

NWWAC/PelAC advice on the impacts of underwater noise and offshore wind energy developments on commercial fisheries

1 Background

It is reported that for the European Union to meet its climate objectives of decarbonising the entire economy and become climate neutral by 2050, there is a need to move away from fossil fuels and towards greener energy such as wind, solar and hydropower. The revised Renewable Energy Directive 2009/28/EC took effect on 01 July 2021 and requires that at least 32% of all energy consumed in the EU is from renewable energy sources by 2030 ([link](#)).

This places marine wind energy developments firmly into the space of viable commercial fisheries in many Member States which is of great concern to fishers and the seafood supply chain. Sustainable fisheries management is at the heart of the Common Fisheries Policy, and the many efforts made by fishers in the North East Atlantic in implementing and adhering to the rules of sustainable stock management have led to the recovery and stabilisation of many commercial stocks.

The NWWAC and PelAC strive for healthy seas, resilient to external pressure factors. This means that pressures from economic activities such as offshore energy production, sea mining and commodity extraction need to occur within the ecological carrying capacity. When it comes to offshore wind however, we also have a dual goal. More renewable energy (to mitigate climate change, which benefits everyone here) and more protection for nature. These goals can sometimes be conflicting. Offshore wind can potentially provide opportunities for nature in the form of certain fishing restrictions and nature strengthening/restoring activities (especially underwater). On the other hand, wind parks and underwater noise can have ecological effects, which, although scientific research is taking place, are still largely unknown. At the same time, the large-scale expansion of offshore wind and increasing underwater noise continue to move forward at a rapid pace among these knowledge gaps.

On both the European and the international level it is yet unclear to what extent (potential cumulative) effects of offshore wind energy developments on fishing areas, for example spawning grounds, nursery areas, or important habitats for fish stocks, are taken into account in a cross-border context, as policy, research and mitigation appear not to be streamlined. Currently, effects on a wide scale are unknown, and research, monitoring and marine spatial planning tend to be carried out at a national level. The studies and especially measures that do exist at the moment are largely focused on protected species (marine mammals and birds) and are limited in scope. Effects are even more unclear at ecosystem level and specifically regarding cumulative effects, including inter-sectoral effects. This is relevant here today as effects on fish and fisheries resources are still a large knowledge

gap, including pelagic species, which perform relevant and important ecosystem functions as forage fish. This leads to a lack of ecosystem-based management measures and MSP decisions. The bottom line is there is still a lot we do not know, and research is at an early stage.

Beyond the ecosystem level, research is still needed to assess the impacts of wind farms at other levels. It should be noted that research on other factors related to wind farms and their connection is necessary, such as the impact of electromagnetic field emissions, the diffusion of chemical elements from wind turbine structures or the turbidity generated.

While the issue of underwater noise is directly linked to the development and operation of offshore wind energy sites, its many aspects are far more wide ranging. Underwater noise is generated across a wide spectrum of activities, and the ocean soundscape is made up of many different sound sources of both natural and anthropogenic origin. To establish a solid risk assessment framework the identification and description of sound sources is vital¹. It is important to note that to date most studies have focused on single sound source, which does not adequately reflect reality in the oceans where combinations and accumulations of sounds and noises are a daily occurrence.

In 2021 the North Sea Foundation conducted an in-depth analysis on the ecological risks² of offshore wind energy developments. The following challenges were found: 1) As mentioned before there are still many ecological knowledge gaps, including cumulative/ecosystem effects and especially in combination with other pressures, such as oil and gas, shipping, sand extraction and fisheries³; 2) the necessity, methods and effects of mitigation measures have not yet been adequately mapped out; and 3) policy is already being drawn up for scaling up offshore wind after 2030, which means there does not seem to be time to implement the results of new studies in policy. As a result, the North Sea Foundation foresees a scenario in which the protection/restoration of North Sea nature and the attainment of climate targets will hinder each other.

In 2020 the North Western Waters AC and the Pelagic AC established a joint Focus Group on impacts from seismic activities and offshore wind farms which developed two separate advice submissions to the Commission (1) for a non-recurrent request to ICES on seismic impacts (04 August 2020, [link](#)), and (2) for a non-recurrent request to ICES on the impact of marine wind energy developments on commercial fish stocks (04 November 2020, [link](#)). The latter advice was also supported by the North Sea AC. Since these Advisory Councils' submissions in 2020, two important reports have been published.

The Commission's 2021 final report "Overview of the effects of offshore wind farms on fisheries and aquaculture" (EASME/EMFF/2018/011 Lot 1: Specific Contract No. 03, [link](#)) identified temporary negative effects during the construction phase of offshore wind farms (OWFs), and mixed effects during the operational phase. Several recommendations are made which tally with the requests made by the Advisory Councils. In addition, a knowledge bridge gap analysis sets out the current knowledge base regarding various tasks, identifies the information needed and makes recommendations as to the desired outcome (Table 4, page 77).

¹ A study of the impact of noise on the environment is planned as part of the GIS ECUME. This study would be established in Normandy, taking into account the different sources, targets: commercial and key species in food webs: under development. Implementation planned for 2023-2024.

² <https://s3-eu-west-1.amazonaws.com/noordzee/app/uploads/2022/03/15134930/202203-SDN-Ecological-risks-Wind-at-Sea.pdf>

³ Please also see this position paper of CRPM Normandie ([link](#))

The European Marine Board's report "Addressing underwater noise in Europe" (Future Science Brief No 7 October 2021, [link](#)) identified that when it comes to underwater noise "while significant progress has been made, knowledge gaps still remain". It also makes several recommendations that tally with the Advisory Councils' submissions and states: "Much knowledge has been gained in the past 13 years on noise effects, especially on behavioural responses in marine mammals, thanks to ground-breaking technology, large-scale and coordinated field efforts, and targeted funding. However, our understanding of effects on fishes and especially invertebrates is lagging behind. Important gaps remain in our knowledge on health effects of noise across all taxa. Finally, we have extremely limited understanding about the population consequences of noise impacts. In this context we need to refocus our attention to ecosystem effects of noise, i.e., how does noise affect the different components of the food web, such as invertebrates and fishes that can then in turn affect marine mammals?"

Both reports make additional recommendations which the Advisory Councils strongly support and wish to follow up on in light of their own requests from 2020. Knowledge has advanced to a certain extent, however, the queries raised by the Advisory Councils have not been addressed.

In order to update their knowledge regarding the current state of play on this topic, the NWWAC and PelAC jointly organised a workshop on the impacts of seismic and offshore wind energy developments on fisheries ([link](#)) which included presentations from DG MARE, DG ENV, the European Marine Board and the ICES Working Group on Offshore Wind Development and Fisheries.

The two previous submissions made in 2020 as well as the results from the discussions at this workshop form the basis for this advice.

Both the NWWAC and the PelAC support the concerns voiced and recommendations made in the European Parliament resolution of 7 July 2021 on the impact on the fishing sector of offshore wind farms and other renewable energy systems ([2019/2158\(INI\)](#)).

We are at a time where renewable energy can help us to mitigate effects of climate change, however, this comes hand-in-hand with new ecological risks and pressures on already heavily environmentally impacted busy seas with other pressure factors taking place such as underwater noise. The wind energy transition can occur successfully within existing frameworks and EU ambitions. This involves investing in research and knowledge development, harnessing opportunities presented including multi-use and nature-inclusive design, mitigating risks as much as possible (such as within MSP decisions), and modifying policy to be adaptive and integrative⁴. There is potential here for a win-win. Healthy ecosystems also mean a successful offshore wind transition alongside robust fisheries.

⁴ Please note this IFREMER report assessing the scallop stocks in the Bay de Seine and changes to the area originally designated as a least impact zone ([link](#)).

2 Recommendations

- The ACs recall their submissions from 2020⁵ and emphasise the urgency of the questions raised in both requests. NWWAC and PelAC members strongly believe that the issues raised in these two submissions have yet to be addressed and should be included in the push to close existing data gaps.
- Research on both topics is being carried out across various Member States as well as by the Commission. The setting up of a publicly accessible, coordinated and continually updated database is encouraged with financial support and under the lead of the Commission.
- More research is needed urgently on the impact on commercial fish and shellfish species across all life stages and on their habitats. Additional funds must be made available under existing EU funding programmes and specific research calls should be set up to address this urgent need for additional scientific evidence.
- Data collection should involve collection of real-time experience from fishers in the affected areas. Surveys must be carried out to tap into the existing knowledge base and link it scientific observations.
- The potential effect of underwater noise related to offshore wind energy or exploratory activities on the schooling behaviour of fish species is unclear. If the impacts are negative and they occur during scientific surveys, this could have significant implications for the reliability of biomass estimates, acoustic time series and the data going into assessments. Research should be carried out to address this issue.
- The risk of displacement of floating offshore wind energy installations due to inclement weather conditions and related potential impacts must be strategically evaluated.
- All research on the impacts of developments must be truly independent and the quality of the science must be assured through independent peer review and publication.
- While the development of offshore wind energy projects is important in order to meet the EU goals for decarbonisation, it is essential that this work is not carried out to the detriment of existing activities in the marine space (especially of the primary catching sector which contributes to ensuring food security in the EU) and the marine environment. The precautionary approach must be adhered to across all sectors involved in the use of the marine environment.

⁵ Joint NWWAC/PELAC advice for a non-recurrent request to ICES on the potential impacts of seismic activities, 04 August 2020 ([link](#)); NWWAC, PELAC and NSAC advice for a non-recurrent request to ICES on the impact of marine wind energy developments on commercial fish stocks, 04 November 2020 ([link](#))

- It is vital that any work carried out by the European Commission and any guidance on best practices are harmonised with the approaches in third countries, for example the UK and Norway, and that efforts are made to jointly address issues, fill data gaps and deliver best management practices.
- Collaboration and coordination between neighbouring Member States and on a regional sea basin level is essential in order to avoid cumulative impacts and the displacement of fishing vessels from traditional fishing grounds with no alternatives. The European Commission must assist the coordination process of this engagement between the different Member States. Measures to avoid and reduce potential negative effects for fishing activities must be systematically adopted. However, should certain fishing practices be hindered temporarily (particularly during the construction phase), mitigation measures including financial compensation should be considered be put in place to compensate for the socio-economic loss of fisheries activities. Compensatory measures must be defined in collaboration with the sector.
- Where mitigation measures are available these must be implemented accordingly. If no measures are available, further work must be carried out to develop these urgently and appropriately in close collaboration with the stakeholders.
- The transferability of skills between the fishing sector and the service providers for marine offshore wind energy developments must be coordinated to allow transfer of employment as well as new entrants into this growing sector. This should be considered as an additional opportunity for fishers and not take away from the employment needs of the seafood sector.
- Early stakeholder engagement at every step of the wind farm development is key. Involved AC members refer to the system established in the Netherlands which could act as a model way forward for a harmonised approach across EU Member States. The ACs recommend that the Commission reviews and adapts this process to ensure a coordinated implementation across Member States.
- The Commission should establish guidelines on co-existence and best practice regarding the development of offshore wind energy projects in relation to fisheries activities.
- The ACs recommend that sufficient funding is made available to allow the Member States to implement the agreed stakeholder engagement model.
- Renewable energy must be planned in a way that takes into account the ecosystem and be safeguarded by a process that includes independent, robust, comprehensive and transparent assessments prior to approval. These assessments should take into account long-term effects as well as consider the precautionary approach and ecosystem-based management. In addition, development plans for renewable energy projects must consider other uses, including fishing, in the long run in order to offer better visibility to all stakeholders.
- To ensure that the large-scale development of offshore wind can occur within the ecological carrying capacity we urge the Commission to match its ambition towards renewable energy to its

biodiversity goals. This means implementing the agreements within the EU Biodiversity Strategy effectively. We currently see an extremely fast pace of offshore wind development and site designations, which are impacting fishing activities in Member States, while nature developments such as implementation of protected areas are still lagging behind.

- Increased research into the ecological impact, mitigation options and innovation of offshore wind farms and proper application of the precautionary principle when knowledge gaps still exist.
- An integral adaptive policy must be in place whereby decisions can be adjusted in a timely manner if ecological research results give reason to do so. This means answers would be available to the most important ecological knowledge gaps before committing to permanent decisions regarding for example site decisions. This should include adaptive designation and long-term assessment with marine planning and reporting elements.
- Inclusion of potential multi-use and differing stakeholders (including for sustainable fisheries and for nature development) at an early stage when designing future offshore wind farms. Involved AC members refer to the example of multi-use as a guiding principle and area passports in the Netherlands.
- It is essential that investments are directed at developing and deploying best available technologies and best environmental practises that will mitigate negative impacts on biodiversity, i.e., by reducing noise levels to leave marine life unharmed. Such approaches have already been proven successful in stimulating the development of alternative foundations (e.g., gravity-based or bucket foundations), floating wind-turbines, alternative piling techniques and sound reduction measures such as bubble curtains and cofferdams⁶.

⁶ UNEP/CMS/COP13/Inf.9: Best available technology (bat) and best environmental practice (bet) for three noise sources: shipping, seismic airgun surveys, and pile driving ([link](#))

3 Recommendations in the European Commission’s “Overview of the effects of offshore wind farms on fisheries and aquaculture (EASME/EMFF/2018/011 Lot 1: Specific Contract No. 03”)

Note: This report is largely based on work done on fixed turbines in shallow water rather than floating turbines in deep water offshore and there are likely going to be significant differences in the impacts the different types will have. Shallow areas like sandbanks in the Irish and North Sea are much more dynamic areas in terms of bottom hydrography than deeper offshore areas therefore they may not see a significant response to the exclusion of bottom fishing in OWFs.

Desired Knowledge (Recommendation)	ACs’ comment
<p>Comparable and documented ecological knowledge which assesses individual, localized and wider effects and responses. This information is important to assess the level of impact of similar structures or site-specific effects.</p>	<p>Impacts are generated both during the developmental as well as the operational phase, and adverse effects remain poorly understood, such as regarding acoustic impacts of seismic acquisition and surveys during the development stage for example on spawning and nursery stocks. There is recent significant research in both South East Australia⁷ and on the Atlantic coastline of the United States and Canada, off the coasts of Newfoundland, Nova Scotia & Coast of Labrador, Maine and south to Florida indicating that that these seismic airgun surveys, sometimes described as seismic blasting, trigger significant adverse impacts to both spawning and nursery stocks up to and including stock collapse. Studies should consider resilience of both habitats and species to the impacts during the development and operational phases.</p> <p>The impact of the electromagnetic fields arising from underwater cabling on the stocks and ecosystem has not been yet sufficiently researched. It is advisable to carry out deeper research on this subject. Furthermore, there is a lack of knowledge regarding cable installation and studies should be carried out about best installation practices, e.g., buried or above ground cabling.</p> <p>As the life span of installations is only approx. 20 years after which these will be removed and possibly replaced, decommissioning must also be considered, for example in the case of floating turbines, will the anchors and anchor cabling be</p>

⁷ Fisheries Research and Development Corporation (FRDC) Australia 2019-072: Multiple - Before After Control Impact (M-BACI) analysis of the effect of a 3D marine seismic survey on Danish Seine catch rates ([link](#))

	recovered or left in situ; in the case of pile driven foundations will these be left in situ; in both cases will the electrical cabling be recovered. In addition, before removal OWFs should be surveyed as the foundations may add to biodiversity (cold-water corals settling for example).
A targeted, integrated analysis aimed at defining what the level of effects (significance) are across sites, responses and scales (e.g., meta-analysis) is needed. Proper communication among stakeholders is key to ensuring a similar level of understanding of the effects.	The ACs agree with this recommendation and support work by the Commission on this topic. This should include a comparison of the different types of turbines (i.e., fixed bottom or floating), as well as type of foundation, power, distance to the coast.
Ecosystem-level research to place into context if OWFs are benefiting ecosystems for fisheries and aquaculture.	The ACs agree with this recommendation and support work by the Commission on this topic.
Determination of ecological pathways and collection of appropriate data, and include commercial fish and crustacean population data of OWF areas within the stock assessment frameworks. A point of attention for the CFP.	The ACs agree with this recommendation and support work by the Commission on this topic. It is vital to obtain data and information about species' breeding areas and seasons before implementing activities of high noise impact, such as air gun systems and pile driving (in the case of fixed turbines), to avoid these areas/seasons.
When can we speak of coexistence, co-location or cooperation between the different sectors? What are good practices in management of aquaculture and fisheries affected by OWF development?	The Commission should establish guidelines on co-existence and best practice regarding the development of offshore wind energy projects, including prospective assessment of direct impacts, the establishment of studies and monitoring of the resource, the environment and fishing activities, carryover (spatial capacity), areas of impact on the environment during the baseline, practical information for professionals, or even the research of OWF setup compatible with fishing activities.
Some guidance and best practice on compensation strategies for the fishery sector should be developed.	Measures to avoid and reduce potential negative effects for fishing activities must be systematically adopted. However, should certain fishing practices be hindered temporarily (particularly during the construction phase), mitigation measures including financial compensation should be considered be put in place to compensate for the socio-economic loss of fisheries activities. Compensatory measures must be defined in collaboration with the sector. The compensation

	process should take into account all impacted fleets and the downstream sector. A protocol for monitoring socio-economic impacts during the operation phase should be defined.
A more uniform application of best practices in stakeholder governance, and early engagement in discussions and planning will be beneficial for future multi-use and colocation of activities.	Early stakeholder engagement is key at every stage of the wind farm development. The system established in the Netherlands could act as a model way forward for a harmonised approach across EU Member States. The ACs recommend that the Commission review and adapt this process to ensure a coordinated implementation across Member States.
A document with the current details on co-location in MSP would help as a 'best practice' document to inform industries and Member States of current practices, to help counter bias and 'polarization' of current approaches.	The ACs agree and have discussed this issue. They welcome additional work being carried out to address this issue in the broader context of MSP. MSP should be continually updated in line with increasing knowledge.
There is a need to study the possibilities and restrictions on operability (including opportunities and risks) of other activities (e.g., fishery and aquaculture) in and around OWFs in Europe within the legal frameworks.	The ACs support this recommendation and recommend that other activities beyond fisheries and aquaculture should be included, for example recreational fisheries, conservation activities and others.
An estimation of the possible socio-economic loss due to OWFs for the EU fishery fleet and aquaculture sector is needed to have a better view on possible compensation and mitigation needs.	The ACs agree with this recommendation and support work by the Commission on this topic and recommend that the full lifecycle is addressed in the socio-economic analysis. Data should be collected to develop economic interest maps for fishing, which estimate the monetary value that every part of the surface area provides the sector.
The existing 'stakeholder guidelines on 'best practice' should be more effectively implemented and in a more transparent way.	The ACs recommend that the best practice guidelines are urgently updated. Early stakeholder engagement is key. The system established in the Netherlands ⁸ could act as a model way forward for a harmonised approach across EU Member States. The ACs recommend that the Commission review and adapt this process to ensure a coordinated implementation across Member States.

⁸ The North Sea Agreement ([link](#))

<p>It is recommended to take the lessons learned from current OWF planning and developments in relation to fishery and aquaculture and consider the synergies and/or differences between floating and fixed OWF from the early planning stages onwards.</p>	<p>The ACs agree with this recommendation and support work by the Commission on this topic.</p>
<p>Information on ecological changes (e.g., some ecological benefits shall change), engineering possibilities (e.g., not increasing the OWF footprint in an area) and socio-economic aspects (e.g., OWF area back as fishing ground?) of removing a structure need to be collected.</p>	<p>The ACs agree with this recommendation and support work by the Commission on this topic.</p>

4 Recommendations from the European Marine Board’s “Addressing underwater noise in Europe, Future Science Brief No 7 October 2021”

Recommendation	ACs’ comments
Develop collaborative international standards applicable to all steps of the risk framework	The ACs agree with this recommendation and urge the Commission to carry out work on this topic.
Conduct comprehensive monitoring combined with spatial ecological modelling of marine species’ dynamic habitat use, movements, behaviour and distribution to establish baselines.	What habitats, including shallower waters, for commercially exploited fish in the NWW region are affected by seismic activities and what possible measures, such as seasonal restrictions would be effective at mitigating these impacts across the ecosystem?
Foster comprehensive monitoring and data collection of current soundscapes / ambient noise, including via joint monitoring programmes in existing and new areas.	The ACs agree with this recommendation and urge the Commission to carry out work on this topic.
Shortlist high priority (and biologically relevant) sound sources and perform standardized source characterization studies.	The ACs agree with this recommendation and urge the Commission to carry out work on this topic.
Promote hearing studies on baleen whales and on selected fish and invertebrate species.	The ACs agree with this recommendation and urge the Commission to carry out work on this topic across all species in the marine ecosystem. These studies should include research on particle motion and its impact on marine species. ⁹
Conduct field and modelling studies on changes in acoustic habitats to identify masking risks to communication in fishes and marine mammals	The ACs agree with this recommendation and urge the Commission to carry out work on this topic. Additional taxa need to be included in these studies (crustaceans, cephalopods, etc.).
Conduct further studies on behavioural response of marine mammals and fishes due to exposure to high intensity impulsive sounds to assess population consequences via e.g., displacement.	The ACs agree with this recommendation and urge the Commission to carry out work on this topic across all species in the marine ecosystem. Fishers in the North Western Waters observed the migration of brown crab to miles away from areas where seismic surveys took place. What are the impacts of seismic activities on migratory patterns of brown crab in the North Western Waters, including shallow water areas?

⁹ Sigray et al., 2022: Particle motion observed during offshore wind turbine piling operation. Marine Pollution Bulletin Volume 180, July 2022, 113734 ([link](#))

	<p>Does increased noise and vibration associated with the operation of windfarm developments and increased boat traffic result in increased larval mortality for commercially exploited fish and invertebrate species, displacement of or interruption to migration patterns and reproductive behaviours, alteration of species distributions, and injury or mortality of fish¹⁰?</p>
<p>Conduct taxa-relevant studies on hearing impairment and physiological stress to address existing knowledge gaps in invertebrates, fishes and marine mammals. Priorities for marine mammals are understanding the relationship between Temporary- and Permanent Threshold Shift and physiological stress; priorities for fishes are stress; and priorities for invertebrates are a basic description of physiological impacts.</p>	<p>The ACs agree with this recommendation and urge the Commission to carry out work on this topic across all species in the marine ecosystem.</p> <p>How does seismic activity affect developing eggs and larvae, with special focus on the commercially exploited stocks (both pelagic and demersal) in the North Western Waters region?</p> <p>Are there any known effects of seismic surveys on mackerel larval development and recruitment? Can these effects potentially affect the mackerel survey outcome in the long term?</p> <p>What are the (short/long term) impacts of seismic surveys happening in areas that are known spawning grounds for herring? E.g., in the Downs herring spawning ground in divisions 4.c and 7.d. or spawning grounds in the Shetland area in division 4a. Can these activities adversely affect herring reproduction in the long term?</p> <p>What are the effects of seismic activity on cod populations, namely on the size and stability of spawning aggregations?</p>

¹⁰ Measurable impacts have been documented in this assessment on the Parc éolien en mer de Dieppe-Le-Tréport by BRL ingénierie ([link](#))

	What are the short-term effects of seismic surveys happening in the spawning burrows for <i>Nephrops</i> at time of spawning?
Conduct dedicated studies including multi-species investigations, predator-prey interactions, and interaction with other food web levels, addressing the question of how noise impacts combine with other stressors.	The ACs agree with this recommendation and urge the Commission to carry out work on this topic.
Develop frameworks and conduct studies to allow population-level assessment of effects from cumulative impact of noise and other pressures.	The ACs agree with this recommendation and urge the Commission to carry out work on this topic.
Conduct dedicated modelling and field studies to improve understanding on effectiveness, safety and cost-effectiveness of noise mitigation devices, mitigation measures and management options. This requires a shortlist of relevant industries and their sound sources (e.g., shipping, marine renewables, unexploded ordnances and geophysical surveys).	Where mitigation measures are available these must be implemented accordingly. If no measures are available, further work must be carried out to develop these urgently and appropriately.
Develop regional action plans and guidelines for Environmental Impact Assessment and policies.	The ACs agree with this recommendation. While it is important to consider regional specificities in the different sea basis, it is also important to harmonise plans and policies across all EU Member States.
Initiate international collaborative projects (via European Union, International Maritime Organization etc.) to develop stakeholder and societal capacity in understanding and addressing underwater noise. These projects should include technical guidance and workshops, sharing data and best practices globally and openly, and supporting transdisciplinary (e.g., between acousticians, biologists and others) science and communication.	The ACs agree with this recommendation and urge the Commission to carry out work on this topic.

- END -

5 Annex

List of previous recommendations and other relevant documents

- Joint NWWAC/PELAC advice for a non-recurrent request to ICES on the potential impacts of seismic activities, 04 August 2020 ([link](#))
- NWWAC, PELAC and NSAC advice for a non-recurrent request to ICES on the impact of marine wind energy developments on commercial fish stocks, 04 November 2020 ([link](#))
- Sigraay et al., 2022 Peter Sigraay, Markus Linné, Mathias H. Andersson, Andreas Nöjd, Leif K.G. Persson, Andrew B. Gill, Frank Thomsen: Particle motion observed during offshore wind turbine piling operation. Marine Pollution Bulletin Volume 180, July 2022, 113734; <https://doi.org/10.1016/j.marpolbul.2022.113734>
- Analysis of ecological risks of offshore wind and recommendations by the North Sea Foundation: <https://s3-eu-west-1.amazonaws.com/noordzee/app/uploads/2022/03/15134930/202203-SDN-Ecological-risks-Wind-at-Sea.pdf>