



Housing crisis: Climate change-induced habitat loss impacts on tropical and temperate fishes

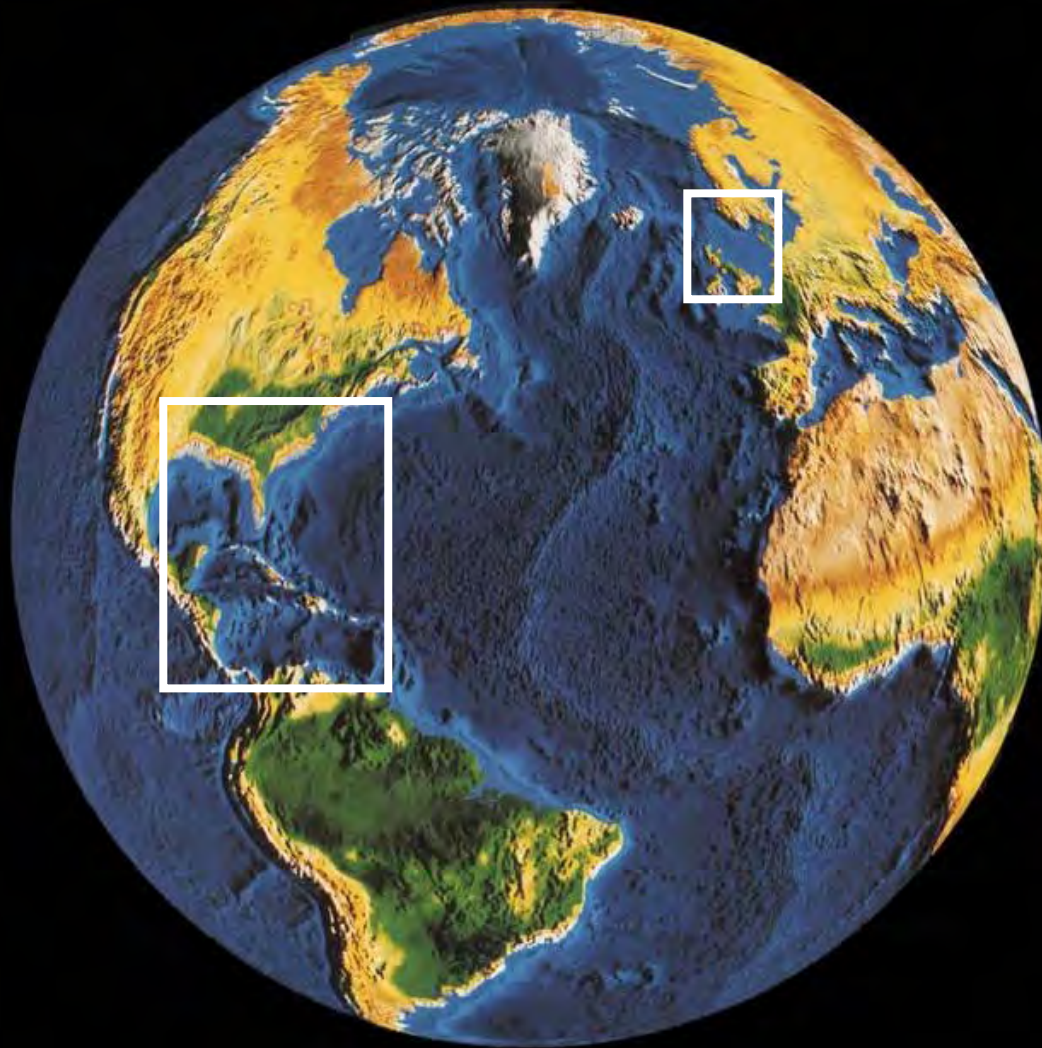
Nicholas K. Dulvy (an a large cast of important people)

Canada Research Chair in Marine Biodiversity and Conservation
Co-Chair of IUCN Shark Specialist Group

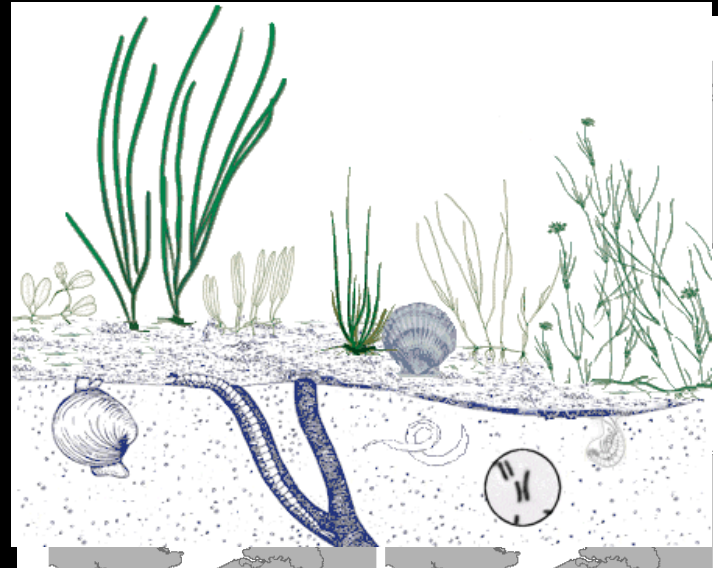
Earth to Ocean Research Group, Simon Fraser University, Vancouver,
Canada

dulvy@sfu.ca

Two contrasting case studies



With the common theme of habitat loss



Habitat complexity in coral reefs: patterns of degradation and consequences for biodiversity



Lorenzo Alvarez-Filip

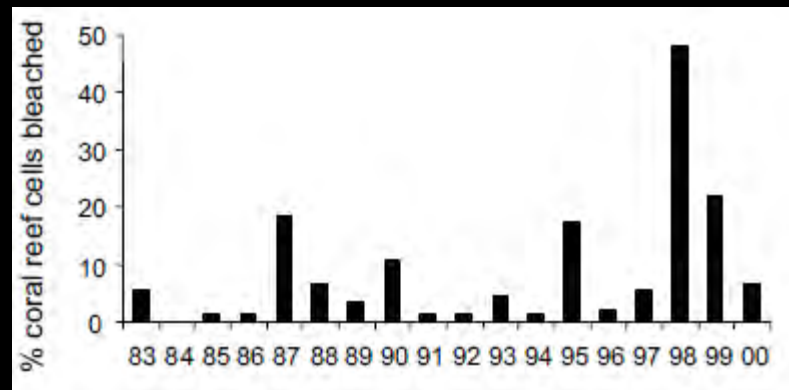
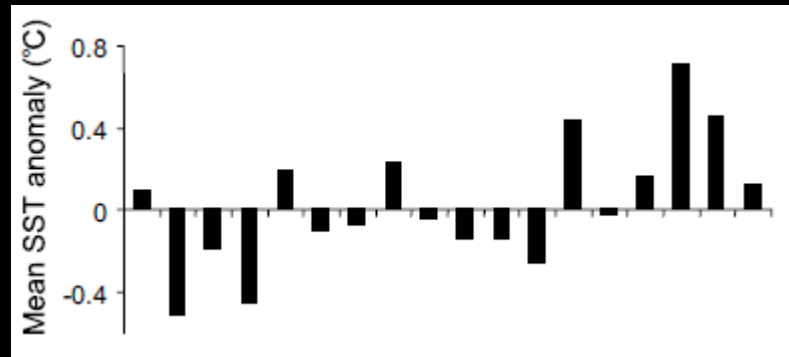


Andrew Watkinson

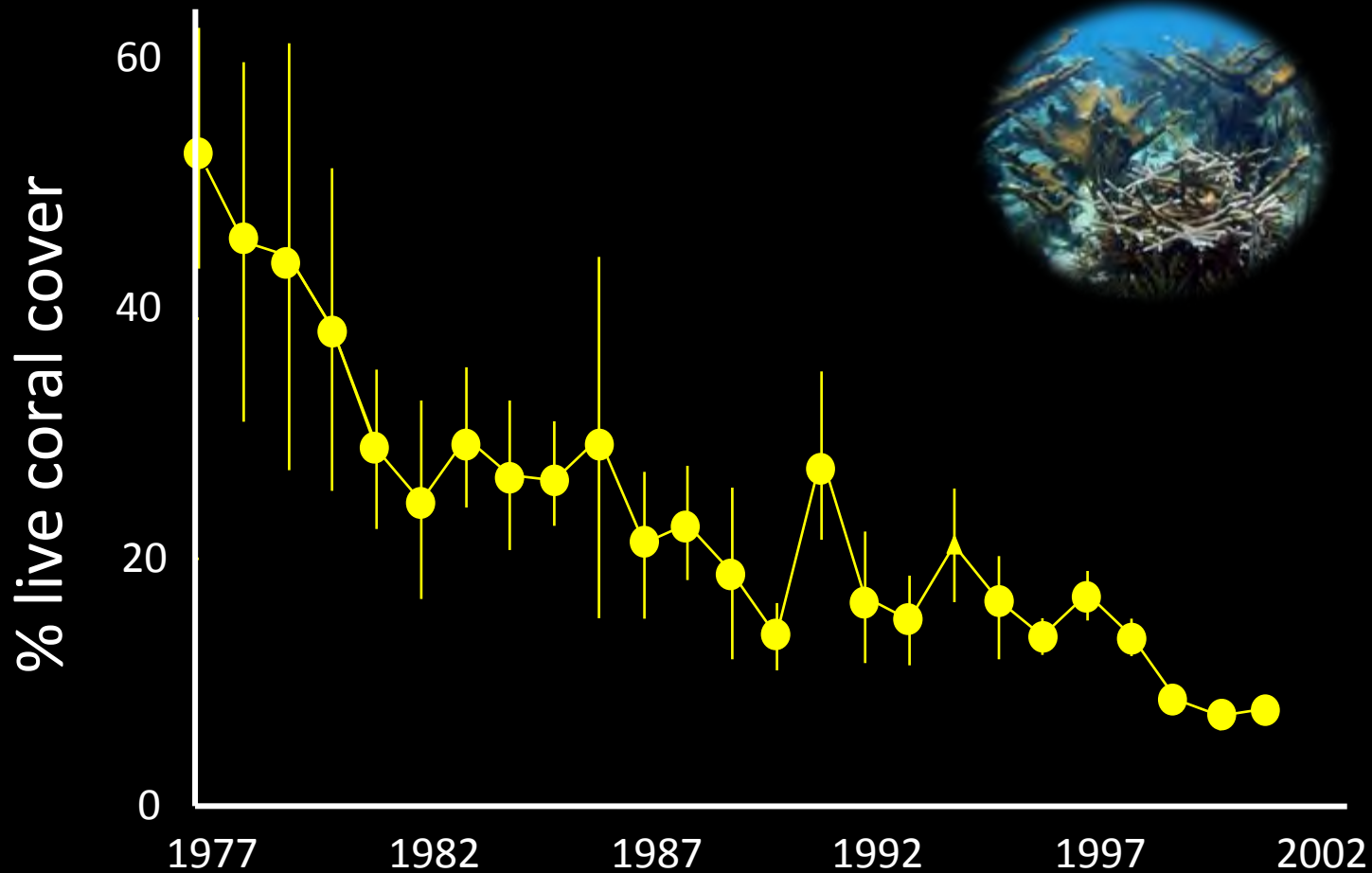
Jenny Gill



Caribbean temperature rise and bleaching



Caribbean coral cover has declined rapidly



Key questions

What is happening to the complexity of Caribbean reefs?

What is the link between coral cover, complexity and fish community structure?

Has there been a change in fish trajectories over time?

Measuring rugosity



1 = flat

3 = very complex

Data collated

Search for average rugosity by reef in:

Published papers

Monitoring programs

Personal communications

FISH DIVERSITY ON A CORAL REEF IN THE VIRGIN ISLANDS

by Michael J. Risk¹

Marine Biology 49, 317-323 (1978)

MARINE BIOLOGY
© by Springer-Verlag 1978

Analysis of the Influence of Substrate Variables on Coral Reef Fish Communities

R.E. Lasker and E. Lasker

Coral Reefs (1984) 1:69-76

Coral Reefs
© Springer-Verlag 1984

Scleractinian Coral Recruitment Patterns at Salt River Submarine Canyon, St. Croix, U.S. Virgin Islands

Caroline S. Rogers*, H. Carl Fitz III**, Marcia Glasick, James Boats and John Hardin

2. Data with temporal replication (effects of coral loss)



• 274 records

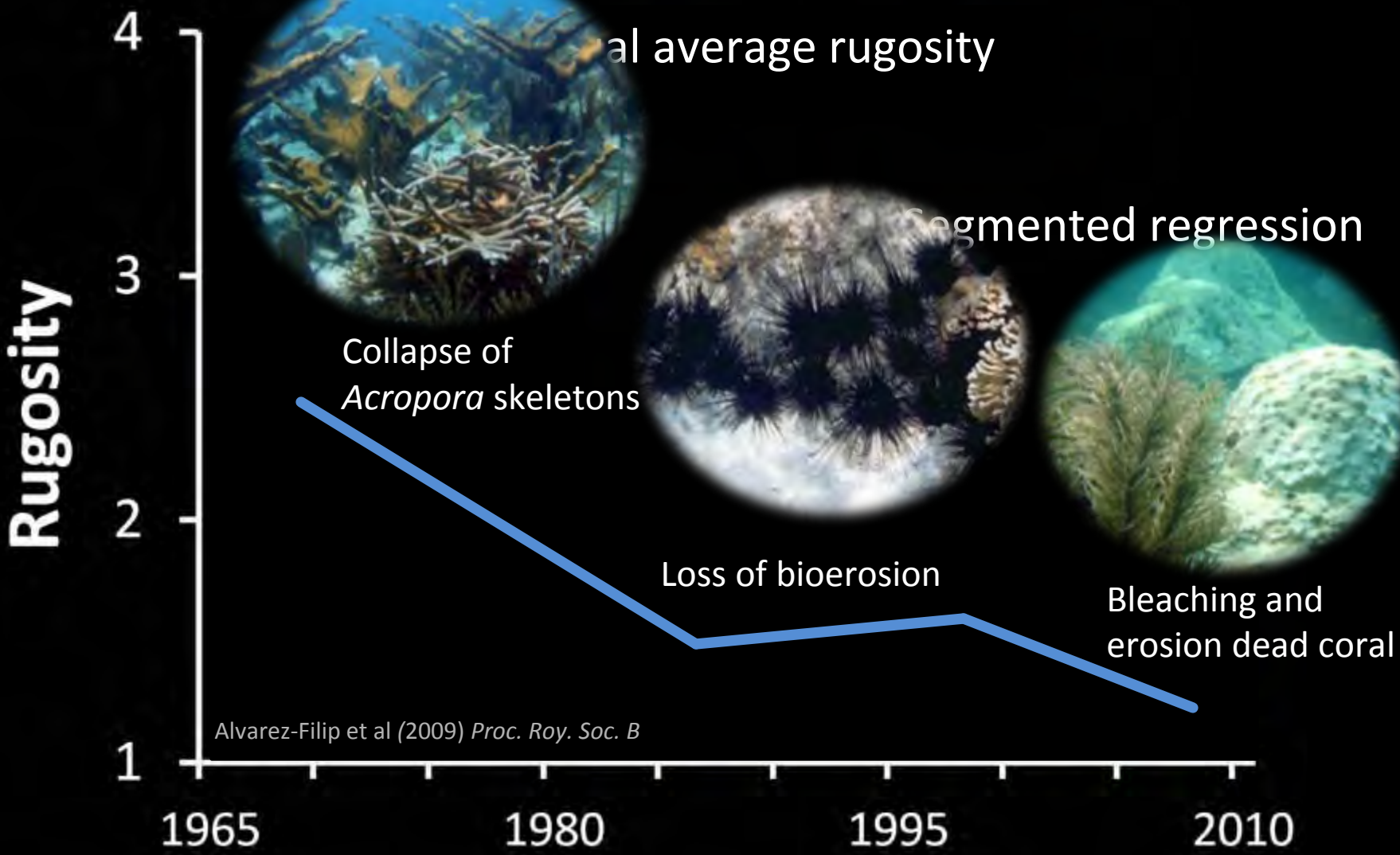
• 24 studies

• 300 reef sites

• 16 countries

• 1978 to 2008

Architectural complexity has declined in the Caribbean



Alvarez-Filip et al (2009) Proc. Roy. Soc. B

How are the fish doing in the face of
Climate change induced region-wide
habitat loss?



What is the link between reef complexity and fishes

-15 reefs (data aggregated)

-93 fish species

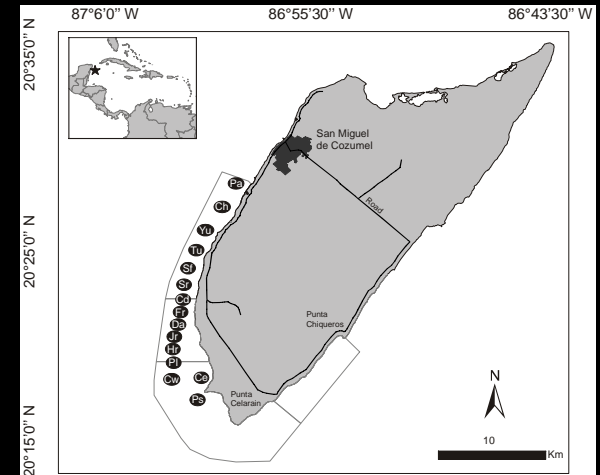
-Number of spp

-Number of individuals

-Biomass

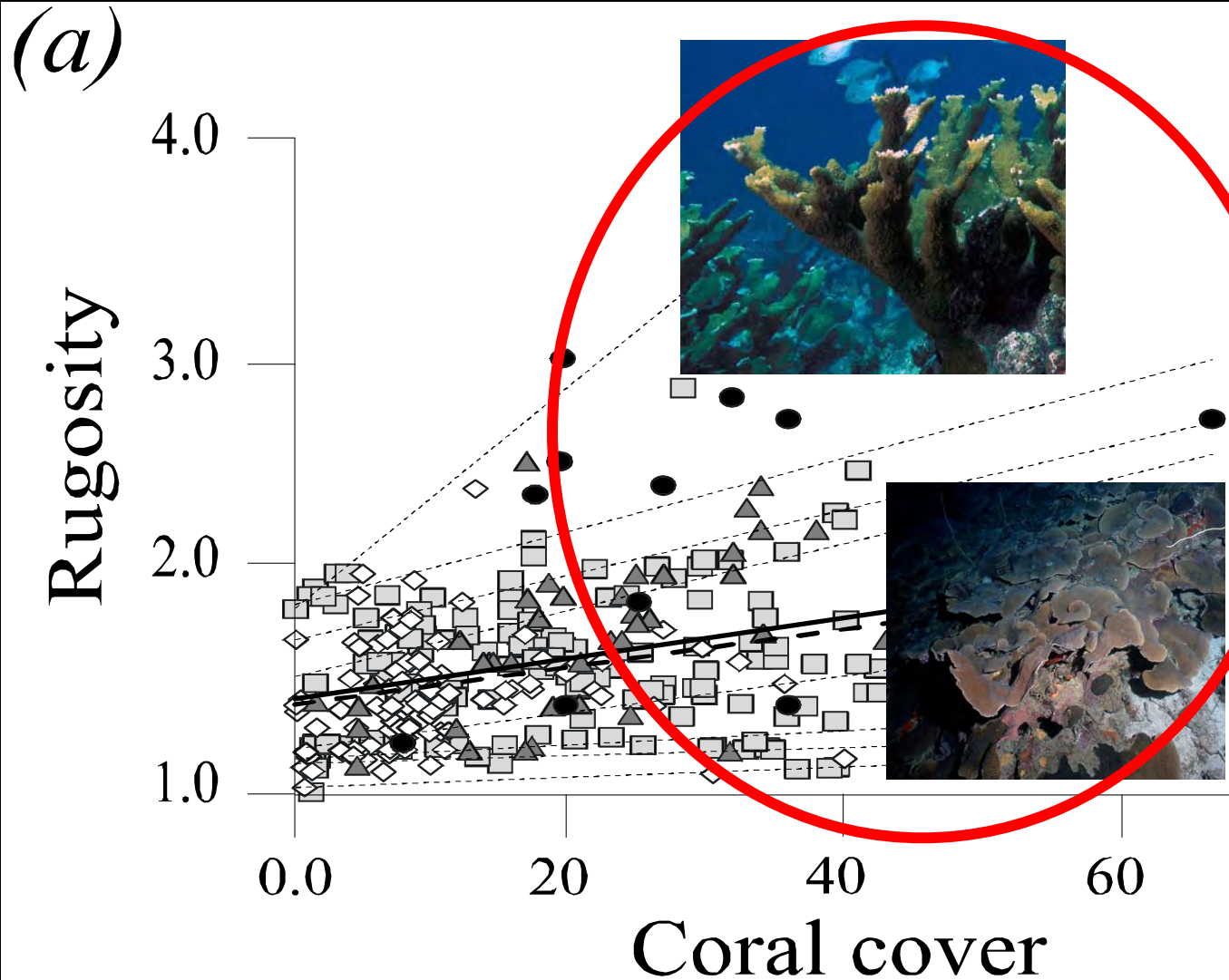
-Trophic level

-Size structure(slope & intercept) = useful indicator for fish assemblages as many life history characteristics size in marine fishes and it can be a useful proxy of overall productivity of fish assemblages



Hierarchical partitioning were used to identify the effect of **different habitat variables on fish assemblages** (calculates goodness of fit using all combinations of independent variables in the model)

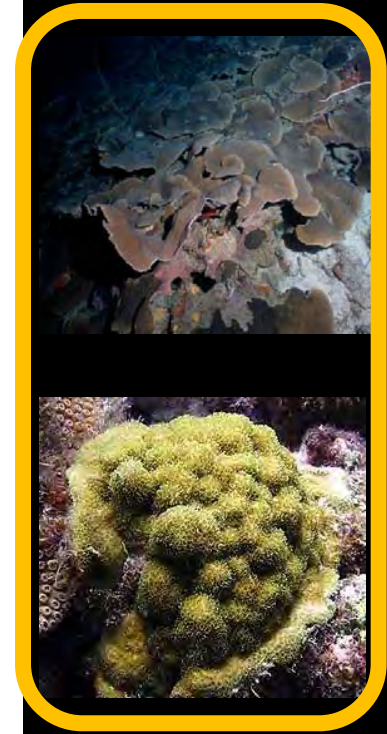
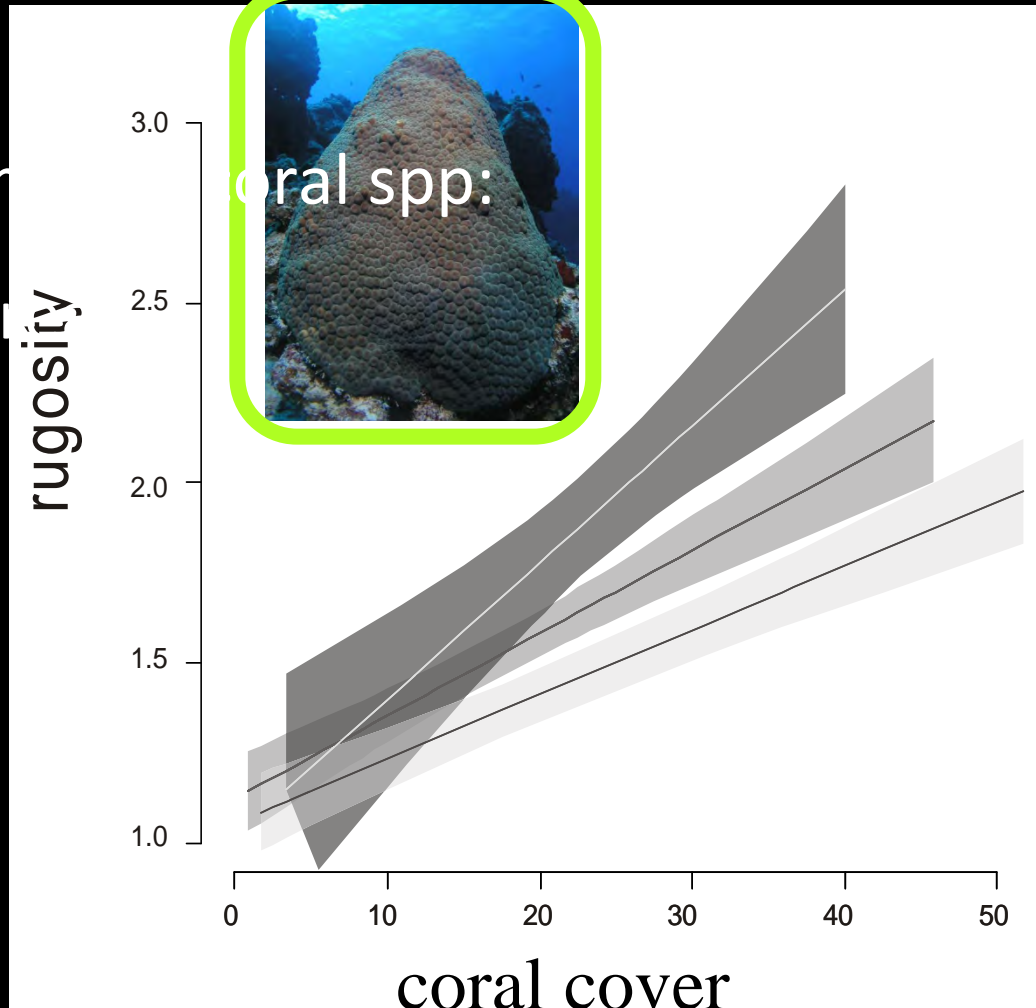
Coral cover – complexity relationship is complex!



The 'identity' of dominant coral affects the coral-rugosity relationship

Major reef-building coral

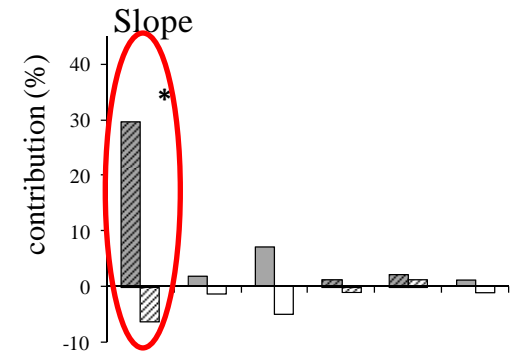
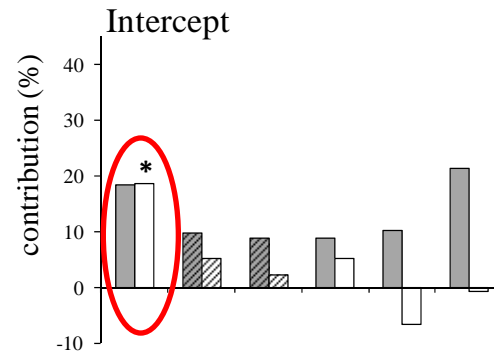
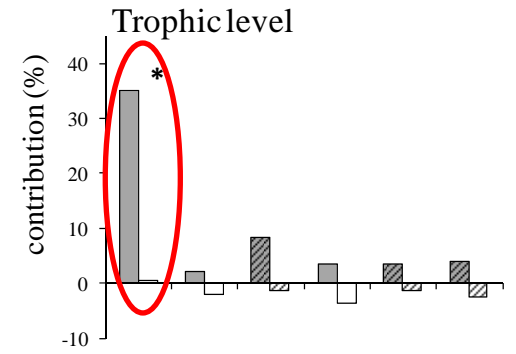
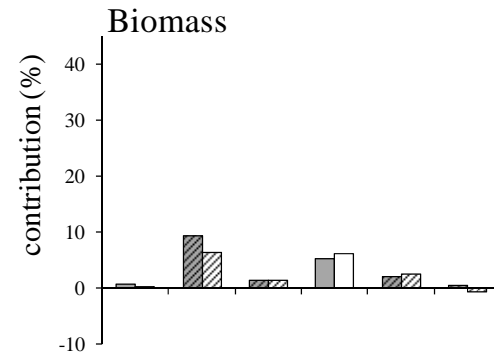
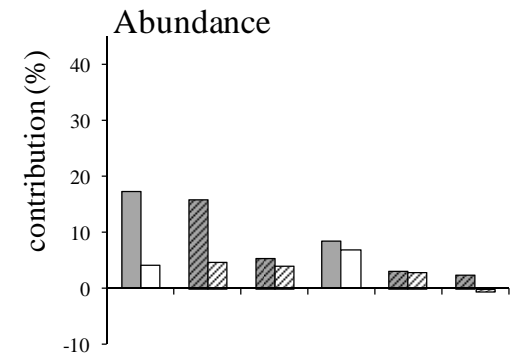
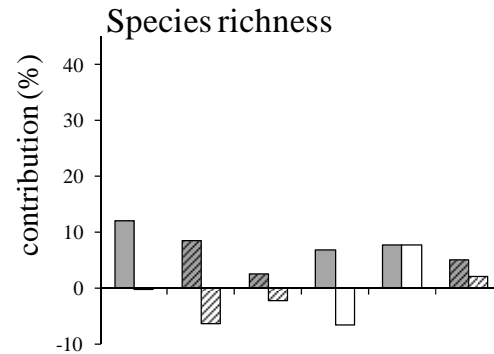
Most corals
Montastraea
Agaricia
Porites



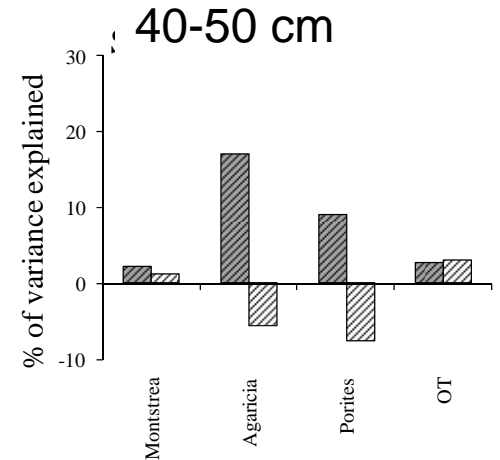
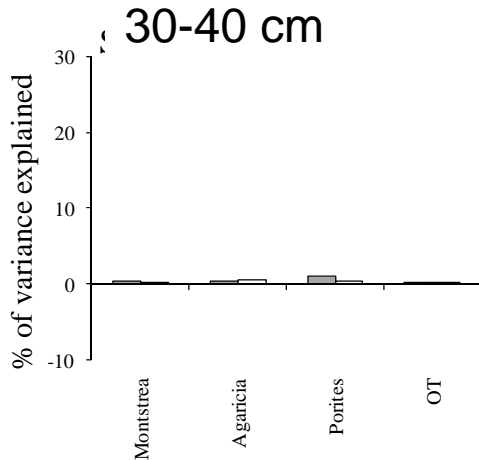
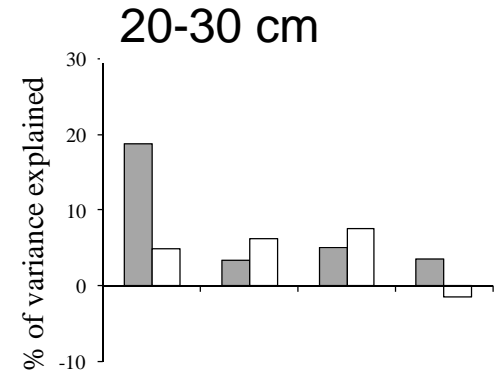
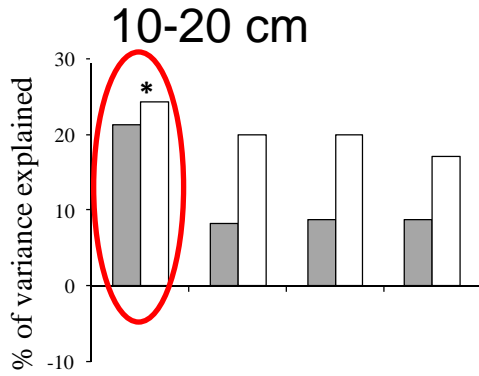
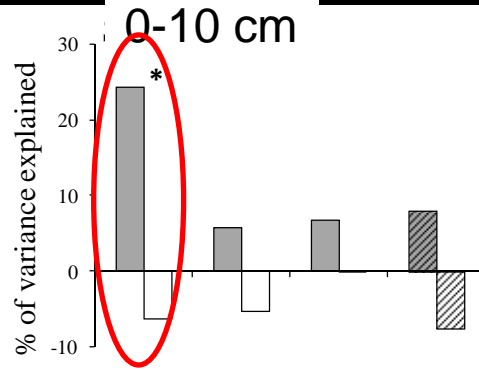
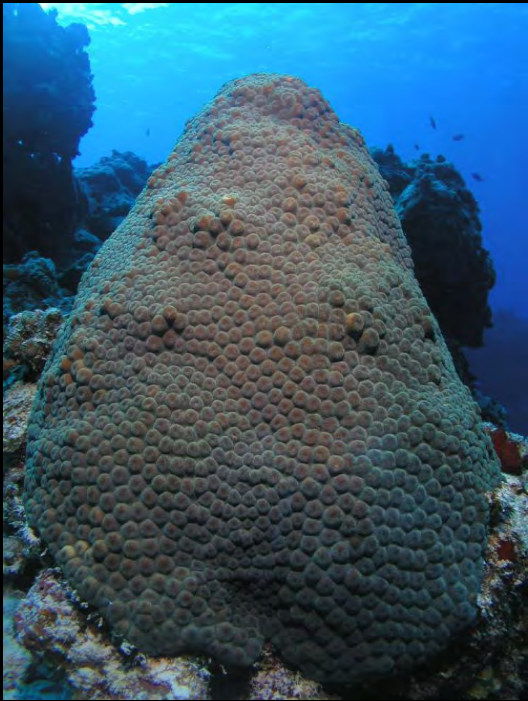
Short-lived and low structure corals

Which components of the fish community are explained by coral cover & complexity?

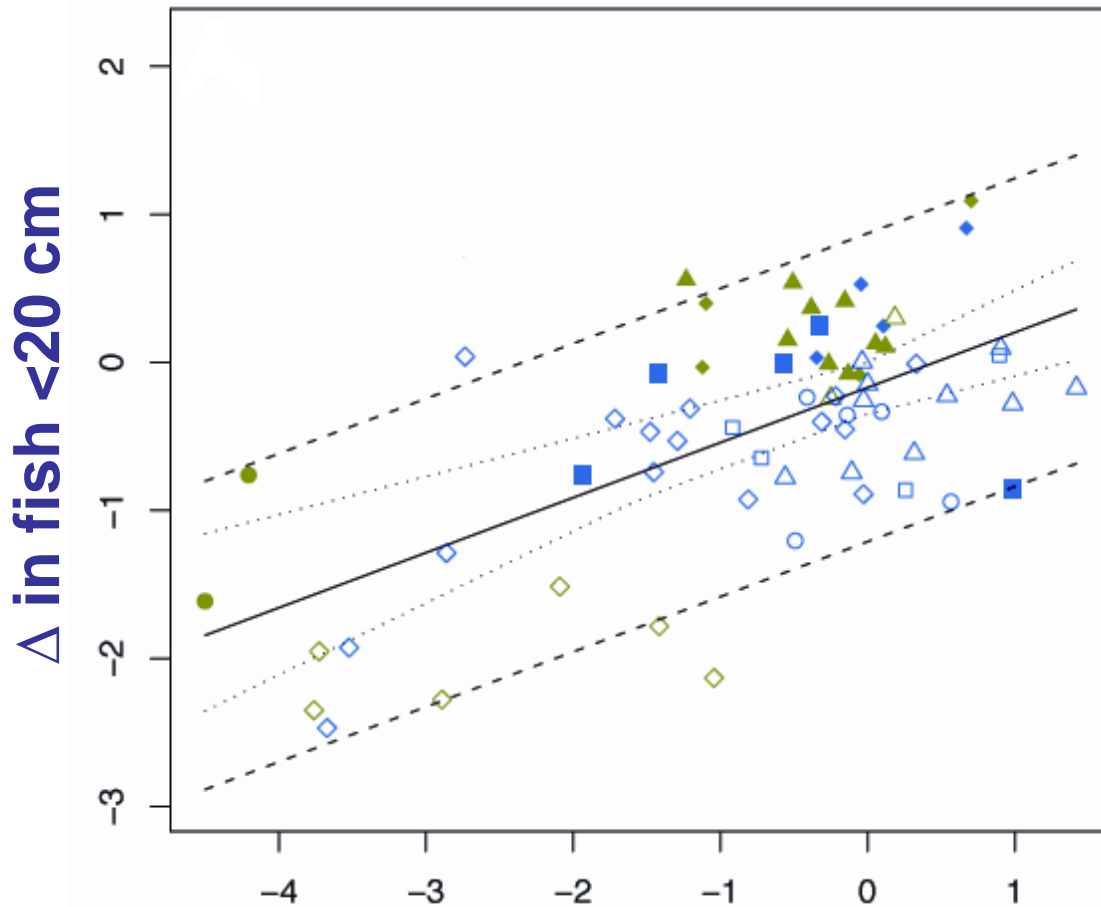
- species richness
- abundance
- biomass
- trophic level
- size spectra



Coral cover and complexity is most important for the recruitment of juvenile fishes

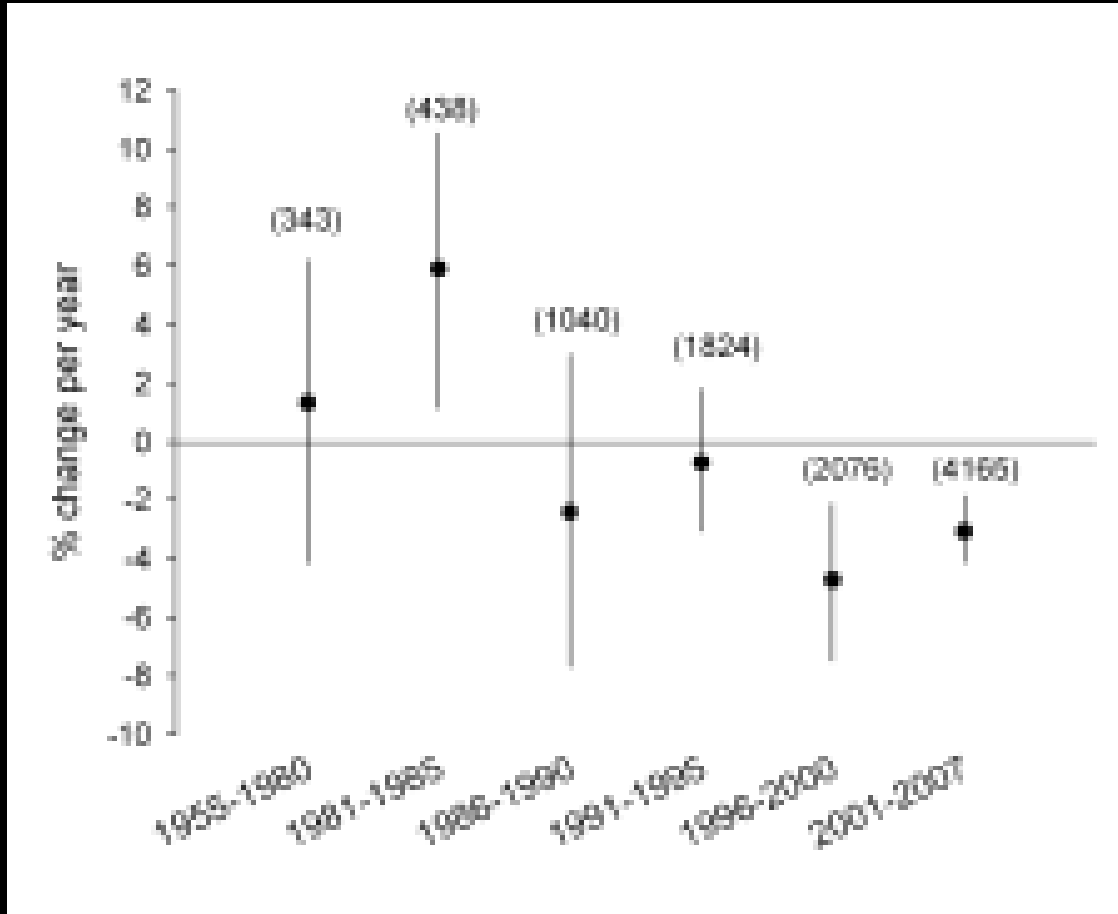


Small fish (<20cm max attainable size) decline as coral lost



Coral depletion index

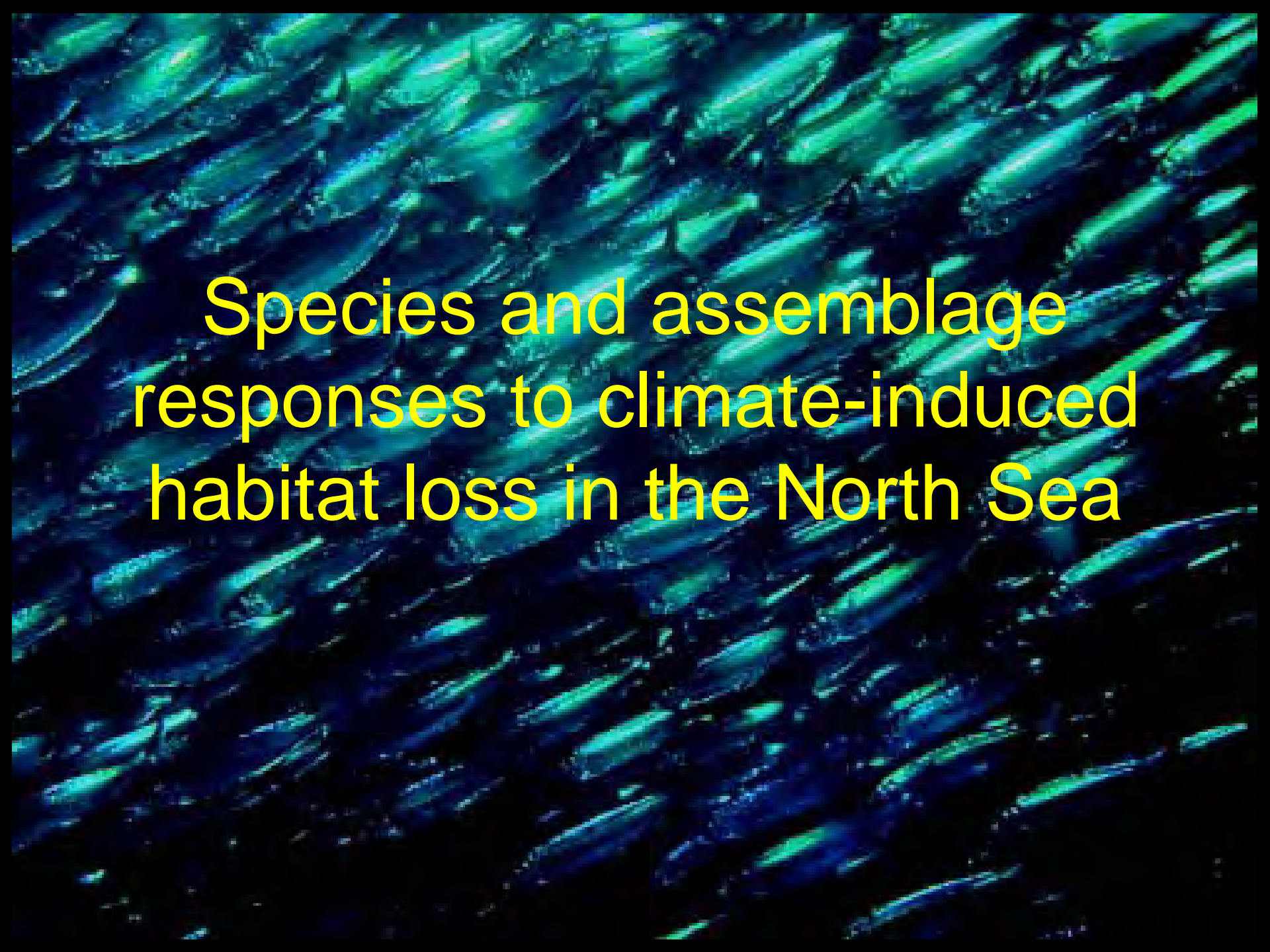
Recent region-wide decline in reef fishes



Paddack, M.J., Reynolds, J.D., Aguilar, C., Appeldoorn, R.S., Beets, J., Burkett, E.W., Chittaro, P.M., Clarke, K., Esteves, R., Fonseca, A.C. et al. (2009) Recent Region-wide Declines in Caribbean Reef Fish Abundance. *Current Biology*, **19**, 590-595.

Summary

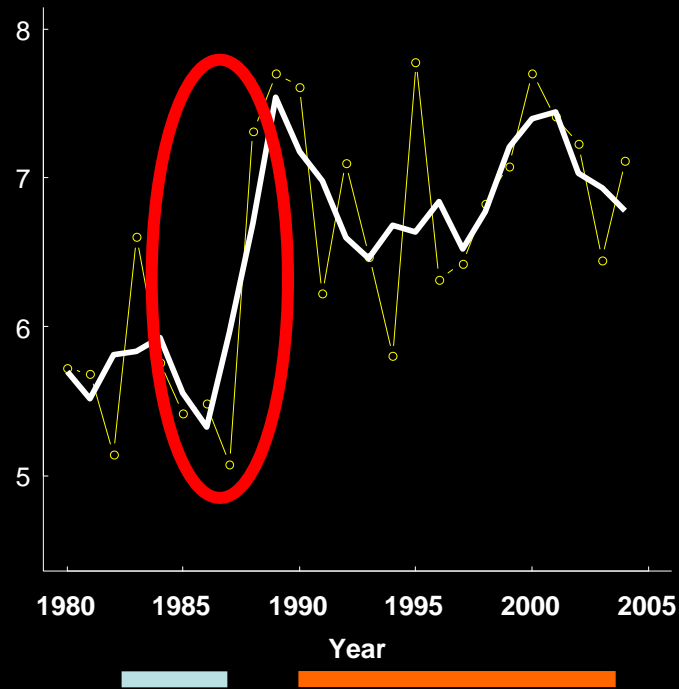
- 80% decline in coral cover
- Collapse of reef and 85% loss of most complex reefs
- *Montastrea* provides the most complex reefs
- Coral cover and complexity has higher abundance of small size classes of fishes
- Region-wide fish collapse – but only recently



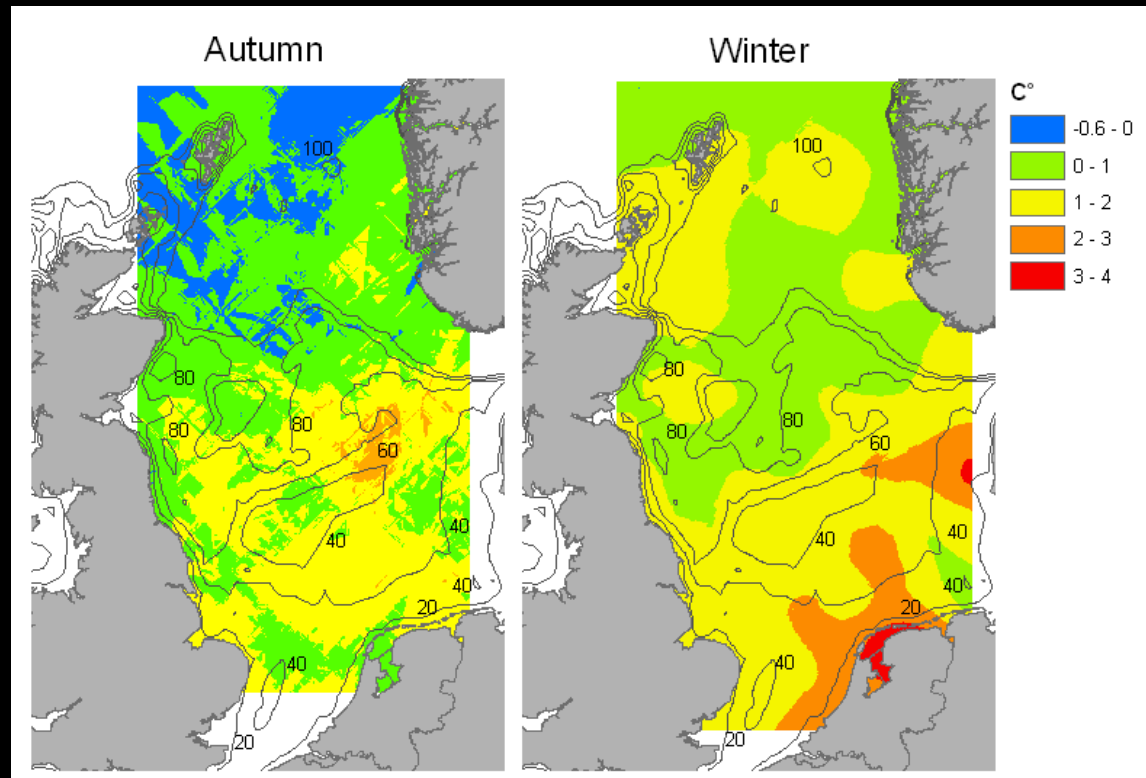
Species and assemblage
responses to climate-induced
habitat loss in the North Sea

1.6°C rise in North Sea bottom temperatures over last 25 years

North Sea Bottom temperature °C



Warming in both summer and particularly winter

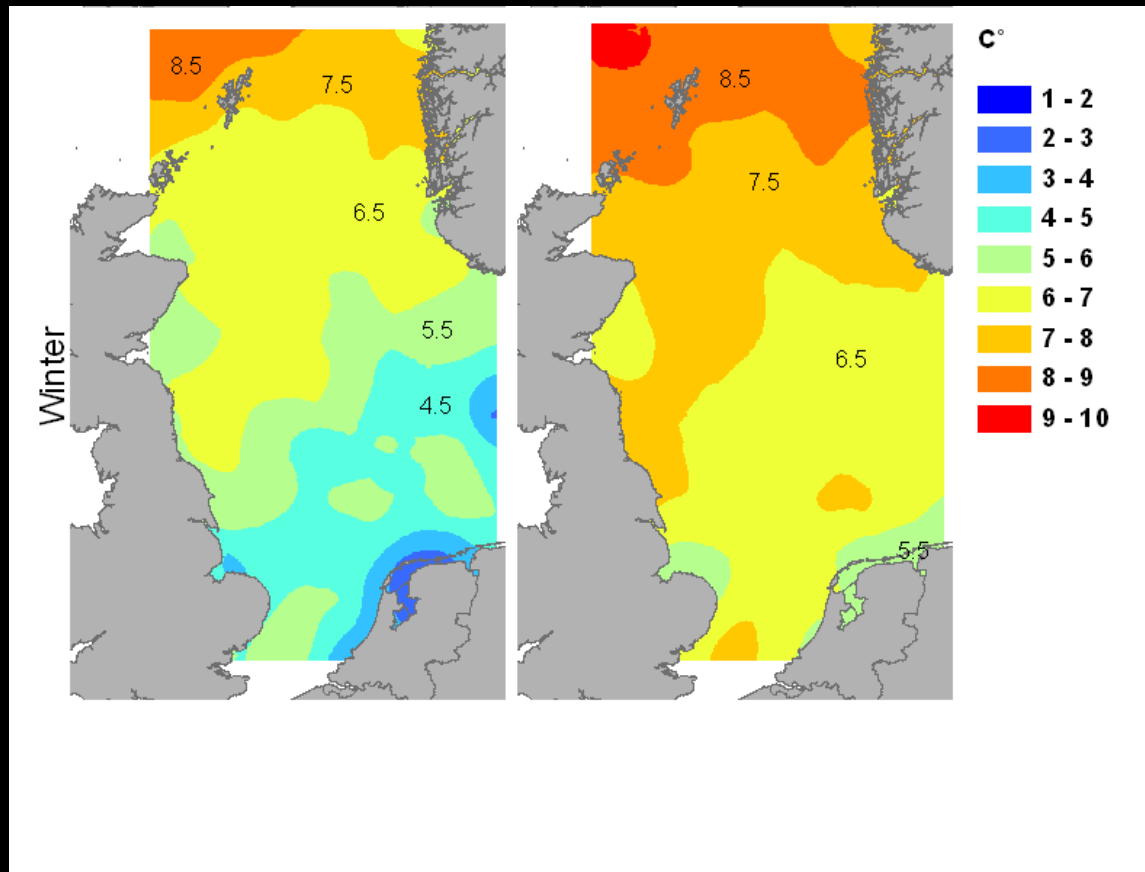


Difference in mean annual temperature between 1980s and 1990s and 2000s

Spatial variation in winter bottom temperature

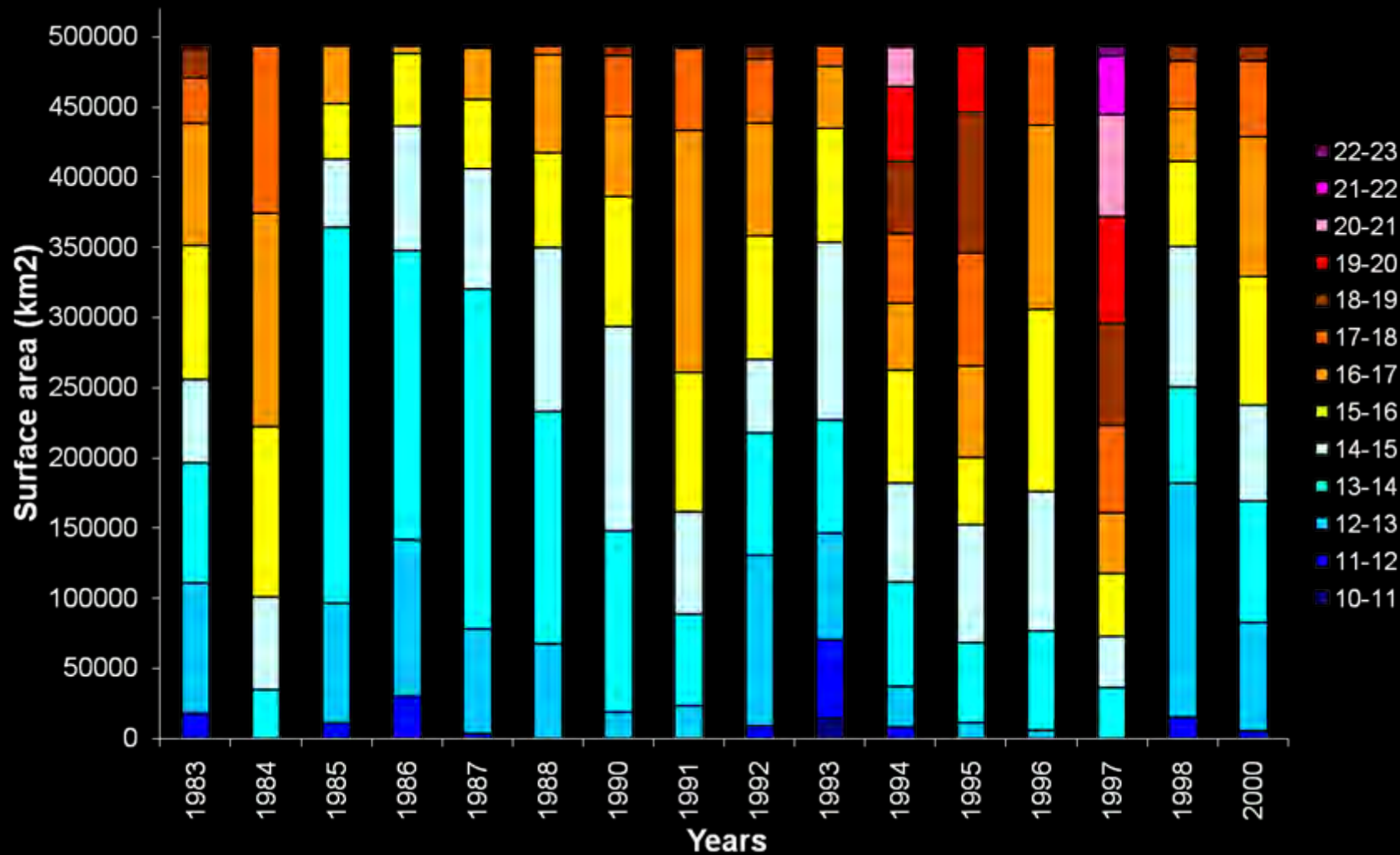
Cool Period 1983-1987

Warm period 1988 - 2003



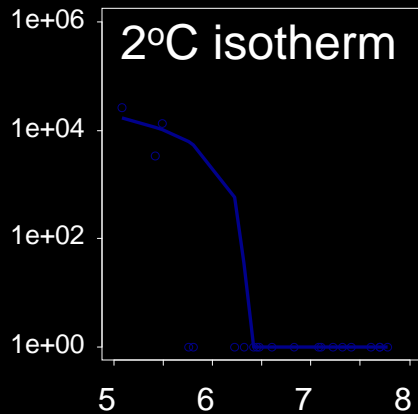
Warming greatest in shallow SE North Sea

Interannual variability in autumn isotherm habitat area



Loss of cold habitats: temperature sensitivity of isotherms

Spatial extent of thermal habitat (log km²)



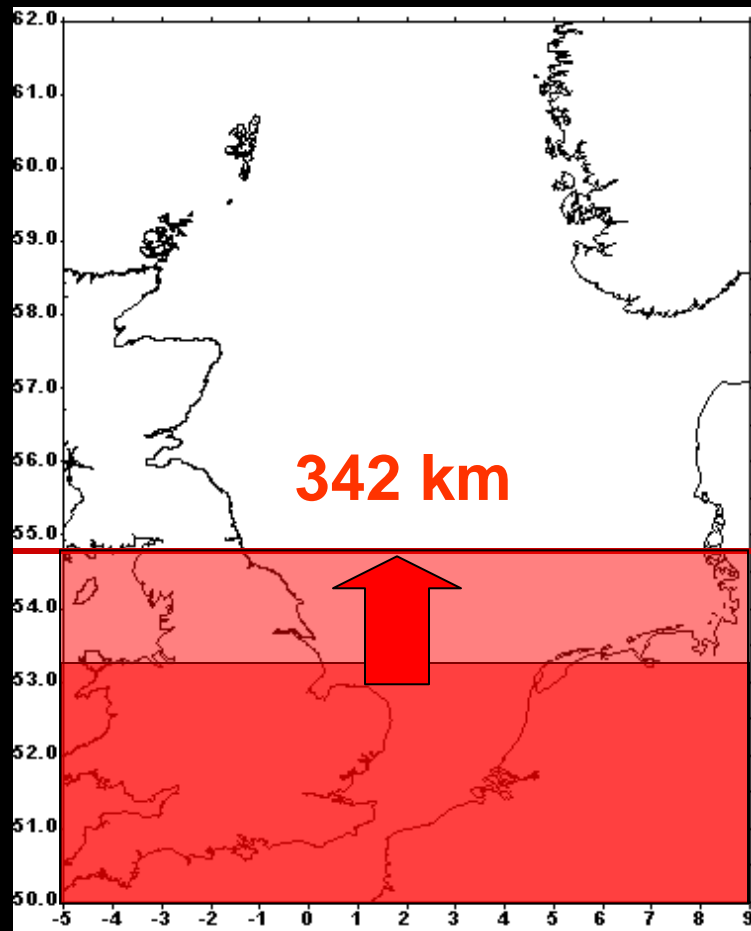
Mean winter sea bottom temperature °C

Range expansion of southern species

bib

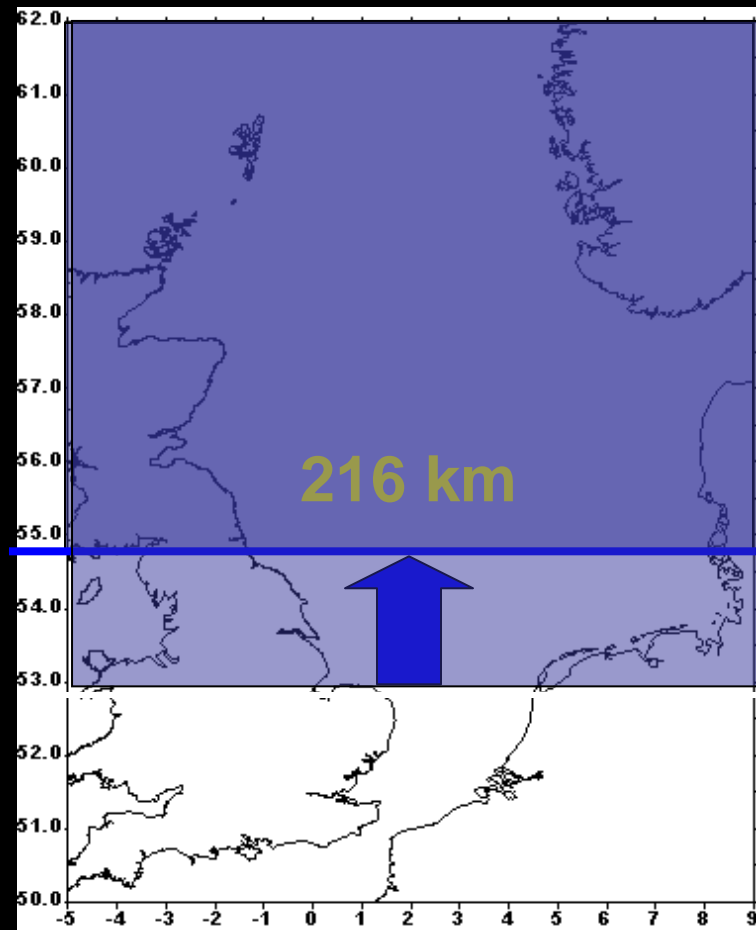


Range expansion of southern species

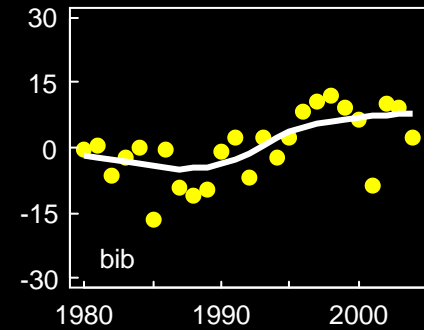
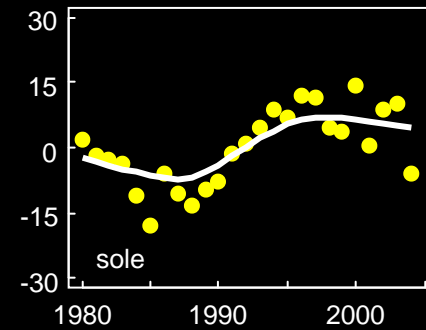
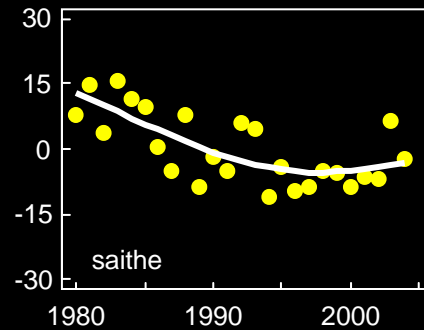
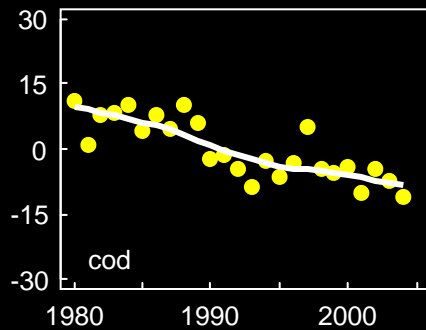
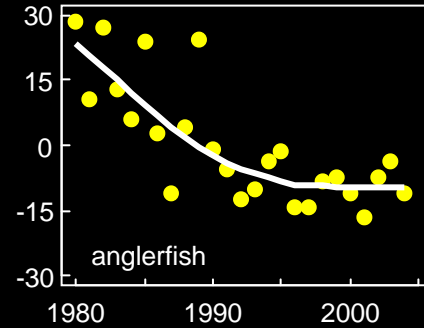
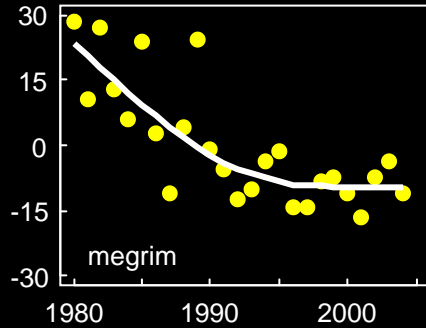


Perry, Low, Ellis & Reynolds (2005) Climate change and distribution shifts in marine fishes. *Science* **308**, 1912-1915.

Range contraction of northern fish species



Deepening of North Sea fishes

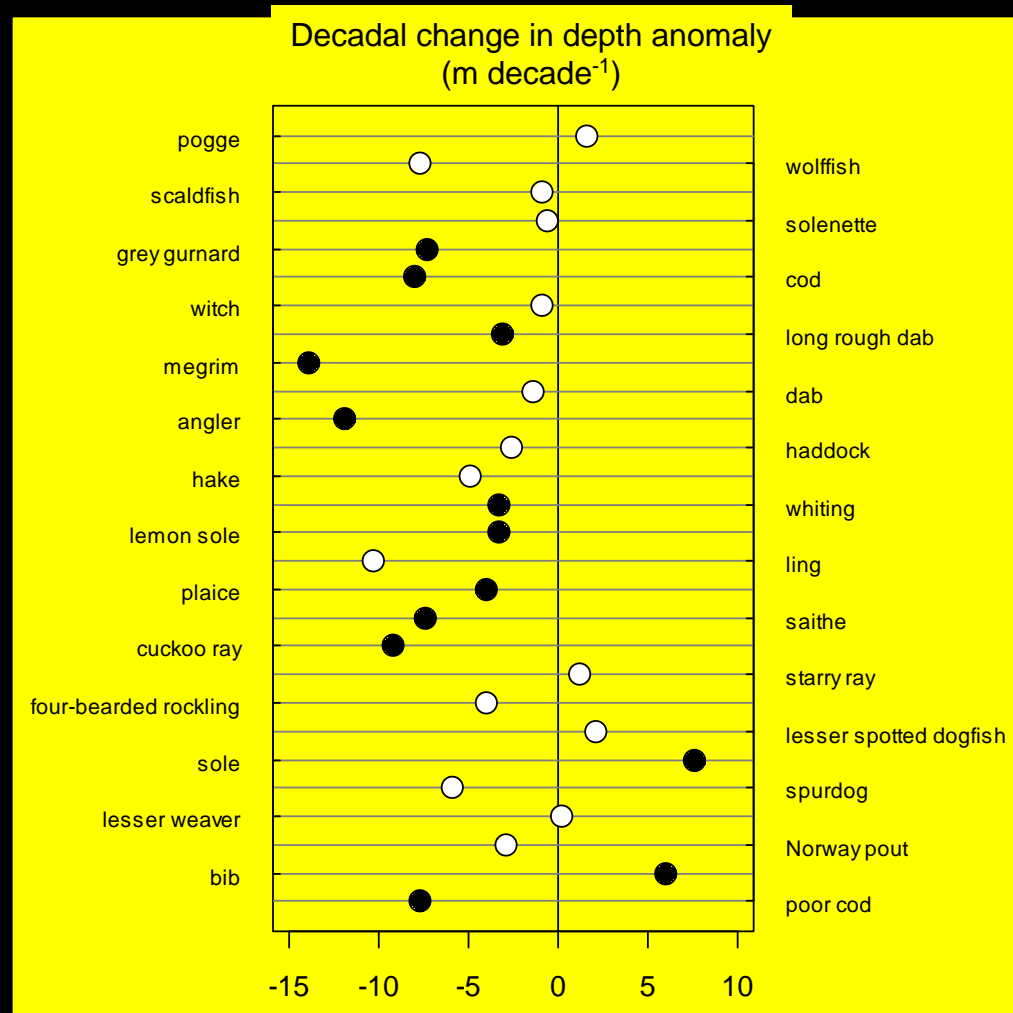


Most species are deepening

Apart from warm-water, species with southern affinities

Not all trends are significant – low power in single species trends...

...and gazillions of tests



Deepening ←



→ Shallowing

Gain power relative to noise by aggregating species distribution anomalies by traits

Thermal preference & range (**warm** vs. **cold**, narrow vs. wide)

Biogeographic origin (**S** vs. **N**)

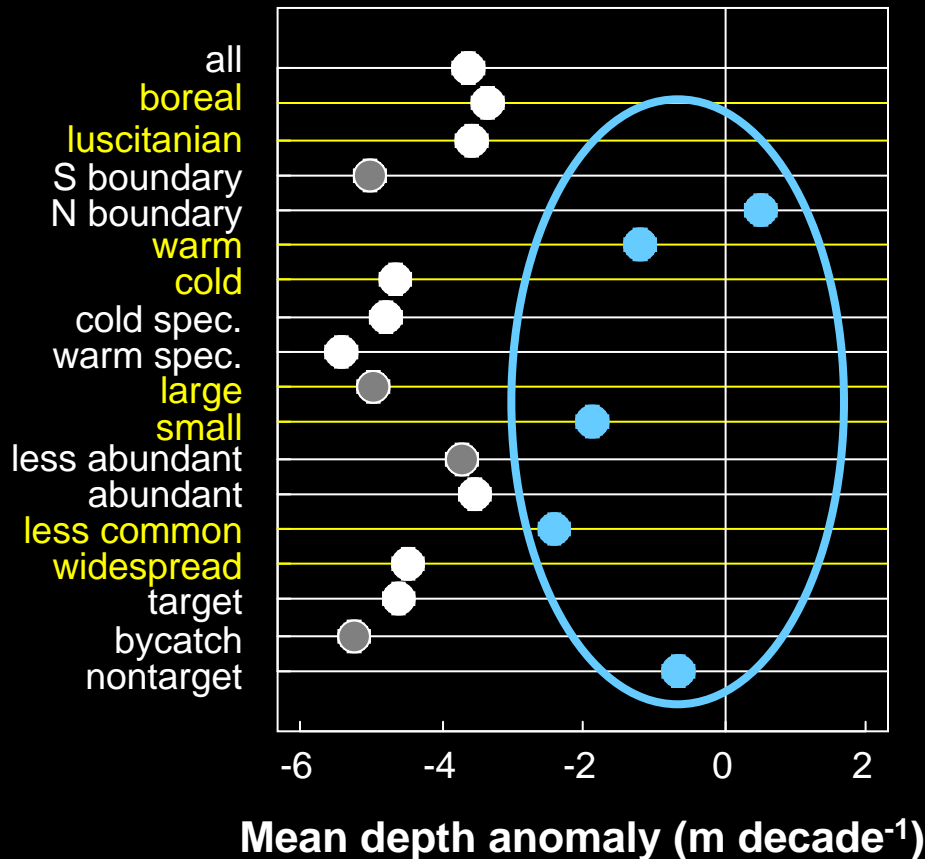
Life history (small vs. large)

Ecology (abundance & occupancy)

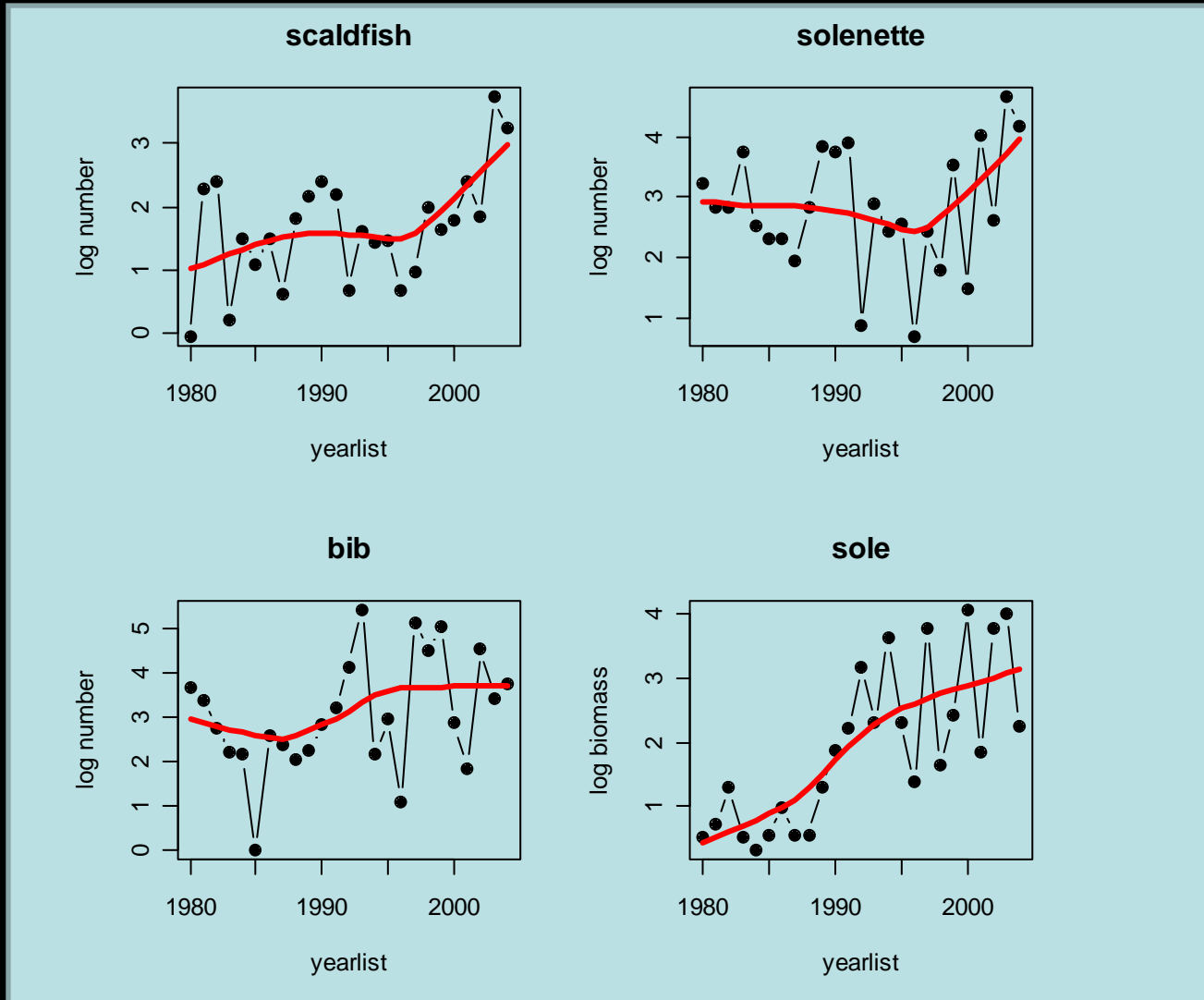
Exploited vs. otherwise

Most assemblages are deepening except...

Small-bodied, warm-tolerant, non-target species with Northern range limit in North Sea

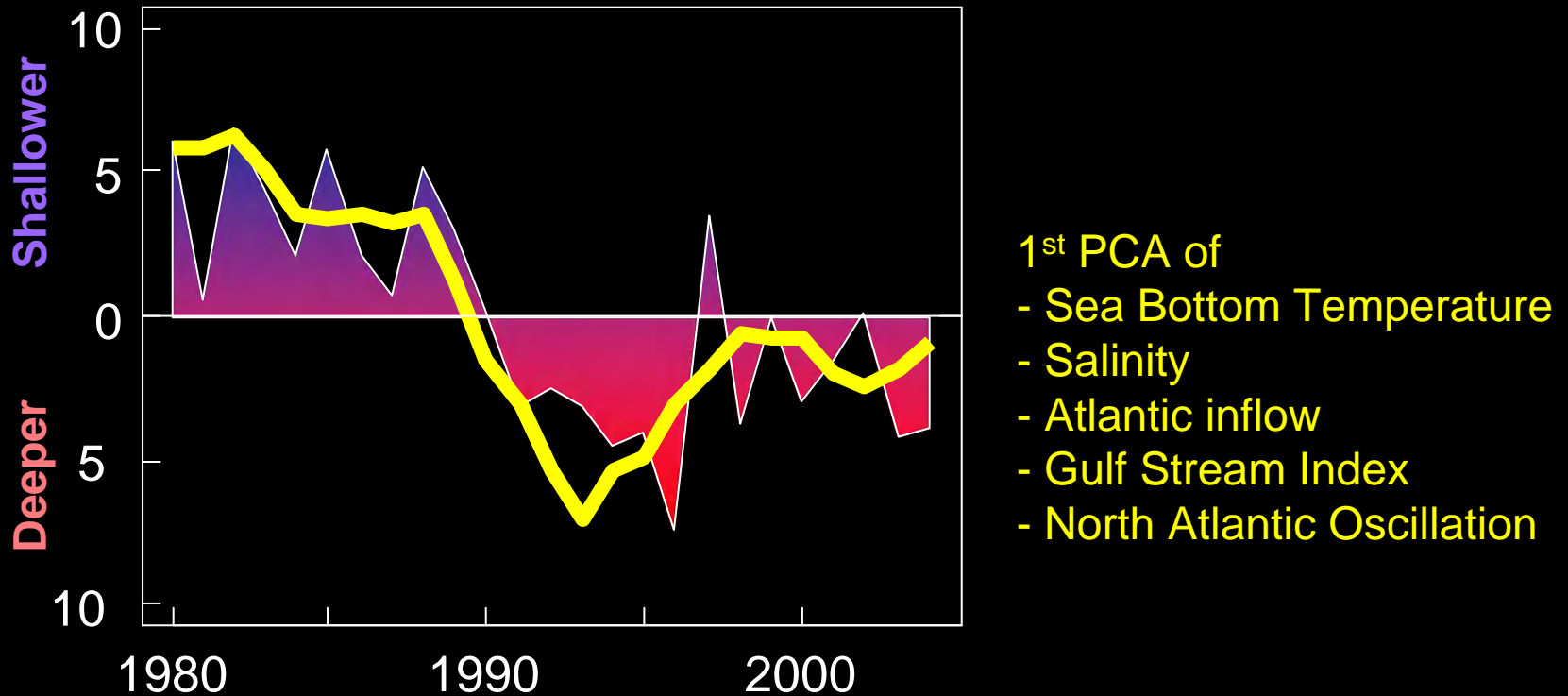


Rising abundance of small, Lusitanian, southern species



Assemblage-wide depth response to local & regional climate variability

mean depth anomaly (m) of fish community



Deepening of North Sea fishes

North Sea bottom temperatures have warmed by 1.6°C in last quarter century

The whole fish assemblage has deepened by 3.6 m decade⁻¹, 22 species have deepened by 5.6 m decade⁻¹

The latitudinal response is heterogeneous due to
Northward shift of abundant, widespread thermal specialists &
Southward shift of relatively small, abundant southerly species with limited occupancy and a northern range boundary (benefiting from indirect impact of fishing – not enough fear!)

Depth response more coherent than the latitudinal response



Acknowledgements

Lorenzo Filip-Alvarez
Isabelle Cote
Jenny Gill
Andrew Watkinson
Stephen Dye
Vanassa Stelzenmüller
Simon Jennings
Stuart Rogers
Hein Rune Skjoldal
Manuel Barange



UK Department for Environment Fisheries and Rural Affairs
Mexican Council for Science and Technology (CONACYT)
Mexican Secretary of Public Education (SEP) scholarship
Mexican Commission of Natural Protected Areas (CONANP) and the PNAC