MACROSEA

# A Knowledge Platform for Industrial Macroalgae Cultivation

## Annual project meeting 25-26 October 2017

**Venue: Radisson Blu Royal Garden Trondheim**

### *Day 1 (Wednesday) - BIOLOGY*

| | | |
|---|---|---|
| *10.00-10.10* | *Welcome* | *Aleksander Handå* |
| | **Results from 2016 and 2017, with discussions** | |
| *10.10-11.00* | WP1 Seedling biology | *Jorunn Skjermo*<br>*Peter S Schmedes* |
| *11.00-11.20* | News from PHYCOMORPH<br>www.phycomorph.org | *Klaas Timmermann* |
| *11.20-11.40* | *Coffee break* | |
| *11.40-12.30* | WP3 Genetics and disease | *Inga Kjersti Sjøtun*<br>*Alexander Thompson* |
| *12.30-14.00* | *Lunch* | |
| *14.00-15.30* | WP2 Sea cultivation<br>Nutrient uptake study<br>Monitoring programme | *Siv Anina Etter*<br>*Silje Forbord*<br>*Sanna Matsson* |
| *15.30-16.00* | *Group photo* | |
| *16.00-17.00* | Planning of 2018<br>Group work in WPs led by WP leaders | *Project partners* |
| | | |
| *19.00* | Dinner at the hotel | |

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## *Day 2 (Thursday) - MODELLING AND TECHNOLOGY*

| | **Results from 2016 and 2017, with discussions** | |
|---|---|---|
| *09.00-09.45* | WP4 Marine modelling | *Ole Jacob Broch* |
| *09.45-10.00* | KELPPRO | *Hartvig Christie* |
| *10.00-10.20* | Effect of salinity and nutrient availability on *Saccharina latissima* and *Laminaria digitata* | *Leiv Mortensen* |
| *10.20-10.50* | *Coffee break* | |
| *10.50-11.30* | WP5 Seedling, deployment and harvest | *Torfinn Solvang* |
| *11.30-12.10* | WP6 Sea farms | *Andreas M Lien* |
| *12.10-12.30* | Comments by the scientific advisory board | *Klaas Timmermann* |
| *12.30-13.30* | *Lunch* | |
| *13.30-13.50* | SEAWEED CULTIVATION VESSEL | *Andreas M Lien* |
| *13.50-14.10* | TAREAL TRØNDELAG | *Ole Jacob Broch* |
| | Closing | *Aleksander Handå* |
| *14.30* | Departure | |

Transport to the airport: Bus from the hotel every 10 min. The trip to the airport takes 30 min.

**List of participants**

| | | |
|---|---|---|
| 1 | Alexander Thompson | SAMS |
| 2 | Silje Forbord | NTNU |
| 3 | Kjell Inge Reitan | NTNU |
| 4 | Siv Anina Etter | NTNU |
| 5 | Peter Søndergaard Schmedes | DTU Aqua |
| 6 | Sanna Matsson | Akvaplan NIVA |
| 7 | Hartvig Christie | NIVA |
| 8 | Morten Alver | SINTEF Ocean |
| 9 | Ole Jacob Broch | SINTEF Ocean |
| 10 | Torfinn Solvang Garten | SINTEF Ocean |
| 11 | Andreas Myskja Lien | SINTEF Ocean |
| 12 | Jorunn Skjermo | SINTEF Ocean |
| 13 | Kristine B Steinhovden | SINTEF Ocean |
| 14 | Bjarne Kvæstad | SINTEF Ocean |
| 15 | Kjersti Sjøtun | University of Bergen |
| 16 | Job Schipper | Hortimare |
| 17 | Guri Ellila Brodahl | NTNU |
| 18 | Solveig Foldal | NTNU |
| 19 | Saifullah Saifullah | NTNU |
| 20 | Jon Funderud | Seaweed Energy Solutions |
| 21 | Maren Sæther | Seaweed Energy Solutions |
| 22 | Andreas Quale Lavik | Seaweed |
| 23 | Daniel Fedøy | Seaweed |
| 24 | Klaas Timmermann | Royal Netherland Institute for Sea Research |
| 25 | Miryam Pippich | The Oslo School of Architecture and Design |
| 26 | Leiv Mortensen | NMBU |
| 27 | Anton Voskoboynikov | Norway Seaweed AS |
| 28 | Pål Anders Nyhus | Norway Seaweed AS |
| 29 | Johan Hernes | Salten Alge AS |
| 30 | Jarl Hernes Gåsvær | Salten Alge AS |
| 31 | Helene Aarland Holm | Ocean Forest |
| 32 | Sunniva Haldorsen | Ocean Forest |
| 33 | Gunvor Øie | SINTEF Ocean |
| 34 | Reinhold Fieler | Akvaplan NIVA |
| 35 | Aleksander Handå | SINTEF Ocean |

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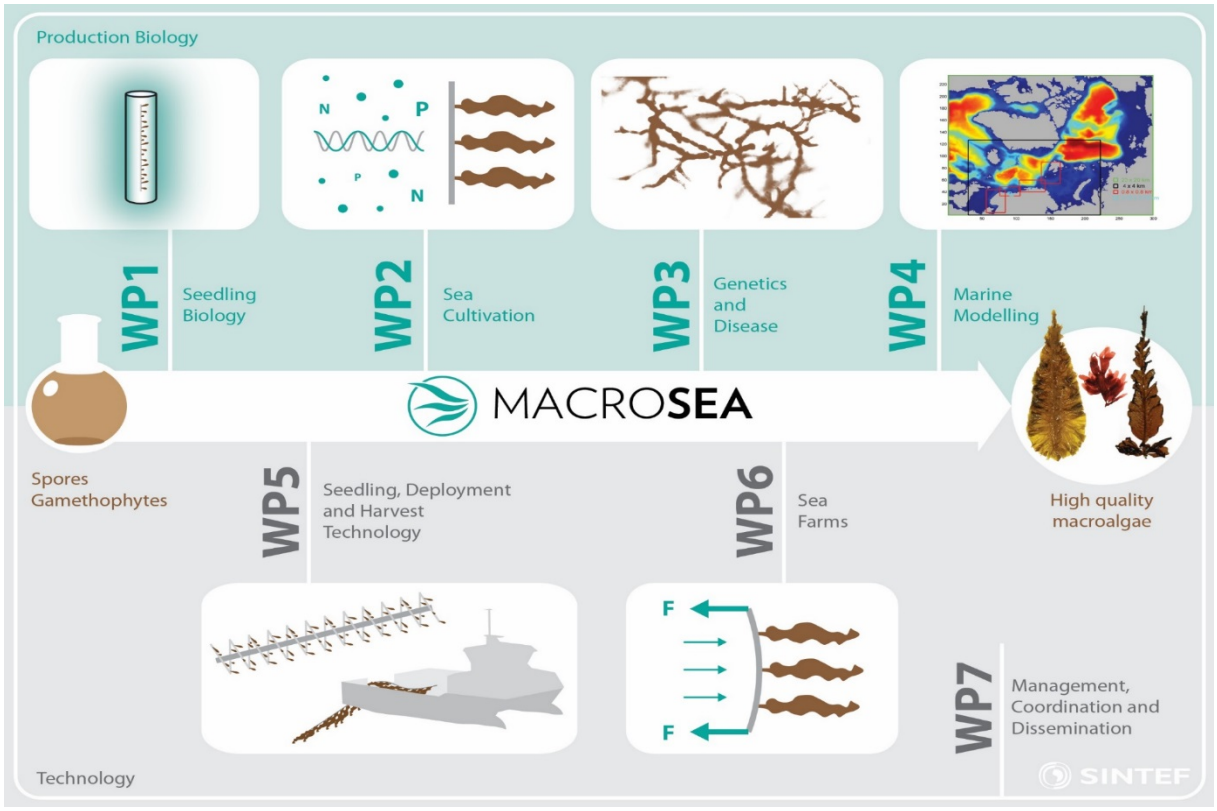
# A Knowledge Platform for Industrial Macroalgae Cultivation




http://www.macrosea.no

SINTEF NTNU Akvaplan niva SEAWEED ENERGY SOLUTIONS AS AUSTEVOLL SEAWEED FARM Hortimare

NIVA UiT THE ARCTIC UNIVERSITY OF NORWAY SAMS BIOKRAFT PE REEFS VITALIZE THE OCEAN Folla Alger AS OCEAN FOREST SEAWEED FROM NORWAY

UiO University of Oslo UNIVERSITY OF BERGEN Clarkson UNIVERSITY AARHUS UNIVERSITY IOCAS INSTITUTE OF OCEANOLOGY, CHINESE ACADEMY OF SCIENCES

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# BRIEF PROGRESS REPORT AS BACKGROUND FOR THE ANNUAL MEETING

**Evaluation of different quality parameters for *Alaria* gametophytes (WP1)**

- We have carried out a number of experiments to identify good methods for quality evaluation of *Alaria* gametophyte cultures. OD- and fluorescence-measurements, chemical composition and photo imaging are among the analysis used on material from experiments with different seeding densities and growth enhancers. Preliminary results suggest that a photoperiod of 23:1 h L:D gives fastest fertility induction and that a period of 8 days are needed before seeding. We have developed image analysis methods for effective counting of gametophytes on seeded material.

- **N-uptake study (nitrate and ammonia) in *Saccharina* (WP2)**
  - A lab experiment was conducted in April with juvenile S. latissima (8-12 cm in length). The experiment was run with both N-saturated and N-starved plants. Six different concentrations of NO3 and NH4 were used (two separate experiments) and samples were taken at seven different time intervals. Analysis are being run these days, and results seems promising.

- **Regional monitoring programme with *Saccharina* (WP1, WP2, WP3, WP4)**
  - Seeded ropes were prepared and sent from SINTEF Sealab to all participants for deployment at sea in early February. A few challenges occurred due to missing licences for some sites the first weeks and some struggled to get equipment and seedlings in place due to bad weather. We have still managed to get quite some good data sets from several locations. In addition to the industry partners our PhD students Silje and Sanna and MSc students Guri and Solveig have done a great job with getting registrations done at the different locations. The monitoring programme is completed and we are currently doing analysis.

- **Population genetics (WP3)**
  - Samples of Saccharina latissima for population genetic analyses have been collected from stations from south to High North along the Norwegian coast in the monitoring programme and along Sognefjorden in a gradient from the innermost parts to the outer coastal parts. Samples of sugarkelp from Hardangerfjord and the coastal parts between the two fjords has been collected in a similar way, and the samples will be used in a study of degree of local population connection and gene flow in a fjord seascape.

- **Follow up the *Saccharina* seedlings from the monitoring program in the lab (WP1)**
  - Since the seedlings in the monitoring programme are deployed at different environmental conditions we also kept seedlings under identical conditions at the lab to evaluate differences in quality. We have collected samples for analysis of amino acids, CN and phlorotannins, comparative to the field samples.

- ***Palmaria* seedlings protocol (WP1)**
    - Based on last season's preliminary studies this years's experiments focus on 1) Disinfection protocol, including test of different chemicals and subsequent incubation conditions, 2) Induction of spore release, and 3) Development of seedlings on rope including studies of time needed for proper attachment, performance in flow-through conditions, effect of different light regimes.

- **Implement light shading model, general individual-based population and farm model for kelp aquaculture (WP4)**
    - Light shading model is being implemented
    - Population model (dynamical simulation of mortality, population structure and individual interactions) for kelp culture has been implemented and is being tested.

**WP5 and WP6 has arranged a workshop on seaweed production technology** with contributions from seaweed producers, equipment manufacturers and R&D institutes in September 2017. The response from the participants was very positive.

- **Seedling, deployment and harvesting technology (WP5)**
    - Adaptations to next generation seaweed rope spinner (designed at SINTEF with the Mtech company as subcontractor) for in situ use in deployment are being studied. The seeding time/speed (meter seeded rope per day) has been increased 6-10 times in MACROSEA. Design and evaluation of a new production concept for large scale production have resulted a design study of the MACROSEA eSpoke seaweed farm concept planned for a fully automated deployment and harvest operation.
    - Camera based method tested for evaluation of seedling content on substrate before deployment. The method was used to document the status of the seedlings for all test locations before they were sent out from SINTEF. Further work will focus on quantification of the results.

- **Testing and drag-measurements using different configurations of seaweeds in sea and towing tank, start developing numerical model (WP6)**
    - Towing experiments have been conducted at the Marine Cybernetics laboratory at NTNU. Two simplified models of *L. saccharina* were tested. Drag forces were measured at different speeds, while the movement of the models were recorded by a camera under water.
    - Towing experiments at sea have been conducted to add to last year's experiment data. 1 m ropes with seaweed from SES' site Taraskjæra were attached to a raft rig towed 100 m behind SINTEF ACE's research vessel Torra. Currents were measured to record the speed and loads were measured with a load cell.
    - Data from the experiments are to be analysed and used for developing a numerical model for seaweed hydrodynamics.

## EDUCATION

Education is an important part of MACROSEA to create a broad knowledge platform.

**PhD candidates**

- ***Silje Forbord*** (NTNU); WP1 & WP2 seedling quality brown species, nutrient ($NO_3$) uptake versus chemical composition in laboratory experiments and at sea as part of the regional monitoring programme. *Supervisor: Yngvar Olsen (NTNU), co-supervisor: Jorunn Skjermo (SINTEF).*
- ***Sanna Matsson*** (APN); WP2 fouling of brown species in laboratory trials and study of regional- , seasonal- and depth-dependency at sea as part of the regional study. *Supervisor: Bodil Bluhm UiT, co-supervisor: Hartvig Christie (NIVA).*
- ***Alexander Thomson (SAMS)*** on disease (WP3). *Supervisor: Michele Stanley (SAMS), co-supervisor: Kjersti Sjøtun (UiB)*
- ***Saifullah Saifullah (NTNU)*** on regional- , seasonal- and depth-dependent growth at sea to be decided; WP2 growth, nutrient uptake and biochemical composition (protein and carbohydrate) in the regional study. *Supervisor: Yngvar Olsen (NTNU), co-supervisor: Aleksander Handå (SINTEF).*
- ***Siv Anina Etter (NTNU - DTU Aqua collaboration)*** on IMTA. WP2 nutrient ($NH_4$) uptake versus chemical composition in laboratory experiments and at sea. *Supervisor: Kjell Inge Reitan (NTNU), co-supervisors: Yngvar Olsen (NTNU) and Aleksander Handå (SINTEF).*
- ***Peter Søndergaard Schmedes (DTU Aqua – NTNU collaboration)*** on *Palmaria palmata* protocol development and cultivation at sea. *Supervisor: Mette Møller Nielsen (DTU-Aqua) , co-supervisor: Kjell Inge Reitan (NTNU)*

**MSc, BSc, internships and summer students**

- ***Master student Tonje Ness*** *at University of Bergen* (WP3 Genetics and disease). *Supervisor: Kjersti Sjøtun (UiB), co-supervisor: Geir Dahle (UiB).*
- **Summer Student Emil Scott Bale** from NTNU (Product development and materials science) will work within WP5 with focus on seaweed production and harvesting technology.
- ***Master student Aires Duarte*** from University of Porto (WP1 Seedling Biology - gamethophytes). *Supervisor: Isabel Sousa Pinto (CIIMAR/University of Porto), co-supervisor: Jorunn Skjermo.*
- ***Internship student Raven Cammenga*** (Hogeschool VHL, University of Applied Sciences Netherland, SINTEF); (WP1 Seedling Biology - gametophytes). S*upervisor: Jorunn Skjermo*
- ***Master student*** Vegard Rønning Dahlen at NTNU; WP2 IMTA; N-uptake in *S. latissima*. *Supervisor: Kjell Inge Reitan, co-supervisor: Siv Anina Etter*
- ***Master student Guri Elilla Brodahl*** at NTNU; WP2 Monitoring programme. *Supervisor: Yngvar Olsen, co-supervisors: Aleksander Handå and Silje Forbord*

- ***Master student Solveig Foldal*** at NTNU; WP2 Monitoring programme. *Supervisor: Yngvar Olsen, co-supervisors Ole Jacob Broch, and Silje Forbord*
- ***Master student Carina Norvik at NTNU:*** **WP6.** SCALING AND SIMPLIFIED REPRESENTATION OF AQUATIC VEGETATION IN STEADY FLOW. *Supervisor: Dag Myrhaug, co-supervisors: Pierre-Yves Henry and Andreas Myskja Lien*
- ***BSc student Sonia Gagen*** from Clarkson University; WP4 Life-cycle inventories for macroalgae aquaculture. *Supervisor: Shane Rogers (Clarkson)*
- ***BSc student Oliver Evans*** from University of Akron, Ohio, REU-prorgramme through Clarkson; WP4: Mechanistic model for light (self) shading in kelp cultures. *Supervisor: Shane Rogers*
- ***Summer student Henriette D*ybvik:** WP5 Development of new technology for industrial macroalgae cultivation. *Supervisor: Morten Alver*
- ***Summer and student*** **Carina Norvik:** WP6 Design of artificial seaweeds for assessment of hydrodynamic properties of seaweed farms. *Supervisor: Andreas M. Lien.*

## DISSEMINATION

### Scientific papers

1. **1st MACROSEA paper:** Thanks to ShaoJun Pang and his research group for supporting knowledge-transfer between MACROSEA partners. You can read their latest publication entitled *Large-scale hatchery of the kelp Saccharina japonica: a case study experience at Lvshun in Northern China*, in Journal of Applied Phycology: https://link.springer.com/article/10.1007/s10811-017-1154-y

### Popular science papers

1. Skjermo, J. 2016. Havet som ressurs – fremtidig potensiale i dyrking av tang og tare. Praktisk økonomi og finans 32, 265-273. *In Norwegian.*

### Book chapters

1. Protocols for Macroalgae Research (Charrier B, Wichard T, Reddy CRK, Eds) CRC Press, Taylor & Francis Group. Chapter 2. Cultivation protocol for *Saccharina latissima. S. Forbord, K. Braaten Steinhovden, K. K. Rød, A. Handå, J. Skjermo*

### Reports

1. Broch OJ, Tiller R, Skjermo J, Handå A. (2017) Potensialet for storskala dyrking av makroalger I Trøndelag (in Norwegian), ), SINTEF report no. OC2017 A-200, ISBN: 978-82-7174-319-2. Summary in English. http://hdl.handle.net/11250/2457837

2. Bale, ES. (2017) Development of area efficient and standardized structures for large-scale macroalgae cultivation. SINTEF summer student report.
3. Norvik, C. (2016) "Design of artificial seaweeds for assessment of hydrodynamic properties of seaweed farms". SINTEF summer student report.
4. Dybvik, H. (2016) "Concept development for macroalgae seeding, deployment and harvesting". SINTEF summer student report.
5. Broch OJ, Skjermo J, Handå A. (2016) Potensialet for storskala dyrking av makroalger i Møre og Romsdal (in Norwegian), SINTEF report no. A27869, ISBN:978-82-14-06099-7. Summary in English. https://www.sintef.no/en/publications/publication/?pubid=SINTEF+A27869

**Media 2016-2017 - press releases with "MACROSEA" from Retriever**

1. Skjær i sjøen for norsk tareproduksjon - Kyst.no 17.07.2017
2. Tror tare kan bli den nye olja - Saltenposten 03.06.2017
3. Kan produsere 500 tonn tare - Kyst.no 22.03.2017
4. Lørdag setter han ut tare i Tana - Sør-Varanger Avis 10.02.2017
5. Flere bruksområder. Fædrelandsvennen 17.01.2017
6. Vil dyrke tare flere steder på Sørlandet - Fædrelandsvennen - 16.01.2017
7. Nå skal forskerne dyrke tang og tare - iTromsø 09.06.2016
8. Akvaplan Niva vil inn i Norges største tareprosjekt - iLaks 08.06.2016
9. Nå vil tromsøforskere dyrke tang og tare - iTromsø 07.06.2016
10. Bør kunne 20-doble produksjonen av tang og tare - Forskning.no 25.04.2016
11. De vokser fra 1 centimeter til 1,5 meter på fem måneder. Nå kan de bli vår nye milliardindustri - Teknisk Ukeblad 23.04.2016
12. Håper på milliardutsikter i tang og tare - iLaks 20.04.2016
13. Utvikler ny, norsk milliard-industri - Kyst.no 20.04.2016
14. Clarkson professor selected for Fulbright Scholar Award to Norway - North Country Now 19.03.2016