

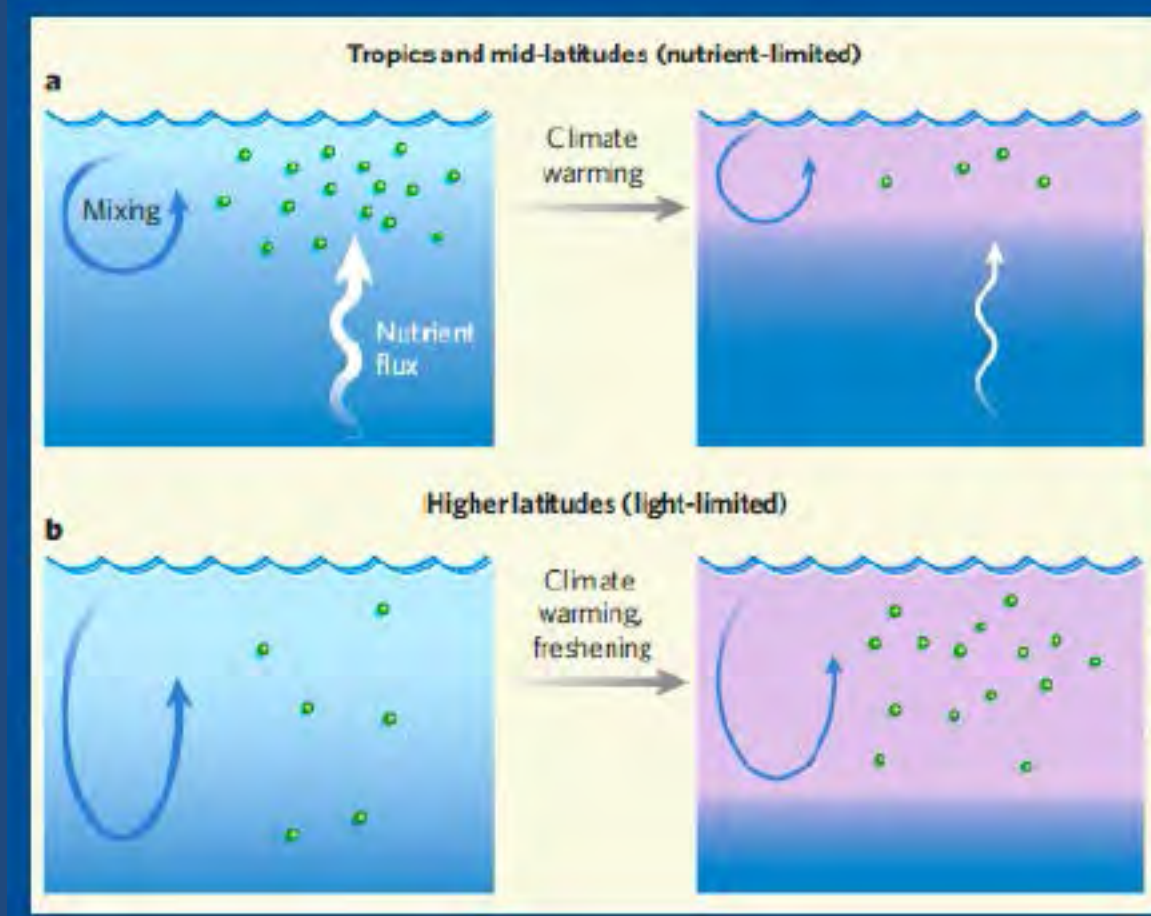
Trophic amplification of ocean productivity trends in a changing climate

Effects of Climate Change on the
World's Oceans
Santos City, Brazil
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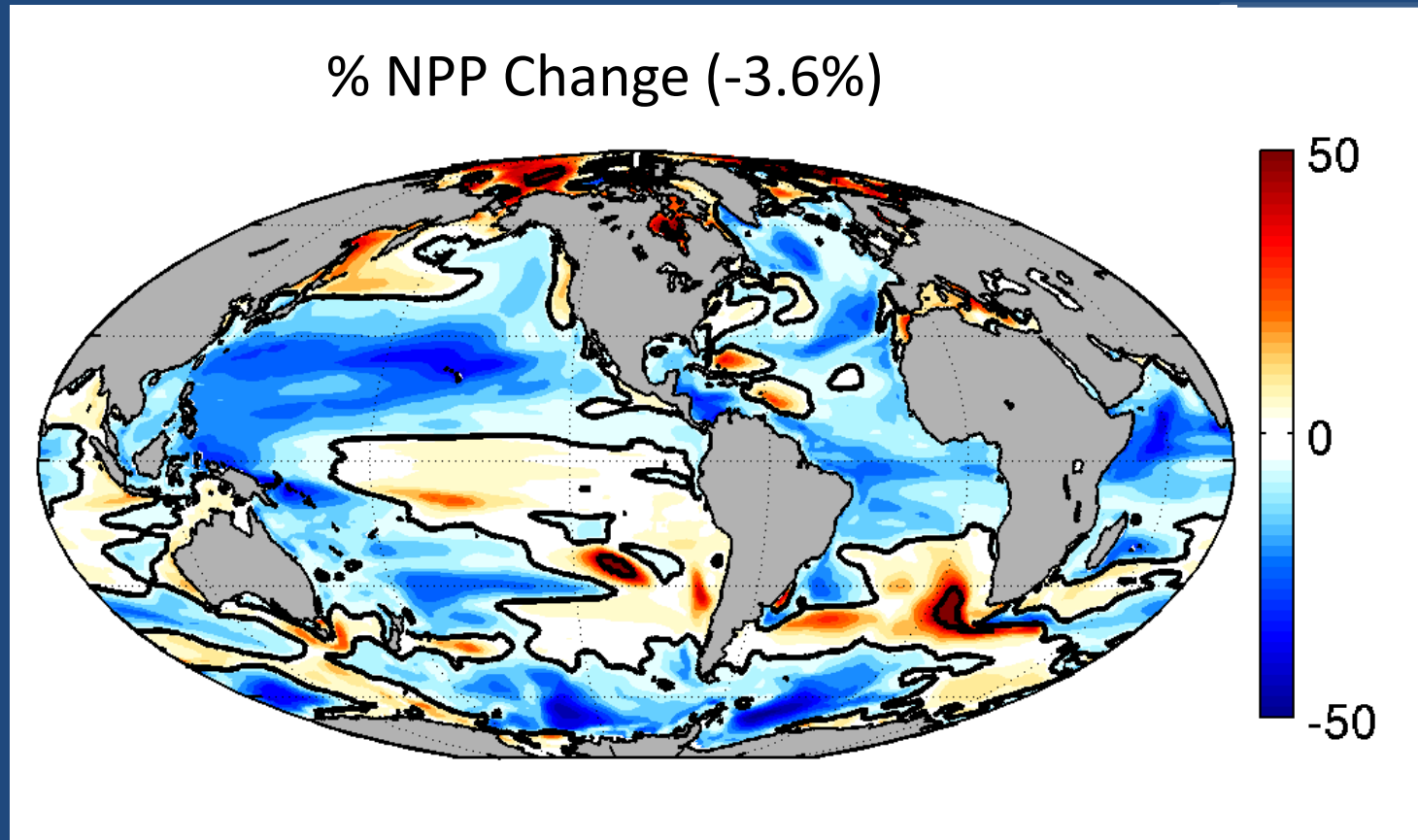


Projected increases in ocean stratification under climate change are expected to impact net primary production (NPP)



Doney, Nature, 2006; see also Bopp et al., GBC 2001;
Sarmiento et al., GBC 2004; Steinacher et al., 2010

Latitudinal tendencies underlie significant regional complexity in most projections



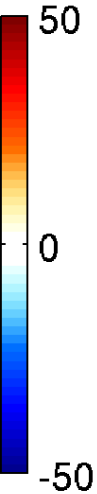
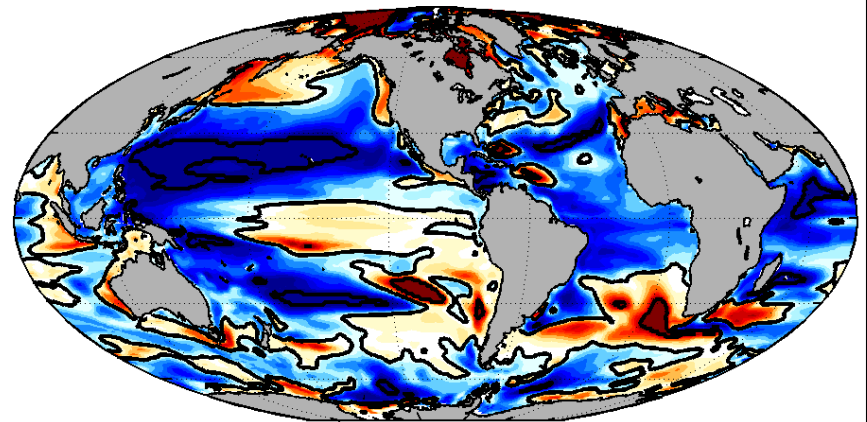
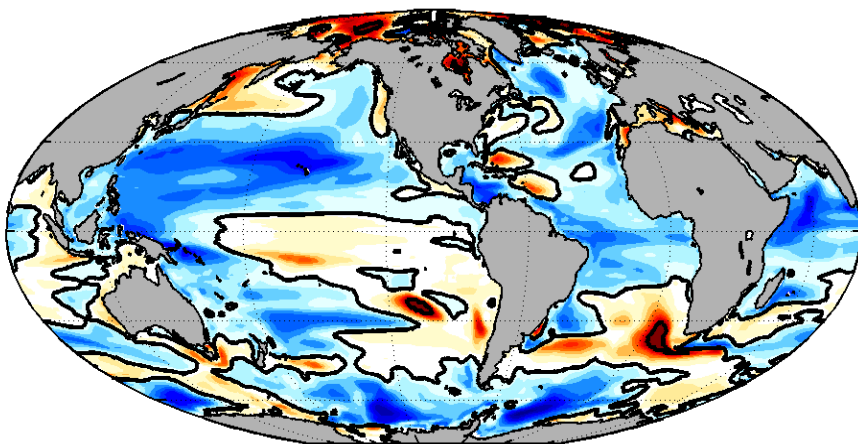
$((2051-2100) - (1951-2000)) / (1951-2000); \text{RCP8.5}$

ESM2M-COBALT Projects mesozooplankton production changes that are:

- ~ 2X projected NPP changes
- Often > 25% at regional scales

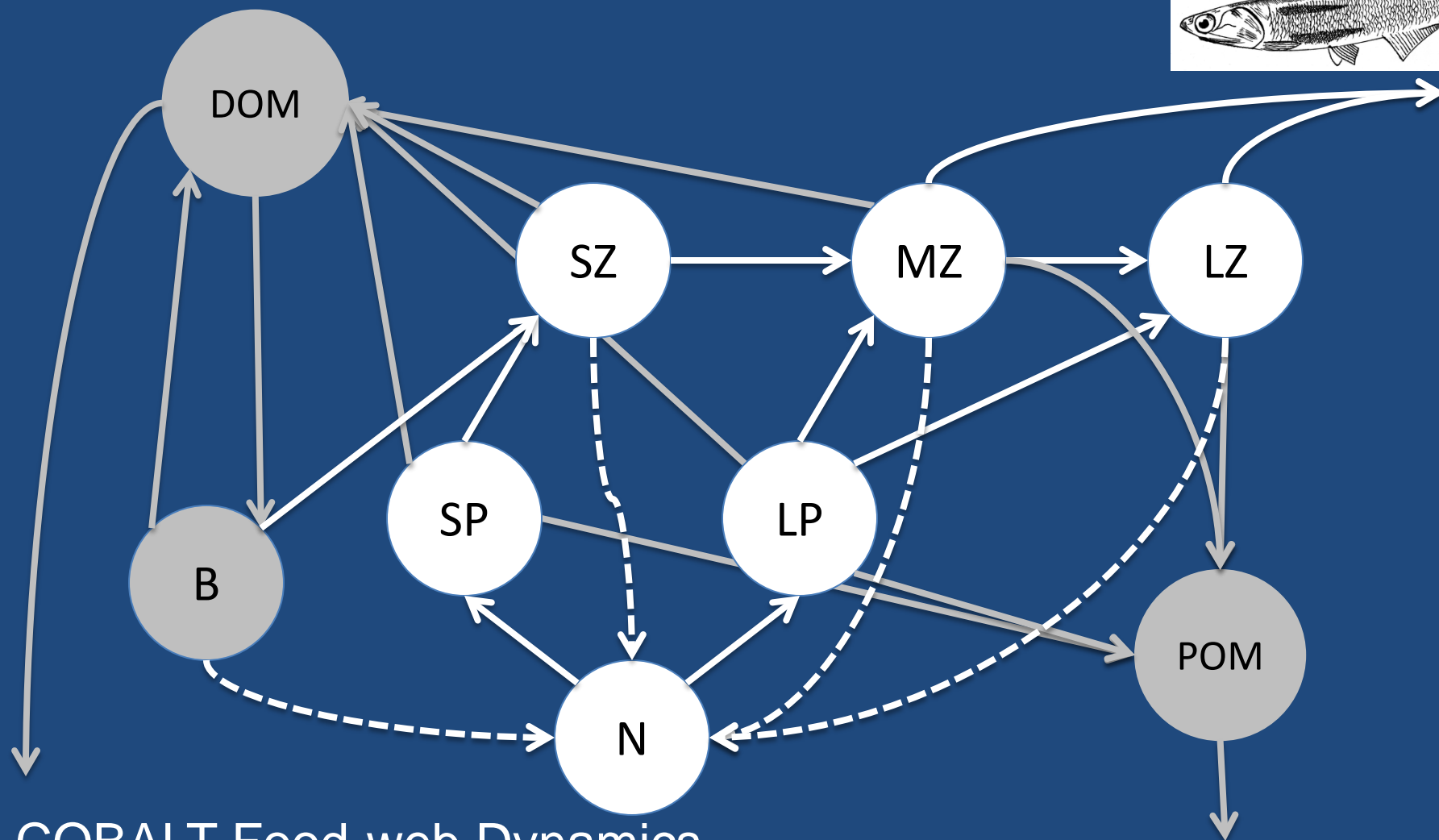
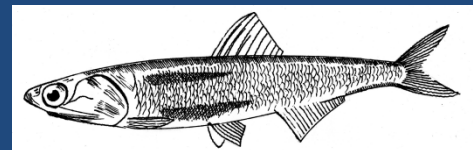
% NPP Change (-3.6%)

% MESOZP Change (-7.9%)



$((2051-2100) - (1951-2000)) / (1951-2000); \text{RCP8.5}$

A complex path between phytoplankton and fish



Define three metrics:

ZGE is the zooplankton growth efficiency, or the fraction of material ingested by zooplankton that results in zooplankton production.

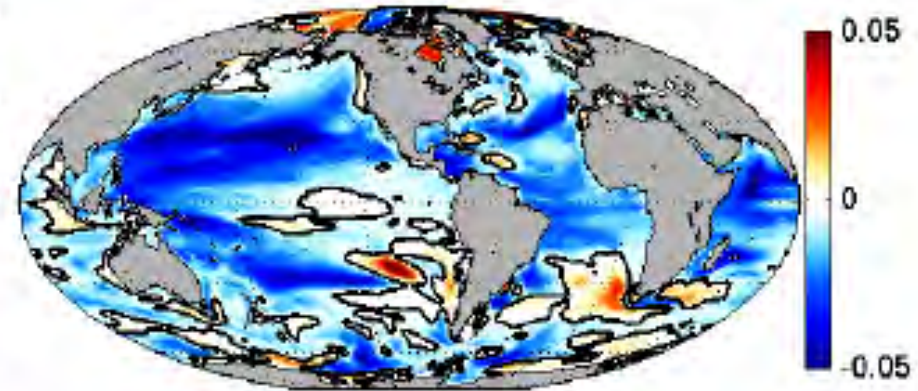
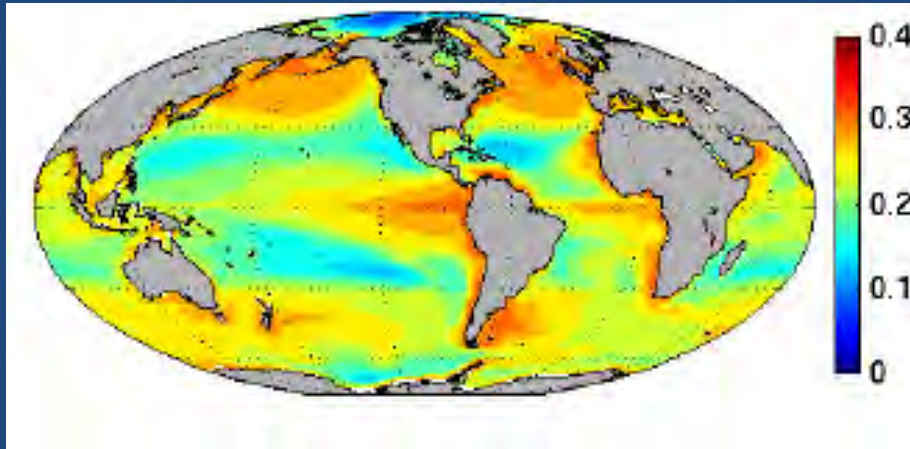
ZPC, is Zooplankton-phytoplankton coupling, the fraction of primary production consumed by all zooplankton.

MESOTL is the mesozooplankton trophic level

ZGE changes covary with NPP changes; largest drop in the low productivity subtropics

Contemporary ZGE

Projected Change (RCP8.5)

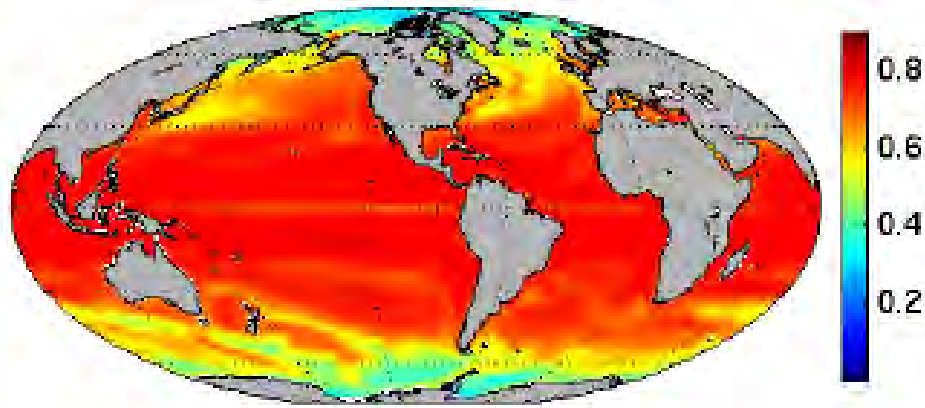


1951-2000

(2051-2100) – (1951-2000)

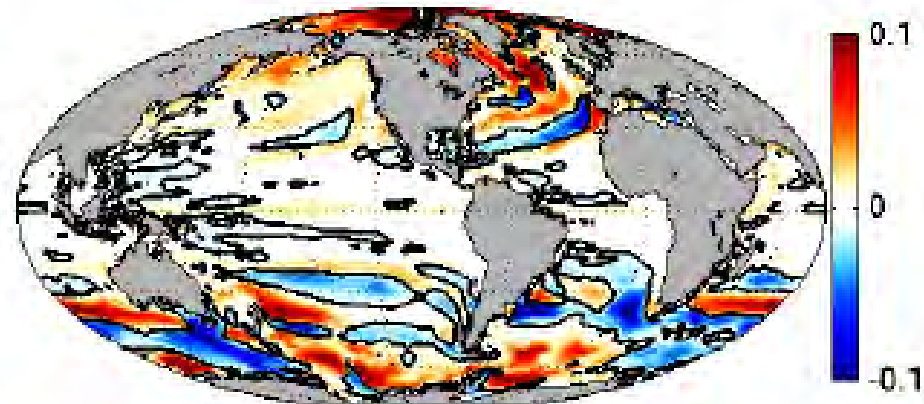
Increased ZPC in most places due to damping of “boom-bust” bloom cycles/phyto aggregation

Contemporary ZPC



1951-2000

Projected Change (RCP 8.5)

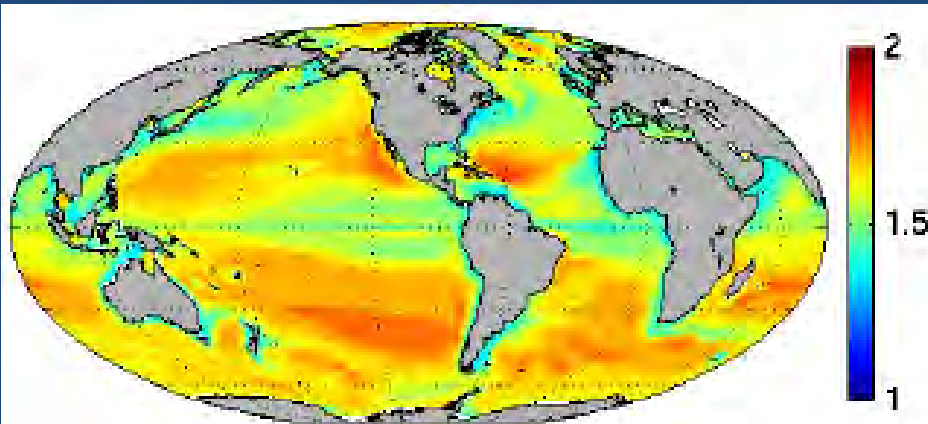


(2051-2100) – (1951-2000)

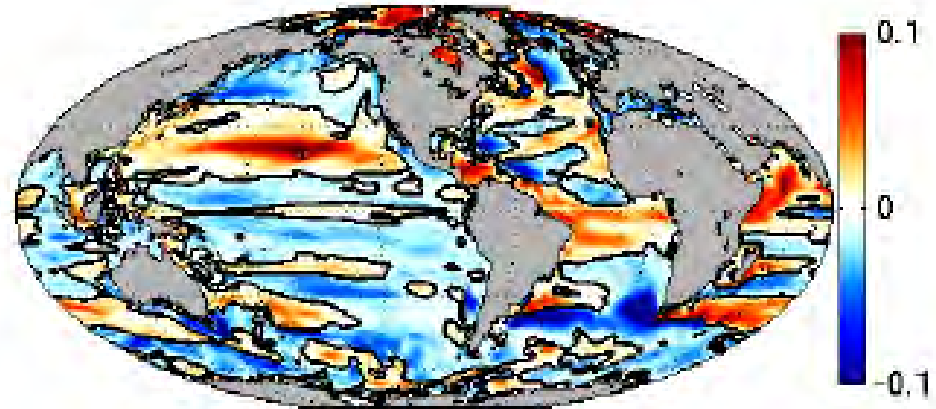
Modest MESOTL changes, off-setting effects of ZPC increase and large phyto decrease

Contemporary MESOTL

Projected Change (RCP 8.5)



1951-2000



(2051-2100) - (1951-2000)

Relating mesozooplankton production to primary production

$$MESOZP \cong ZPC \times NPP \times ZGE^{MESOTL}$$

MESOZP = mesozooplankton production

ZPC = zooplankton-phytoplankton coupling

NPP = net primary production

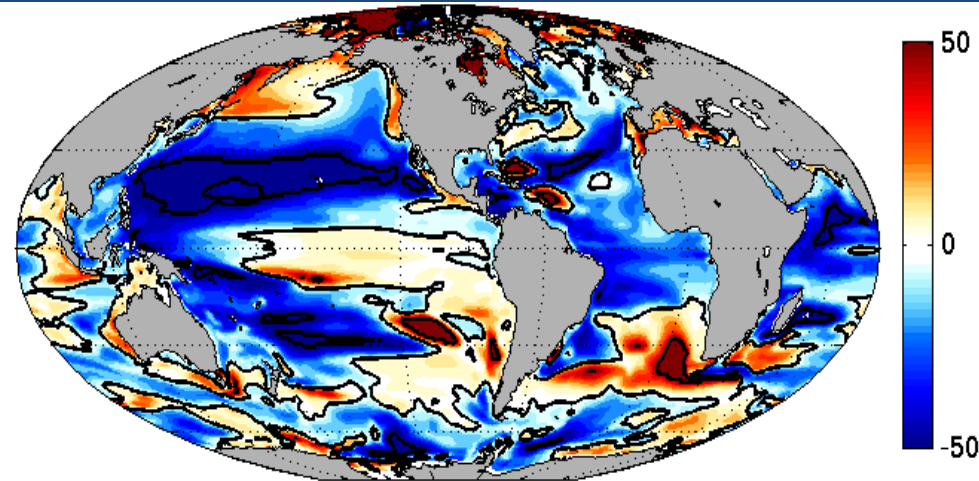
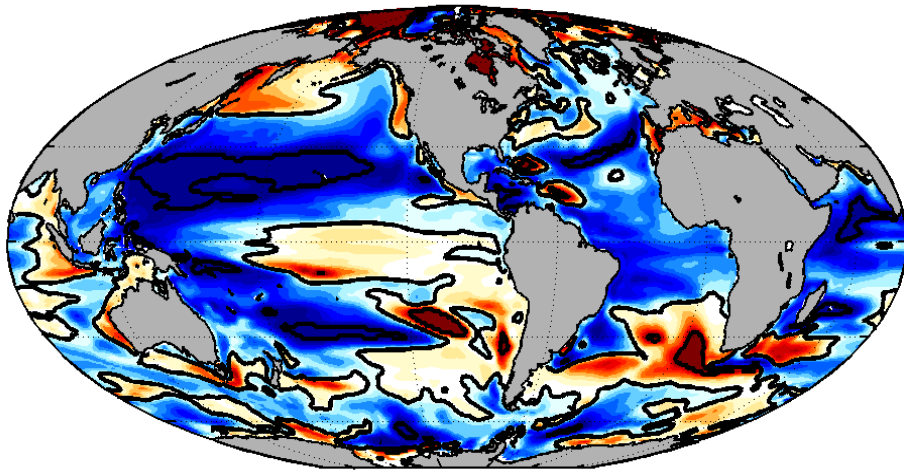
ZGE = zooplankton growth efficiency

MESOTL = trophic level of the zooplankton

Can approximate MESOZP change from NPP change and changes in 3 food web properties

% MESOZP Change

% MESOZP Change

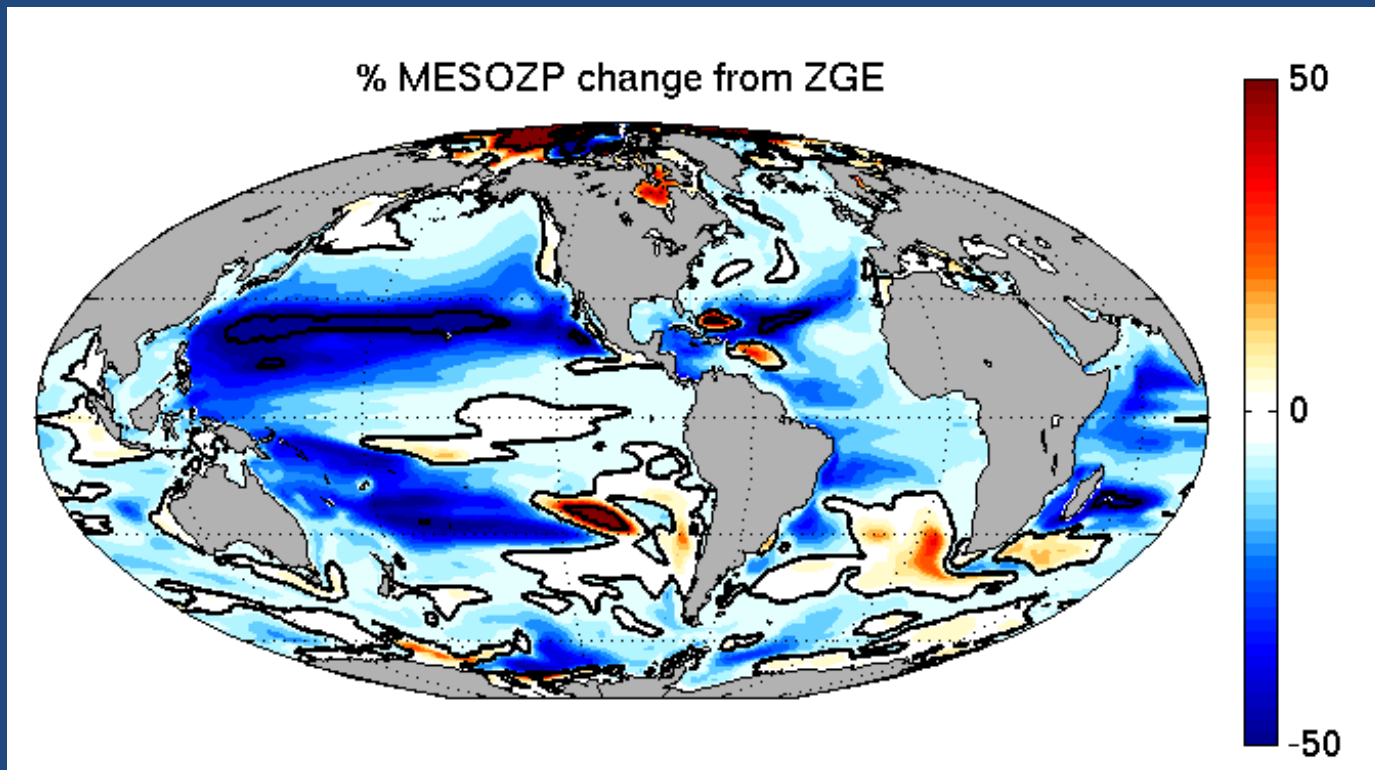


Exact

Approximate

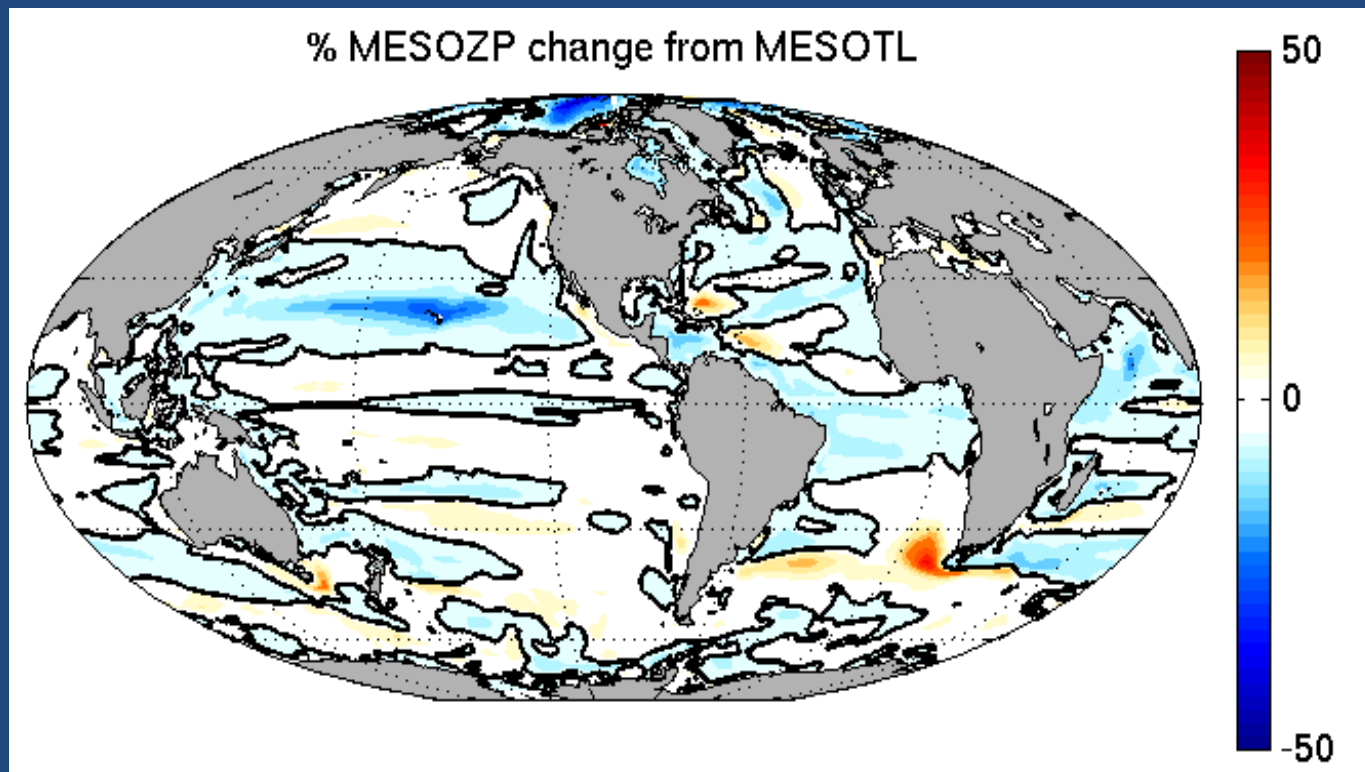
The primary effect of ZGE declines is to exacerbate NPP declines in the subtropics

Contribution to the percent change in Mesozooplankton production from ZGE



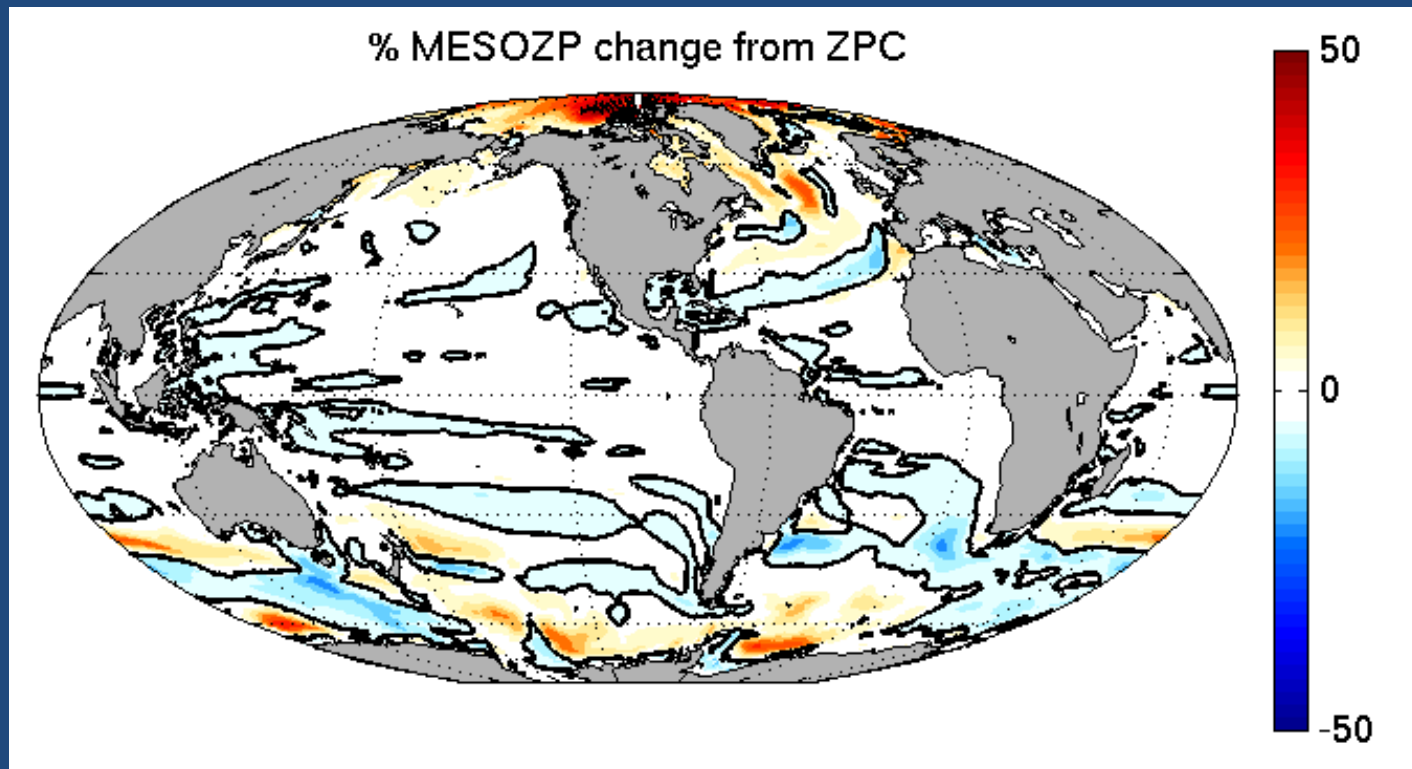
Meso TL changes also exacerbate subtropical NPP declines, but are generally secondary to ZGE

Contribution to the percent change in Mesozooplankton production from MESOTL



ZPC amplifies NPP increases in the Arctic and damps projected declines elsewhere

Contribution to the percent change in Mesozooplankton production from ZPC



Conclusions

- Projected changes in mesozooplankton productivity are amplified relative to projected changes in NPP
- Suggest the potential for substantial regional-scale changes, with implications for food security.
- Amplification arises from (quite basic) food web dynamics assumptions; particularly the amplifying effect of ZGE on NPP changes.

Caveats

- Although COBALT has been rigorously assessed against diverse observational constraints; it is one model.
- Further research is needed to explore sensitivities within COBALT, and across other models.
- Most global biogeochemical models, however, have highly simplified planktonic food web dynamics and have not assessed ocean productivity beyond NPP.

For more detail:

Stock, Charles A., John P Dunne, and Jasmin John, December 2014: Drivers of trophic amplification of ocean productivity trends in a changing climate. *Biogeosciences*, 11(24), DOI:10.5194/bg-11-7125-2014.

Stock, Charles A., John P Dunne, and Jasmin John, January 2014: Global-scale carbon and energy flows through the marine food web: an analysis with a coupled physical-biological mode. *Progress in Oceanography*, 120, DOI:10.1016/j.pocean.2013.07.001.