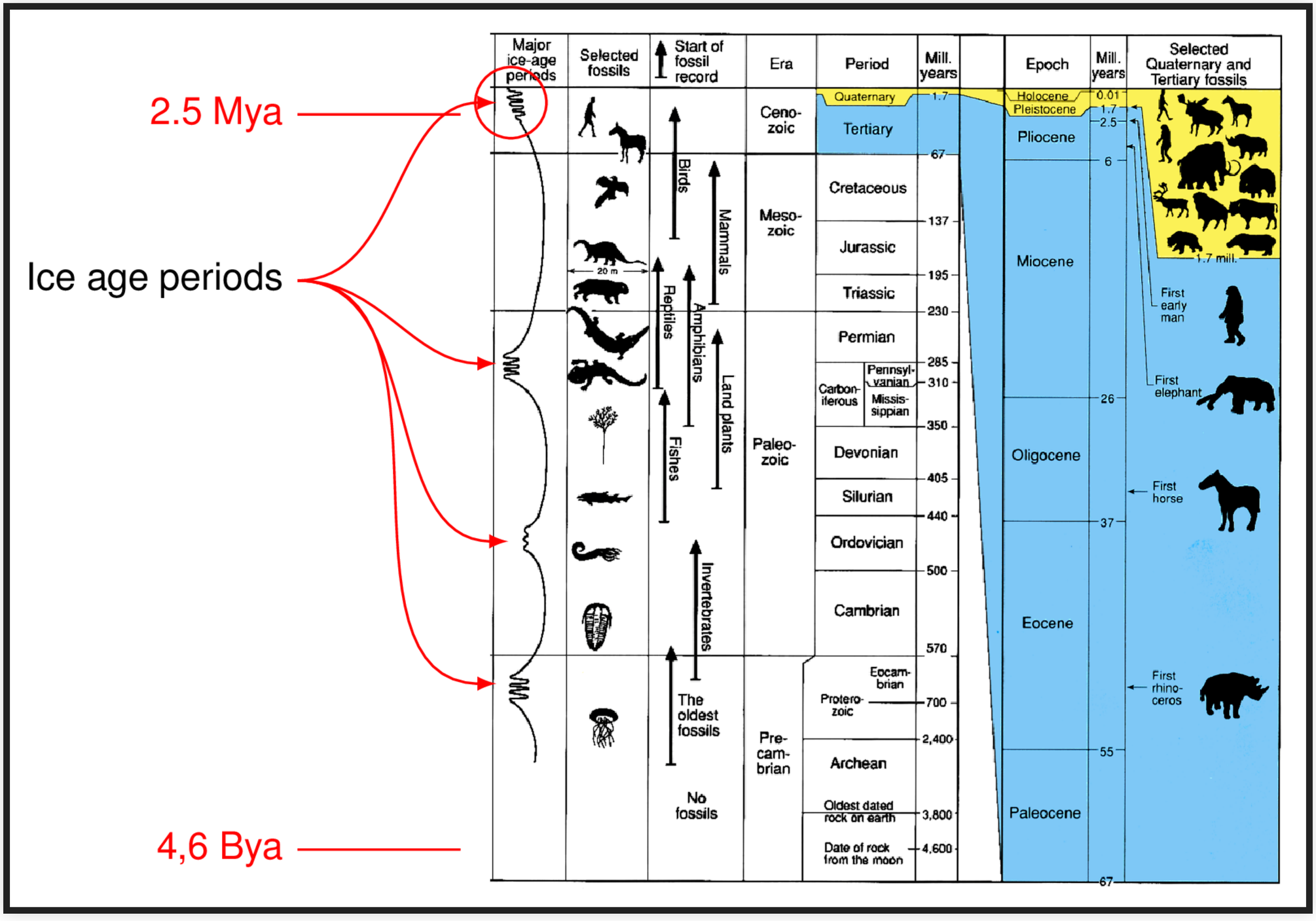
Climate change impact on ocean forests and their biodiversity

Trial lecture 03.05.2019

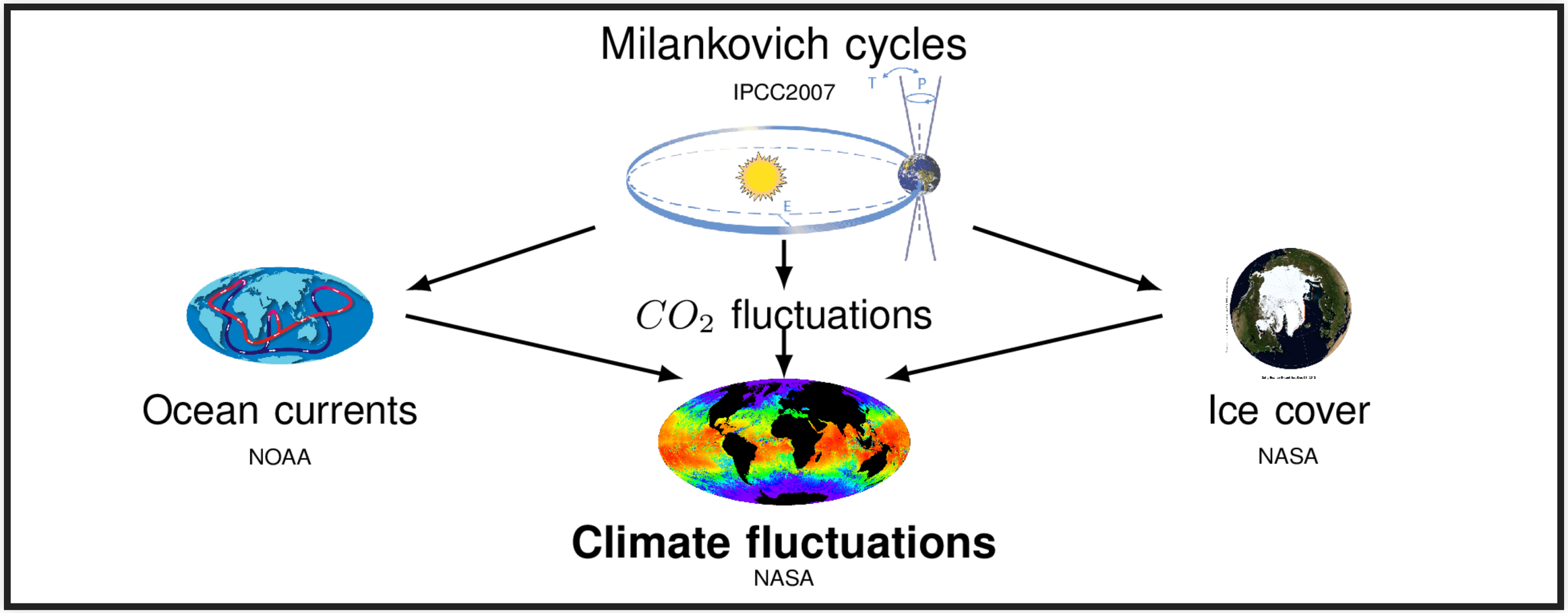
Alexander Jueterbock, Researcher at Nord University

The origin of fjords -
a hint to climate changes in the past

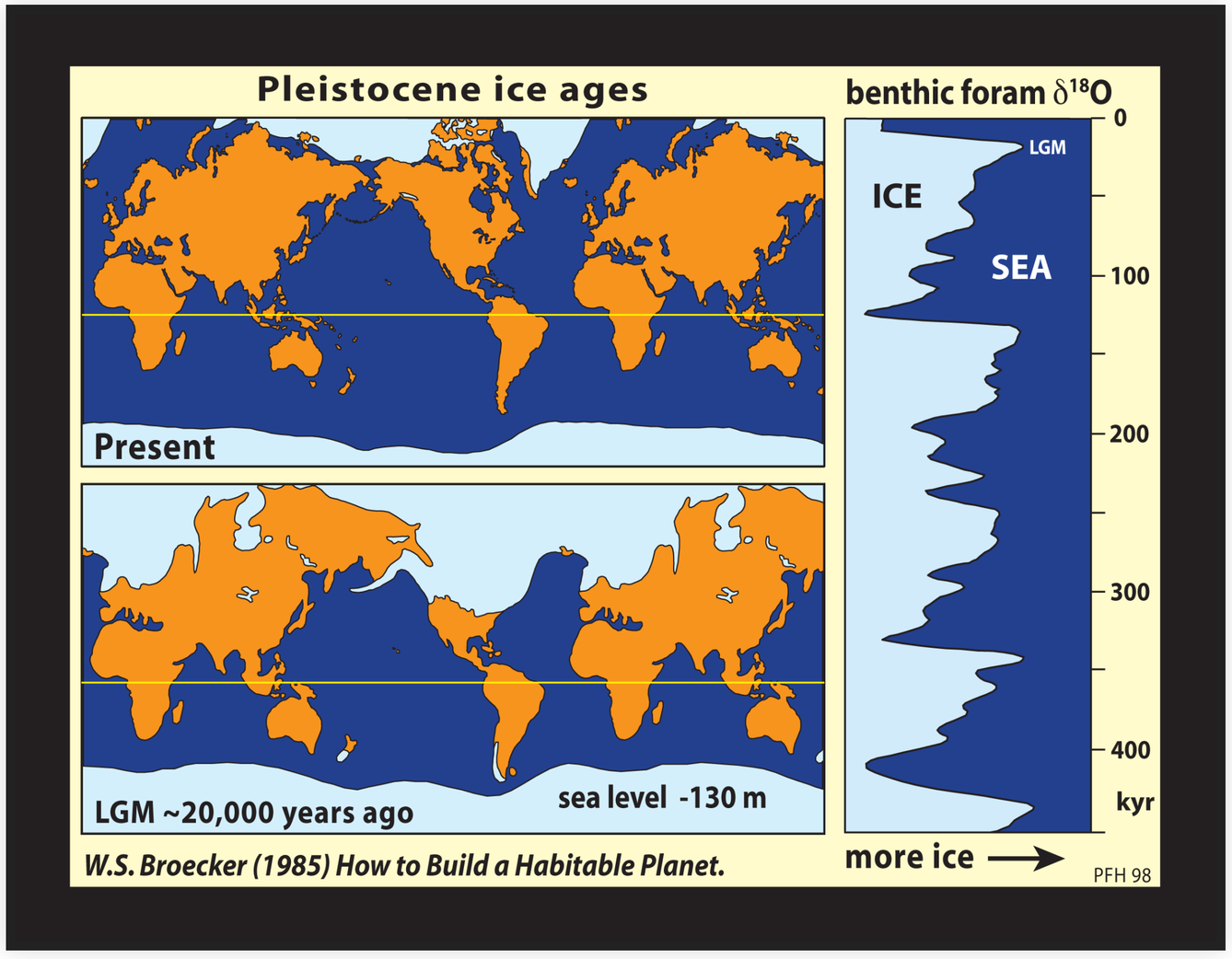
Ice ages in earth history



Causes of climate fluctuations



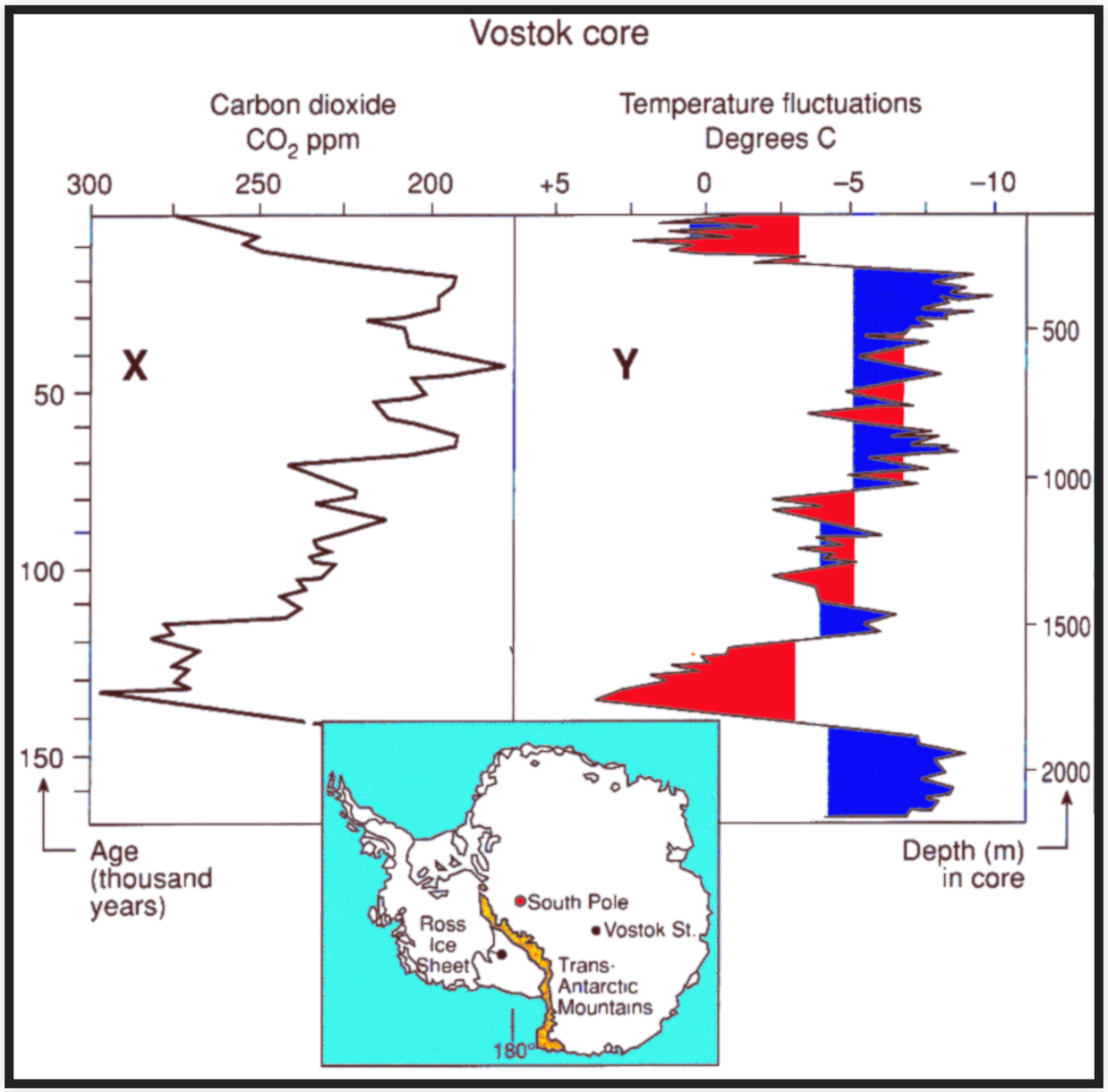
Pleistocene ice ages



Changes in

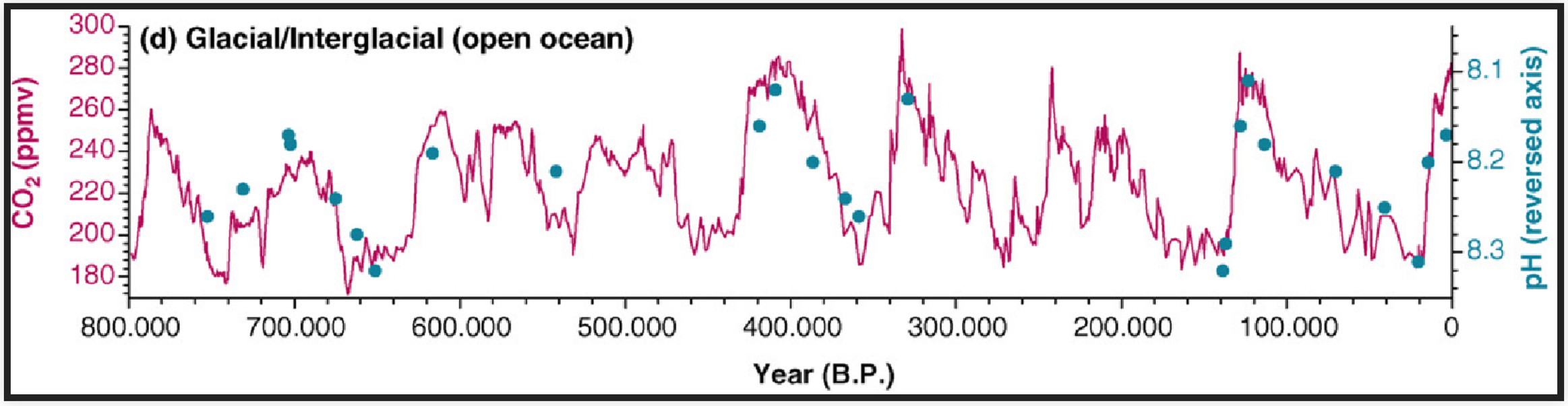
- Sea level
- Ocean currents
- Ocean gateways

Fluctuations in temperature and CO_2



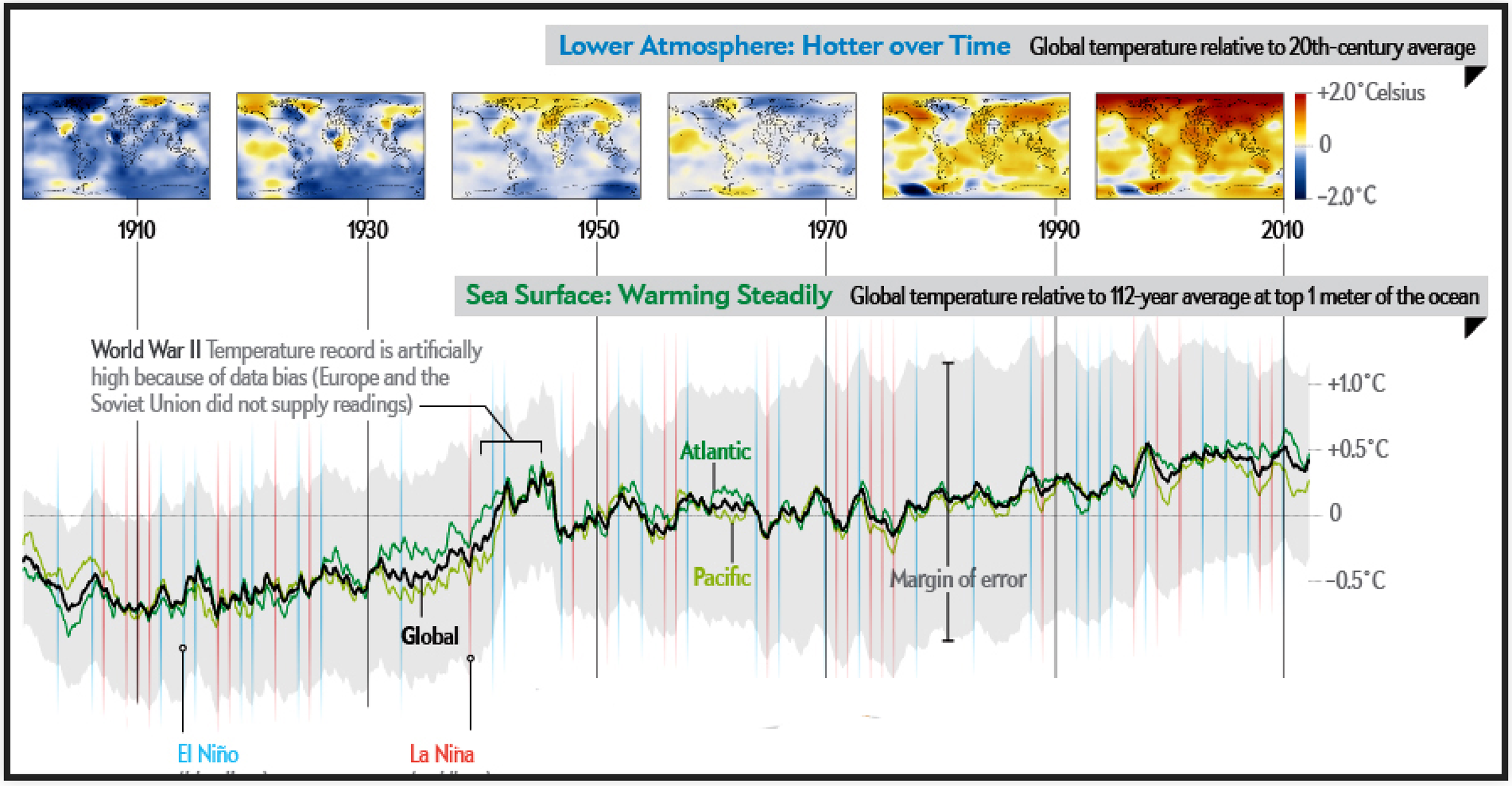
Andersen & Borns (1997); Scandinavian University Press

Ocean acidification - the other CO_2 problem



Pelejero et al. (2010); Trends Ecol. Evol.

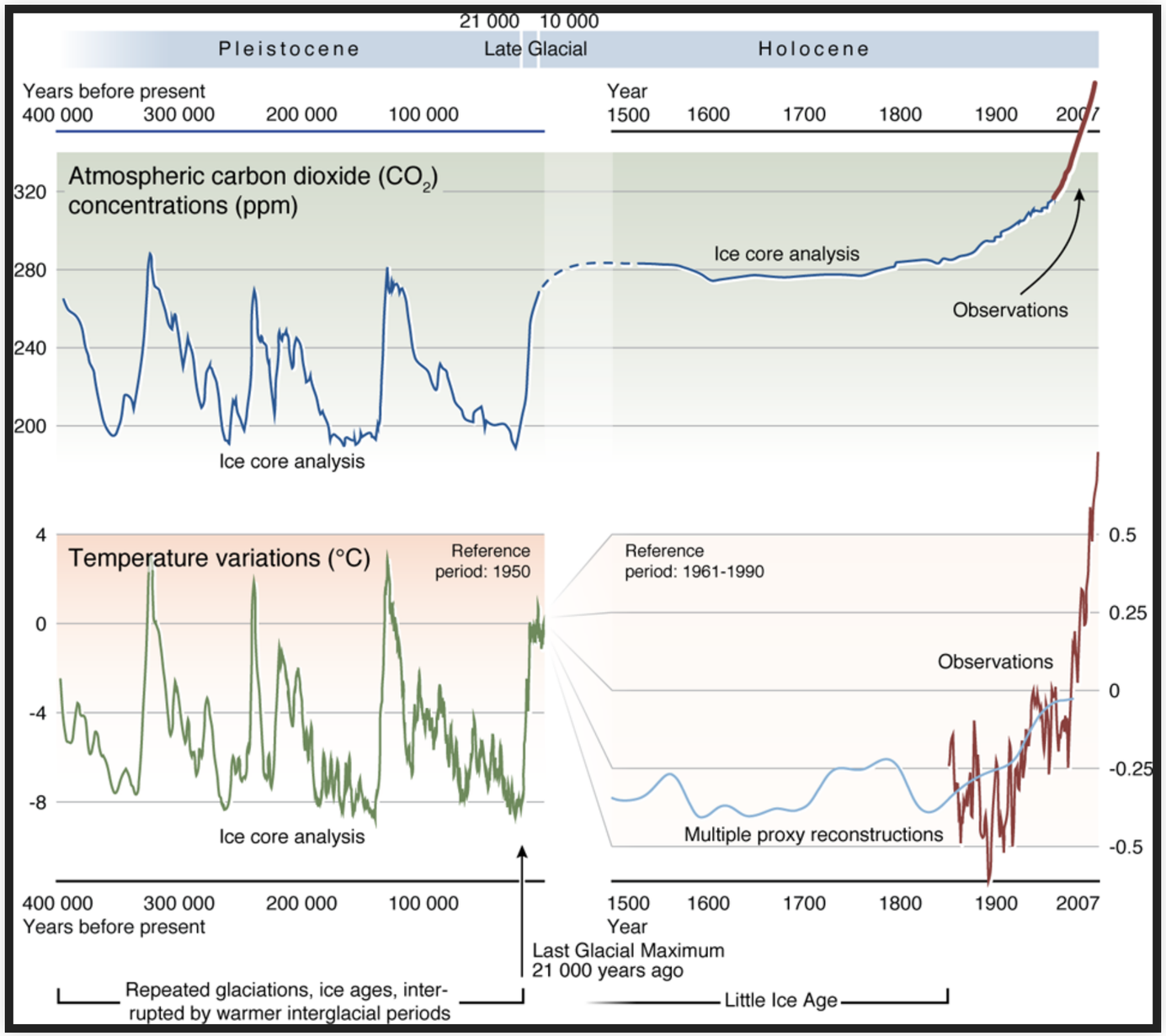
Recent land and ocean warming



Christiansen, J. (2013); Scientific American

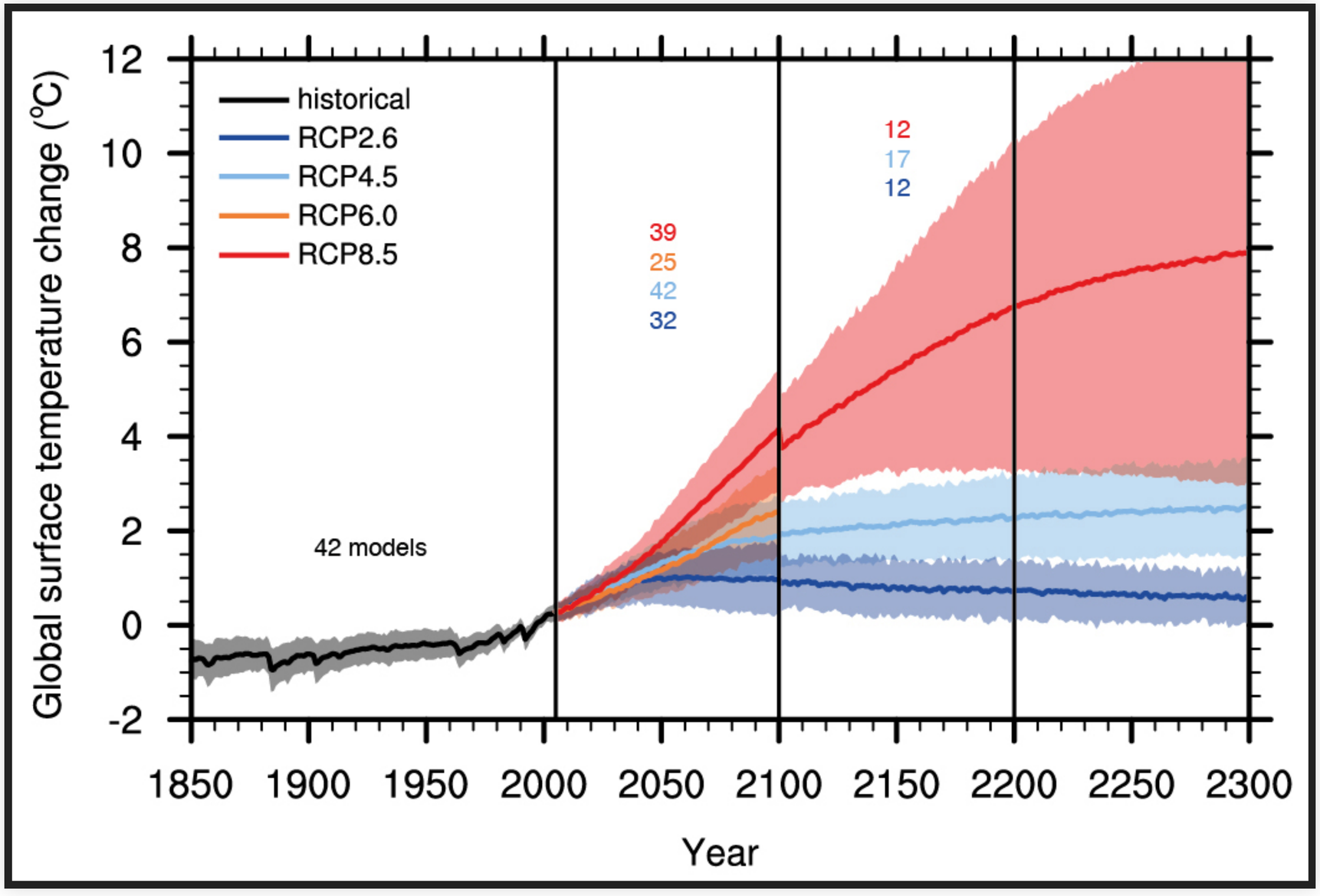
Recent vs. historical warming

Higher CO_2 concentrations



Ahlenius, H.; UNEP/GRID-Arendal

Predicted temperature increase

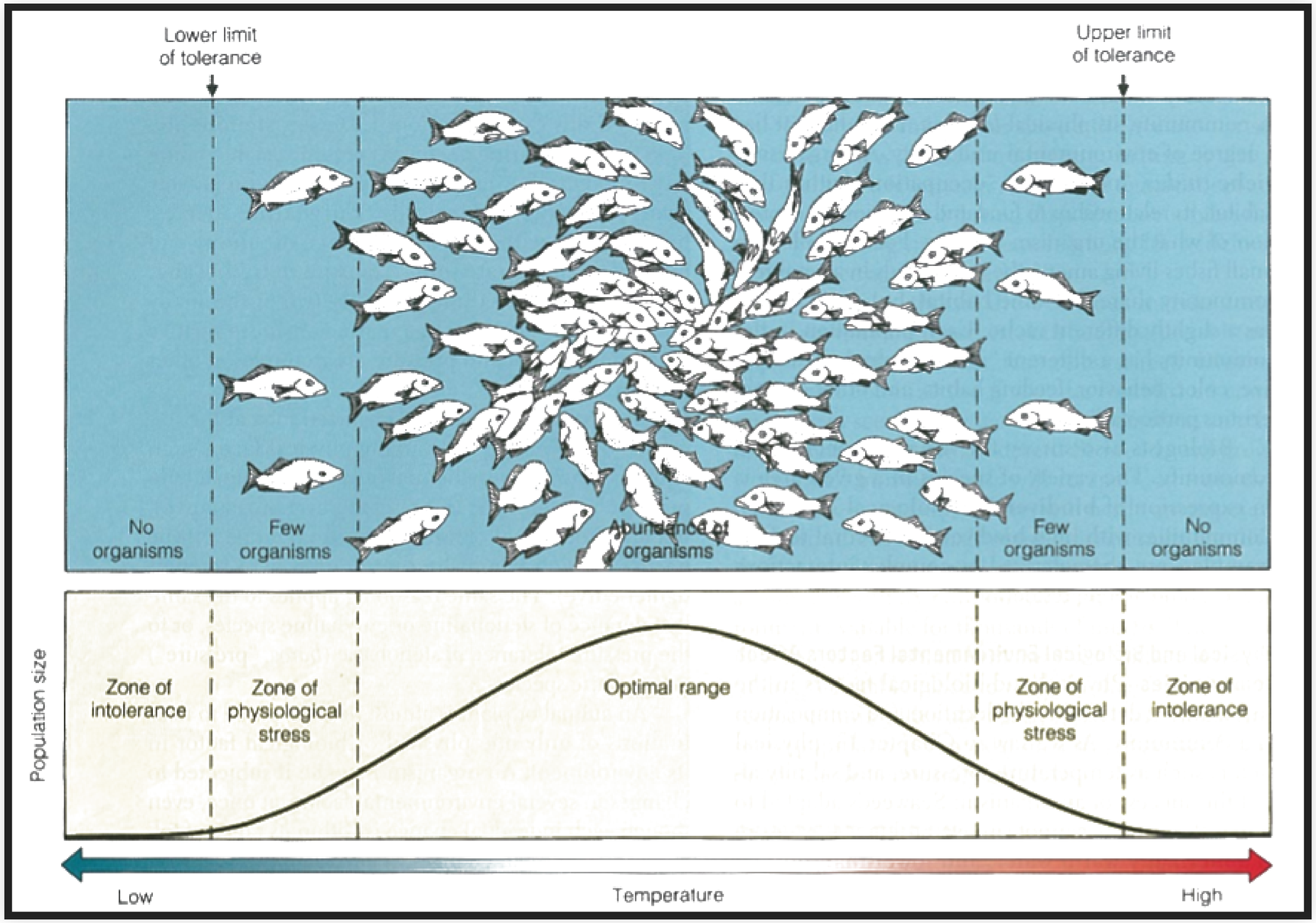


IPCC AR5 WG1 (2013), Chapter 12, Fig. 12-5.

+6°C in next 200 years

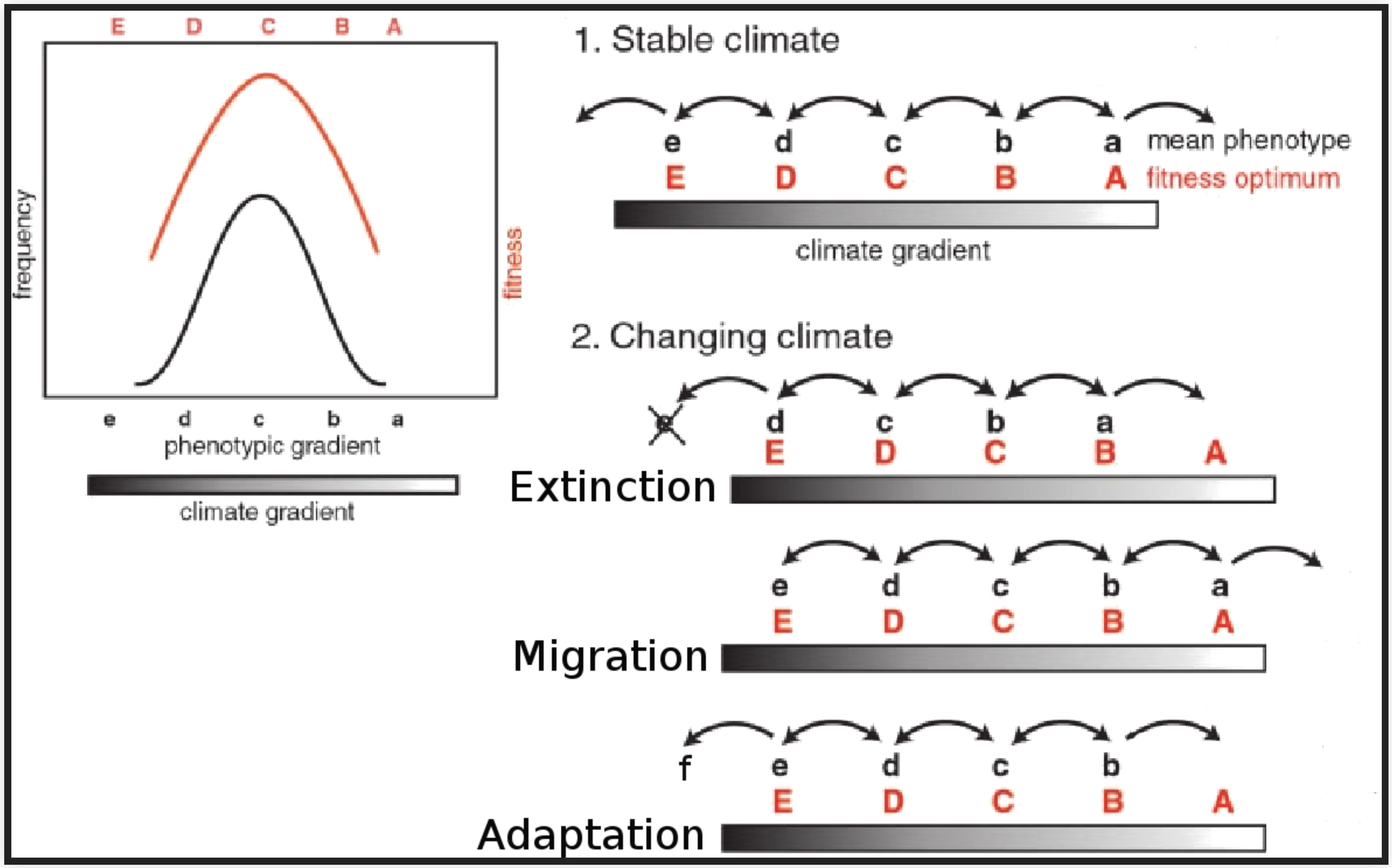
>4 times faster than historical temperature changes

Temperature tolerance of a population



Garrison (2010); Oceanography

Impact of climate change



Davis & Shaw (2001); Science

Intertidal species are particularly sensitive

What is the impact on impact on ocean forests and their biodiversity?

Why should we care about the climate change impact on ocean forests?

Ecosystem services are worth

>16 000 Euros ha^{-1} $year^{-1}$

Nursery grounds

Christoffer Boström

Protection from erosion

Christoffer Boström

Habitat and food

Christoffer Boström

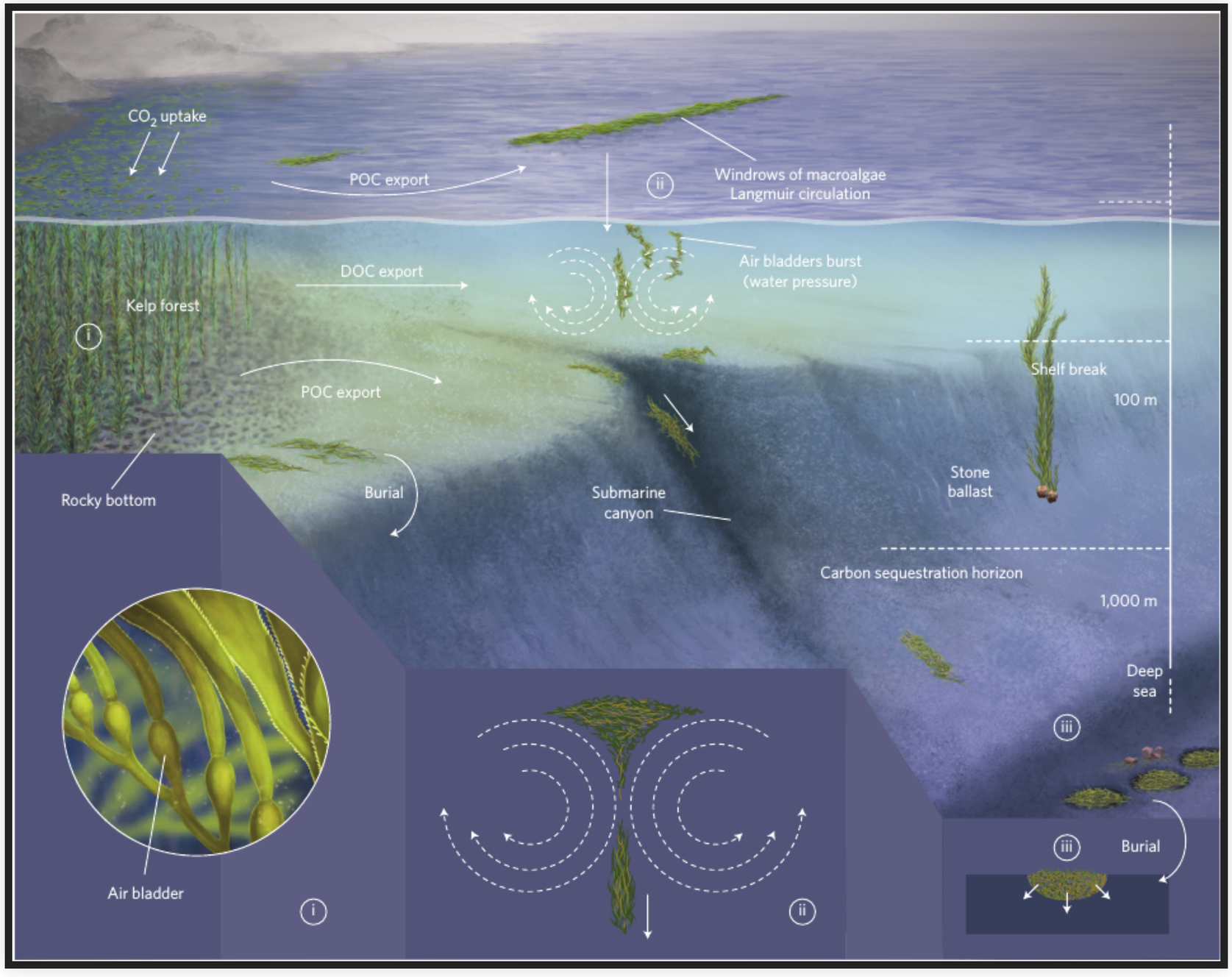
Nutrient fixation

Galice Hoarau

Protection from desiccation

Carbon sequestration

Carbon sequestration

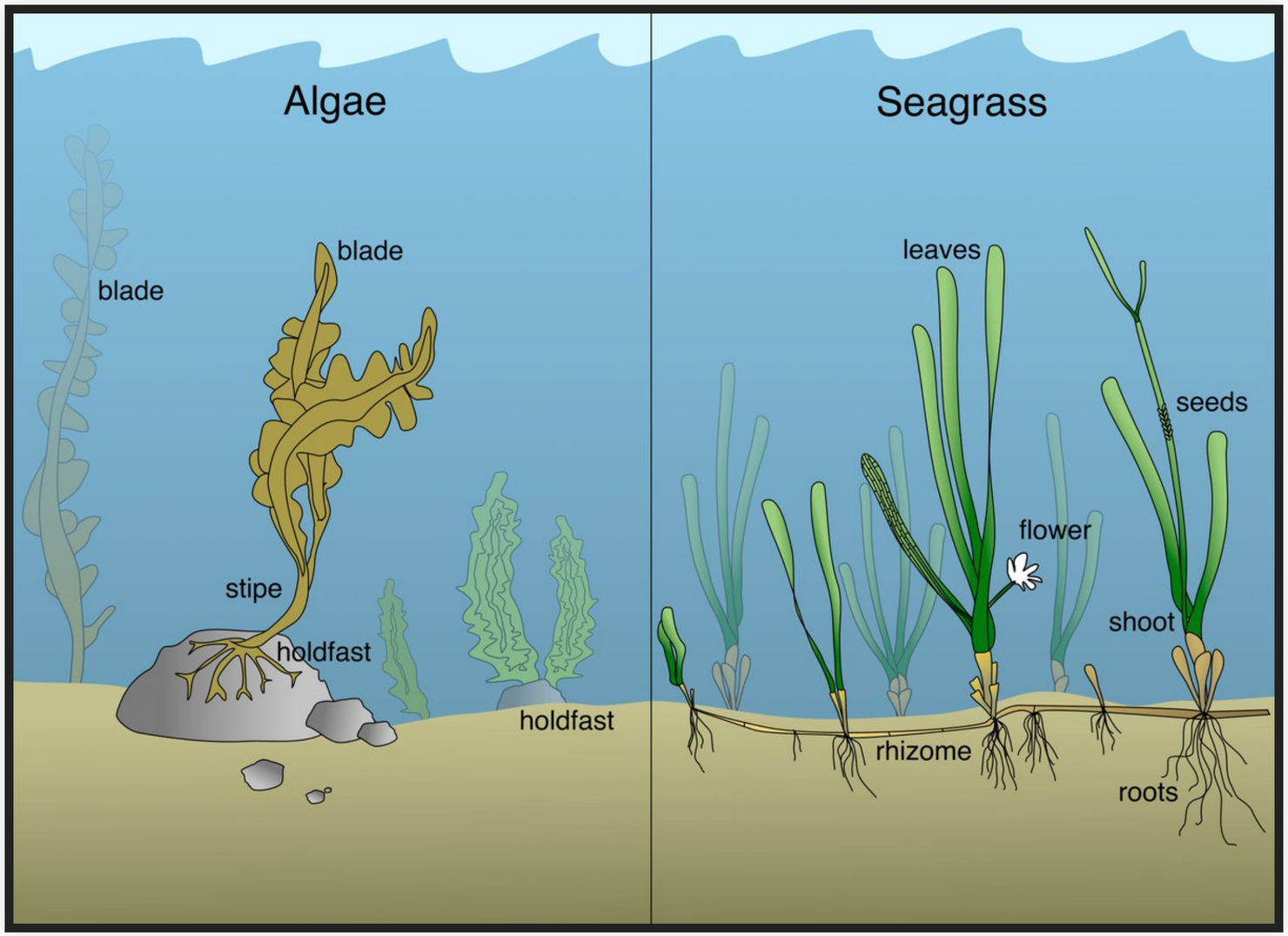


Krause-Jensen & Duarte (2016); Nature Geoscience

What is the impact on ocean forests and their biodiversity?

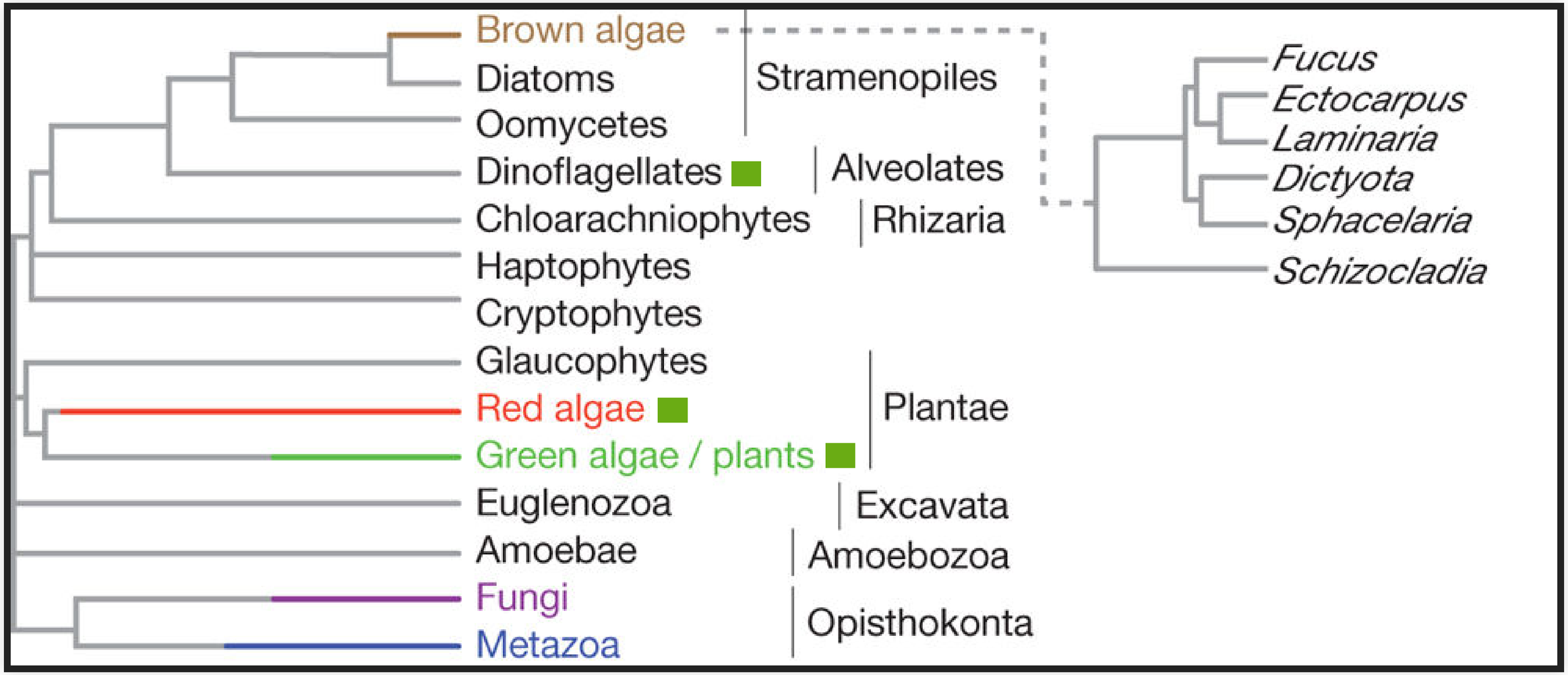
Ocean forests

seagrass and vs. seaweed (macroalgae)



https://twitter.com/projectseagrass/status/1050099510326808577

Algae and plants are not closely related



Cock et al. (2010); Nature

Seagrass: ca. 60 species

Seaweed: >5,000 species

What is the impact on ocean forests and their biodiversity?

The biodiversity of ocean forests

Levels of biodiversity

- genetic
- species
- ecosystem

How to study the climate change impact on ocean forests?

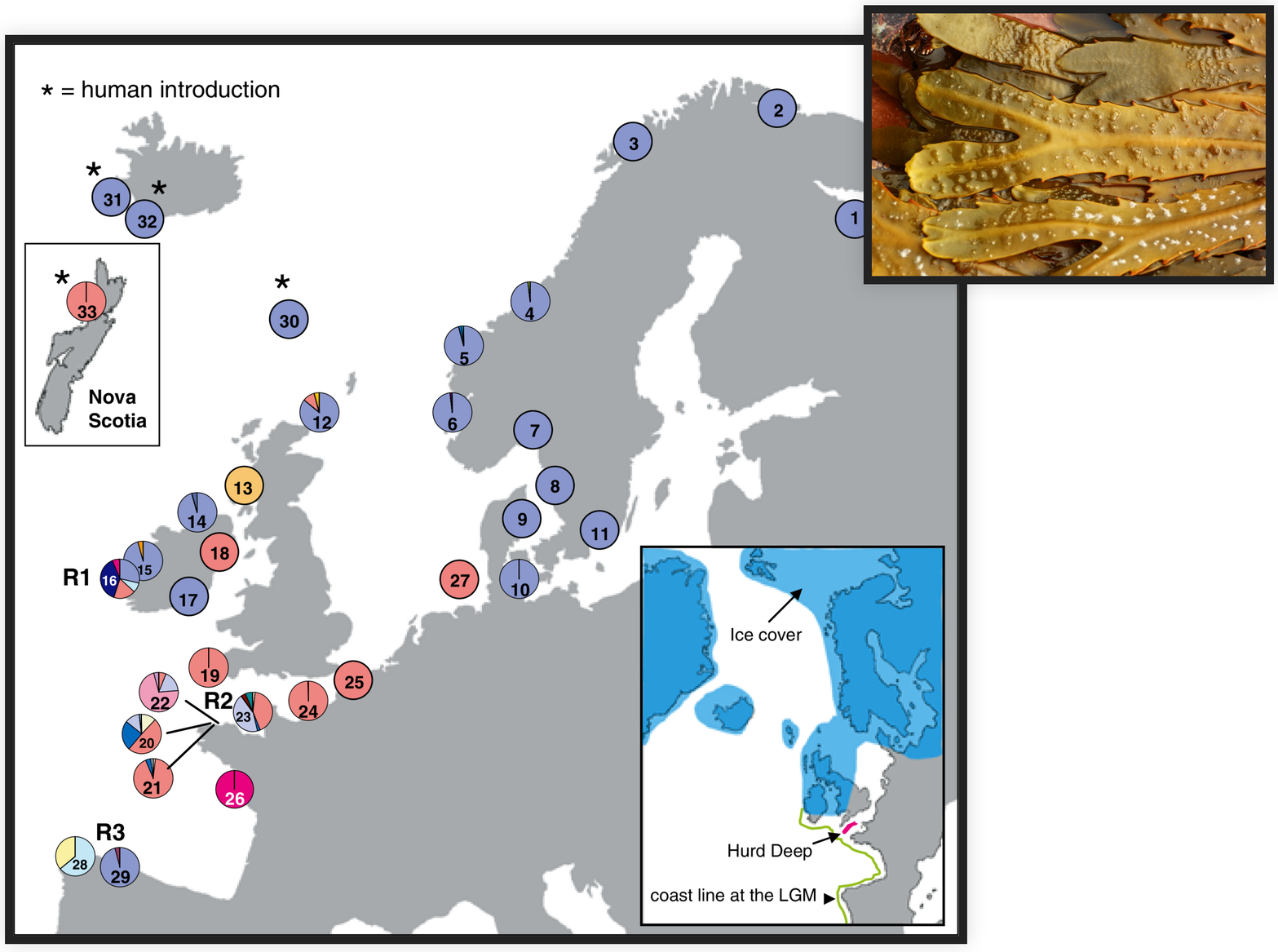
The past

is the key to the present

is the key to the future

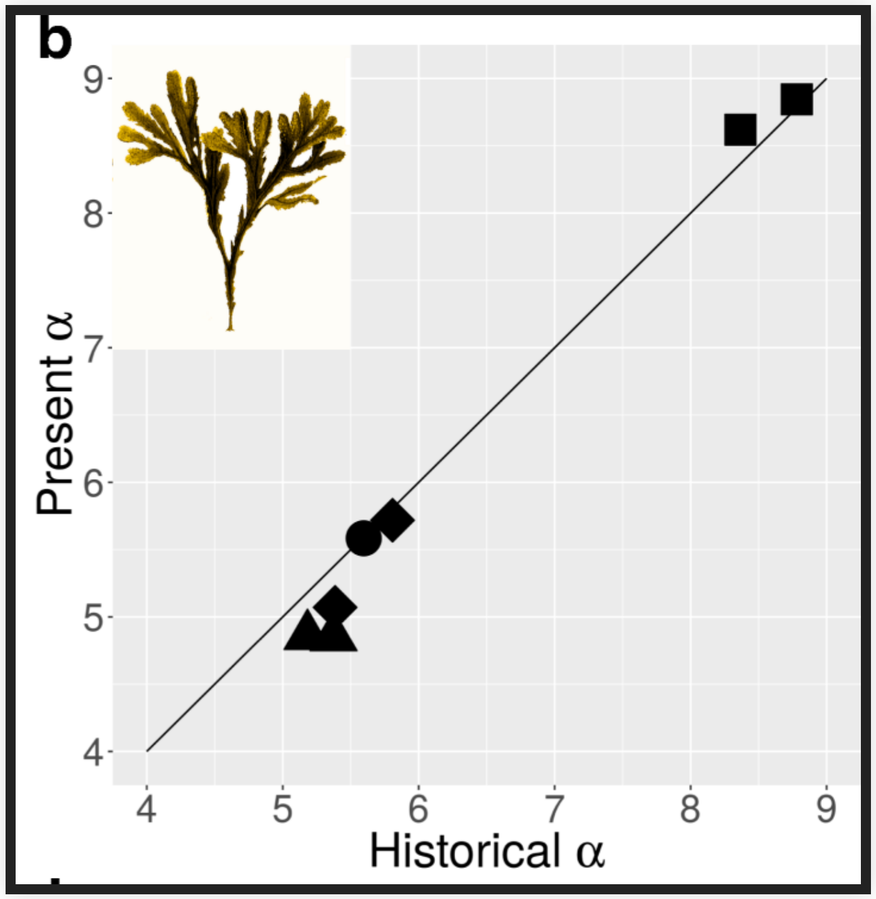
Genetic diversity of *Fucus serratus*

Three glacial refugia

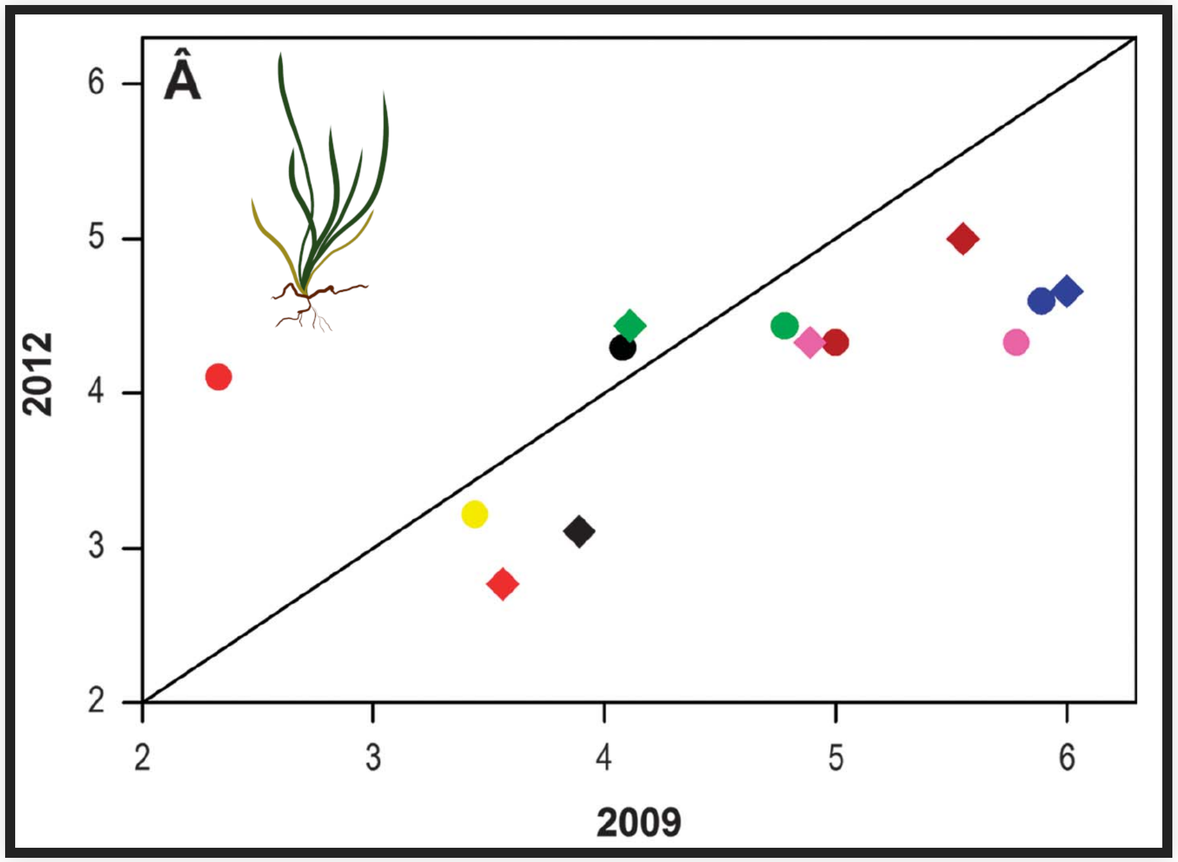


Hoarau et al. (2007); *Molecular Ecology*

Temporal stability of genetic diversity

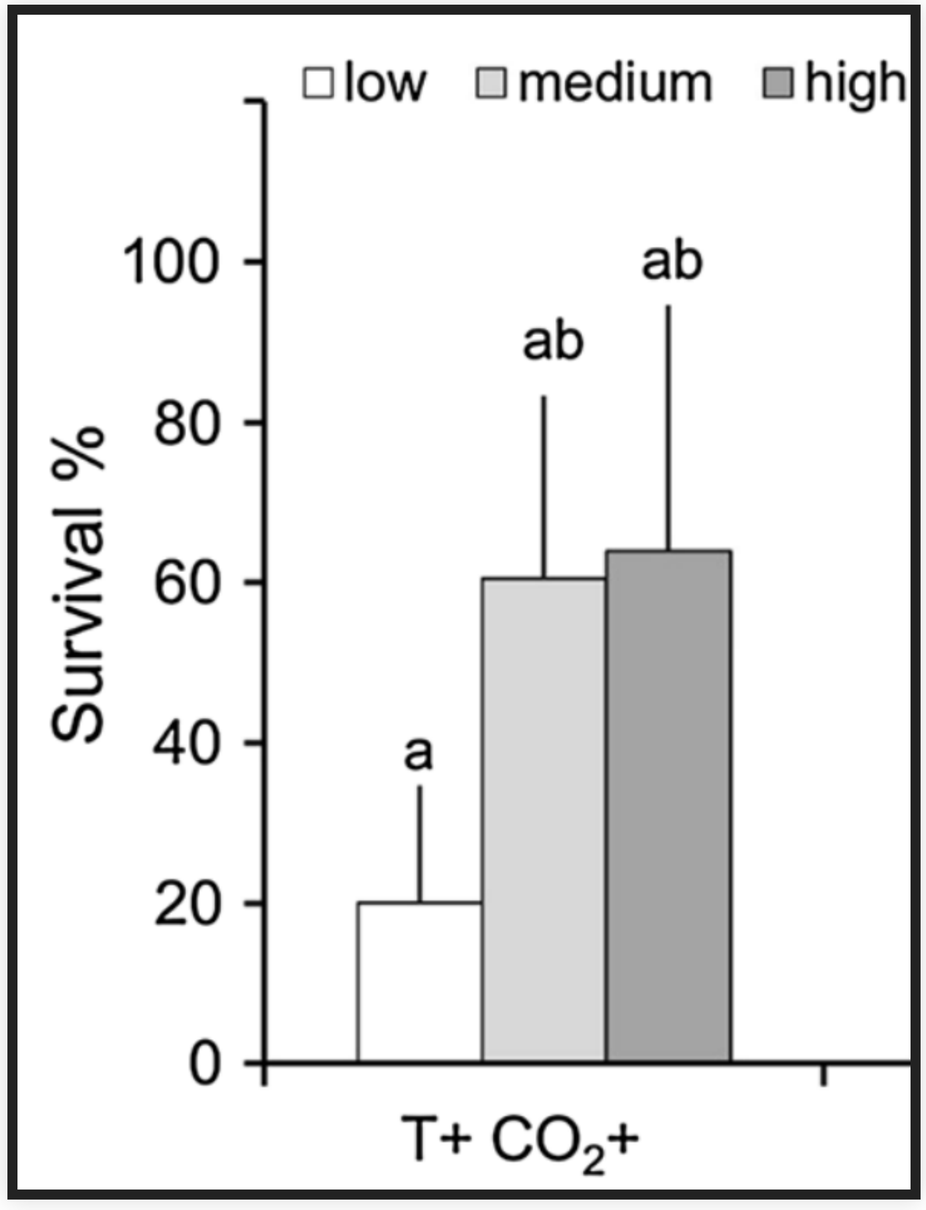


Jueterbock et al. (2018); *BMC Evolutionary Biology*



Becheler et al. (2014); *Heredity*

Genetic diversity enhances survivability

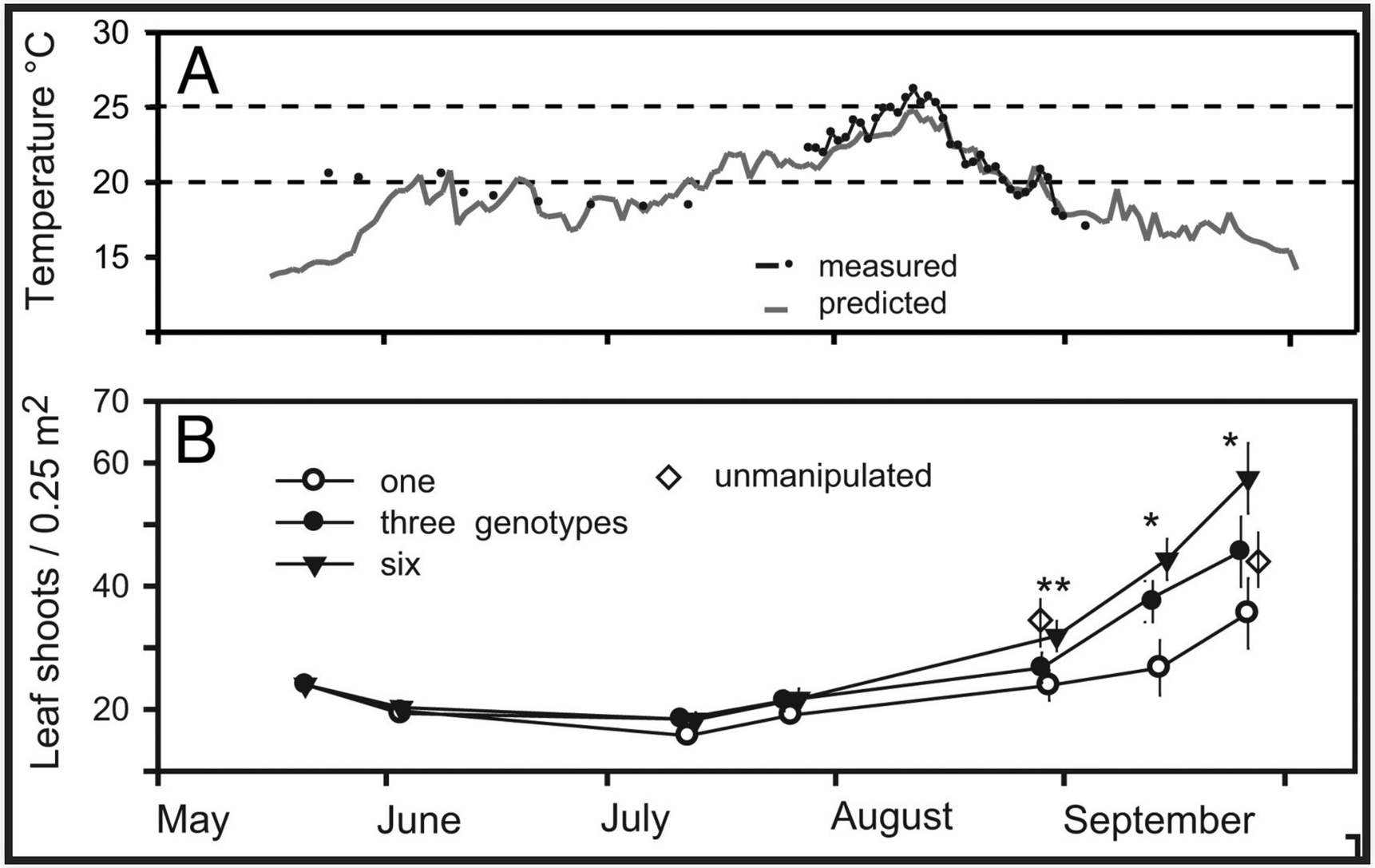


Fucus vesiculosus

Al-Janabi et al. (2016); *Marine Biology*

...heat stress recovery..

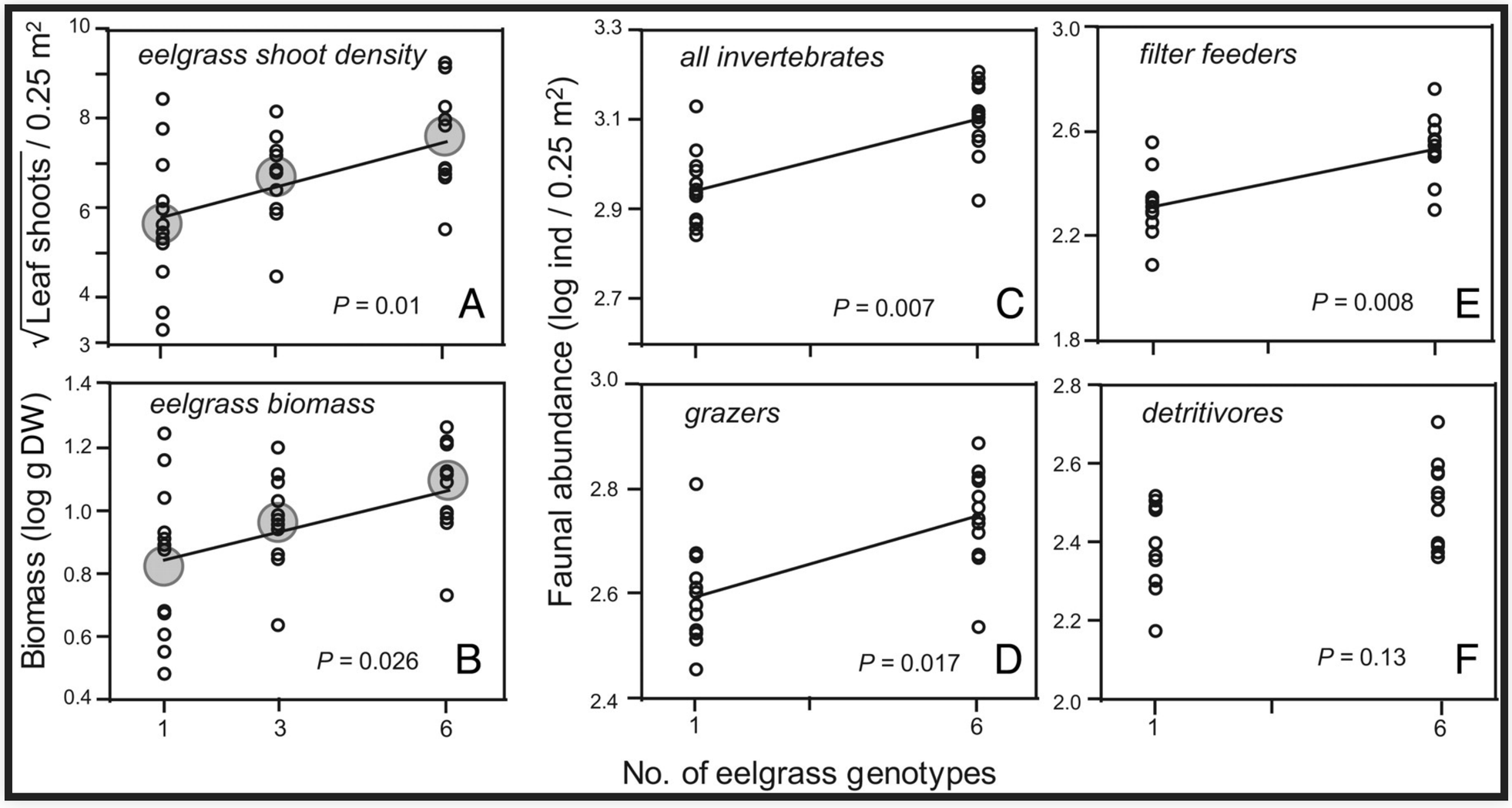
in *Zostera marina*



Reusch et al. (2005); *PNAS*

...biomass and faunal abundance...

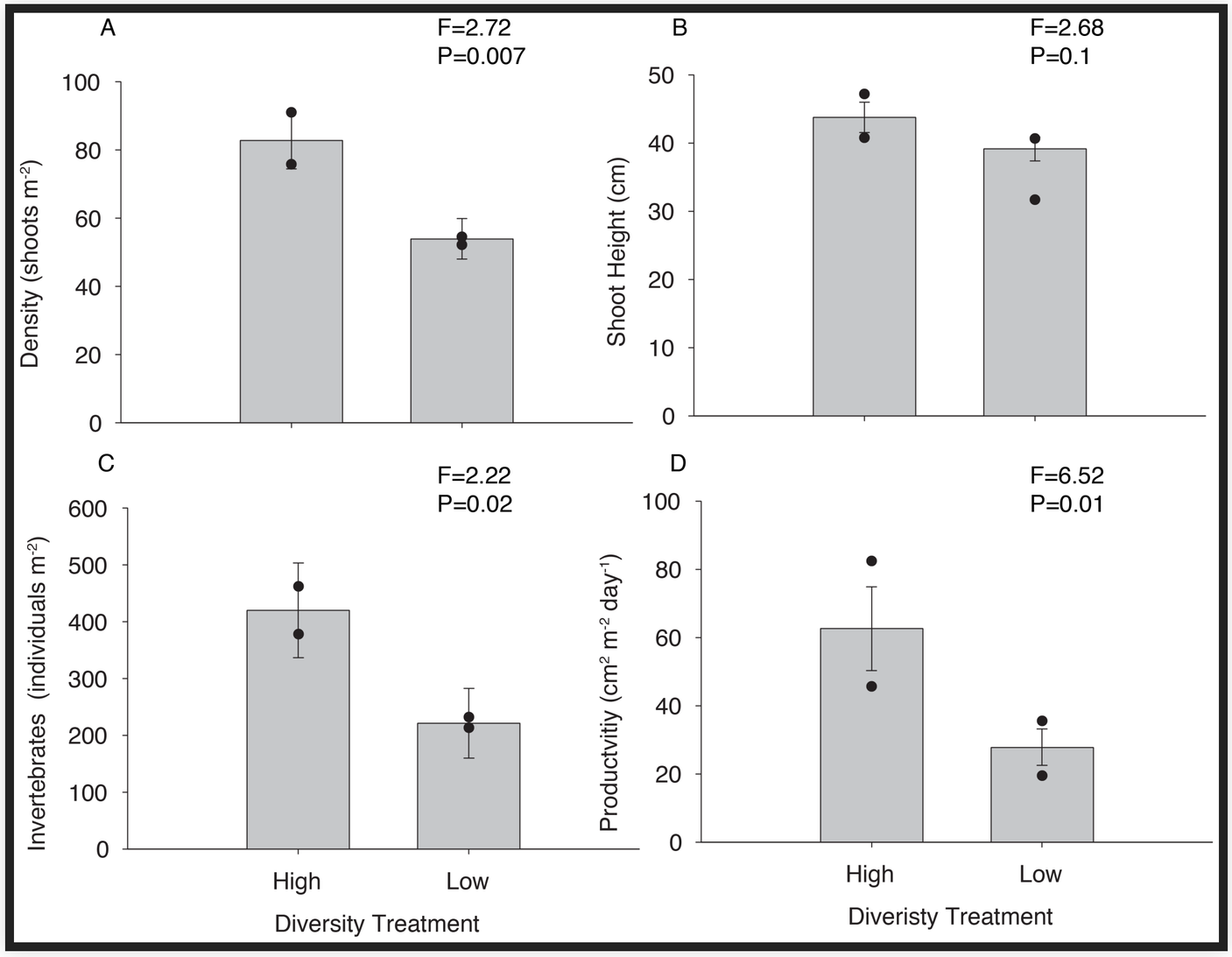
in *Zostera marina*



Reusch et al. (2005); *PNAS*

...density and productivity.

in *Zostera marina*



Reynolds et al. (2012); *PLOS ONE*

Genetic diversity important for

- long-term survival
- ecosystem services
- restoration

The past

is the key to the present

is the key to the future

1999: extensive meadows of *Fucus serratus*

Jueterbock et al. (2013); *Ecology and Evolution*

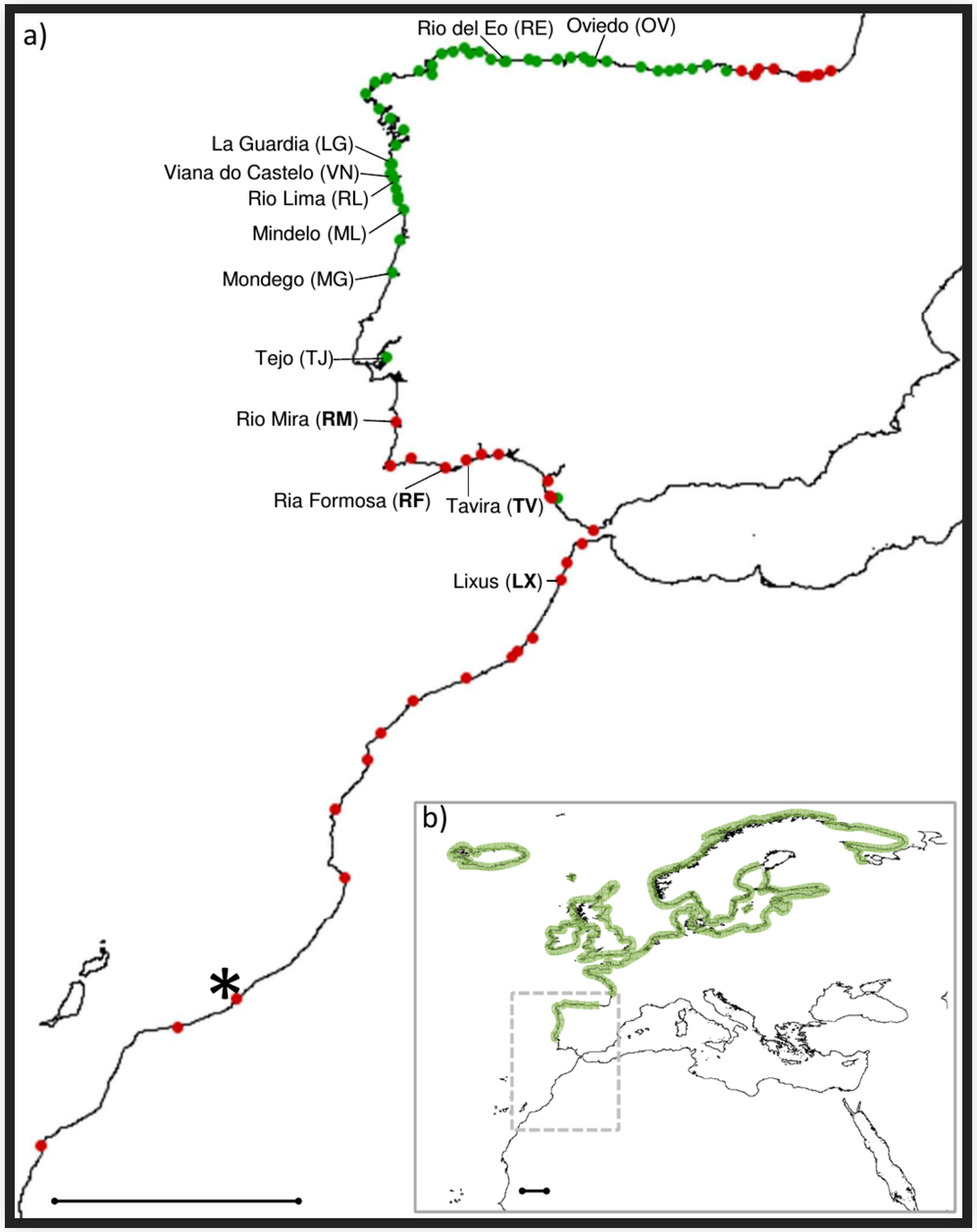
2010: 90% abundance decline in 11 years

Jueterbock et al. (2013); *Ecology and Evolution*

Dwarf forms with reduced reproductive capacity in Spain

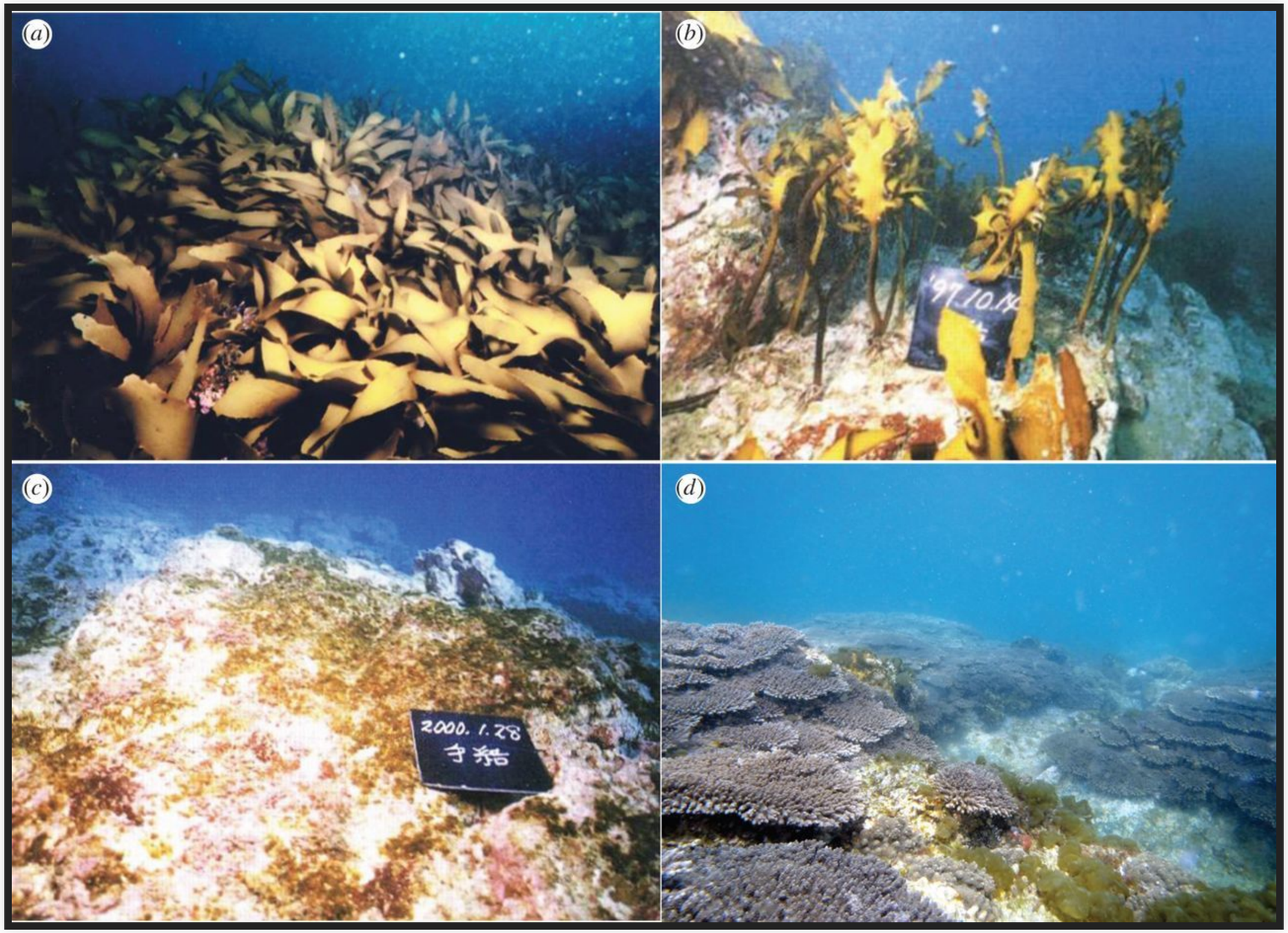
Viejo et al. (2011); *Ecography*

1,250 km loss of southern range of *Fucus vesiculosus*



Nicastro et al. (2013); *BMC Biology*

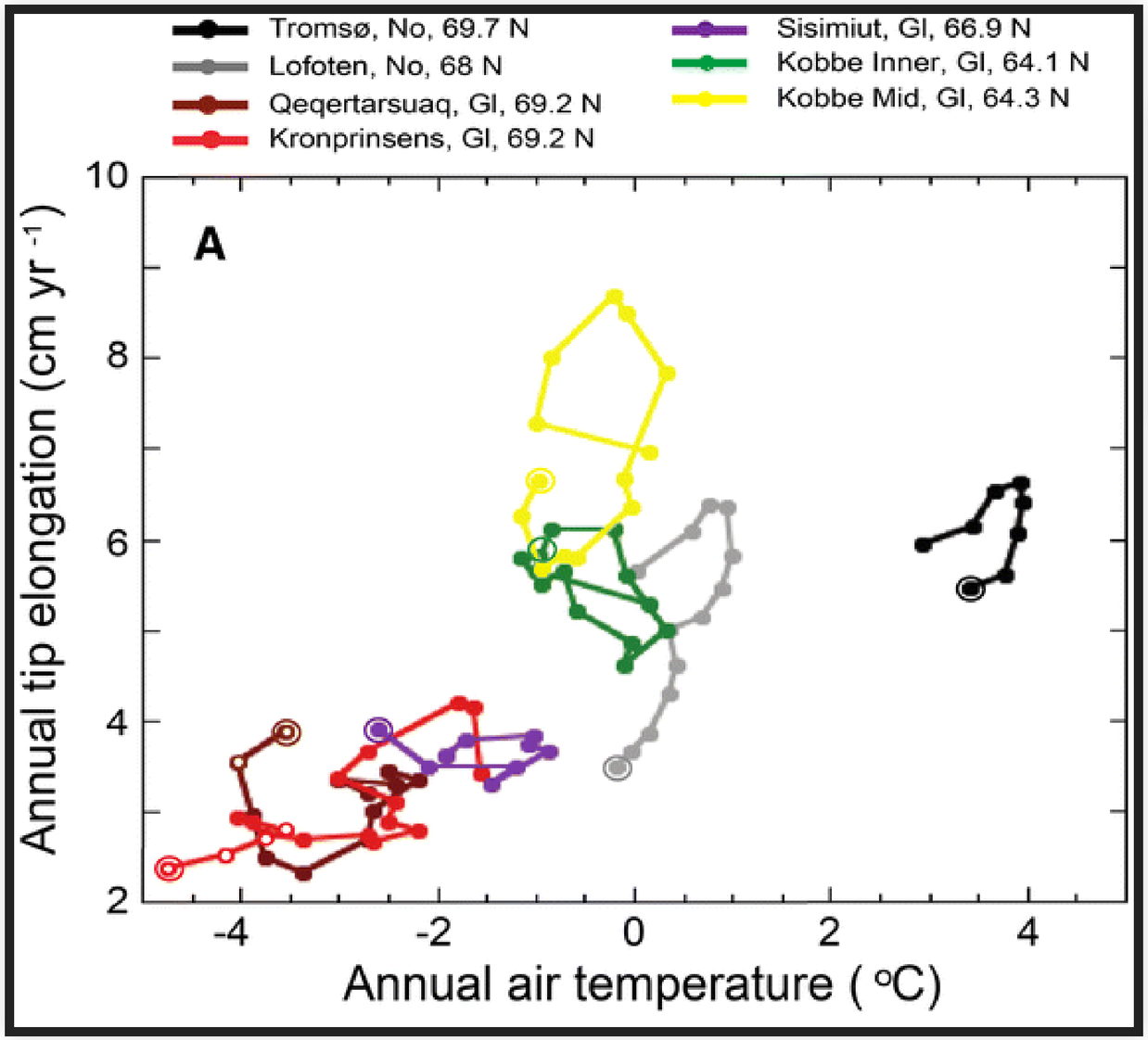
Tropicalization of kelp forests in Southern Japan



Verges et al. (2009); *Proc. R. Soc. B Biol. Sci*

36% of Shark Bay's seagrass meadows damaged after heatwave in 2010/2011

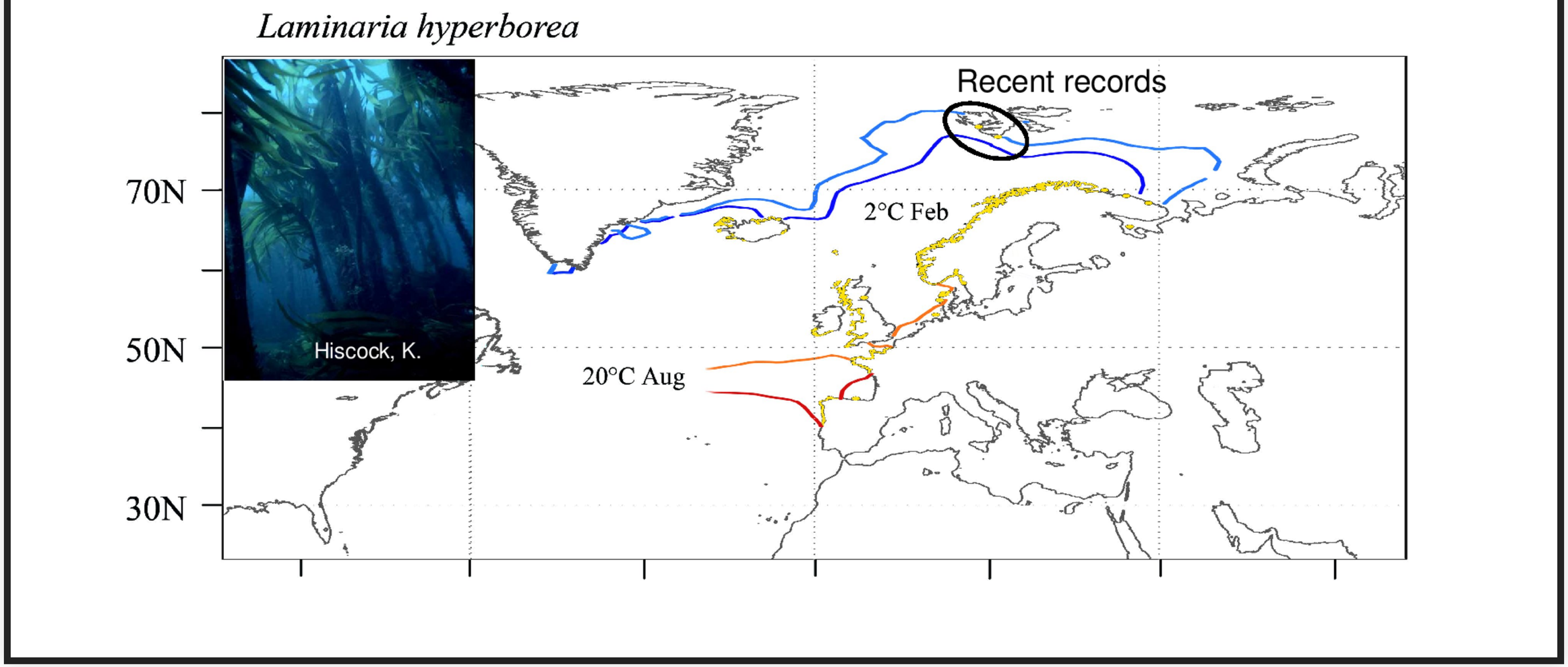
Warming stimulates growth in northern populations



Ascophyllum nodosum

Marba et al. (2017); *Ambio*

Poleward range extension of *Laminaria hyperborea*



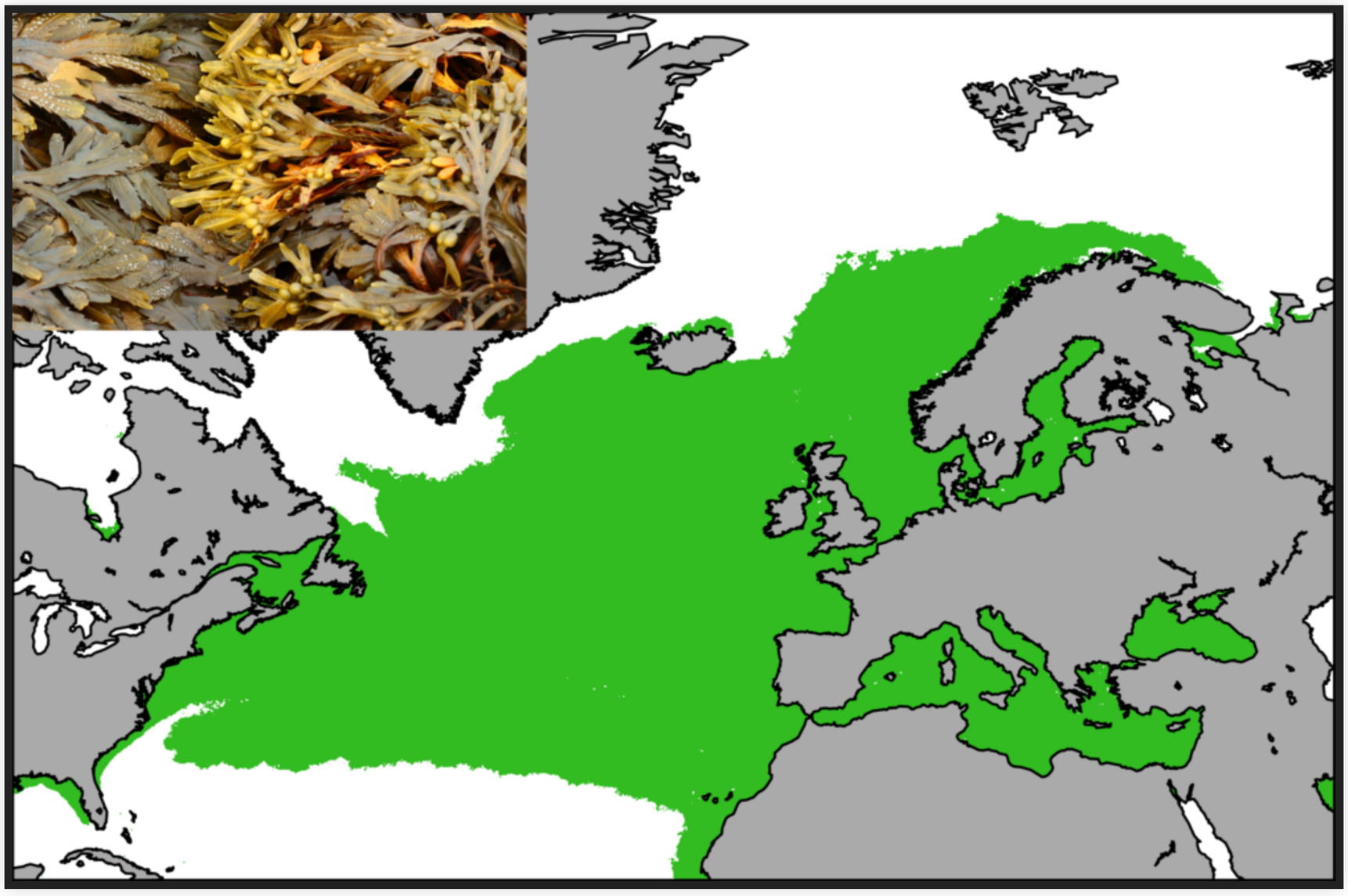
Müller et al. (2009); *Botanica Marina*

The past

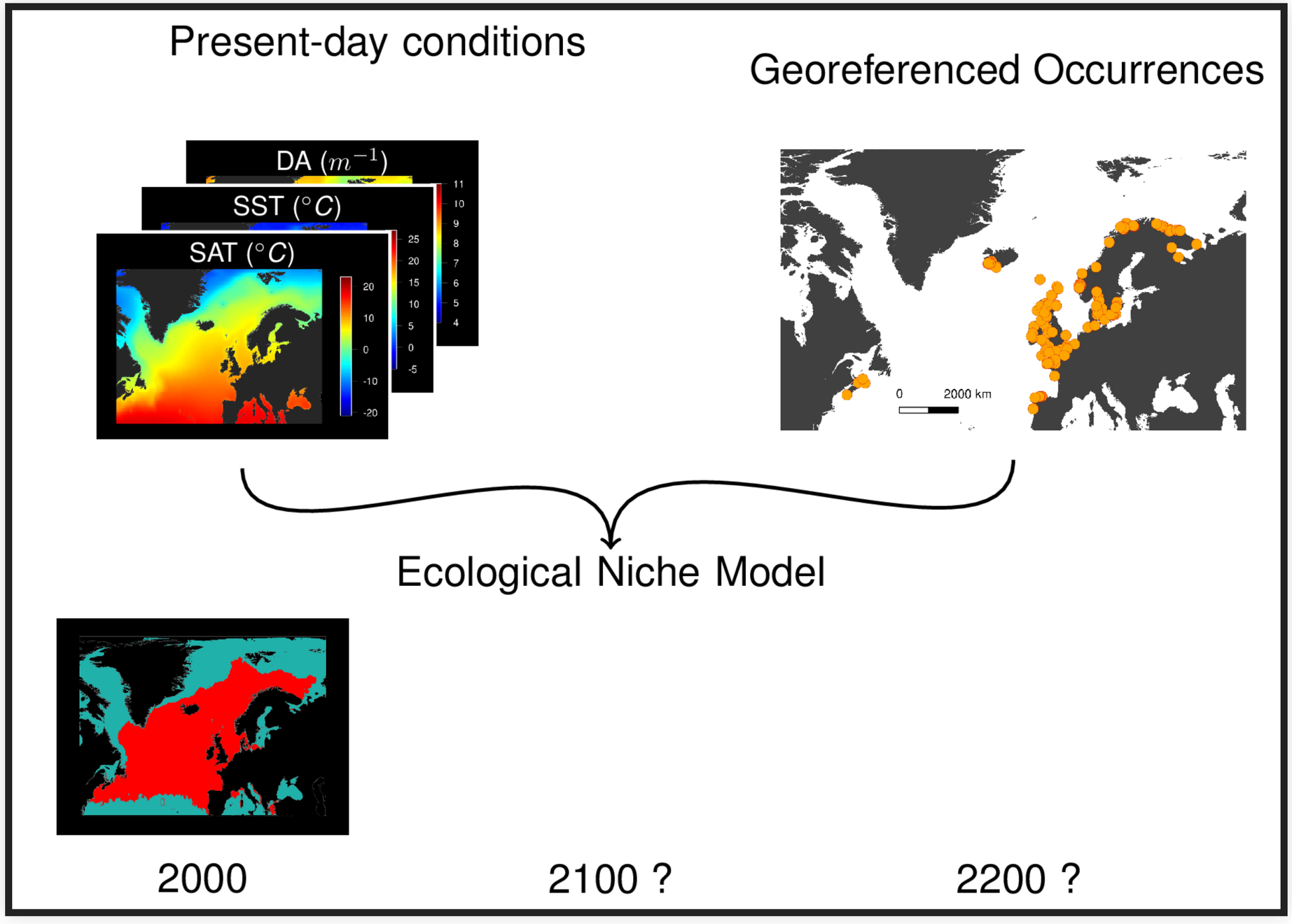
is the key to the present

is the key to the future

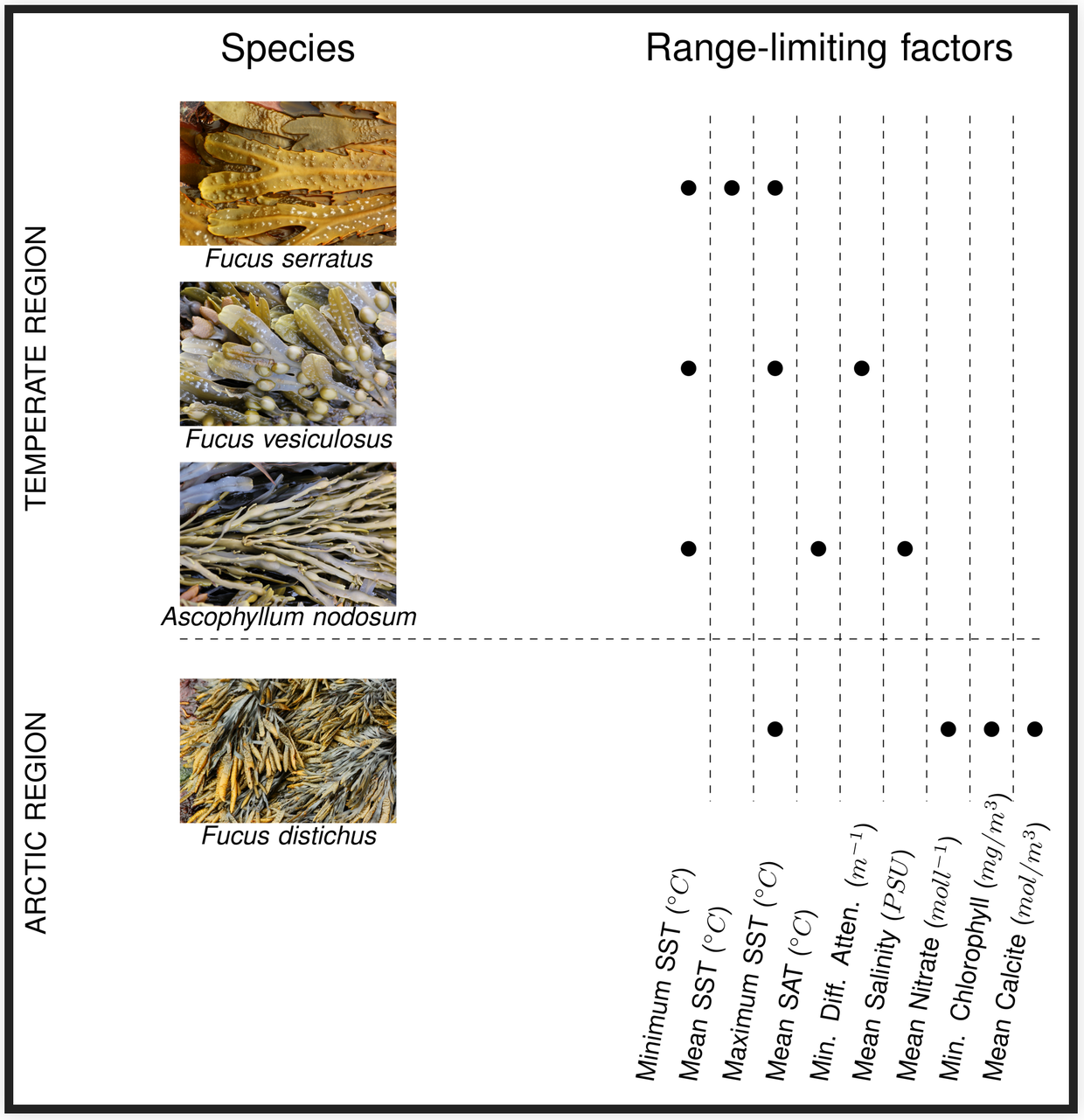
Temperate seaweed distribution limited by 10°C summer and 20°C winter isotherm



Ecological Niche Modeling to predict future distribution

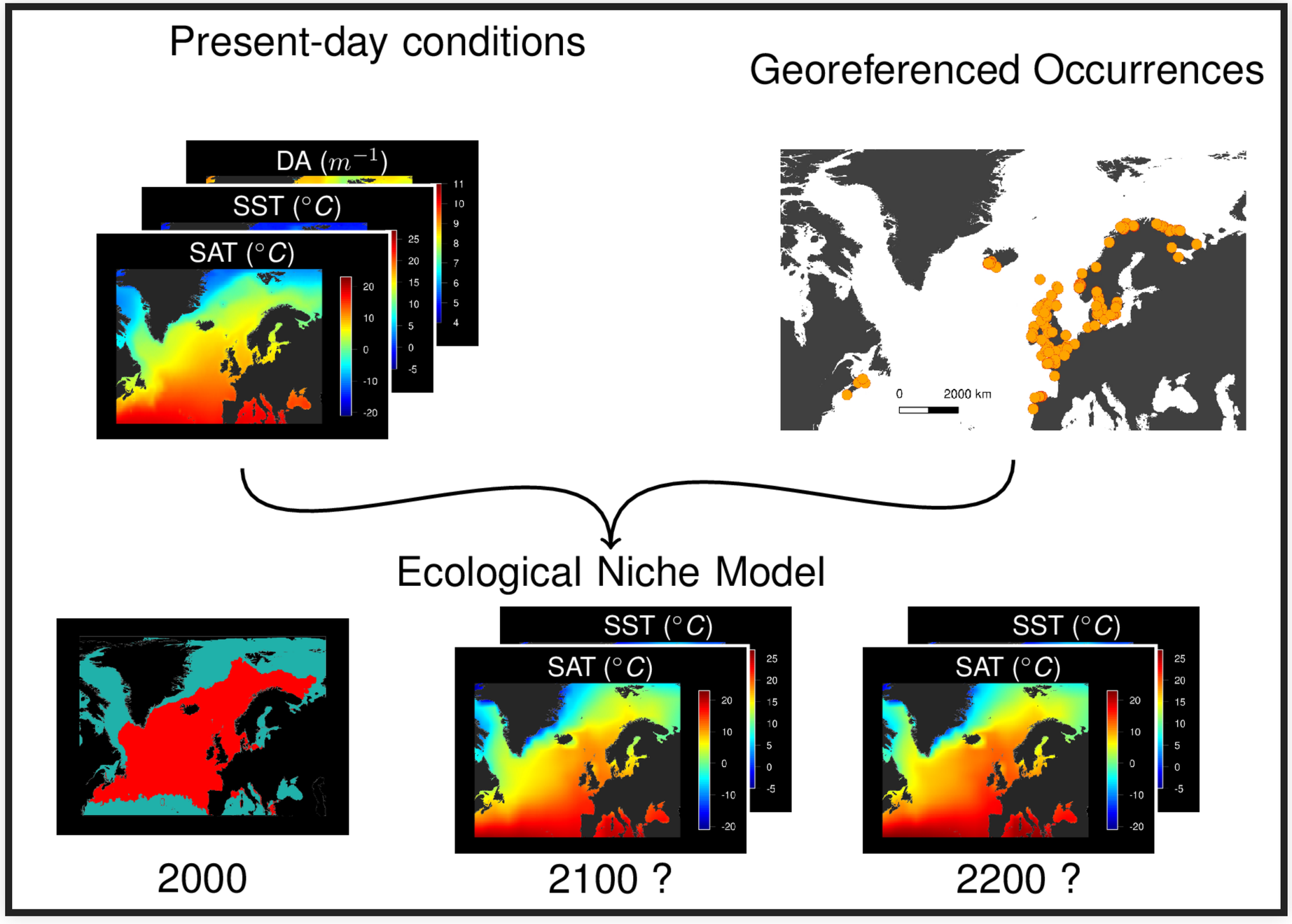


Range-limiting factors for dominant macroalgae

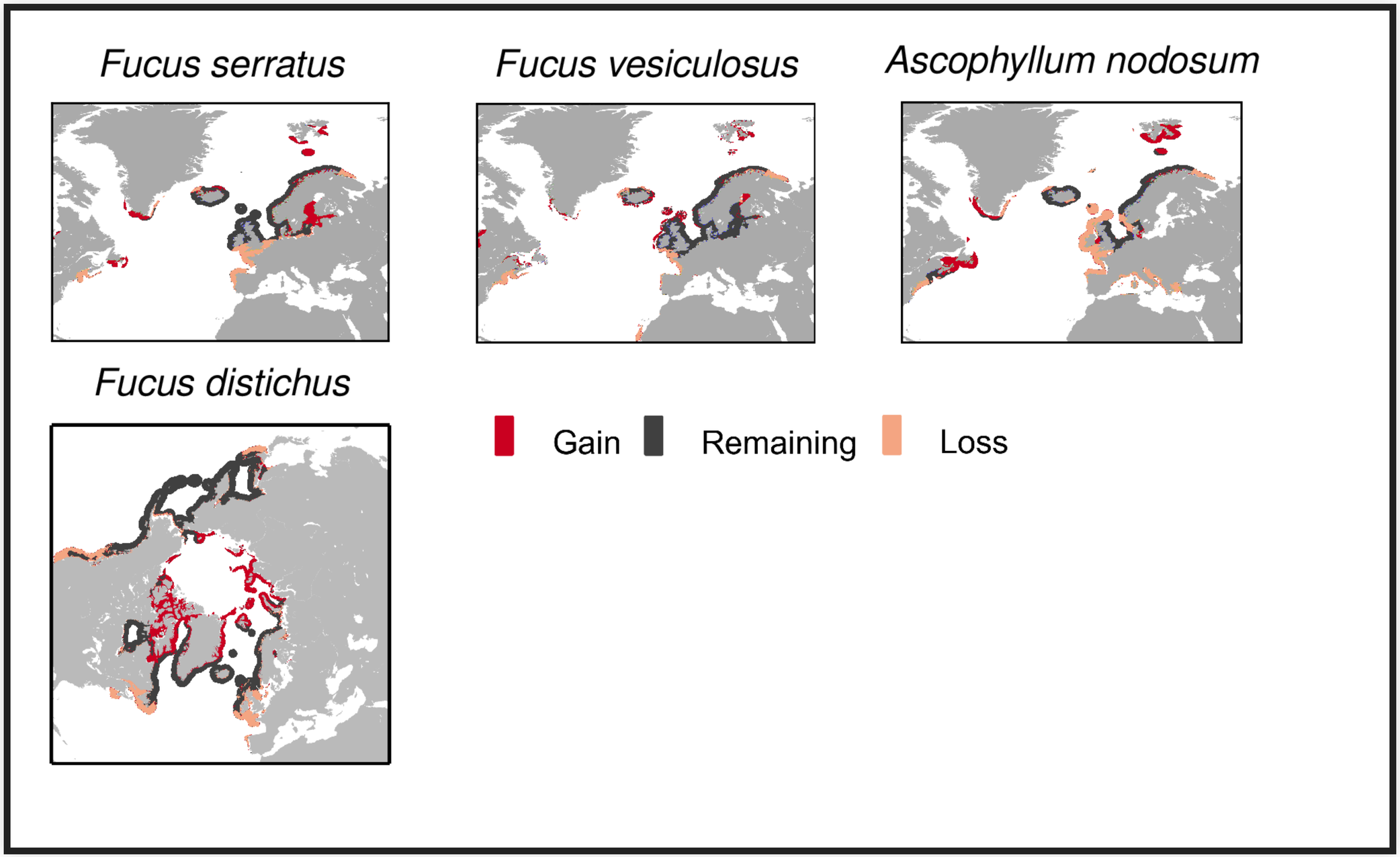


Jueterbock et al. (2013,2016); *Ecology and Evolution*

Ecological Niche Modeling to predict future distribution



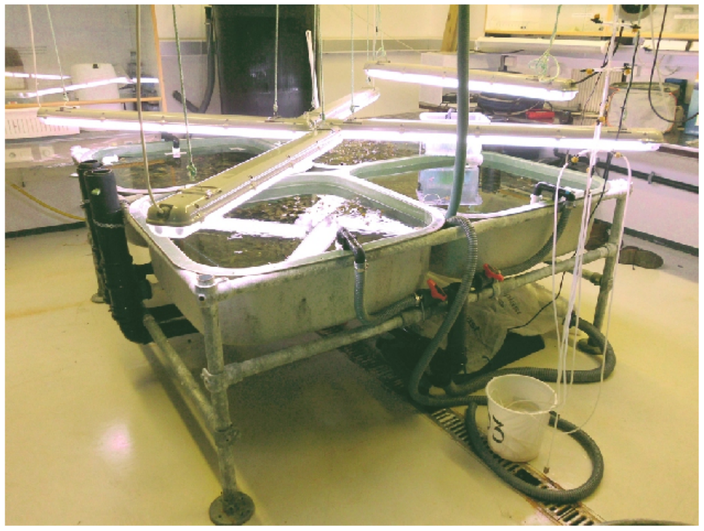
Predicted range shifts until year 2200

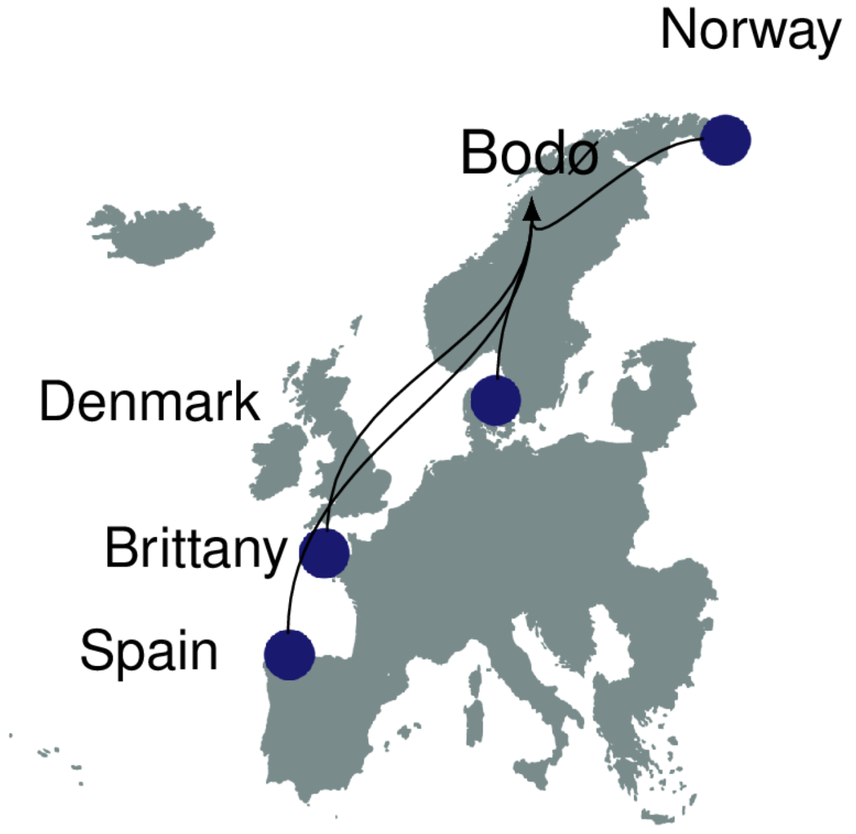


Jueterbock et al. (2013,2016); *Ecology and Evolution*

Common garden heat stress experiments

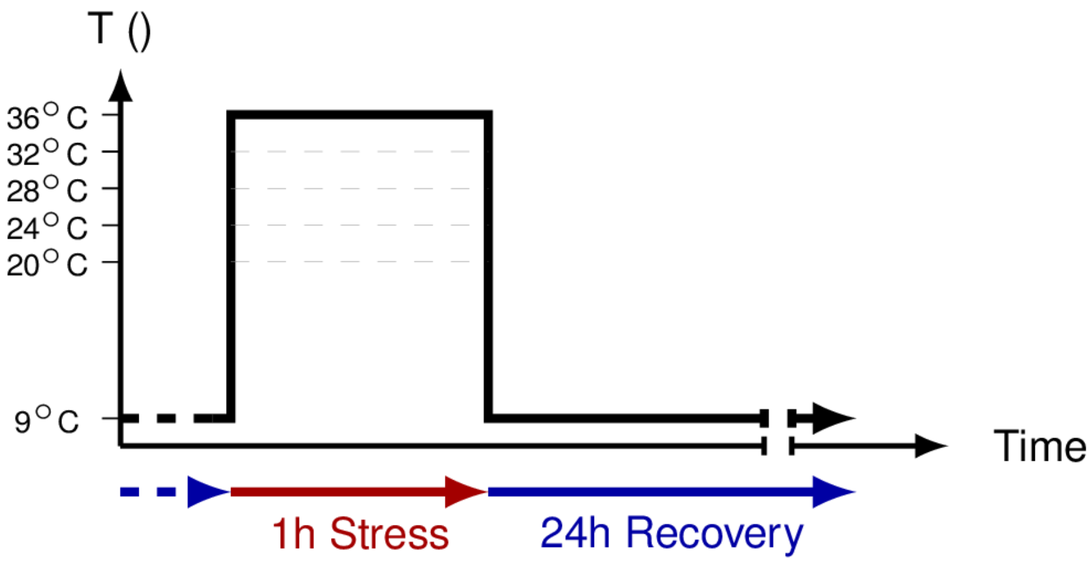
Acclimation at 9°C





Common garden heat stress experiments

Heat stress, ⩾ 6 ind./pop

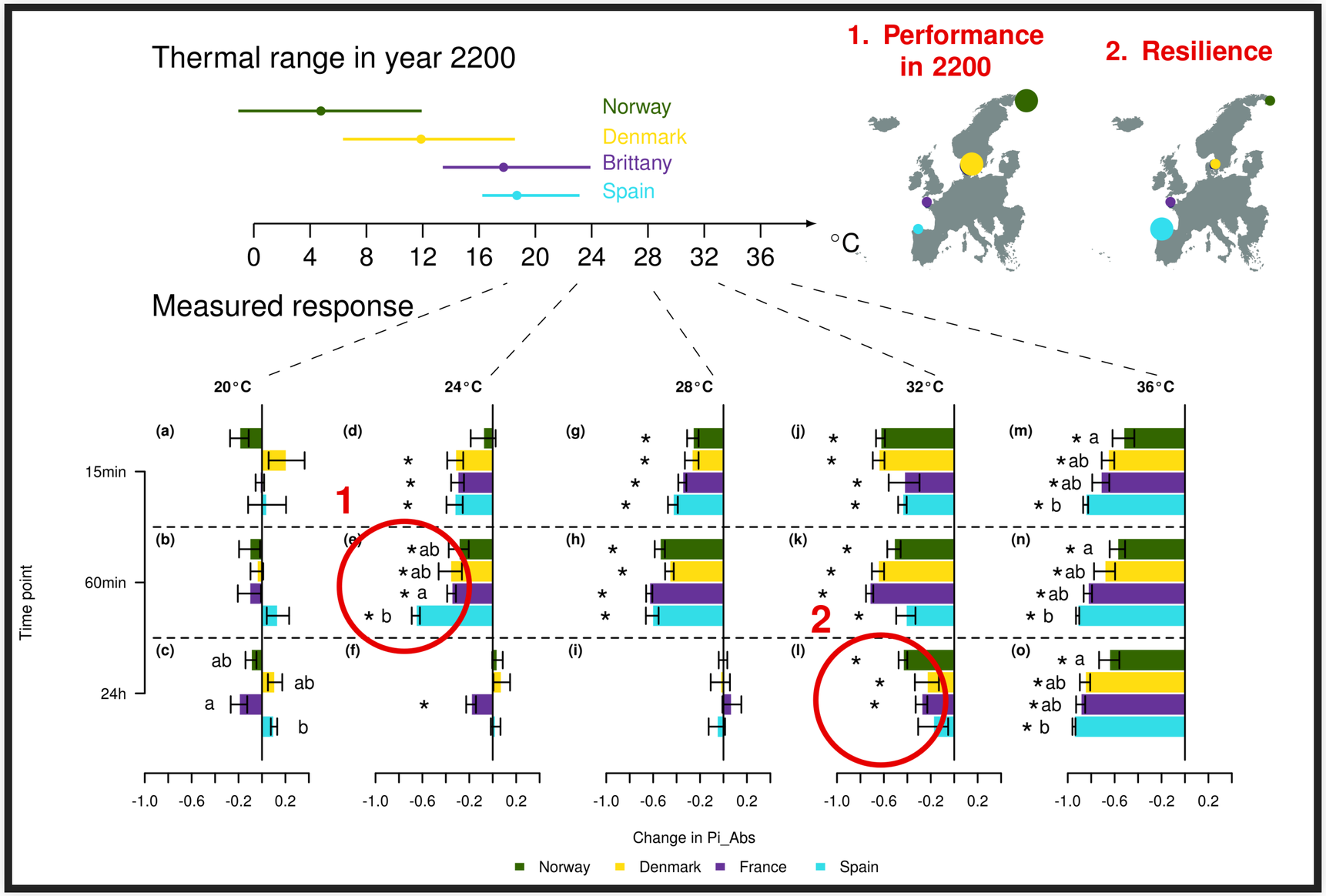


Measurements

Photosynthetic performance

hsp gene expression (*hsp70*, *hsp90*, *shsp*)

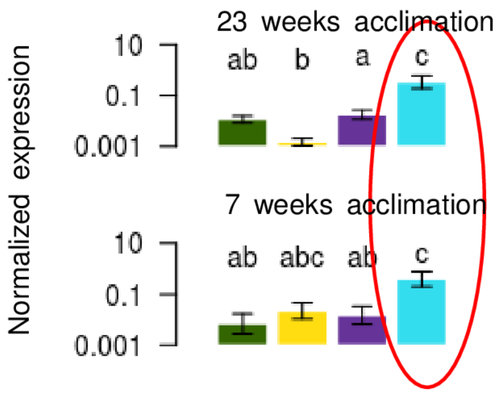
Photosynthetic performance

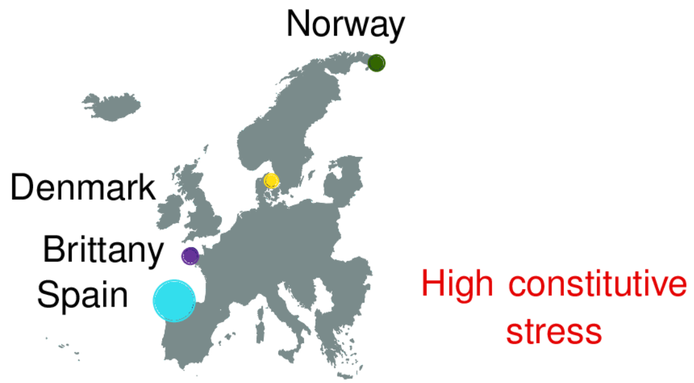


Jueterbock et al. (2014,2016); *Marine Genomics*

Heat stress response

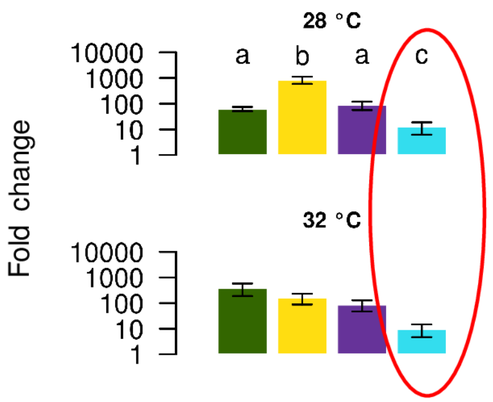
Constitutive *shsp* gene expression before heat shock

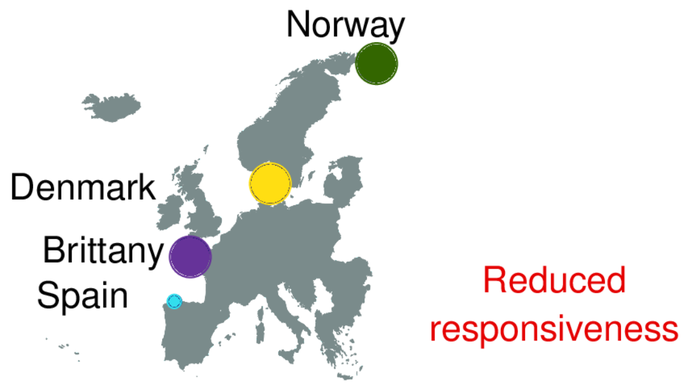




High constitutive stress

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





Reduced responsiveness

Jueterbock et al. (2014,2016); *Marine Genomics*

Impact on biodiversity

Acidification is beneficial

Seagrass and most macroalgae can use CO_2 and bicarbonate for photosynthesis

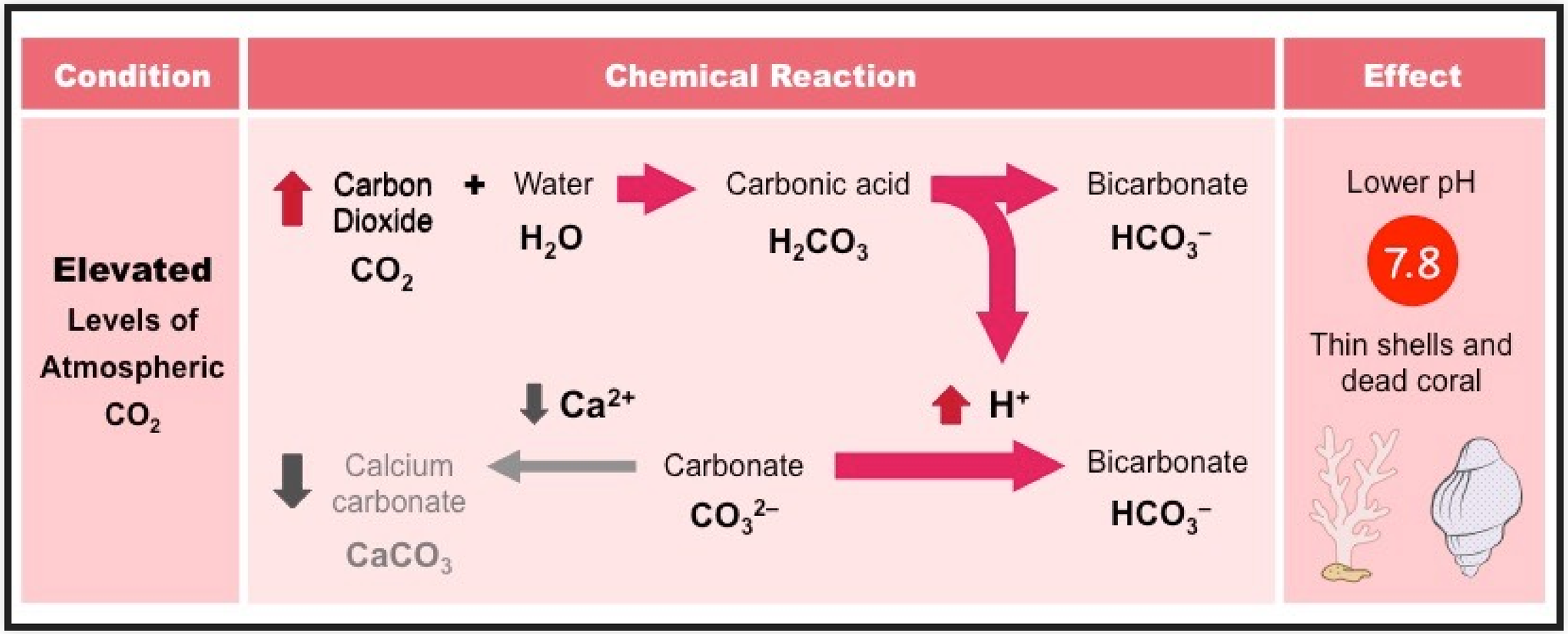
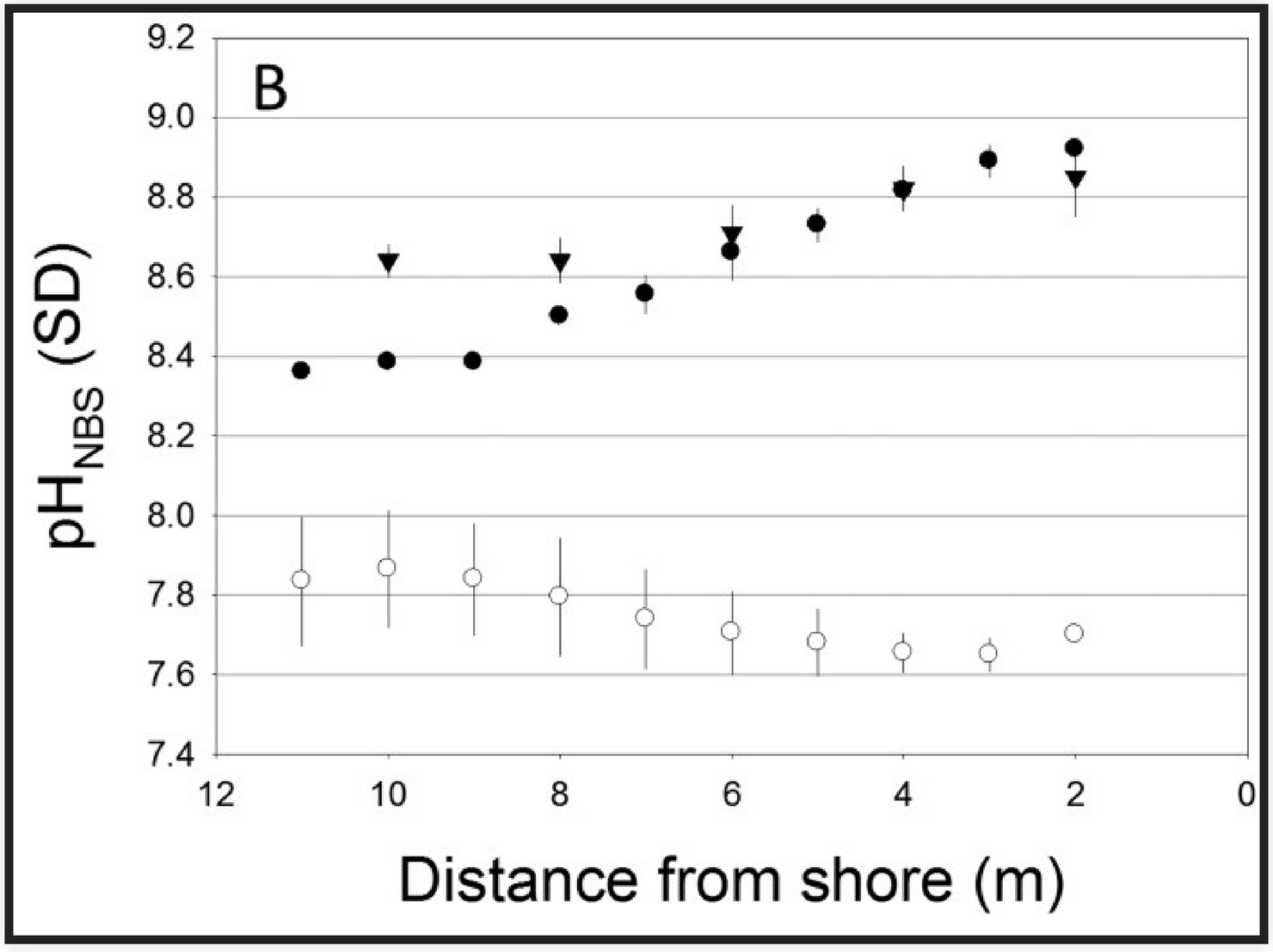


Figure credits: ib.bioninja.com.au

Koch et al. (2013); Global Change Biology

Cornwall et al. (2017); Scientific Reports

pH fluctuations in macroalgal beds

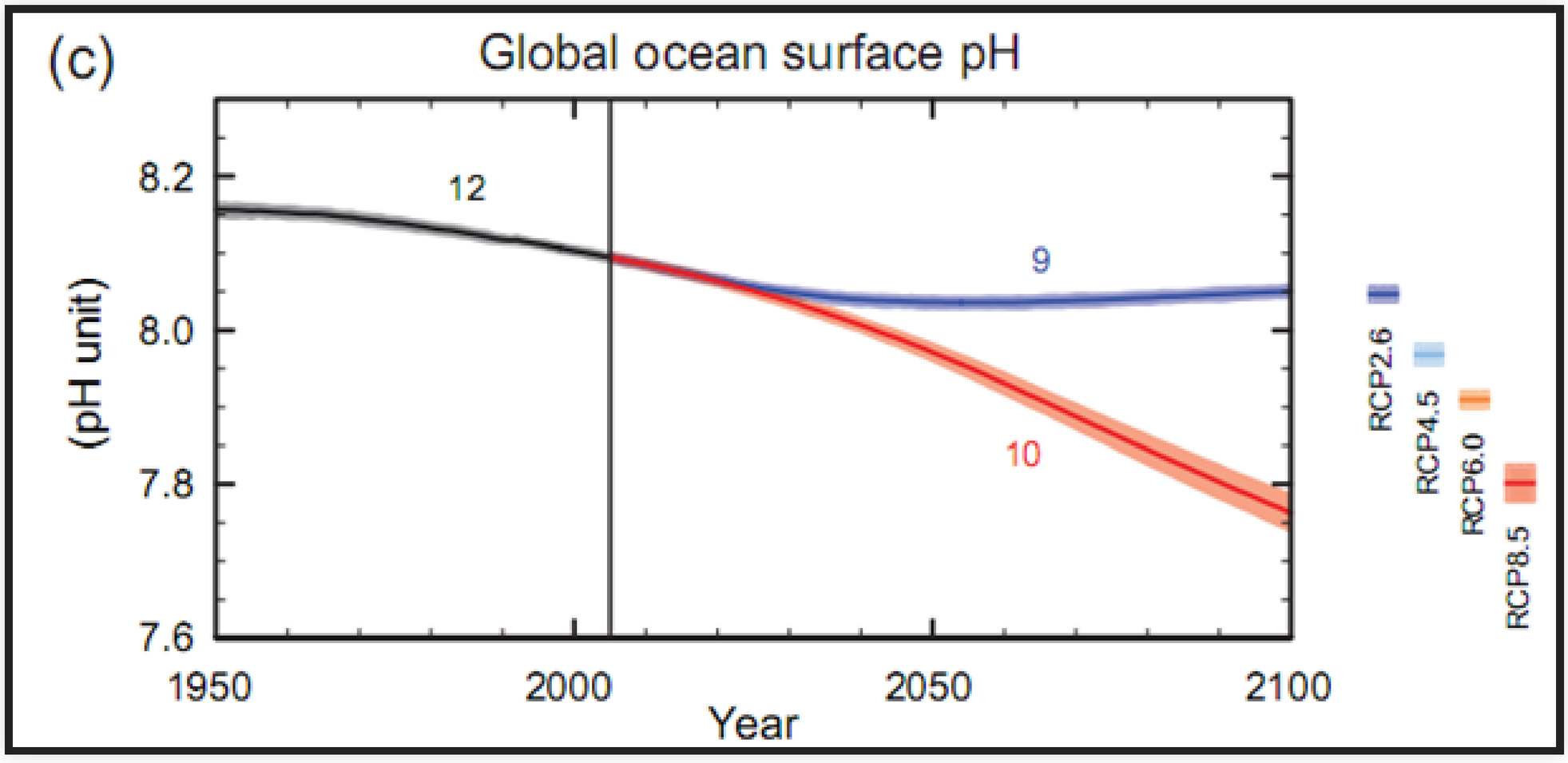


pH profile through a *Fucus* belt under calm conditions day time = black dots, night time = white dots) and on a windy day (black triangles).

Wahl et al. (2017); Limnology and Oceanography

Projected pH decrease

The projected decrese in pH until 2100 is lower than the daily pH fluctuations in macroalgal beds



IPCC AR5 WG1 (2013), Fig. SPM.7c