Simply Blue Group

Operations & Maintenance Plan for the NSF#1 project

Document Number:

SWD-SBG- WOD-

Document No.	20230329 SB- NSF1 – Operations & Maintenance Plan	Version	B: updated for HKZ location
Client	Simply Blue Group	Date	13 Jan 2024
Project	North Sea Farm 1	Location	NSF1

Table of Contents

1 Introduction

This chapter provides a general project description and the scope of work covered under this method statement including the requirements.

1.1 Purpose and scope Of The North Sea Farm#1 Project

The purpose of the North Sea Farm#1 project is to boost the scale-up of the European seaweed sector and become a visible stakeholder in discussions about the future of the Dutch North Sea. The project aims to demonstrate the technical feasibility of seaweed farming between offshore wind turbines, showcasing safe and robust growing systems with high yields. The goal is to reduce offshore visits by developing sensors that allow remote monitoring of the farm. The project also aims to organize the young seaweed sector by showcasing various companies involved in the supply chain, from seedling providers to processing and distribution companies. Furthermore, the project seeks to confirm genuine interest from European markets in seaweed products by demonstrating the use of locally and sustainably cultivated seaweed in various applications, such as food ingredients, cosmetics, and agriculture. The availability of tangible samples can facilitate conversations and attract investment in the sector.

The goal of NSF#1 is ultimately to manage a large-scale seaweed farm within the Hollandse Kust Zuid wind farm. The first step in this process, and therefore also for this permit application, is:

- Developing and implementing the first multi-use seaweed farm in Europe within an offshore wind farm.
- 1 seaweed cultivation module.
- Type of seaweed: Saccharina Latissima.
- Expected harvest: 6 tons of wet weight seaweed (net weight).
- With a duration of one year:
    - Installation from May to October 2024.
    - Seeding in September-October 2024.
    - Harvest in May-June 2025.
    - Decommissioning in June-July 2025.
- Using the experience gained from this first step to optimize the processes towards the next step of scaling up.

1.2 Scope of this document

This document details the seeding, inspection and harvest of the 2 seaweed cultivation systems, including their seeding as listed above. In **Error! Reference source not found.** the layout of one seaweed module is depicted. In general, the eco-anchors will be installed first. Directly after, headrope with connected pipe floaters will be connected between anchors (4 pipes per set of anchors). Then the seeded nets will be attached to the head ropes. After that the operational period of the NSF#1 project starts during which the growth of the seaweed will be monitored as to establish the best moment for harvesting of the seaweed in the spring of 2024. After harvest it will be transported to onshore processeling locations for processing pilots for food, biostimulant and cosmetics ingredients.

2 Roles & responsibilities

2.1 Organisation

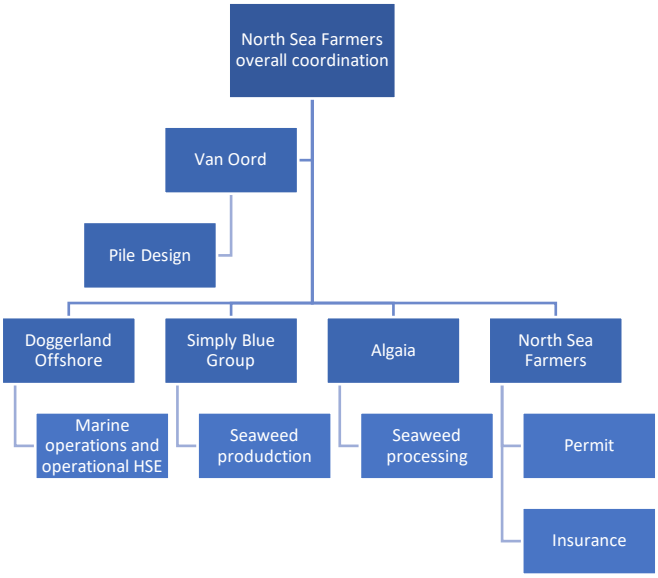


Figure 1: Roles & responsibilities in the NSF#1 Project

Table 2.1 Overview of the roles and responsibilities of the operational project team members

Role	Responsibility	Responsible party
Project Overall Coordination	Overall coordination and end-reponsible for the NSF#1 project, including HSE	North Sea Farmers
Project Manager (PM) Works	Project management and coordination with all partners relating to onshore and offshore operational activities, including HSE	Doggerland Offshore
Seaweed production	Seeding, inspection and harvesting of the seaweed, including logistics onshore. Falls under HSE regime of PM Works	Simply Blue Group
Seaweed processing	Processing of the seaweed in an onshore facility	Algaia
Structural design	Lead engineer on seaweed farm design	Van Oord

As listed above, SBG will be responsible for the seaweed production for the NSF#1 project. It is highlighted that SBG works exclusively under the operational and safety management and responsibility of Doggerland Offshore.

3 Seaweed in the NSF#1 project

3.1 Seed

At the heart of this project lies the critical role of seed, which serves as the foundation for successful seaweed cultivation. Seaweed needs to be (re)seeded every season. For this, the best seed material (depending on location and/or market) will be procured from specialised seed companies. Seeding itself is a time critical process to be executed onshore, after which nets will be installed on to the farm infrastructure. The NSF1 project 1 intends to farm Saccharina Latissima for the purpose of this project.

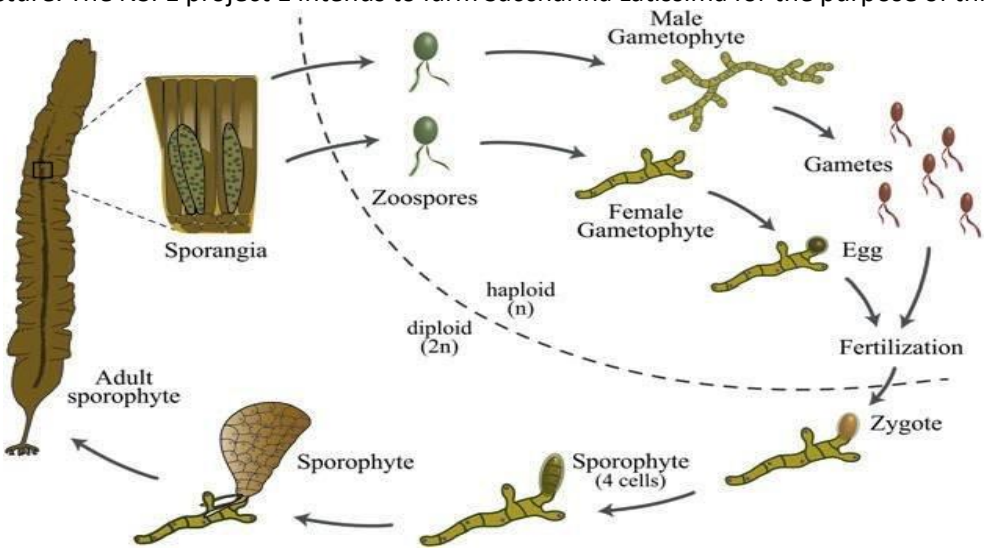


Figure 2: Lifecycle of Kelp, Saccharina latissima is a Kelp species

The seed stock gathered for this project is of Dutch Origin and is being supplied by the company Seawiser. Seawiser's Project Lead is Mr. Job Schipper and he is highly experienced with respect to seaweed propagation, seeding, with over two decades of hands-on experience. The intention is to aim for a high plant density on our nets and to seed approximately 16,000 juvenile sporophytes per meter. Due to offshore conditions, we intend on seeding an additional 20,000 not induced gametophytes per meter net to insure a successful crop.

4 Seeding

Based on lessons learnt from various pilot projects, such as the Wier & Wind project, the following guidelines for the NSF#1 project have been determined

- Net Types- Materials need to be evaluated under the same conditions.
- Seeding Techniques – True two-step process delivers the best results
- Nursey development is optimal but difficult to scale.

A key goal within this project is to determine the technical feasibility of offshore seaweed farming. For the NSF1 project we will test two seeding procedures:

- True two step manual seeding process. (Figure 2)
- Utilising the innovate Boeg Seaweed Net seeder. (Figure 3)

Figure 3: Two step manual seeding (left) and seeding using a seeding machine (right)

For the project the seeding of the seaweed will be performed onshore in a controlled environment. Each net material will be tested under the same seeding conditions to ensure the results are comparable.

4.1.1 True two step manual seeding process

For this step the sporophytes and gametophytes will be applied to the nets using a spray. Following the application of the seed we will spray a glue-like substance onto the seeded seaweed nets. This a technique known as seed adhesion. This process involves applying a thin layer of adhesive material onto the seeds to improve their attachment to the cultivation net. The adhesive coating helps ensure that the seeds remain in place, preventing them from being dislodged or washed away by water currents after deployment. Coating seaweed seeds with glue or adhesives aids in their even dispersal across the cultivation area. It allows for a controlled and uniform distribution of seeds, ensuring optimal spacing and coverage, which can lead to better growth and resource utilization.

4.1.2 Boeg Seaweed Net seeder

The Boeg Seaweed Seeder is a innovate piece of equipment that automates the process of attaching seed in a controlled and efficient manner. Introducing mechanisation into the seeding process will reduce the time taken to seed and will increase the feasibility of offshore deployment.

The Boeg allows a two-step seeding process.
Seed Hopper: The machine is equipped with a seed hopper where the seeds are stored. The hopper is filled with the desired seed variety, and it has mechanisms to regulate the flow of seeds.

Metering Mechanism: The seeding machine utilizes a metering mechanism to control the quantity of seeds being released. This mechanism ensures a consistent and uniform distribution of seeds, preventing over-seeding or under-seeding

Seed Distribution: The seeds are then sprayed through a series of spray bars onto the net.

Movement: The net is pulled through the system by a chain mechanism.

Glue: The Seeded net is then sprayed with a glue-like substance to ensure seed adhesion.

The Net is then transferred to a tarp and wrapped to be protected from the environmental conditions and transferred to the deployment Vessel.

5 Net deployment offshore

5.1 Introduction

Once the net has been seeded it is crucial to the success of the project that the net is transferred to the deployment vessel in a safe steady procedure. The nets will be loaded onto the vessel via the on-board crane and will be stored on the deck of the vessel until arrival at the offshore site. At that stage the nets will be connected to the head-rope of the cultivation using specific shackles.

5.2 Method statement

A method Statement for the Deployment is attached. It is noted that for the net deployment the same vessel will be used as for the installation works

6 General inspection & monitoring

The seaweed farm will be inspected in two ways: 1) by means of realtime monitoring via sensors with telemetry and 2) by means of monthly inspection visits by boat.

6.1 Remote monitoring

The seaweed farm will be equipped with sensors and cameras to determine:

- Position of the seaweed cultivation system via GPS
- Condition of the system via camera and load sensors (optional)
- Relevant environmental data

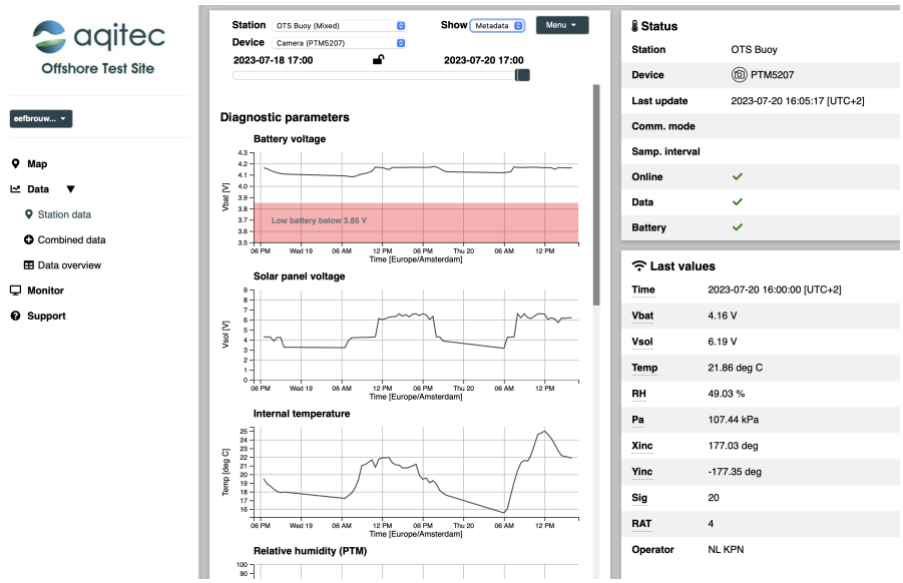


Figure 4: Example of a remote monitoring dashboard as will be used in NSF#1

6.2 Inspections

It is the intention to perform one visual inspection per month with the following schedule:

Month	Activities
Nov	General visual inspection, inspection of nets
Dec	General visual inspection, inspection of nets
Jan	General visual inspection, inspection of nets, replacement of sensors (if applicable)
Feb	General visual inspection, inspection of nets, seaweed sampling
Mar	General visual inspection, inspection of nets, seaweed sampling
Apr	General visual inspection, inspection of nets, seaweed sampling

The inspections will be coordinated by SBG and will be performed using a small Wind Farm CTV vessel with crane capacity, see also figure below

Figure 5: O&M operations with a typical CTV as used previously on the NSF OTS

6.2.1 First Inspection

The First Inspection should occur 6 weeks after deployment to ensure the seed has attached correctly or the next best available weather window.

6.2.2 Growth during season

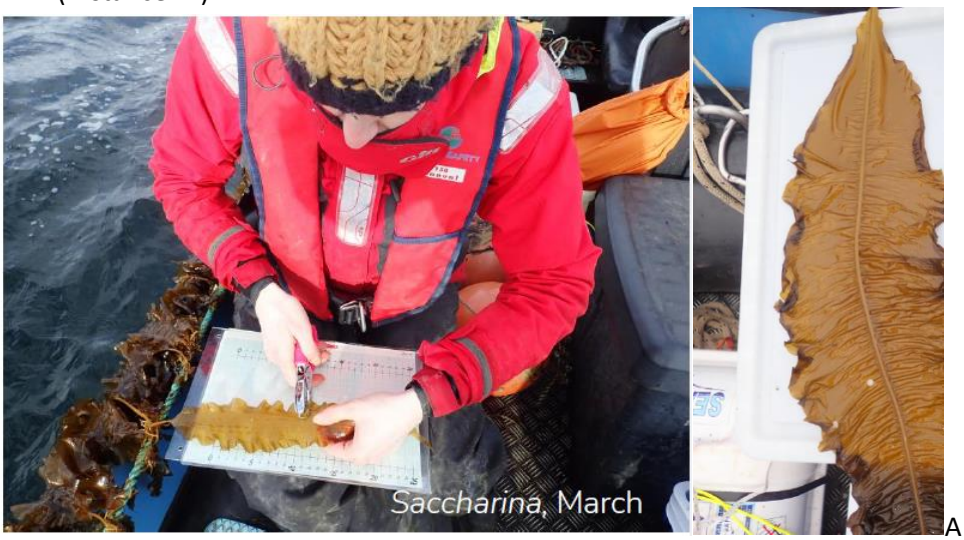
Seaweed biomass yield needs to be recorded at every opportunity during Inspections and shall include as a minimum the following steps:

- Randomly select and define a net area of optimal growth.
- Identify what position net by identifying the numbered Sinker at the top of the Net.
- Collect all seaweed individuals growing in area outlined.
- Remove Excess Seawater – drip dry.
- Weigh the Seaweeds wet weight and calculate biomass yield:

$$Biomass\ Yield\ (kg/m) = \frac{Seaweed\ Wet\ Weight\ (kg)}{Line\ Area\ (m)}$$

Figure 6: Examples of growth inspections

- Measure Seaweed Growth in individual plants:
  - Select, mark, and revisit the same individuals.
  - Take the plant closest to the Surface and directly under a labelled sinker rope so it can be re visited.
  - Punch a hole (~5mm) below the meristem and measure the distance to the blade's base.
  - (Distance T0)
  - Revisit same individuals and measure the distance between blade base and hole again (Distance Tx)



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$$SGR\ (cm/day) = \frac{Distance\ (T_x) - Distance(T_0)}{(T_x - T_0)}$$

6.2.3 Biofouling checks:

Biofouling is important aspect of monitoring and should be recorded with photos during inspection periods. The environmental conditions vary on each Site. The establishment of fouling (typically

May) will be initially small and restricted to the tips of the frond and will rapidly worsen. Understanding when this occurs is crucial to be profitable harvest.

6.2.4 Determining optimal harvest date

Saccharina is known to grow 2.0cm per day per plant during May June. Optimizing the harvest commence date can have a significant impact on harvest yield.

6.2.5 Sampling for CO2 sequestration research

As part of the carbon capture potential research performed by Plymouth Marine Laboratories, field measurements will be performed. This will including sampling of the seaweed as described above. In addition, box core samples will be taken directly below or close to the NSF#1 seaweed farm. Whether this can be done from a CTV-type vessel will be agreed with the marine coordinator Doggerland Offshore. This will include the following:

- Minimum baseline scenario
    - What gear: 3-4 multi-corer deployments, 1-2 cores each deployment + plankton net deployment.
    - What data : Get sediment profiles (carbon and nitrogen content & stable isotopes, eDNA data, 210Pb data, biodiversity data) plus carbon sources (carbon and nitrogen content & stable isotopes, eDNA data).
    - Time: 3.5 hours max.
- Gold standard baseline scenario
    - What gear: 6-8 multi-corer deployments, 1-2 cores each deployment; plankton net deployment; 2-4 box corer deployments.
    - What data : Get sediment profiles (carbon and nitrogen content & stable isotopes, eDNA data, 210Pb data, biodiversity data) plus carbon sources (carbon and nitrogen content & stable isotopes, eDNA data); seabed carbon fluxes.
    - Time: 1.5 days of work.

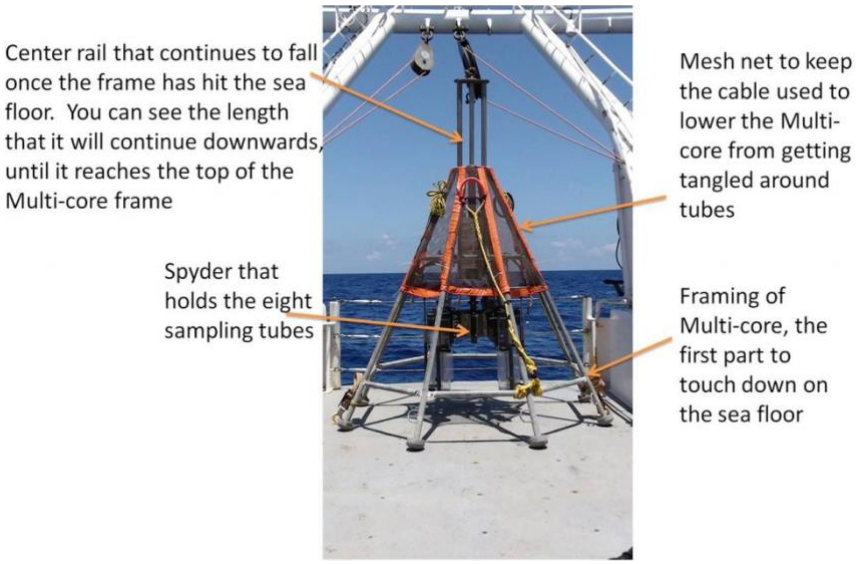


Figure 7: Typical multi-core sampling tool

6.2.6 The Cultivation Rig monitoring

A Visual Check is required on Seaweed System during each inspection. As this system is operating in a high energy environment there is the possibility of the sections of the nets becoming damaged.

6.2.6.1 Damaged Nets

Identify any areas of the nets that are damaged and appear under strain.

- Assess the extent of the damage and determine whether it can be repaired or if the net needs to be removed.
- If repairable, mend the damaged sections using appropriate techniques and materials.
- Ensure that the repaired sections are securely fastened and the C-links and slings above are in good condition.

6.2.6.2 Loose or Broken Connections

- Inspect the connections of the nets including ropes C-links and attachment points.
- Identify any loose, damaged or broken connections.
- Tighten or replace any loose or damaged connections to ensure the integrity of the net structure.
- Check the Strength of the knots or fasteners and re tie or replace as necessary.

6.2.6.3 Net Tension.

Seaweed depends on light to grow and therefore it is crucial to ensure the system is correctly tensioned to deliver a good harvest yield.

- Monitor the tension of the net and take note of any points of sagging or overstretching.
- Visual signs of sagging on the net indicate that there is not enough weight on the system or too much support is in place. Add weight to the System will reduce the sagging effect.
- Visual signs of the net being over stretched indicate that too much force is being applied and therefore additional rope support should be added to the system to support.
- Any areas showing signs of Strain need to be reenforced.

6.2.6.4 Sensor Equipment

- *Load link* to measure the forces on the structure: check for any visual damage
- *GPS sensors* (two different types) to measure real time if the NSF1 structure is in place: check for any visual damage
- *Obscape camera* with image burst to see if the NSF1 is functioning as it should: The Camera lens needs to be checked and cleaned to ensure it is free from fouling.

6.2.6.5 Always be prepared for small repairs

- Prior to departure of the vessel, it is important that sufficient rope and additional C-links are on hand to repair or replace any damaged or strained structures.
- Upon arriving at the test is prudent to do a visual inspection to ensure that 4x50 meter nets are all secured to the slings and c-links and the net is hanging freely.
- In the event that any of the slings appear loose or detached. The structure should be lifted from the water at that point and a visual inspection undertaken. Any slings that appear loose or worn should be replaced. C-links should be replaced during the seaweed monitoring and the location noted for future reference.

6.3 Maintenance

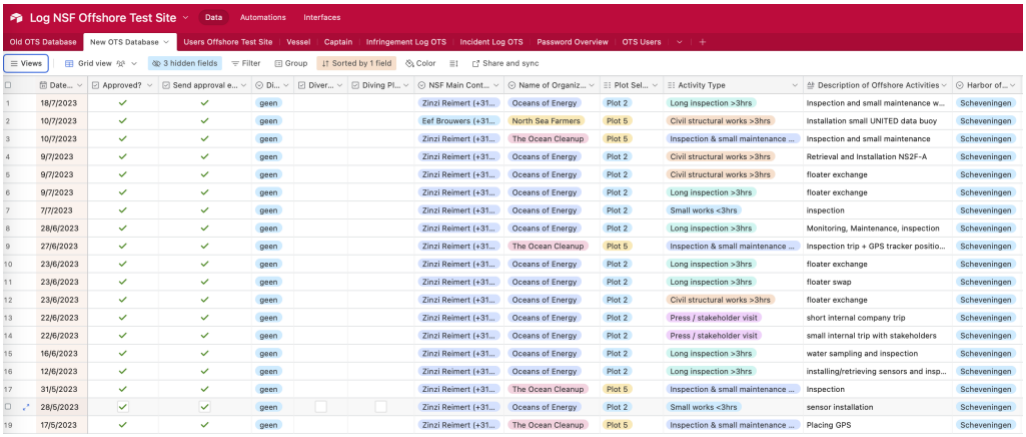
The seaweed cultivation systems are intended to be maintenance free so no planned maintenance is foreseen during the project. However, there may be unforeseen failures in the system. These could become known via:

- Indications from the remote monitoring system
- Inspections by NSF#1
- Observations by others

Upon such an observation, an assessment will be made whether the failure has any adverse impact on the HSE performance of the system. If this is the case then corrective maintenance will be performed by Doggerland Offshore to bring the system back into a safe state. This will include root cause analysis, selection of the best corrective actions, preparing the RAMS and executing the corrective works with a specifically charted and suitable vessel.

6.4 Documentation

Detailed records will be made and kept of all inspection and corrective maintenance works. All activities undertaken at the site will be recorded in a dedicated activity log.



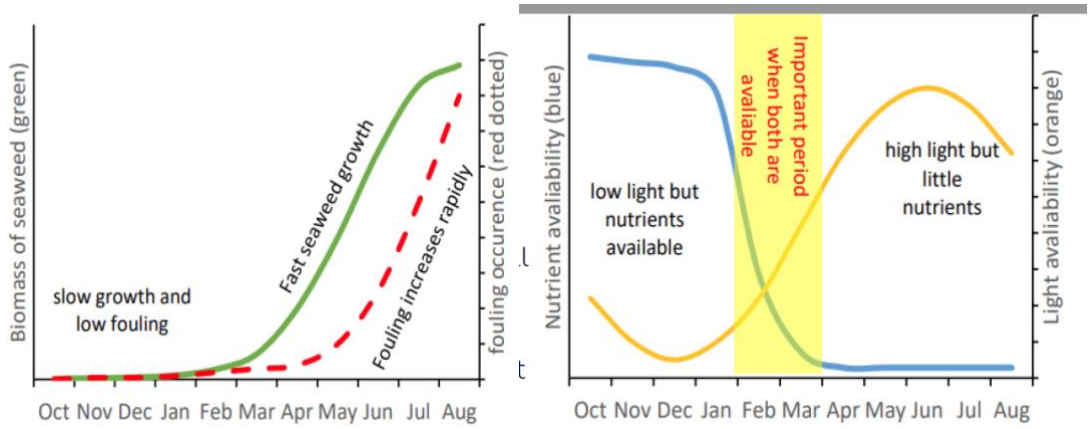
	Date...	Approved?	Send approval e...	Di...	Diver...	Diving Pl...	NSF Main Cont...	Name of Organiz...	Plot Sel...	Activity Type	Description of Offshore Activities	Harbor of...
1	18/7/2023	✓	✓	geen			Zinzi Reimert (+31...	Oceans of Energy	Plot 2	Long inspection >3hrs	Inspection and small maintenance w...	Scheveningen
2	10/7/2023	✓	✓	geen			Eef Brouwers (+31...	North Sea Farmers	Plot 5	Civil structural works >3hrs	Installation small UNITED data buoy	Scheveningen
3	10/7/2023	✓	✓	geen			Zinzi Reimert (+31...	The Ocean Cleanup	Plot 5	Inspection & small maintenance ...	Inspection and small maintenance	Scheveningen
4	9/7/2023	✓	✓	geen			Zinzi Reimert (+31...	Oceans of Energy	Plot 2	Civil structural works >3hrs	Retrieval and Installation NS2F-A	Scheveningen
5	9/7/2023	✓	✓	geen			Zinzi Reimert (+31...	Oceans of Energy	Plot 2	Civil structural works >3hrs	floater exchange	Scheveningen
6	9/7/2023	✓	✓	geen			Zinzi Reimert (+31...	Oceans of Energy	Plot 2	Long inspection >3hrs	floater exchange	Scheveningen
7	7/7/2023	✓	✓	geen			Zinzi Reimert (+31...	Oceans of Energy	Plot 2	Small works <3hrs	inspection	Scheveningen
8	28/6/2023	✓	✓	geen			Zinzi Reimert (+31...	Oceans of Energy	Plot 2	Long inspection >3hrs	Monitoring, Maintenance, inspection	Scheveningen
9	27/6/2023	✓	✓	geen			Zinzi Reimert (+31...	The Ocean Cleanup	Plot 5	Inspection & small maintenance ...	inspection trip + GPS tracker positio...	Scheveningen
10	23/6/2023	✓	✓	geen			Zinzi Reimert (+31...	Oceans of Energy	Plot 2	Long inspection >3hrs	floater exchange	Scheveningen
11	23/6/2023	✓	✓	geen			Zinzi Reimert (+31...	Oceans of Energy	Plot 2	Long inspection >3hrs	floater swap	Scheveningen
12	23/6/2023	✓	✓	geen			Zinzi Reimert (+31...	Oceans of Energy	Plot 2	Civil structural works >3hrs	floater exchange	Scheveningen
13	22/6/2023	✓	✓	geen			Zinzi Reimert (+31...	Oceans of Energy	Plot 2	Press / stakeholder visit	short internal company trip	Scheveningen
14	22/6/2023	✓	✓	geen			Zinzi Reimert (+31...	Oceans of Energy	Plot 2	Press / stakeholder visit	small internal trip with stakeholders	Scheveningen
15	16/6/2023	✓	✓	geen			Zinzi Reimert (+31...	Oceans of Energy	Plot 2	Long inspection >3hrs	water sampling and inspection	Scheveningen
16	12/6/2023	✓	✓	geen			Zinzi Reimert (+31...	Oceans of Energy	Plot 2	Long inspection >3hrs	installing/retrieving sensors and insp...	Scheveningen
17	31/5/2023	✓	✓	geen			Zinzi Reimert (+31...	The Ocean Cleanup	Plot 5	Inspection & small maintenance ...	Inspection	Scheveningen
	28/5/2023	✓	✓	geen			Zinzi Reimert (+31...	Oceans of Energy	Plot 2	Small works <3hrs	sensor installation	Scheveningen
19	17/5/2023	✓	✓	geen			Zinzi Reimert (+31...	The Ocean Cleanup	Plot 5	Inspection & small maintenance ...	Placing GPS	Scheveningen

Figure 8: Example of an activity log that will be setup fot ehr NSF#1 project

7 Harvesting

Decisions around harvest timing will impact cultivation performance and overall success of the cultivation cycle. Harvest time in an offshore environment would be determined by the environment e.g., rapid reductions in nutrient availability and increasing fouling pressure. Rate of growth or biomass doubling time (approximately 30 days) is greatest in the months approaching harvest meaning that significant yield losses are possible if a decision is made to harvest too early.

Based on previous experience from Wier&Wind project it is thought that the optimal harvest period is early June and due to the nature of offshore conditions required to be booked in advance and a decision has been taken to schedule the harvest for early June. The harvesting operations will be coordinated by Doggerland Offshore with SBG staff working under specific instruction and method statement as setup and enforced by Doggerland.



The harvesting machine will remove the seaweed from the net, and it will be transferred directly into ton bags where it will be stored on board the vessel and taken ashore and transferred to Algia by refrigerated container. Given the time of the year consideration of air temperature will need to be considered and IBC containers may need to be acquired so that the seaweed can be held in seawater to prevent an immediate decay of the product.

8 Attachments

Attachment1: Offshore Maintenance toolbox kit

As the Project will be involved in offshore maintenance it is important to have a supply of materials on board to repair any wear and tear on the systems.

	Supplier:	Owner:
Maintenance Equipment Basic Hand tools: Screwdrivers, Wrenches, Vice grips. Portable Lights /Headtorches Hard Brush (Fouling) Knives with knives log. 20 X 10 Meter Lifting straps **Rope** 24 mm Delphin 4-strand rope Full role of twine Twine sowing needle C-link ø16mm stainless steel X10 Additional weight for the system – led line or lead weights **Sampling** Underwater Drone for imagery Water sample Kit Water temperature probes Containers for handling Seaweed samples Waterproof paper		

Attachment 2: Method Statement Net Seeding & Deployment