Global Warming, Fish and Fisheries

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Ocean Conservation Masterclass
(Lecture 7 of 10)
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As you know, things are heating up…
Observed climate-induced shifts in distribution ranges

Poleward shifts in distribution ranges of marine species, e.g., in the North Sea (Perry et al. Science, 2005).
Simulating poleward shifts using temperature-abundance profiles...

Small yellow croaker

*(Larimichthys polyactis)*

**Probability of occurrence by water temperature**

![Map of temperature-abundance profiles](image)

- **Relative abundance**
  - Low
  - High

![Graph showing probability of occurrence](image)

- **Probability of occurrence**
  - 0.00
  - 0.05
  - 0.10
  - 0.15
  - 0.20

- **Temperature (degree C)**
  - 2
  - 4
  - 6
  - 8
  - 10
  - 12
  - 14
  - 16
  - 18
  - 20
  - 22
  - 24
  - 26
  - 28
Small yellow croaker

Year 0
Small yellow croaker

Year 2
Small yellow croaker

Year 4
Small yellow croaker

Year 6
Small yellow croaker

Year 8
Small yellow croaker

Year 10
Small yellow croaker
Small yellow croaker

Year 14
Small yellow croaker

Year 16
Small yellow croaker

Year 18
Small yellow croaker

Year 20
Small yellow croaker

Year 22
Small yellow croaker

Year 24
Small yellow croaker

Year 26
Small yellow croaker

Year 28
Small yellow croaker

Year 30
Baldchin groper, Western Australia

Year 2001

Low relative abundance

Relative abundance
0 - 0.00015
> 0.0015 - 0.0038
> 0.0038 - 0.0062
> 0.0062 - 0.0095
> 0.0095 - 0.012
> 0.012 - 0.016
> 0.016 - 0.023
> 0.023 - 0.030
> 0.030 - 0.040
> 0.040

High abundance
Baldchin groper, Western Australia
Baldchin groper, Western Australia
Baldchin groper, Western Australia
Baldchin groper, Western Australia
Baldchin groper, Western Australia
Baldchin groper, Western Australia
Baldchin groper, Western Australia
Cheung, Lam, Kearney, Sarmiento, Watson and Pauly (Fish and Fisheries, 2009)
Fish have been migrating to cooler water so we just parked here and got the last of them.

And to all a good night.
Projected change in catch potential in 50 years

Cheung, Lam, Kearney, Sarmiento, Watson, Zeller and Pauly (Global Change Biology, 2009)
Changes in catch potential by EEZs

Cheung, Lam, Kearney, Sarmiento, Watson, Zeller, Pauly (2009, Global Change Biology)
Shrinking of fishes exacerbates impacts of global ocean changes on marine ecosystems


Now recall that fishes breathe through gills…

But we don’t realize how difficult it is…
Why fish shrink when the water gets warm and they can’t leave

A

Gill area / body weight (or relative O₂ consumption)

\[ K_1 \]

Maintenance metabolism

Body weight

\[ W_{\infty 1} \]

B

G-line

\[ K_1 \]

Maintenance metabolism

Body weight

\[ W_{\infty 2} \]
Predicted changes in assemblage-level maximum body weight by 2050 relative to 2000

• Assemblage-averaged $W_\infty$ is projected to decrease by 14 – 24% from 2001 to 2050 (20-year average);

• Changes in the tropics and temperate regions are predicted to be large, with an average reduction of around 20%.

Source: Cheung, Sarmiento, Dunne, et al. (2012) Nature Climate Change
Moreover, we shouldn’t forget that global warming already began several decades ago…

Ocean warming in the 4 decades from 1970 to 2009 (from Hadley Centre)
And thus we did now what we could have done years ago...

Signature of ocean warming in global fisheries catch

William W. L. Cheung¹, Reg Watson² & Daniel Pauly³

Marine fishes and invertebrates respond to ocean warming through distribution shifts, generally to higher latitudes and deeper waters. Consequently, fisheries should be affected by 'tropicalization' of catch⁴ (increasing dominance of warm-water species). However, a signature of such climate-change effects on global fisheries catch has so far not been detected. Here we report such an index, the mean temperature of the catch (MTC), that is calculated from the average inferred temperature preference of exploited species weighted by their annual catch. Our results show that, after accounting for the effects of fishing and large-scale oceanographic variability, global MTC increased at a rate of 0.19 degrees Celsius per decade between 1970 and 2006, and non-tropical MTC increased at a rate of 0.23 degrees Celsius per decade. In tropical areas, MTC increased initially because of the reduction in the proportion of subtropical species catches, but subsequently stabilized as scope for further tropicalization of communities became limited. Changes in MTC in 52 large and increased vulnerability of many coastal fisheries to climate change, particularly in the tropics⁶. Climate change effects on some fisheries have been detected¹⁴,¹⁵. For example, the rapid increase in catches of red mullet (Mullus barbatus), a warm-water species, around the UK is suggested to be related to ocean warming¹⁵. However, a signature of the effect of climate change on global fisheries has so far not been demonstrated. Because marine fisheries contribute to the economy and food security of many coastal communities, fisheries’ responses to climate change need to be better understood to inform the development of effective management and adaptation policies⁷.

Shifts in distributions of exploited stocks are expected to affect their availability to fisheries. Spatial distributions of marine fishes and invertebrates are strongly dependent on the relationship between physiological optima and limits under different temperatures, oxygen levels and other biotic and abiotic conditions¹⁶,¹⁷. Organisms living in temperatures outside their thermal optima experience reduced aerobic
We invented a new indicator: the ‘Mean Temperature of Catch’ (MTC)

Median preferred temperature = 8 °C
Median preferred temperature = 10 °C
Median preferred temperature = 12 °C
Median preferred temperature = 6 °C

MTC = Average preferred temperature weighted by the catch
Trends in the ‘Mean Temperature of the Catch’ in two climate types.
The Yellow Sea and the East China Sea, China
Summarizing the ocean warming effects:

**Subtropic and temperate ocean**

![Subtropic and temperate ocean diagram](image)

**Tropics**

![Tropics diagram](image)

Finis!