

GENERAL OUTLOOK

Our first observation is that excellent progress has been made in the environmental monitoring programmes since our previous full review in March 2002. There is no doubt that the research being carried out is world-leading science that is internationally recognised and is increasingly being watched, and used as a model, by the many nations now embarking on the establishment of marine wind farms, from neighbours in Scandinavia to the USA. We encourage the continuation of these programmes, and all of the comments we make in this report are of a relatively minor nature in the context of a very effective ongoing programme.

The panel recognises that many of its previous recommendations have been incorporated into the Environment Group's recommendations for environmental monitoring programmes 2003-2006 and welcomes this. We feel that the changes that have been implemented have strengthened the overall programme, but we are aware that the basic philosophy of all of the monitoring is to use a BACI approach. By its very nature, a BACI design requires complete comparability of methods between the 'before' and the 'after' phases of the data collection. We therefore would wish at this stage to avoid recommending changes to the programme that would detract from this comparability. This issue also arises as a result of current research experience and learning by researchers and new technological developments. It is clear that in many cases researchers can improve their data collection by modifications of methods. While we would wish to see the best possible science being carried out, it is implicit in the BACI approach that data gathering should be directly comparable to previous 'background' data collection. Any development of new technology or methodology should only be introduced if it can be clearly established that 'new' data can be compared rigorously with established data. The main focus must be before-after comparison to measure impacts of the wind farms, rather than a systematic change generated by the adoption of 'improved' methodologies that may obscure the BACI objective.

We suggest that there may be considerable value in holding research workshops focused on specific topics where gathering researchers from a variety of countries may help to introduce best practices and standardised approaches. Given the plans of many EU states to establish marine wind farms, it may be appropriate to share expertise and costs and avoid duplications of effort. Recognising the major financial input by Denmark, and the fact that marine wind farms are now being developed internationally by many European countries, we would encourage efforts to develop international collaborations to take forward particular parts of the current programme beyond 2006.

We perceive a longer term additional need to consider cumulative impacts of multiple developments of marine wind farms in several adjacent countries along flight lines or within a particular habitat. It is not clear how this should best be achieved, and it probably should follow after specific results from the two demonstration wind farms are established, rather than at this relatively early stage.

BIRDS

Recommendations:

- The bird work is generally progressing well, and programmes should be continued as proposed in the Environment Group's recommendations but with the following suggested amendments;
- Consider deployment of more TADS to add to the single camera available at present,
- Consider deployment of TADS at Nysted so that the entire arc of a turbine can be viewed, even if this precludes seeing small birds (passerines), in order to increase the ability to quantify collisions of large birds (such as sea ducks and seabirds),
- Consider deployment of TADS at Horns Rev but as a lower priority to the establishment of collision rates at Nysted,
- Consider the development of alternative methods to detect collisions,
- Consider possible international collaborations in the development of TADS and novel approaches to detecting collisions, including possible sources of additional research funding from other countries or internationally,
- Continue radar observations of the directions of movement of birds and any deflections of path caused by the Nysted wind farm, and implement such observations at Horns Rev
- Continue to develop the GAM approach to measure bird avoidance,
- Continue aerial counts at Horns Rev, including emphasis on diver distributions,
- Examine the possibility that scoter distribution in spring in the areas near Horns Rev wind farm relates to a particular seasonal diet by sampling scoter stomach contents and by forensic markers of diet such as fatty acids and stable isotopes, and by GIS comparisons between scoter spatial distribution and data on spatial distribution of sediment types and/or sandeels (if data are available).

Wind farms might affect birds by increasing mortality rates through collisions, by disturbance of birds from feeding habitat, or by altering the amount of feeding habitat. Large wind farms may also produce a barrier effect, deflecting bird movements away from their intended tracks. Of these potential effects, collision risk is likely to have the greatest long-term impact on bird populations, so requires priority consideration. Birds may learn the hazards presented by marine wind farms, so that impacts may change over time as birds gain experience. This is particularly relevant when considering birds with high adult survival rates such as seabirds and sea ducks, many of which may live for 20 years or more.

Collision risk

The development of a technological solution to observing collisions between birds and turbines has apparently been progressing well since our previous meeting in 2002. The Thermal Animal Detection System (TADS) is about to be tested in the field, after promising controlled trials. However, with the proposed method of deployment, the single camera will view only about one third of the arc of the blades of a single

turbine. Even by selecting the turbine thought most likely to present the greatest risk of collision (probably at the edge of the array, perhaps on the east side), unless the numbers of collisions are remarkably high, this camera is likely to record rather few 'hits'. Last year we stated that a very high priority should be given to the quantification of bird collision rates at demonstration marine wind farms, and we still hold this view.

Because risks appear to be very much higher at Nysted than at Horns Rev, the measurement of collision rate should focus on the Nysted site, but should not ignore Horns Rev, particularly because the species of birds at Horns Rev are very different from those predominating at Nysted. Nevertheless we suggest that consideration should be given to whether it may be better to install the presently available TADS camera at Nysted so that the entire arc of a turbine can be viewed, even if this precludes seeing small birds (passerines), in order to increase the ability to quantify collisions of large birds (such as sea ducks and seabirds).

We also suggest that consideration be given to deployment of more TADS to add to the single camera available at present. We feel that this is such an important part of the overall environmental monitoring that if necessary funding should be taken from lower priority topics to allow two, or even three, TADS to be installed. These, or at least one of these, should be deployed at Horns Rev after the collision rate at Nysted has been established, but the primary focus should be on determining collision rate at Nysted, and then on monitoring variation in collision rate over time (as there is likely to be seasonal variation) and over years (as it is likely that long-lived and social birds may change behaviour over time as they learn about wind farms).

Collision risk is likely to vary according to weather conditions, being higher in foggy conditions. We understand from the presentation and report that the TADS may have slightly reduced capabilities under conditions of low visibility such as fog. Flying birds generate considerable surplus heat from muscular activity, and they need to lose this. They therefore will probably have a much stronger heat signal than an inactive caged bird. We suspect that free-living flying birds will have a warmer (so more visible) signal than a caged domestic bird, so the controlled tests performed probably provide rather conservative assessment of the TADS range and susceptibility to poor conditions.

We support the view that radar studies of bird movements should be continued in relation to assessment of the movement responses of birds to the presence of wind farms and in the assessment of collision risk.

We would encourage consideration of the possibility to make direct observations of the behaviour of birds within wind farms (probably more relevant at Nysted than at Horns Rev) from the viewing platforms available. This could provide a better understanding of how birds move and forage within the wind farm, and how disturbance of birds within the farm may contribute to collision risk (which would complement the studies focusing more on the risk to birds approaching the farm from a distance).

Impacts on the habitat of birds

We are pleased to see the further development of the GAM approach to measure bird avoidance. We recommend continuing aerial counts at Horns Rev, including emphasis on diver distributions. In the analyses carried out so far on the changes in bird distribution we have some reservations regarding the statistical analysis. The analysis of disturbance effects is constrained by the small numbers of birds in the 'experimental' and 'control' areas. This makes finding statistically significant differences difficult. However, change can be quite large. For example, diver numbers fell by a huge percentage but not 'significantly' based on the analysis using a close area, a larger area, and a control area. The interpretation of such comparisons needs to take careful account of the percentage change as well as statistical significance, and should use the spatial scale carefully. It is probably inappropriate to conclude 'the numbers of divers in the wind farm area was not significantly lower during the period of construction'. The number fell from 10 or 11 to 1. This is a huge decrease, and was not 'significant' only because the sample size was so small. The fact that numbers fell significantly (based on Chi squared) from 32 to 2 in the 'Wind Farm plus 2km' area is more reliable as this gives a larger sample size but an equally large negative impact as percentage decrease. In general, use of Chi squared tests may not be appropriate in this analysis, as the test assumes that data are independent – i.e. each bird behaves individually regardless of other birds. Birds are often social and show aggregated distributions. In such cases (most obviously with sea ducks) Chi squared tests based on individual bird numbers are inappropriate.

We note the numerical importance of the scoter population near Horns Rev, and the fact that the scoters apparently move closer to the wind farm area each spring, and that their sensitivity to disturbance is well known. Because of the risk of disturbance to these birds and potential loss of critical foraging habitat during the spring period when sea ducks need to build up body reserves to sustain breeding, we encourage studies to examine the possibility that scoter distribution in spring in the areas near Horns Rev wind farm relates to a particular seasonal diet. This could best be achieved by sampling scoter stomach contents and by forensic markers of diet such as fatty acids and stable isotopes, and by GIS comparisons between scoter spatial distribution and data on spatial distribution of sediment types and/or sandeels (if data are available). A number of internationally known research groups have expertise in fatty acid analysis and in stable isotope analysis to investigate seabird diet, and it would be best for the scoter studies to form links with such groups.

Our suggestion that observations might be made of birds using the area within the wind farm would also be relevant to better understanding the influence of the wind farm on bird habitat. It would be useful to make observations of foraging and resting by birds, given that the immediate area occupied by the farm had (prior to construction) been used by relatively small numbers of birds.

There was some discussion at the meeting regarding the development of techniques to automatically extract counts of sea-ducks from images derived from digital aerial photography. This deserves a follow-up, but is arguably outside the remit of the current windfarm project.

MARINE MAMMALS

Recommendations

- Continuation of the seal telemetry study at both sites with substantial technical additions.
- Continuation of the aerial counts of seals at Nystedt
- Reduced effort regarding the video camera surveys of seals
- Continue surveys on harbour porpoise distribution at Horns Rev
- Continue studies on habitat use by porpoises at both sites
- Discontinue the use of towed T-POD / Replace by towed online hydrofone
- Access and analysis of the acoustic data on the construction noise at Horns Rev
- Measurement of operational noise at both sites for different wind conditions

After having finished the baseline surveys and the monitoring during the construction phase at both sites it is our view that the studies related to the marine mammals should be continued at the high scientific level which has been achieved for most of the aspects covered. Many of the technical and methodological developments along with the sophisticated data analysis will set standards for comparable studies on an international level. The panel felt strongly that an intensive workshop bringing together researchers actively engaged in telemetric studies on marine mammals might be useful at this stage of the investigations in ensuring that the sophistication of devices currently available can be utilised now that the open questions have been well defined. The idea of workshops at this mid-way point of the windfarm project might be explored for other sectors as well.

Based on data presented and discussed during the meeting as well as input from the Environmental Group (document 10 April 2003) the following recommendations can be made regarding marine mammals:

Comments in detail:

Seals:

The telemetry study on harbour seals at Horns Rev has yielded valuable information on the home range of the seals in the Danish Wadden Sea . A first tentative conclusion on the importance of the Horns Rev windfarm area as a less important habitat for the seals seems appropriate, but these data need to be backed by an increased sample size. A special emphasis should be put on tagging adult animals of both sexes as it has been indicated that the home range of these animals is more confined to the offshore areas adjacent to their haul-out sites compared to juvenile and subadult seals.

Even though the telemetry study on harbour seals at Nystedt has been facing logistical problems the data collected up to now indicate that the home range of this harbour seal colony is much more confined i.e. "local" than for the North Sea seals. The question of the windfarm as a potential feeding habitat remains unanswered and should be investigated in more detail. The main problem seems to be that it is not

possible to draw reliable conclusions on the habitat use of the seals at both sites due to the limited resolution of the dive data. So far the results will not allow critical analysis of the underwater behaviour of the animals. Also there is an unavoidable sensitivity of the satellite data towards being biased by the positional data gathered during the haul-out periods. Nevertheless the identification of feeding behaviour as compared to travelling and resting is crucial in order to identify the critical habitats of the seals. A combined use of the suggested new GPS/GSM tag with a specially designed data logger for seals would provide the necessary information and sample data at a high resolution which can directly be linked to the the habaitat use by the seal by using dead-reckoning analysis. Until both devices (satellite transmitter and datalogger) are incorporated into one unit a simultaneous should be considered for the telemetry studies at both sites. Then even after the windmill have been put into operation by now it would be possible to evaluate in which manner the animals are using both sites. A BACI analysis could still be conducted to some extent if the new GPS/GSM tag can also be sucessfully tested in combination with a tag of the type used up to now. Deployment of the improved tags might make strict application of the BACI approach tenuous, but even so it will still be possible to draw a conclusion in a positive direction as to whether or not the windfarm site is being used by the seals in the operational phase .Quantification of seal usage of the windfarm site depends on recording underwater activity and this feature requires modification of the program. It has been recognised that the combined use of two tags will induce a stronger behavioural effect on the tagged animals but assuming that suitable seals can be caught it is considered to be worthwhile to use a double-tag approach until a combined unit is available. Due to the logistical problems regarding the seal catch at Rodsand a goal of a minimum of 5 animals to be tagged in this area should be set for 2003/2004. These 5 animals should all be adult animals in order to confirm the supposedly more "local" habitat use of these animals in comparison with the west coast seals.

The video camera observations at Rosand have been a valuable tool to assess the effect of the construction and the comissioning of the windmills. After this status has been established it is not necessary to continue this effort at the same intensity as neither a diurnal activity pattern nor short term changes in the occurrence of harbour seals at Rodsand is crucial for assessing the impact of the windmills on these animals. It is nevertheless recognized that this approach has a high potential for presenting the monitoring study at Rodsand to the public and for a better appreciation of the environmental efforts connected to the offshore windmill issue in general. A reduced schedule of analysis of the video material is suggested (once per week). Based on good baseline data a higher priority should be given to a continuation of the aerial surveys at Nystedt and the surrounding haul-out sites. This method is the only avenue to assess a potential longterm effect on the use of the Rodsand seal sanctuary by the animals. This approach will also provide information on the seal distribution for the entire area and therefore it will be very beneficial to gather such data as a baseline for future extension plans for the windmill farms around the south of Zeeland. This work should continue unabated until the end of the remit (2005). A compelling benefit of maintaining effort is the potential to compare pup counts from the Baltic to the ongoing TMAP initiative in the Wadden Sea to document the relative well being of the population utilising the windfarm area.

Harbour porpoises:

The distribution surveys at Horns Rev as well as the T-POD studies at both sites have proven to provide good data and should be continued without alterations. The panel was impressed with the progress made since our last meeting and is confident that the methods followed will answer the basic questions. In particular, we were impressed by the power of the analysis showing that the impact of construction noise differed between the two sites. Highlighting the effects on mother-calf pairs deserves following up in this data set.

Even though the approach of using an acoustic detection method during the sighting surveys continues to be reasonable in order to increase the detection probability the “towed T-POD” has failed to prove its usefulness. Rather than being excluded from the survey design completely the acoustic methodology should if feasible be modified to employ the commercially available towed online hydrophone systems.

Noise and vibration:

As real baseline data on the acoustic emissions of the type and size of windmills at Nystedt and Horns Rev is lacking so far, it is important to access and analyze the data on the construction noise (at both sites) and subsequently to conduct sound measurements at both sites during the operational phase. In order to obtain sufficient information it should be the goal to measure the background noise level at different wind speeds with and without the windmills in operation. The analysis of the construction noise is crucial in order to assess a potential impact of these emissions on the reference area as compared to the windmill area during that focal period. As the operational noise is assumed to be of low intensity it is nevertheless important to quantify the real detection range and to conduct behavioural studies for the different biota.

A separate experiment to assess the response of the porpoises to the deterring sounds as proposed seems highly rewarding with a view towards establishing general guidelines for mitigation in future construction (or repair) projects.

FISH

Recommendations

- Continue the sand eel surveys at Horns Reef with an equal number of control and impact stations.
- Include monitoring of the hard bottom fish fauna associated with the windmills using diver visual census and DIFRES Research Gill Nets at Horns Reef and Nystedt.
- Resume the fish survey at Nystedt using the general setup from the 2001 baseline study (control and impact) but use Research Gill Nets from DIFRES

in order to improve catches. It should be considered to conduct the survey in autumn to catch fish fry as well larger juvenile and adult fish.

- Continue the study on magnetic fields and fish migration, but consider the possibility of moving the pound nets closer to the cabled

Studies of the effect of offshore windmills on the fish fauna conducted so far have been aimed at creating baselines for the impact studies as well as identifying and developing the proper methodology. Furthermore, preliminary studies of the effect of hard bottom substrate on the fish fauna have been carried out at both Nysted and Horns Reef and has revealed a diverse fish fauna associated.

Several problems have been encountered during baseline surveys, some of which have precluded the use of BACI-designs for statistical tests of the windfarm impact.

Horns Rev

Baseline surveys for sandeel have been carried out, and suggest that four species of sandeel use the area. The density of the sandeels was lower than the density recorded in many other sandeel habitats in the North Sea, however this may be due to annual differences in recruitment and mortality. The baseline surveys should be followed up by surveys during the operational phase of the windmills. These should be modified to make use of an equal number of control and impact stations in order to improve quantification of spatial variation in sandeel density and allow for more powerful tests of the impact hypothesis. More detailed information on the spatial distribution of sandeel in the Horns Reef area could be used in the attempt to explain the distribution of e.g. common scoter in the area.

The fact that a substantial fouling community has been observed on the windmills at Horn Reef makes it likely that an associated fish fauna will develop. This development should be monitored alongside the epifauna and –flora using diver visual census and the Danish Fisheries Research (DIFRES) Research Gill Nets

Nysted

The outcome of the baseline fish surveys at Nysted revealed several problems that will preclude the use of the standard ANOVA BACI-design. An evaluation of possible statistical methods revealed alternatives. However, it may be more profitable to try to change the sampling strategy in order to decrease the number of zero catches, though this approach makes the before-after comparison less straight forward. The nets used in the impact area should be set at positions in-between rows of windmills in order to focus on the fish fauna on the sandy bottom and in the water column, and avoid the fish fauna directly associated with the hard bottom substrate around the windmills. The studies should be conducted in early autumn in order to include fish fry in addition to larger juvenile and adult fishes.

The fish fauna associated with the hard bottom substrate surrounding the towers should be monitored using the same strategy as at Horns Reef, ie. diver visual census and DIFRES Research Gill Nets.

The studies on the possible effect of the cable connection on fish migration should be continued using the modified pound nets. It should however be considered whether the position of the nets at a distance of 300 meters from the cable is optimal, or

whether a more reliable estimate of the fish numbers crossing the cable would be obtained by positioning the pound nets closer to the cable.

At present it is felt that the inclusion of the SIMRAD acoustic technology is not appropriate as the questions posed by the programme can be adequately answered (and with the advantage of species identification and stomach contents analysis) using conventional research nets and visual census.

BENTHOS AND HARD SUBSTRATUM

Recommendations:

- Continue the epibenthic survey of the monopile and scour protection at Horns Rev and intergrate with a fish survey.
- Continue the infaunal survey at Horns Rev to complete the environmental impact assessment programme
- Continue the epibenthic survey of the foundations and scour protection at Nysted and intergrate with a fish survey.
- Continue the seabed epibiota surveys at Nysted to complete the environmental impact assessment programme

Horns Rev

Epifaunal surveys have revealed a surprising complex fouling community compared to the original estimates that were based on data from the meteorological tower. This may, in some part, be related to the relatively benign weather conditions during 2003 that meant that the windfarm fouling community was not subject to storm induced 'sandblasting'. Whilst many of the species present are those expected in a newly developed fouling community (which will take years to achieve a mature population structure) the substantial settlement of mussels has provided a food source for starfish and crabs, providing evidence of a basic ecosystem function of the new habitat. The physical structure of the filter bed stones and scour protection rocks have also provided a habitat exploited by a variety of fish, with more species than had been expected, probably benefiting from the physical presence of the rock and the shelter from currents more than feeding opportunities. Experience of sampling the area as detailed in report, presentation and video has shown that it is possible to deploy scientific divers to record quantified data and research gill nets to trap fish species on the site, something that was in doubt in 2002. The initiative of the team undertaking benthic surveys in deploying a gill net, albeit for a short period, has proved that using such a technique is feasible at Horns Rev given suitable weather conditions, a valuable contribution to the development of the survey recommendations.

Given the unexpected level of biotic development and the provision for fouling surveys in the overall budget, (something that was in doubt in 2002 and which led to the previous comments on prioritisation of survey effort) advice regarding frequency of epibiotic fouling surveys at Horns Rev and their priority with regard to Nysted needs to be reviewed. In line with the Environment Group's recommendation the fouling monitoring for Horns Rev should be continued in 2004 and 2005 (suggest

spring/summer to assess the community after winter and late summer to evaluate the biota at its peak of annual development) to follow the changes and developments in the community but with an added provision for near to monopile fish surveys conducted by diver visual census (using standardised techniques) and research gill nets. The combining of epibiotic and fish monitoring activities is recommended and described in more detail in the section dealing with fish surveys. The aim should be to provide a description of the biota associated with the monopile and scour protection in a fully marine, shallow North Sea environment. This will be of value to future windfarm developers looking for environmental data (should more windfarms be planned along the Danish North Sea coast) as well as assessing the current project.

Infauna. The infaunal surveys have been successful in describing a heterogenous area and the presentation showed that future surveys would be of value in describing any major changes in this community. It is noted that the limitations on the survey are such that only major changes in the infaunal community will show in data analysis. In line with previous recommendations surveys in 2004 and maybe 2005 would allow the completion of the baseline through to operation monitoring programme and provide a unique data set appropriate for the demonstration wind farm project. These surveys should be undertaken.

Nysted

Initial reports and images from a survey of the foundations and rock scour protection undertaken shortly before the 2003 meeting show that initial fouling settlement has taken place. The continued assessment of this developing community on the foundation structure and associated scour protection (by diving surveys as described by presentation and report) is recommended. As at Horns Rev the epibiota study should be associated with a fish survey (using diver visual census and research gill nets, see the fish section for detail) to evaluate the fish associated with the foundation and scour protection. Spring/early summer and late summer surveys are recommended. Both suggestions are in line with Environment Group recommendations. This low salinity site, so different in environmental character to Horns Rev will provide data of use to developers looking to place wind farms in the Baltic areas around Denmark as well as providing information to evaluate the much quoted 'artificial reef effect' at Nysted.

Completion of the seabed benthic biota baseline to operation study around Nysted is also recommend to provide the evaluation of any impact of construction and operation. This parallels the infaunal survey programme at Horns Rev and is in keeping with the original aspirations of the demonstration programme to provide an evaluation of the windfarm construction and operation process of use to future developers.

PRIORITIES

1. Study of collision risk for birds at both sites but especially Nysted
2. Studies of habitatloss for seabirds and marine mammals at both sites
3. Benthos and fish survey of scour protection areas of both sites
4. Double-tagging of seals

5. Analysis of acoustic data from ramming and operational phase
6. Gillnet fish survey at Nysted