Impacts of Noise and Vibration on Fish Conference

Wednesday 22nd - Thursday 23rd May 2013.
Kenworth Hall Hotel, Sheffield

Abstracts

Paul Lepper, Loughborough University.
"Acoustic characterization of large scale marine piling operations for offshore windfarm development"

Paul Lepper (1), Stephen Robinson (2), Dick Hazelwood (3), Pete Theobald (2), Tanja Pangerc (2).

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With the UK's current and planned developments of offshore wind energy capability we have already seen extensive constructions phases under 'round 1' and 'round 2' offshore windfarm sites. With the development of 'round 3' we will see continuing growth in this activity over the next decade in UK waters, with similar planned activities in neighboring territorial waters. Concerns about uncertainty of potential impacts of underwater noise on marine fauna (marine mammals, fish, crustacean, etc.) from construction phase and more recently operational noise are increasing seen as barriers to these developments.

Currently the most commonly used foundation constructive method in the UK is percussive piling. Hollow steel mono-piles with diameters ranging from a few meters up to 6.5 m are typically driven around 15-25 m into seabed using hydraulic hammer. Water depths may range from a few meters to greater than 30 m. This process may take from 30-40 minutes to several hours with numbers of strikes of several thousands. Hammer energies may range from a few 10's kJ up to 2 MJ per strike. Much of this energy is used to physically moving the pile into the seabed however high amplitude pressure field impulses are generated in the water column as well as sediment borne pressure and shear waves. Measurement methodology and results will be presented for measurement made at a number of major UK windfarm developments. In addition to sound propagation within the water column, seabed vibration is also likely however currently rarely measured. Data from a test piling in the Netherlands will be presented showing seabed vibration measured during a piling operation.

Julia Purser, University of Bristol
"Noise pollution and the MSFD: effects of introduced sound on juvenile European eels *Anguilla anguilla"*

In response to the UK'c commitment to the EU Marine Strategy Framework Directive, and the need for science to inform a better understanding of the impacts of underwater noise pollution in the marine environment, we have established a large new research project (funded by Defra) to conduct controlled experimental investigations into the effects of anthropogenic noise pollution. This project explores the effects of introduced sound on the physiology, development and behaviour of a range of fish and invertebrates found in coastal UK waters. Here, we present some of the scientific approaches and results from this on-going project, with a focus on the influence of shipping sounds on juvenile European eels *Anguilla anguilla*. We consider a number of impacts, including effects on metabolism, swimming dynamics and indicators of stress, the influence of body condition, and the recovery of normal function after the cessation of an acute exposure to playback of ship sounds versus location-matched ambient controls.

Rafael Perez-Dominguez, APEM Ltd

"Use of controlled exposure experiments to detect reaction thresholds of fish to playback noise in the field"

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Marine noise and its impact on the marine environment are under much debate. There is a lack of robust scientific evidence on the sensitivity and effects of underwater noise upon fish and an almost complete absence of data for invertebrates. This lack of reliable evidence is in part a direct consequence of the technical difficulties we face when attempting to reproduce realistic noise signatures in laboratory conditions. This study was undertaken to develop methods to study the behaviour of free-living fish and crustaceans exposed to realistic noise dosage by means of control exposure experiments. Two approaches to track responses were trialled; sonar and stereoscopic video. The former was very successful in documenting responses of schooling fish. The second approach used bait to attract animals to the cameras' field of view and was better suited for demersal coastal species. This paper presents the development of the stereoscopic video equipment and field testing of the baited camera approach. Playbacks of impact pilling and shipping noise were undertaken using a custom designed projector array able to reproduce source levels up to 190 dB re 1µPa @ 1m (peak-to-peak). Approximately 90 independent exposures have been conducted at several coastal shallow locations by randomly playing noise clips (pilling & shipping) of various levels and blanks. The sound projector was deployed at a distance of approximately 10 metres from the frame to ensure a realistic far-field type exposure with recorded sound levels baited station ranging from 144 to 168 dB re 1uPa (peak-to-peak) (140 dB background level). Playback was initiated once fish were in the field of view, attracted by bait, and the responses were recorded on tape for later analysis using 3D motion analysis software. The recording equipment and image analysis is now operational providing a viable method to assess response of naïve animals to play-back noise in their natural environment.

Andrew B. Gill, Cranfield University
"The behavioural response of Atlantic cod and common sole to pile-driving sound"

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Worldwide there is much interest in the potential impacts of anthropogenic noise on marine life. In order to determine any impacts it is first necessary to quantify the response of multiple individuals to a noise source. In terms of fish, little is known about how high an intensity impulsive sound (e.g. resulting from pile driving) affects their behaviour. In particular, there is a lack of data on behavioural thresholds, response distance and sound exposure levels. Yet, such data are important in order to develop judgement criteria for the behavioural effects related to various sound sources. In this study, two fisheries important species, Atlantic cod (*Gadus morhua*) and common sole (*Solea solea*), held in large semi-natural net cages, are shown to react in terms of movement direction and activity level to pre-recorded pile-driving sound, with received sound pressure levels 133 to 156 dB re 1 µPa and measured particle acceleration 6.5 $x10^{-3}$ to 8.6 $x10^{-4}$ $m/s^2_{(peak)}$). The peak sound pressure levels that the fish were exposed represent those that are likely to occur several kilometres from a pile-driver. The results of this study suggest that construction activities, such as associated with offshore wind farms, could potentially affect fish species behaviour over a significant area centred on the source.

Matthew Styles, Hull International Fisheries Institute.
"Fish ejection from pumping stations"

Fish entrainment is a key consideration in the conservation of fish stocks in heavily modified rivers. Long serving hazard prevention initiatives for the proactive management of flood risk have resulted in a network of riverine structures such as water pumping stations. The operation of pumping stations carries a high risk of fish entrainment and several measures have been implemented in recent history with the aim of reducing entrainment risk. Many have involved the use of acoustics, typically in the form of scaring devices. Acoustic scaring devices aim to affect fish behaviour, expelling abd deterring fish from pumping stations and consequently reducing the potential for their entrainment during water transfer.

The efficacy and effectiveness of an acoustic scaring device array at expelling and deterring fish from a pumping station was examined in February and August of 2012. The results from this study will ultimately contribute to reducing the negative impacts of pumping stations on fisheries.

Elena San Martin, ABPmer
"Green Port Hull Case Study: Assessment of the potential effects of underwater construction noise on fish"

Associated British Ports (ABP) has been granted planning permission and a marine licence to construct Green Port Hull (GPH) at Alexandra Dock at the Port of Hull. The main components of the development include a new quay, dredging and partial infilling of Alexandra Dock. The Environmental Impact Assessment (EIA) for GPH, which was undertaken in 2011, involved assessing the potential impacts of underwater construction noise and vibration, namely from piling and dredging, on fish. The fish species of particular concern in the Humber Estuary are the protected migratory fish species: Atlantic salmon, sea trout, European eel, river and sea lamprey. A number of approaches were applied to predict the potential behavioural and physiological effects of the scheme on fish. These were developed in an iterative manner in close consultation with the Environment Agency. They involved a combination of simple logarithmic models underpinned by published measurement data, the dBht noise criteria proposed by Nedwell et al (2007), an in-house modelling tool developed by the United States' National Marine Fisheries Service (NMFS) and also temporal considerations (i.e. the frequency and duration of exposure). In addition, more sophisticated underwater noise modelling was undertaken using the Range Dependent Acoustic Model (RAM) to take account of bathymetry and bottom type. Following current guidance from the Environment Agency, potential effects were investigated in relation to the available channel width from the noise source. Given the risk that behavioural effects might occur for more than half the width of the estuary during piling activities, a range of mitigation measures will be adopted to ensure that there are no significant adverse effects on migratory fish. Active noise monitoring will also be undertaken during piling to verify the impacts that were predicted in the EIA, the details of which are currently being agreed with the Environment Agency.

Mark D. Bowen, Turnpenny Horsfield Associates
"Live tracking of Chinook smolts at acoustic/strobe-light barriers"

Acoustic telemetry was used to develop two-dimensional tracks in the vicinity of acoustic/bubble/strobe light barriers in the Central Valley of California, USA. At two sites, there were different hydrophone arrays established during the chinook salmon smolt outmigration in two different years. These four hydrophone arrays will be shown, the methodologies described, and results interpreted for the effectiveness of the barriers in each of the migratory periods. In summary: 1) at Site 1 in 2009, the overall efficiency was 36.5%, 2) at Site 1 in 2010, the overall efficiency was 27.6%, 3) at Site 2 in 2011, the overall efficiency was 90.8%, and 4) the overall efficiency at Site 2 in 2012 will be delivered at the oral presentation.
Modelling the propagation of underwater noise and the potential responses of marine fish

Katherine Harris, HR Wallingford
"Modelling the propagation of underwater noise and the potential responses of marine fish"

Anthropogenic underwater noise is an area of increasing interest and some concern as human activities related to marine energy projects move into new areas of the global marine ecosystem. This presentation will describe the use of an underwater noise modelling tool (HAMMER) which combines hydrodynamic, underwater acoustic propagation and individual based modelling to predict both the transmission loss of anthropogenic sources of sound and the potential responses of marine fish to that sound. The use of such models is valuable in informing the planning and consenting process for offshore activities. By incorporating a range of parameters such as hydrodynamic conditions, bathymetry, salinity and temperature into modelling studies, underwater noise propagation can be realistically predicted: to demonstrate this, a case study will be presented which compares real-life noise monitoring data to model outputs. The presentation will also introduce an on-going NERC funded internship project, hosted by HR Wallingford, investigating the behavioural data required for ecological response modelling tools to predict the response of target fish species to noise emitted by marine renewable construction activities.

Theresa Redding, Royal Haskoning DHV
"Fish, Noise and Licence Conditions"

This case study reviews the historical development of Offshore Wind Farms from Round 1 (2000) to Round 3 (2010) and considers the licence conditions which address potential effects of and concerns surrounding underwater noise from marine construction activities (mainly percussive piling) on fish. With each Round of offshore wind development in the UK there has been a progressive increase in the distance of the development from shore, the number of turbines, the energy output and potentially increased construction noise from installing progressively larger turbines.
This paper considers whether this progression in project parameters is reflected in the marine licence conditions or whether a precautionary approach taken irrespective of the size and location of the wind farm? The study looks at the drivers for such conditions, if any, and whether advances in underwater noise modelling techniques have contributed to an understanding of the behavioural and physiological responses of fish to noise or whether there is still a gap in knowledge which requires further research.

M. v. Nieuwenhuyzen, Aquatic Control Engineering
"Ensuring the Development of Robust and Effective Fish Deterrent Systems"

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Good practice guidelines and regulatory advice have been useful in enabling engineers and product developers to gain a better understanding of the current position and best practice of engineering deterrent systems and screening intakes to reduce fish and eel mortality in the UK. It has allowed successful design from Europe to be tailored to the best available advice and installed in the UK successfully.
Aquatic Control Engineering and FishFlow Innovations have developed and installed a number of multi-functional deterrent systems using the effects of noise, vibration and strobe lights across Europe and the USA and a number of independent monitoring reports are available. This has fuelled design and development which has further refined efficiencies and understanding of the multi-functional deterrent system. A number of design innovations are discussed which originate from gaps in legislation, researcher requirements and post monitoring reports.
Translating this back to the original guidelines for fish, published in 2005 and eel guidelines seen as a 'living document', a number of suggestions and recommendations are made into the future shape of guidelines and regulatory advice for such projects in the UK. These recommendations are a result of the fast and successful evolution of a range of new technologies, and how innovation may not be best represented in current practice documents and guidelines.
In addition the cost benefit matrix is re-visited, demonstrating how cost effective new technologies are compared to traditional counterparts on which the guidelines are based.