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The Potential Impact of Offshore Wind Farms on Fishes and Invertebrates

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Introduction

The construction and operation of wind farms may have significant effects upon a range of fishes and invertebrates. As wind farms operate for many years, they have the potential for affecting animal stocks adversely over an extended period. Some aquatic animal populations are of national and international importance, including salmon, sea trout, cod and haddock, and crabs and lobsters, all of them being important from a socioeconomic perspective, and they may be adversely affected by wind farms. Some key marine fishes and invertebrates live close to the seabed, and some spawn there, and will be adversely affected by sounds and especially by substrate vibration. Others are in midwater and will also be affected by sounds. Survey and construction activities for wind farms may generate sounds that may affect the behaviour of fishes and invertebrates directly or might mask the detection of important biological signals and orientation cues. Seismic and other surveys, pile driving or drilling, rock breaking, rock filling, dredging and trenching, the installation of foundations, and increased levels of shipping may all produce noise within the frequency bands to which aquatic animals are sensitive. Some noise may also be generated when the wind farm is operational, through the running of the wind turbines and the production of substrate vibrations on the seabed. Electric cables from the wind farm may also affect fishes and invertebrates adversely, by causing habitat damage when they are installed, and by generating noise, chemical pollution, heat, and electromagnetic field emissions during their operation [1]. It is important that migrating fishes reach their destinations without significant delay. Many migratory fishes, including salmon and sea trout, are moving along the coast to particular destinations. There

should be no obstruction of their movements which will cause problems in reaching those destinations, whether the fish are wishing to move upstream into rivers flowing into the sea, or have entered the sea from local rivers and are migrating to their feeding grounds. The eel is another fish that may swim past coastal wind farms on their marine spawning migrations. Delays may also result in additional energy costs for returning adult salmon, some of which may have ceased feeding. Spring running adult salmon entering under cold winter conditions may be particularly vulnerable to energy run-down. Migrating fishes may also fail to arrive at their spawning destinations at an appropriate time, incurring adverse effects.

Fishes need to have access to the various cues that they use to position and orientate themselves during their migrations. During passage through the sea, fishes use a variety of cues to orientate and navigate. It is evident that many species, including the salmon, have a sense of direction. In some cases, this sense may be based on an ability to orientate with respect to the earth's magnetic field, or perhaps to celestial cues (Smith et al., 1981). Other cues might include sounds associated with the locations they are seeking, and also odour cues associated with particular locations or bodies of water, or the presence of particular patterns of water currents. The presence of excessive sediment may affect the ability of fish to detect odour cues and high levels of suspended sediments may be especially damaging to pelagic species. There is potential for fish to be affected adversely by any increase in marine pollution and disturbance arising from ships and other activities during both the construction and future operation and maintenance of the wind

farm. Alterations to migratory cues as a result of wind farm and other developments may have severe effects upon migratory fish populations and must be avoided.

The Adverse Effects of Underwater Noise

Many marine mammals, fishes, and aquatic invertebrates use sounds for obtaining information about their environment, and also for communicating with one another. Sound propagates very quickly, and travels great distances in water, compared with air. Interference with the ability of aquatic animals to detect sounds adversely affect their fitness and survival and therefore, has adverse impacts, especially upon the sounds made by spawning animals, including cod and haddock. The noise generated by installing wind farms, or during the operation of wind turbines are often not considered when evaluating proposals for the installation of offshore wind farms. In particular, there is little work done on the generation and effects of substrate vibration. All fishes are sensitive to particle motion, and only a few species are sensitive to sound pressure. The use of sound pressure as a metric when monitoring noise is therefore inappropriate, especially for evaluating behavioral responses of fish and invertebrate species. However, there is little information available on the levels of particle motion generated by anthropogenic sources in water, especially close to the seabed where there is substrate vibration, or on the levels and the characteristics of the particle motion generated by the anthropogenic sources which may have major effects upon fishes and invertebrates. The particle motion generated at a wind turbine foundation was measured in the Baltic Sea [2] and was compared with the audiograms of the cod and plaice. The wind turbine generated relatively strong broadband sounds as well as tones. It was concluded that all the sounds were likely to induce behavioral responses by fishes. It is also important consider the possible adverse impact upon fishes and invertebrates of infrasound (sound at frequencies below 20 Hz), that may be especially generated by the construction and operation of wind farms. Few appropriate data have been collected on the effects of underwater noise and substrate vibration, especially upon fishes and invertebrates [3].

The Adverse Effects of Underwater Electric Cables

It has been shown that salmon returning home through the sea do actively swim in a particular direction [4], indicating that they do use the earth's magnetic field for orientation and direction finding during their migrations. It is likely that other fish species also utilize the earth's magnetic field. The electromagnetic fields (EMFs) from subsea cables might interact with migrating fishes in the close vicinity of the cables, particularly if they are laid in shallow water. Floating wind turbines might also have electric cables within the water. It is common for returning adult salmon to follow the coast, swimming close to the shore, where they may be especially susceptible to EMF effects from cables. The magnetic fields generated by the export and inter array cables can perhaps

result in small- or large-scale disorientation and serve as a barrier to migration. However, there is currently little actual evidence available to enable full assessment of the overall effect of EMFs from subsea cables on the migrations and behaviour of salmon and other species at the present time. There is also insufficient evidence on the use of magnetic cues for orientation and migration by fishes and few data are available to be able to assess the effects of local changes in magnetic fields upon the migrations of fishes. Taormina et al. [1] recently examined the potential ecological effects of submarine power cables upon the marine environment, during their installation, operation and decommissioning. During the installation of the cables there is seabed disturbance, sediment generation, chemical pollution and the generation of noise. During the operation of the wind turbines the cables generate electromagnetic fields, emit heat and cause chemical pollution. However, the authors concluded that many uncertainties are currently present, particularly in relation to the electromagnetic effects of the cables. It is evident that currently the impacts of electric cables remain poorly studied.

What is Now Needed?

Comprehensive monitoring of both the effects and impacts of sound particle motion, substrate vibration, and electromagnetic fields on the migratory and spawning behaviour of fishes are necessary before, during, and after the construction of wind farms. There is a need to assess the importance of such stimuli to a wide range of marine species. A current problem is that most research is based on effects upon marine mammals. There is currently much less effort in assessing effects and impacts upon fishes and aquatic invertebrates, despite their importance. There is a real need to conduct research that will enable regulators to assess the impact of the construction and operation of offshore wind farms upon the behaviour, physiology, and physical condition of all aquatic animals.

Acknowledgement

None.

Conflict of Interest

No conflict of interest.

References

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