BE WILD

Biodiversity Enhanced Wind Farm development, Integrated monitoring & inspection and Localized Design

A MOOI project progress report year 1

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Seekable
Mecal Advanced Tower Systems
CrossWind

This project is executed with a Top-sector Energy subsidy from the Dutch ministry of Economic Affairs and Climate, as implemented by Rijksdienst voor Ondernemend Nederland (RVO). The specific subsidy for this project is the MOOI-subsidy, round 2022.

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1 Summary

Background
In the coming years, many new wind farms are to be built in the North Sea. In 2030, these wind farms are projected to provide 21.5 GW, which is 40 percent of the current electricity consumption in the Netherlands. Wind farms both offer opportunities and pose risks for nature. There are for example risks for birds and bats, while construction work causes temporary disruption to marine mammals and could potentially affect marine life on the seafloor (in particular cable laying activities). Opportunities arise especially underwater. In wind farms it is not allowed to carry out seabed disturbing activities such as trawl fishing. By installing artificial structures that are integrated in existing offshore wind structures, it is possible to accelerate and strengthen the development of biodiversity within wind farms.

Impact on sea life in the area of wind farms is not yet fully understood (negative and positive effects), while performing in-depth ecology research on-site is expensive due to the logistics. Yet, there are little incentives for offshore wind farm operators to invest in ecological optimizations when the benefits are not clear and the risk of failures for chosen biodiversity interventions are high. Moreover, investments in offshore wind farms are already very costly, and as a consequence investors want to reduce external risks as much as possible. Potential other users of the same wind farm location, such as shipping, fishery and nature, are therefore not much welcomed in the same area as they could potentially harm the operational reliability of the wind farm. An integral understanding is needed in order to accelerate the roll out of offshore wind in the North Sea in a (ecologically) sustainable manner.

Purpose of the project
Without measures, the wind farm operators are limiting other functions that could be performed in the area, while the environmental footprint of O&M tasks in wind farms is relatively high. By implementing an integral approach on data collection and analyses for wind farm operations and ecology, the operational costs can be reduced while valuable datasets can be delivered, with positive outcomes for the wind sector and nature. Furthermore, the deployment of robotic systems such as Unmanned Surface Vessels (USVs) and underwater Remotely Operating Vehicles (ROVs) hold the potential to substantially reduce operational costs for wind farm inspection and maintenance compared to common practise of using (large) support vessels with staff in the wind farm.

The objective of the project is to develop synergies between ecological and technological needs, activities and requirements in order to effectively tackle key challenges in **realizing an economically and ecologically sustainable expansion of offshore wind energy** in the North Sea towards 72 GW in 2050, thereby reducing societal costs.

In order to reach such synergies, it is crucial to integrate **new measuring and sensor systems (such as eDNA sampling)** and to ensure optimal data collection and analyses methods, preferably onboard

of robotic systems such as USVs and ROVs. This requires advancements in the measurement systems and improved robotization techniques that allow for **more autonomous operations** (remotely controlled) with smaller vehicles, which makes deployment of multiple units commercially feasible and therefore expanding the measurement capabilities (more measurements in less time). This contributes to speeding up the phase of site preparation of offshore wind farms, while **enlarging the data collection capacity** during the operational stages of wind farms. In combination with new advancements in underwater robotics (ROV's), it will be possible to collect data closer to the existing structures than currently possible. Lastly, the implementation of **Biodiversity Enhanced Scour Protection** measures that can be delivered on the scale, price and quality required for offshore windfarms, fully adaptable to local conditions, will speed up ecological developments in wind farms.

Results

At the end of the project, the following results will have been achieved:

- Monitoring with e-DNA samples: this is a cost-efficient and non-invasive method to identify which species are present at a particular location in the wind farm. It does not require a detailed look with camera's subsea and/or interacting with living organisms, making it a low-cost and scalable solution.
- Cable detection sensor: having an integrated, highly accurate cable detection sensor onboard on an USV-ROV allows for making more frequent cable inspection surveys and, in case of a failure, to pinpoint the location of the cable fraction much faster.
- Biodiversity enhancing scour protection based a modular and industrialized design that can be modified in such a way that in addition to its primary protective function, it can enhance ecological functioning against low additional costs compared to existing scour protection measures.
- Integrated USV solutions. Having the latest sensing and analyses capabilities integrated on an unmanned vessel allows to do more measurements all at the same time, creating a complete view of the status of both the subsea structures and subsea life. The integrated IRM solution allows for more frequent data collection of all different variables at the same time, enabling the offshore wind farm operators to make well-informed decisions on possible interventions that are needed. This lowers the risk on possible technical or ecological failures subsea.

Actual status

At the end of our second year, the project is still running on time and on budget. Developments started during the first year and commenced as planned within the second year. Fugro continued to work on the prototype eDNA sampler and the vision technology so they can be deployed on the e-ROV. Wageningen, Marine ecology, continued research on e-DNA sampling and filtering techniques together with Fugro hardware development to actual sample and preserve the sampler correctly for analysis. Wageningen is increasing insights from different samplings done offshore during last year. Wageningen Marine Policy continue to research environmental policies in place for Dutch Wind parks and started

also a comparison with related regulation, legislation and policies used in other countries, starting with the UK. Seekable continued the development of the cable tracking solution and the combination with ROV's in order to find and locate offshore wind related power cables. Seekable is research prototype stage. Mecal continued the development of so called nodes for scour-protection. A concept is developed and prototypes are currently being tested in simulated controlled environments as well as in open water (near shore in Zeeland). Furthermore a project publication was presented during the Wind Europe event that was held in Bilbao Spain during 20-22 March 2024.

The project progressed almost as planned during the second year of execution but we have over run milestone 2 by two month : Milestone 2: Novel USV-ROV equipment and biodiversity enhancing measures developed (31-12-2024); First prototypes of novel USV/ROV equipment are developed. Biodiversity enhancing methods are developed in concept and are still being tested and researched. Under Milestone 2 we have planned result 2 and 3. Result 3 is still running and we are on track to finalize this result in the second half of March 2025 when we deploy the world's first fully remote ecology survey of an operational wind farm; reaching Milestone 2 two and half months later than planned.

In conclusion the project is commencing in a positive way but encountered some minor delays. We continue the development in 2025 and are confident we will be able to reach all milestones and results within the available project duration.

2 Description of executed activities

Project activities follow the following result-based structure (Results 1-6):

1. Design of an integrated full area measurement and analysis strategy
2. Development of novel USV/ROV monitoring equipment (new sensor developments)
3. Integration of new devices with the Fugro USV/ROV combination
4. Selection and design of biodiversity enhancement options
5. Validation and market preparation of the integrated USV-ROV monitoring and inspection solutions
6. Research into new and improved policy strategies

The project is currently running for 2 years. The following activities are planned to reach the above results:

Result 1 Design of an integrated full area measurement and analysis strategy

1.1 Design of an ecological measurement strategy
1.2 Design of an overall wind farm inspection and measurement strategy
1.3 Development of improved eDNA analysis methods
1.4 Research and development regarding possibilities for remote eDNA analysis on board the USV

Status after year 2:
Over the past year, significant progress has been made within Result 1. The design strategy for ecological measurements has been completed, and the associated sampling campaign has been carried out. Where necessary, training sessions were conducted, and Crosswind facilitated transport and access to offshore wind farms to enable the measurements. Additionally, the overall inspection and measurement strategy for wind farms, including a cable detection strategy based on USVs, has been successfully finalized.

In the field of eDNA analysis, sampling was conducted within a wind farm throughout the year, after which the collected samples were analyzed and labeled. Wageningen University has conducted research to improve the shelf life and quality of the samples, as well as their further processing and storage in the eDNA databank. Furthermore, efforts have been made to expand the number of samples and refine DNA recognition and the genome database.

Additionally, in 2024, Fugro started developing a prototype for a remotely operated eDNA analysis unit, a machine learning process for epibenthic biota detection, integrated high-definition cameras to the USV, and planned an approach for 3D photogrammetry for ecology purposes. The focus is on providing an optimal combination of eDNA samples and videography to gain the best insight to subsea ecology without excessive marine operations. The combined remote eDNA and visual prototype is expected to be tested in open water in 2025, where the remote-controlled deployment of the USV, ROV, visual methodologies and eDNA sampler will also be evaluated.

These developments contribute to more efficient and accurate ecological monitoring within offshore wind farms. By combining ecological surveys that include both eDNA and advanced computer vision with engineering inspections, not only is the quality of data improved, but the safety of operations, carbon emissions due to vessel operations, and cost effectiveness of monitoring processes are also optimized.

Result 2: Development of novel USV/ROV monitoring equipment
2.1 Design and prototyping of a novel submarine cable tracking methodology
2.2 Design and prototyping of an offshore USV eDNA water sampler and filtration device
2.3 Design and prototyping of a subsea water sampler to be fitted onto an ROV
2.4 Design and prototyping of sensor systems for environmental monitoring and other core USV equipment

Status after year 2:
Significant progress has been made in the development of novel USV/ROV monitoring equipment. Seekable developed and tested a prototype frame solution for submarine cable tracking, designed to carry different sensors. Improvements are being made to the software supporting these

measurements, while the sensors have been enhanced to improve detection quality, direction, and the field of detection near and under the seafloor.

In parallel to Seekable's developments, Fugro has also developed and tested an alternative magnetic approach to cable tracking. This approach has proven to be unsuccessful and will not be taken further.

The design and prototyping of an offshore USV eDNA water sampler and filtration device have taken longer than expected. However, substantial progress was made in the second year, particularly in researching additional sensors. While the eDNA sampler is not yet finalized, Fugro is constructing a prototype, which has undergone pressure testing in the lab before being released for open-water testing in Q1 of 2025. Test plans are currently being prepared for 2025.

Regarding the subsea water sampler designed for ROV integration, Fugro has continued developing a concept for eDNA samplers tailored for this purpose. These samplers are being designed to be as compact as possible, with automated sampling and sample preservation capabilities. The finalization of this activity is planned for the first half of 2025.

In parallel with the delays in the eDNA sampler development (2.2 and 2.3), the prototyping of sensor systems for environmental monitoring has progressed well. It was concluded between Fugro and Wageningen that a visual approach was most effective for corroborating the eDNA findings and this has been the focus over other measurements. A machine learning process that speeds up the process of identifying species living on the seabed has been developed and successfully tested on several European projects. High definition cameras have been integrated to the ROV and tested for the purpose of producing both 2D orthomosaics and 3D photogrammetry for ecological survey. Both methods have been successfully tested and plans are being finalized for testing at the CrossWind site. In addition, Fugro has engaged the Scottish Association for Marine Science (SAMS) for further support on utilizing 3D photogrammetry for biomass estimation. This approach will be further integrated to the future surveys.

Result 3 Integration of devices with the Fugro USV/ROV combination
3.1 Design and prototyping of required technical modifications to the ROV for effective deployment of new measuring devices
3.2 Design and prototyping of required technical modifications to the USV for effective deployment of new measuring devices
3.3 Development of enhanced control systems to enlarge autonomy of the system

Status after year 2:
Progress has been made in integrating devices with the Fugro USV-ROV combination. Throughout the second year, development continued on the necessary technological modifications to the USV, ensuring

the effective deployment of new measuring devices. A decision was made to further invest in the development of ROV-mounted sampling devices, with integration efforts continuing into 2025.

The integration of the sampler with the ROV remains an ongoing area of research and is closely tied to the finalized designs developed under Results 2 and 3. Integration of high definition cameras for ecology purposes has been completed and successfully tested. Additionally, the integration of the cable tracking system is being explored. Currently, it is expected that the cable tracing sensor array will function as an attachable unit rather than an integrated component of the ROV. However, alternative solutions that incorporate the sensor array as an integral part of the ROV are under investigation.

In parallel, research on enhancing control systems has begun, with the goal of increasing the system's autonomy and enabling automatic adaptation of movements based on incoming data. This research is directly connected to the developments in Results 2, 3.1, and 3.2, ensuring a more streamlined and efficient integration of the various components.

Result 4 Selection and design of biodiversity enhancement options
4.1 Design and prototyping of biodiversity enhancing and functionally sound elements for scour protection
4.2 Validation of the new scour protection, including installation thereof, in a realistic environment
4.3 Supply chain and logistical analysis
4.4 Research into additional applications of development biodiversity enhancing structures

Status after year 2:
In the second year of the project, significant progress was made in the selection and design of biodiversity enhancement options. A final design for scour protection elements, known as the "Node" design, was developed and tested at Deltares laboratories. The test results were positive, confirming the functional effectiveness of the design.

For the validation of the new scour protection in a realistic environment, several field test options have been identified, with implementation planned for 2025 and 2026. In 2024, Mecal initiated a field experiment in Zeeland (Grevelingen), where the nodes were placed in salt water. Growth on these nodes is being monitored as part of the ongoing validation process.

The supply chain and logistical analysis were successfully completed in 2024. Production options were researched, and suitable manufacturers capable of producing the nodes were identified. With these findings, this activity has been finalized.

Additionally, research into further applications of biodiversity-enhancing structures continued. Various experiments were conducted to introduce live animal larvae into the nodes. However, initial attempts were unsuccessful in sustaining the larvae after placement. This research will continue into the third year, with a focus on infusing the nodes with oyster larvae to facilitate ecosystem development.

Result 5 Validation and market preparation of the integrated USV-ROV monitoring and inspection solutions
5.1 Development and planning of testing campaigns to validate the developed integrated monitoring inspection strategy
5.2 Performing testing campaigns and analysis and reporting of results
5.3 Supporting actions toward market introduction

Status after year2:
Significant steps have been taken in the validation and market preparation of the integrated USV-ROV monitoring and inspection solutions. Throughout 2024, various tests were conducted to validate the developed monitoring and inspection strategy. eDNA sampling took place at specific, representative locations within the Offwind offshore wind farm. Additionally, Mecal installed a test-bed of Nodes in the

Grevelingen lake to assess their effectiveness in a real-world environment. Project partners are positive about the results, and testing is expected to continue throughout the project.

Testing campaigns, including analysis and reporting, are closely linked to the initial validation efforts. The ongoing tests will provide further insights into the effectiveness and optimization of the developed strategies, ensuring reliable data collection and monitoring.

Market introduction efforts are also progressing, with supporting actions such as publications and knowledge dissemination. These initiatives aim to raise awareness and establish the developed monitoring solutions as viable tools for ecological and technical assessments in offshore wind environments.

Result 6 Research into new and improved policy strategies
6.1 Review current and upcoming policies regarding biodiversity in the offshore wind sector.
6.2 Identify opportunities for governing automated biodiversity data by variety a range of offshore wind energy related actors
6.3 Research into strategies to stimulate biodiversity enhancing activities
6.4 Establishing and sharing of recommendations to relevant stakeholders

Status after year 2:
Progress has been made in researching new and improved policy strategies for biodiversity in the offshore wind sector. The review of current and upcoming policies regarding biodiversity within the sector has been completed, providing a solid foundation for further research and policy recommendations.

Research on governing automated biodiversity data is ongoing, with a focus on data frameworks. Insights have been gained regarding Dutch regulations and legislation, leading to the decision to compare these findings with frameworks in neighbouring countries such as the UK, where similar offshore wind conditions exist. This comparative analysis will begin in the third year of the project.

Empirical data collection was conducted throughout 2024 on various strategies used to enhance biodiversity within offshore wind projects, tenders, and environmental policies. These insights will support the development of effective biodiversity enhancement strategies within the sector.

Additionally, efforts to establish and share recommendations with relevant stakeholders are ongoing. Consultations have taken place through network contacts in the Netherlands, and the UK, ensuring that findings are disseminated and integrated into broader policy discussions.

3 Description of contribution towards MOOI regulation

The project is part of MOOI innovation theme A-1 as included in the thematic description of the MOOI subsidy scheme (link), i.e. 'electricity, innovations as integral part of offshore wind energy farms'. Within this theme the following of the mentioned 'research and development topics' are addressed:

R&D topics Mission A, theme 1	Contribution of the BE WILD project
Increasing the safety and reliability of wind farms and decreasing the costs of exploitation through robotisation of monitoring and maintenance, using innovations within the fields of diagnostics, sensors, communications systems, AI and control systems (bullet 1 of the MOOI R&D theme description).	The consortium will develop new sensors and analysis software to perform better inspection, monitoring and maintenance tasks in offshore wind farms. In addition, the robot systems that Fugro uses in its IRM services (USVs and ROVs) will be significantly upgraded in order to accommodate the new sensors and will have better processing, positioning and station keeping functions that allow for more reliable and complete surveys in offshore wind farms. Such advanced robotisation allows that more functions can be performed by unmanned systems which leads to significant cost reduction for wind farm operators.
R&D topics Mission A, theme 1	**Contribution of the BE WILD project**
Modular, circular and integral design methods and standardization of components in order to reduce costs and (raw) material usage (bullet 4 of the MOOI R&D theme description);	The project entails an integrated technological and ecological sensing system onboard of one robotic system (USV-ROV), which will be modular in design and components (sensor units and collected samples) can be exchanged/transferred depending on the exact inspection mission needs. Moreover, the projects includes the development of a modular industrialized scour protection system that fosters subsea biodiversity in wind farms. This will be the first time that such biodiversity enhancing scour protection will be implemented on large scale (for an entire turbine) with the perspective to standardize (industrialize) this for upscaling to entire wind farms.
Optimalization of wind farm management strategies with the aim of optimally embedding the renewable energy production and reducing operational and maintenance costs (bullet 5 of the MOOI R&D theme description);	The Operations & Maintenance (O&M) strategy for offshore wind farms can be optimized based on insights derived from the complete datasets that are collected from the integrated technological and ecological sensing systems onboard of the USV-ROV combination. For example, after monitoring seabed changes over a period of 5 years, it could appear that on particular locations in the wind farm there is very little change, while in other locations there is lot of dynamics (e.g. new depositions of sand, washing away of rocks, etc.). The O&M strategy can then be optimized by having only more frequent inspections in the dynamic sites, which will save on O&M costs.
Innovations in the field of design, installation and exploitation of wind farms that have a positive	This subject is very close to the overall objective of the project, as we aim for including the monitoring of the ecological situations by eDNA techniques when performing the regular

net impact on habitats and ecology (below and above water) by means of mitigations and compensation of potential negative effects and by means of strengthening of natural systems (bullet 8 of the MOOI R&D theme description).	technical inspections in wind farms. In this way, wind park owners/operators generate additional insights 'in one go' about the impacts on subsea habitats and ecology without extra costs. In addition, the project will introduce cost-efficient (because industrialized) scour protection measures that are aimed at promoting new habitats for underwater species. This will not only compensate for possible negative effects of wind farm installation and operations, but will even further enhance the natural system underwater, which potentially could even generate new revenue streams (e.g. ideas on 'biodiversity credits' as part of new policy research).

4 Spin off

The activities within the project did not yet yield any tangible spin-off.
However there is internal spinoff within the companies that are cooperating within the project.
Fugro has undertaken considerable scientific and market research which has led to two significant findings:

1. The services being developed for deployment from an ROV deployed from a USV are also desirable from an ROV deployed from a crewed vessel. Several offshore wind customers have expressed interest and this will be explored further.
2. Industry organisations such as the Offshore Renewable Energy Catapult, Renewables Grid Initiative, and Wind Europe are promoting a regional approach to environmental monitoring. This is founded on understanding the oceanographic drivers of primary production and therefore predator-prey interactions. Starting a large scale covering several wind farms and iteratively progressing to a fine scale covering one or more wind turbine generators. This research creates a framework within which the BeWild R&D contribute to a larger understanding of ecosystem dynamics.

The project shows potential to generated more spin-off in the environmental assessment market that goes beyond the offshore wind sector.

5 Publications

The project yielded the following publication in 2024:

Article: Poster Presentation "Advancing biodiversity monitoring in offshore wind farms with novel technologies: practical and policy challenges and opportunities.".
Author: Fugro, on behalf of the BEWILD consortium
Publication date: 20-22 March 2024 Wind Europe conference in Bilbao Spain.

Where to find: attached as annex to this report

Furthermore a few other interesting publications relating to the BEWILD project are published.
Via partner Crosswind:
https://www.linkedin.com/posts/eneco_biodiversiteit-noordzee-oneplanet-activity-7199393559509123073-1Ol-?utm_source=share&utm_medium=member_desktop

Mecal published a short movie on the teste done with the Mecal Nodes at Deltaris.
https://www.youtube.com/watch?v=RdaJwbZ2u68

Beside the above publication the BEWILD project team also set up a handbook on how to organize and approve publication from the BEWILD consortium.
Following a solid approach on communications the project team is able to develop mutual approved publications.
Currently the project can be found in the public space mainly through publications done by the partners in 2023 and that were picked up by other magazines (Windtech International, ECO-magazine, windpower nl etc).

PO 033

Advancing biodiversity monitoring in offshore wind farms with novel technologies: practical and policy challenges and opportunities.

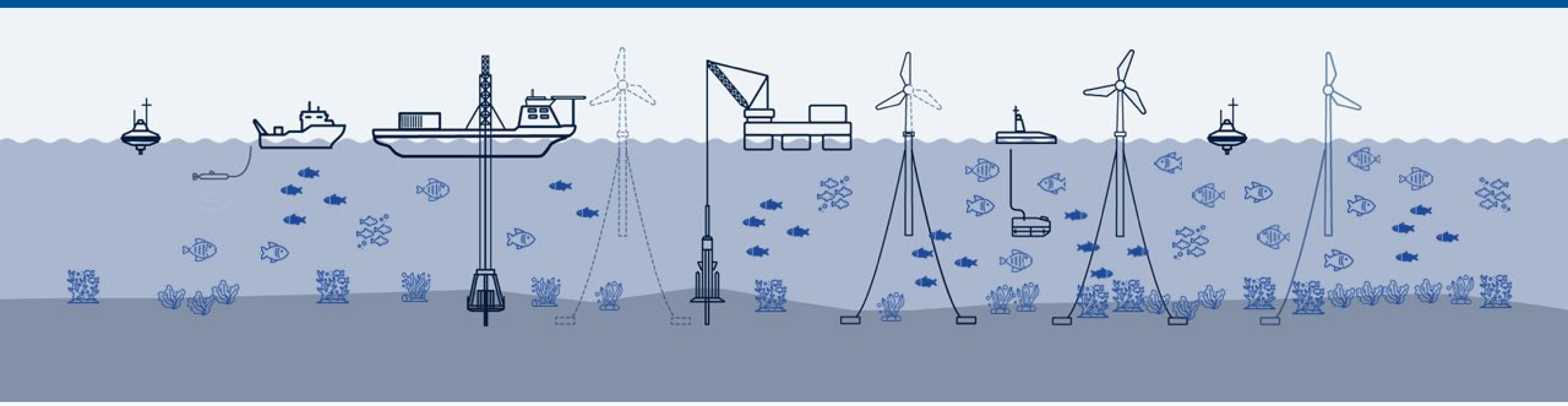
Daniel Smith, Samantha Kristensen

Fugro / Wageningen University / CrossWind / Mecal / Seekable / The Rich North Sea

Policy requirements before site allocation, and…

…data collected during site assessment….

….influences long term monitoring capabilities and biodiversity enhancement opportunities.



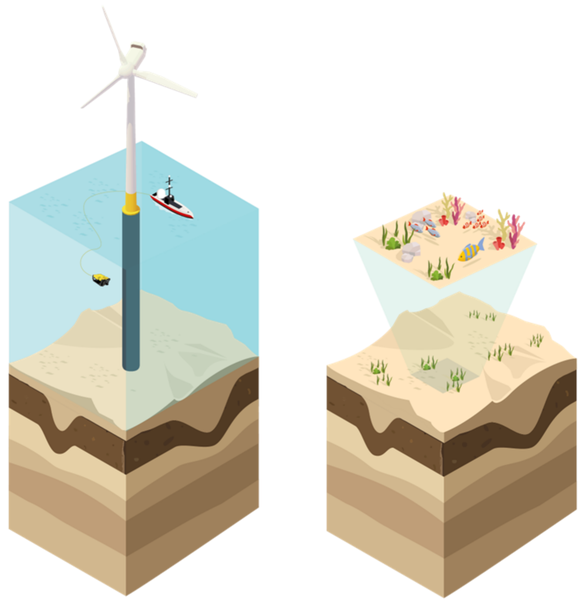
BeWild is a Public Private Research Consortium Supported by the Dutch Government

FUGRO	Consortium lead, remote eDNA sampling, and photogrammetry for ecological survey development.
CROSSWIND	Offshore wind industry (in-kind) partner, operational advice, and offshore site access.
WAGENINGEN UNIVERSITY & RESEARCH	Molecular Marine Ecology and Marine Policy Research.
seekable	Development of submarine power cable detection technology.
MECAL	Development of novel biodiversity enhancing scour protection.
The Rich North Sea	Advisor on North Sea biodiversity enhancement and monitoring approaches.

The aim of BeWild is to develop remote technology to indicate species richness on offshore wind sites

Remote asset inspection utilising Fugro's Uncrewed Surface Vessel (USV) and electric Remotely Operated Vehicle (eROV)

Concurrently acquiring environmental DNA (eDNA) samples and visual data of seabed.



eDNA data, analysed at Wageningen University, provides information of diversity of fish species.

Visual data, analysed by machine learning developed by Fugro, provides information on diversity of species epibenthic communities.

Policy challenges

- There is need for to define how net positive biodiversity impacts will be measured and reported;
- The definition needs to accommodate different environmental and regulatory factors;
- Agreement is needed about how data will be managed and shared between phases to connect baseline to monitoring data; and
- Between projects to understand cumulative effects.

Scientific challenges

- Policy needs to be driven by scientific consensus on target species and desired improvements beyond national boundaries;
- Genome database for marine and benthic species requires development compared to terrestrial species – requiring collaboration; and
- Research connecting species composition and genetic diversity into ecosystem functions would be beneficial.

Practical challenges

- Projects that have passed Final Investment Decision are unlikely to have baseline data intended for biodiversity monitoring;
- Increasing vessel costs limits the amount of additional monitoring feasible; and
- Solving this requires combining scopes to cover ecology monitoring with engineering inspection which requires early coordination within developer.

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