Predicting the regional impacts of ocean acidification: Integrating sediment biodiversity and ecosystem function

Finlay Scott, Ruth Parker and
Silvana N. R. Birchenough

UK Ocean Acidification
Research Programme

Cefas

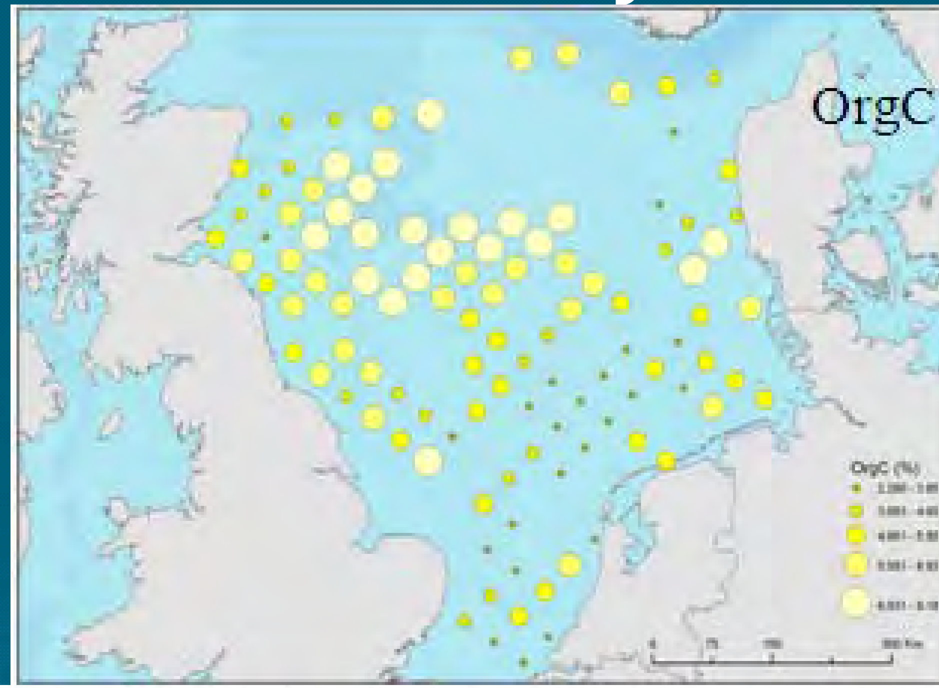
Introduction

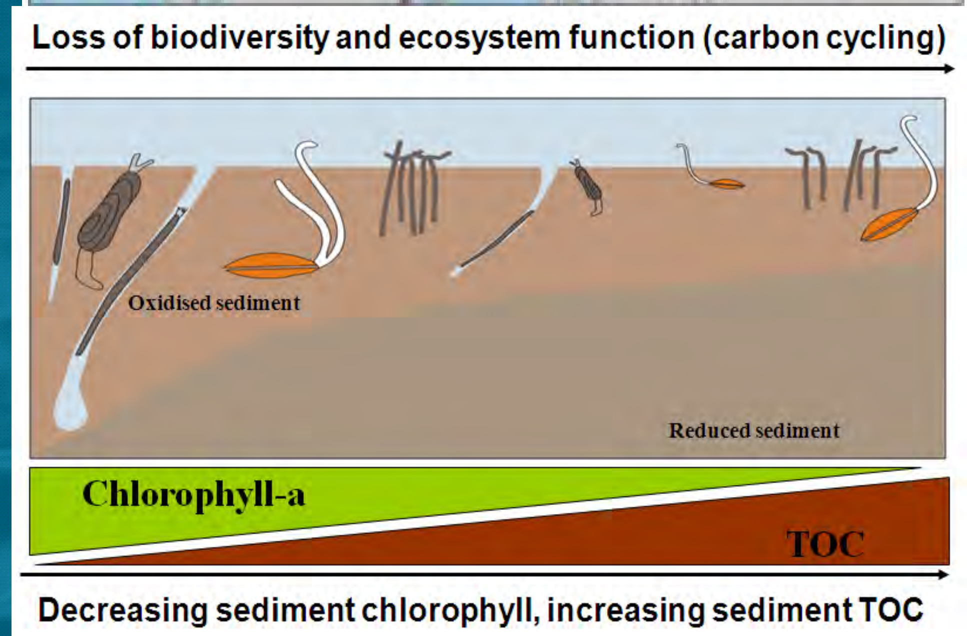
- Understanding the potential impact of ocean acidification is necessary to support development of informed marine environmental policy
- Anticipated that OA will affect life history characteristics of individuals
- *Question: How to scale up impacts on individuals to impacts at community level?*
- Sensitivity to OA and functional importance of species
- Spatial heterogeneity – local stressors on local communities
- Focus on sediment biodiversity in the North Sea (Europe)
- Combine data with simulations to link spatial OA impacts on individual species and ecosystem function

Cefas

Data – North Sea Benthos Survey 1986

- North Sea – Europe
  - 575,000 km^2
  - Shallow ~40m
- 109 stations
- Benthic macrofaunal species abundance and biomass
- Species richness: 557 (13 to 106 at each station)
- Measures of Chl-a and TOC
- Indicators of bioturbation- controls the rate of organic matter decomposition





Linking individuals to community

Each species

Abundance
Indiv. Biomass
Reworking
Mobility

At each station

Individual: $BPi = \log_{10}(Bi) \cdot Mi \cdot Ri$
Population: $BPp = BPi \cdot Ai$
Community: $BPC = \sum BPp$

$BPC = \sum \log_{10}(Bi) \cdot Mi \cdot Ri \cdot Ai$

Impact of Stressor

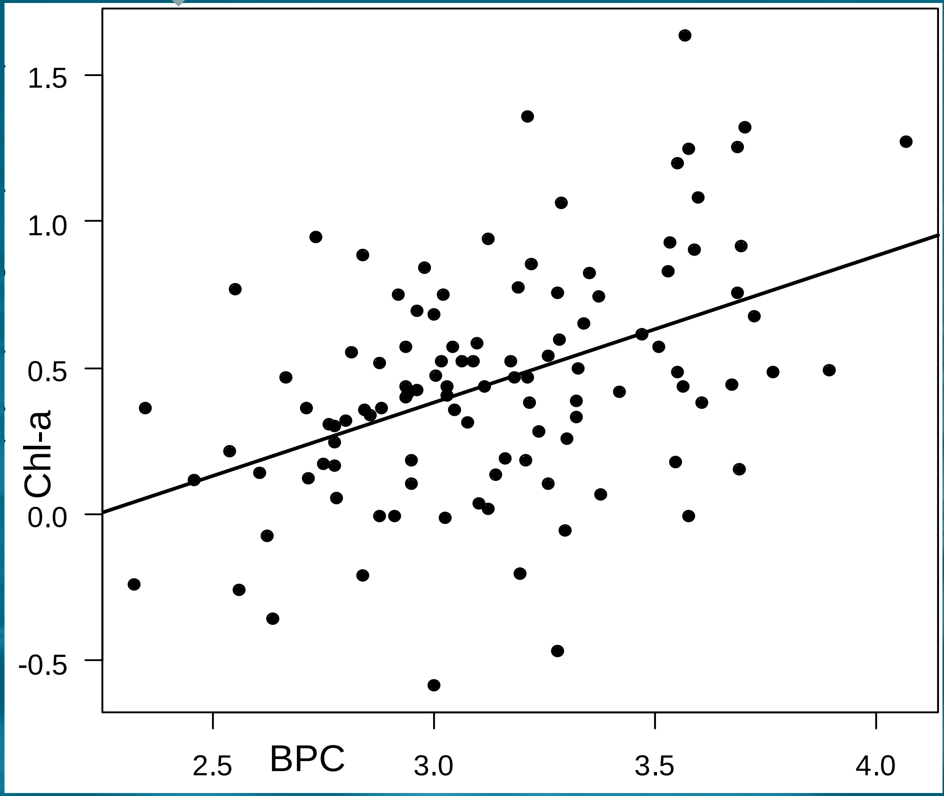
Change *individuals* (Ai, Bi, Ri, Mi).
Recalculate BPC at *community* level

Reworking

1 = epifauna
2 = surficial modifiers
3 = head–down / head-up feeders
4 = biodiffusers
5 = regenerators

Mobility

1 = in a fixed tube
2 = limited movement, sessile, not in tube
3 = slow movement through sediment
4 = free movement via burrow system

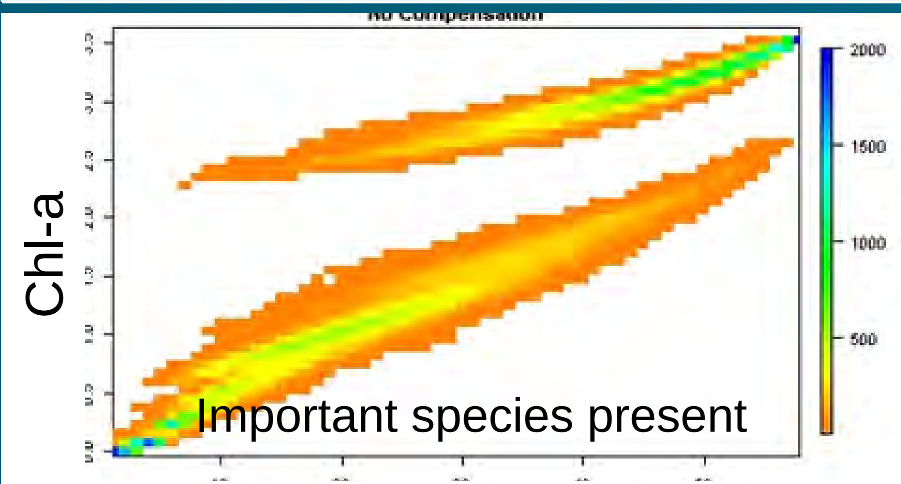


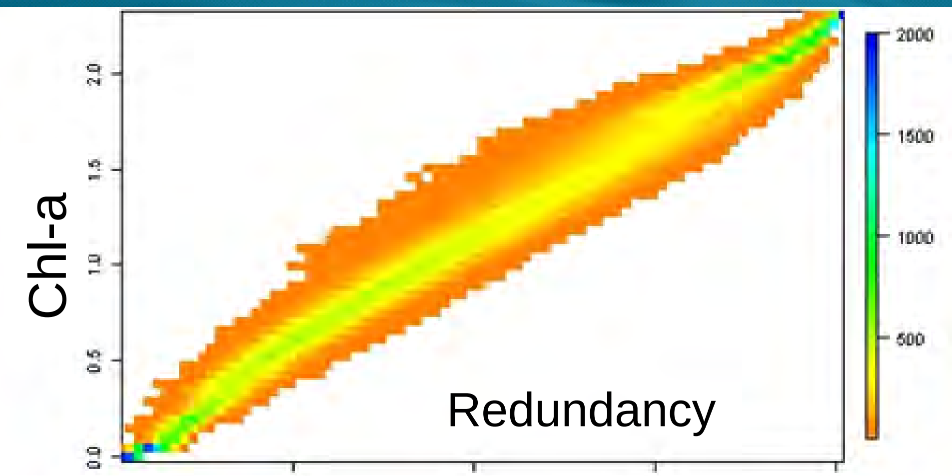
Adapted from Solan et al (2004)

Functional importance

Species	No. stations >30% to BPc	No. stations present (/ 109)
Amphiura filiformis	28	79
Chamelea gallina	8	49
Echinocardium cordatum	4	61
Luniatia poliana	3	66
Mysella bidentata	3	73
Nephtys cirrosa	2	33
Ophelia borealis	1	54
Ophiura albida	1	61
Protodorvillea kefersteini	1	6

- Functional importance: *Proportional contribution to BPC*
- Spatial variation: functional redundancy vs dominance of ‘functionally important’ species
- Just because a species is functionally important does not mean it is sensitive to OA
- What about sensitivity to OA?





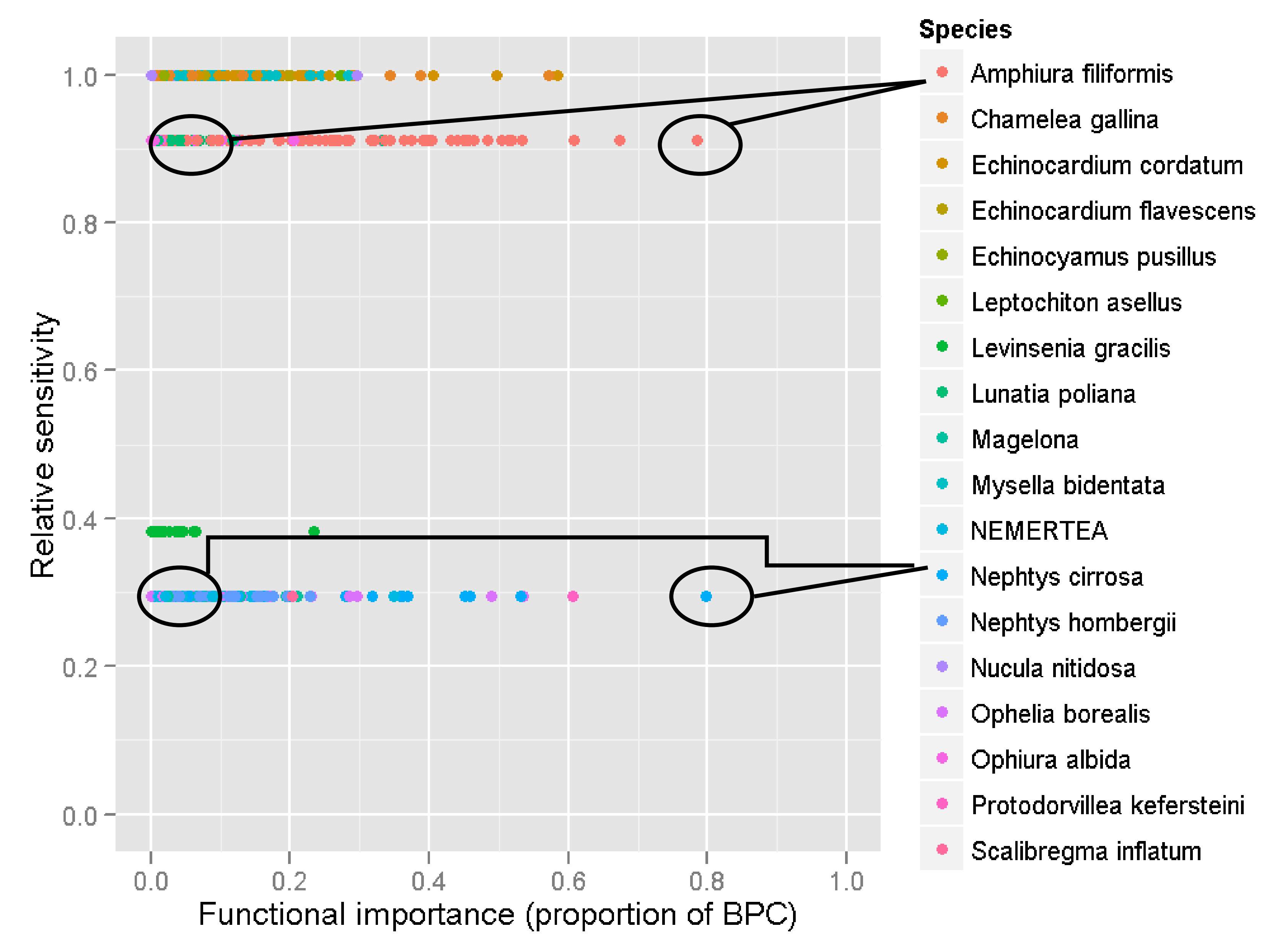
Number of species left

Species Sensitivity to OA

- How likely will species be affected by OA?
- 557 species:
  - Lab experiments – limited range of species
- **Biological Traits Analysis** to estimate *relative sensitivity* to OA
- Determine Traits and Modalities (work in progress!)
- Set sensitivity o
- Score each spe
- Combine score of each species
- Higher the rela impact species
- Same sensitivit

Trait	Calcerou								Living habit		
Modality	TRUE	FA							Low	Med.	High
Sensitivity	10								3	6	9
Amph. fil.	1								0	1	0
Nephtys cirrosa	0								1	0	0

Sensitivity vs Importance



fas

Scaling up the impacts

Model: BPC = $\sum \log_{10}(Bi) . Mi . Ri . Ai$

Experimental evidence: R and / or M change under OA

OA affects some species more than others.

Given exposure to OA, probability that R and / or M changes given by *Relative Sensitivity* (BTA).

Direction of change unknown: 50% +- 1

Stochastic simulations

<u>Each iteration:</u>

For each species determine:

- Do R / M change?
- Which directions (+- 1)?

Recalc. BPC

1000 iterations

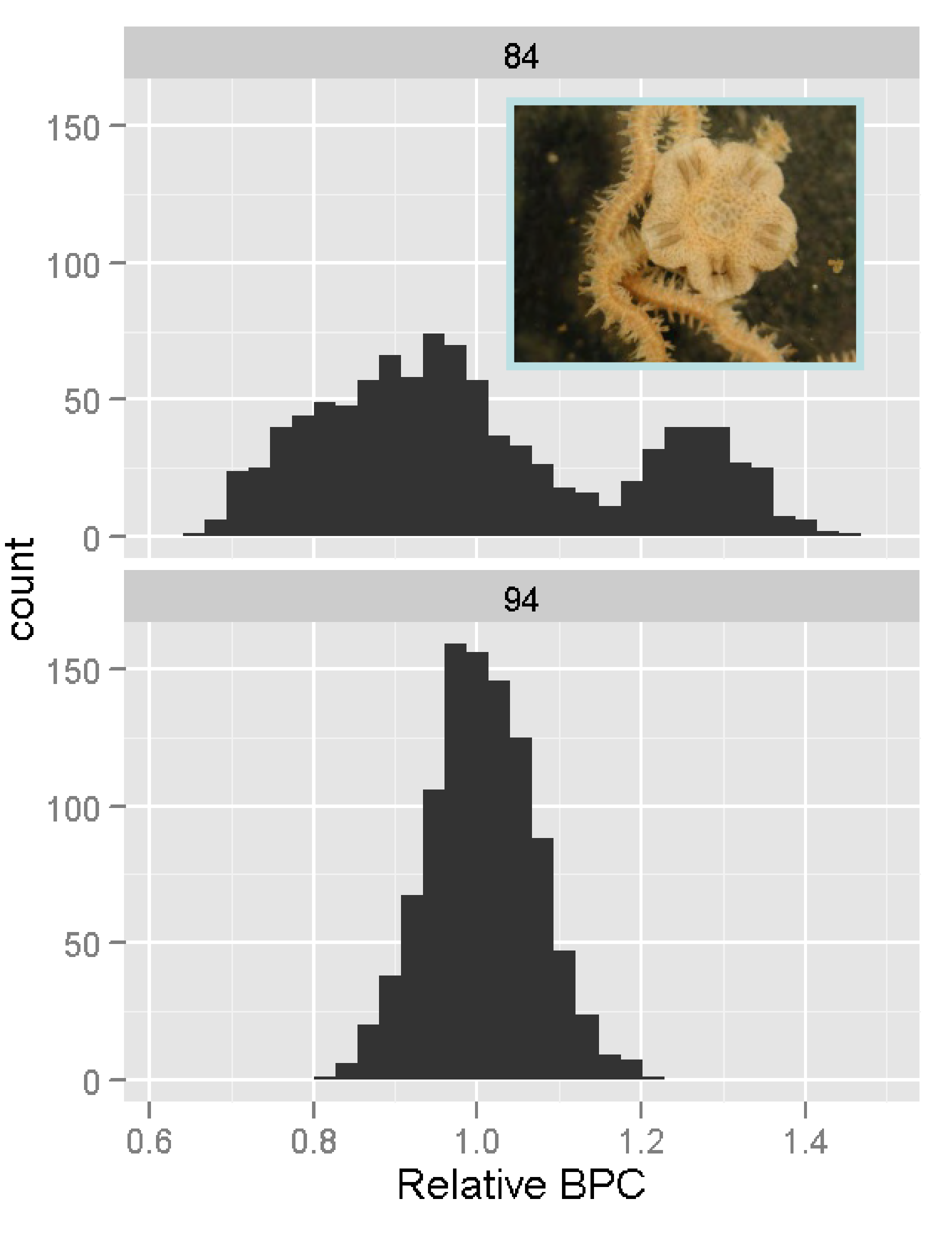
Preliminary method and results

Need sensitivity of all species

Future scenario - scale probability of change to reflect magnitude of OA

Cefas

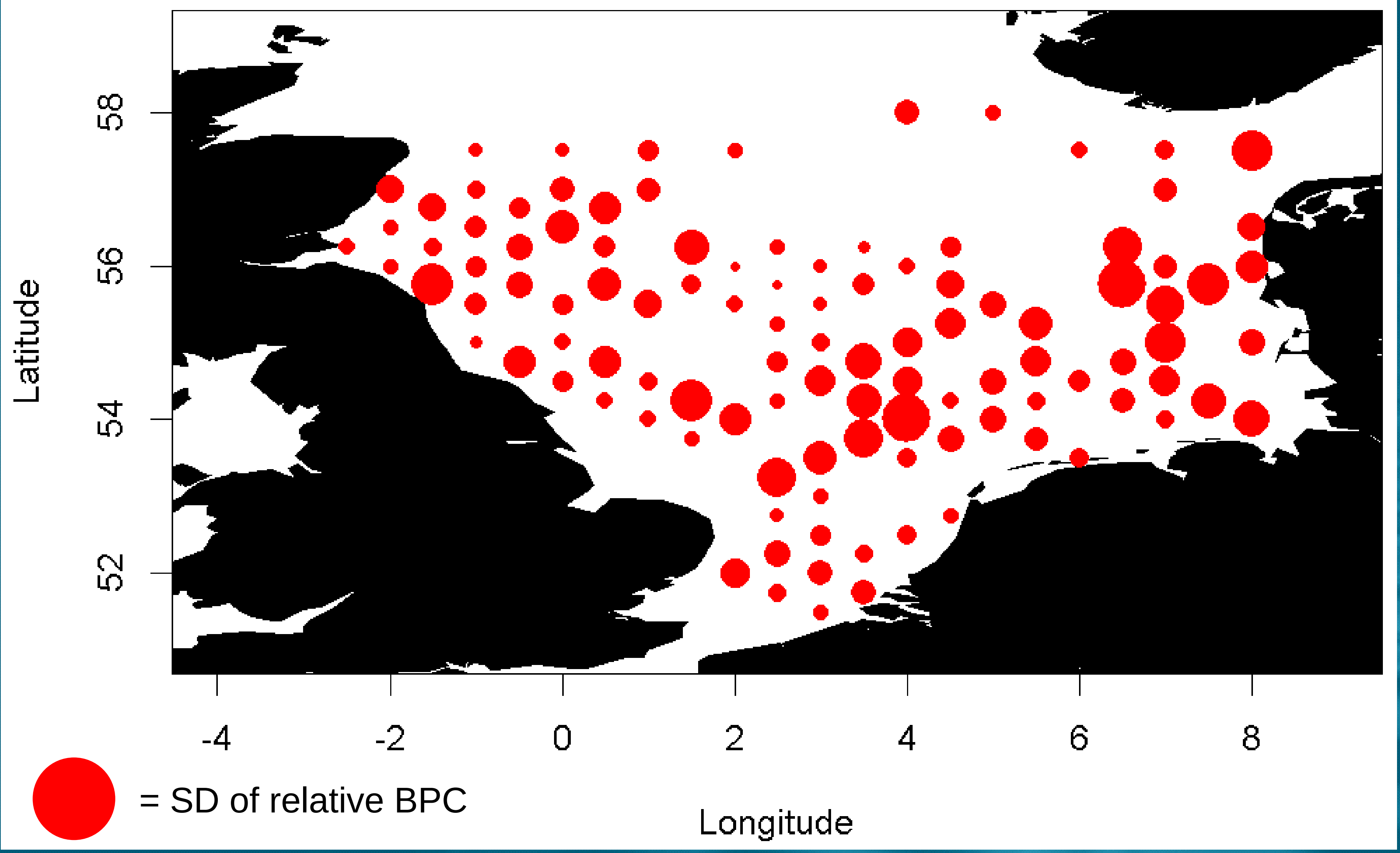
Example results



- Range of values is indicator of impact of OA on community
- Shape indicates presence of important species
- Impact of OA given by combination of sensitivity and importance of species

Cefas

Explore Spatial Impacts



Conclusions and future work

- Results are preliminary!
- Outline method for scaling up impacts on species to impacts on communities at a spatial scale
- Limitations:
  - Model is explanatory i.e. no ecological or temporal dynamics
  - Ignore changes to A and B
- But… first steps
- Future
  - Put all species into BTA
  - Need to scale probability of change to reflect magnitude of stressor – future scenarios
  - More life history characteristics
  - Include other ecosystem functions - not just bioturbation (OrgC and Chla)

Cefas

Acknowledgements

- NERC / Defra / Decc
- UKOA Project symposium
- Julie Bremner (Cefas)

UK Ocean Acidification Research Programme

Cefas


Thank you