BUNDESAMT FÜR SEESCHIFFFAHRT UND HYDROGRAPHIE

Workshop on Pile Driving at „Ozeaneum“, Stralsund, Germany

on 21 March 2010
organised by the Federal Maritime and Hydrographic Agency (BSH)

Abstracts of talks

TOPIC 1
Underwater noise emmissions of pile driving:

Licensing procedures, regulations, field results

1. Underwater construction noise at alpha ventus

Klaus Betke, Institute for applied and technical Physics (itap), Germany

In 2009, Germany's first offshore wind park, alpha ventus, has been built 45 kilometres north of Borkum island. Underwater noise measurements have been made at various distances from the construction site, with special emphasis on pile driving noise. Results will be presented in comparison to other offshore construction sites. Noise mitigation methods will be discussed and the effect of the so-called bubble curtain tested at alpha ventus will be shown as well.

2. Pile driving and cetaceans - implementation of European Directive requirements

Mark Tasker, Joint Nature Conservation Council (JNCC), UK

In the European Union, the Habitats Directive prohibits the injuring and disturbance of cetaceans, particularly disturbance that is likely to impact on survival, reproduction, movements and local abundance and distribution. Pile driving as used in the construction of large offshore developments is an activity that has the potential to cause injury and/or disturbance. The risk of injury can be minimised through the adoption of mitigation measures aimed at ensuring animals are absent from the vicinity of the piling. Mitigating the risk of disturbance is more challenging since there is evidence that animals can be significantly displaced from large areas around the noise source. Alternative methods to pile driving will

be the most effective mitigation tool. Another option is to establish a licensing regime which could control the scale of disturbance to ensure that population of cetaceans maintain conservation status. Such a system may also be useful in the future to help Member States meet their obligations under the Marine Strategy Framework Directive. Conservation agencies in the UK have provided guidance for assessing the likelihood of causing disturbance, how this can be avoided; and the conditions under which an activity could go ahead under licence. Developers and their consultants, regulators, conservation agencies and researchers need to work together to implement the Habitats Directive and ensure species protection whilst maximising the gains from renewable energy.

3. Licensing requirements and conditions in the German EEZ

Carolin Abromeit, Federal Maritime and Hydrographic Agency (BSH),Germany

For the construction and operation of an offshore wind farm in the German EEZ a permit has to be applied for. BSH is the competent authority to grant these permits and has done so for the past 10 years. Within the licensing procedure an Environmental Impact Assessment has to be carried out and the project has to be assessed under the aspects of habitat and species protection. The assessment generally results in different conditions, aiming to reduce impacts on marine mammals, especially harbour porpoises. These conditions will be presented and discussed.

4. Implications of pile driving noise for mitigation strategies involving acoustic monitoring

Alexander M. von Benda-Beckmann, C. de Jong, M. Ainslie, F.P.A. Lam, Netherlands Organisation for Applied Scientific Research (TNO), The Netherlands

With the increasing number of offshore wind farms, there is a need for environmental impact assessments of noise emitted by construction activities such as pile driving. Underwater noise measurements of pile driving activities during the construction of two Dutch wind farms, and associated underwater noise maps are presented. The need for international standards for underwater noise measurement is highlighted. Finally, the implications of the measured noise levels for acoustic monitoring of harbour porpoises for mitigation purposes will be discussed.

TOPIC 2
Effects of pile driving on marine mammals

5. Potential effects of offshore wind farms on harbour porpoises – the auditory perspective

Klaus Lucke, Research and Technology Centre Westcoast (FTZ), University of Kiel, Germany

The installation of offshore wind turbines (OWTs) is linked to intense acoustic emissions into the underwater environment if the piles are driving into the ground by impact pile driving. The emitted levels have the potential to cause substantial effects on the auditory system of harbor porpoises if exposed at close range. Information on the relevant auditory parameters will be presented along with comparable results from other marine mammal species. The assessment of potential auditory effects gets complicated if the realistic exposure to multiple stimuli is considered. These can originate from repeated exposures to impulses from the same pile driving activity as well as from synchronously emitted impulses from e.g. distant pile driving sites or even other types of sound sources. Moreover, effects of noise exposures can also accumulate over time in the auditory system of these animals and can be caused by impulsive as well as continuous sounds. To assess the cumulative effect of such a diverse acoustic scene on the hearing of harbor porpoises is very challenging. Results from a simplified model will be presented that has been used to describe the effect of multiple exposures to pile driving sound in order to depict the scope of a realistic scenario. Finally a new study will described that aims at verifying the existing data and has the potential to improve the assessment situation if expanded systematically.

6. Cumulative Impacts of Underwater Noise with Other Stressors on Marine Mammals

Andrew Wright, National Environmental Research Institute, Denmark, Department of Environmental Science and Policy, George Mason University, Formerly at Leviathan Sciences, USA

Cumulative impact assessment (CIA; also called cumulative effect assessment: CEA) is a requirement in many environmental impact assessment processes around the world. These CIAs are intended to be a consideration of the impacts of a proposed project or action upon the environment in combination with past, present and reasonably foreseeable future activities. However, CIAs have become the “Holy Grail” of environmental management, as the tools, and often the information, available are simply insufficient to achieve this lofty goal. Similarly, CIAs usually take place as part of project-based assessments without a sufficiently wide ecosystem scope, limiting effective management. To address this issue, Okeanos – Stiftung für das Meer held an international, multi-disciplinary workshop in Monterey, California, in August 2009, on the cumulative impacts of ocean noise and other anthropogenic stressors on marine mammals. Short presentations on topics as diverse as bioacoustics, current management practice and network theory allowed for longer discussions on the various difficult facets of this issue. Specifically, participants considered three aspects: how currently available tools for regionally mapping several anthropogenic

pressures on the environment could be applied to the management of species; how the reported consequences in marine mammals of exposure to these pressures, and their known interactions within an individual, could be modelled; and how population modelling could best include cumulative impact assessment. The available data for many marine mammals is sparse, but participants felt all three approaches could be realised in at least two data-rich populations: southern resident killer whales and North Atlantic right whales. These case studies could then be used as examples of how different pressures can combine and impact populations (e.g., through changes in demographic rates), and inform management decisions, perhaps based on exposure data alone, in other odontocete and mysticete species, as well as other marine mammals. Participants believe this could be applied with great effect to marine spatial planning. They also believe that reducing ocean noise is an achievable goal that will help marine life cope with less tractable threats such as climate change. Several participants continue to work to realise these goals beyond the scope of the workshop.

7. Towards a precautionary approach for the regulation of noise introduction in the marine environment from pile driving

Stefanie Werner, Federal Environmental Agency (UBA), Germany

Human activities introduce sound into the marine environment either incidentally as a side effect of activities such as pile driving for offshore-constructions or intentionally for a particular purpose (e.g. active sonar to detect objects). Most, if not all, marine vertebrates rely to some extent on sound for a wide range of biological functions, including orientation, communication and/or detection of predators and prey. Anthropogenic underwater noise can have various impacts on marine species, ranging from exposure causing no adverse impacts to behavioural disturbance, loss of hearing and mortality.

With the implementation of the EC-Marine Strategy Framework Directive (2008/56/EC) underwater noise is now for the first time becoming a subject of European relevance and its impacts need to be carefully and fully evaluated. In particular the cumulative impacts of noise have to be assessed to meet the holistic approach of the Directive. For now pile-driving is the established foundation method for offshore wind turbines. As a noise intensive process it has the capacity to harm marine life. More than 1800 turbines are approved to be built in the German EEZ. In connection with these construction activities two problems should additionally be considered: the parallel ramming at different sites and the cumulative impact of long construction phases. The talk will present new considerations of the so-called UBA proposal on noise threshold levels in offshore pile driving as well as ideas about how to possibly deal with the cumulative assessment of different noise sources and inputs.

TOPIC 3
Mitigation measures and alternatives

8. A new foundation concept: the Drilled Concrete Monopile

Edwin van de Brug, Ballast Nedam Offshore, The Netherlands

This concept consists of the installation of concrete monopiles by HLV Svanen using a vertical drilling method, based on the onshore used horizontal tunnel drilling methods.
Main reasons for this concept were:

- Concrete monopiles are inexpensive compared to steel monopiles; concrete is less vulnerable to price fluctuations; unlimited fabrication capacity and a wide range of suppliers is available;
- Underwater noise is limited;
- Suitable for various soil types even with boulders.

Concrete monopiles were designed for 3,6 and 5 MW turbines at 30 meter water depth. Top of the Monopile is +3.5m MSL including a concrete ice cone.
The monopiles are made of pre-cast reinforced concrete ring elements and are fitted with a steel cutting shoe to „cut through the soil creating an overcut. This overcut is filled with self hardening drill fluid. The monopiles are transported floating to the offshore site.

The floating monopile is upended by the Svanen using a proven work method and positioned on the seabed within Svanen□s guiding frame. The monopile will settle several meters in the seabed after which the drilling machine is installed in the monopile. Drilling starts and the monopile will continuously be lowered to the required depth. At this point the drill will be removed and the drill fluid will harden. The ice cone will be placed and grouted on top of the monopile.
The drilling machine, including the cutter head is designed to drill through the various soil layers. The diameter of the cutter head is extendable. This enables the machine to drill inside and under the monopile. It excavates in two directions and is able to crush boulders in front of the cutter head.

9. Pile Driving Noise Reduction Using New Hydro Sound Dampers

Karl-Heinz Elmer, Germany

The founding of offshore wind turbines by means of pile driving induces considerable hydro sound emissions, that are potentially harmful to marine life, in particular to marine mammals.

Hence, effective noise reducing methods are necessary to keep the German BSH standard level of 160 dB SEL at 750m distance.

Very expensive applications of bubble curtains during pile driving operations of FINO3 and “alpha ventus” only achieved noise reductions of 10-13 dB. The main problems are the installation of the bubble curtain, the supply with compressed air, the control of the bubble size and distribution, and the influence of the tide current of the sea like the North Sea.
Above 1 kHz, the bubble curtain attenuation of high frequency noise is sufficient high. But the

sound level of the piling noise mainly depends on the lower frequency noise, where the attenuation of bubble curtains is only poor.

All these problems are solved by a new noise reducing method using gas filled envelope bodies as hydro sound dampers, instead of free natural air bubbles, similar to elastic balloons. Scattering, multiple reflections of traveling sound waves and mainly the dissipation of the vibrating air filled bodies reduce the noise transmission. The size of the bodies, the effective frequency range, the damping rate and the number and distribution of the hydro sound dampers can be controlled, if the envelope bodies are fixed to pile surrounding frames or fishing nets.

The hydro sound dampers are very effective, even in the decisive lower frequency range of 50 Hz to 500 Hz, independent of compressed air, not influenced by the tide current, easy adaptable to different applications, and they are of course not expensive.

10. Effects of mitigation options with regard to pile driving

Ansgar Diederichs, BioConsultSH, Germany

Pile driving of wind turbine foundations into the sea bed will lead to intense acoustic emissions into the underwater environment. The emitted levels have the potential to harm harbour porpoises if they are exposed at close range. In order to minimise the risk of injury the adoption of seal-scarers as a mitigation measure became mandatory along pile driving activities in German Waters with the effect to keep harbour porpoises out of a potential danger zone.

Mitigation guidelines along the construction of Germany's first Offshore Windfarm alpha ventus were designed recommending the use of two pingers and one seal-scarer from board the ramming vessel 40 minutes, respectively 30 minutes before piling started. BioConsult SH was assigned to investigate effects of pile driving on harbour porpoises using passive acoustic monitoring devices (PAM). As a by-product also the effectiveness of mitigation guidelines during construction process was studied.

Whereas a strong significant effect of pile driving on the presence of harbour porpoises has been found, it was not possible to separate the effects of mitigation measures from piling effects. Relative porpoise abundance measured by PAM was already reduced at least 5 hours before mitigation procedures started. Noise measurements clearly showed that seal-scarer worked out well with regard to producing noise but with a very large variation of Sound Exposure Level (SEL), for which the reasons remain unclear.

A summary of the mitigation protocol shows that it was difficult to comply with the mitigation guidelines during the construction process.

However, the effectiveness of such measures is of fundamental importance and has to be proved in separate projects independently of pile driving activities.

11. Research and application of a „Little Bubble Curtain (LBC)“ at Alpha Ventus

Tanja Grießmann, Institute for Structural Analysis (ISD), Leibniz University Hannover, Germany

Gas bubbles change the acoustic properties of the medium water. Due to the different impedances of the two media acoustical scattering occurs at the border. In addition to this effect the single bubble reacts as an acoustical resonator when insonified by an incident wave. The result is a very high ratio of (effective) acoustical cross section to geometrical cross section at resonance. In total the two effects lead to a significant reduction of the sound pressure in greater distances. Research aspects referring to the bubble curtain concept are presented.
In June 2009 a little bubble curtain close to the foundation was tested under the construction of a wind turbine of type AREVA Multibrid. Hydrosound levels were measured in different directions from the pile driving center. Detailed results will be shown and discussed. The presentation ends with a short comparison to the results of the FINO3's application of a large bubble curtain.

12. Underwater Noise and Offshore Wind Farms – Scientific Findings and Further research Needs

Tobias J. Petrovic, Jülich Centre for Research (PtJ), Germany

Offshore wind energy is one of the basic pillars within the European climate protection strategy. However, the installation of wind turbines in the marine environment may cause environmental impacts. Of particular concern is underwater noise which occurs when piles for offshore foundations are driven into the seabed. Moreover, the operation of offshore wind farms is causing more or less continuous noise emissions on a minor level. The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) has acknowledged that there is need to further develop wind energy in an ecologically sound way. Hence, the national strategy for offshore wind energy deployment is accompanied by ecological research. With the first projects starting in 2001, the knowledge about the marine environment was increased significantly. Extensive monitoring programmes were carried out in the German Seas to determine the distribution and the habitat use of marine mammals. The hearing abilities of local species - harbour porpoises and seals - were subject to thorough investigation. Alongside this, expected noise emissions from offshore wind farm installations were pre-estimated and modelled. Noise mitigation measures for impact pile driving were designed and tested during installation of the research platform FINO-3 and the first German offshore wind farm “alpha ventus”. At present, alternative noise-reduced foundation concepts are under development, and the effectiveness of acoustic deterrent devices is being tested. So far, the funding by the BMU for the accompanying ecological research of the offshore wind energy is totalling almost 30 million Euros. The present findings are promising, but yet it is clear that more research is needed and technical improvements are necessary. Further funds will be allocated to achieve that the national climate protection strategy, which is substantially based on the extension of renewable energies, is meeting the demands of nature protection in the most successful way.