

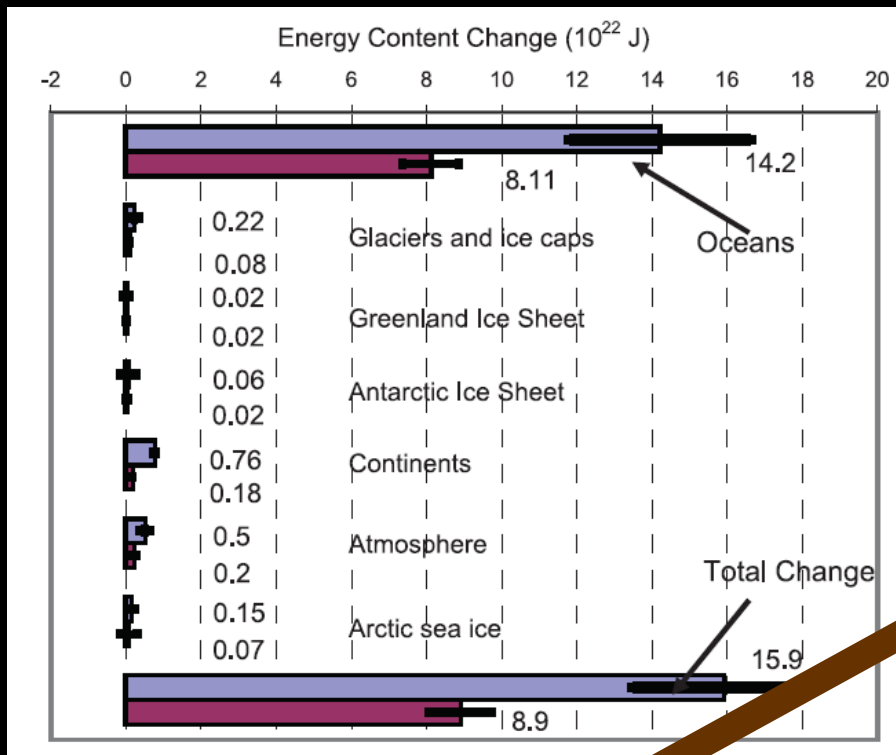
An aerial photograph showing a vast colony of seabirds, likely gulls, nesting on a grassy field. The birds are densely packed, creating a textured pattern of dark and light spots across the landscape. The overall scene is captured from a high angle, emphasizing the scale of the nesting site.

Rapid ecological change in the Northeast Atlantic climate change hotspot

Nicholas K. Dulvy¹, Doug J. Beare², Julia L. Blanchard³, Stephen R. Dye,
Jan G. Hiddink⁴, Simon Jennings⁵, Brian J. MacKenzie⁶ & Allison L. Perry⁷

dulvy@sfu.ca

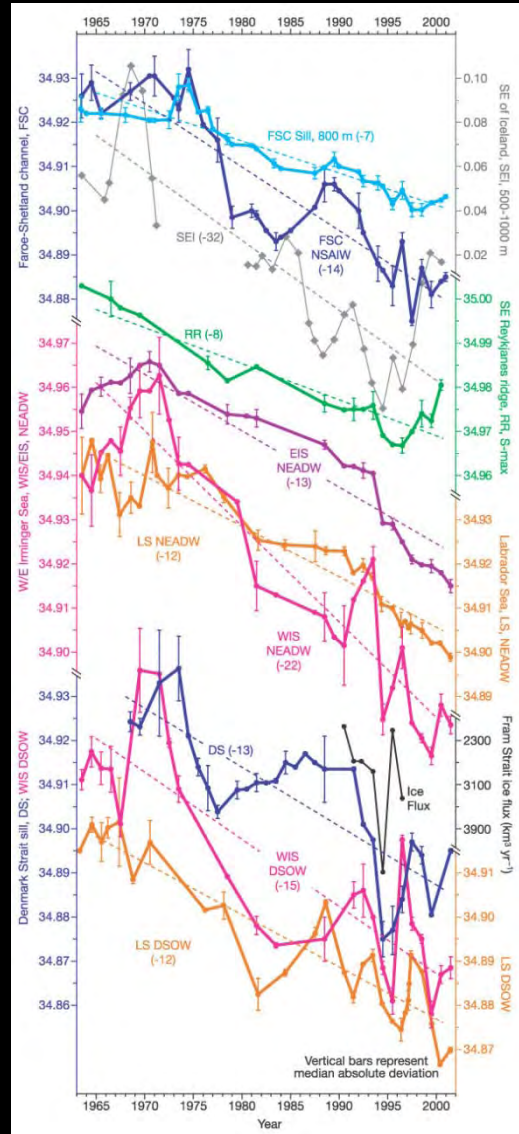
Most heat is being transferred to the oceans



Since 1955, 84% of “global warming” is found in the ocean

Arctic warming increases river flows

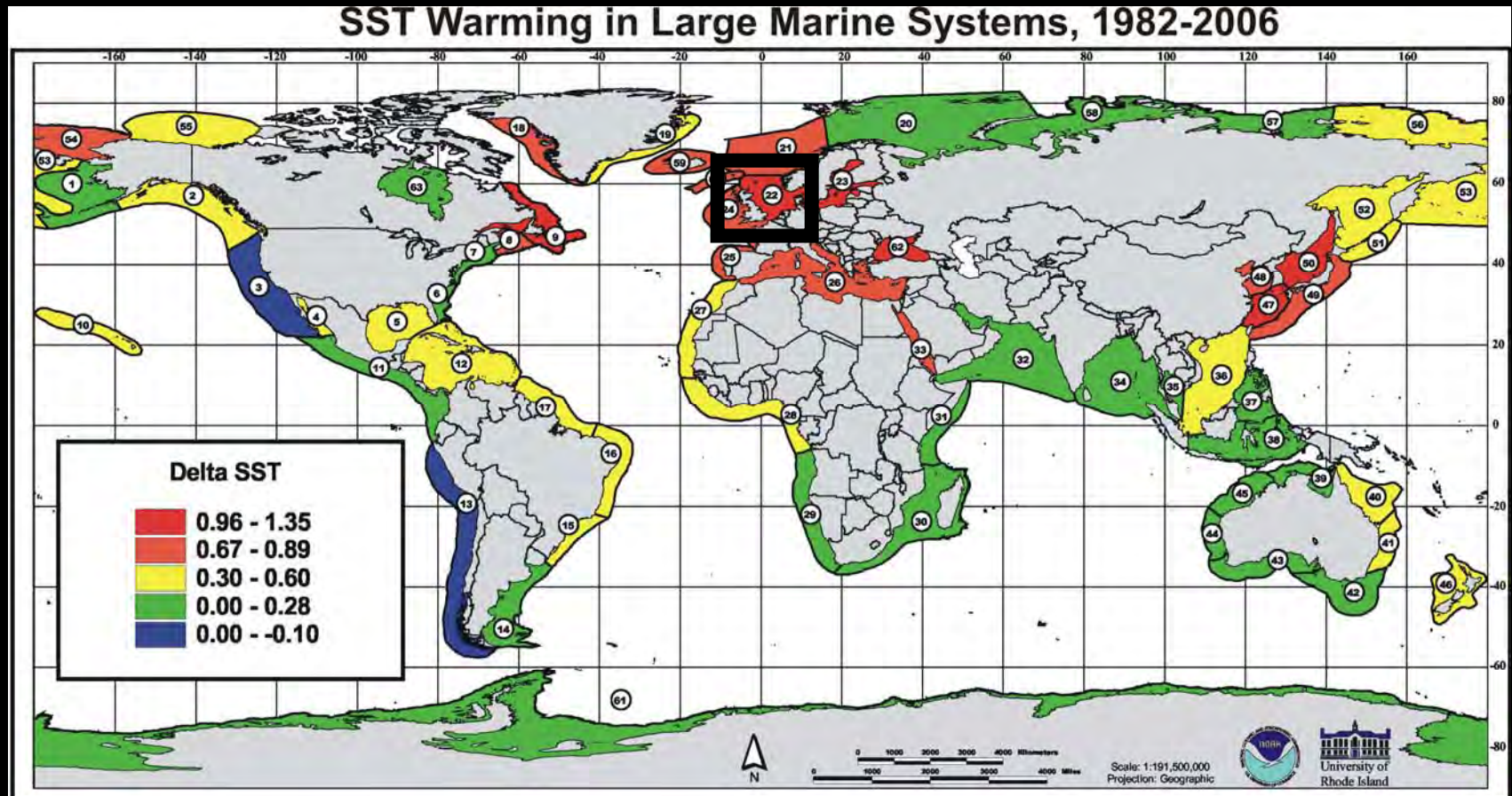
Salinity change over 10 NE Atlantic Stations



...freshening & warming the Meridional Overturning Circulation...



Arctic warming is pumping heat straight into the North Atlantic



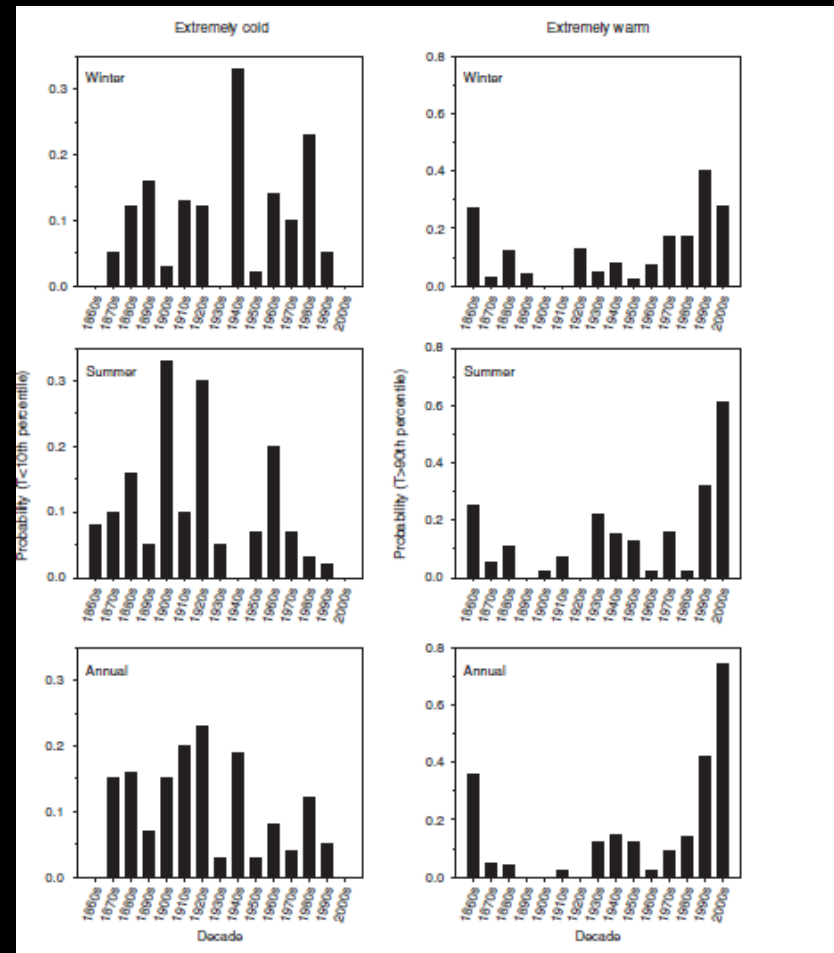
Empirical SSTs 1982 – 2006; Igor Belkin & Ken Sherman

A microscopic image of skeletal muscle tissue, showing numerous parallel muscle fibers with distinct transverse striations. The fibers are arranged in a regular, repeating pattern, characteristic of striated muscle. The overall color is a deep red, likely due to the presence of myoglobin and blood in the tissue.

Physical changes

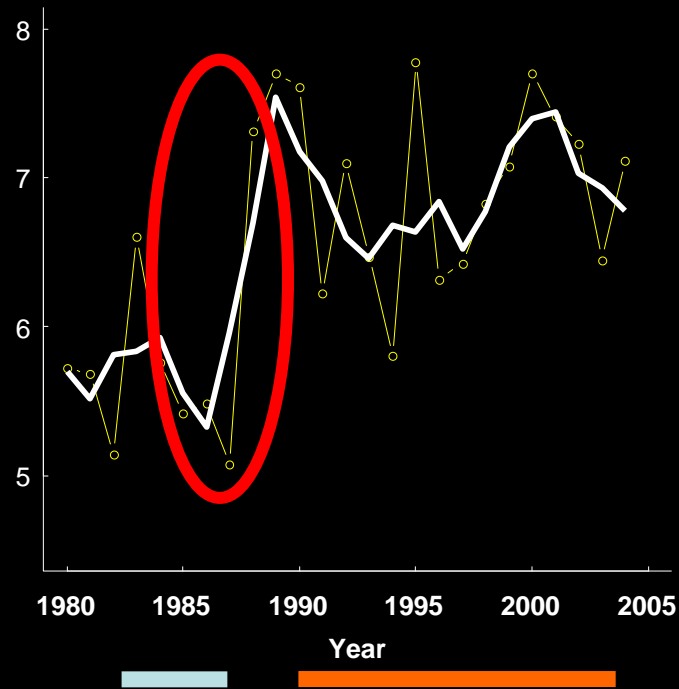
Probability of extreme cold and extreme warm years

In Baltic and NS summer temperatures have risen 2-5 times faster compared to other seasons, mainly due to the increased frequency of extremely warm years.

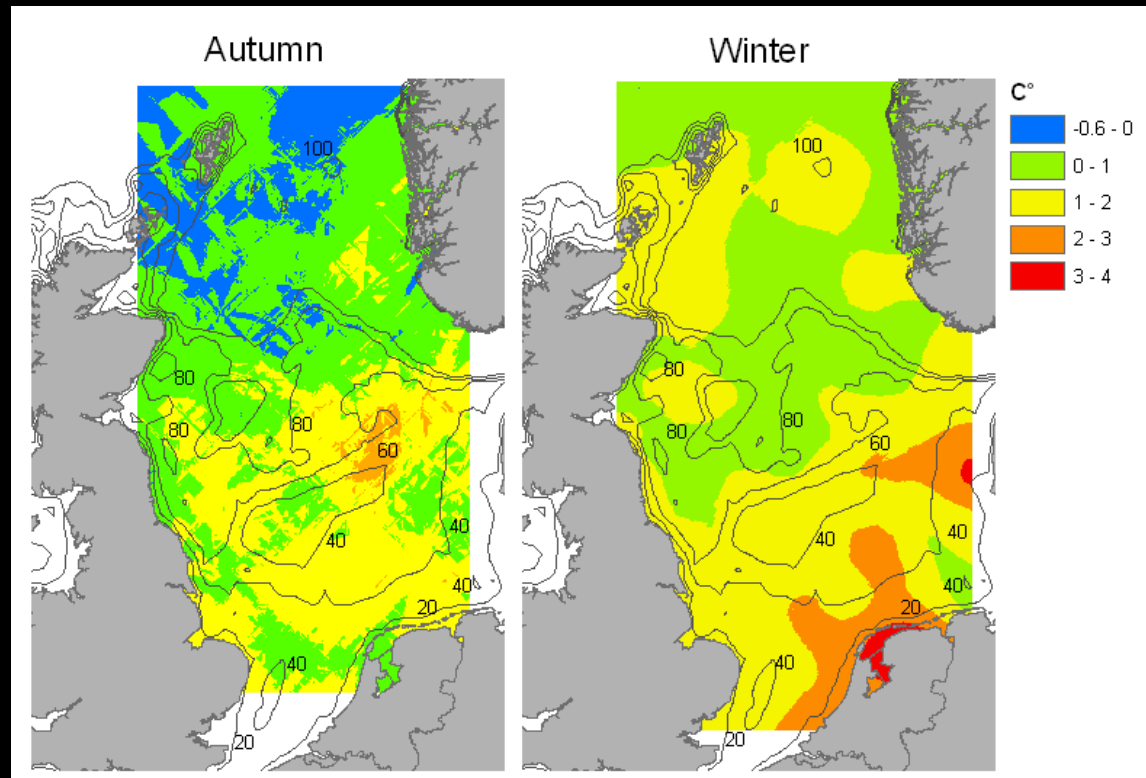


1.6°C rise in North Sea bottom temperatures over last 25 years

North Sea Bottom temperature °C



Warming in both summer and particularly winter

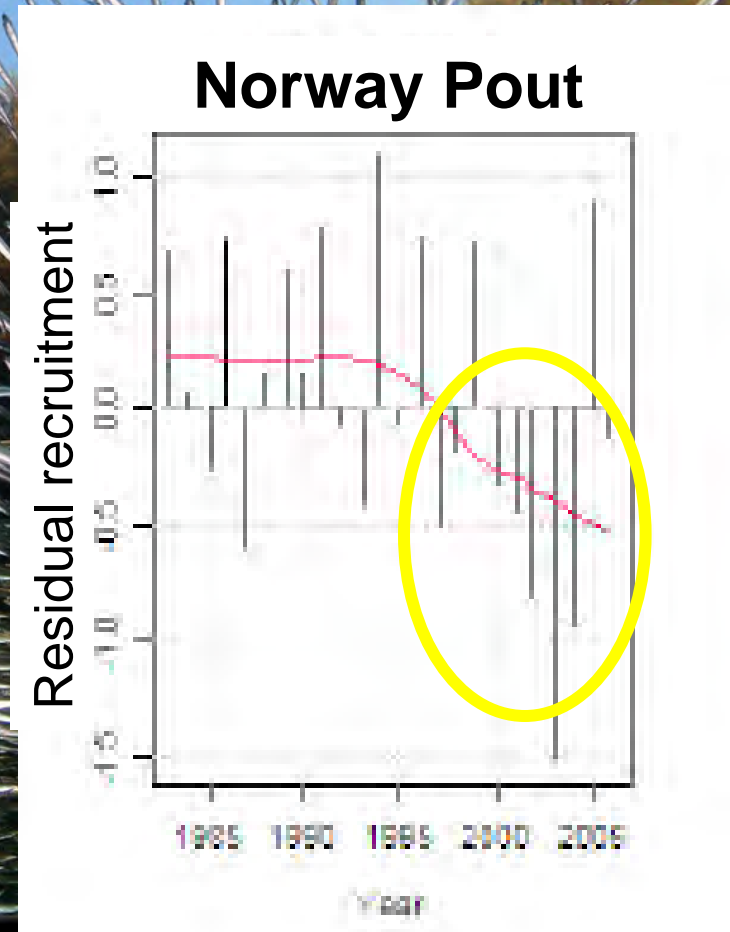
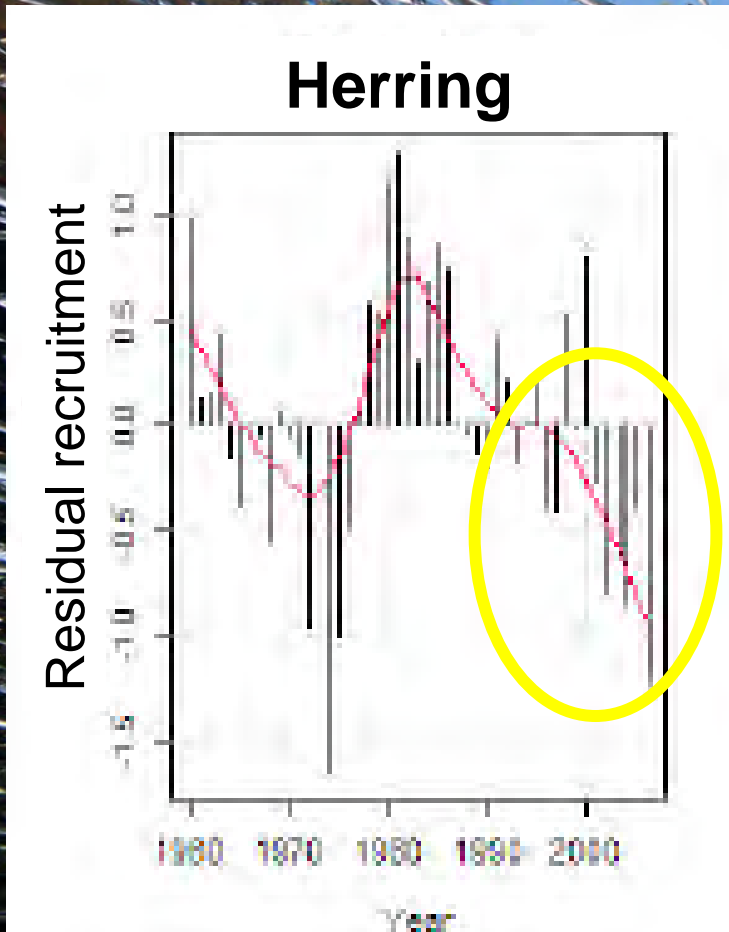


Difference in mean annual temperature between 1980s and 1990s and 2000s



Component demographic effects

Declining recruitment of pelagic planktivorous fishes



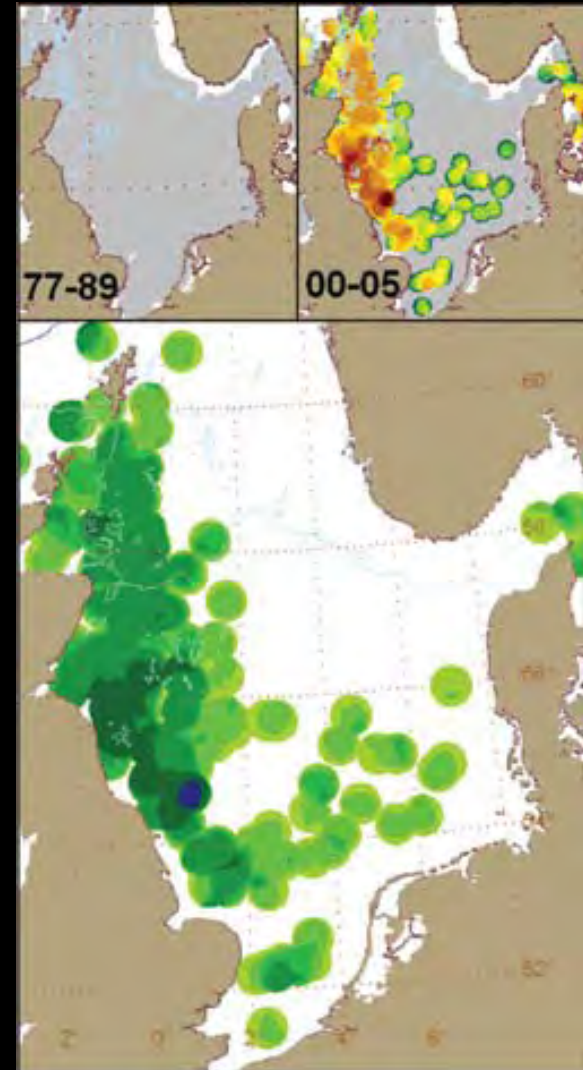
A large school of small, silvery fish, likely sardines or anchovies, swimming in clear blue water. The fish are densely packed and moving in a coordinated pattern, creating a shimmering effect. The word "Invasions" is overlaid in the center in a bold, black, sans-serif font.

Invasions

Red Mullet invasion

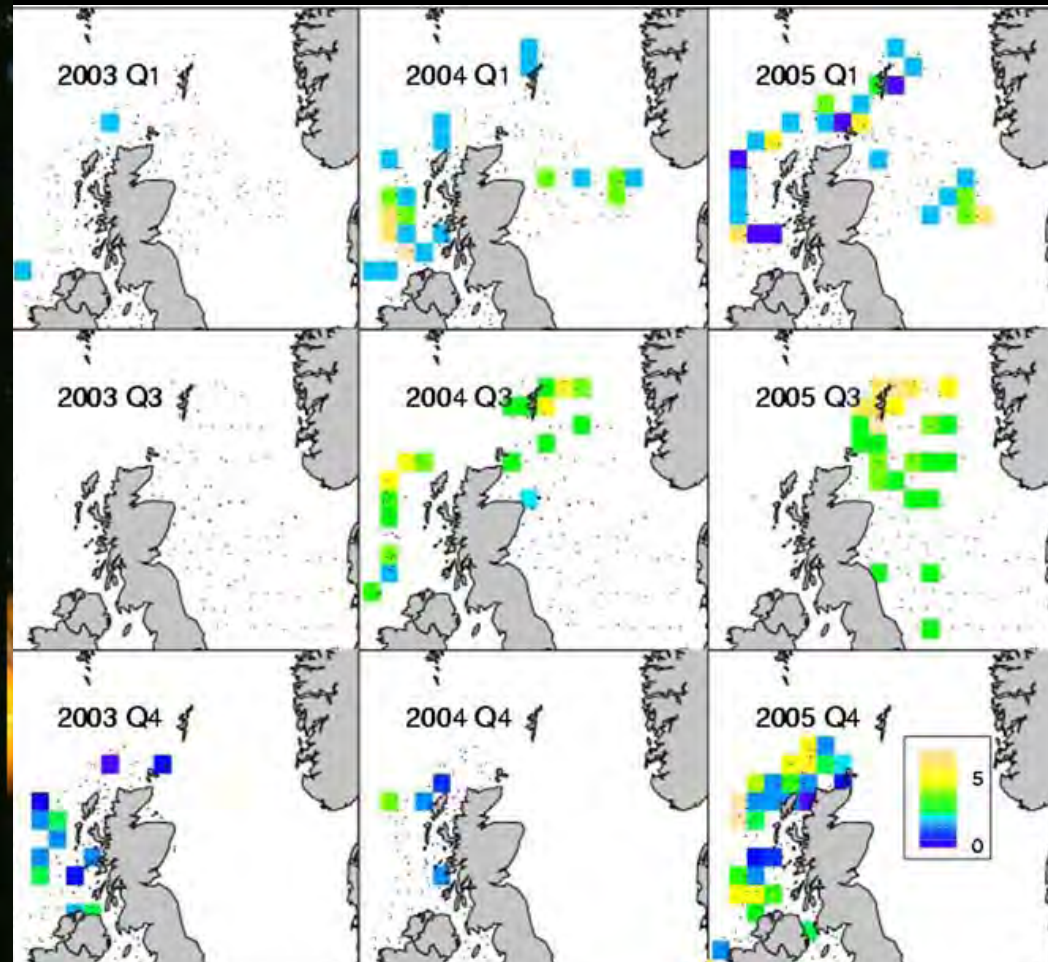


Striped red mullet (*Mullus surmuletus*).
Courtesy of Robert A. Patzner, Salzburg University.



The change in distribution of striped red mullet (*Mullus surmuletus*) between the periods 1977–1989 and 2000–2005 in the first quarter (Q1) of the North Sea

Invasion of the pipefishes

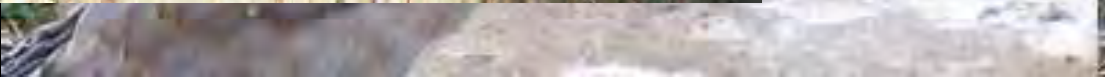
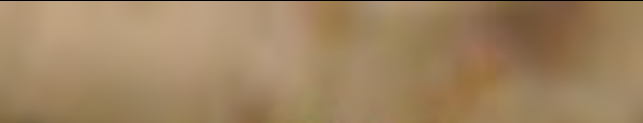


Harris, M. P., Beare, D., Toresen, R., Nøttestad, L., Kloppmann, M., Dörner, H., Peach, K., Rushton, D. R. A., Foster-Smith, J. & Wanless, S. (2007) A major increase in snake pipefish (*Entelurus aequoreus*) in northern European seas since 2003: Potential implications for seabird breeding success. *Marine Biology*, **151**, 973-983.

What seabirds prefer to eat



Pipefishes and seabirds



Potential synergistic effect of climate, fishing & invasion on small pelagic fishes and seabirds



“At UK colonies a major increase in the presence of pipefish in seabird diet was usually associated with poor or catastrophic breeding success”

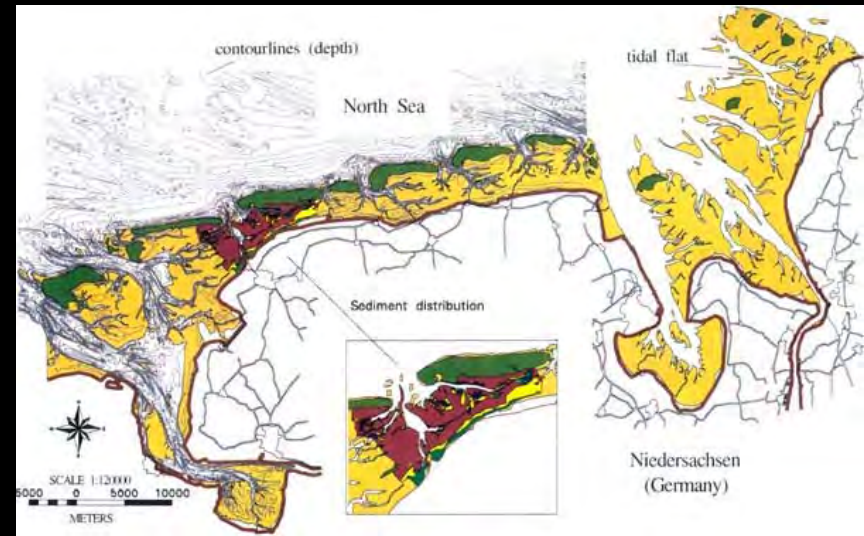
“Researchers repeatedly commented on the difficulty chicks had in swallowing pipefish and there were graphic descriptions of terns on Coquet Island and the Farne Islands, and Atlantic puffins on St Kilda with pipefish protruding out of their bills and of chicks choking to death trying to swallow them”



Population response of
residents

Die or move?

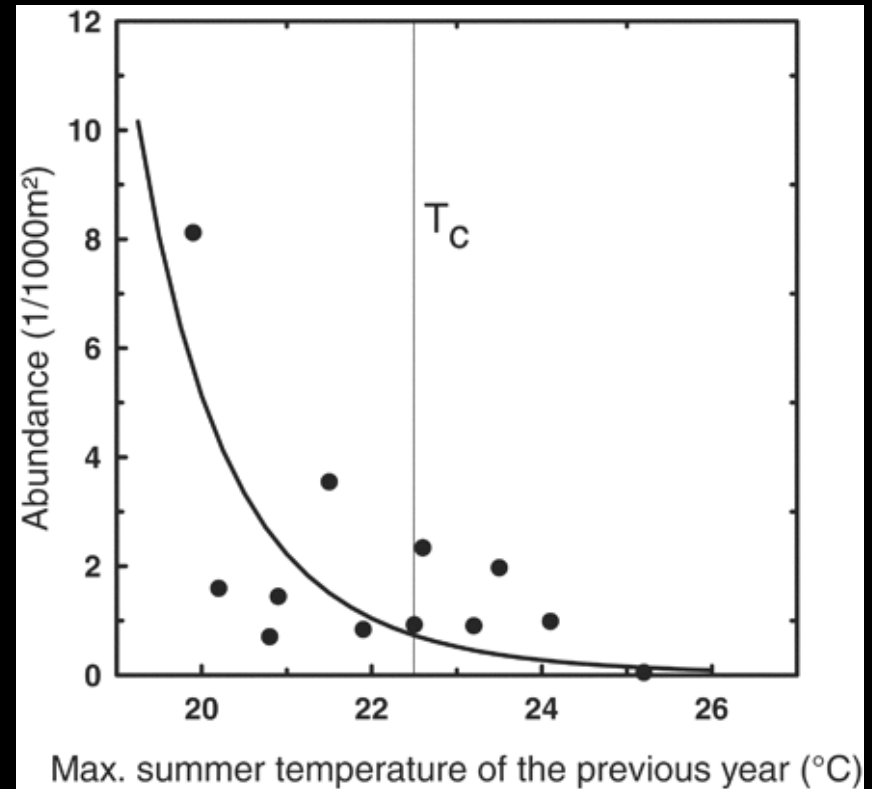
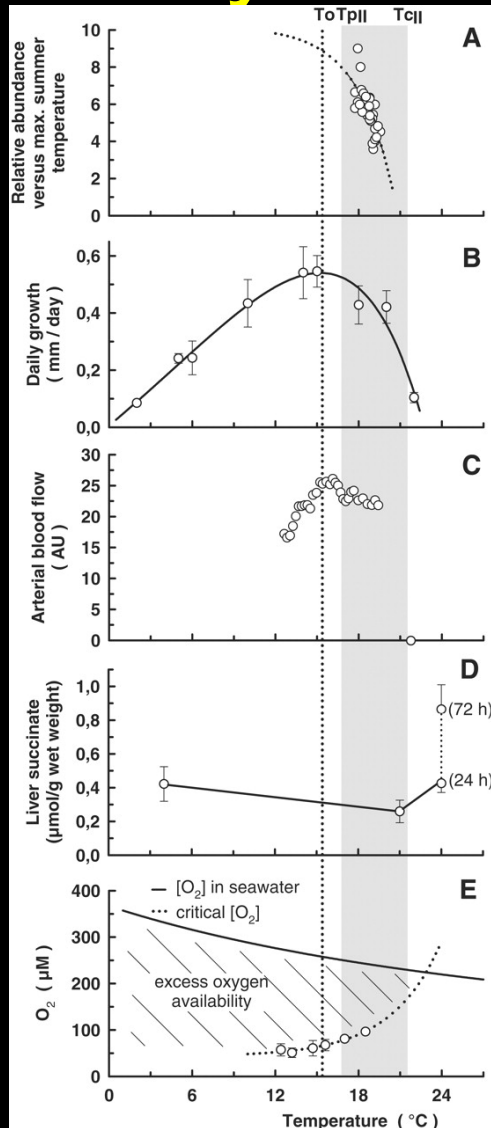
What is the drive to move?



What happens if you can't move?

Pörtner, H.O. & Knust, R. (2007) Climate change affects marine fishes through the oxygen limitation of thermal tolerance. *Science*, **315**, 95-97.

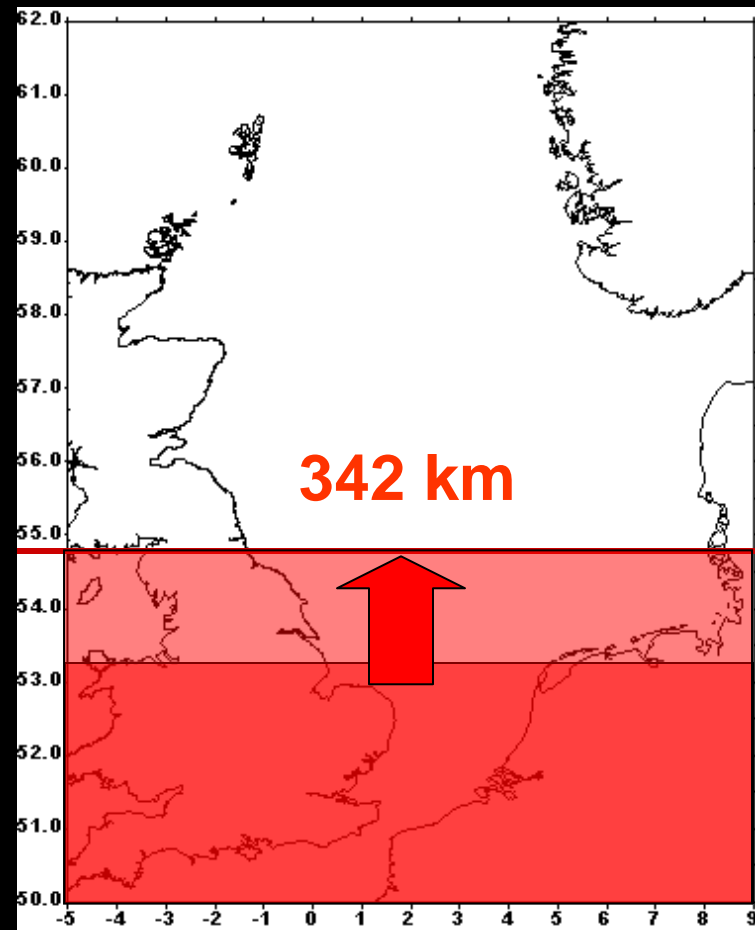
Linking physiology to demography: if you can't move you die



Changing geographic distributions of fish populations and species

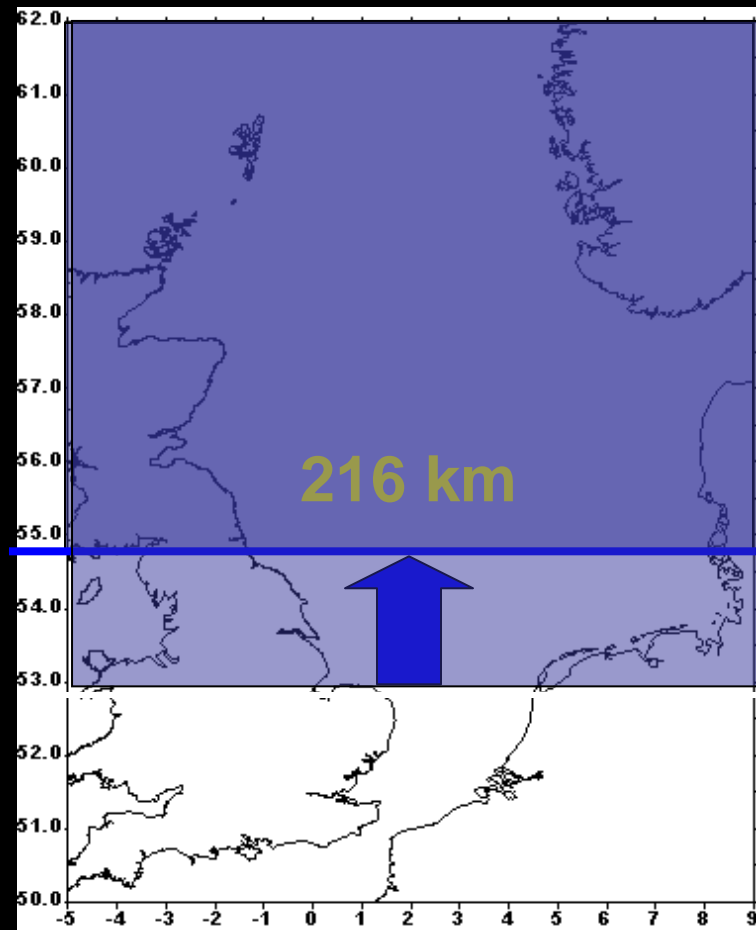


Range expansion of southern species



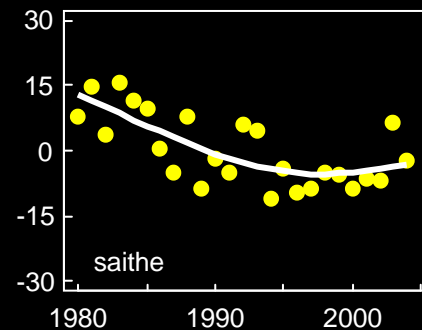
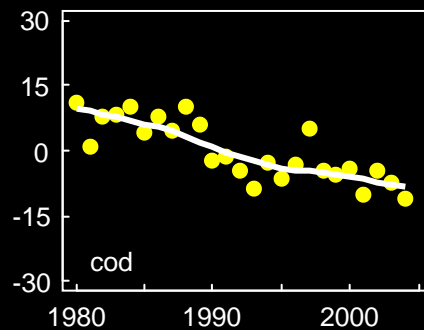
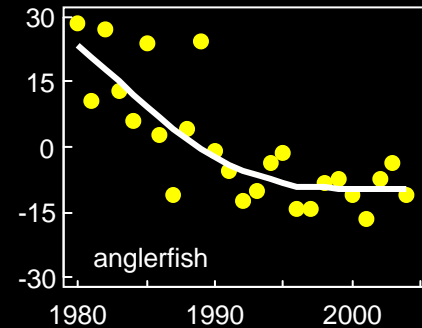
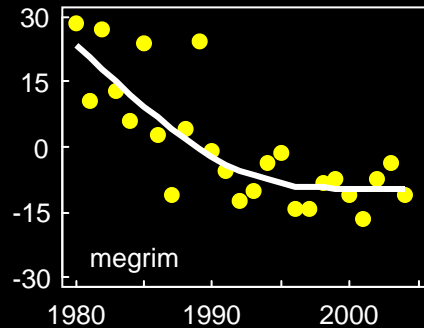
Perry, Low, Ellis & Reynolds (2005) Climate change and distribution shifts in marine fishes. *Science* **308**, 1912-1915.

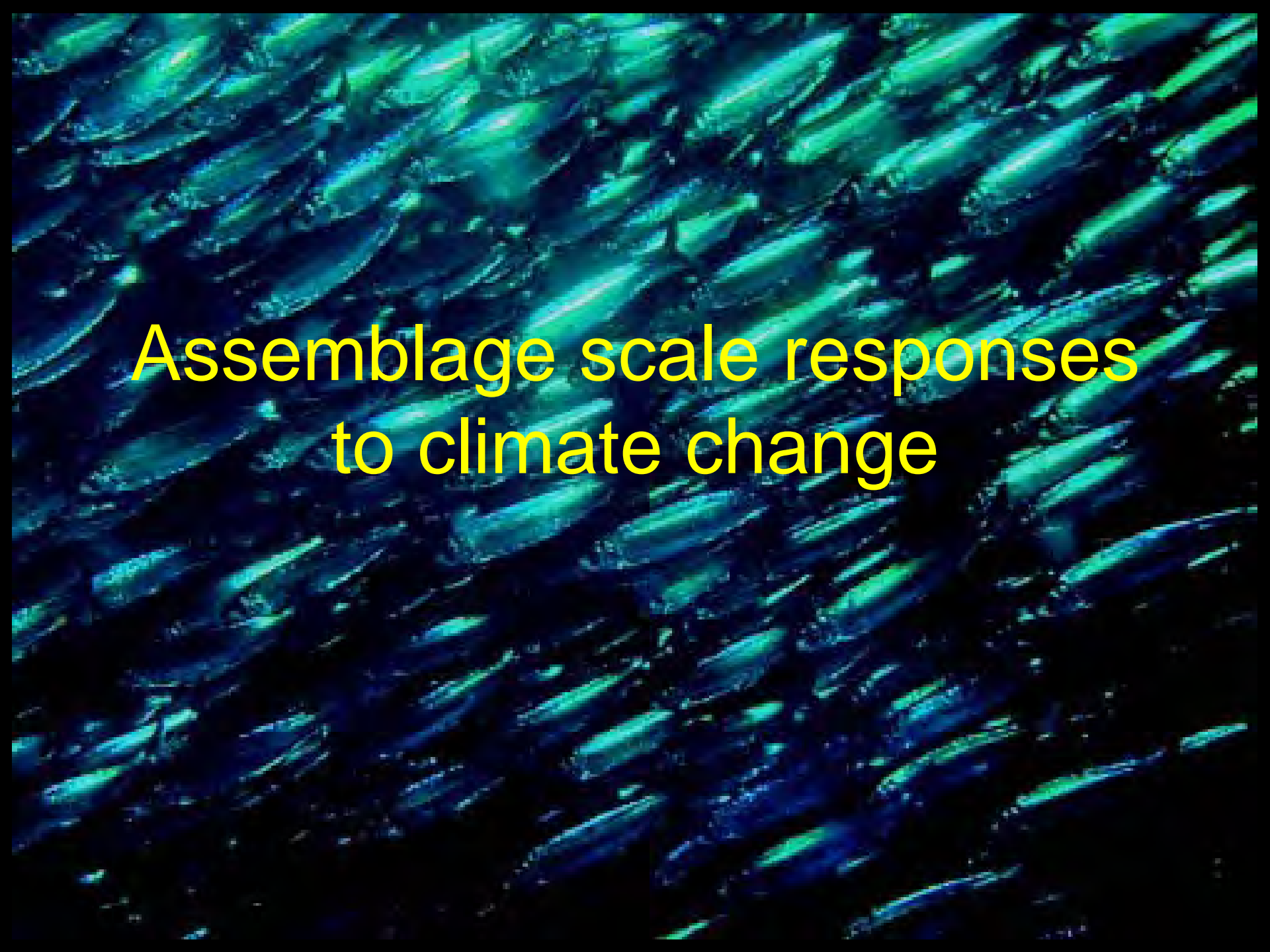
Range contraction of northern fish species



Deepening of North Sea fishes

Depth anomaly (m)

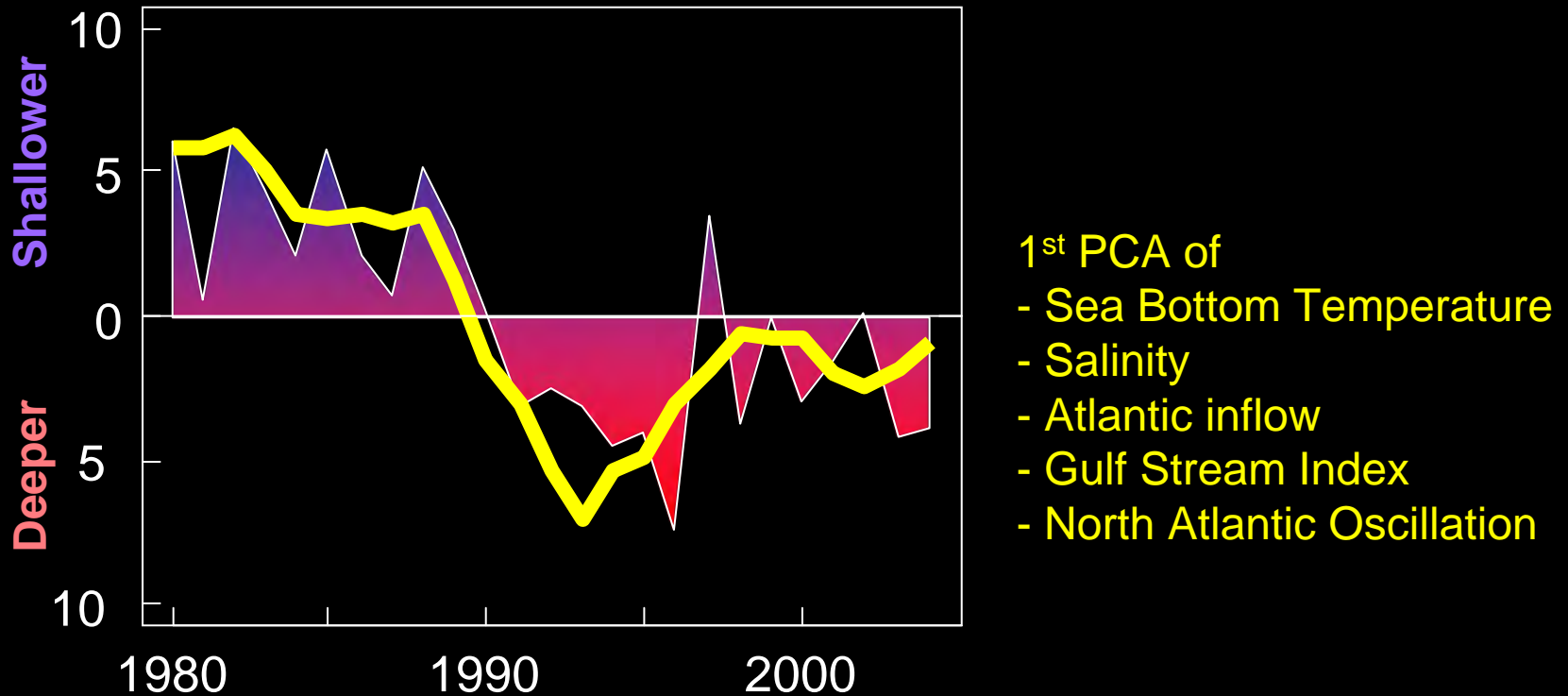




Assemblage scale responses to climate change

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

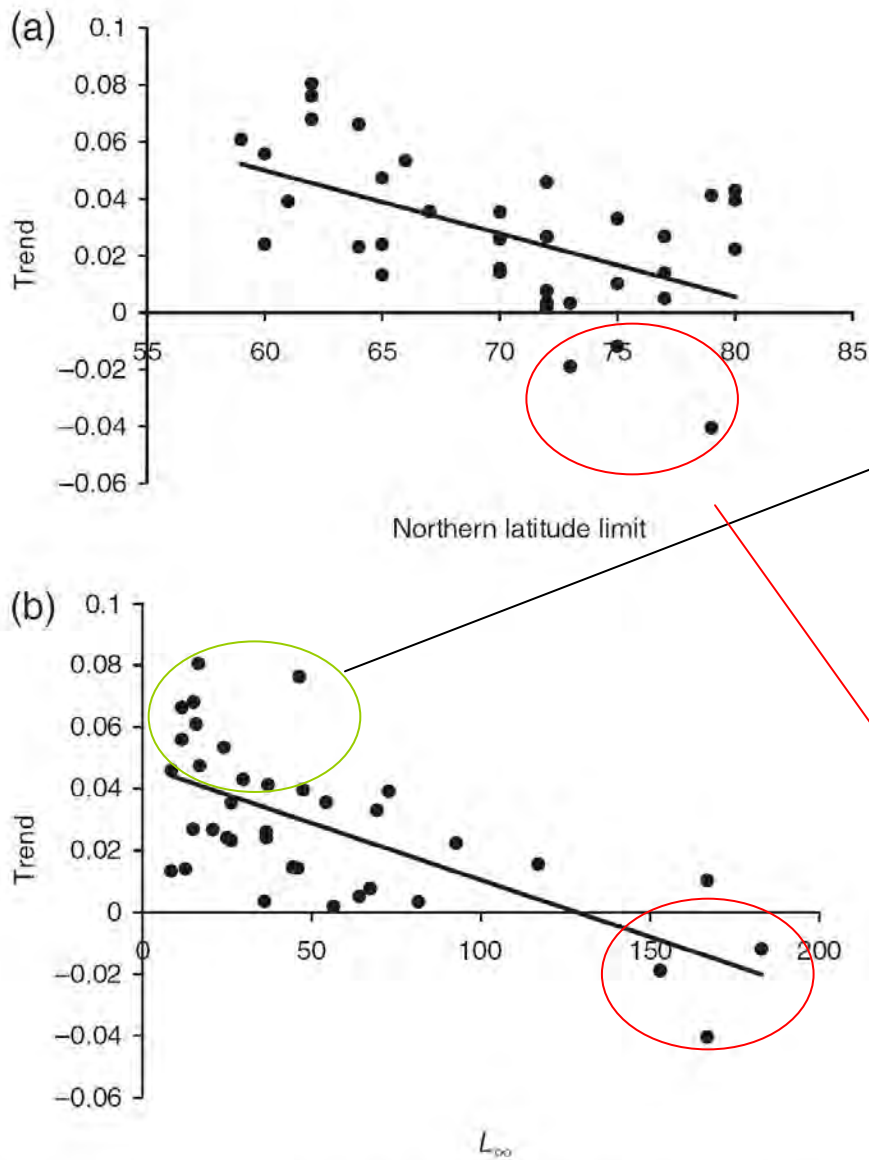
The whole fish assemblage has deepened by 3.6 m decade⁻¹, 22 species have deepened by 5.6 m decade⁻¹

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!)

Latitude response less coherent than the deepening response



Life histories drive a differential climate shift response

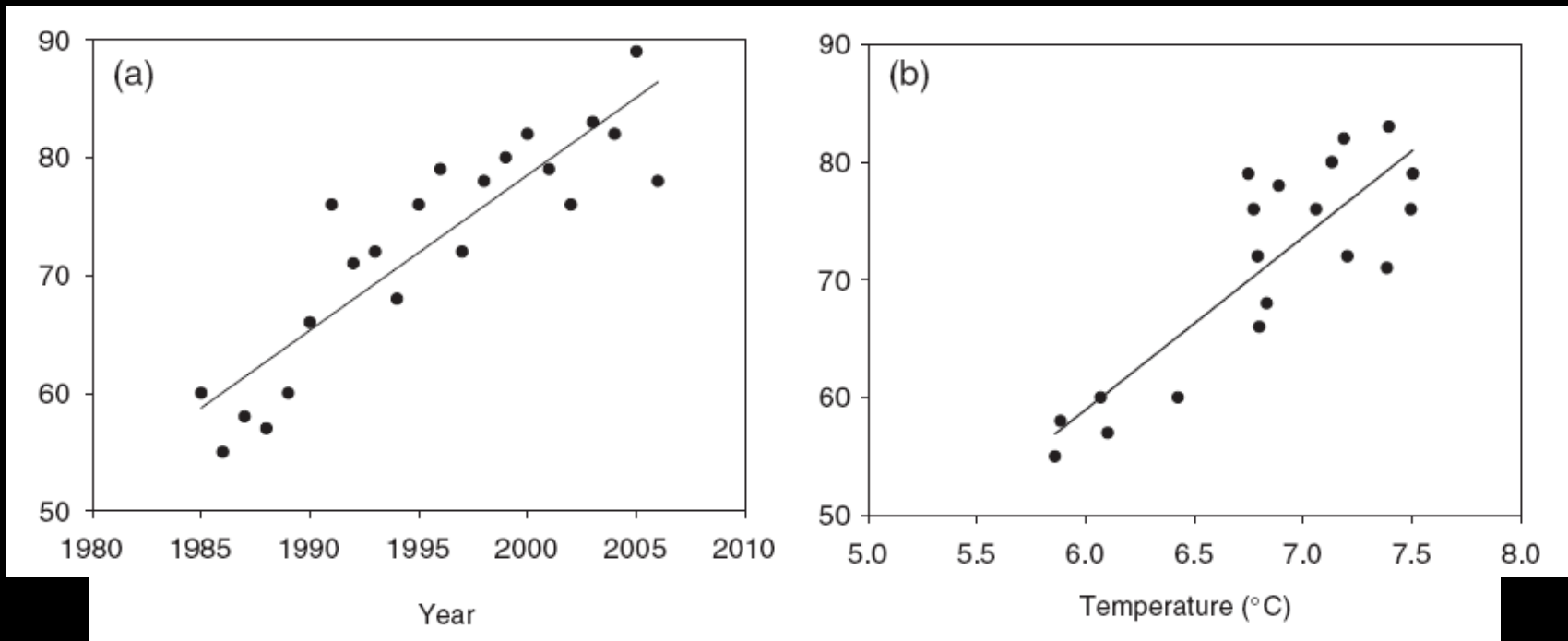


Few species decreasing
Wolffish *Anarhichas lupus*
Spurdog *Squalus acanthias*
Ling *Molva molva*

Fig. 4 Effect of (a) latitude limit and (b) life-history on distribution trends of fish species in the North Sea ($R^2 = 0.53$, latitude limit: $F_{1,34} = 6.2$, $P < 0.017$, L_{∞} : $F_{1,34} = 32.8$, $P < 0.0001$).

Hiddink, J.G. & ter Hofstede, R. (2007) Climate induced increases in species richness of marine fishes. *Global Change Biology*.

Fish species richness increasing over time with increasing temperature

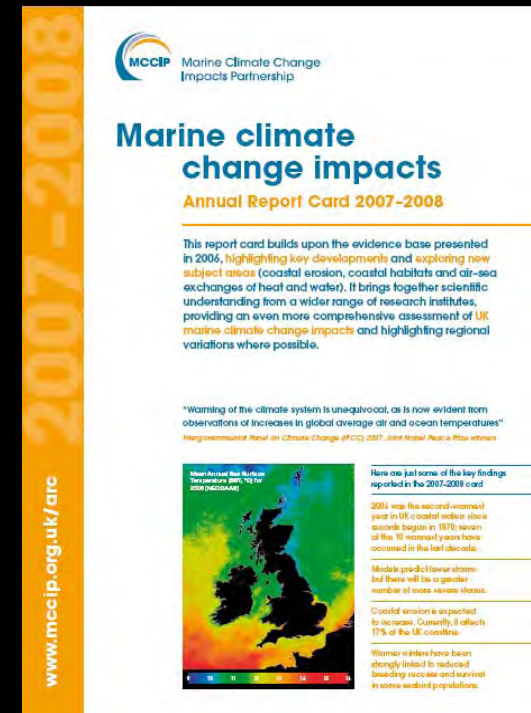




Where can I learn more?

The Marine Climate Change Impacts Partnership annual report card

- Last published 2008
- 60 scientists from 30 institutes contributed to 26 topics
- 8 page-summary card with headline messages
- Communicates **uncertainty** on each topic
- Peer-reviewed backing reports online
- Highlights changes to **ocean climate** (e.g. warming UK seas) and impacts on **biodiversity, cleanliness and safety** and **commercial interests**.
- 3rd full report card due in **summer 2010**



The screenshot shows the MCCIP Annual Report Card website. The navigation bar includes: Welcome, About MCCIP, Partners, News & events archive, Annual Report Card (selected), Ecosystem Linkages, and Contact us. The main content area is titled 'Fish' and is authored by Cefas, FRS, and MBA. It provides information from a joint scientific review on fish and fisheries. The page is divided into two columns: 'WHAT IS ALREADY HAPPENING' (Medium Confidence) and 'WHAT COULD HAPPEN' (Low Confidence). The 'Medium Confidence' section lists three bullet points about warm-water fish species, snake pipefish, and juvenile cod. The 'Low Confidence' section lists two bullet points about climate change impacts on fish populations and the need for more research on future impacts. At the bottom, there are seven expandable sections: Executive summary, Full scientific review (with references), Confidence assessments, Knowledge gaps, Commercial impacts, and Authors.

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2007-08

- Introduction
- Marine environment
- Healthy and diverse marine ecosystem
 - Plankton
 - Fish**
 - Marine mammals
 - Seabirds
 - Non-natives
 - Intertidal species
 - Seabed ecology
 - Coastal habitats
- Clean and safe seas
- Commercially productive seas
- Further details
- List of Contributors
- Feedback and contacts
- Glossary
- Download PDF version (462 KB)
- Welsh version (PDF, 460 KB)

2006

Fish

Cefas; FRS; MBA

Information provided on this page refers to 'fish' only but is taken from a joint scientific review on 'fish and fisheries' (see full scientific review)

WHAT IS ALREADY HAPPENING	WHAT COULD HAPPEN
<p>MEDIUM CONFIDENCE</p> <ul style="list-style-type: none">Abundances of warm-water fish species (e.g. red mullet, John Dory, triggerfish) have increased in UK waters during recent decades, while many cold-water species have experienced declines.There has been a notable influx of snake pipefish to UK waters since 2004, and research is under way to explain this.Poor 'recruitment' of juvenile cod may be associated with a climate-related shift in the composition of zooplankton, but also by a reduction of the adult, parental population by fishing.In some parts of the southern North Sea, cold-water species, such as cod and eelpout, have been shown to experience metabolic stress during warm years, as evidenced by slower growth rates and difficulties in supplying oxygen to body tissues.	<p>LOW CONFIDENCE</p> <ul style="list-style-type: none">Climate change will have far-reaching impacts on the dynamics of fish populations; however, current knowledge of underlying mechanisms is limited.Much less is understood about the possible future impacts of climate change on non-commercial fish species, compared to those targeted by fisheries.

- + Executive summary
- + Full scientific review (with references)
- + Confidence assessments
- + Knowledge gaps
- + Commercial impacts
- + Authors

- Access to full reviews

Collaborative reviews across institutes

- Individual topics with 'drop down' menus:

- Executive summaries
- PDFs of full reviews
- Confidence rationale
- Knowledge gaps
- Socio-economic impacts

- Online questionnaire

Raising the profile of UK marine climate change impacts

Media coverage of the 2007-2008 ARC launch

eGov monitor

The Press Association

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Climate change 'causes flood risk'
2 days ago

['Big climate impact' on UK coasts](#)

New report in Scotland says marine climate change on the increase

Source: Scottish Executive
Published Wednesday, 16 January, 2008 - 10:46

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Fishermen's grouping welcomes climate change move
Published: 16 January, 2008

RESPONDING today to the annual 'report card' produced at the meeting in Edinburgh of the Marine Climate Change Impacts Partnership, Scottish Fishermen's Federation chief executive Bertie Armstrong said he welcomed the forum as a means for providing clear information on the current status of climate change.

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British coasts under threat: govt report
January 16, 2008 - 3:54PM

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MCCIP predicts climate change will affect U.K.

Posted On: Jan. 16, 2008 3:26 AM CST
By [Stuart Collins](#)

LONDON—Industries that rely on the U.K.'s marine environment—shipping and fisheries—are likely to experience a significant impact change, according to a report published Wednesday.

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UK: Climate Change impact:
16 Jan 2008, 0938 hrs IST, AP

UK: Climate Change Impacts Coasts
By RAPHAEL G. SATTER - 2 days ago

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UK: Climate Change Impacts Coasts

LONDON (AP) — Climate change is warming Britain's waters, eroding it harming its marine wildlife and increasing the likelihood of devastating storms, the government said in a report published Wednesday.

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Last Updated: Wednesday, 16 January 2008, 10:57 GMT

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'Big climate impact' on UK coasts

Climate change is having a major impact on Britain's coast, the seas around the coast, and the life in those seas, a government-sponsored report concludes.

The Marine Climate Change Impacts Partnership (MCCIP) says seas are becoming more violent, causing coastal erosion.

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EcoSolutions

January 15, 2008 - Updated 0251 GMT (1051 HKT)

UK: Coasts under climate threat

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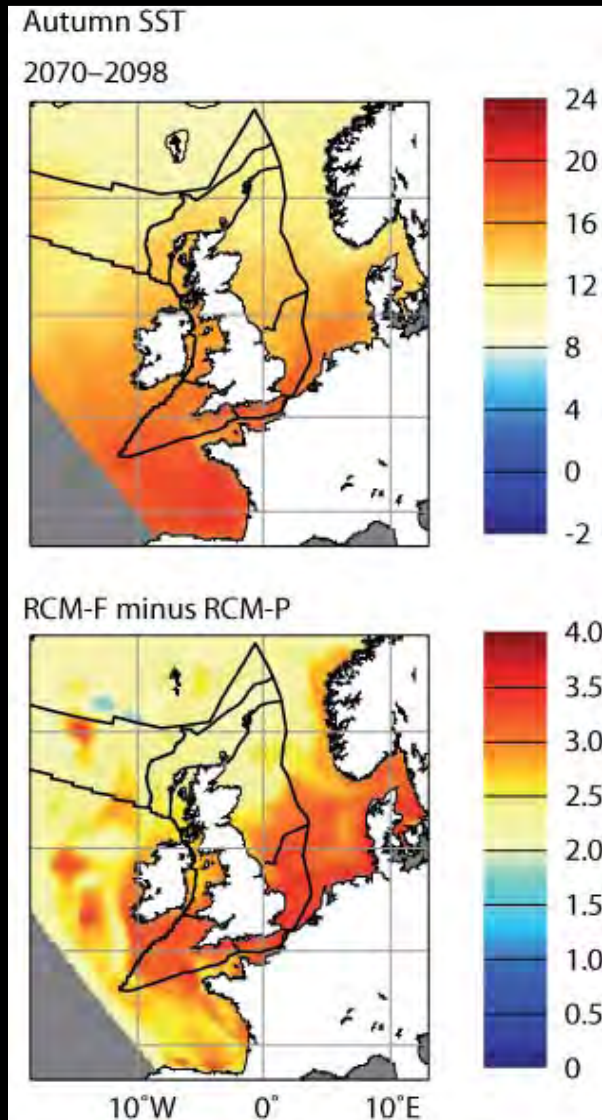
Changing climate 'is leading to rougher seas'
By Paul Eccleston
Last Updated: 12:01am GMT 16/01/2008

Climate change is having a significant impact on the health of the seas surrounding Britain, says a new report.

• **Britain on alert as floods threaten once more**



Rising seas, bigger waves, flooding, and more violent storms are already happening as temperatures increase.

MCCIP report card – Launch July 2010



- Almost 100 researchers from 40 institutes contributing to 31 topics.
- Over 30 specialist peer-reviewers.
- More regional level information and 'first look' at implications of latest UK marine scenarios
- **New topics**
 - human health impacts
 - air-sea CO₂ fluxes
 - waterbirds
 - deep sea habitats
- **Knowledge gaps and socio-economics**

MCCIP Ecosystem linkages report card 2009



Marine climate change impacts


Exploring ecosystem linkages

Understanding the links between climate change impacts on the oceans is a critical priority for our future wellbeing. By taking a new 'bigger picture' approach, we can start to show how the interconnected nature of the marine ecosystem magnifies the many discrete impacts of climate change, documented in the MCCIP Annual Report Cards.


To support this new approach, we asked five groups of leading scientific experts on issues such as ocean acidification, Arctic sea-ice loss, seabirds and food webs, non-native species, and coastal economies to give us their views.




CO₂ and ocean acidification
In the last 200 years, ocean acidity has increased by 30% and at a rate much faster than anytime in the last 65 million years. This has serious implications for marine ecosystems and climate regulation.




Arctic sea ice
In the last decade there has been a 35% decrease in summer sea ice extent and a 15% reduction in winter sea ice, leading to changes in habitats and ecosystems.



A view from above
Climate change has already caused changes in plankton, fish distribution and species composition in the seas around the UK. Declines in some seabird populations such as black-legged Kittiwakes, terns and skuas may continue as a result.



Non-native species
Most introductions of non-native species have arrived via human intervention, intentional or otherwise. The likelihood that they will establish and flourish in the UK marine environment could be greater due to climate change.



Coastal economies and people
Many of our coastal communities will face both challenges (e.g. increased flood and erosion risks, declining traditional fisheries) and opportunities (e.g. new tourism patterns, new fisheries) through climate change.

PHOTOS from top: National History Museum; Shutterstock.com/stephphd; Linné Sjöström; Paul Newman/McGill; Davey Brown.

www.mccip.org.uk/eir

- MCCIP launched a new product in mid-2009 looking at **ecosystem connections**:

- Topics focus down from **broad scale to local scale issues** (acidification – arctic sea ice - food webs - non-natives - coastal economies and people)

- Aimed to help politicians, policy makers, advisors and stakeholders **understand how marine climate change impacts come together.**

Summary

Climate change is already affecting fishes and ecosystems and will potentially have profound effects in the near future

Understanding the response of fishes and fisheries will be challenging and we may not be able to wait for the necessary mechanistic detail

But beware of invasions and ecological surprises

Considerable latitudinal and depth changes and species turnover

There is a broad life history link to the degree of response, this may be muted in low connectivity areas, such as the Baltic and Wadden Sea.

If you can't move you die. Might expect higher local extinction rates in enclosed seas with lower connectivity.