



DELIVERABLE 2.4

REPORT ON OPTIMIZATION OF SCHEDULING, OPERATIONS, AND MAINTENANCE

Work Package 2

Technology

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	<p>ing tools were established and used and the German and Belgian pilot preferred personal communication within scheduled meetings. The great importance of reliable timeframes and support companies was reported upon and the advice is given to carefully choose subcontractors and plan for extra time and money needed due to unforeseeable events. Regarding operations, all pilots agree that weather conditions and weather forecast monitoring play a crucial role. Hand in hand with the weather goes the monitoring of biological process as they are bound to specific seasons to optimize operations. Also, the use of remotely activated safety releases of anchored experiments and equipment is proposed to allow for emergency retrieval without the need of diver assistance. Remote monitoring of the installations is one optimization that allows time and money efficient use of labour force. Also, budget to include insurances is recommended to have an emergency fall back plan. Final maintenance optimization is tied to the seasonal plan and can be arranged to take place in the off-seasons when tourists are involved (Greek and Danish Pilot) or during the calmer summer periods (Dutch, Danish and German Pilot). The findings within this report are not yet final, as more data is expected to come in during a later phase of the project. Further optimizations will be seen during the ongoing operations of the pilots.</p>
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ACRONYMES

BPNS	Belgian Part of the North Sea
CCT	Coordination Committee Team
CSET	Core Services Exploitation Team
CT	Consortium Coordination Team
DSS	Decision Support System
DWD	Deutscher Wetterdienst
EEZ	Exclusive Economic Zone
EC	European Commission
IPR	Intellectual Property Right
km	Kilo Meter
m	Meter
MU	Multi-Use
MUCL	Multi-Use & Co-Location
MW	Megawatt
NGO	Non-Governmental Organization
PA	Partner Assembly
PM	Project Management
ROV	Remotely Operated Vehicle
SAB	Stakeholder Advisory Board
TRL	Technical Readiness Level
WP	Work package

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1. ABSTRACT

Focus in this report is given to the optimization of scheduling, operations and maintenance within the five UNITED Pilots. Regarding scheduling, all pilots report on the great importance of early planning and communication. Regular meetings were held in all pilots. Special dedicated WhatsApp groups were established for example within the Dutch pilot. Within the Danish and Greek pilot specialised online scheduling tools were established and used and the German and Belgian pilot preferred personal communication within scheduled meetings. The great importance of reliable timeframes and support companies was reported upon and the advice is given to carefully choose subcontractors and plan for extra time and money needed due to unforeseeable events. Regarding operations, all pilots agree that weather conditions and weather forecast monitoring play a crucial role. Hand in hand with the weather goes the monitoring of biological process as they are bound to specific seasons to optimize operations. Also, the use of remotely activated safety releases of anchored experiments and equipment is proposed to allow for emergency retrieval without the need of diver assistance. Remote monitoring of the installations is one optimization that allows time and money efficient use of labour force. Also, budget to include insurances is recommended to have an emergency fall back plan. Final maintenance optimization is tied to the seasonal plan and can be arranged to take place in the off-seasons when tourists are involved (Greek and Danish Pilot) or during the calmer summer periods (Dutch, Danish and German Pilot). The findings within this report are not yet final, as more data is expected to come in during a later phase of the project. Further optimizations will be seen during the ongoing operations of the pilots.

2. INTRODUCTION AND BACKGROUND

2.1. Description of Deliverable

Using automation and scheduling tools, activities will be monitored for directive and legal compliance, aquaculture functionalities, and dynamic synergies required for co-location and co-use of marine space from the multiple platform features. Furthermore, scheduling platform capacity building and refinement would help to lower costs associated with subcontracting ships and resources for maintenance and operations as well as enhancing the lifecycle operations of the platforms and associated multi-use functions. This will not only be important for the life-time of the envisaged commercial activities, but can result in minimising costs after the life-span of the exploitation of the MUCL. Through multiple user workshops and clear outlining of operation, use, maintenance, and servicing needs for co-location activities and multi-use platforms, the synergies between activities, where synchronized, linked, or supporting actions can be taken to minimize redundancies and increase the mutual benefit and reduced costs of operations will be taken in order to optimize the benefits and maximize cost reduction of activities. The results of the task will feed into the deliverable report on Optimization of Scheduling, Operations, and Maintenance (D2.4).

2.2. Background and context

UNITED enables the large-scale installation of the multi-uses of marine space through the development of pilots in marine environments elaborating on five different pillars: technology, regulatory, economy, social and environment. Optimal multi-use concepts and co-location activities will be implemented in close cooperation of local stakeholders and industrial actors. UNITED will enhance the technology readiness level of the technology validated in a relevant environment (TRL5) to demonstration in an operational state (TRL 7+), handling difficulties and offering solutions at the five pillars to promote the economic benefits for key industrial actors, highlighting the sectors renewable energy, aquaculture, and tourism.

Based on identified promising designs and tackled regulatory and technological barriers for multi-use platforms and/or Co-Location at platforms (MUCL) from previously funded projects, UNITED will enhance on the five pilots across the North Sea, the Baltic and the Mediterranean, involving industrial actors and integrating the knowledge, technologies and facilities, in multi-use platforms and/or co-location of different activities in a marine space. The five pilots exhibit a wide range of dynamic conditions in different regional seas and demonstrate the benefits, challenges and risks of different combinations of marine activities. UNITED elaborates on the economic situation and benefit of combining activities for renewable energy (wind and solar), aquaculture, bio-resources, environmental restoration (oyster bed restoration), maritime transport, and tourism services, in the same marine space. This is achieved by developing monitoring solutions suitable for offshore MU operations and increasing their efficiency; dividing and reducing the costs of offshore operations and the demand on space; and expanding and enhancing previously developed business models to reduce risks for operators and investors. WP2 (Technology) will address the technological requirements of the pilots to achieve feasibility of multi-use production sites, building on the findings from WP1 (Framework and Facilitation). The enhancements to observational and automated networks within the existing pilots will be designed in WP2 (Technology) in order to allow for an integrated system which collects, processes, and stores information from a range of sensors, thereby enhancing operational aspects of multi-use platforms and space.

This report addresses the pilot's optimizations for scheduling, operations and maintenance that the pilots have identified. It reports on each pilot's current status, optimizations and tools that were used and the lessons learned which will give an outlook for optimizations that can be applied for future projects and or/the commercialisation of multi-use.

2.3. Objective, approach and outcome

The main objective of this deliverable is to identify the synergies between activities in the pilots or where supporting actions can be taken to minimize redundancies and increase the mutual benefit to reduce costs of operations. The approach is to map the optimizations for scheduling, maintenance and operations. For each of the

sections, the current status of the pilot will be described, followed by the implementation of optimizations, synergies identified, and lessons learned. Finally, recommendations are given for the identified future optimizations that are not likely to be reached within UNITED.

Another important aspect of this report is the use of automation and scheduling tools (D2.3). Since both, the automation and scheduling tools (UNITED-HiSea platform¹) as well as, the decision support system (DSS) (D2.5) have not been fully functional by the time this deliverable was due, the findings from using both tools will be reported in the upcoming deliverables D7.4, D7.5 and D2.6. Nevertheless, pilots used their own automation and scheduling tools like the AQUAWINGS platform, messengers, calendars or weekly online meetings, as reported in this deliverable.

2.4. Structure of the report

The report is sectioned into the three main parts:

- Optimization of scheduling
- Optimization of operations
- Optimization of maintenance

Firstly, each Pilot describes the current status of the Pilot to provide an overview of the location as well as the achieved activities to provide a basis for the optimizations described below. Moreover, the sections will give an overview about the optimizations and synergy effects that have been reached and how they have been implemented or observed. Tools and methods to reach these optimizations are presented. Finally, each Pilot summarizes its lessons learned regarding optimization procedures and gives examples and recommendations for optimizations and synergies for future multi-use activities.

¹ UNITED HiSea Platform: <https://united.hidromod.com/>

2.5. Pilot Overview

2.5.1. German Pilot

The German Pilot located in the exclusive economic zone (EEZ) of the German North Sea right at the edge of the offshore wind park DanTysk approximately 80 km west of the island Sylt aims to demonstrate the economic, environmental and societal benefits of the multi-use offshore wind farming and aquaculture activities, while reducing the technological, financial, health, safety, and environmental risks for both mariculture and offshore platforms. In this context, the challenges of developing a technological support system and planning and operating (e.g., monitoring and maintenance) a complex multi-use system in a real offshore environment will contribute to the business cases and blueprints (business plan, business model canvas, PESTEL analysis, SWOT analysis). Furthermore, knowledge on the interactions between target crop species with natural biota and the impact of aquaculture farms on the offshore environment is part of the overall UNITED Assessment Framework. Moreover, the pilot project aims to provide a platform for exchange between stakeholders with different backgrounds (NGOs, industry, academia, authorities) in order to increase the general acceptance of MU in the North Sea and to explore opportunities for local cooperation.



Figure 1 FINO3 research platform with aquaculture area in the front, located in the North Sea, Germany

2.5.2. Dutch Pilot



Figure 2 Dutch Pilot, during seaweed net installation in 2020, North Sea, Netherlands

The Dutch Pilot demonstrates the integration of an offshore photo voltaic and seaweed cultivation system, assessing technological risks as well as the economic feasibility. These investigations will provide the basis for a contractual framework regulating a commercial roll-out. With regard to the floating solar array, the wave dampening effect and its potential benefits to seaweed cultivation is examined via field measurements and numerical modelling. Moreover, the technical feasibility of using the solar power production system as an energy and communication hub for aquaculture is studied.

2.5.3. Belgian Pilot

The operational phase of the Belgian pilot combines aquaculture and restoration of the European flat oyster (*Ostrea edulis*) and cultivation of sugar kelp (*Saccharina latissima*) in an offshore wind farm. The pilot is situated in the Belgian part of the North Sea (BPNS), more specifically in the offshore wind farm of Belwind, operated by Parkwind. The BPNS is characterised by a system of submerged sandbanks and gullies, which are predominantly formed and sustained by the tidal currents. The offshore wind farm area is situated at the eastern border of the BPNS, and includes three sand banks (Bligh Bank, Lodewijkbank and Thorntonbank) and the adjacent gullies (Figure 3). Parkwind develops, finances, builds and operates offshore wind farms in the North Sea since 2009. The vast experience of the Parkwind team builds on the success of the wind farms Belwind (56 turbines), Nobelwind (50 turbines), Northwind (72 turbines), and Northwester 2 (23 turbines) operating in total 776MW mainly in the Belgian exclusive economic zone. Each turbine is built on a monopile foundation. Around each foundation, a scour protection layer is present, and the turbines are connected with each other and with an offshore transformer station by power cables buried in the seabed, transporting the generated electricity. The offshore wind farm area is situated at the eastern border of the BPNS (Figure 3), has an average depth of 15-35m, and includes three sand banks (Bligh Bank, Lodewijkbank and Thorntonbank) and adjacent gullies.

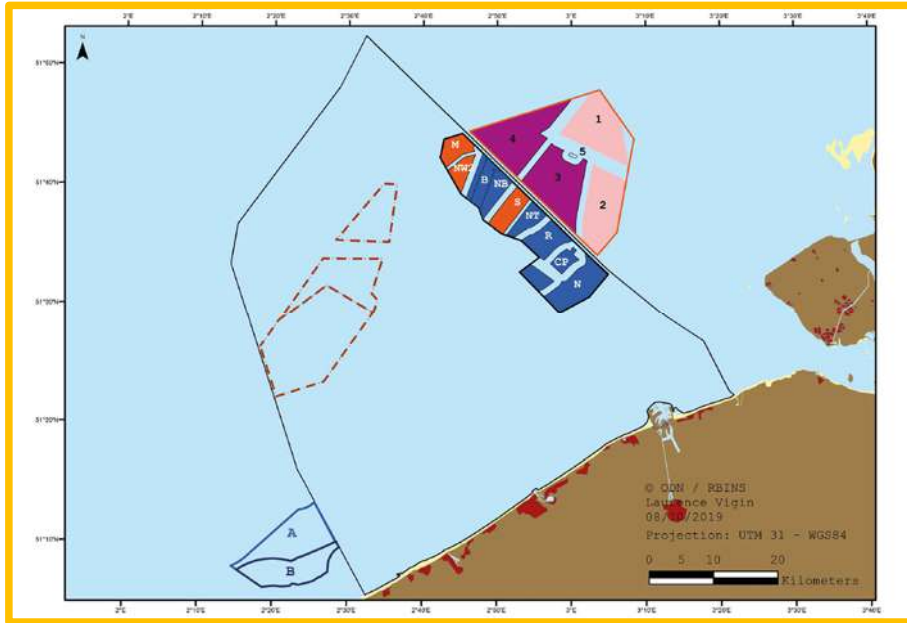


Figure 3 Belgian part of the North Sea with realised and planned offshore wind farm concessions. The approximate position of the Pilot site (at the offshore wind farm of Belwind, operated by Parkwind) is indicated by the yellow star. Figure taken from the WinMon

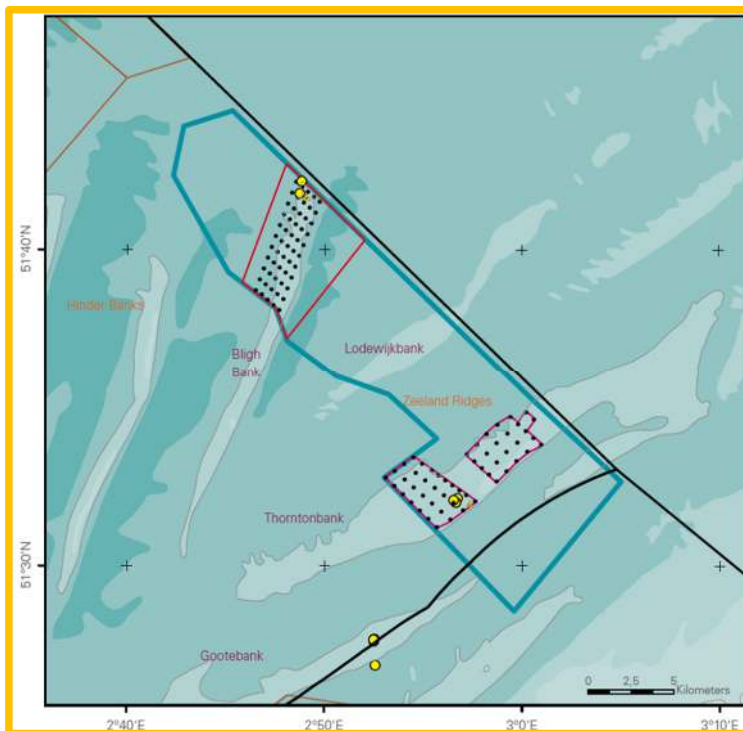


Figure 4 The Belgian Pilot will be set up in the Belwind offshore wind farm, operated by Parkwind. By the end of 2020, all wind farms were in place in the 'Area reserved for electricity production'. Figure taken from the WinMon report 2013 (Van den Eynde et al.)

2.5.4. Danish Pilot

Middelgrunden Offshore Wind farm in Copenhagen, Denmark, is the location of the Danish Pilot. The Pilot combines offshore renewable electricity production from 20 wind turbines, rated at 2MW each, and tourism activities. The wind farm is located 3 km away from Central Copenhagen and can be viewed from many locations in the capital. It has been voted as the second greatest landmark of Copenhagen by its citizens. Tourism activities usually imply a guided tour to the turbines, sometimes preceded by an hour presentation onshore. Only if the weather permits it, tourists are invited to climb to the foundation and discover what is hidden inside a wind turbine.



Figure 5 Danish Pilot « Middelgrunden Wind Farm », Baltic Sea, Denmark

Tourism activities have reached a lot of attention over the last years, with international visitors being the most common ones. For example, delegations from Taiwan, South Korea, USA or France have come to visit. Visitors might have a technical background, or indeed work in the wind energy sector, but never had an opportunity before of visiting a wind farm. Visitors can also be Master or Bachelor students in exchange programs travelling from abroad to Denmark / Europe.

2.5.5. Greek Pilot

The Greek pilot is situated in the marine area near islet "Patroklos", Sounio, Eastern Attika district, Greece. The pilot expands tourism activities (leisure scuba-diving) at aquaculture site. The KASTELORIZO AQUACULTURE SA operates a fish-farming unit, on floating facilities. KASTELORIZO provides the aquaculture unit (Figure 6) that shares the same marine space with the touristic diving activities of Planet Blue company. The two companies perform a number of co-existence scenarios that are facilitated with the use of WINGS' monitoring and management platform, AQUAWINGS, that is deployed to ensure best multi-use of aquaculture and tourist activities and minimization of environmental impact.



Figure 6 The aquaculture unit of the Greek pilot at Patroklos, Sounio, Eastern Attika district, Greece

The multi-use activities that are taking place in the site during the operational phase are the combined activities of the aquaculture unit with scuba diving tourist expeditions. These multi-use activities will facilitate touristic growth in the area, as well as help the aquaculture activities to gain social acceptance and facilitate a long-term touristic growth in the wider area. For these purposes, a tour around the marine area stopping at aquaculture facilities and scuba-diving tours, as the seabed within the area of the aquaculture unit carries great interest (food waste from the aquaculture pens attract wild fish) have been organized. Except for that, with the use of Remote Operational Vehicles (ROVs) the mapping of underwater landscape of aquaculture site, the inspection of aquacul-

ture site, and of the infrastructural parts takes place. A software platform has been developed by WINGS facilitating the operational management of the unit, monitoring the environmental conditions in the pilot (Figure 7) site, scheduling the operational activities and monitoring the fish behaviour in the cages.

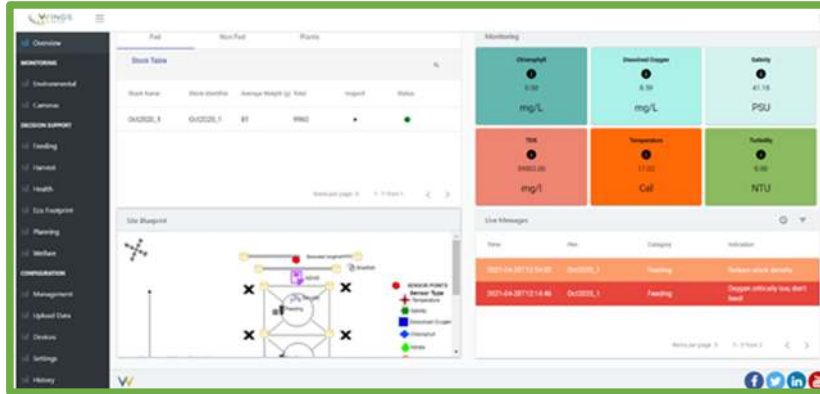


Figure 7 The AQUAWINGS platform. Environmental conditions of fish cage are being monitored and displayed in the dashboard.

3. OPTIMIZATION OF SCHEDULING

3.1. German Pilot

Current Status:

The intention of this deliverable, like all deliverables prepared before the final phase of the project, is to present the current status of the pilots at this specific stage of the project. Some experiences, achievements and solutions have already been made and more are definitely to follow. This overview serves as an orientation to be enabled to assess the following description of the optimizations and synergy effects.

The following list provides a short overview what structures can be found at the offshore location of the German pilot. Many more installations and tests have been implemented at the nearshore site of the German pilot, but the final aim of all activities is a functioning offshore system.

- Aquaculture-Systems:
 - Seaweed-System: “heavy” equipment is partially installed
 - One main buoy and mooring
 - Mussel-System: whole system is fully installed and operating
- Monitoring:
 - Lander: installed in spring 2022, Data collection started, remote connection is not fully established, hindering remote data collection, Connection Problems shall be solved in summer 2022
 - Server-equipment: fully installed and operating
 - Remote operating safety system: Web-Cam: fully installed and operating
 - Longline-Monitoring: partially installed
 - Load-Cells: installed and operating
 - NO₃+AquaTroll: installed – connection for data transmission from monitoring unit to the offshore platform to the onshore base is established and functioning. Data recording started.

Optimizations

Scheduling includes the consideration of many different needs and requirements of diverse parties involved in the installation, operation and maintenance activities. All offshore projects, especially at such an extreme offshore location as the German pilot, are strongly depending on the weather conditions. Many activities can take place only at a wave height below 1m.

Weather reports

- Throughout the entire scheduling phase, a permanent check of diverse weather reports was established to ensure to minimize the risk of a failed installation, to maximize the safety for staff and material and to stay within the planned budget.
 - Diverse weather reports from different sources (e.g., Windfinder, Danish weather reports, internal data of the FINO3 research platform, national weather forecast systems, etc.) have been selected over the course of the pre-operational phase for reliability to be checked daily.
 - These reports are constantly interpreted by highly experienced offshore experts who are able to help drawing the right conclusions for the conditions for this specific location and making the right decision to start an installation trip or to wait for a less risky option.
 - One weather report is checked daily online at [windfinder.com](https://www.windfinder.com)²

² Link to weather forecast of Nordseeboje 2 close to FINO3 (https://www.windfinder.com/forecast/nordseeboje_2?utm_source=en.windfinder.com&utm_medium=web&utm_campaign=redirect)

- The vessel company sends one report from DWD³ daily

Adjustment of procedures and vessel selection

- There was a permanent and direct exchange with the vessel company regarding availability of vessels and adjustments to the installation procedure due to additional requirements.
- This direct exchange developed from a first contact with the project presentation to a temporary daily exchange with multiple user meetings (online and in present) that served as workshops, daily phone calls and e-mail communication.

Pre-Assembly

Scheduling of offshore operations always implies to reduce the working time offshore as much as possible. The timing of the following steps in the work plan are mandatory to reach an optimized scheduling:

- All parts of the systems which were able to be assembled onshore have been pre-assembled to minimize/reduce time at sea
 - In addition, parts that have already been assembled and checked can no longer be put together incorrectly.
- Installation of server-equipment was scheduled way before the deployment of the lander to ensure a connection between 4HJena-Office and FINO3 to avoid malfunction of server at the deployment date of the lander

Making the most of the options available

- Foreseeable bad weather windows in the North Sea (December '21 and January '22) that could not be used for installation offshore were used to test equipment such as cameras, echosounder and Aqua-Buoy again at the nearshore site.
 - Although our hands were tied for the offshore season, valuable additional data and knowledge about the equipment could be collected.
 - These additional tests helped all users to outline the operations and to gain hands on experience in handling the equipment.

Tools and methods

Since the HiSea platform was still developed for the first 36 months of the project, this scheduling tools could not be used. Schedules and timelines in Excel to highlight the big and critical events were created until the development of the common data platform was finalized and ready. For example, to schedule the seaweed installation these were the most critical events:

1. The last possible date for collecting wild seaweed in order to be able to start the propagation in time before the seaweed season.
2. The latest day on which the seaweed seedlings can be collected from the hatchery
3. The latest day on which the seaweed seedlings need to be deployed in the North Sea -> this was automatically the same day on which the whole seaweed-system needed to be ready for deployment (all parts and equipment needed to be in place and ordered depending on the delivery time up to 8 months in advance)

³ Germany's National Meteorological Service, Deutscher Wetterdienst (DWD)

Coming closer to the installation date of the seaweed system, permanent e-mail and phone contact with the shipping company to discuss weather reports was necessary to identify possible weather windows and the availability of vessels.

Lessons Learned

- The decisive factor determining the schedule are the biological cycle of the cultured species, the water temperatures of the offshore area and delivery times for equipment.
 - This makes it possible to set end dates up to which a delivery/deployment still makes sense.
- Start licensing procedure as early as possible -> even though there is a limit in Germany of starting the licensing procedure no earlier than 12 weeks before a planned installation date, for future intended installations the authorities should be informed from the beginning to reduce delays.
- Communicate across partners when changes/additions/reparations need to be made, even if the effort is small and seems to have little impact. A missing, incomplete or malfunctioning component can shut down an entire operation or mean an additional mission.
- When planning for installation steps, start with individual steps and then consider which steps can be combined if applicable. If you try to plan everything at once, the operations become very complex and the risk for possible failures or cancellations is high.
- When the seedlings and pre-seeded twines for seaweed seeding are ready for deployment there is only a small-time window to store them
 - Preparation of seedlings starts several months before the deployment therefore it is difficult to align the deployment day with a good weather window
 - For the future, methods need to be developed to extend the storage time of the seeding material
- Storage of seeded nets/longlines in the harbour isn't applicable for a duration of more than 2-4 weeks
 - Turbidity leads to less light for the seedlings to grow and massive fouling of other organisms rapidly cover the tiny seedlings
- Coordination in planning between nearshore and offshore site is a central issue
 - Everything that was tested and used at the nearshore site during the wait for licensing and the bad weather periods in the North Sea had to be ready for recovery and deployment offshore as soon as possible and on very short notice.
 - It is therefore important to arrange possible recovery appointments in close communication with all partners involved, including internal Pilot partners and external partners like the vessel company
 - Even though the nearshore site of KMF is only a few hundred meters off the coast and they have their own boat to operate, the farm is not reachable at all times due to wind and waves and/or other commitments of the project partners. (KMF has worked hard to make every schedule for tests, inspections or installations at the nearshore site possible, even though the pre-operational phase had already been completed for a long time.)
- The findings from this task will also help to evaluate the functions and widgets of the HiSea platform which will be used for future automation, scheduling and decision making as soon as it is available.

3.2. Dutch Pilot

Current Status

At the moment the seaweed pilot as well as the solar farm pilot are operational in co-location on the Offshore Test Site of North Sea Farmers as described in chapter 2.5.

Optimizations

The scheduling in the Dutch pilot has continuously been improved as part of a wider effort to improve the safety and communication between the various users of the Offshore Test Site (OTS). This includes primarily:

- General coordination of the OTS by North Sea Farmers with users and on behalf of users towards external stakeholders
- Bi-weekly alignment meetings between the seaweed and solar farm pilot
- Weekly alignment meetings on the seaweed pilot
- Direct communication lines via dedicated WhatsApp-groups
- Permit to work system
- Central registration of all offshore activities on the OTS

In addition, as part of the continuous improvement effort the following steps are foreseen in the near future

- Improvement and extension of the OTS Safety Management System

The HiSea system has not been used yet as part of the scheduling/coordination efforts on the Offshore Test Site.

Lessons Learned

Various variants of scheduling optimization have been attempted. In general, it is quite difficult to combine activities between two co-located activities. That is mainly due to the fact that each party is already trying to optimize the use of the vessel for its own operation. Good and frequent communication is key in optimising scheduling.

3.3. Belgian Pilot

Current status

In June 2021, four restoration structures with nature-inclusive scour materials were installed on the scour protection layer of two monopiles, as described further. Currently (May 2022), we are in full preparation for the installation of the two aquaculture longlines (one for oysters, one for seaweed) which are estimated to be operational by end of the summer 2022.

Optimized communication before a planned offshore sea campaign

The scheduling in the Belgian pilot offshore site location involves an excellent communication between all partners and subcontractors involved in a certain task. Therefore, the following requirements, meetings and communication systems are planned:

- The vessel needs to have permits to enter the wind farm
- Permit to work system
- Central registration of all offshore activities in the OTS
- Four general pilot updates organized per year with all Belgian pilot partners
- Weekly alignment meetings internally per partner
- Before installation or before a sea campaign, there is direct communication via messaging apps/telephone to keep track on possible weather delays and hence last-minute changes in travel plans
- Safety trainings and certificates need to be added to the central system no later than 24h before boarding
- There is a briefing before boarding the ship, in which safety guidelines (e.g., muster station, etc.) are explained again
- Once on board, there is a good communication between captain and crew. During a manipulation on deck, only certified people are allowed on deck and there is continuous communication via walkie-talkie between these people and the captain.

For the scientific diving to the oyster structures in the offshore wind farm, an additional communication and working procedure is in place (as described by Norro & Woit, 2021).

When scientific diving work is done in a wind farm concession, an authorization (work permit) is required. Work permits for scientific diving operations are asked one week in advance to the relevant operator/company by sending the cruise plan, (vessel, sampling locations, etc.).

The operator/company/concessioner responds if the planned activities can be executed or if the campaign conflicts with the activities of the operator/company/concessioner on site. In case of the latter, an alternative for or adjustment of the planned activity is sought in order to carry out the scientific diving work.

Scientific diving work is confirmed when permit(s) is (are) granted and weather conditions allow the planned scientific diving operations to be carried out.

Offshore Belgian North Sea is a highly dynamic environment dominated by weather constraints. From an operational point of view, many of the planned scientific dives are postponed due to unsuitable weather conditions and in that case re-planning of the work is made at shorter notice but always executed when a new permit is granted.

Specific communication with operator/company/concessioner the day of scientific diving work

In general, it is agreed that:

- An offshore working cell phone number will be communicated along with the request of the campaign responsible or vessel responsible.
- The scientific diving operations vessel (cruise leader or Master of the vessel) contacts the work vessel coordinator at the following times: (a) at the time of departure to the location (leaving port), (b) upon arrival on site but before entering the 500m exclusion zone, (c) when leaving the site.

Reference: Work method statement - Scientific diving operations, A. Norro & V.Woit, 33pp and 12 annexes, 2021 (not a public document)

The HiSea system has not been used yet as part of the scheduling/coordination efforts on the Offshore Test Site.

OYSTER RESTORATION STRUCTURES

The installation of the offshore oyster restoration structures was planned for and executed on June the 25th of 2021. Four restoration structures with nature-inclusive scour materials were placed on the scour protection of two monopiles.

1. At each monopile, two structures were placed: one in north-east and the other in south-east direction.
2. At the first monopile, adult European flat oysters (*Ostrea edulis*) ready-to-spawn were added. These structures were called structure 1 and 2. In the monopile downstream of the first one, no adult oysters were added. The two structures placed there were called 3 and 4. This reason why is to verify whether settlement on the scour protection materials and reef restoration could be enhanced when adding adult oysters.

Immediately after installation, the structures were scanned with a multibeam to see if they were installed at the exact chosen position. One of these structures (structure 2) was released too early. As a result, the structure intended for instalment Southwest of one monopile was located at an unforeseen location several hundred meters off the desired location. Another structure (structure 1) was placed in the sandy bed just next to the scour protection layer around the monopile.

PRIMARY INSTALLATION OFFSHORE OF THE RESTORATION STRUCTURES

Lessons learned for scheduling

- Installation window of opportunity is limited (good weather, slack tide)

Plan activities well in advance and always perform weather assessments to account for all potential weather-related risks.

RECOVERY AND REINSTALLTION OF STRUCTURE 2

As structure 2 was misplaced and installed upside down, it was decided to recover and reinstall this at the correct location. This had to be done by hiring a DP2 vessel with on board a working class ROV as operational diving in the wind farm is not allowed for safety reasons. The mission proved to be very successful.

Lessons learned for scheduling

- Installation window of opportunity is limited (good weather, slack tide)

Plan activities well in advance and always perform weather assessments to account for all potential weather-related risks.

SCREW ANCHORS & LONGLINES

The installation of screw anchors in project UNITED was initially foreseen to take place in the period of late Spring to early Summer 2021, shortly before the attachment of the aquaculture longlines was planned. Due to unforeseen difficulties with persisting bad weather, vessel eligibility and intellectual property disputes persisting between one partner and a vessel supplier, the installation was postponed.

Lessons learned for scheduling

- Demand for screw anchors is high at this moment. A small-scale project (4 screw anchors in total) is of little interest and makes short-notice installation difficult. Main interest for these subcontractors is to get acquainted with consortium partners and to have references for the future.

Sign installation contract well in advance and include clause to determine a more limited installation period contractually.

- Investigation of alternative subcontractors that are able to place screw anchors was not done thoroughly enough beforehand. As a result, "all eggs were placed in one basket" and budgeting was done based on internal project partner's price estimates that are well below market price.

Be sure to have at least 2-3 offers from external subcontractors to get a clear view of what the market price is like currently. Especially if this price would vary by a lot it is worth knowing how the offer is made up and what part(s) of the quotation are most volatile (e.g. vessel supplier, procurement, installation method).

- Companies that provide screw anchor installation services in Europe are scarce, especially when it comes to companies that are eligible to work offshore. Mobilization and demobilization costs therefore tend to take up a large chunk of the installation cost (up to 20%) since these companies are usually not Belgian based and therefore lead to an underestimation budget wise.

Depending on the abundance of nearby subcontractors it is worth to consider accounting for (at least) part of the average mobilization and demobilization cost in case a non-Belgian based subcontractor should be required. This could also be used as an overhead cost buffer or for further research during project execution.

- Concerns related to intellectual property were expressed after the method statement writing phase had begun.

Intellectual property concerns can arise, especially during innovation projects. However, these risks should be exposed and communicated well beforehand when working with external parties might be required. Even if this is not the case, mutual non-disclosure agreements should always be in place nonetheless.

- Risk analysis and method statement (RAMS) writing has proven to be very difficult when working with companies that are not used to working offshore or are less invested/interested in the project.

Avoid working with companies that are unable to commit or are lacking experience in working offshore unless motivation is clearly shown. Nearshore experience can be brought offshore but this requires a lot more effort and does not facilitate writing RAMS that are mandatory when working offshore.

- Subcontractor has no vessel that is capable of going offshore and needs to adjust its installation method to a new type of vessel it has never worked with before. If this is not calculated through, significant risks are knowingly introduced into the operation and no approval shall be granted by the wind farm owner.

When working offshore there is always some room for innovation, however, in order to minimize the number of risks that are included in the operations, one should always be careful to rely on techniques that have not yet reached beyond their proof-of-concept phase. More thorough planning and evaluation or even nearshore testing of the new technique and equipment is in this case a good practice.

- Certification of all equipment and any adjustments that are done needs to be accounted for with great attention for detail, this is of vital importance to a well-written RAMS. This requires a larger budget both time and finance wise.

Create buffers budget and time wise to avoid exceeding the foreseen budget. Be clear to everyone about what is expected and what needs to be done, especially for companies who are not used to working offshore this is very important. Offshore experience is key and advice should be sought on all topics that contain the slightest uncertainty.

- Timeline for RAMS approval

RAMS to be prepared well in advance prior to the date of planned activities, as it requires time for reviewing by HSSE department, feedback from the parties involved and so on.

3.4. Danish Pilot

The Danish Pilot offers guided tours on a client basis. These tours are tailored according to the wishes of the clients. There are some physical and logistic boundaries (type of boat, tour duration, safety requirements i.e., type of shoes allowed, number of people in a boat, etc.) but clients can normally choose the time of departure and the date that the tour will take place.

Accordingly, every tour requires its own scheduling. The number of tours per year (in a normal year, pre-covid times) is about 40. And most of them are concentrated in the spring and summer months. This number of tours, together with the high flexibility of the guides, allows a flexible scheduling system - based on boat and client's availability.

Once a tour has been scheduled, the Danish Pilot uses own software to indicate whether a tour has been pre-confirmed, confirmed, paid or payment pending. This is internally shared among the guides involved in the Danish Pilot. Boat operators, which are subcontracted on a tour basis, are also flexible as they usually have more than one boat available. They are notified once the tour has been scheduled and confirmed.

There are two important facts to keep in mind on the scheduling of tours: the time of arrival after a tour, and the tours to be held in autumn and winter.

Usually, the time of arrival after a tour is only indicative and can actually not be known precisely. Arrival times are provided as tentative, as boat speeds depend on the water current, on the wind, and on the combination of both. Indeed, if the combination of both is not appropriate, we might only be able to sail to the turbines but without accessing them. And sometimes the whole tour gets cancelled because of storm / high wind conditions. Cancellations are done as soon as weather conditions are certainly known, or the captain cancels the tour.

In winter there are generally no tours (too cold, dark and very little daylight hours; and boat availability is limited due to maintenance). And in the autumn period, tours might be re-scheduled more frequently than in spring and summer. This is due to the seasonal variability of winds, which get stronger during this period of the year, limiting the access to the turbines.

One of reasons of creating the **Virtual tours of the Danish Pilot**⁴ has been to increase the opportunity of people visiting the wind turbines even in periods where the scheduling of the visits is not possible or very limited. This is,

⁴ <https://www.h2020united.eu/pilots-denmark>

in the winter months. We acknowledge the importance of creating these tours to reach more public throughout longer periods of time.

3.5. Greek Pilot

For the Greek pilot a scheduling system has been implemented in order to plan the multi-use activities between the aquaculture unit, the touristic expeditions (and all the linked activities and scenarios between the two). Planet Blue, or KASTELORIZO can have access to the calendar (Figure 8) and are able to check availability of the aquaculture and book a co-use activity. This scheduling tool has been created by WINGS as part of the software platform that is connected to the sensors and camera in the aquaculture site.

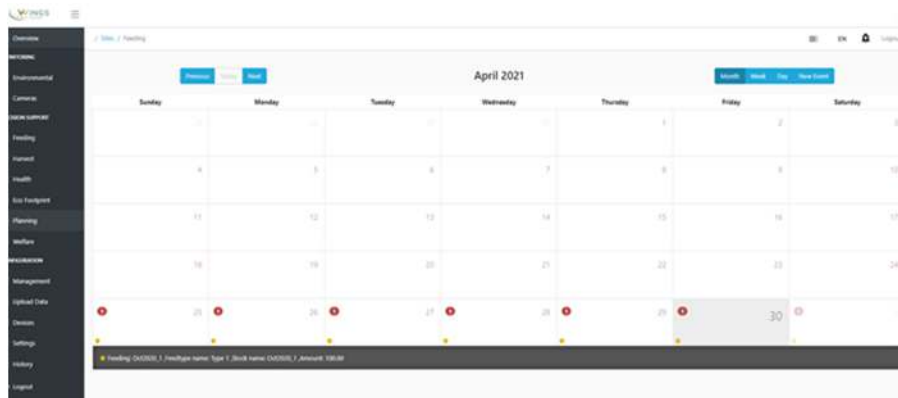


Figure 8 The planning tool of AQUAWINGS platform

Apart from that, communication through calls is being implemented as part of the scheduling of different activities among the different stakeholders. Individually, the diving centre organizes the touristic diving expeditions after appointments with customers either through social media or through calls. The diving activities are taking place mainly from spring to autumn when the weather conditions are appropriate.

4. OPTIMIZATION OF OPERATIONS

4.1. German Pilot

Optimizations

Operating a functional multi-use offshore pilot involves good and close cooperation with all parties involved, as well as detailed preparation. Detailed scripts and manuals are useful tools to communicate and document processes and to detect possible synergies. Scheduling and operations need to be closely linked in order to be able to react quickly to changes at short notice, be it due to weather changes, lack of equipment or vessels.

Seaweed Seeding

A good example for the optimization of operations is the seaweed seeding. Since end of October 2021, the freshly seeded net had to be stored in the harbour of Cuxhaven to bridge the time between seeding and the final deployment offshore. This was the case in the Dutch and the German pilot. Both pilots experienced that the harbour environment wasn't suitable for the survival of the young seedlings for several months. The initial idea was to store the net for maximum 2-3 weeks until the next possible weather window for an installation, but unfortunately a few weeks turned into a few months due to persistent bad weather conditions. Seeding the net for a second time within a few months gave a good opportunity to optimize the seeding procedure as explained below.

- Instead of spreading out the whole net (30x3m) to seed it with two different seeding methods (direct seeding and twine seeding) one half of the net was wrapped up to a roll which and the other half was spread out. In order to shorten the working paths, the net was folded in the middle (see Figure 9)



Figure 9 Partly folded and wrapped-up seaweed net before seeding (left side of the net for twine seeding and right side of the net for direct seeding)

- It was much easier to spray on the seedlings and glue on a wrapped-up net (net roll) instead of applying the seedling on a spread-out net. Afterwards the already seeded parts were immediately covered with wet blankets instead of spraying seawater with a pump-can-> this helped to keep the whole net and therefore the seedlings moist without flushing them away
- The part that was seeded with twine seeding was kept moist with wet sheets instead of spraying seawater with a pump.

Installation of Mussel-System

As described above, close communication with all parties involved is one of the most important requirements to identify optimizations and to prepare successful operations. Several meetings lead by the German pilot team,

together with the producer of the mussel-system and the operating vessel company helped to identify optimizations for the installation of the system.

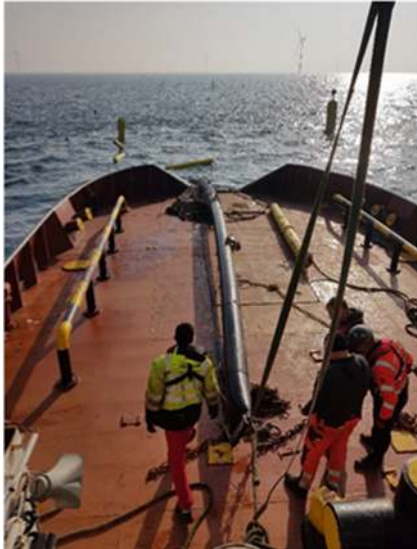


Figure 10 Deploying the mussel-system at the German pilot location

- Safety at sea and using the limited time at sea as efficient as possible are key goals.
- The installation procedure was optimized to the site-specific requirements in an ongoing process according to the findings within and outside the project.

Tools and methods for optimization of the operation

- Preparation of detailed installation manuals as a basis for discussion in meetings and as a final tool for carrying out the operations to avoid any misunderstandings and so that everyone knows exactly what their tasks are.
- Multiple user workshops and online meetings, if needed even on a daily basis
 - Close collaboration between all persons included in the operation and additional experts where useful to discuss every operation and make first decisions, e.g., choice of suitable vessel
- Clear outlining of operations
 - Meetings in present which were used as user workshops to discuss installation steps directly at the harbour/vessel/pre-assembled system to check feasibility and potential difficulties, to gain hands-on-experience and test every item possible

Lessons Learned

- Weather forecasts are only a prediction, the real situation often differs from the predictions. For example, the weather forecast stated a significant wave height of max. 1m, but when arriving at the FINO3 site, the significant wave height was at about 1.5m which was really limit for a safe operation.
 - It is therefore advisable to reduce the limits for an operation in order to have a small buffer for the actual prevailing circumstances. A very costly and frustrating situation would be to start sailing exactly at the predicted limit and when reaching the location, the operation might have to be cancelled for safety reasons.
- Ideas for installation steps that have been added to the manual need to be verified by hands on experience at the harbour/vessel/pre-assembled system.
- All steps that can be done onshore have to be done before the installation to minimize the time offshore and potential risks.

4.2. Dutch Pilot.

Tools and methods for optimization of the operation

As already mentioned above optimization is seen in combination of efforts- However, offshore activity may prove to take longer than anticipated making it difficult to combine activities. The approach that seems to work best is if larger maintenance and installation activities with the same vessel are combined in a sequential way. This means that party A uses the vessel day X and party B uses the vessel day X+1. This at least allows you to share any mobilisation and demobilisation cost whilst keeping some margin if one or the other party experiences delays. For all of the smaller, single day activities this is much more difficult as these are usually fully planned by one party.

Optimization efforts for the future

There are certainly optimizations possible for the future. Especially when the scale of the multi-use operations will increase and the various multi-use operations will have more similarities, e.g., anchoring system. In such a case it could be well imaginable that an activity, e.g., cleaning of anchoring infrastructure, can be done for both a seaweed farm and a solar farm by a single marine contractor. Not only would this save on the above-mentioned mobilisation and demobilisation cost but also it would allow the contractor to optimize the cleaning operation making it faster and cheaper for the farm operators.

4.3. Belgian Pilot

Optimized communication before a planned offshore sea campaign

In analogy with what is mentioned higher for scheduling, operations in the Belgian pilot offshore site location also involves an excellent communication between all partners and subcontractors involved in a certain task. Therefore, each task to be performed is well-documented and discussed with all parties involved in the meetings as mentioned higher under "scheduling in the Belgian pilot".

OYSTER RESTORATION STRUCTURES

As mentioned higher, the installation of the offshore oyster restoration structures was planned for, and executed on June the 25th of 2021. Four restoration structures with nature-inclusive scour materials were placed on the scour protection of two monopiles (structure 1 and 2 at the first monopile, structures 3 and 4 at the second one). Structures 1 and 2 also contained adult oysters. Structure 1 ended up too far from the monopile and structure 2 was installed on the wrong location, leading to it reinstallation and recovery.

PRIMARY INSTALLATION OFFSHORE OF THE RESTORATION STRUCTURES

Lessons learned for operations

1. Alternative system to manual control of installation ropes is proposed

A quick-release system would be significantly better than manually disconnecting the bollard. Alternatively, an ROV assisted installation removes the need for an installation rope entirely and benefit the installation accuracy. Cost-benefits should be considered.

2. Changes in the way of working

If any change to the approved RAMS is deemed necessary during the activities, it should be discussed with all partners involved and decided in mutual agreement the best and safe way forward.

RECOVERY AND REINSTALLATION OF STRUCTURE 2

As structure 2 was misplaced and upside down it was decided to recover and reinstall this at the correct location. This had to be done by hiring a DP2 vessel with on board a working class ROV as operational diving in the wind farm is not allowed for safety reasons. The mission proved to be very successful.

Lessons learned for operations

- Working with divers in an offshore wind park is only allowed on very limited occasions (such as for environmental research and monitoring).

When writing out the research plan and drafting the budget, diving activities should be explicitly accounted for if these might be expected during some stage of the project (sampling, decommissioning, incidents). Operational ROV is the most commonly used way of sampling in an offshore wind park, however this is always significantly more expensive. In addition, more and more wind farms implement a zero-diving operations policy. In this case, equipment can be designed to function without divers, or an alternative approach needs to be sought. However, sometimes there exists no alternatives for diving operations, such as for certain environmental monitoring or research activities. In any case, diving offshore always involves risks and should be avoided whenever this is possible.

- ROV operations are very expensive when compared to diving, especially for very short interventions.

Funding these types of operations is best budgeted beforehand or funded using insurance in case its implementation is incident related. For the installation of a large number of structures, an ROV assisted approach might be more economically feasible compared to when only a few interventions are needed.

OFFSHORE STATUS AFTER THREE MONTHS DEPLOYMENT OF RESTORATION STRUCTURES

During the recovery mission of structure 2, structure 1 (at the same monopile but the other direction) was visually inspected by ROV. It was observed that one side of the structure was covered in sand (Figure 11). This was mainly due as structure 1 was placed in the sandy seabed and not on the intended scour protection layer. Therefore, the table is vulnerable to both high current scouring and migrating sand dunes. Structure 2 was correctly placed on the scour protection during redeployment via the ROV. Monitoring both structures will help to assess the scouring of the structures and the influence of sand dune migration, allowing for a comparison of both conditions.

Lessons Learned for operations

- Structures outside the scour protection layer are expected to be covered by sand under influence of high current speeds. Also, the threat of migrating sand dunes is higher outside the (slightly elevated) scour protection layer.

To avoid this in the future, a more accurate method of installing should be applied to ensure that the structure is placed on the scour protection layer by applying e.g., a DP2 vessel. Ideally, the cages for oyster restoration are installed when the scour protection is being placed. More general, nature-inclusive and restorative designs need to be part of the initial design of the wind farm, to avoid the logistic issues currently faced.

- Scouring and migrating sand dunes can lead to burial or loss of the structures.

Monitoring of the structure needs to point out whether an intervention might be required in order to prevent losing the structure entirely.

- When diving, installed structures are difficult to identify from one another due to the low visibility (hard to orientate if the turbine is not visible under water).

Label the tables before installation so they can be easily identified under water (e.g. with tie wraps or a plastic label).

Possibly, the use of acoustic releases is a possibility to explore for certain steps in the installation/retrieval of the structures. The design of the structures might need adjustments then too.



Figure 11 Survey image oyster structure 1 just before reinstallation with ROV 1- top: part which is not covered in sand, bottom: part which is covered in sand)

4.4. Danish Pilot

The Danish Pilot has some years' track-record in the Optimization of Operations.

For the Danish Pilot, operations include:

- Getting into the boat – from harbour to boat
- Going from the boat to the wind turbine foundation by climbing up a staircase
- Opening the gate of the tower
- Getting in and out of the tower
- Going from the wind turbine foundation down to the boat by descending a staircase
- Getting off the boat – from boat to harbour

All operations are covered by relevant insurances (either from the boat operator or the tour guide) and instructions are provided for the most critical and unusual operation, which is both *Going from the boat to the wind turbine foundation by climbing up a staircase*, and *Going from the wind turbine foundation down to the boat by descending a staircase*

In both cases, only one person on the ladder or staircase is allowed, they must have free hands (so they are able to hold themselves to the staircase all the time), and nothing can be handled at the same time (e.g., all zips closed and no camera, mobile phone, no dangling or moving accessories are allowed)

Both the guides and the boat captains have strong experience in providing instructions and guidelines (both in Danish and in English). A manual is being developed to have all instructions registered for new guides.

4.5. Greek Pilot

Multi-use activities are now carried out as planned. The activities that have been taking place are:

- Recreational and touristic activities in the area of the aquaculture site, including underwater activities, diving expeditions to the aquaculture site (unique wetland for divers to see)
- Infrastructure monitoring using diving equipment and resources
- Mapping of underwater landscape of aquaculture site with the use of ROV (owned by Planet Blue)
- Diving expeditions for cleaning aquaculture area from waste
- Inspection with the use of ROV of the aquaculture diver while repairing the infrastructure
- Inspection with the use of ROV of the aquaculture infrastructure that are placed in great depths (anchors)

In combination with these activities, AQUAWINGS platform offers constitutive monitoring of the aquaculture site:

Advanced monitoring of environmental parameters responsible for the farm's productivity and sustainability.

1. Monitored data are processed for the development of Predictive Analytics for:

- Fish behaviour monitoring
- Disease diagnosis
- Biomass estimation & forecasting
- Water quality analytics

2. Decision Support System, producing early warnings/alerts, and suggestions for:

- Optimal Feeding
- Optimal Harvesting & Seeding
- Disease Prevention and Mitigation
- Planning

3. Farm Performance and Assessment provides records of farm performance by keeping farm and stock information such as:

- Average weight biomass
- Feed Conversion Ratio (FCR)
- Fish volume
- Stocking density

Of course, there were some bottlenecks and some lessons learned through the operational period of the pilot such as that COVID19 restrictions posed a great issue in the carrying out of the touristic activities during the operational period, but we managed to have the touristic expeditions once the lockdown restrictions were withdrawn. Through the world economic crisis that is taking place during spring of 2022, the cost of fuel is very high making the tours around the Patroklos island more expensive. Fortunately, COVID19 did not pose a great barrier for the technological installations, so we were able to work in the site at the lockdown period.

5. OPTIMIZATIONS OF MAINTENANCE

5.1. German Pilot

Optimizations

Since the deployment of the Aquaculture Systems was delayed due to an unforeseeably long permission procedure and subsequently persistent bad weather fronts currently there were only a few maintenance trips necessary. However, more maintenance trips will be needed during the operational phase of the German Pilot and therefore be reported in later Deliverables (e.g., D7.4, D7.5 and D10.7)

The maintenance trips themselves could not be optimized due to their individuality and unpredictability but the opportunities for synergies were used in the two maintenance missions so far.

Spare parts are sometimes essential to use and create synergy effects.

- The webcam that is used to monitor and control the aquaculture area started to work incorrectly. Since the error occurred before the aquaculture systems were even installed, the work of demounting the webcam and transporting it back to Kiel could be scheduled into one of the general maintenance flights to FINO3. This saved costs, time and resources. The same applied to the reinstallation after the repair of the webcam. Here, too the work was integrated into one of the regular maintenance trips.
 - In the event of further malfunctions, the broken camera can be replaced directly with a spare camera. This would then allow the work to be scheduled in only one operation and the downtime can be shortened even more.

Close communication between all users provides unplanned synergy effects:

- During the first weeks of the operation of the aquaculture site, one of the side-marking buoys started to drift due to a heavy storm. The drifting was quickly noticed by the surveillance web-cam and the engineering team of the offshore research platform. Other offshore users provided access to their web-cams to observe and decide on the risk and suitable measure. Another maintenance trip of another user could be shared to bring the buoy back to its intended location and secure it with an additional anchor weight. The close collaboration between the FINO3 Team, the vessel company and the UNITED Team enables quick plan changes and operations adjustments on short notice.

Tools and Methods

- Daily monitoring of the aquaculture system and supported by other offshore users within the area can serve to identify the damages as well as changes before they become a risk or a costly problem.
- Close collaboration and communication between all offshore users and offshore contractors are necessary to arrange maintenance trips on short notice.

Lessons Learned

- Generating synergy effects: Assessing the risk and urgency of reparations to schedule it with pre planned maintenance trips of other offshore users.

Repair operations themselves are difficult to optimize because of their unpredictability, but the multi-use idea provides a great potential for synergies. Based on a close communication between offshore users planned maintenance trips can be scheduled with necessary repair.

5.2. Dutch Pilot

The TRL-levels of the pilot systems are still quite low. Therefore, optimization of maintenance is not yet relevant. The pilots are in prototype stage and as a consequence, the maintenance involved is primarily reactive maintenance and emergency response (contrary to planned maintenance). By its nature, this type of maintenance cannot be planned, hence is difficult to optimize. In general, it can be stated that the design should improve such that the only maintenance required would be preventative/planned maintenance. This level of maturity has not yet been achieved in the Dutch pilot.

5.3. Belgian Pilot

As the installation of the longlines offshore was delayed, we have no current data yet on maintenance of the offshore longlines.

The restoration structures installed offshore of course do not need maintenance as the fouling is part of the research goals.

5.4. Danish Pilot

Maintenance activities in Middelgrunden Wind Farm can be divided into the maintenance of the offshore wind turbines, and maintenance of the boats used for carrying out the people out to the wind farm.

In both cases, maintenance activities are out of the scope of the Danish Pilot. Maintenance of the wind turbines are subcontracted to a third party, who own his own boat and has a specific contract with the turbine Cooperative on turbines' maintenance.

Maintenance of the tourism boats is the responsibility of the boat owners, also a third party.

However, some lessons can be shared. The Danish Pilot has experienced lack of boat availability because of boat maintenance. This is usually carried out in winter months, but there was a lap on a spring / summer period where we could not find a boat with a proper ladder to climb the turbines.

We have also experience that if minor maintenance is being done in one of the turbines while there is an ongoing guided tour in the wind farm, this is actually not a problem. There are 10 turbines that we could potentially visit, so we just need to choose one turbine with no ongoing maintenance. And indeed, it can be an advantage for the group, as it could potentially get some extra knowledge and unique experience.

5.5. Greek Pilot

Maintenance activities in the Greek pilot are mainly related to the technical installations in the aquaculture site (sensors, cameras, smart gateway). Solar panels were added for power supply and the WINGS smart gateway was restructured to receive wireless internet in order to transmit data from sensors and cameras from each cage.

6. CONCLUSION & RECOMMENDATION

One of the main findings is to allow ample time for preparation and factoring in extra time for unexpected events. Installations and traveling at sea take longer and small problems can escalate quickly. Vessels and processes that are optimized and designed for a specific task might be unsuitable for common usage and have to be adapted beforehand. Calm weather conditions are crucial for ship travel (deployment, maintenance, tourist vessels) and need to be monitored closely. Algae in particular, follow a natural biological cycle and take some time to be prepared for seeding events- this planning is difficult to coordinate with rapid changing weather conditions. Material supplies, especially for small scale facilities, are in certain times of the year in high demand and hard to get by. Synergies in using the same vessel for different offshore tasks is possible, but has to be thoroughly planned. For this reason, multiple workshops and close collaboration among the users are necessary to create synergies between the activities. The aid of divers and ship crews during operations is a great help and sometimes necessary. Optimizations can often only be seen and recognized during operations. The use of ROVs gave great results and allowed for longer working hours in the Belgian Pilot and could be used where divers were not allowed to work, however they are costly. Remote monitoring solutions provide data on a steadier basis and decoupled from harsh weather conditions, to a certain extend. Maintenance of vessels, equipment and structures (turbines, net cages, longline systems) are in general good plannable and also reschedulable to a certain degree and hence adaptable.

It is recommended to start early and have a backup plan. Communication with the different partners and people working on the project is crucial and can be aided by the use of online scheduling systems. Monitoring of weather conditions and agreement on "no go" conditions guarantee safety of personnel. Planning ample funding for backup procedures and lay back days is wise. Not all eventualities (such as a pandemic) can be covered. Allowing for extra and additional time of up to one year to account for the biological growth cycles is prudent.

Small-scale projects like R&D projects and demonstration pilots shown to be of minor economic interest for contracting partners and suppliers. This extremely limits the choice of e.g., shipping companies. One recommendation for future projects would be to try to combine offshore operations to represent a more extensive order. This in turn would mean heavier requirements for the bidders such as work permits for different OWP in different national jurisdictions.



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