbird migration between Djursland-Anholt**

From Figure 3-51 and Figure 3-52 it is evident that the main flight direction for landbird species on diurnal migration at Gjerrild Klint is towards northeast. Only few species have a more northerly or easterly main flight direction; Common Starling for instance was flying on an easterly course from Gjerrild Klint. Flight directions towards northwest-north and south relate to birds changing course when they reached the coastline or birds following the coastline around the peninsula.

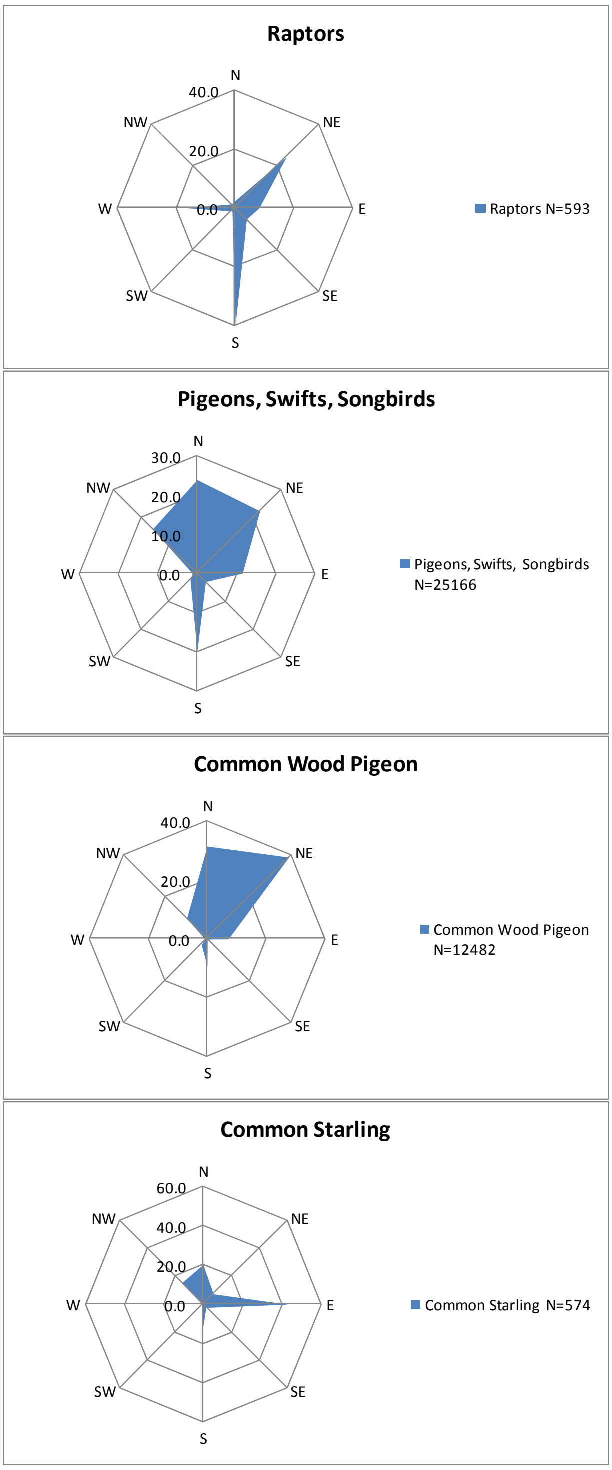
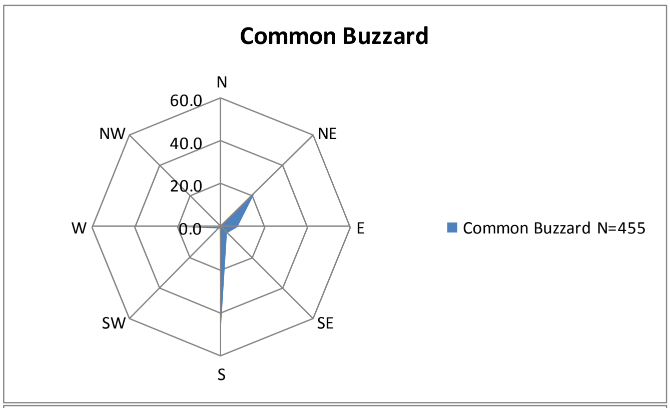


Figure 3-51. Flight directions at Gjerrild Klint for all species of Raptors, an assembly of all Pigeons, Swifts and Songbirds species, Wood Pigeon and Common Starling.

The intensities of bird migration recorded by the visual observations do not readily point at a heavy use by migrants of the pathway to Anholt. This is reflected in the much higher migration intensities recorde during visual observations at Gjerrild Klint compared to Anholt (Gjerrild Klint: mean 897 birds/day; Anholt: mean 60 birds/day). When flying towards northeast from Gjerrild Klint a large proportion of the migrants will soon be able to see the island of Anholt. To which degree the migrants are attracted by the island varies much between species and will also depend strongly on the weather conditions. During unfavorable weather Anholt undoubtedly attract most of the migrants which get within viewing distance of the Island. However, judged from the much lower visually observed migration intensities at Anholt it seems that of large numbers of migrants are attracted to the island, a large proportion pass the island at some distance especially in good weather conditions.

For certain species of migrants with large wings such as raptors and cranes the open waters of the Kattegat clearly represent a strong barrier during migration. For such species Anholt may constitute an important stepping stone between Djursland and Sweden. This is particularly the case for Common Buzzard which is a broad-winged species relying heavily on souring and gliding. Lifted by upward airflow the Buzzards reach heights from where they can see the Island of Anholt. On severel occations the same flocks of Common Buzzards were recorded both leaving the mainland at Gjerrild Klint and coming in the from the sea at Anholt later the same day. On the 2nd of April 2009 there was a strong migration of 500 Common Buzzards flying northeast at Ålsrode, Djursland and 445 flying northeast at Anholt. All the Common Buzzards leaving Gjerrild Klint was seen flying towards Anholt.

At Anholt the main flight direction for migrating landbirds was east (or southwest for birds returning to Djursland) as opposed to northeast on Gjerrild Klint. The more easterly flight direction on Anholt could result both from the orientation of the coastline at the observation point, and from the change in flight direction towards the closest point on the Swedish west coast, Figure 3-53.



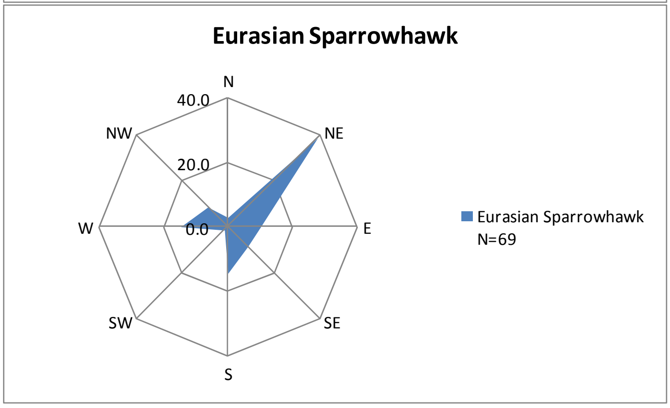
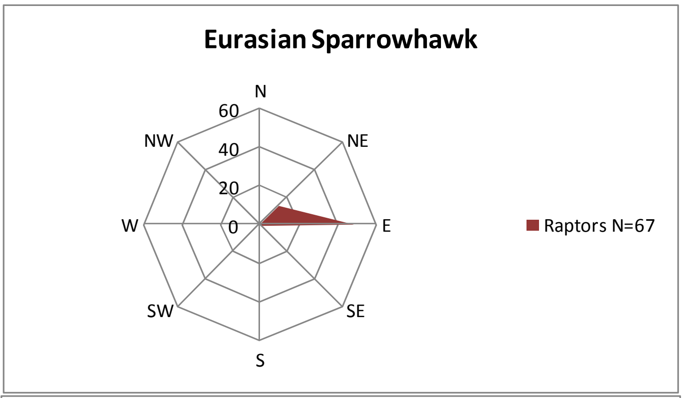


Figure 3-52. Flight directions at Gjerrild Klint for (a) Common Buzzard and (b) Eurasian Sparrowhawk.



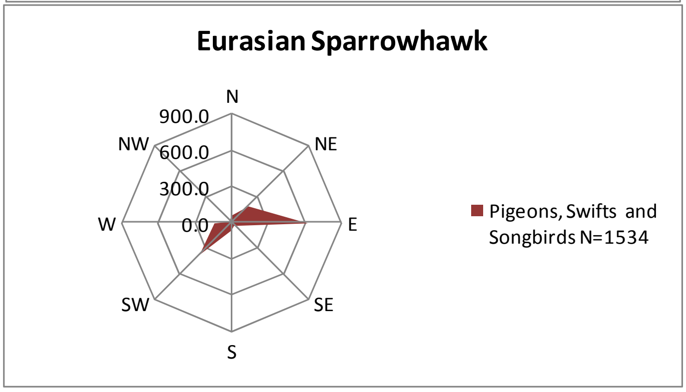


Figure 3-53 Flight directions at Anholt harbour for a) all species of Raptors and b) an assembly of all Pigeons, Swifts and Songbirds species.

Migrating Honey Buzzard

3.2.3.4 Migration intensities recorded by radar

The degree to which migrants use the potential migration pathway between Djursland and Anholt, crossing the Anholt OWF, was mainly determined by analysis of the radar data on relative migration intensities. After all, the range of visual observations for most species of passerines is limited to less than 1000 m, and for pigeons and larger species to a few kilometers. The statistical analysis of relative migration intensities measured the temporal variability over 5-day periods in the number of bird tracks recorded within each of the five 4*4 km squares located along the pathway, Figure 3-54.

Intensities in the square located 1-5 km SW of the radar at Gjerrild Klint (Gjerrild W) displayed a clear temporal pattern with marked peaks having intensities at 5 during the second period in April and the first and second periods of May. A secondary peak with intensities just below 5 occurred during the fourth period in May. The first migration peak coincided with the pulses of short- and medium-distance migrants like finches, pigeons, thrushes and buzzards leaving Djursland in early April. The peaks in May coincided with the movements of long-distance migrants, mainly passerines like pipits, yellow wagtails, warblers and swallows.

Intensities in the square located immediately NE of the radar at Gjerrild Klint (Gjerrild E1) displayed a similar temporal pattern, however an additional peak occurred during the fourth 5-day period in April. Migration intensities in this square were generally 10 times higher than in the square southwest from Gjerrild. Migration intensities dropped significantly in the square located 8.5 kilometers northeast from Gjerrild Klint (Gjerrild E2). The level of migration intensities and the temporal pattern were very similar to the square Gjerrild W, although intensities were somewhat lower during the fourth period of May.

Approaching Anholt, migration intensities dropped further in the square located 8.5 kilometers southwest from the radar on Anholt Harbour (Anholt W2). The Anholt W1 square located just SW of the radar on Anholt held high migration intensities during the peaks of the second period in April, and the first and second period of May. The level of migration intensities during the first two periods was similar to the intensities recorded in Gjerrild E1, while intensities during the second period of May were slightly higher than in Gjerrild E1.

Figure 3-54 Relative migration intensities along the potential migration pathway between Djursland and Anholt, recorded as the total number of bird tracks (corrected for scanned volume) per 5-day period, in each of the five statistical squares outlined in Figure 4-1.

3.2.3.5 Migration heights recorded by radar

The migration heights below 1500 m recorded at the two radar stations are summarised in figures Figure 3-55 and Figure 3-56. The temporal trends and the level of relative migration volume at the two locations follow the results for the horizontal radars close to the stations. However, it's apparent that the vertical radars picked up more echoes during the migration in May than in April, and that high-altitude migration was more frequent over Gjerrild than over Anholt. At Gjerrild, between 25% and 40 % of the migration took place at altitudes below 200 m during the night, while during the day between 40% and 60% of the migration was recorded below 200 m altitude, Figure 3-55. Relative intensities at Gjerrild were lower below 100 m altitude than between 100 and 600 m altitude during all 5-day periods and parts of the day.

At Anholt, a significant proportion of the migration took place at low altitude, Figure 3-56. This was most notable in April, when virtually all migrants were travelling below 100 m. In May, between 5 and 15 % of the migration at Anholt took place at altitudes below 100 m.

Migrating Wood Pigeons

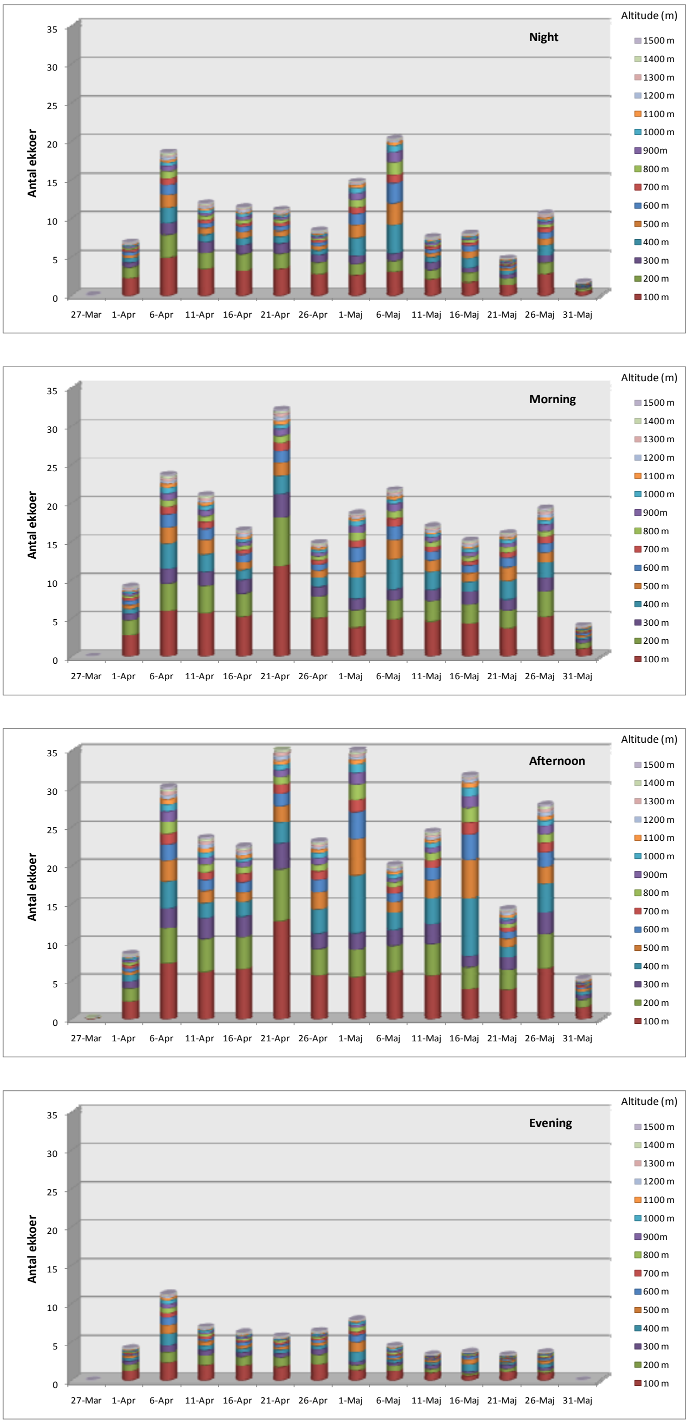


Figure 3-55 Altitudinal distribution of relative migration intensities below 1500 m recorded at Gjerrild Klint, recorded as the total number of bird tracks per 100 m altitude band (corrected for scanned volume) per 5-day period.

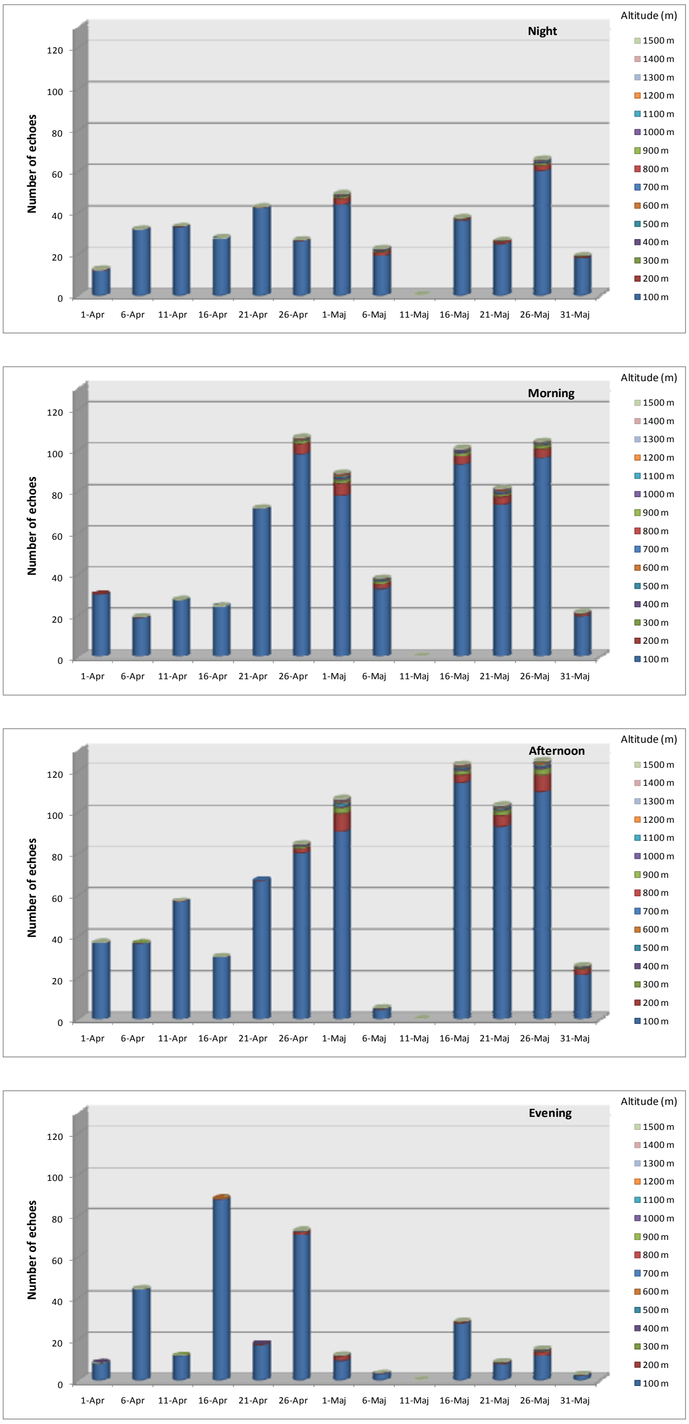


Figure 3-56 Altitudinal distribution of relative migration intensities below 1500 m recorded at Anholt, recorded as the total number of bird echoes per 100 m altitude band (corrected for scanned volume) per 5-day period.

3.2.3.6 Conclusion regarding bird migration at the Anholt OWF

The results unambiguously indicate the existence of a migration pathway or corridor of landbirds between Djursland and Anholt in spring 2009. The geographical variability in the density of landbird migration followed the expected gradient as a function of distance from the major exodus point (NE Djursland) and the distance to the receiving coast on Anholt. Clearly, the 'island effect' of Anholt is reflected, and the island seems to function as a magnet on migrants during spring, - a well-known phenomenon documented from many islands worldwide, Ref. 2. Although an unknown proportion of the birds arriving at Anholt in large numbers may have been recruited at other migration hot spots than NE Djursland the parallel temporal trends in the timing of migration peaks across all five statistical squares along the pathway make it most likely that the majority of migrants arrived to Anholt from Djursland. Although the Anholt OWF is located on this migration corridor the densities of bird migration at the site can be safely assessed to be below the densities close to Djursland and Anholt. It should, however, be born in mind that the lower densities of tracks recorded in the offshore parts of the corridor may partly be explained by a lower detection probability of bird echoes at distances beyond 6 km from the radar Ref. 46.

The altitudinal distribution of the migration during spring 2009 indicates that most migrants pass Anholt at low altitude (< 100 m), whereas a large volume of migrants leave Djursland at altitudes up to 600 m. These patterns are in line with visual migration observations which show a stronger tendency for migrants to fly at lower altitudes at the receiving coast as compared to the coast of departure. The fact that a larger proportion of the landbirds use higher altitudes during the night than during the day has been recorded by a number of radar studies Ref. 10. Given these differences between Anholt and Djursland the general altitudinal distribution of migrants at the Anholt OWF site during spring cannot be accurately assessed with the data at hand from the two land stations. It is most likely that migration altitudes will be lower at the site than at Djursland, and probably approaching the 'average' situation over open ocean with 25-75 % of the birds migrating below 200 m, depending on local weather conditions Ref. 23.

3.3 Impact assessment

3.3.1 Methodology

In order to generate an overview of the effects of the Anholt OWF on birds all effects are rated using criteria outlined in Table 3-4.

Table 3-4 Criteria used in the environmental impact assessment for the off-shore wind park.

Intensity of effect	Scale of effect	Duration of effect	Overall significance of impact[1]
No	Local	Short-term	No impact
Minor	Regional	Medium-term	Minor impact
Medium	National	Long-term	Moderate impact
Large	Transboundary		Significant impact

[1]: Evaluation of overall significance of impact includes an evaluation of the variables shown and an evaluation of the sensitivity of the resource/receptor that is assessed.

The potential impacts on birds from the construction and operation of the Anholt OWF are predicted to fall under four main headings:

1. Physical change of the habitat where the turbines are erected.
2. Disturbance effects (habitat displacement).
3. Barrier effects.
4. Collision risk.

3.3.2 Impacts during construction

Establishment of a marine wind farm covers a period of at least 12 months and is associated with a number of construction activities primarily including: traffic (vessels), pile driving, preparation of the seabed, sediment removal and deposition and cable laying. These activities result in a number of different impacts on the biological communities:

- Habitat displacement
- Habitat change

3.3.2.1 Habitat displacement

Habitat displacement effects on waterbirds during construction may vary as a function of the intensity of construction activities. Disturbance levels will probably approach disturbances due to the wind farm structures during operation during intensive construction works, especially due to the concentration and movements of boats in the wind farm area. Divers, which occur in the area in relatively high densities react strongly on boats. Reaction distances of more than 500 m are commonly observed (own observations). As the numbers of waterbirds using the area shows strong seasonal variability, the potential habitat displacement will depend on the timing of construction activities. As the abundance of most species of waterbirds peaks during October-April the potential for habitat displacement impacts is largest during winter (see Chapter 5.3 on assessment of impacts during operation for details).

3.3.2.2 Habitat Change

The physical changes imposed by constructing the Anholt OWF are assessed to have insignificant impacts on birds in the area. Disturbance effects on potential benthic prey organisms living in the construction site were assessed as being limited, Ref. 11. Sediment dispersal affecting available food supplies of benthic invertebrates and fish was estimated to be small-scale, Ref. 11. and no direct habitat loss as a result of enhanced sediment concentrations is expected. The simulations of the dispersal of suspended matter showed rather low concentrations, which although visible plumes could be expected rarely exceeded 5 mg/l. The threshold of 15 mg/l considered as relevant in relation to feeding birds in the water column Ref. 11 was not exceeded.

Judged from the density models the potential habitat loss for feeding birds during the construction phase will amount to less than 0.1 % of the available habitat in the region.

3.3.2.3 Summary

Table 3-5 Summary of impact on birds during construction.

Impact	Intensity of effect	Scale/geographical extent of effect	Duration of effect	Overall significance of impact
Construction noise	Minor	Locall	Medium-term	Minor
Traffic	Minor	Local	Medium-term	Minor
Sediment dispersal	Minor	Local	Short-term	Minor
Habitat displacement	Minor	Local	Long-term	Minor

3.3.3 Impacts during operation

By far the highest impacts on birds are associated with the operation phase due to the long-term duration of habitat displacement, barrier effect and collision risk impacts. Assessment of habitat displacement and habitat change impacts were made on the basis of the documented specific responses of the different waterbird species to offshore wind farms (see Table 3-6) and the modelled mean densities of the same species. As a worst case scenario modelled densities during the peak season of occurrence were selected for each species. In order to assess the magnitude of potential displacement effects on birds using the vicinity of the Anholt OWF the percentage of birds within the wind farm area was estimated in relation to the percentage of birds in the total investigated area.

In order to rate the impacted areas associated with the Anholt OWF in relation to their conservation importance across the wide range of species the Marine Classification Criterion (MCC) was applied. MCC has been developed as objective criteria for ranking marine sites when examining candidate areas for protection measures

Ref. 40.

The MCC uses the Ramsar 1% criterion for wetlands for waterbirds with clustered

distribution in offshore habitats. The MCC is evaluated as the proportion of the biogeographic population of a particular species concentrated in an area (site) against the average density of the species in the investigated regional sea. The specific MCC values are then cumulated across species to achieve spatially resolved estimates of cumulative conservation importance over the whole area.

Assessment of barrier effect and collision risk impacts on landbird migration were made on the basis of the temporal and spatial profile analyses of the horizontal and vertical distribution of bird migration at Gjerrild and Anholt recorded during spring 2009. The impacts for the Anholt OWF site were assessed by extrapolating the values from the statistical zones of the radar detection ranges.

3.3.3.1 Habitat displacement

The evidence gathered from existing monitoring programmes at offshore wind farms indicate that specific responses of waterbirds to wind farms are highly variable, both as a function of specific disturbance stimuli and site-specific characteristics (see Table 3-6). In addition, adaptations to the turbines and rotor blades are observed, which make accurate assessment of the scale of habitat displacement rather difficult, especially over the long term Ref. 32/. A further complication is the fact that habitat displacement impacts as documented during the monitoring programmes of existing OWFs may not have taken (natural) changes in food supply into consideration. Despite these uncertainties, habitat displacement is generally regarded as the main source of impact on birds from OWFs Ref. 32.

This assessment has applied a worst case scenario building on the reported maximum disturbances from established wind farms within the distance range of 2 km (Table 3-6).

Table 3-6 Reported response types of waterbirds and seabirds during OWF post-construction monitoring in relation to potential habitat displacement within a distance of 2 km from the wind farm.

Species	Site	Response type	Reference
Red-throated Diver (Gavia stellata)	Horns Rev 1 Nysted Kentish Flats, UK North Hoyle, UK	Complete avoidance of wind farm area Indication of habituation over time Indication of habituation over time	Ref. 283 Ref. 28 Ref. 51
Black-throated Diver (Gavia arctica)	Horns Rev 1 Nysted	Complete avoidance	Ref. 28
Fulmar (Fulmar glacialis)	North Hoyle, UK	Indication of complete avoidance	Ref. 69
Cormorant (Phalacrocorax carbo)	Nysted North Hoyle	No avoidance No avoidance	Ref. 28 Ref. 32
Gannet (Morus bassanus)	Horns Rev 1 North	Complete avoidance Indication of no avoidance	Ref. 28 Ref. 69

	Hoyle		
Common Eider (Somateria mol-lissima)	Nysted	No or moderate displacement	Ref. 28
Long-tailed Duck (Clangula hye-malis)	Nysted	Complete avoidance	Ref. 28
Common Scoter (Melanitta nigra)	Horns Rev 1 North Hoyle	Initial moderate to complete avoidance of wind farm area followed by habituation Indication of Habituation	Ref. 28 Ref. 69
Little Gull (Larus minutus)		Indication of no avoidance	Ref. 32
Herring Gull (Larus argentatus)	Nysted Horns Rev 1 Kentish Flats	No significant avoidance or attraction Indication of no avoidance	Ref. 28 Ref. 20
Great Black-backed Gull (Larus marinus)	Kentish Flats	Indication of no avoidance	Ref. 16
Kittiwake (Rissa tridactyla)	North Hoyle	No avoidance	Ref. 69
Sandwich Tern (Sterna sand-vicensis)	Kentish Flats North Hoyle	Indication of no avoidance	Ref. 16 Ref. 69
Common Tern (Sterna hirundo)	Kentish Flats North Hoyle	Indication of no avoidance Indication of no avoidance	Ref. 16 Ref. 69
Arctic/Common Terns (Sterna paradisaea/hirundo)	Horns Rev 1	Indication of moderate avoidance	Ref. 28
Common Guillemot (Uria aalge)	Kentish Flats North Hoyle	Indication of avoidance Indication of no avoidance	Ref. 16 Ref. 69
Razorbill (Alca torda)	Kentish Flats North Hoyle	Indication of avoidance Indication of no avoidance	Ref. 16 Ref. 69
Common Guillemot/Razorbill (Uria aalge/Alca torda)	Horns Rev 1	Indication of avoidance	Ref. 28

From Table 3-6 it can be seen that a pattern emerges in which species with offshore habitats display stronger reactions to OWFs than species with more coastal habitats. Species occurring widespread close to human developments, like gulls, are generally not disturbed by wind farms, while seabirds like divers and auks seem to be. Among the seaducks the more marine Common scoters and Long-tailed ducks have a higher potential for habitat displacement than the more coastal Eider. As experience is gathered at the increasing number of OWF sites habituation by several marine bird species to the structures becomes apparent. With the increasing number of monitoring activities a variance in specific responses by birds is observed, which may be accounted for by differences in site-specific characteristics as well as by variable levels of knowledge and data obtained. For example, aerial monitoring of birds around offshore wind farms in the United Kingdom are not allowed to survey the wind farm area at optimal altitude, and thus numbers of birds in the wind farm are generally missing from these reports.

Despite the documented reductions in densities of some of these species following construction of offshore wind farms it should be pointed out that the reported numbers displaced so far are relatively small in comparison to total population levels, and hence bear no significance to the overall populations.

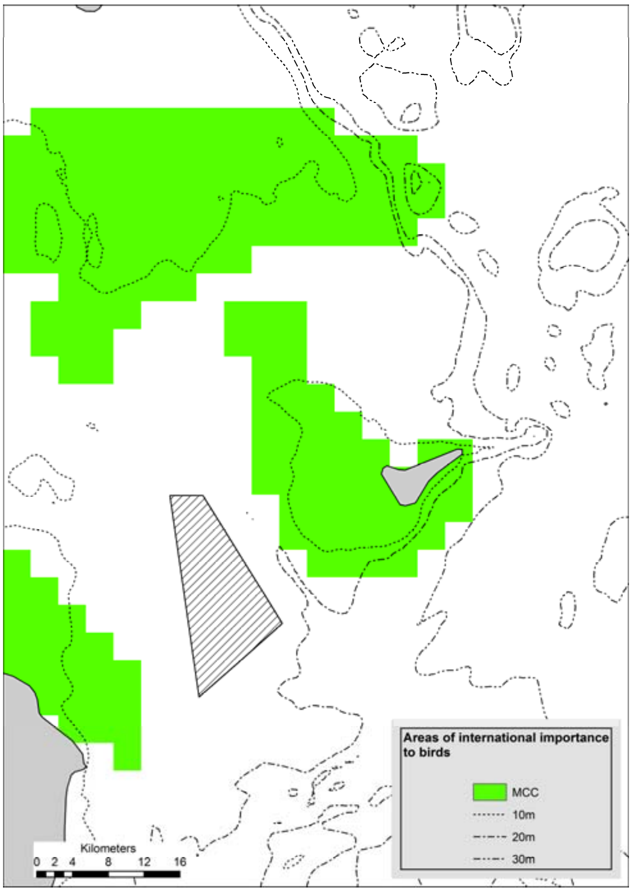


Figure 3-57. Results of the estimation of total conservation importance for different areas of the region to waterbirds. The areas have been estimated using the Marine Classification Criterion (MCC).

The estimation of areas of international importance using the Marine Classification Criterion (MCC) revealed three areas located 5-10 km from the wind farm site, and reflecting combined benthic and pelagic species, Figure 3-57. Hence, in terms of the general avoidance of the wind farm shown by many waterbird species that occur in the area, most species will not suffer any major displacement effect by the construction of the Anholt OWF. One exception is Red-throated/Black-throated Divers for which species the main occurrence and highest densities within the region are found in a zone around and west of Anholt, including the wind farm site. This concentration of divers is estimated to hold approximately 1000 birds on average during winter and spring, and should be judged as being just below international significance as the population estimates for NW-Europe currently is 400-950,000 birds. The other species occurring at the Anholt OWF either show little sign of displacement at existing OWFs (e.g. gulls) or are present in such low densities within 2 km of the assigned project area that the effect locally will be small and insignificant on the population level (e.g. Red-necked Grebe, Common Scoter, Velvet Scoter).

The actual range of habitat displacement in divers due to wind farms is uncertain, as monitoring results have only been concluded on for projects like Horns Rev 1 located outside primary habitats to divers. Horns Rev 2, Gunfleet Sands, Kentish Flats and London Array are all located within prime diver habitat, and once the monitoring activities have been concluded from these projects the potential habitat displacement range in divers may be more accurately determined. Ref. 32 documented a minimum displacement range of 2 km at Horns Rev 1. For an assessment of the significance of the displacement impact on divers due to Anholt OWF the displacement range has been set to 2 km from the wind farm site. The proportion of the available high-density areas (> 0.66 birds/km^2) within the region from which divers could be displaced amounts to 24.7 %, equivalent of 260 km^2. The displaced population of divers is estimated at 150 birds. The Danish mid-winter population of divers is estimated at 10,000 birds Ref. 33. Thus, the number of displaced birds does not have any significant impact at the population level.

Overall, it is assessed that divers are going to be most disturbed by the Anholt OWF, although at the population level the disturbance effect is going to be insignificant.

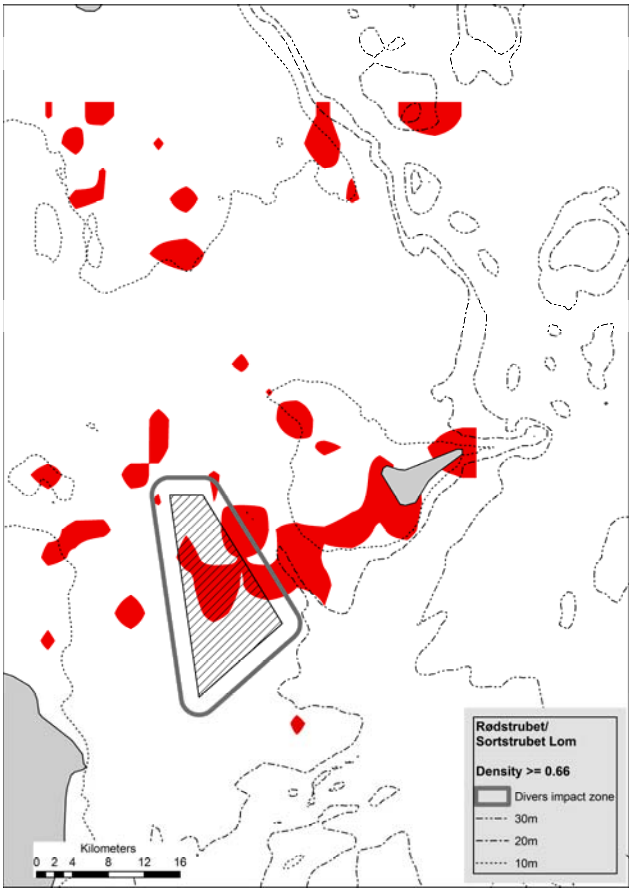


Figure 3-58. The displacement impact range from the Anholt OWF in relation to areas of higher densities of divers, defined as more than 0.66 birds/km2 (equivalent to the mean density + 1 standard deviation).

3.3.3.2 **Habitat Change**

The presence of the Anholt OWF may affect bird habitats directly by either reducing the available area by its physical presence and by increasing available food supplies through creation of artificial reefs at the foundations of the turbines. Additionally,

the turbines may serve as platforms for resting and perching birds, thereby attracting birds to the area that would not have exploited it previously.

The foundations of the Anholt OWF are expected to physically cover an area of approximately 0.1 km^2, including a 20 m zone with added scour protection. Compared to the total wind farm area of 88 km^2 in which the turbines are placed, the foundations will only cover a very small proportion of the benthic area within the wind farm, and only a small fraction of the benthic area available to seaducks in the whole region. Even if the area of feeding habitat loss due to the foundations can be compensated for by scour protection Ref. 11, seaducks may not be able to utilise mussel beds on the scour protection. The reduction of the biomass of mussels in the wind farm on account of the reduction in the flow velocity over the seabed caused by the foundations and structures was assessed at 10 %, and hence at a higher level than the impact due to direct habitat change. However, the density and habitat models clearly showed that very few seaducks utilise the wind farm site, and that the benthic habitats to seaducks were unsuitable to seaducks. Therefore, the habitat loss caused by direct and indirect physical changes is expected to be insignificant to birds.

With respect to artificial reef effects on birds the changes in benthos diversity and biomass as well as fish abundance are expected to be less pronounced in the coarser sediments at Anholt OWF than at Horns Rev, but comparable to Nysted, where the scour protection was introduced into a benthic environment which was already influenced by coarse sediments and stones. No significant changes in the numbers of feeding waterbirds were recorded following the construction of the Nysted OWF, and similarly no artificial reef effects on birds are expected for the Anholt OWF.

The bird species recorded to use the turbines as resting or perching platforms mainly include Cormorants and large gull species. However, in general the number of records of resting or perching birds associated with OWFs is very low compared to oil & gas installations, suggesting that the turbines do not represent attractive resting or perching platforms to birds.

The physical changes imposed by constructing the Anholt OWF are assessed to have insignificant, if any, impacts on birds in the area. Specifically, no impact is expected in relation to 'direct habitat loss' as a result of the physical presence of 88-174 turbines because of the very little area that is actually affected.

3.3.3.3 Barrier effects

A barrier effect exists if birds which intend to fly through a channel or strait of open water as part of a long-distance migration, or movements related to resting and feeding are partly or entirely hindered by ships, wind farms or other obstacles to do so, resulting in a change of migration or flight routes and altitudes and thus in energetic costs to the birds.

Although monitoring at the established offshore wind farms have only partly involved combined visual and radar-based observations of behavioural responses of migrating birds to the structures experiences of species-specific responses have been gathered. Least is known about the barrier effects exposed on the landbirds, including large species like raptors and cranes, whereas due to the Danish demonstration projects a large amount of information is available on the behavioural responses of migrating waterbirds to offshore wind farms. Waterbirds reacted to the wind farms at Horns Rev 1 and Nysted at distances of 5 km from the turbines, and generally deflected at the wind farm at a distance of 3 km Ref. 4. Within a range of 1-2 km more than 50% of birds heading for the wind farm avoided passing within it. At the Rønland offshore wind farm 4.5 % of all waterbird flocks entered a zone of 100 m from the wind farm. At the Utgrunden wind farm in Kalmar Sund low-flying flocks of eiders were rarely seen to pass within 500m of the wind turbines during daytime, and avoidance behaviour was observed, with some birds altering direction 3-4 kms before reaching the Utgrunden wind farm to fly around it, Ref. 5.

At the Nysted wind farm waterbirds entering the wind farm minimised their risk of collision by re-orientating to fly down between turbine rows, frequently equidistance between turbines and by reducing their fleight altitude below rotor height and by readjusting flight orientation once within the wind farm to take the shortest exit route Ref. 6.

The Anholt OWF will be located centrally in the 45 km wide strait between Djursland and Anholt. Even if large numbers of seaducks are likely to use this area én route between the wintering area in the north-western Kattegat and their breeding grounds the potential for large-scale barrier effects is small. Although the spatial characteristics of the waterbird migration have not been mapped during the baseline investigations it is most likely that the migration occurs over a broad front with weak tendencies for aggregations along the coasts of Djursland and Anholt. Depending on the lay-out chosen, the cross-sectional diameter of the wind farm will span 10-12 % of the width of the strait, and consequently barrier effects will potentially cover a zone of 20-25 % of the width of the Strait between Djursland and Anholt.

3.3.3.4 Collision risks

Collision risks can be seen as the inverse of the barrier effects, hence a smaller barrier effect involving a smaller deflection of the bird's flight route or increase in flight altitude increases the risk of the birds colliding with the structures. The collision risk of generally flying and especially migrating birds is considered a problem particularly in a marine environment. There are no natural obstacles on the migration at sea; birds might be attracted by the lights of the vertical structures, which is a well known phenomena from various other illuminated structures at sea; in addition, in particular slowly manoeuvring birds and birds flying in formations might misjudge or underestimate the risk; last but not least, in situations of low visibility or inclement weather birds might simply not be able to recognize the man-made structures. These and so far unknown additional facts support the assumption, that the collision risk of birds with man-made structures at sea most likely exceeds the risk on land.

Although monitoring at the established offshore wind farms have only partly involved combined visual and radar-based observations of behavioural responses of migrating birds to the structures experiences of species-specific responses have been gathered. Least is known about the collision risks exposed on the largest component of long-distance migration: the migration of passerines. However, passerines and other terrestrial bird species are expected to collide with offshore wind farms Ref. 27 and Ref. 22. Many studies on collisions on land have reported that passerines are being killed in larger number than other birds. Ref. 23 reported the same from the Fino offshore research platform in the German Bight with several hundred passerines being killed during isolated events. Still, it's important to recall that passerines outnumber other terrestrial bird species on migration by at least an order of magnitude, and hence the relative impact may not be highest for passerines. In fact, the experience from land-based wind farms point at larger species as the most sensitive to collision. Frequent collisions, however, have been reported from only a few exposed sites with high migration densities (e.g. at passes, straits and peninsulas) and large numbers of, for example, soaring resident raptors Ref. 1, Ref. 2, Ref. 3, Ref. 27, Ref. 45, Ref. 12 and Ref. 14. In such worst-case scenarios like the Altamont Pass and Smöla wind farms Ref. 18, mortality rates of raptors as a direct result of collisions with the rotor blades are relatively high in comparison with the size of the affected populations.

There is an almost complete lack of experience regarding the behavioural responses of large birds on long-distance migration like raptors and cranes around offshore wind farms, as wind farms have not yet been erected in migration corridors for these species groups. A worst case scenario offshore would be a situation in which raptors were being attracted to an offshore wind farm along a major migration corridor. Only monitoring will tell us to what extent the different species of raptors using the Djursland-Anholt corridor will change their flight route on approach to the structures or get attracted to the wind farm due to their aversion to migrate over open sea. It should also be stressed that the degree to which migrating terrestrial bird species will be potentially attracted towards the structures as a result of the design of the installed lights cannot be taken into account in the present assessment, due to a complete lack of knowledge relating to this issue.

The altitude of raptors on spring migration at the Anholt OWF can only be guessed, but judged from the vertical radar data and the observations from Anholt a large proportion of the raptors may migrate at low altitude (< 200 m), - a situation which may increase the risk of collision. As the raptor migration along the Djursland-Anholt corridor includes species with small population sizes listed in the Annex I of EU Birds Directive (EU Birds Directive 1989) like Golden Eagle, Osprey, Honey Buzzard and Peregrine Falcon impacts due to collisions (extra mortality) may not be in line with the Directive and may be significant at the level of the affected populations.

At the Nysted wind farm waterbirds entering the wind farm minimised their risk of collision by re-orientating to fly down between turbine rows, frequently equidistance between turbines and by reducing their flight altitude below rotor height and by re-adjusting flight orientation once within the wind farm to take the shortest exit route (Petersen et al. 2006). Based on parameters derived from radar investigations and TADs seasonal collision risks to Common Eiders were estimated at 41-48 out of 235,000 passing birds (0.018-0.020 %). Based on radar data collision risks at the smaller wind farms on Utgrunden and Rønland were estimated at 5-15 per year and less than one collision per year.

Waterbirds will probably deflect the wind farm at distances of 3-5 km; a minor adjustment which will have limited effect on the energy expenditures of the birds. Even if a similar proportion of birds enter the wind farm (10 %) collision risks will be smaller than at Nysted where waterbird migration is funnelled into a corridor, which crosses the wind farm. Accordingly, collision risks to migrating waterbirds should be expected to be at a low level with no or minor consequences for the populations passing the strait. Even if the collision frequencies will be smaller than at the Nysted wind farm the number of collisions per season may be higher, as the number of seaducks passing the strait might be several times larger than the number passing Nysted. The number of seaducks wintering in the shallow areas of north-western Kattegat has been estimated between 800,000 and 1.2 million Ref. 17.

In relation to local movements of birds considerations should be focused on staging birds. The modelling of local densities of waterbirds (Chapter 4.2) documented that mainly divers are using the site of the Anholt OWF. The local movements undertaken by divers in wintering areas may be attributed to current drift, movements between sites in response to prey aggregation and between sites of different functional role. No field studies have yet investigated the frequency of local movements by divers in their wintering areas, and hence the risk of collision for these birds cannot be assessed.

3.3.3.5 Summary

Table 3-7. Summary of impact on birds during operation.

Impact	Intensity of effect	Scale / geographical extent of effect	Duration of effect	Overall significance of impact
Habitat displacement	Minor	Local	Long-term	Minor
Habitat change	Negligible	Local	Long-term	Negligible
Barrier effects	Minor	Transboundary	Long-term	Minor
Collision risks – waterbirds and smaller landbird species	Minor	Transboundary	Long-term	Minor
Collision risks – large landbird species	Medium	Transboundary	Long-term	Moderate

3.4 Mitigation measures

The paucity of detailed knowledge on the behavioural reactions of migrating landbirds on offshore wind farms currently limits mitigation actions which can effectively minimise the potential collision risk to larger species like raptors and cranes using the corridor between Djursland and Anholt.

3.5 Cumulative effects

The Anholt OWF will be developed in a region of moderate human activities, currently only shipping, ferry services (three ferries crossing the region) and fisheries are relevant and cause additional impacts on birds. In addition, a wind farm is planned for the area at Store Middelgrund, located 30 km from the Anholt OWF. These impacts are mainly in the terms of habitat displacement and to some extent habitat change (fisheries) and barrier effects (fisheries and ferry services). Although boats and ships disturb foraging waterbirds, no quantitative judgements on the scale of habitat displacement involved based on monitoring data have been published. The most intensive fishing activities and the Anholt-Grenå ferry service crosses the high-density area used by Red-throated and Black-throated divers. The cumulative displacement of divers may therefore exceed the estimated displacement on account of the Anholt OWF (24.7 % of high density area in the region ≅ 150 birds). Thus, it seems reasonable to assess the joint impact of fisheries, ferry services and the Anholt OWF as potentially displacing divers from a large proportion of the available habitat in the region. The total number displaced, however, is likely to be well below levels which are significant. The Store Middelgrund OWF will not be placed in suitable habitat for the two species of divers.

Despite fishing activities and ferry services are going on in the migration corridor between Anholt and Djursland the cumulative barrier effects are not expected to exceed the estimated barrier effects for the Anholt OWF alone (20-25 % of the width of the strait between Djursland and Anholt. This is both due to low height and the likely frequency of these vessels in the corridor.

3.6 Decommissioning

Impacts on staging and migrating birds envisaged during decommissioning are similar to some of the disturbance impacts expected during construction, depending on the activities of pile removal and service boats.

3.7 Technical deficiencies or lack of knowledge

Data on behavioural reactions of large species of migrating landbirds (raptors and cranes) on offshore wind farms are generally lacking. As the Djursland-Anholt corridor is of international significance to several species of raptors the impact assessment of collision risks to these species is uncertain.

4. Transformer platform and offshore cable

4.1 Project description

An offshore transformer platform will be established to bundle the electricity produced at the wind farm and to convert the voltage from 33 kilovolts to a transmission voltage of 220 kilovolts, so that the electric power generated at the wind farm can be supplied to the Danish national grid.

4.1.1 Transformer platform

Energinet.dk will build and own the transformer platform and the high voltage cable which runs from the transformer platform to the shore and further on to the existing substation Trige, where it is connected to the existing transmission network via 220/440 kV transformer.

The transformer platform will be placed on a location with a sea depth of 12-14 metres. The length of the export cable from the transformer station to the shore of Djursland will be approximately 25 km. On the platform the equipment is placed inside a building. In the building there will be a cable deck, two decks for technical equipment and facilities for emergency residence.

The platform will have a design basis of up to 60 by 60 metres. The top of the platform will be up to 25 metres above sea level. The foundation for the platform will be a floating caisson, concrete gravitation base or a steel jacket.

4.1.2 Subsea Cabling

The wind turbines will be connected by 33 kV submarine cables, so-called inter-array cables. The inter-array cables will connect the wind turbines in groups to the transformer platform. There will be up to 20 cable connections from the platform to the wind turbines. From the transformer platform a 220 kV export cable is laid to the shore at Saltbæk north of Grenå. The cables will be PEX insulated or similar with armouring.

The installation of the cables will be carried out by a specialist cable lay vessel that will manoeuvre either by use of a four or eight point moving system or an either fully or assisted DP (Dynamically Positioned) operation.

All the subsea cables will be buried in order to provide protection from fishing activity, dragging of anchors etc. A burial depth of minimum one meter is expected. The final depth of burial will be determined at a later date and will vary depending on more detailed soil condition surveys and the equipment selected.

The cables will be buried either using an underwater cable plough that executes a simultaneous lay and burial technique that mobilises very little sediment; or a Remotely Operated Vehicle (ROV) that utilises high-pressure water jets to fluidise a narrow trench into which the cable is located. The jetted sediments will settle back into the trench.

4.1.3 Onshore components

At sea the submarine cable is laid from a vessel with a large turn table. Close to the coast, where the depth is inadequate for the vessel, floaters are mounted onto the cable and the cable end is pulled onto the shore. The submarine cable is connected to the land cable close to the coast line via a cable joint. Afterwards the cables and the cable joint are buried into the soil and the surface is re-established.

On shore the land cable connection runs from the coast to compensation substation 2-3 km from the coast and further on to the substation Trige near Århus. At the substation Trige a new 220/400 kV transformer, compensation coils and associated switchgear will be installed. The onshore works are not part of the scope of the Environmental Statement for the Anholt Offshore Wind Farm. The onshore works will be assessed in a separate study and are therefore not further discussed in this document.

4.2 Baseline study

For a description of the baseline study please refer to section 3.2.

4.3 Impact assessment

4.3.1 Methodology

In order to generate an overview of the effects of the substation and offshore cable associated with the Anholt OWF on birds all effects are rated using criteria outlined in Table 4-1 Criteria used in the environmental impact assessment for the offshore wind farm.

Table 4-1 Criteria used in the environmental impact assessment for the offshore wind farm.

Intensity of effect	Scale of effect	Duration of effect	Overall significance of impact[1]
No	Local	Short-term	No impact
Minor	Regional	Medium-term	Minor impact
Medium	National	Long-term	Moderate impact
Large	Transboundary		Significant impact
[1]: Evaluation of overall significance of impact includes an evaluation of the variables shown and an evaluation of the sensitivity of the resource/receptor that is assessed.			

The potential impacts on birds from the substation and offshore cable are predicted to fall under four main headings:

1. Physical change of the habitat where the structures are constructed.
2. Disturbance effects (habitat displacement).
3. Barrier effects.
4. Collision risk.

4.3.2 Impacts during construction

As the numbers of waterbirds using the area shows strong seasonal variability, the potential habitat displacement will depend on the timing of construction activities. As the abundance of most species of waterbirds peaks during October-April the potential for habitat displacement impacts is largest during winter (see Chapter 10.2.3 on assessment of impacts during operation for details).

The physical changes imposed by constructing the substation and offshore cable are assessed to have insignificant impacts on birds in the area. Disturbance effects on potential benthic prey organisms living in the construction site were assessed as being very limited, Ref. 11. Sediment dispersal affecting available food supplies of benthic invertebrates and fish was estimated to be small-scale (Ref. 7), and no direct habitat loss as a result of enhanced sediment concentrations is expected. The simulations of the dispersal of suspended matter showed rather low concentrations, which although visible plumes could be expected rarely exceeded 5 mg/l. The threshold of 15 mg/l considered as relevant in relation to feeding birds in the water column, Ref. 7 , was not exceeded.

Judged from the density models the potential habitat loss for these groups during the construction phase will amount to less than 0.1 % of the available habitat in the region.

4.3.2.1 Summary

Table 4-2 Summary of impact on birds during construction

Impact	Intensity of effect	Scale/geographical extent of effect	Duration of effect	Overall significance of impact
Construction noise	Minor	Local	Medium-term	Minor
Traffic	Minor	Local	Medium-term	Minor
Sediment dispersal	Minor	Local	Short-term	Minor
Habitat displacement	Minor	Local	Long-term	Minor

4.3.3 Impacts during operation

Despite documented reductions in densities of some waterbird species following construction of offshore wind farms only small-scale habitat displacement is expected on birds as a result of the construction of the cable and substation. The key areas for wintering waterbirds are located offshore off NE Djursland, NW Anholt and south of Læsø, Figure 4-1.

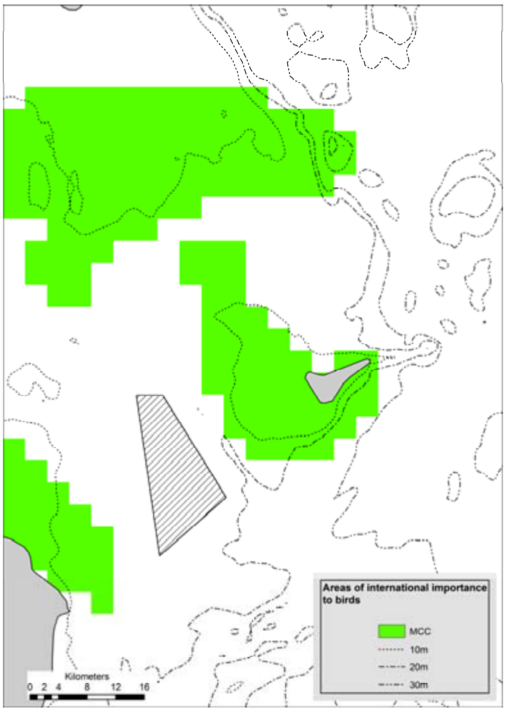


Figure 4-1. Estimation of total conservation importance for different areas of the region to waterbirds. The areas have been estimated using the Marine Classification Criterion (MCC, Skov et al. 2007).

The establishment of the substation and offshore cable is not expected to cause any reduction in the biomass of mussels available to seaducks, Ref. 8, and hence impacts on these species will be negligible and the physical changes imposed by constructing the substation and offshore cable are assessed to have insignificant, if any, impacts on birds in the area.

A barrier effect exists if birds which intend to fly through a channel or strait of open water as part of a long-distance migration, or movements related to resting and feeding are partly or entirely hindered by ships, wind farms or other obstacles to do so, resulting in a change of migration or flight routes and altitudes and thus in energetic costs to the birds. Collision risks can be seen as the inverse of the barrier effects, hence a smaller barrier effect involving a smaller deflection of the bird's flight route or increase in flight altitude increases the risk of the birds colliding with the structures. No increase in the barrier effect or collision risk of birds migrating through the region is expected due to the establishment of the substation and offshore cable, due to the limited area covered by the installations.

4.3.3.1 Summary

Table 4-3. Summary of impact on birds during operation.

Impact	Intensity of effect	Scale / geographical extent of effect	Duration of effect	Overall significance of impact
Habitat displacement	Negligible	Local	Long-term	Negligible
Habitat change	Negligible	Local	Long-term	Negligible
Barrier effects	Negligible	Local	Long-term	Negligible
Collision risks	Negligible	Local	Long-term	Negligible

4.4 Mitigation measures

None.

4.5 Cumulative effects

The joint impact of fisheries, ferry services and the Anholt OWF will considerably exceed the impacts from the substation and offshore cable, e.g. habitat displacement of Red-throated and Black-throated Divers.

4.6 Decommissioning

Impacts on staging and migrating birds envisaged during decommissioning are similar to some of the disturbance impacts expected during construction.

4.7 Technical deficiencies or lack of knowledge

Behavioural reactions of large species of migrating landbirds (raptors and cranes) on offshore wind farms are generally lacking, however this lack of knowledge is judged of limited importance to the assessment of collision risks due to the substation.

5. Conclusion

In Table 5-1 the impacts assessed on birds during the construction of the Anholt OWF are concluded based on the principles from Ref. 37.

The impact on landbirds has been assessed as moderate during the operational phase based on the potential collision risks exposed on larger species of landbirds migrating along the corridor between Djursland and Anholt. Impacts on landbirds during the construction phase and impacts on waterbirds have been assessed as minor.

Table 5-1 Impact on landbirds and waterbirds during construction and operation of the Anholt offshore wind farm.

Effect on birds		**Overall significance of impact**	**Significance rating for the assessment**
IMPACTS ON THE BIOLOGICAL ENVIRONMENT			
Landbirds	Construction period	Minor	3
	Operational period	Moderate	2
Waterbirds	Construction period	Minor	3
	Operational period	Minor	3

Table 5-2 Principles for the EIA evaluation of potential impact, the significance rating of the assessed impact and the quality of data/documentation (from the memo describing “Method for Impact Assessment (May 2009)”.

Quality of availably data

In order to evaluate the quality and significance of data and documentation for the impact assessment a significance rating of data and documentation should be evaluated within the specific technical subject topics using the following categories:

- 1 – Limited (scattered data, some knowledge)
- 2 – Sufficient (scattered data, field studies, documented)
- 3 – Good (time series, field studies, well documented)

For the EIA-document an impact arising from a planned activity will, depending on its magnitude and the environmental sensitivity, be given a significance rating as follows:

: No impact	*No impact*: There will be no impact on structure or function in the affected area;
: Minor impact	*Minor impact*: The structure or functions in the area will be partially affected, but there will be no impacts outside the affected area;
: Moderate Impact	*Moderate Impact*: The structure or function in the area will change, but there will be no significant impacts outside the affected area;
: Significant impact	*Significant impact*: The structure or function in the area will change, and the impact will have effects outside the area as well;

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Appendix 1. List of bird species and numbers recorded during the baseline aerial and ship-based surveys.

Table 6-1 Total number observed during the 2009 aerial surveys.

Species	sum	28 Jan.	24 Feb.	29 Mar / 2 Apr	10 May
Red-throated Diver (Gavia stellata)	65	0	23	42	0
Black-throated Diver (Gavia arctica)	11	0	1	9	1
Great Northern Diver (Gavia immer)	4	0	4	0	0
White-billed Diver (Gavia adamsii)	1	0	1	0	0
Divers -unidentified sp. (Gaviidae indet.)	193	2	48	143	0
Great Crested Grebe (Podiceps cristatus)	50	47	1	2	0
Red-necked Grebe (Podiceps grisegena)	3	0	3	0	0
Grebe -unidentified sp. (Podicipedidae indet.)	25	22	0	3	0
Northern Gannet (Sula bassana)	43	1	0	35	7
Cormorant (Phalacrocorax carbo)	365	190	16	32	127
Common Shelduck (Tadorna tadorna)	14	4	2	2	6
Mallard (Anas platyrhynchos)	17	2	15	0	0
Tufted Duck (Aythya fuligula)	1	0	0	0	1
Scaup (Aythya marila)	2	0	2	0	0
Eider (Somateria mollissima)	7374	3043	2445	1830	56
Long-tailed Duck (Clangula hyemalis)	111	49	51	11	0
Common Scoter (Melanitta nigra)	10390	4769	3277	2339	5
Scoter -unidentified sp. (Melanitta indet.)	182	130	52	0	0
Velvet Scoter (Melanitta fusca)	2643	873	743	1027	0
Common Goldeneye (Bucephala clangula)	1	0	1	0	0
Smew (Mergus albellus)	2	2	0	0	0
Red-breasted Merganser (Mergus serrator)	6	0	1	5	0
Little Gull (Larus minutus)	2	0	1	0	1
Black-headed Gull (Larus ridibundus)	78	4	59	15	0
Common Gull (Larus canus)	597	114	413	63	7
Black-backed Gull (Larus fuscus)	227	0	0	164	63
Herring Gull (Larus argentatus)	1829	1080	557	169	23
Common/Herring Gull (Larus argentatus/canus)	200	200	0	0	0
Great Black-backed Gull (Larus marinus)	504	430	30	42	2
Gulls (Larus spec.)	3	0	3	0	0
Kittiwake (Rissa tridactyla)	7	5	0	0	2
Seagull family -unidentified sp. (Laridae indet. = Larus sp. + Rissa sp.)	59	51	8	0	0
Sandwich Tern (Sterna sandvicensis)	8	0	0	0	8

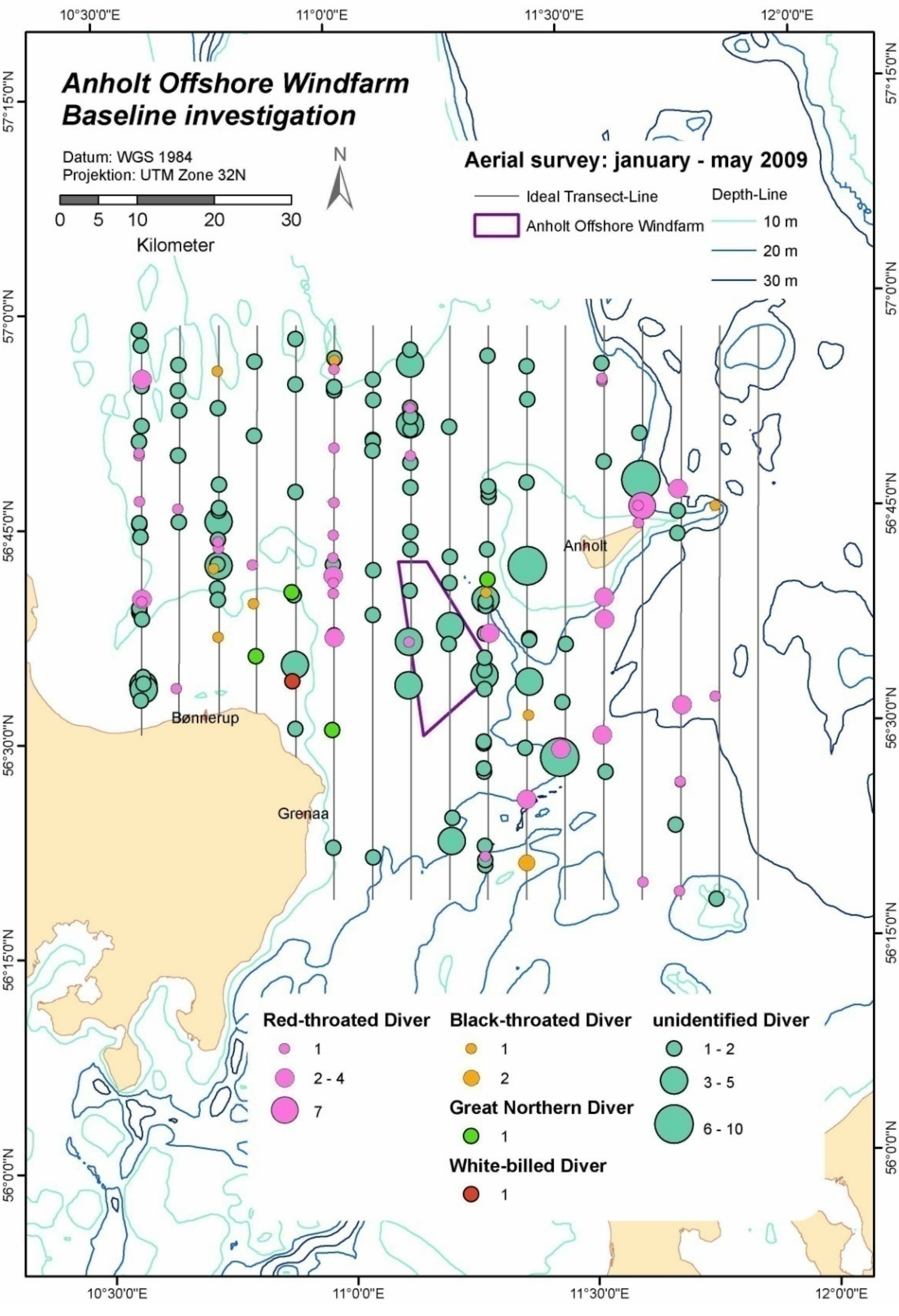
Common / Arctic Tern (Sterna hirundo/paradisaea)	10	0	0	2	8
Common Guillemot (Uria aalge)	79	53	26	0	0
Razorbill/Guillemot (Alca torda / Uria aalge)	215	9	190	16	0
Razorbill (Alca torda)	75	6	60	9	0
Black Guillemot (Cepphus grylle)	7	0	6	1	0

Table 6-2. Total observed species during the 2008-20099 ship-based surveys.

Species	29/12 08	19/2 09	28/3-2/4 09	20/4 09	14/5 09	
Species	12	2	3	4	5	sum
Red-throated Diver (Gavia stellata)	3	12	5	26	0	46
Black-throated Diver (Gavia arctica)	14	55	0	13	2	84
Great Northern Diver (Gavia immer)	0	5	5	7	0	17
White-billed Diver (Gavia adamsii)	0	6	6	18	0	30
Diver sp. (Gaviidae indet.)	31	16	49	43	0	139
Great Crested Grebe (Podiceps cristatus)	0	3	1	0	0	4
Red-necked Grebe (Podiceps grisegena)	19	232	9	6	0	266
Grebe sp. (Podicipedidae indet.)	0	0	2	0	0	2
Sule (Sula bassana)	0	0	7	1	0	8
Cormorant (Phalacrocorax carbo)	27	43	8	14	0	92
Eider (Somateria mollissima)	41	239	16	38	0	334
Common Scoter (Melanitta nigra)	891	1923	5057	3456	152	11479
Scoter sp. (Melanitta indet.)	0	0	0	22	0	22
Velvet Scoter (Melanitta fusca)	325	2102	1570	2196	9	6202
Greylag Goose (Anser anser)	0	0	0	4	0	4
Common Teal (Anas crecca)	0	0	0	2	0	2
Mallard (Anas platyrhynchos)	0	5	0	0	0	5
Long-tailed Duck (Clangula hyemalis)	8	138	0	0	0	146
Red-breasted Merganser (Mergus serrator)	0	16	2	1	0	19
Merganser sp. (Mergus indet.)	3	0	0	0	0	3
Eurasian Oystercatcher (Haematopus ostralegus)	0	0	0	2	0	2
Black-headed Gull (Larus ridibundus)	0	0	1	1	0	2
Common Gull (Larus canus)	0	12	1	18	0	31
Lesser Black-backed Gull (Larus fuscus)	2	0	0	0	4	6
Herring Gull (Larus argentatus)	4	62	54	53	1	174
Great Black-backed Gull (Larus marinus)	7	43	13	29	0	92
Gulls sp. (Laridae indet.)	0	0	1	3	0	4
Sandwich Tern (Sterna sandvicensis)	0	0	0	1	0	1
Common/Arctic Tern (Sterna hi-rundo/paradisaea)	0	0	0	0	2	2
Common Guillemot (Uria aalge)	12	12	0	0	0	24
Razorbill (Alca torda)	31	0	0	3	0	34
Black Guillemot (Cepphus grylle)	13	13	4	5	0	35
Common Swift (Apus apus)	0	0	0	0	5	5

Barn Swallow (Hirundo rustica)	0	0	0	0	5	5
European Starling (Sturnus vulgaris)	0	0	8	0	0	8
Chaffinch (Fringilla coelebs)	0	0	0	1	0	1

Appendix 2 Selected observations of birds and mammals during aerial baseline surveys in Kattegat 2009



Anholt Offshore Windfarm
Baseline investigation
Datum: WGS 1984
Projektion: UTM Zone 32N
0 5 10 20 30
Kilometer
N
Aerial survey: january - may 2009
Ideal Transect-Line
Anholt Offshore Windfarm
Depth-Line
10 m
20 m
30 m
Anholt
Bønnerup
Grenaa
Red-throated Diver
1
2 - 4
7
Black-throated Diver
1
2
Great Northern Diver
1
White-billed Diver
1
unidentified Diver
1 - 2
3 - 5
6 - 10
10°30'0"E
11°0'0"E
11°30'0"E
12°0'0"E
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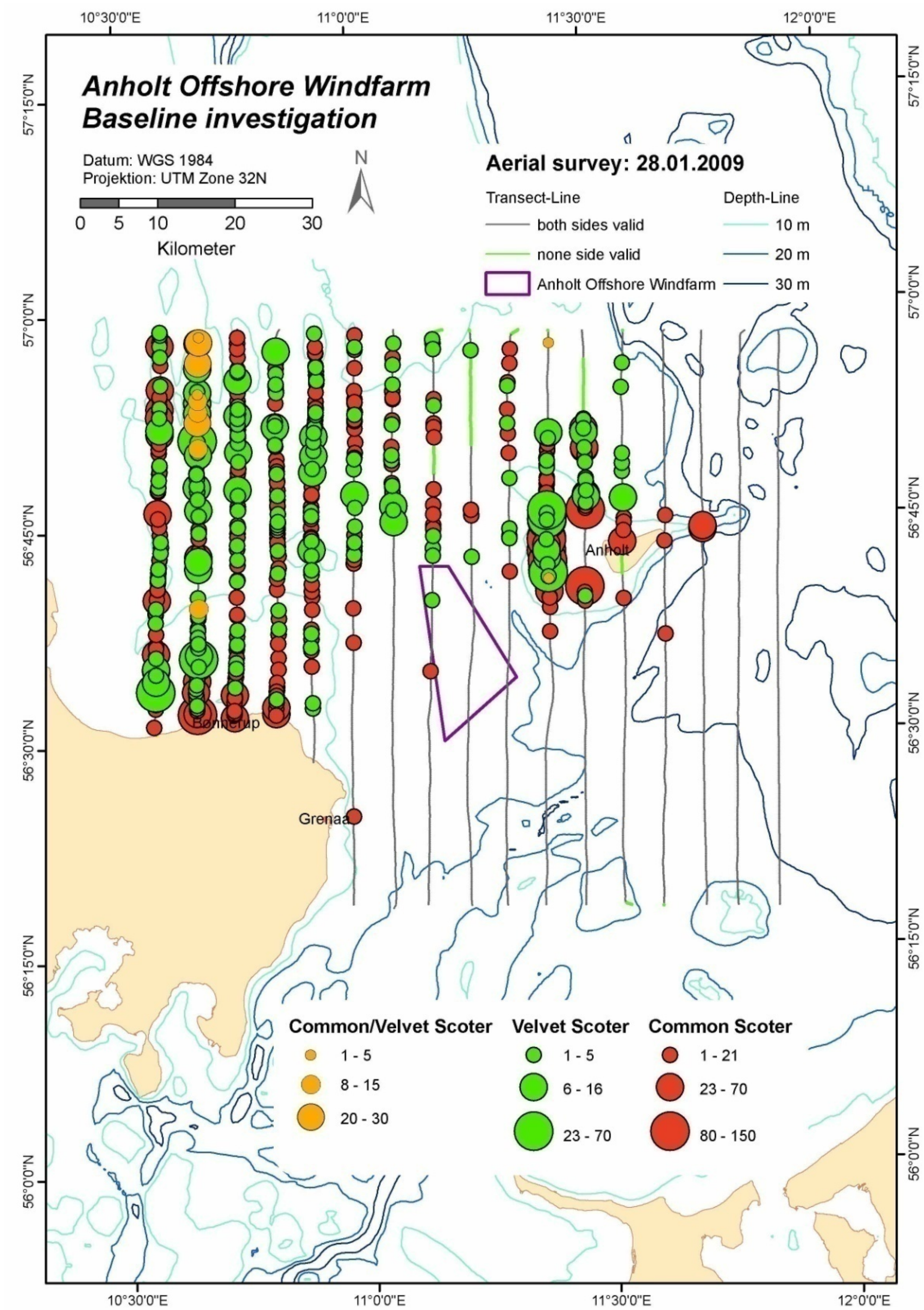
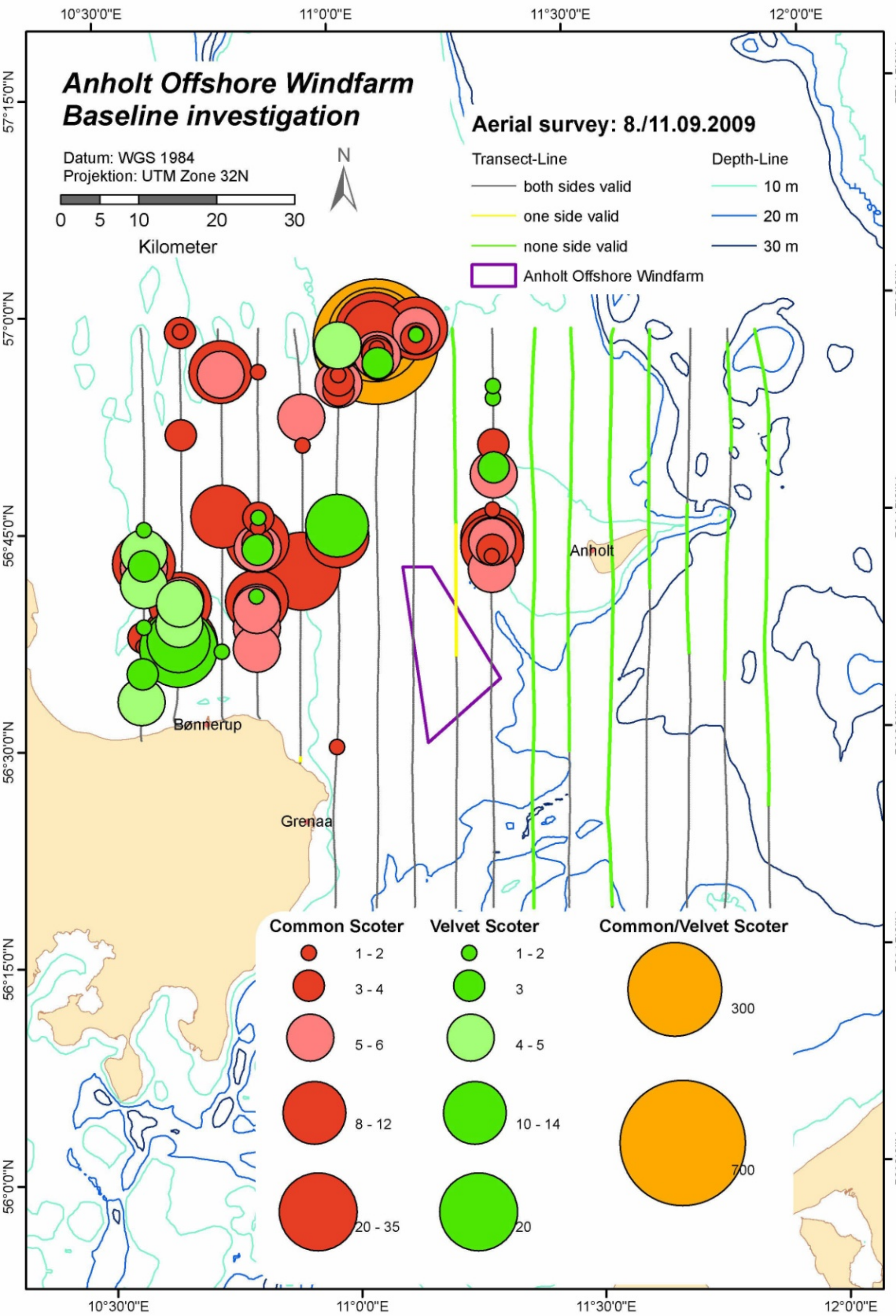
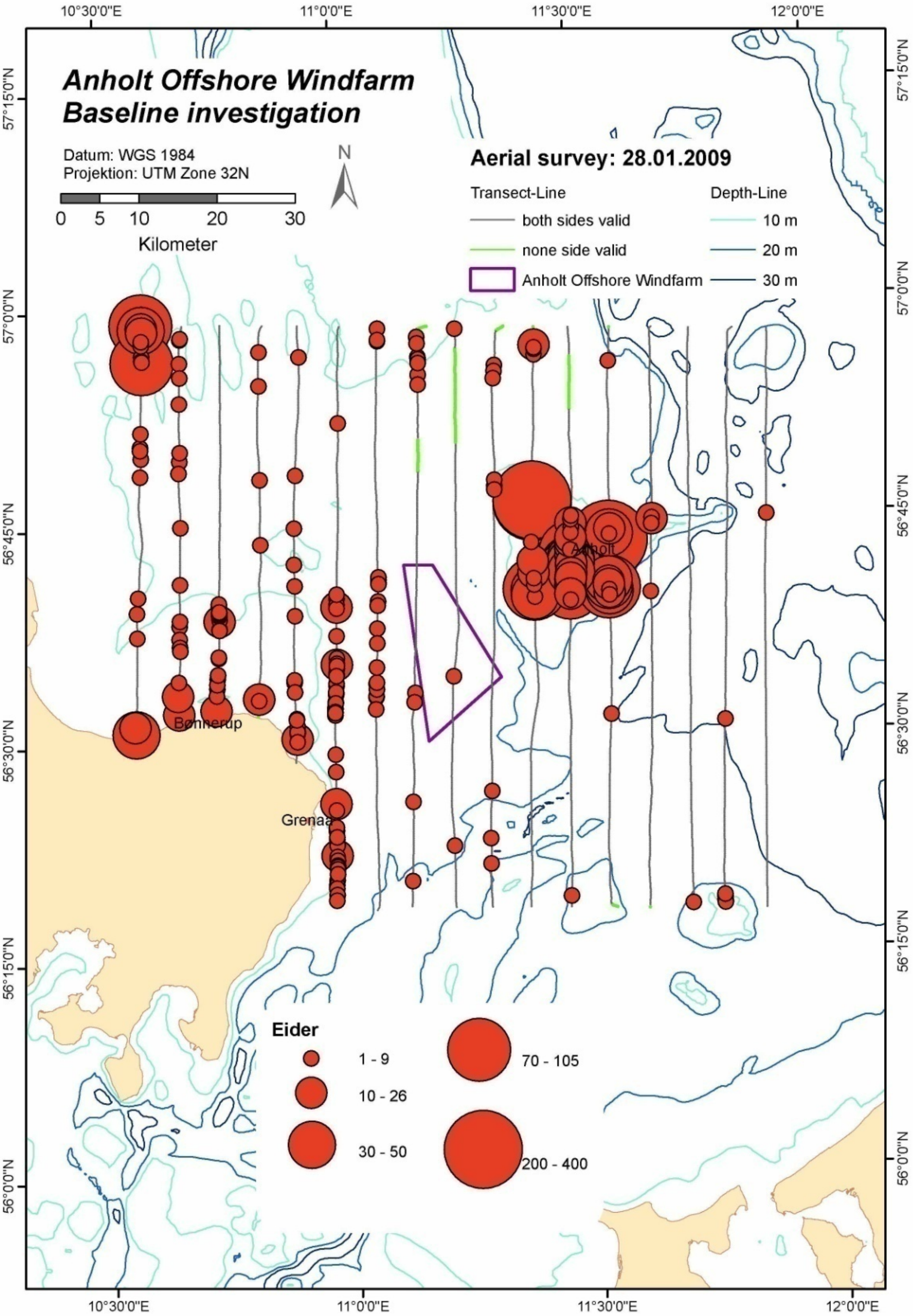
57°0'0"N
56°45'0"N
56°30'0"N
56°15'0"N
56°0'0"N

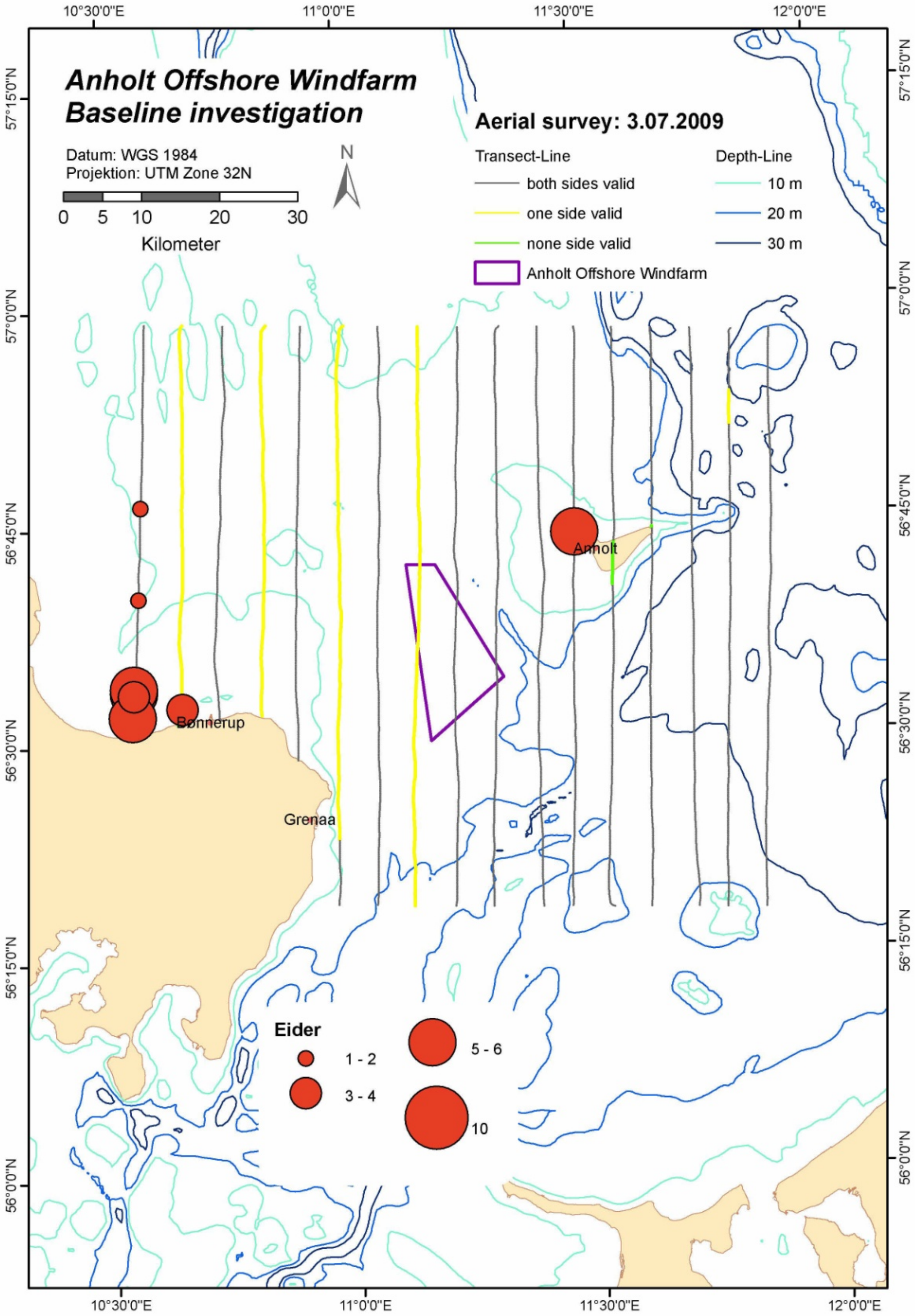

10°30'0"E
11°0'0"E
11°30'0"E
12°0'0"E
57°15'0"N
57°0'0"N
56°45'0"N
56°30'0"N
56°15'0"N
56°0'0"N
Anholt Offshore Windfarm
Baseline investigation
Datum: WGS 1984
Projektion: UTM Zone 32N
0 5 10 20 30
Kilometer
N
Aerial survey: 28.01.2009
Transect-Line
both sides valid
none side valid
Anholt Offshore Windfarm
Depth-Line
10 m
20 m
30 m
Bønnerup
Grenaa
Anholt
Common/Velvet Scoter
1 - 5
8 - 15
20 - 30
Velvet Scoter
1 - 5
6 - 16
23 - 70
Common Scoter
1 - 21
23 - 70
80 - 150

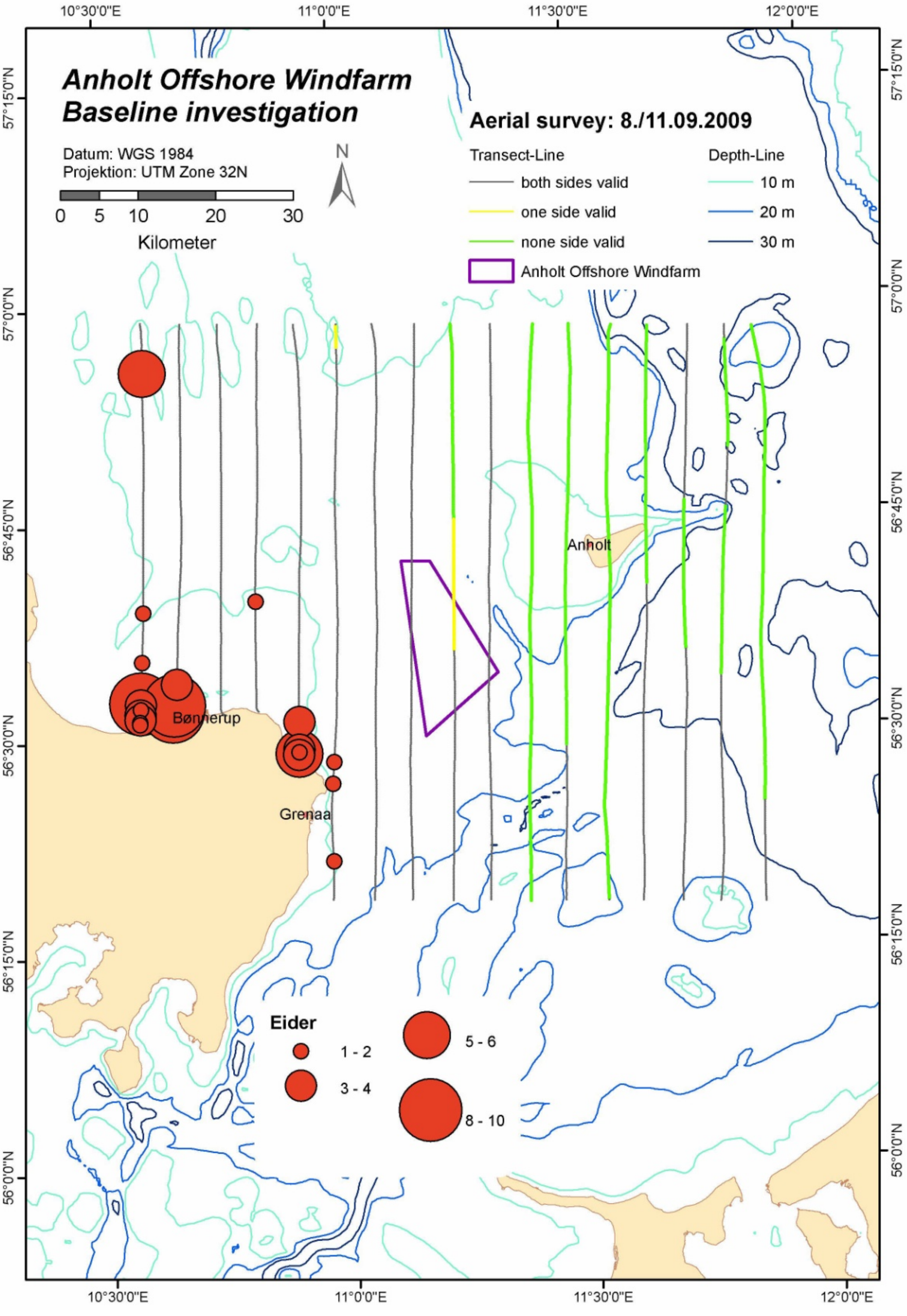


Anholt Offshore Windfarm
Baseline investigation
Datum: WGS 1984
Projektion: UTM Zone 32N
0 5 10 20 30
Kilometer
N
Aerial survey: 8./11.09.2009
Transect-Line
both sides valid
one side valid
none side valid
Anholt Offshore Windfarm
Depth-Line
10 m
20 m
30 m
Anholt
Bønnerup
Grenaa
Common Scoter
1 - 2
3 - 4
5 - 6
8 - 12
20 - 35
Velvet Scoter
1 - 2
3
4 - 5
10 - 14
20
Common/Velvet Scoter
300
700
10°30'0"E
11°0'0"E
11°30'0"E
12°0'0"E
57°15'0"N
57°0'0"N
56°45'0"N
56°30'0"N
56°15'0"N
56°0'0"N

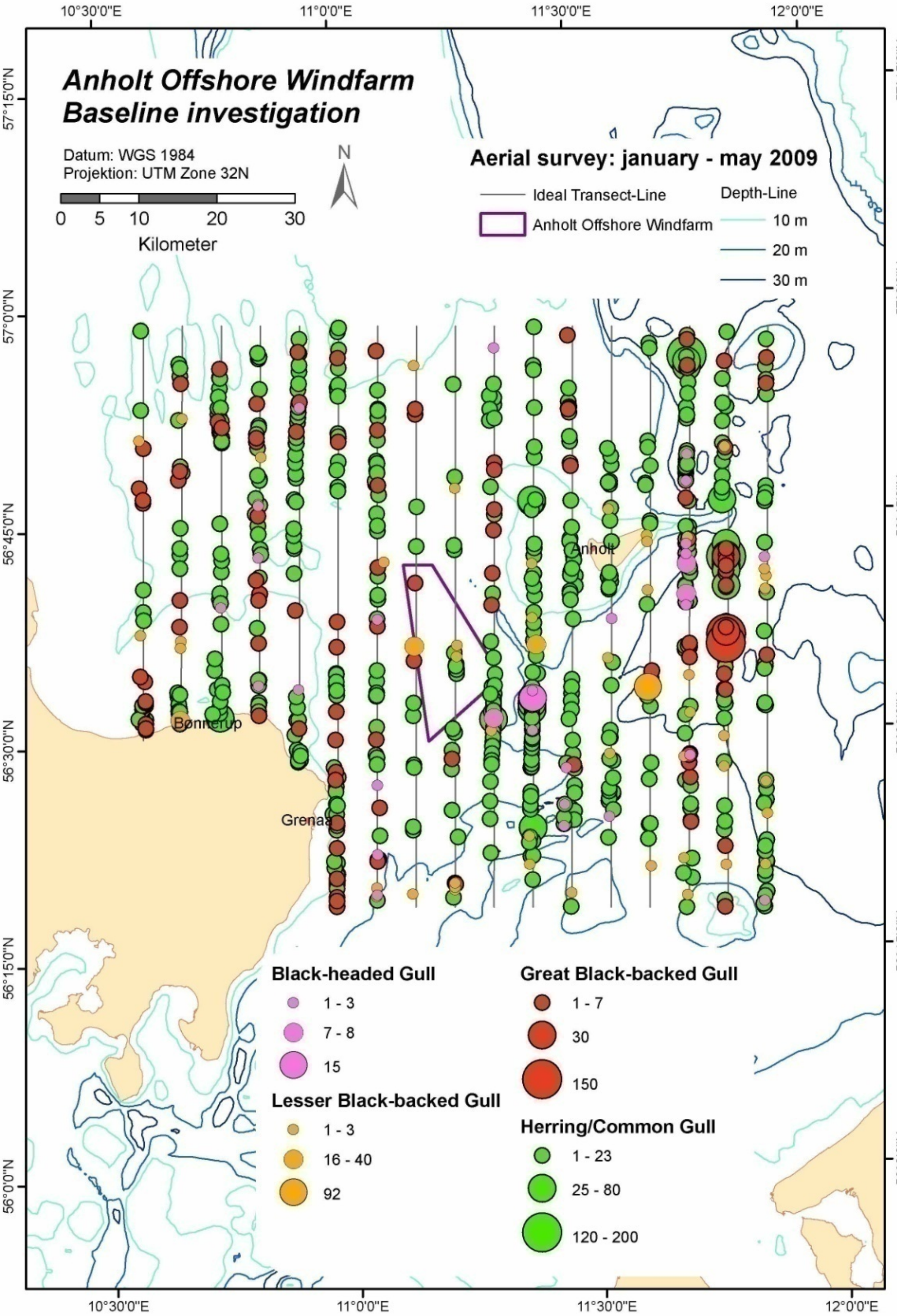


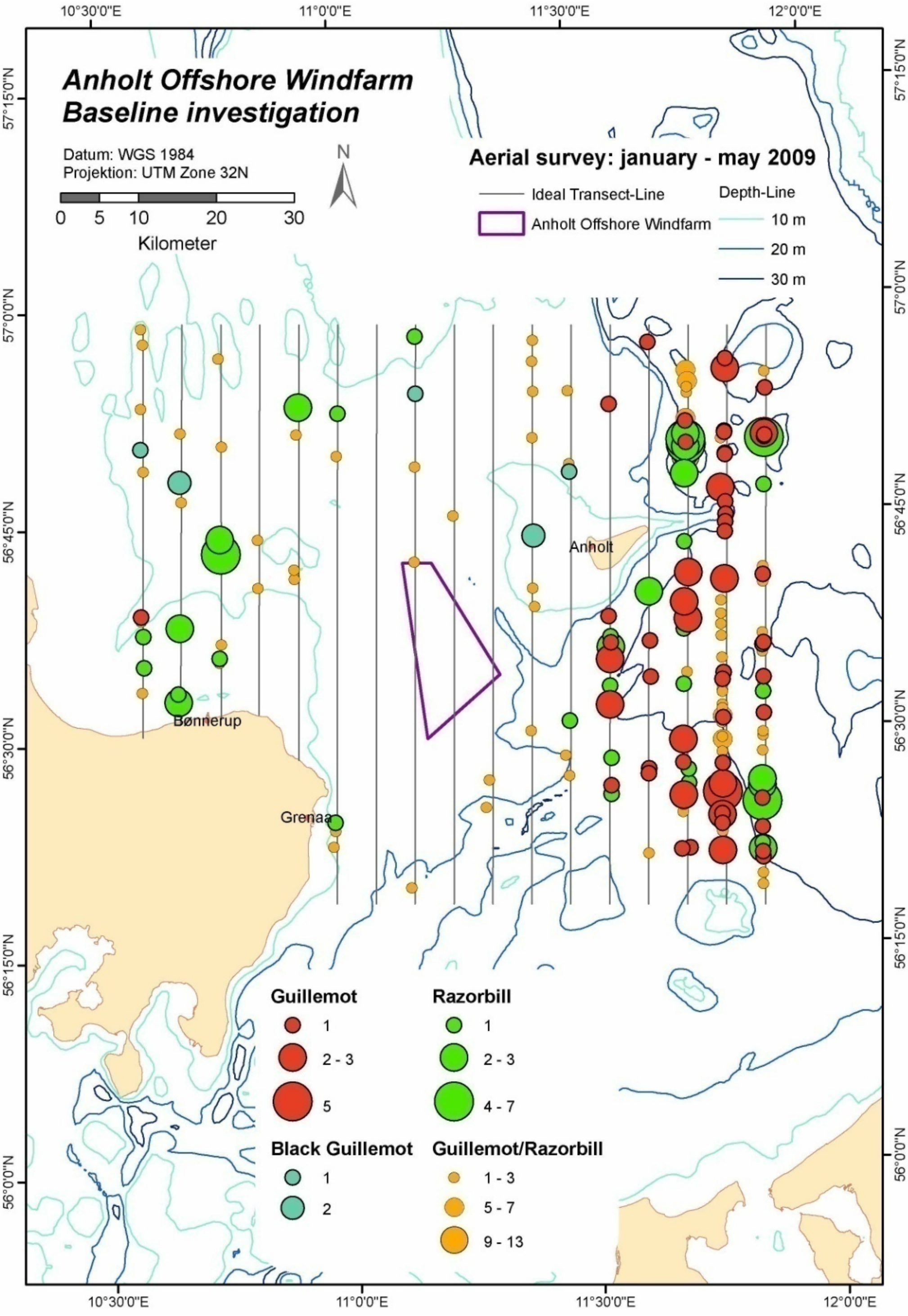
Anholt Offshore Windfarm
Baseline investigation
Datum: WGS 1984
Projektion: UTM Zone 32N
0 5 10 20 30
Kilometer
N
Aerial survey: 28.01.2009
Transect-Line
both sides valid
none side valid
Anholt Offshore Windfarm
Depth-Line
10 m
20 m
30 m
Bønnerup
Grenaa
Anholt
Eider
1 - 9
10 - 26
30 - 50
70 - 105
200 - 400
10°30'0"E
11°0'0"E
11°30'0"E
12°0'0"E
57°15'0"N
57°0'0"N
56°45'0"N
56°30'0"N
56°15'0"N
56°0'0"N


Anholt Offshore Windfarm
Baseline investigation
Datum: WGS 1984
Projektion: UTM Zone 32N
0 5 10 20 30
Kilometer
N
Aerial survey: 3.07.2009
Transect-Line
both sides valid
one side valid
none side valid
Anholt Offshore Windfarm
Depth-Line
10 m
20 m
30 m
Anholt
Bønnerup
Grenaa
Eider
1 - 2
3 - 4
5 - 6
10
10°30'0"E
11°0'0"E
11°30'0"E
12°0'0"E
57°15'0"N
57°0'0"N
56°45'0"N
56°30'0"N
56°15'0"N
56°0'0"N



Anholt Offshore Windfarm
Baseline investigation
Datum: WGS 1984
Projektion: UTM Zone 32N
0 5 10 20 30
Kilometer
N
Aerial survey: 8./11.09.2009
Transect-Line
both sides valid
one side valid
none side valid
Anholt Offshore Windfarm
Depth-Line
10 m
20 m
30 m
10°30'0"E
11°0'0"E
11°30'0"E
12°0'0"E
57°15'0"N
57°0'0"N
56°45'0"N
56°30'0"N
56°15'0"N
56°0'0"N
Anholt
Bønnerup
Grenaa
Eider
1 - 2
3 - 4
5 - 6
8 - 10


Anholt Offshore Windfarm
Baseline investigation
Datum: WGS 1984
Projektion: UTM Zone 32N
0 5 10 20 30
Kilometer
N
Aerial survey: january - may 2009
Ideal Transect-Line
Anholt Offshore Windfarm
Depth-Line
10 m
20 m
30 m
Anholt
Bønnerup
Grenaa
Black-headed Gull
1 - 3
7 - 8
15
Lesser Black-backed Gull
1 - 3
16 - 40
92
Great Black-backed Gull
1 - 7
30
150
Herring/Common Gull
1 - 23
25 - 80
120 - 200
10°30'0"E
11°0'0"E
11°30'0"E
12°0'0"E
57°15'0"N
57°0'0"N
56°45'0"N
56°30'0"N
56°15'0"N
56°0'0"N


Anholt Offshore Windfarm
Baseline investigation
Datum: WGS 1984
Projektion: UTM Zone 32N
0 5 10 20 30
Kilometer
N
Aerial survey: january - may 2009
Ideal Transect-Line
Anholt Offshore Windfarm
Depth-Line
10 m
20 m
30 m
Anholt
Bønnerup
Grenaa
Guillemot
1
2 - 3
5
Razorbill
1
2 - 3
4 - 7
Black Guillemot
1
2
Guillemot/Razorbill
1 - 3
5 - 7
9 - 13
10°30'0"E
11°0'0"E
11°30'0"E
12°0'0"E
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57°0'0"N
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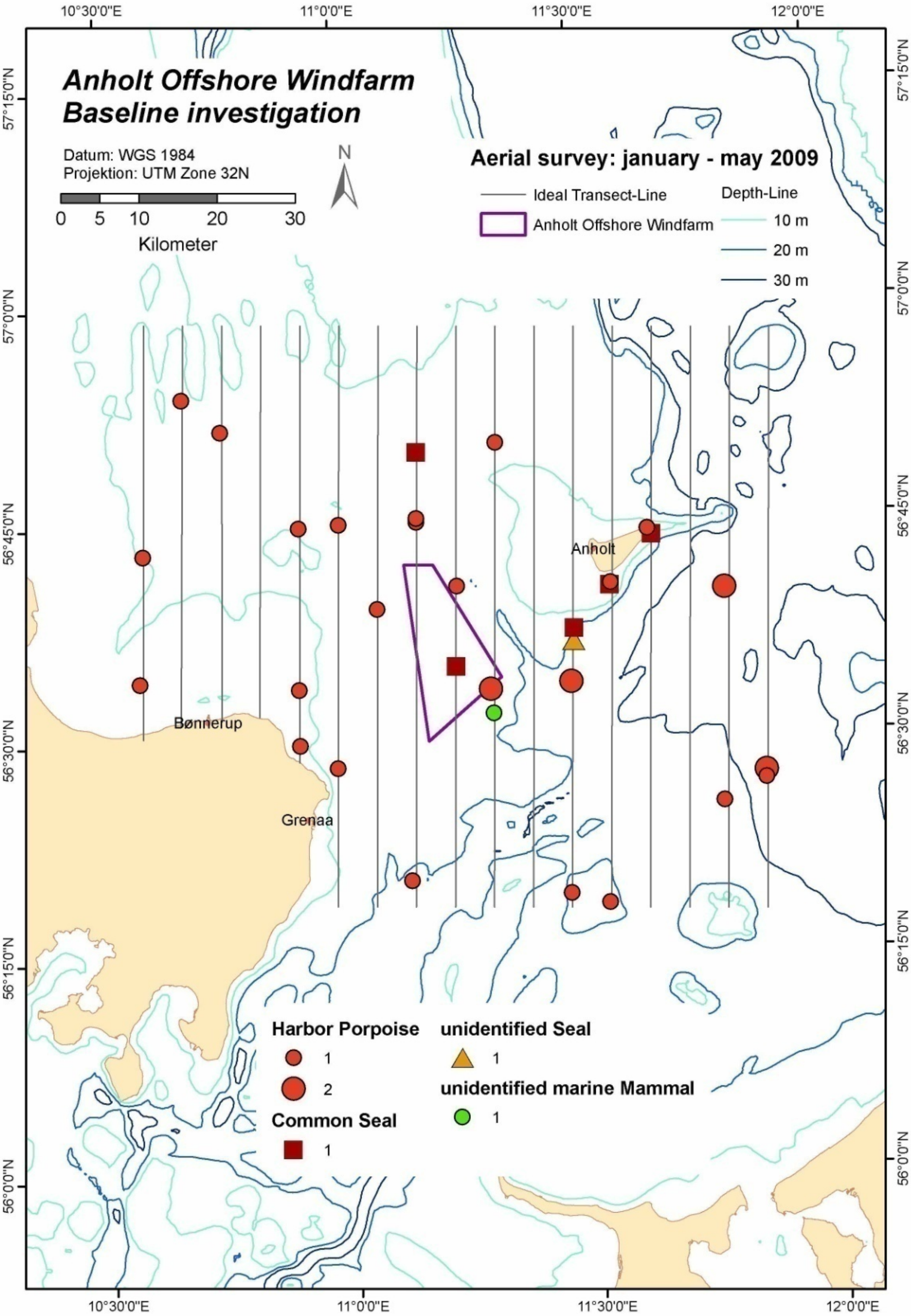
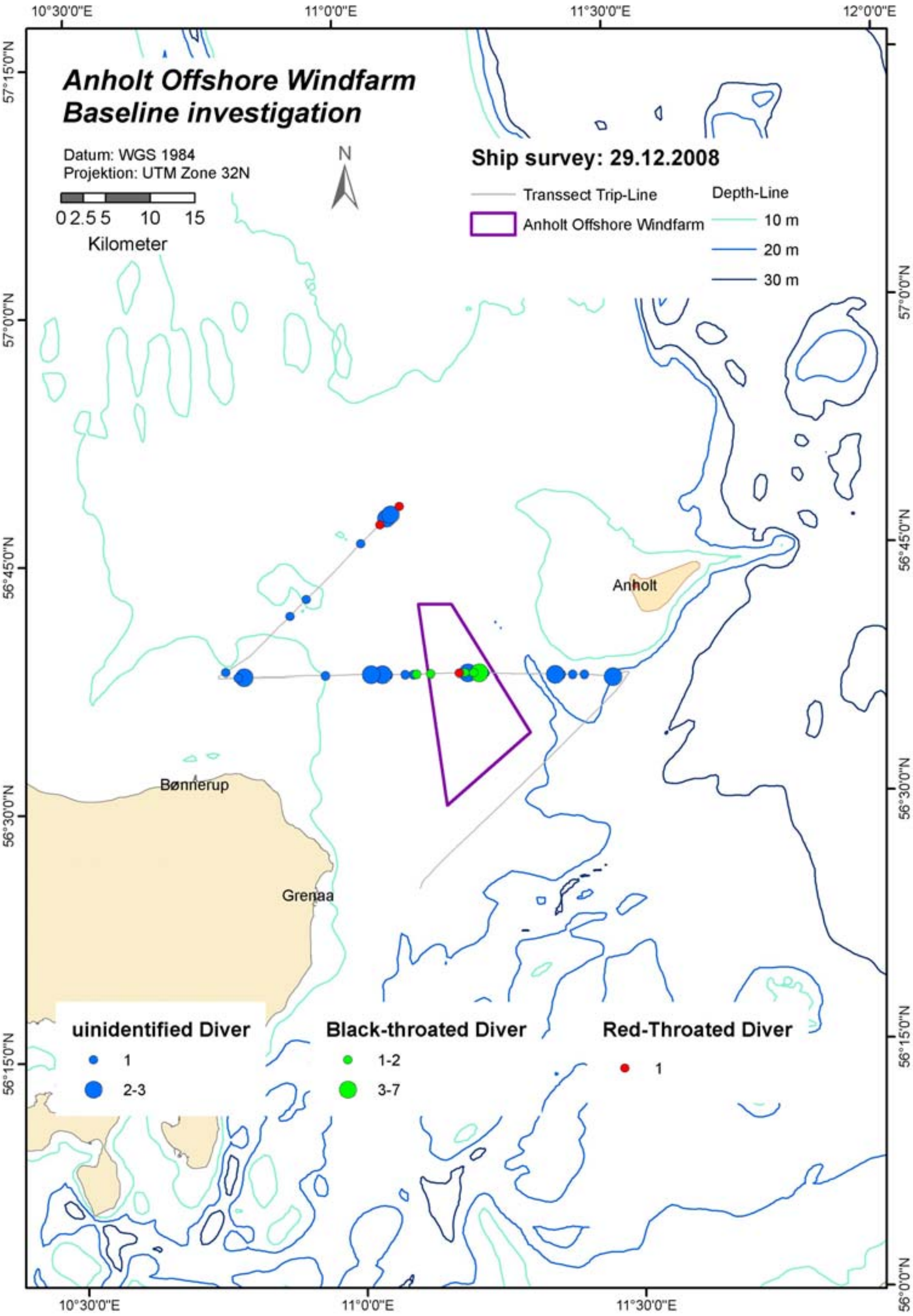
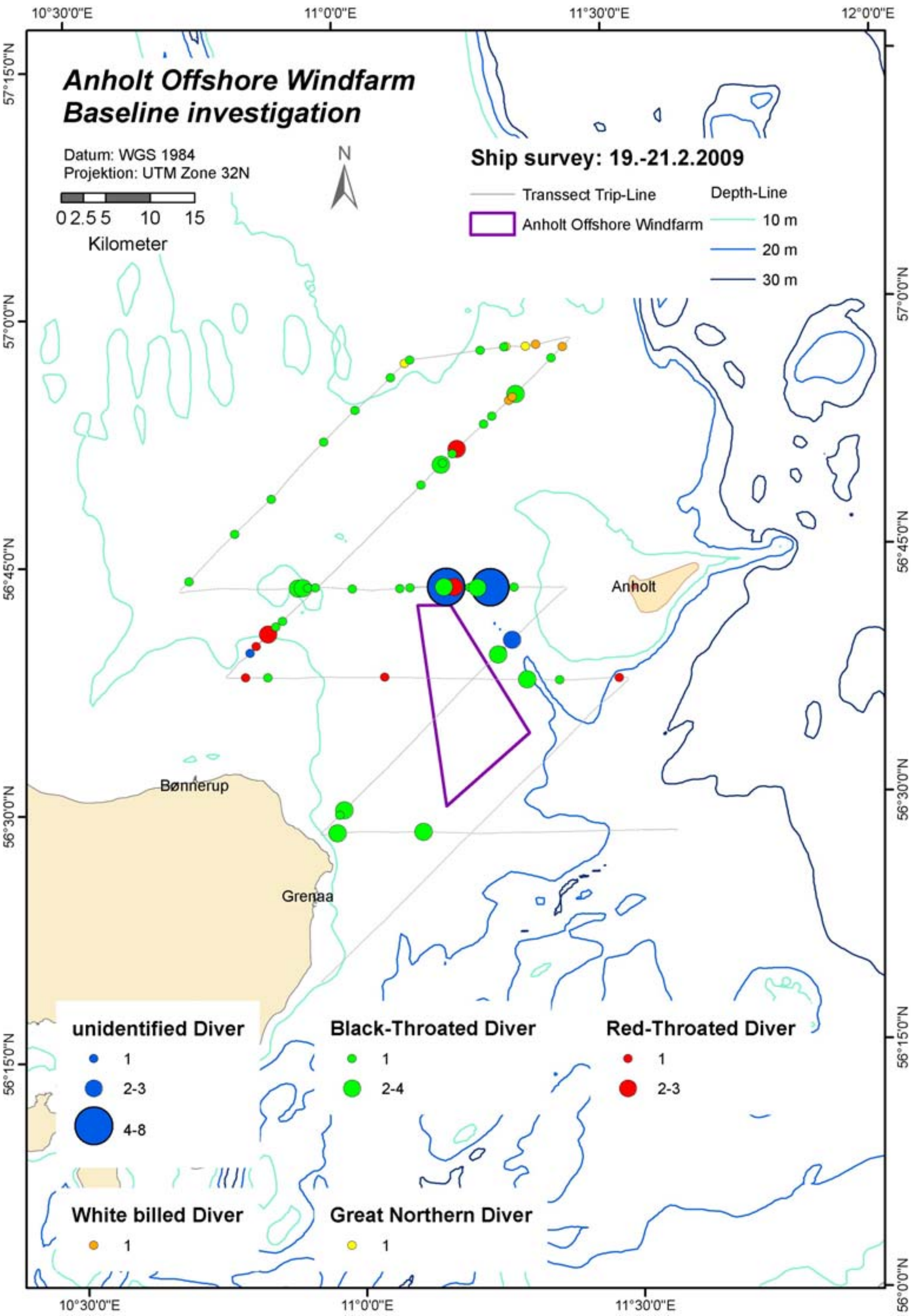
56°0'0"N



Anholt Offshore Windfarm
Baseline investigation
Datum: WGS 1984
Projektion: UTM Zone 32N
0 5 10 20 30
Kilometer
N
Aerial survey: january - may 2009
Ideal Transect-Line
Anholt Offshore Windfarm
Depth-Line
10 m
20 m
30 m
Anholt
Bønnerup
Grenaa
Harbor Porpoise
1
2
Common Seal
1
unidentified Seal
1
unidentified marine Mammal
1
10°30'0"E
11°0'0"E
11°30'0"E
12°0'0"E
57°15'0"N
57°0'0"N
56°45'0"N
56°30'0"N
56°15'0"N
56°0'0"N

Appendix 3 Selected observations of birds and mammals during ship-based baseline surveys in Kattegat 2008-2009


Anholt Offshore Windfarm
Baseline investigation
Datum: WGS 1984
Projektion: UTM Zone 32N
0 2.5 5 10 15
Kilometer
N
Ship survey: 29.12.2008
Transsect Trip-Line
Anholt Offshore Windfarm
Depth-Line
10 m
20 m
30 m
Anholt
Bønnerup
Grenaa
uinidentified Diver
1
2-3
Black-throated Diver
1-2
3-7
Red-Throated Diver
1
10°30'0"E
11°0'0"E
11°30'0"E
12°0'0"E
57°15'0"N
57°0'0"N
56°45'0"N
56°30'0"N
56°15'0"N
56°0'0"N


Anholt Offshore Windfarm
Baseline investigation
Datum: WGS 1984
Projektion: UTM Zone 32N
0 2.5 5 10 15
Kilometer
N
Ship survey: 19.-21.2.2009
Transsect Trip-Line
Anholt Offshore Windfarm
Depth-Line
10 m
20 m
30 m
Anholt
Bønnerup
Grenaa
unidentified Diver
1
2-3
4-8
Black-Throated Diver
1
2-4
Red-Throated Diver
1
2-3
White billed Diver
1
Great Northern Diver
1
10°30'0"E
11°0'0"E
11°30'0"E
12°0'0"E
57°15'0"N
57°0'0"N
56°45'0"N
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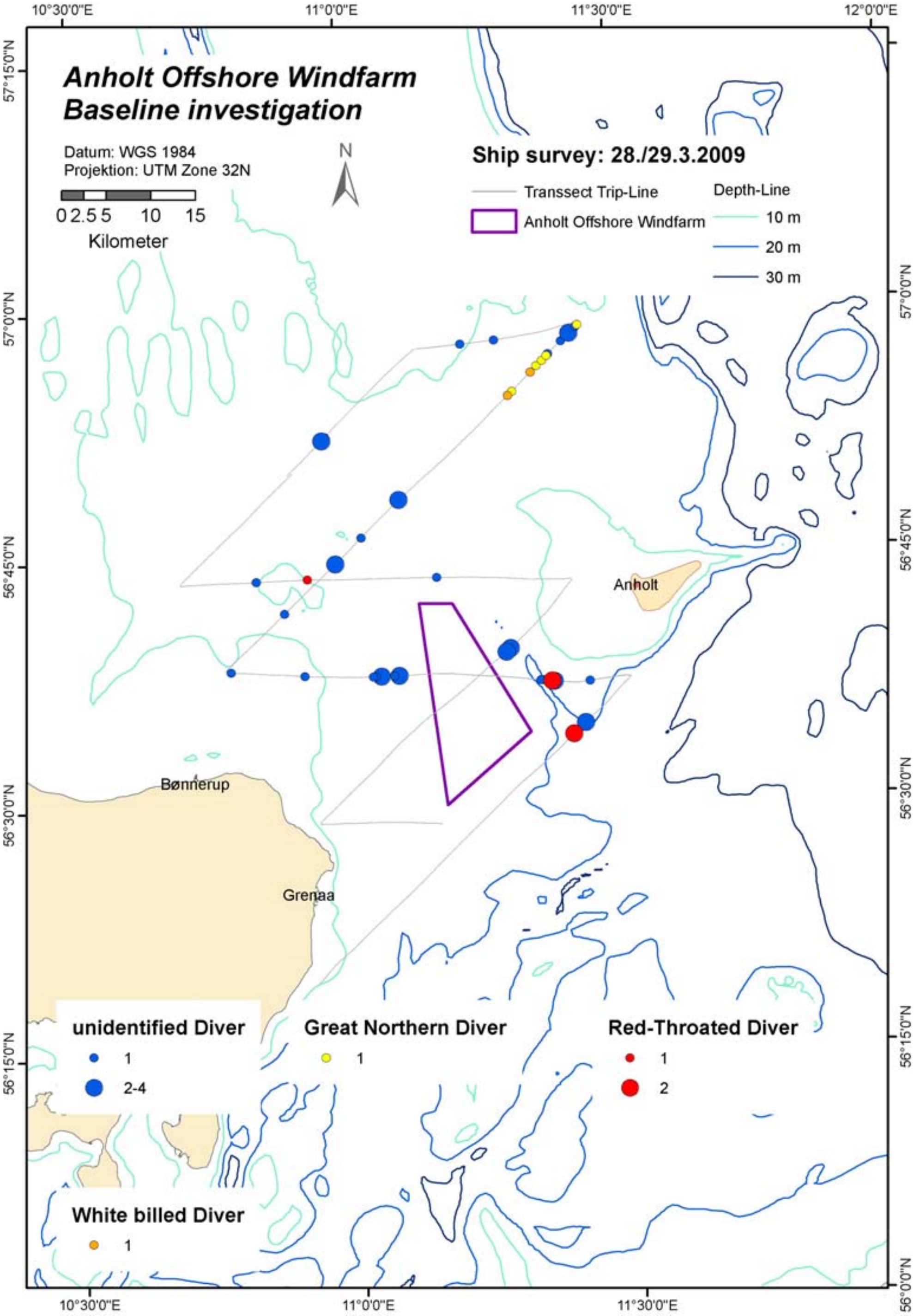
56°0'0"N



Anholt Offshore Windfarm
Baseline investigation
Datum: WGS 1984
Projektion: UTM Zone 32N
0 2.5 5 10 15
Kilometer
N
Ship survey: 28./29.3.2009
Transsect Trip-Line
Anholt Offshore Windfarm
Depth-Line
10 m
20 m
30 m
Anholt
Bønnerup
Grenaa
unidentified Diver
1
2-4
Great Northern Diver
1
Red-Throated Diver
1
2
White billed Diver
1
10°30'0"E
11°0'0"E
11°30'0"E
12°0'0"E
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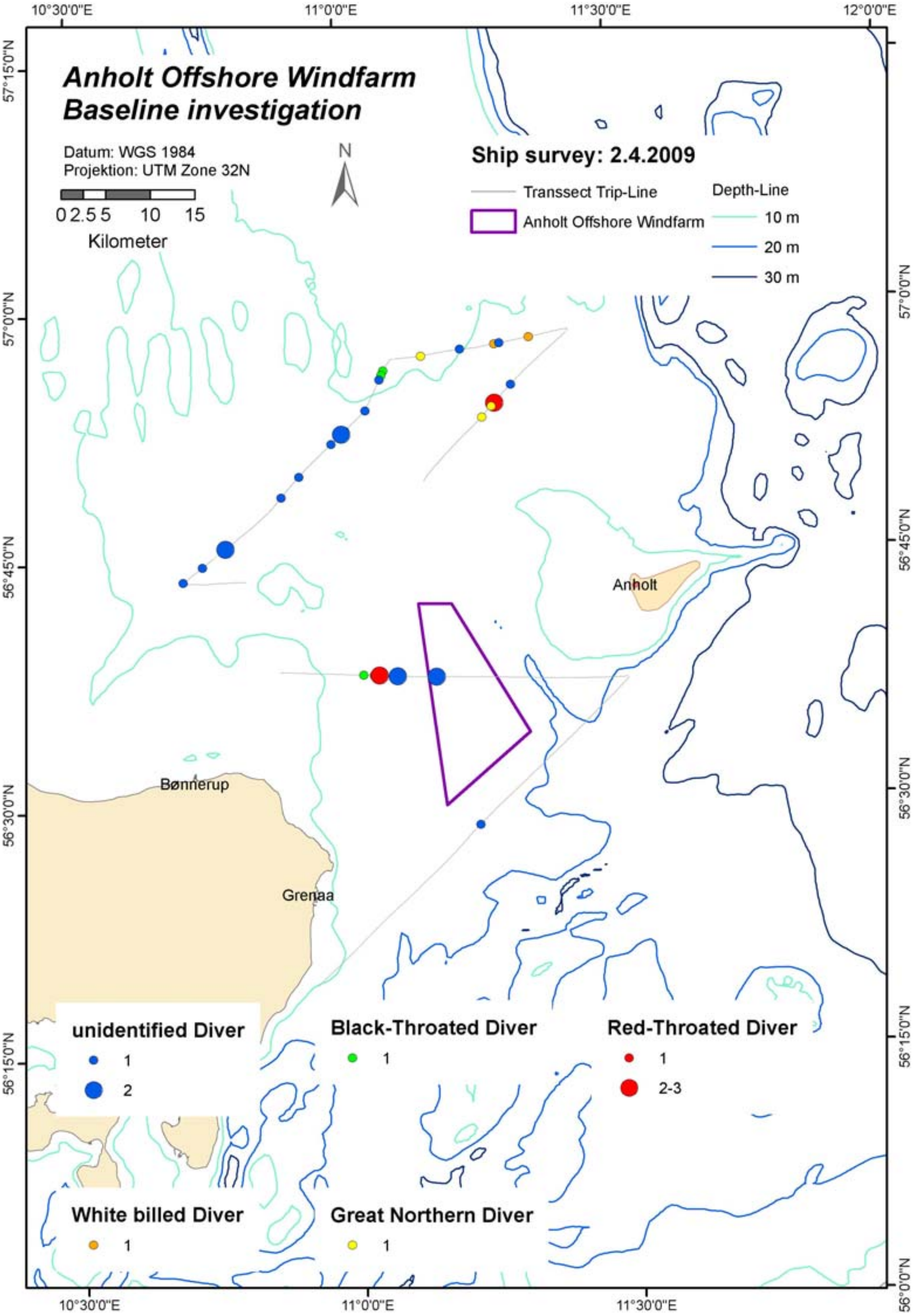
56°0'0"N



Anholt Offshore Windfarm
Baseline investigation
Datum: WGS 1984
Projektion: UTM Zone 32N
0 2.5 5 10 15
Kilometer
N
Ship survey: 2.4.2009
Transsect Trip-Line
Anholt Offshore Windfarm
Depth-Line
10 m
20 m
30 m
Anholt
Bønnerup
Grenaa
unidentified Diver
1
2
Black-Throated Diver
1
Red-Throated Diver
1
2-3
White billed Diver
1
Great Northern Diver
1
10°30'0"E
11°0'0"E
11°30'0"E
12°0'0"E
57°15'0"N
57°0'0"N
56°45'0"N
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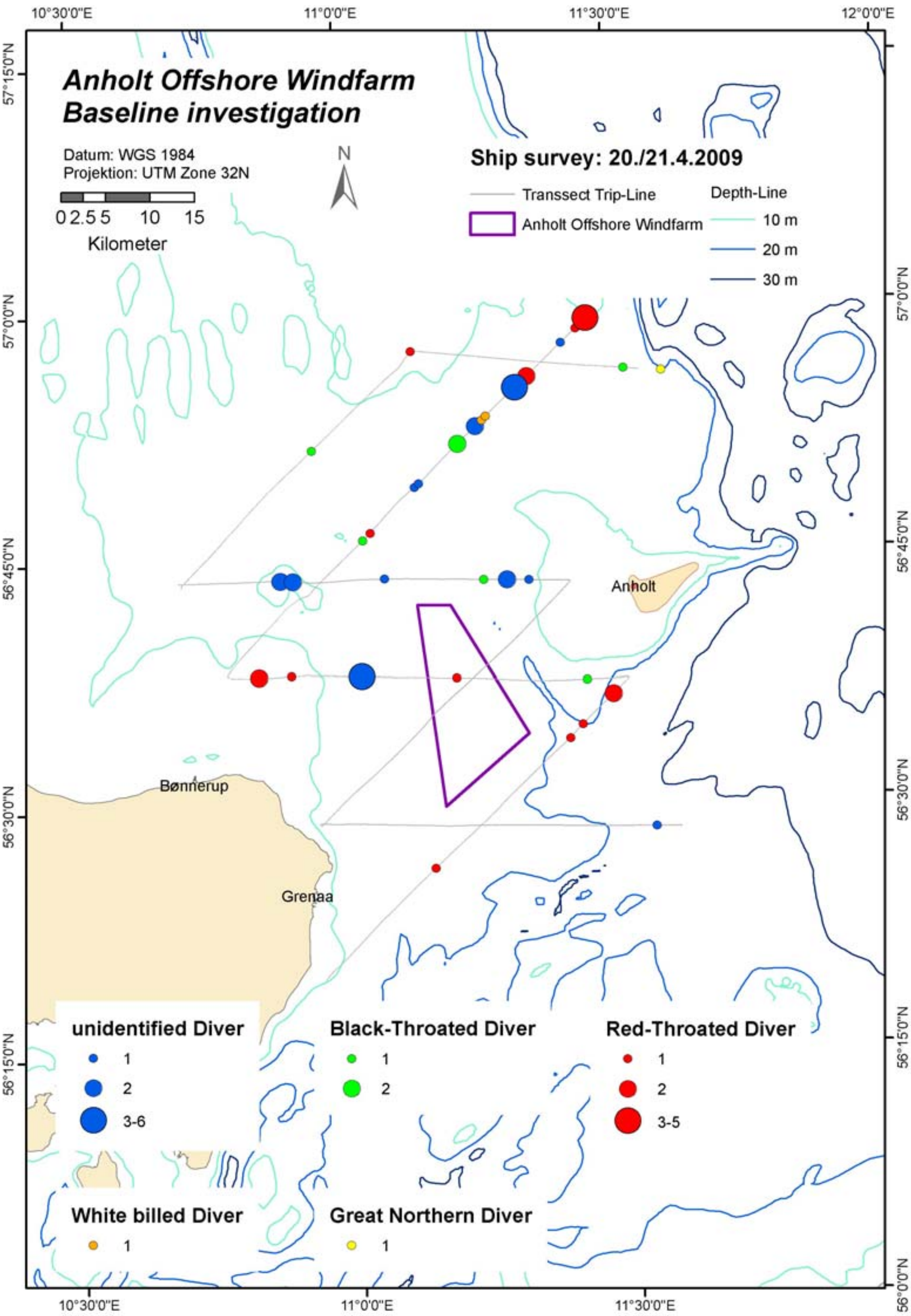
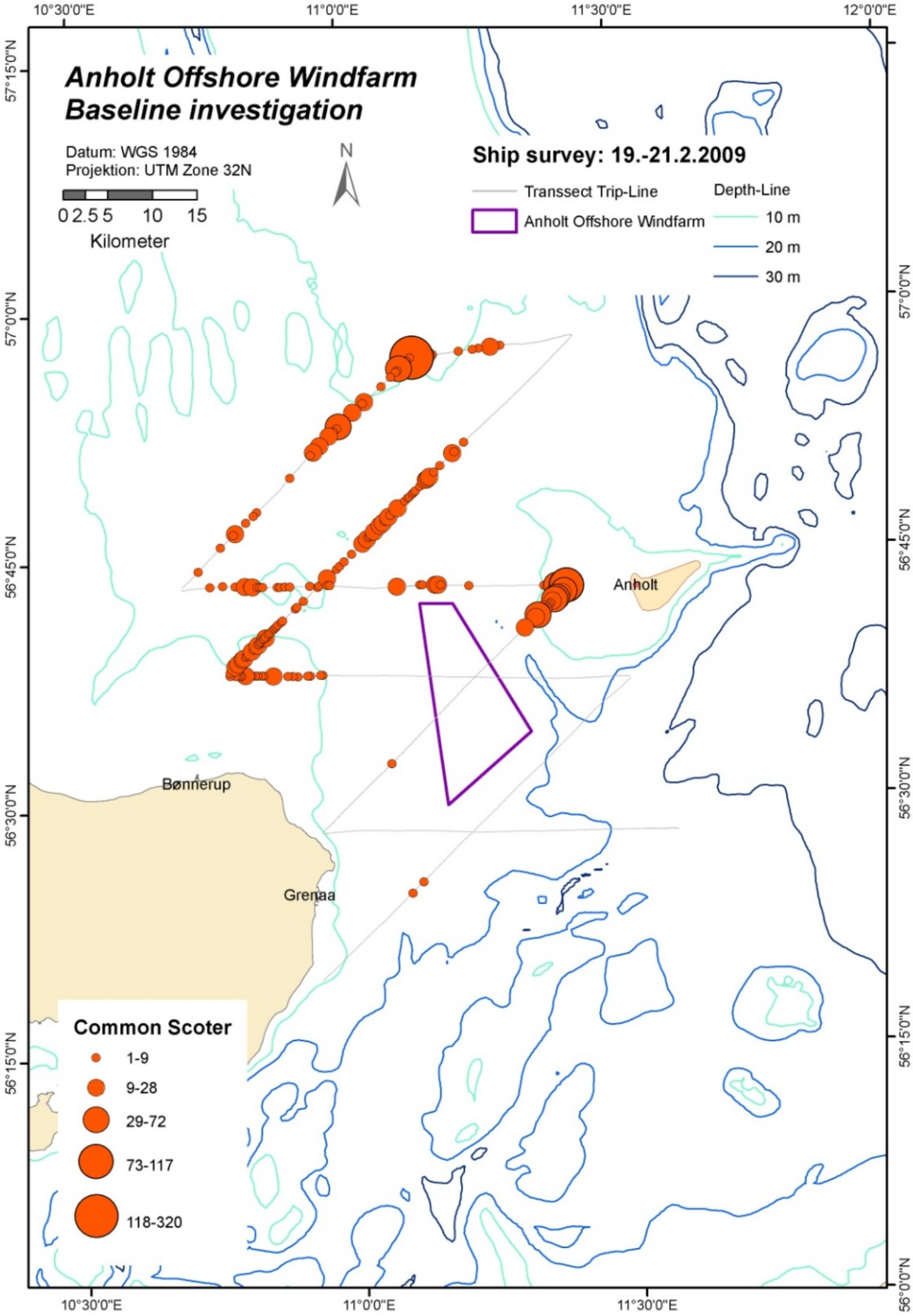
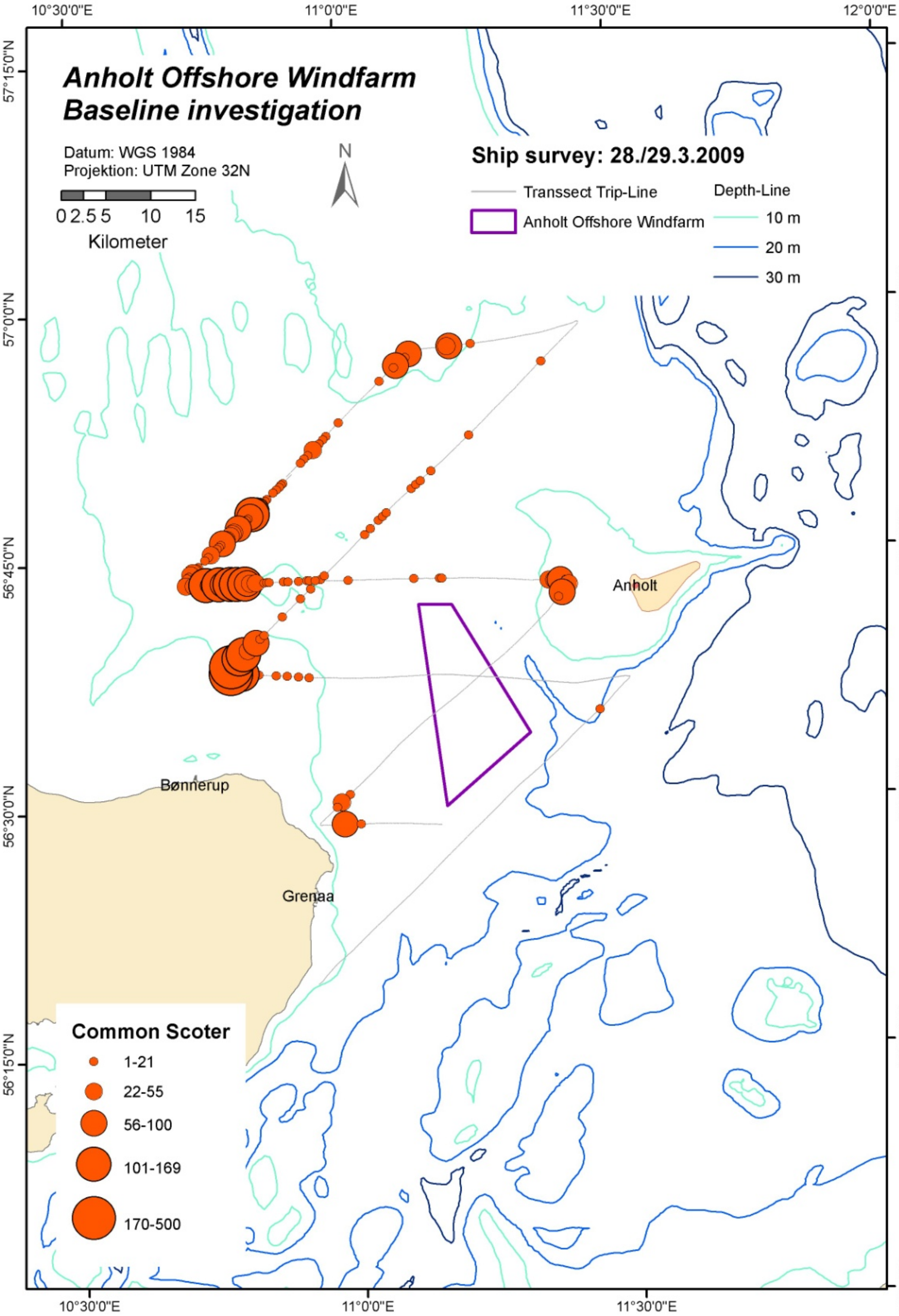
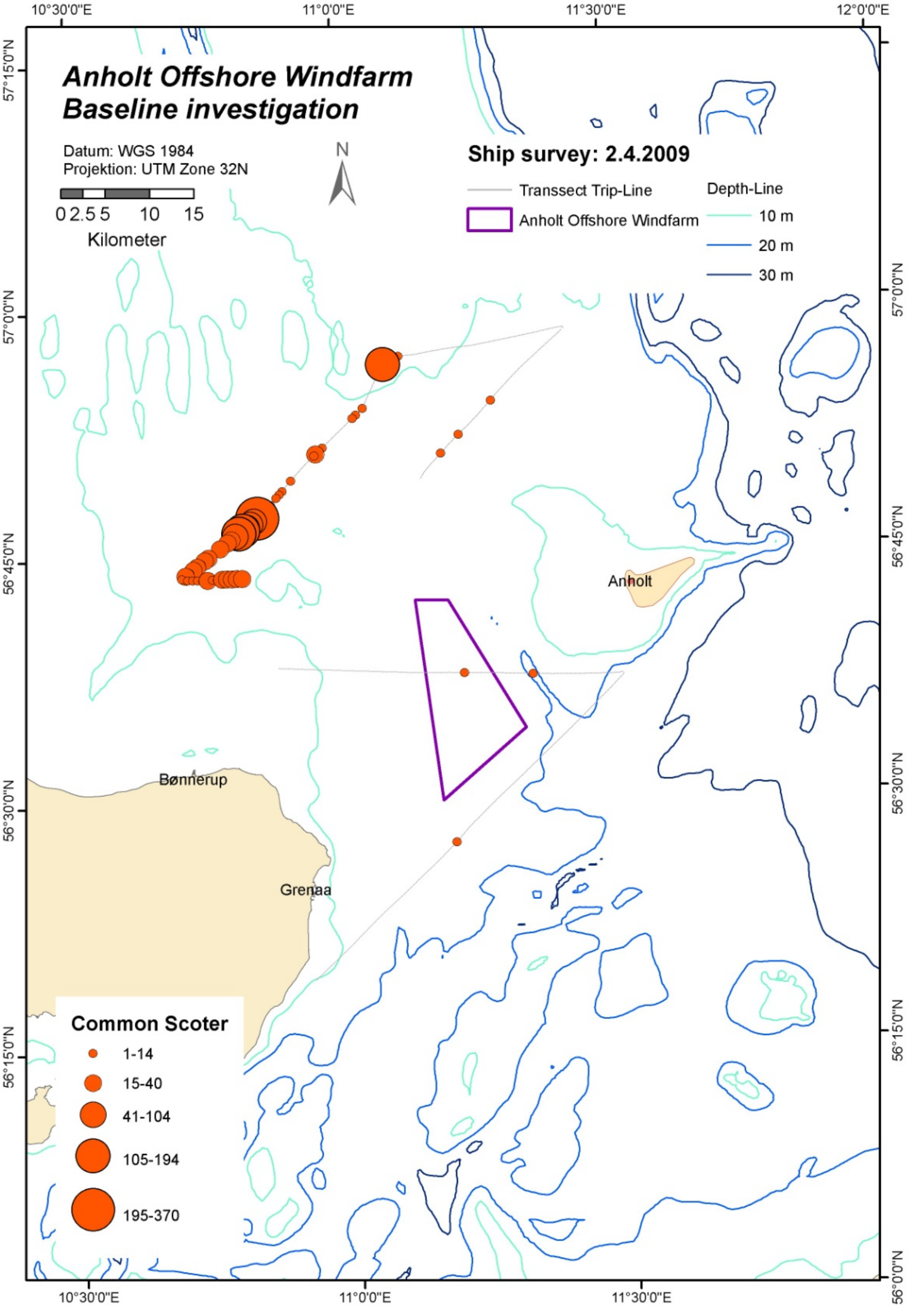
56°15'0"N
56°0'0"N

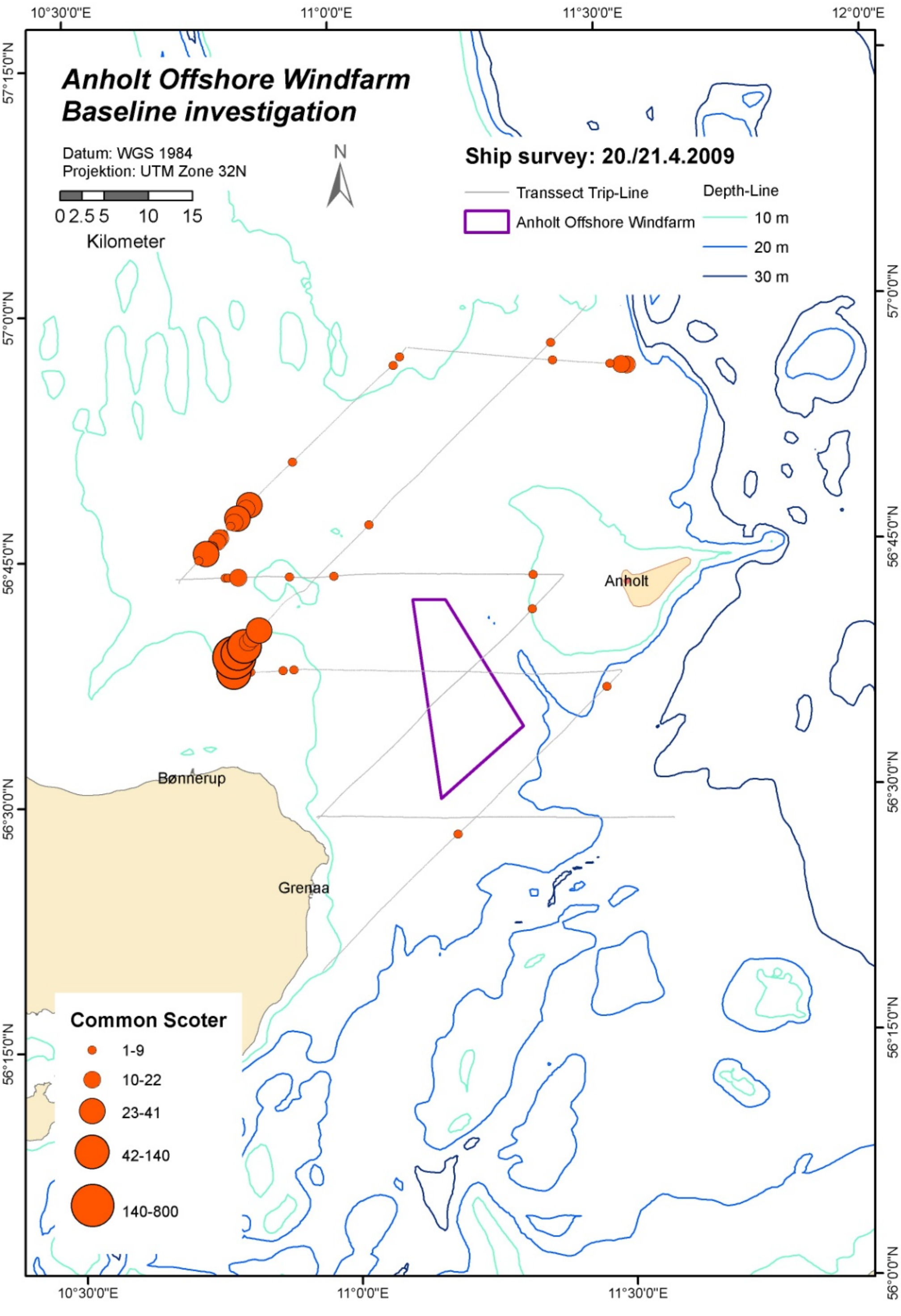

Anholt Offshore Windfarm
Baseline investigation
Datum: WGS 1984
Projektion: UTM Zone 32N
0 2.5 5 10 15
Kilometer
N
Ship survey: 20./21.4.2009
Transsect Trip-Line
Anholt Offshore Windfarm
Depth-Line
10 m
20 m
30 m
Anholt
Bønnerup
Grenaa
unidentified Diver
1
2
3-6
Black-Throated Diver
1
2
Red-Throated Diver
1
2
3-5
White billed Diver
1
Great Northern Diver
1
10°30'0"E
11°0'0"E
11°30'0"E
12°0'0"E
57°15'0"N
57°0'0"N
56°45'0"N
56°30'0"N
56°15'0"N
56°0'0"N


Anholt Offshore Windfarm
Baseline investigation
Datum: WGS 1984
Projektion: UTM Zone 32N
0 2.5 5 10 15
Kilometer
N
Ship survey: 19.-21.2.2009
Transsect Trip-Line
Anholt Offshore Windfarm
Depth-Line
10 m
20 m
30 m
Anholt
Bønnerup
Grenaa
Common Scoter
1-9
9-28
29-72
73-117
118-320
10°30'0"E
11°0'0"E
11°30'0"E
12°0'0"E
57°15'0"N
57°0'0"N
56°45'0"N
56°30'0"N
56°15'0"N
56°0'0"N

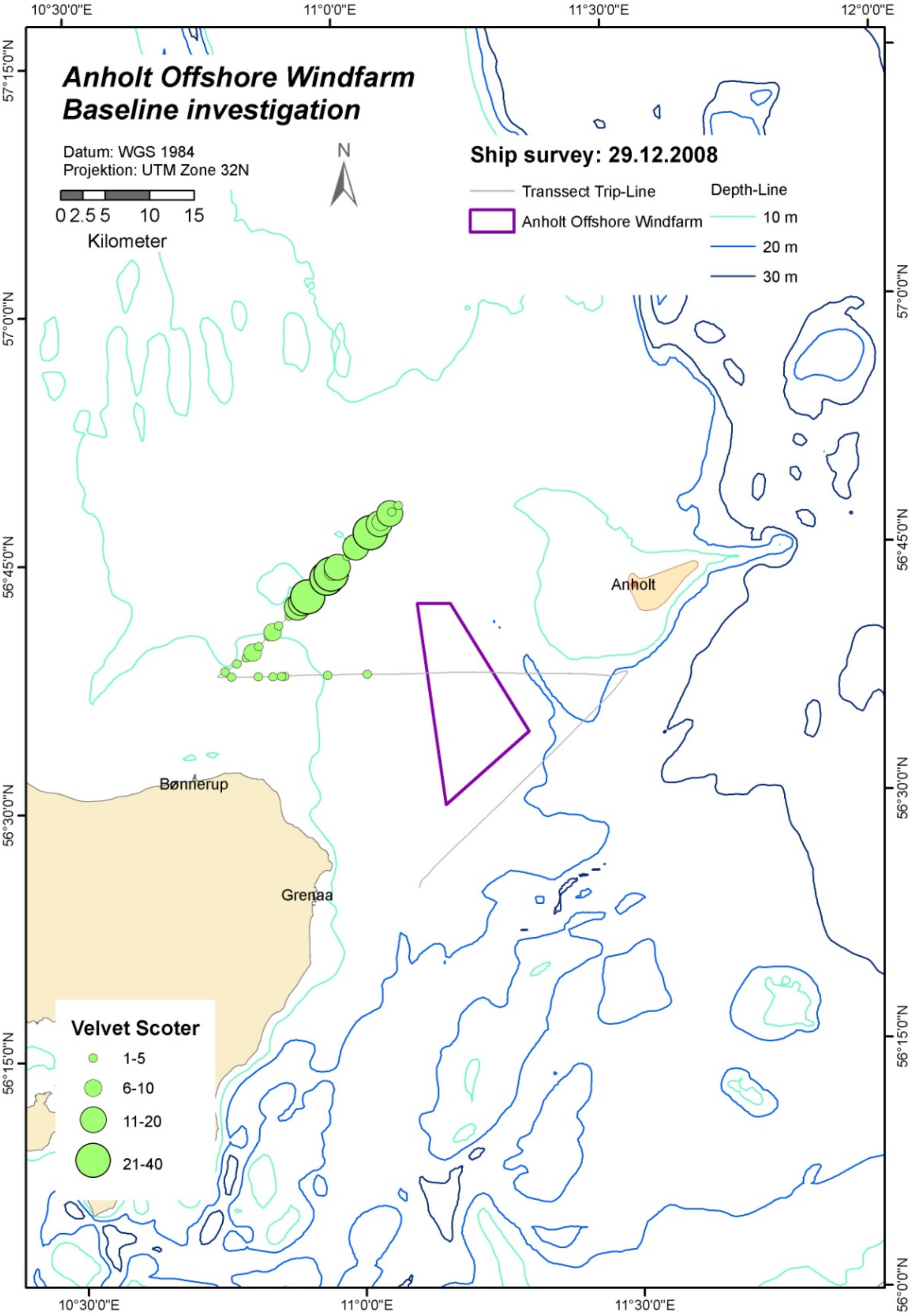

Anholt Offshore Windfarm
Baseline investigation
Datum: WGS 1984
Projektion: UTM Zone 32N
0 2.5 5 10 15
Kilometer
N
Ship survey: 28./29.3.2009
Transsect Trip-Line
Anholt Offshore Windfarm
Depth-Line
10 m
20 m
30 m
Anholt
Bønnerup
Grenaa
Common Scoter
1-21
22-55
56-100
101-169
170-500
10°30'0"E
11°0'0"E
11°30'0"E
12°0'0"E
57°15'0"N
57°0'0"N
56°45'0"N
56°30'0"N
56°15'0"N
56°0'0"N



Anholt Offshore Windfarm
Baseline investigation
Datum: WGS 1984
Projektion: UTM Zone 32N
0 2.5 5 10 15
Kilometer
N
Ship survey: 2.4.2009
Transsect Trip-Line
Anholt Offshore Windfarm
Depth-Line
10 m
20 m
30 m
Anholt
Bønnerup
Grenaa
Common Scoter
1-14
15-40
41-104
105-194
195-370
10°30'0"E
11°0'0"E
11°30'0"E
12°0'0"E
57°15'0"N
57°0'0"N
56°45'0"N
56°30'0"N
56°15'0"N
56°0'0"N



Anholt Offshore Windfarm
Baseline investigation
Datum: WGS 1984
Projektion: UTM Zone 32N
0 2.5 5 10 15
Kilometer
N
Ship survey: 20./21.4.2009
Transsect Trip-Line
Anholt Offshore Windfarm
Depth-Line
10 m
20 m
30 m
Anholt
Bønnerup
Grenaa
Common Scoter
1-9
10-22
23-41
42-140
140-800
10°30'0"E
11°0'0"E
11°30'0"E
12°0'0"E
57°15'0"N
57°0'0"N
56°45'0"N
56°30'0"N
56°15'0"N
56°0'0"N



Anholt Offshore Windfarm
Baseline investigation
Datum: WGS 1984
Projektion: UTM Zone 32N
0 2.5 5 10 15
Kilometer
N
Ship survey: 29.12.2008
Transsect Trip-Line
Anholt Offshore Windfarm
Depth-Line
10 m
20 m
30 m
Anholt
Bønnerup
Grenaa
Velvet Scoter
1-5
6-10
11-20
21-40
10°30'0"E
11°0'0"E
11°30'0"E
12°0'0"E
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57°0'0"N
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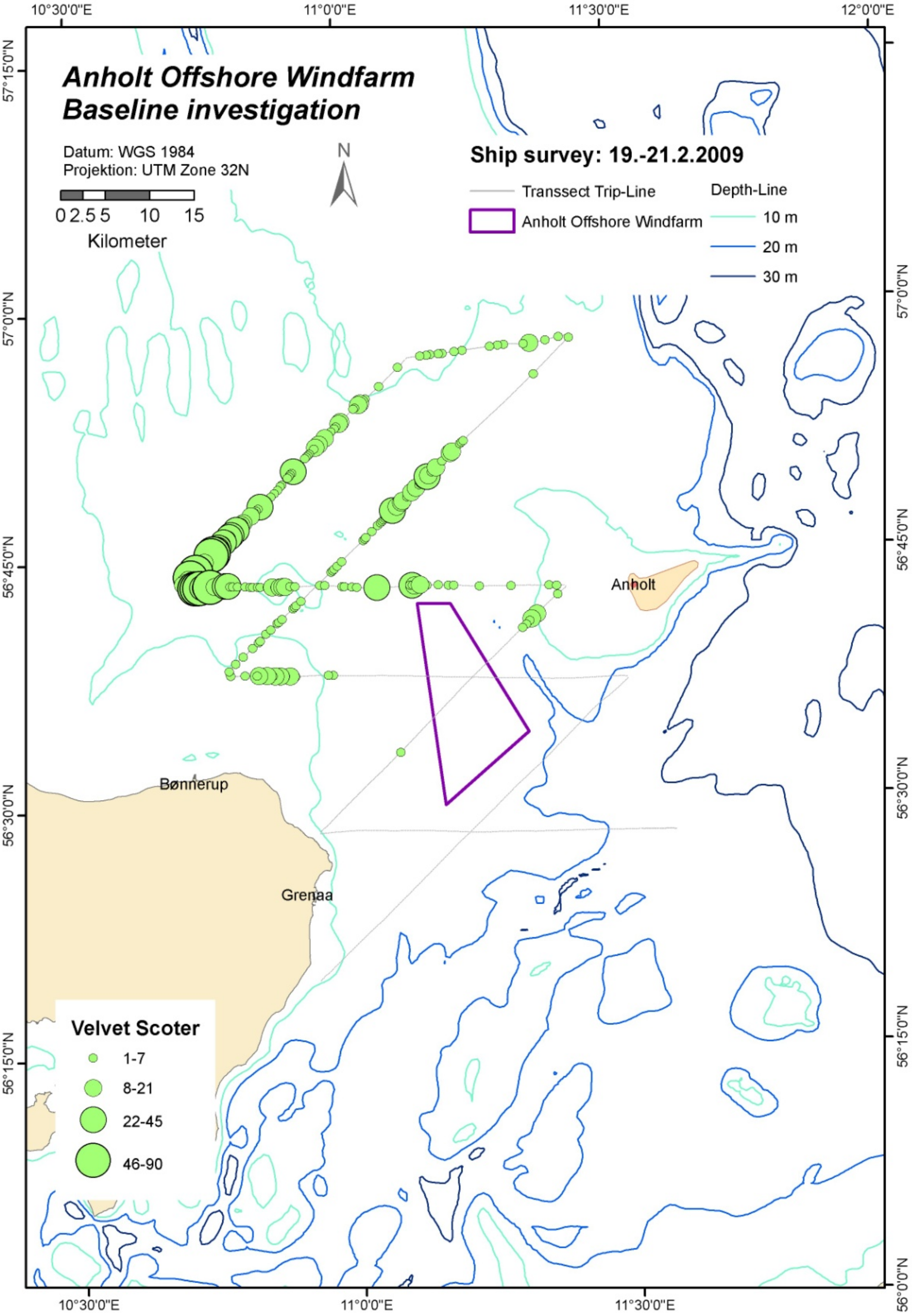
56°0'0"N


Anholt Offshore Windfarm
Baseline investigation
Datum: WGS 1984
Projektion: UTM Zone 32N
0 2.5 5 10 15
Kilometer
N
Ship survey: 19.-21.2.2009
Transsect Trip-Line
Anholt Offshore Windfarm
Depth-Line
10 m
20 m
30 m
Anholt
Bønnerup
Grenaa
Velvet Scoter
1-7
8-21
22-45
46-90
10°30'0"E
11°0'0"E
11°30'0"E
12°0'0"E
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57°0'0"N
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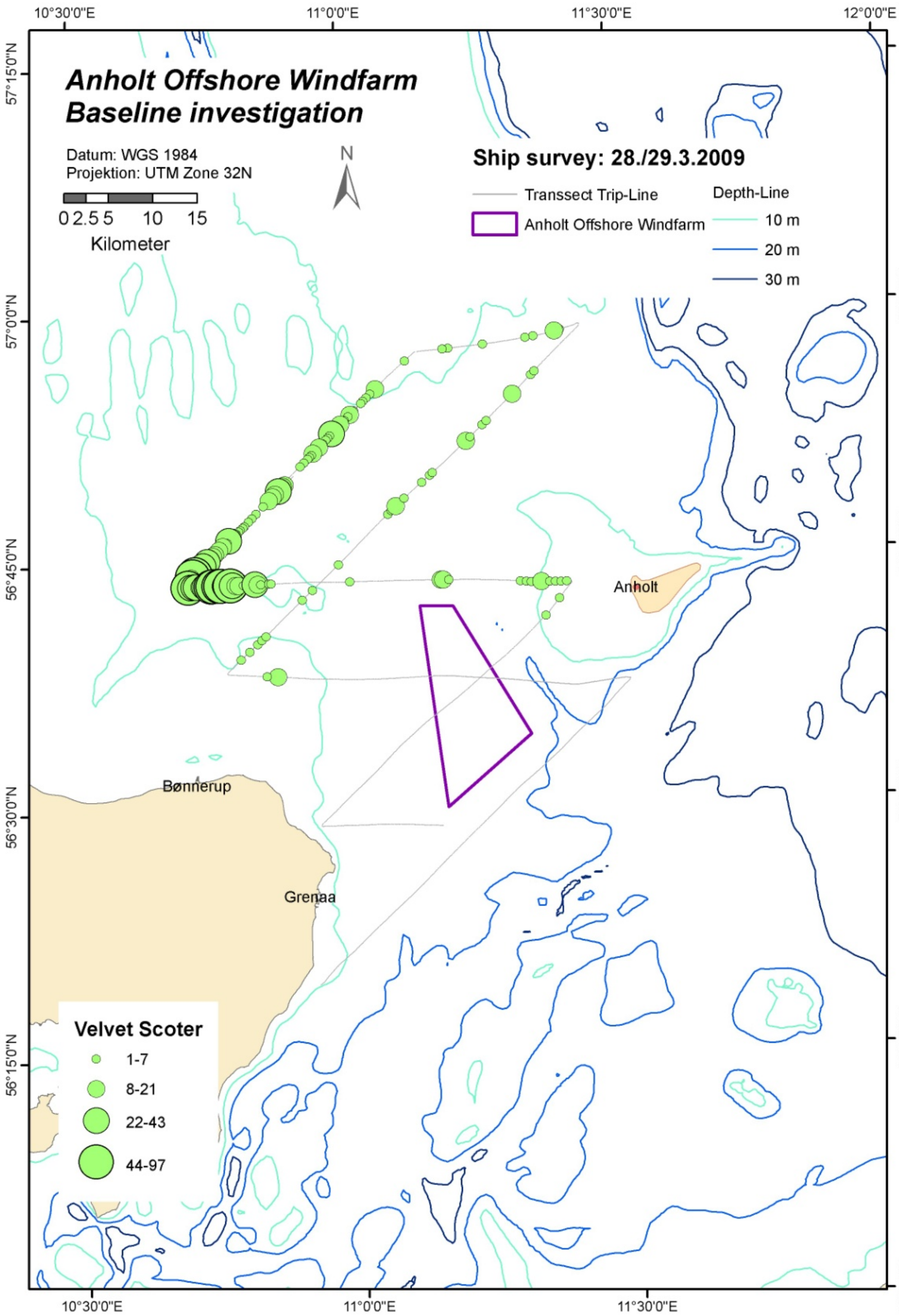
56°0'0"N



Anholt Offshore Windfarm
Baseline investigation
Datum: WGS 1984
Projektion: UTM Zone 32N
0 2.5 5 10 15
Kilometer
N
Ship survey: 28./29.3.2009
Transsect Trip-Line
Anholt Offshore Windfarm
Depth-Line
10 m
20 m
30 m
Anholt
Bønnerup
Grenaa
Velvet Scoter
1-7
8-21
22-43
44-97
10°30'0"E
11°0'0"E
11°30'0"E
12°0'0"E
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57°0'0"N
56°45'0"N
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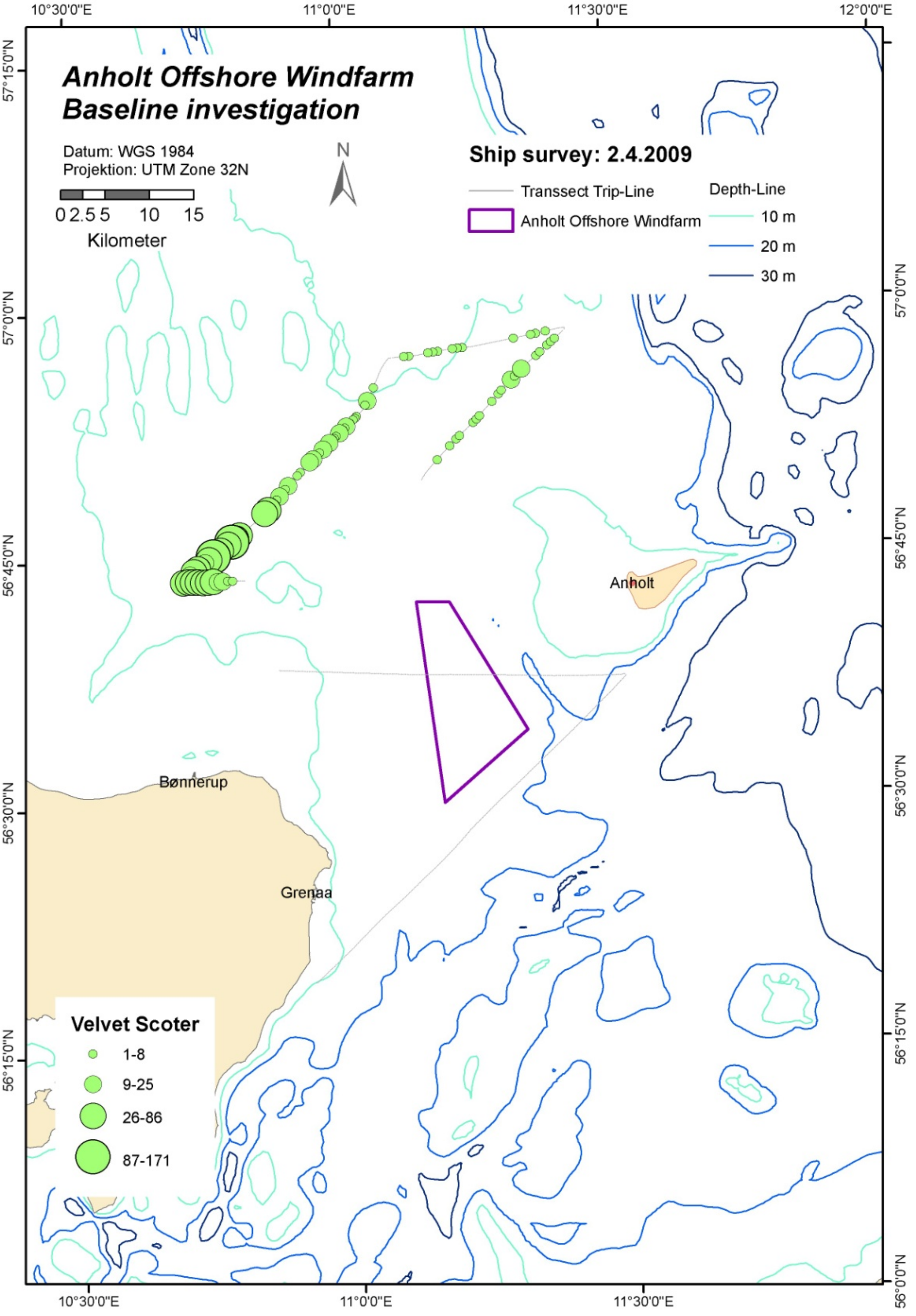
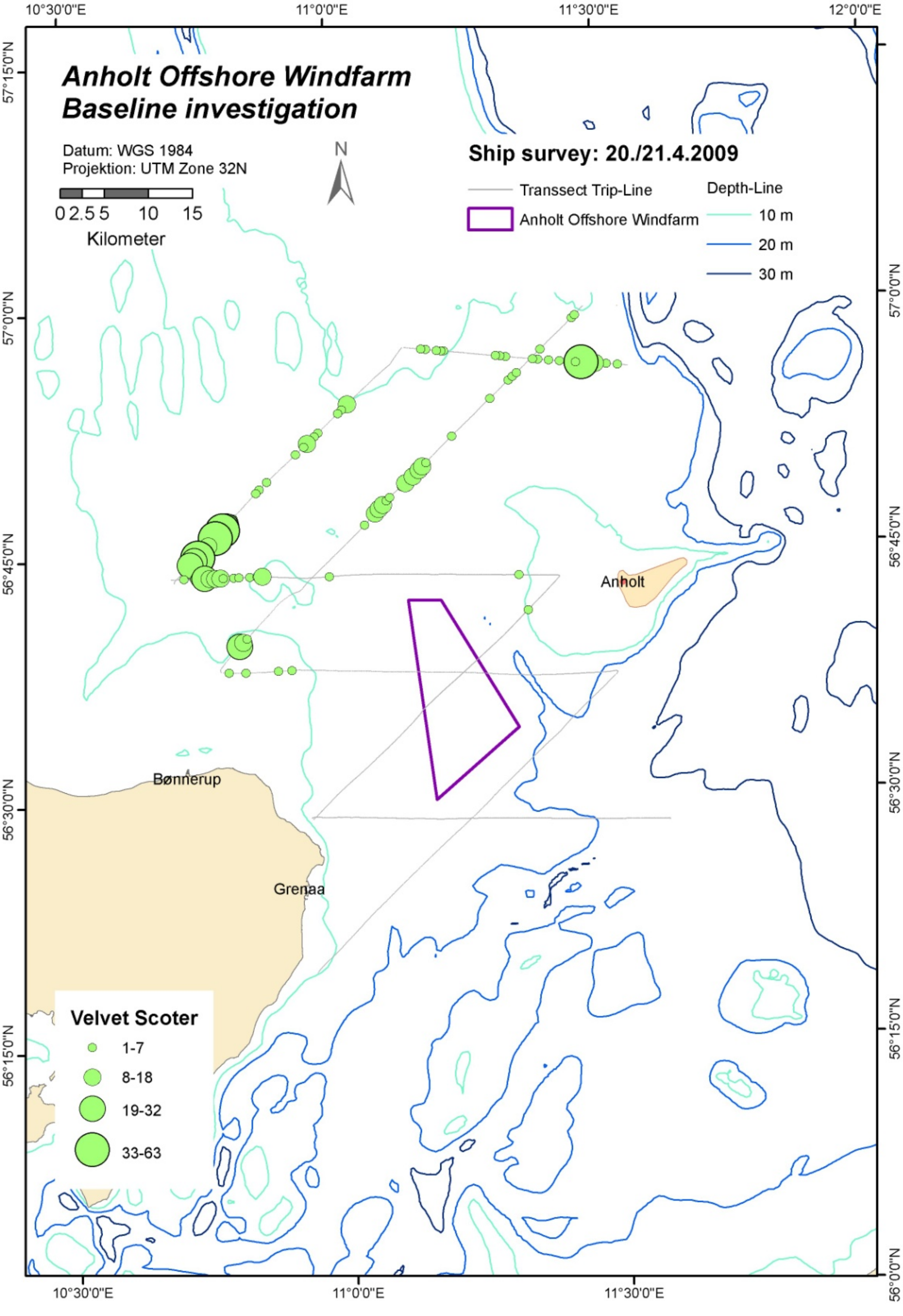
56°0'0"N



Anholt Offshore Windfarm
Baseline investigation
Datum: WGS 1984
Projektion: UTM Zone 32N
0 2.5 5 10 15
Kilometer
N
Ship survey: 2.4.2009
Transsect Trip-Line
Anholt Offshore Windfarm
Depth-Line
10 m
20 m
30 m
Anholt
Bønnerup
Grenaa
Velvet Scoter
1-8
9-25
26-86
87-171
10°30'0"E
11°0'0"E
11°30'0"E
12°0'0"E
57°15'0"N
57°0'0"N
56°45'0"N
56°30'0"N
56°15'0"N
56°0'0"N



Anholt Offshore Windfarm
Baseline investigation
Datum: WGS 1984
Projektion: UTM Zone 32N
0 2.5 5 10 15
Kilometer
N
Ship survey: 20./21.4.2009
Transsect Trip-Line
Anholt Offshore Windfarm
Depth-Line
10 m
20 m
30 m
Anholt
Bønnerup
Grenaa
Velvet Scoter
1-7
8-18
19-32
33-63
10°30'0"E
11°0'0"E
11°30'0"E
12°0'0"E
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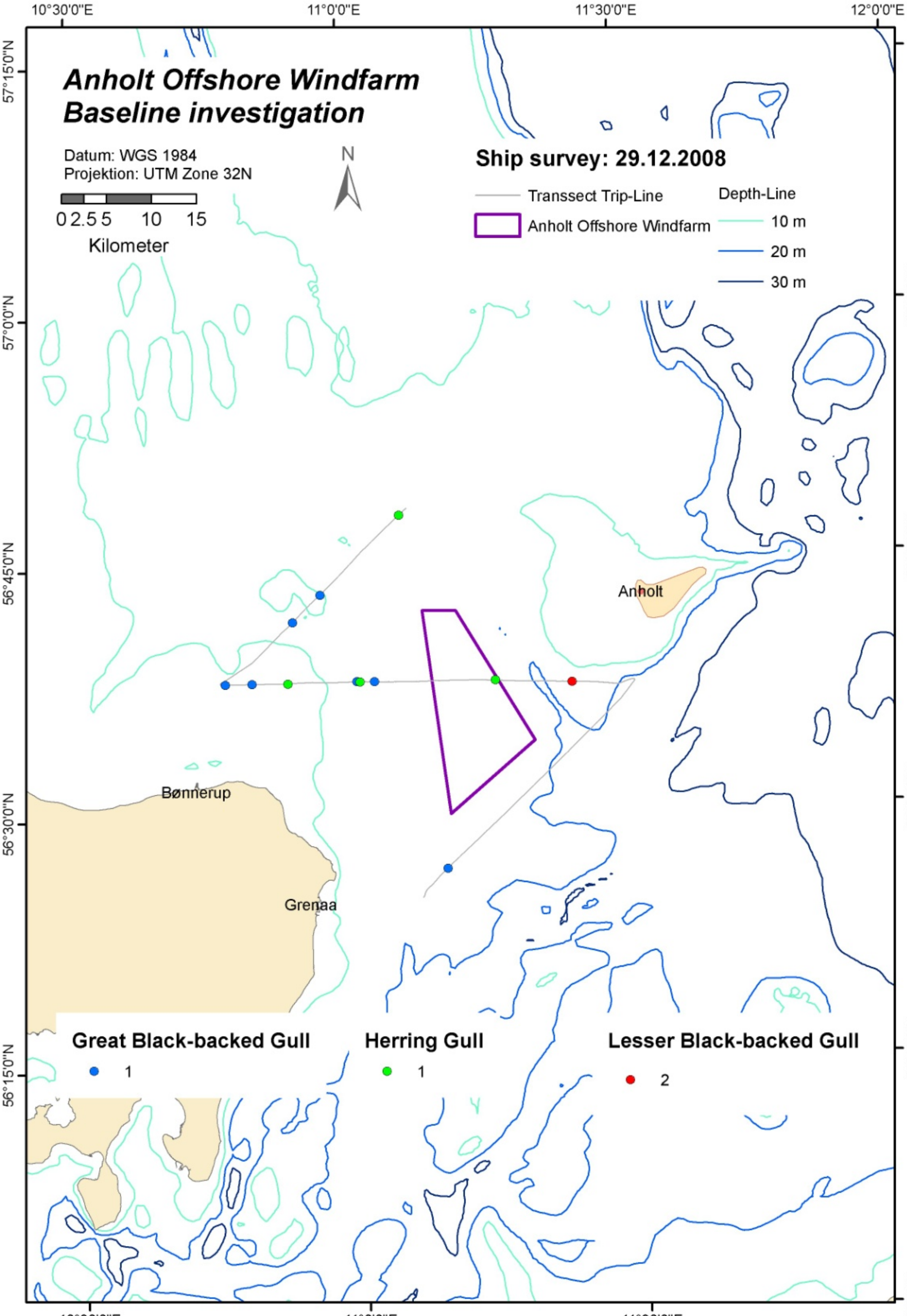
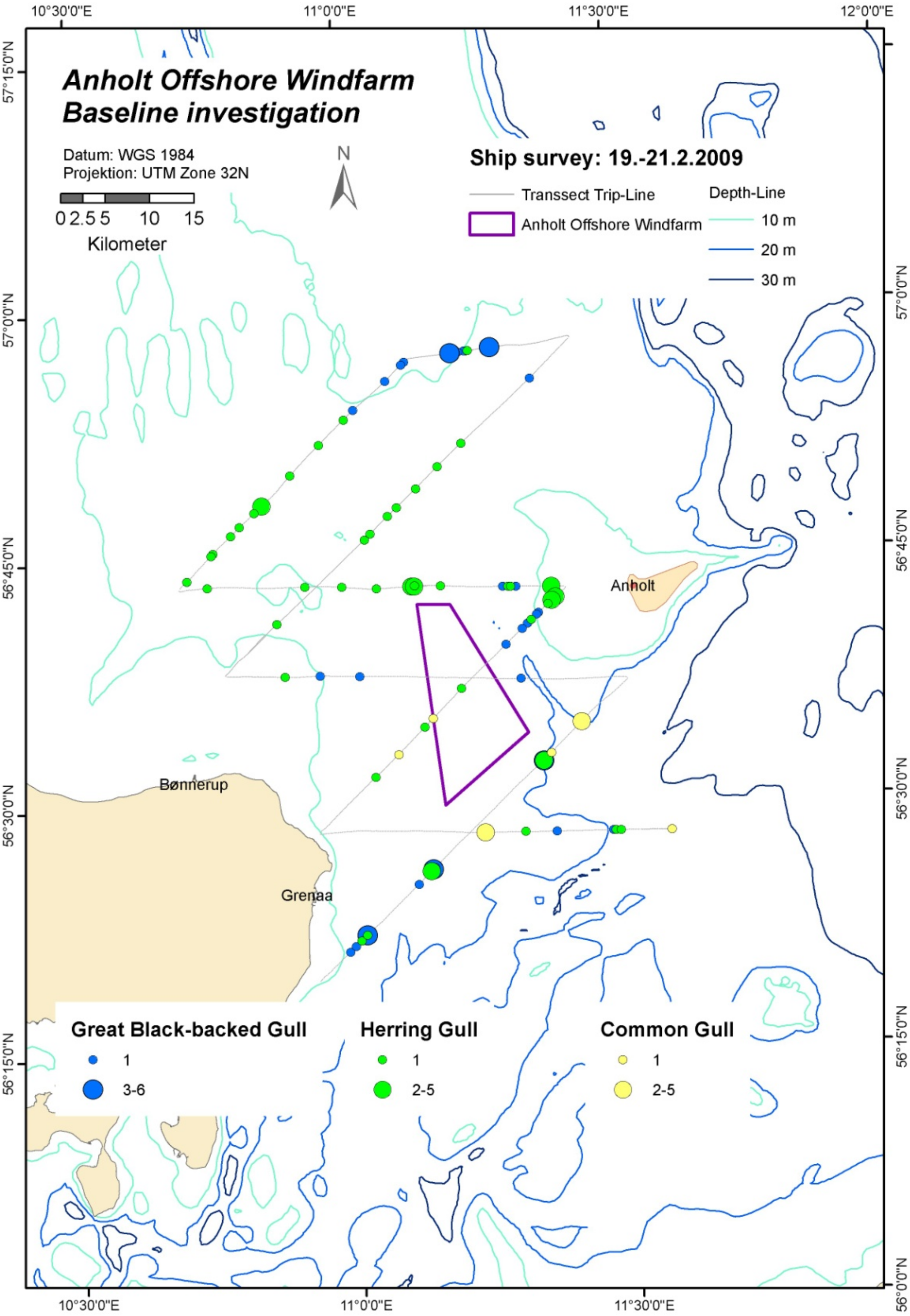
57°0'0"N
56°45'0"N
56°30'0"N
56°15'0"N
56°0'0"N


Anholt Offshore Windfarm
Baseline investigation
Datum: WGS 1984
Projektion: UTM Zone 32N
0 2.5 5 10 15
Kilometer
N
Ship survey: 29.12.2008
Transsect Trip-Line
Anholt Offshore Windfarm
Depth-Line
10 m
20 m
30 m
Anholt
Bønnerup
Grenaa
Great Black-backed Gull
1
Herring Gull
1
Lesser Black-backed Gull
2
10°30'0"E
11°0'0"E
11°30'0"E
12°0'0"E
57°15'0"N
57°0'0"N
56°45'0"N
56°30'0"N
56°15'0"N
56°0'0"N



Anholt Offshore Windfarm
Baseline investigation
Datum: WGS 1984
Projektion: UTM Zone 32N
0 2.5 5 10 15
Kilometer
N
Ship survey: 19.-21.2.2009
Transsect Trip-Line
Anholt Offshore Windfarm
Depth-Line
10 m
20 m
30 m
Anholt
Bønnerup
Grenaa
Great Black-backed Gull
1
3-6
Herring Gull
1
2-5
Common Gull
1
2-5
10°30'0"E
11°0'0"E
11°30'0"E
12°0'0"E
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57°0'0"N
56°45'0"N
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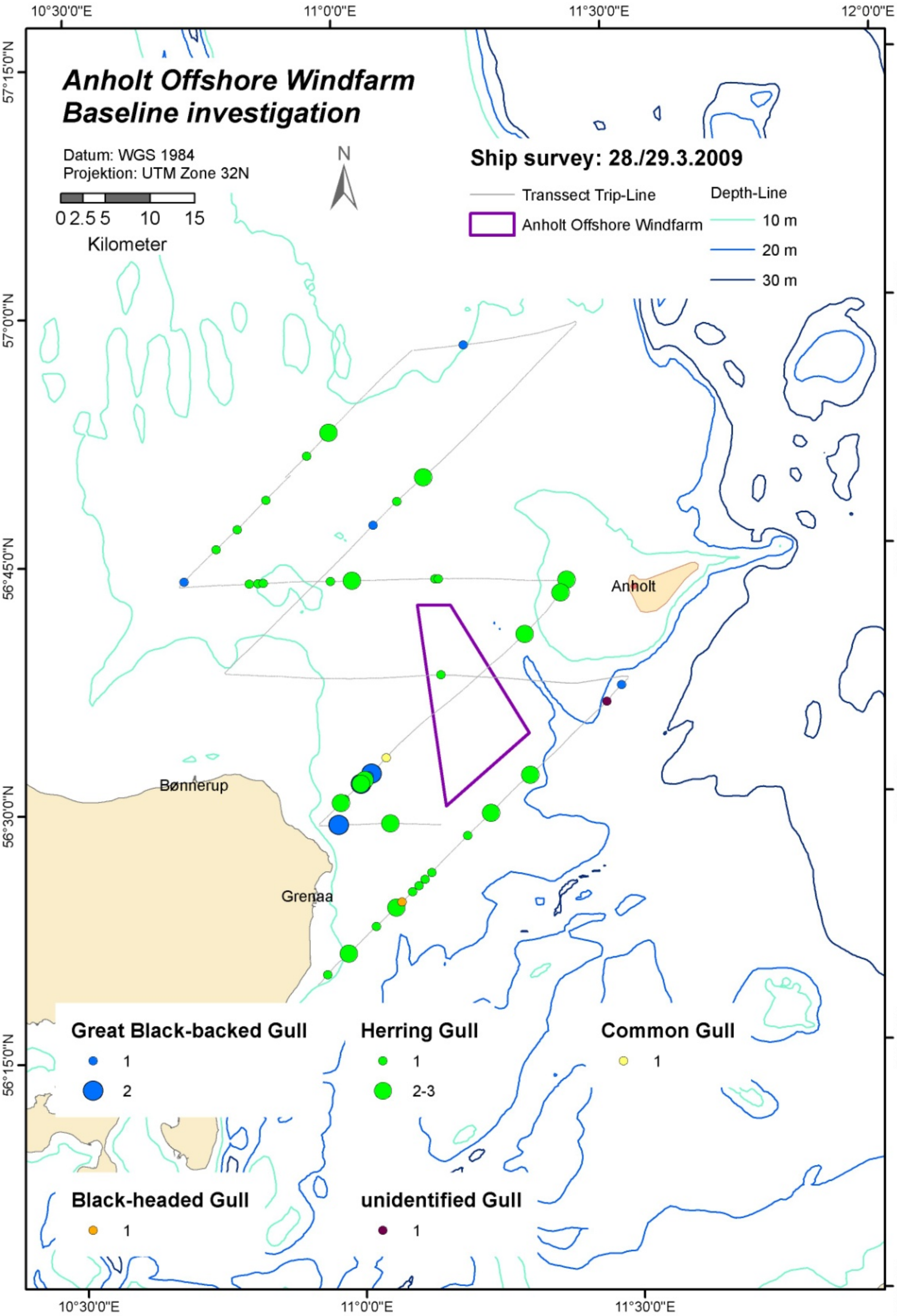
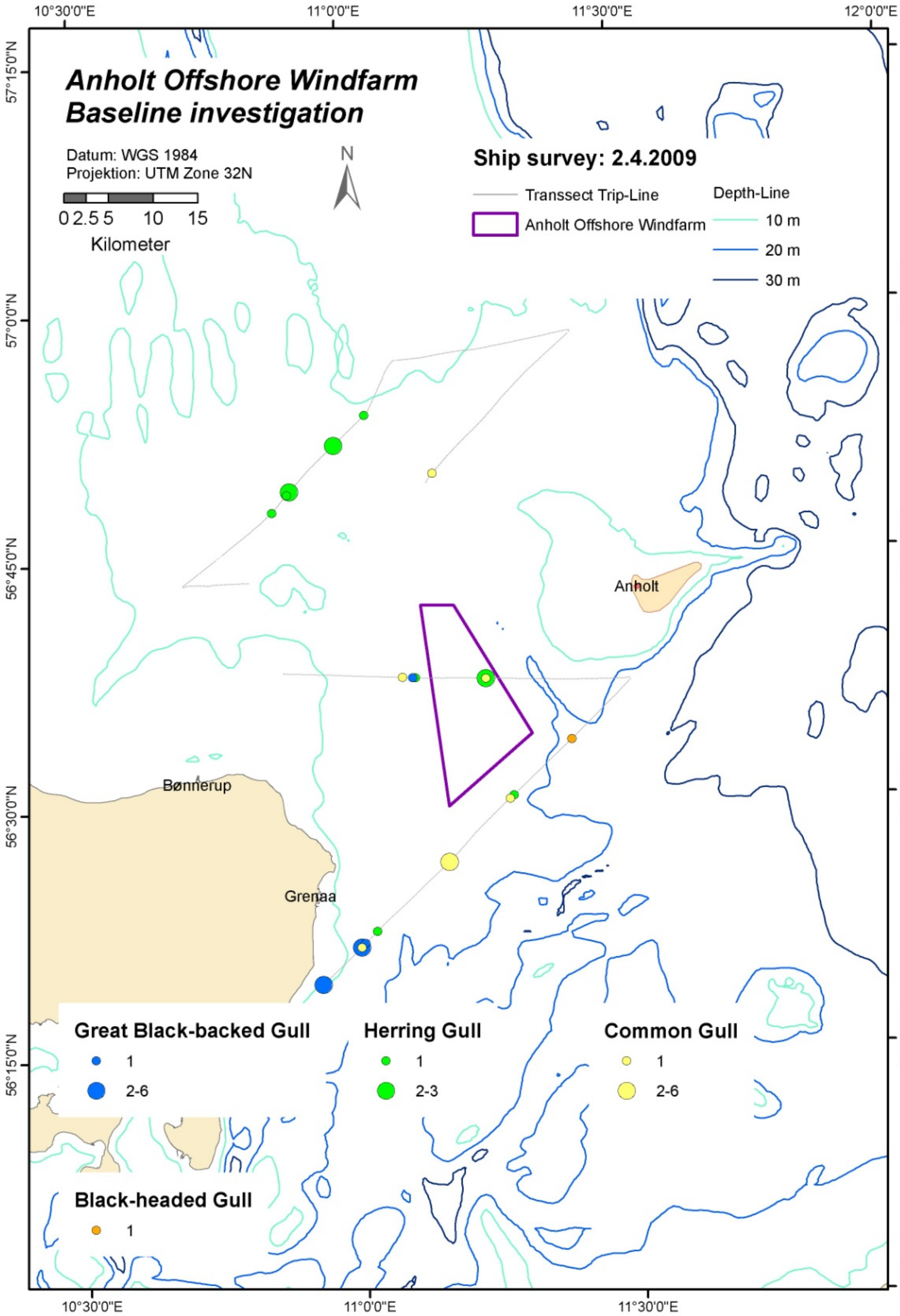
56°0'0"N



Anholt Offshore Windfarm
Baseline investigation
Datum: WGS 1984
Projektion: UTM Zone 32N
0 2.5 5 10 15
Kilometer
N
Ship survey: 28./29.3.2009
Transsect Trip-Line
Anholt Offshore Windfarm
Depth-Line
10 m
20 m
30 m
Anholt
Bønnerup
Grenaa
10°30'0"E
11°0'0"E
11°30'0"E
12°0'0"E
57°15'0"N
57°0'0"N
56°45'0"N
56°30'0"N
56°15'0"N
56°0'0"N
Great Black-backed Gull
1
2
Herring Gull
1
2-3
Common Gull
1
Black-headed Gull
1
unidentified Gull
1


Anholt Offshore Windfarm
Baseline investigation
Datum: WGS 1984
Projektion: UTM Zone 32N
0 2.5 5 10 15
Kilometer
N
Ship survey: 2.4.2009
Transsect Trip-Line
Anholt Offshore Windfarm
Depth-Line
10 m
20 m
30 m
Anholt
Bønnerup
Grenaa
Great Black-backed Gull
1
2-6
Herring Gull
1
2-3
Common Gull
1
2-6
Black-headed Gull
1
10°30'0"E
11°0'0"E
11°30'0"E
12°0'0"E
57°15'0"N
57°0'0"N
56°45'0"N
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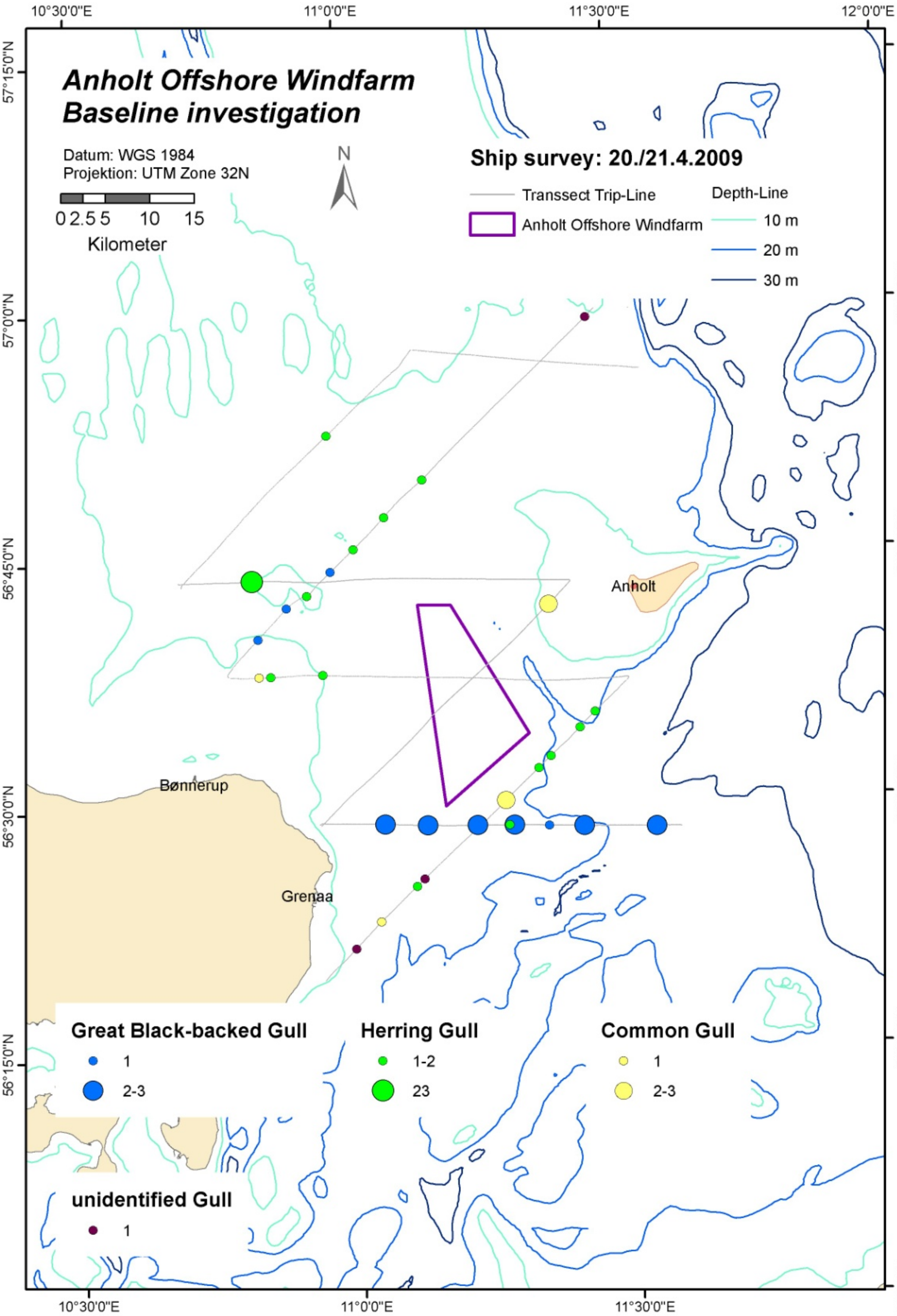
56°0'0"N



Anholt Offshore Windfarm
Baseline investigation
Datum: WGS 1984
Projektion: UTM Zone 32N
0 2.5 5 10 15
Kilometer
N
Ship survey: 20./21.4.2009
Transsect Trip-Line
Anholt Offshore Windfarm
Depth-Line
10 m
20 m
30 m
Anholt
Bønnerup
Grenaa
Great Black-backed Gull
1
2-3
Herring Gull
1-2
23
Common Gull
1
2-3
unidentified Gull
1
10°30'0"E
11°0'0"E
11°30'0"E
12°0'0"E
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57°0'0"N
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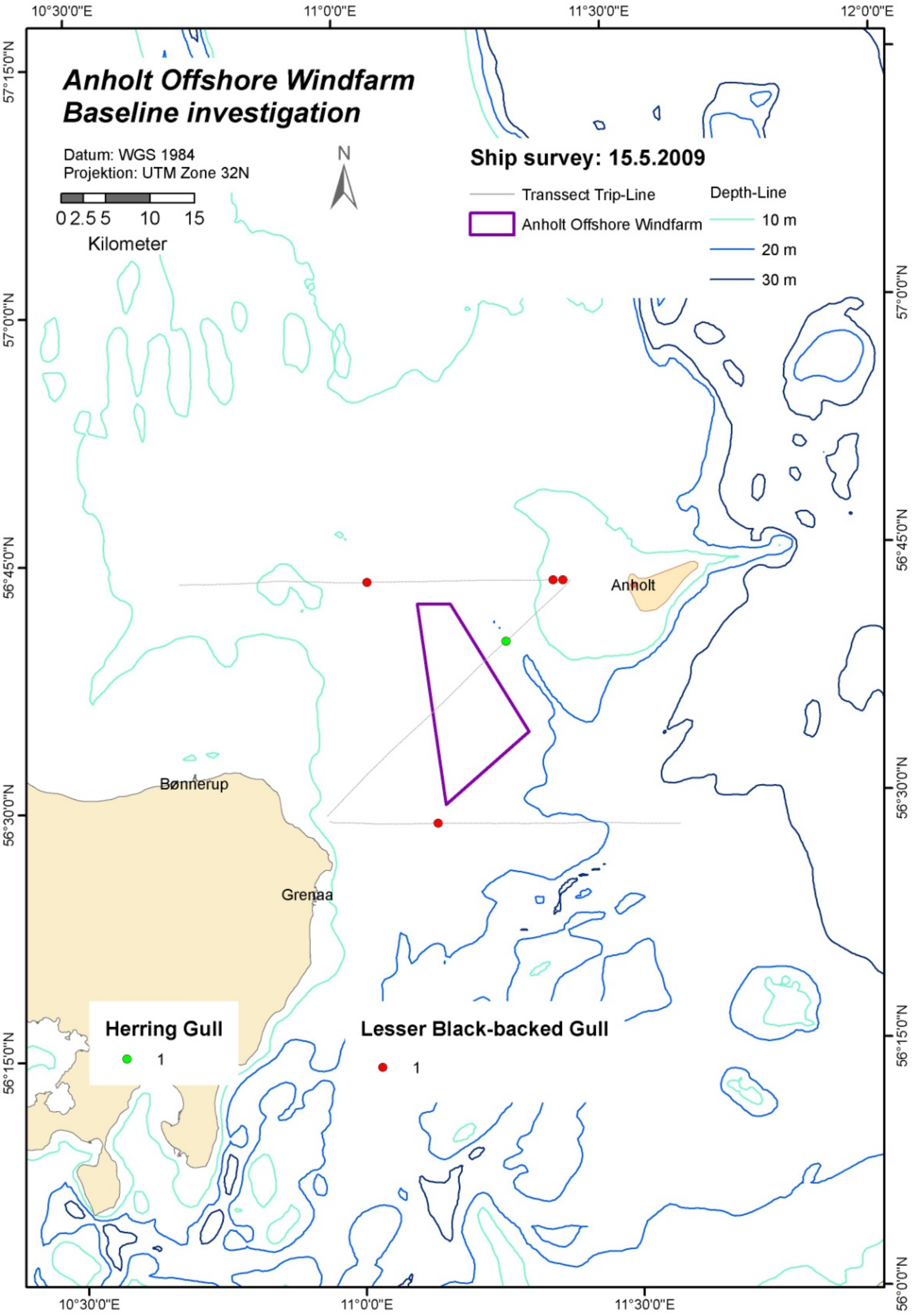
56°30'0"N
56°15'0"N
56°0'0"N



Anholt Offshore Windfarm
Baseline investigation
Datum: WGS 1984
Projektion: UTM Zone 32N
0 2.5 5 10 15
Kilometer
N
Ship survey: 15.5.2009
Transsect Trip-Line
Anholt Offshore Windfarm
Depth-Line
10 m
20 m
30 m
Anholt
Bønnerup
Grenaa
Herring Gull
1
Lesser Black-backed Gull
1
10°30'0"E
11°0'0"E
11°30'0"E
12°0'0"E
57°15'0"N
57°0'0"N
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56°30'0"N
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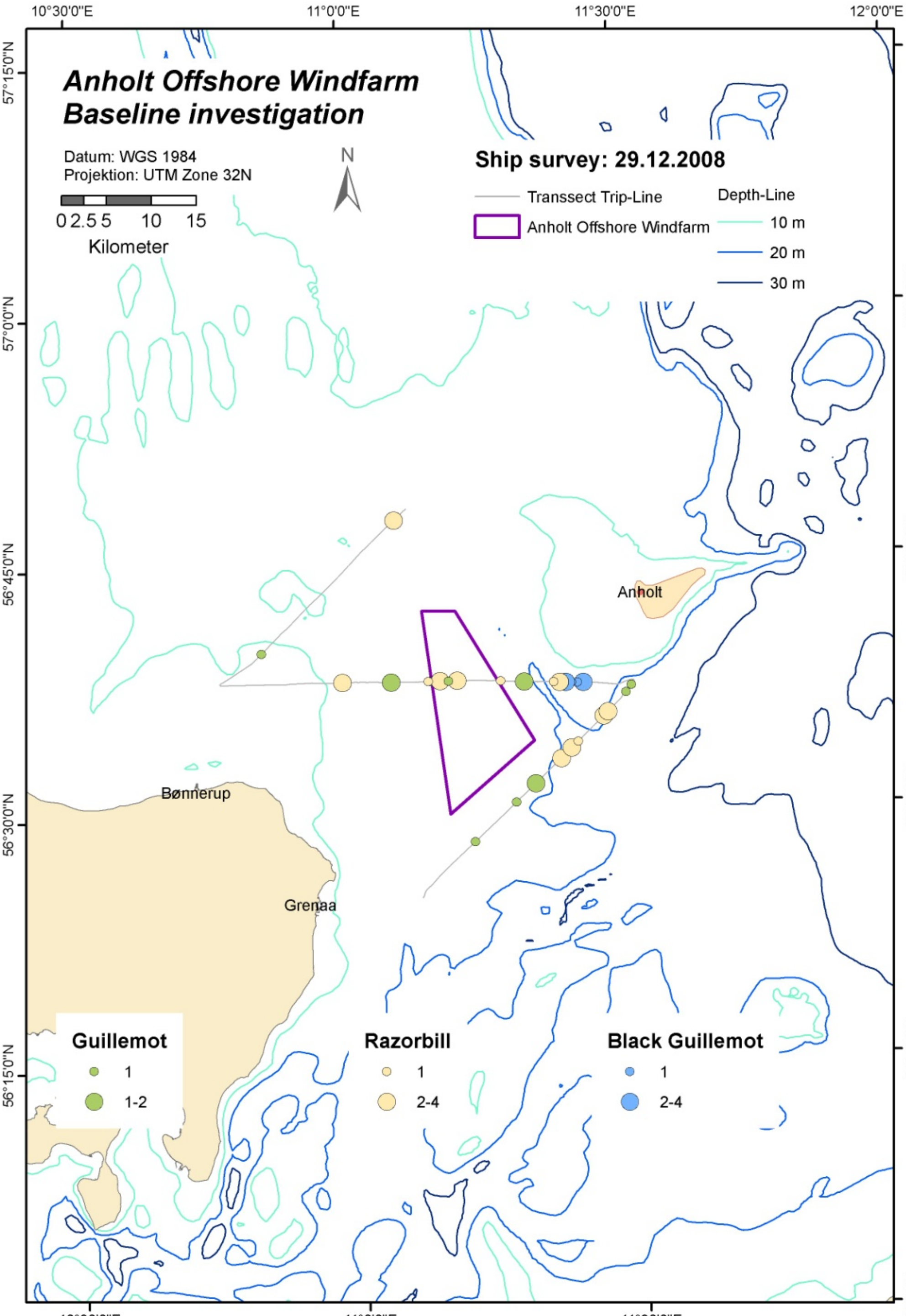
56°0'0"N



10°30'0"E
11°0'0"E
11°30'0"E
12°0'0"E
57°15'0"N
57°0'0"N
56°45'0"N
56°30'0"N
56°15'0"N
56°0'0"N
Anholt Offshore Windfarm
Baseline investigation
Datum: WGS 1984
Projektion: UTM Zone 32N
0 2.5 5 10 15
Kilometer
N
Ship survey: 29.12.2008
Transsect Trip-Line
Anholt Offshore Windfarm
Depth-Line
10 m
20 m
30 m
Anholt
Bønnerup
Grenaa
Guillemot
1
1-2
Razorbill
1
2-4
Black Guillemot
1
2-4

Appendix 4 Goodness of Fit Tests for applied spatial models

Species	**Survey platform**	**Period**	**Goodness of Fit Method**	**Df**	**Value**	**Value / Df**
Red-throated/Black-throated Diver (Gavia stella/arctica)	Aircraft	Baseline 2008-2009	Scaled deviance	211	431.76	2.05
Red-throated/Black-throated Diver (Gavia stella/arctica)	Aircraft	Baseline 2008-2009	Pearson Chi^2	211	775.74	3.68
Red-necked Grebe (Podiceps grisegena)	Ship	Baseline 2008-2009	Scaled deviance	119	63.92	0.54
Red-necked Grebe (Podiceps grisegena)	Ship	Baseline 2008-2009	Pearson Chi^2	119	105.34	0.89
Common Eider (Somateria mollissima)	Aircraft	Historical data by NERI 2000-2008	Scaled deviance	331	7480.05	22.6
Common Eider (Somateria mollissima)	Aircraft	Historical data by NERI 2000-2008	Pearson Chi^2	331	13178.80	39.82
Common Scoter (Melanitta nigra)	Aircraft	Historical data by NERI 2000-2008	Scaled deviance	330	9520.71	28.85
Common Scoter (Melanitta nigra)	Aircraft	Historical data by NERI 2000-2008	Pearson Chi^2	330	20519.13	62.18
Common Scoter (Melanitta nigra)	Aircraft	Baseline 2008-2009	Scaled deviance	223	128.65	0.58
Common Scoter (Melanitta nigra)	Aircraft	Baseline 2008-2009	Pearson Chi^2	223	184.94	0.83
Common Scoter (Melanitta nigra)	ship	Baseline 2008-2009	Scaled deviance	123	16452.37	133.8
Common Scoter (Melanitta nigra)	Ship	Baseline 2008-2009	Pearson Chi^2	123	64637.79	525.51
Velvet Scoter (Melanitta fusca)	Aircraft	Baseline 2008-2009	Scaled deviance	223	88.01	0.39
Velvet Scoter (Melanitta fusca)	Aircraft	Baseline 2008-	Pearson Chi^2	223	106.38	0.48

		2009				

Species	**Survey plat-form**	**Period**	**Goodness of Fit Method**	**Df**	**Value**	**Value / Df**
Long-tailed Duck (Clangula hyemalis)	Aircraft	Baseline 2008-2009	Scaled deviance	215	22.65	0.11
Long-tailed Duck (Clangula hyemalis)	Aircraft	Baseline 2008-2009	Pearson Chi^2	215	171.64	0.80
Black Guillemot (Cepphus grylle)	Ship	Baseline 2008-2009	Scaled deviance	121	124.00	1.02
Black Guillemot (Cepphus grylle)	Ship	Baseline 2008-2009	Pearson Chi^2	121	124.00	1.03