

An aerial photograph of a long, straight pier extending from a coastline into the ocean. The pier is supported by numerous vertical pilings and has a road with a few vehicles on it. At the end of the pier, there is a small structure. The ocean is dark blue with white-capped waves breaking near the shore. The sky is a deep blue with scattered white clouds. In the bottom right corner, there are some red flowers in the foreground.

Anticipated Impacts of Global Warming On the Coldwater Prawn Fishery

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International Coldwater Prawn Forum (ICWPF)

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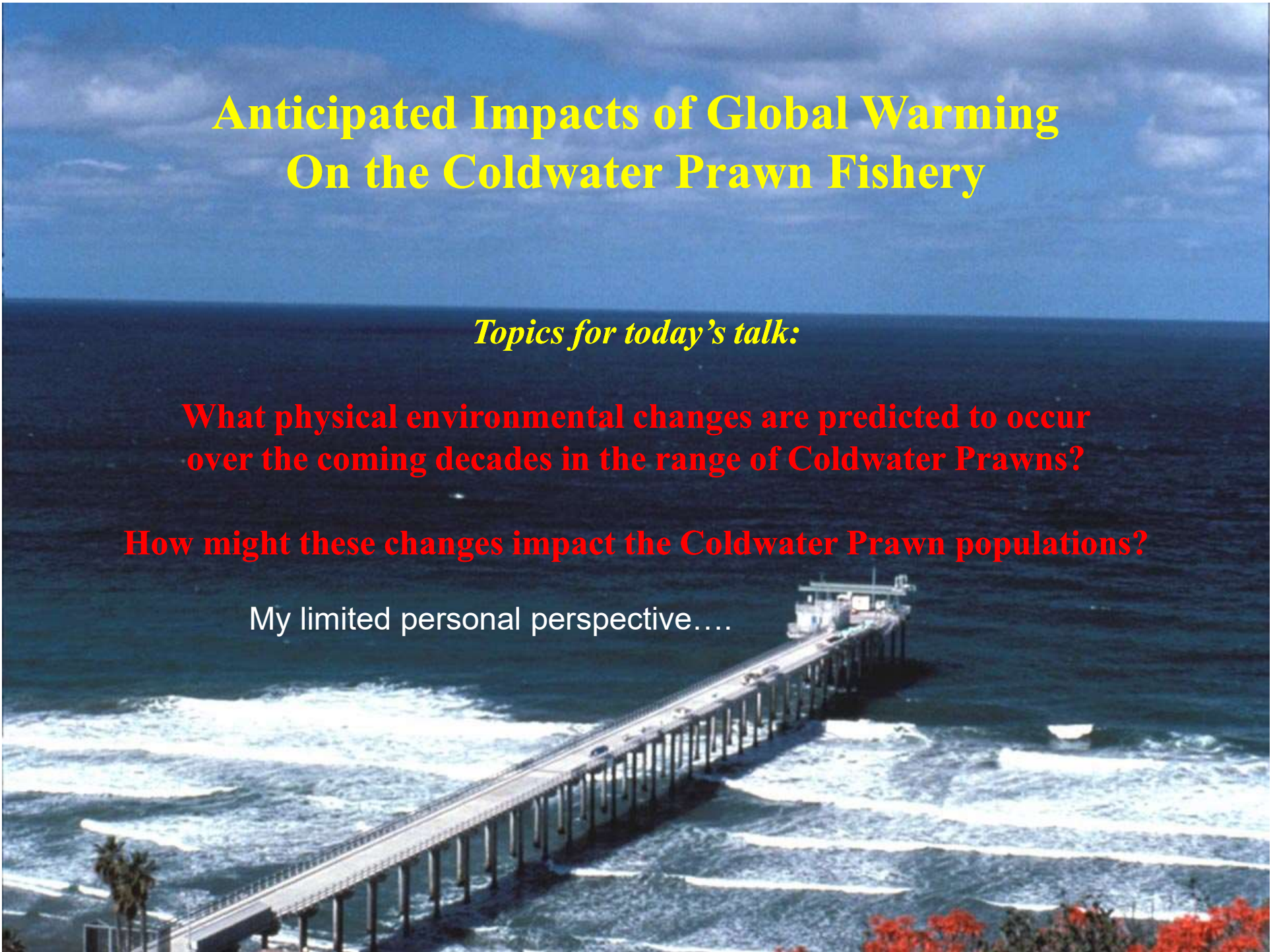
Anticipated Impacts of Global Warming On the Coldwater Prawn Fishery

Topics for today's talk:

**What physical environmental changes are predicted to occur
over the coming decades in the range of Coldwater Prawns?**

How might these changes impact the Coldwater Prawn populations?

My limited personal perspective....



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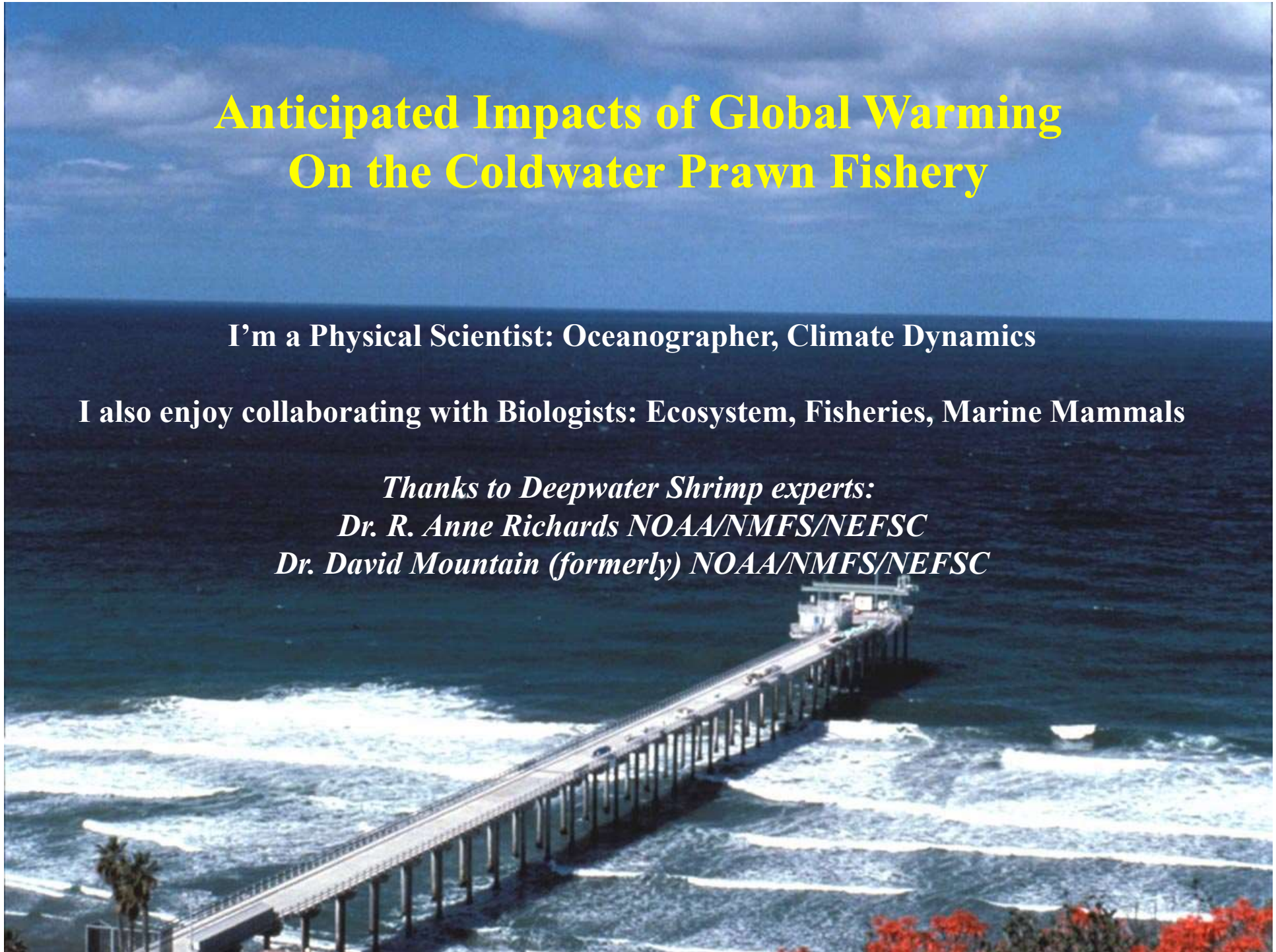
I'm a Physical Scientist: Oceanographer, Climate Dynamics

I also enjoy collaborating with Biologists: Ecosystem, Fisheries, Marine Mammals

Thanks to Deepwater Shrimp experts:

Dr. R. Anne Richards NOAA/NMFS/NEFSC

Dr. David Mountain (formerly) NOAA/NMFS/NEFSC

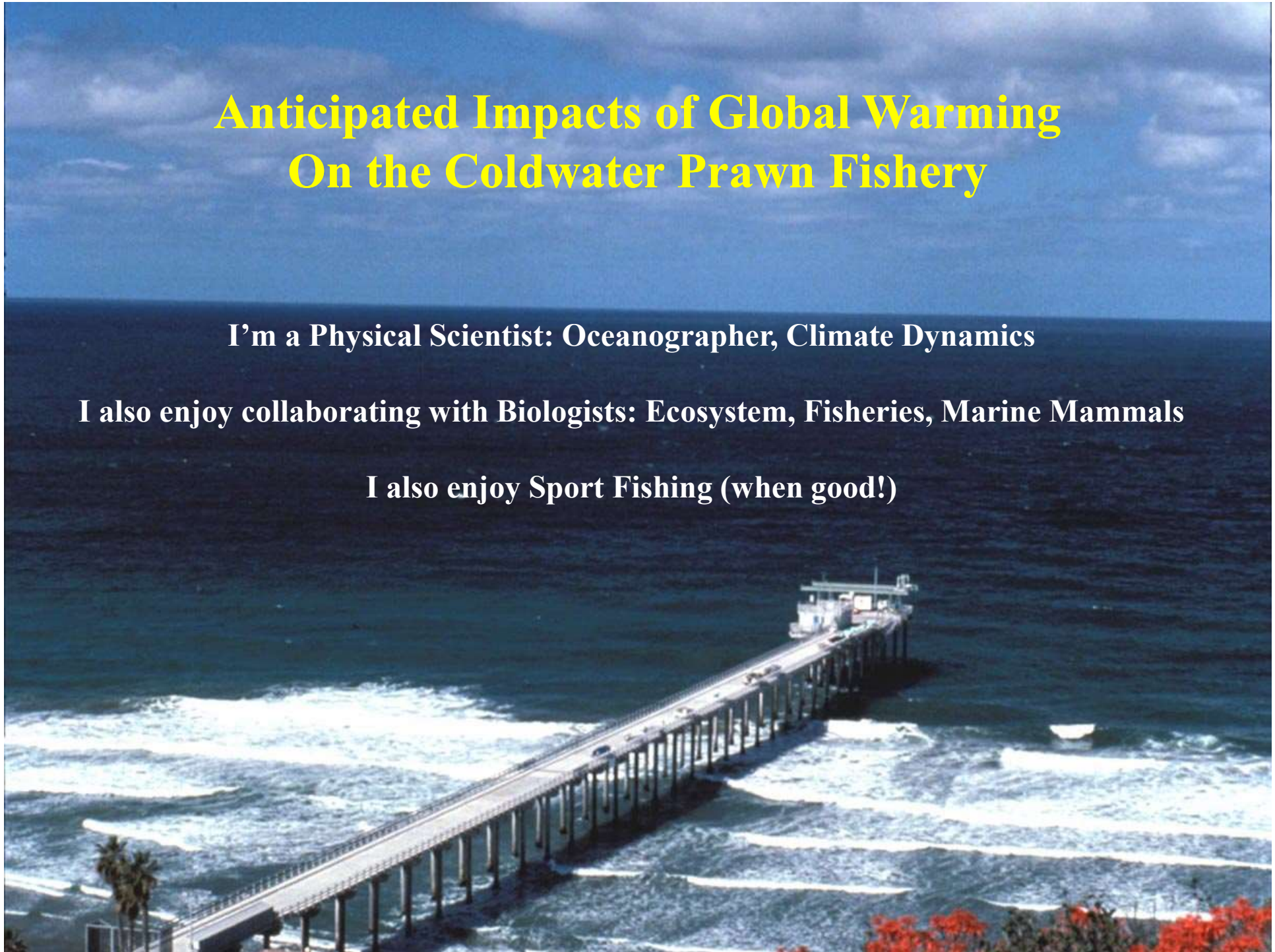


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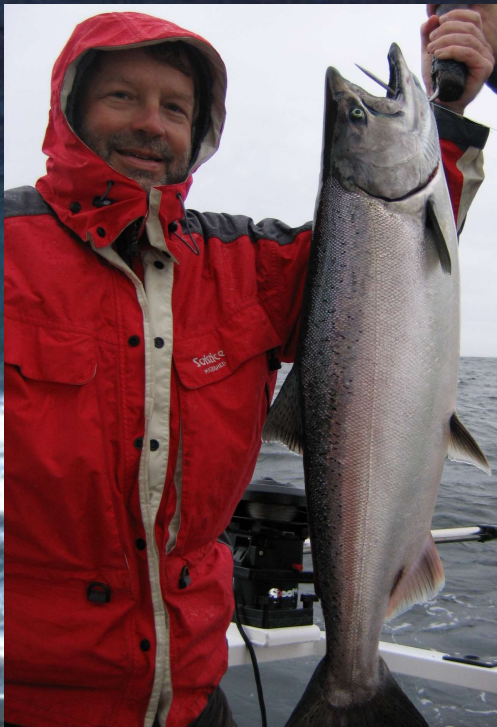


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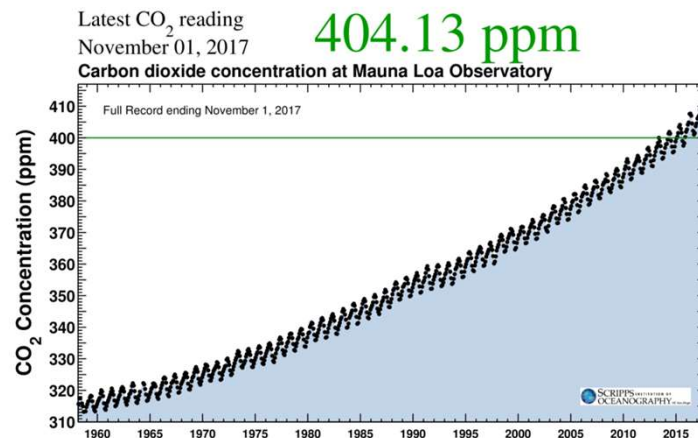


Global Warming, Quickly

- **Greenhouse Effect** already keeps us warm

Average Earth Surface Temp: 57F vs. -2F or 14C vs. -19C

- **Enhanced Greenhouse Effect** (i.e., Global Warming) due to anthropogenically released greenhouse gases increasingly traps additional heat in the Air, Ocean, Land, Ice system



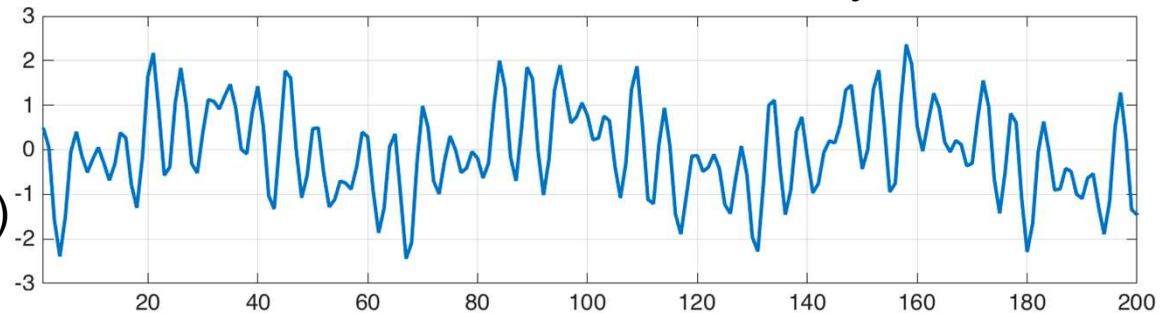
90% of extra heat goes into **oceans**
--- the rest melts ice, warms land,
warms air, etc.

What can we actually expect to predict in the coming decades?

Schematic!

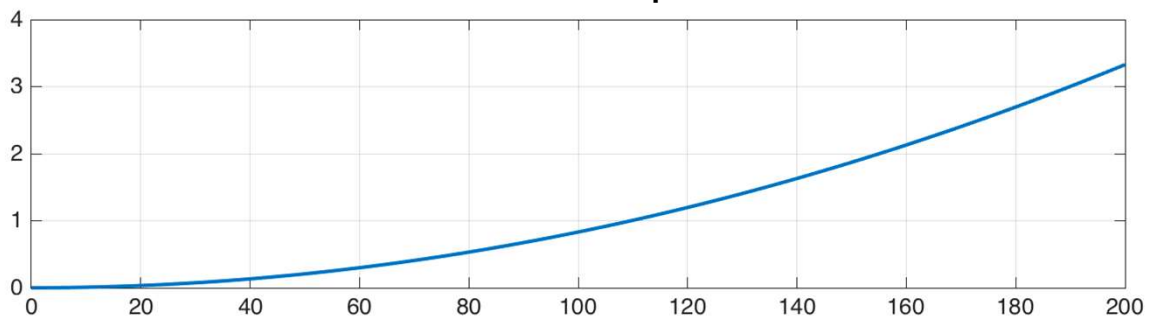
Unpredictable part
(due to natural variations)

Natural Climate Variability



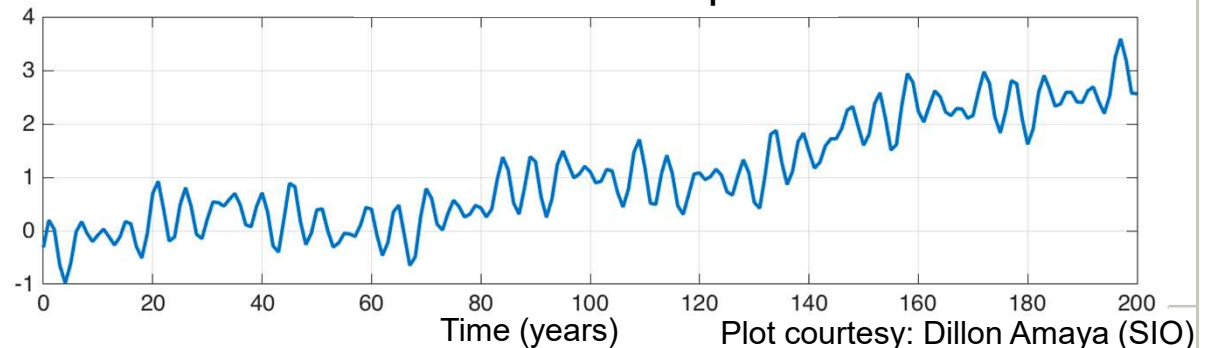
Predictable part
(due to known forcing
by greenhouse gases
released by humanity)

Forced response

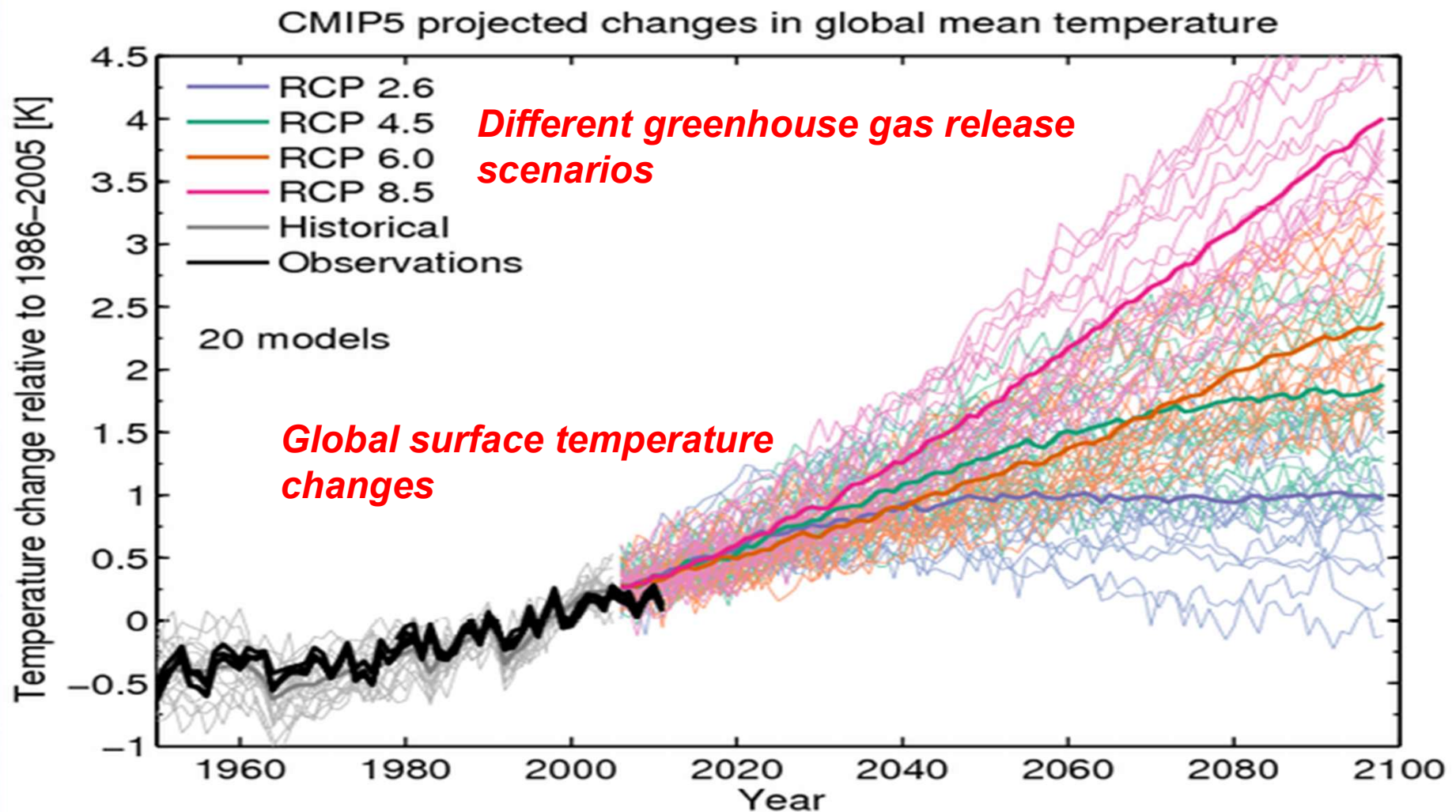


Together they comprise
the **one realization**
we experience on earth

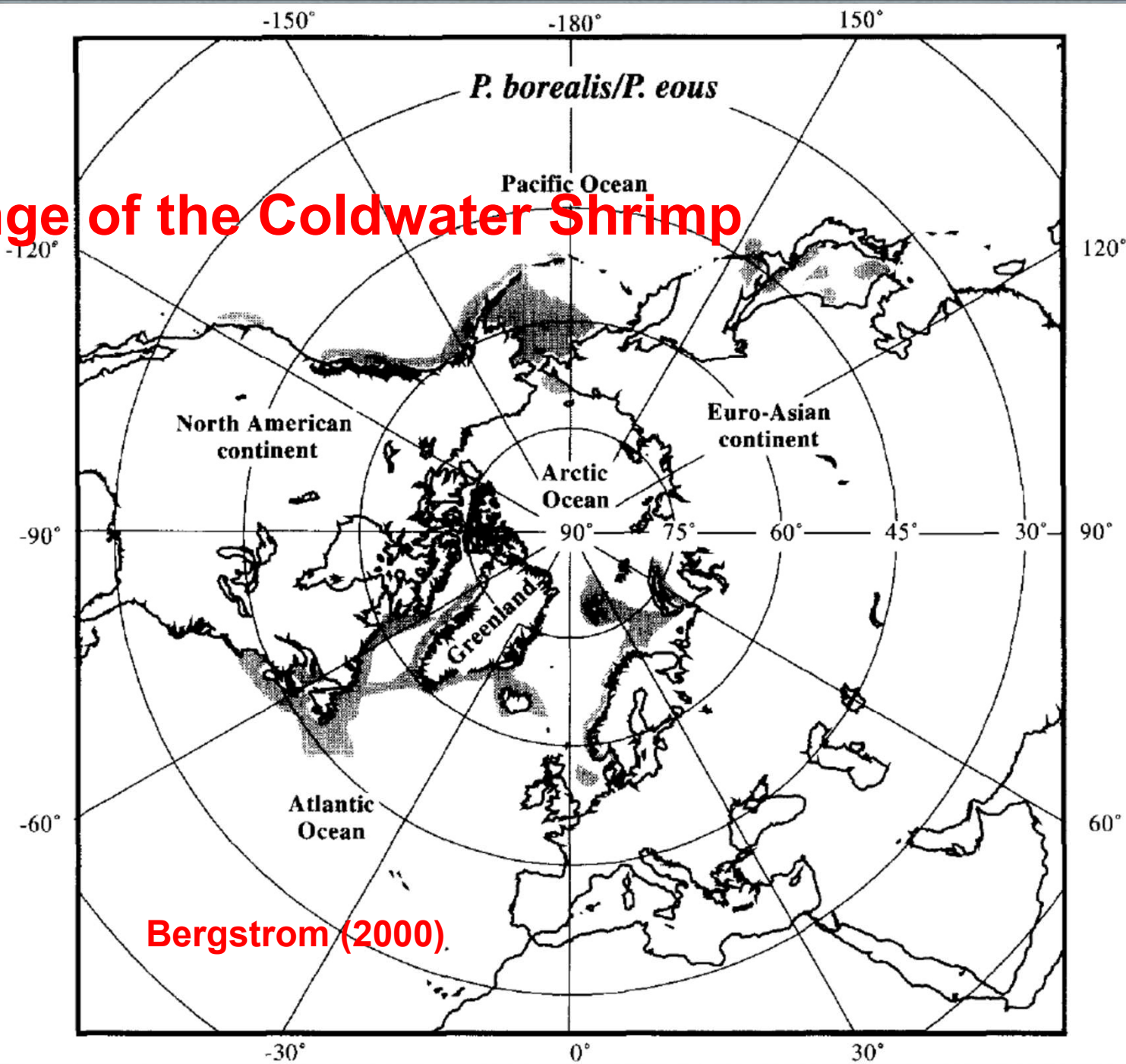
Sum of the two parts



Model Projections of Global Warming



Range of the Coldwater Shrimp



Global Warming, Quickly

Regional Impacts Relevant to Deepwater Prawns

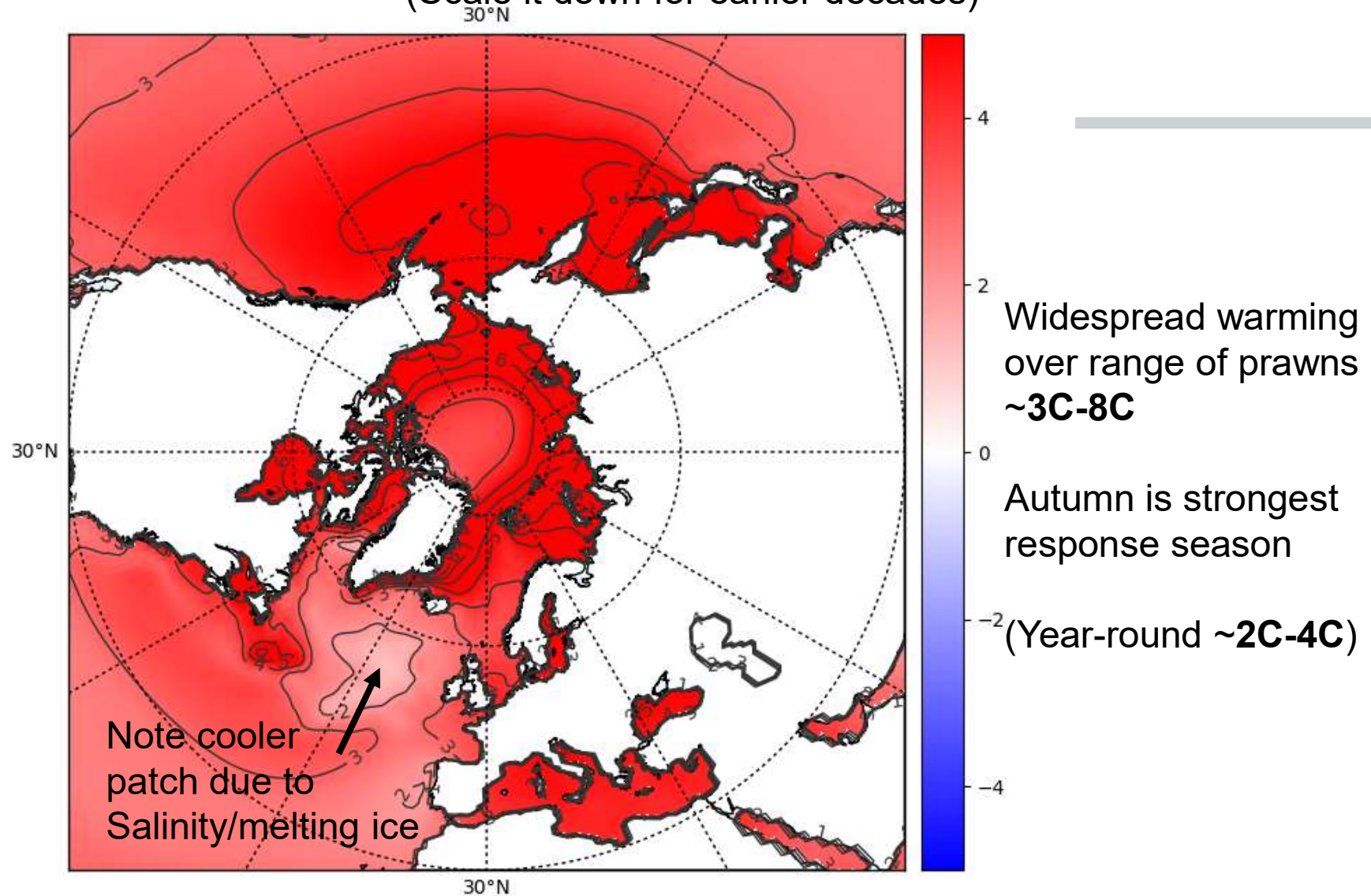
- **Arctic Amplification** means strongest temperature signals north of 50N latitude
- **Arctic sea ice loss**
- Atmospheric **storm tracks** shift northward
- Oceans become more **acidic**, affecting Calcium-shell-based organisms
- **Sea level rise and fresh-water input** from land-locked ice

Climate Model Projections

- Here, we use NCAR's Large Ensemble for CESM (Community Earth System Model)
- Take 25-year average of future climate **2076-2100** compared to the average of **1981-2005**
- Average 33 ensemble members together to suppress natural variability and *isolate forced part*
- Greenhouse gas release scenario RCP8.5 (relatively high)

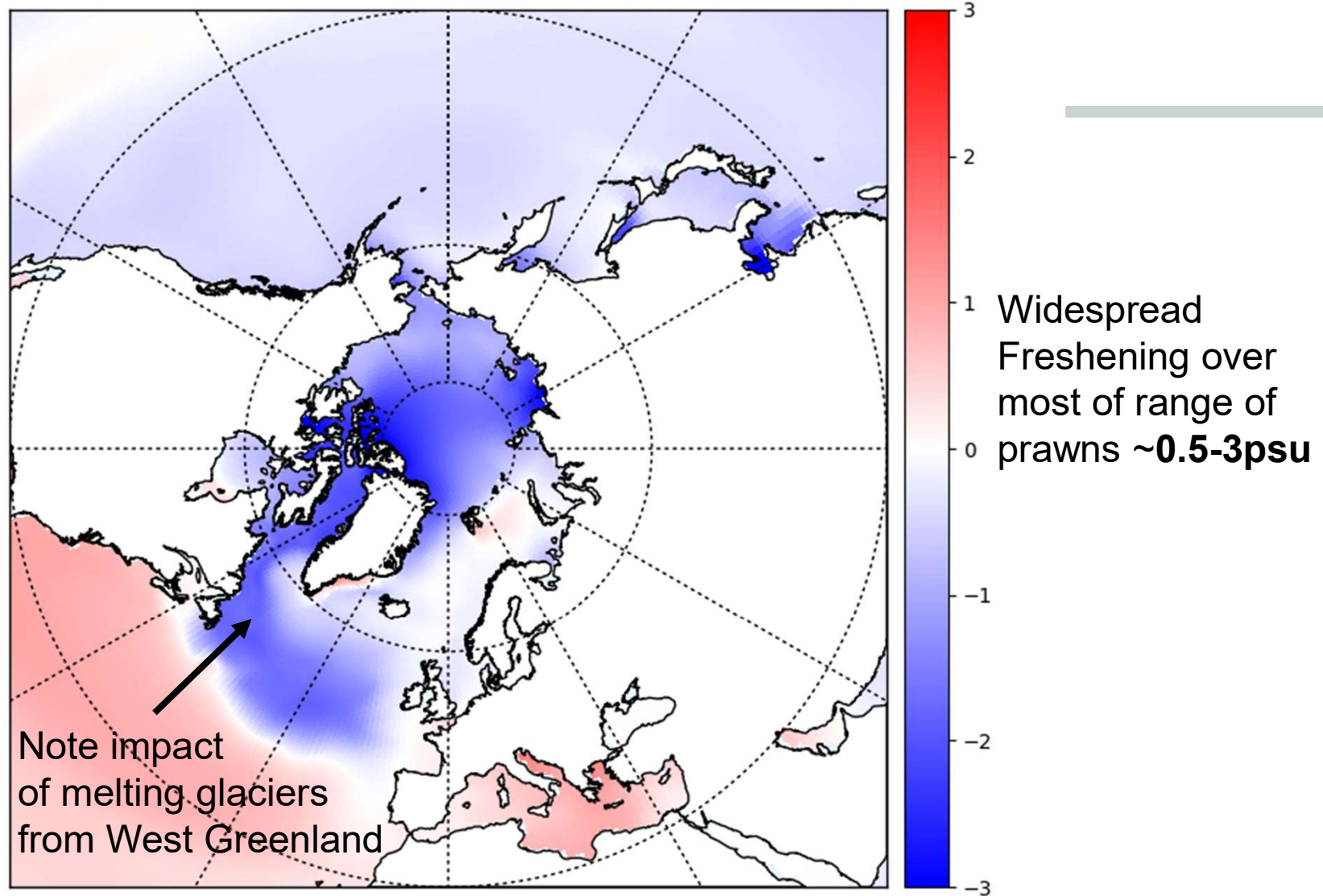
Calculations by post-doc Dr. Liz Drenkard (SIO)

Average Sea Surface Temperature Change (2076-2100, **September**)
(Scale it down for earlier decades)



Courtesy: Dr. Liz Drenkard (SIO)

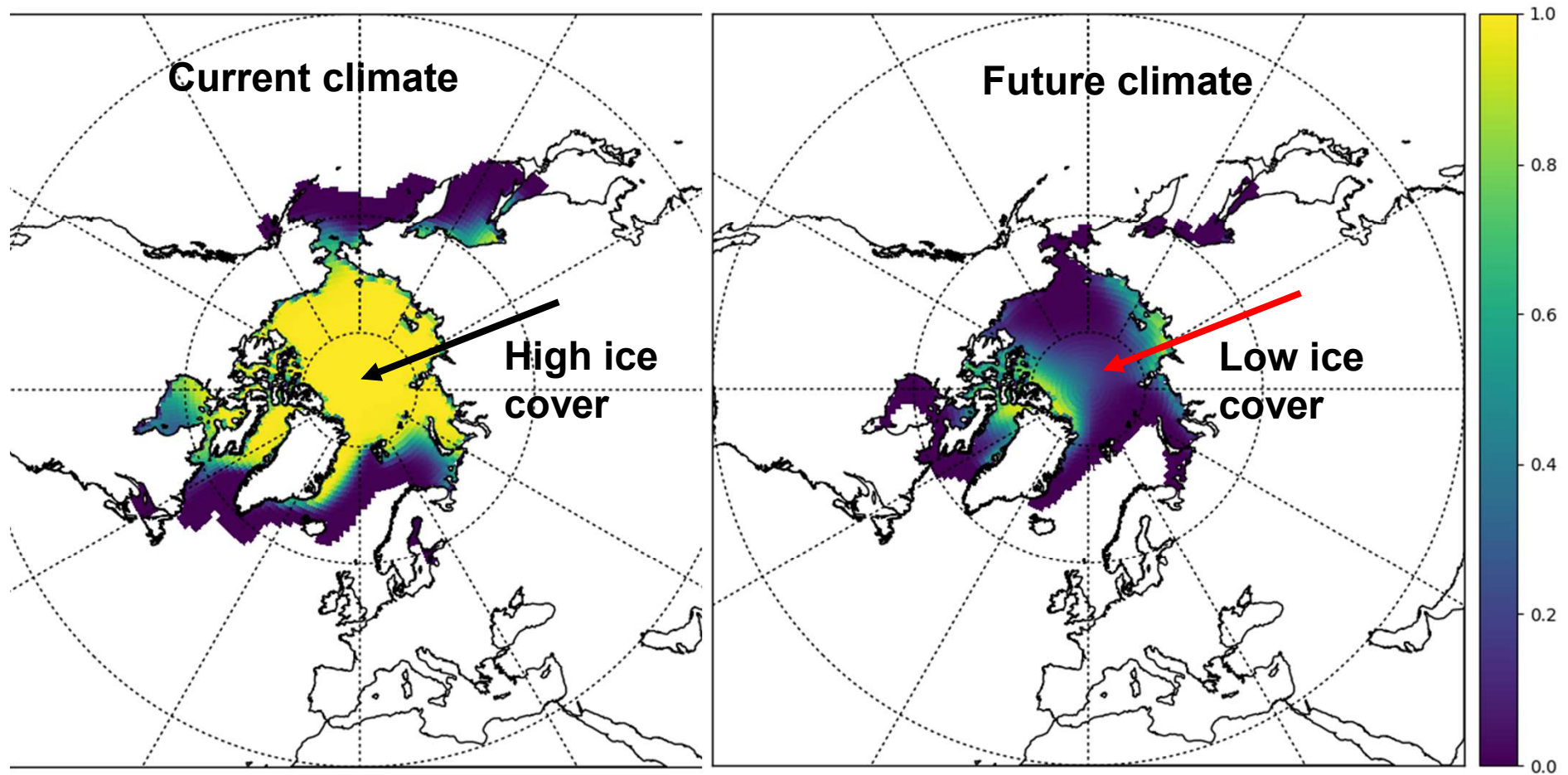
Average Sea Surface Salinity Change (2076-2100, **Annual**)
(Scale it down for earlier decades)



Courtesy: Dr. Liz Drenkard (SIO)

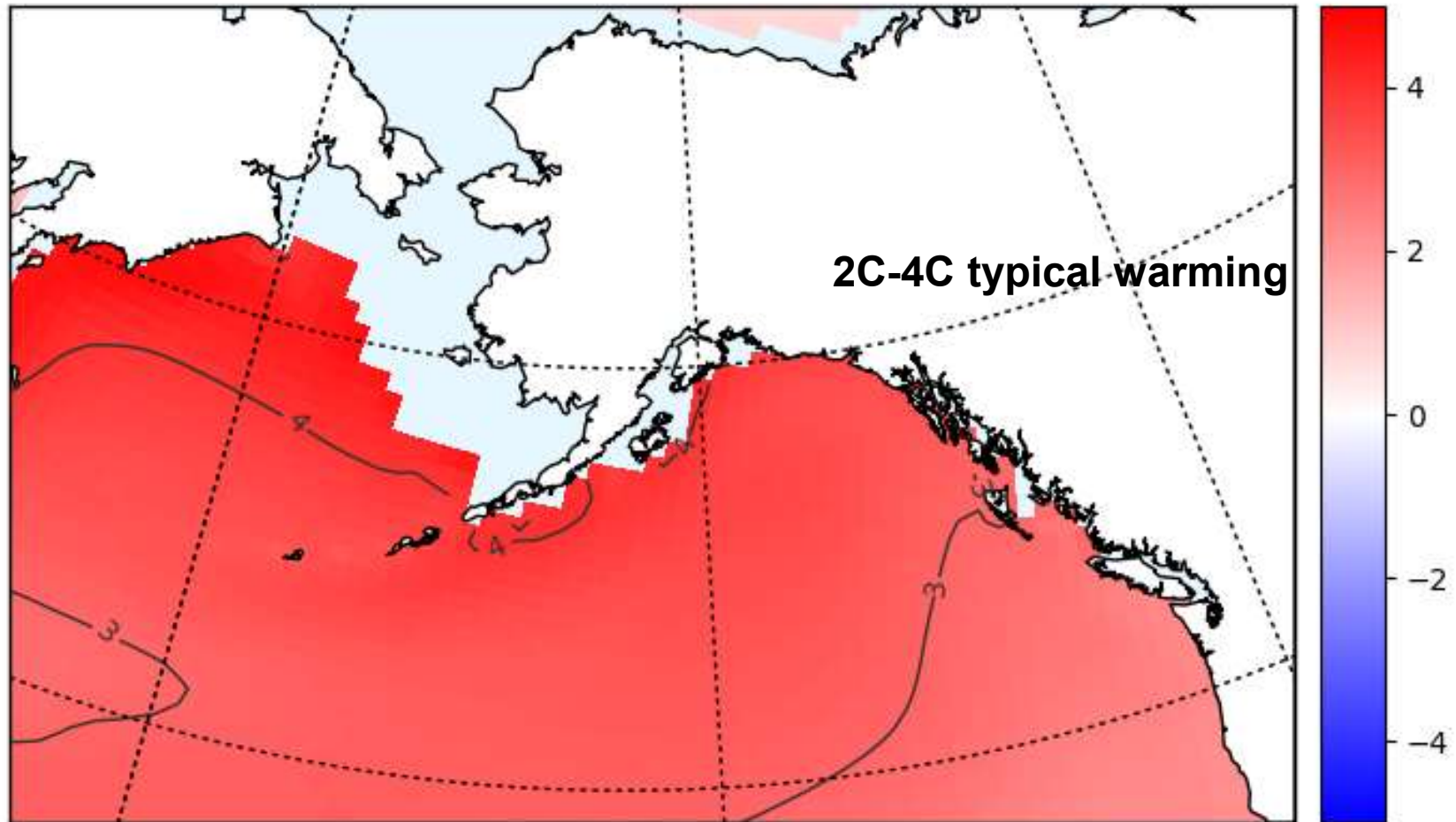
Average Sea Ice Fraction and Extent Change (2076-2100, **December**)

- Loss of sea ice leaves Arctic Ocean open in December
- Deeper into winter (Jan, Feb, Mar) the ice still develops



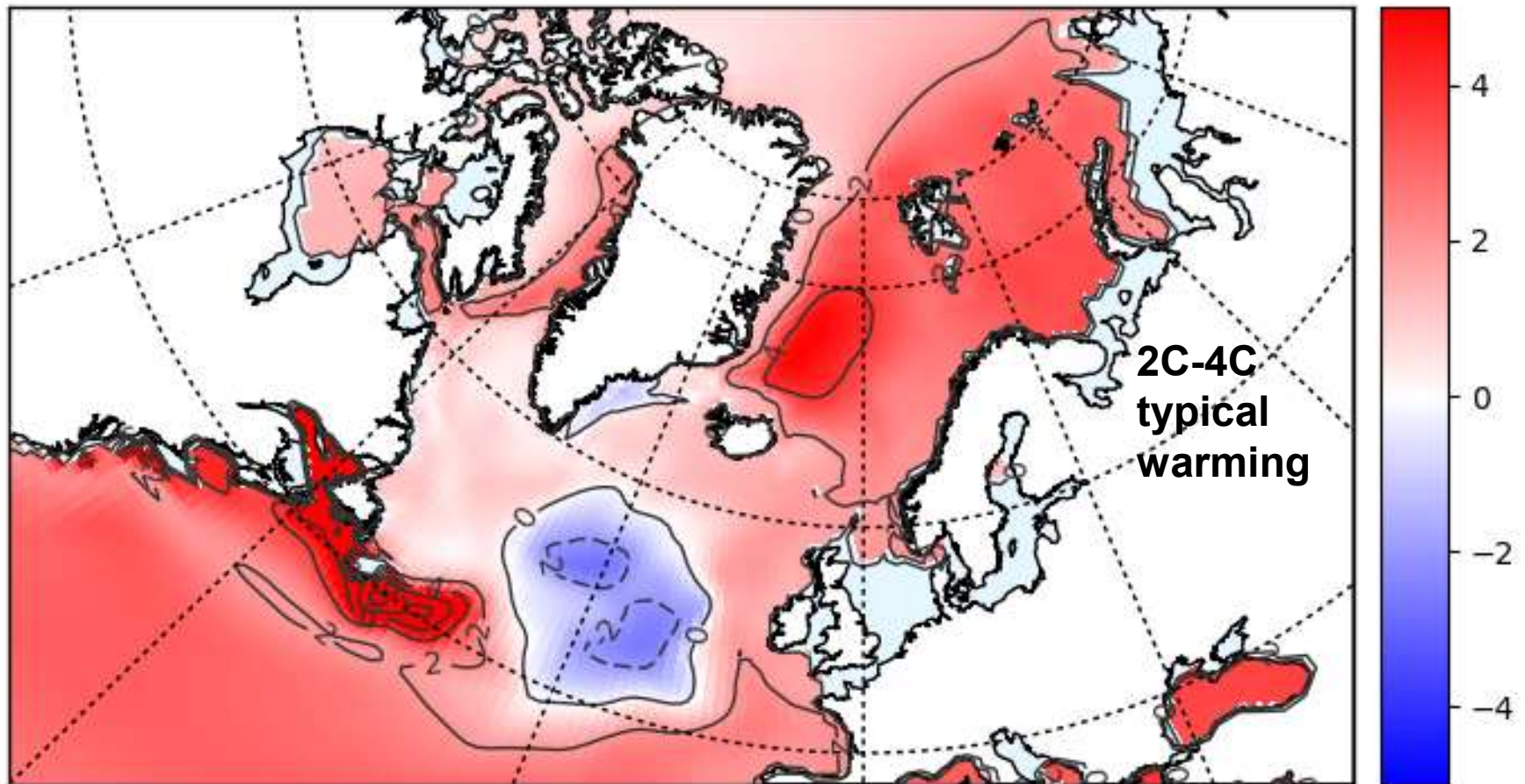
Courtesy: Dr. Liz Drenkard (SIO)

Pacific **Deepwater 100m** Temperature Change (Annual Average)



Courtesy: Dr. Liz Drenkard (SIO)

Atlantic **Deepwater** 100m Temperature Change (Annual Average)



Courtesy: Dr. Liz Drenkard (SIO)

Deepwater Shrimp, Possible Impacts

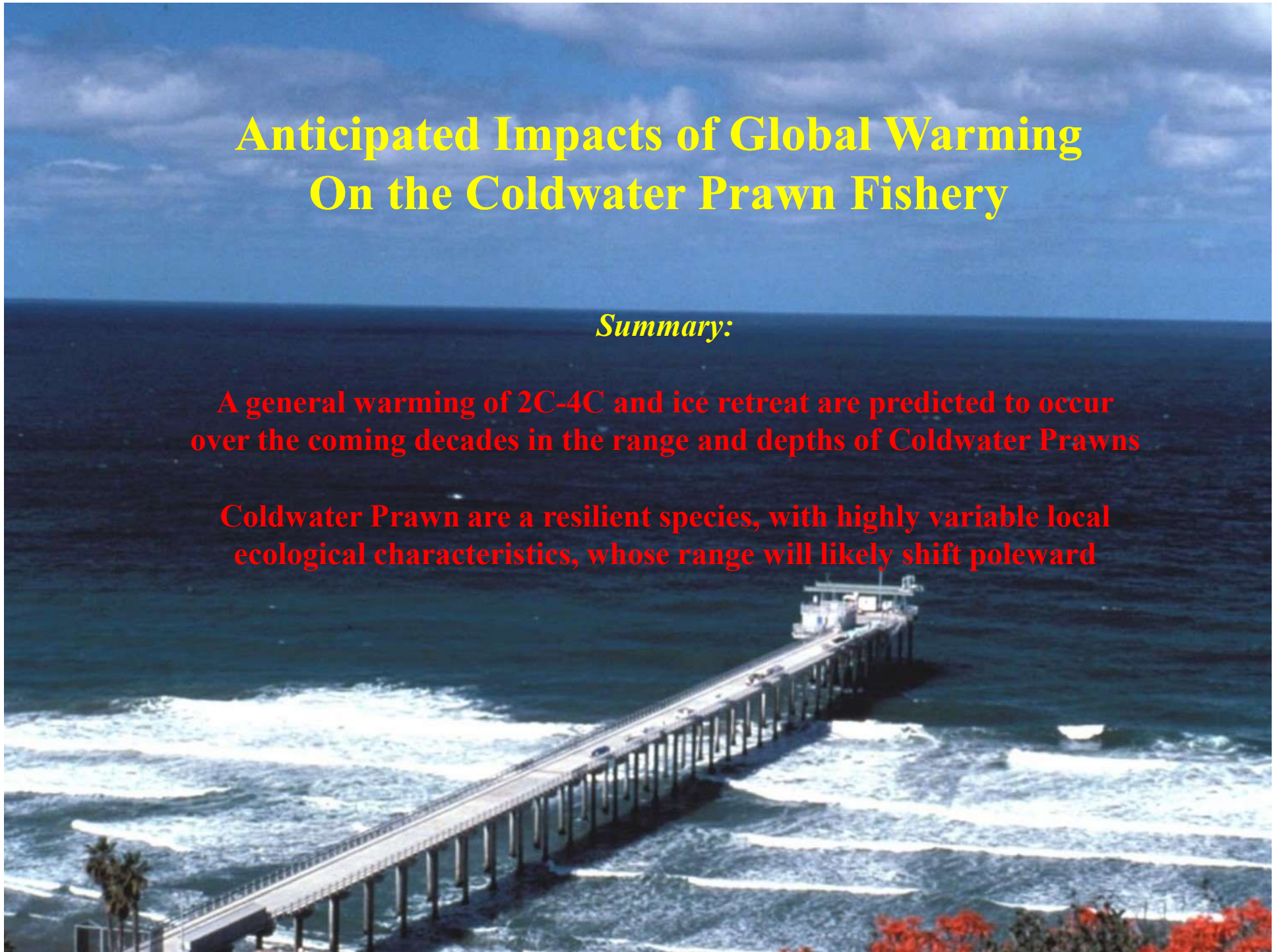
- Healthy shrimp adult temperature range at depth threatened, may *contract southerly range*
- Healthy shrimp *larval development* temperature range near surface threatened
- Shifts in *spring bloom* and consequent prey availability may affect shrimp larval development
- Altered *ranges of shrimp predators* may cause enhanced predation
- Retreating sea ice and warming may *expand northerly range*
- *Acidification* may delay shrimp larval development and reduce exoskeleton transparency

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Summary:

A general warming of 2C-4C and ice retreat are predicted to occur over the coming decades in the range and depths of Coldwater Prawns

Coldwater Prawn are a resilient species, with highly variable local ecological characteristics, whose range will likely shift poleward



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Thanks!

