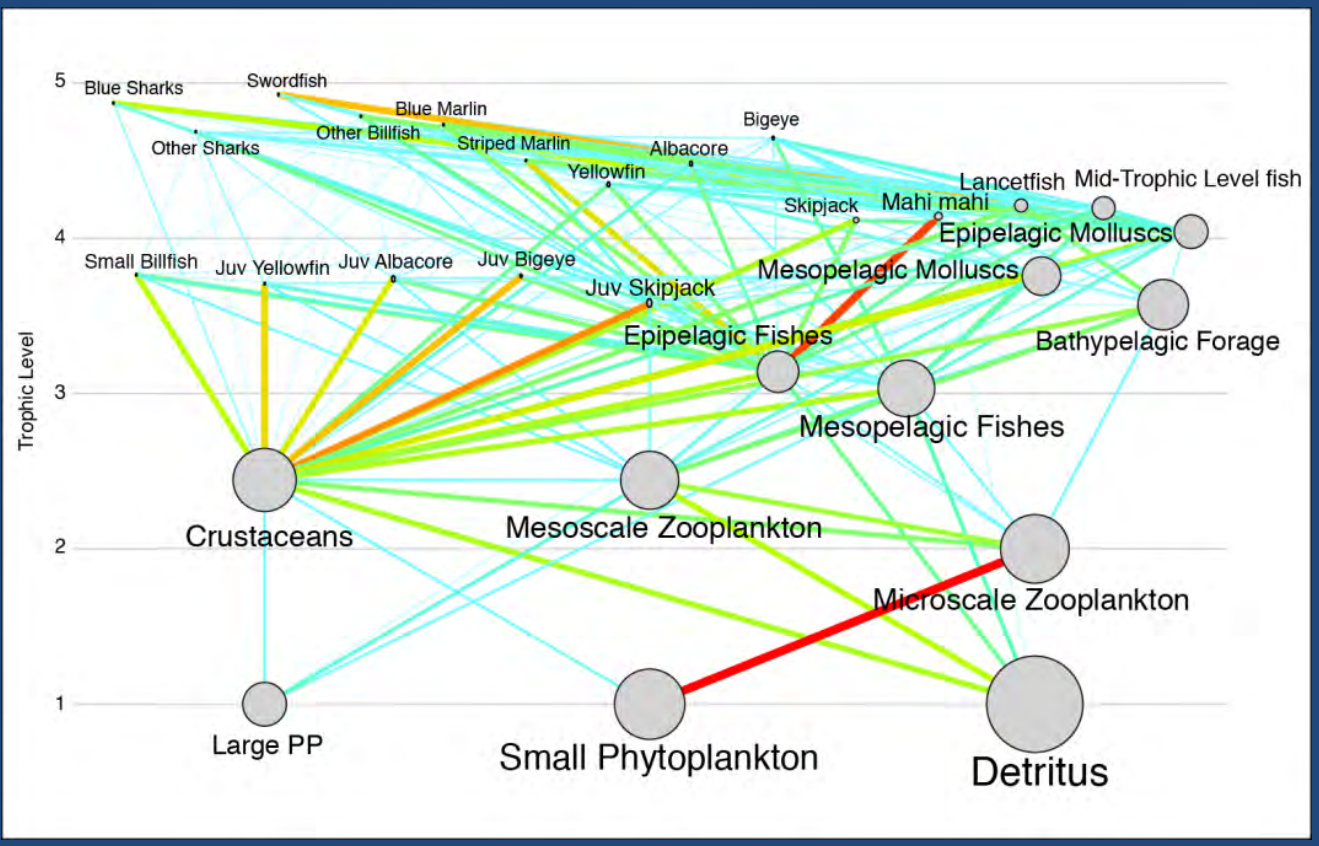
Using climate model output to project climate change impacts over the 21st Century in the North Pacific Subtropical Ecosystem

Jeffrey Polovina and Phoebe Woodworth-Jefcoats
Pacific Islands Fisheries Science Center
NOAA Fisheries
Honolulu, HI. USA
S-CCME

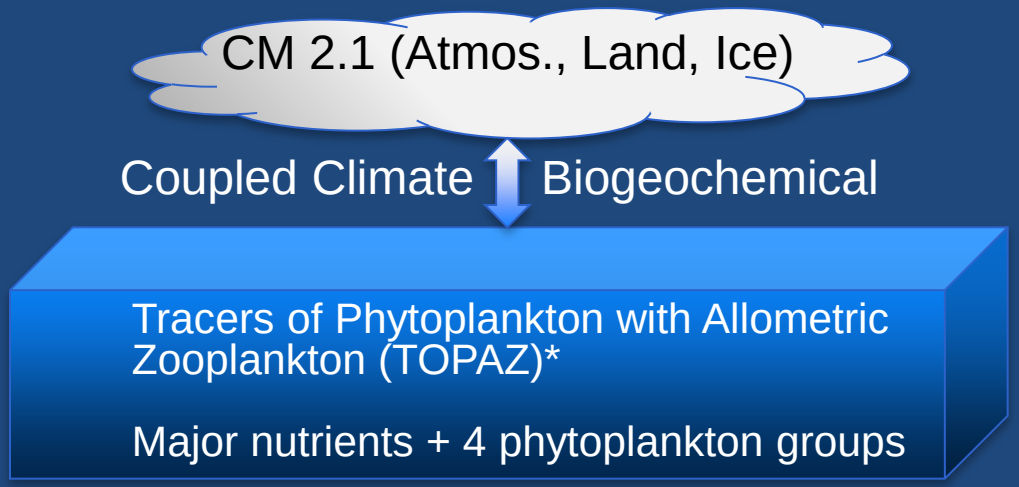
Central North Pacific Subtropical Ecosystem Food Web

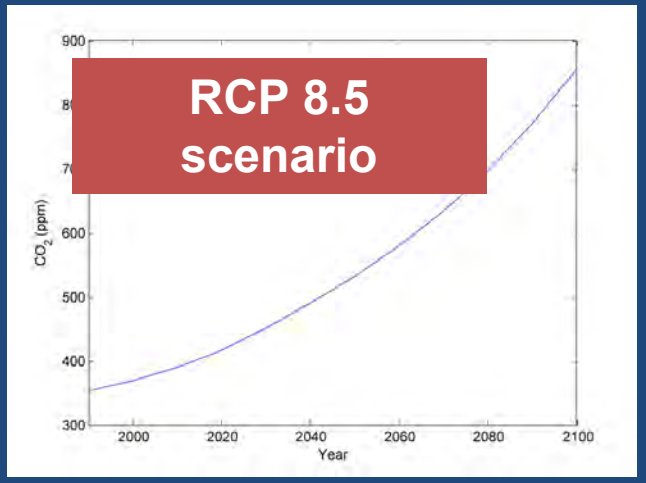


FISHING IMPACTS: Over past 2 decades fishing has reduced apex species (tunas, billfishes, sharks) resulting in a increase in smaller species (mahi, pomfret, lancetfish, snake mackerel). (Polovina and Woodworth-Jefcoats 2013 *Plos One)*

How will future climate change impact this ecosystem?

NOAA GFDL Earth System Model 2.1 (*ESM2.1 A2 NPZ*)





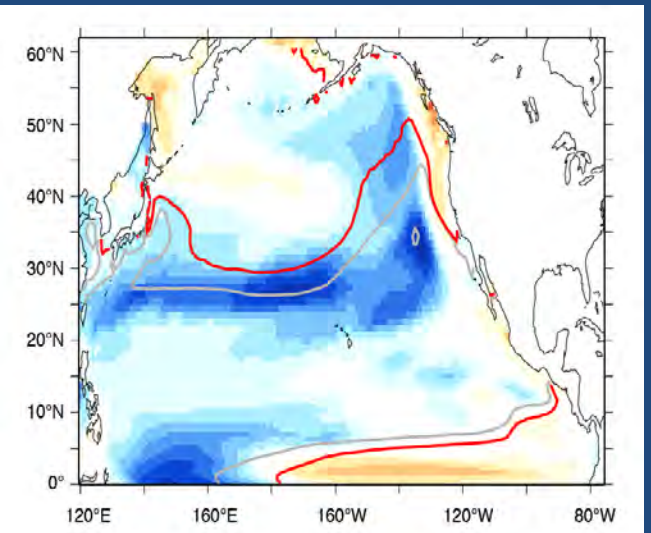
1° x 1° north of 30°N, with latitudinal resolution increasing to 0.33° at equator

Ocean has 50 levels, with 22 10m spacing levels in the upper 220m

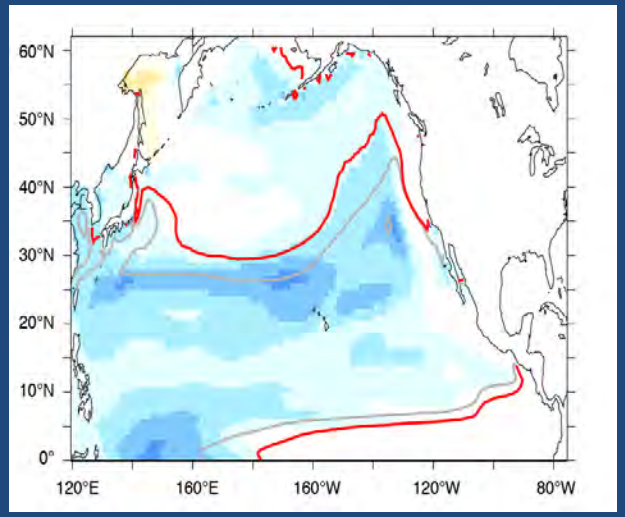
We used monthly values from 1991 - 2100

**Dunne et al. (2005, 2007)*

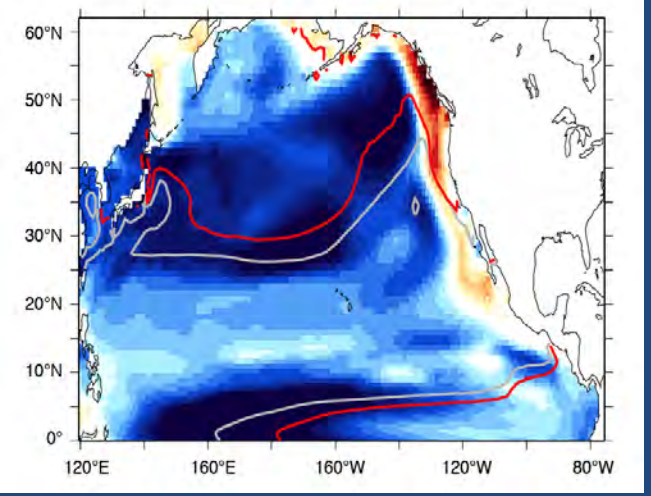
Change Over the 21st Century projected from GFDL model



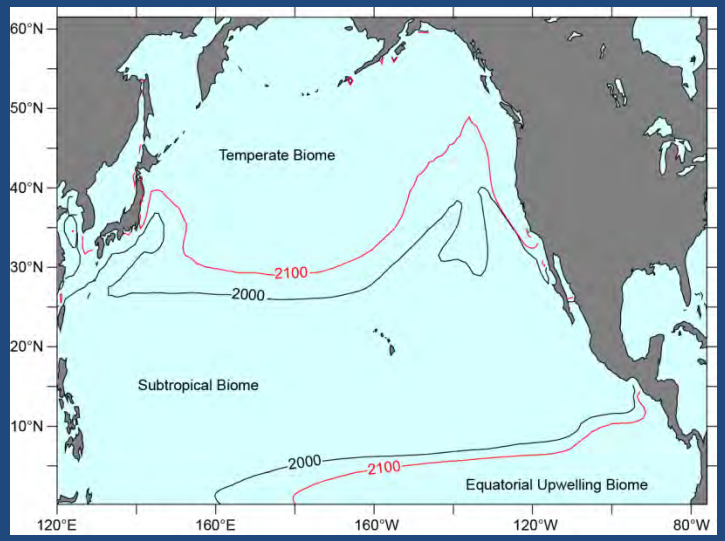
ΔPP

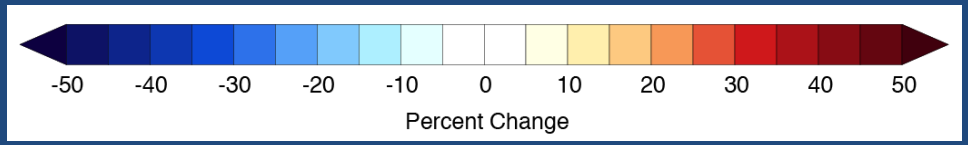


ΔSm

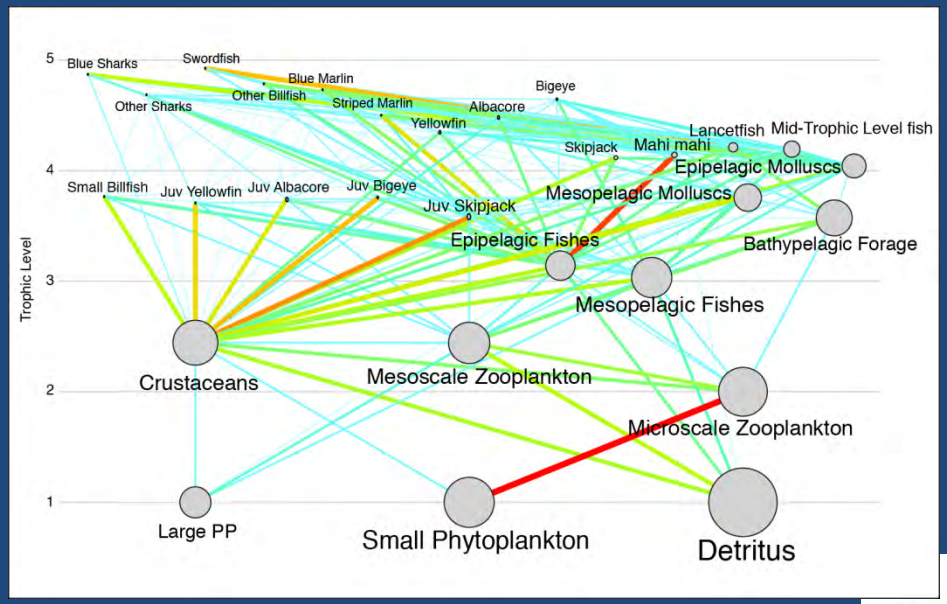


ΔLg





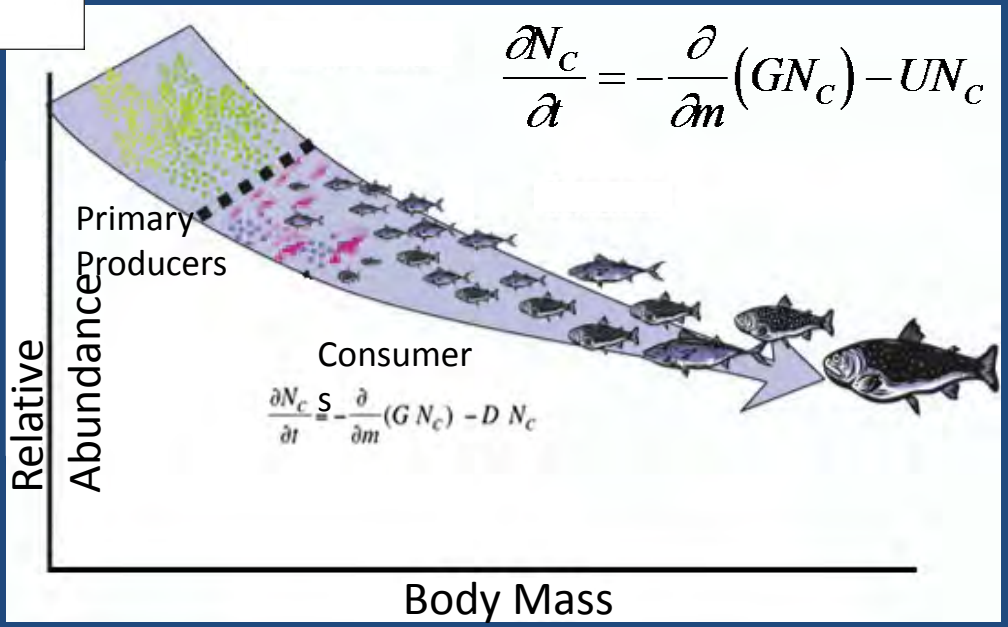
Species-based (Ecopath with EcoSim Model)



Use 2 different ecosystem models to project bottom-up impacts from phytoplankton changes to the entire subtropical ecosysem

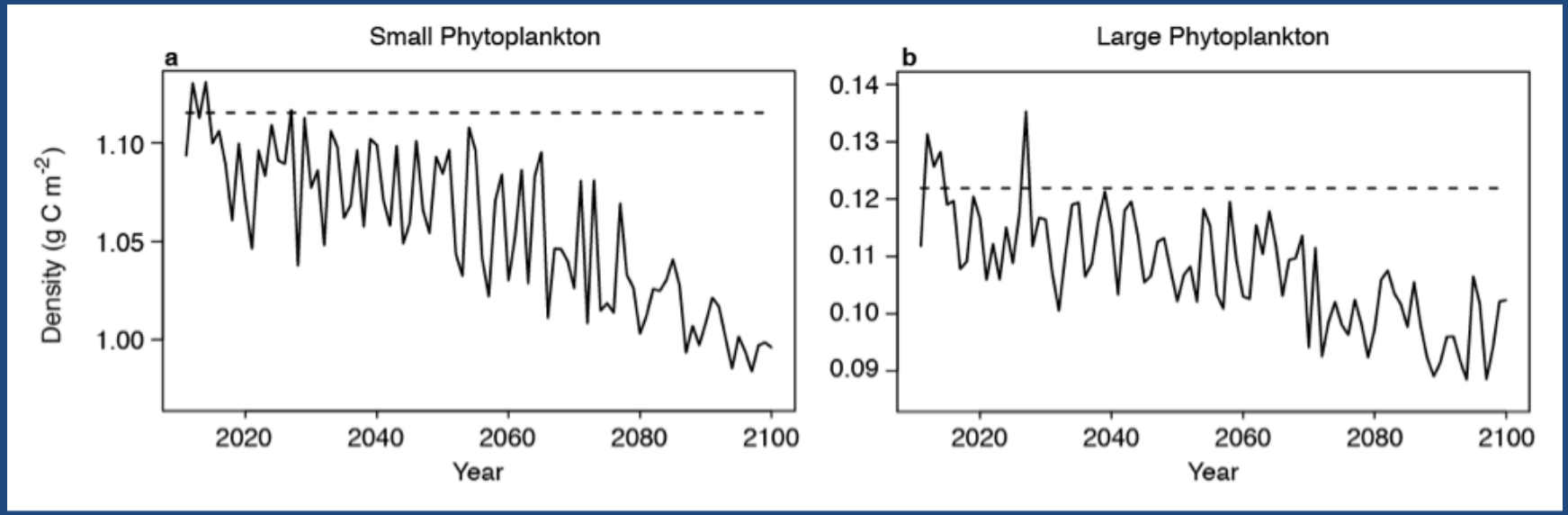
Currently only using 1-D ecosystem models so no need to downscale ESM output

Size-based Food Web Model

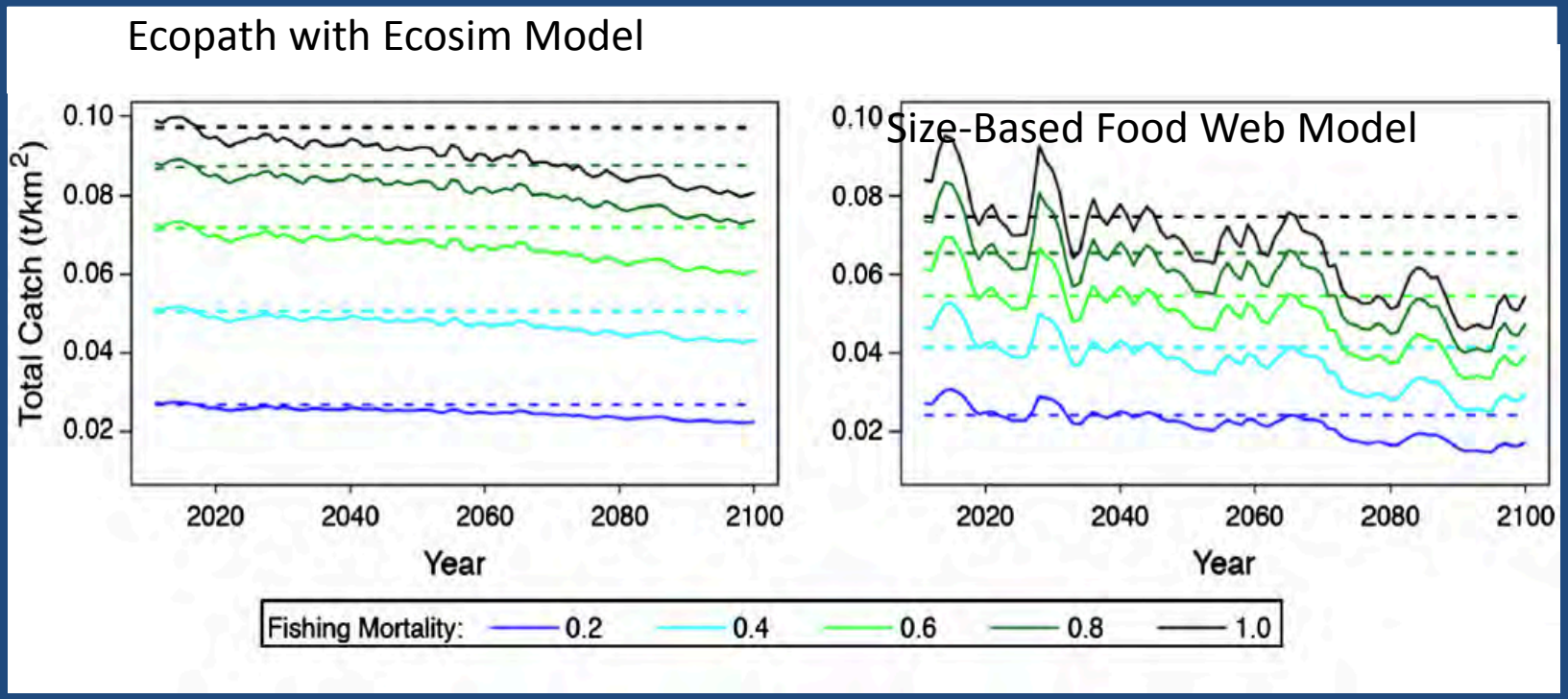


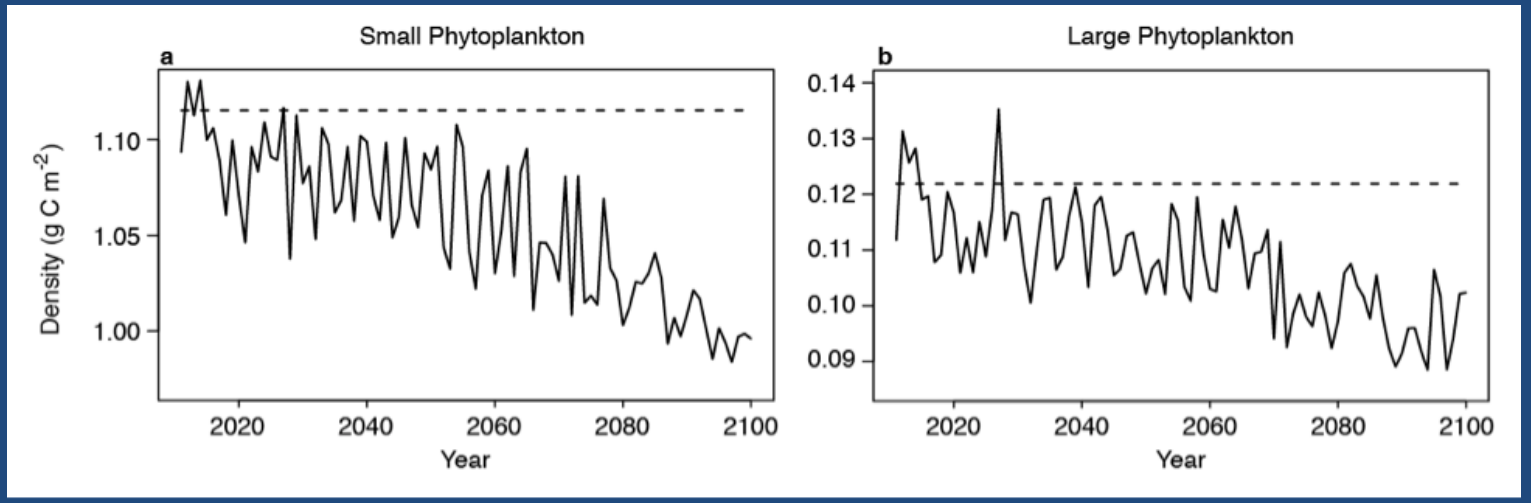
From Blanchard *et al.* 2009, modified

GFDL ESM projected phytoplankton and SST time series for central North Pacific



Total longline catch time series from each model as a function of F

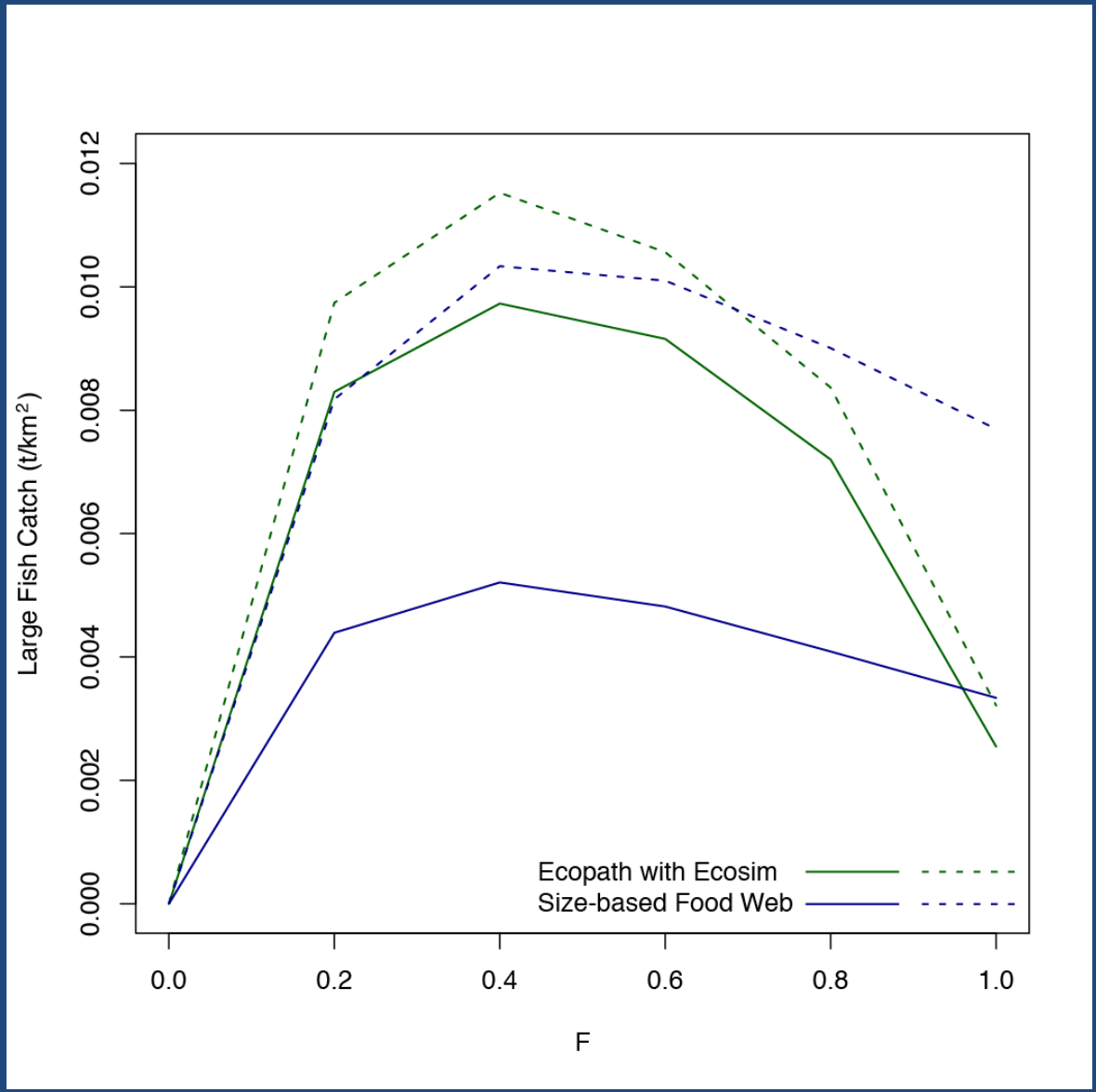




Yield curve large fish (>25 kg)(2080-2100) for each model with and without climate change

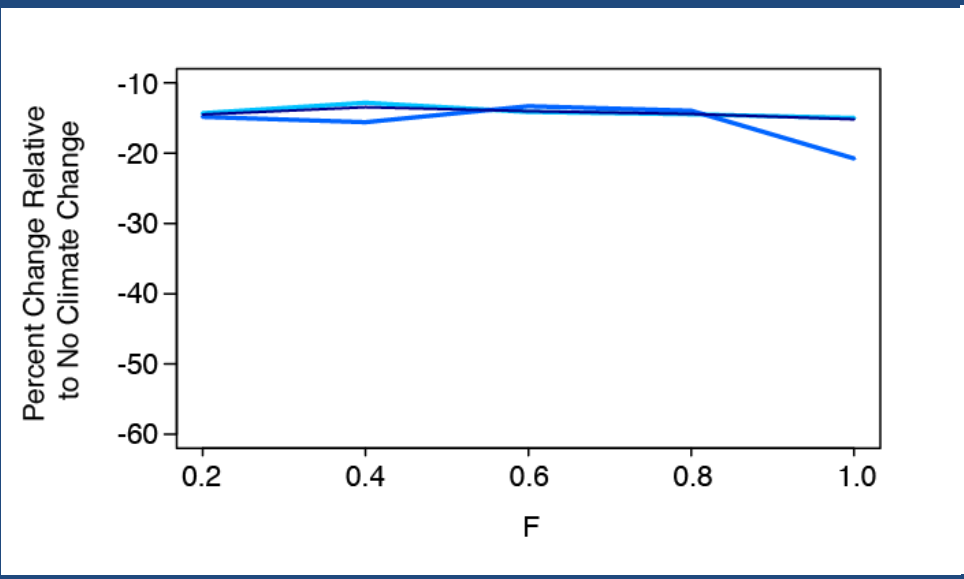
Ecopath with Ecosim
Size-Based Food Web

Solid lines: climate change scenario
Dashed lines: no climate change change

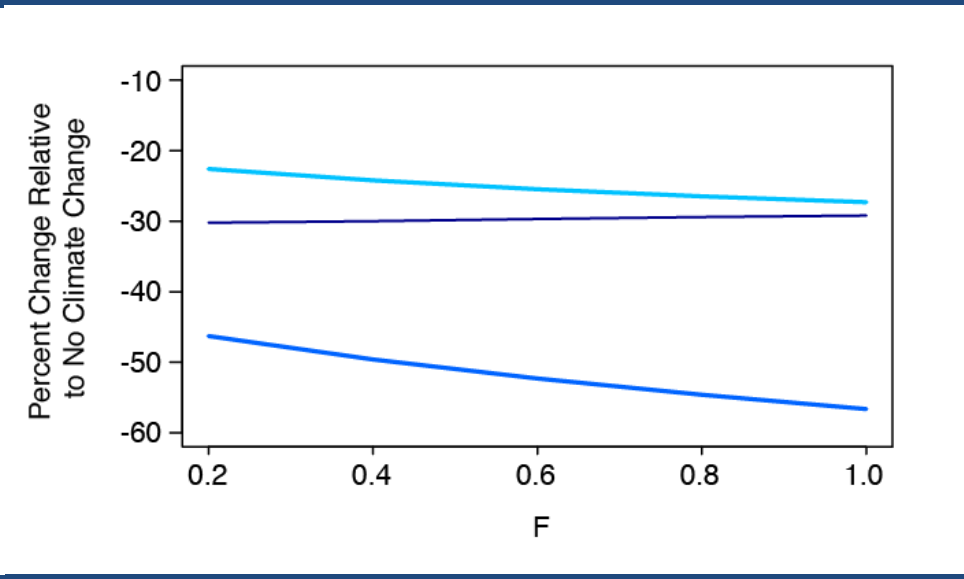


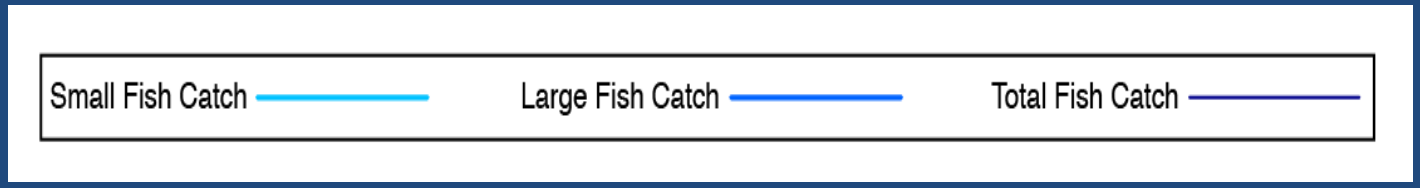
Climate impacts on large (>25 kg) and small (<25 Kg) fish catch

Ecopath with Ecosim Model



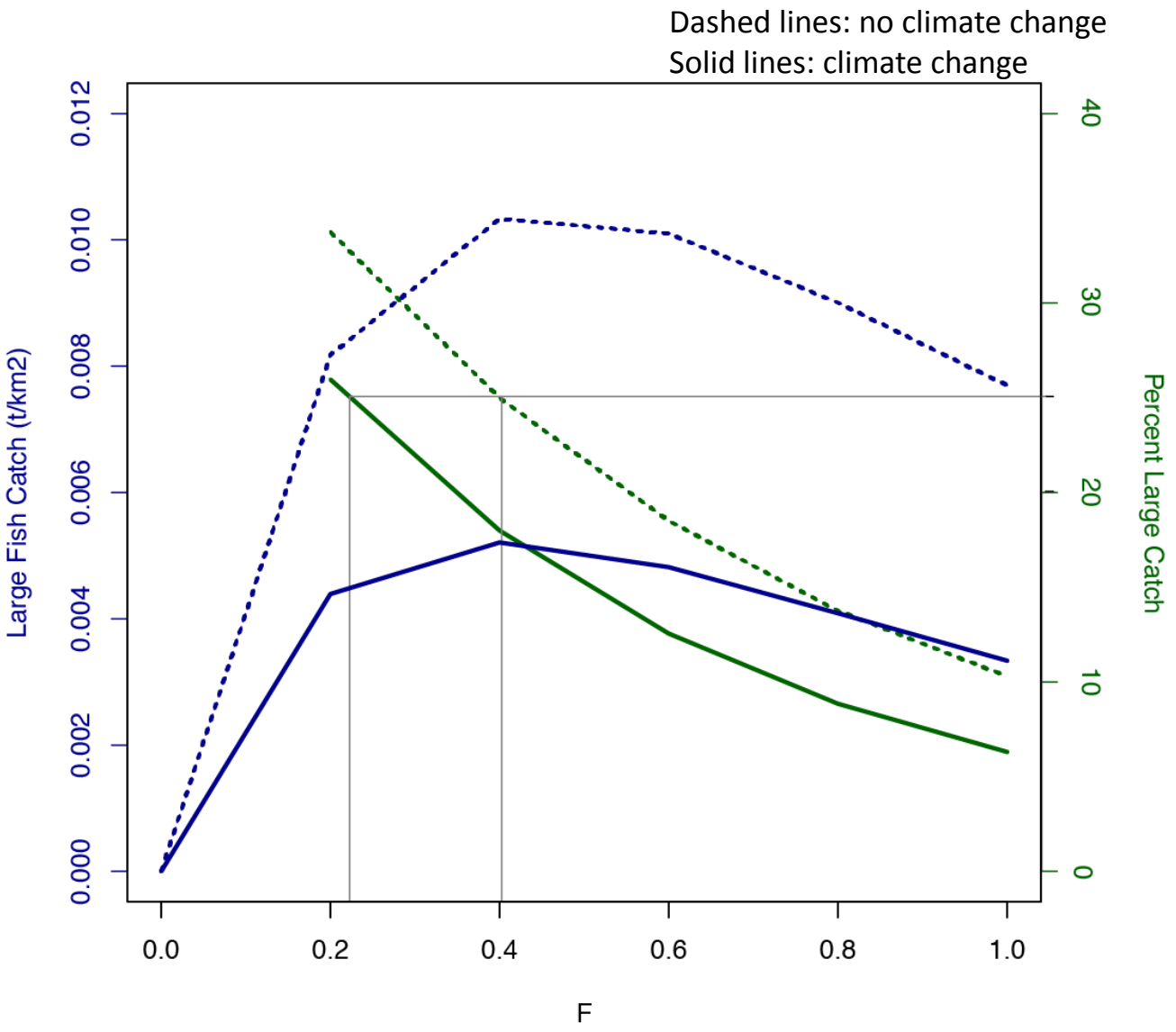
Size-Based Food Web Model



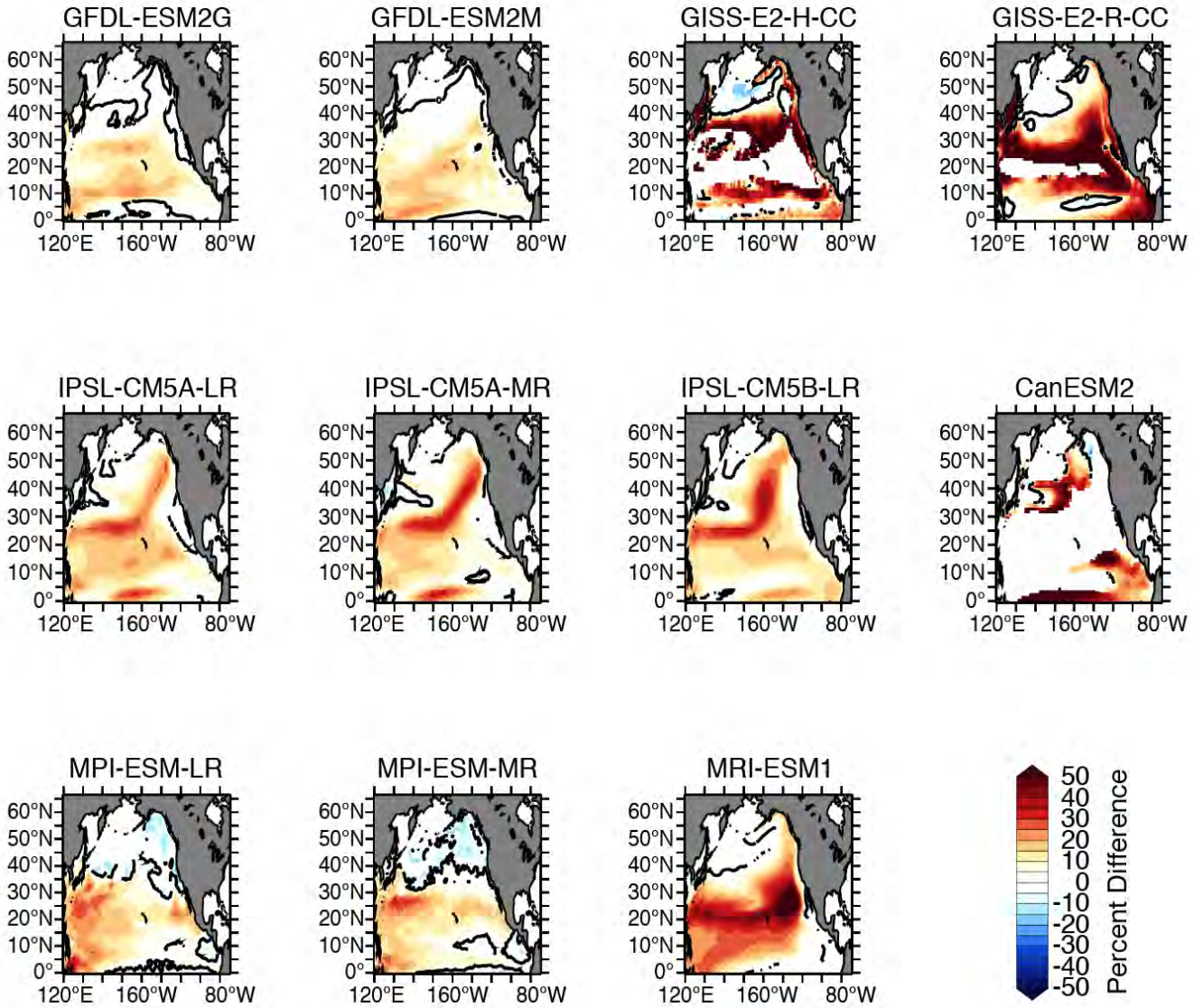


Woodworth-Jefcoats et al. 2015 *Prog. Oceanogr*

Size-based food web model for large fish catch and % large fish in catch with and without climate change (2081-2100)

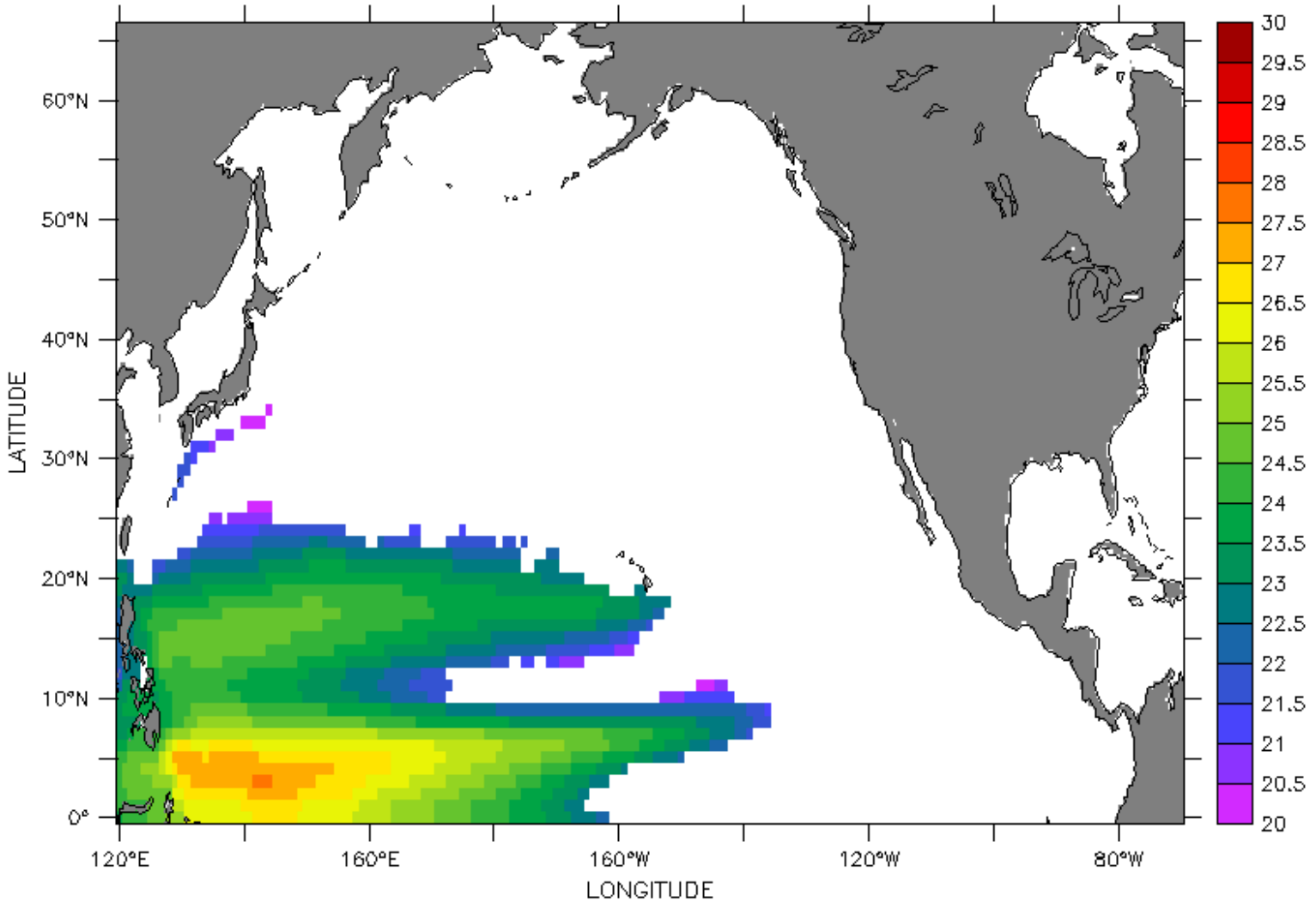


Percent decline in zooplankton minus percent decline of phytoplankton over the Century



GFDL-ESM2G Increasing thermal habitat

Shaded pixels are those that have at least one monthly epipelagic temperature between 24.5 – 32 °C during 1986 – 2005.



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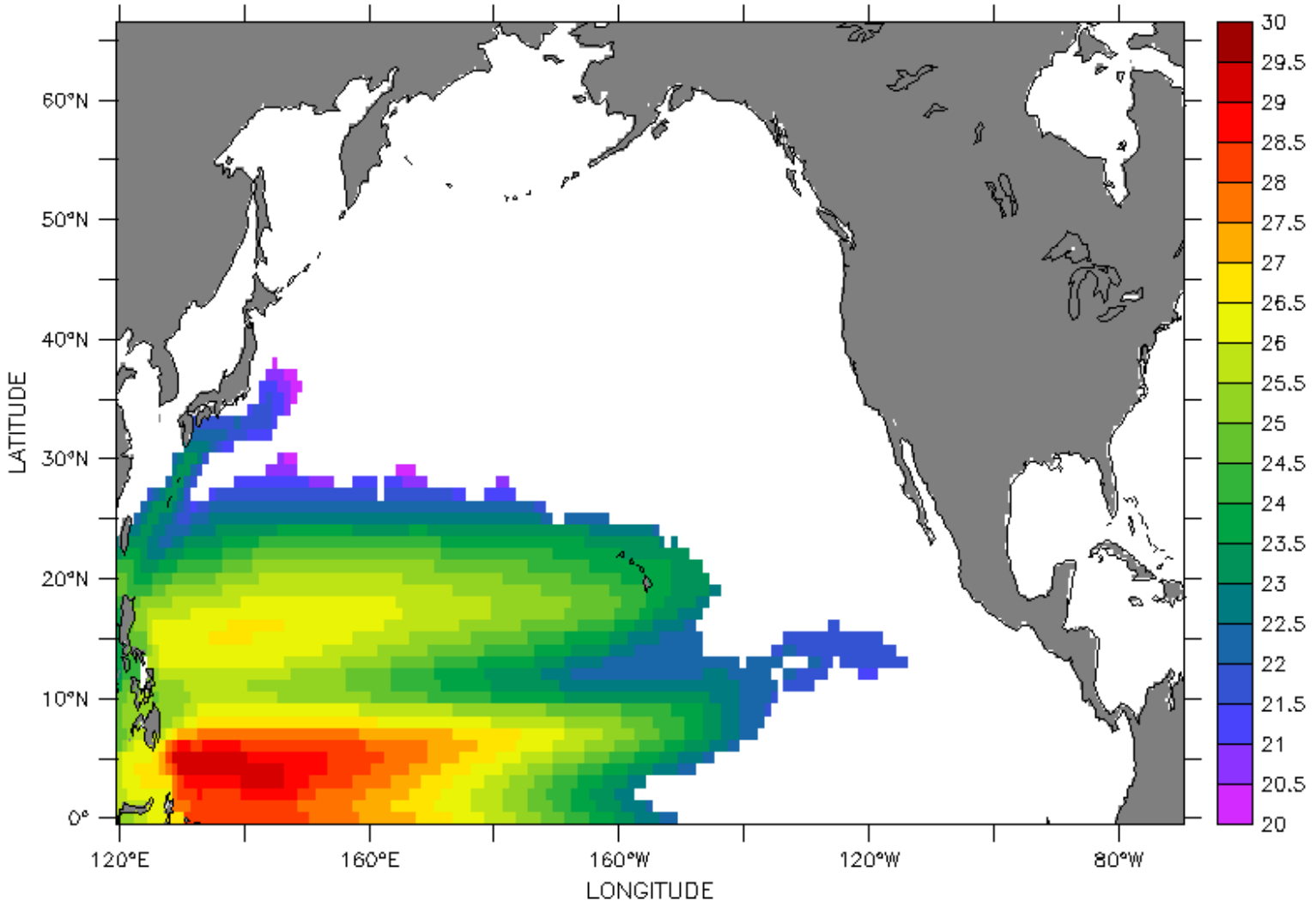
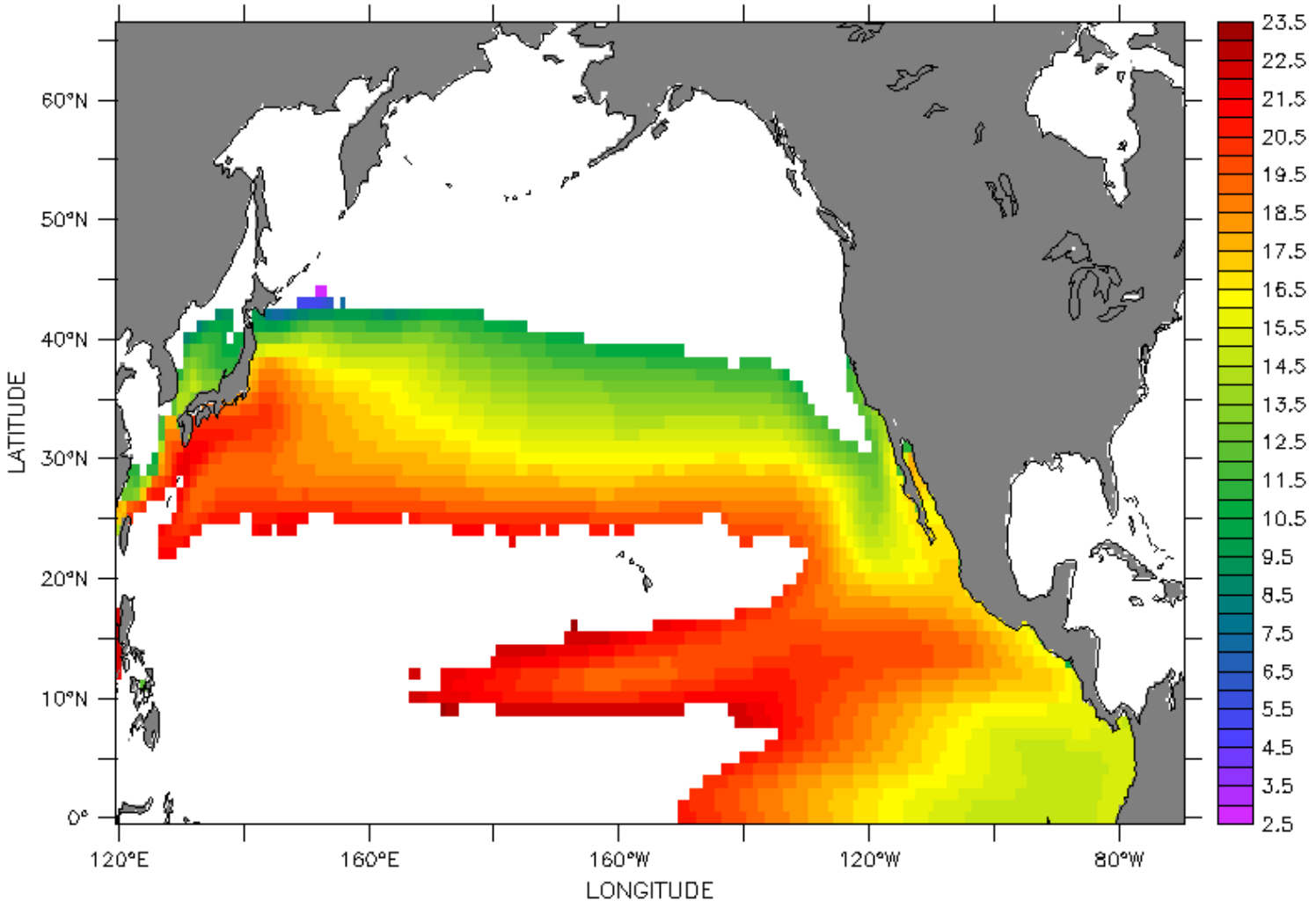


GFDL-ESM2G Decreasing thermal habitat

Shaded pixels are those that have at least one monthly epipelagic temperature between 13 – 18.5 °C during 1986 – 2005. Shading indicates 1986 – 2005 mean epipelagic temp.



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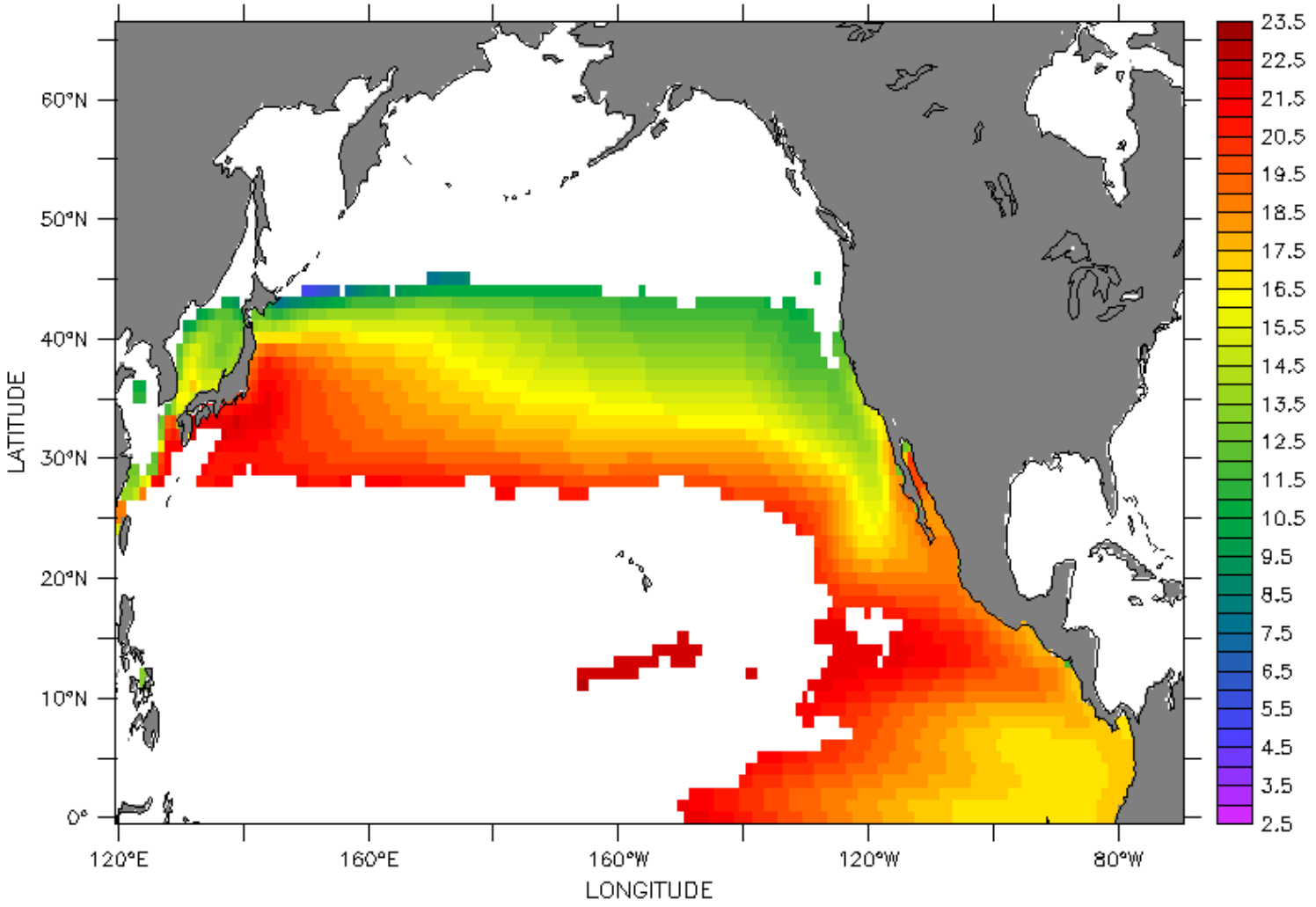
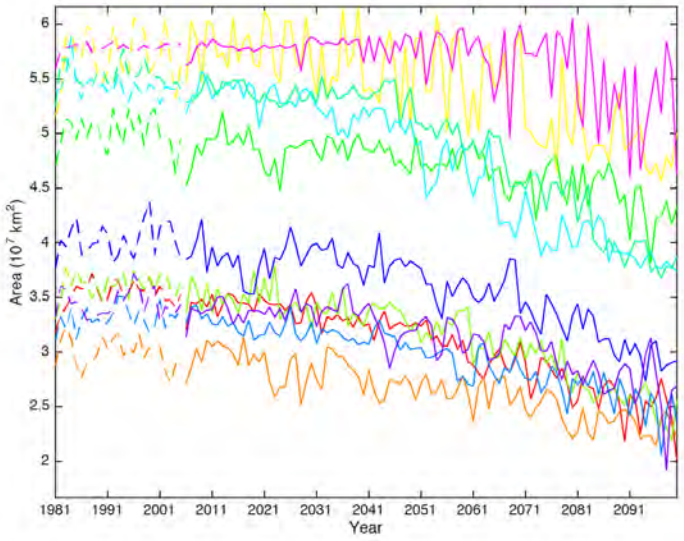
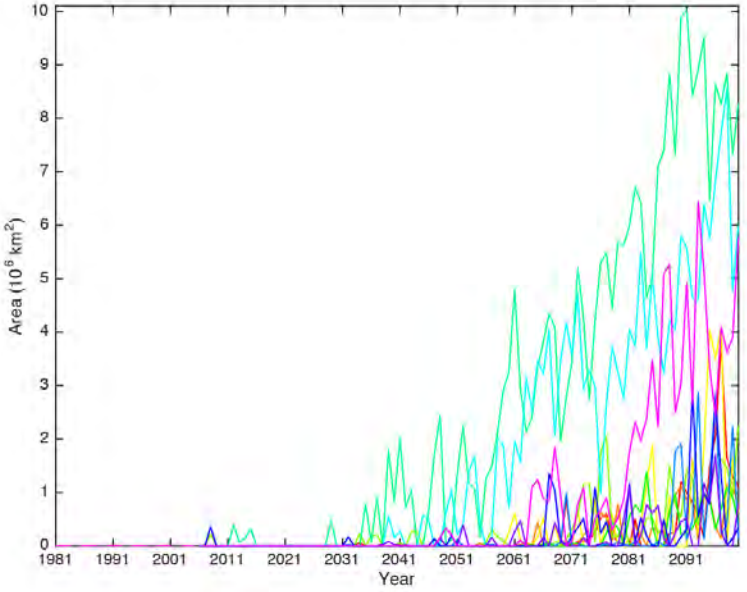


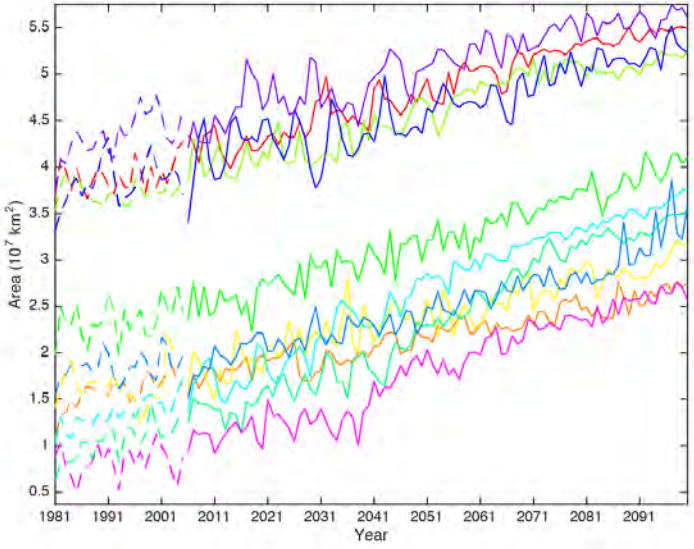
Total annual area of declining moderate subtropical temp habitat



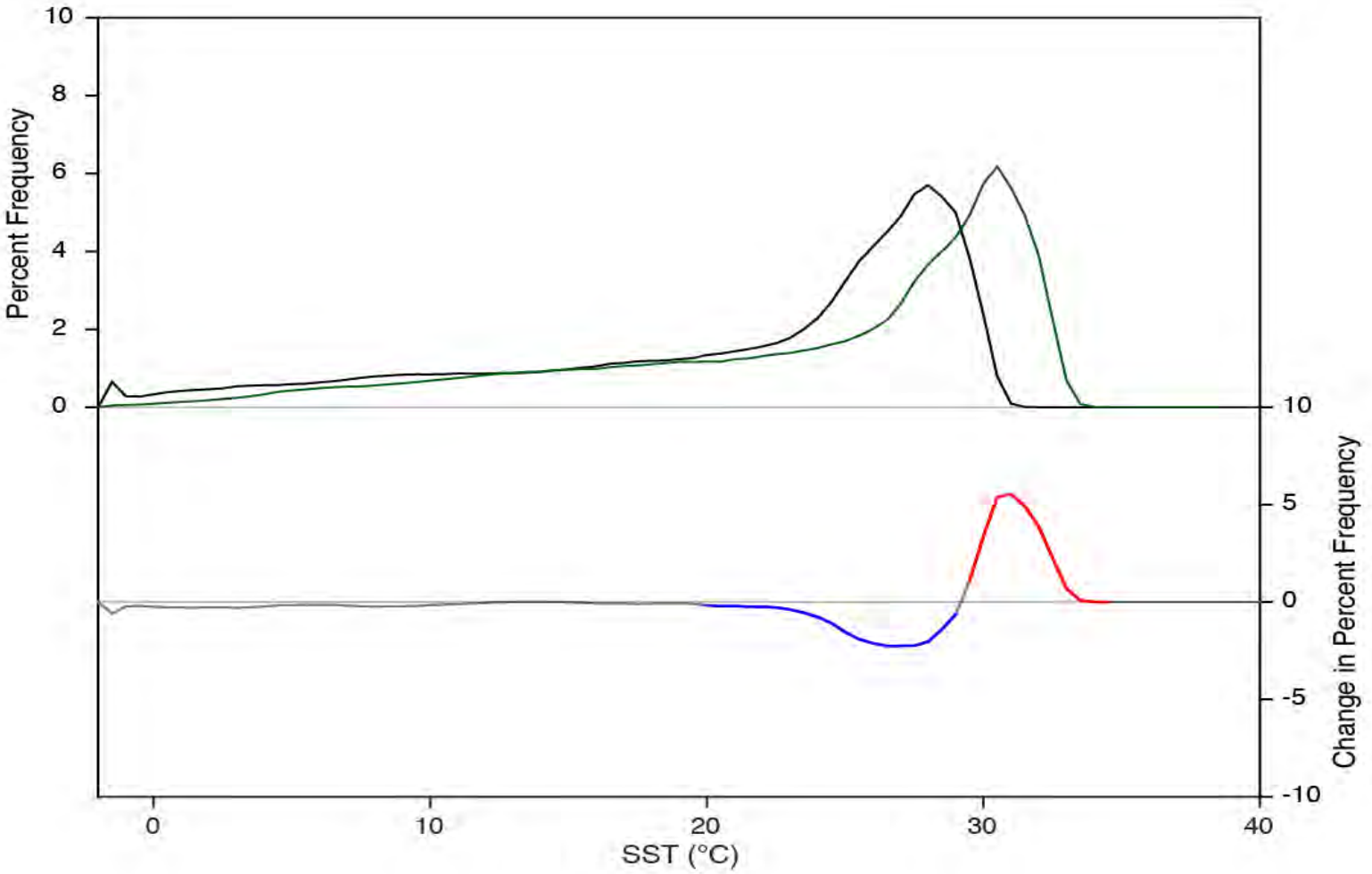
Total Annual Area of new habitat



Total annual area of increasing warmest subtropical temp habitat



Shift in temperature (SST) frequency distribution between beginning and end of the Century



Summary – Fishery impacts

- Ecosystem models driven with plankton output from Earth System Models provide a means of estimating fisheries impacts and identifying climate-informed ecosystem reference points. Value in using several different types of ecosystem models.

- One Earth System Model phytoplankton output used in 2 ecosystem models projects fishery catch of apex species will be reduced by 15-50%.Further a 50% reduction in F may be required to maintain ecosystem size structure.

- Going forward need to incorporate zooplankton and temperature changes in ecosystem models.

Summary- Epipelagic thermal habitat

- Thermal gradients in the subtropical gyre run east to west as well as south to north. As the ocean warms the temperature frequency distribution changes.

- There is a replacement of 10 million km^2 of the mid-range subtropical thermal habitat with the upper range thermal habitat altering areas of preferred habitats for various subtropical species.

- 1-10 million km2 of new thermal habitat with temperature exceeding anything previously seen emerges

- Assessing the complete suite of climate impacts to an ecosystem will likely require several different modelling approaches .