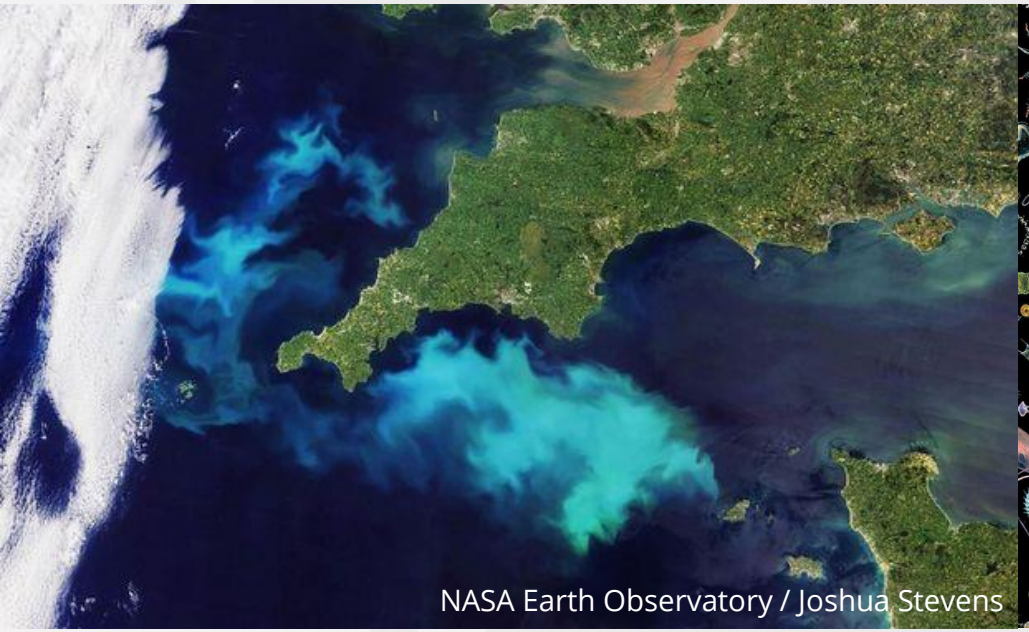
Shifts in benthic-pelagic coupling induced by climate change and implications for temperate reef ecosystems

NEA PANACEA

North East Atlantic project on biodiversity and eutrophication assessment integration and creation of effective measures

Matthew Holland*, Abigail McQuatters-Gollop


NASA Earth Observatory / Joshua Stevens


Christian Sardet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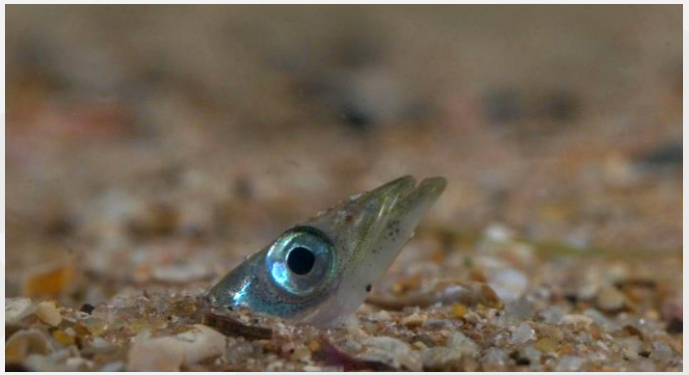
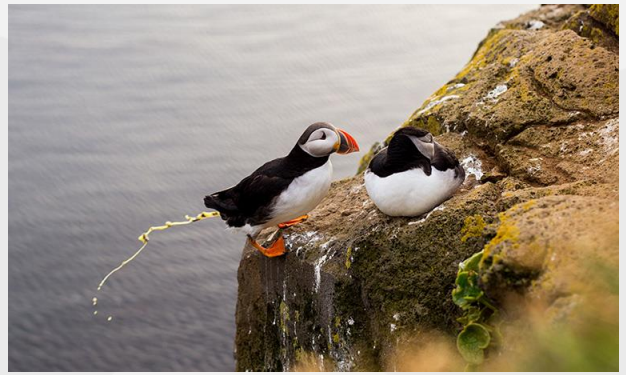
Cross-ecosystem subsidies Marine → Terrestrial









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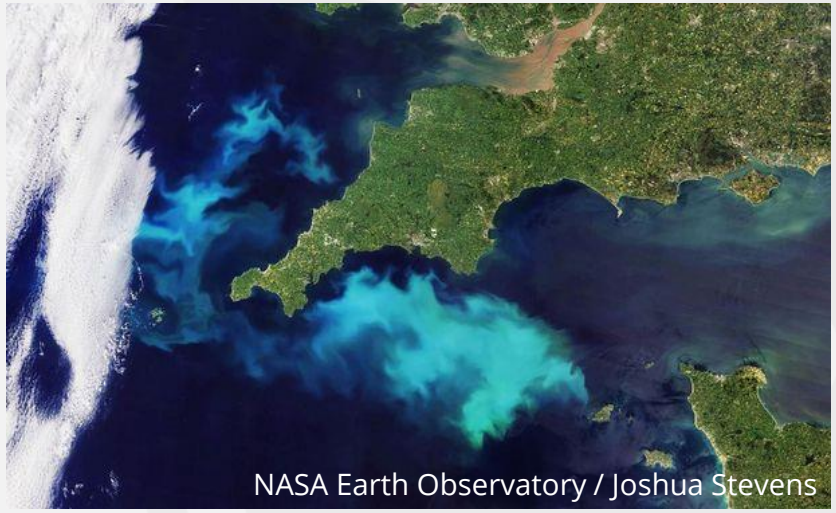
Marine → Terrestrial

Cross-ecosystem subsidies: Marine → Marine



- Boundaries between marine systems are far less discrete / more open than marine to terrestrial boundaries
- Marine → Marine cross-ecosystem subsidies are less visible/obvious and typically involve more steps
- Despite this, the level of connectivity among marine systems typically far greater than Marine → Terrestrial

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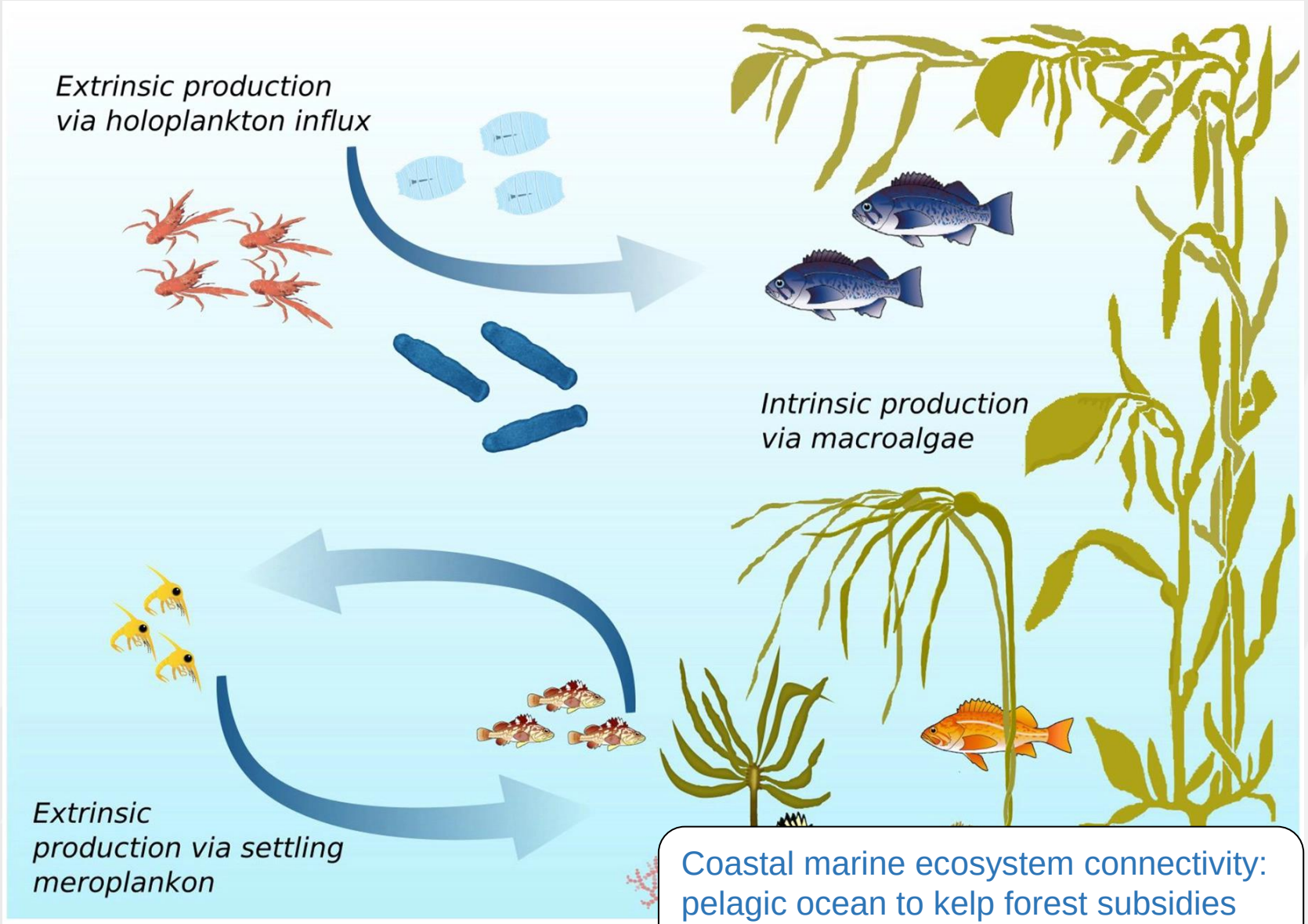
Connectivity of benthic and pelagic habitats

- Local benthic productivity contributes to coastal ecosystems
- Benthic production either consumed locally or exported as detritus
- This only supports a portion of consumer biomass
- Pelagic subsidies supporting coastal ecosystems can be produced over much larger area
- To contribute, plankton must be captured and retained
- This role is fulfilled by planktivorous fishes and sessile invertebrates



Coastal marine ecosystem connectivity: pelagic ocean to kelp forest subsidies
Zuercher and Galloway (2019)

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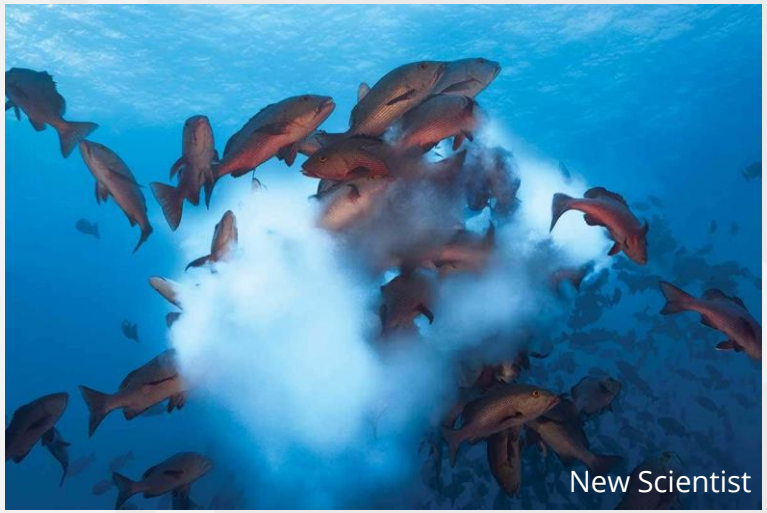
Cross-ecosystem subsidies via pelagic larvae of benthic fauna



- Pelagic ecosystems further subsidise benthic ecosystems through providing temporary habitat for benthic offspring
- Meroplankton: pelagic larvae of benthic invertebrates

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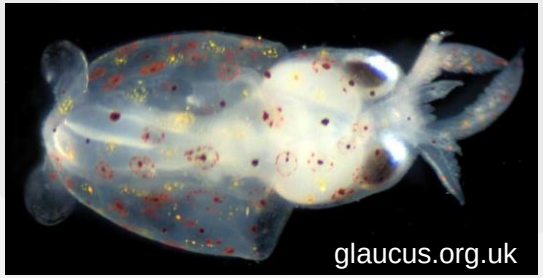
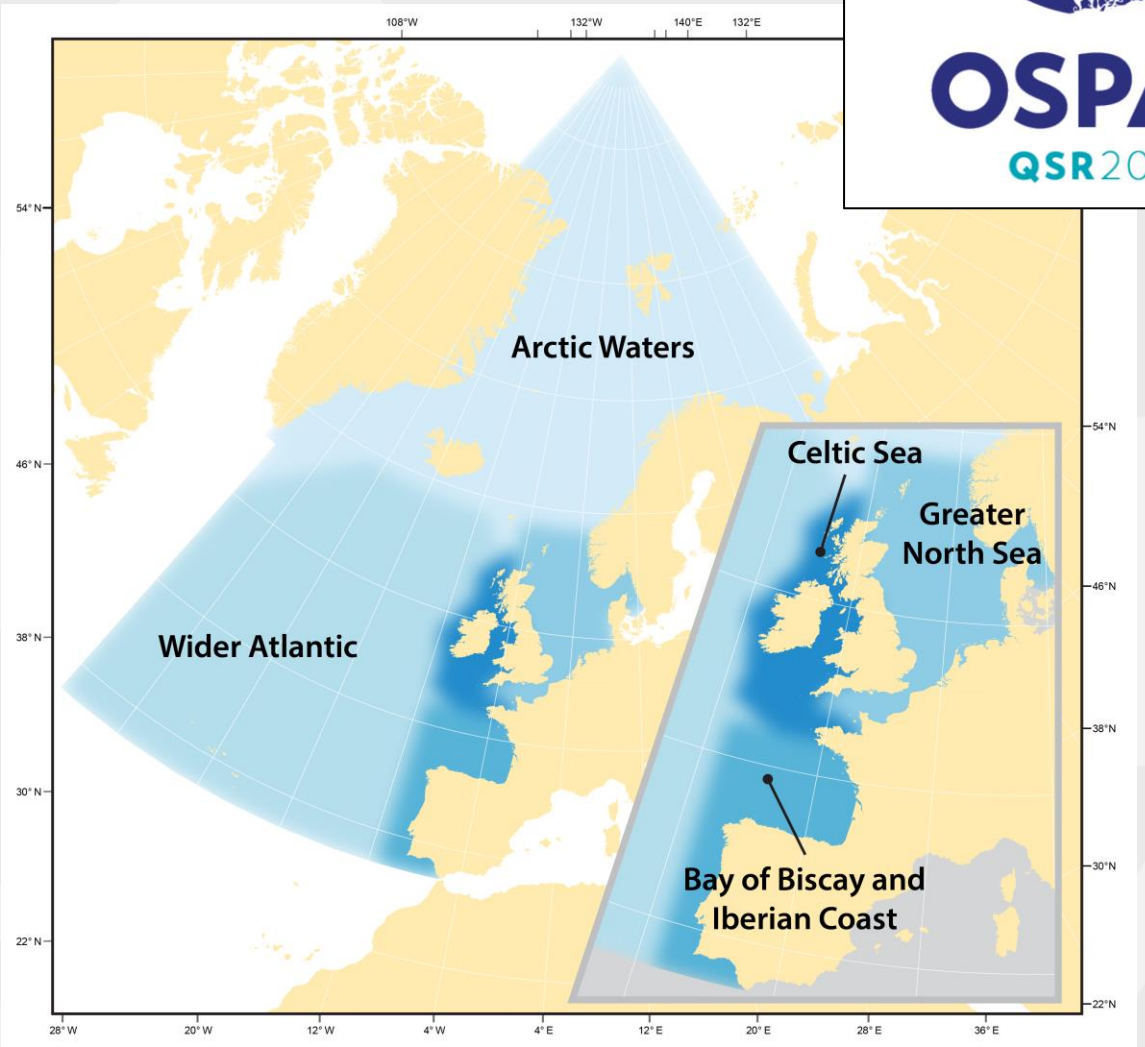
Holoplankton

Meroplankton



OSPAR and the Quality Status Report 2023

- OSPAR Convention – Regional seas convention for the protection of the marine environment in the North-East Atlantic
- Cooperation among 14 European member countries
- Most comprehensive marine environmental assessment ever attempted
- Working groups covering fish, birds, mammals, benthic habitats, pelagic habitats, and more!



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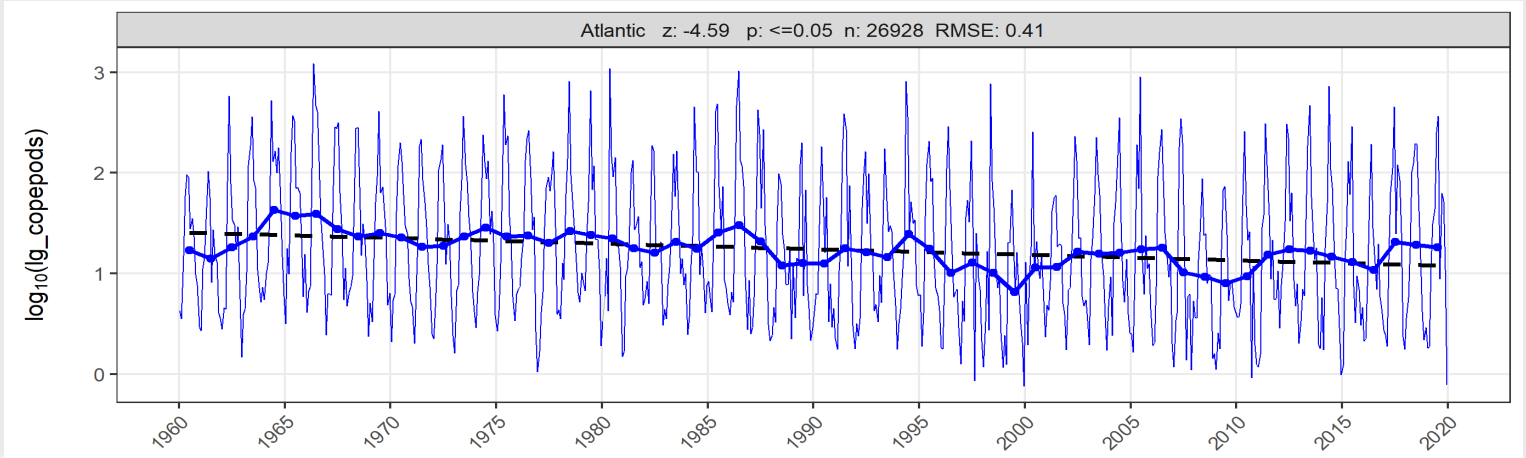
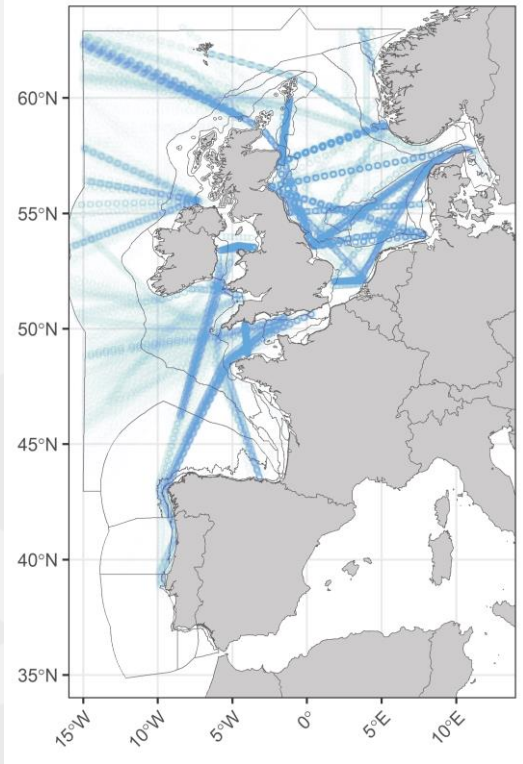
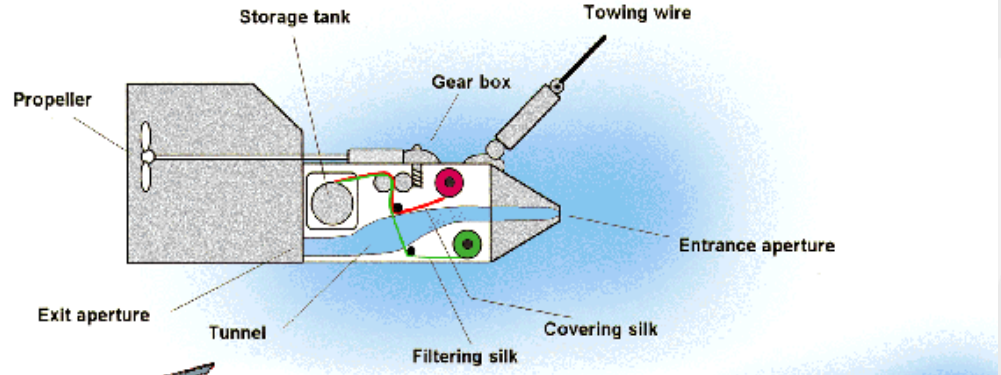
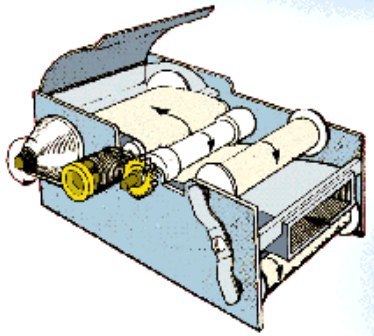
What about the data?

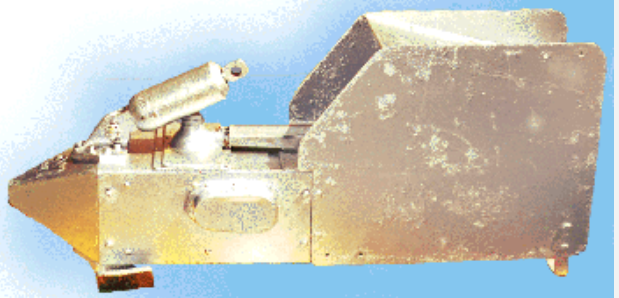
- 60 years of Continuous Plankton Recorder (CPR) data to assess long-term change
- Longest running, large-scale marine biological survey in the world
- Towed from ships of opportunity (cargo ships, ferries, research vessels)
- Flow-through of seawater onto moving silk, automatically preserved in formalin
- All analysed via light microscopy in Plymouth, UK











Studying changes in pelagic habitats

Objectives

1. Determine how meroplankton and holoplankton abundances in the Northeast Atlantic have changed over the past 60 years

2. Rationalise what changes detected in pelagic communities can tell us about how benthic ecosystems are changing

3. Determine potential implications of these changes for marine food webs

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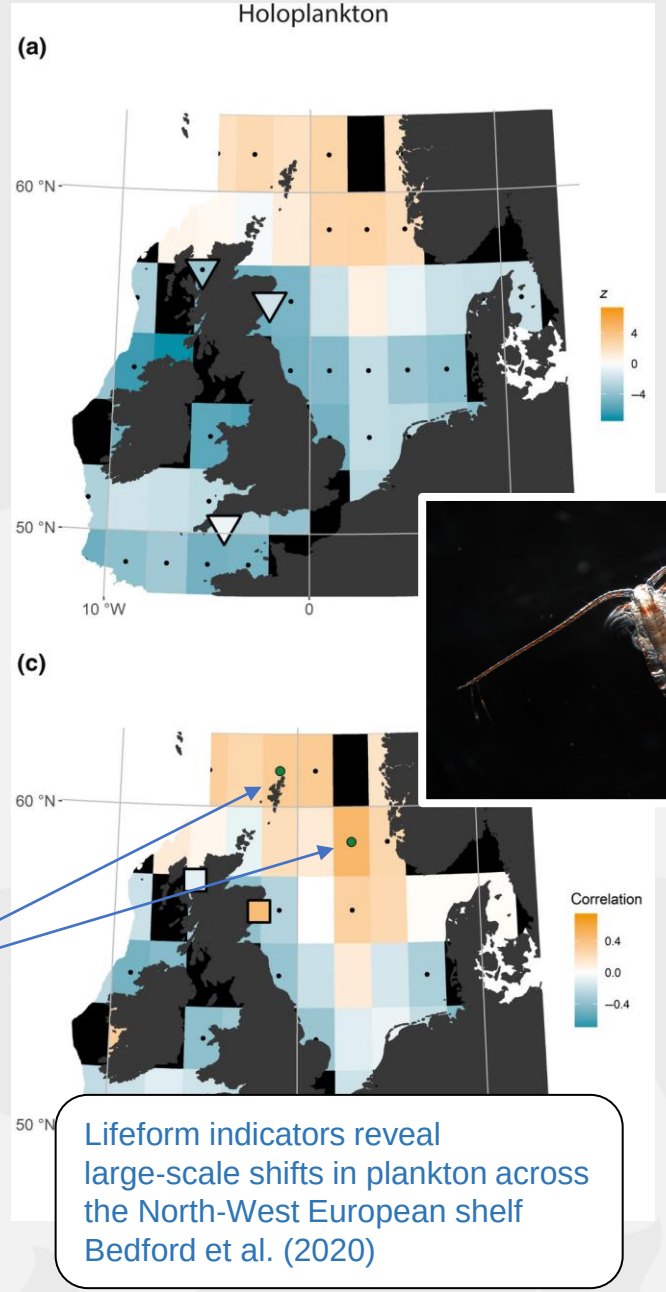
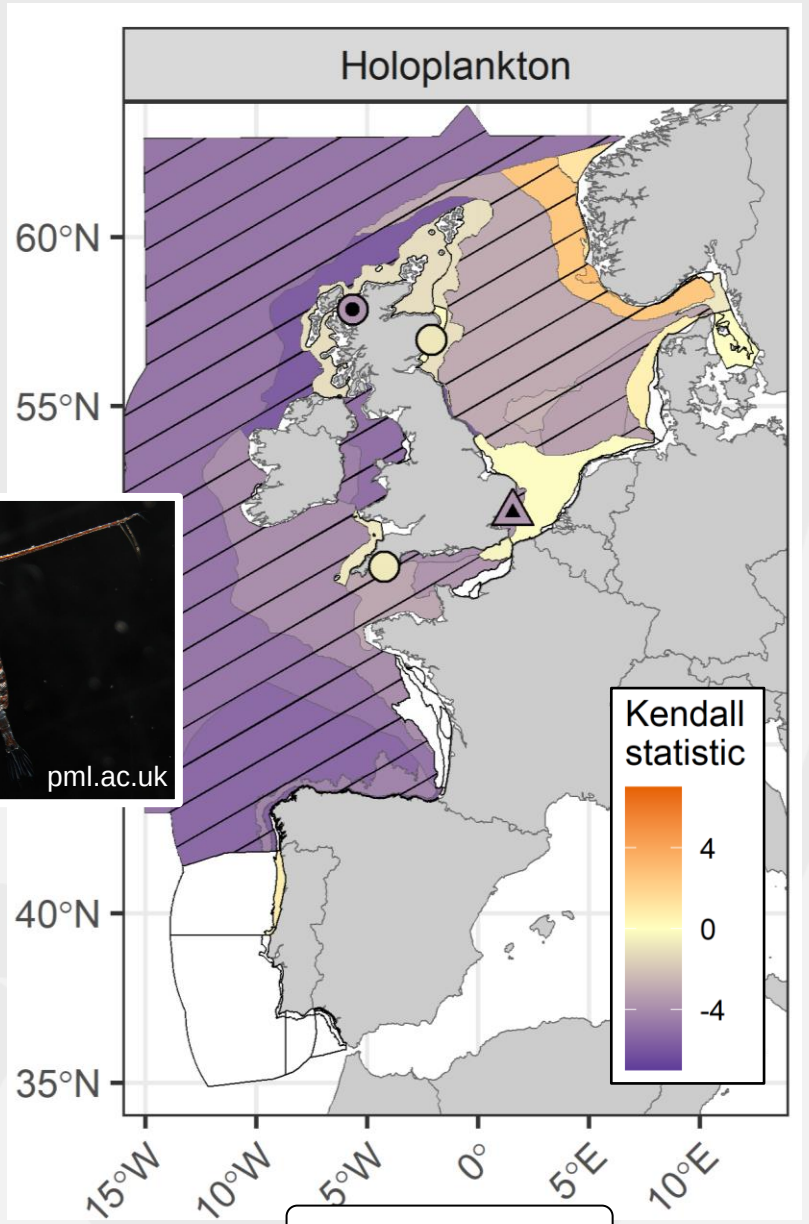
Changes in holoplankton

- Median decrease in holoplankton abundance was ~7% decade^{-1} from 1960 to 2020
- Slightly increasing along Norwegian coast and decreasing in North Sea and Celtic Seas
- Extended time-series from a previous study
- Observed similar changes in holoplankton abundance
- Little evidence of correlation with SST (green circles: $p < 0.05$)



Lifeform indicators reveal large-scale shifts in plankton across the North-West European shelf
Bedford et al. (2020)



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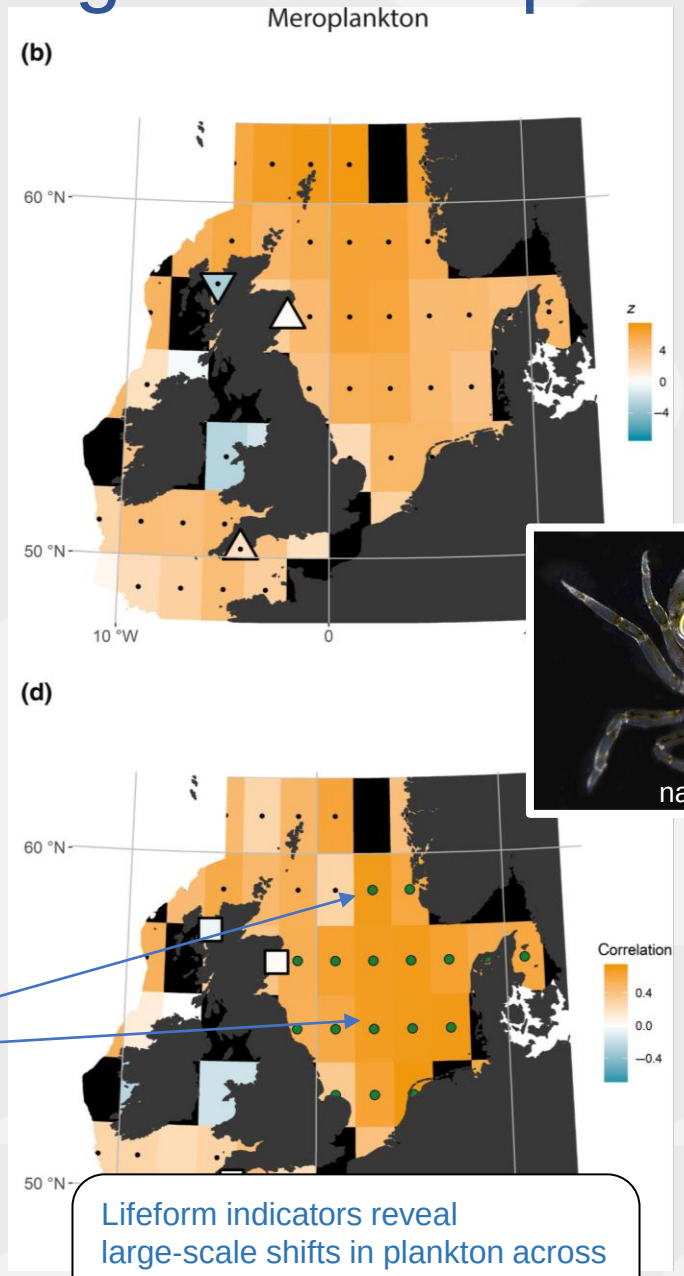
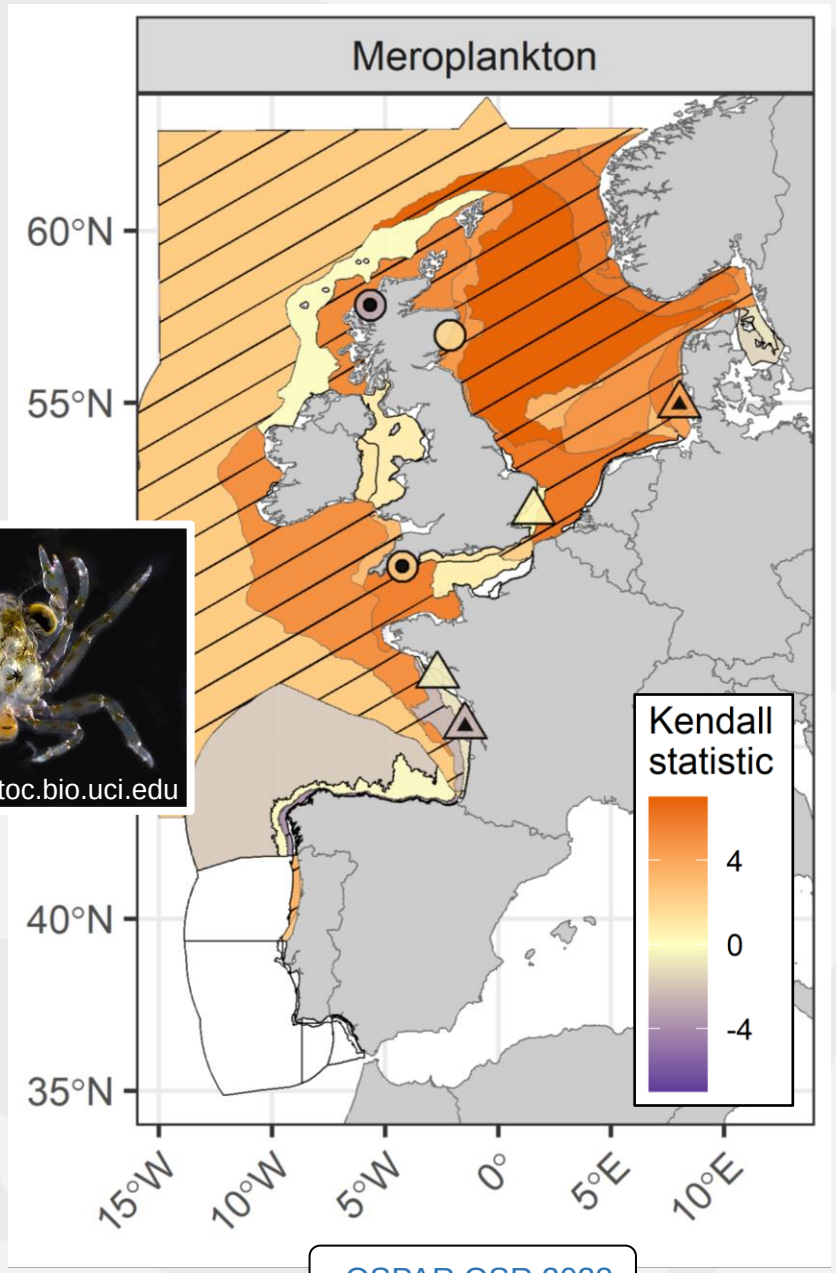
Changes in meroplankton

- Mean increase in meroloplankton abundance was ~12% decade^{-1} from 1960 to 2020
- Also observed similar changes in meroplankton abundance in previous study
- Increasing abundance nearly everywhere
- Change in meroplankton abundance shows strong correlation with SST (green circles: p < 0.05)





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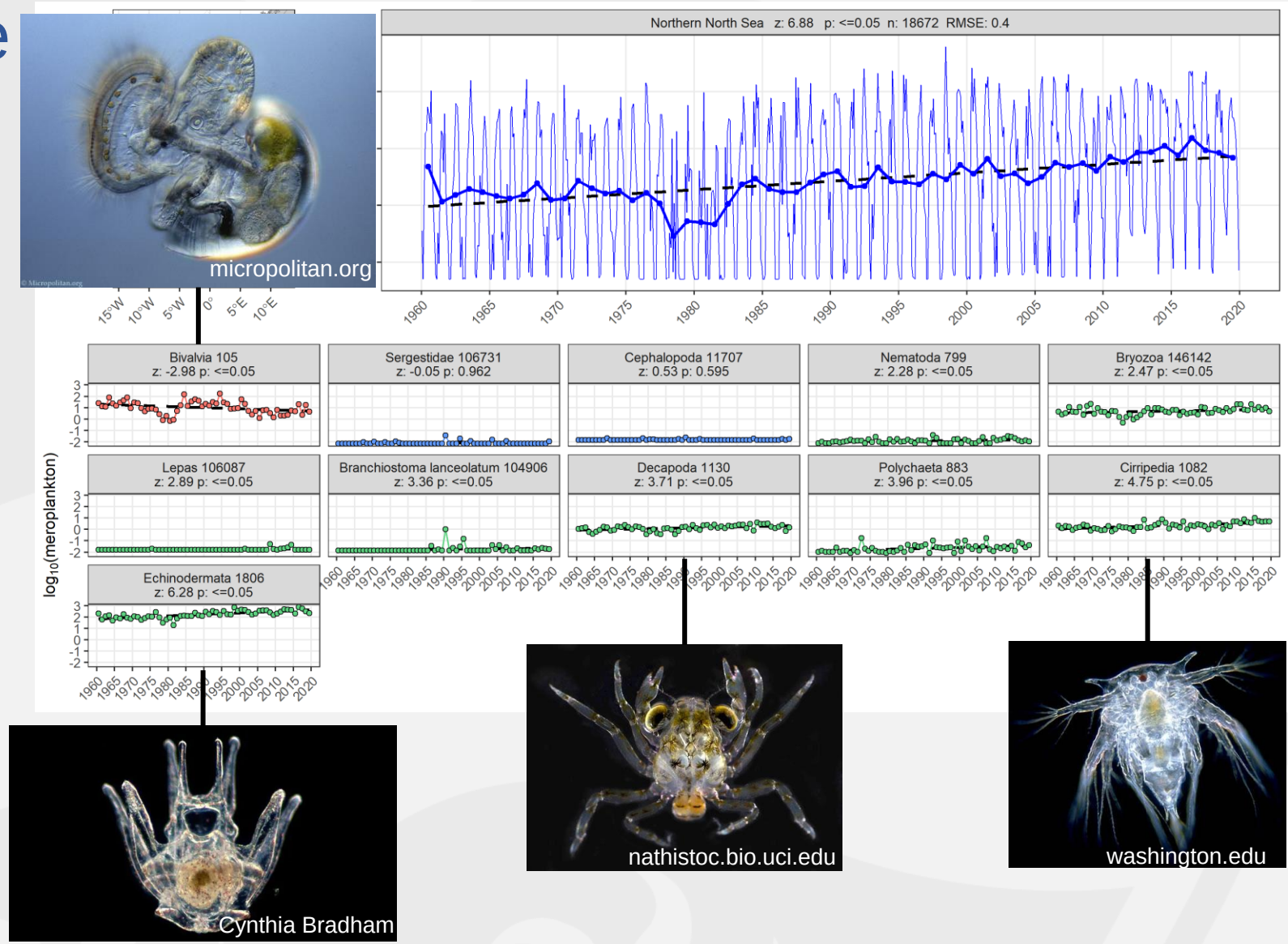
How might temperature affect meroplankton?

- However, not all meroplankton taxa respond positively to temperature
- Obvious increasing trend in decapods, echinoderms, and cirripedes
- Only meroplankton subgroup showing decrease is bivalves



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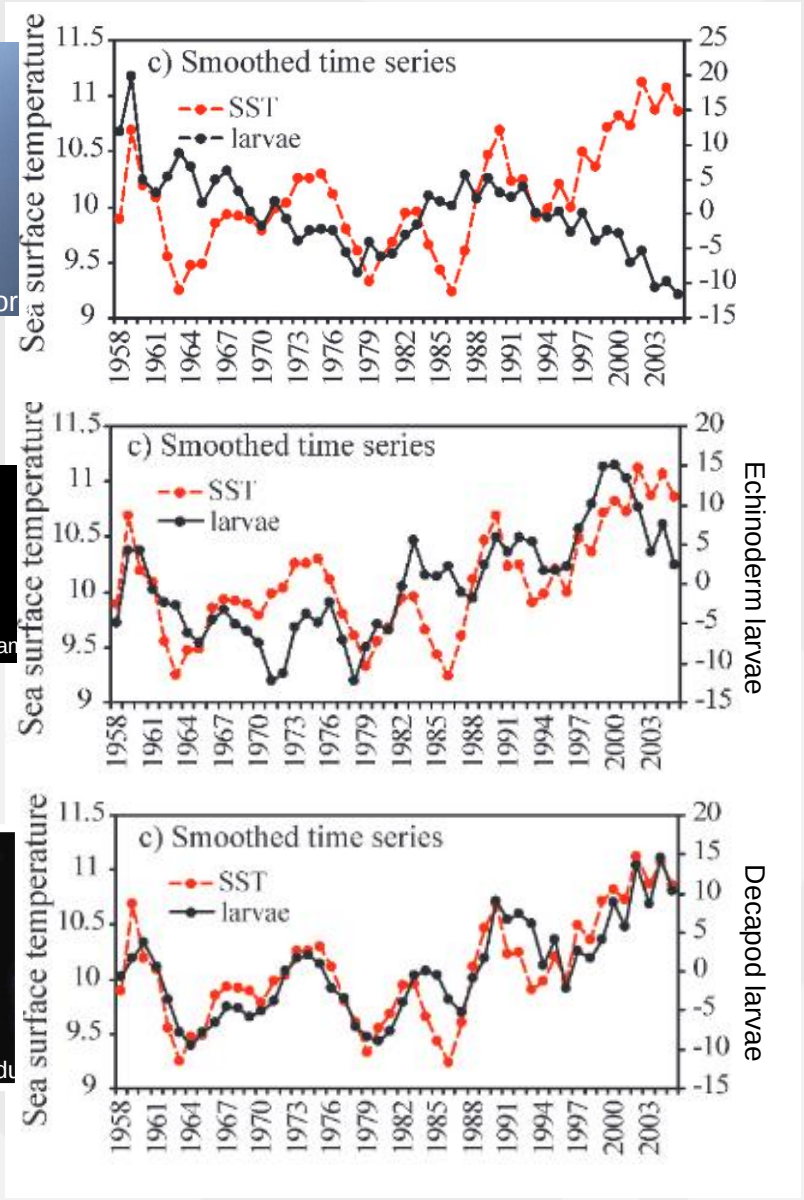
Increase in meroplankton linked to rising temperature

- Trends in echinoderms, decapods, and bivalves also described in Kirby, Beaugrand and Lindley (2008)
- Trends in echinoderms and decapods closely track SST
- Trends in bivalves show negative correlation with SST since early 1990s
- Kirby, Beaugrand and Lindley (2008) only examined CPR time-series up until 2004
- We observed the same trends continuing through 2020



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Climate-induced effects on the meroplankton and the benthic-pelagic ecology of the North Sea
Kirby, Beaugrand and Lindley (2008)

Potential consequences for benthic habitats

- Likely winners and losers under climate change
- Higher temperatures increase reproductive output of many benthic invertebrates
- Newly settled decapods feed on newly settled bivalves
- Possible increase in adult decapods could inflict greater predation pressure on adult bivalves
- Ecosystem-wide restructuring of trophic interactions

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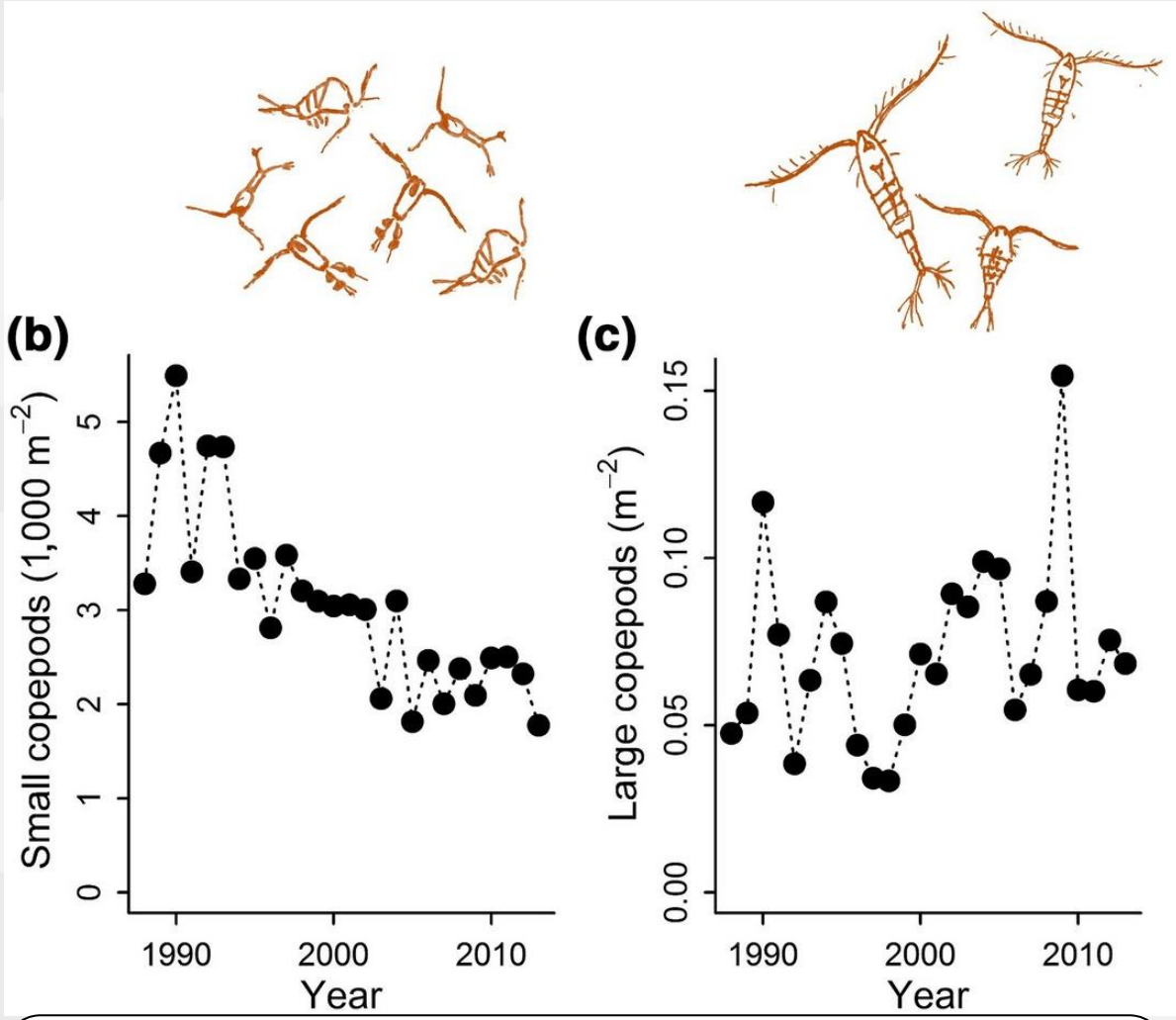
Implications for the future

- Decline in holoplankton likely associated with increased summer stratification and reduced mixing, lower replenishment of nutrients
- Very concerning for continued productivity of pelagic food webs
- Reduced holoplankton production could also ultimately impact pelagic subsidies to benthic habitats
- Increased meroplankton abundance could potentially be positive, particularly if the increasing groups are exploited species.
- However, impacts of increased decapod abundance on bivalves warrants further investigation.



A decline in primary production in the North Sea over 25 years, associated with reductions in zooplankton abundance and fish stock recruitment
Capuzzo et al. (2008)

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Digging deeper into benthic-pelagic coupling

- Develop more detailed traits list for meroplankton and holoplankton to better understand taxonomic sub-groups most affected by climate change
- Which decapods are increasing? Are they commercially exploited species? Unintended climate change benefits?
- Study benthic grab data to understand how changes in meroplankton relate to changes in the abundance of benthic adults

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