OSPAR COMMISSION

Report of the OSPAR Workshop on research into possible effects of regular platform lighting on specific bird populations

Offshore Industry Series

2012

OSPAR Convention

The Convention for the Protection of the Marine Environment of the North-East Atlantic (the "OSPAR Convention") was opened for signature at the Ministerial Meeting of the former Oslo and Paris Commissions in Paris on 22 September 1992. The Convention entered into force on 25 March 1998.

It has been ratified by Belgium, Denmark, Finland, France, Germany, Iceland, Ireland, Luxembourg, Netherlands, Norway, Portugal, Sweden, Switzerland and the United Kingdom and approved by the European Union and Spain.

Convention OSPAR

La Convention pour la protection du milieu marin de l'Atlantique du Nord-Est, dite Convention OSPAR, a été ouverte à la signature à la réunion ministérielle des anciennes Commissions d'Oslo et de Paris, à Paris le 22 septembre 1992. La Convention est entrée en vigueur le 25 mars 1998.

La Convention a été ratifiée par l'Allemagne, la Belgique, le Danemark, la Finlande, la France, l'Irlande, l'Islande, le Luxembourg, la Norvège, les Pays-Bas, le Portugal, le Royaume-Uni de Grande Bretagne et d'Irlande du Nord, la Suède et la Suisse et approuvée par l'Union européenne et l'Espagne.

Acknowledgement

This report has been prepared by Andrea Weiss (Germany) and Sandra Van der Graaf (the Netherlands), Dick Stoppelenburg (Netherlands) and Hans-Peter Damian (Germany) as organisers of the workshop, with support from the OSPAR Secretariat.

Contents

Opening and Representation at the meeting

The workshop was held at the premises of the OSPAR Secretariat in London. It was organised by Dick Stoppelenburg (Netherlands) and Hans-Peter Damian (Germany).

The meeting was chaired by Sandra van der Graaf (Netherlands) and welcomed the support by an expert core group consisting of:

- Ommo Hüppop (Institut für Vogelforschung, Inselstation Helgoland, Germany), specialist in avian migration and involved in research on effects of lighting of marine constructions on birds;
- Dimitry Kishkinev (Carl von Ossietzky Universität, Oldenburg, Germany), specialist in magnetic field orientation of migrating birds;
- Graham Martin (Centre for Ornithology, University of Birmingham, UK), specialised in bird visions and involved in all aspects around effects of lighting on migratory birds and best mitigation practices.

The meeting was attended by representatives from the following:

a. Contracting Parties: Germany, Netherlands and the UK;

b. Non-Governmental Observer Organisations: International Association of Oil and Gas Producers (OGP), Association Robin des Bois, Seas at Risk, World Wide Fund for Nature (WWF).

and by invited experts.

Adoption of the Agenda

The draft agenda was adopted without amendment.

In considering the terms of reference for the workshop and an explanatory note specifying the tasks of the workshop, the meeting noted that

a. effects of artificial light sources at night on migrating birds is a phenomenon not only linked to oil/gas platforms but also to other illuminated offshore sources such as windfarms and ships which all contribute to light pollution at night. Associated research was relevant for all sources, including offshore platforms. The meeting therefore agreed to refer in the following more generally to human-made offshore constructions;

b. artificial light sources at night could have impact on other marine taxa and ultimately on the marine ecosystem. While there is a need to consider such impacts in the context of broader ecosystem assessments, the workshop limited itself to the question of the effects of artificial light sources at night on migrating birds.

Review potential impact of conventional illumination of offshore oil and gas platforms in the North Sea on migratory bird populations

Mr Leo Bruinzeel presented the study prepared for the Netherlands' Government on the impact of conventional illumination of offshore platforms in the North Sea on migratory bird populations. The study is based on (published) field data and lighthouse studies concerning behaviour of birds which are migrating at night in response to illumination of offshore platforms which can lead to fatal collisions with platforms, and on modelling to estimate the probability of species-specific mortality. The study highlights a number of uncertainties due to lack of data and knowledge and this required a series of assumptions. Considerable uncertainties are associated with estimating mortality and its significance. One reason is that estimates of mortality at human-made structures are imprecise although upper and lower limits can be determined. Another reason is that there are gaps in our understanding of: nocturnal bird migration over the North Sea; the fact that volumes of birds from particular populations migrating across the North Sea can vary year-on-year; the definition of reference population; the difficulty to link species-specific casualties with geographically separated breeding sites; and a threshold to judge whether there is an effect at the level of populations. The study considered the group of bird species which have populations that annually migrate across the North Sea in large numbers. The study used a rule of thumb of an additional mortality of more than 1% of the natural mortality of the reference population as a threshold for defining a deleterious effect at the level of populations.

bis WWF emphasised the so-called 'Cork Ecology Study'[1], referred to in the Netherlands' study, for which field data had been collected by a large community of ornithologists in the UK. All species found to be attracted in high numbers in the British Waters faced high impacts in the Netherlands's study (exceeding the 1% mortality threshold by a factor between 10-28x in a worst case scenario). The Netherlands' study confirms that species composition, numbers of species involved and risk factors in Dutch waters are in general applicable in the whole North Sea Region. The Cork Ecology Study also found cases where juveniles seem to be more attracted to artificial light than adult birds.

The meeting welcomed information on the recent publication Ballasus, Hill, Hüppop (2009), Artificial light as threat for birds and bats and encouraged Germany to have this publication translated into English to share it with the wider research community.

Behavioural response of migratory birds to light at night

In the discussion of the behavioural response of migrating birds to light at night, the meeting noted the following scientific clarifications:

a. Birds are attracted to all kinds of light sources (*e.g.* isolated point sources, pools of extended light, steady and flashing light) at night. Permanent light has shown to attract more migrating birds and result in higher impacts than flashing lights. The workshop's discussion on mitigation should focus on clustered lights which create permanent pools of light;

b. Response of birds to illuminated coastlines is unclear. There is some observation that some populations use the coast as guidance line during the night, once they have crossed the barrier of the sea. There is also evidence from North America of birds colliding with land-based illuminated skyscrapers and lighted telecommunication towers. There is good historic evidence that birds were attracted to light houses which employed rotating beams of light which created a continuously present pool of light. The workshop's discussion should focus on illuminated human-made offshore structures;

c. Migrating birds are also attracted to light sources under good visibility conditions, but with headwinds. Little is known about the behaviour of individual birds which could help explain this. One possible explanation offered is that, in contrast to poor visibility conditions which are associated with attraction to light sources, birds consider the platform as a safe haven. This is subject for research. The workshop's discussion should be limited to conditions of poor visibility leading to the attraction of birds to illuminated platforms which is by far the most important cause of migratory bird mortality in the North Sea;

d. Available laboratory tests under controlled light conditions and field studies do support conclusions that light at certain wavelengths interferes with the magnetic compass

[1] *Barton & Pollock* (2009), Study to evaluate the significance of impact of UK offshore installations on migratory birds, Cork, Ireland, January 2009. Cork Ecology, www.corkecology.net.

orientation of migratory birds. There should be caution to generalise the laboratory results to the field situation of birds on their migration route. Knowledge about the wavelength-dependent light attraction needs more investigation in both field and laboratory trials;

e. The main cause of death as a result of light-attraction is the collision with the structure, not exhaustion due to poor body condition of those attracted to the light source. Birds which are attracted to these light sources at night typically circle around the illuminated platform for extended periods of time (sometimes many hours) and it is this circling which increases the risk of collision leading to traumas and deaths. Moreover, some observations suggest that long circling might result in birds interrupting their migration. This latter aspect is subject for research.

Estimation of bird mortality

In the discussion of the estimation of bird mortality, the meeting noted that the model used in the Netherlands' study was based on 30 night observations by one person over 10 years at several platforms in the Dutch part of the North Sea. A worst-case scenario suggests a death toll of 60 000 birds at one platform per year; a total of 100 platforms might take a toll of 6 million birds annually. Of the 120 species observed at North Sea platforms, 72 species have been recorded as attracted to an illuminated platform at night, and of these 58 species are prone to collision risks with illuminated platforms. Highest numbers of killed birds are distributed among only a few species (four species of thrushes provide 75% of the victims, further 22% of the victims are robins, skylarks and common starlings). The model results strongly resemble (published) field data on species composition of birds crossing the North Sea and studies of birds attracted to light houses (e.g. Netherlands, UK, DE, Baltic).

In the discussion, the meeting noted that some participants challenged the model results on the ground of the limited data used and their extrapolation to the Greater North Sea, and that they did not provide sufficient evidence for any conclusions. They advised that further evidence is required to demonstrate the magnitude of mortality. Other participants challenged the call for further field data as this required automatic registration of birds over a long period of time to build up relevant time-series and tracing birds on their migration routes. These are not trivial tasks.

The meeting noted observations on the German research platform FINO 1: Some 1000 collision victims were collected in slightly more than six years (i.e. on average 160 birds per year). A conservative and simple estimate of 200 collision victims per year per platform (noting that many victims are lost to the sea) results in an estimate of a minimum of more than 120 000 birds per year at the 600 offshore platforms in the North Sea.

Effects at the level of populations

A 'population' has various definitions within ecology, one principle definition that the group thought appropriate for its discussions is 'a group of organisms of the same species occupying a particular space at a particular time'.2 In the discussion of effects at the level of populations, the meeting noted differences in views and practical difficulties about defining a reference population for the purpose of effects of lighting of offshore constructions on migrating birds and the feasibility of estimating effects at population levels. There was no unanimity at the meeting over the most appropriate definition of the reference population:

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[2] Source: *Krebs, C.J.* (1978). Ecology, the experimental analysis of distribution and abundance. Harper & Row publishers.

a. for the purpose of the Netherlands' study, 'population' was defined as the population size of those birds in each species which cross the North Sea annually on their migration. The population used for calculating the background mortality was the North-West European population. When calculating the species-specific mortality, the annual species-specific survival rate and basic life-history trade-offs were taken into account. The study compared the estimated mortality against a rule of thumb of 1% of the background mortality of the study population. A worst case scenario suggests that collision and death at North Sea platforms for 49 species is above an additional 1% of the natural mortality. Of these, the threshold is exceeded for 11 species by a factor of 20, and for 13 species by a factor 10-20;

b. some participants argued that mortality should be considered for specific biological populations in the North Sea region through considering their demographic structure. This meant that recruitment and natural mortality needed to be taken into account in an equation with estimated collision-based mortality in order to determine whether the population is sustained despite the loss of individual birds or whether collision-based mortality has negative effects on the population. In the absence of any such data, namely under the aspect of density-dependent effects, no statement can be made about significant or even potential effects at the level of populations;

c. some participants emphasised that it is not always necessary to consider the impact at the level of populations before action is required. Other regimes such as planning laws and EIAs do not only require assessments at local level of populations but also at the level of individual bird mortality.

In the discussion, the following main views were noted:

a. there is no definition of 'population' in OSPAR and it is not clear from the question put forward by OIC how 'population' should be understood in the given context;

b. there are different valid approaches for defining a 'population' (e.g. geographically, biologically, legally) and different spatial scales for determining a 'population'. For example, the study used a geographic definition in relation to the North Sea for calculating the collision mortality whereas some participants considered the use of the demographic population definition in line with the EU Birds-Directive as a requirement;

c. it is difficult, if not un-feasible, to define the geographic breeding population for most individual birds crossing the North Sea and to undertake an assessment of their demographic structure. Even if such an assessment could be made for one population, the result couldn't be extrapolated to other populations or times of deviating ecological conditions;

d. the threshold of 1% exceeding natural mortality is arbitrary but has a precedent in that it is used as a "rule of thumb" e.g. under the EU Birds Directive for considering population decreases due to human activity (e.g. hunting) to be unsustainable. Further consideration should be given to other thresholds for determining the significance of the effect on the population;

e. without further investigation into populations, knowledge on vulnerable bird species is of sufficient confidence to allow the following expert judgement, noting that as those birds are rare there are fewer collisions with human-made structures[3]:

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[3] *Garthe & Hüppop* (2004). Scaling possible adverse effects of marine wind farms on seabirds: developing and applying a vulnerability index. J. Appl. Ecol. 41: 724-734.

(i) it is more likely that kills of migratory bird species that are classified nationally or internationally as ‘threatened’, ‘declining’ or ‘endangered’ may have a negative effects on their populations;

(ii) it is more likely that kills of large, long-lived, slowly reproducing bird species may have a negative effect on their populations;

f. for other species than those referred to in (e) above, it is not possible, on the basis of currently available information, to make a statement in relation to effects at the level of demographic populations.

Conclusions and advice to OIC 2012

Based on the above discussion and considerations, the meeting noted that over 60 million birds of different species migrate across the North Sea at least twice a year or use the Greater North Sea (OSPAR Region II) as feeding and resting area. The meeting concluded that:

a. migratory birds are part of the biodiversity in the OSPAR area and are protected by **various national, European and international laws and conventions. The migratory** behaviour is an essential part of their natural life cycle;

b. birds migrate (species-dependent) both by night and at day. Migration takes place year round and there are passage peaks mainly in autumn and spring;

c. birds (species-specific) can become attracted to offshore light sources, especially in deteriorating weather conditions which result in restricted visibility (e.g. low clouds, mist, drizzle);

d. this attraction can be fatal and may involve large numbers of individuals of many species of birds;

e. there is sufficient evidence to confirm that conventional lighting of human-made offshore structures has impact on large numbers of birds. Evidence is, however, not sufficient to conclude that there is an effect on populations, nor is there evidence to exclude such population effects;

f. the North Sea harbours a substantial number of illuminated human-made offshore structures (oil/gas platforms, windfarms, ships) which is increasing. The cumulative effect on birds may grow.

In response to the question defined by OIC *“Could regular platform lighting result in potential significant impact on specific bird population(s)?”* the meeting agreed to advise OIC 2012 of the conclusions above and that:

a. the model calculations present the best knowledge currently available. Although the power of models and the data can be improved, it is not likely that this will augment the evidence given in the short term. There is however opportunity to improve the evidence base;

b. it is unlikely that sufficient evidence on species-specific demographic population effects will become available to clearly demonstrate that effects are significant at the level of populations in the near future. In light of this, the meeting advises OIC to consider the available evidence in light of the precautionary principle;

c. OIC may wish to note:

(i) estimates of some hundred thousands of migratory birds that are expected to die annually in collision with illuminated human-made offshore constructions and the negative public perception associated with this (see sub-§ 'e' in second paragraph under section 'Effects at the level of populations' above);

(ii) some species are more vulnerable than others (see sub-§ 'e' and 'f' in second paragraph under section 'Effects at the level of populations' above);

(iii) possible cumulative effect of the steadily increasing numbers of illuminated human-made offshore constructions;

(iv) commitments under national laws of OSPAR Contracting Parties that include protection of individual birds and not only the protection of birds at the level of populations.

Exchange of best practices and options for advancing theoretical research

The meeting noted that the description of the objective of the workshop was directed towards options for theoretical research. The meeting agreed that this request should be expanded to any research activity that might be helpful in taking the topic forward.

The participants were invited for a poster session and brainstorming on options to address mitigation, best practices and gaps in knowledge.

In the discussion, it was noted that birds attracted by light of oil platforms at night were not only at risk of collision with the offshore structures but also of flaring. The meeting noted the view of some experts that avoidance of flaring at the time of peak passages of birds should be taken at the same time as measures to reduce attraction by light. Some other experts were of the opinion that consideration of flaring was outside the scope of the workshop and should not be included in options for measures.

Mitigation

Following discussion of mitigation measures, the meeting agreed to advise OIC that there is a need for a paradigm shift towards considering: 'Are all lights needed at all time on the platform?' The meeting agreed to advise OIC of the following suite of possible actions:

As a first step:

a. reduce light at night in number and intensity as far as possible;

As subsequent steps:

b. reduce impact of necessary light as far as possible through:
    - change of the light spectrum;
    - intermittent light (i.e. change to flashing lights);
    - shielding;

c. switch lighting on platforms to least harmful regimes when radars or any other observations detect highest probability for collisions (e.g. peak of passage and low visibility). There is good practice in place for the operation of windfarms onshore from which we can learn: Some are switched off for short periods of time at events of high risks of collision with migrating birds. It is emphasised that a significant reduction of light levels (i.e. emergency lighting, switching lights off) is a measure limited to a relatively short period of time (e.g. until birds disperse from the platform which is usually within an hour) to respond to specific situations of high risks of collision (poor visibility, at peak of migratory period).

In addition to the steps described under section 'Mitigation' , the meeting agreed to advise OIC of other possible measures that may be considered:

a. that licensing of new platforms should ensure that the construction design builds in flexibility for technical change concerning use of different lighting regimes;

b. to install bird movement and weather monitoring systems on platforms and further develop bird migration forecast systems;

c. that any mitigation taken needs to be accompanied with research and monitoring;

d. that environmental impact assessments should take into account impacts on migratory birds;

e to recommend to OSPAR 2012 to keep track of innovations in human navigation (e.g. aviation, shipping) with a view to making use of such innovations which also benefit migrating birds e.g. through avoiding light or reducing its impacts on migrating birds;

f to recommend to OSPAR 2012 that 'darkness' should be considered as a natural value of the North-East Atlantic.

Examples of best practices

The meeting agreed to include examples of best practices in the written procedure for the adoption of the summary record. Therefore, paragraphs 3.7 and 3.8 below summarise the contributions on best practices received after the meeting.

There are a number of examples from offshore platforms and other industries aimed at reducing lighting impacts on migrating birds:

(a) shield lights such, that they illuminate only the area for which it is meant;

(b) reduce quantity and intensity of light;

(c) change from steady light to blinking/flashing light; the longer the dark, the shorter the light, the better;

(d) better use of light with short wavelength and of narrow spectrum, e.g. avoid white light;

(e) switch lighting off at crucial times;

(f) operate observation tools to detect probability for collisions.

However, there may be practical and safety considerations that need to be taken into account.

In the following, examples of best practices and their effectiveness to mitigate lighting impacts and its negative effects on migratory birds are compiled in relation to the mitigation measures at second paragraph above as follows:

Ad (a) and (b) The new lighting regime of RWE Dea oil platform *Mittelplate* in the German Wadden Sea shows a significant reduction of light emissions while maintaining all safety standards.[4]

[4] http://www.rwe.com/web/cms/en/688976/mittelplate/home/safety-and-environmental-protection/lightning-concept/

Ad (c) Light houses which have changed from steady light to blinking light and observed reduced impact on birds; the same holds for light houses where light beams were reduced in intensity or width.[5] The light regime of the *Öresund Bridge* was changed after a mass collision in October 2000 affecting some 1000 birds. Since then, no mass collision has been observed.[6] A study in the US showed that communication towers lit at night with only flashing lights were involved in significantly fewer avian fatalities than towers lit with other systems (http://docs.darksky.org/Reports/Communication-tower-lights-and-avian-collisions.pdf).[7]

Ad (d) The NAM green lighting research project tested new spectrum lamps following mass attraction of birds to lighting of North Sea platforms during cloudy/foggy weather.[8] A second research is expected to be published soon (2012). A short test with newly developed blue/green lighting showed that fewer birds were trapped around the platform. The examples shows good practice of R&D-based development and change of the conventional platform lighting regime by multiple parties cooperation (including NAM, scientists, lamp supplier in the chain).

Ad (e) and (f) To minimise collision of migratory birds with rotating blades of land-based wind turbines under certain weather conditions and at certain times of the year when birds cross the Strait of Gibraltar, mitigation has been developed in southern Spain and Portugal to stop the rotation of turbine blades at times of high collision risk.[9] When to stop the rotations of the blades is determined

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5 Substitution of constant light by blinking bluish light: *Baldwin, D. H.* (1965). Enquiry into the mass mortality of nocturnal migrants in Ontario. The Ontario Naturalist, Vol 3(1): 3-11. Longer dark and shorter light phases lead to less collisions: *Ballasus, H.* (2007). Vogeltod an Leuchttürmen: Welche Relevanz haben 100 Jahre alte Daten für die aktuelle Offshore-Forschung? Vogelwarte, 45: 307-308. Narrower less powerful beam leads to less collisions: *Jones, J., C. M. Francis* (2003). The effect of light characteristics on avian mortality at lighthouses. Journal of Avian Biology, 34: 328-333. Further reading: *Martin, G.R*. The visual problems of nocturnal migration, in: Gwinner, E. (editors). Bird Migration: Physiology and ecophysiology. 185-197. 1990, Berlin, Springer-Verlag. *Martin, G.R*. Birds at Night. 1990, London. T & A D Poyser.

6 *Nilsson, L., M. Green* (2009). Bird strikes with the Öresund Bridge (in Danish with English Summary). Rapport 2001, Lunds Universitet, Sweden, Unpublished report. N*ilsson, L., S. Henningsson, R. Strandberg, M. Green* (2009). Bird migration at the Öresund Bridge. Report on field and radar studies 2008. Unpublished report.

7 Further references to US studies on towers and onshore windfarms: Blinking light is less attractive to birds than steady light: *Gehring, J., P. Kerlinger, A. M. Manville* (2009). Communication towers, lights, and birds: successful methods of reducing the frequency of avian collisions. Ecological Applications, 19 (2): 505-514. *Kerlinger, P., J. L. Gehring, W. P. Erickson, R. Curry, A. Jain, J. Guarnaccia* (2010). Night migrant fatalities and obstruction lighting at wind turbines in North America. . The Wilson Journal of Ornithology , 122 (4): 744-754.

8 Cf. e.g. *Poot, H., Ens, B.J., de Vries, H., Donners, M.A.H., Wernand, M.R., Marquenie, J.M.* (2008). Green light for noturnally migrating birds. Ecology and Society 13(2): 47. [online] URL: http://www.ecologyandsociety.org/vol13/iss2/art47/

9 See recent conference held in Jerez: *I Congresso Iberico sobre Energis eolica y Conservacion de la fauna* (January 12th – 14th 2012) (http://www.energiaeolicayfauna.org/) with the following presentations: *Methods of monitoring raptors and reducing their risk in wind farms: a review* by Ricardo Tome (Strix Lda); *How to achieve zero mortality of soaring birds at a wind farm* by Ricardo Tome (Strix Lda); *DT Bird: a self-working system developed to detect flying birds and to take programmed actions linked to real-time bird detection* by Agustin

by monitoring the passage of birds in the vicinity of the wind farms. This is achieved through either (1) direct observations of birds (concentrated at times of predicted bird passage) or (2) using a radar system to detect birds and either set an automatic trigger or have an observer request turbine shut-down based upon their observation of the radar tracks. These procedures work very well and mortality rate of migrating birds due to collisions with wind turbines have been significantly reduced. For example, at the Barão de S. João coastal wind farm in Southwest Portugal, the wind farm obtained zero mortality of the critically endangered griffon vulture in two complete migration seasons in 2010 and 2011, due to the shut-down measures, despite 40.000 recorded bird movements through the wind farm area per year.[10] Similarly in Texas, USA, radar systems prevent fatal collisions by detecting approaching birds and analysing weather conditions. Shut-down of the wind farms is enabled automatically if bad weather hits in peak migration times.[11] These examples of good practice combine precautionary management through radar and visual surveillance with shut-down-on-demand technology.

There are also examples of good practices in the cooperation between governments, industry and NGOs to help developing better knowledge and technologies to mitigate negative impacts of lighting on migratory birds.[12]

Gaps in knowledge

In light of the gaps in knowledge identified, the meeting agreed to advise OIC as follows:

a. to bolster future quantifications, the power of the models should be increased through more empirical data as a basis for assumptions and to feed the models. This includes that:

   (i) future model estimates should be based on data for the relevant demographic populations involved. This includes information on the origin of birds migrating across the North Sea and being killed at platforms, and the population structure of those birds;

   (ii) estimates of mortality should be enhanced through empirical quantification of species-specific bird mortality at platforms, including estimates of carcasses lost to the sea or to scavengers;

b. migration routes and birds behaviour in relation to light attractions have been studied.[13] To evaluate the impact of light and the associated effects on bird populations and to take efficient mitigation measures, there is a need to further improve the understanding of:

Rioperez (DTBird Bird Detection and Dissuasion), *Merlin Radar-SCADA system implementation mitigating risk situations of bird collision in wind farms* by Sandra Villar Sagredo (Toquero Renovales S L), *Bird mortality at wind farms: distribution of fatalities and active mitigation measures* by Antonio-Roman Munoz (Fundacion Migres)

10 http://www.youtube.com/watch?v=5gUXeJ_i5kQ&feature=related

11 http://www.guardian.co.uk/environment/2009/may/01/wind-farm-bird-radar.

12 E.g. the research and development project of BARD developed new technology for reduction of underwater noise during pile driving in order to meet the governmental standard for pile driving for new offshore windfarms. The example shows how a relatively strict standard put forward by the government towards the offshore wind industry caused an incentive to invest in R&D and to start a project with cooperation of governments, industry and NGOs and the NAM project mentioned above in paragraph 3.8.

(i) the bird migration across the North Sea in space and time and the causes of light attraction;

(ii) the attraction range of platforms (dependent on light intensity, wavelength, and bird species);

(iii) the energetic costs for birds that are delayed at platforms, using relevant estimation methods, for example based on their weight at the start and end of their migration;

(iv) avoidance of areas by water birds that are resting and foraging in the area as result of light during night.

Conclusions of the meeting

The conclusions of the meeting (agenda items 2 and 3) and recorded discussion under agenda item 2 were adopted at the meeting on 20 January 2012. The summary record was finalised in written procedure.

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[13] E.g. *Wernham, C. et al.* (2001). The Migration Atlas; Movements of the Birds of Britain and Ireland. T&AD Poyser, London. *Alerstam, T.* 1990. Bird Migration. CUP, Cambridge. *Berthold, P.* 2001. Bird Migration: A general survey. OUP, Oxford

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