Effect of salinity and nutrient availability on Saccharina latissima and Laminaria digitata.

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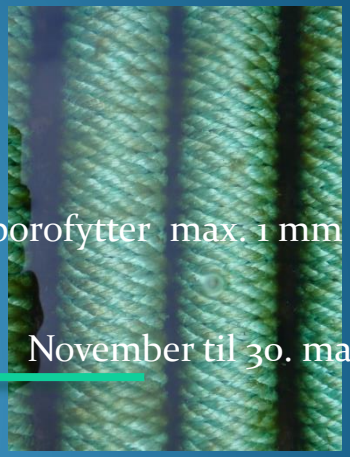
Main focus on CO_2 exchange rates

My background:

Growing macro algaes in Lysefjorden?

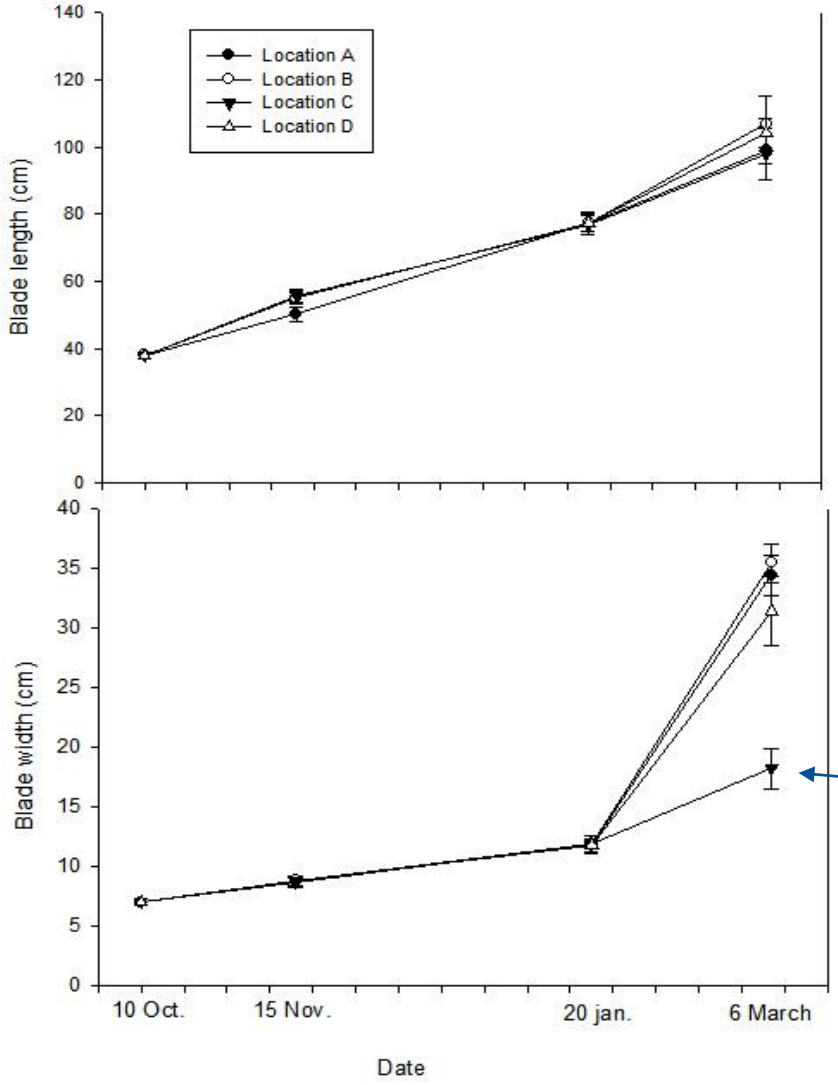
My experience:
Starting up with 1-5 cm sporophytes will strongly increase the yield in the period October-May



Sporofytter max. 1 mm

November til 30. mai

Sporofytter 1-5 cm



We cultivated S. latissima at four locations: Close to salmon cages, in an artificial upwelling zone caused by freshwater from a waterfall down to 30 m depth in Lysebotten (Aure et al. 2007), and two reference locations

In the upwelling zone lower salinities (20‰) and indication of lower growth rates of Saccharina latissima. Decreased blade width an indication of stress?

The salinity in the fjords

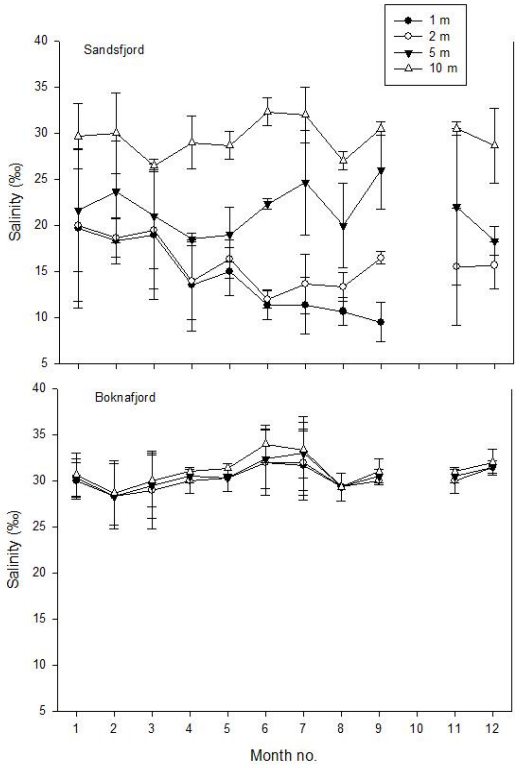
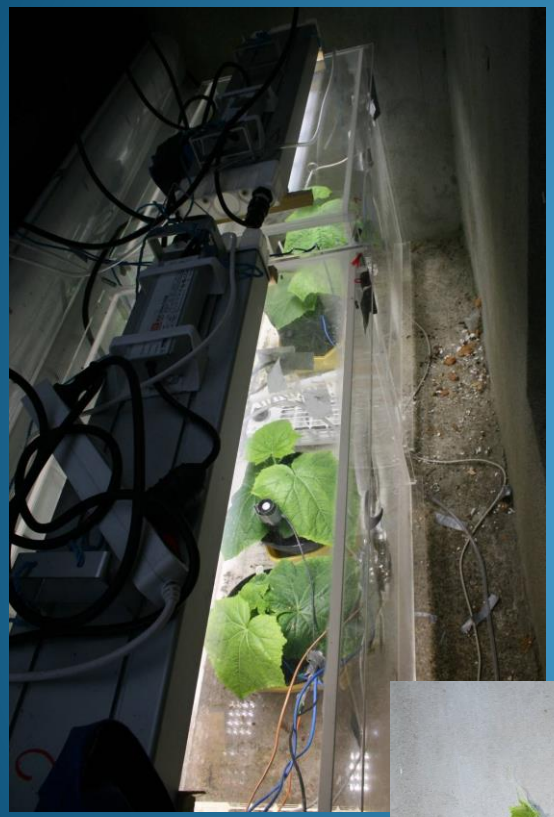
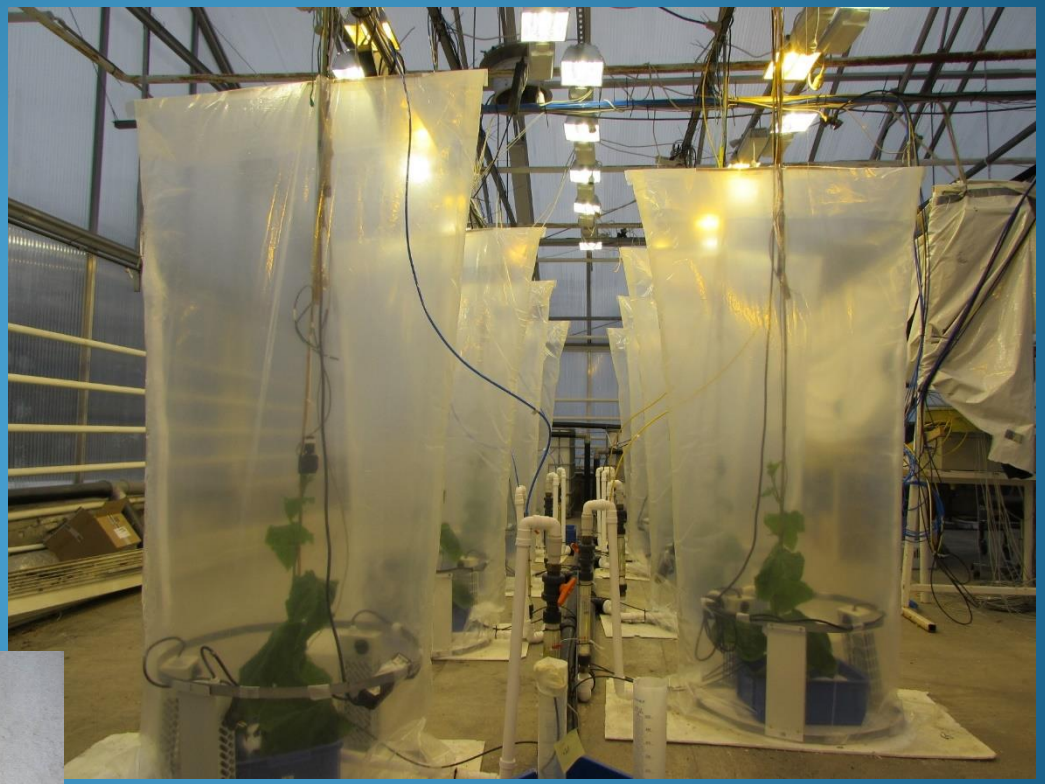


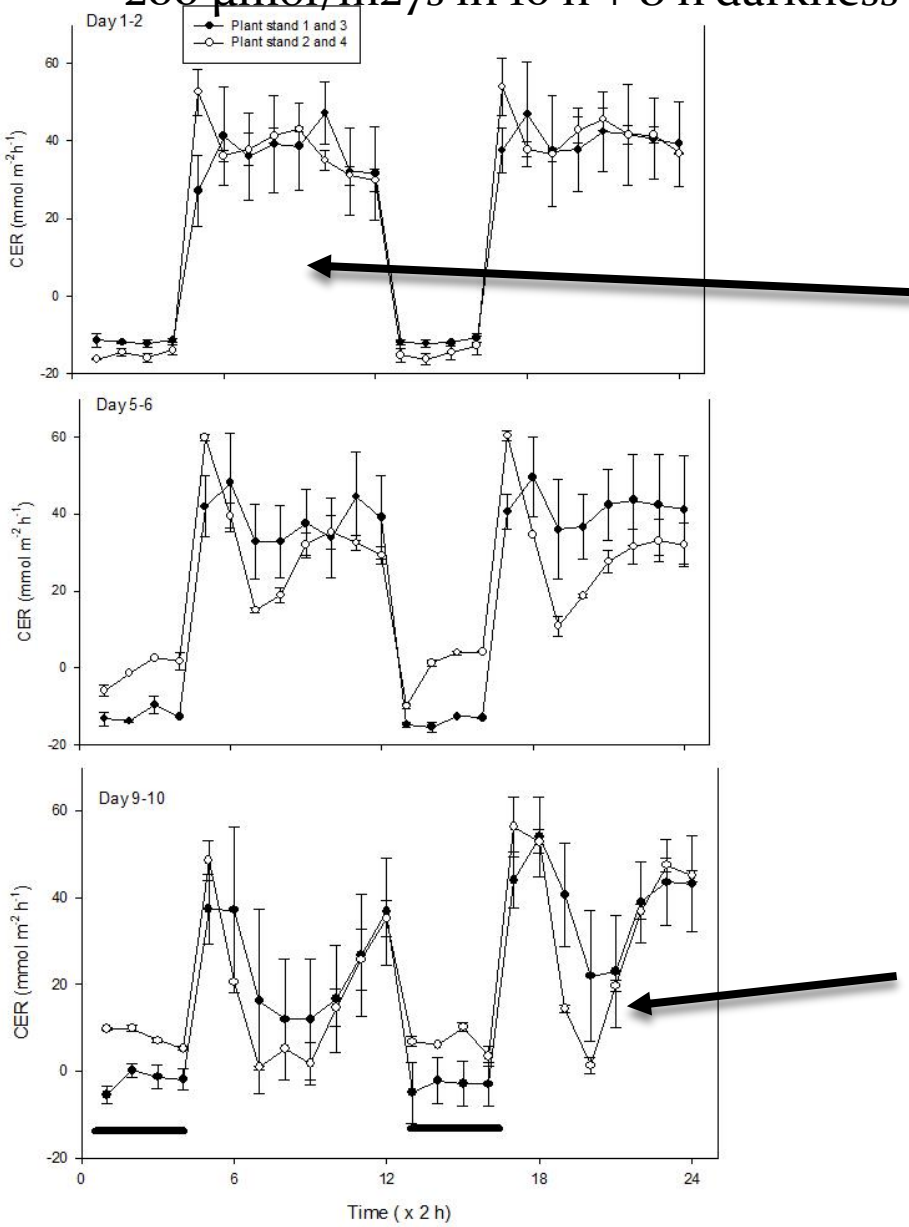
Fig. Salinity levels measured once a month during January-December as a mean of three years in the Sandsfjord (±SD, n =3) and the Boknafjord (±SD, n=3) as measured at four different depths. Data from Uni Research (2015).

Photosynthesis measured as CO_2 gas exchange rates in macroalgae





Kalanchoe blossfeldiana



C3 photosynthesis follow light/dark cycle

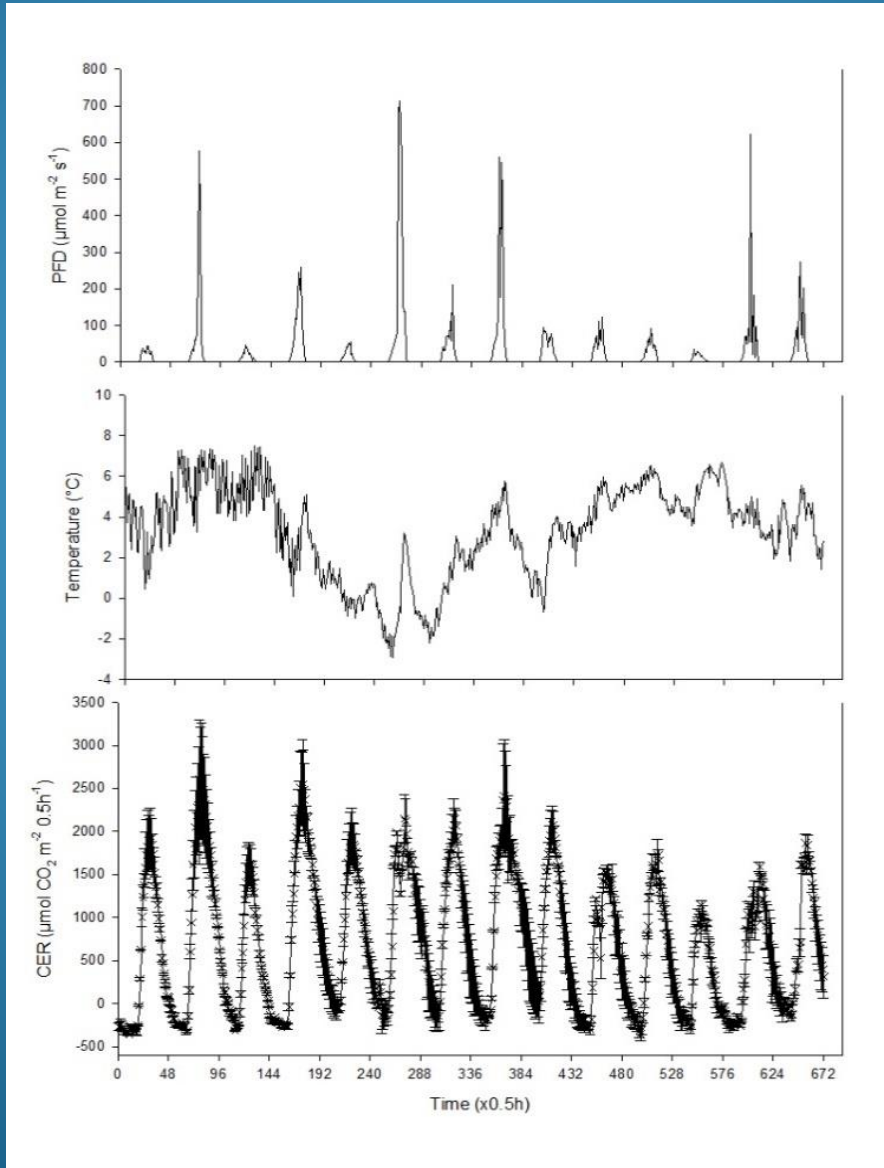
CAM photosynthesis CO_2 uptake also in darkness and strong drop in the Middle of the day

CO2 exchange rates in S. latissima as measured in January

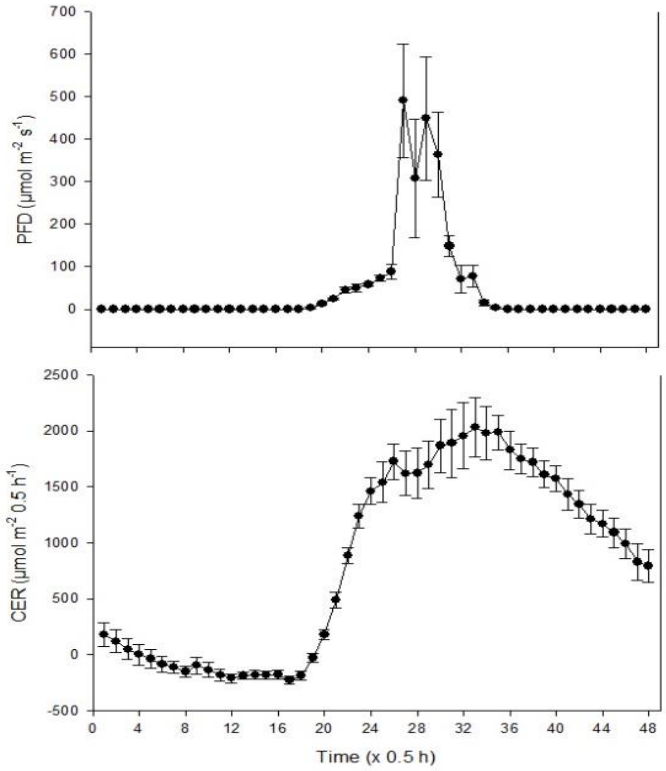
$$P_{net} = (CO_{2\text{-inlet}} - CO_{2\text{-outlet}}) \times \text{Flowrate}$$

CO_2-opptak (ml/time) – positiv fotosyntese/vekst ved svært lave lysnivå gjennom 3 uker i januar ved lave temperaturer (ned mot -2°C)

Photon flux density, temperature and carbon dioxide exchange rate (CER) during two weeks, of *S. latissima* as measured in late January in Rogaland



CER during a day with a relative high irradiance in January



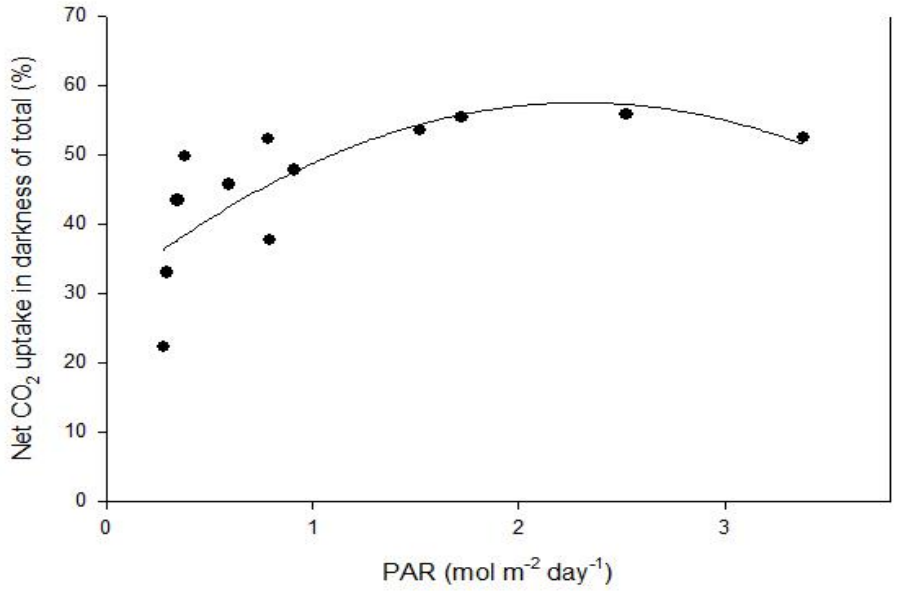


Fig. Contribution of net CO_2 uptake in darkness as dependent on the PAR during the preceding day. Regression equation (order 2): $y = 30.1 + 23.8x - 5.2x^2$ ($r^2 = 0.57$, $p<0.05$).

Experiment with changing the salinity

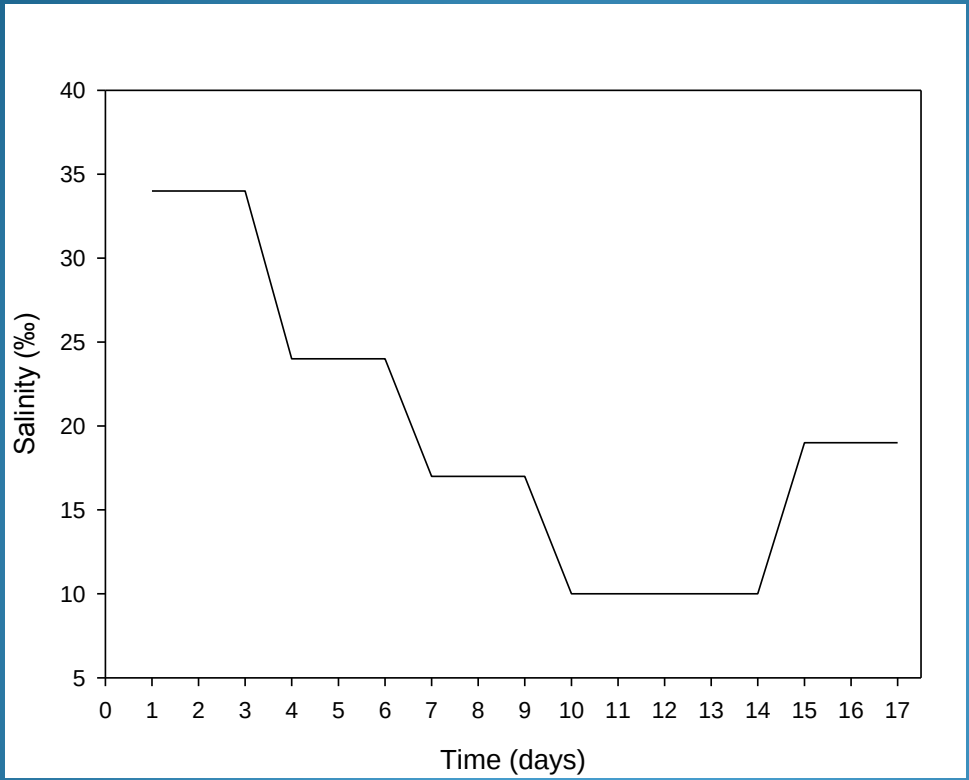
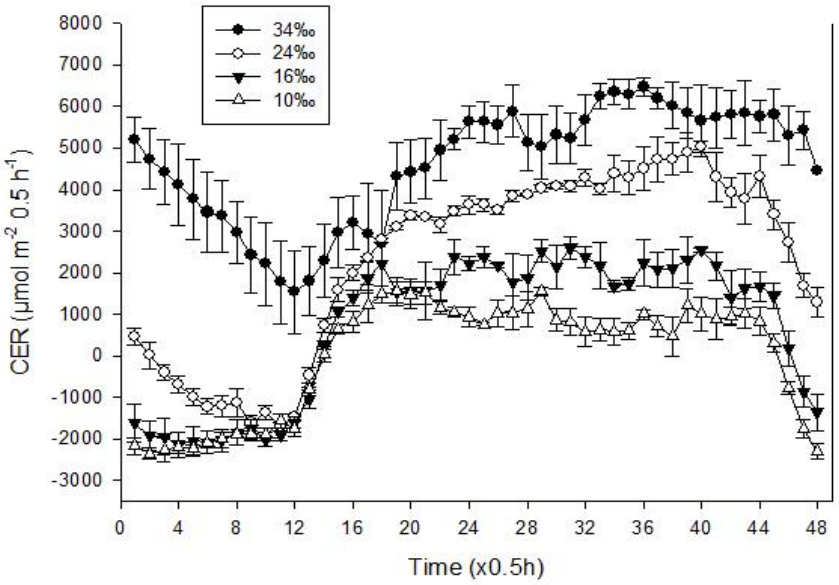


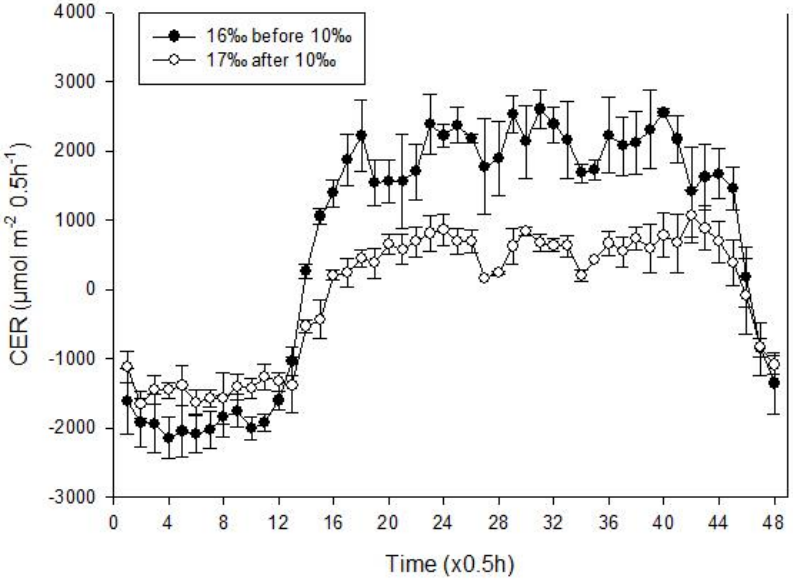
Fig. 3. Salinity levels during the measurements of CER in *S. latissia* and *L. digitata*

The system for measurments of photosynthesis

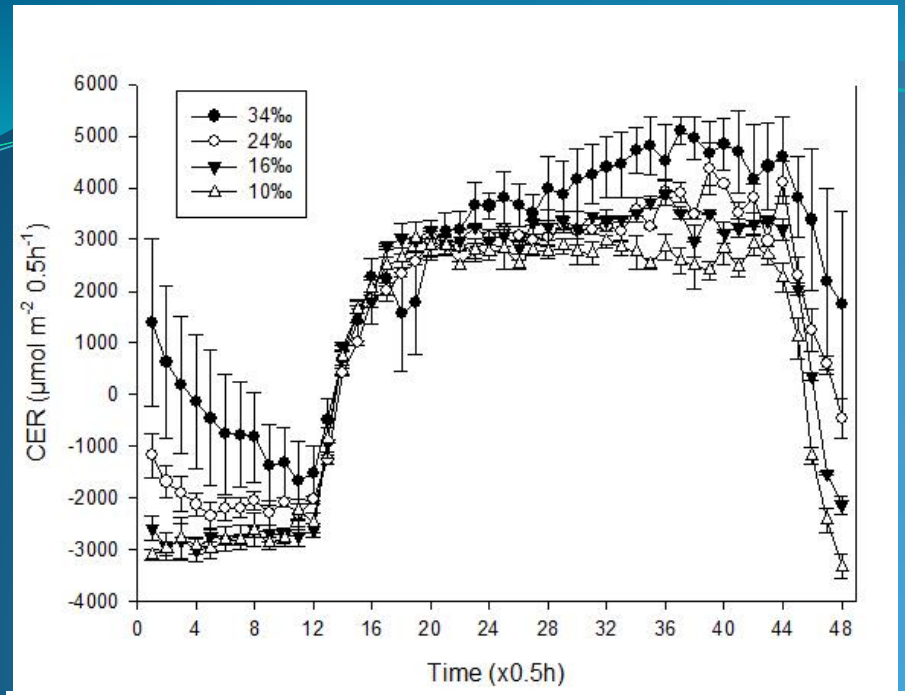
200 µmol/m2/s in 16 h/day



The diurnal CER measured at different salinities in *S. latissima* .



CER measured before and after exposure to 10‰ (B).



A.

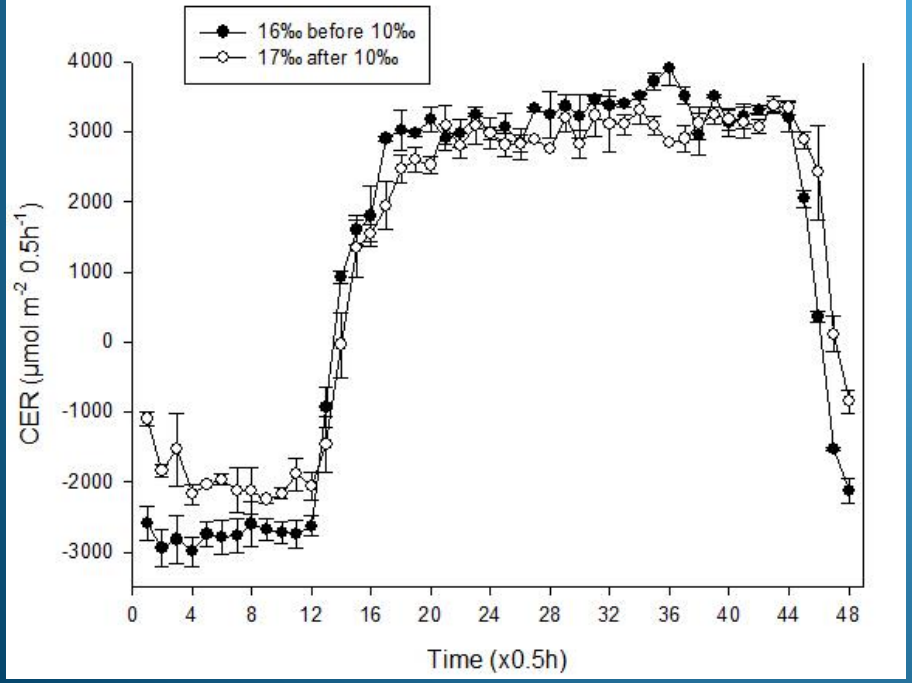


Fig. 5. The diurnal CER measured at different salinities in *L. digitata* (A) and CER measured before and after exposure to 10‰ (B).

B.

In an upwelling zone with nutrient-rich deepwater as well as very close to salmon cages the protein concentration in Saccharina latissima was 16.0±0.3% as compared with 9.7±0.9% inreference locations at 1 June.

Question was raised:

How fast can the protein concentration be increased by nutrient exposure. Of interest to increase the protein concentration before harvest if the kelp should be used for salmon feed.

The experiment with nutrient uptake:

Four tanks with mixture of deepwater and freshwater supplied with nutrients giving a salinity of 18‰ and concentrations of around 50 µg/ l nitrate and phosphate.
Four tanks with seawater with around 5 µg/l nitrate and phosphate

Klaus Lüning a good friend and colleague in the cultivation experiments

Table 1. Chemical contents (means±SE, n=3-4) based on dry weight of young sporophytes of *S. latissima* and *L. digitata* grown for 13 days in seawater (25 and 34 ‰ salinity) without nutrients or in a mixture of deep seawater and freshwater (18 ‰ salinity) added nutrients (Mix.) in the period from 14 to 27 June, 2014 (Experiment 1). Adjusted values of protein using a conversion factor of 5.0 in brackets.

	S. latissima			L. digitata		
	Seawater	Mix.	F-value	Seawater	Mix.	F-value
N (%)	2.09±0.07	3.07±0.05	129***	1.76±0.14	2.34±0.04	17.3**
NO_3^- - N (%)	0.043±0.026	0.116±22	4.69†	0.059±0.047	0.152±0.022	3.30
Leco protein (%)	15.0±0.9 (12.0±0.7)	18.7±0.5 (15.0±0.4)	41.3***	11.4±0.4 (9.1±0.3)	14.9±0.2 (11.9±0.2)	53.8**
ß-glucans (%)	11.2±1.5	4.1±0.8	18.1**	4.6±2.0	5.7±1.0	0.24^{ns}
P (%)	0.32±0.01	0.46±0.05	8.44*	0.25±0.02	0.34±0.02	16.8**
N:P ratio	6.48±0.14	6.89±0.74	0.29^{ns}	7.22±0.40	6.86±0.24	0.62^{ns}
Iodide (mg kg^{-1})	1690±295	870±100	6.86*	3320±306	2790±220	2.00^{ns}

Table 2. Chemical contents (means±SE, n=4) based on dry weight of young *Saccharina latissima* grown for 5 days in seawater without nutrients (25 ‰ salinity) or in a mixture of deep seawater and freshwater (17‰ salinity) added nutrients (Mix.) in the period 27 June until 2 July, 2014 (Experiment 2). F-values and significance levels are given as in Table 1.

	Young			**Old**		
	Seawater	Mix.	Sign.	Seawater	Mix.	F-value
N (%)	1.73±0.05	2.43±0.06	86.1***	1.89±0.09	1.90±0.21	0.00^{ns}
P (%)	0.28±0.02	0.35±0.02	9.88*	0.30±0.02	0.31±0.02	0.15^{ns}
N:P ratio	6.3±0.3	7.0±0.4	2.91^{ns}	6.4±0.4	6.0±0.6	0.33^{ns}

Table 3. Chemical contents (means±SE, n=4) based on dry weight of young and old *Laminaria digitata* grown for 5 days in seawater without nutrients (25 ‰ salinity) or in a mixture of deep seawater and freshwater (17 ‰ salinity) added nutrients (Mix.) in the period 27 June until 2 July, 2014 (Experiment 2). Adjusted values of protein using a conversion factor of 5.0 in brackets. F-values and significance levels are given as in Table 1.

	Young			Old		
	Seawater	Mix.	Sign.	Seawater	Mix.	F-value
N (%)	1.81±0.03	2.43±0.05	132***	1.96±0.05	2.36±0.06	28.6**
NO_3^- - N (%)	0.018±0.006	0.147±0.015	65.8***	0.037±0.007	0.148±0.059	4.16†
P (%)	0.24±0.01	0.29±0.02	6.27*	0.23±0.01	0.28±0.01	18.6**
N:P ratio	7.65±0.25	8.04±0.30	0.97ns	8.75±0.29	8.51±0.31	0.32ns
Iodide (mg kg^{-1})	4710±1080	4800±410	0.01ns	4040±530	3310±1630	0.18ns

Thanks to Rogaland fylkeskommune, Lerøy Seafood group, Ewos Innovation, Ryfylkefondet, Blue Planet and to prof. emer. Klaus Lüning for valuable support during the last years

Thank you for listening to me