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Effect of cultivation sites on biomass yield of Sugar kelp *Saccharina latissima* off the coast of Mid-Norway

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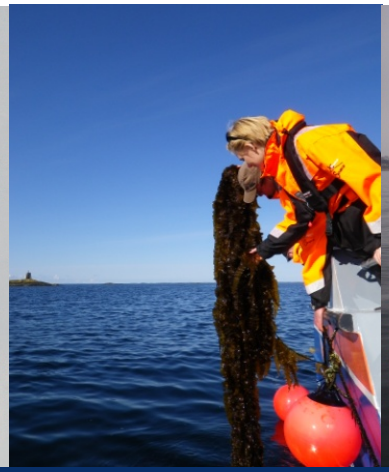
Outline

- Seaweed industry in Norway – state and potentials
- Characterization of cultivation sites by 3D modeling
- Cultivation experiment with sugar kelp
- Biogas potential in the seaweed biomass

Seaweed industry in Norway

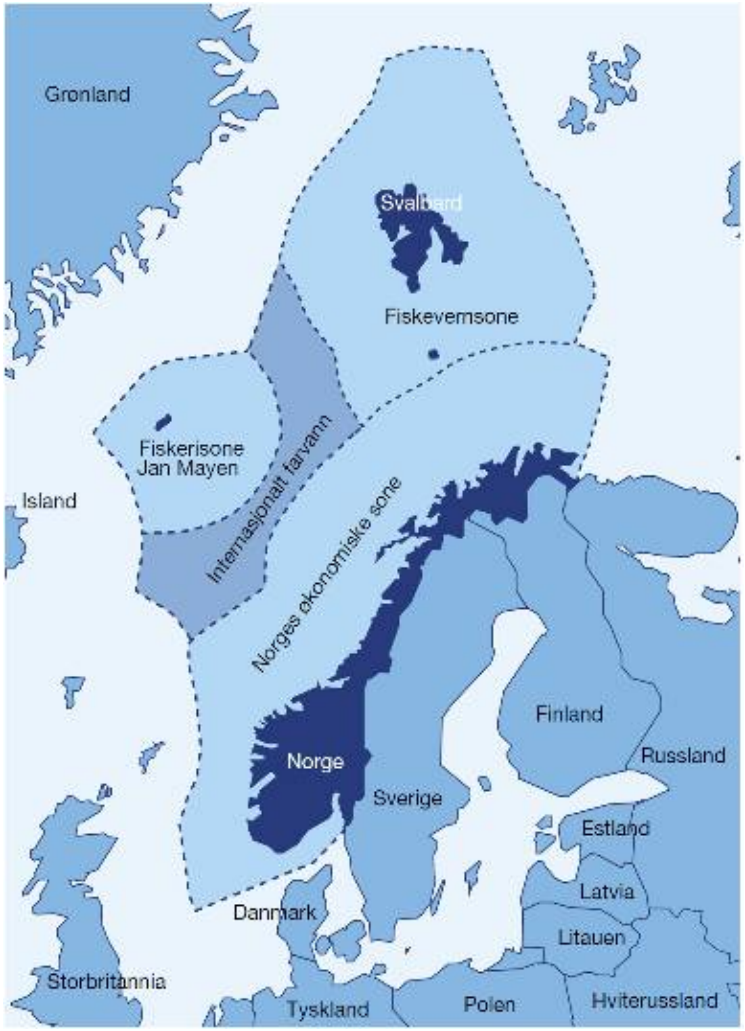
Species	Harvesting (tons wet weight per year)	Region	Usage	Company
Laminaria hyperborea	130 000 – 180 000	Rogaland – Sør Trøndelag	Alginate	FMC Biopolymer
Ascophyllum nodosum	10 000 – 20 000	Midt-Norge - Troms	Seaweed meal, extracts	Algea

Economic value (2011): 1,2 billion NOK (0,16 billion €)

No cultivation
Hugh potential in seaweed biomass not exploited

Photo: Mentz Indergaard

Norwegian advantages for seaweed cultivation (i)



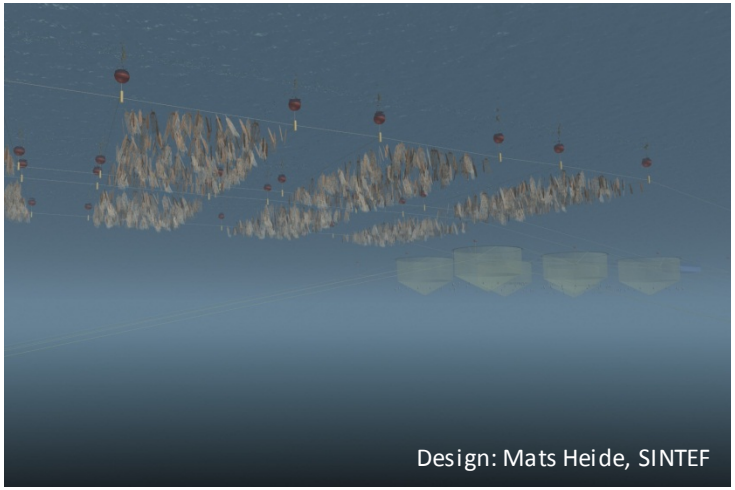
Geography

- Long coastline: 2 200 km
- Large economic zone
  - Inside sea boundary: 90.000 km^2

480 macroalgae species

- 205 red
- 175 brown
- 100 green

Norwegian advantages for seaweed cultivation (ii)



Knowledge and competence

- Technology
  - Aquaculture and off-shore oil&gas industry
- Biotechnology
  - Phycocolloids

The salmon aquaculture

- Possibilities for integrated cultivation (IMTA)

Industrial scale cultivation in Norway

Industrial scale a prerequisite

- Demands for cultivation areas outside the sheltered fjords

AIM of study

- Compare the suitability of sites with strong water currents with sheltered sites

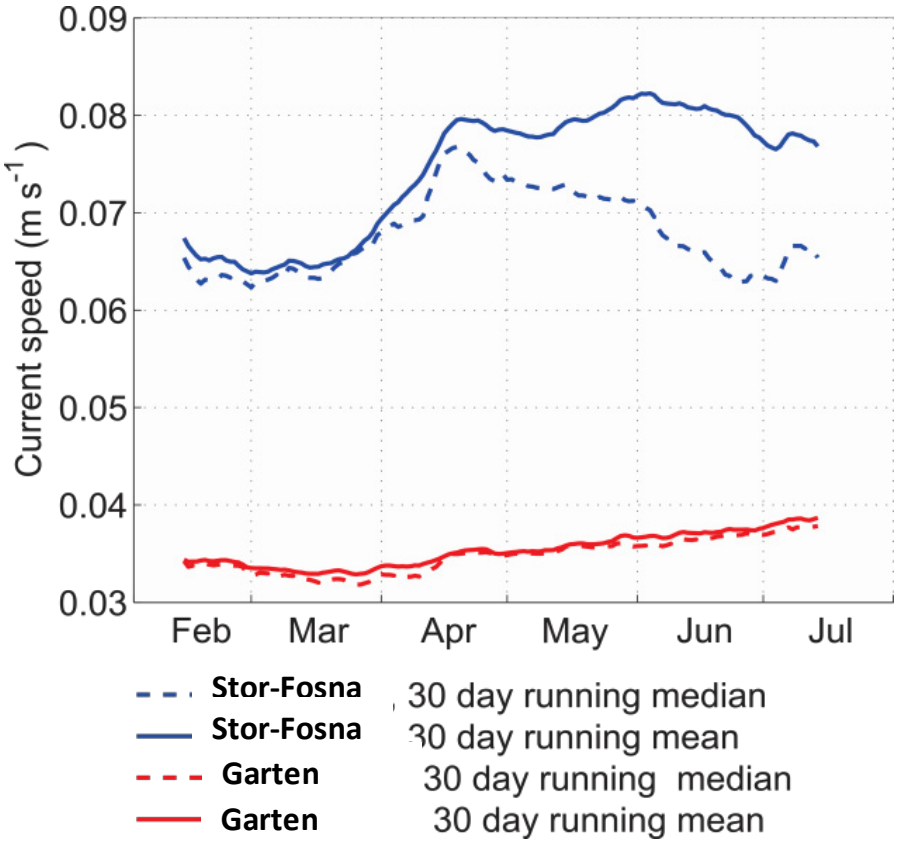
Method

- Cultivation trial with *Saccharina latissima* winter-spring 2012

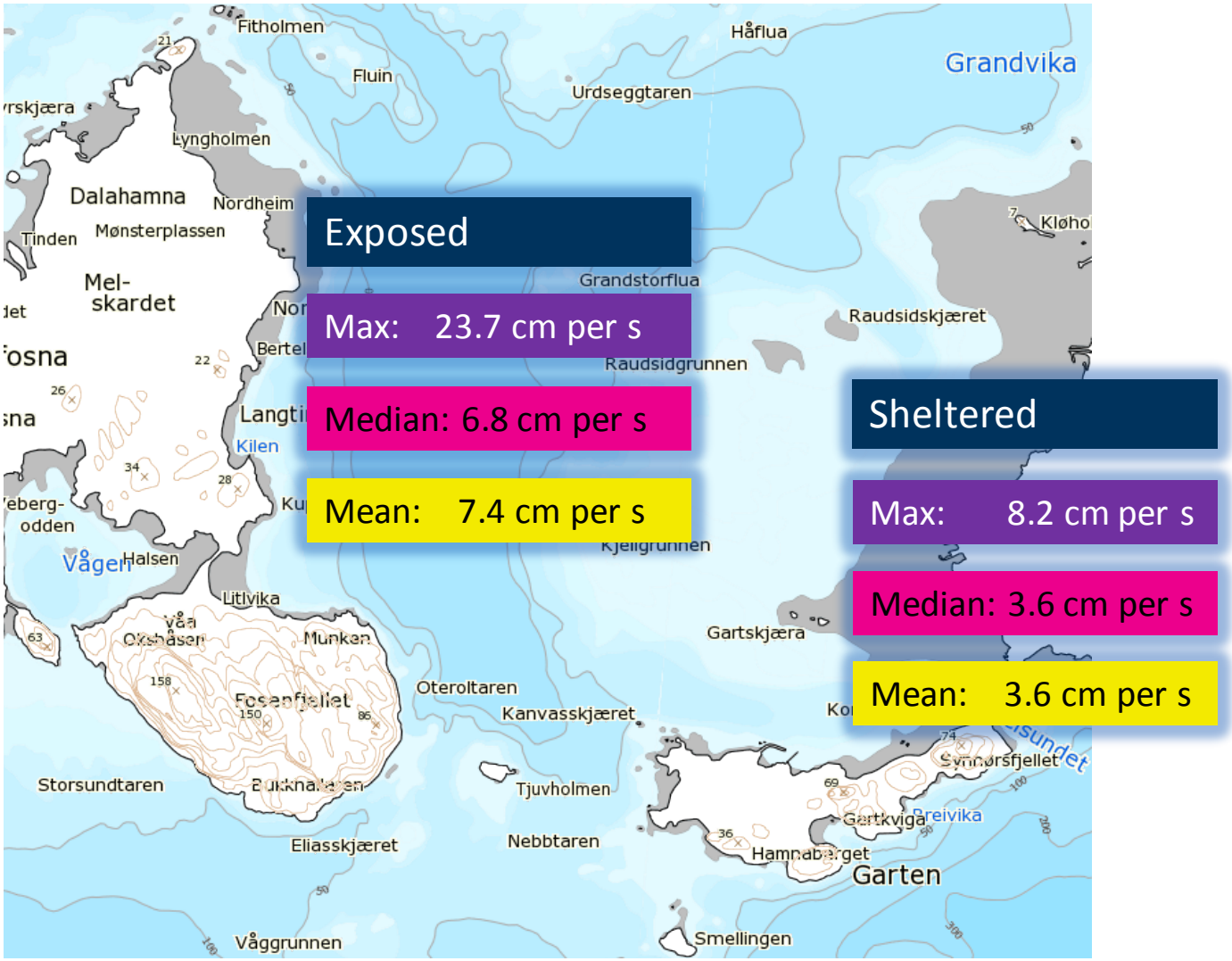
Cultivation sites: Exposed ✖ and sheltered ✖

Water currents simulation:

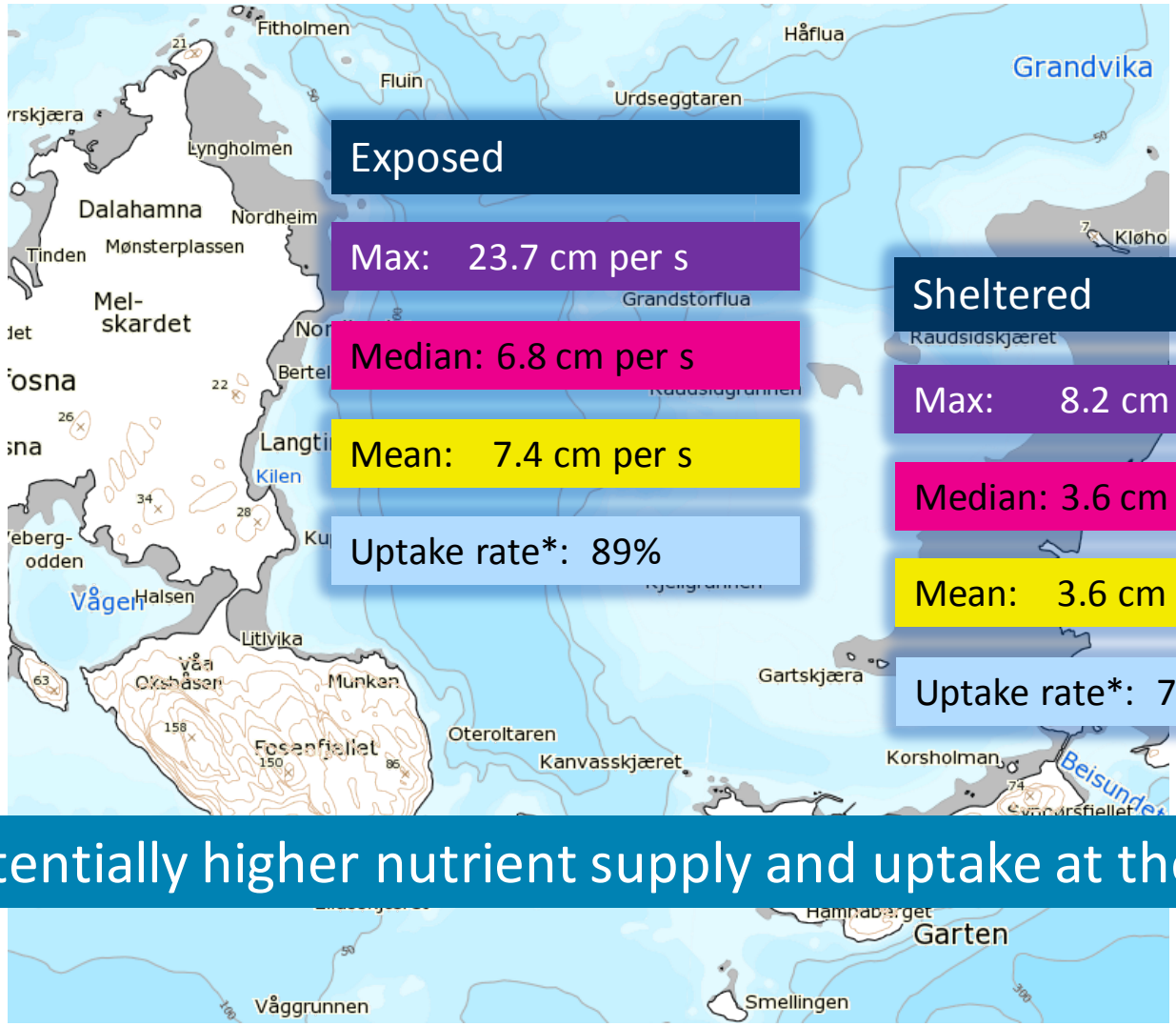
- 3D hydrodynamic model system SINMOD
- 5 m depth



Water currents speed at the two sites in February-July (simulated)



Potential nutrient uptake rates* (simulated)



Exposed

Max: 23.7 cm per s

Median: 6.8 cm per s

Mean: 7.4 cm per s

Uptake rate*: 89%

Sheltered

Max: 8.2 cm per s

Median: 3.6 cm per s

Mean: 3.6 cm per s

Uptake rate*: 70%

**As %* of MAX uptake more than half the time ($U_{0.63}$=0.03)

Potentially higher nutrient supply and uptake at the exposed site

Cultivation trial with *Saccharina latissima:* The seedlings production

Spores

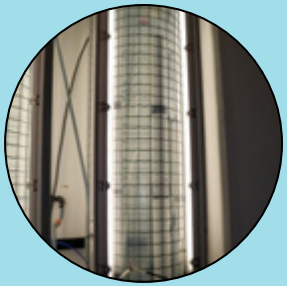
Induced spores production

Lines

Polyestersilk

1.2mm

on spools

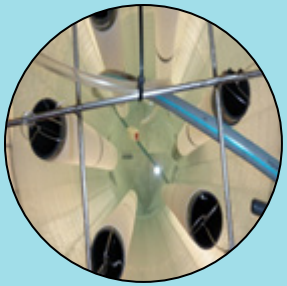


Incubators

350 L's cylinder (plastic bag)

4 luminous tubes

1km line



Water

Continuous exchange

13X per day

2 L per min

UV-treated

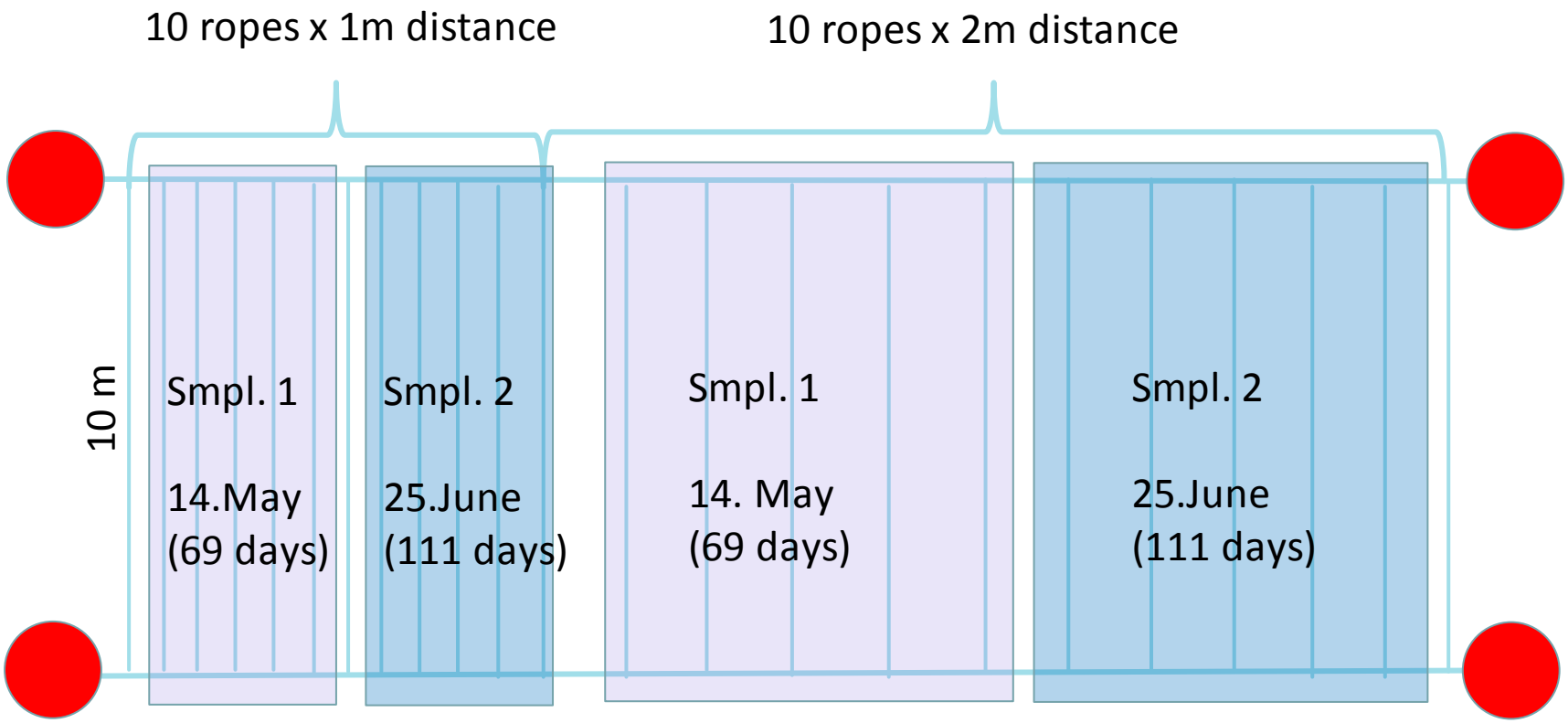
10°C

Incubation of sporophytes

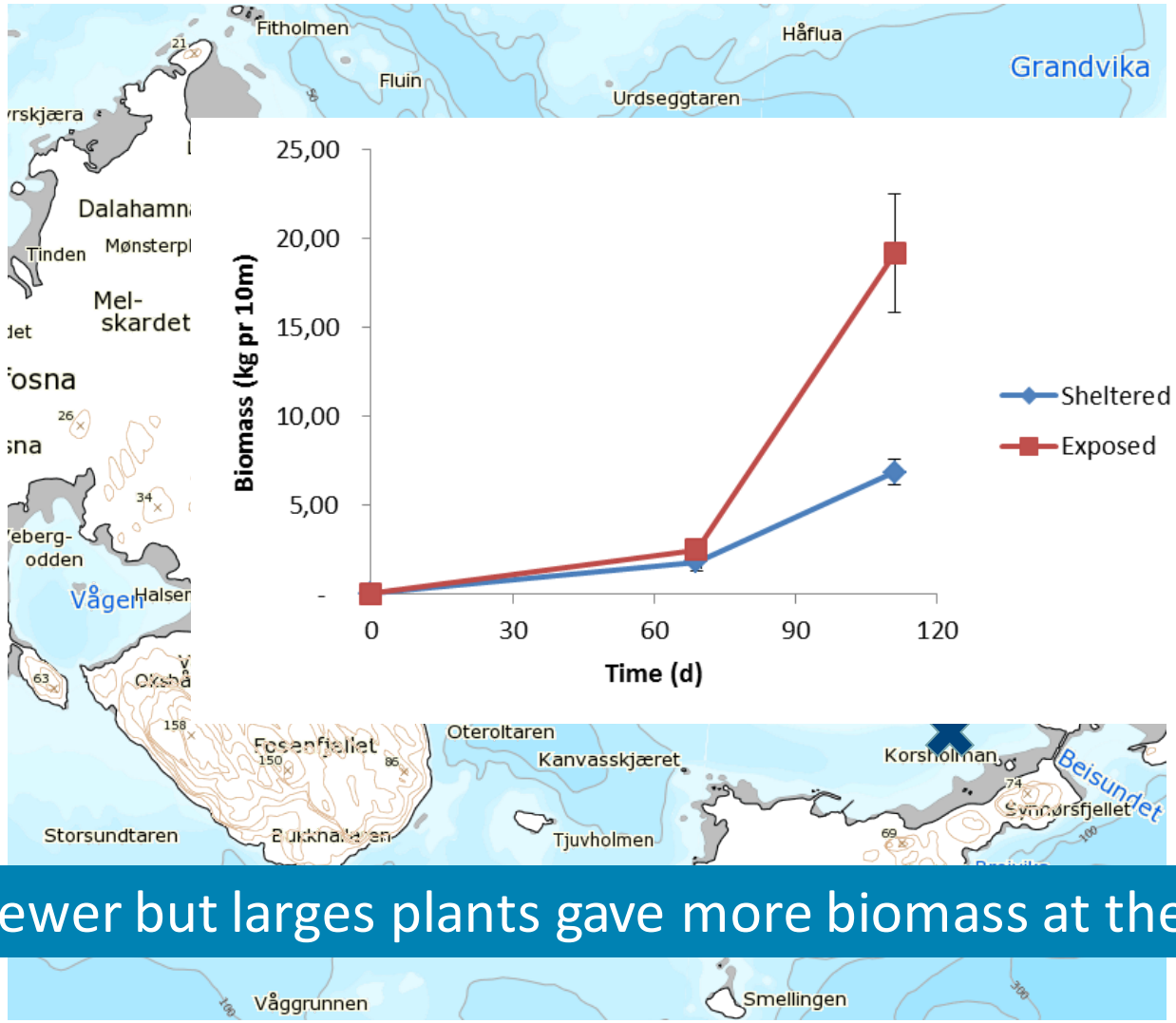
Deployment: 6.March 2012

2.5 months

The experimental seaweed farm



Effect of currents exposure on seaweed production



Cultivation period:
6.March – 25.June
(111 days)

SGR
Exposed 6.8% day^{-1}
Sheltered 5.9% day^{-1}

Fewer but larges plants gave more biomass at the exposed site

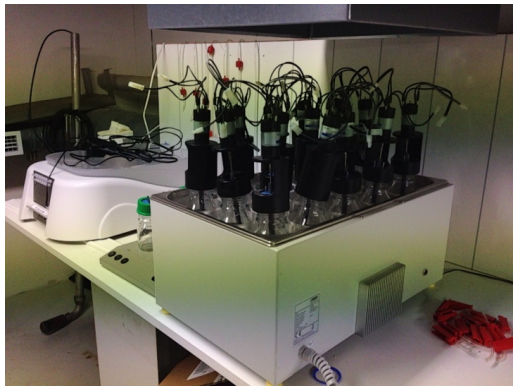
Biogas production from seaweed

Case The Tokyo Gas Company

- Input: 1 ton seaweed per day
- Outcome: 22 m^3 CH_4 per ton ww
- (Kelly et al, 2009, Crown Estate)

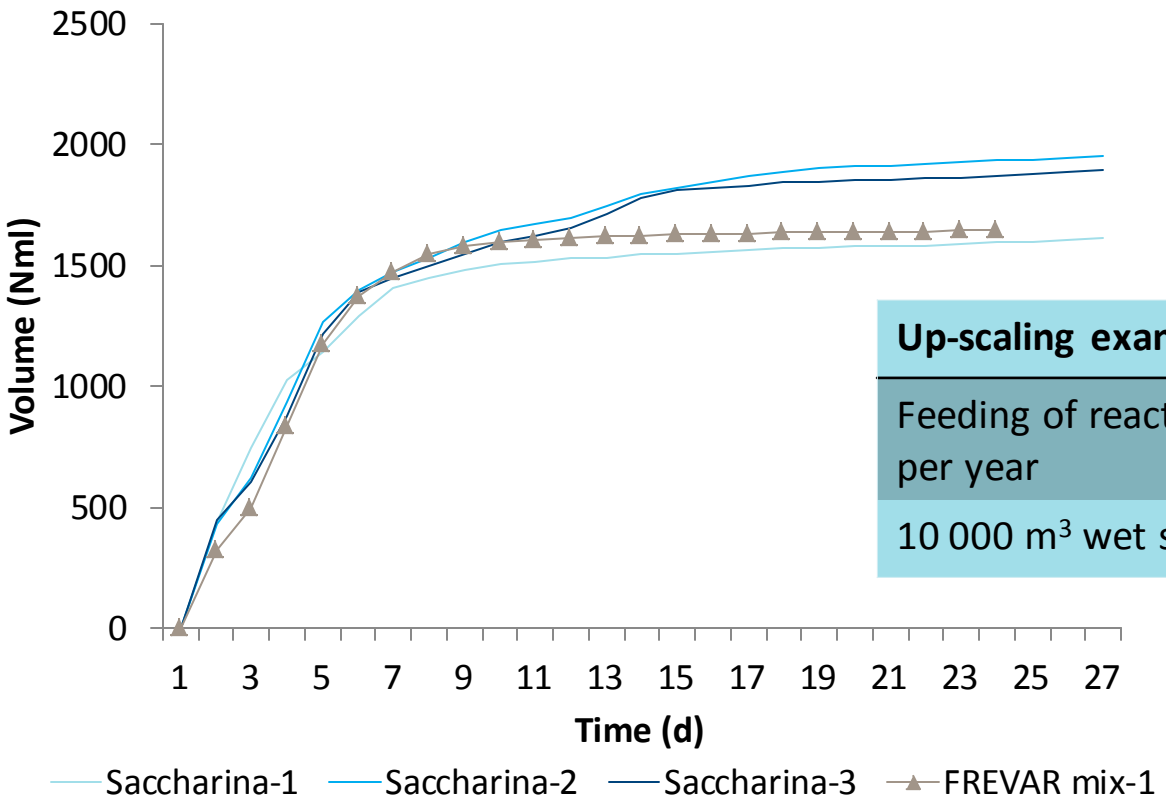
Our Case FREVAR

- Ampt II Test Kit
- Grinding and inoculation with seed sludge
- Methane measurement: 100% CH_4



Biogas production from *Saccharina latissima*

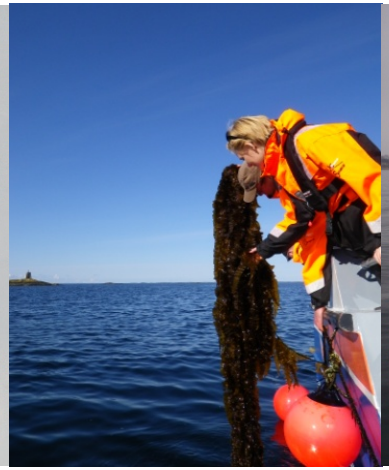
Accumulated daily production



Up-scaling example (theoretical)	
Feeding of reactor, per year	Methane yield per year
10 000 m^3 wet seaweed	4.73 GWh

Conclusions

- Exposed cultivation areas are advantageous
  - Better nutrients uptake
  - Fewer but bigger plants
  - Higher biomass yield
- Biogas outcome from *S.latissima* biomass equal to treated household waste

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