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Climate change responses in canopy-forming seaweeds

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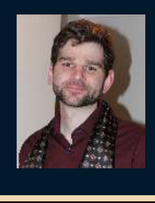


Background Climate change affects seaweed meadows on temperate rocky shores

Canopy-forming seaweeds provide foundational habitat for **diverse ecosystems**. Along their southern edges of distribution, however, seaweeds are **threatened with extinction** due to climate change. To **predict the impact of climate change** on temperate and sub-polar seaweed meadows, we used a **multidisciplinary approach** integrating ecological (migration, acclimation) and evolutionary (adaptation) responses to increased temperatures.

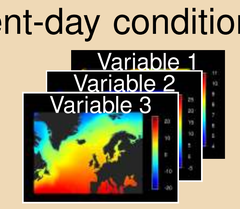
year 1999 → year 2010

90% abundance decline in *Fucus serratus*

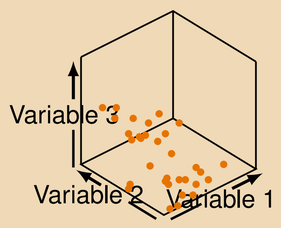
Migration Niche modeling [1], [4]

Occurrences

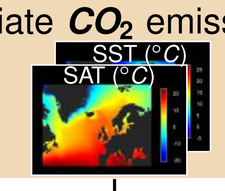
Present-day conditions [5]



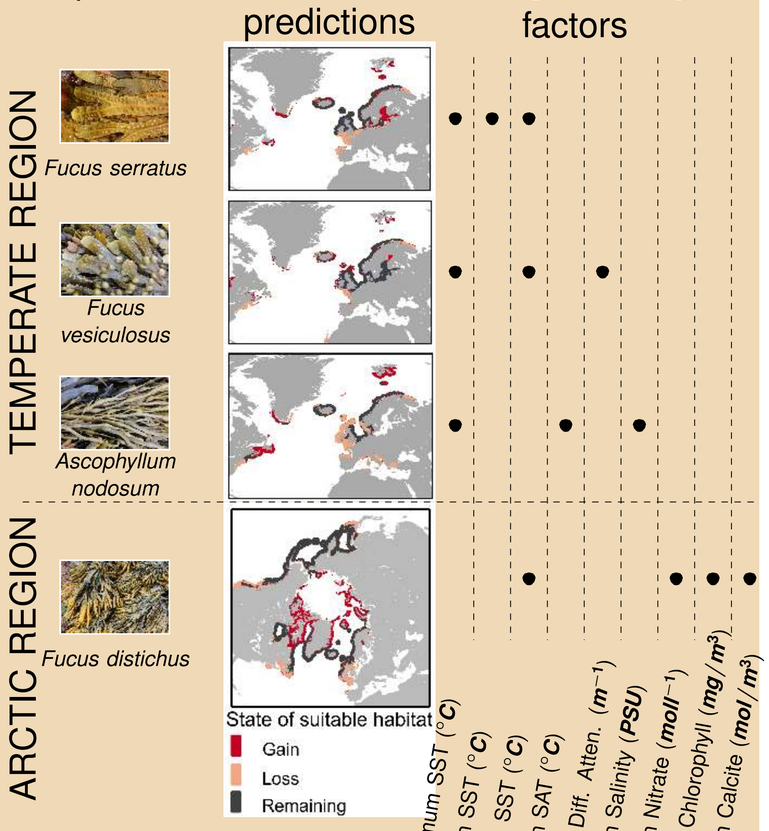
Realized niche space



A1B SREC predictions to year 2200
(intermediate CO_2 emission scenario)



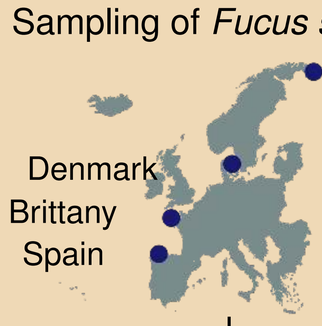
Species | Distribution predictions | Range-limiting factors



Biggest ecological changes expected in the warm temperate and Arctic regions

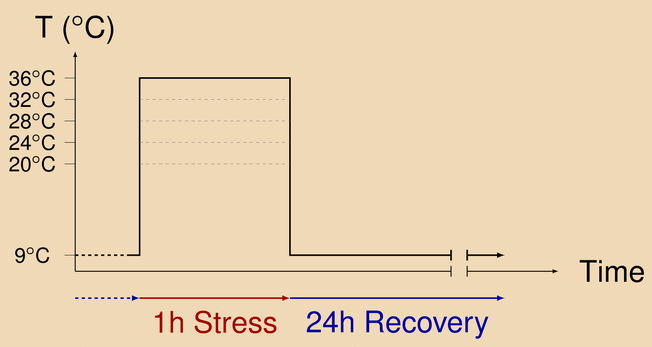
Acclimation Heat-stress response [3]

Sampling of *Fucus serratus*

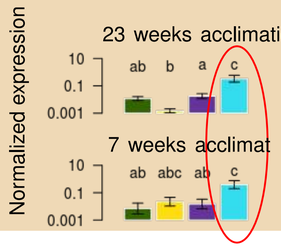


Acclimation at 9°C, 4 weeks

Heat stress, ⩾ 6 individuals/population



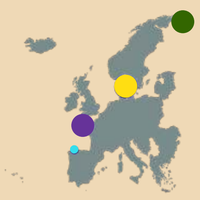
Constitutive *shsp* gene expression before heat shock



High constitutive stress in Spain

Heat shock response of *shsp* gene expression after 24h recovery

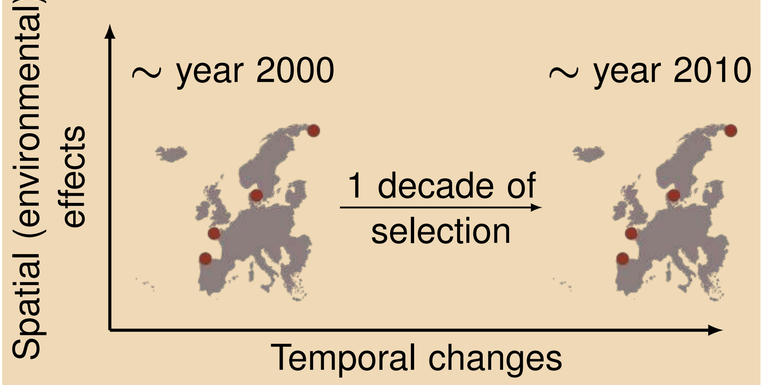
Reduced responsiveness in Spain



Highest risk of extinction from an ancient glacial refugium in Spain.
Risk to lose unique genetic variation

Adaptation Genetic changes [2]

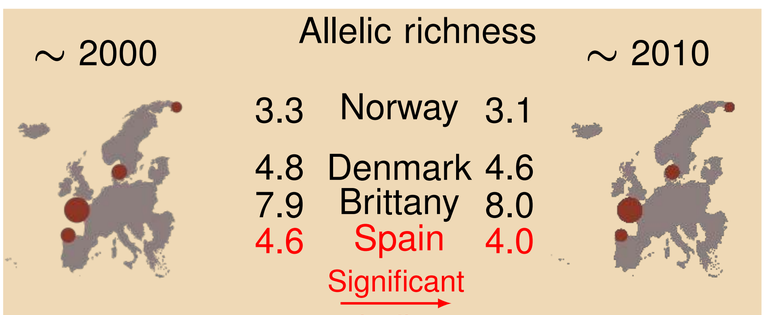
Sampling of *Fucus serratus*
(50-75 indiviuals/population)



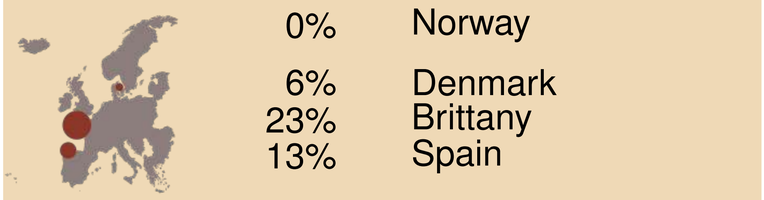
Genotyping for 31 microsatellite markers
(20 EST-linked)

Effective population size N_e
(Reflecting adaptive capacity))

Allelic richness



Temporal outlier loci



Adaptive responsiveness highest in Brittany and likely insufficient in Spain

Conclusions

Opening of new seaweed habitat in the **Arctic** and disappearance of seaweed habitat from **warm-temperate** regions can **disturb species interactions and ecosystem services** in the associated rocky-shore ecosystems. The integration of plastic and adaptive responses improved the predictive power of our niche models to project range shifts and extinction risks under climate change. The **remaining key question** is whether the **adaptive potential** of seaweeds is high enough to save their southern centers of genetic variation in ancient glacial refugia.

References

[1] Jueterbock, A.; Tyberghein, L.; Verbruggen, H.; Coyer, J.A.; Olsen, J.L. & Hoarau, G. (2013): Climate change impact on seaweed meadow distribution in the North Atlantic rocky intertidal. *Ecology; Evolution* 5(3):1356–1373

[2] Jueterbock, A. (2013): Climate change impact on the seaweed *Fucus serratus*, a key foundational species on North Atlantic rocky shores. *PhD Thesis, University of Nordland*

[3] Jueterbock, A.; Kollias, S.; Smolina, I.; Fernandes, J.M.O.; Olsen, J.L.; Coyer, J.A. & Hoarau, G. (2014): Thermal stress resistance of the brown alga *Fucus serratus* along the North-Atlantic coast: Acclimatization potential to climate change. *Marine Genomics* 24393606

[4] Jueterbock, A.; Smolina, I.; Coyer, J.A. & Hoarau G. (In Preparation): The fate of arctic Fucus distichus under climate change: an ecological niche modeling approach.

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