VINDVAL

Effects of wind power on marine life – a summary

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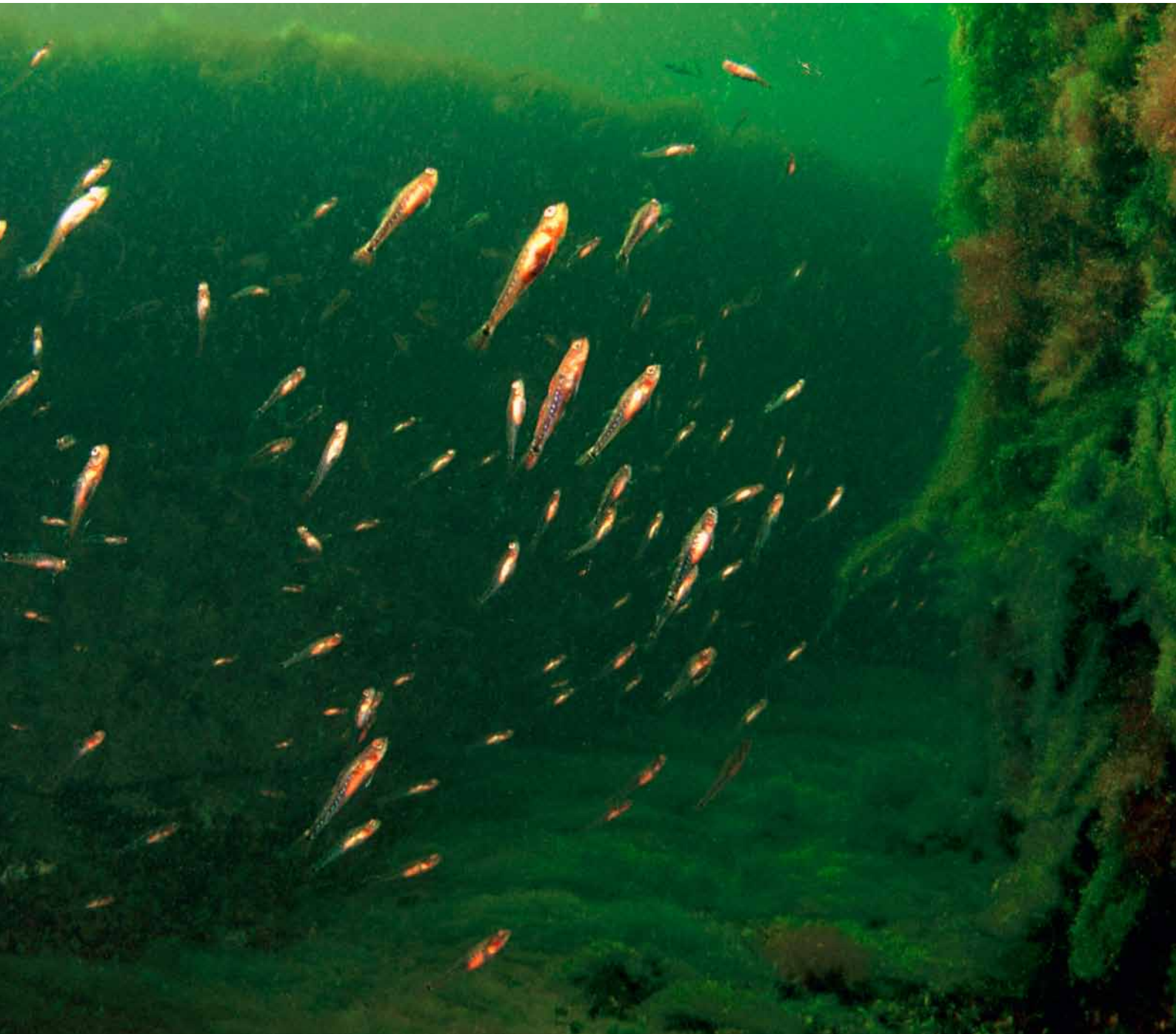

As in many other countries, an expansion of wind power is expected in Sweden during the coming decades. The expansion is driven by rising prices on electricity and the need for an increased production of renewable energy. Since wind conditions at sea are good and relatively constant, several offshore wind farms are planned in Swedish waters. Offshore wind power with a total effect of about 2500 MW has been granted permission and additionally 5500 MW are being planned for in Sweden. Examples of granted projects are Storgrundet with an effect of 265 MW, Stora Middelgrund with an effect of 860 MW and Kårehamn with an effect of 48 MW. Today Sweden's largest offshore wind farm is Lillgrund in Öresund with its 48 turbines with an installed effect of 110 MW.

Prior to this expected expansion, it is important to investigate the environmental impact of offshore wind power, and how possible negative effects can be minimized.

This is a summary of the synopsis "Effects of wind power on marine life" / "Vindkraftens effekter på marint liv", published in March 2012. The synopsis is based on more than 600 studies, most of which are scientific articles, but also reports by companies and authorities.

A complete English version of the synopsis will be available in June 2012 on the webpage: www.naturvardsverket.se/vindval

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Vindval is a research programme and a cooperation between Energimyndigheten (Swedish Energy Agency) and Naturvårdsverket (Environmental Protection Agency) in Sweden. The purpose of the programme is to collect and distribute scientific facts regarding the impacts of wind power on humans and nature.

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Turbot on a offshore bank in the Baltic Proper. Sensitive reproductive periods for marine species should be avoided when installations of winds farms are planned.

Habitats and species in Swedish marine areas

The Swedish marine areas are characterized by a unique salinity gradient that varies from the marine conditions in Skagerrak to almost limnic environments in the Gulf of Bothnia. There are also vast differences between areas in terms of environmental factors such as light supply, temperature and wave exposure. This entails variation in species composition, dominance by different populations and structural differences in plant and animal communities. Therefore, this synopsis provides environment descriptions of some widely separated marine areas: Kattegat together with Skagerrak, the Baltic Proper and the Gulf of Bothnia (Bothnian Sea and Bothnian Bay). The main focus is on occurrence of species and communities within the depth interval that is of interest for establishing offshore wind power in Sweden.

Offshore wind power

There are mainly two types of foundation structures used in Sweden today: gravity-based foundations and monopile foundations. These are also the most commercially viable. Offshore wind farm projects affect the environment in different ways during installation, operation and decommissioning. The installation stage is assessed to have the largest impact on the environment, since high noise levels and sediment dispersal can affect marine organisms. A wind farm in operation can cause barrier effects as well as changes in the natural environment. The decommissioning phase can again enhance noise levels and lead to sediment dispersal in the park and its adjacent area.

Effects on marine organisms and communities

Since marine environmental conditions vary between different locations as well as over time, it is difficult to make universal assessments of the effects of offshore wind power. This increases the importance of well-designed pilot studies and monitoring programs of the local environment. Also, location-specific surveys minimize the risk that costly measures are used when they are not needed. In general, installation and decommissioning of offshore wind farms should be planned so that sensitive reproductive periods for marine species are avoided. Particular consideration might also be needed for constructions in important growth and spawning areas for fish and marine mammals, or specific environments, such as offshore banks with high nature values.

Acoustic disturbances during the installation

As monopile foundations are being driven into the sea floor, a lot of noise is generated that spreads in the water. Cod and herring can potentially perceive noise from pile driving at a distance of 80 kilometers, experiencing physical damage and death at just a few meters from the place of installation. For all types of work involving noise, flight reactions in fish are expected within a distance of about one kilometre from the source. The greatest risk of significant harm to fish populations exists if the installation overlaps with important recruitment areas for threatened or weak populations. Among the marine mammals, porpoises have proved to get both impaired hearing and behavioural disturbances from noise associated with pile driving. There are no studies indicating any long-term negative effects on any of the Swedish seal species. It is not possible to draw any general conclusions of the effects on invertebrates from pile driving noise, since the group is too large and diverse. The few studies that exist, however, show that oysters are relatively sensitive, whilst mussels are not affected at all. The effects of high noise levels can be reduced by, for example, successively increasing the power and thus the noise at piling, so that larger animals such as fish, seal and porpoises are intimidated at an early stage and leave the construction area well before high noise levels are reached.

Sediment dispersal

Dredging work during the construction of gravity-based foundations, and wiring between the turbines and land, can cause sediment from the bottom to whirl up and disperse in the water mass. The amount of sediment dispersed depends on the type of sediment, water currents and which dredging method is being used. Increased concentrations of sediment in the water affect mainly fish fry and larval stages negatively. Invertebrates are often adapted to re-suspension of sediment, since it naturally occurs in their environment. The sediment dispersal at the construction of a wind farm is often confined to a short period. The effects are also relatively small due to the fact that the bottom sediment is usually coarse-grained. The overall assessment is therefore that sediment dispersal is a limited problem for most animal and plant communities.

Introduction of a new habitat

The foundations of wind turbines can function as artificial reefs and attract many fish species, particularly around gravity-based foundations that have a structurally complex erosion protection. At first there is often a redistribution of fish from nearby areas to the wind power foundations, but over time an actual increased fish production within the park is possible, as long as the park is large enough and the fishing pressure is low. The structure of the erosion protection can mean local positive effects for crustaceans such as lobster and crab, by functioning as shelter as well as increasing their foraging area. One example of specie that seems to increase locally around foundation structures in the Kattegat and Skagerrak and the Baltic Proper is the blue mussel. Which species that will dominate depends on the

salinity in the area. There are no studies showing that the foundation structures may facilitate the distribution of new species to Swedish marine areas. The total amount of hard bottom surface formed by the foundations and their structures is relatively small.

Turbine noise and boat traffic

Maintenance work of the wind turbines causes a certain increase in boat traffic in the area of an operating wind farm. Also, different parts of the turbines generate noise that spreads through the water. The reactions of fish on noise from turbines and boat engines vary, but study results indicate that the effect on most species from noise in a wind farm is low. There are, however, no studies on the long-term effects of stress due to an increased noise level and effects of noise disturbance on fish spawning behavior. Especially porpoises, but to some extent even seals, are sensitive to noise disturbance. Today there are no studies showing negative effects of the on-going sounds in a wind farm on populations of marine mammals. The noise of both storms and engines from ships often exceeds the noise generated by wind farms in operation.

Electromagnetic fields

The cables leading from a wind turbine generates a magnetic field that decreases with distance from the cable. The expected effect on most fish species is low, but since the effect is on-going throughout the entire operational stage, the risk should be considered in areas that are important to migrating fish species. No studies have been found that show how electromagnetic fields affect marine mammals. The few studies that have been found on invertebrates indicate that the electromagnetic fields around common transmission cables have no effect on either reproduction or survival.

Exclusion of birds

Most birds do not avoid wind farm areas. An exception is several common diving ducks that avoid flying or swimming within wind farms and keep a safe distance of at least 500 meters to a turbine tower. The most common food for these species in the Baltic Sea is blue mussels. Areas within the Swedish economic zone where a large-scale expansion of wind power would have the greatest effect on the ducks, and thereby indirectly affect the benthic community, are the offshore banks in the central Baltic Proper, mainly Hoburg Bank and Northern Midsjo Bank, where two thirds of the oldsquaw populations in Europe overwinters. The level of impact will depend on the total area of the park, and the distance between the turbine towers. Large-scale studies are needed in order to assess if the effect might lead to substantial changes for the benthic community.

Assessments of the different effects of wind power on fish, marine mammals and benthic organisms

Below is a list of the effects that according to existing knowledge and accessible literature might affect marine organisms and communities. Each effect has been assessed after how long, to what areal scale and to what extent it affects marine life in the wind farm area. Each assessment has also been valued depending on the amount of litterature found on the subject.

Effects on marine organisms and communities		Level of certainty in the assessment (1 = low, 4 = high)	Assessment of the effect			
			Areal scale	Time scale	Swedish sea area in which assessment is relevant	Extent of effect on populations and communities
Fish	Acoustic disturbances during the installation	3	Big	Short	All	Moderate - Big
	Sediment dispersal during the installation	3	Big	Short	All	Small
	Introduction of a new habitat	3	Local	Long	All	Small - Moderate
	Turbine noise and boat traffic	2	Big	Long	All	Small - Moderate
	Electromagnetic fields	2	Local	Long	All	Small - Moderate
	Attraction of predators	1	Big - Very big	Long	All	Moderate
	Altered fishing	2	Big - Very big	Long	All	Moderate - Big
Marine mammals	Acoustic disturbances during the installation	2	Very big	Short	All	Big
	Turbine noise and boat traffic	2	Very big	Long	All	Small
	Electromagnetic fields	1	Local	Long	All	Small
Benthic animals and plants	Acoustic disturbances during the installation	2	Big	Short	All	Small
	Sediment dispersal during the installation	3	Big	Short	All	Small
	Introduction of a new habitat	4	Very local	Long	Kattegat, Skagerrak, Baltic Proper	Moderate
	Electromagnetic fields	3	Very local	Long	All	Small
	Exclusion of birds	3	Big	Long	Kattegat, Skagerrak, Baltic Proper	Moderate - Big
	Organic enrichment on the bottom	3	Very local	Long	Kattegat, Skagerrak, Baltic Proper	Moderate

Identified effects of wind power on marine life should be weighed and put in relation to other human acitivities, as well as today´s need of increasing the use of renewable energy and reduce environmental pollution.

Gaps of knowledge

The basis of this synopsis is research results from studies concerning single wind turbines or small wind farms, which in many cases is enough to assess the effects that can be expected on different groups of marine organisms. However, there is a lack of knowledge on how the large-scale wind power development will affect marine ecosystems in the long term. Since it is impossible to extrapolate knowledge based on a single wind turbine or wind farm, further studies are needed where changes in larger parks are followed over long periods of time. Since a large-scale expansion of wind power is expected along the coasts of many countries around the Baltic Sea and in the North Sea, there is a need for a coordinated international research program, for example an interdisciplinary EU-project.

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Effects of wind power on marine life – a summary

This is a summary of the synopsis “Effects of wind power on marine life”/ “Vindkraftens effekter på marint liv”. The synopsis gather existing knowledge of the effects of wind power on marine organisms and contains suggestions of how possible negative effects can be minimized. The main effects are seen when monopole foundations are being driven into the sea floor, and during the dredging work.

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