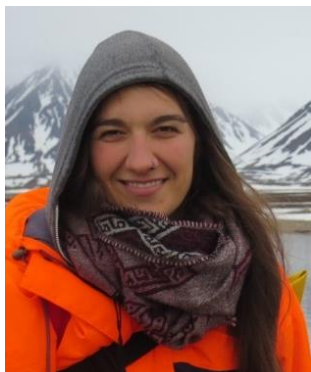


KELPS IN THE ARCTIC: THEIR ABILITY TO COPE WITH WARMING

Inka Bartsch, Marie Dankworth, Kiara Franke, Daniel Liesner, Neusa Martins, Nele Schimpf, Katharina Zacher

Key Note Talk SYM14: Algae at the Extremes - IPC 12 – Chile 2021



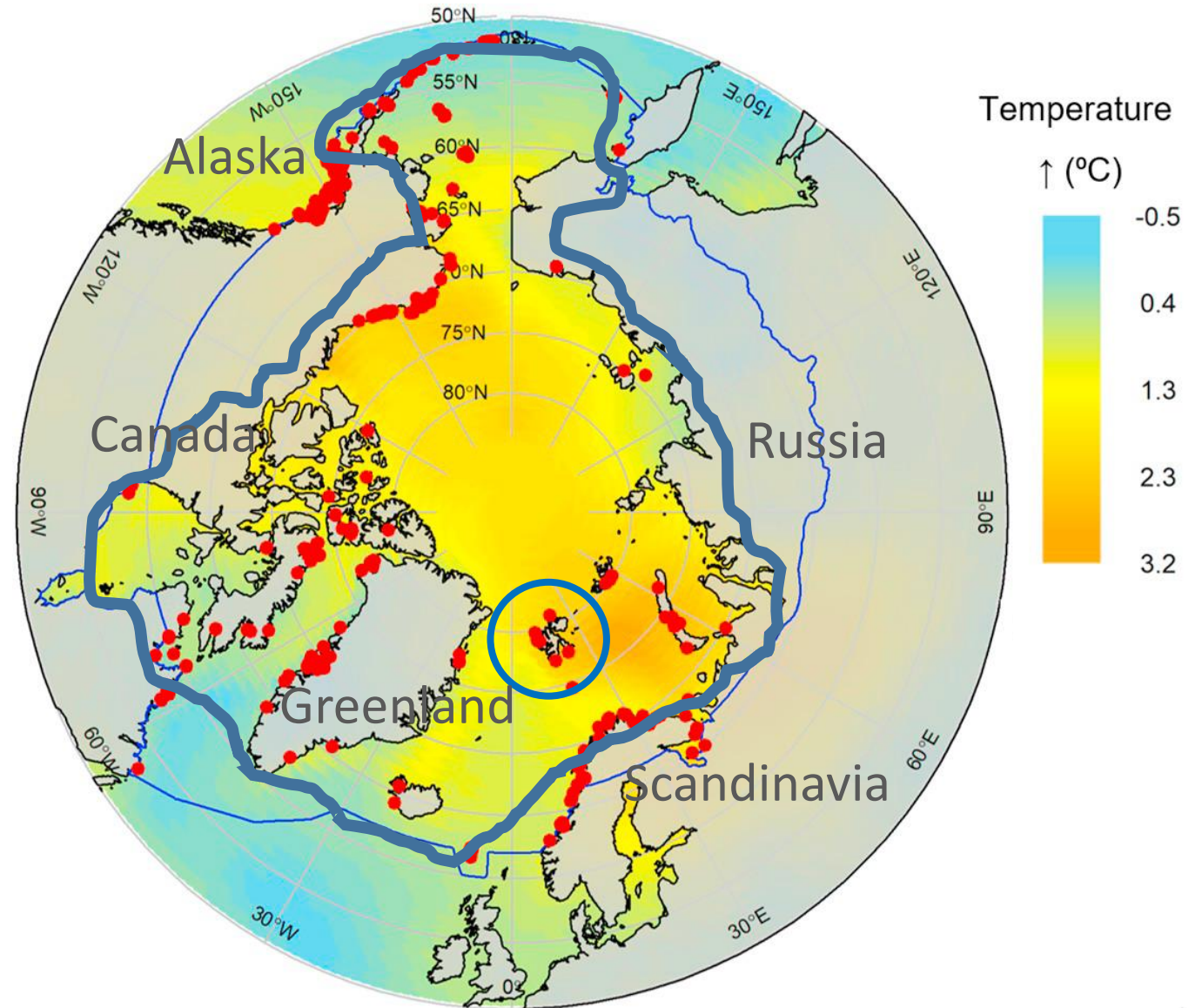
The Arctic and Kelp occurrence

— Border defined by Arctic monitoring and assessment program

● Kelp forest

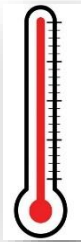
— +10°C July isotherm

○ Svalbard



The Arctic - extreme for seaweeds?

Annual temperature cycle:
-1.5 – 6 (9) °C

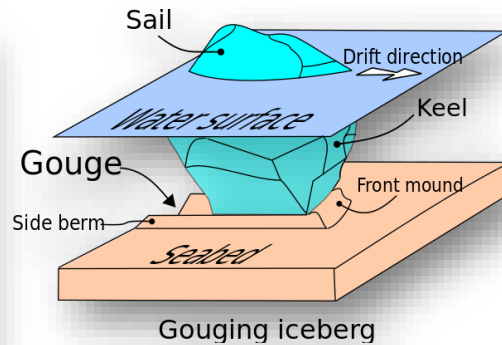


Sea-Ice:
0 – 48 weeks



Salinity: low in phases

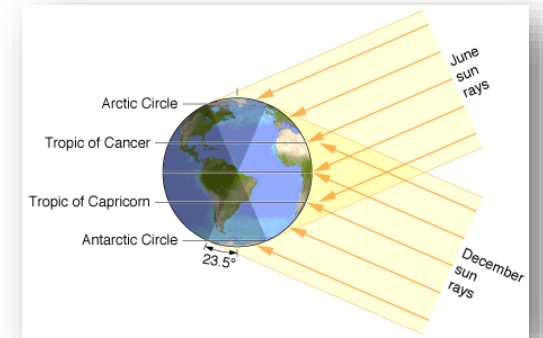
Ice Scour:
variable



Sedimentation:
high in phases



Irradiances:
Overall low



Sun angle: low
Daylength cycle: extreme



Under change

constant



Kelp species in the Arctic

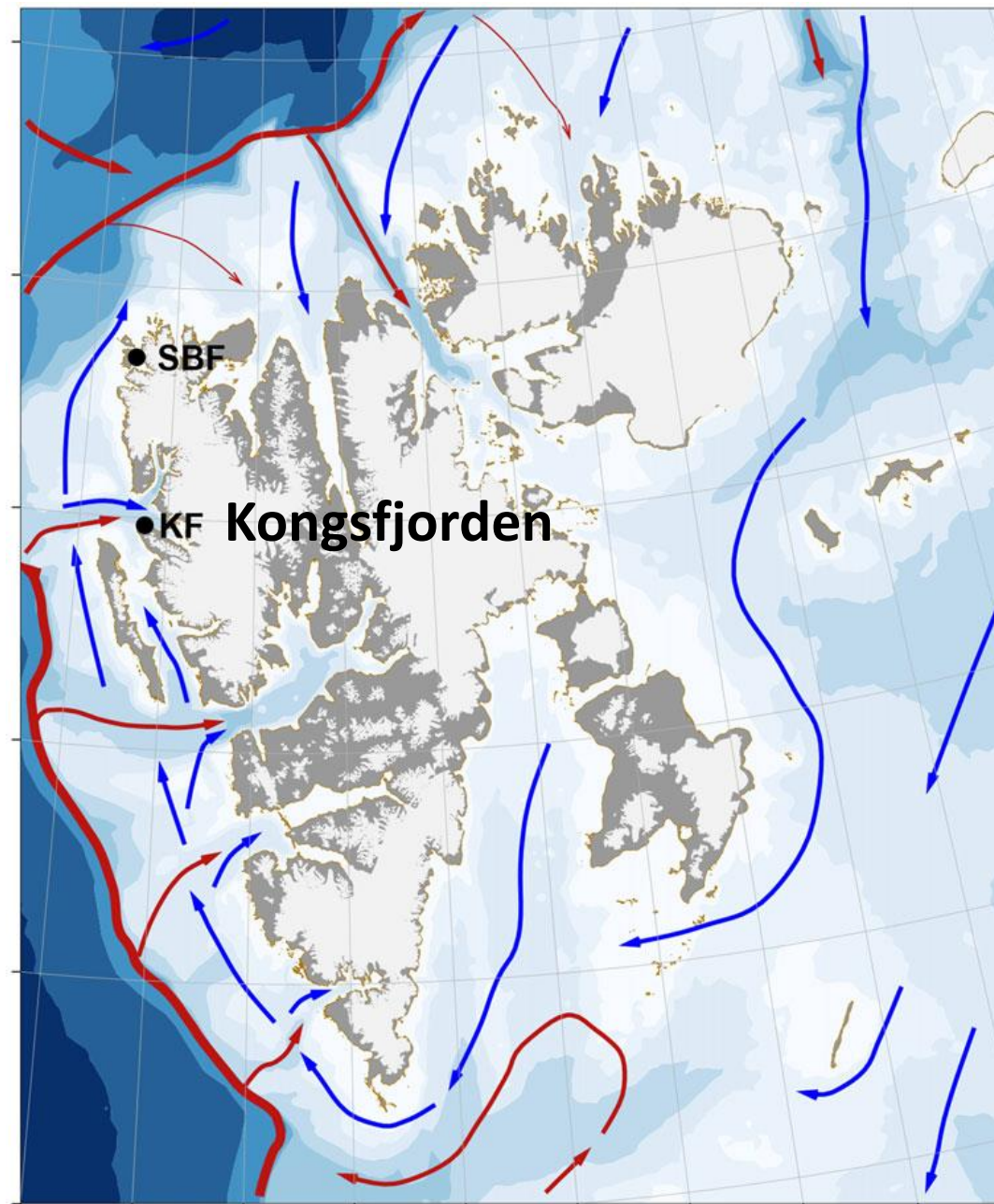
- *Nereocystis luetkeana*- NE Pacific
- *Hedophyllum nigripes* – NE Pacific / **N-Atlantic**
- *Agarum clathratum* – NW Atlantic
- *Saccharina longicruris* – NW Atlantic
- *Laminaria solidungula* – **N-Atlantic**
- *Saccharina latissima* – **N-Atlantic**
- *Laminaria digitata* – **N-Atlantic**
- *Alaria esculenta* – **NE-Atlantic**
- *Laminaria hyperborea* – NE Atlantic
- *Eualaria fistulosa* – NE Pacific
- *Alaria elliptica* / *A. oblonga* (Russian Arctic)



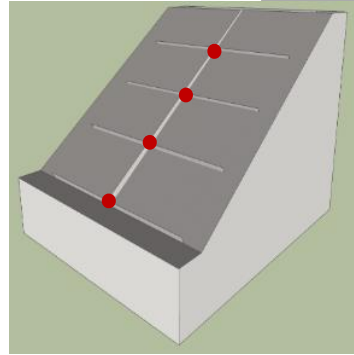
Svalbard and Warming



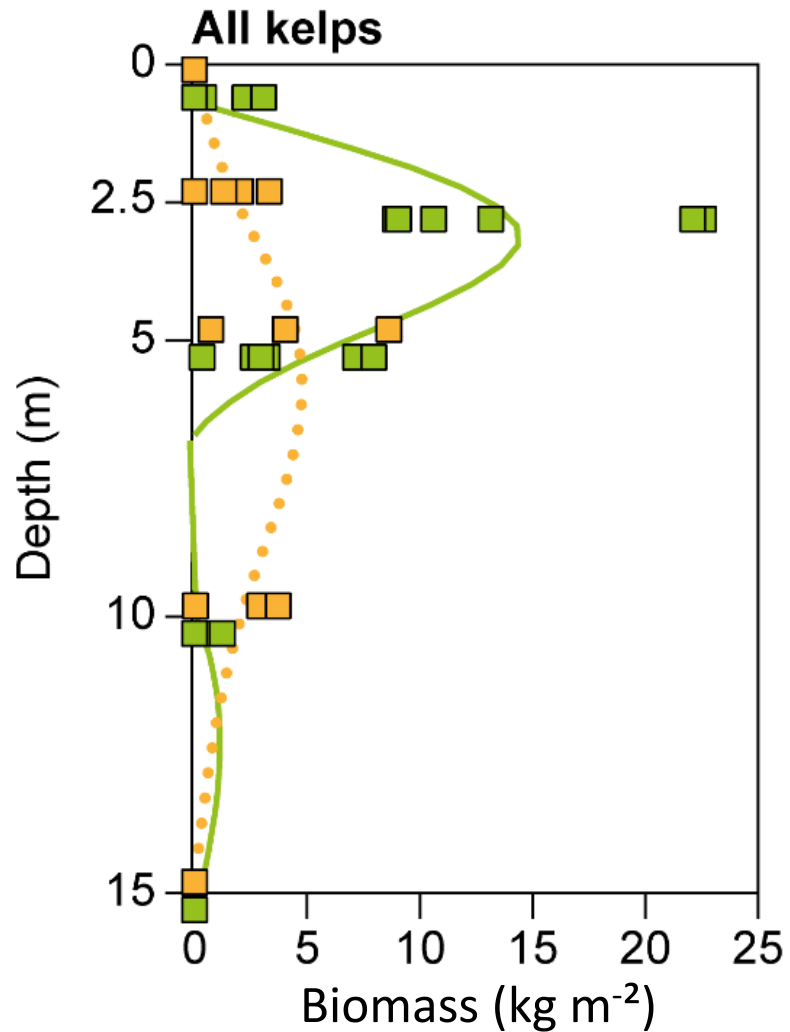
Decadal average Sea Surface Temperature Increase from the West Spitsbergen Current







Quantification of seaweeds and fauna along depth gradient: comparison 1996/98 – 2012/13



Warming induce massive community changes



2012/2013  
1996/1998  



Significant 2.5 fold biomass increase

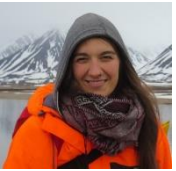
Biomass peak shifted from 5 to 2.5 m depth

Reduced depth occurrence of kelps

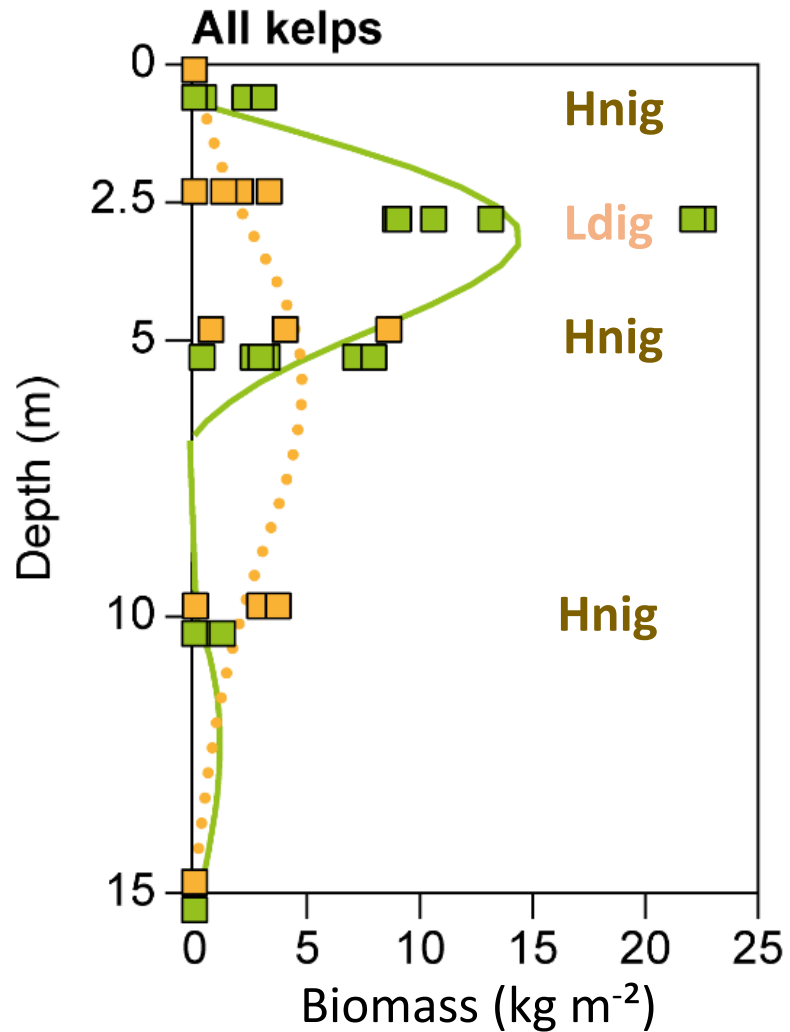


- Reduced Ice – Scouring
- Less Light

L. digitata in fact is two species



M. Dankworth



Laminaria digitata

Co-occurrence with pronounced zonation pattern

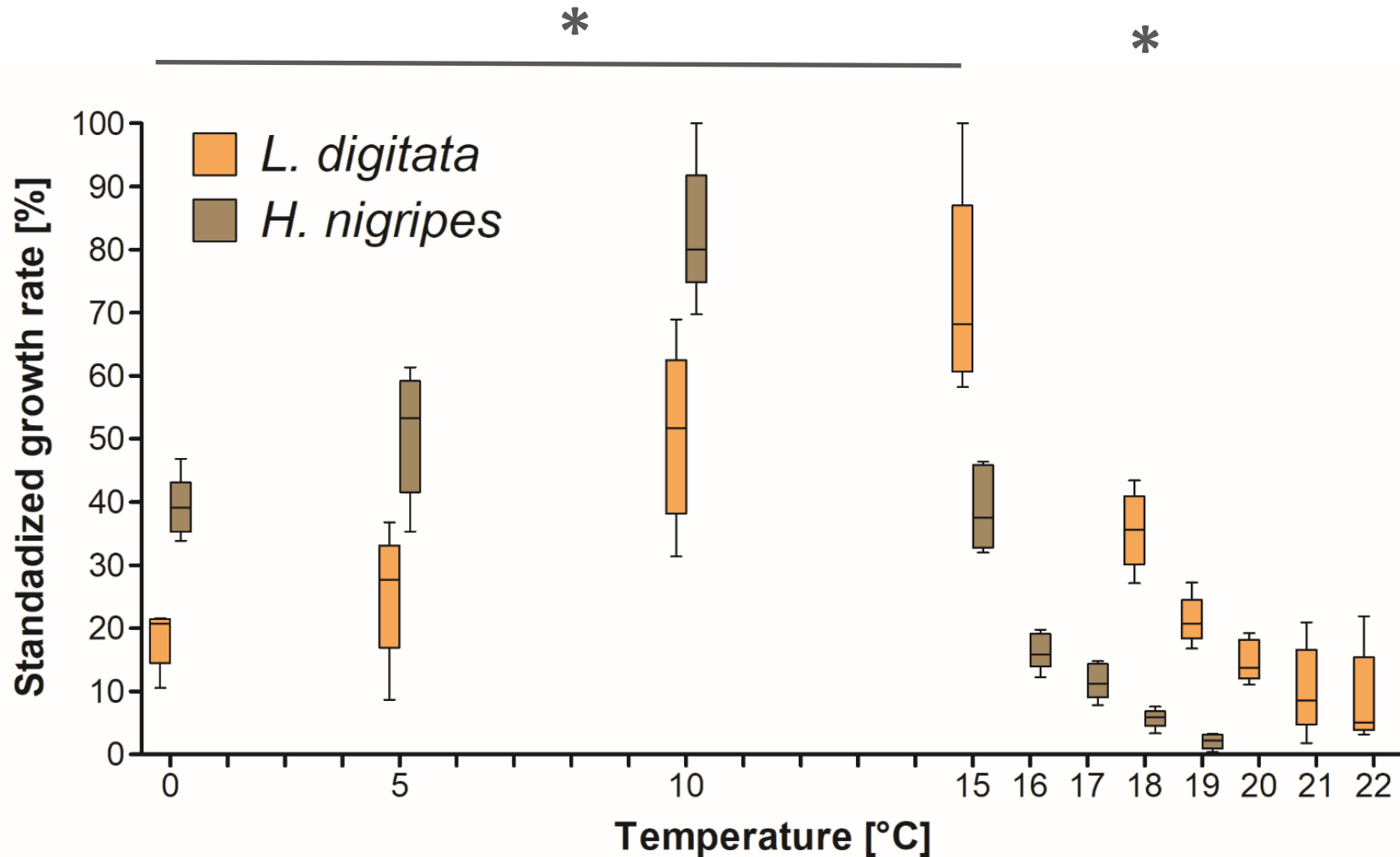
Hedophyllum nigripes

Differences revealed by cox1 - barcoding

Similar morphology \neq similar response pattern: *L. digitata* vs *H. nigripes*



K. Franke



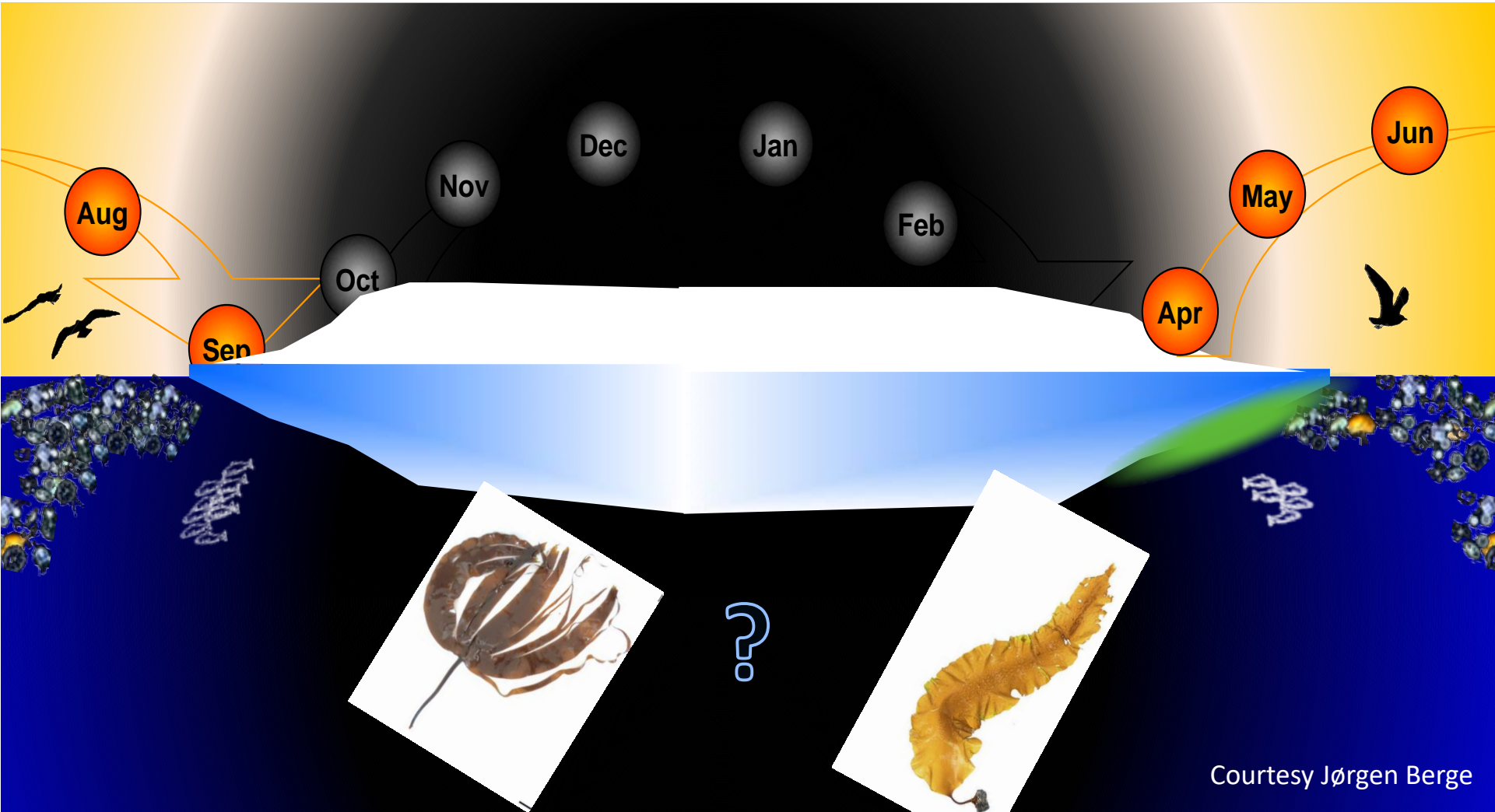
H. nigripes with 3-4 °C lower temperature limits in:

- Sporophyte growth optimum
- Sporophyte survival
- Gametophyte survival
 - Gametophyte reproduction



ARCTIC kelp

Warm and dark – the future of Polar Nights



Sporophyte recruitment after 4.5 month of darkness in a warming scenario



K.Zacher

After 12 days

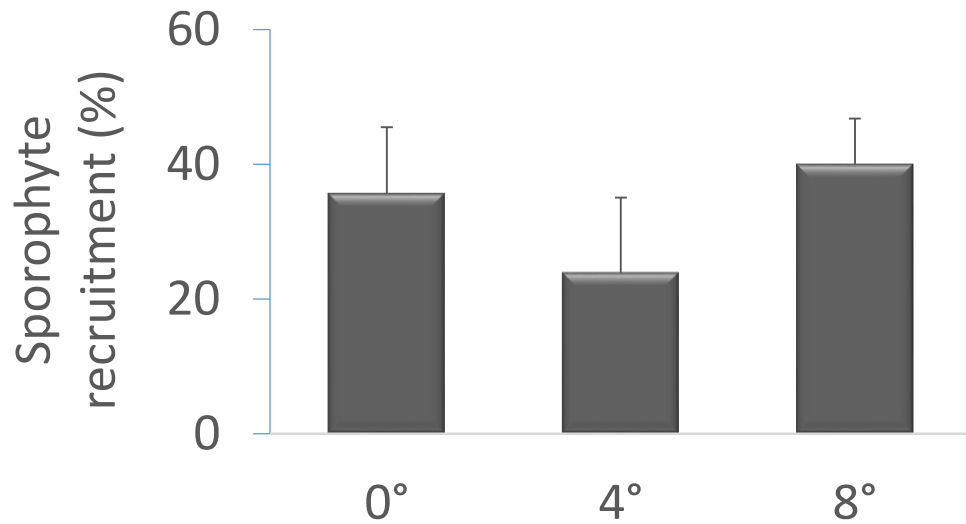
33%

>

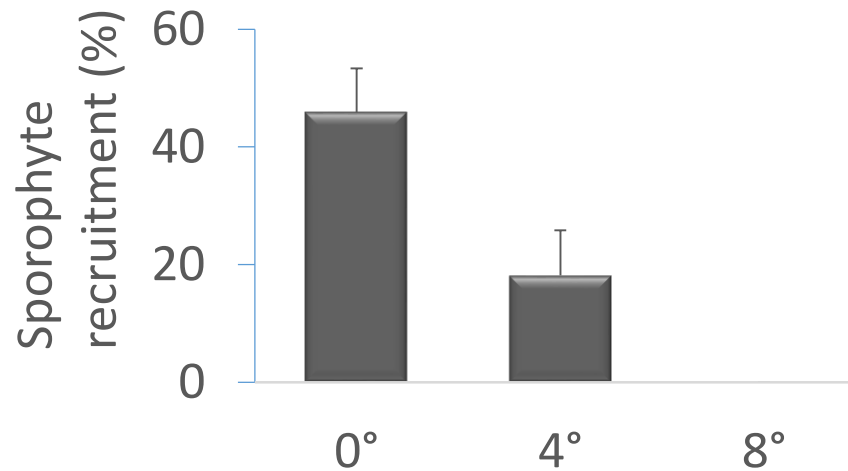
21%

(Species $p < 0.001$)

Saccharina latissima



Hedophyllum nigripes



Temperature (°C)



Warming winters reduce recruitment capacity of species with cold temperature characteristics in spring

What about Local Adaptation in temperate to Arctic kelps?

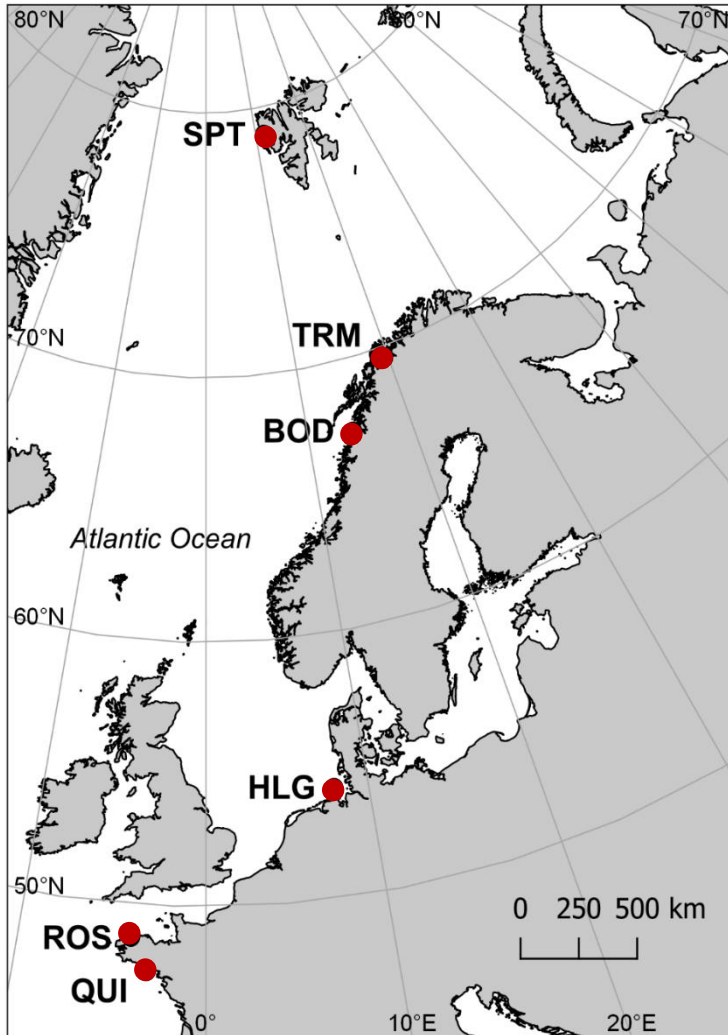
Are Arctic kelp populations better adapted to the Arctic environment than their temperate brothers and sisters?

Showcase *Laminaria digitata*



B

Sampling strategy and local temperature history



Spitsbergen: 0 – 6°C

Tromsø: 2.5 – 11°C

Bodø: 5 - 15°C

Helgoland: 4.5 - 19°C

Roscoff: 10 - 17°C

Quiberon: 9 – 20°C

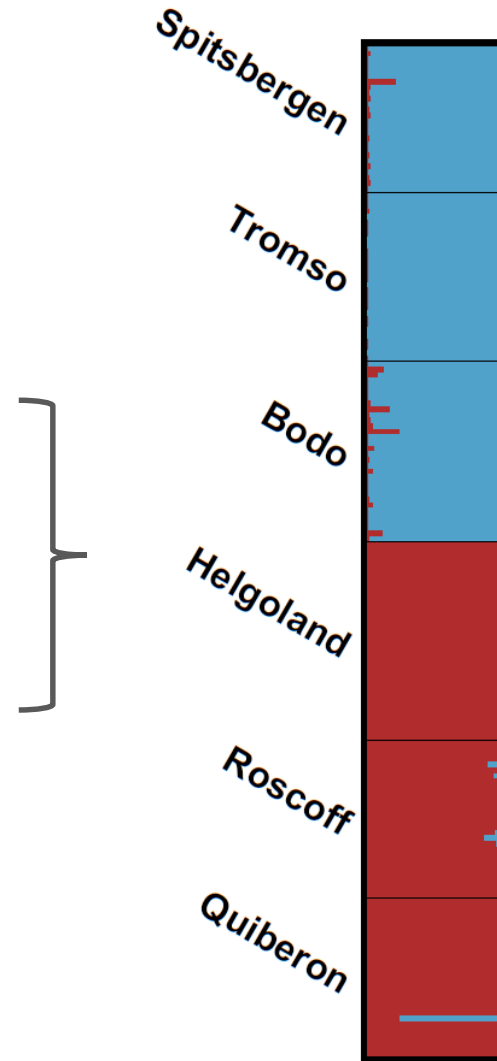
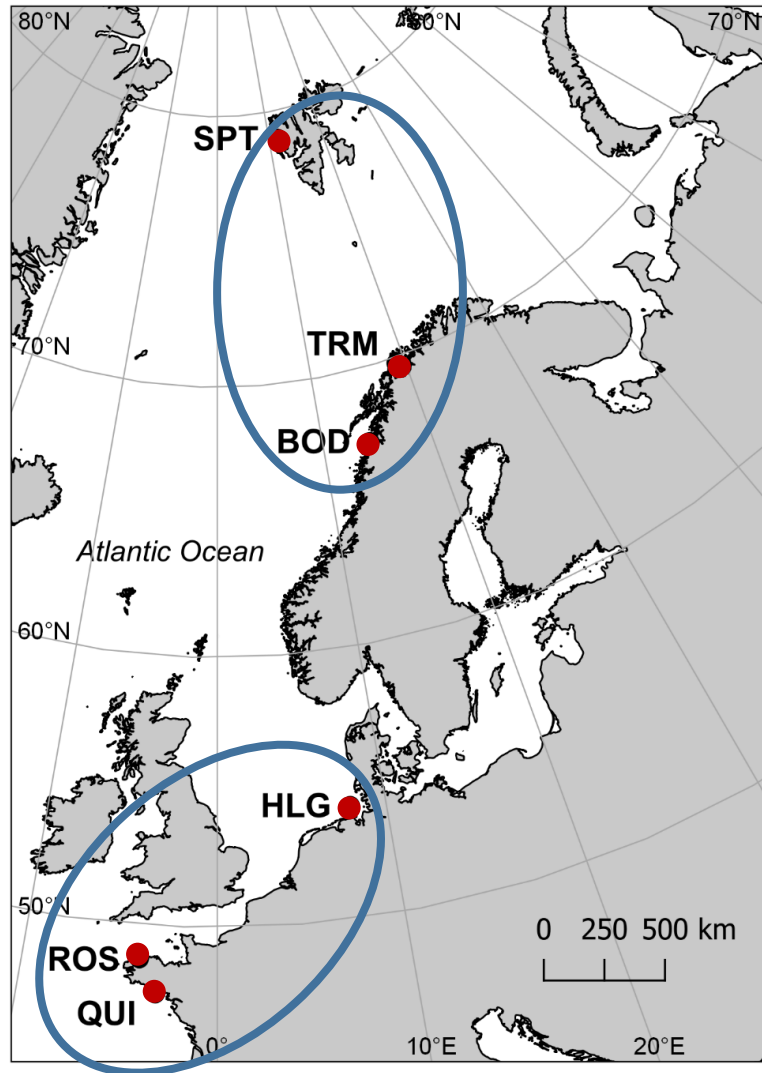


Laminaria digitata- Spitsbergen

Laminaria digitata population genetics



D. Liesner

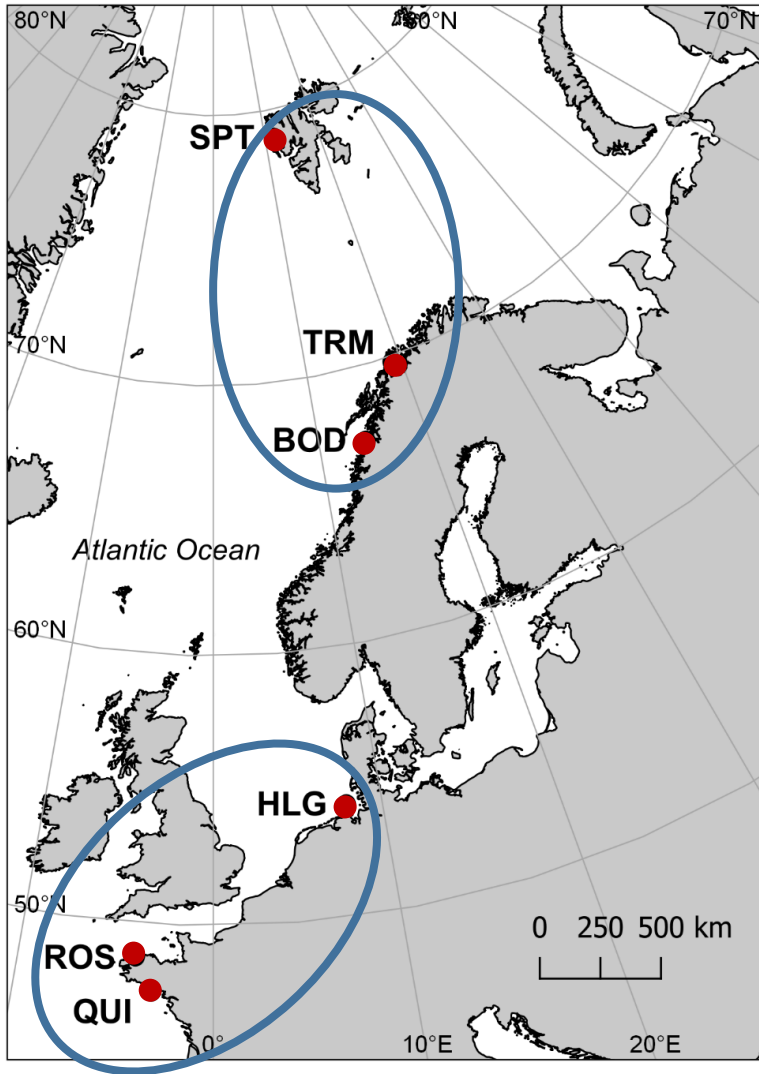


Northern clade



Southern clade

Laminaria digitata: Survival limit at **high** temperatures



Spitsbergen

Tromsø

Bodø

Helgoland

Roscoff

Quiberon



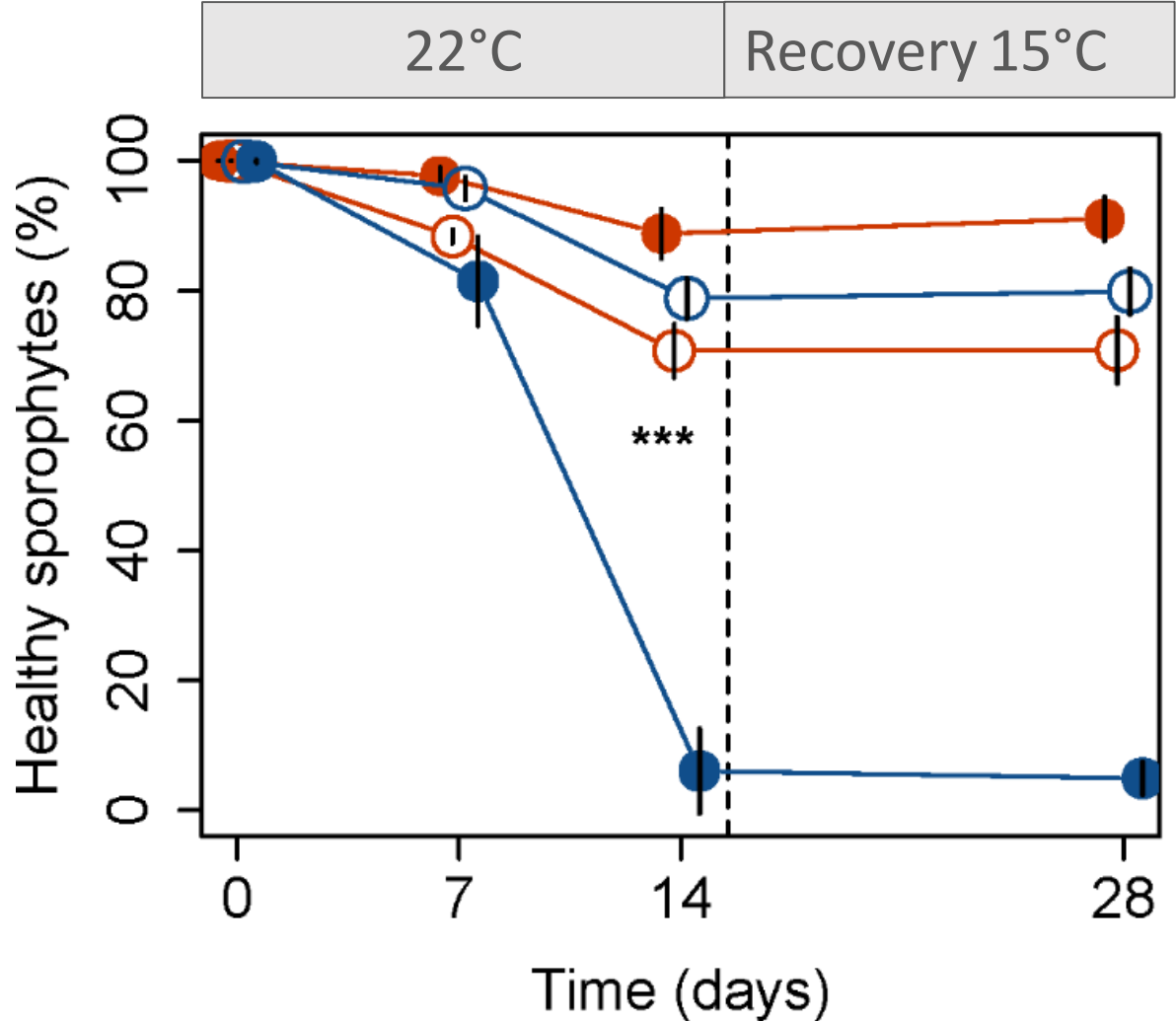
23-24°C

21-22°C

uniform

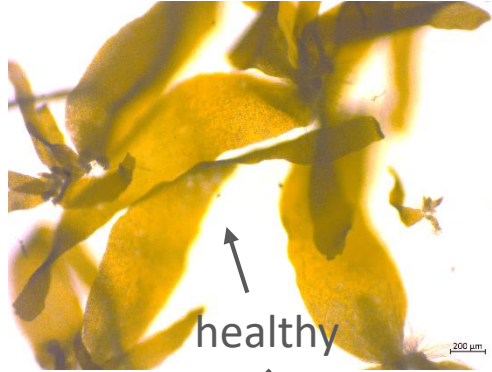
Laminaria digitata: survival at **sublethal** high temperatures

See SYMO5 – Talk by Daniel Liesner



● North Sea
} hybrids

● Spitsbergen



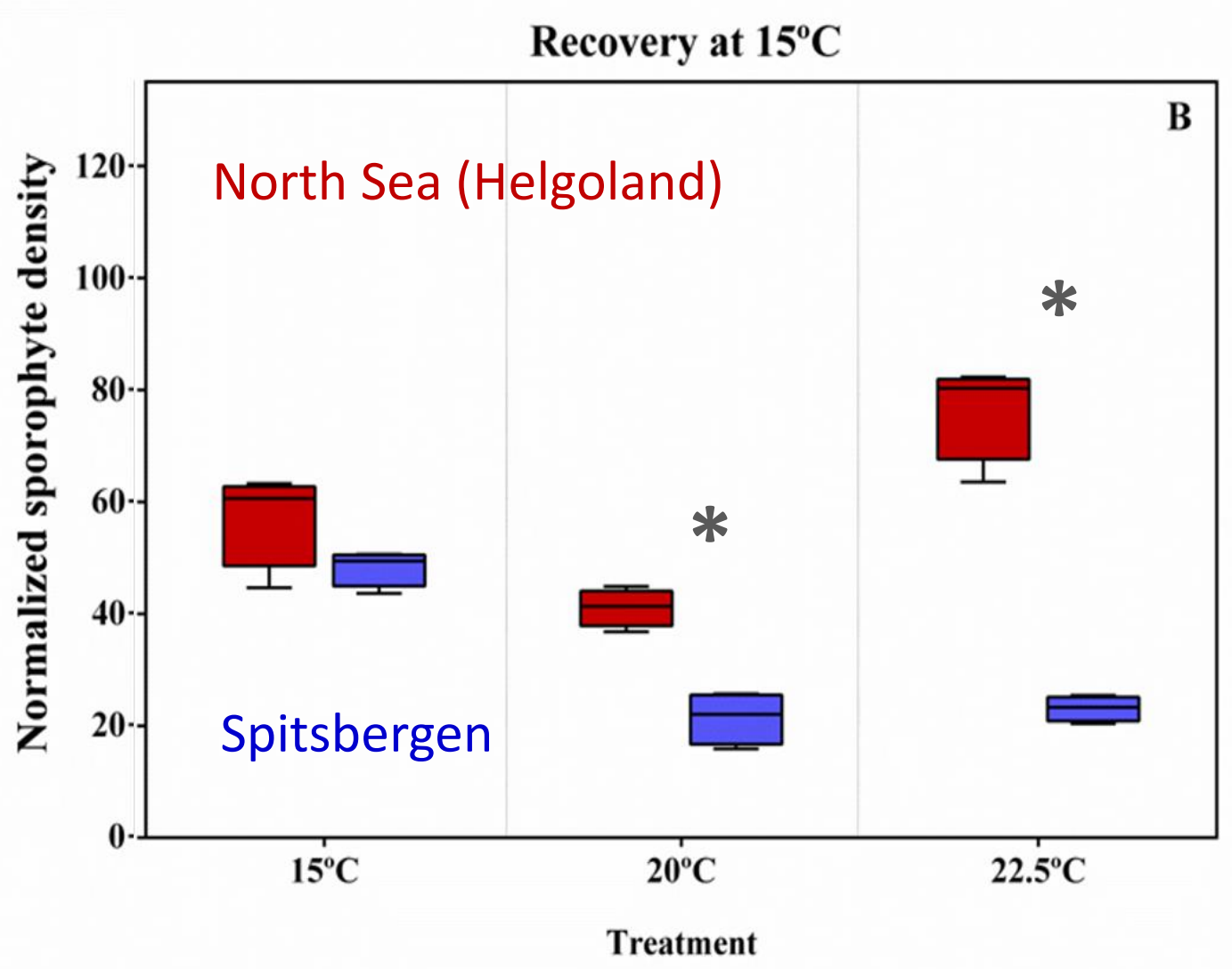
Laminaria digitata: recruitment following heat stress



N. Martins



Foto: C. Gauci



Spitsbergen material = ecotype

↓

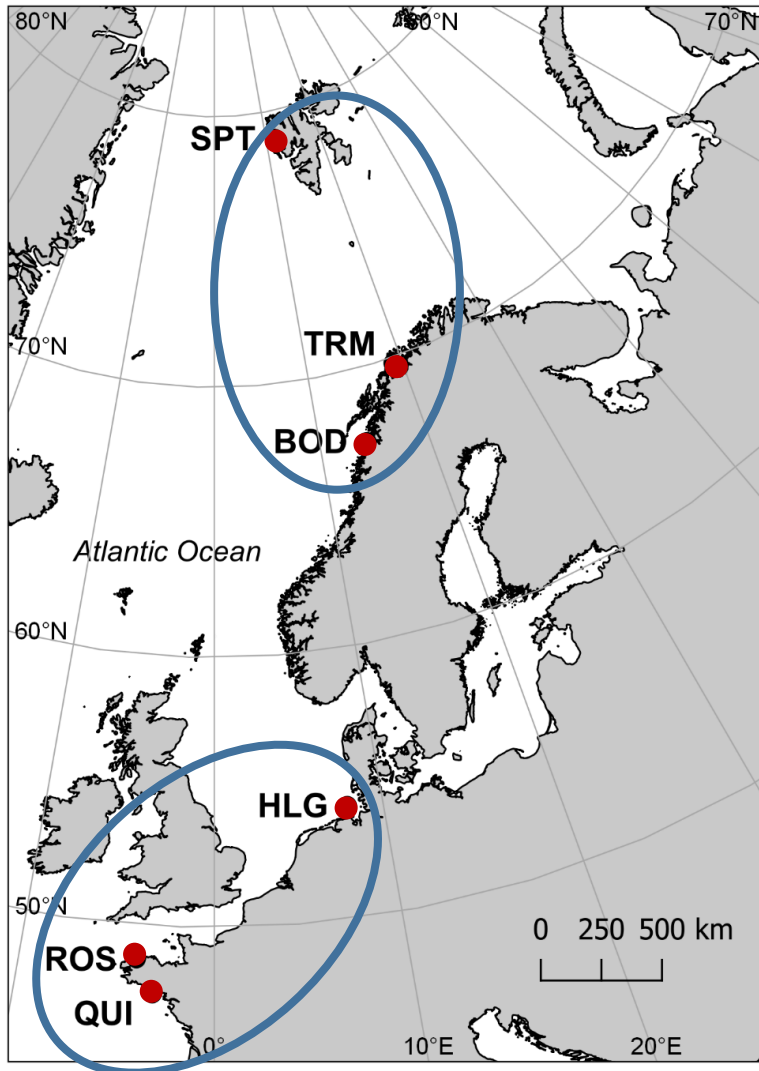
reduced performance at sublethal high temperatures

n= 5, ANOVA, p=0.05

Laminaria digitata: Survival capacity at **lower** temperatures



N. Schimpf



Spitsbergen: 0 – 6°C

Tromsø: 2.5 – 11°C

Gametophyte survival

Sporophyte recruitment

0, 3, 6, 9, 12, 15°C

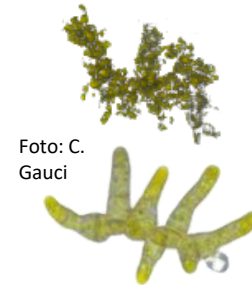
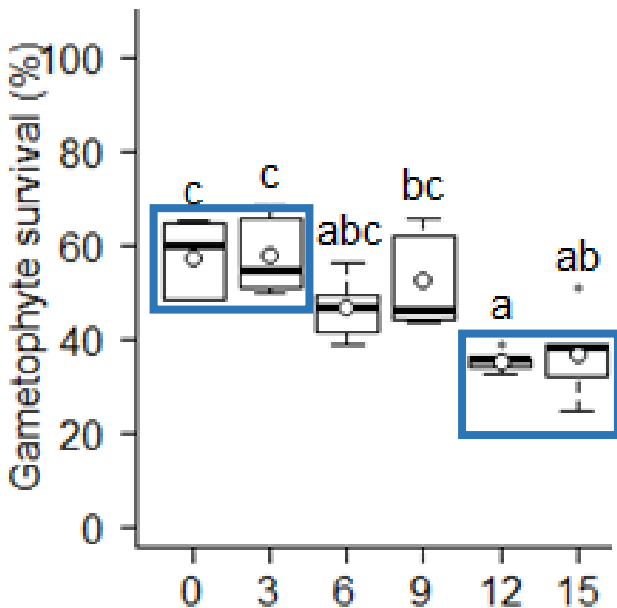


Foto: C. Gauci

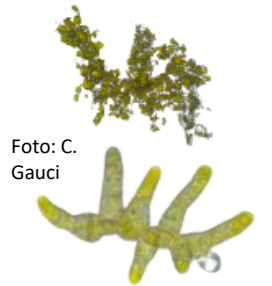
Quiberon: 9 – 20°C

Laminaria digitata: Survival capacity at lower temperatures

Spitsbergen

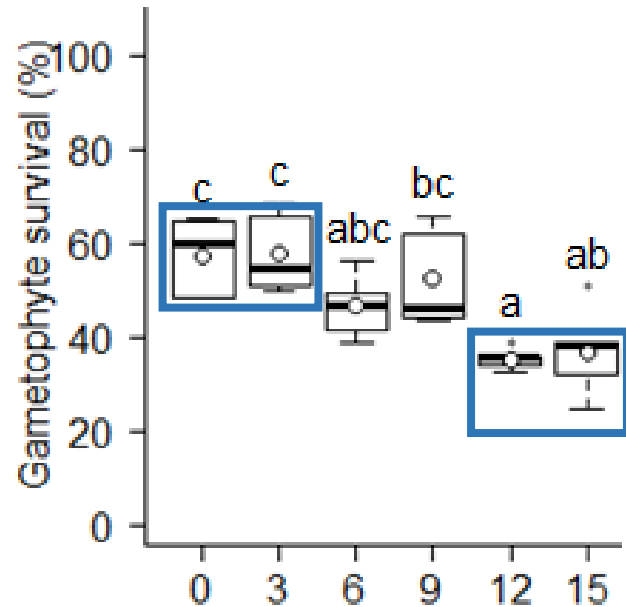


0 -3°C > 12-15°C



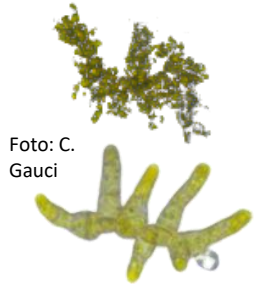
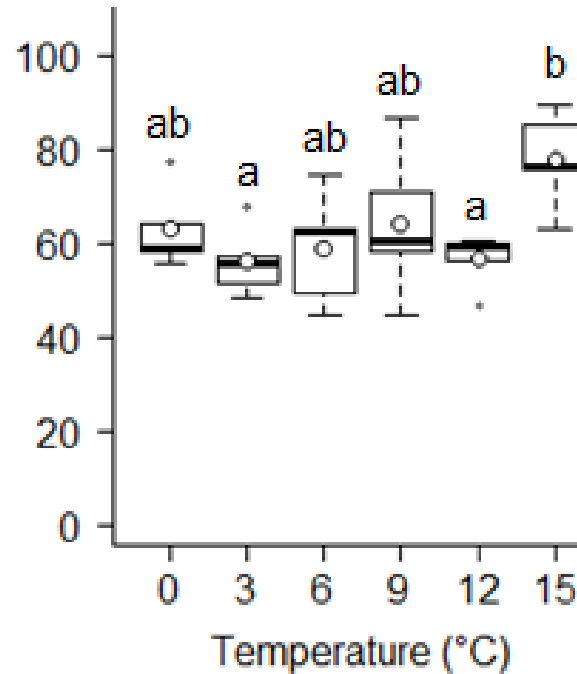
Laminaria digitata: Survival capacity at **lower** temperatures

Spitsbergen



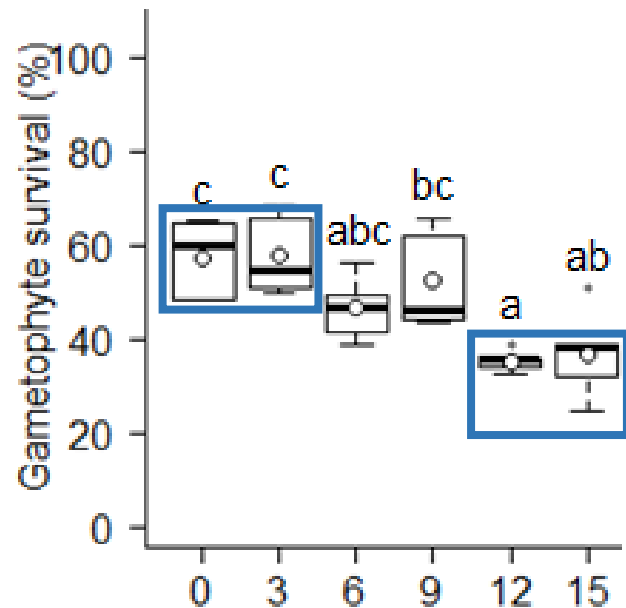
0 -3°C > 12-15°C

Tromsø



Laminaria digitata: Survival capacity at lower temperatures

Spitsbergen



0 -3°C > 12-15°C

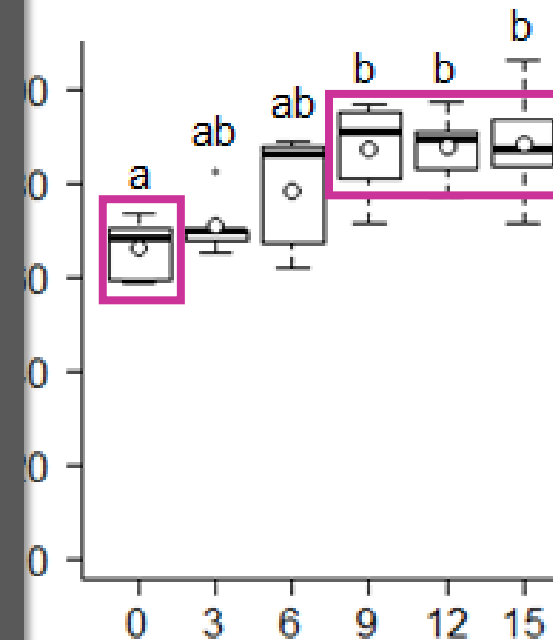
Local adaptation in northern and southern population

Neutral reaction norm in Norwegian population

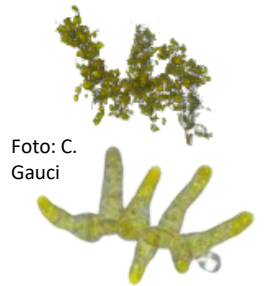
↓

Reflection of long term local temperature history?

Quiberon



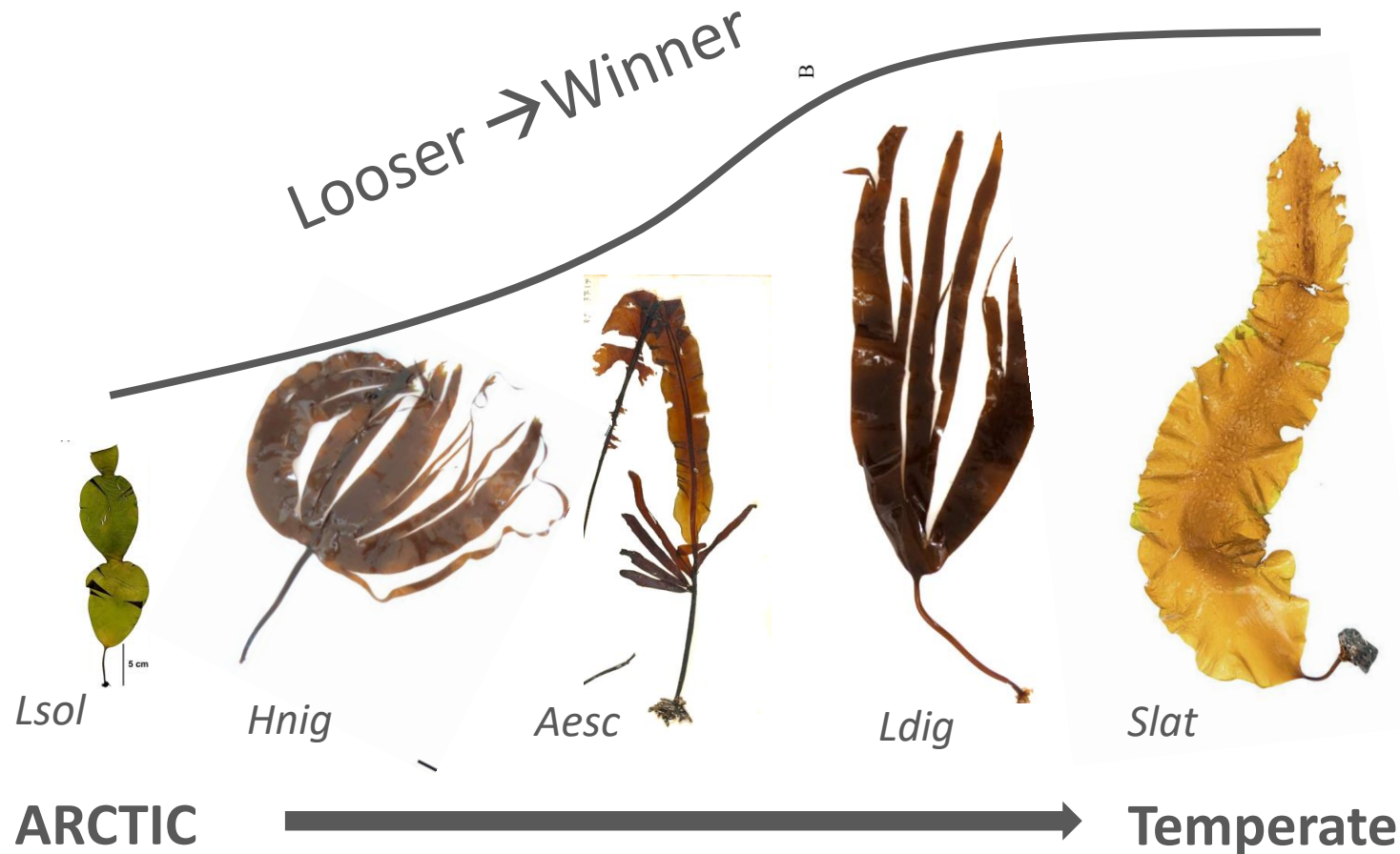
0 °C < 9-12 °C



Local adaptation / ecotypes
→ some but low buffer capacity

Kelps with Arctic temperature imprint lose competitive advantage if SST rise > ~8°C

High temperature tolerance of Arctic kelps will not be sufficient to counteract competition with temperate species



Changes in productivity, species abundances, overall functional ecology of system

UNSTOPPABLE

Thank you

- Klaus Valentin
- Gernot Glöckner
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- Kai Bischof
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- Myriam Valero
- Gareth Pearson
- Ester Serrao
- Andreas Wagner
- Claudia Daniel
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- AWI Diving Team 2012 -2014 / 2015 / 2016 / 2019
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HELMHOLTZ
RESEARCH FOR GRAND CHALLENGES



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Station Biologique
de Roscoff**

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