UNIVERSITY OF PLYMOUTH

Seagrass and climate change: implications for management

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THE MARINE BIOLOGICAL ASSOCIATION 125 years

Contents

- A quick introduction to seagrasses
- Ecology and functions
- Factors regulating ecology
- Effects of climate change
- Ideas for delivering adaptation responses

- Sexual reproduction:
  - Flowering triggered by increase in water temperature
  - Pollen dispersal is assumed to be limited to the extent of meadows themselves
  - Seed dispersal and survival is unpredictable due to stochastic events

Small seeds to giant meadows

Interesting fact:

A 1 km^2 seagrass bed in the Baltic was found to be over 1000 years old and to have originated from a single seed. (Reusch *et al*., 1999)

- Clonal growth **key feature** in appearance, development and maintenance of seagrass landscapes
- Rhizome elongation rates vary (1-500 cm yr-1)
- Smaller clones characterizing physically disturbed environments (Hämmerli, 2002).

Seagrass meadow near Tresco, (Source: South West Coastal Moniotoring Programme)

In 2005 IKEA had a global turnover of US$ 22 billion

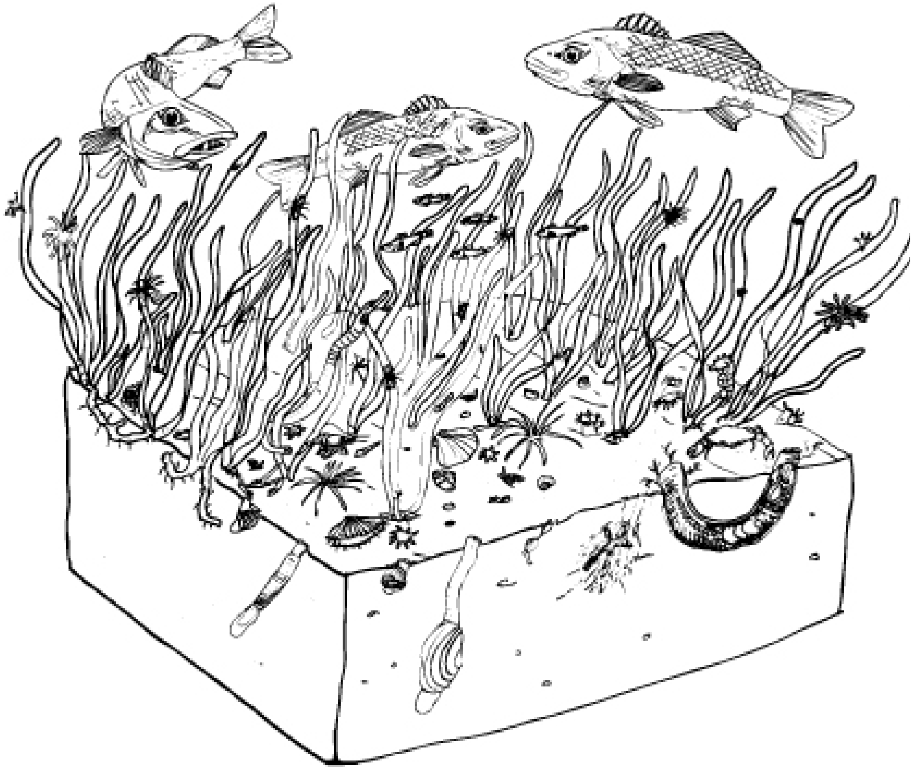
Global value of all ecosystem services provided by seagrass beds
US$ 3.8 trillion · yr^{-1}
(Costanza *et al.*, 1997)

Blue carbon sinks

"mangroves, salt marshes and seagrasses among most cost effective carbon capture and storage systems on planet."

"Preventing the further loss and degradation of these ecosystems and catalyzing their recovery can contribute to offsetting 3-7% of current fossil fuel emissions – over half of that projected for reducing rainforest deforestation"

Foundation/ Engineering species

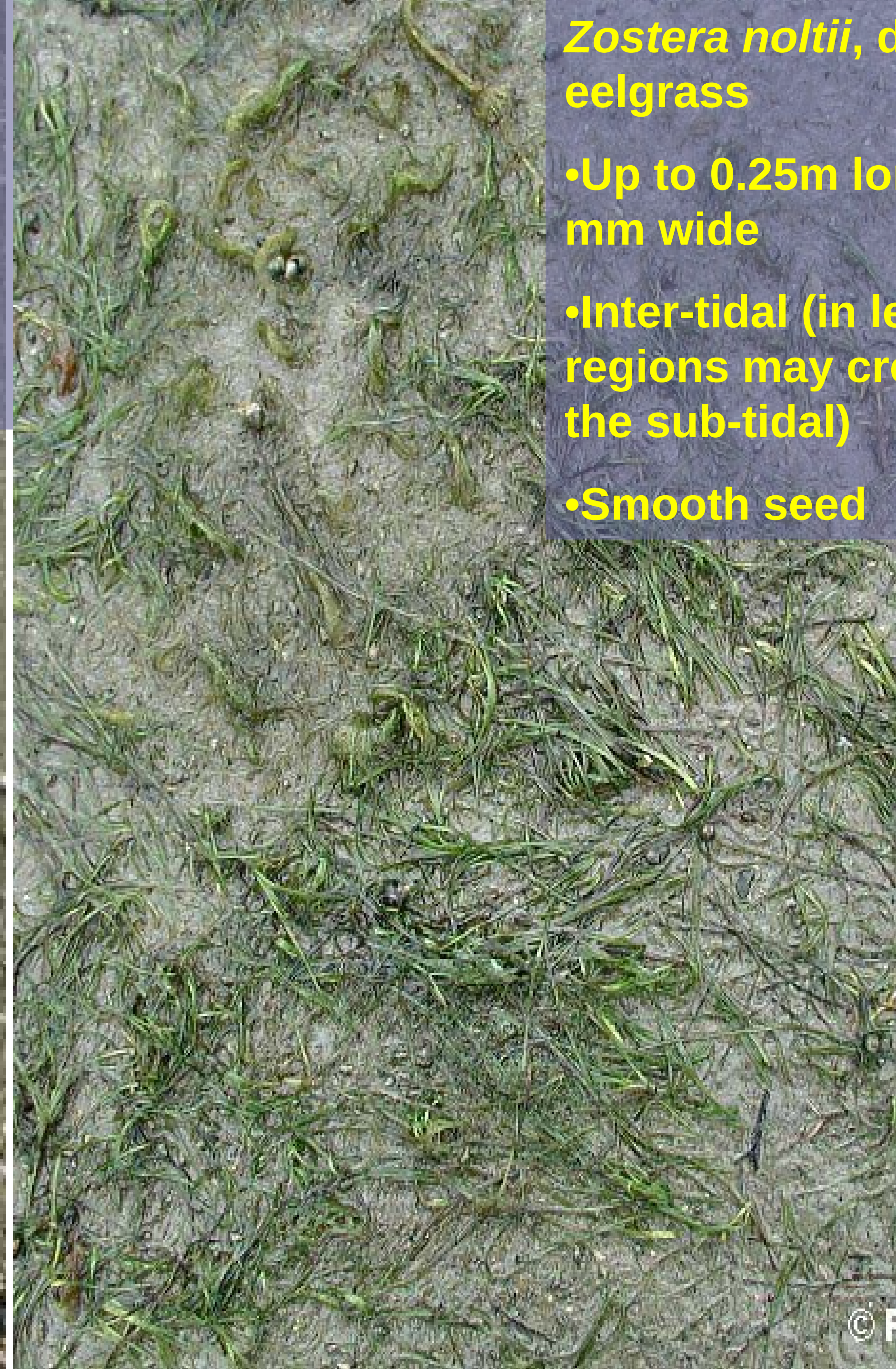


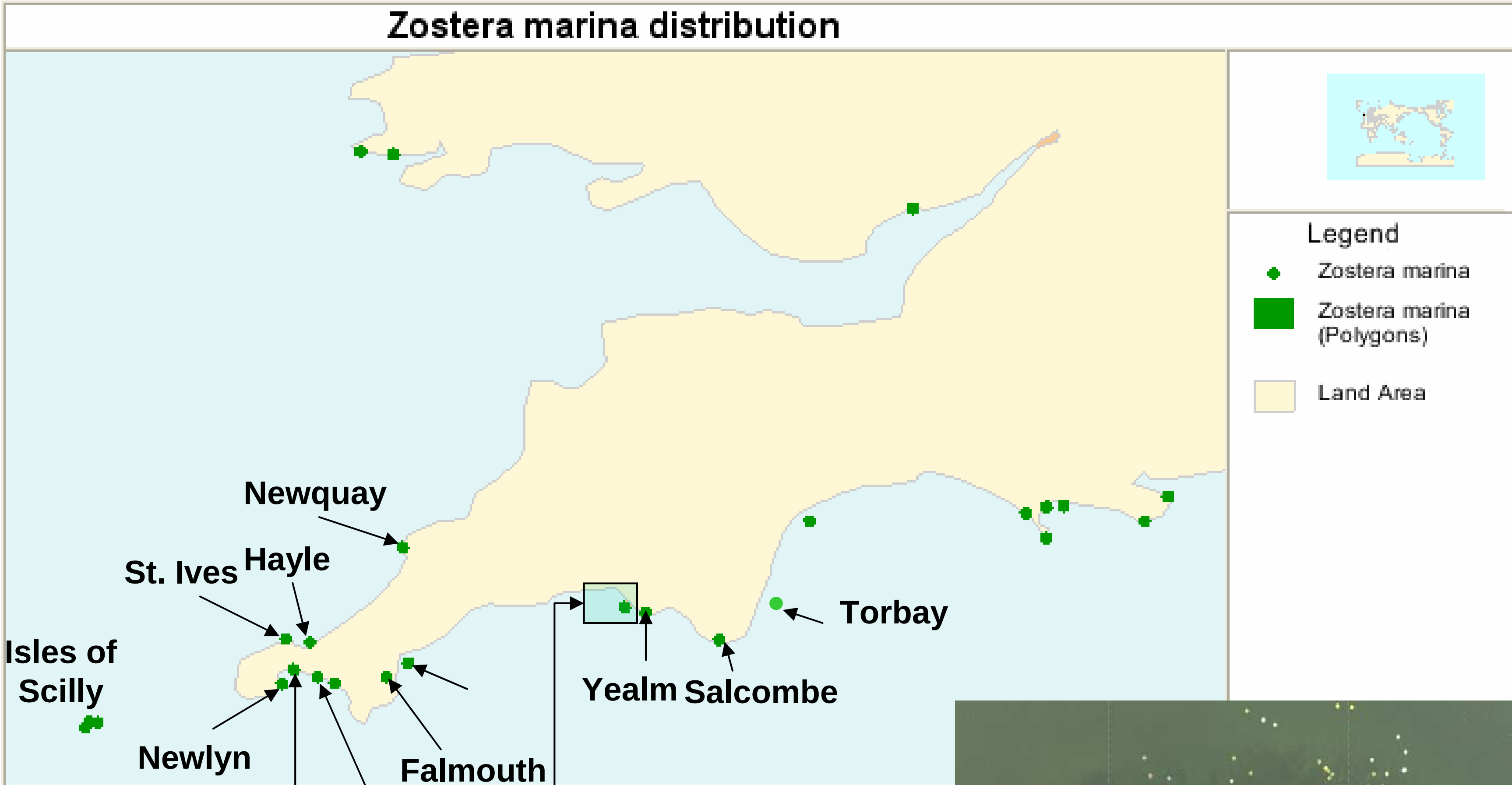
Support high biodiversity

Photos: Fiona Crouch, Dominic Flint; Illustrations by Jack Sewell


Seagrass currently bind sediment and protect beaches from erosion
Mill Bay beach, Salcombe


Zostera marina, eelgrass
• up to 2m in length, 10mm wide
• Inter-tidal and sub-tidal down to 10m
•Ridges on seeds


Zostera noltii, d
eelgrass
•Up to 0.25m lo
mm wide
•Inter-tidal (in le
regions may cr
the sub-tidal)
•Smooth seed
©



Penzance

Porthleven

Plymouth area: Drakes Island, Jennycliff, Firestone bay, Cawsand

Irving et al., 2006

Which factors regulate seagrass growth, distribution and function?

Photo: Mark Woombs

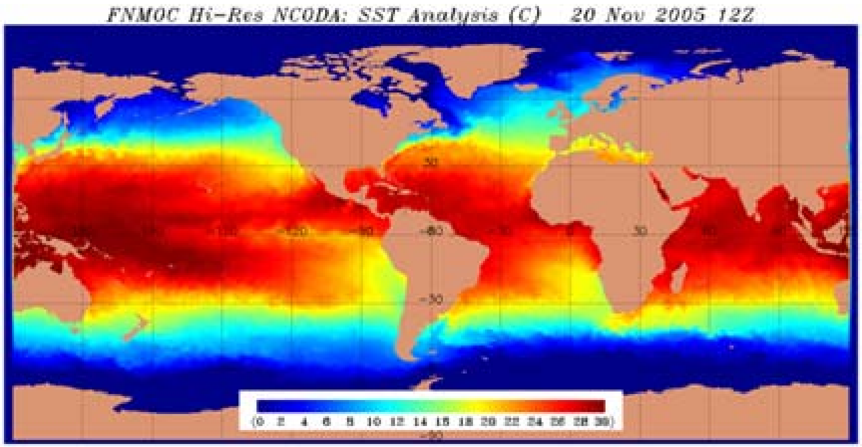
- Physical
  - Light
  - Hydrology
  - Geology
  - Temperature
- Chemical
  - Salinity
  - Oxygen
  - Nutrients
- Biological
  - Competition
  - Disease
  - Anthropogenic

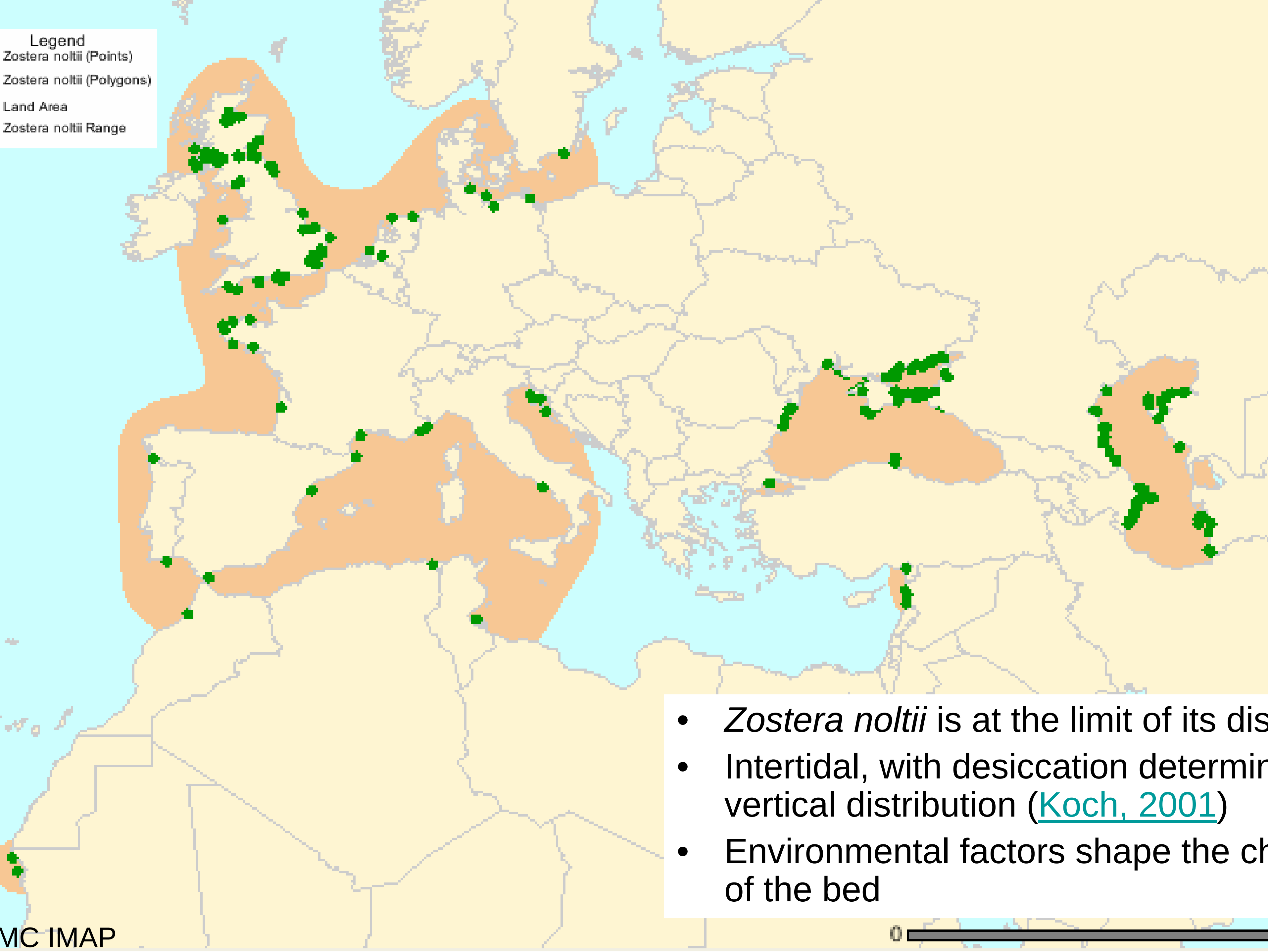
Climate change has the potential to influence each of these factors

Temperature changes?

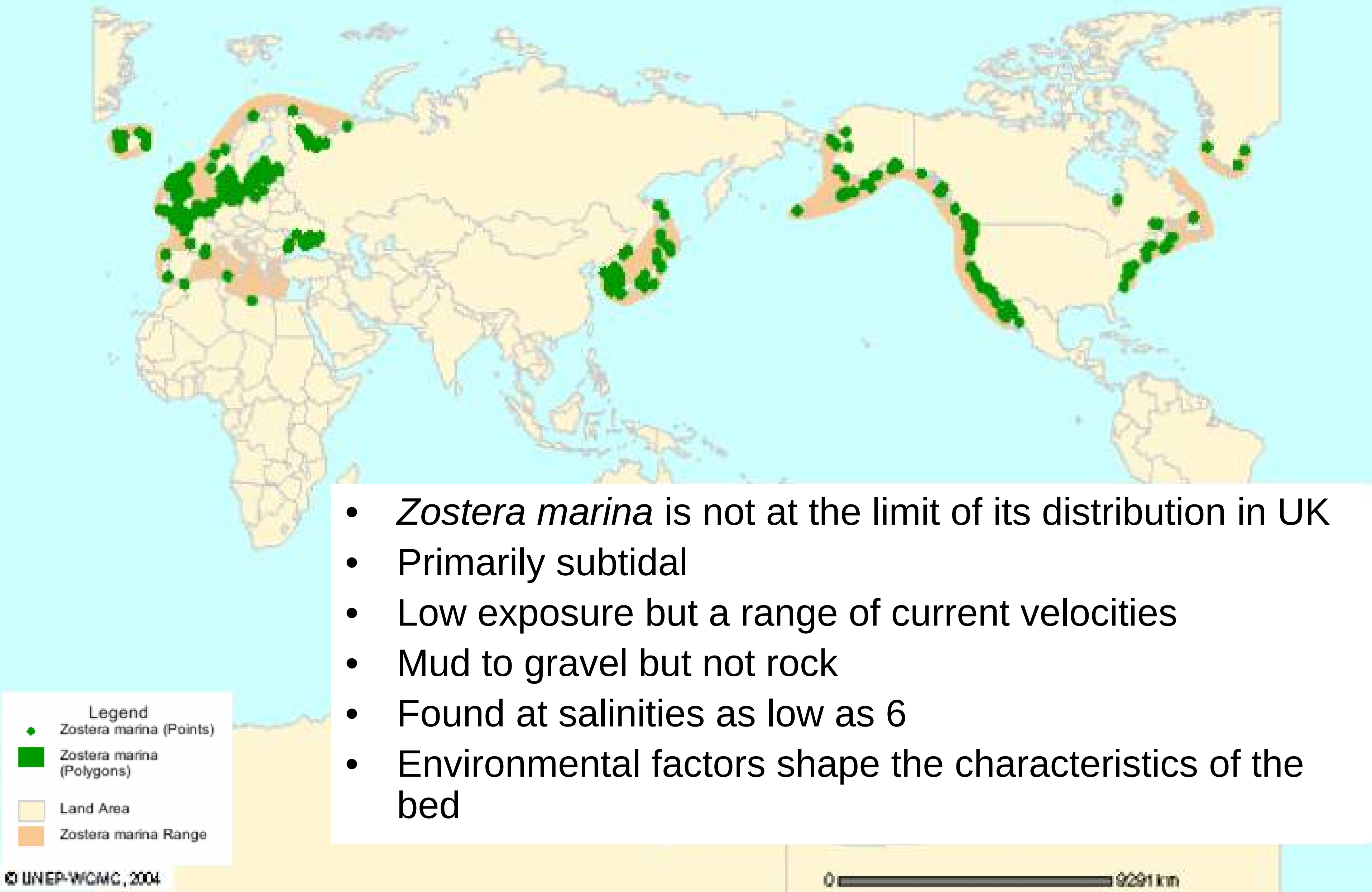
- Positive relationship with Photosynthesis and Respiration
- But at high temperatures R > P = -ve energy balance
- Seagrass species vary in their temperature tolerances
  - *Zostera noltii* upper temperature tolerance of 38ºC (Massa et al., 2009)
  - *Zostera marina* -1ºC to 25ºC

The temperature is therefore considered the overall parameter controlling the global geographical distribution of the seagrass species.





- *Zostera noltii* is at the limit of its dis
- Intertidal, with desiccation determin vertical distribution (Koch, 2001)
- Environmental factors shape the ch of the bed



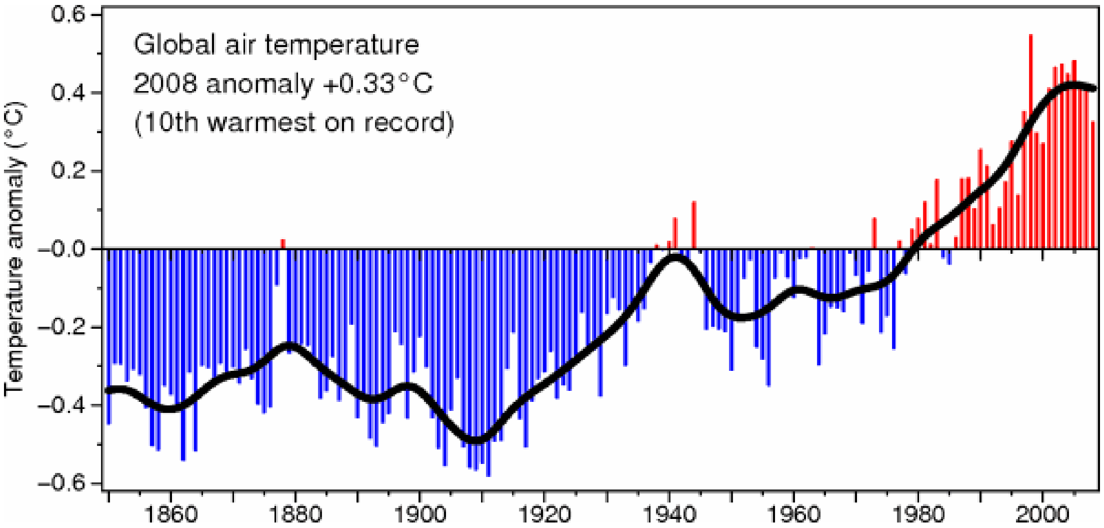
- *Zostera marina* is not at the limit of its distribution in UK
- Primarily subtidal
- Low exposure but a range of current velocities
- Mud to gravel but not rock
- Found at salinities as low as 6
- Environmental factors shape the characteristics of the bed

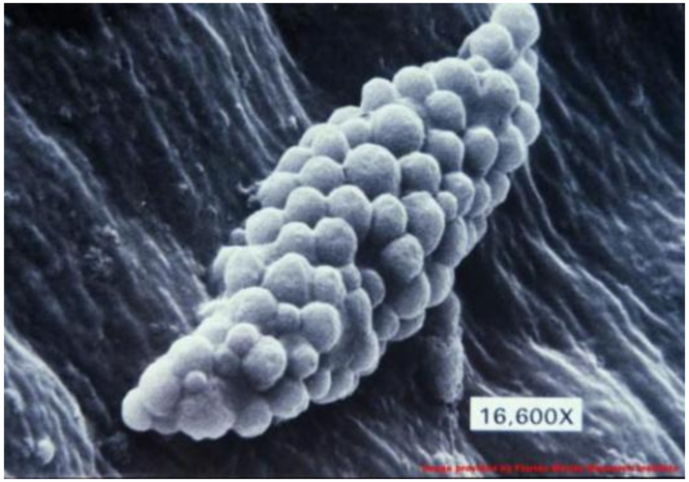
Increased temperature

- Increased seagrass metabolic processes
- New niche for invasive species colonisation
- Decrease production species at thermal tolerance
- Increased dessication for intertidal species
- Shift in distribution of species
- Enhance growth of competitive algae
- Increase metabolism of microbes

Zostera's Wasting Disease

- Slime mold protist *Labyrinthula macrocystis*
- 1930-40s- large scale (North Atlantic wide) outbreak (Temperature?)
- Some populations survived (primarily subtidal)
- Theory that today's populations more resilient





Labyrinthula: **Image from** **UNCW-Marine and Coastal Botany.**

Brohan et al., 2006: Uncertainty estimates in regional and global observed temperature changes: a new dataset from 1850. *J. Geophysical Research* 111, D12106, doi:10.1029/2005JD006548

Genetic diversity: key to resilience?

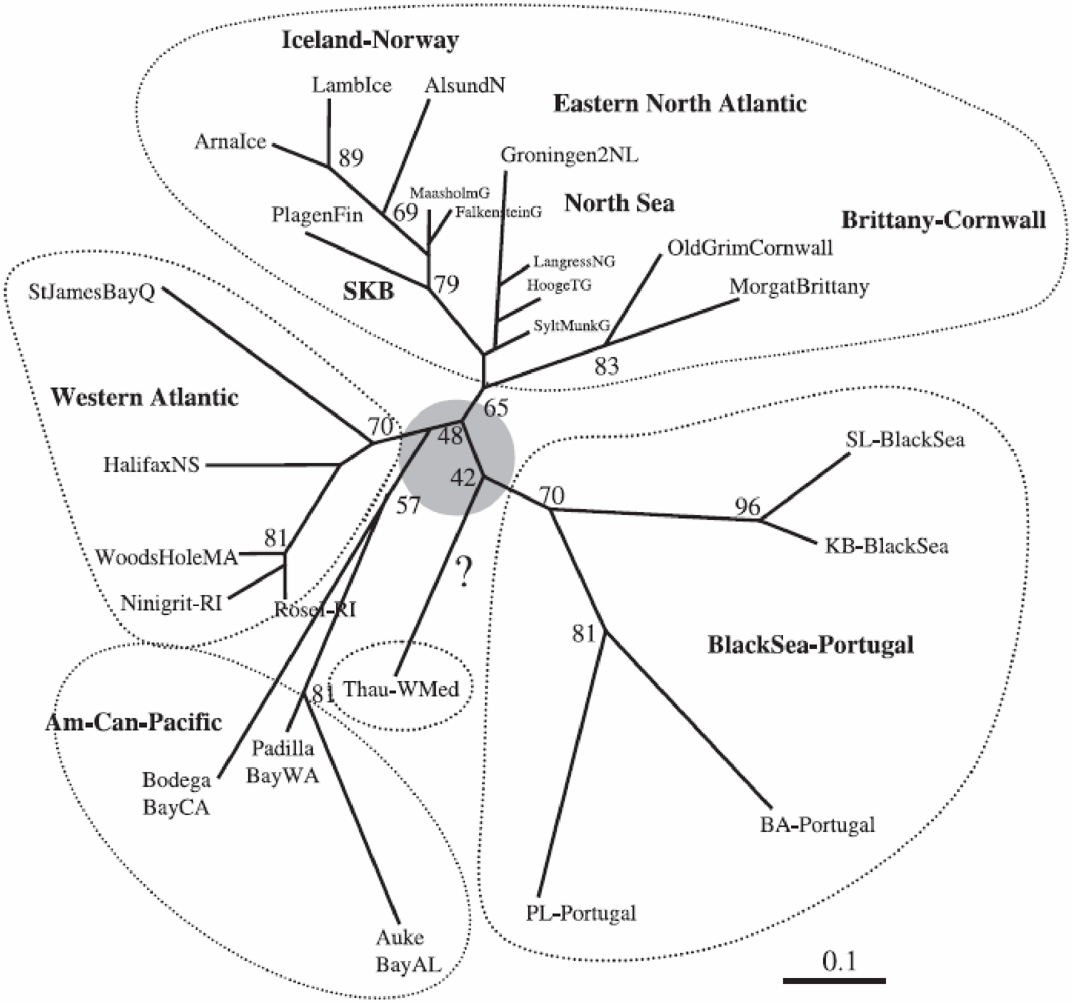
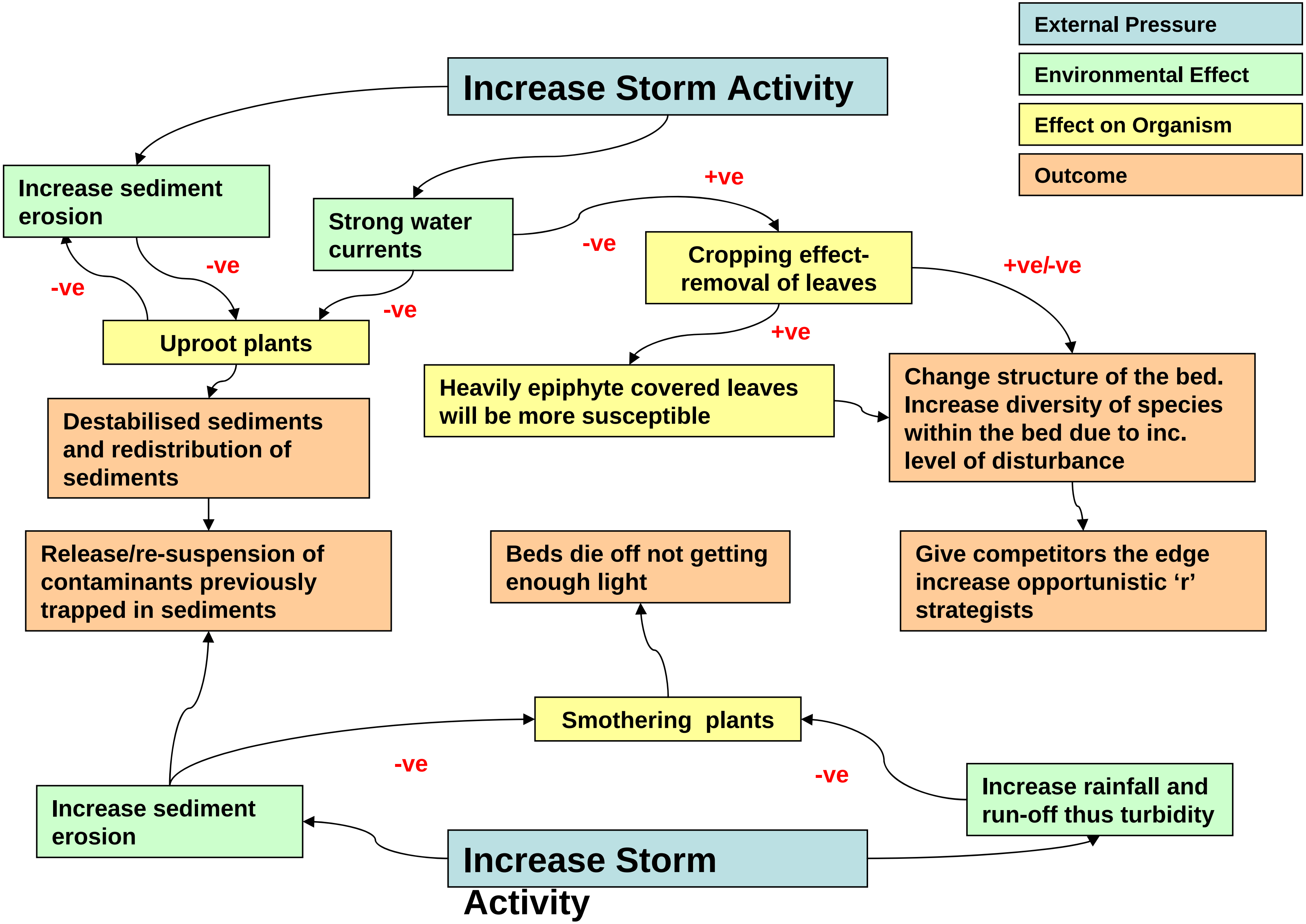


Fig. 4 Neighbour-joining tree based on Reynold's distances derived from the microsatellite data for *Zostera marina*. Source: Olsen et al., 2004

Physical exposure

- Currents, wave action and tide control the upper depth limit
- Flow velocities < 1.5 $m.s^{-1}$
- Affect light climate of the water column
- High exposure:
  - reduce vegetative spreading
  - inhibit seedling colonisation
  - decreased accumulation of fine sediments and organic matter

(Fonseca *et al.*, 1983)



Deposition of Physical Materials

Light

- Water column transmissivity and depth
- Controls the lower depth limit of seagrass

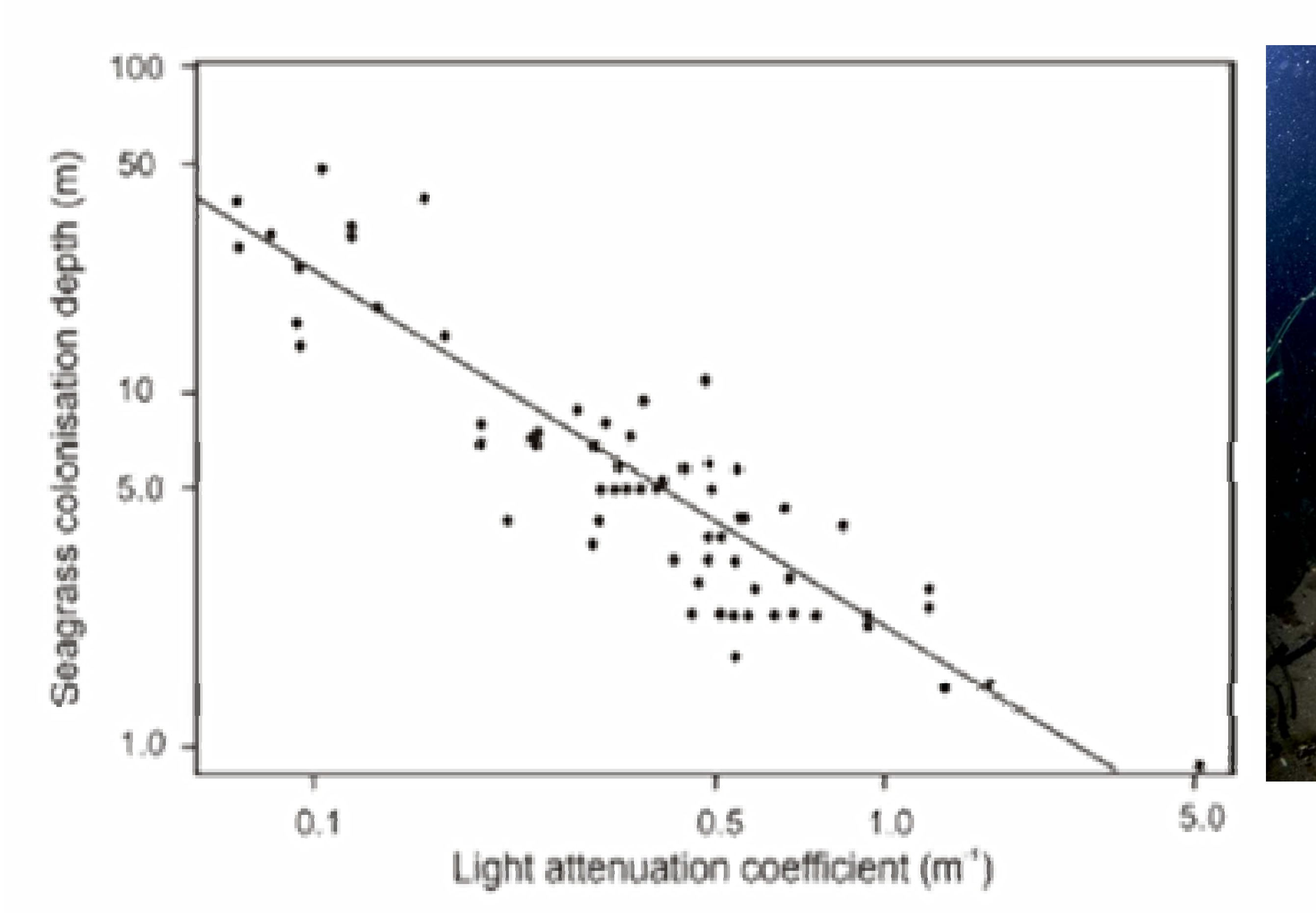
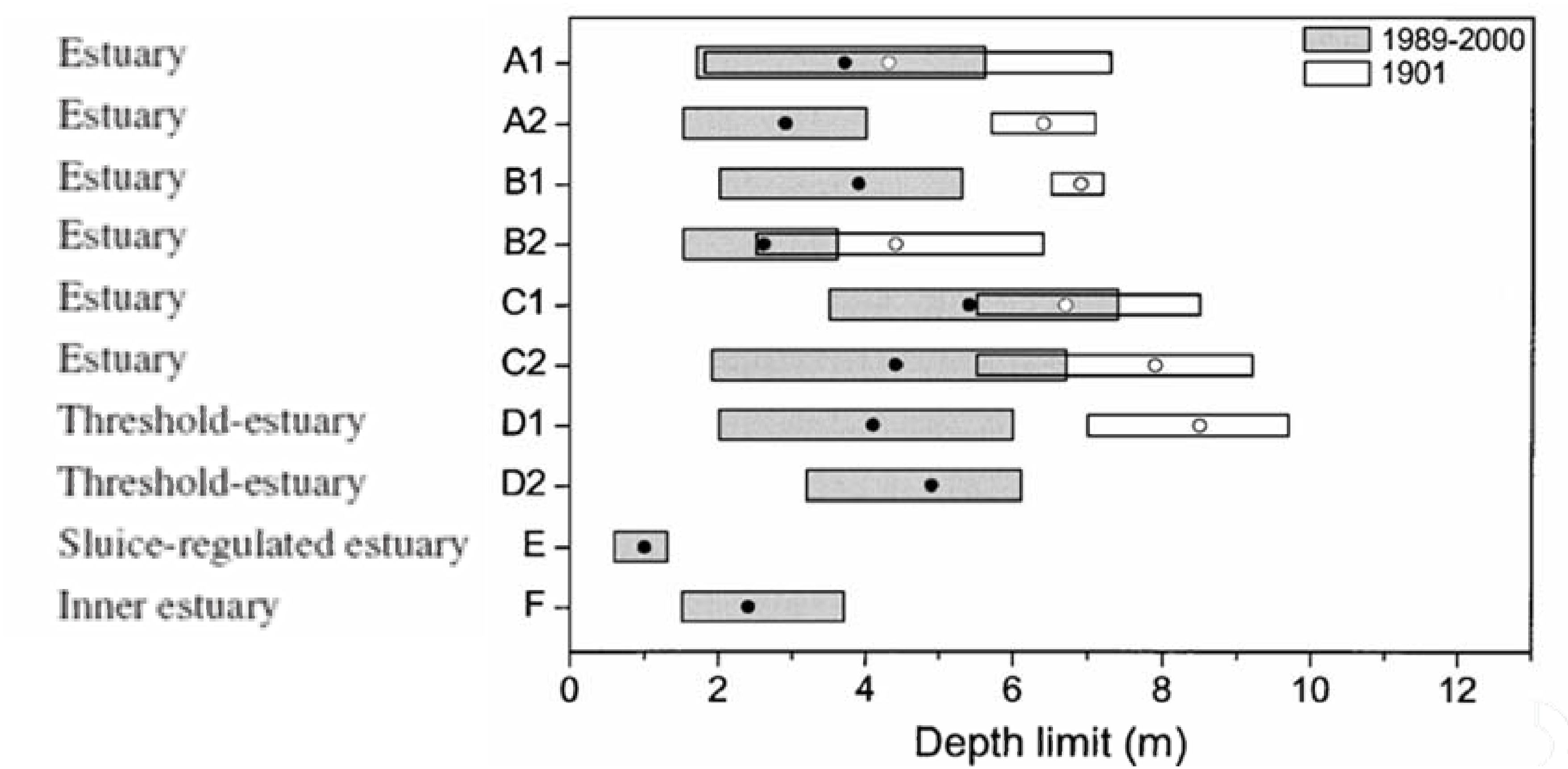


Photo: Steve Trewhella

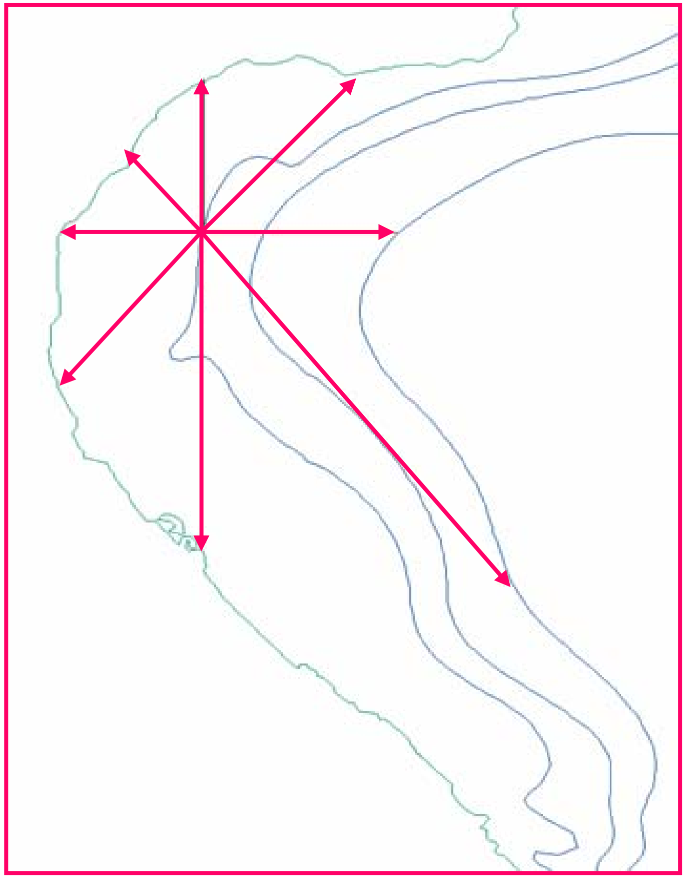
Use of *Zostera* depth limits as a bioindicator under the WFD



Krause-Jensen *et al.*, 2005

Relative exposure

$$\mathrm{REI} = \sum_{i=1}^{8} (V_i \times P_i \times F_i)$$



i is ith compass heading (eight readings, 45° increments), *V* is mean monthly maximum wind speed (ms-1) *P* is the percent frequency at which wind occurred from the ith direction and *F* is the effective fetch (m) to #m isobath.

Fonseca and Bell (1998)

CO_2: Ocean acidification

- IPCC (2001) predict increasing [CO_2]
- Increase of dissolved inorganic carbon and decrease in seawater pH of up to 0.5 units by 2100
- Increase in the HCO_{3-}/CO_2 ration in seawater
- Seagrasses can utilise HCO_{3-} will lead to increase in photosynthetic rate
- Alter compensation depth
- Impacts on epiphytic load but also on mollusc grazers with calcareous shells

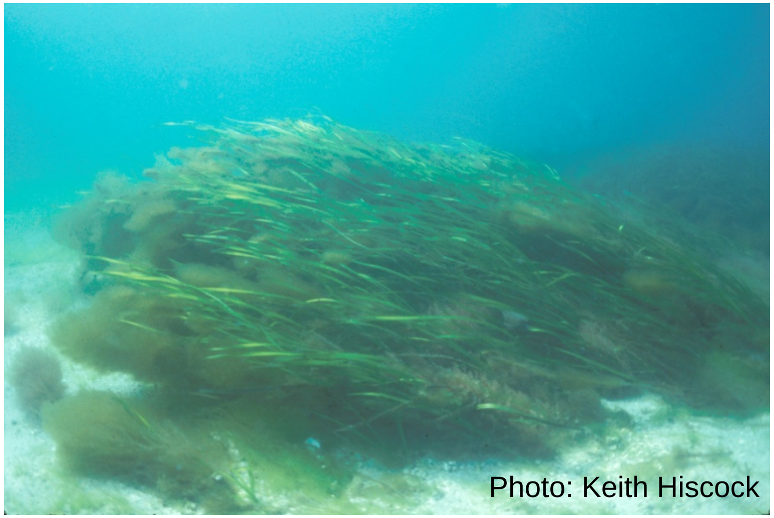


Photo: Keith Hiscock

Photo: **Chris Pickerell (check out his website for information on seagrass restoration: http://seagrassli.blogspot.com/)**

Invers et al., 2002 (Bull Mar Sci 71(3)

See also Hall-Spencer et al 2008: Vol 454| 3 July 2008| doi:10.1038/nature07051

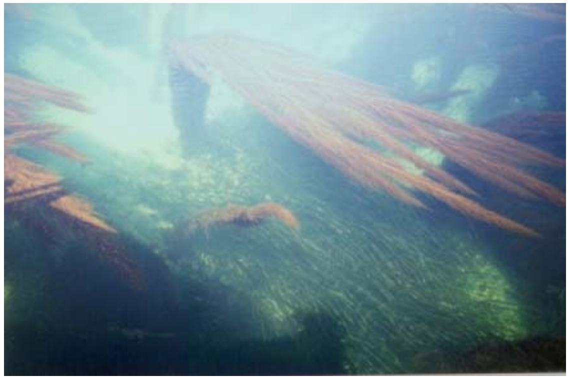
Ideas for delivering adaptation responses

- Resilience-building adaptation strategies:
  1. Protect diversity of seagrasses from gene to geographical distribution
  2. Protect seagrass from manageable vectors of change which may stress or remove populations of seagrass (particularly those important to point 1).
  3. Identify and fully protect seagrass communities that are at low risk of succumbing to climate change and anthropogenic impacts.
  4. Restore critical seagrass areas that are positioned to survive climate change impacts by eliminating manageable
  5. Raise awareness of the value and threats to seagrasses, ensure that coastal zone management or land use policies and plans address potential impacts to seagrasses and implement codes of conduct for fishing and boat anchoring to reduce disturbances.

Important text: Bjork et al., 2008
IUCN Resilience Science Group
Working Paper Series - No 3

Non climate related pressures

- Nutrient enrichment
- Invasive species
- Mooring and anchor damage
- Increases in turbidity



Adaptive management

- Develop good baseline maps (Plymouth Sound, Salcombe, Torbay, Isles of Scilly etc.)
- Implement monitoring that provide feedback on the results of coastal management, (SeagrassNet; Isles of Scilly monitoring programme) not just for reporting cycles.
- Monitor the right things at the right time (pressures and state)
- One of the most direct early warnings for declining seagrass meadows is a decrease in growth and productivity (measure PSS)
- Accept uncertainty and set appropriate operational targets and review periods

Practical steps and research needs

- Based on climate change predictions, model impacts on seagrass beds spatially to identify risk levels
- Assess genetic diversity of UK seagrass beds
- Research into the ecosystem effects of climate change on UK seagrass beds
- Support UK SeagrassNet stations (the Fal and Helford is home to the first UK site in this global monitoring network!)

http://www.seagrassnet.org/

http://zosteramarina.blogspot.com/