Report

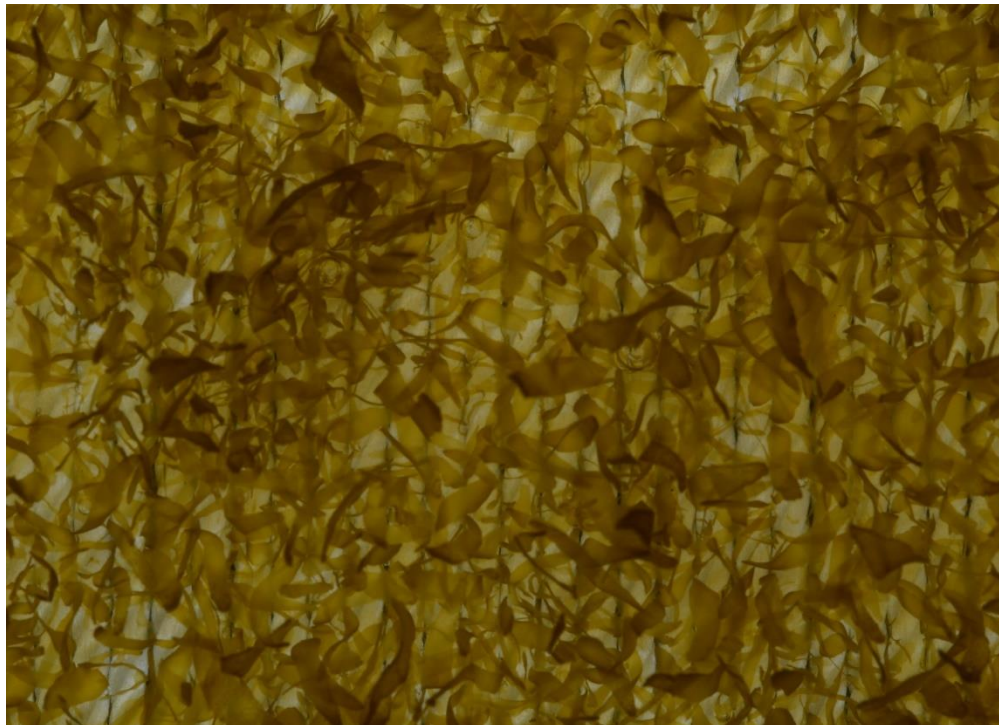## D5.2 Proof of concept on seeding systems

MACROSEA WP5

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Report

D5.2 Proof of concept on seeding systems

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ABSTRACT
This brief report documents the deliverable D5.2 Proof of concept on seeding systems from MACROSEA WP5. By seeding systems we mean the technology used to produce substrate with seedlings ready for deployment at sea. SINTEF Ocean has demonstrated a partly automated production line based on carrier rope with seeded twine for deployment.

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1 Introduction

This brief report documents the deliverable *D5.2 Proof of concept on seeding systems* from MACROSEA WP5. By *seeding systems* we mean the technology used to produce substrate with seedlings ready for deployment at sea. SINTEF Ocean has demonstrated a partly automated production line based on carrier rope with seeded twine for deployment.

2 Seeding systems

The process of preparing seeded carrier rope for deployment consists of three process steps: preparation of spools with twine, seeding of twine, and spinning of twine onto carrier rope. The technology for each of these steps as demonstrated at SINTEF Sealab is described in the following sections.

2.1 Preparation of spools

The spools need to be prepared by spinning the twine to form a tight layer of twine around the spool cylinder. To automate this task, a device has been developed that has a capacity to prepare two spools in parallel (Figure 1). The twine is initially fastened at the bottom end of the empty spools, and the machine will automatically spin the twine tightly around the spools, to the top, and stop when finished. The spinning process takes approximately 90 seconds.

Figure 1: Device for automated spinning of twine onto spools.

2.2 Seeding of twine

2.2.1 Automation system for seeding tanks

The seeding process takes place by spraying or bathing spools with water containing spores or gametophytes and after a 10 min settlement hanging the spools vertically in cylindrical tanks filled with sea water for growth into seedlings of appropriate size for deployment in the sea farm. During this period, the water temperature, water exchange, aeration and light needs to be controlled appropriately.

To simplify this process and reduce manual work, an automated system has been designed and implemented. The system is capable of monitoring water temperature, along with controlling air flow, water flow and brightness on the growth light. The system will save all sensor data every minute, this data can on a later time be exported to programs such as MATLAB or Excel. The user can configure custom sessions for each reactor, with a schedule for automatic control of light, water flow and air flow, as shown in Figure 2.
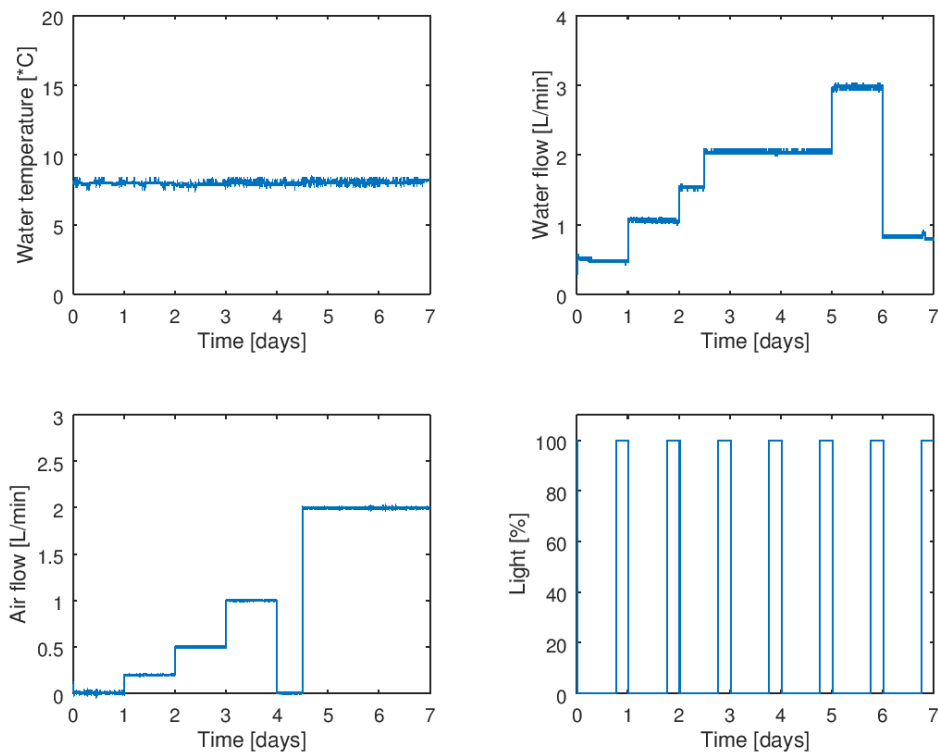

Figure 2: plot of reactor parameters over seven days

Parameters can be monitored or set on a touch monitor or in a web-based user interface, meaning there is possibilities for remote controlling the system. A screenshot from the user interface is presented in Figure 3.
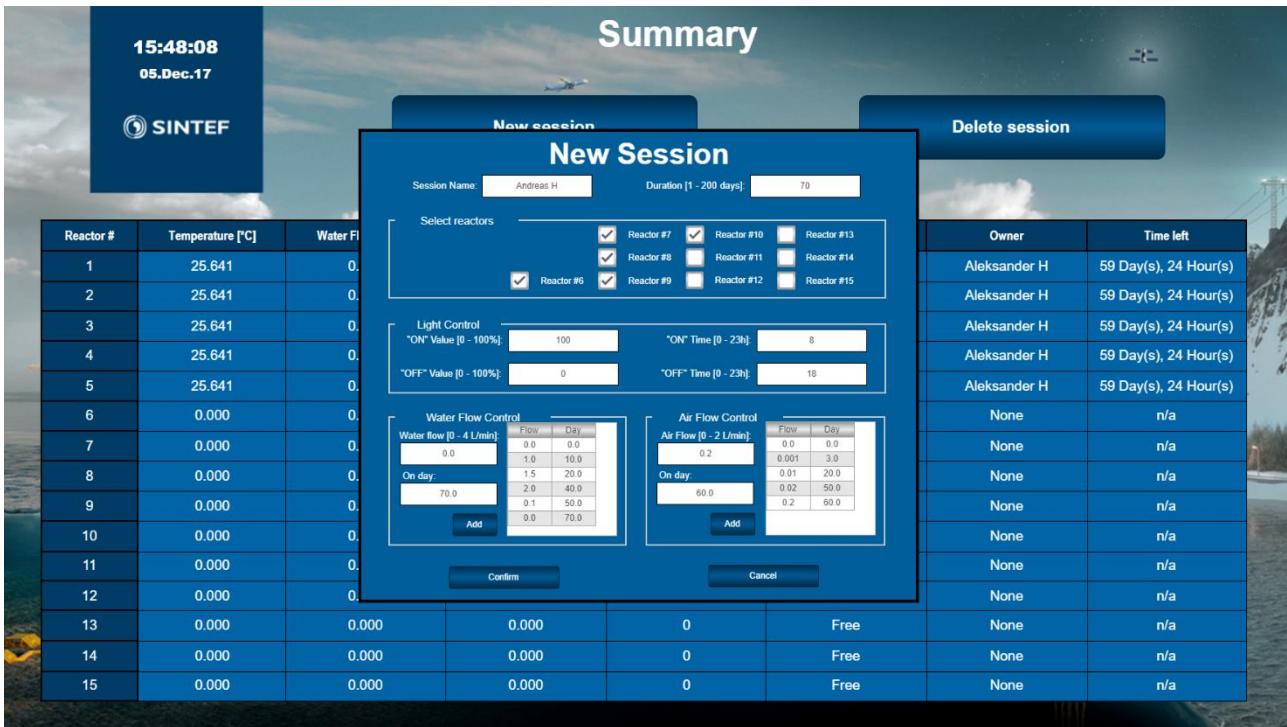
Figure 3: screen shot of user interface

The system consists of:
- Wago PLC
- HMI display
- Sensors for measuring temperature, water flow and air flow
- Valves for controlling water flow and air flow
- Electronic dimmer for controlling lights

For a full system overview, please see Figure 4.

The PLC is programmed with a IEC 61131-3 compatible language, implementing functions such as data acquisition, PI-regulators, user interface and scheduling. The sensor- and actuator communications is done using a current loop (4 – 20 mA). The system is built for monitoring and controlling 15 reactors, containing 12 spools each.
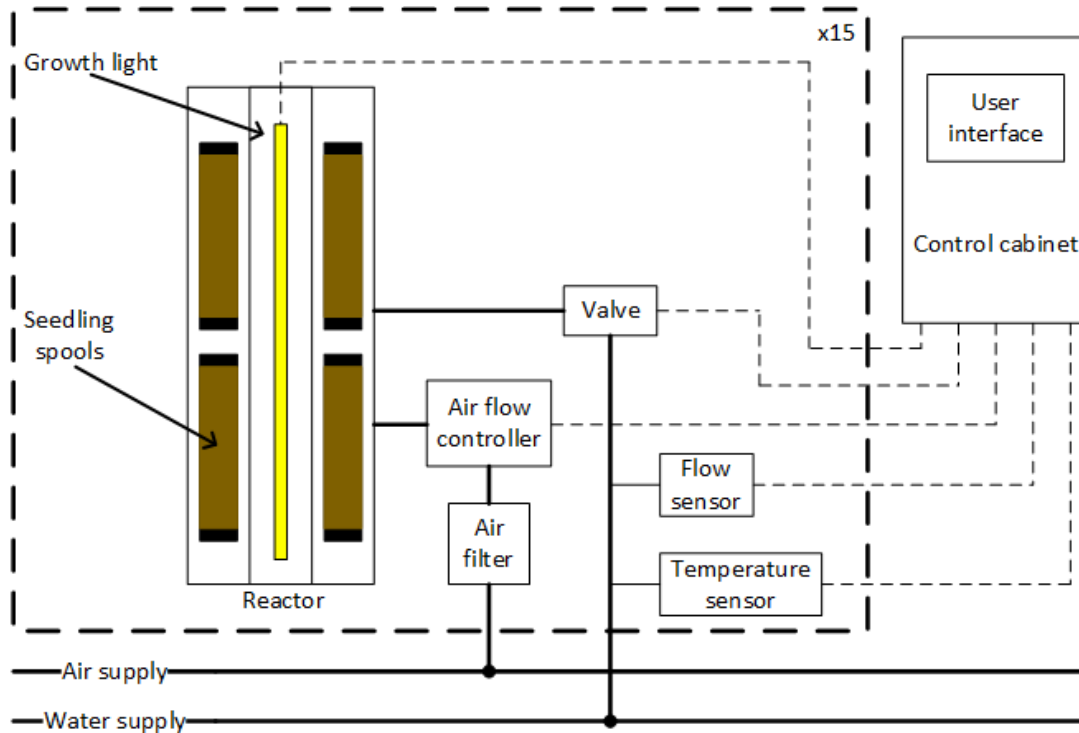
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Figure 4: system block diagram

2.2.2 Monitoring of seedling growth

The seedlings production process takes typically around 6-7 weeks. It is important both to know when seedlings are ready for deployment and to know as early in the process as possible if the process is not proceeding as well as expected. Tools for objective assessment of the amount of seedlings on the spools are needed, and the machine vision approach to this has been tested in MACROSEA. A setup for taking standardized photos of parts of each spools was established (Figure 5). The setup consists of an aquarium equipped with a rig for fastening each spool, a LED ring-light and a Nikon D800 camera with a 105mm macro lens. The distance of the light source and camera from the aquarium wall is fixed, as well as their vertical position, to achieve repeatable image quality. Several parts of the spool can be photographed by moving the tripod along the tank.
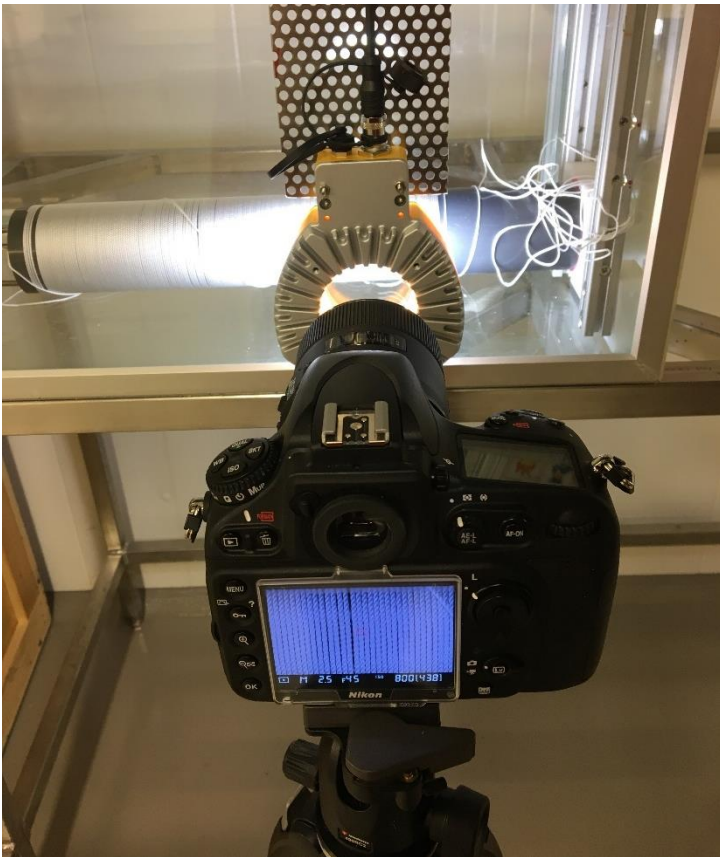
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Figure 5: Setup for standardized photography of seedling spools.

In the seeding phase of the 2017 MACROSEA field study, the status of seedlings from four of the experimental locations was monitored regularly as they developed at SINTEF Sealab. Example images for the Austevoll location are shown in Figure 7-Figure 10. In the earliest image the seedlings are small and only cover a small part of the image surface. Over time, they gradually cover larger parts of the image, and the amount of overlap increases as the seedlings grow to larger sizes.

An algorithm was developed to automatically quantify the coverage rate of seedlings in the images. This algorithm was run for the four selected locations for the images taking throughout the seeding period (Figure 11). The results show clear differences in the initial development rate among the locations.

Quantification of the seedling coverage on the white substrate was done using a dedicated software developed in LabVIEW (Figure 6). The software allows the user to manually select between digitized conversions of the original images, thresholded using one of the planes from the color model *Hue, Saturation* and *Value*. The representation that best sorts the background (substrate) from the seedlings is selected, and the ratio of background pixels vs foreground gives the coverage.
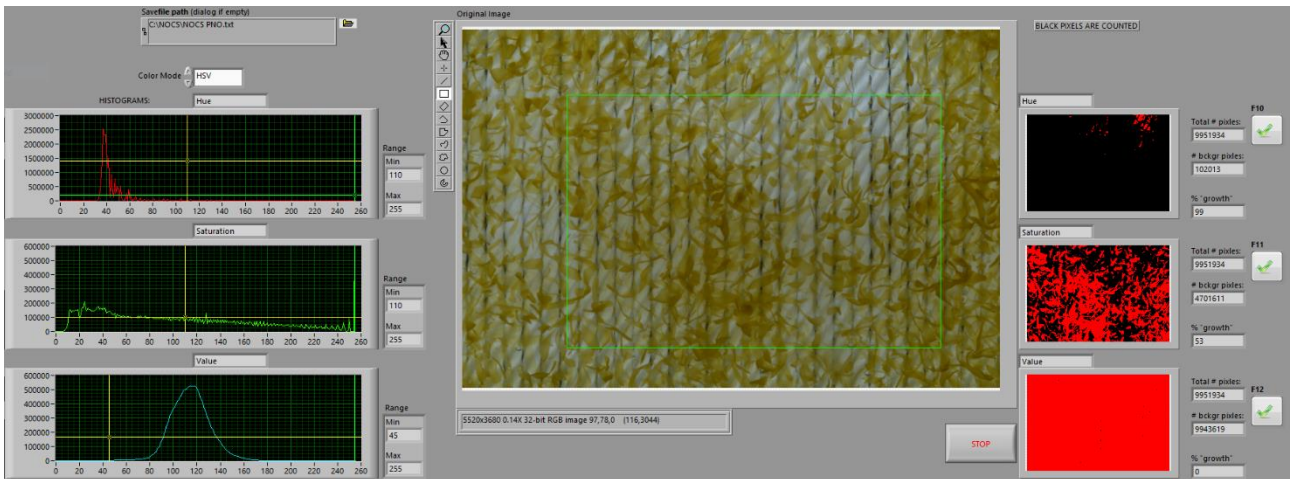
Figure 6: GUI from software developed for seedling density measurements

Figure 7: Photo of seeding state for seedlings from Austevoll at January 13, 2017.

Figure 8: Photo of seeding state for seedlings from Austevoll at January 20, 2017.

Figure 9: Photo of seeding state for seedlings from Austevoll at January 30, 2017.

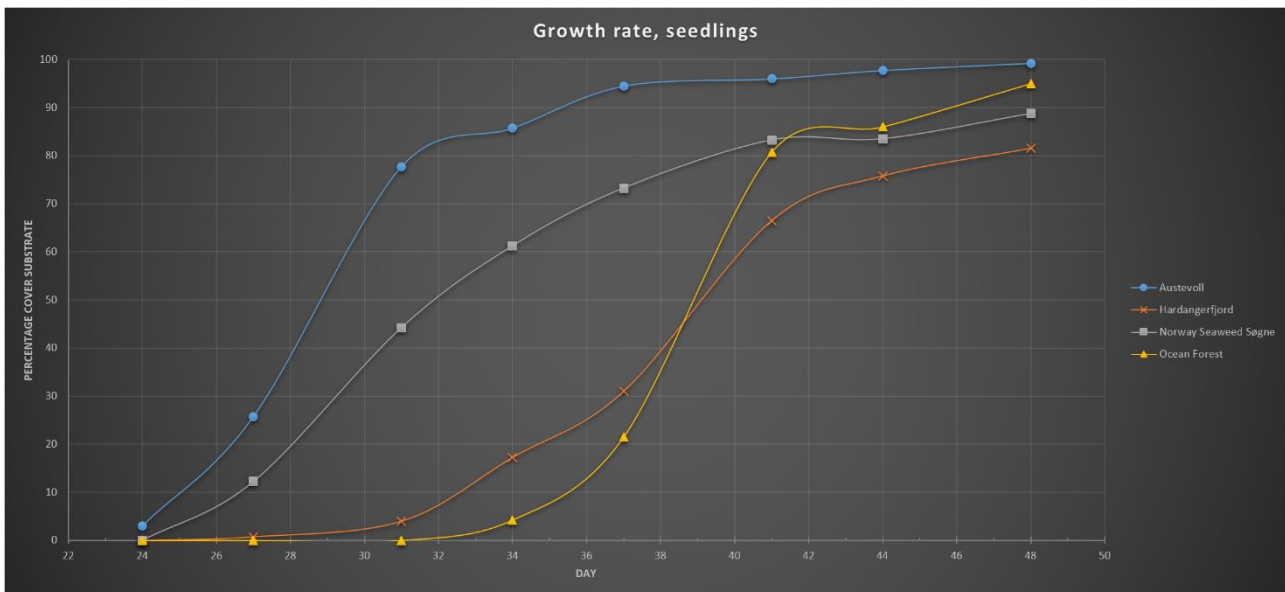**Figure 10: Photo of seeding state for seedlings from Austevoll at February 6, 2017.**

Figure 11: Quantification of the coverage rate of seedings in images from four of the MACROSEA locations.

2.3 Spinning of twine onto carrier rope

When seedlings are ready for deployment, the seeded twine needs to be fastened to the carrier rope – either before or during the deployment process. A good way to fasten the twine is by wrapping it around the carrier rope, and fastening it at intervals of a few m, but the process of wrapping the twine is very time consuming if done manually. A machine referred to as a "seaweed spinner" has been developed to automate the wrapping of twine at a rapid rate (Figure 12).

The seaweed spinner allows the carrier rope to be inserted radially (from the top of the machine), without requiring the end of the rope to be available (i.e. the rope can be inserted into the machine even while fastened at both ends). Spools of seeded twine are loaded into the machine, and easily replaced. During operation, the carrier rope is fed through the machine, and the spool is rotated around the rope at a speed coordinated to wrap the twine at a constant distance per round trip. The speed of the process can be regulated by the operator up to maximum speed of approximately (10 m/min).
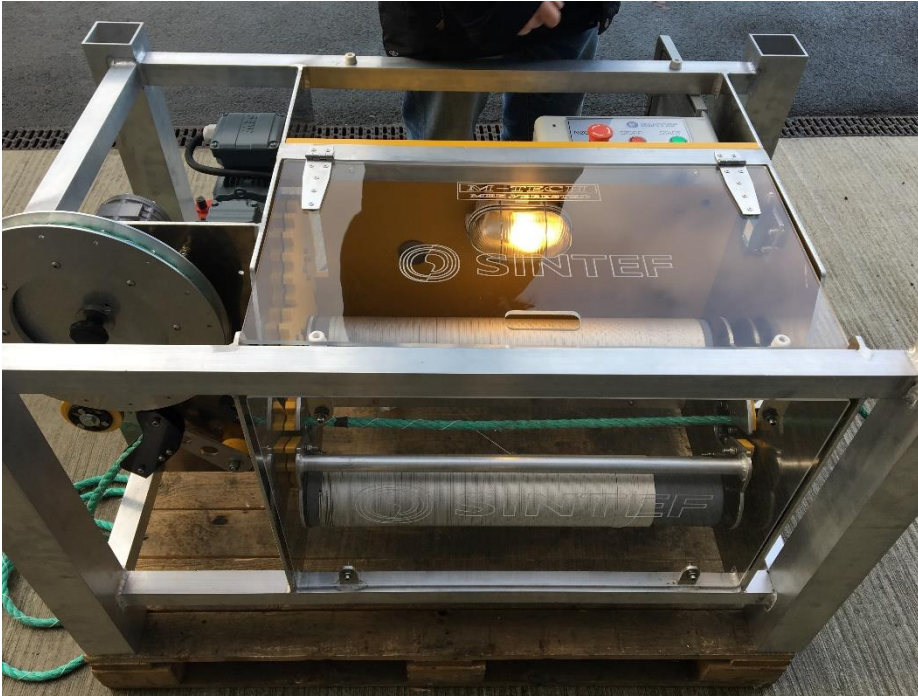

Figure 12: Seaweed spinner.

3 Conclusion

This report has outlined a partly automated production line for seeding and deployment on carrier ropes established at SINTEF Sealab.