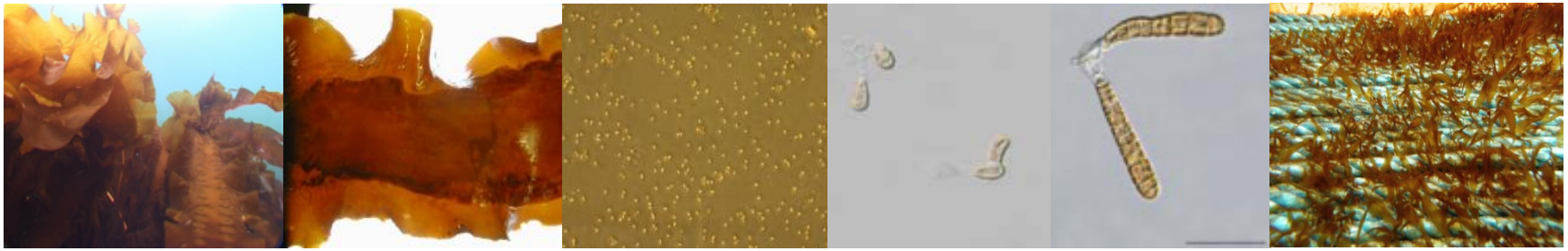
Seaweed Hatchery and Cultivation Methods



Silje Forbord

SINTEF Fisheries and Aquaculture

Zeeland 18-19 September

Outline

1. Development of *Saccharina latissima* (Phaeophyceae) kelp hatcheries with year-round production of zoospores and juvenile sporophytes on culture ropes for kelp aquaculture

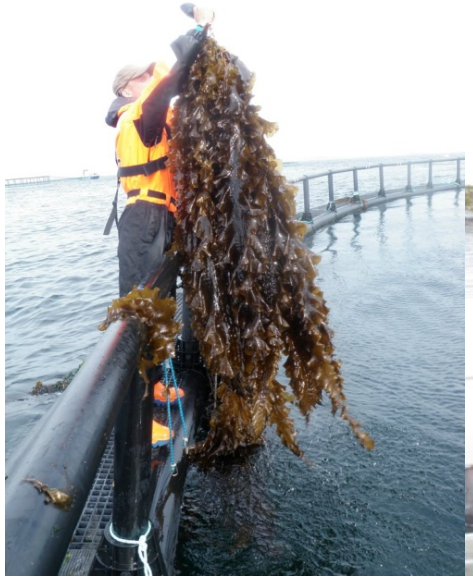
2. Sorus disinfection methods

3. Seedling production and hatchery systems

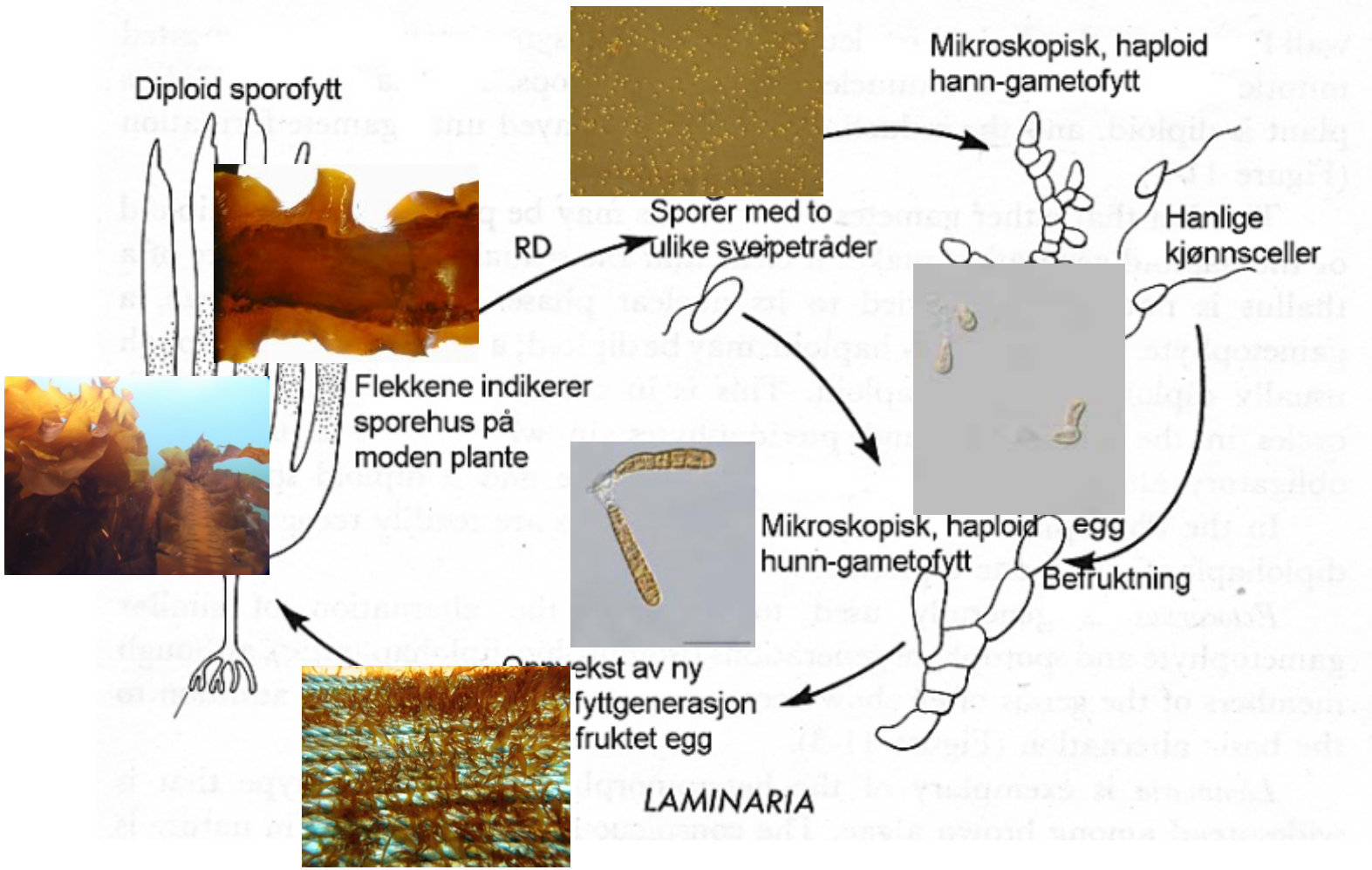
4. Projects and partners

Background

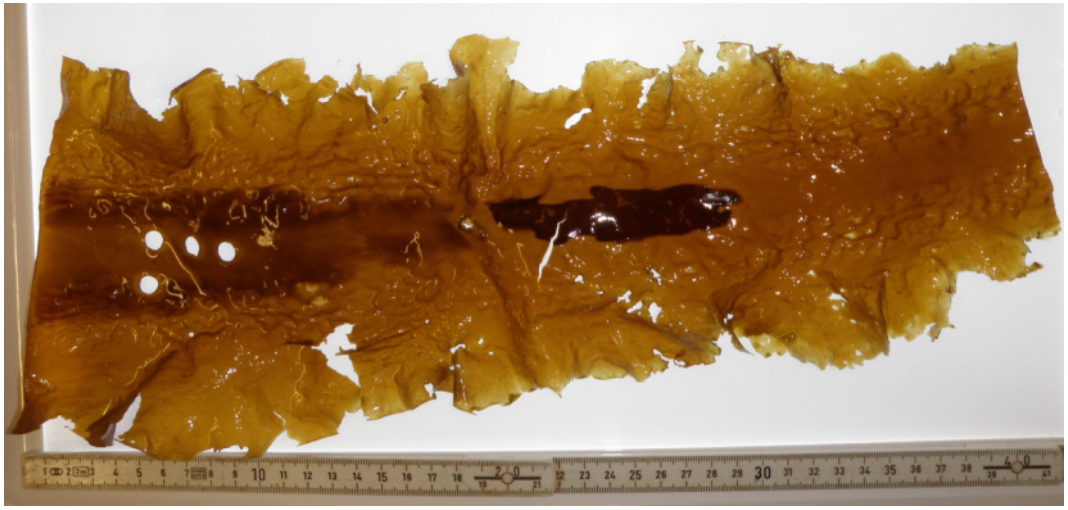
- A biomass with great potential
  - 3.generation biofuel
  - Food and feed
  - Chemicals
  - Fertilizers and minerals
- Integrated Multi-Trophic Aquaculture (IMTA)
- Challenges:
  - Cost efficient
  - Industrial biomass production
  - Areas for cultivation
  - BioRefinery
  - Year-round production



Laminaria life cycle



Induction of sorus



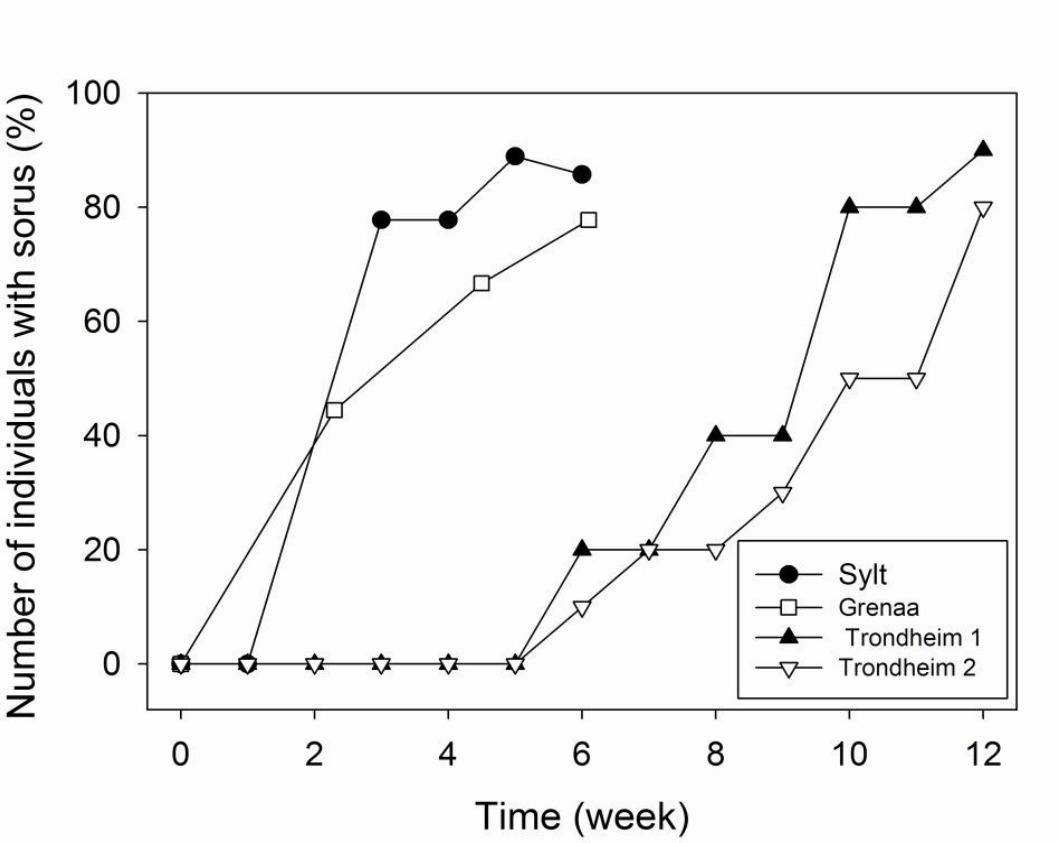
Short day (8:16)
Low light intensities (100 µmol)
Low temperature (10 degrees)
Number of weeks? Time of year?

January 2010-March 2011

Locations for lab and field studies

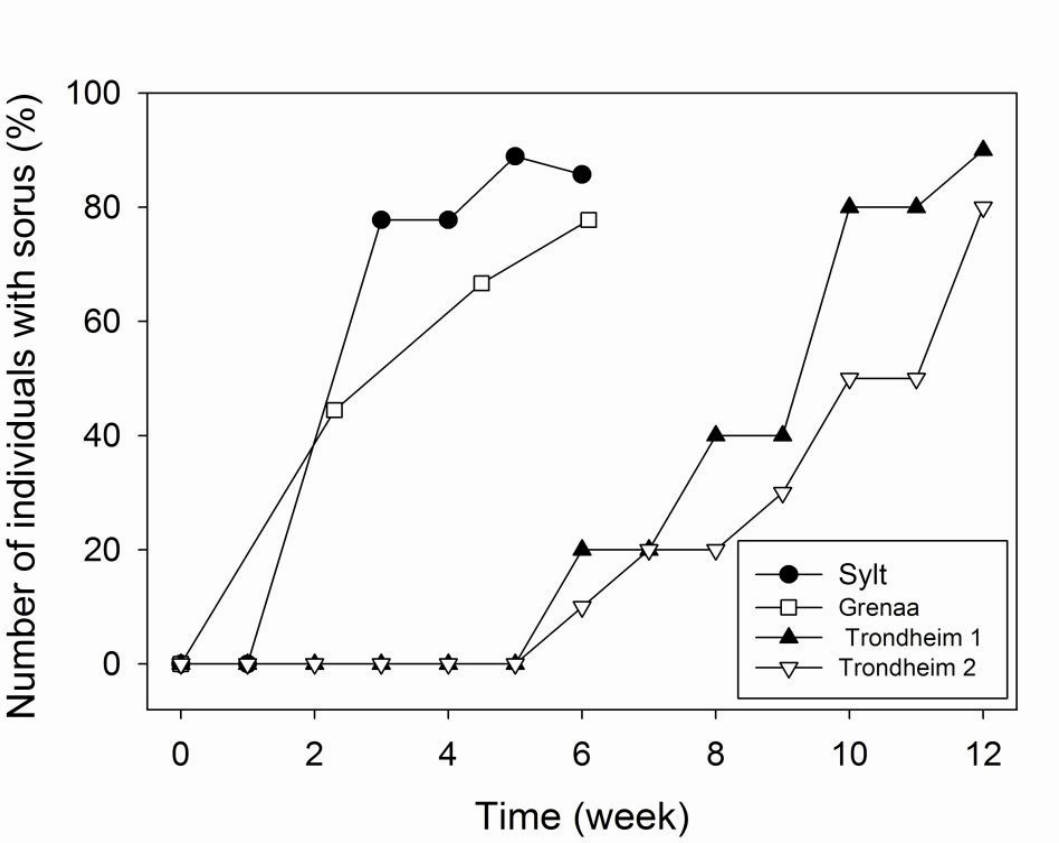
- Trondheim (Norway)
- Grenaa (Denmark)
- Sylt (Germany)

Results sorus developement



- Visible sorus were first evident after 2-3 weeks in Sylt and Grenaa and 6 weeks in Trondheim
- Around 80% of the sporophytes formed sorus at all three locations

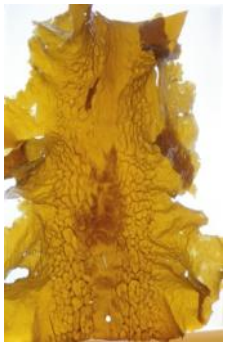
Results sorus developement



6 weeks

11 weeks

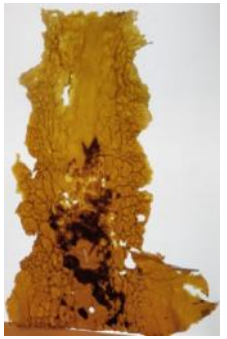
9 weeks



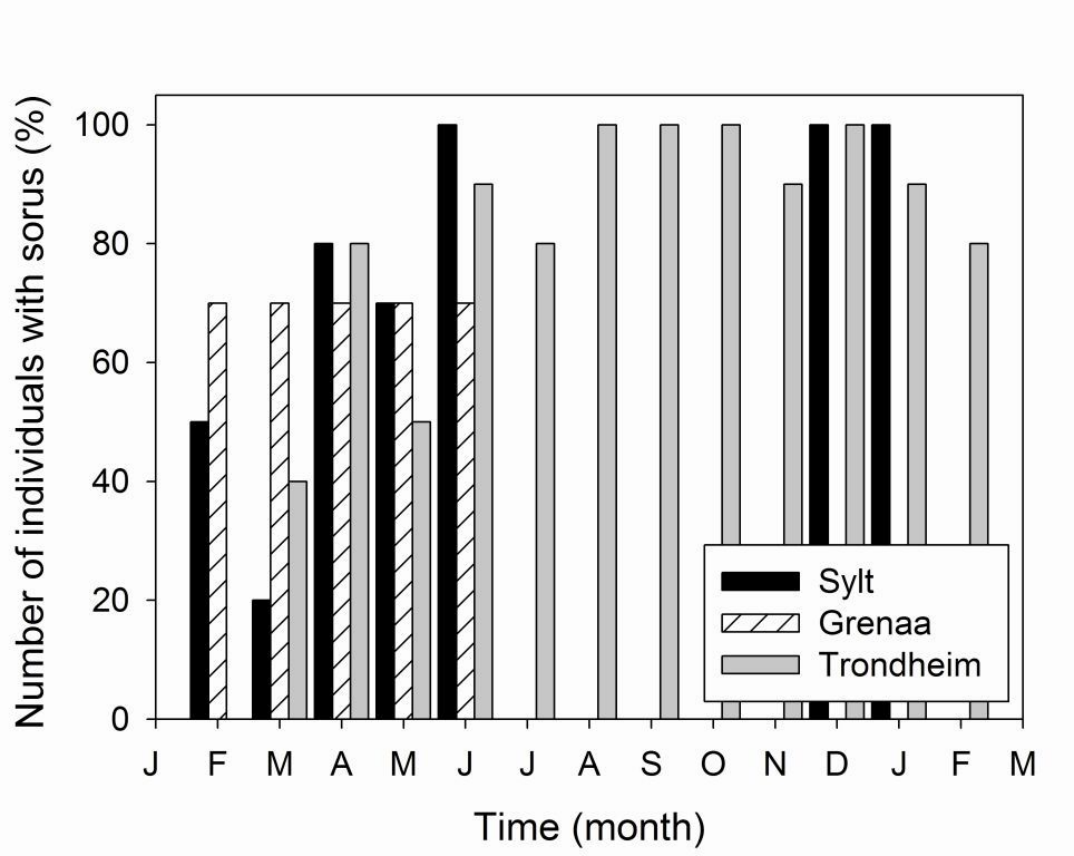
12 weeks

10 weeks

14 weeks

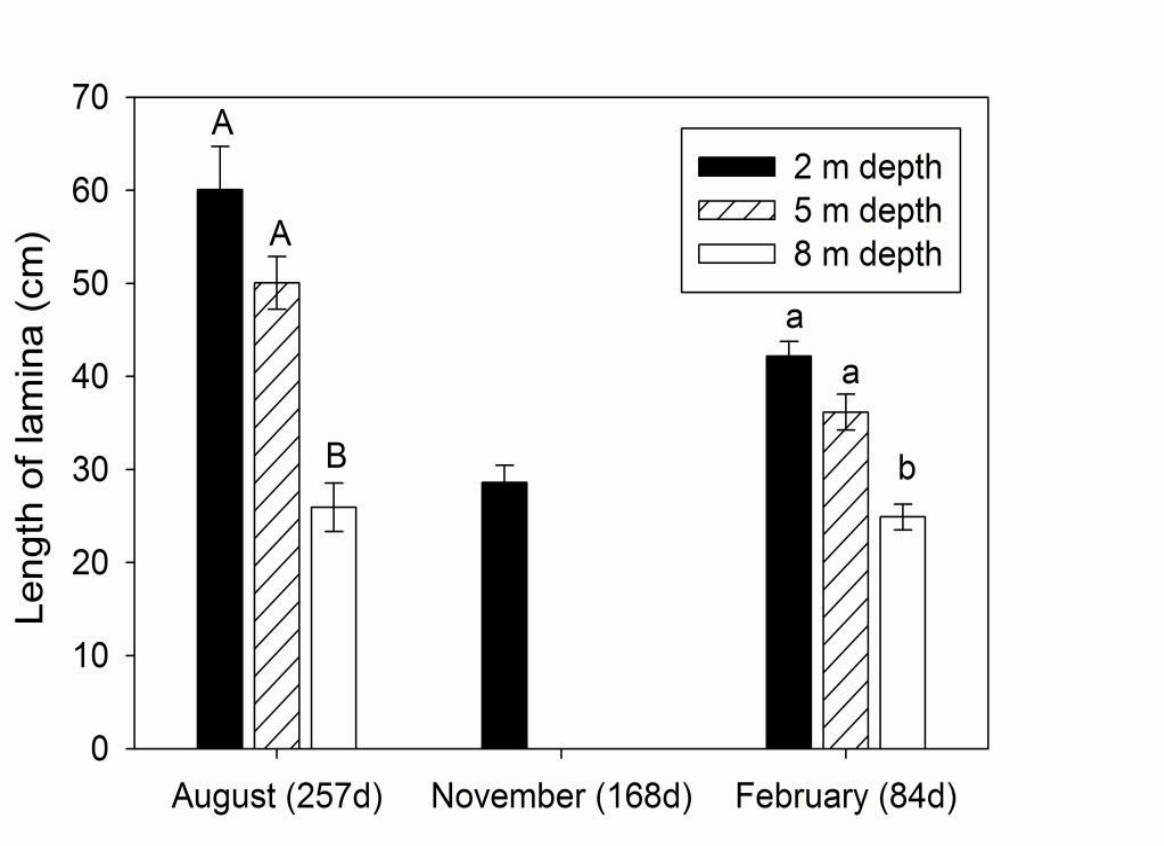


Seasonal sorus development



- Visible sorus at the end of experimental series
- 70-100% of the treated individual formed sorus
- High variability during the year
- Successful at time of year when sorus is naturally lacking in the field

On-growth at sea



2 m

5 m

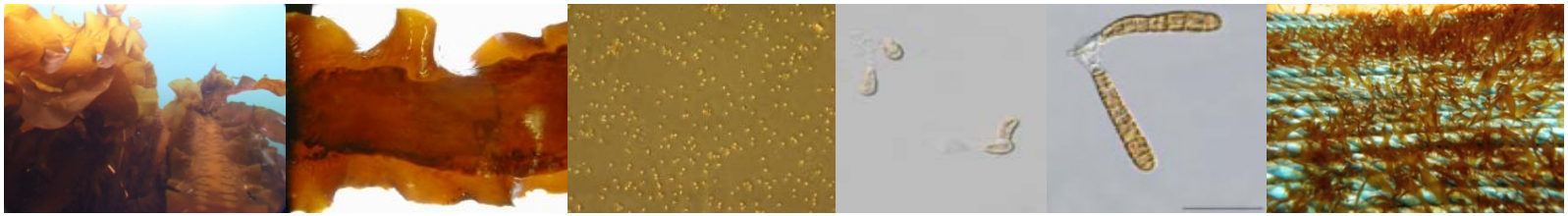
8 m

Conclusions

- The majority of the vegetative blades may be reliably converted into sporogenous blades independent of season
  - Some small differences in cultivation procedures between the labs ⇨ robust method

- Viable zoospores independent of season
  - Year-round production makes it possible to exploit the plants good growth potential on the most suitable time of the year
  - Not all seasons are favorable for deployment and on-growth in sea
  - Need continous access of zoospores to maintain gametophyte cultures

Forbord S., Skjermo J., Arff J., Handå A., Reitan K. I., Bjerregaard R., Lüning K. (2012) Development of *Saccharina latissima* (Phaeophyceae) kelp hatcheries with year-round production of zoospores and juvenile sporophytes on culture ropes for kelp aquaculture. J Appl Phycol 24:393-399



Sori disinfection in cultivation of *Saccharina latissima*

Aim of the thesis:

To find a disinfecting method that relieves sori from diatom contamination, without damaging spores or affect early development of young sporophytes

Chemical survey on diatoms

Positive growth when SGR > 0.05

Chemical	Exposure time	Exposure temp: 10°C				Exposure temp: 15°C			
Acetic acid	*Concentration*	*1%*	*7%*	*35%*	*50%*	*1%*	*7%*	*35%*	*50%*
	2min	-	-	-	-	-	-	-	-
	4min	-	-	-	-	-	-	-	-
	10min	-	-	-	-	-	-	-	-
	30min	-	-	-	-	-	-	-	-
Ethanol	*Concentration*	*25%*		*50%*	*70%*	*25%*		*50%*	*70%*
	2min	+		+	-	-		+	-
	4min	+		-	-	-		-	-
	10min	-		+	-	-		-	-
	30min	-		-	-	-		-	+
Formaldehyde	*Concentration*	0.04%		0.4%	4%	0.04%		0.4%	4%
	2min	+		+	-	+		+	-
	4min	+		-	-	+		+	-
	10min	+		-	-	+		-	-
	30min	+		-	-	+		-	-

Chemical survey on diatoms

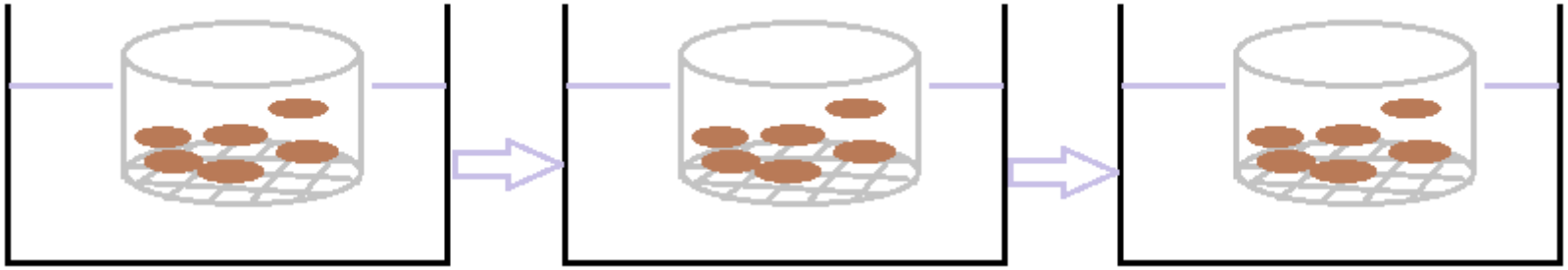
Positive growth when SGR > 0.05

Chemical	Exposure time	Exposure temp: 10°C			Exposure temp: 15°C		
Lugol's solution	*Concentration*	*0.02%*	*0.2%*	*2%*	*0.02%*	*0.2%*	*2%*
	2min	+	-	-	-	-	-
	4min	+	-	-	-	-	-
	10min	+	-	-	-	-	-
	30min	+	-	-	-	-	-
Sodium hypochlorite	*Concentration*	6ppm	60ppm	600ppm	6ppm	60ppm	600ppm
	2min	-	-	-	-	-	-
	4min	-	-	-	-	-	-
	10min	-	-	-	-	-	-
	30min	-	-	-	-	-	-

➡ Acetic acid, Lugol's and Sodium hypochlorite were selected for sori disinfection experiments

Sori disinfection method

1. Disks of mature sori were punched out



2. Sori were bathed in a disinfecting solution for a given time interval

3. Sori were rinse in sterile seawater for 30seconds

4. Sori were rinse in sterile seawater for 30seconds

5. Spores were released

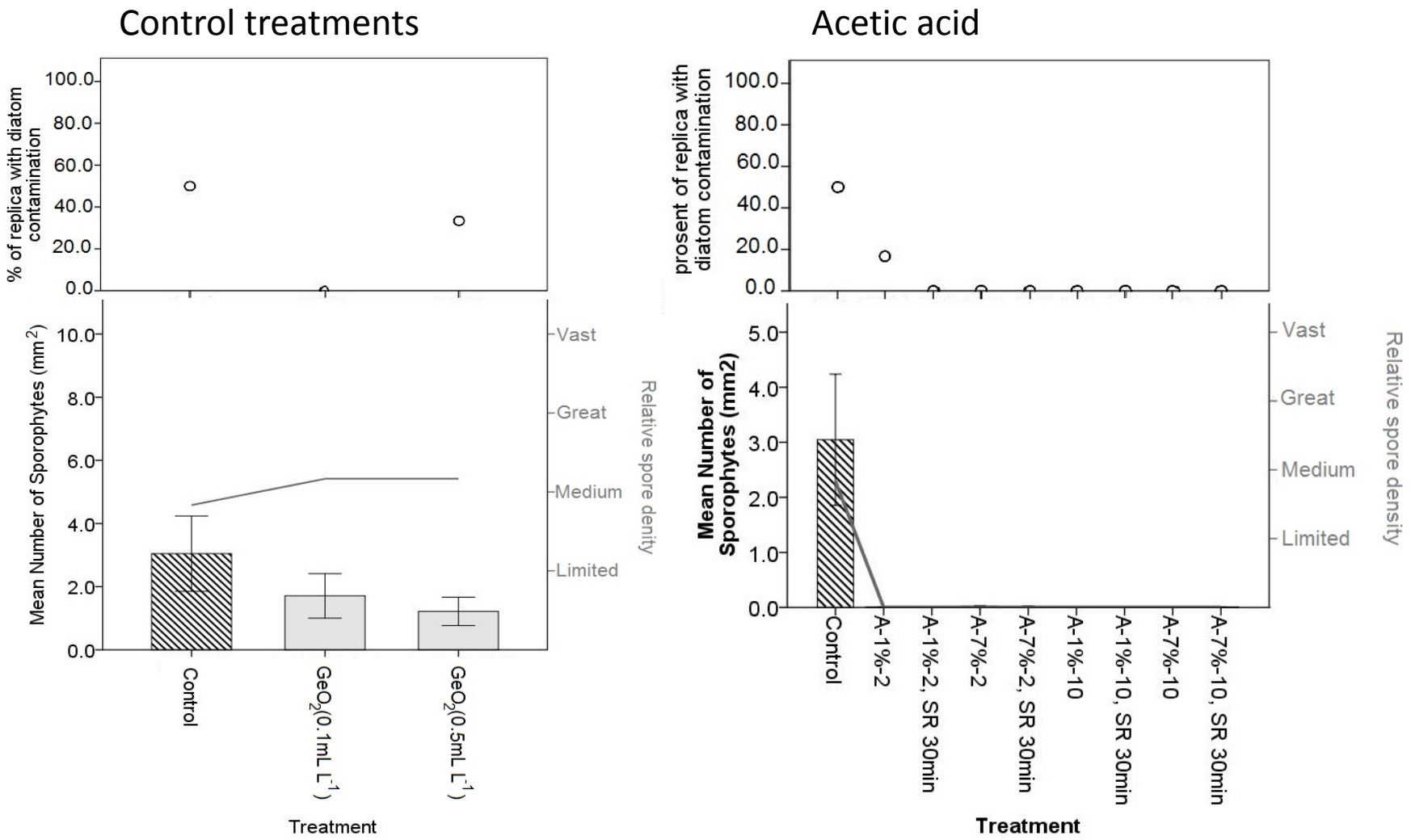


Figure 9: *Sporophyte density, relative spore density during spore release and presents of diatoms in samples added GeO2 (left) and samples from acetic acid disinfection (right). All samples treated with acetic acid were significant different from the control. Bars are mean ± 1SE, n=6. Line is relative spore density. The above dots are %-replica with diatoms present.*

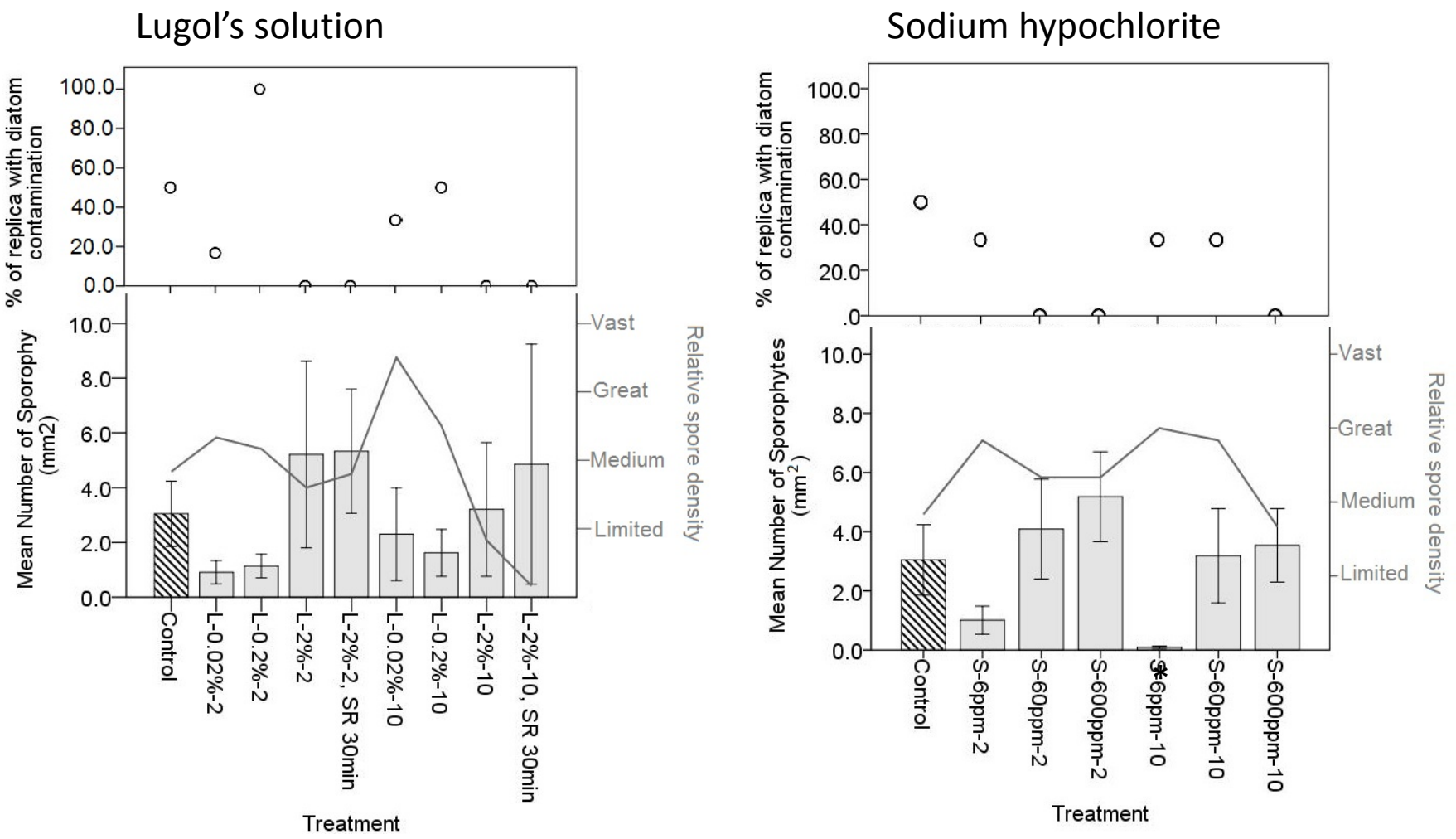


Figure 10: *Sporophyte density, relative spore density during spore release and presents of diatoms in samples from sorus disinfected with Lugol's solution (left) sodium hypochlorite (right). Bars are mean ± 1SE, *=Significant different from the control. Line is relative spore density. The above dots are %-replica with diatoms present.*

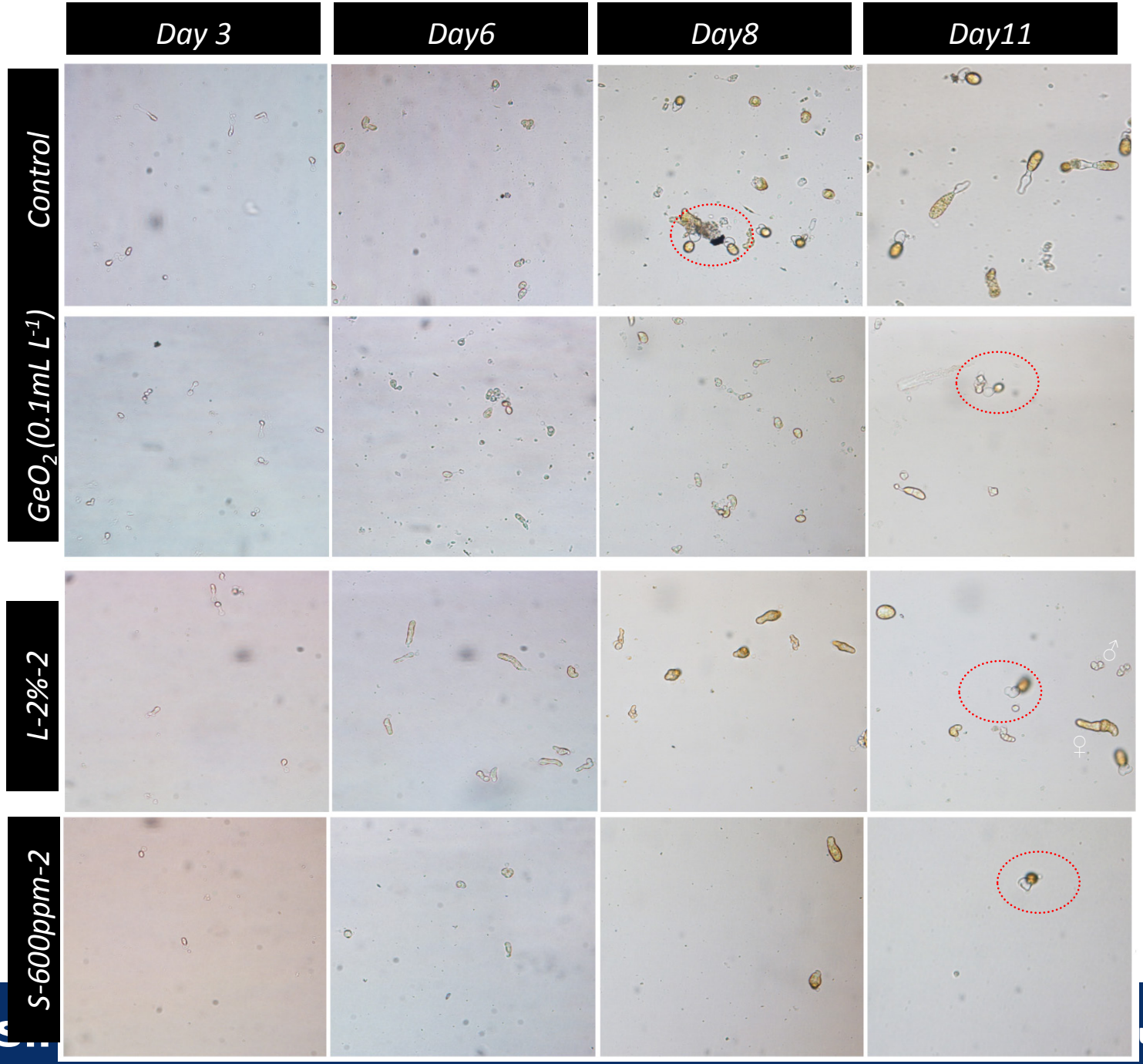


Foto: Kaia K. Rød

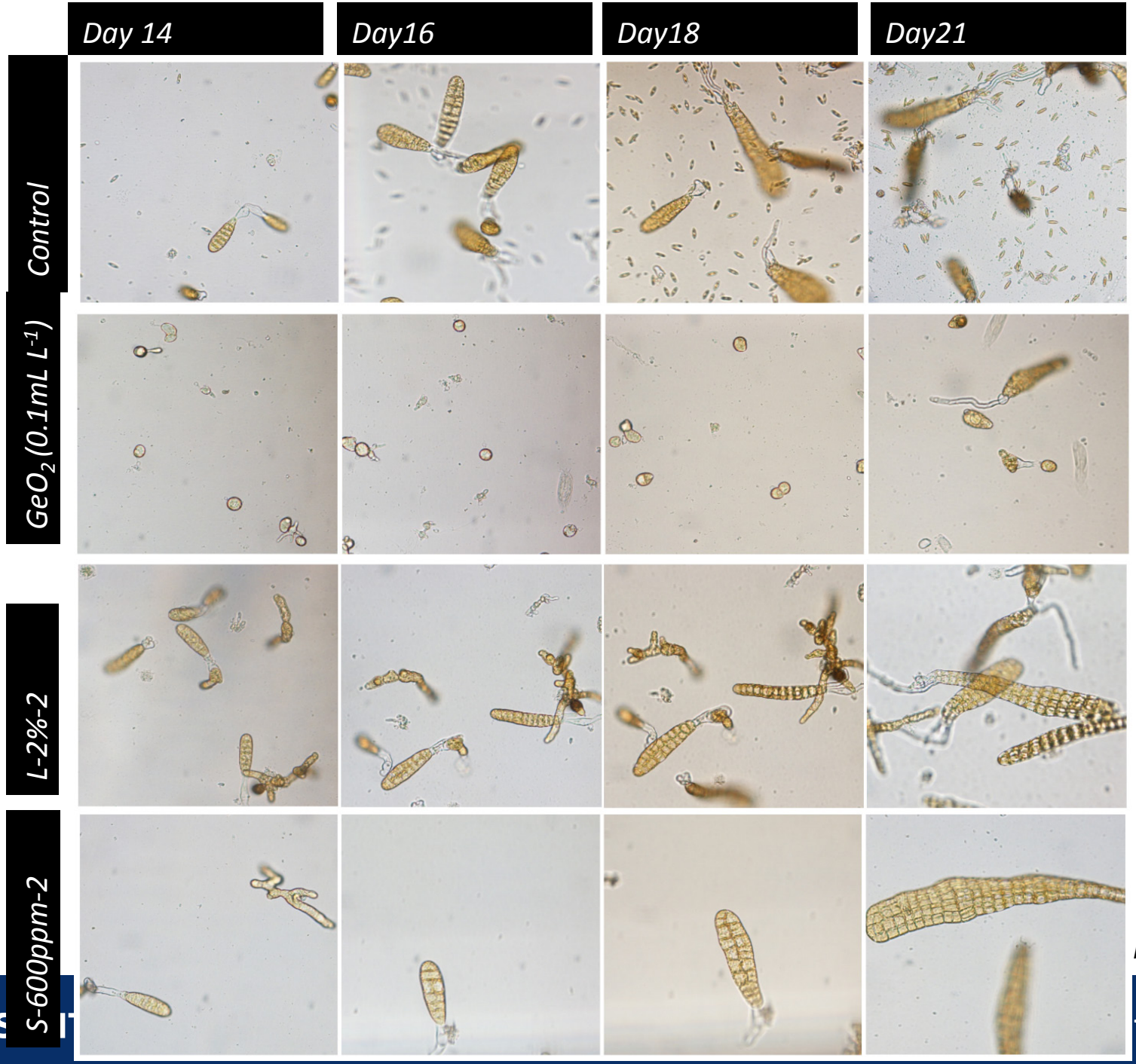


Foto: Kaia K. Rød

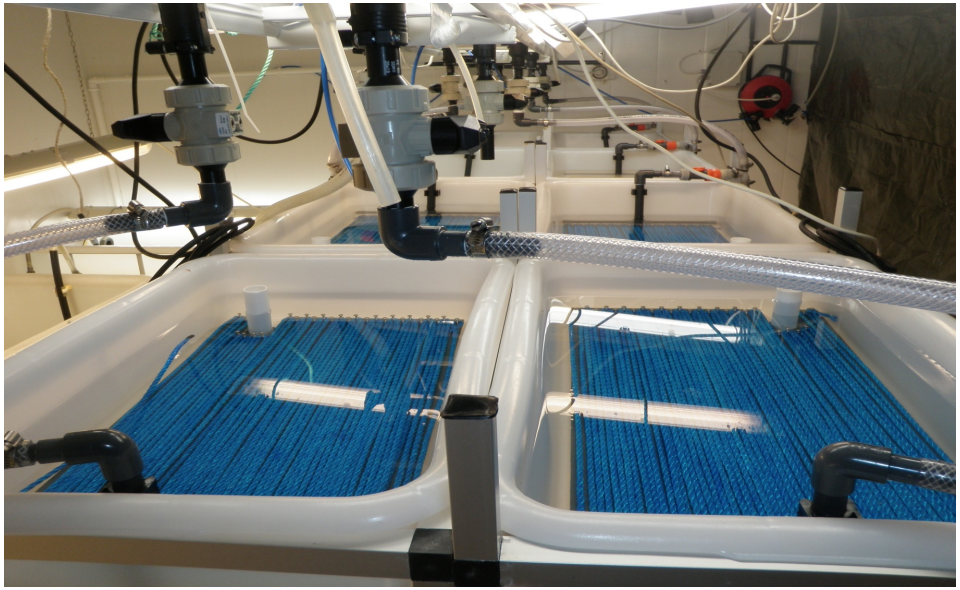
Conclusions

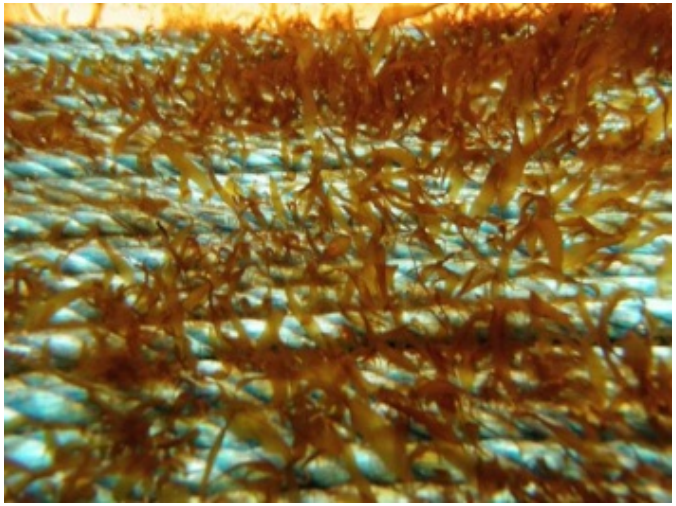
- Sodium hypochlorite-600ppm-2min-10°C and Lugol's solution-2%-2min-10°C are suitable disinfecting treatments
- Higher sporophyte density in absent of diatoms
- Indications of higher sporophyte density when the initial spore density is low
- Low density gives long sporophytes

Foto: Kaia K. Rød

Seedling production

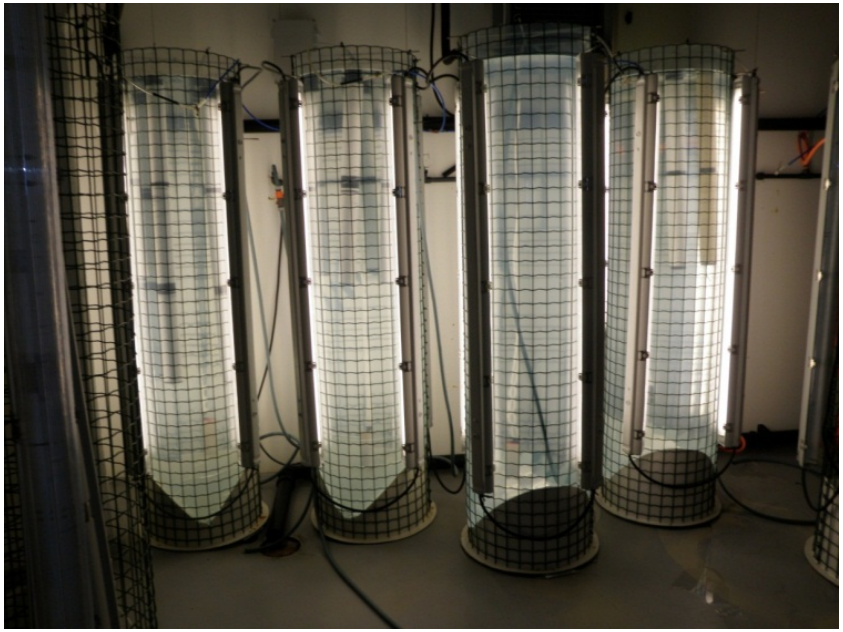
Hatchery system I

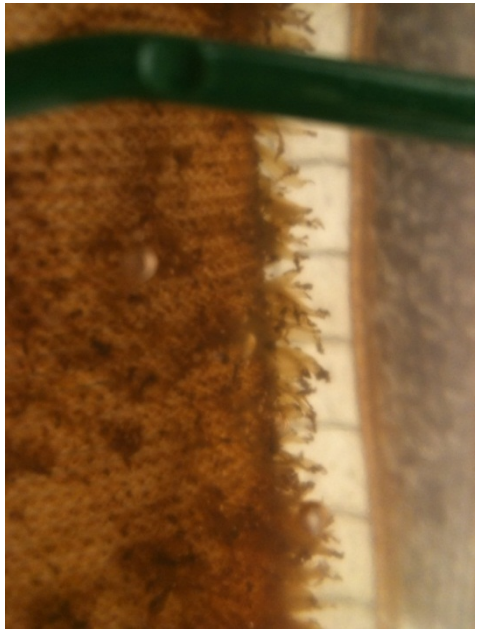




- 6-8 mm thick string
- Water exchange rate of 0.5 L/min
- UV treated water
- 16:8 h light:dark regime
- Good growth but not very space efficient (27 m rope per tank)
- Not necessary to attach to motherlines at deployment

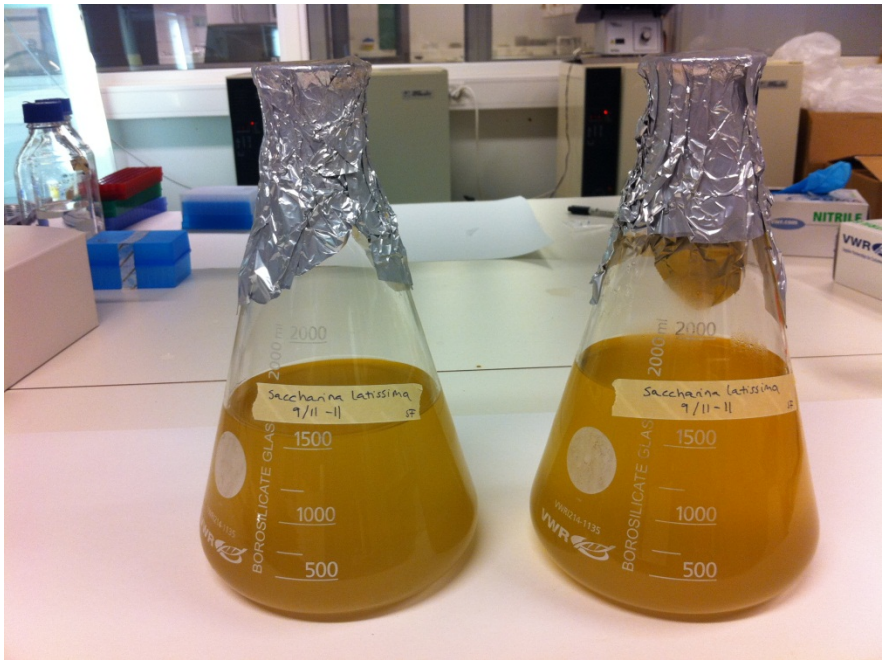
Hatchery system II

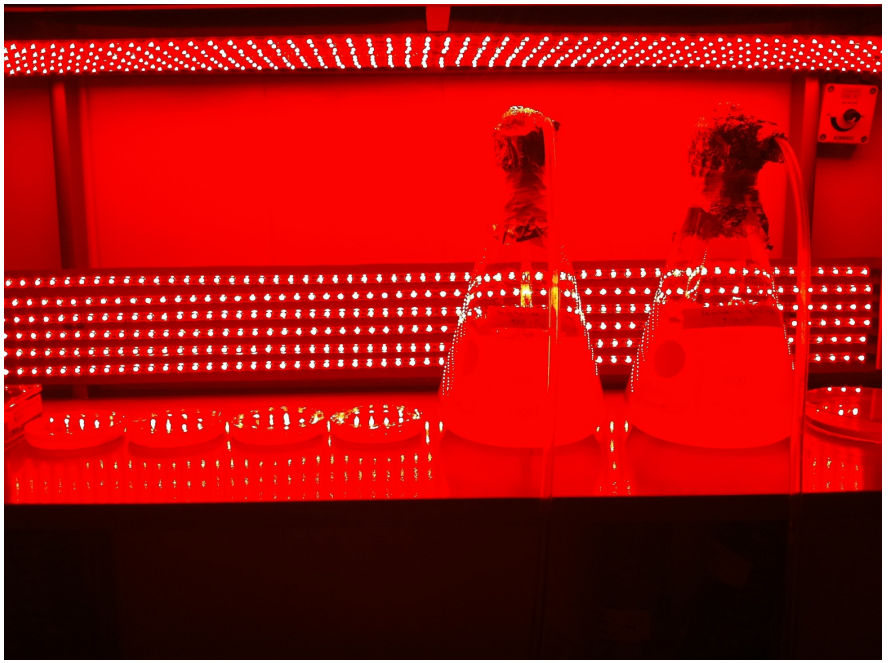




- 1-2 mm thick string
- Water exchange rate of 0.5 L/min
- UV treated water
- Aeration
- 16:8 h light:dark regime
- Space efficient, 720 m string per cylinder
- Seeded both with spores and gametophytes by spraying

Gametophyte cultures

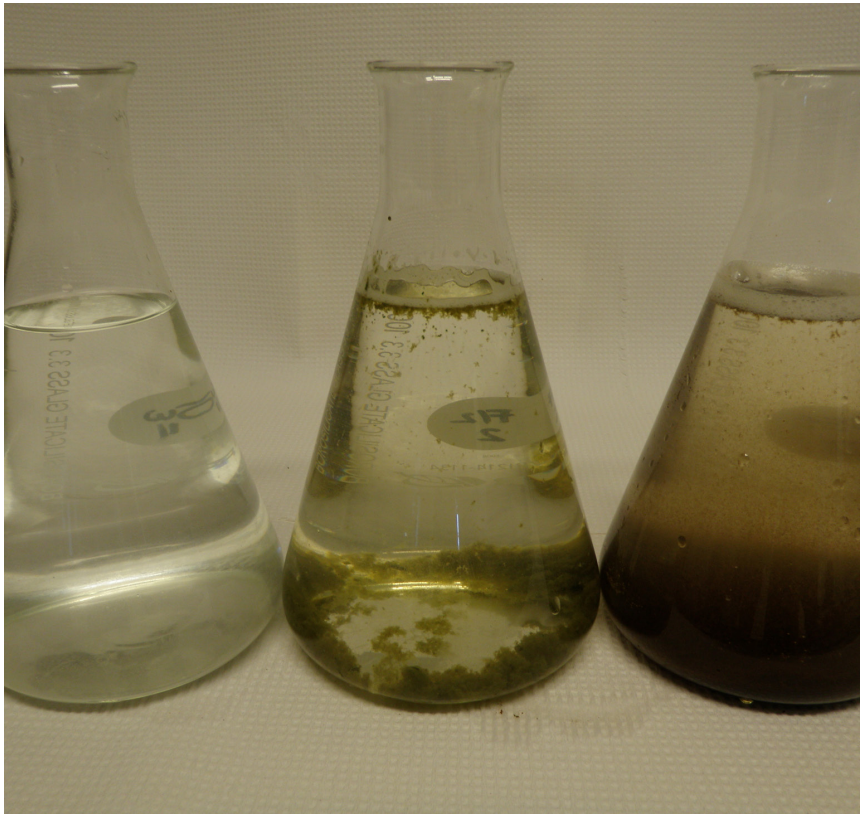




- Easy to upscale to an industrial scale
- Shorten the seedling phase
- Necessary for breeding work
- Ongoing experiments with growth medium, hormones, light intensities

Growth medium

Medium changed every week:
Seawater, F/2 (contaminated), Provasoli



Medium changed every second week:
Seawater, F/2, Provasoli

Projects and partners

- **MacroBiomass**
  - Duration: 2010-2012
  - Partners: SINTEF Fisheries and Aquaculture, Norwegian University of Science and Technology (NTNU), University of Oslo, Sylter Algenfarm (Germany), Blue Food (Denmark)
  - Financed by the Research Council of Norway

- **SeaBreed**
  - Duration: 2011-2013
  - Partners: SINTEF F&A, Seaweed Energy Solutions, CIIMAR (Portugal), Stolt Seafarm (Spain), NTNU
  - Financed by the Research Council of Norway

- **Exploit**
  - Duration: 2012-2014
  - Partners: SINTEF F&A, Institute of Marine Research, NTNU, Bellona
  - Financed by the Research Council of Norway

- **Norwegian Seaweed Technology Center**
  - SINTEF F&A and Materials and Chemistry, NTNU Biology and Biotechnology (main partners)
  - Norwegian and international R&D-institutions and industry (associated)
  - Financed by the Regional Research Council

Thank you for your attention!

Thanks to:
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Sanna Matheson (NTNU)
Klaus Lüning (Sylter Algenfarm)
Rasmuss Bjerregård (Blue Food)

Jorunn Skjermo, Aleksander Handå, Kristine Braaten Steinhovden, Kjell Inge Reitan and Johanne Arff
Norwegian Seaweed Technology Center

Welcome to the workshop "Seaweed for biofuels" in Trondheim, 25-26.September 2012!

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