DELIVRABLE 4.1

REVISION OF THE CURRENT ENVIRONMENTAL ASSESSMENT AND STATUS OF PILOTS

Work Package 4
Environmental gain of multi-use of marine space and infrastructure

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ACRONYMS

BPNS	Belgian Part of the North Sea
BE	Belgium
DSS	Decision Support System
DE	Germany
DK	Denmark
DIN	Dissolved Inorganic Nitrogen
EU	European Union
EIA	Environmental Impact Assessment
GR	Greece
IMTA	Integrated Multi Trophic Aquaculture
MU	Multi-Use
MSP	Maritime Spatial Planning
NL	Netherlands
OWF	Offshore wind farms
SEA	Strategic Environmental Assessment
WP	Work Package

EXECUTIVE SUMMARY

Introduction

Ocean multi-use can potentially contribute to a more sustainable and efficient use of ocean resources and provide tangible environmental benefits, among other. UNITED project promotes the ocean multi-use through the installation of real-world demonstration pilots exploring, among other, environmental requirements and impacts.

The research in the context of Environment in UNITED will address current gaps in know-how on how to measure and assess the cumulative environmental impacts of ocean multi-use, both at the local as well as at a broader ecosystem level. It will also respond to a need for harmonized monitoring frameworks, as well as harmonized methods to assess both negative impacts and environmental gains of ocean multi-use in the marine space.

This deliverable reflects the status of UNITED project pilots with regard to **current environmental assessment practices and requirements, content of existing assessments**, **as well as existing monitoring regimes**.

Methodology

The report aims to provide an **initial overview of currently available information for each of the pilots** based on the pilot background, desk research, and discussion with those involved in pilots' implementation. The report highlights the content of available assessments including positive and negative effects and risks and monitoring capacities, as well as relevant recommendations for each pilot, extracted from other comparable studies and background research.

The review focuses on **five specific ocean multi-use pilots** which are to be developed and demonstrated in the UNITED project:

1. Offshore wind, blue mussels and seaweed (Germany)
2. Offshore wind, solar and seaweed (Netherlands)
3. Offshore wind, flat oyster aquaculture & restoration, & seaweed cultivation (Belgium)
4. Offshore wind and tourism (Denmark)
5. Aquaculture and tourism (Greece)

The report is structured in a way that **for each of the five pilots following aspects are presented**:

- Baseline environmental account in the pilot site
    - Vulnerable animal and plant species
    - Habitat types
- Environmentally responsible mission of the pilot
- General overview of regulatory requirements for the environmental impact assessment and environmental monitoring for the given pilot
- Overview of existing environmental assessment results and monitoring regimes
    - List of existing assessments submitted to the authorities
    - Overview of main environmental assessment results
    - Current monitoring regimes and monitoring capacities
- Recommendations for the pilot

Main results

The review has shown that **most of the UNITED pilots already have an EIA conducted for the pre-existing single use** while the multi-use was not considered at the stage when the EIA was conducted. The scale of the UNITED pilots is in most cases too small and for the research purposes, thus authorities do not require additional assessments for the added use. Therefore, one can only assume what the EIA requirements would be in case of a large scale commercial multi-use development and in a case of a joint development of multi-use (vs. the staggered multi-use that is mainly present in UNITED pilots).

The parameters used in the existing environmental assessments of single uses presented for each of the pilots, will advise the development of the assessment approach. The information collected on potential impacts will feed into the application of the assessment approach. Nevertheless, **additional studies and interviews may be needed for a more in-depth assessment for each of the pilots.** The application of the assessment framework on the four UNITED pilots that focus on the combinations with offshore wind and aquaculture may provide comparable results. Thus, it may be advisable to **develop an assessment approach that builds on the EIAs that have already been applied** in these wind farms, and extend it to cover also other possible multi-use combinations, be it tourism or aquaculture. The combination of aquaculture and tourism in Greece may not have too much in common with other pilots, and thus the development of a generic universal assessment approach for all pilots may not be suitable and will hence be tailored to each of the pilots. Subsequently, the comparison of the Greek pilot results with other pilots may not provide meaningful results. However, in subsequent tasks, information on the overarching environmental impacts and benefits of multi-use and its associated activities will be collected and further evaluated.

The **recommendations extracted from transferable studies in the context of pilots in DE, BE and NL** may be transferable across pilots given that the three pilots have the offshore wind and seaweed multi-use combination in common. Nevertheless, the pilot in DE is considerably further offshore and is as such demonstrated in a much different environment characterised by strong winds and waves, then the two other pilots. It is thus questionable how transferable to this pilot are the recommendations from studies done for the locations relatively close to shore.

While the **Netherlands has recently (2020) developed a multi-use procedure** for applying for the offshore wind multi-use permit, similar practices have not been identified in other countries[1]. It is thus relevant to assess for what types of offshore wind multi-uses this procedure may be (partially) applicable and in which countries such practice could be replicated.

Next steps and input to other research pillars of UNITED

The information collected, as well as the key information gaps and information sources identified in this report, is meant to primarily serve as a **state-of-the art baseline for the subsequent activities under the environmental pillar.** Namely, the information collected on existing assessments and assessment requirements, will serve as an inspiration for the development of the UNITED **Environmental Assessment Framework**. The Assessment Framework will then be applied in the five pilots where more specific information will be collected for each of the pilots and effects will be assessed. The results of the assessments will advise the development Decision-Support System (DSS) targeting environmentally optimized ocean multi-use, and Environmental impact assessment models for the commercial rollout of ocean multi-use addressing the transferability and upscaling potential of the UNITED pilots. Nevertheless, the report may also provide thought-provoking insights to other readers including policy developers and regulators, as well as wider industry and research community.

The information collected on the monitoring regimes and capacities is expected to advise the development of the monitoring system in UNITED project (WP2). Namely, specific attention in the development of monitoring system will be given to the monitoring activities in the context of each of the pilots to make sure that the collected (sensor) data is archived, processed and disseminated in the best possible way and available to any of the project partners.

[1] More about the Dutch Multi-Use procedure available at: https://www.noordzeeboerderij.nl/en/projects/multi-use-procedure

1. INTRODUCTION

The UNITED project aims to provide evidence for the viability of ocean multi-use through the development of five demonstration pilots in the marine environment. As such, it will address current challenges for the employment of multi-use across five key pillars:

1. technological,
2. economic,
3. societal;
4. legal/policy/governance; and
5. environmental.

The careful combination of different maritime uses may lead to a positive or negative environmental impact and/or added environmental benefits and/or costs when compared to a situation where each maritime use is conducted independently[2].

The Environmental pillar of UNITED project will address current gaps in know-how on **how to measure and assess the cumulative environmental impacts** of ocean multi-use, both at the local as well as at a broader ecosystem level. This pillar will also respond to a need for **harmonized monitoring frameworks**, as well as harmonized methods to assess both negative impacts and environmental gains of ocean multi-use in the marine space. The environmental assessment framework developed under the Environmental pillar should be able to capture the gains by applying not only a local perspective, but also a regional sea perspective.

This report presents the results of a first step in addressing the environmental pillar. It aims to provide a **review of the current environmental assessment and status of pilots**, **as well as monitoring regimes and capacities.**

The review focuses on **five specific ocean multi-use pilots** which are to be developed and demonstrated in the UNITED project:

1. Offshore wind, blue mussels and seaweed (Germany)
2. Offshore wind, solar and seaweed (Netherlands)
3. Offshore wind, flat oyster aquaculture & restoration, & seaweed cultivation (Belgium)
4. Offshore wind and tourism (Denmark)
5. Aquaculture and tourism (Greece)

The report is meant to chiefly serve as a state-of-the art foundation for the subsequent activities under the environmental pillar including the development and application of the environmental assessment framework, Decision-Support System (DSS) targeting environmentally optimized ocean multi-use, and Environmental impact assessment models for the commercial rollout of ocean multi-use addressing the transferability and upscaling potential of the UNITED pilots. Nevertheless, the report may also provide thought-provoking insights to other readers including policy developers and regulators, as well as wider industry and research community.

[2] Angela Schultz-Zehden, Ivana Lukic, Joseph Onwona Ansong, Susanne Altvater, Rebecca Bamlett, et al. (2018). Ocean Multi-Use Action Plan, MUSES project. Edinburgh.

2. LINK WITH OTHER WORK PACKAGES

WP8: UNITED Assessment Framework

The UNITED Assessment Framework, as it is currently envisaged, aims to assess the impacts of multi-use projects in the marine space against alternative scenarios, including no-use and single use. As such, the UNITED Assessment Framework could demonstrate the added value of multi-use projects in comparison with alternative uses. To do this, the perceived concerns of multi-use projects will be assessed through different assessment criteria, after which the outcomes will be compared with the outcomes of the assessments of alternative scenarios.

The concerns of the different scenarios are approached around the five pillars of the UNITED project. Each of these pillars will apply different tools and assessment criteria in the scope for concerns and assessment of impacts, allowing flexibility for each pillar. However, the key steps that are followed will be the same for all pillars and these steps form the backbone of the UNITED Assessment Framework.

Schematically, the UNITED Assessment Framework looks as in Figure 1.

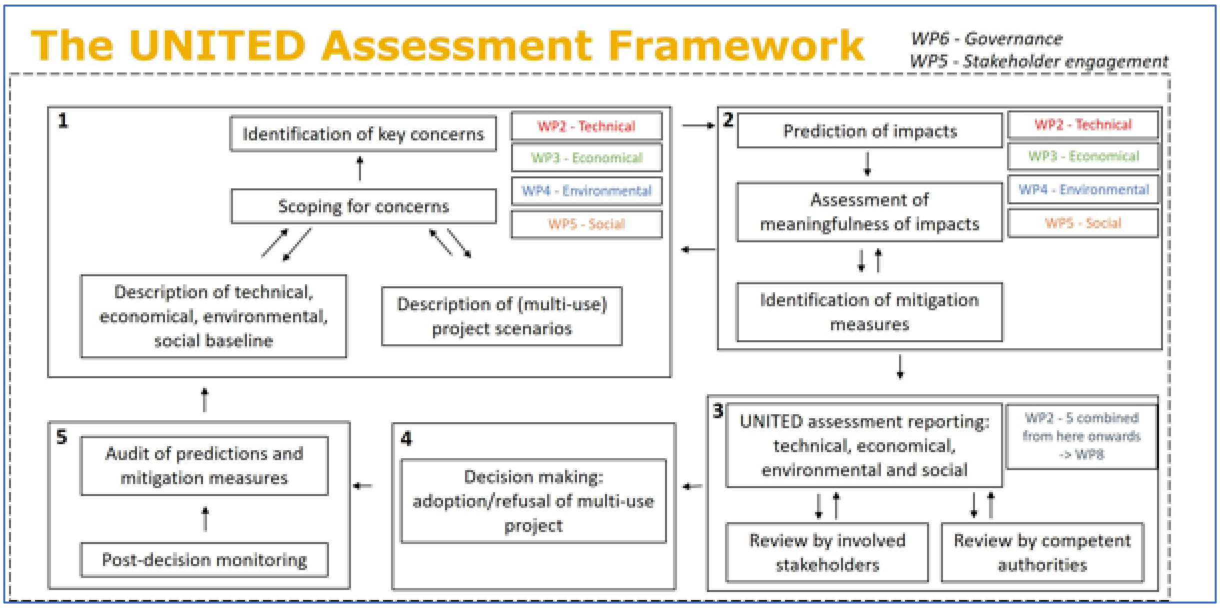

Figure 1 UNITED Assessment Framework

The first step (Early Stages, Box 1) for each pillar starts with a description of the baseline situation and of the proposed multi-use project; be it from a technical, economical, regulatory, environmental or societal perspective. Based on these descriptions, a scope for concerns is conducted, followed by the identification of key concerns. These are those concerns that are considered priority issues for further processing during the Prediction Stages. In the Prediction Stages (Box 2), the impacts related to the key concerns, are predicted and the meaningfulness of these impacts is assessed. Comparison between the alternative scenarios enables to inform on the added value of multi-use. If relevant, also mitigation measures are identified to deal with undesirable impacts of the preferred scenario.

For each pillar, different tools are applied, such as life-cycle analysis, cost-benefit analysis and environmental impact analysis, to identify the concerns and predict the impacts.

The next step consists of reporting the outcomes of the different analyses and reviewing these by the competent authorities (Reporting Stages, Box 3). Based on this, the optimal scenario is chosen (Decision Stage, Box 4). When adopted, a monitoring scheme is implemented to audit the predictions and mitigation measures proposed during the assessment (Monitoring Stages, Box 5). Governance and stakeholder engagement (may) encompass all steps of the UNITED Assessment Framework.

WP3 – Economics

Work Package 3 of UNITED addresses the 'Economics of Multi-use Platforms'. This WP supports the economic assessment of multi-use combinations by providing and applying a multi-method economic assessment framework. This includes an assessment of the costs and benefits of multiuse as compared with single use alternatives. The outcomes of the assessment framework can steer future decisions regarding multi-use of the different pilots. The work in WP4 is crucial for the understanding of the environmental impacts of multi-use and the identification of relevant indicators to measure changes in associated ecosystem services that affect human wellbeing.

WP2: Technology

Within Work Package (WP) 2, the technological requirements of the different UNITED pilots will be addressed. Information relating to the technological improvements of multi-use will be collected for pilots' implementation to help overcome technological issues or optimize pilot activities. Specific attention in this work package will be given to the monitoring activities in the context of each of the pilots to make sure that the collected (sensor) data is archived, processed and disseminated in the best possible way and available to any of the project partners. The chapter 9 of this report provides a more detailed recommendations for the WP2 as a result of this report.

3. METHODOLOGY

This report has been prepared based on the review of past and on-going multi-use related projects, as well as the revisit of the information available for each of the UNITED project pilots. The EU-wide multi-use projects, such as those supported by the **FP7 and Horizon Programmes**, have provided relevant general background information on the topic of environment in multi-use. However, **specific local projects, such as EDULIS and SOMOS**, have been essential in providing more focused information for the respective pilot sites and multi-use cases.

The thorough **revisit of current environmental assessment practices and requirements** in the pilots relayed mainly on the interviews with the UNITED partners and their sub-contractors, involved in respective pilots, as well as a thorough review of regulatory documents and submissions such as the past Environmental Impact Assessment reports of the pilots' primary use, whenever available.

The report is structured in a way that for each of the five pilots following aspects are presented:

- Baseline environmental account in the pilot site
    - Vulnerable animal and plant species
    - Habitat types
- Environmentally responsible mission of the pilot
- General overview of regulatory requirements for the environmental impact assessment and environmental monitoring for the given pilot
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The scope of this exercise encompasses only the multi-use activity offshore i.e. the location that is occupied by the multi-use project operations. This document provides an overview environmental assessment results that are currently available for each of the activities that are being combined to form a multi-use system. It also provides an overview of legal requirements for environmental assessments that may be needed for the development of the multi-use system. The impacts considered in this report refer mainly on the impacts of the multi-use activity and not of separate activities per se. In other words, this review focused only on impacts that result from combining the two or more activities. While impacts may be present at each of the three phases of the multi-use development (i.e. development, operation, decommissioning), it should be noted that the focus of this review was mainly on the operational phase.

Defining the cumulative, in-combination and synergetic effects

The effects of human activities on the ecosystem should not be considered separately. Observed effects on species and at ecosystem level may be the result of an accumulation (build-up) of effects of various activities (in time and/or in space).

The UNITED project defines different types of effects based on the definitions used in the MUSES project assessment[3], and other Environmental Impact Assessment (EIA) guiding documents, including the Royal Belgium Institute of Natural Sciences EIA practices. Namely, there are different kinds of **cumulative effects**:

- effects of repeating the same activity (in time and/or in space) = cumulative *sensu stricto*;
- effects of multiple activities that result in the same kind of disruption;
- effects of multiple activities that result in a build-up of disruptions.

These latter two can be regarded as in-combination effects.

In addition to direct effects, accumulation may also cause indirect effects on the ecosystem. These cannot be attributed to a single activity but are the result of a complex interaction of cause and effect relations of different activities, which is also the case in the multi-use system. These are also referred to as **in-combination** effects. If these effects reinforce each other, we speak of **synergetic effects**, if these effects cancel one another, the term **antagonistic effects** are used.

In UNITED, specifically in-combination effects are in our interest, specifically on the project level (of the pilots). To expand the scope beyond a project basis, a strategic environmental assessment (SEA) is more appropriate.

4. GERMAN PILOT: OFFSHORE WIND, MUSSEL & SEAWEED CULTIVATION

The German pilot is piloting the multi-use combination of offshore wind, mussels and seaweed aquaculture in the offshore environment of the North Sea. The pilot is located in the FINO 3 research platform in the North Sea, German EEZ, about 45 nautical miles (80 kilometers) west of Sylt (Figure 2) on the edge of the potential aptitude for wind turbines off the Schleswig-Holstein North Sea coast. The coordinates are: 55º 11,7 'N, 007º 9,5' E , which is close to the German offshore wind farms: Butendiek, DanTysk and Sandbank (Figure 3).

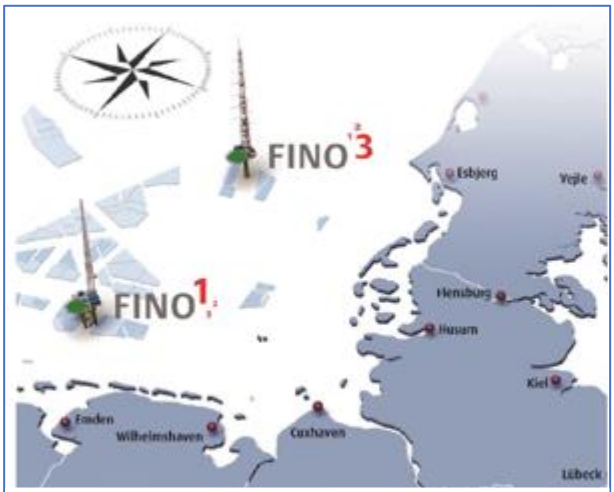

Figure 2 Location of the German pilot site at the research platform FINO3 in the North Sea

The North Sea is a relatively shallow shelf sea with a wide opening to the North Atlantic Ocean in the north. The oceanic climate of the North Sea - characterized by salinity and temperature - is largely determined by this northern opening to the Atlantic. In the southwest, the Atlantic has less influence on the North Sea due to the shallow English Channel and the narrow Dover Strait. The Baltic Sea is connected to the Kattegat/Skagerrak and the North Sea by the Great and Little Belt and the Sound.

[3] Zaucha J., Bocci M., Depellegrin D., Lukic I., Buck B., Schupp M., Caña Varona M., Buchanan B., Kovacheva A., Karachle P.K., et al. (2016) Analytical Framework (AF) – Analysing Multi-Use (MU) in the European Sea Basins. Edinburgh: MUSES project. Available at: https://muses-project.com/muses/wp-content/uploads/sites/70/2017/06/MUSES-AF-Version-10_22.pdf

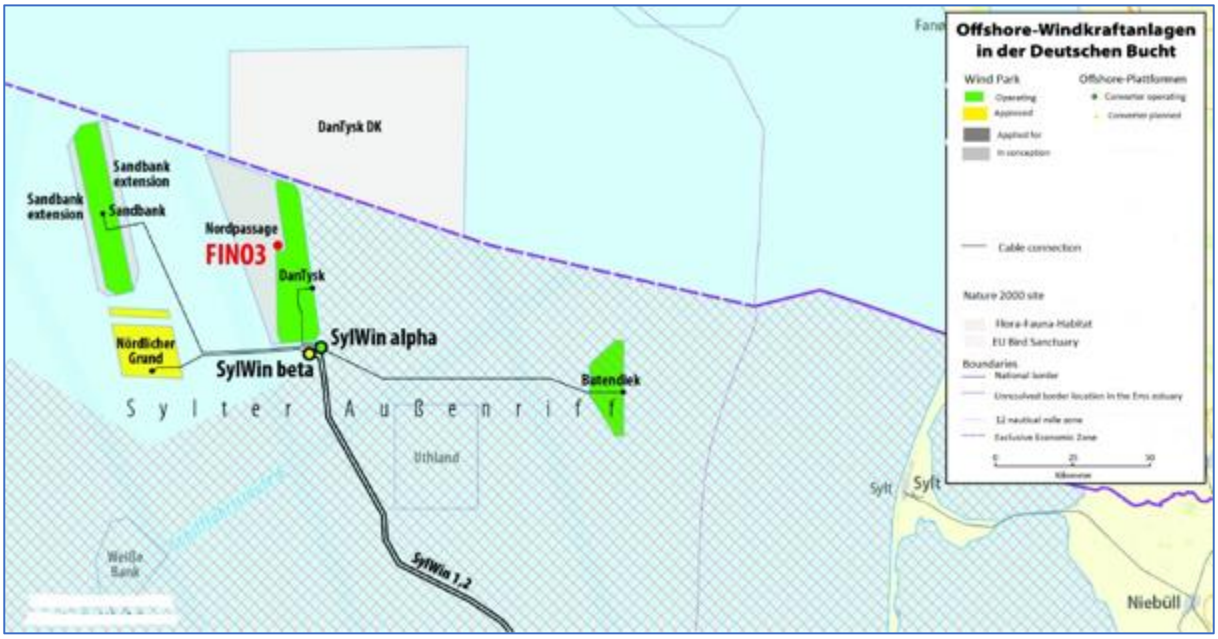

Figure 3 Location of the German pilot at the research platform FINO3 with operating and planned wind farms, and protected areas in vicinity, and administrative boundaries in the North Sea

4.1. Baseline environmental account in the pilot site

4.1.1. ABIOTIC FACTORS

At the location of FINO3 various long-term monitoring projects have been conducted and some are still ongoing. The following description of the abiotic factors is based on the results of these projects assembled in the databases COSYNA (Coastal Observing System for Northern and Arctic Seas) database of the Helmholtz Centre for Materials and Coastal Research Geesthacht (2017) and the FINO database of the Federal Maritime and Hydrographic Agency (2017). All available data for the parameters oxygen (dissolved, saturation), temperature, salinity, turbidity, chlorophyll-a, nitrate, nitrite, maximum swell, and currents were used to describe the environmental conditions. The data of the respective parameters were evaluated with a time series analysis as well as a descriptive, statistical frequency analysis.

Seabed

The seabed serves as a habitat for a wide variety of organisms which are an important part of the North Sea ecosystem. Data on the condition of the seabed around the site in a water depth of 21m were collected in 2006 prior to the construction of the research platform. The uppermost layer (0-0.5 m) consists of fine sand and medium sand with humus admixtures (FuE-Zentrum FH Kiel GmbH, 2006). This is organogenic soil, i.e. organic material such as humus or detritus (dead organic matter) is added to the sand. There are further layers of sandy soil underneath. The sediment distribution is heterogeneous at this site. According to current knowledge, the upper 30 to 50 centimetres of the sea floor are regularly displaced by natural sediment dynamics. During storm events, larger amounts of sediment can be temporarily relocated and visibly change the conditions on the sea floor.

Seawater

Oxygen: The changing water temperature and interaction of oxygen-producing plants or algae and oxygen-depleting microbial processes causes strong fluctuations in the overall oxygen content in the North Sea. It is therefore essential to consider the oxygen conditions of the Pilot site. For the evaluation of oxygen conditions, two variables were used, the oxygen saturation and the concentration of dissolved oxygen in the water body. At higher water temperatures the solubility of oxygen in water decreases, leading to reduced oxygen availability during warm summer months. The oxygen conditions at the German Pilot in the North Sea are subject to strong seasonal and short-term fluctuations (Figure 1 in Annex 1).

The oxygen situation at the FINO3 site is subject to seasonal fluctuations, which, however, have no major impact on mussels, especially since reduced oxygen concentrations are temporarily. Dissolved oxygen concentrations are consistently above 2mg/l during the observed period (Figure 2 in Annex 1), which is considered the minimum concentration for survival. For a macro-algae culture, the oxygen content is hardly important.

Temperature: The envisaged water depth for the installation of the longlines is around 5-8m. The interaction between currents and the bottom relief of the North Sea can provide vertical temperature layers in the water body. The surface currents, strongly influenced by winds, lead to varying surface temperatures, whereas deeper water layers are characterized by more stable temperatures, affected by large currents of the North Sea. Therefore, the temperature profiles at 6, 12 and 18m depths were considered. The temperatures at the site are also subject to seasonal fluctuations, which should be considered for cultivation. The seasonal minimum temperature at this site usually occurs at the end of February/beginning of March, seasonal warming begins between the end of March and the beginning of May, and the temperature maximum is reached in July (6m depth) and August (12m depth). Based on temperature data for the period of 2013-2016 extreme values of 2.5 °C in February and 22.5 °C in August have been recorded. This corresponds to an amplitude of 20.0 K. The lethal temperature ranges of the target species are not reached at any time during the measuring period. Half of the measured data ranges within temperatures between 10 and 19°C, which can be considered optimum for the production of Mytilus edulis and Saccharina latissimi. The freezing point was never reached during the time of data collection. (Figure 3 in Annex 1).

Salinity: The North Sea is mainly fed by water from the North Atlantic and therefore has a relatively uniform and unstratified water body regarding salinity. Within the course of a year, the measured fluctuations in salinity at this location are negligible and suitable for a sufficient growth for the targeted organisms and those adapted to salt water (Figure 4 in Annex 1).

Turbidity: Turbidity of the water determines the amount of the smallest particles in the water column. A high turbidity can have negative consequences for cultured and other organisms. Mussels feed by filtering the water column surrounding them, i.e. they absorb nutrients mainly from phyto- and zooplankton. Excessive water turbidity can have a growth-inhibiting effect on macroalgae as soon as the available sunlight is scattered too much and is no longer sufficiently available for photosynthesis.

According to Buck (2007), marine environments with a visibility depth of less than 15cm are unsuitable for mussel culture production, this corresponds to a turbidity of more than 50 NTU (Nephelometric Turbidity Unit). The prevailing turbidity conditions at the Pilot1 site do not exceed 50 NTU and are optimal for mussel cultivation (Figure 6 in Annex 1). The turbidity of the water is below 30 NTU for 99% of the time and just under 7 NTU for 90% of the time.

Nitrite and Nitrate: Nitrite and nitrate are dissolved nitrogen compounds, which are important macronutrients for many aquatic organisms, but can be toxic in high concentrations. An excess of these nutrients, which occurred in the 1970s and 1980s due to extremely high nutrient inputs caused by industry, transport and agriculture, leads to a high accumulation of nutrients in seawater and thus to eutrophication. Based on the eutrophication assessment according to the OSPAR "Common Procedure" in the assessment period 2006-2014, the coastal waters and large parts of the German Exclusive Economic Zone (EEZ), (a total of 55% of German North Sea waters) are classified as eutrophic (Brockmann et al. 2017). The nitrite and nitrate concentrations show a typical annual cycle, with high concentrations in winter and low concentrations in the summer months. The nitrite and nitrate concentrations at the Pilot1 site during 2013 varied in an optimal harmless range for mussel and algae production (Figure 7 in Annex 1).

Swell: Wave height is a major parameter affecting the stability long line systems and their mooring. The anchoring structures of macro algae or mussels (byssus threads) can only resist certain wave heights and will otherwise detach from the substrate. Especially, mussels show severe shell abrasion in high swell and as shells have primarily a protective function, the animals are weakened and sustainably inhibited in growth. The collected data depicted a mean maximum swell height of 2.4m, a mean significant swell height of 1.5m during the years 2014 until 2017, while the maximum wave height was 9m every year at least on one occasion (Figure 8 in Annex 1).

Current: The currents in the North Sea consist of a superposition of the half-day tidal currents with the wind- and density-driven currents. The current is an essential factor for mussel production, as they are sessile organisms, which depend on the passive influx of food particles. Although a strong current means an increase in passing and available food particles, increased drag forces have a negative impact on the of filtration physiology and inhibit mussel growth due to increased stress (Buck 2012; Syvret et al. 2013). Moreover, byssus threads and thallus of kelp may not be able to withstand strong currents resulting in loss of biomass (mussels, seaweed). The mean current flows with 5 cm/s and the maximum tidal current of 70 cm/s in a north western or south eastern direction. The. For an adequate nutrient uptake, current velocities between 0.5 and 1 m/s are optimal (Syvret et al. 2013), which are present at 2m depths (Figure 9 in Annex 1).

Atmosphere and Climate

The location of the German pilot has a temperate oceanic climate. The coldest month has a mean temperature of -4 °C, while the hottest month a mean temperature of 21°C. Mean rainfall is 750mm/a. At this location 25 thunderstorm days occurred on average per year. The mean number of flashes are 2/km/a. The annual sunshine is measured as 2000h. At sea, the dominant wind direction is west, with a mean speed of 27,8 m/s.

Seascape

Due to the offshore location of the wind farms and FINO3, the seascape remains undisturbed from the coast.

Cultural Heritage

No further information is available on soil monuments, such as settlement remains, in the EEZ (BSH 2019).

4.1.2. FAUNA AND FLORA

Plankton

Chlorophyll-a: The concentration chlorophyll-a is used to estimate the amount of phytoplankton. A strong increase of chlorophyll concentration usually indicates an algal bloom. Beside zooplankton, phytoplankton serves as main food source for filter feeders (e.g. mussels). Hence, the consideration of chlorophyll production and associated phytoplankton biomass is necessary to assess the growth and thus the production of certain target species. The chlorophyll-a concentrations are linked to water temperatures, the prevailing light and nutrient availability for microalgae. They are therefore also subject to strong fluctuations. The measurements considered (Figure 5 in Annex 1), indicate unnaturally high chlorophyll-a concentrations (up to 450 µg/l) in spring 2015. Literature data on chlorophyll in the North Sea usually range around <50µg/l (Rick and Wiltshire 2016), which is why the 2015 data series is probably due to a measurement error or incorrect probe calibration. For this reason, only measurements before 2015 were considered.

The measured concentration of chlorophyll-a is of minor importance for macroalgae, as the concentrations are far below a range in which it would reduce the light incidence and thus negatively affect photosynthesis. For mussels however, phytoplankton is the direct food source. For mussels, the measured amount is sufficient mainly in the summer months.

Fish

No fishing surveys were conducted directly in the project area. Commercial fishing is prohibited in the surrounding area due to the nearby wind farms and the safety zone around FINO3. So, no commercial fishing data is available either. The available fishing data of the planning phase of the wind farm are date from the years 2003 and 2004. There have been too many changes in the fish population in the North Sea since then to use this data as a reference.

Benthos

Benthos samples were not taken directly from the FINO3 platform. However, extensive benthos analyses were carried out in the DanTysk wind farm in the immediate vicinity. Factors within the water column such as light, temperature, salinity, pressure and nutrients determine the structure of the pelagic species and their fluctuation between time and space, while whirls, upwelling and currents lead to local differences in nutrient availability and therefore, spatial heterogeneity, influencing the concentration of plankton biomass and species diversity. The results nevertheless provide some references. In the area of the fine sandy sediments are the snail *Lunatia alderi*, the bivalves T*ellina fabula* and *Phaxas pellucidus*, various polychaetes such as *Magelona mirabilis* and *Spiophanes bombyx*, as well as the *Echinocardium cordatum* and the brittle star *Amphiura brachiata*. In epifauna species (organisms living on the sediment) were found Crangon spp., the starfish *Asterias rubens*, the starfish *Astropecten irregularis* and the crab *Liocarcinus holsatus*. The majority of them are characterized by a Tellina-fabula community. The Tellina-fabula community is predominantly associated with fine and medium sandy sediments. The same sediments as in the project site. Character species are *Tellina fabula* (Bivalvia), *Magelona papillicornis* (Polychaeta) and *Urothoe poseidonis* (Amphipoda). In the tellina-fabula-association is not a rare or endangered benthic community.

Marine Mammals

As the German Pilot is closely located to the Sylt Outer Reef ("Sylter Außenriff": 7°20'00 E 54°55'00 N) in the northern Wadden Sea, a Flora-Fauna protected sanctuary is of particular importance for harbor porpoises (estimated population size: 1 001 – 10 000), where the highest concentration within the German North Sea have been recorded, implying rich food supply. The Sylt Outer Reef directly borders the harbor porpoise sanctuary west of Sylt, the only cetacean sanctuary in the North Sea (Federal Agency for Nature Conservation, 2008). Moreover, harbor seals (*Phoca vitulina*) (estimated population size: 1 001 – 10 000) and grey seals (*Halichoerus grypus,* population size: 11 – 50) use the area as feeding grounds or pass through on their way to their resting and reproduction sites. Due to strong seasonal fluctuations in population numbers, it can be assumed that there is a strong exchange with animals from other colonies around the North Sea (e.g. Great Britain). Thus, the protection of these migration corridors is of great importance for maintaining the very small population of grey seals in the German North Sea (Federal Agency for Nature Conservation, 2008).

Birds

Intensive research activities have been conducted to provide information on the spatial-temporal course of flight movements of birds as well as the variability of species-specific migrations intensities in the daily and annual course in the German part of the North Sea.

Based on the available long-term studies, the data situation can therefore be considered as very comprehensive. FINO3 belongs to a network of automatic receiving stations in the area of the German Bight, which receive signals from songbirds, which are equipped with tiny radio telemetry transmitters. A species list can be found in the annex (Table 1 in Annex 1) to provide a qualitative overview. Additionally, birds have been recorded acoustically during the migration seasons between 2010 and 2018. The results are presented in Table 2 in the Annex 1 and give a quantitative assessment.

Seabirds are highly mobile, and their species-specific migration behaviour leads to a highly variable distribution and abundance over the seasons. The location of the German pilot is an important migration route for numerous bird species. Between three (2016) and 39 species (2014) were identified in spring and between 22 (2016) and 41 species (2010) in autumn (Table 1 and 2). Singing bird species were over-represented in the method, because after eight years of sampling, 41 singing bird species (Passeres) are compared to 33 registered non-singing bird species (Nonpasseres). Among the nonpasseres listed on FINO 3, limpet species (n = 20) dominate in particular, while the spectrum of songbirds is more diverse and includes nine registered finches, six species of thrushes and stilts or beepers and three species of crows. Considering seven migration periods (note: no data available in 2015), a pattern emerges, according to which, there can be particularly strong night-time approaches of birds to the platform between the end of September and mid/end of November.

A carcass survey of birds was carried out between 2009 and 2018. The results are presented in the annex (Table 3 in Annex 1). During the 665 inspections carried out between 28.07.2009-31.12.2018, 98 dead birds of at least 22 species were discovered on the FINO 3 platform (Table 3 in Annex). Songbirds made up the majority of the colliding birds and totalled 95 individuals (97.0%). With 51 cases, more than half of the carcasses were thrushes, with red and juniper thrushes being particularly common with 14 and 13 individuals respectively. Starlings were the species most frequently recorded as collision victims (n = 15; 15.3 %). With this, whitethroat *Sylvia communis* and wheatear, only three long-distance moth species were represented in the dead-found spectrum (5 Ind., 5.1 %). Collisions occurred mainly during the core migratory periods of the mainly affected songbirds. The majority of the carcass finds occurred late in autumn within two months from the beginning of October to the end of November with a clear concentration at the turn of the month. In winter, collision events were rarely recorded, but in January 2010, during a cold spell, they included nine juniper thrushes. During the migration home, carcasses were found over an extended period of time between mid-February and the end of May, the majority of them in the early phase until the beginning of April. Overall, fewer collisions were recorded on the return migration than in autumn.

Identified gaps

Overall, regarding flora and fauna, their density, diversity and behaviour, uncertainties remain especially for:

- Mussels/Seaweed: The influence of different environmental interactions between the cultivation of mussels and algaes and the enviroment need to be examined. The suitability of different environmental and biological factors: water temperature, oxygen, pH, turbidity, availability of phytoplancton as food for mussels) for the installation are naturally fluctuating and will be monitored. Time and concentration of spat fall of blue mussels has not yet been monitored at FINO3. This remains an important topic, when planning up scaling offshore mussel aquaculture in multi-use systems. Moreover, so far little is known about the date and extent of toxic algae blooms in that area. These environmental factors need to be closely monitored. One of the most relevant critical issues of aquaculture is a possible negative impact on the already existing eutrophication. Although, the expected nitrogen input from mussels can be considered negligible and will be immediately diluted due to the strong current and swell at that location, the NO3 production will closely be measured to investigate this matter and test the hypothesis.
- Bats: So far there are no reliable studies on the occurrence and behaviour of bats at sea and their behaviour, as well as the number of collision casualties.
- Fish/Birds/Mammals: It is unclear, whether the diversity of fish species, settling at newly introduced substrate, such as long lines and gravity anchors, is affected and how this in turn will affect the attraction of seabirds or other predators (e.g.: seals, porpoises) and leads to changing biological interactions. This topic is well discussed but the degree of this possible impact of offshore installations on the environment is unknown.

4.1.3. HUMAN ACTIVITIES AND CURRENT THREATS

All human activities are forbidden within 500m radius around the research platform FINO3. The only human activities are the installation and maintenance work at the research platform. These are regular helicopter flights and tank ship delivery twice per year.

Outside of this safety zone threats of human activities were taken from the "Conservation objectives for the Sylt Outer Reef SCI (DE 1209-301) in the German North Sea EEZ" from the Federal Agency for Nature Conservation (2008). The Sylter Outer Reef is located in the near vicinity and the following human activities are listed in the annex.

4.1.4. VULNERABLE ANIMAL AND PLANT SPECIES

Birds: The Black-legged Kittiwake (Rissa tridactyla) is listed in the current European Red List as "vulnerable". Another three bird species are "near threatened" and another seven species are listed in annex I of the Birds Directive (Table 4 in Annex).

Marine mammals: Phoca vitulina, Halichoerus grypus and Phocoena phocoena are species of the Habitats Directive Annex II.

4.1.5. HABITAT TYPES

The pilot area may generally be classified as Open Sea and Tidal areas Habitat type: 1100, according to the EU Habitats Directive classification. Nevertheless, to date, there is a lack of detailed mapping of biotope types including legally protected biotopes. There is currently no comprehensive mapping of the distribution of biotope types of the project site, so that the occurrence of other marine biotope types cannot be adequately represented at present. The known characteristics are described in this deliverable, but it is impossible to derive specific habitat types. Nevertheless, general findings can be applied to the site at FINO3: In the shallower sea areas (approx. below 30 m), sands are regularly displaced in large areas (especially with fine and medium sands) by swell, so that the fauna living there can be very variable (Rachor & Gerlach, 1978). Small stone fields can be so strongly influenced by sand movements (over-sanding, exposure) that long-lived reef communities cannot survive.

Moreover, the pilot site is closely located to the Sylt Outer Reef ("Sylter Außenriff": 7°20'00 E 54°55'00 N) in the northern Wadden Sea. Some known habitat parameters of this area can possibly also apply to the location of Pilot 1: Coarse sand/gravel slopes and sandy areas predominate. In places, small reefs protrude through the sandbank. The sea floor moving east mainly consists of reworked, mostly fine sands. In places, coarse sand and gravel patches with individual stones, boulders and reefs (relict sediments) show through the frequently thin sediment cover.

4.1.6. POTENTIAL POSITIVE AND/OR NEGATIVE ENVIRONMENTAL IMPACTS OF A GIVEN TYPE OF MULTI-USE

Since mussels are filtering organisms and seaweed represents a low trophic level no major or continuing negative impacts are foreseen in this pilot. The section below presents some of the known impacts for the given type of multi-use that may be applicable at the pilot site.

Water: No negative effects on the water are expected. On the contrary, mussels have a purifying function as filtering organisms.
Seabed: For construction reasons, the soil in the project area is not used and is not permanently sealed. There are also no vibrations to be expected due to the design of the plant and the type of installation. For operational reasons, the sediment is not expected to be polluted by the excrements of the mussels, as the strong current drifts them away. It is foreseen to measure any effects on the sediment with an echosounder over the whole duration of the offshore-phase of the project.
Climate/Air: Local effects on the climate are not expected from the construction and operation of the plants.
Vegetation: The vegetation is not expected to be affected, as neither the soil is sealed, nor are sediments stirred up and rearranged, nor are pollutants introduced during construction and operation of the plants.
Benthos: The German pilot is not expected to affect the benthic community, as neither the soil is sealed, nor are sediments stirred up and rearranged, nor are pollutants introduced during construction and operation phase.
Fish: Although no data on fish is available the German pilot is not expected to negatively affect any fish populations. Cameras and echosounders will monitor the effects of the installation on the surrounding fish behaviour (attract or scare away).
Marine mammals: The German pilot is not expected to negatively affect migrating or feeding marine mammals. Cameras and echosounders will monitor the effects of the installation on the behaviour of these species (attract or scare away).
Birds: Especially migratory birds, such as the common starling or fieldfare are not expected to be negatively impacted by the longlines as they will be submerged 4 m deep under the surface. However, negative impacts on seabirds such as entangling or even positive effects (additional food source), will be investigated by cameras installed at the long lines as well as at FINO3. According to Jansen et al. (2019), birds are not necessarily attracted by the seaweed long lines as such, but rather by the increased number of prey animals. They may also use structures (e.g. buoys) to rest upon.
Cultural and other material goods: To the best of our knowledge, the construction and operation of the plant is not expected to have any impact on cultural and other tangible assets.
Human activities: No human beings and human activities are affected, due to the distance of approx. 70 km to the Danish mainland or the nearest German island Sylt not even as a holidaymaker in search of relaxation.

Transportation/Traffic: Four additional ship cruises and helicopter rides are necessary for installation, maintenance and decommissioning of the aquaculture farm. This additional traffic implicates a risk of accidents and pollution.

4.2. Environmentally responsible mission of the pilot

At the location of the German pilot the effects of a joint utilization of a research platform and several projects at an exposed site will be monitored. In general mussels and seaweed likely have a minor and transitory or no or even positive impact on the environment. One reason is the fact that no additional nutrients (e.g. like fish food in fish aquaculture) will be added to the ecosystem. A NO3 sensor and an echosounder (measuring the content of faeces in the benthos) will be installed to measure any possible negative impacts.
Possible positive effects could include attractiveness for invertebrates and fishes, additional fish habitats and nursery areas. Hard substrate was removed from the North Sea in the last century and became therefore a rare but important habitat. The planned construction partially serves as a hard substrate. Specific monitoring units (e.g. cameras, echosounder) are foreseen to measure this expected positive effect on the environment.

The overall goal is to ensure that materials, equipment and installation processes do not negatively affect the environment. The whole aquaculture installation will be removed at the end of the project so that no long-term impacts will occur. In addition to the statutory national and international waste regulations, a detailed internal waste management concept will be prepared. It will describe what types of waste will be expected and how they will be avoided or kept to a minimum, in which way they will be transported, stored and disposed of in an economic and ecologic friendly way. The whole aquaculture installation will be removed at the end of the project so that no long-term impacts will occur.

Harsh environmental conditions could pose could pose a considerable barrier for implementing the multi-use aspects. Long-term monitoring of climate/weather data are available at FINO3 to derive conclusions about when the platform will not be accessible and to coordinate logistics based on these results. This way, not only economic but also ecological goals will be pursued by minimizing energy consumption (e.g. marine diesel).

The following aspects have not been explicitly addressed above but are important factors when measuring the impact of offshore installations. They are mentioned here to give a full picture as much as possible. However, aspects such as the following either do not apply or do not represent relevant barriers for the implementation of the proposed multi-use activities at FINO3: introduction of invasive species; excessive nutrient loadings; underwater noise; disturbance of seabed sediments; collision risks; or the attraction of unwanted invasive species. However, increased traffic due to maintenance and operating the MUP could impose disturbance potential for the surrounding environment. All maintenance operations will be combined with the already scheduled regular visits of the engineering team to FINO3 to minimize costs and resources. Hence, a common timetable for required maintenance operations on and around the plant will be aligned planned long-term.

However, for planning and up-scaling of mussel farming, potential carrying capacity models should provide insight in the maximum level that can be sustained in a given area.

4.3. General overview of regulatory requirements for environmental impact assessment and environmental monitoring for the given pilot

There was no need to carry out an environmental impact assessment study prior to the approval or construction of the research platform. The Offshore Installations Regulations in 2006 explicitly supported the possibility/idea of building offshore research facilities in the North Sea. The Offshore Installations Regulations stipulated that the competent authority, the Federal Maritime and Hydrographic Agency (BSH), is informed about the project's location, content, scope and construction. The Offshore Installations Regulations was amended in 2009. Today, a simplified approval procedure has to be passed. The FINO3 research platform defined the basis for conducting environmental impact studies for offshore wind turbines in the North Sea and Baltic Sea.

4.4. Overview of existing environmental assessment results and monitoring information

4.4.1. EXISTING ASSESSMENTS SUBMITTED TO THE AUTHORITIES

As stated above, there was no need to carry out an EIA for FINO3. However, the feasibility study (Geisler et al., 2018) and results of other projects addressed environmental aspects (see 4.1.6).

4.4.2. OVERVIEW OF MAIN ENVIRONMENTAL ASSESSMENT FEATURES/ RESULTS

As stated above, there was no need to carry out an EIA for FINO3 so far.

4.4.3. OVERVIEW OF CURRENT MONITORING REGIMES AND CAPACITIES

To date, a large number of ecological research projects have been carried out at the FINO3 platform. However, the impacts of multi-use have not yet been measured with indicators so far. One of the synergies in this Pilot will be the shared environmental monitoring data and surveillance between OWF and aquaculture. Additionally, it is planned to test remote automated recording and monitoring of environmental data with different monitoring units during the UNITED project.

These monitoring results should serve to reveal and identify adverse impacts and the required measures to mitigate or reduce them not only in this pilot and project but also in future projects. At the end of the project advice on reporting and monitoring timeline modalities for offshore multi-use projects should be given.

4.5. Recommendations for the pilot

The aquaculture of Mytilus edulis is based on the natural spat fall. Spat fall means the settling and attachment of young mussels to the substrate. The concentration of mussel larvae and the period of time varies greatly between years and locations. The most important factors influencing the spat fall are known. One recommendation for this pilot is to use all already existing long-term monitoring data to derive conclusions about time periods and concentration of spat fall. This way the risk of missing the spat fall can be reduced. The collector material for the mussel spat is also of great importance for the success. So, pre-tests for different material for collectors should take place.

4.6. Conclusions

While a vast amount experience for single use aquaculture in sheltered sites is already available, the multi-use aspects at an exposed site have to be considered as research aspects within German Pilot. This will address (apart from other factors) synergies between already existing offshore structures and aquaculture with respect to environmental factors.
Within the environmental pillar of UNITED, the German Pilot aims at:

- Improving environmental monitoring data and surveillance (e.g. database on fish habitats, nursery areas, site attractiveness for invertebrates and fishes)
- Enhancing knowledge on interactions between target culture species with other natural biota and effects of aquaculture farms in the offshore environment

These monitoring results should serve to reveal and identify adverse impacts and the required measures to mitigate or reduce those, not only in this pilot and within the UNITED project, but also in future projects.

Additionally, the environmental impact would have to be determined for each location separately, as each has their own characteristics and impacts in one location may not occur in another one. Thus, every planning process is based on the fundamental understanding of diverse environmental parameters and how they interact.

In the case of the German pilot, a sufficient database of biotic/abiotic factors (fields of: meteorology, physical oceanography, marine chemistry, biology, geology, geography) is available for the planning/conception phase (simulation and calculation are based on long-term data recordings).

In general mussels and seaweed likely have a minor and transitory or no or even positive impact on the environment. Possible negative and positive impacts will be recorded using a comprehensive monitoring programme.

Experience from former and ongoing offshore projects at the research platform FINO3 will be used to avoid or minimize any negative impacts e.g. a detailed waste management concept and multi-use of transport facilities like helicopter flights and ships.

At the end of the project, advice on reporting and monitoring of timeline modalities for offshore multi-use projects should be provided.

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5. DUTCH PILOT: OFFSHORE WIND, SOLAR AND SEAWEED

The Dutch pilot combines the offshore wind energy, floating solar energy and seaweed farming. Figure 4 presents the conceptual visualization of the pilot. The pilot is located at the North Sea Innovation Lab, 12 km offshore from Scheveningen (The Hague). The Lab is an independent offshore site for research, pilots and the upscaling of innovations in the field of seaweed cultivation, floating solar and other renewable energy innovations, and co-use of wind farms. The size of the offshore site is 600ha, divided into 6 plots 100ha each, with different projects going on in each of the plots. The site is oriented close to but not in a windfarm setting.

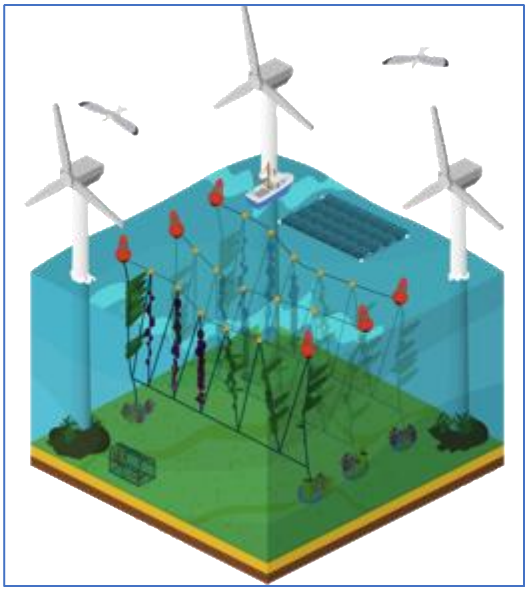

Figure 4 Conceptual visualisation of the Dutch pilot 'Multi-use seafarm cube'

In particular, UNITED activities in the pilot sites will focus on:

- Demonstrating the feasibility and viability of offshore solar integration in offshore wind farms, including economic feasibility, risk reduction, legal and contractual framework for commercial development;
- Demonstrating a safe operational plan for commercial roll-out of seaweed cultivation in wind farms by means of simulation and demonstration, defining the legal and contractual framework for application in commercial settings;
- Demonstrating and quantifying the wave dampening of floating solar array, defining the most efficient configuration of an up-scaled floating solar field in relation to an aquaculture field; and
- Demonstrating the technical feasibility of an energy and communications connection between aquaculture and floating solar power production system.

5.1. Baseline environmental account in the pilot site

This section provides the description of the location with regard to its environmental characteristics. It explains what species and habitats are present at the given site, and what are the non-living natural characteristics such as type of habitats, and what human activities are historically taking place in the relative proximity to the site.

The description of the baseline environmental account in the pilot site of the Dutch pilot is mainly based on the Maritime Strategy for the Netherlands part of the North Sea 2012-2020 and the Environmental Impact Study of the Hollandse Kust (zuid) Wind Farm Sites III and IV (PONDERA Consult, 2016) (Netherlands Enterprise Agency, 2018). The study was conducted in 2016 by a consultancy PONDERA Consult on behalf of the Dutch Enterprise Agency. These wind farm sites are located approximately 5km from the UNITED pilot, and given the proximity the assumption is that these sites have the same environment as the Dutch pilot site. There have been no environmental studies to date referring specifically to the location of the Dutch pilot site.

5.1.1. ABIOTIC FACTORS

Seabed

The seabed in this area is made up of medium-fine to coarse sand at a depth of 20-30 meters.

Seawater

The water originates from the English Channel. It is clear and has a salinity in excess of 34‰. The water column is mainly mixed throughout the year. Given the strong tidal current (up to 1.0 m/s), there is no permanent sedimentation of suspended material. Wind generated waves may also cause seabed material to be displaced.

Seascape

Along the Dutch coast the windfarms are visible at the horizon, there is no longer a free and undisturbed view of the sea. By placing newly planned windfarms at >12 miles from the shorelines, the wind turbines will not be visible in future windfarm, due to the earths curve. The energy and aquaculture production systems are not visible from the shoreline.

Underwater cultural heritage

Ship wrecks are present in the North Sea. Nevertheless, there is no information about cultural heritage being present at the pilot site.

5.1.2. FAUNA AND FLORA

Plankton

Phytoplankton and macroalgae Phytoplankton, microalgae suspended in the seawater, are the basis of the North Sea's productivity. 'Blooms', i.e. brief periods of mass exponential algal growth occasionally occurring over vast surfaces, are characteristic of the phytoplankton in the North Sea. They disappear just as quickly as they appear due to the depletion of the nutrients present, viral infections and zooplankton grazing. Algae blooms occur naturally in the period between March and October throughout the North Sea. With several hundreds of species, phytoplankton in the North Sea is very diverse. Only a limited number of them form mass blooms (mainly *Phaeocystis sp, Noctiluca sp*).

Zooplankton

Zooplankton is usually dominated by Copepods, which make up a large part of the total biomass in the seawater, forming a key link in the food web. The production pattern of zooplankton is irregular in time and space as a result of variable algae blooms. The phytoplankton and zooplankton composition are determined mainly by natural factors, such as origin and composition of the water, local aspects such as water depth and stratification, and the changing of the seasons. To a degree, human activities also influence the composition of phytoplankton and zooplankton, particularly eutrophication.

Eutrophication

Problems with eutrophication are limited. Algae blooms and foam on the beach from decaying algal remains are some of the nuisances caused by eutrophication.

Using the quantity of chlorophyll-a, which is the indicator for eutrophication: Between 2006 and 2008, scores fluctuated between 'good' and 'moderate', depending on the body of water; the Zeeland Coast and the Northern Delta Coast have had 'moderate' scores for years. The low oxygen values that occur in the Oyster Grounds (Northern parts on the Dutch North Sea with depths above 30m) sedimentation area during some summers are mainly caused by the natural decomposition of deposited organic material of dead algae (OSPAR Commission, 2008).

Fish

The shallow, productive North Sea is by nature very rich in fish. Of the shoaling *pelagic* species, herring is by far the most important, with a total quantity of 1.3 million tonnes. Other important open-water species are mackerel and horse mackerel. Species that play a key role in the food web are the sand eel, sprat, Norway pout and young herring. The *demersal* species, which live on or near the bottom, can be divided into round fish (including cod-like fish such as cod, whiting, haddock and pollack) and flat fish (such as plaice, sole, dab and flounder). The diversity in fish species is highest in the coastal zone. Outside the coastal zone, diversity in the southern half of the Netherlands part of the North Sea is higher than in the northern half. *Diadromous* species, which live in freshwater part of their lives, also contribute to that biodiversity. These are migrating species such as salmon, eel, river lamprey and stickleback, and, in the past, Allis shad, common sturgeon, North Sea houting, etc. In general, it is difficult to determine a spatial distribution pattern for the diversity of fish species as fish are very mobile and some species migrate large distances during specific periods. Thus, the information about the specific species at the Dutch pilot site is scars.

Benthos

The largest differences in species composition occur between the hard substrates, sandy beds and silty soils. The fauna of the sandy beds of the Southern Bight, where the Dutch pilot is located, with its strong tidal current is characterised by a relatively low species diversity and a low biomass (see Figure 5).

Marine mammals

The most common marine mammals in the Netherlands part of the North Sea are the harbour porpoise, the harbour seal, the grey seal and the white-beaked dolphin.

Non-indigenous species

There are 37 known established non-indigenous species in the Netherlands part of the North Sea (including estuaries and the Wadden Sea). These mainly concern algae, crustaceans, shellfish (molluscs) and worms. Sixteen of these non-indigenous species are known to be harmful to the ecosystem. Two non-indigenous species whose introduction has had major consequences are the Atlantic jackknife clam (Ensis directus) and the Pacific oyster (Crassostrea gigas). The Pacific oyster, for example, not only proved a formidable competitor of indigenous species, it also brought with it the pathogen Bonamia. The indigenous flat oyster (Ostrea edulis) has almost become extinct in the Netherlands part of the North Sea: due to overfishing in the first half of the 20th century, competition from the Pacific oyster and susceptibility to Bonamia. This parasite is possibly also preventing the return of the flat oyster (see Belgium pilot in Chapter 0, which describes the Belgium pilot that focuses on the restoration of the indigenous flat oyster).

This Project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement no 862915

Birds

Birds of the open sea, pelagic species, live scattered across the Southern North Sea. These are birds such as fulmars, shearwaters, gannets, auks (including guillemots, razorbills, puffins), kittiwakes and skuas, species that often breed on the (rocky) coasts of Great Britain and other parts of the northwest Atlantic area and spend their winters roaming the Southern North Sea. Auks have a clear preference for specific areas: guillemots and auks convene in numbers ranging from the thousands to the tens of thousands in the Southern Bight.

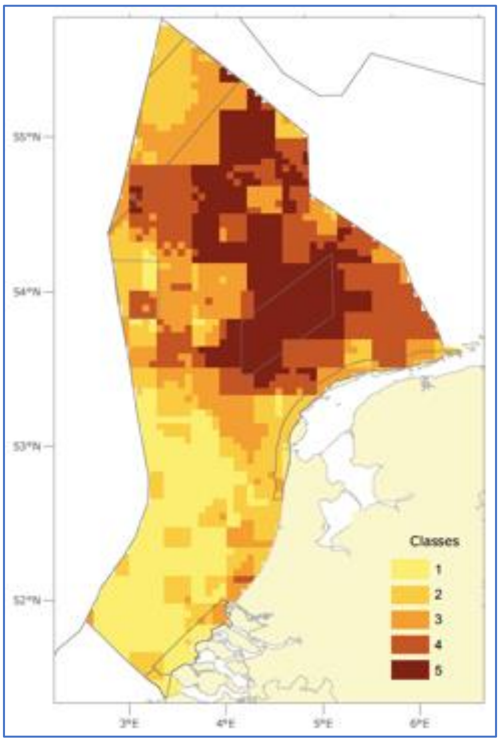

Figure 5 Average biodiversity of the total benthos (O.G. Bos et al, 2011)

Identified gaps

The environmental impact study notes that the current knowledge about animal species and their densities, diversity and behaviour needs to be supplemented. In short, the following gaps have been noted:

- Local birds: in general, knowledge of the distribution in space and time of seabirds at sea is still incomplete;
- Migratory birds: in general, knowledge of the duration and the spatial extent of bird migration is still incomplete. The lack of representative data is related to often hard-to access habitats and the absence of standardised counting methods. However, there are indications for various migration routes in the North Sea area. Quantitative data on this, data on how large the share of these migration routes is in relation to migration as a whole, as well as data on local densities in the different areas of the North Sea are missing.
- Bats: knowledge gaps exist regarding the occurrence of bats at sea and their behaviour in wind farms, as well as the number of collision casualties.
- Benthos: knowledge gaps exist with regard to the ability to predict the consequences of abiotic changes (especially sediment change in the surroundings of the wind farm) on benthos. In addition, the effects of electromagnetic fields along the cables are not yet well known.
- Marine mammals: there are gaps in knowledge on aspects such as distribution of marine mammals, migration patterns, threshold values for TTS, PTS and avoidance, behavioural reactions as a result of underwater sound, and foraging behaviour. Model calculations of the distribution of underwater sound in combination with threshold values derived from several studies predict the occurrence of avoidance, TTS and PTS in marine mammals. Further research in the form of monitoring in the field, additional laboratory research and further model development is needed to fill gaps in knowledge.
- Fish: specific knowledge gaps with respect to wind farms exist, especially with regard to species and the extent of changes on fish fauna in the longer term as a result of setting restrictions on fishery and the application of hard substrate.
- Other use functions: The actual economic effects of tourist activities following the construction of visible wind farms have never been investigated before in the Netherlands.

The gaps in knowledge do not mean that it is not possible have a suitable view of the effects of a wind farm at wind farm site. A wind farm site decision can be taken despite the existing gaps in knowledge and associated uncertainties. In the decision-making process it is important to understand the uncertainties that played a role in the impact predictions. This understanding is provided by the EIA.

5.1.3. CURRENT HUMAN ACTIVITIES AND THREATS

The pilot is in relative proximity to large urban cities, a high degree of industrialization, intensive agriculture, and a dense and intensively used transport network. In general, the North Sea has many uses, such as shipping, oil and gas recovery, sand extraction, fisheries, wind farms and recreation. The Southern North Sea is one of the most intensively used seas in the world, particularly in terms of shipping. The Netherlands part of the North Sea is an important hub in the international transport network, with some 260,000 shipping movements, especially concentrated between Texel and the Belgian border (Ministry of Infrastructure and the Environment, 2012). The pilot is closest to the port of Rotterdam, one of the major Dutch seaports, with the ports of Antwerp and Amsterdam also in its relative proximity.

The offshore wind energy is present close to the site, with first offshore wind farms being located only 5km from the pilot site in the Hollandse Kust (zuid) Wind Farm Zone. In this zone, the four sub-zones have been designated for the development of offshore wind power generation, with combined capacity of around 1400MW.

The nutrient-rich shallow waters have traditionally undergone intensive fishing. In general, in the Dutch part of the North Sea a considerable part of the fish biomass is commercially exploited. The main fish stocks for the Dutch fishing industry are: pelagic species (e.g. mackerel, horse mackerel, herring) demersal species (e.g. cod, blue whiting, langoustine and flatfish such as sole, plaice, turbot, brill, dab, flounder, lemon sole and witch) and shrimp.

The coastal zone of the densely populated hinterland provides the platform for busy recreation and tourism. The city of the Hague with its long beach, especially popular in summer months, is also located in the vicinity of the pilot site.

5.1.4. VULNERABLE ANIMAL AND PLANT SPECIES

There have been no studies to date that could provide information about the presence of vulnerable species at the pilot site including the migrating ones (i.e. present only at some time of the year). In general, when it comes to mammals, the species of grey seal and harbour porpoise, live mainly in the Wadden Sea, but also along the Zuid-Holland and Zeeland coast and further from the coast in the Southern Bight and on a wide stretch of the north-western coastal area from Klaver Bank to Dogger Bank. Thus, their presence may also be in the pilot site. Their conservation status under the Habitats Directive is moderately unfavourable. However, the study by Bos, O.G., et al. (2011) shows that the populations are developing favourably in terms of population size. With regard to fish species, there is too little information on many of the fish stocks to make any reliable statements on their population size and development.

5.1.5. HABITAT TYPES

The Dutch pilot is located in a part of the relatively shallow Southern North Sea. Given its limited depth, there is a strong interaction between physical and chemical processes and life in and on the seabed and in the water column. The main habitat type, following the EU Habitat Directive classification, may be characterised as Habitat 1110B – Permanent flooded sandbanks, although the pilot site has not been appointed as such. The habitat in this location has been classified based on the European Nature Information System EUNIS level 3 as Mid-depth mixed sand[4] with in proximity shallow depth and fine sand. This type covers the southern half of the Netherlands part of the North Sea outside the coastal zone. The seabed in this area is made up of medium-fine to coarse sand at a depth of 18-20 meters. The water originates from the English Channel. It is clear and has a salinity in excess of 34‰. The water column is fully mixed throughout the year. Given the strong tidal current (up to 1.0 m/s), there is no permanent sedimentation of suspended material. Wind generated waves may also cause seabed material to move.

[4] The classification used is based on the European Nature Information System EUNIS level 3. The classification has been adjusted to conditions in the Netherlands part of the North Sea. (EEA, European habitat)

5.1.6. POTENTIAL POSITIVE AND/OR NEGATIVE ENVIRONMENTAL IMPACTS OF A GIVEN TYPE OF MULTI-USE

The study by van den Burg SWK et al. (2020), has identified the key environmental risks of seaweed cultivation at offshore wind farms in the Dutch North Sea. The risks were identified through literature review and were characterized based on stakeholder consultation. The Table 1 below presents the main risks identified in the study.

Table 1 Key environmental risks of seaweed cultivation at offshore wind farms in the Dutch North Sea

Key environmental risks of seaweed cultivation at offshore wind farms	
Ecosystem Change Due to Increased Sedimentation	Changes to the ecosystem are discussed as a risk of seaweed aquaculture. Increased sedimentation is reported by various authors as a risk of aquaculture (Buschmann et al., 1996; Eng et al., 1989; Zhang et al., 2009). The sedimentation of fall off seaweeds could lead to organic enrichment. Through degradation and mineralization, this organic material can become a source of food for other species in the ecosystem. The fall-off effect is potentially stronger in a combined seaweed and wind farm system where wind turbine foundations cause disturbances in the water layers (Vanhellemont and Ruddick, 2014). At the same time, these disturbances might result in rapid dilution of organic matter.
Decreased Primary Production	The combined impact of wind turbines causing a disturbance in the water column and growth of seaweed can negatively affect primary production in the area, also given the impact of offshore wind on ocean circulation (Broström, 2008). Eklöf et al. (2005) reported how shading due to seaweed aquaculture could impact the ecosystem. If a seaweed farm is located above or near an area of a natural hard substrate where seaweeds grow naturally, the naturally grown seaweed below is potentially outcompeted by the farmed seaweed due to the absorption of the sunlight near the surface. Competition for nutrients might occur; the nutrients taken up by seaweed are not available to other species. In some locations with a nutrient surplus, seaweed cultivation can have a positive impact by removal of excess nutrients (Kim et al., 2014).
Effect on Biodiversity, Including Invasive Species, and Bioinvasions	Seaweed cultivation can cause effects on biodiversity, including the possibility of introducing invasive species, bio-invasions (Bindu and Levine, 2011), and potential species translocations (Beveridge et al., 1997). Concerning offshore wind, there is a danger that the hard substrate of the foundations and turbines come to serve as stepping-stones by enabling further distribution of invasive species. Petersen and Malm (2006) described the impact of the "reef-effect" of a hard substrate on habitat and species composition. In combination with seaweed cultivation, the wind turbines can act as "stepping stones" multiplying the risk of introduction and further distribution of exotic species. The presence of a seaweed farm (offshore or nearshore) can amplify the risk of exotic species invasion. The multi-use setting poses a potential cumulative effect because both activities introduce additional artificial hard substrates to the environment, and the presence of seaweed itself can be a stepping stone or substrate for exotic species.
Impact on Animals, Including Birds, Marine Mammals, and Bats	Offshore wind farms and other marine constructions can have an impact on flora and fauna. The addition of hard substrates creates a new area for the potential settlement of species, while the (partial) closure of areas for other activities – like fishing – can lead to "sheltered areas." Petersen and Malm (2006) described changes in marine mammal abundance around wind farms due to added hard substrate and increased food availability. Since seaweed farms are also considered to stimulate local biodiversity, the combination of wind and seaweed farming can have a more substantial positive effect. However, this is potentially also a negative effect. For example, large mammals can get stuck in structures, while bird and bat mortality can increase due to collisions with turbines or turbine blades (Furness and

	Tasker, 2000; Lagerveld et al., 2014; Röckmann et al., 2015). If the seaweed farms attract avian predators, the combination of wind with seaweed farming might even lead to increased bird or bat mortality; for marine mammals, an offshore seaweed farm can pose a possible barrier effect due to the "closed" construction (Lagerveld et al., 2014).
Pollution	Pollution in the marine environment can be taken up by the growing seaweeds, rendering them potentially unsafe for food and feed applications. This risk is recognized by all respondents. Seaweeds are known to accumulate heavy metals; the question is whether or not levels pose a human or animal health risk (Roleda et al., 2018). From a multi-use perspective, the question here is whether multi-use of seaweed cultivation at an offshore wind farm increases the chances of this happening. The infrastructures for offshore wind energy generation must be protected against corrosion and biofouling. The substances used for this protection may pollute the seaweed produced, and vice versa, the presence of an aquaculture facility might increase corrosion and biofouling of infrastructures.

Jansen (2018), highlighted that ecosystem interactions such as biodiversity can be influenced by seaweed aquaculture, but empirical data is largely lacking. This makes it difficult to evaluate changes in specific fauna groups as a function of seaweed farming (as a stand-alone activity or in combination with wind farming), including changes throughout the production cycle. It is therefore unknown if farm management can be adapted to account for temporality and/or further stimulation of the ecosystem services. For example, seaweed farming provides shelter for juvenile fish, yet this nursery function is temporal, and it is unknown if seaweed harvest (removal shelter) takes place before or after the juveniles have migrated to areas outside the farm for further growth. To stimulate or reduce the attraction of marine mammals and birds one could also think of technical adaptations to develop advanced nature inclusive farming systems. Furthermore, the cumulative effects of seaweed farming in relation to the already existing reef-network (incl. wind farms) in the North Sea should be evaluated in terms of attracting native and invasive sessile (hard substrate) fauna. Site specific information is thus important as interactions between seaweed, potentially mussels, and the ecosystem are complex and environmental factors are important drivers. Effects of large-scale seaweed farming are therefore not straight forward and vary from system to system and depending on other marine activities in the area (e.g. in a multi-use setting with wind farming). Development of the seaweed sector should thus go hand in hand with (standardised) monitoring of environmental interactions.

In the European funded project ***Intelligent Management System for Integrated Multi-trophic Aquaculture*** (IMPAQT) project, an Integrated Multi-Trophic Aquaculture (IMTA) model has been developed to provide spatially explicit information on the interaction of multi-trophic aquaculture with the environment. The model was applied to seaweed and mussel co-production scenarios to have a first insight in the effects of IMTA upscaling 1) in terms of production yield targets within the NSF and 2) in terms of spatial implementation in the NSF and future potential farming areas (planned windfarm areas).

The results show that seaweed and mussel production can be increased to 10 tons/ha of seaweed and 5 tons/ha of mussels over all 6 farm modules of the NSF, without visible limitation by Dissolved Inorganic Nitrogen (DIN) and microalgae biomass, and with very little environmental impact. IMTA farming in future windfarm areas, further offshore and outside of the influence area of the Rhine plume would be more fruitful in terms of seaweed production, and less in terms of mussel production. This is due to higher nutrient turnover due to higher mixing, and lower microalgae biomasses (lower feed for mussel cultivation). The environmental impacts of IMTA development in these areas, such as decrease of DIN concentrations and of chlorophyll-a, is more visible, especially where water velocities are the lowest and hence retention times highest. Results also show advantages of IMTA farming, since, in the present scenarios, mussel oxygen consumption is overcompensated by production by seaweed photosynthesis.

In the current implementation, the effects of IMTA farming on ambient water quality are however most likely underestimated, and the model needs some adjustments in order to accurately assess the production and ecological carrying capacities of farming locations. This could be achieved by including feedback effects of the farms on water flows and improving the representation of competition between seaweed and microalgae for nutrient uptake. With such additions, the IMTA model would be fitted to optimize the location and operation of IMTA farming.

There have been no studies at the site nor comparable studies in other environments related to the impacts of solar panels offshore combined with seaweed aquaculture and/or offshore wind. Thus, this has been identified as a gap to be explored further in this project.

5.2. Environmentally responsible mission of the pilot

The Dutch pilot will work to create sustainable production area with green energy, nature and food production in balance with the ecosystem. The optimal combination of functions has been chosen in order to pursue a truly sustainable and environmentally friendly production multi-use area in the Dutch pilot. The project partners aim to do so by developing the state-of-the-art 1km2 'multi-use sea farm cube' suitable for a single 'farmer' (Figure 4). This cube, initially suitable for one single farmer, is a building block, that can be scaled up at a later stage. The overall aim is to support the development of such multi-use sea farms within offshore wind farms of the North Sea.

5.3. General overview of regulatory requirements for environmental impact assessment and environmental monitoring for the given pilot

The pilot is the small-scale for research purposes. Thus, there is no monitoring required by law. However, in case of the commercial scale up of the pilot, an EIA would need to be submitted.

In case of a larger commercial scale up of the multi-use the same EIA would need to be followed, as for the Hollandse Kust (zuid) Wind Farm Sites. All relevant permits are encompassed with this EIA document. This EIA is considered the state of the art as it was done by the government itself (consultancy on behalf of relevant ministries). Comparable EIA (one joint one) would need to be made for the combined activities of large-scale multi-use i.e. offshore wind, solar and seaweed farming.

Monitoring activities will be employed in this pilot. Over the summer of 2020, the UNITED pilot in NSF will be implemented. Ahead of the implementation of the pilot instruments, a monitoring plan will be made for the pilot activities to make sure that we are able to analyse the relevant processes for the assessed types of multi-use. Effectively this means that multiple wave buoys will be deployed to measure the incoming wave characteristics and the effect of the floating solar panels on the wave dampening.

The pilot specific monitoring will be executed in addition to the measurements already taken by a measurement buoy that is already in place and recording data for a.o. the H2020 project IMPAQT. This measurement buoy is located on a central location in the NSF plot and is equipped with sensors measuring the following parameters:

- Turbidity
- Chlorophyll-A:
- Conductivity & temperature
- ADCP Nortek Aquadopp profiler: horizontal & vertical flow profile
- DAS module: LoraWan gateway
- AIS (Automatic Identification system)
- Weather station

5.4. Overview of existing environmental assessment results and monitoring information

5.4.1. EXISTING ASSESSMENTS SUBMITTED TO THE AUTHORITIES

No environmental assessment has been submitted to the authorities. The pilot activity is small scale, for research purposes and temporary, thus no environmental permits were required.

5.4.2. OVERVIEW OF MAIN ENVIRONMENTAL ASSESSMENT FEATURES/ RESULTS

There have been no previous environmental impact assessments conducted for the pilot site. Nevertheless, the EIA has been compiled for the Hollandse Kust (zuid) Wind Farm Sites III and IV (PONDERA Consult, 2016/ Netherlands Enterprise Agency, 2018). Table 2 below provides the summary of this EIA. The study was conducted by a consultancy PONDERA Consult on behalf of the Dutch Enterprise Agency. These wind farm sites are located approximately 5km from the UNITED pilot and given the proximity the assumption is that these sites have the same environment as the Dutch pilot site. There have been no environmental studies to date referring specifically to the location of the Dutch pilot site and pilot activities of solar, offshore wind and seaweed farm development.

Table 2 Overview of the EIA compiled for the Hollandse Kust (zuid) Wind Farm Sites III and IV

Overview of the EIA compiled for the Hollandse Kust (zuid) Wind Farm Sites III and IV:	
Impact assessment method:	An EIA assesses alternatives to an activity by examining their effects and comparing them. An alternative is a possible way in which the proposed activity, in this case power generation with wind turbines, can be realised considering the purpose of this activity. In this EIA, alternatives for two areas, each with one wind farm, were examined (two so-called 'wind farm sites'). The alternatives are based on a bandwidth for various wind turbine set-ups and types that are possible within such a wind farm site. In order to be able to compare the effects of the options per aspect, they are assessed on a +/- scale in relation to the zero option (i.e. the current situation and autonomous development). The following rating scale is used for this purpose. The assessment provides a justification for the scoring. The Appropriate Assessment quantifies the effects in order to evaluate whether the preferred alternative has any significant impact on Natura 2000 areas. In addition to the effect of a wind farm at wind farm site III, cumulative effects of other wind farms and activities are considered, and mitigating measures examined.
Results:	Assessments of the alternatives per aspect against various assessment criteria were presented in tables – one per each aspect: Birds and bets, Underwater life, Shipping safety, Morphology and hydrology, Landscape, Other use functions, and Electricity yield. The cumulation table was also compiled which lists the cumulative effects that occur and the consequences they have for the wind farm site decision.
Potential mitigation measures:	After assessment, it appears that the conditions in the legal framework can be satisfied for virtually every aspect, although mitigating measures are required to limit the cumulative effects on birds, bats and porpoises. However, the occurrence of other adverse effects due to the construction, operation and removal of the wind farm cannot be excluded. These possible effects can be mitigated by the following measures. A number of these potential mitigating measures will be selected for the purpose of the preferred alternative. See Figure 6 below with an example for birds and bets.

Aspect	Effect	Mitigating measure
Birds and bats	Construction and removal phase	Construction from June to September due to the limited presence of species of sea birds susceptible to disturbance. Minimising lighting on ships and/or use of a bird-friendly lighting colour. Reduction of pile-driving noise. However, the effect of the sound of pile driving on birds is unknown and therefore it is not known how necessary this measure is.
	Operational phase	Installing fewer large turbines instead of more small ones as much as possible. Connecting Dutch Coast (south) to Luchterduinen wind farm to the greatest extent possible in order to keep the disturbance area as small as possible. Installing two-blade instead of three-blade turbines. Creating a corridor in the wind farm that birds may use. Increasing the chances of birds detecting the wind farm through the use of reflectors, lasers and sound (depending on the species of bird and subject to various restrictions). Avoiding maintenance works at night and above all during the migration season. Minimising lighting on ships and/or use of a bird-friendly lighting colour. Shutting down in certain weather conditions in combination with identified peaks in migration. Increasing cut-in wind speed (for bats) in the relevant season and at relevant time of day (dusk). Increasing maximum lowest tip point. As small as possible wind farm surface (least habitat loss).

Figure 6 Possible mitigation measures - example for birds and bets

5.4.3. OVERVIEW OF CURRENT MONITORING REGIMES AND CAPACITIES

There are no current monitoring regimes at the pilot site. Nevertheless, the Dutch Energy Agreement for Sustainable Growth (SER agreement, September 2013) contains an agreement to achieve the objectives more quickly and reduce offshore wind power costs by 40% (Parliamentary Papers II, 2012/13, 30 196, no. 202). For these reasons, the Ministry of Economic Affairs and the Ministry of Infrastructure and the Environment decided in 2015 to launch an integral monitoring programme in order to investigate the knowledge gaps with regard to the impact on offshore wind farms in the North Sea ecosystem and to achieve further cost reductions within the ecological boundaries. A monitoring and evaluation programme called Wozep (windenergie op zee ecologisch programma – offshore wind energy ecological programme) focuses on key environmental issues related to the construction and operation of offshore wind farms. Such issues are predominantly generic rather than specific to individual wind farms. Both the development of the KEC instrument (update and implementation of knowledge) and the MEP (monitoring and research programme) fall under Wozep. In turn, monitoring and research – in so far as required by the Environmental Management Act – fall under the MEP. Wozep therefore replaces the monitoring obligation for each wind farm. This results in improved efficiency, which also makes it more cost efficient to achieve the objectives for offshore wind power. In the Wozep evaluation, attention is paid to the translation of new knowledge in the KEC instrument (this can also mean verifying assumptions and/or impact calculations) on the one hand, and translation into policy and management implications on the other. This is demonstrated by the establishment or modification of mitigating measures. In Wozep, the investigation focuses in particular on those aspects that may increase costs, provide a clear view of them and advise the competent authorities on them. Wozep began in 2016 and will last for five years.

5.5. Recommendations for the pilot

The three uses being examined as part of the multi-use system in the Dutch pilot; seaweed, solar and offshore wind are sectors with strong potential and predicted growth in the European waters. While the offshore wind already has numerous farms in place and developed technology, the seaweed and solar are still in the process of getting the first developments offshore. Thus, questions of technology, logistics as well as commercialisation of these two later sectors are still to be explored.

The following list presents some of the recommendations in the context of seaweed production offshore that may also be relevant in the context of this multi-use pilot:

- Demonstrate effects of carrying capacity of the ecosystem based on the pilot and further development options.
- Cultured species (avoid non-indigenous species)
- Fully resistant construction to withstand weather, use and cross over (Buck 2007b)
- Consider seasonal effects of seawead production on the ecosystem
- Consider seasonal effects of the ecosystem on the prduction system
- Consider quality (and composition) of the product in relation to harvesting period
- Consider quality (composition), harvesting strategies, and economics
- Identify means for full year production cycles, instead of seasonal

Following bullet list present some of the requirements/preconditions relevant for the sustainable and economic seaweed production, extracted from the relevant literature The list may serve as an inspiration for the ongoing research in the context of the Dutch pilot, including its technical design, environmental consideration, logistics, operation and economics.

- Fully balanced floatation (Daley 2010);
- Sufficient growth (Langan & Horton 2003);
- No excessive fouling of other organisms (Cheney et al. 2010);
- No excessive predation (Mille & Blachier 2009);
- No pollution: neither contaminants nor parasites (Buck 2007a, Van Nieuwenhove 2008);
- Avoidance of loss of seaweed by drop offs the ropes (Mille & Blachier 2009);
- Reliable and robust harvest method (Cheney et al. 2010);
- Biodiversity increases as an ecosystem service, conflicts with biomass increase of biodiversity on production systems;
- Clear agreements and clear marking to allow sailing traffic (Buck 2007b, Van Nieuwenhove 2008).

The pilot may use the existing SOMOS health and safety risk framework to helps assess hazards and evaluate control measures to ensure safe multi-use at sea[5]. According to the SOMOS project, the multi-use is possible, but safety given a multi-use perspective should continuously be evaluated. Methods, such as multi criteria analysis, are available to assist in analysing safety aspects and appraise multi-use.

5.6. Conclusions

The multi-use system combining seaweed, solar energy and offshore wind can potentially contribute to a more efficient use of the space and to reaching the renewable energy targets and more sustainable food/feed production. Nevertheless, this multi-use combination comes with uncertainties with regard to possible impacts, mainly due to low maturity of the solar and seaweed sectors. As mentioned in this chapter, some of the past projects have conceptualised the health and safety assessment framework for the seaweed production in the

[5] For more information about the SOMOS project and its framework see here: https://www.wur.nl/en/project/SOMOS.htm

context of multi-use, while others have explored its technology and logistics. Learning from these past projects and testing some of the concepts will be crucial for the successful implementation of the Dutch pilot.

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6. BELGIAN PILOT: OFFSHORE WIND, FLAT OYSTER AQUACULTURE & RESTORATION, AND SEAWEED CULTIVATION

The Belgian pilot is testing the multi-use combination of offshore wind, flat oyster aquaculture & restoration and seaweed cultivation. Namely, Belgian offshore wind farms might offer a unique environment to interactively restore oyster reefs and develop aquaculture. Bottom fishing is not allowed in wind parks – and oyster reefs would thus not be damaged. In addition, the hard substrate used as scour protection around wind turbine poles may be the perfect substrate for oyster larvae to settle on and initiate natural oyster reefs. Aquaculture could be developed hand in hand with restoration efforts, as the two activities would enhance each other: aquaculture would provide the initial stocking material to help developing natural reefs and, in the longer term, natural oyster reefs would provide oyster larvae to the aquaculture sector. The Belgian pilot is applying models to correctly position the longlines, developing proper systems for spat collection and grow-out, and testing several scour protection materials. In addition, the culture of flat oyster and sugar kelp will be combined on the same longline, and the characteristics will be compared with those of sugar kelp grown nearshore and offshore.

The Belgian pilot is situated in the Belgian part of the North Sea (BPNS), more specifically in one of the offshore wind farms (yet to be determined) operated by Parkwind (Figure 7).

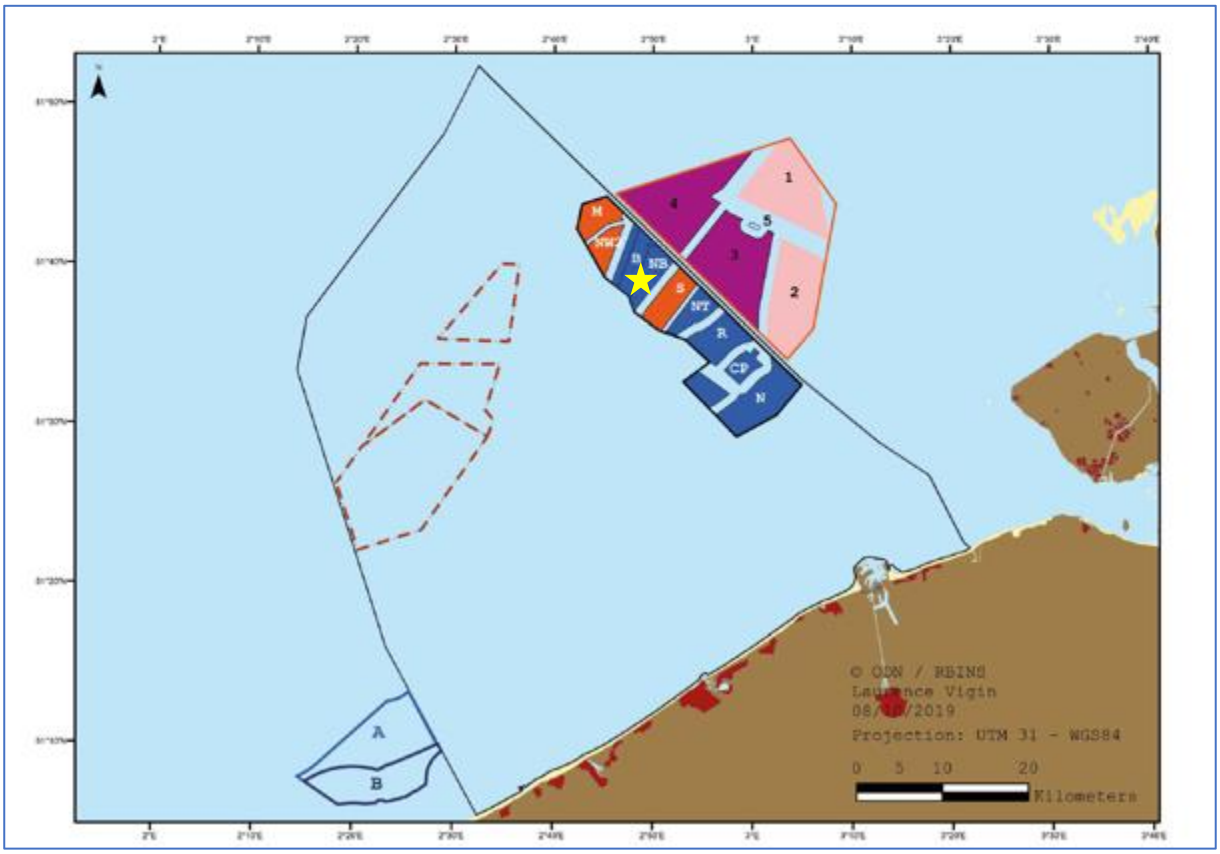

Figure 7 Belgian part of the North Sea (BPNS) with realised and planned wind farm concessions. The approximate position of the pilot site (at one of the offshore wind farms (yet to be determined) operated by Parkwind) is indicated by the yellow star. Figure taken from the WinMon report 2019 (Rumes&Brabant 2019 in *Degraer* et al. *2019).*

While it is still to be decided in which exact location the pilot will be located offshore, the description of the baseline environmental account is mainly based on the environmental impact study of the Belwind wind farm (operated by Parkwind) (Ecolas 2007), and the environmental impact study from the adjacent SeaStar wind farm (not operated by Parkwind), which is more recent (IMDC 2013). Furthermore, information was also obtained from the yearly monitoring reports of the offshore wind farms, the WinMon reports.

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 Thortonbank) and adjacent gullies.

6.1. Baseline environmental account in the pilot site

6.1.1. ABIOTIC FACTORS

Seabed

The water depth in the area of the Parkwind wind farms is generally between 15 (at the sand banks) and 37 m (at the gullies). Bligh Bank and surrounding gullies, which may most probably be the best location for the offshore pilot, are part of a system of tidal banks and belong to the Hinderbanks. Both banks and gullies are characterised by the presence of mobile sand dunes. Bligh Bank has a steep eastern side and a more gentle-sloping western side. Sand is the predominant sediment here, with a grain size of 300-350 µm and a maximum of only 1 % clay. The gully may contain coarser gravel-sands.

Mean (surface) current velocity at Bligh Bank is 0.55-0.57 m/s, and while in the deeper gullies the mean current velocity is lower, maximum current velocity (up to 1.09 m/s) is higher in the gullies than at the sandbanks. In general, current velocity ranges between 0.25-0.95 m/s.

Seawater

In the BPNS, including the pilot site, mean seawater temperature is 11 °C, which can increase up to 19 °C in summer and decrease down to 0.05 °C in winter. Salinity of the seawater ranges between 31 and 35 ppt. Suspended particulate matter content in the offshore BPNS, including the pilot site, is low, around 4 mg/L.

Atmosphere and climate

Belgium has a temperate oceanic climate. The coldest month has a mean temperature of 3 °C, while the hottest month a mean temperature of 16.9 °C. Mean rainfall ranges between 50 and 80 mm/month.

At sea, the dominant wind direction is west-south-west, with a mean speed of 9.6 m/s.

No relevant statistics on atmosphere (air quality related to pollution) are available for the BPNS, as no measuring station is present at sea, only land-based stations. However, it can be assumed that the air quality at sea is satisfactory at least.

Seascape

At as good as every position on the Belgian coastline, a free and undisturbed view of the sea is apparent.

Cultural heritage

Paleo-landscapes nor shipwrecks are known from the pilot site.

6.1.2. FAUNA AND FLORA

Plankton

Phytoplankton are unicellular microalgae suspended in the water column, and form the basis of the North Sea's productivity. Phytoplankton blooms are brief periods of mass exponential algal growth and are generally observed in the period between March and October. In spring, the first bloom is formed by diatoms, followed by massive blooms of *Phaeocystis globosa*. Phytoplankton blooms may disappear quickly again due to the depletion of nutrients, viral infections and zooplankton grazing. Although several hundred of phytoplankton species occur in the North Sea, only a few can form mass blooms.

Zooplankton

Zooplankton is usually dominated by Copepods, which make up a large part of the total biomass in the seawater, forming a key link in the food web. The production pattern of zooplankton is irregular in time and space as a result of variable algae blooms. The phytoplankton and zooplankton composition are determined mainly by natural factors, such as origin and composition of the water, local aspects such as water depth and stratification, and the changing of the seasons. To a degree, human activities also influence the composition of phytoplankton and zooplankton, particularly eutrophication.

The fish fauna is dominated by lesser weever *Echiichthys vipera*, whiting *Merlangius merlangus*, common dab *Limanda limanda*, solenette *Buglossidium luteum* and European plaice *Pleuronectes platessa*. At the sandbanks, *Echiichtys vipera* is the dominant fish species.

Since the installation of the wind turbines several species of fish are found in large densities around the foundations of the turbines, such as whiting pout *Trisopterus luscus*, Atlantic cod *Gadus morhua*, Atlantic horse mackerel *Trachurus trachurus* and Atlantic mackerel *Scomber scombrus*.

Benthos

The sandbanks and gullies of the pilot site are characterized by two macrobenthic communities: the *Nephtys cirrosa* and the *Ophelia limacine - Glycera lapidum* community. These communities are characterised by relative low density and diversity compared to the more coastal macrobenthic communities. Their habitat consists of medium grain-sized sands (300-500 µm), a low mud percentage (max mean of 4.3 %) and a low organic matter percentage (max mean 0.3 %).

Epibenthic organisms at the pilot site are dominated by Echinodermata and Anomura. A higher density and diversity is found in the gullies compared to the sandbanks.

Since the installation of the wind turbines and the accompanied erosion protection layers, hard substrates have been introduced in the otherwise sandy area. The hard substrates are colonised by a number of pioneer species, but the climax community is mainly characterised by the presence of the tube-dwelling amphipod *Jassa herdmani*, plumose anemone *Metridium senile* and blue mussel *Mytilus edulis*.

Marine mammals

In the BPNS, including the pilot site, five species of sea mammal are regularly spotted: harbour porpoise *Phocoena phocoena*, harbour seal *Phoca vitulina*, grey seal *Halichoerus grypus*, bottlenose dolphin *Tursiops truncates* and white-nosed dolphin *Lagenorhynchus albirostris*.

Birds

The area of the pilot site is important for two bird species, little gull *Hydrocoloeus minutus* and great skua *Stercorarius skua*. With the wind farm at Bligh Bank (close to the pilot site) already installed since 2010, it has been observed that the wind farm attracts greater black-backed gull *Larus marinus*, lesser black-backed gull *L. fuscus* and European herring gull European *L. argentatus*.

Identified gaps

The following gaps have been noted:

- Bats: knowledge gaps exist regarding the occurrence of bats at sea and their behaviour in wind farms, as well as the number of collision casualties.
- Pathogens: so far there is no knowledge on the presence of parasites, bacteria, viruses in the offshore areas of the BPNS. This might be important in the framework of biosecurity.
- Biological interactions: changing food webs through predation of phyto- and zooplankton by oysters, the attraction of hard-substrate-associated species and changes in benthic habitats by aquaculture installations could all lead to changes in biological interactions. Additionally, the scale of these impacts is unknown in relation to the wind turbines and scour protection.
- The impact of the production of (pseudo)faeces by oysters is not known at the pilot location. The strong currents may however dilute this quickly.
- The impact of oyster larvae predation by fouling fauna on both aquaculture installations and wind turbines is unknown, this could however have consequences on the success of the oyster restoration.

6.1.3. HUMAN ACTIVITIES AND CURRENT THREATS

Offshore wind energy: The pilot site is an area which has been designated as an area for offshore renewable energy production, including wind energy. Currently, a fully operational wind farm is present at the pilot site, consisting of 50 (Nobelwind) and 56 (Belwind) turbines on monopile foundations. Around each foundation an erosion protection layer is present, and the turbines are connected with each other and with an offshore transformer station by power cables under the seabed, transporting the generated electricity.

Fishery: The most targeted species in the BPNS are *Pleuronectes platessa* and Dover sole *Solea solea*, and closer to the coast also the brown shrimp *Crangon crangon*. Fish species are mainly targeted in the gullies, while shrimp predominantly on the coastal sandbanks. Although the pilot site was not an important site for fishery, the designation as a wind farm zone closed the area for any vessel traffic, *de facto* prohibiting fishery here.

Aquaculture: Although no commercial aquaculture is currently active in the BPNS, commercial interest is present and some research pilots are, have been or will be conducted. The wind farm zones are the ideal areas for this, since active fishery is banned here. At other areas, opposition from fishermen could occur as aquaculture might interfere with existing fishing grounds.

Scientific research: Despite the limited size of the Belgian coastline and the BPNS, Belgium has a long tradition in marine research, with a considerable number of marine researchers currently active. The development of the offshore wind farms and other Blue Economy sectors is contributing to research and monitoring programmes, and the interest for marine research in the BPNS is expected to continue and even increase in the near future.

6.1.4. VULNERABLE ANIMAL AND PLANT SPECIES

Three protected bird species (Annex I of the EU Bird Directive) can be observed in the offshore wind farm area, including the pilot site: little gull, Sandwich tern *Sterna sandvicensis* and common tern *S. hirundo*.

On the Belgium red list, Sandwich tern is categorised as critically endangered and common tern as vulnerable. Additionally, greater black-backed gull is classified as rare and lesser black-backed gull as vulnerable.

All sea mammals present in the BPNS are protected (Annex II and IV of the EU Habitat Directive). Harbour porpoise is listed as Vulnerable on the Belgium red list, harbour seal as critically endangered, grey seal as endangered, while bottlenose dolphin is listed as extinct and white-nosed dolphin as least concern.

Although all above bird and mammal species are listed on the Belgium red list, their status on the IUCN (global) red list is listed as least concern for all.

6.1.5. HABITAT TYPES

The main habitat type, following the EU Habitat Directive classification, might be characterised as Habitat 1110B – Permanent flooded sandbanks, although the pilot site (and the complete offshore wind area) has not been appointed as such.

6.1.6. POTENTIAL POSITIVE AND/OR NEGATIVE ENVIRONMENTAL IMPACTS OF A GIVEN TYPE OF MULTI-USE

One of the aims of the Belgian pilot is to restore flat oyster reefs in the BPNS. Oyster reefs were once a common feature in the North Sea but overfishing led to their decline in the early 20th century. The restoration of this important habitat (Habitat 1170 – biogenic reefs, EU Habitat Directive) will be an important positive environmental impact of the project. The combination with wind farms ensures the protection of the reefs from fishing activities. Oyster reefs provide several ecosystem services, including enhanced water quality, increased fish production, improved sediment stability and possibly carbon sequestration. Furthermore, they are an important habitat for numerous fish and invertebrate species, acting as breeding grounds, feeding grounds and refugee areas. They provide hard substrates that can be colonized by sessile organisms, thus promoting biodiversity. Additionally, the increased abundance of invertebrates and small fish will attract predators such as larger fish, sea birds and marine mammals to the oyster reefs to feed.

Next to that, the combination of aquaculture and restoration of flat oyster with the growth of seaweed (sugar kelp) **is a form of extractive aquaculture.** The oysters themselves feed on plankton, while sugar kelp will remove carbon and nitrogen (as well as phosphorus) from the marine ecosystem. As such, the excretion products from one species is the food for the other, leading to a sustainable way of performing aquaculture. Moreover, both oysters and seaweed purify the surrounding water from waste products, which is a unique scenario.

Offshore wind farms might exert an **attraction of birds**: common gull *L. canus*, European herring gull, greater and lesser black-backed gull, black-legged kittiwake *Rissa tridactyla* and great cormorant *Phalacrocorax carbo*, increasing the **risk of collision with a wind turbine**. Also, several species of **fish are attracted to wind turbine** foundations (artificial reef effect). If aquaculture will be installed at the pilot site, this **attraction will likely increase** for these species.

The implementation of aquaculture at an offshore wind farm will introduce additional hard substrates such as anchors, buoys and aquaculture lines. This will lead to an **increase in fouling organisms**, both attached on the aquaculture species and on the aquaculture structures, and as such provide additional stepping stones, next to the wind turbine foundations and erosion protection layers, for these hard substrate fauna. This fauna includes non-native species such as Pacific oyster *Crassostrea gigas*, slipper limper *Crepidula fornicata* and several species of barnacles. The introduction of aquaculture species may also lead to the **unwanted introduction of associated pathogens.**

However, the **increased traffic** at the multi-use pilot site, due to wind turbine maintenance, aquaculture maintenance and harvesting and scientific research, might increase the chance of **accidents such as collisions and spills** of harmful substances such as oil and other chemicals.

Oyster reefs could induce potential **increased fish production**, **better water quality, and improved soil stability.** The oyster reefs are also important for the diversity of species in the sea, as breeding grounds, food sources and resting and refuge places. Certain corals attach themselves to oyster reefs and attract in their turn other species, this way **enhancing biodiversity**. Sharks, rays, smaller fish and cuttlefish deposit eggs on the shells, and growing fish find food and refuge there. In addition, all kinds of **birds are attracted** by the many small fish and prawns or shrimps that live on and around shellfish banks.

Moreover, positive impacts of the proposed multi-use in the form of oyster aquaculture and restoration at an offshore wind farm might be the **increase in scientific research and knowledge**. Also, an **increasing interest of the tourism sector and of recreational divers** could be expected, to investigate the possibilities for visits and diving activities at the wind farm/aquaculture site.

6.2. Environmentally responsible mission of the pilot

Aquaculture of the native flat oysters will take place in Belgium pilot, re-introducing this species to the pilot site. Additional substrate will be added on the erosion protection layer in order to facilitate the settlement of offspring from the aquaculture specimens into the natural environment. As such, flat oyster could be reintroduced in the BPNS, where it might form oyster reefs, enhancing overall biodiversity and restoring an important habitat in the BPNS. As the offshore wind farm zones are essentially no fishing areas, these reefs have a much greater chance to persist compared to other areas and as such, could act as refugee areas for numerous invertebrates and fish.

The filtering capacity of bivalve reefs – such as oysters and mussels – is well recognised. Oysters in both aquaculture and settled on the added substrate will decrease the turbidity and improve the water quality by their filtering capacity.

The North Sea is considered to be eutrophic so extractive aquaculture, such as the culture of bivalves, is considered to be beneficial. In addition, one of the legal requirements to develop aquaculture activities in wind farms, is that it should be at least nutrient-neutral or better even reduce the nutrient levels of nitrogen and phosphorus. Evidently, the oysters fulfil this requirement since nutrients are removed indirectly by filtering the microalgae out the water, by enhancing the denitrification process in the bottom and eventually by removing the animals from the ecosystem at harvest.

Since fouling is one of the major problems the aquaculture activity will face, specific flat oyster culture methods have been selected to reduce this problem and nature-friendly antifouling solutions are being investigated. Materials of the culture systems will be reusable and have a long shelf-life.

In order to reduce the ecologic footprint, the wind farm maintenance crew and vessels will be used for sampling activities at the pilot site. As demanded by the wind farm concession holders, every item put in the sea will be removed from the sea after the project has finished, unless removal of the devices (in particular the gabions/tables for oyster reef restoration) will lead to a loss in biodiversity and all involved stakeholders agree to leave them.

6.3. General overview of regulatory requirements for environmental impact assessment and environmental monitoring for the given pilot

The development of an offshore wind farm requires an environmental impact assessment (EIA) trajectory. An EIA for the aquaculture part of the pilot is not required since it is a research pilot. Commercial exploitation in the future, however, will have to conduct an EIA. Additionally, there are regulations concerning the introduction of aquaculture species and associated pathogens/diseases (defined by different institutions, including FAVV (Federal Agency for Food Safety).

6.4. Overview of existing environmental assessment results and monitoring information

6.4.1. EXISTING ASSESSMENTS SUBMITTED TO THE AUTHORITIES

The pilot is a scientific project, so no formal EIA is needed. The pilot is situated in an offshore wind farm, for which an EIA was performed. This wind farm EIA was conducted in 2007 (Ecolas 2007). The possibilities for multi-use, including aquaculture and alternative (passive) ways of fishing are touched upon but not further elaborated since this falls out of the scope of the EIA for the wind farm at that time and since no concrete plans for aquaculture were foreseen in the near future.

Interesting, before installation, a risk analysis needs to be conducted on the demand of the concession holder of the wind farm in which the pilot will be set-up. This analysis also includes an evaluation of possible impacts on the environment of the pilot.

6.4.2. OVERVIEW OF MAIN ENVIRONMENTAL ASSESSMENT FEATURES/ RESULTS

Since no multi-use assessment nor assessment for aquaculture has been performed for the pilot (nor the BPNS), this information is currently non-existent.

6.4.3. OVERVIEW OF CURRENT MONITORING REGIMES AND CAPACITIES

The potential impacts of the offshore wind farms in the BPNS are assessed through a monitoring programme that started in 2005 (WinMon programme). Both physical (hydro-geomorphology and underwater noise) and biological (epifouling community on the hard substrates, macro- and epibenthos on the soft substrate, fish, seabirds and marine mammals), as well as socio-economic (seascape perception and offshore renewables appreciation) aspects of the marine environment are targeted (Degraer *et al.* 2013).

In the framework of that monitoring programme, results and possibly monitoring capacities might be applicable to the pilot.

6.5. Recommendations for the pilot

Since aquaculture in the BPNS is still in its early stage, publicly available information on its environmental impacts is scarce. There are and have been some research projects for aquaculture in the BPNS, focussing mainly on blue mussel *Mytilus edulis*, but final reports are not available yet.

However, the multi-use project "Edulis" (blue mussel culture offshore in wind farm Belwind and C-Power), taught us that the offshore environment is favourable for the culture of bivalves and that aquaculture is technically spoken possible. The longline with blue mussels did favour fouling with tube-dwelling amphipod *Jassa herdmani*, leading to an important increased overall weight of the lines during harvest. The impact of this fouling organism on mussel growth and total harvest was not determined. No problems were encountered to decommission the system at the end of the project, although some small buoys got lost during the project and were never recovered. An elementary calculation was done to estimate the amount of nitrogen and phosphorous that was removed from the ecosystem by harvesting the blue mussels.

NORA (Native Oyster restoration alliance) gathers scientists, NGO's and producers of the native oyster that are interested in restoring the oyster reefs in Europe. They produced a document, Berlin Oyster Declaration, with recommendations that should guide any restoration effort (Pogoda, B. et al, 2019). Concerns about the origin of oyster seed (genetic pollution) and presence of diseases, like bonamiasis, are expressed, and a "code of conduct" is formulated, since oyster broodstock and spat are transported all over Europe for aquaculture and restoration purposes. Our pilot project will follow these recommendations.

Interestingly, an environmental impact assessment has been started very recently (May 2020) for the aquaculture of mussel, oyster and seaweed in the coastal zone of the BPNS. Although no environmental permit has been granted for this project yet, environmental impacts observed might also be applicable to the Belgian pilot.

6.6. Conclusions

The majority of the impacts identified for the Belgium pilot are already apparent at the offshore wind farm without any multi-use implemented. Aquaculture of native oyster in the Belgian pilot at an offshore wind farm adds additional hard substrates, but its scale is likely to be negligible compared to the wind turbine foundations and erosion protection layers. Additional attraction of seabirds to the aquaculture installation might increase the risk of collision with a wind turbine, especially for gull species which are already attracted to the offshore wind farms. The envisaged oyster reef restoration however, might increase biodiversity by providing valuable feeding, breeding and refugee areas for a range of species. Additionally, an important native habitat -oyster reefs- will be restored in the BPNS, providing valuable ecosystem services including improved water quality, increased fish production and carbon sequestration. Moreover, by combining flat oyster aquaculture and sugar kelp growth, this extractive aquaculture might lead to a sustainable way of performing aquaculture and purify the surrounding water from excess nutrients.

One concern, which is not applicable to an offshore wind farm as a single use, is the unwanted introduction of pathogens, diseases and non-native (fouling) species when introducing aquaculture individuals. These species might spread further in the BPNS by using the hard substrates and their associated fauna as stepping stones, and as such establishing themselves in the BPNS.

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7. DANISH PILOT: OFFSHORE WIND AND TOURISM

The multi-use demonstration pilot in Denmark is located in the Middelgrunden offshore wind farm site. It comprises the combination of offshore wind energy generation and tourism & recreation. Since 2002, the local cooperative that owns and manages the farm has offered guided tours in collaboration with boat companies mostly for getting around the turbines. Every two years a visit including climbing the turbines has been organised mainly for share owners. Since 2012 SPOK has organizing 30 to 40 trips every year mainly for students and businesspeople interesting in offshore wind. Nevertheless, the safety procedures and challenging scheduling processes with boat operators, remained the challenge. Thus, the pilot will address the key multi-use challenges and investigating new opportunities for the site, such as: addressing existing legal and insurance challenges; expanding the tours by enhancing the boat service; and explore new opportunities for multi-use, such as for example scuba-diving and fishing around the site.

The Middelgrunden was established on a natural reef with 3 to 6 metres water depth, 3.5km outside Copenhagen harbour (Figure 8), in the autumn of 2000. It is right in front of Copenhagen city, and thus visible from the most important city beaches and tourist points of high value, like *The Little Mermaid* and the *Round Tower*. The offshore wind farm consists of twenty 2 MW turbines from Bonus Energy, now Siemens Gamesa Windpower, and is owned 50% by HOFOR (Copenhagen local energy and water supply) and 50% by The Middelgrunden Wind Turbine Cooperative with 8,553 members. It is the largest wind farm in the world based on cooperative ownership.

Figure 8 The position of the 20 wind turbines within the 6-meter water depth contour

The wind farm consists of 20 turbines, each with a rated capacity of 2 MW. The maximum height of the wingtip is 102 meters. The electricity production is anticipated to be about 100 GWh a year. The turbines are erected on standard gravity foundations, which are placed on firm seabed after the upper layer of soft sediment has been removed.

Middelgrunden site is heavily influenced by human activity in many respects. For example, the nearest area on land is characterised by technical installations, industry and harbour facilities. The closest recreational areas are the Middelgrunds Fortification (today called Ungdomsøen and operated by the Scout organisations) situated 1.3 km north of the wind farm and Amager Strand Park situated 2.5 km south west of the wind farm. The island of Saltholm is situated 5 km south east of the wind farm, with its surroundings it constitutes an international nature conservation area.

7.1. Baseline environmental account in the pilot site

7.1.1. ABIOTIC FACTORS

Seabed

Middelgrunden as natural reef is defined to be within the 6-meter depth as shown in Figure 9. The seabed consists of sand in the south, limestone in the central part and glacial deposits in the norther part. The natural reef was created about 7.500 years ago when a post glacial barrage in the Baltic Sea at level with Stockholm collapsed (Figure 9). The reef has been used as waste deposits for more than 200 years up to 1990. Therefore, remains of sludge with heavy metals like Cu, Pb, Ca Zn and Hg can be found in spots equalling the dump volume of a boat load.

The authorities are recommending the Reef as "not suitable for sailing" as the seabed is changing all the time caused by waves and current. In some areas you can find big boulders where the sea depth is only 1 meter.

Leisure boats do not always respect this recommendation as there was found 17 ship wrecks of newer type 17-23 foot boats during the scanning of the seabed along the turbine line.

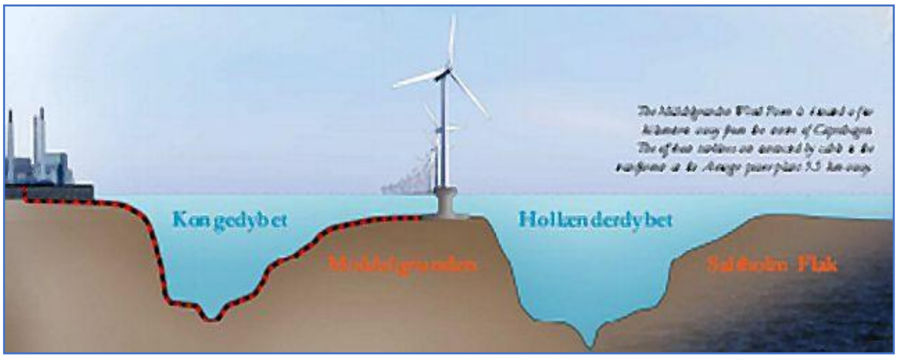

Figure 9 The Middelgrunden Reef between the sailing rout to Copenhagen: Kongedybet 11-16 meter deep and the south/south sailing route Holænderdybet 19 meter deep

Seawater

The flow across the reef is very complicated as often the flow in Øresund is separated in two layers where one is going north and the other south. The inflow of salt water to the Baltic Sea is extremely important for the breeding of the cod in the Baltic Sea. Therefore, the turbine foundation was made circular to minimize the flow resistance. Further on it was discussed to move about 4.000 m^3 of seabed to compensate for the flow reduction. The risk of having more pollution spread from the contaminated soil at the seabed by the dissolution of sediments resulted in not doing the compensation mitigation.

Every 6 to 8 years sea ice is appearing in the area and drifting large "icebergs" can be expected. The shape of the foundation is formed at a glass to break the icebergs.

7.1.2. FAUNA AND FLORA

Plankton

Not registered.

Fish

The fish fauna is dominated by cod, flatfish (flounder/plaice *limoque obvoluto*) and eel. At the edge of the reef many other fish species can be found. Around nine professional fishing vessels were operating in the area before and after establishment of the wind farm.

Benthos

The reef is covered by eelgrass 50-60% in the southern part and 25-30% in the norther part, look figure.
Blue mussel *Mytillus Edulis* is another important bottom benthos.

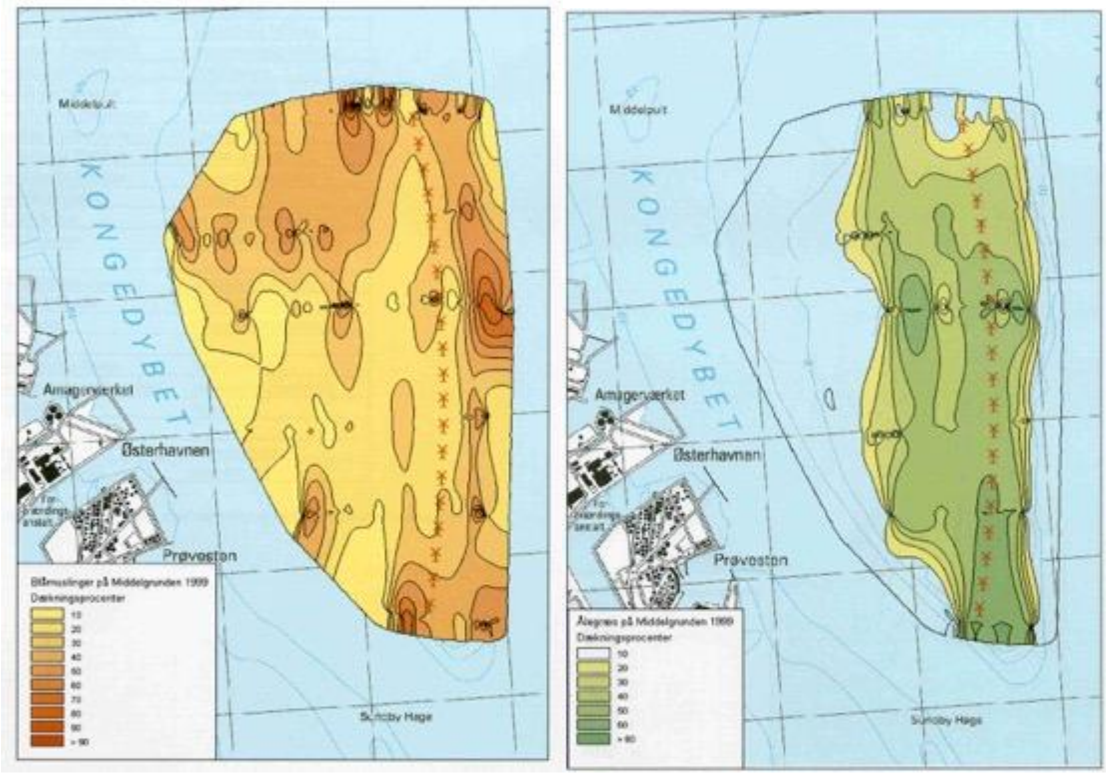

Figure 10 The cover of Common Mussel and Eelgrass before establishment

During dredging the habitat was destroyed where sailing routs and foundation had to be. A video inspection was established 3 years after the construction showing that the habitat was re-established. Other species at the reef are Ceramium nodulosum, *Ulva* and *Chaetomorpha*.

Marine mammals

Marine mammals are seldom observed.

Birds

The area of the pilot site is populated by swans, ducks, eiders, and gullets. The birds are usually attracted to the nearby NATURA 2000 area: Saltholm.

7.1.3. VULNERABLE ANIMAL AND PLANT SPECIES

This section refers to the environmental impact report conducted for the MIddlegrunden wind farm. Namely, when the VVM (environmental impact report) is made for a specific application, the project with the least environmental effect and negative impact (and/or addition of positive impacts) will naturally outweigh the competition. The Energy Authority in Denmark is normally responsible for such making decisions on such assessment.

For each nature or wildlife reserve or protected area, there is an order that describes the limitations and restrictions. Disturbing activities are prohibited fully or partially. Natura 2000 areas are administered on the basis of Natura 2000 plans, where the habitat order (no. 926 of June 2016) as well as a number of other acts and orders apply. Natura 2000 plans also include all the Ramsar areas, but these are not designated on the basis of the EU directives (i.e. EU Bird Protection Directive and Habitat Directive)

7.1.4. HABITAT TYPES

The main habitat type, following the EU Habitat Directive classification, might be characterised as Habitat 1110B – Permanent flooded sandbanks, although the pilot site (and the complete offshore wind area) has not been appointed as such. In general, the habitat consists of eel grass and common mussels. None of this species are vulnerable. Fishing takes place by professionals and private people mainly catching eel, cod and flatfish. There are no sensitive bird species in the area; the existing birds like swans, ducks, eiders and gullets are not influenced by the operation of the wind farm.

7.1.5. DESCRIBE IF THERE ARE KNOWN POTENTIAL POSITIVE AND/OR NEGATIVE ENVIRONMENTAL IMPACTS OF A GIVEN TYPE OF MULTI-USE

The Middelgrunden pilot is already heavily influenced by intense boat traffic in the area. Thus, the risk of introducing tourism boat tours in the area was considered marginal. The foreseen risk of this multi-use is that the higher intensity of boat traffic may result in spread of litter from tourism.

Introduction of scuba diving does not increase the environmental impacts as it is carried out within an organisation used to dive on sensitive areas. The EIA investigations have shown that the reef does not include other shipwrecks than modern wrecks. The National museum of archaeology is concerned for possible looting of wooden shipwrecks which all diver organisations are aware of. Moreover, the EIA investigations have shown that the reef does not include wooden shipwrecks.

Studies of this type of multi-use in Denmark and in other countries may also provide valuable recommendations for this pilot in terms of possible risks to be avoided. Most examples of this type of multi-use are situated in the Baltic and North seas. In the coastal areas of Denmark, Belgium, Sweden, Germany and the UK, offshore wind farms are already being consciously integrated into regional tourism activities. According to MUSES project case study conducted in Denmark (Lolland), the sheltering effect of the wind park and the new underwater environment could provide a completely new form of water tourism, allowing for the establishment of e.g. diving and marine nature education and study. Joint use of human resources could involve e.g. surveillance and data collection and dissemination of information as part of a tour. Moreover, such boat tours usually also include a lecture about the importance of the renewable energy its benefits to the environment, thus increasing the knowledge of those aboard about the offshore wind farms and contributing to easier acceptance of future such projects, which are important for achieving CO2 reduction targets.

The MUSES case study in Denmark[6] has listed following environmental impacts related to this type of multi-use in Denmark:

- Limited information regarding EIA of MU
- Introduction of habitats possibly supporting invasive species.
- Possible bio-fouling
- Increase of bacteria levels in the water due to increased bird and tourist population and excreta
- Fouling of the area due to spillage from transport vehicles, OW maintenance equipment, lubrication, paint and other chemicals

The water-based tourism in Denmark is expected to increase considerably in the future. For example, Lolland Municipality together with Business Lolland-Falster has made a "Plan of Potentials 2030" for tourism development on the south coast of Lolland, including the increase of coastal tourism as part of its strategy[7].

According to the MUSES project multi-use case study in Denmark, there are already small-scale private boat excursions to the offshore wind parks at Nysted (Rødsand 1 and Rødsand 2), while diving around the turbine foundations, hunting for" treasure", is an up and coming trend. However, these are arranged specifically for visiting groups and are not an established tourist service. It is so far not precisely specified where and by whom

[6] Available at: https://sites.dundee.ac.uk/muses/wp-content/uploads/sites/70/2018/02/ANNEX-8-CASE-STUDY-5.pdf

[7] Available at: http://www.businesslf.dk/turisme

More information at: http://www.southbaltic-offshore.eu/reports-studies/img/OFFSHORE_WIND_FARMS_AND_TOURISM.pdf these excursions have been organised[8]. In terms of commercialization, the distance from shore usually drives up the marginal costs of wind farm tours (due to fuel and staff cost increases). The case study emphasizes that it is questionable whether there are enough potential visitors or divers ready to invest the time and money. In general, it needs to be assessed how valuable excursions to offshore wind farms are as a multi-use. It is arguable in how far this multi-use increases spatial efficiency as it re-directs tourists from locations, such as beaches, to the open sea and increases activity / traffic there. This multi-use could be developed on a commercial level if the boat tour would be promoted as a unique attraction and the scope would be broadened (i.e. educational, boat parties, summer school). At the same time, the question remains what scale such excursions could take. In case such an offer would be limited to a niche market (e.g. one tour per wind park per day or every couple of days), the increase of activity at sea or spatial efficiency gains (depending on what side of the coin you look at) may be negligible. This multi-use combination, however, seems more relevant from the perspective of easing pressure at touristic hotspots by diversifying the offer or strengthening the local economy.

The acceptability of offshore wind farms by the society-at-large is not an issue in Denmark and the general opinions are positive for such developments. Therefore, in Denmark this would not be a driver for this multi-use from the offshore wind developer/operator's perspective. Developing this multi-use to a commercial scale might enable the access of the offshore wind farm operator to the site and impose safety issues. For the operator is important not to have any interference in the running operations and maintenance. Therefore, commercial development of this multi-use on a large scale from the offshore wind developer point of view may bring more losses than gains.

7.2. General overview of regulatory requirements for environmental impact assessment and environmental monitoring for the given pilot

There are no specific regulatory requirements for the combination of offshore wind and tourism, in this case, boat tours to the wind farm. Nevertheless, any matter relating to offshore wind turbines in Danish territorial waters or within Danish EEZ is administered by the Danish Energy Agency. The Danish Energy Agency issues the necessary permits and organises contacts with all other concerned authorities according to a „one-stop-shop" principle. Prior to the approval of an offshore wind farm, an environmental impact (VVM) report must be produced, cf. the order on assessment of the environmental impact in connection with projects for establishment of electricity production at sea. The Danish Energy Agency on the basis of the VVM report grants a permit (establishment permit), under section 25 of the act for promoting sustainable energy. The same agency grants a permit for establishing the cable to shore. Before the establishment of offshore wind turbines, thorough geophysical and geotechnical investigations of the seabed must be performed, and an extensive EIA is also compulsory. According to the Danish Proclamation 815 on EIA (dk. *Bekendtgørelse 815 om VVM)* EIA must 'identify, describe and evaluate' the consequences of the project (Ministerium: Energi-, Forsynings- og Klimaministeriet, 2017)

Until 2019, a particular provision in the Danish law stipulated that the owner of a wind power facility funded by any other than the Government is obligated to grant at least 20% of the ownership to the local inhabitants. Anyone over the age of 18, who is registered at an address not more than 4.5 km from the facility, or within the municipality where the facility is built, had the right to buy shares (Malin Odalen, 2013).

7.3. Overview of existing environmental assessment results and monitoring information

7.3.1. EXISTING ASSESSMENTS SUBMITTED TO THE AUTHORITIES

For the Middelgrunden wind farm, involved in the UNITED pilot, the environmental impact assessment was conducted in 1999 following the implementation of the EIA Directive in Denmark. Additional licences are not

[8] The Seal Colony on Redsand: https://www.nystedsealsafari.com/vores-venner

needed for the tourism multi-use activity. In comparison to many other countries, Denmark does not have strict zoning and safety zone regulations in place for the offshore wind farms.

Nevertheless, a series of analysis were conducted in order to examine various impacts of the offshore wind farm development project. The resulting Environmental Impact Assessment was submitted to the authorities. There have been no assessments for the boat tours to the wind farm nor for the multi-use aspect of the offshore wind farm. Such assessments were not requested nor submitted.

7.3.2. OVERVIEW OF MAIN ENVIRONMENTAL ASSESSMENT FEATURES/ RESULTS

The environmental assessment has been conducted for the Middelgrunden offshore wind farm and published in 1999. As stated in the EIA about the operational phase: the activity related to the wind farm is minor compared to the overall activities in the surrounding water. This will not change even with an increased multi-use activity of two or three boat tour visits a day; this would still be a small additional activity compared with the traffic caused by the busy port nearby.

Impact assessment method: The subjects evaluated with regard to the offshore wind farm development EIA were the visual impact, the risk of leaking debris and heavy metal contamination from the former dump site, noise propagation, influence in the free flow of water in the Sound (Øresund) suspension and sedimentation of sediment, release of heavy metals due to suspension, impact on flora, fauna, and fishing, reduced emissions from power plants, saved fuel and avoided pollution, visual impact, risk of finding shipwrecks and deposits from the Stone Age of archaeological interest, and collision risk with vessels. The environmental assessment also presents the alternatives to the project. That includes environmentally benign electricity production methods and energy savings.

Results: The impacts from heavy metals and sediment due to suspension is found to be insignificant because each dredging operation only takes 2 days, that makes 50 days altogether, and because the quantities released are negligible, see table 7.3. It is possible though; that adjacent areas covered with eelgrass will be temporarily weakened by a layer of sediment. The firm surface of the foundations and their erosion protection will permanently change a tiny part of the bottom of Middelgrunden because it will replace the present soft surface. That means that the present growth of eelgrass will disappear, but after a few years it will be succeeded by a new and different ecosystem which can support other species and provide better conditions for parts of the present flora and fauna.

The presence of birds on Middelgrunden is limited and the area is strongly influenced by human activity. Common species are as ducks, swans, eiders and gullets. There are no sensitive bird species in the area. It was estimated that at maximum app. 400 birds will be influenced by the project in the sense that they are expected to leave the area due to the operation of the turbines. The consequences for the birds are most important in the installation phase. It was also expected that birds will return and continue to use the area as before.

Calculations on noise emissions prove that no land area will be influenced by a noise level higher than 34 dB(A) where the limit is 40 dB(A), see table 7.6 and figure 7.1.

Calculations prove that the project at maximum decreases the water flow in Øresund by 0.005%, see table 7.7. The effect on the water flow in Øresund from the recent compensation dredging, necessitated by Øresundsforbindelsen, can only be calculated with a +/- 0.2% uncertainty. This implies that the uncertainty concerning the calculation is 50 times higher than the influence induced by the foundations. Thus, it is stated that influence of the project on the overall water flow in Øresund is marginal.

Intensive netting takes place in the area predominantly for eel, cod and flatfish. Compensation was settled with the local fishers and fishing was prohibited only during the construction. Fishing resumed after the wind farm was installed, but trawling was prohibited in the area, as well as anchoring 200m from the sea bottom cable. Moreover, the offshore wind turbine foundations were expected to serve as an artificial reef and create a habitat for bottom animals and food for more fish in the area, and therefore benefit fishing.

In addition, alternative sites are presented within Middelgrunden and at alternative locations near Copenhagen. It is concluded that it is not possible to find alternative sites or production techniques, regarding the motives of the originators of the project.

Mitigation measures: The environmental assessment also presents the measures considered to minimise the environmental impact of the project. Compensation dredging may take place in order to compensate for the reduced water flow in Øresund, but it is not recommended.

7.3.3. OVERVIEW OF CURRENT MONITORING REGIMES AND CAPACITIES

The EIA of the offshore wind farm presents a monitor programme. Before the project is initiated, photographs and video recordings will register the flora and fauna in the area. After a few years, a similar investigation is carried through in order to register possible changes.

In year 2003, three years after commissioning of the wind farm, the key parameters from the environmental surveys and investigations carried out before and during construction was analysed[9]. The two main indicators for the aquatic environment on the site are eelgrass and shell fish. The report concludes that the construction of the wind farm did not have any significant influence on the marine vegetation in the area. Already during installation of the turbines, we have seen a beginning recovery of the eelgrass. The follow up investigation showed an almost 100% recovery. A good indicator is that the fishermen have returned, and the site is attractive for them.

After 2003 no monitoring has taken place and there is no monitoring expected during the UNITED pilot implementation. Nevertheless, the UNITED WP2 will review what type of monitoring would have been useful to carry out in the Danish pilot and provide recommendations.

7.4. Recommendations for the pilot

According to the MUSES project case study in Denmark the combination of offshore wind and boat tours may be relevant from the perspective of easing pressure at touristic hotspots by diversifying the offer or strengthening the local economy. Moreover, the presentations on board the vessel given by the operator about the importance of the renewable energy technology and the role that offshore wind farms play with regard to the CO2 reduction targets, may also contribute to the more aware society and ease acceptance of such farms in the future.

Recommendations:

- Consider advertising the boat tours in the areas of the Copenhagen city where the tourism may be the most intensive as to divert tourists to Middelgrunden and thus ease the pressure on popular touristic spots;
- Consider developing informative and innovative curriculum integrating the knowledge about the importance of offshore wind farms in the CO2 reduction and in combating climate change and consider issuing certificates for those taking the tour;
- Consider providing briefings about the environmentally responsible behaviour onboard i.e. no littering, no feeding animals, no noise making.

7.5. Conclusions

The offshore wind farm in Denmark that is a part of the UNITED pilot demonstration project is one of the oldest ones in the world. Regulation in Denmark regarding the access to the offshore wind farms may be more relaxed then in the other EU Member States, thus enabling the existence of this multi-use.

Nevertheless, the multi-use of the site is not expected to create any serious environment impact and is not subject to any approval by the authorities. Anyhow it is important not to create an image of "public access to the site"; it is relevant to underline that tourism is carried out under supervision of professionals. Thus, the multi-use

[9] Hedeselskabet, Middelgrunden, Biologisk undersøgelse ved vindmølleparken på Middelgrunden ved København, efteråret 2003. www.middelgrunden.dk/projektinfo/

demonstration pilot should not give an impression that there is free access for individuals which may increase environmental risks and impacts at the site.

References and further reading

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H. C. Soerensen et al., Middelgrunden 40 MW offshore wind farm, a prestudy for the Danish offshore 750 MW wind program, Proceedings ISOPE 2000 Conference Seattle I (2000) 484-491

NOVANA: The Danish monitoring program for nature and water: https://mst.dk/natur-vand/overvaagning-af-vand-og-natur/

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https://www.kattegatcentret.dk/files/Pressemeddelelser/Tang_til_foedevarer,_foder_og_et_bedre_havmiljoe_i_Danmark_-_pressemeddelelse_-_ACDK.pdf

The Danish Sea Strategy (2012) : https://mst.dk/natur-vand/vandmiljoe/havet/havmiljoe/danmarks-havstrategi/

Is under revision.

8. GREEK PILOT: AQUACULTURE AND TOURISM

The Greek pilot site (PATROKLOS) is situated in 59th km Athens-Sounio Ave., Palaia Fokaia, Attiki, Greece, in the wider area of Cape Sounio. Cape Sounion is located at the southern end of Attica peninsula. During the Classical and Hellenistic periods, the Cape and the ancient harbour city of Sounion were of prime geostrategic importance located on the main maritime route surveying all traffic and enemy fleets towards the metropolis of Athens and the silver mines of Lavreotiki. On the Cape there are today visible important remains of the sanctuaries of Athena and Poseidon, the fortification circuit and the settlement of the promontory, and of a naval base. The naval base built originally by the Athenians in the 5th century BC lies at the north-western side of the cape and was incorporated in the fortress. It consisted of two rock-cut slipways intended to house light patrol ships.

The wider area now, is protected under NATURA 2000[10]. It is a characteristic example of Mediterranean landscape. It includes an area declared a National Park since 1971 and is regarded as an archaeological site of great importance. 68% of the area is public. It is threatened by anthropogenic pressures (crops on the north and east sides of the area, pastures, residential activity that develops mainly along the coastal road) and fires. It is protected by the Treaty of Barcelona. Changing the extent to which anthropogenic activities occupy within the

[10] The online data form with Natura's description of the site is: https://natura2000.eea.europa.eu/Natura2000/SDF.aspx?site=GR3000005#2.

boundaries of the area is important. If the rate of change continues, the problem of maintaining this character will be maximized.

The current operator of the site is KASTELORIZO AQUACULTURE, a company that operates on the field of production, marketing and exploitation of fish farms with all kinds of fish, shellfish in fresh or frozen form as well as distribution of product at Greek premises and abroad. On the opposite of the aquaculture unit, there is an islet with the name "Patroklos". Islet Patroklos, has a great coastline where local people as well as tourists from the wider Attica area, enjoy swimming and spending time in the beach. Access to the islet is only by private boats, while in the summer time a private vessel transfers tourists to the islet. Islet Patroklos has been claimed as protected ancient are due to remnants of fortification existing there, from two walls that used to close all over the east to and the 1944 shipwreck as well.

Figure 11 Proposed pilot space (source: Google Earth)

Figure 12 Google earth view. (Yellow square depicts aquaculture unit)

Figure 11 Aquaculture unit and islet Patroklos on the opposite side

8.1. Baseline environmental account in the pilot site

8.1.1. ABIOTIC FACTORS

Seabed

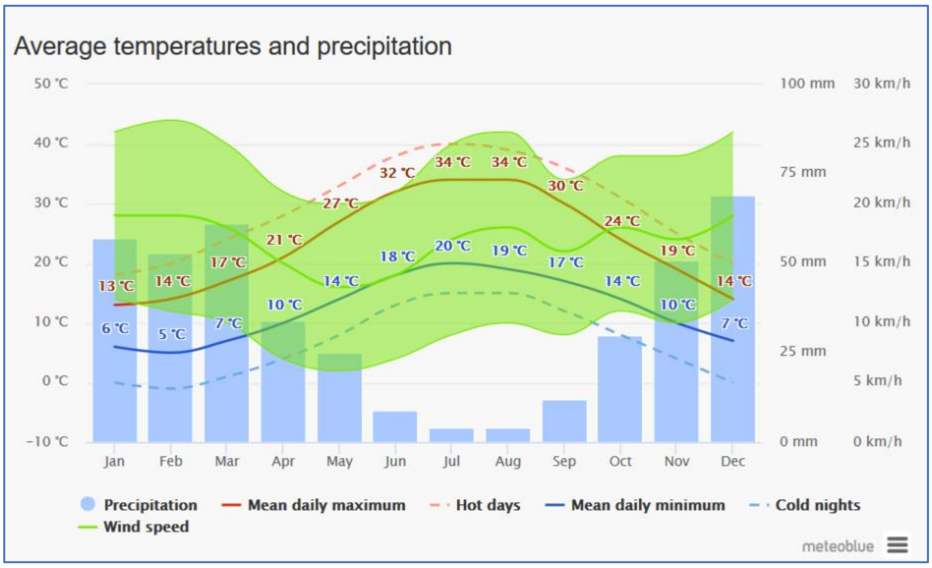
A complex seafloor composed of a sandy to rocky substrate, often covered by seagrass.

Seawater

The pilot site seawater temperature is between 16 °C to 22°C in summer.

Atmosphere and climate

Weather of site can be described by diagram below:



Source: meteoblue.com

The "mean daily maximum" (solid red line) shows the maximum temperature of an average day for every month for Sounio. Likewise, "mean daily minimum" (solid blue line) shows the average minimum temperature. Hot days and cold nights (dashed red and blue lines) show the average of the hottest day and coldest night of each month of the last 30 years. For vacation planning, you can expect the mean temperatures, and be prepared for hotter and colder days. Wind speeds are displayed with the green solid colour and do not exceed 19km/h yearly.

Monthly precipitations above 150mm are mostly wet, below 30mm mostly dry.

Seascape

No major physical boundaries or exist in the area, a free and undisturbed view of the sea is apparent.

Cultural heritage

Patrokos islet, right opposite to the aquaculture site, has a long history. In ancient times, the island was known as Patroklou Charax ("Camp of Patroclus") or Patroklou Nesos ("Island of Patroclus"), after the Ptolemaic admiral Patroclus, who established a fortified base there during the Chremonidean War. In the late Middle Ages, the island was notorious as a haven for pirates. The Byzantine emperor John VIII Palaiologos was nearly captured by Catalan pirates in December 1437, when his ship sought shelter from a storm on the island during his journey to the Council of Ferrara. On 12 February 1944, SS Oria sank in a storm on the south east rocks of Patroklos island with 4,074 killed, most Italian military internees.

8.1.2. FAUNA AND FLORA

The pilot site is coastal area in the southwestern tip of Attica dominated by phrygana, mackerel and Pinus forest remnants. The island of Patroklos is also included. The area is a typical Mediterranean landscape. It consists of three ecosystems, which represent all three species of Mediterranean ecosystems in Greece, namely pine forests, maquis plants ecosystem (continental and coastal) and phrygana, in various successive stages. Maquis plants is dominated by highly degraded pastures with Quercus coccifera and small trees. The above tables are depicting the species as they were reported by Natura 2000.

Flora

Most common species are Centaurea attica ssp. Asperula, Centaurea laureotica, Centaurea raphanina ssp. Mixta, Dianthus serratifolius ssp. Serratifolius, Fumaria judaica ssp. Amarysia, Galium melanantherum, Lamium garganicum ssp. Striatum, Malcolmia graeca ssp. Graeca, Onobrychis ebenoides. There are interesting vegetation formations of meadows (wet meadows) and wetlands with a characteristic flora in the area of abandoned salt flats. Species of aquatic and wetland flora have been recorded, such as: a) species of the genus Chara (Chara canescens, Chara vulgaris s.l,), as well as the very rare aquatic mammal Riella helicophylla. The latter species often characterizes Mediterranean seasonal habitats (priority habitat based on Community Directive 92/43) and has been recorded in very few places in Greece, b) plant species gatherings that resemble natural formations in coastal alimony and almyrova. Coastal lakes (e.g. two small lakes with Ranunculus aquatilis agg., extensive formations of Mediterranean fishes (Juncetalia maritimi) with various species of junipers (Juncus spp.) were found) as well as scattered alophytic vegetation). Typical species that are rare on the coastline and in wetlands of Attica are: Alopecurus rendlei, Juncus hybridus, Crassula tillea, and the locally rare Hymenolobus procumbens. In general, the conditions of integrity or naturalness of plant communities are degraded, but there is a mosaic of different shapes and characteristic stages of natural succession.

Fauna

Most common invertebrates: Anisoplia tritici, Anthocharis gruneri, Eopolita protensa, Lindholmiola barbata, Pedinus quadratus, Poecilimon propinquus, Tanyproctus reichei.

Amphibian: Bufo viridis

Mammals: Monachus monachus

Reptiles: Chalcides ocellatus, Vipera ammodytes

More specifically, the species that have been reported in the Article 4 of Directive 2009/147/EC and listed in Annex II of Directive 92/43/EEC (see Annex I) are Miniopterus schreibersii, Rhinolophus ferrumequinum, Testudo marginata and Tursiops truncates. Other important species reported are Bufo viridis, Centaurea raphanina ssp. Mixta, Chalcides ocellatus, Hypsugo savii, Lacerta trilineata, Onobrychis ebenoides, Pinna nobilis, Pipistrellus kuhlii, Tadarida teniotis,and Vipera ammodytes.

Birds

Most common bird species are Ciconia ciconia, Circaetus gallicus, Hieraaetus pennatus, Anthus campestris, Lanius collurio. The mainland area has not been fully explored for its avifauna and is experiencing significant human distress. Uncontrolled human annoyance (leisure activities often displace birds from the area). However, it is certain that it gathers a remarkable variety of aquatic birds, especially during the spring migration. 36 species of birds were recorded (most importantly the protected species Ardeola ralloides, Chlidonias leucopterus, Phoenicopterus roseus, Glareola pratincola, Tringa glareola, Philomachus pugnax, Calandrella brachydactyla). We also know that there is a more complete list of poultry farms than the regular records of the EOE and the wetland is one of the locally important small wetlands for the poultry farm of Attica. Regarding other groups of fauna, we do not have in mind if there is special research. The aquatic or wetland fauna of invertebrates, as well as related vertebrates that are dependent on water, have degradation characteristics in relation to the expected reference conditions for such types of coastal wetland formations. For example, the gatherings of fish, amphibians and reptiles are absent or very poor.

8.1.3. CURRENT HUMAN ACTIVITIES AND THREATS

Aquaculture: KASTELORIZO AQUACULTURE is a company that operates in the site, farming gilt-head bream (Sparus aurata), European bass (Dicentrarchus labrax), as well as shellfish and other types of fish such as sheephead bream (Diplodus puntazzo), red sea bream (Pagellus bogaraveo), scup (Stenotomus chrysops), common pandora (Pagellus erythrinus), common dentex (Dentex dentex), sand steenbras (Lithog-nathus mormyrus) and flathead grey mullet (Mugil cephalus).

The company operates a fish-farming unit, on floating facilities in the marine area near islet "Patroklos" (the islet is located near the coast, 850 meters away). The aquaculture total annual production of marine Mediterranean fish in that area is 230 tones.

Touristic activities: There is great touristic interest in the area, as many tourists visit the coasts of Patroklos islet mostly with private boats, while in the summer a boat provides the service of transferring tourists to the island. The islet is private property; thus it is allowed to visit Patroklos beaches to swim.

Scuba-diving: Scuba-diving is also very popular in that area, as there are many underwater attractions in site, one of them is a shipwreck, as well as ancient artefacts that can be traced in the seabed of the area. to explore the area's exceptional natural beauty. Other interesting underwater sites that exist in the area, is an underwater car cemetery next to the aquaculture site, as well as a shipwreck on the opposite side, near islet Patroklos. The above sites frequently attract scuba-diving activities.

8.1.4. VULNERABLE ANIMAL AND PLANT SPECIES

According to the data of the map of the habitats of GR300005 (EKBY - YPEHODE, 2000) the floating cage installation site adjacent to a site covered by the habitat priority "1120 Meadows Poseidonia". Also, article 9, par. 1.d) of Law 3937/2011 (A '60), stipulates that "the establishment and operation of fish farms in Poseidon meadows is prohibited". The pilot site also is an area is a winter zone crossing for migratory birds, such as many species of herons, Eurasian coots and cranes. Bird protected species: Ardeola ralloides, Chlidonias leucopterus, Phoenicopterus roseus, Glareola pratincola, Tringa glareola, Philomachus pugnax, Calandrella brachydactyla

8.1.5. HABITAT TYPES

Habitat types present on the site and their assessment

The most important habitat types according to the EU Habitats Directive that have been identified existing in the area around the pilot site, including it as well, are (for more information see ANNEX II):

Posidonia beds (Posidonion oceanicae) (Habitat 1120)

Beds of Posidonia oceanica (Linnaeus) Delile characteristic of the infralittoral zone of the Mediterranean (depth: ranging from a few dozen centimetres to 30 - 40 metres). On hard or soft substrate, these beds constitute one of the main climax communities. They can withstand relatively large variations in temperature and water movement, but are sensitive to desalination, generally requiring a salinity of between 36 and 39 per 1000.

Southern riparian galleries and thickets (Nerio-Tamaricetea and Securinegion tinctoriae) (Habitat 92D0)

Tamarisk, oleander, chaste tree galleries and thickets and similar low ligneous formations of permanent or temporary streams and wetlands of the thermo-Mediterranean zone and south-western Iberia, and of the most hygromorphic locations within the Saharo-Mediterranean and Saharo-Sindian zones.

Annual vegetation of drift lines (Habitat 1210)

Formations of annuals or representatives of annuals and perennials, occupying accumulations of drift material and gravel rich in nitrogenous organic matter (Cakiletea maritimae p.).

Vegetated sea cliffs of the Mediterranean coasts with endemic Limonium spp (Habitat 1240)

Vegetated cliffs and rocky shores of the Mediterranean, of the Mediterraneo-temperate eastern Atlantic (south-western Iberia) and of the Black Sea. Crithmo-Limonietalia.

Cisto-Lavenduletalia dune sclerophyllous scrubs (Habitat 2260)

Sclerophyllous or lauriphyllus scrubs established on dunes of the Mediterranean and Warm-Temperate Humid regions. Codes of Pal. 32 may be used in addition to Pal. 16.28 to precise the habitat. Also similar sclerophyllous dune vegetation included in Pal. 16.28 of the Pistacio-Rhamnetalia and Cisto-Micromeritia

8.1.6. DESCRIBE IF THERE ARE KNOWN POTENTIAL POSITIVE AND/OR NEGATIVE ENVIRONMENTAL IMPACTS OF A GIVEN TYPE OF MULTI-USE

The location of the aquaculture unit is located opposite the land area of zone A ' mountainous volume of Lavreotiki, which is governed by the from 24.01.2003 p.d. (D '121). Zone A is a zone of absolute protection, that could be used for recreational uses, outdoor cultural events, outdoor small-scale sports and environmental education facilities, which are allowed to construct outdoor or semi-outdoor seating and historical and environmental kiosks used to provide information about the area.

In-depth analysis of aquaculture and tourism multi-use combination was undertaken by the MUSES project for case study in the Eastern Atlantic (South Coast of Mainland Portugal (Algarve) and the Azores Archipelago) and case study in the Northern Adriatic Sea (Italian coast from Emilia Romagna to Veneto). Some of the existing examples of this multi-use include the Piran Bay in Slovenia, Algarve region in Portugal, Malta, and Rhodes Island in Greece. In the example of the Slovenian marine area there is a fish farm (sea bass and mussel production), in a preserved fishing area and Natural Park. The fish farm has become a refuge for numerous fish and other marine organisms, performing a function similar to artificial underwater reefs or wrecks. In this environmental context, touristic and educative activities are offered by Piran Bay aquaculture farmers. Farmers of Piran Bay participate in national and European research projects concerning environmental, biological and supply chain traceability issues of economically significant fish species in the Portorož fishing preserve (e.g. ICT-PSP, Farm to Fork project). Also, the experience in the Algarve region Portugal demonstrates the recovery of an abandoned traditional activity using modern technology and innovation. The "tuna catch" in the Algarve has its origin in the ancient Arab "almadrava" technique. This activity was recovered in the 1990s with a system of trapping ponds to catch Bluefin tuna 2.5 nautical miles offshore. Tunipex, one of the companies which invested know-how and technology in the recovery of tuna traps, also conducted the farming, catching and processing of fish. Tuniplex adopted an innovative approach by offering the possibility to visit and dive in its installations.

According to the MUSES Ocean Multi-Use Action Plan the Aquaculture and Tourism multi-use activities provide various environmental opportunities and benefits. Such solution may raise public awareness of sustainable aquaculture practices and increase commercialisation of local fish products. This way the local aquaculture products gain added value and acceptance as they are better recognised by consumers and local residents. This relieves dependence on imported fish products.

A common concern in promoting this multi-use is the possible increase in touristic pressure in already overcrowded areas, with possible increases in coastal cumulative impacts. Certain environmental concerns also arise with the involvement of recreational fishing activity next to aquaculture plants. There is the possibility of fish stock overexploitation if multi-use activities involving fishing are not well monitored.

8.2. Environmentally responsible mission of the pilot

For the purposes of the project, sensors and cameras are planned to be installed in the aquaculture facility in order to monitor any environmental disturbance in the unit. For the purposes of accurately and timely monitor and manage properly the infrastructure and the environmental conditions, project UNITED will install sensor devices and cameras on site. The data will be collected and transmitted to a software platform that will be able to monitor the environmental parameters and send notices and alerts when necessary.

Water Quality parameters to be monitored: The water quality parameters of interest for the site include temperature, dissolved oxygen, and current measurements, while environmental parameters will also be considered to measure the environmental impact of the activities to the area.

Another important parameter for the aquaculture undisturbed operation is the need to make sure the stress levels of the fish in the aquaculture unite remain low. For the purposes of this, underwater cameras will be installed in the site to monitor fish behaviour.

8.3. General overview of regulatory requirements for environmental impact assessment and environmental monitoring for the given pilot

At the moment the aquaculture unit already operating in site has to comply with the rules set by the license agreement of the Ministerial order. These rules should be followed during the multi-use phase, when the touristic activities of scuba-diving will take place in the same marine space. Some of the indicative rules are:

1. Boundary values for the Distribution of Pollutant Loads in accordance with applicable law for Emission of particulate matters (dust): ≤100mg/m3, as defined in p.d. 1180/1981.

2. During installation and operation of the unit: The permissible noise limit emitted in environment from the operation of all fixed mechanical installations should be in accordance with article 2 par. 5 of p.d, meaning the noise level measured at the boundaries of the field of the unit must be <55 dBA.

3. To consider the provisions of Law 3028/2002 (A '153) "For the protection of Antiquities and Cultural Heritage in general "

4. The arrays of fish cages should be oriented at an angle of less than 90o to direction of the prevailing currents.

5. The materials of construction or impregnation, application, painting, welding of floats installations (fish cables, anchors, floating work platforms, boxes, etc.) not to contain the substances mentioned in the decisions of the AXS 1100/1991 (B '1008), 475/2002/2003 (B'208) and 121/2003/2003 (B '1045), ie mercury, male and organ saccharides, as well as other chemicals considered dangerous, according to the relevant legislation on hazardous substances, and for which restrictions apply for their circulation and use, for the marine and in general the aquatic environment.

6. The aquaculture company must comply with the provisions of Law 743/1977 (A '319), such as coded with p.d. 55/1998 (A '58) "Protection of the marine environment" and to take all necessary measures, as well as any additions to instructions indicated by the Port Authority, to avoid pollution of the sea. In particular, the aquaculture company should comply with the provisions requiring the collection and legal disposal of all petroleum products, lubricants, sewage, waste and all kinds of pollutants, in reception facilities or in designated land area, after relevant permission of the competent Services of the Regional Unit of Eastern Attica.

7. The project operator should ensure that proper equipment for seawater pollution prevention and control is installed in the unit, as well as placed barriers and sufficient amounts of absorbent, approved type of material, which will be indicated to the Port Authority in accordance with p.d. 11/2002 "National Emergency Plan in the need to deal with oil pollution and other harmful substances " (A '6), issued by authorization of Law 2252/1994 (A' 192).

8.4. Overview of existing environmental assessment results and monitoring information

8.4.1. EXISTING ASSESSMENTS SUBMITTED TO THE AUTHORITIES

The aquaculture unit has already requested and got an environmental assessment for the site (date: 28/02/2020), which regulates any operations necessary for the extension of the unit. Some of these regulations are described in this document in previous subchapter 7.3. Parts of the environmental assessment have been used to describe the environmental state of the pilot in this deliverable. The according document is described as:

Ministerial Order by the Ministry of Environment, Spatial Planning and Energy, taken in the 28th of February, 2020, with the subject: "Approval of Environmental Terms, which concerns the expansion of an existing floating marine unit for fish farming, in the marine area 29.76 acres (from 20 acres) and an annual capacity of 462.12 t (from 230 t / y), in the place "Kasidiara", sea area "Stenou Gai-douronisiou", Municipality of Saronikos, Regional Unit East Attica, Attica Region, with "KASTELLORI-ZO SA" as its body."

8.4.2. OVERVIEW OF MAIN ENVIRONMENTAL ASSESSMENT FEATURES/ RESULTS

The ecological as well as the chemical condition of the Coastal Water System is characterized as good, therefore in accordance with Measure M06B0704, of the 1st Revision of the Basin Management Plan of the Attica Water Department, for the establishment of new units, relocation or the expansion of existing marine aquaculture units, with the rule of non- degradation of the status of the Water System to which it belongs, within the limits of the leased or for rent of maritime area.

8.4.3. OVERVIEW OF CURRENT MONITORING REGIMES AND CAPACITIES

Currently, the aquaculture unit in the pilot site monitors the water quality parameters by sampling and taking the samples for laboratory testing. The aquaculture unit also operate the farm by complying to the Ministerial Order's regulations, such as:

1. The arrays of fish cages should be oriented at an angle of less than 90 degrees to direction of the prevailing currents.

2. The materials of construction or impregnation, application, painting, welding of floats installations (cables, anchors, floating work platforms, boxes, etc.) should not contain the substances mentioned in the decisions of the AXS 1100/1991 (B '1008), 475/2002/2003 (B'208) and 121/2003/2003 (B '1045), i.e. mercury, arsenic and organosaccharides, as well as other chemicals considered dangerous, according to the relevant legislation on hazardous substances, and for which restrictions apply their circulation and use, for the marine and in general the aquatic environment.

The applicable Community and National Veterinary Legislation shall apply veterinary medicinal products, health, protection, and health certification farmed species, food hygiene and safety and animal management by-products, including dead fish, particularly:

- The disposal of animal by-products in the environment is prohibited.
    - Animal by-products to be sent for further management in units approved, in accordance with Regulations 1069/2009 / EC and 142/2011 / EU, for processing / incineration, in the case of materials of category 1, 2, 3 and for production biogas, fertilizer or silage, in the case of class 3 materials. Dead or sick animals, after checking the cause of death or disease, to be removed daily, to be recorded, to be characterized as far as the ZYP category is concerned belong to and undergo management as above.

- The unit should have a special refrigerator for exclusive use for temporary storage of animal by-products as their further management.
- To keep a Register of Medicinal Breeding Education, the veterinary medicines to are administered with a veterinary prescription and the waiting time of each is observed veterinary medicinal product used in breeding.

8.5. Recommendations for the pilot

All pre-operational and operational phase procedures that will take place under project UNITED should comply with the regulations as set by the Ministerial order that regulates the aquaculture unit operations till now. Moreover, the wider pilot area is also protected under NATURA 2000 and therefore any multi-use operations have to comply with the rules set by NATURA 2000.

Another recommendation provided by the aquaculture industry that has also been taken into consideration is to ensure that the operations of the aquaculture unit remain undisturbed and the fish growing in the aquaculture unit not to be distressed by tourism activity.

The Ocean Multi-Use Action Plan has provided a number of recommendations for the multi-use combination of aquaculture and tourism that may be applicable on the case of Greek UNITED pilot. Namely, ensuring the development of this multi-use is especially important in coastal areas where there is competition for space and where aquaculture may not always be welcome. Maritime spatial planning (MSP) and other area-based approaches and policies are important in supporting coexistence and thus ensuring space for aquaculture that may also provide benefits to other users. Namely, MSP should explore the possibility of developing multi-functional sites (including tourism and environmental protection) in connection with aquaculture plants (e.g. areas equipped for diving, snorkeling and/or sport fishing could be added to aquaculture plants).

The high demand for goods and services created by tourism in Southern Europe also provides an opportunity for aquaculture farmers to diversify their income with complementary activities. According to the Ocean Multi-Use Action Plan, inconsistencies in legal and regulatory frameworks are a key barrier to the its development. Such legislative framework should facilitate licensing for joint activities, specify processes for risk assessment and ensure environmental sustainability of aquaculture. Moreover, the Baltic Sea, particularly Denmark, has already some of the successful examples of multi-use between aquaculture, tourism and environmental protection in the form of 'sea gardens'. These and similar examples are presented in the Action Plan together with possible challenges for further development of the concept. According to the Action Plan, some of the main environmental benefits of this multi-use may be the increase of commercialisation and thus increased use of local fish products that may decrease the need for imports. Namely, the aquaculture products gain added value and acceptance as they are better recognised by consumers and local residents. Moreover, the multi-use contributes to raising public awareness of sustainable aquaculture practices and increase acceptance by the public, thus promoting the wellbeing of rural and coastal communities and providing a reliable supply of high-quality seafood. A common concern in promoting this multi-use concept is the possible increase in touristic pressure in already overcrowded areas, with possible increases in coastal cumulative impacts. Certain environmental concerns also arise with the involvement of recreational fishing activity next to aquaculture plants. There is the possibility of fish stock overexploitation if multi-use activities involving fishing are not well monitored. In the UNITED Greek pilot site, fishing is not allowed in the area around the aquaculture site and that has as a consequence a large number of wild fish approaching the cages to get the food that is left from the feeding of the fish in the aquaculture pens. Other significant concerns that have been reported are regarding the impact of aquaculture on water quality as well as the waste that touristic activities produce. Feeding caged fish introduces a large source of nutrients to coastal areas which can lead to eutrophication. This eventually leads to increased algae growth, including toxic species of algae, rendering the water less suitable for certain recreational activities. Regarding the touristic waste impacting aquaculture, the disposal of untreated sewage from vessels can affect aquaculture, especially shellfish beds. These concerns and risks identified in existing pilots and past studies should be taken into consideration in the Greek pilot.

The experience of Piran Bay in the Slovenian marine area can be considered a good example of a multifunctional site. It is a fish farm (sea bass and mussel production) located in the southernmost part of the Slovenian Sea, in a preserved fishing area and Natural Park. The fish farm has become a refuge for numerous fish and other marine organisms, performing a function similar to artificial underwater reefs or wrecks. In this environmental context, touristic and educative activities are offered by Piran Bay aquaculture farmers. This experience is also an example of a triplet multi-use combination (Aquaculture, Tourism and Environmental Protection). Farmers of Piran Bay participate in national and European research projects concerning environmental, biological and supply chain traceability issues of economically significant fish species in the Portorož fishing preserve. **Integration of such educational and research activities could be considered in the Greek pilot as well.**

8.6. Conclusions

This pilot site is a unique marine area, where many things should be taken into consideration when attempting a multi-use approach on the site. The environmental assessments that have been carried out in the area have uncovered an ecosystem of a variety of birdlife as well as the environmentally protected "Poseidonia meadows "that boarder on the current aquaculture unit. These meadows are of great ecosystem importance and should be protected at all times, during every multi-use operation.

References and further reading

Ministerial Order by the Ministry of Environment, Spatial Planning and Energy, taken in the 28th of February, 2020, with the subject: "Approval of Environmental Terms, which concerns the expansion of an existing floating marine unit for fish farming, in the marine area 29.76 acres (from 20 acres) and an annual capacity of 462.12 t (from 230 t / y), in the place "Kasidiara", sea area "Stenou Gaidouronisiou", Municipality of Saronikos, Regional Unit East Attica, Attica Region, with "KASTELLORIZO SA" as its body."

George Papatheodorou, Maria Geraga, Dimitris Christodoulou, Margarita Iatrou, Elias Fakiris, Stuart Heath and Kalliopi Baika, A MARINE GEOARCHAEOLOGICAL SURVEY, CAPE SOUNION, GREECE: PRELIMINARY RESULTS, Mediterranean Archaeology and Archaeometry, Vol. 14, No 1, pp. 357-371, Copyright © 2014 MAA

1st ANNOUNCEMENT OF THE MANAGEMENT OF MANUFACTURING FLOORS OF THE Rivers of Attica Water Department (EL 06) Intermediate Phase 1, Deliverable P9: Update of the Register of Protected Areas

9. RECOMMENDATIONS FOR MONITORING IN WP2

The Work Package (WP) 2 will address the technological requirements of the different UNITED pilots. Specific attention in this work package will be given to the monitoring activities in the context of each of the pilots. This report aims to provide the baseline information about what environmental data is currently present in pilots, and what monitoring technologies and procedures are used, if any. This information aims to advise further monitoring developed in the framework of this project. Moreover, this report collects information about known impacts of current multi-use technologies, per each pilot. This information may serve WP2 in selecting the multi-use technology solutions with least impacts on the environment or improving the existing solutions. The table 3 provides the summary recommendations for the potentially relevant elements to be monitored in each of the pilot sites. It is important to note that the list is not exhaustive and further analysis is needed to specify the list of characteristics to be monitored within the monitoring plan for each of the pilots under WP2. The table 3 is to provide an initial snapshot extracted from the baseline analysis and give an overall initial idea and base for further work under WP2.

Table 3 Key links and recommendations for the environmental monitoring aspect of WP2

Pilot location	Recommendation for characteristics that may need to be prioritized for monitoring due to lack of information and/or possible impacts
Germany	- Number of Black-legged Kittiwake (Rissa tridactyla) listed in the European Red List as "vulnerable".

	- Number of Phoca vitulina, Halichoerus grypus and Phocoena phocoena, listed in the Habitats Directive Annex II. - Suitability of different environmental and biological factors impacting the health of cultivated mussels and seaweed - Time and concentration of spat fall of blue mussels - Date and extent of toxic algae blooms - Eutrophication i.e. nitrogen input from mussels - Occurrence and behavior of bats - Diversity of fish species, settling at newly introduced substrate, such as long lines and gravity anchors, - Number of attracted seabirds and/or other predators (e.g.: seals, porpoises)
Belgium	- Distribution of marine mammals, migration patterns, threshold values for TTS, PTS and avoidance, behavioural reactions as a result of underwater sound, and foraging behaviour (harbour porpoise *Phocoena phocoena*, harbour seal *Phoca vitulina*, grey seal *Halichoerus grypus*, bottlenose dolphin *Tursiops truncates* and white-nosed dolphin *Lagenorhynchus albirostris)* - Distribution in space and time of seabirds at sea: little gull *Hydrocoloeus minutus* and great skua *Stercorarius skua*. greater black-backed gull *Larus marinus*, lesser black-backed gull *L. fuscus* and European herring gull European *L. argentatus*. - Occurrence of bats at sea and their behaviour in wind farms, as well as the number of collision casualties. - Presence of parasites, bacteria, viruses - Attraction of hard-substrate-associated species and changes in benthic habitats by aquaculture installations - Retention of oyster (pseudo)faeces in water at the pilot location. - Impact of oyster larvae predation by fouling fauna on both aquaculture installations and wind turbines
Denmark	- Number and behaviour of ducks, swans, eiders and gullets
Netherlands	- Presence of invasive sessile (hard substrate) fauna - Number and behaviour of Grey seal and Harbour porpoise i.e. Distribution of marine mammals, migration patterns, threshold values for TTS, PTS and avoidance, behavioural reactions as a result of underwater sound, and foraging behaviour - Distribution in space and time of seabirds at sea - Knowledge of the duration and the spatial extent of bird migration (i.e. how large the share of these migration routes is in relation to migration as a whole, as well as data on local densities in the different areas of the North Sea). - Occurrence of bats at sea and their behaviour in wind farms, as well as the number of collision casualties - Consequences of abiotic changes (especially sediment change in the surroundings of the wind farm) on benthos. - Effects of electromagnetic fields along the cables

	- Extent of changes on fish fauna in the longer term as a result of setting restrictions on fishery and the application of hard substrate
Greece	- Number and behaviour of migratory birds, such as many species of herons, Eurasian coots and cranes. Bird protected species: Ardeola ralloides, Chlidonias leucopterus, Phoenicopterus roseus, Glareola pratincola, Tringa glareola, Philomachus pugnax, Calandrella brachydactyla

10. SUMMARY & NEXT STEPS

As evidenced from previous chapters, most of the UNITED pilots are staggered multi-use – defined as multi-use where one use is already in place (pre-existing), while the other use is added to it at the later stage. Thus, most of the pilots already have an EIA conducted for the pre-existing single use and multi-use was not considered at the stage when the EIA was conducted. The scale of the UNITED pilots is in most cases too small and for the research purposes, thus authorities do not require additional assessments for the added use. Therefore, one can only assume what the EIA requirements would be in case of a large scale commercial multi-use development and in a case of a joint development of multi-use (vs. the staggered multi-use that is mainly present in UNITED pilots).

The recommendations extracted from transferable studies in the context of pilots in DE, BE and NL may be transferable across pilots given that the three pilots have the offshore wind and seaweed multi-use combination in common. Nevertheless, the pilot in DE is considerably further offshore and is as such demonstrated in a much different environment characterised by strong winds and waves, then the two other pilots. It is thus questionable how transferable to this pilot are the recommendations from studies done for the locations relatively close to shore. While the Netherlands has recently (2020) developed a multi-use procedure for applying for the offshore wind multi-use permit, similar practices have not been identified in other countries[11]. It is thus relevant to assess for what types of offshore wind multi-uses this procedure may be (partially) applicable and in which countries such practice could be replicated.

The information collected for this report per each pilot, will be used for the development of the UNITED environmental assessment framework and for the implementation of this framework in pilots, in concert with the overall assessment framework for the project integrating the environmental, economic, societal and other pillars (i.e. UNITED WPs 2 - 6).

The parameters used in the existing environmental assessments of single uses presented for each of the pilots, will advise the development of the assessment approach. The information collected on potential impacts will feed into the application of the assessment approach. Nevertheless, additional studies and interviews may be needed for a more in-depth assessment for each of the pilots.

The application of the assessment framework on the four UNITED pilots that focus on the combinations with offshore wind and aquaculture may provide comparable results. Thus, it may be advisable to develop an assessment approach that builds on the EIAs that have already been applied in these wind farms, and extend it to cover also other possible multi-use combinations, be it tourism or aquaculture. The combination of aquaculture and tourism in Greece may not have too much in common with other pilots, and thus the development of a generic universal assessment approach for all pilots may not be suitable and will hence be tailored to each of the pilots. Subsequently, the comparison of the Greek pilot results with other pilots may not provide meaningful results. However, in subsequent tasks, information on the overarching environmental impacts and benefits of multi-use and its associated activities will be collected and further evaluated. In Task 4.2, the UNITED Assessment Framework will be operationalised for the environmental pillar, and detailed specifically for each pilot, while Task 4.3 will apply this operationalisation for the pilots. The information gathered in the current deliverable concerns the Early Stages of the UNITED Assessment Framework and will feed into its application in Task 4.3 The Table 4 below provides the summary of the environmental assessment status in five UNITED pilots.

[11] More about the Dutch Multi-Use procedure available at: https://www.noordzeeboerderij.nl/en/projects/multi-use-procedure

Table 4 Summary of the information per pilot

Pilot	Type of multi-use	Multi-use permitting requirements and submitted assessments	Comparable environmental impact studies	Monitoring in place
DE	Offshore wind*, mussels aquaculture	Pilot: No specific requirements for the pilot scale apart from the existing EIA for the offshore wind. Commercial scale: Not known	Yes	Yes
NL	Solar, seaweed aquaculture	Pilot: No specific requirements for the pilot scale. Commercial scale: An EIA wold need to be conducted comparable to the Environmental Impact Study of the Hollandse Kust conducted on behalf of the Dutch Enterprise Agency.	No	No
BE	Offshore wind*, oyster restoration and seaweed aquaculture	Pilot: No specific requirements for the pilot scale, apart from the existing EIA for the offshore wind. Commercial scale: An EIA needs to be submitted to the authorities	Yes	Yes, for the offshore wind
DK	Offshore wind*, boat tours*	Pilot: No specific requirements for the pilot scale apart from the existing EIA for the offshore wind. Commercial scale: Not known	No	Yes (not any more)
GR	Aquaculture*, tourism	Pilot: No specific requirements for the pilot scale. Commercial scale: Not known	No	Yes

*primary use, in place already

ANNEX 1: GERMAN PILOT – ADDITIONAL INFORMATION

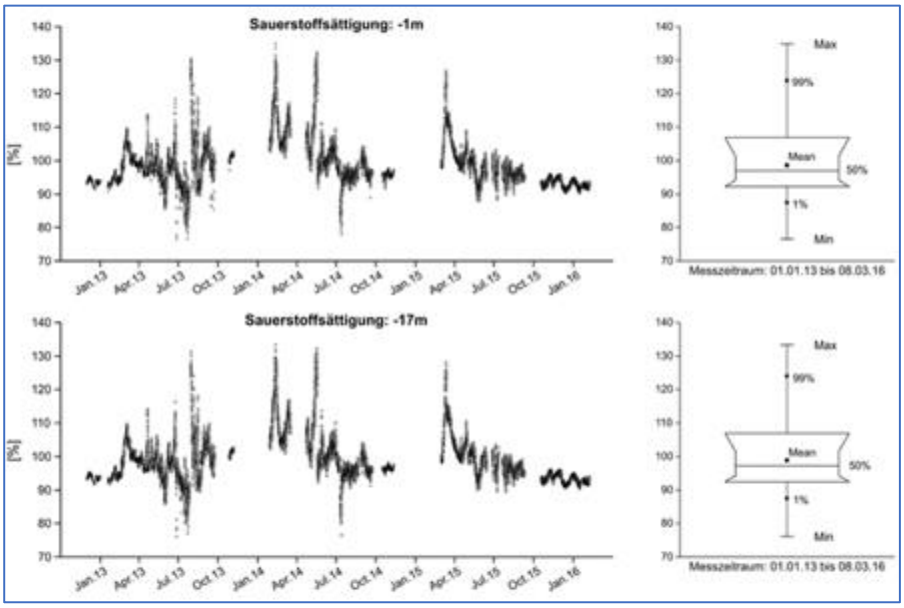


Figure 1: Temporal oxygen saturation in % in a water depth of 1m and 17m (left) and oxygen saturation as boxplot with minimum, maximum, mean and 1%, 50% and 99% quantiles (right) at FINO3 during January 2013 until March 2016. Source: FUE 2020

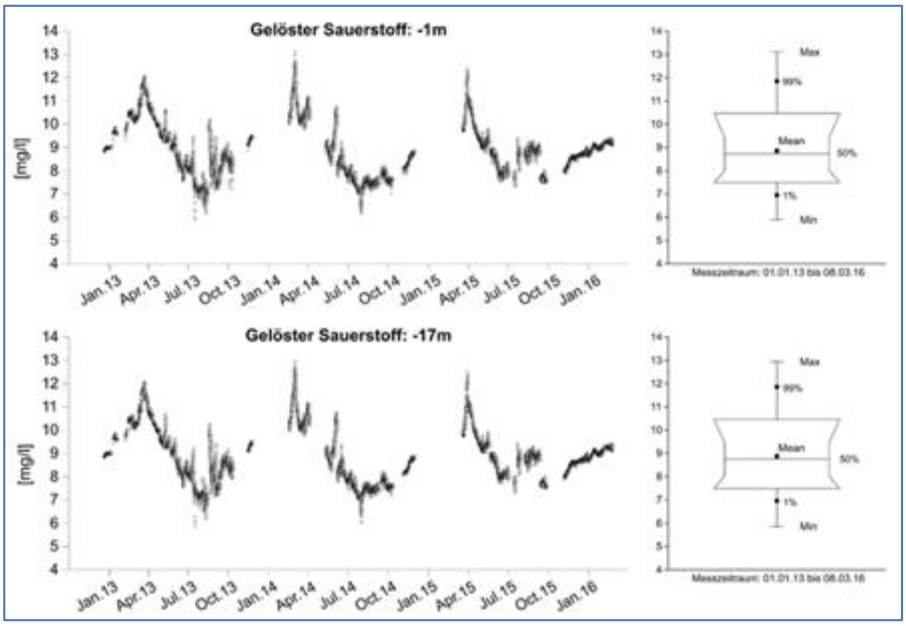


Figure 2: Temporal dissolved oxygen in mg/l in a water depth of 1m and 17m (left) and dissolved oxygen as boxplot with minimum, maximum, mean and 1%, 50% and 99% quantiles (right) at FINO3 during January 2013 until March 2016. Source: FUE 2020

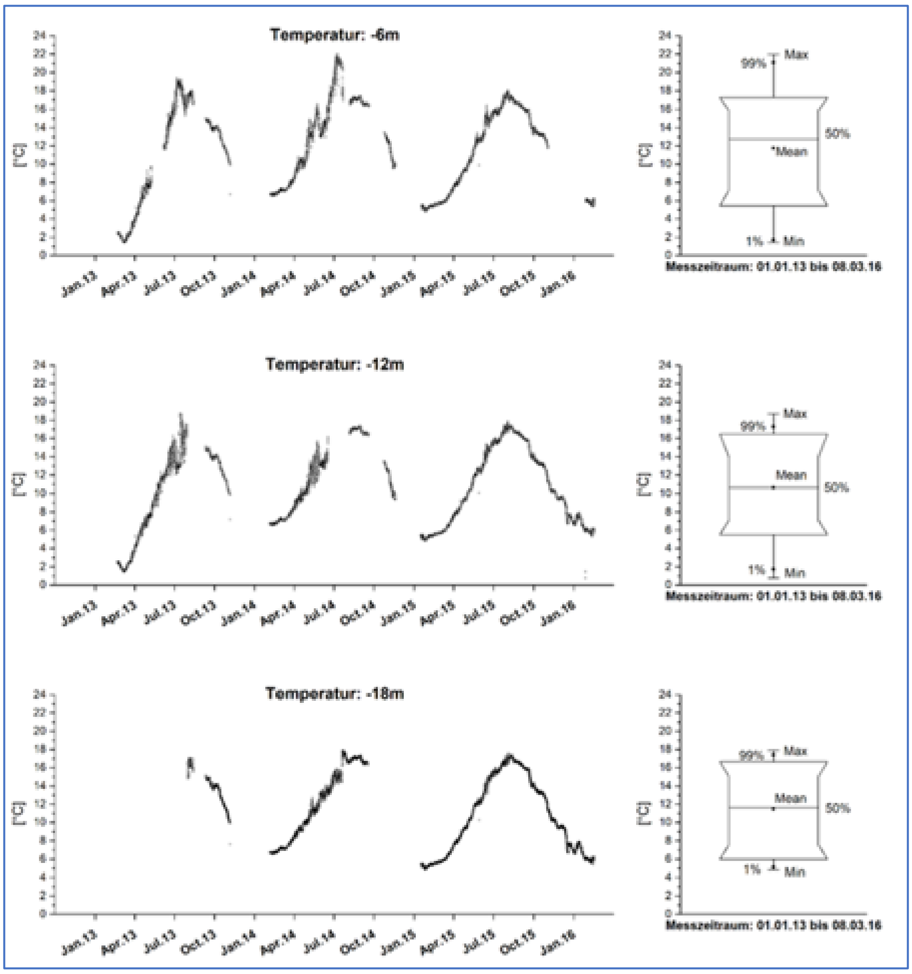


Figure 3: Water temperature (°C) during the measurement period from January 2013 to March 2016 at water depths of 6, 12 and 18m (left) and as boxplot with minimum, maximum, mean and 1%, 50% and 99% quantiles (right) at FINO3. Source: FUE 2020

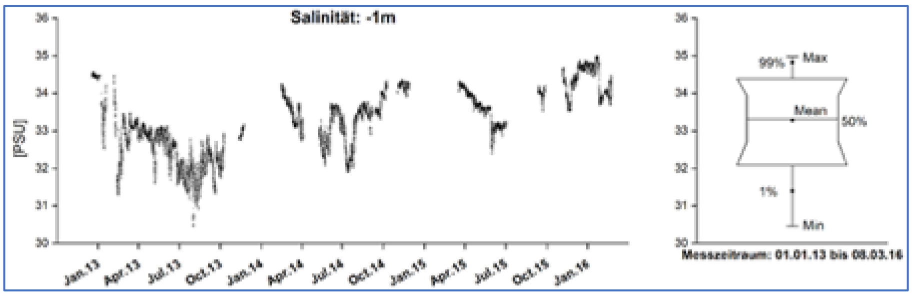


Figure 4: Salinity (PSU) data during measurements from January 2013 to March 2016 in a water depth of -1m (left) and as boxplot with minimum, maximum, mean and 1%, 50% and 99% quantiles (right) at FINO3. Source: COSYNA

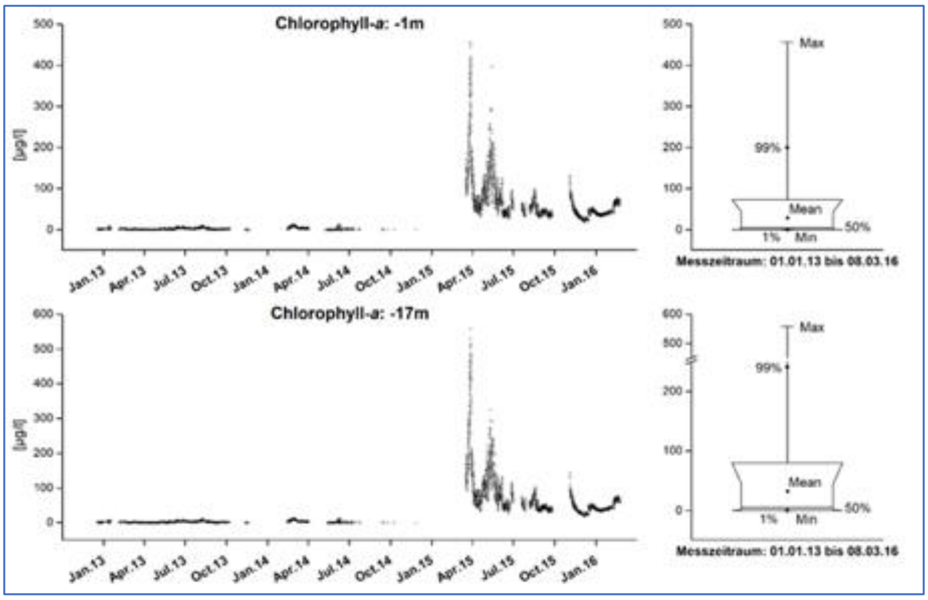


Figure 5: Chlorophyll-a concentration in µg/l during the measuring period January 2013 to March 2016 in 1 and 17m water depth (left) and as boxplot with minimum, maximum, mean and 1%, 50% and 99% quantiles (right) at FINO3. Source: COSYNA

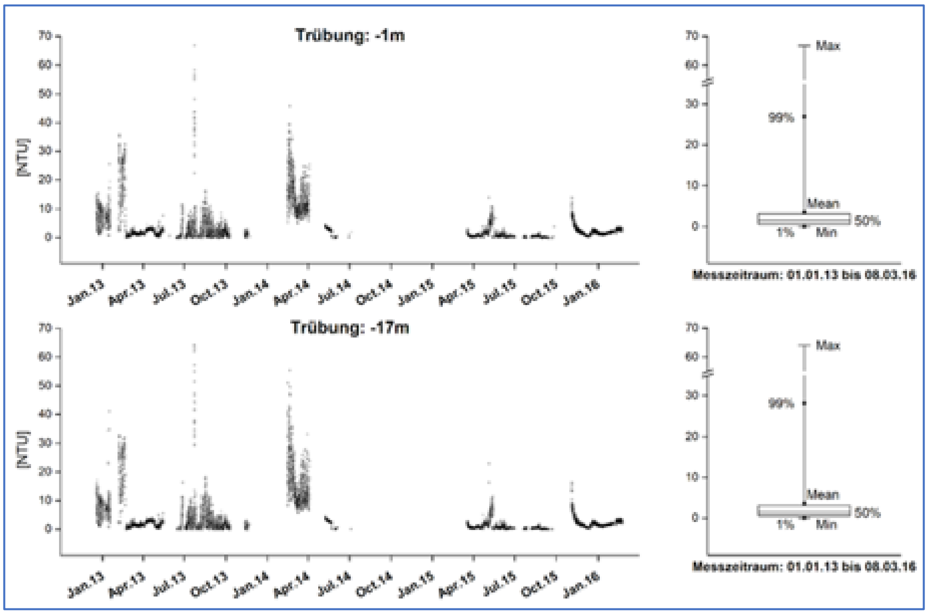


Figure 6: Turbidity (NTU) during the measurement period from January 2013 to March 2016 at 1 and 17m water depth (left) and as boxplot with minimum, maximum, mean and 1%, 50% and 99% quantiles (right) at FINO3. Source: COSYNA

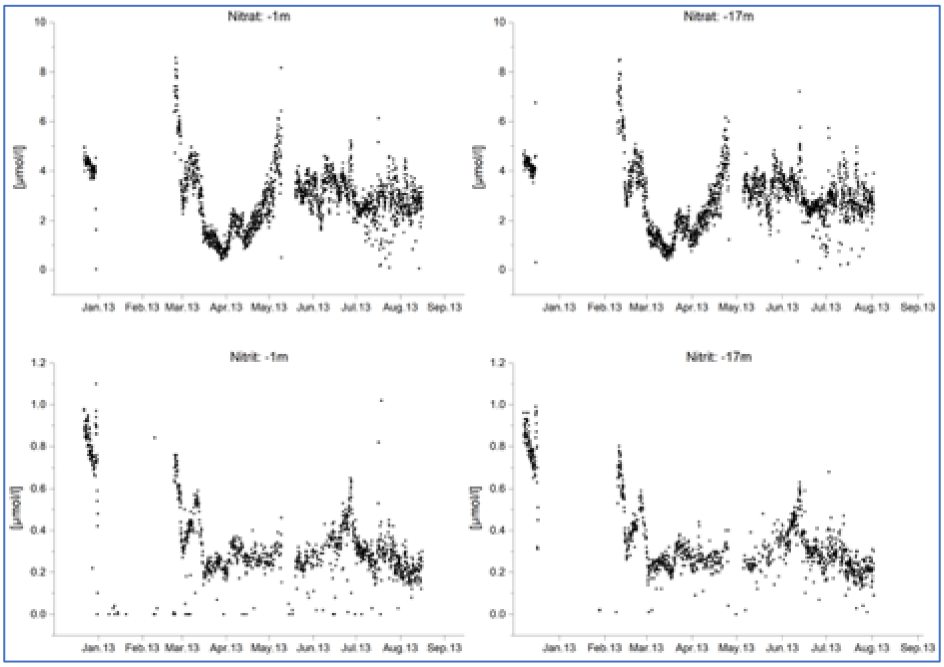


Figure 7: Nitrate concentration (figures above) and nitrite concentration (figures below) in µmol/l as a time curve in the measuring period January 2013 to August 2013 in a water depth of 1m and 17m

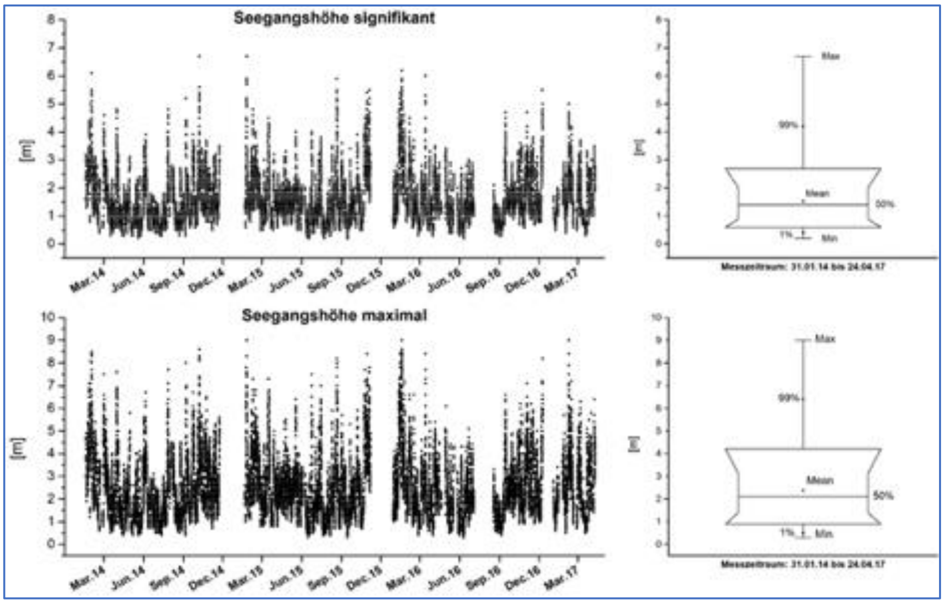


Figure 8: Significant and maximum swell (m) (left) during the measuring period from January 2014 to April 2017 and as boxplot with minimum, maximum, mean and 1%, 50% and 99% quantiles (right) at FINO3, North Sea, Source: FUE 2020

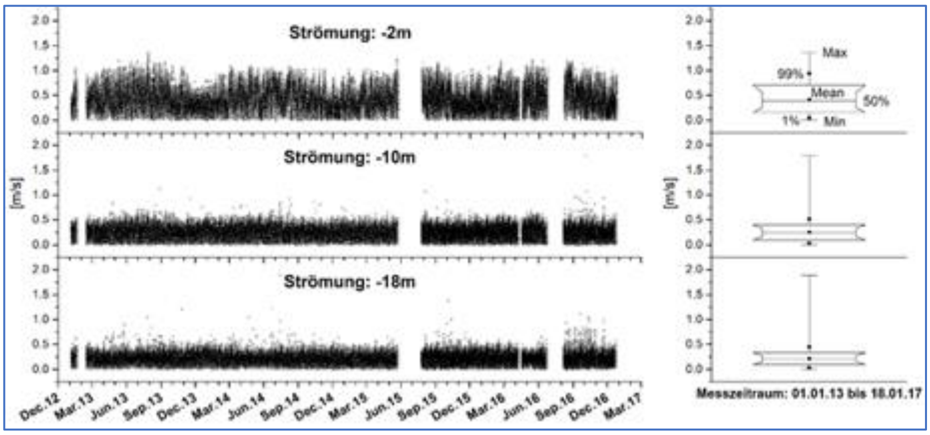


Figure 9: Current velocity in m/s between January 2013 to March 2016 in a water depth of 2m, 10m and 18m (figures on the left). Current velocity in m/s as a box plot with minimum, maximum, mean value, as well as 1%, 50% and 99% quantiles (figures on the right). Source: FUE 2020

Table 1: Detected bird species via video capture at FINO3, North Sea between July 28, 2009 and May 31, 2018, Source : Avitech 2019

Tabelle 8: Liste über die Videoerfassung zwischen 28.07.2009-31.05.2018 nachgewiesener Vogelarten am Standort FINO 3.

	Art	Jahr										
		2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Gesamt
Schwarzbrauenalbatros	*Diomedea melanophris*								x			x
Dunkler Sturmtaucher	*Puffinus griseus*				x							x
Basstölpel	*Morus bassanus*		x	x	x		x		x	x	x	x
Kormoran	*Phalacrocorax carbo*		x	x					x	x	x	x
Krähenscharbe	*Phalacrocorax aristotelis*								x			x
Kornweihe	*Circus cyaneus*					x						x
Sperber	*Accipiter nisus*		x							x		x
Fischadler	*Pandion haliaetus*		x	x						x		x
Turmfalke	*Falco tinnunculus*			x					x		x	x
Wanderfalke	*Falco peregrinus*	x							x		x	x
Austernfischer	*Haematopus ostralegus*		x									x
Waldschnepfe	*Scolopax rusticola*					x						x
Skua	*Stercorarius skua*			x						x		x
Lachmöwe	*Chroicocephalus ridibundus*			x	x		x		x	x	x	x
Sturmmöwe	*Larus canus*								x	x	x	x
Heringsmöwe	*Larus fuscus*	x	x	x	x	x	x	x	x	x	x	x
Silbermöwe	*Larus argentatus*	x	x	x	x	x	x	x	x	x	x	x
Mantelmöwe	*Larus marinus*	x	x	x	x	x	x	x	x	x	x	x
Dreizehenmöwe	*Rissa tridactyla*		x	x	x	x	x		x	x	x	x
Brandseeschwalbe	*Thalasseus sandvicensis*		x	x						x	x	x
Straßentaube	*Columba livia f. domestica*		x		x		x		x	x	x	x
Hohltaube	*Columba oenas*		x									x
Ringeltaube	*Columba palumbus*		x									x
Mauersegler	*Apus apus*		x			x	x		x	x		x
Rauchschwalbe	*Hirundo rustica*		x	x	x					x	x	x
Mehlschwalbe	*Delichon urbica*			x								x
Hausrotschwanz	*Phoenicurus ochruros*			x								x
Neuntöter	*Lanius collurio*		x									x
Dohle	*Corvus monedula*	x	x									x
Rabenkrähe	*Corvus corone corone*				x						x	x
Star	*Sturnus vulgaris*	x	x		x	x		x		x	x	x
Buchfink	*Fringilla coelebs*								x		x	x
Bergfink	*Fringilla montifringilla*		x									x
Bluthänfling	*Carduelis cannabina*				x							x
Schneeammer	*Plectrophenax nivalis*		x									x
Goldammer	*Emberiza citrinella*			x								x
Anzahl		**6**	**20**	**15**	**12**	**8**	**8**	**4**	**15**	**16**	**16**	**36**

Table 2: Frequencies (absolute and relative) via audio files during the migration seasons to the summer quaters (upper table) and winter quarters (table below) 2010 to 2018 of bird species recorded at the FINO3 site with 1% relative total frequency. In addition, the number of nights with species-specific presence is given. Source : Avitech 2019

Tabelle 5: Häufigkeiten (absolut und relativ) über Audiodateien während der Heimzugperioden 2010 bis 2018 am Standort FINO 3 nachgewiesener Vogelarten mit ≥ 2,0 % relativer Dateisummenhäufigkeit. Zusätzlich ist die Anzahl von Nächten mit artspezifischer Präsenz angegeben. Beachte: Auf einer Datei können mehrere Arten enthalten sein.

Art		n-Rufdateien	n-Nächte	Anteil am Gesamtdatei
Rotdrossel	*Turdus iliacus*	1.947	43	28,1
Sturmmöwe	*Larus canus*	1.414	38	20,4
Amsel	*Turdus merula*	1.075	57	15,5
Singdrossel	*Turdus philomelos*	891	46	12,9
Rotkehlchen	*Erithacus rubecula*	693	42	10
Star	*Sturnus vulgaris*	344	25	5
Wacholderdrossel	*Turdus pilaris*	275	11	4
Buchfink	*Fringilla coelebs*	169	12	2,4
Andere		781	105	11,3
Gesamt		**6.919**	**178**	

Tabelle 6: Häufigkeiten (absolut und relativ) über Audiodateien während der Wegzugperioden 2010 bis 2017 (ohne 2015) am Standort FINO 3 nachgewiesener Vogelarten mit ≥ 2,0 % relativer Dateisummenhäufigkeit. Zusätzlich ist die Anzahl von Nächten mit artspezifischer Präsenz angegeben. Beachte: Auf einer Datei können mehrere Arten enthalten sein.

Art		n-Rufdateien	n-Nächte	Anteil am Gesamtdateiaufkommen (%)
Rotdrossel	*Turdus iliacus*	17.187	128	46,7
Amsel	*Turdus merula*	12.637	103	34,3
Singdrossel	*Turdus philomelos*	4.297	79	11,7
Star	*Sturnus vulgaris*	1.992	30	5,4
Rotkehlchen	*Erithacus rubecula*	1.386	75	3,8
Buchfink	*Fringilla coelebs*	1.085	18	2,9
Bergfink	*Fringilla montifringilla*	1.012	11	2,7
Wacholderdrossel	*Turdus pilaris*	886	34	2,4
Andere		2.891	179	7,9
Gesamt		**36.814**	**288**	

Table 3: Species and number of bird carcasses found on the research platform FINO3, North Sea between July 28, 2009 and December 31, 2018. Source : Avitech 2019

Tabelle 7: Arten und Anzahl der zwischen 28.07.2009-31.12.2018 gefundenen Vogelkadaver am Standort FINO 3.

Art		Anzahl Totfunde [n]	[%]
Mantelmöwe	*Larus marinus*	1	1,0
Dreizehenmöwe	*Rissa tridactyla*	1	1,0
Ringeltaube	*Columba palumbus*	1	1,0
Feldlerche	*Alauda arvensis*	2	2,0
Rauchschwalbe	*Hirundo rustica*	1	1,0
Wiesenpieper	*Anthus pratensis*	2	2,0
Bachstelze	*Motacilla alba*	1	1,0
Rotkehlchen	*Erithacus rubecula*	3	3,1
Steinschmätzer	*Oenanthe oenanthe*	1	1,0
Ringdrossel	*Turdus torquatus*	2	2,0
Amsel	*Turdus merula*	8	8,2
Wacholderdrossel	*Turdus pilaris*	13	13,3
Singdrossel	*Turdus philomelos*	9	9,2
Rotdrossel	*Turdus iliacus*	14	14,3
Drossel sp.	*Turdus sp.*	5	5,1
Dorngrasmücke	*Sylvia communis*	1	1,0
Mönchsgrasmücke	*Sylvia atricapilla*	3	3,1
Fitis	*Phylloscopus trochilus*	3	3,1
Wintergoldhähnchen	*Regulus regulus*	3	3,1
Goldhähnchen sp.	*Regulus sp.*	1	1,0
Star	*Sturnus vulgaris*	15	15,3
Buchfink	*Fringilla coelebs*	6	6,1
Bergfink	*Fringilla montifringilla*	1	1,0
Erlenzeisig	*Carduelis spinus*	1	1,0
Gesamt		**98**	**100**

Additional information on regarding human activities and current threats in the German plot area:

The following threats of human activities were taken from the "Conservation objectives for the Sylt Outer Reef SCI (DE 1209-301) in the German North Sea EEZ" from the Federal Agency for Nature Conservation (2008).

1. Professional fishing (code 210) including trawling (code 212)
    - By catch of marine mammals, birds and fish due to low-selectivity fishing methods
    - Risk of injury to mammals, seabirds and fish from nets
    - Bottom and beam trawls, shellfish trawling: destruction of bottom fauna/feeding grounds and reduction of predominantly later stages of slow-growing species
    - Overfishing of food fish and endangered fish species
2. Leisure fishing (code 220)
    - Disturbance
    - Deterrent effect due to periodic and episodic noise
    - Locally large numbers of individuals of in some cases rare or threatened fish species taken in leisure fishing
    - Risk of injury to marine mammals and seabirds due to shipping waste or angling materials
3. Sand and gravel extraction (code 300)
    - Modification of sea floor morphology and topography
    - Destruction of bottom fauna
    - Modification (short-term or permanent) of the sediment regime and habitat modification/destruction
    - Loss of feeding grounds (marine mammals and seabirds)
    - Habitat loss (seabirds and fish)
    - Destruction and damage to spawning grounds and fish spawn
    - Removal of bottom-living fish species
4. Exploration and extraction of oil or gas (code 320)

    - Deterrent and barrier effect for harbor porpoises, fish and birds, e.g. due to constant, periodic or episodic noise (from hydro acoustic exploration methods)
    - Pollution from drilling
5. Other industrial/commercial areas (code 419), notably offshore wind farms
    - Habitat loss (deterrent and barrier effect), habitat modification, masking of relevant environmental phenomena for and risk of injury to marine mammals due to periodic and episodic noise during construction and operation
    - Habitat loss (deterrent and barrier effect) and habitat modification for birds, fish and bottom fauna
    - Destruction of fish spawning grounds and fish spawn
6. Energy transport (code 510)
    - Habitat loss due to electromagnetic fields disturbing the orientation of marine mammals and fish and impairing migration
    - Habitat loss due to disturbance (marine mammals, fish)
    - Destruction or harm to benthos during cable-laying
    - Warming of the sea floor
7. Shipping (code 520)
    - Gradual or acute poisoning due to contamination, e.g. with oil from marine accidents, bilge water or waste oil
    - Risk of injury to seabirds due to shipping waste
    - Disturbance and deterrence of wintering seabirds in their resting sites and of fish in their spawning, feeding and wintering areas
    - Marine mammals: Risk of injury from fast-moving ships
    - Habitat loss due to constant, periodic or episodic noise or vibration (impairment of orientation/communication)
    - Disturbance/perturbation (increased mortality through disturbance of mother-calf groups)
    - Introduction of alien species with potential dominance shifts in ecological communities (primarily benthic species and fish), possibly extending to eradication of individual species
8. Nautical sports (code 621)
    - Disturbance
    - Risk of injury or death to marine mammals due to rapidly travelling vessels and to seabirds as a result of shipping waste
    - Deterrent effect due to periodic and episodic noise
9. Military maneuvers (code 730)
    - Deterrent and barrier effect for marine mammals, fish and birds, e.g. due to constant, periodic or episodic noise during military exercises
    - Masking of relevant environmental phenomena for marine mammals, risk of injury to marine mammals due to impacts from the use of high-energy hydro acoustic technologies and detonations
    - Accumulation of waste
10. Other pollution or human impacts/activities (code 790)

Activities and impacts outside the SCI

11. Water pollution (code 701) (discharge of pollutants and nutrients from rivers)
    - Gradual or direct poisoning
    - Pollutant accumulation
    - Promotion of fast-growing, opportunistic species and impairment of underwater light availability due to eutrophication and excess phytoplankton production
12. Air pollution (code 702)
    - Gradual or direct poisoning
    - Pollutant accumulation
    - Promotion of fast-growing, opportunistic species and impairment of underwater light availability due to eutrophication and excess phytoplankton production

Table 4: Documented vulnerable species according to Habitat Directive, Birds Directive and the European Red List at the location FINO3, North Sea between July 28, 2009 and December 31, 2018. IUCN definition: LC = Least Concern; NT = Near Threatened, Potentially Endangered; VU = Vulnerable, Endangered; EN = Endangered, Highly Endangered; CR = Critically Endangered.

Scientific name	IUCN category	Habitat Directive Annex II	Birds Directive Annex I
Phoca vitulina		x	
Halichoerus grypus		x	
Phocoena phocoena)		x	
Circus cyaneus	LC		x
Accipiter nisus	LC		x
Pandion haliaetus	LC		x
Falco peregrinus	LC		x
Haematopus ostralegus	NT		
Rissa tridactyla	VU		
Thalasseus sandvicensis	LC		x
Lanius collurio	LC		x
Fringilla coelebs	LC		x
Turdus iliacus	NT		
Anthus pratensis	NT		

Table 5: Sensors and parameters of environmental monitoring for Pilot 1 – FINO3

	Sensor	Detected parameters
1	Combined CTD and O2-Sensor	Conductivity, Temperature, depth, O2, salinity
2	PH-Sensor	PH-Value
3	Fluor Sensor	Chlorophyll and Algea-Values
4	Echosonder	Water contents (concentration of faeces)
5	Pan- and tilt-device echosonder	Ensure wide angels (movement of longline)
6	Electronic and transponder echosonder	Necessary for function
7	ADCP	Local current velocity
8	Light sensors	Day light intensity
9	Turbidity sensor	Turbidity
10	Cameras (4 pc.)	Photos (mussels, fish, antifouling)
11	LED Lights (4 pc)	Next to cameras
12	NO3 Sensor	NO3 and UV Light
13	Biofouling Sensor (15 pc.)	Biofouling

ANNEX 2: GREEK PILOT- ADDITIONAL INFORMATION

Table 1: Species referred to in Article 4 of Directive 2009/147/EC and listed in Annex II of Directive 92/43/EEC and site evaluation for them

Species					Population in the site						Site assessment			
G	Code	Scientific Name	S	NP	T	Size		Unit	Cat.	D.qual.	A|B|C|D	A|B|C		
						Min	Max				Pop.	Con.	Iso.	Glo.
M	1310	Miniopterus schreibersii			p				P			B	C	
M	1304	Rhinolophus ferrumequinum			p				P			B	C	
R	1217	Testudo hermanni			p				P		C	C	C	C
R	1218	Testudo marginata			p				P		C	C	C	C
M	1349	Tursiops truncatus			p				P		D			

- **Group:** A = Amphibians, B = Birds, F = Fish, I = Invertebrates, M = Mammals, P = Plants, R = Reptiles
- **S:** in case that the data on species are sensitive and therefore have to be blocked for any public access enter: yes
- **NP:** in case that a species is no longer present in the site enter: x (optional)
- **Type:** p = permanent, r = reproducing, c = concentration, w = wintering (for plant and non-migratory species use permanent)
- **Unit:** i = individuals, p = pairs or other units according to the Standard list of population units and codes in accordance with Article 12 and 17 reporting (see reference portal)
- **Abundance categories (Cat.):** C = common, R = rare, V = very rare, P = present - to fill if data are deficient (DD) or in addition to population size information
- **Data quality:** G = 'Good' (e.g. based on surveys); M = 'Moderate' (e.g. based on partial data with some extrapolation); P = 'Poor' (e.g. rough estimation); VP = 'Very poor' (use this category only, if not even a rough estimation of the population size can be made, in this case the fields for population size can remain empty, but the field "Abundance categories" has to be filled in)

Table 2: Other important species of flora and fauna (optional)

Species					Population in the site				Motivation					
Group	CODE	Scientific Name	S	NP	Size		Unit	Cat.	Species Annex		Other categories			
					Min	Max		C|R|V|P	IV	V	A	B	C	D
A	1201	Bufo viridis						P			X			
A	1201	Bufo viridis						P					X	
A	1201	Bufo viridis						P	X					
P		Centaurea raphanina ssp. mixta						P				X		
R	1274	Chalcides ocellatus						P			X			

R	1274	Chalcides ocellatus						P					X	
R	1274	Chalcides ocellatus						P	X					
M	5365	Hypsugo savii						C			X			
M	5365	Hypsugo savii						C					X	
M	5365	Hypsugo savii						C	X					
R	1251	Lacerta trilineata						P			X			
R	1251	Lacerta trilineata						P					X	
R	1251	Lacerta trilineata						P	X					
P		Onobrychis ebenoides						P				X		
I	1028	Pinna nobilis						P			X			
I	1028	Pinna nobilis						P					X	
I	1028	Pinna nobilis						P	X					
M	2016	Pipistrellus kuhlii						C			X			
M	2016	Pipistrellus kuhlii						C					X	
M	2016	Pipistrellus kuhlii						C	X					
M	1333	Tadarida teniotis						P			X			
M	1333	Tadarida teniotis						P					X	
M	1333	Tadarida teniotis						P	X					
R	1295	Vipera ammodytes						P			X			
R	1295	Vipera ammodytes						P					X	
R	1295	Vipera ammodytes						P	X					

- Group: A = Amphibians, B = Birds, F = Fish, Fu = Fungi, I = Invertebrates, L = Lichens, M = Mammals, P = Plants, R = Reptiles
- CODE: for Birds, Annex IV and V species the code as provided in the reference portal should be used in addition to the scientific name
- S: in case that the data on species are sensitive and therefore have to be blocked for any public access enter: yes
- NP: in case that a species is no longer present in the site enter: x (optional)
- Unit: i = individuals, p = pairs or other units according to the standard list of population units and codes in accordance with Article 12 and 17 reporting, (see reference portal)
- Cat.: Abundance categories: C = common, R = rare, V = very rare, P = present
- Motivation categories: IV, V: Annex Species (Habitats Directive), A: National Red List data; B: Endemics; C: International Conventions; D: other reasons

Table 3: Habitat types identified for Greek pilot (Source: https://natura2000.eea.europa.eu/Natura2000/SDF.aspx?site=GR3000005#2.)

Annex I Habitat types						Site assessment			
Code	PF	NP	Cover [ha]	Cave [number]	Data quality	A|B|C|D	A|B|C		
						Representability	Relative Surface	Conservation	Global
1120	X		0	0.00	G	A		B	B
1210			1.10243	0.00	G	B	C	C	C
1240			4.81707	0.00	G	B	C	B	B
1420			6.1048	0.00	G	B	C	C	C
2110			4.39428	0.00	G	B	C	C	C
2260			1.59781	0.00	G	B	C	B	B
5210			28.3919	0.00	G	B	C	B	B
5420			317.824	0.00	G	B	C	B	C
6220	X		3.33491	0.00	G	B	C	C	C
8210			7.77739	0.00	G	A	C	A	B
92D0			9.51987	0.00	G	B	C	B	B
9320			1416.2	0.00	G	C	B	C	C
9540			1137.32	0.00	G	B	C	B	B

- **PF:** for the habitat types that can have a non-priority as well as a priority form (6210, 7130, 9430) enter "X" in the column PF to indicate the priority form.
- **NP:** in case that a habitat type no longer exists in the site enter: x (optional)
- **Cover:** decimal values can be entered
- **Caves:** for habitat types 8310, 8330 (caves) enter the number of caves if estimated surface is not available.
- **Data quality:** G = 'Good' (e.g. based on surveys); M = 'Moderate' (e.g. based on partial data with some extrapolation); P = 'Poor' (e.g. rough estimation)