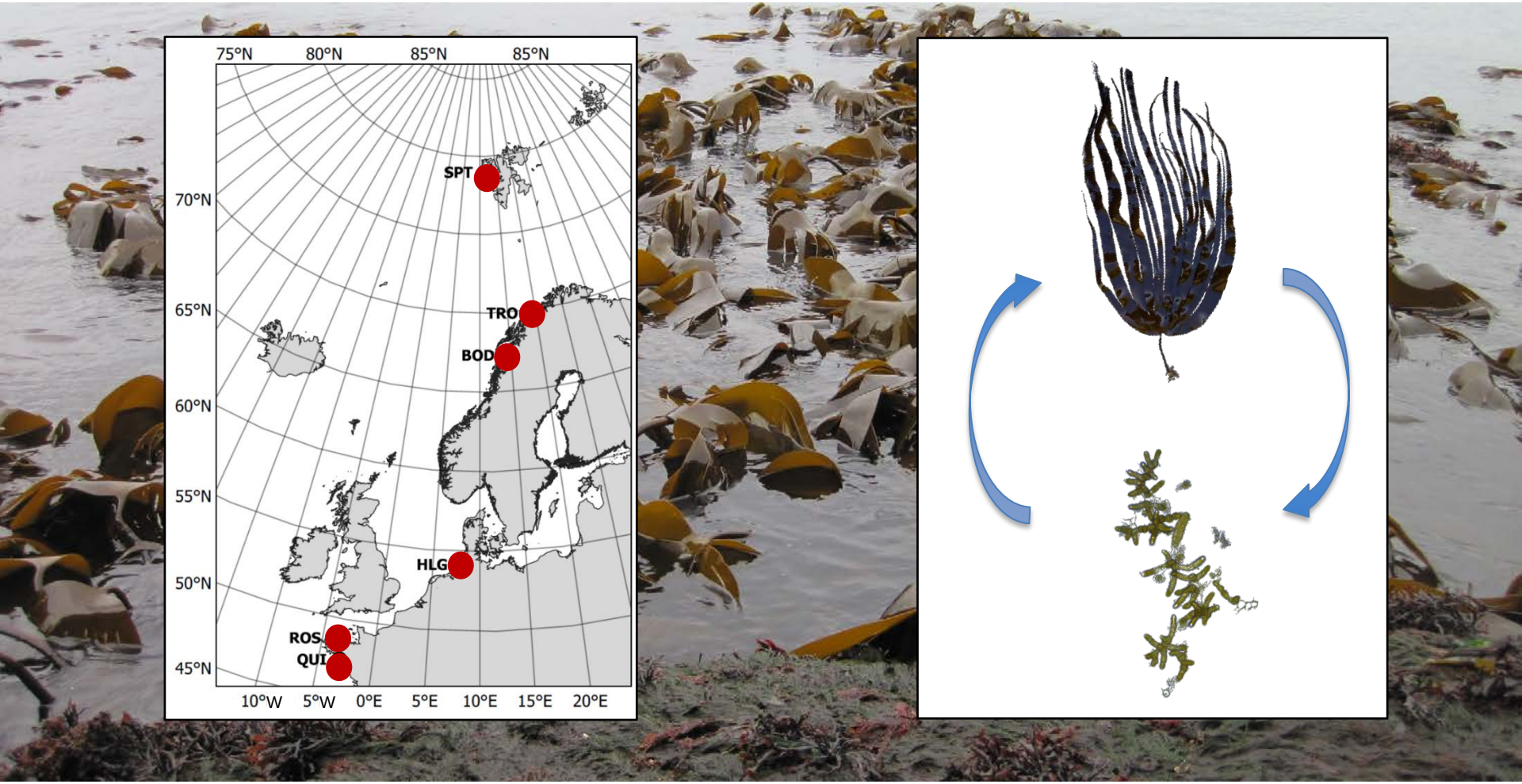
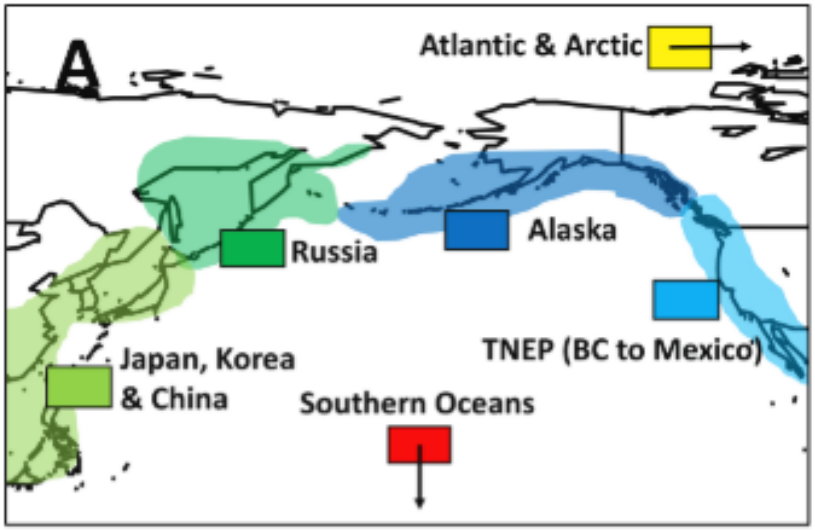
Thermal plasticity of the kelp *Laminaria digitata*

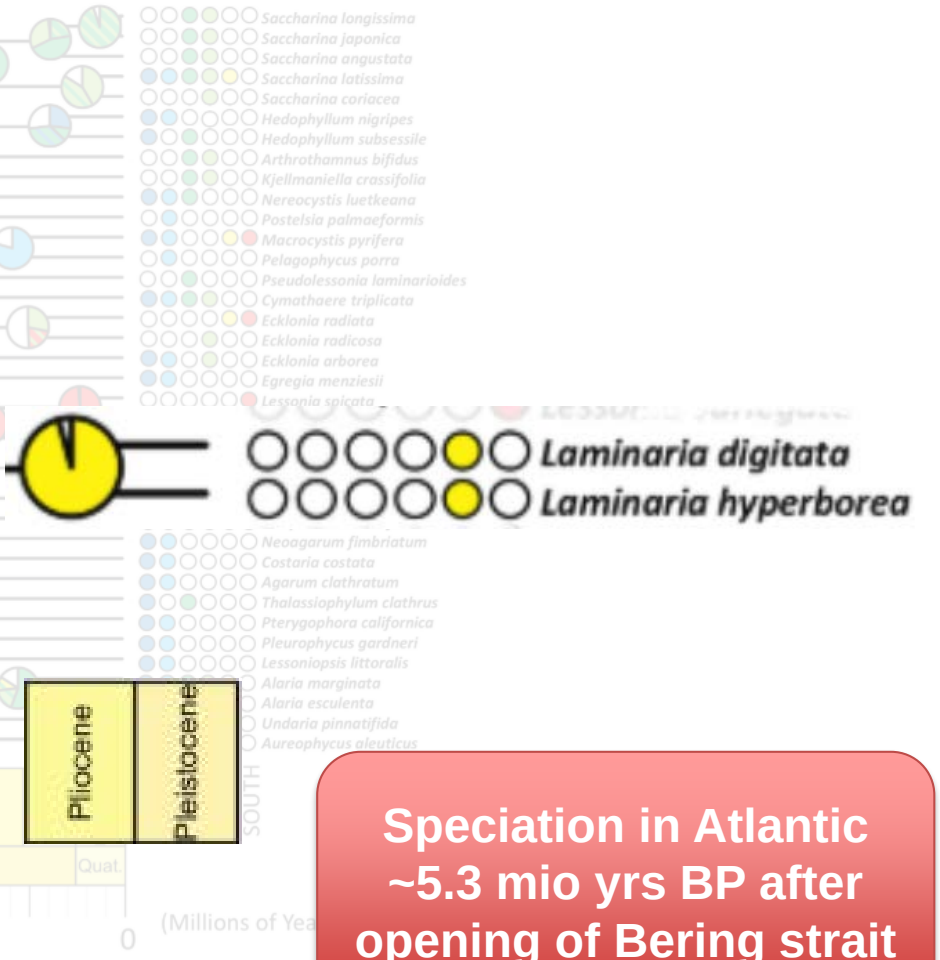
ALFRED-WEGENER-INSTITUT
HELMHOLTZ-ZENTRUM FÜR POLAR- UND MEERESFORSCHUNG

Daniel Liesner



Phylogeographic history

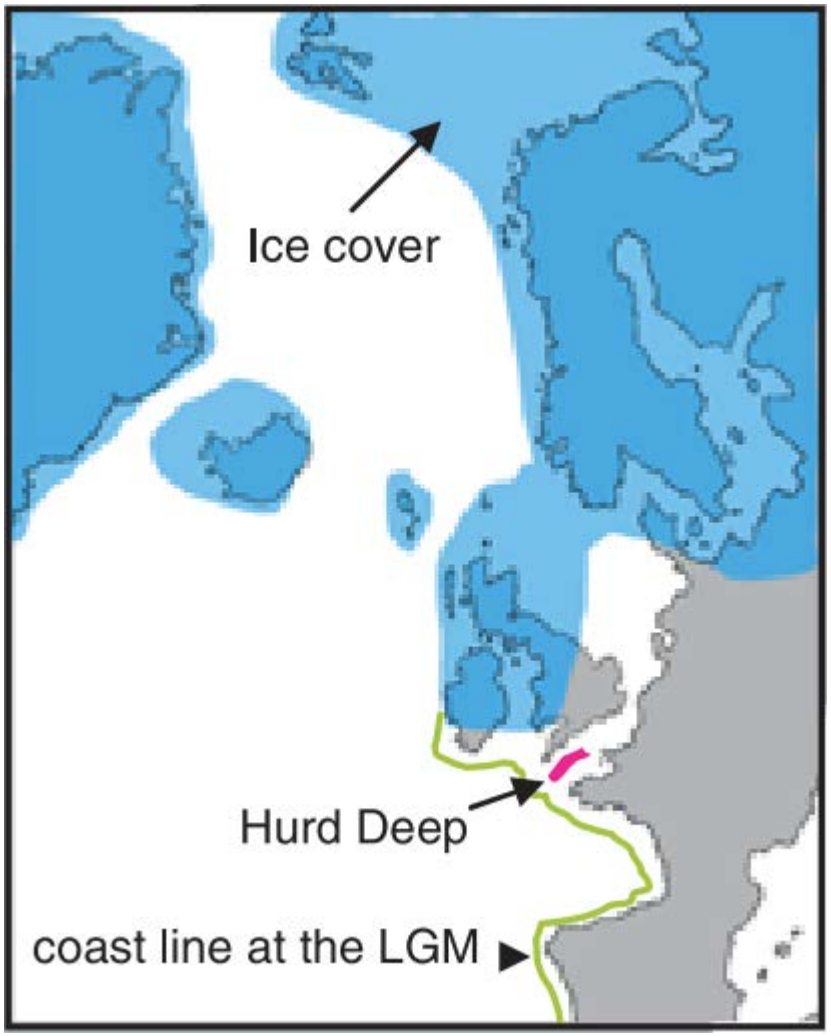


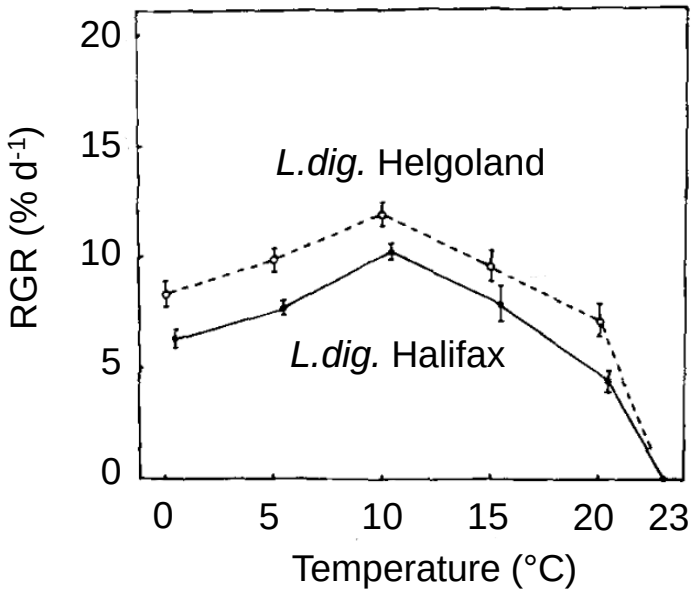


Speciation in Atlantic ~5.3 mio yrs BP after opening of Bering strait

Gladenkov *et al*. (2002). A refined age for the earliest opening of Bering strait. Palaeogeogr / climatol / ecol.
Rothman *et al*. (2017). A phylogeographic investigation of the genus *Laminaria* … J Phycol
Starko *et al*. (2019). A comprehensive kelp phylogeny sheds light on the evolution ... Mol Phylogenetics Evol.

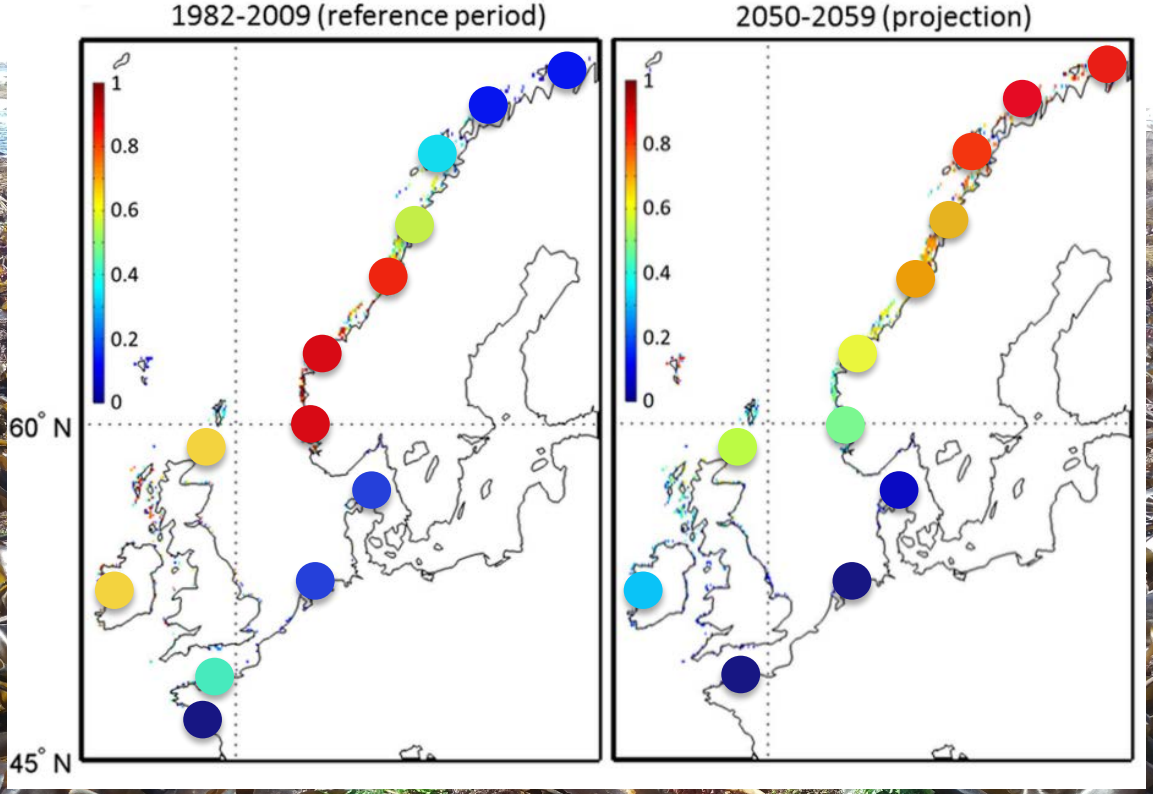
Phylogeographic history





Stable, cold-temperate temperature characteristics

Hoarau *et al*. (2007). Glacial refugia and recolonization pathways in the brown seaweed *Fucus serratus*. Mol Ecol.
Robuchon *et al*. (2014). Contrasting genetic diversity patterns in two sister kelp species … Mol Ecol.
Bolton & Lüning (1982). Optimal growth and maximal survival temperatures … Mar Biol

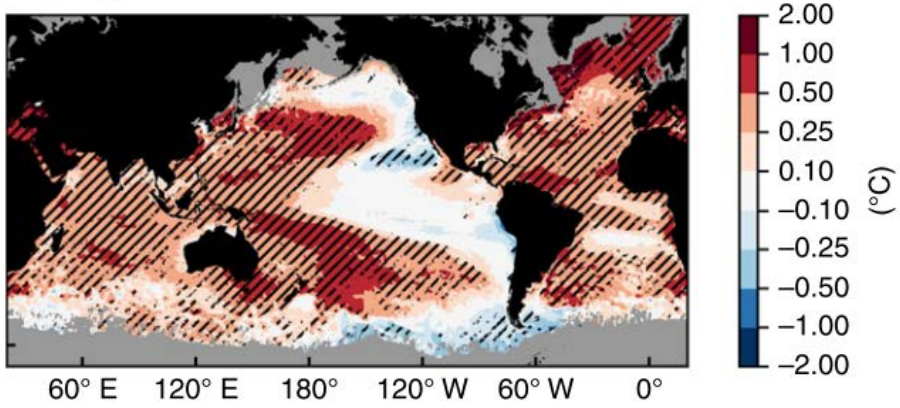


Global warming leads to range shifts of kelp forests.

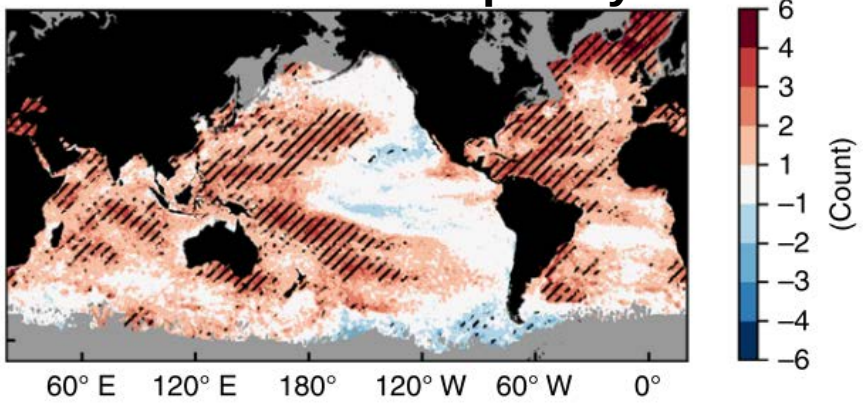
Raybaud *et al*. (2013). Decline in Kelp in West Europe and Climate. PLoS ONE

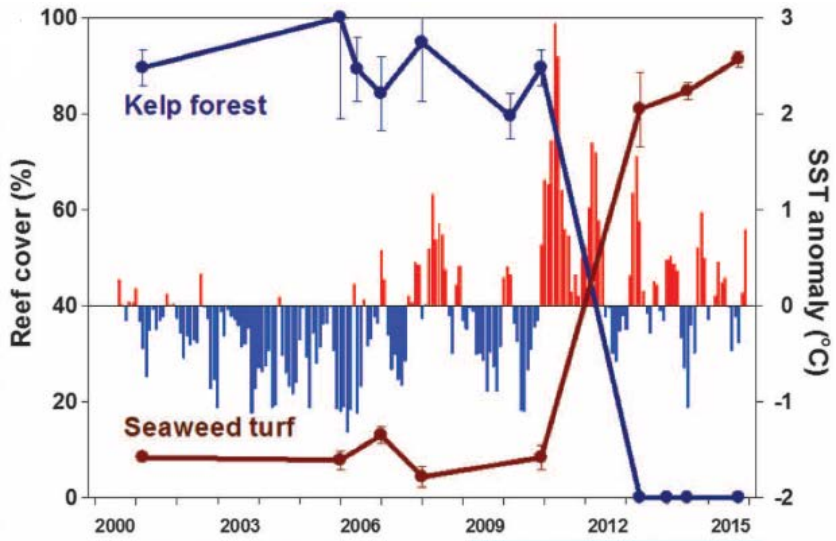
Marine heatwaves

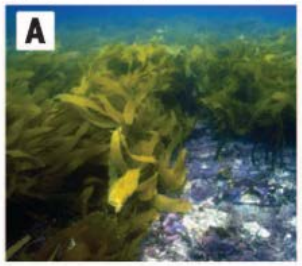
SST: 2000-2016 vs. 1982-1998

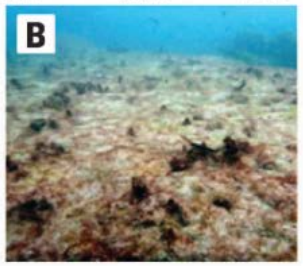


Marine heatwave frequency





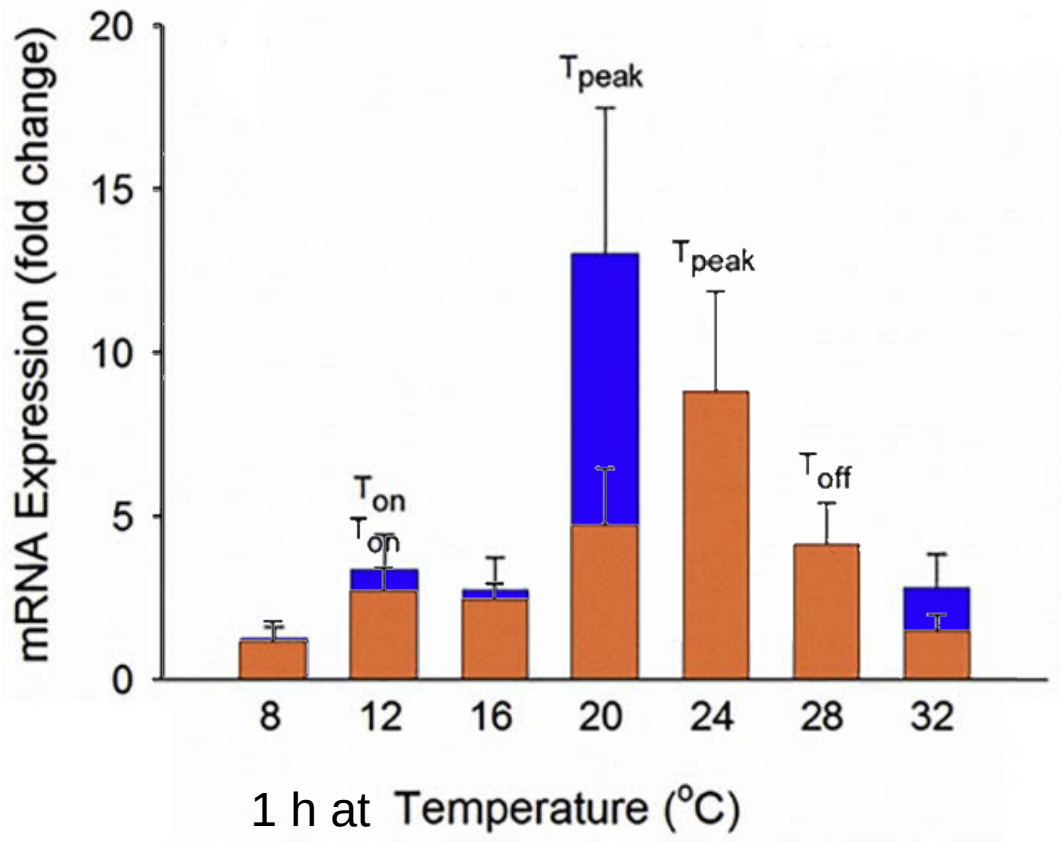


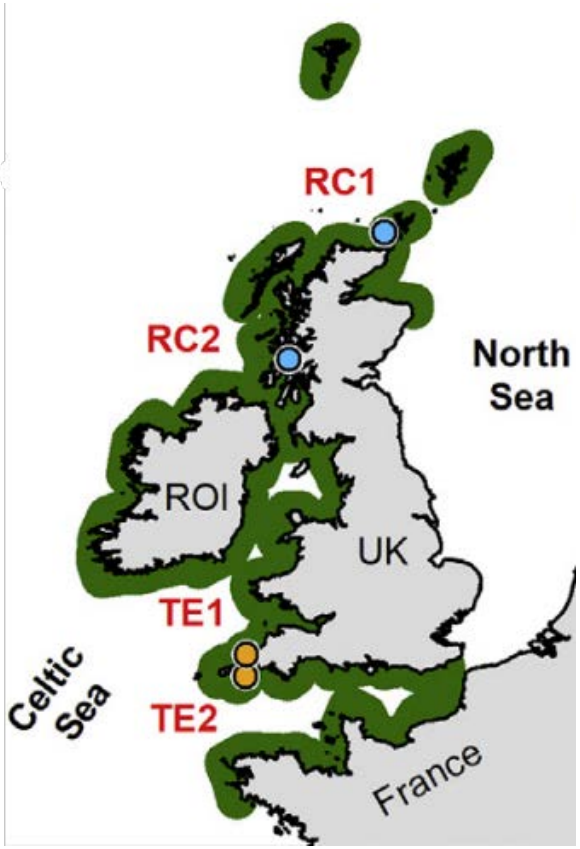


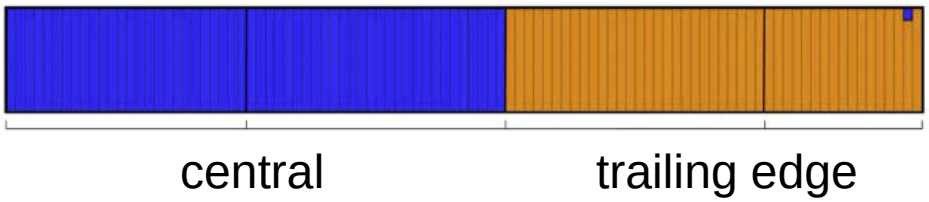
Marine heatwaves threaten trailing edge kelp populations.

Oliver *et al*. (2018). Longer and more frequent marine heatwaves over the past century. Nat Commun.
Wernberg *et al*. (2016). Climate-driven regime shift of a temperate marine ecosystem. Science

Local adaptation in *L. digitata*



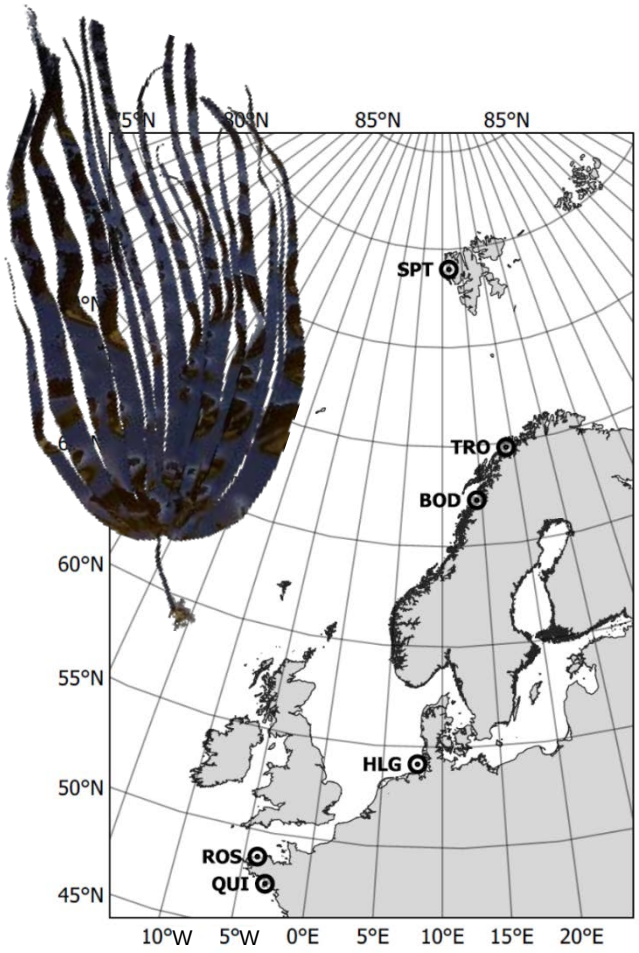




Local thermal adaptation between central and trailing edge populations.

King et al. (2019). Evidence for different thermal ecotypes in range centre and trailing edge … JEMBE

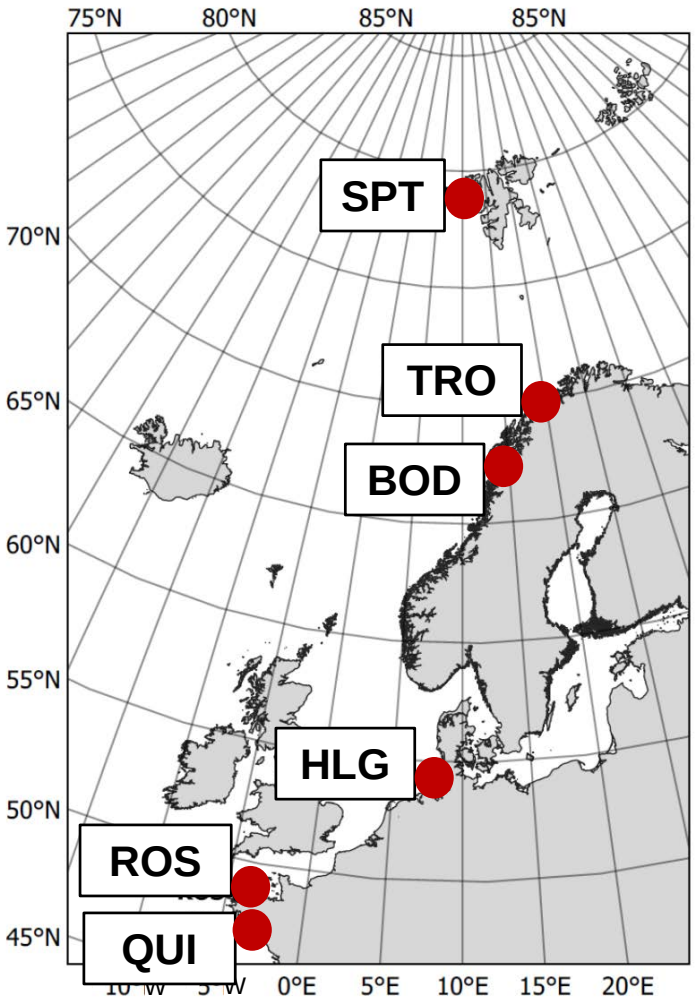
Local plasticity for heat tolerance?

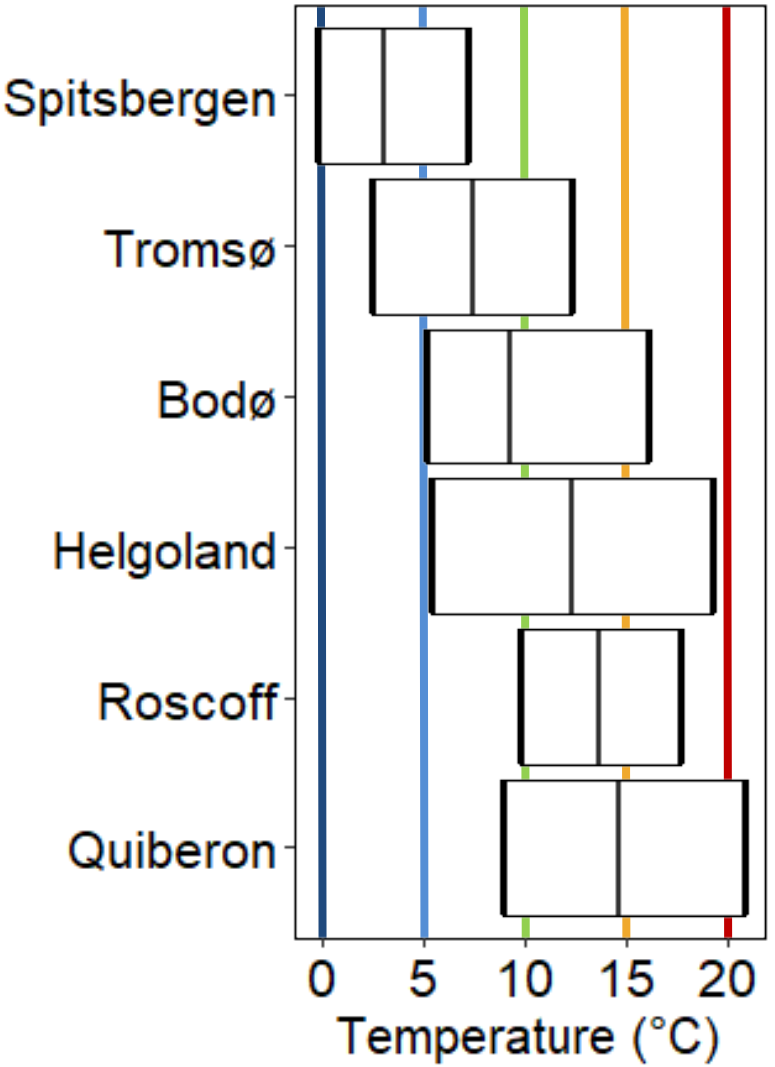


Do populations of *Laminaria digitata* differ in short-term heat tolerance?

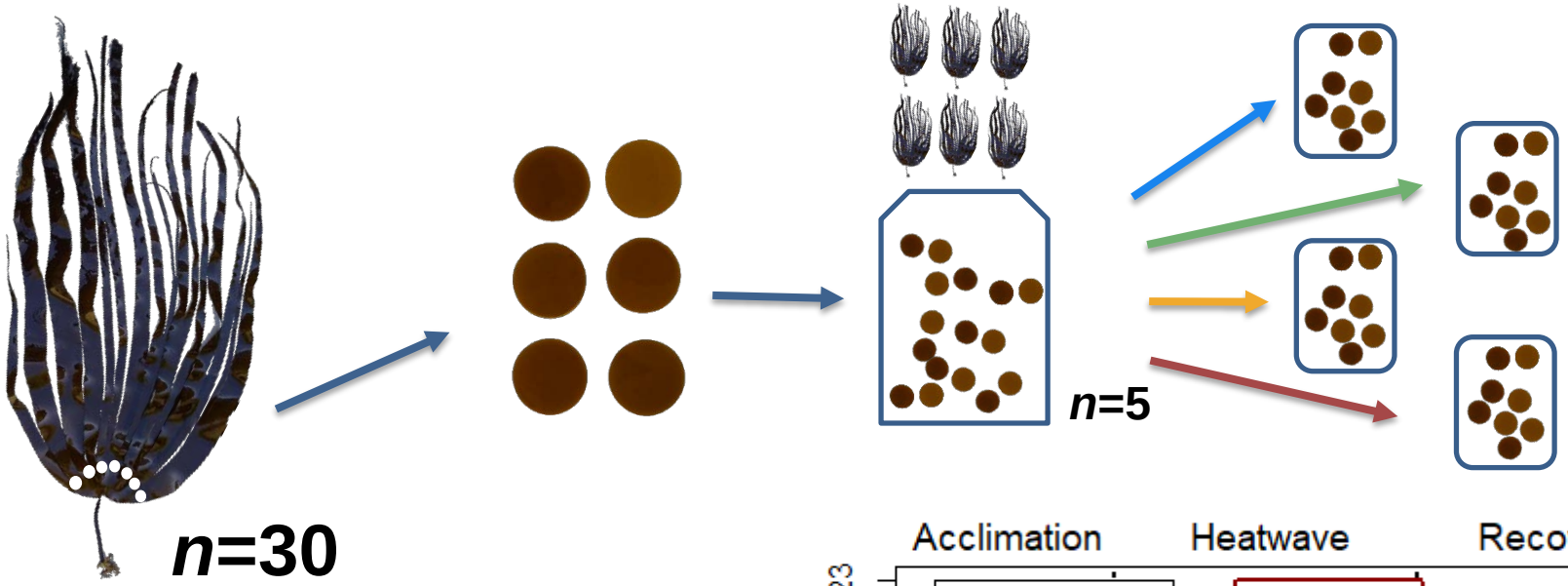
Can population genetic characteristics be connected to physiological responses?

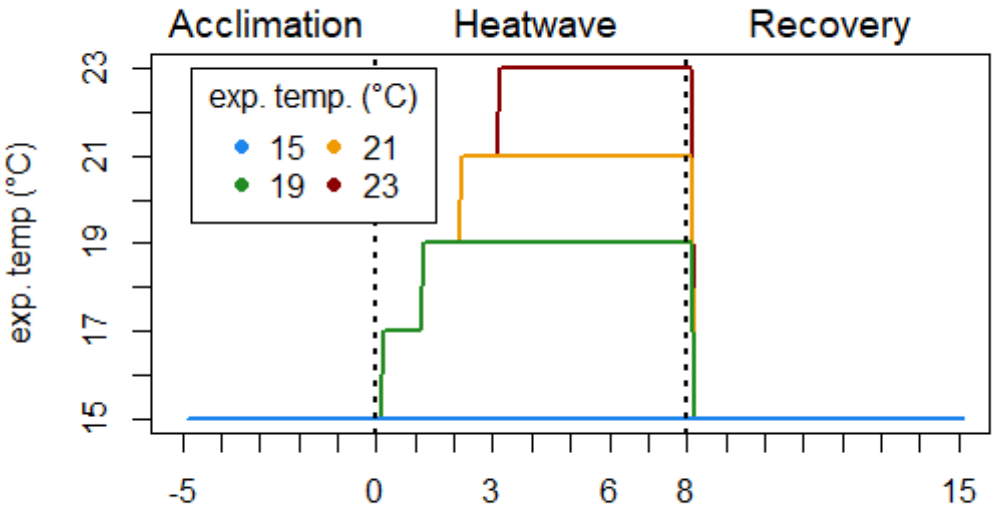
Sampling locations





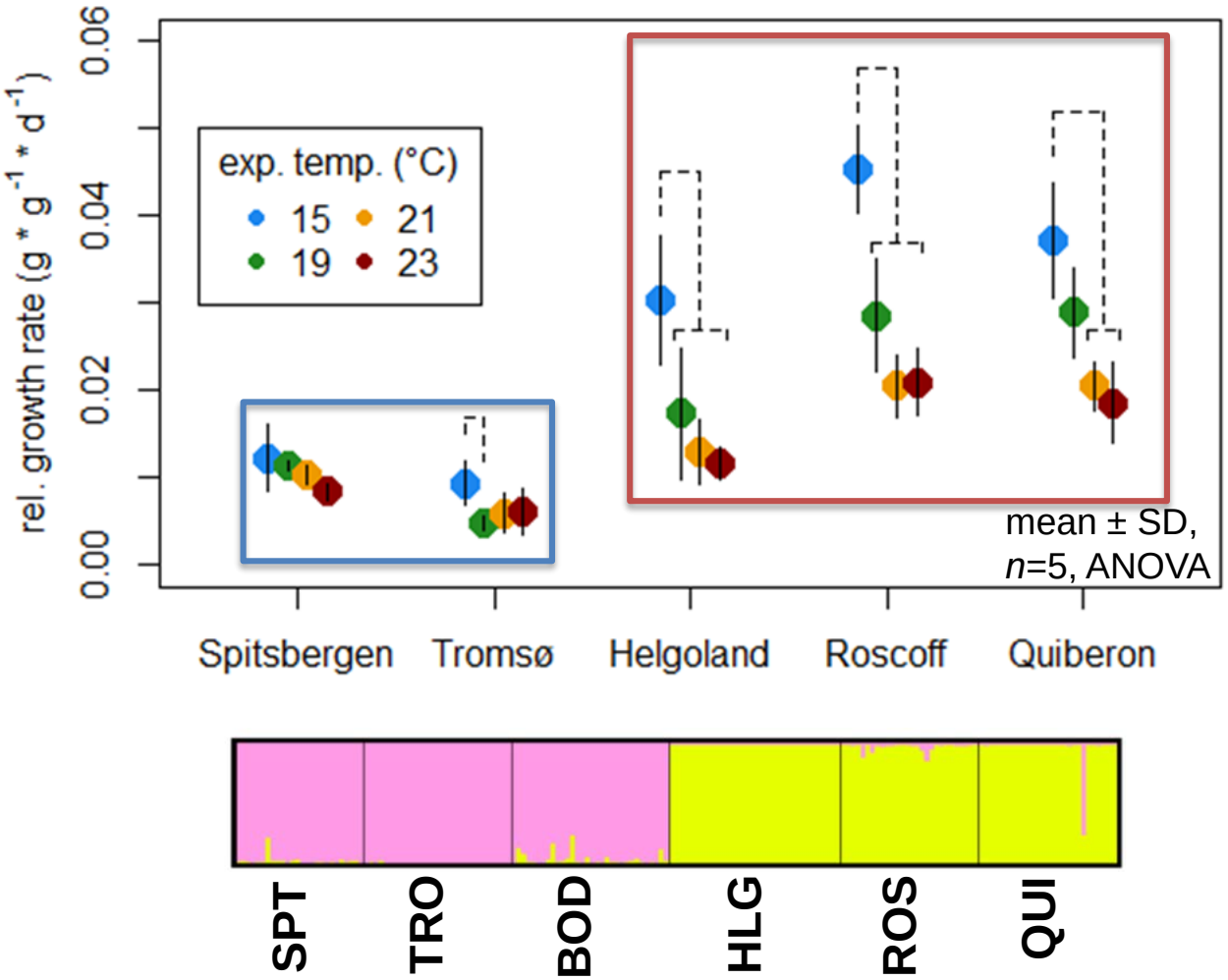
Experimental design

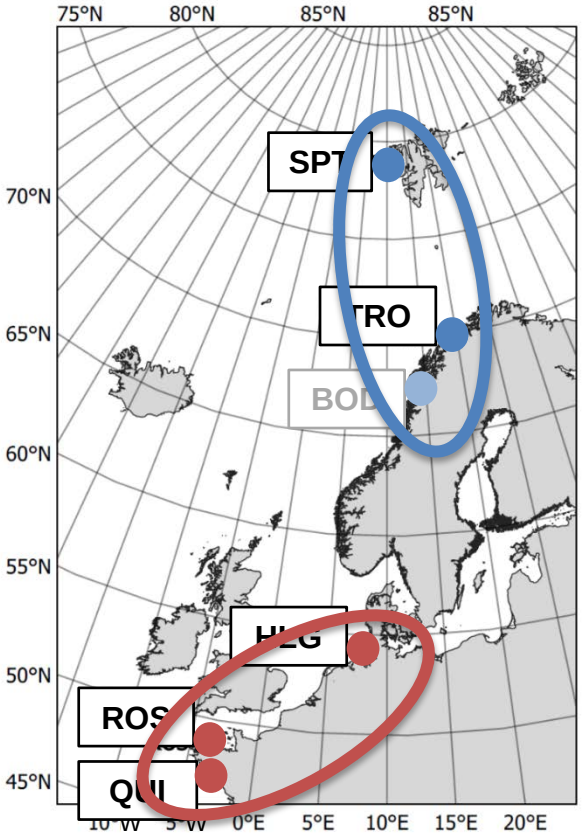




Physiology and population genetics

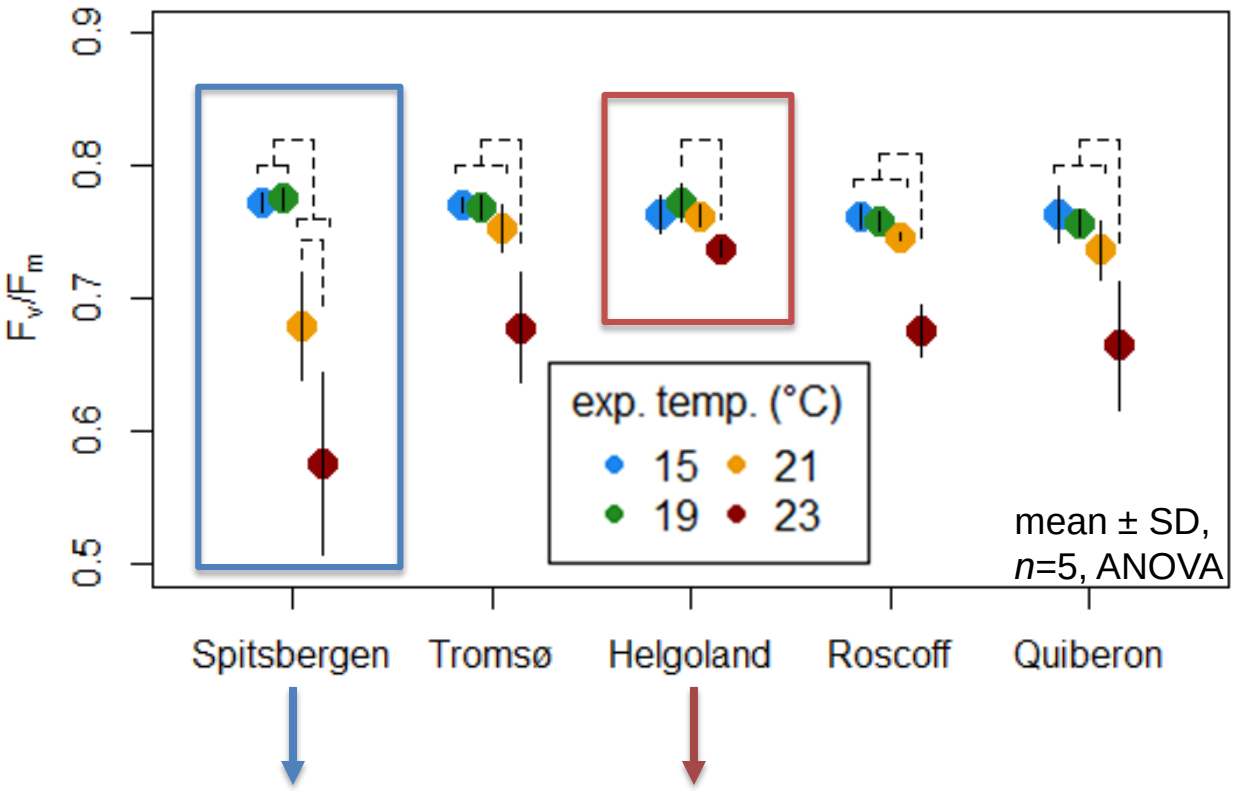
Two clades of *L. digitata*

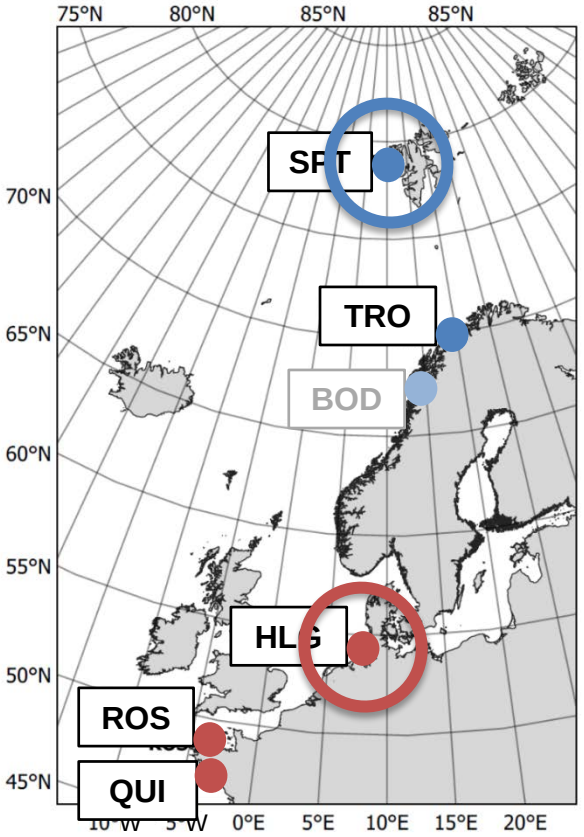




Northern and southern clade

Two isolated populations



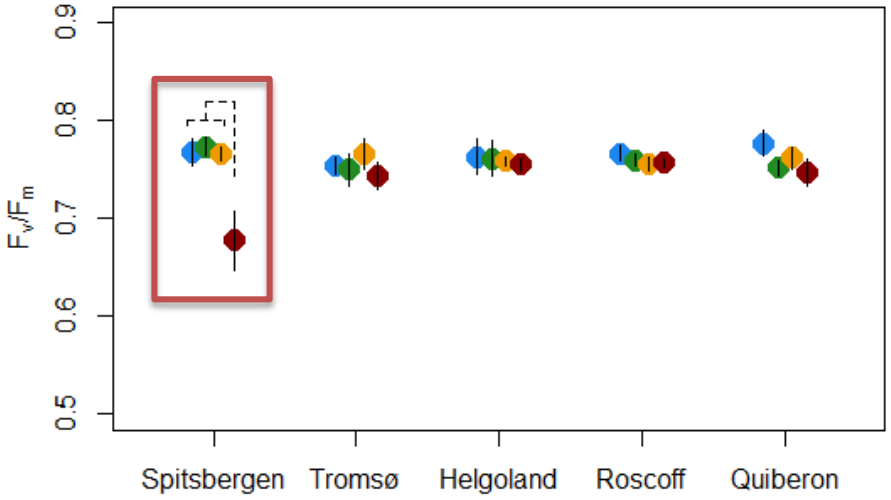


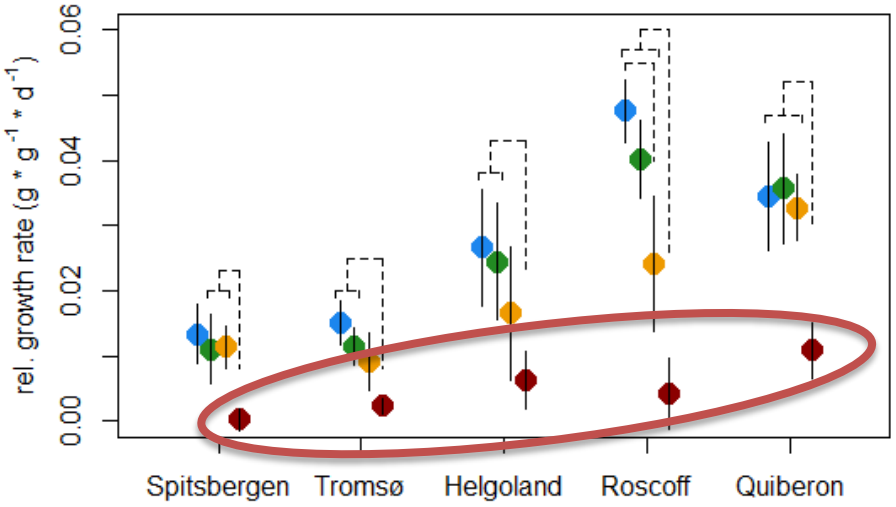
F_{IS}: 0.13 ± 0.05 *
N_e: 17 ± 4
AR: 3.5 ± 0.4
H_e: 0.44 ± 0.07

F_{IS}: 0.04 ± 0.03
N_e: 120 ± 4
AR: 2.6 ± 0.4
H_e: 0.31 ± 0.08

Inbreeding in SPT, Differentiation in HLG?

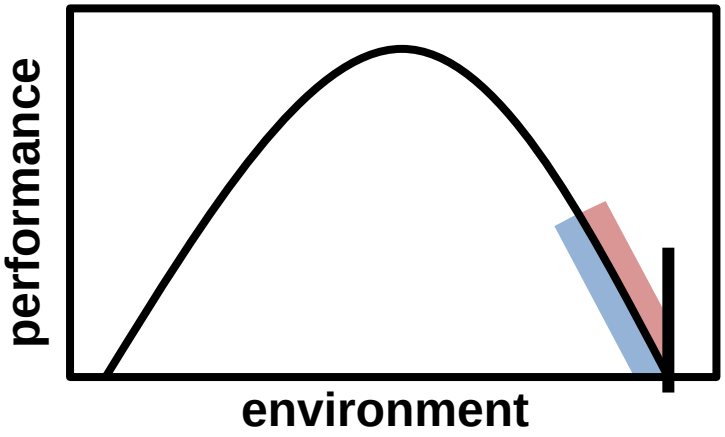
Recovery

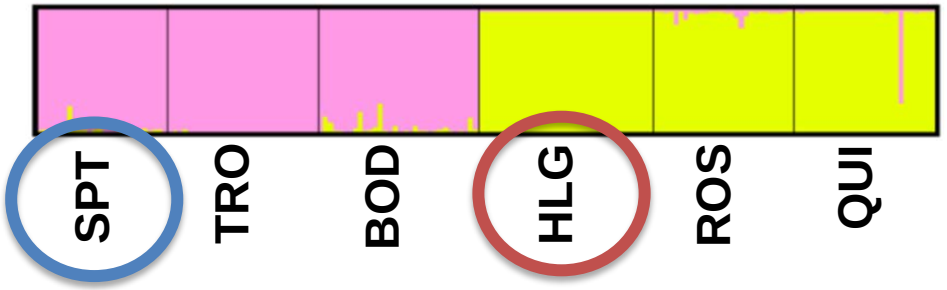




5 days at 23°C harmful for all populations.

Synthesis: local plasticity



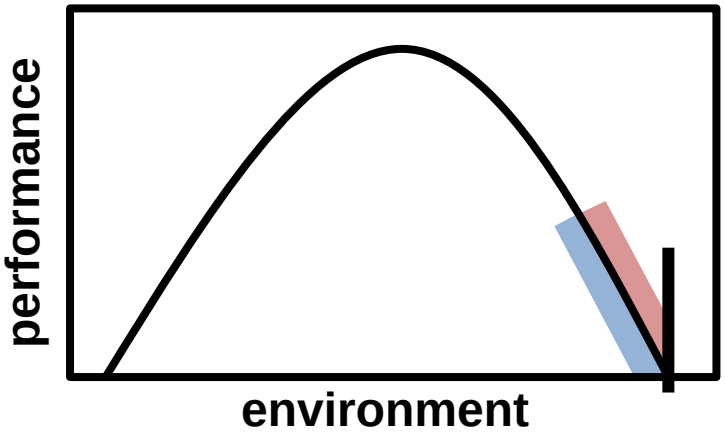


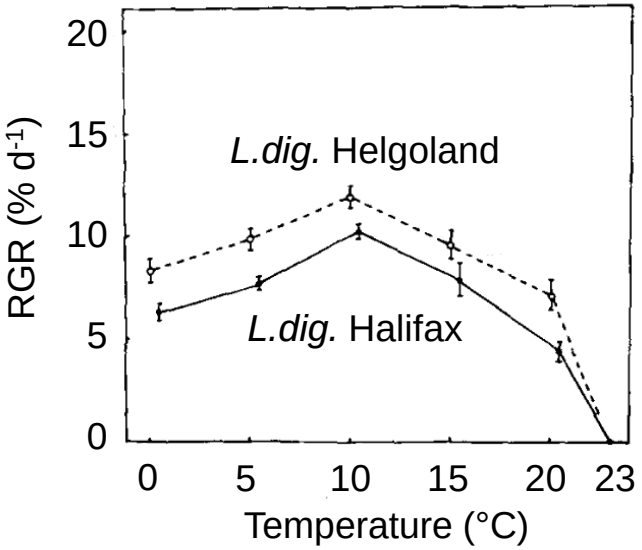
Fixed thermal limits

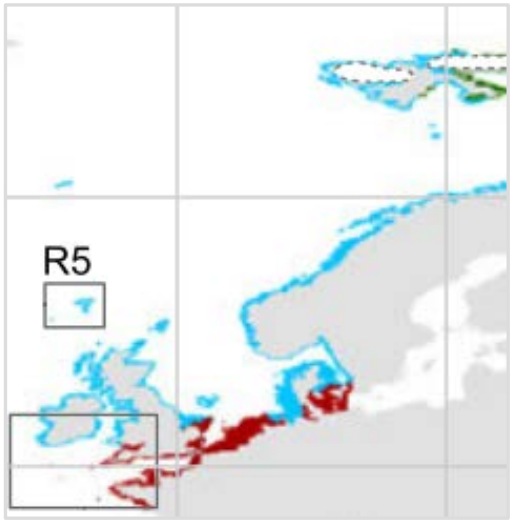
Northern and southern clades

Subtle differentiation in marginal populations

Relevance







Loss of southern refugia
&
dispersal of “northern“ genotypes?

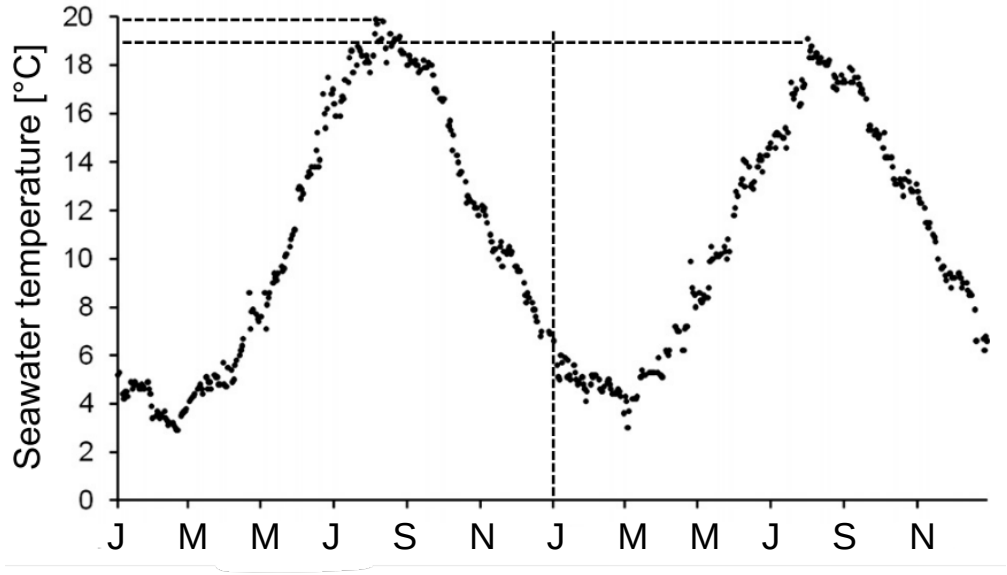
Bolton & Lüning (1982). Optimal growth and maximal survival temperatures … Mar Biol
Assis *et al*. (2018). Projected climate changes threaten ancient refugia of kelp … Global Change Biol

The special case of Helgoland

Future loss of this and other "southern" populations?

Sep 2003

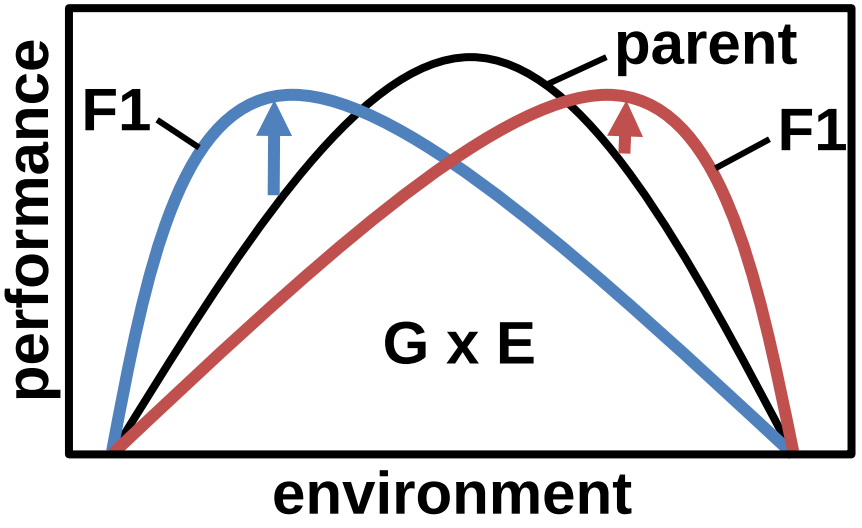
Sep 2004



Assis *et al*. (2018). Projected climate changes threaten ancient refugia of kelp … Global Change Biol
Bartsch *et al*. (2013). Prevailing sea surface temperatures inhibit summer reproduction … J Phycol

Transgenerational plasticity

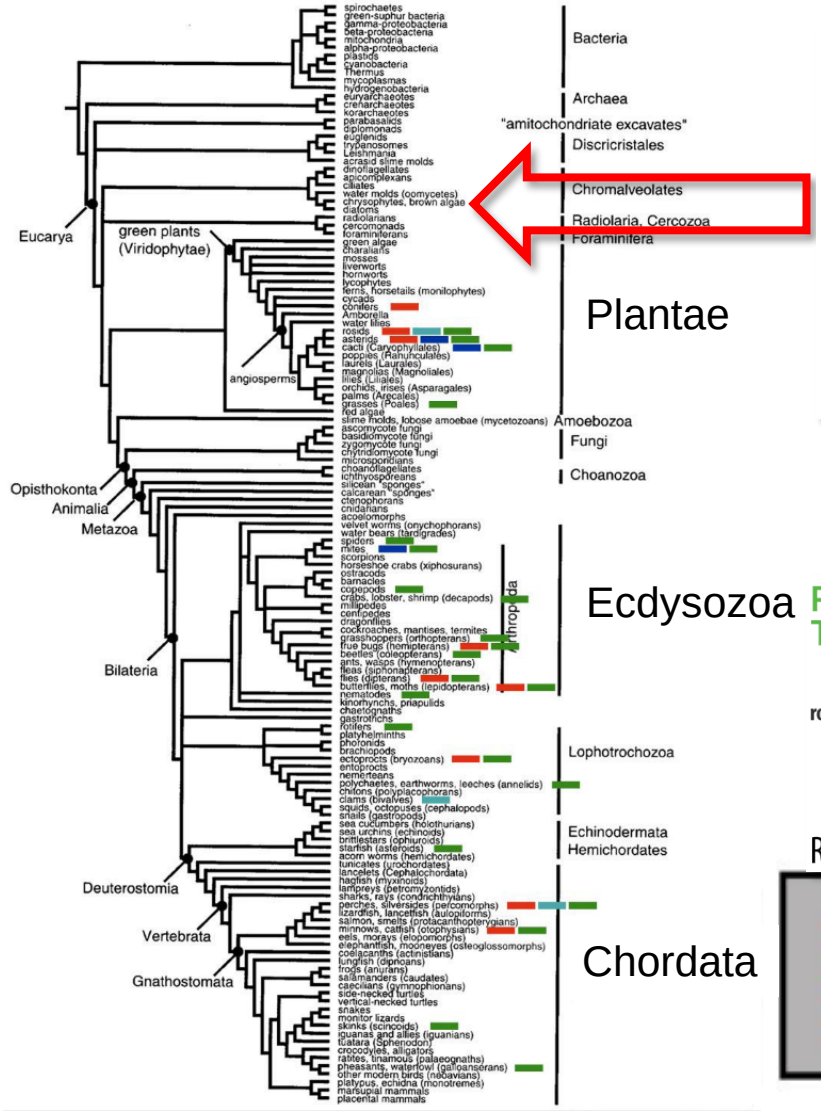
TGP: interactive effects of parental and offspring environment on offspring phenotype



Adaptive TGP: beneficial parental effects in predictable environments

Galloway, (2005). Adaptive transgenerational plasticity in plants … Front Plant Sci.
Mousseau & Fox, (1998). The adaptive significance of maternal effects. Trends Ecol Evolut.

Prevalence of TGP



ORIGINAL ARTICLE

WILEY MOLECULAR ECOLOGY

Transcriptomics reveal transgenerational effects in purple sea urchin embryos: Adult acclimation to upwelling conditions alters the response of their progeny to differential pCO_2 levels

Juliet M. Wong[1]

Gretchen E. Hofm

SCIENTIFIC REPORTS

OPEN

Transgenerational exposure of North Atlantic bivalves to ocean acidification renders offspring more vulnerable to low pH and additional

Received: 19 May 2017
Accepted: 24 August 2017

PHILOSOPHICAL TRANSACTIONS B

royalsocietypublishing.org/journal/rstb

Within-generation and transgenerational plasticity of mate choice in oceanic stickleback under climate change

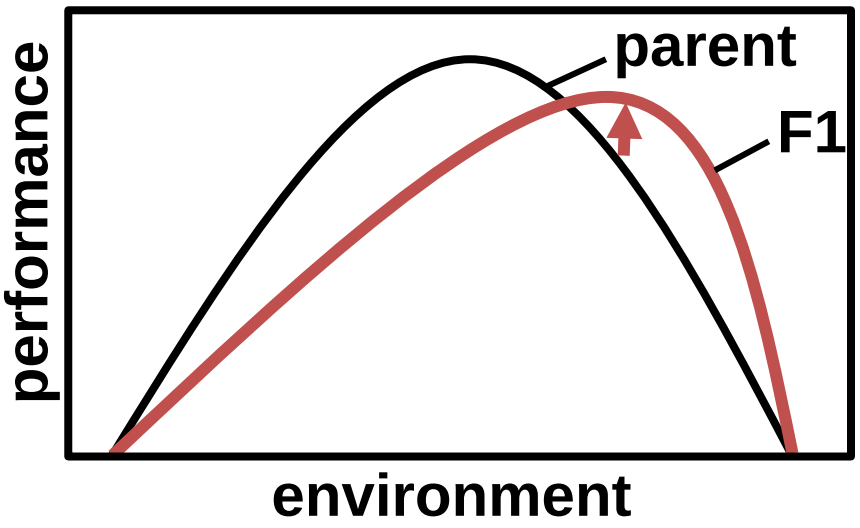
Lukas Fuxjäger[1,2], Sylvia Wanzenböck[1,2], Eva Ringler[3], K. Mathias Wegner[1], Harald Ahnelt[2,4] and Lisa N. S. Shama[1]

Research

Check for updates

- Temperature
- Precipitation
- Carbon dioxide
- Other

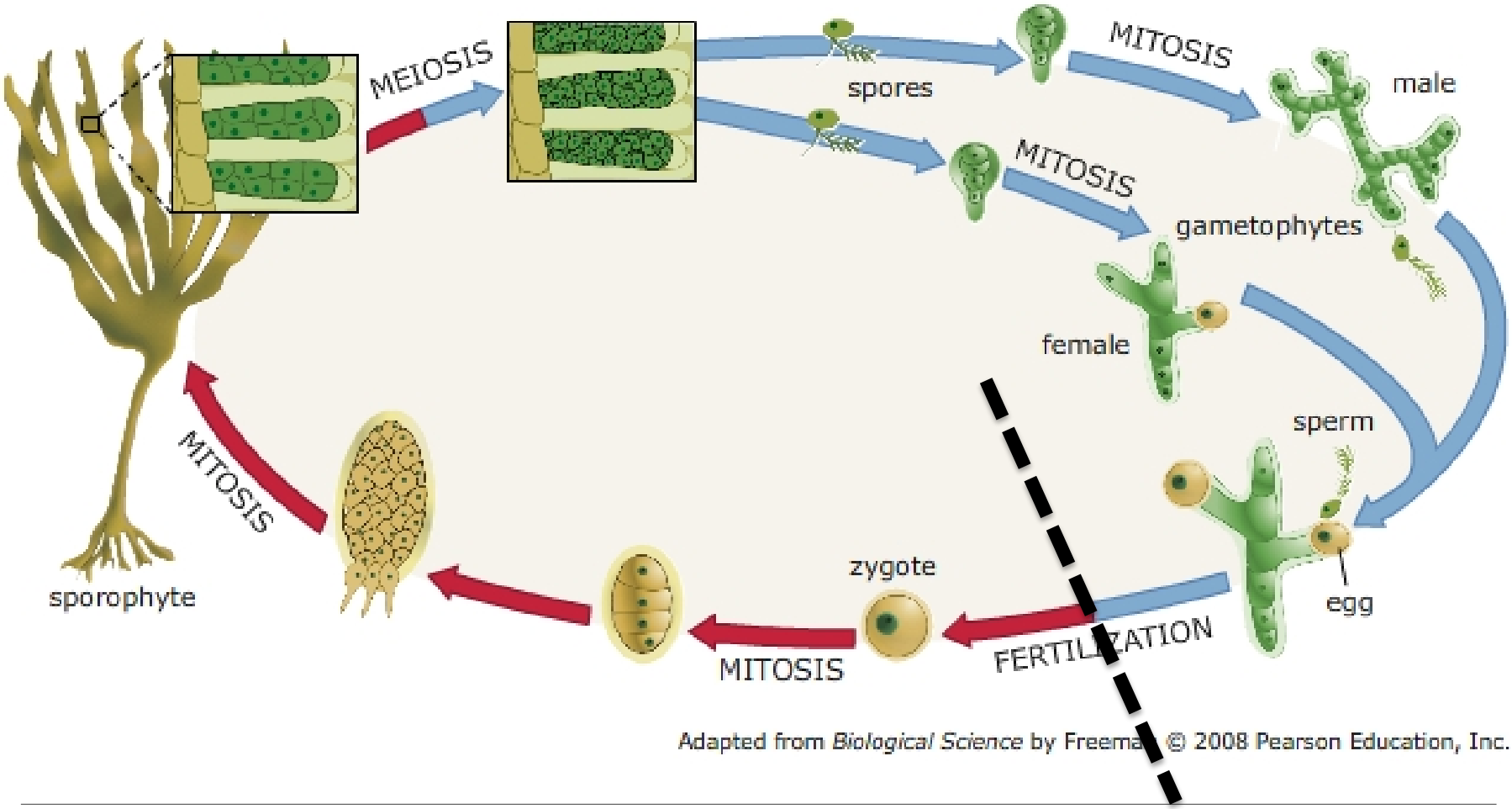
TGP in macroalgae?



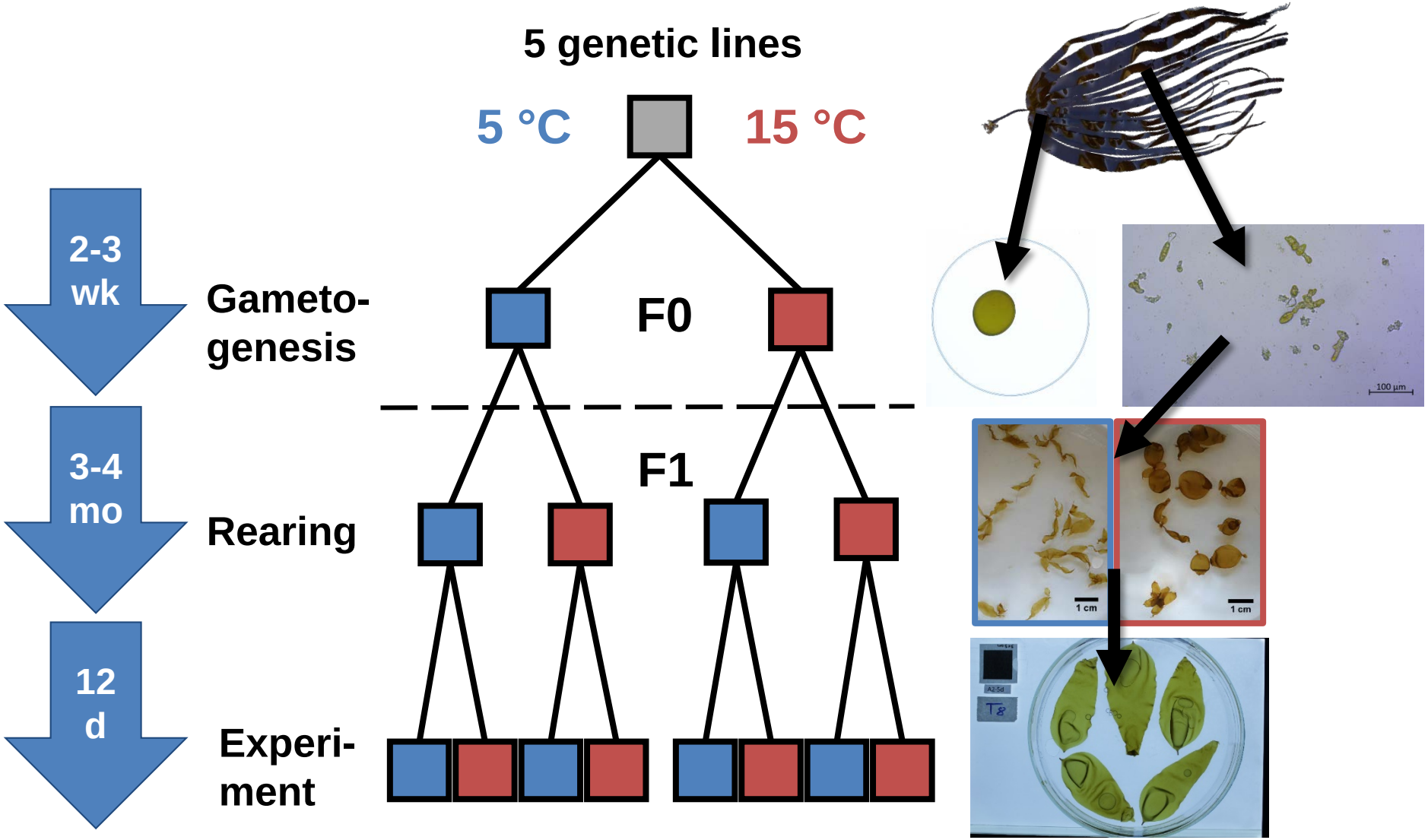
?

Does adaptive TGP prime kelp offspring for higher temperatures across life cycle stages?

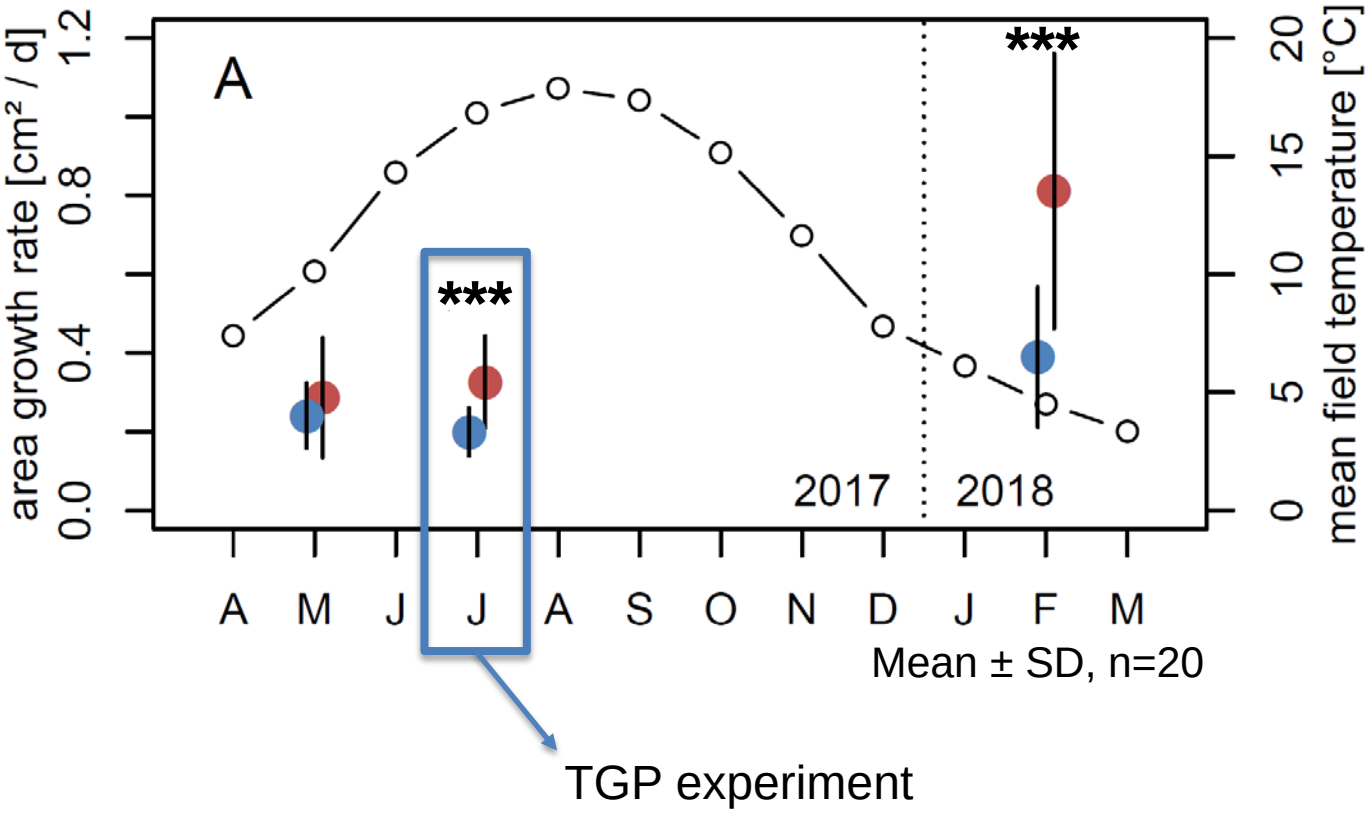
Kelp life cycle

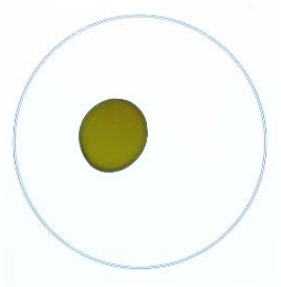


Hypothesis:
Adaptive TGP for parental gametogenesis temperature.



Field material: Reaction norm

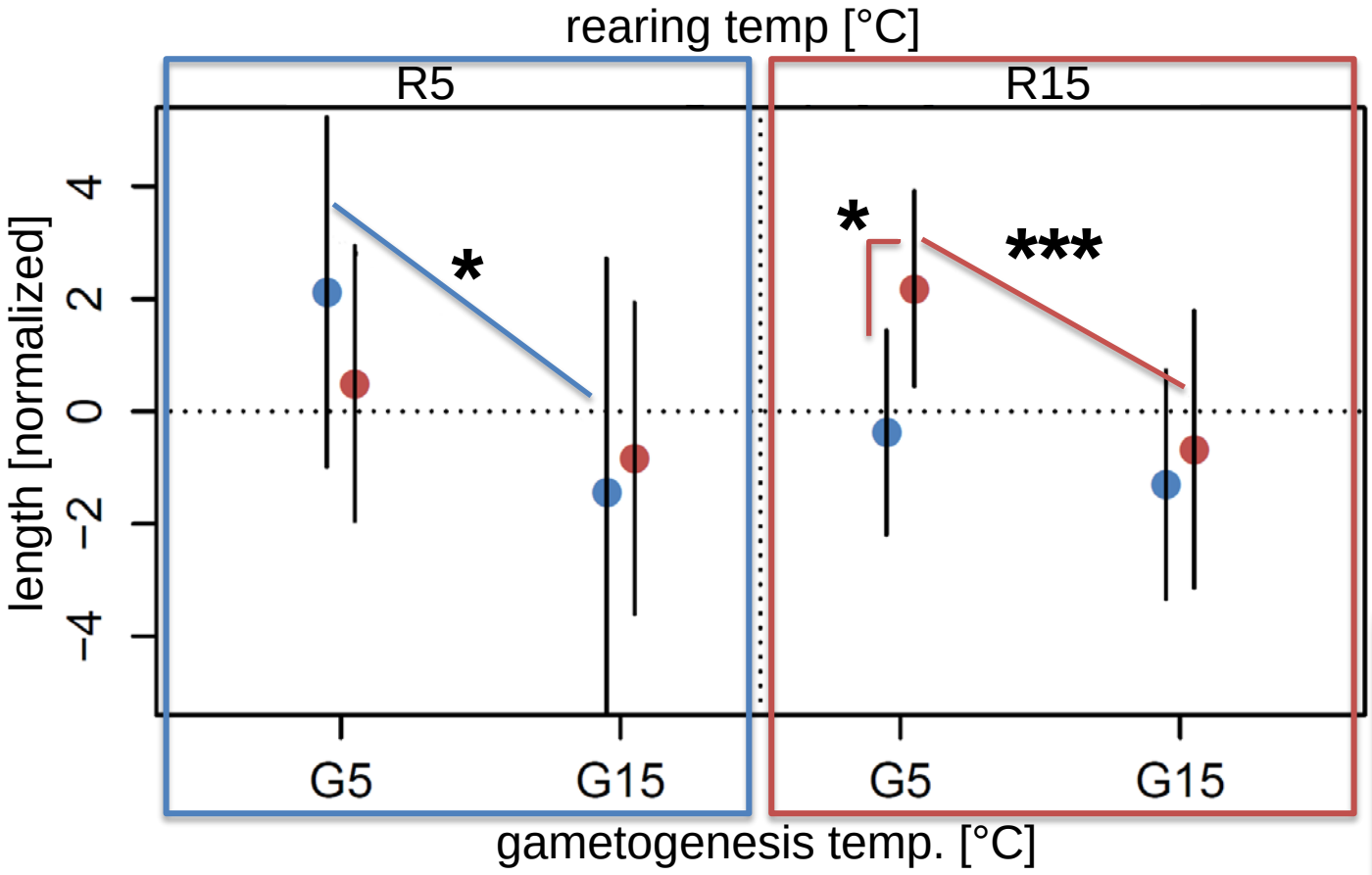




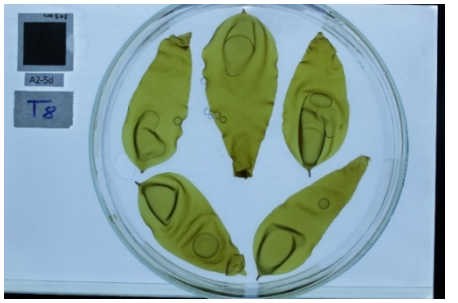
Temperature
- exp. 5 °C
- exp. 15 °C
- field temp.

Field meristems grow faster at 15 °C

TGP: Growth



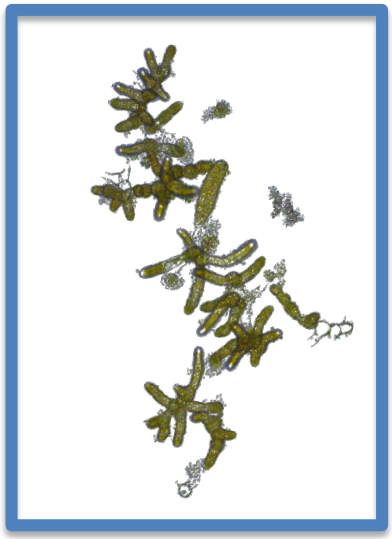
Mean ± SD, *n*=4 for 5 genetic lines

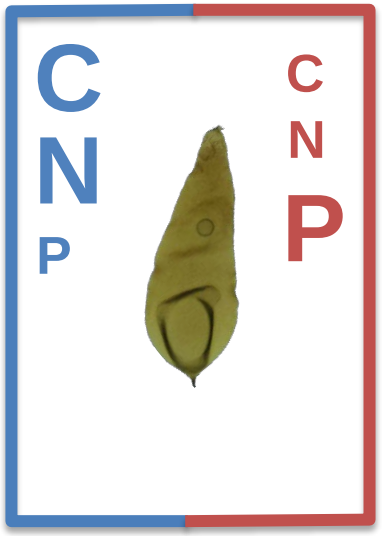


exp. temp. [°C]
- E5
- E15

TGP:
Beneficial effect of 5 °C gametogenesis on growth.

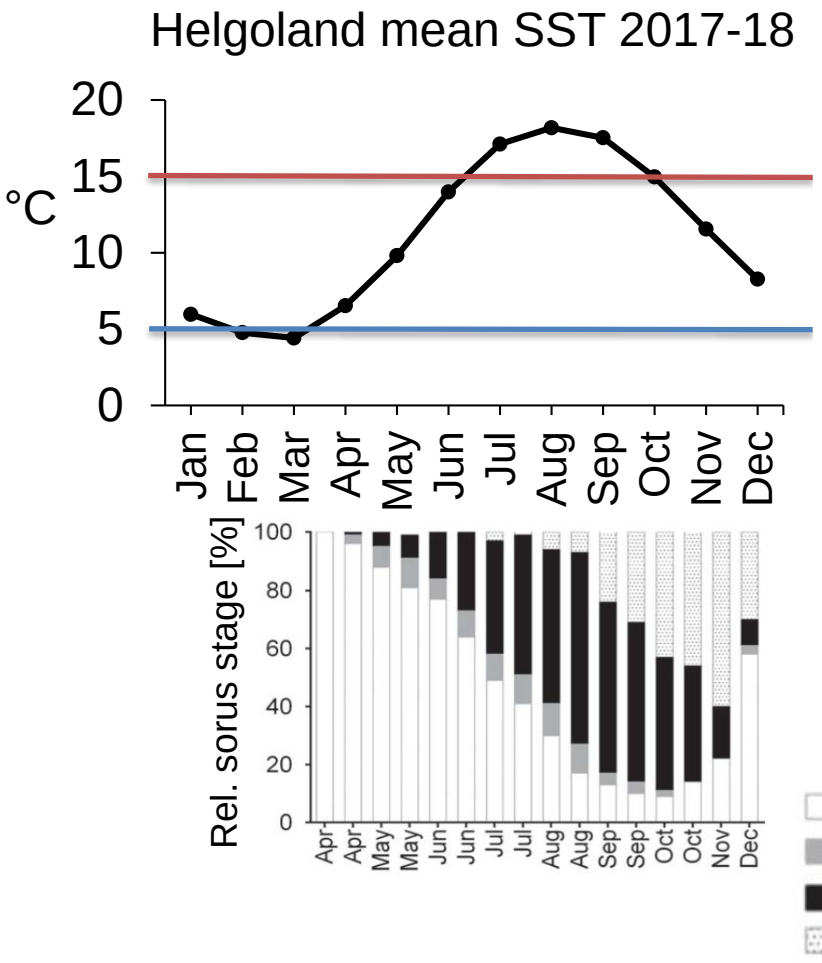
Synthesis: TGP

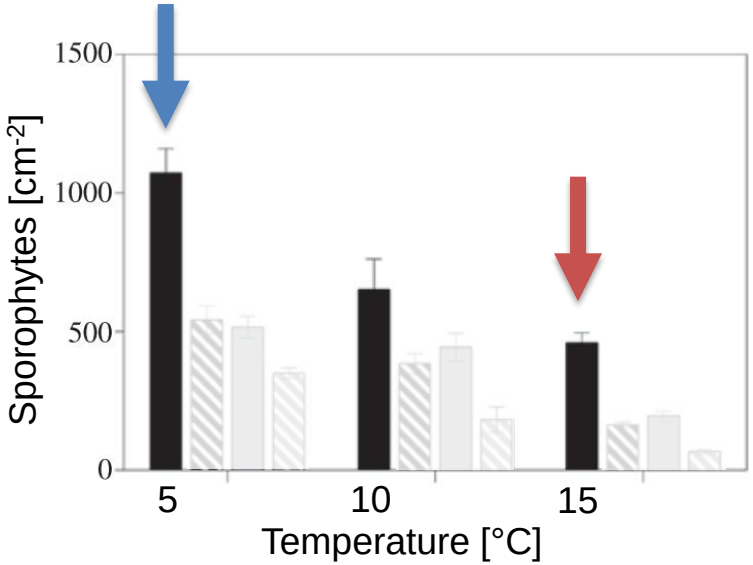




TGP: Beneficial growth effects following cold parental treatment.
No adaptive TGP regarding warm temperature.

Relevance





Importance of cold refugia during winter!

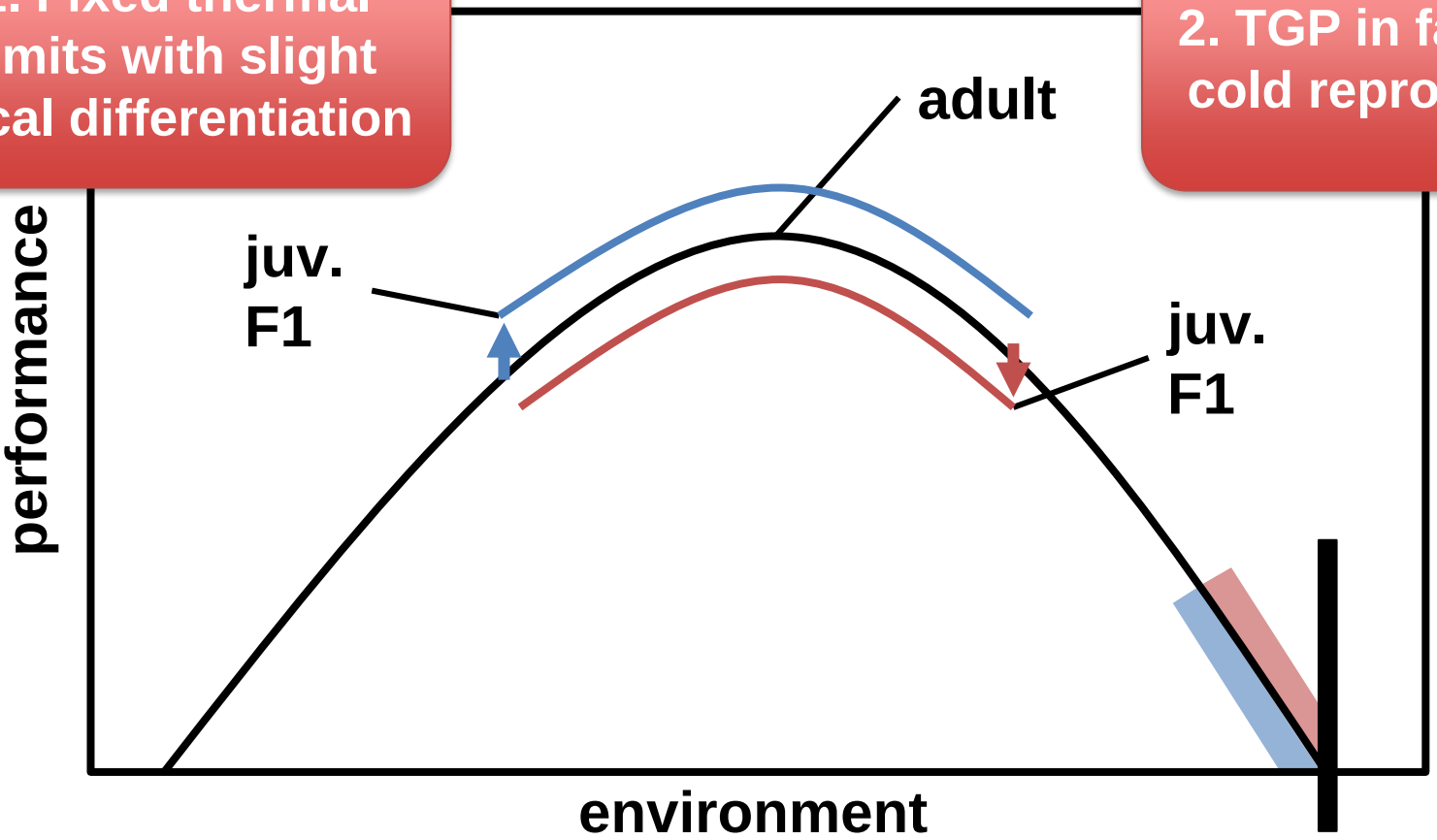
Bartsch *et al*. (2013). Prevailing sea surface temperatures inhibit summer reproduction of the ... J. Phycol.
Martins *et al*. (2017). Interactions of daylength, temperature and nutrients affect thresholds ... Bot. Mar.

Conclusion

***Laminaria digitata* thermal response**

1. Fixed thermal limits with slight local differentiation

2. TGP in favour of cold reproduction



Thank you!

ALFRED-WEGENER-INSTITUT
HELMHOLTZ-ZENTRUM FÜR POLAR- UND MEERESFORSCHUNG

I thank

DFG Deutsche Forschungsgemeinschaft

for funding within the ERA-Net Cofund

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program MARFOR
ANR-16-EBI3-0005-01

Personal thanks to:

Inka Bartsch
Klaus Valentin
Myriam Valero
Louise Fouqueau
Michael Roleda
Kai Bischof
Andreas Wagner
Claudia Daniel
Lisa Shama
Mathias Wegner
Nora Diehl
Gareth Pearson
Neusa Martins
AWIPEV
AWI dive team
Ulf Karsten
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