SPATIAL VARIATION IN THE BIOCHEMICAL COMPOSITION OF *SACCHARINA LATISSIMA*

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GRENÅ 2014

BIOCHEMICAL VARIATION IN KELP BIOMASS

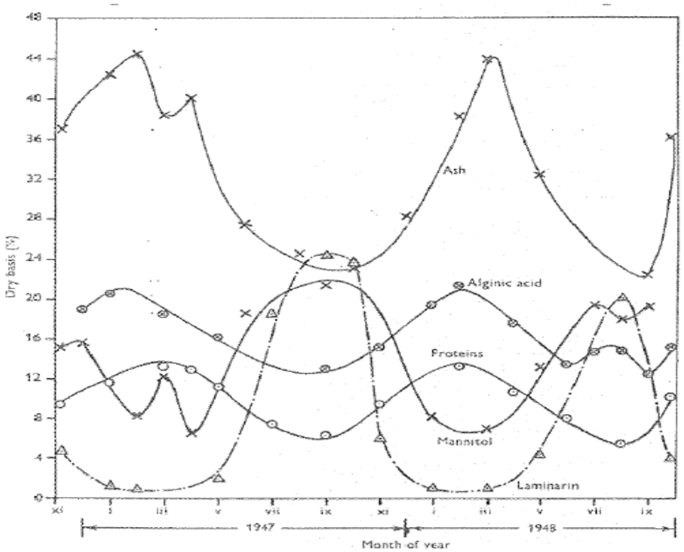
- *Saccharina latissima* cultivation is gaining momentum in Europe
- The MacroAlgae Biorefinery MAB3 in Denmark
  - Strategic Research Council
  - 2012-2016
  - Stabile biomass yield and quality
  - Optimal biochemical composition
  - Pretreatment
  - Biorefinery: ethanol & fish feed

DET STRATEGISKE FORSKNINGSRÅD

BIOCHEMICAL VARIATION IN KELP BIOMASS

- Temporal fluctuations – well described[1]
- Life strategy response to environmental parameters – light, nutrients

- In Denmark environmental parameters also fluctuate on a spatial scale
- Will we find differences in biochemical composition on a spatial scale?



[1]Black, 1950

THE STORY

- Why would we expect to find spatial variation in Danish waters?
- How did we look for it?
- Did we find it?
- How do we interpret this?
- What are the implications for cultivation?

WHY DO WE EXPECT SPATIAL VARIATION?

- Until ~ 10,000 years ago, the Baltic Sea was a lake
- Now the worlds largest estuary[2]
- 940 km^3 freshwater from rivers in the Baltic run out annually
- Saline North Sea water runs in

[2]Lund-Hansen, 1994

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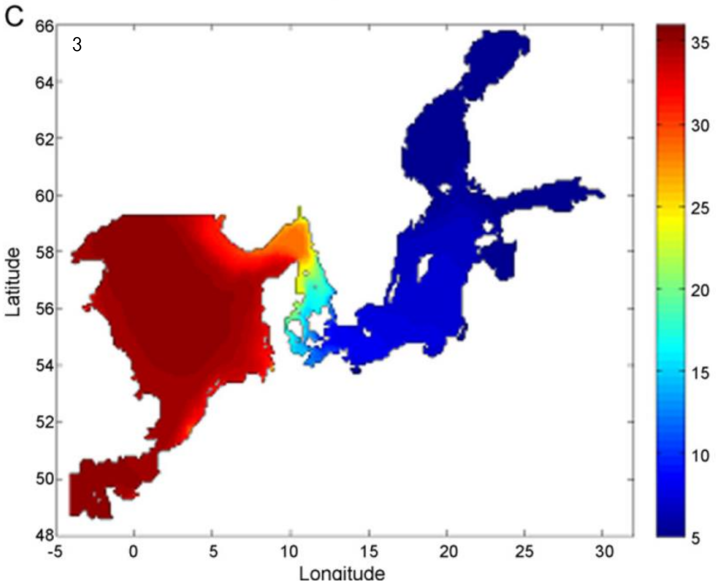
WHY DO WE EXPECT SPATIAL VARIATION?

Salinity in Danish waters

- Strong north-south gradient (10-33 psu)
- Almost constant vertical stratification of the water column
    - Surface water – low salinity, high temperature, no nutrients
    - Bottom water – high salinity, low temperature, nutrients



[3]Maar et al, 2011

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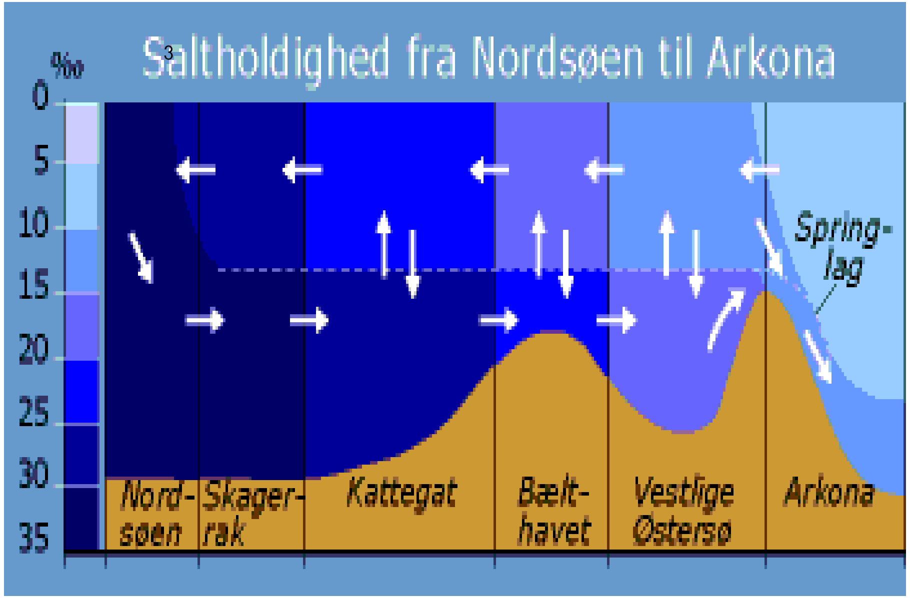

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SALINITY AND KELPS

- Kelps are stenohaline (23-31psu)[4]
- Marine species colonised inner Danish waters from the saline North Sea
- Kelps spread via available patchy hard bottom – "stepping stones"
- Salinity has direct impact on physiology[4]
- Changes in environment stimulate adaptations[5]
- Decreasing salinity may have driven differentiation of ecotypes[6]

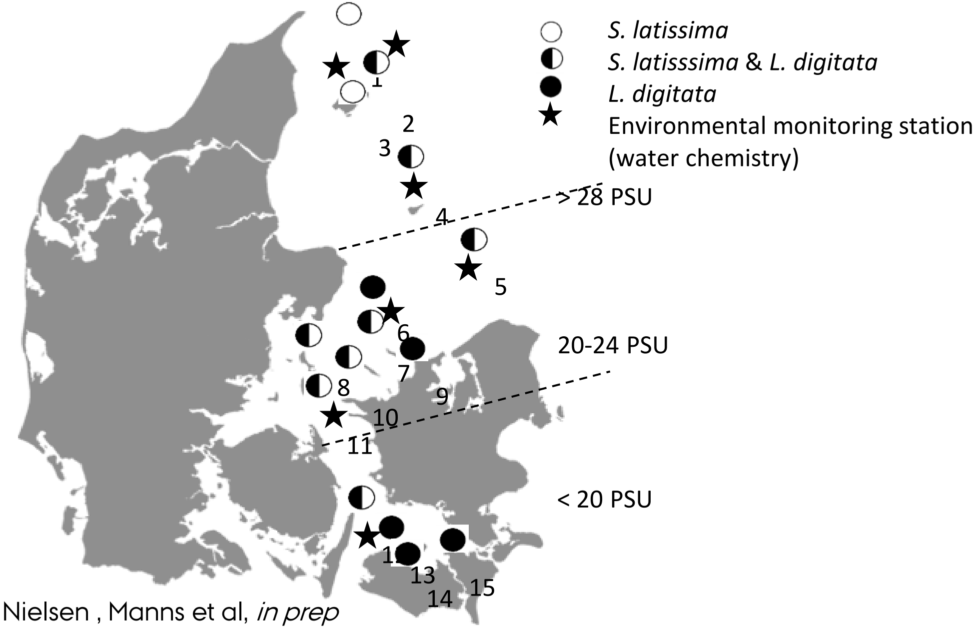
[4]Bartsch et al, 2008. [5]Blossey et al, 1995. [6]Gerard et al, 1987

HYPOTHESES

Spatial variations in biochemical composition may be driven by:

1. Direct physiological effects of salinity (osmo-regulation)
2. Direct effect of other environmental parameters linked to salinity (nutrients, temperature)
3. Genetic differentiation as adaptation to lower salinity

HOW DID WE LOOK FOR SPATIAL VARIATION?



[7] Nielsen , Manns et al, *in prep*

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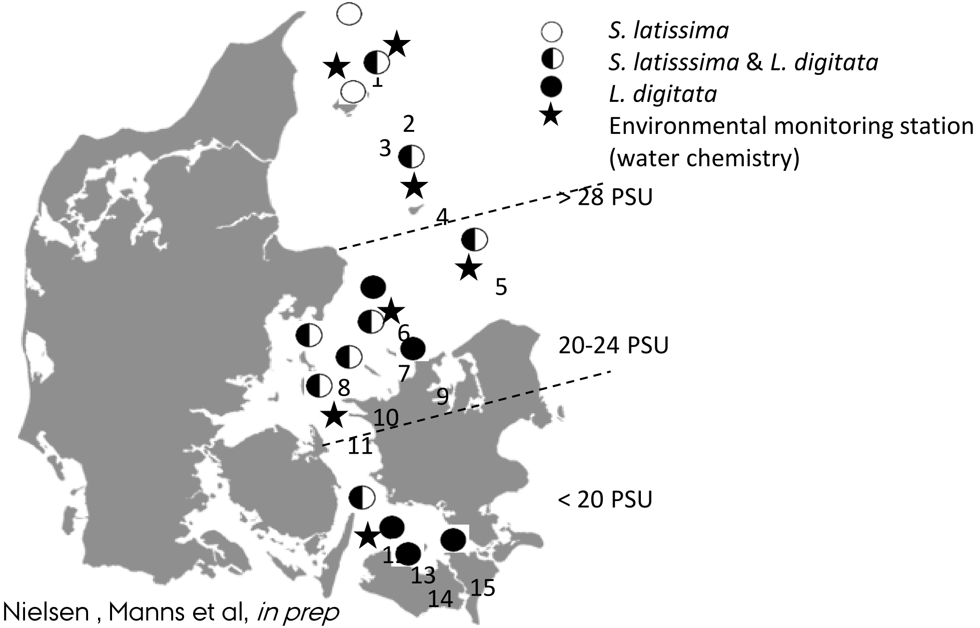
HOW DID WE LOOK FOR SPATIAL VARIATION?

- *S. latissima* (10 stations, 10 individuals)
- *L. digitata* (13 stations, less individuals)
- Morphology
- Biochemical composition
  - Dry matter and ash
  - Nitrogen, phosphorus and metals
  - Sugars, amino acids



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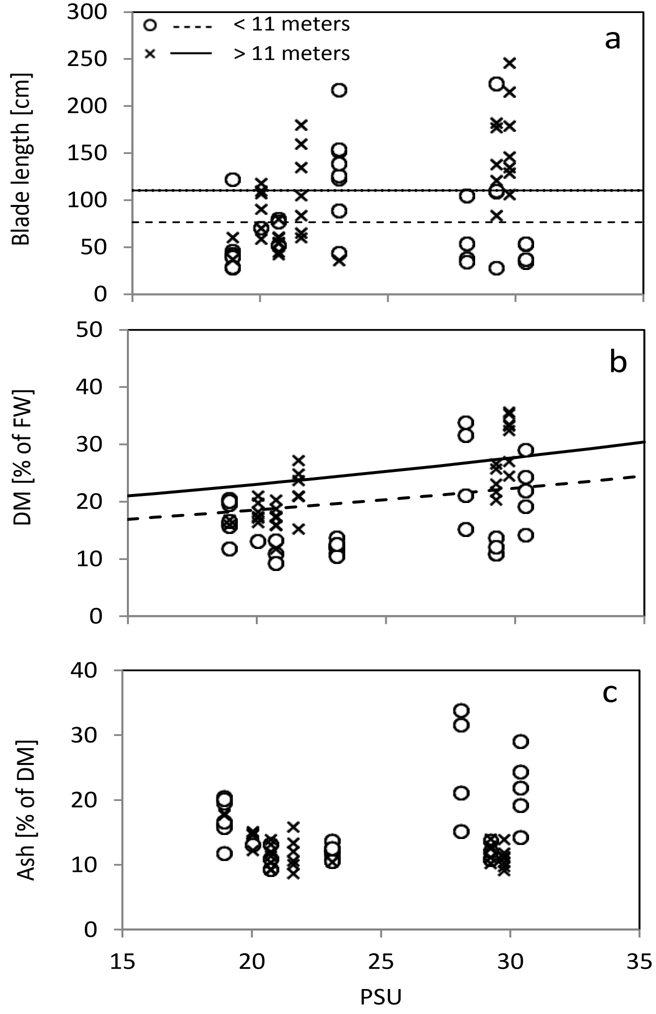
SO - DID WE FIND IT?

Preliminary results and interpretation

SIZE, DRY MATTER, ASH

- Blade length – depth, (salinity)
- Dry Matter (DM) content – salinity and depth
- Ash – not significant

- **Higher salinity**
    - **Higher DM content – not only ash/minerals**
    - **Larger individuals**



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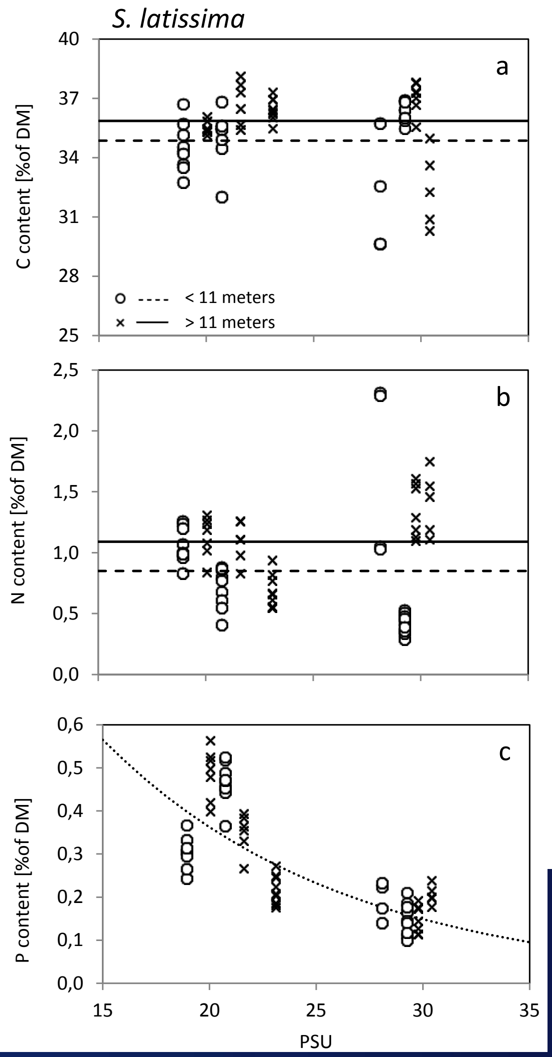
C, N, P

- Carbon content – increase with depth (and decrease with salinity at depths <11m)
- Nitrogen (protein) content – increase with depth (and with salinity at depths < 11m)
- P content decrease with increasing salinity

- **Increasing salinity – lower P, lower C (surface) and higher N (surface)**

[7]Nielsen , Manns et al, *in prep*

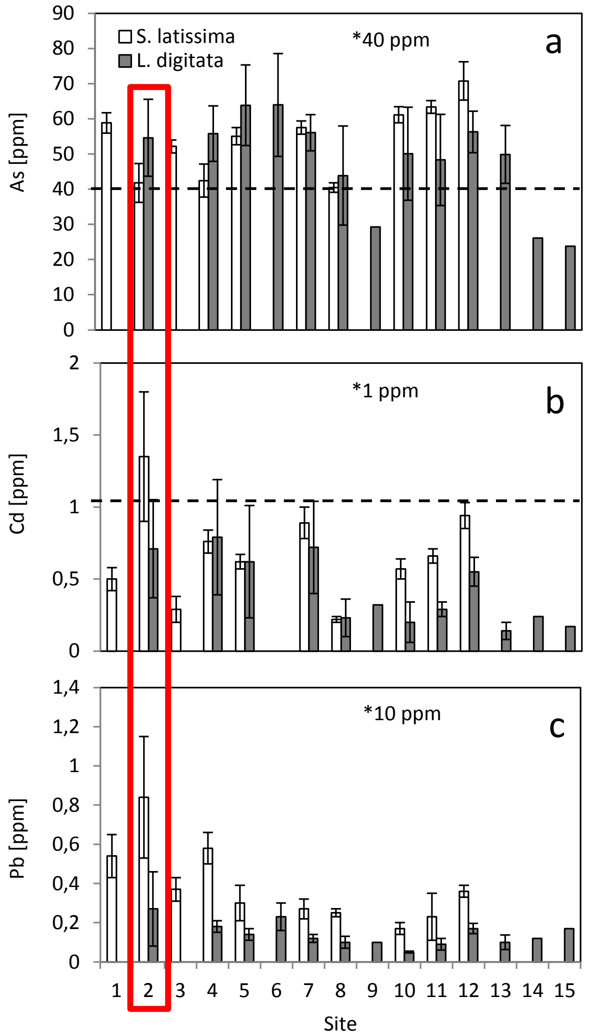


METALS

- As – all *S. latissima* above limit values ([8,9]food/feed)
- Cd – few over limit values
- Pb – none over limit values

- As, Cd – negative correlation to salinity
- Pb – positive correlation to salinity

- **At specific stations tissue metal concentrations are high**



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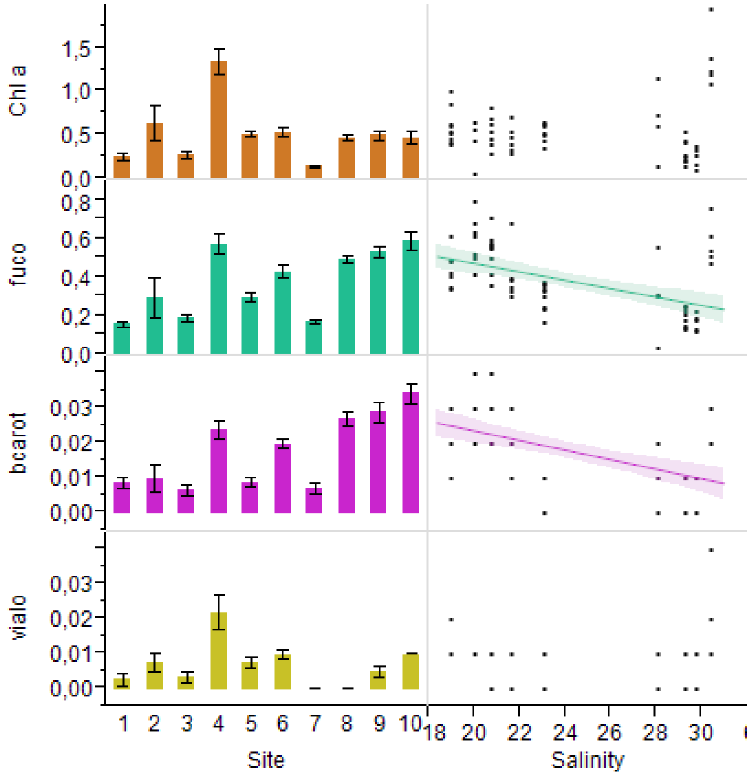
PIGMENTS

- Pigments/antioxidants
- Fucoxanthin and β-carotene
  - decrease with increasing salinity ($p<0.0001$)
- Chlorophyll a and violaxanthin
  - no correlation

Increasing salinity - concentration of major carotenoids decrease



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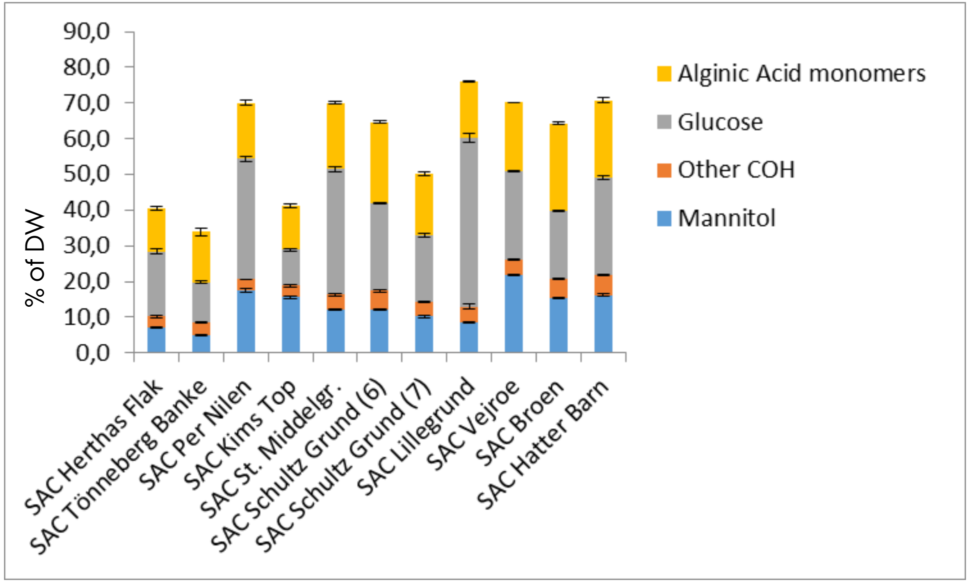
SUGARS

- Variation in sugar monomer content and composition
- Alginic acid components, other sugars (COH) and the sum of mono-saccharides decrease with increasing salinity
- Also decrease with increasing nutrient (N) availability
- N limitation or not



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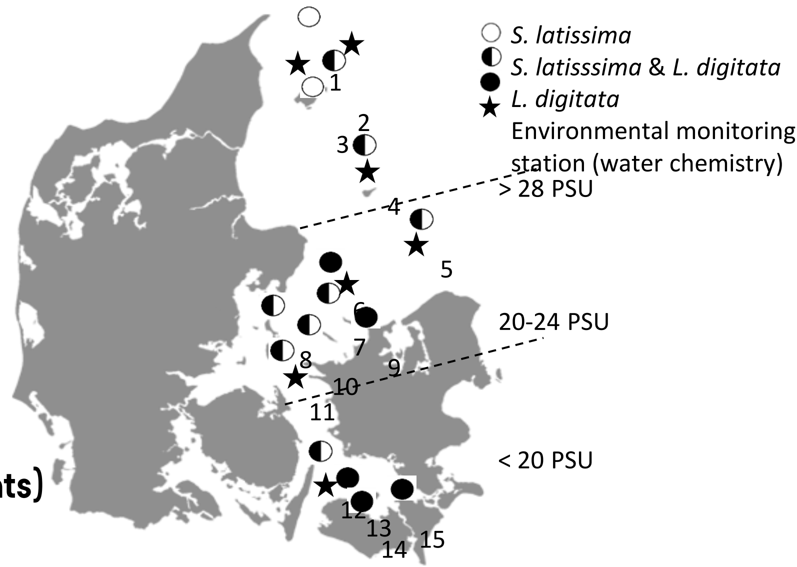
RESULTS SUMMARY

Increasing salinity

- **Higher DM content – not only ash/minerals**
- **Larger individuals**
- **Lower concentrations of sugars (alginic acid components)**
- **Lower P, lower C (surface) and higher N (surface)**
- **Lower As, Cd**
- **Higher Pb**
- **Lower concentration of major carotenoids**

- **At specific stations tissue metal concentrations are high**



HOW DO WE INTERPRET IT?

- Depth and undefined local conditions also have impact on the biochemical composition of the biomass

- Genetics are being investigated using microsatelites

	Genetics	Salinity direct	Salinity indirect (nutrient)
Size and DM	x	x	(x)
C, N, P		(x)	x
Sugars	x	x	x
Pigments	(x)		x
Metals		x	

IMPLICATIONS FOR CULTIVATION

- **Focus on a maximal biomass production**: sites with or ecotypes from higher salinity should be preferred

- **Focus on maximal production of specific compounds:** a more nuanced picture (salinity or nutrient dynamics)

- **Genetic definition of ecotypes** opens for fundamental studies on effects of environmental variables and ultimately selective breeding

THANKS FOR YOUR ATTENTION!

DET STRATEGISKE FORSKNINGSRÅD

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