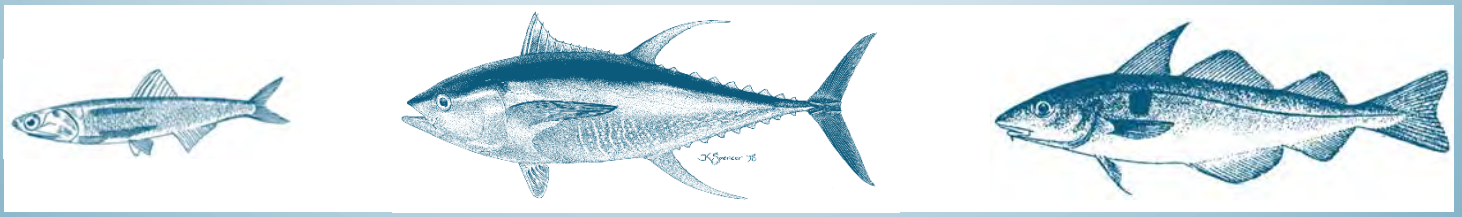
The Response of Fisheries Production to Natural and Anthropogenic Forcing: Past, Present, and Future



Colleen Petrik

PICES Annual Meeting San Diego

10 Nov 2016

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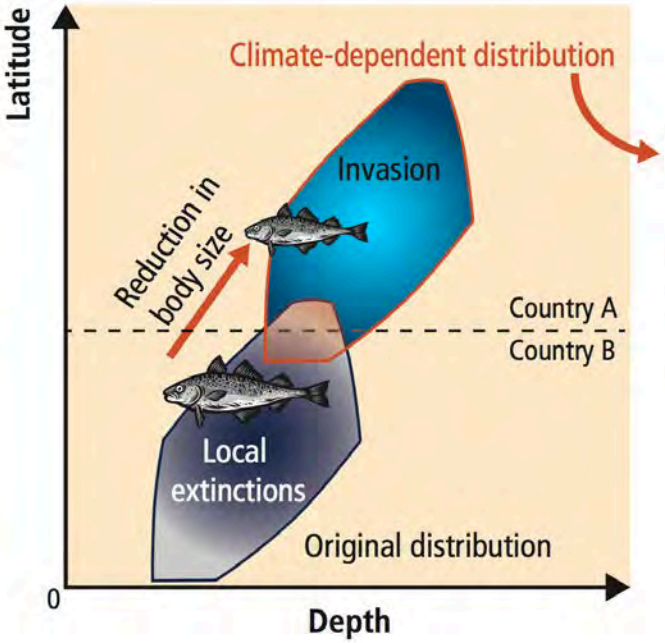
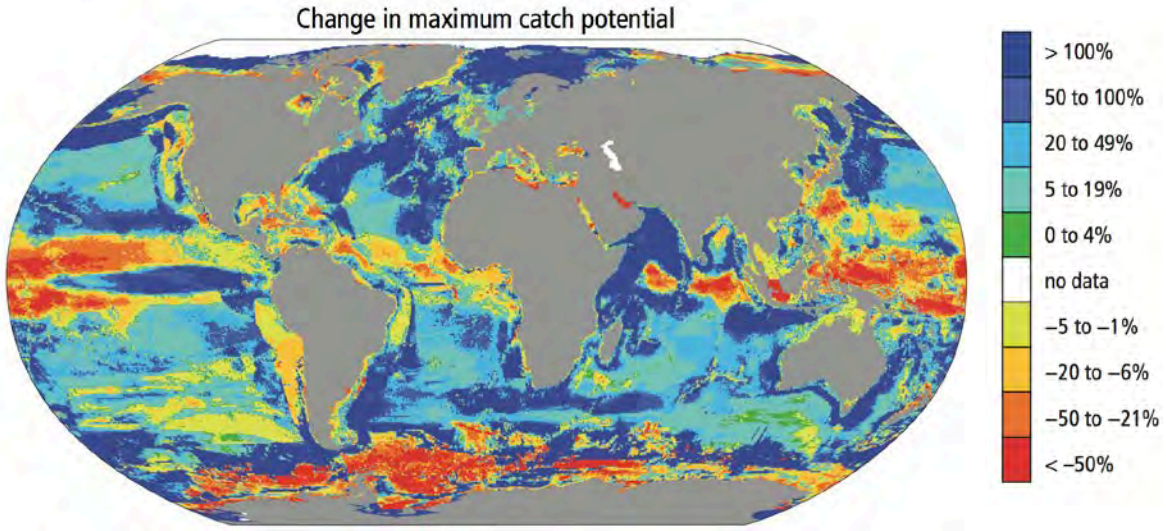
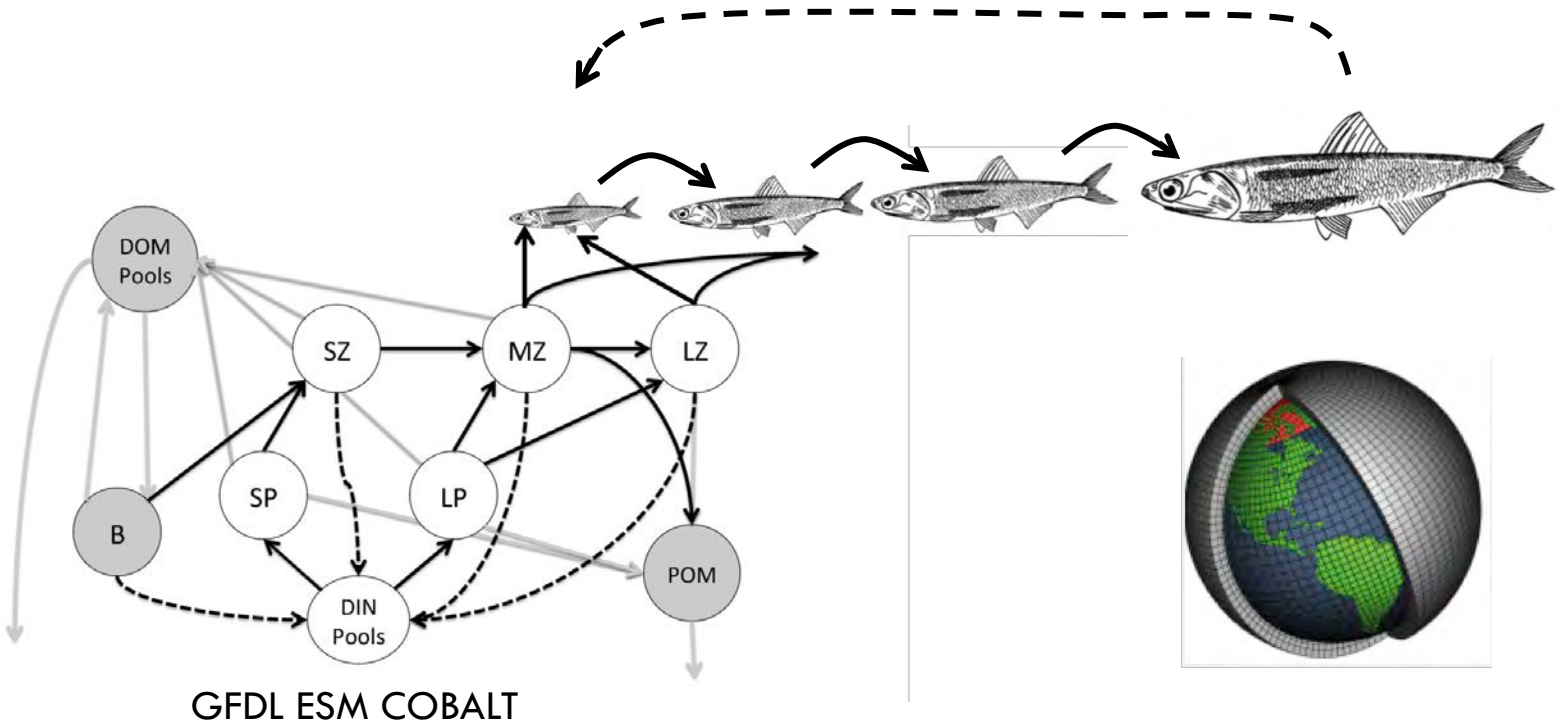
Expected changes to fish





IPCC AR5 Ch. 6 Pörtner et al. 2014

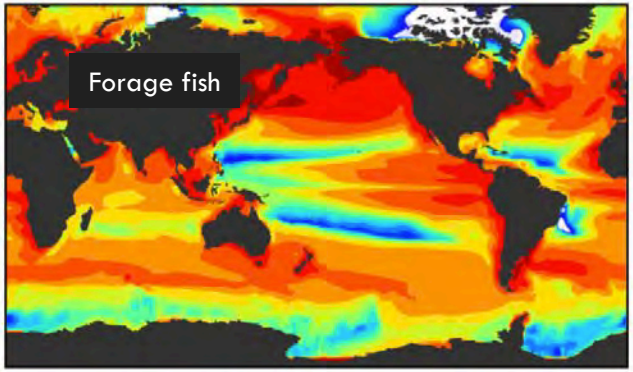
Global size-based fish model

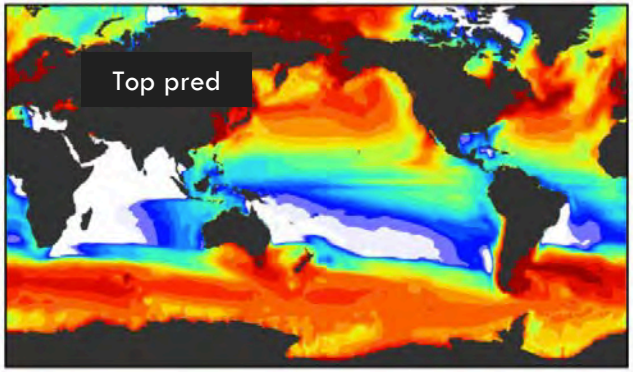


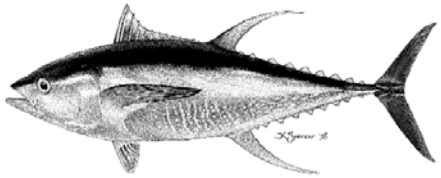
GFDL ESM COBALT

Stock et al. 2014; Watson et al. 2014

Global size-based fish model







- Pelagic
- Adults

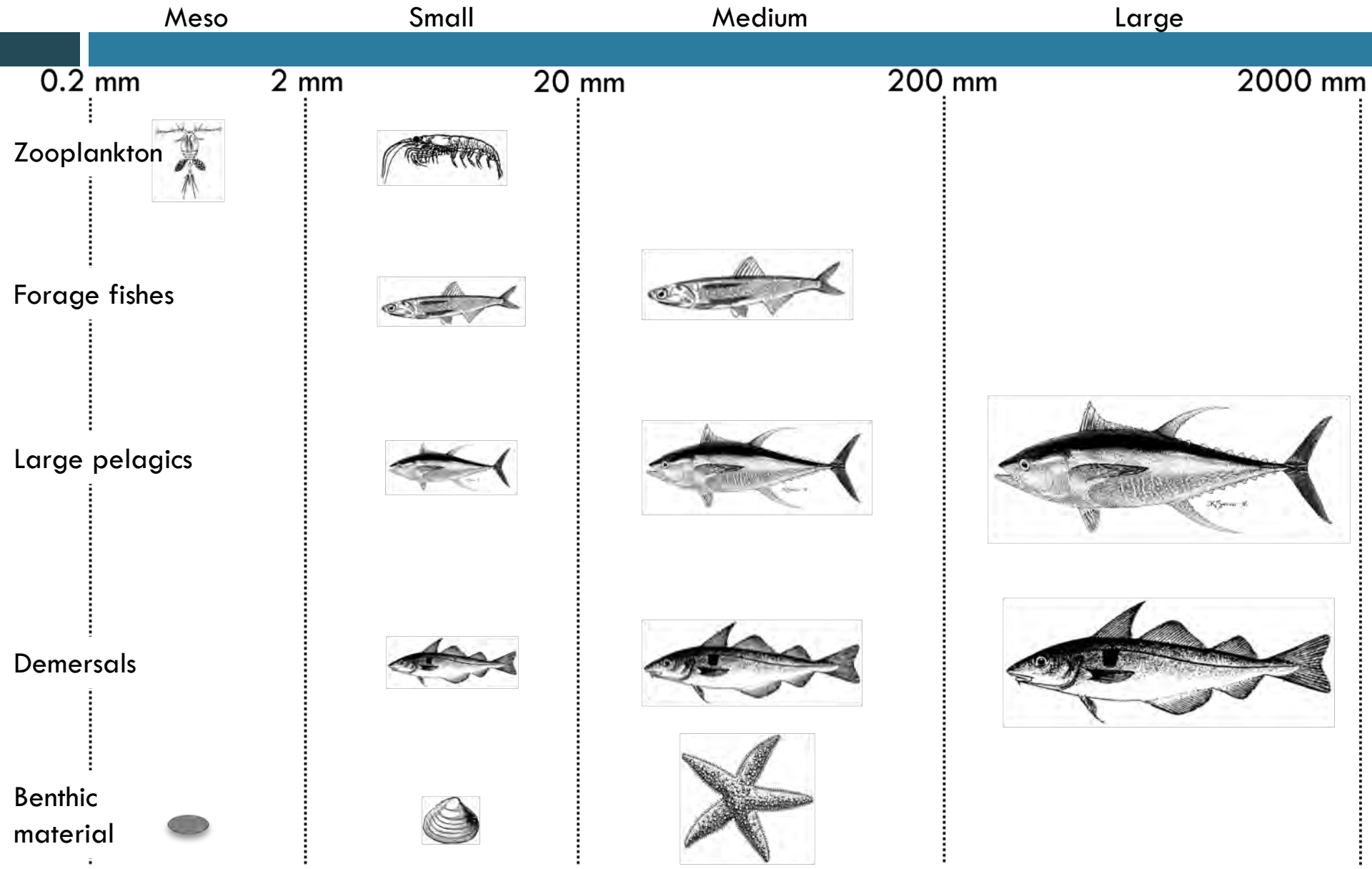
Watson et al. 2014

Global size- and type-based fish model

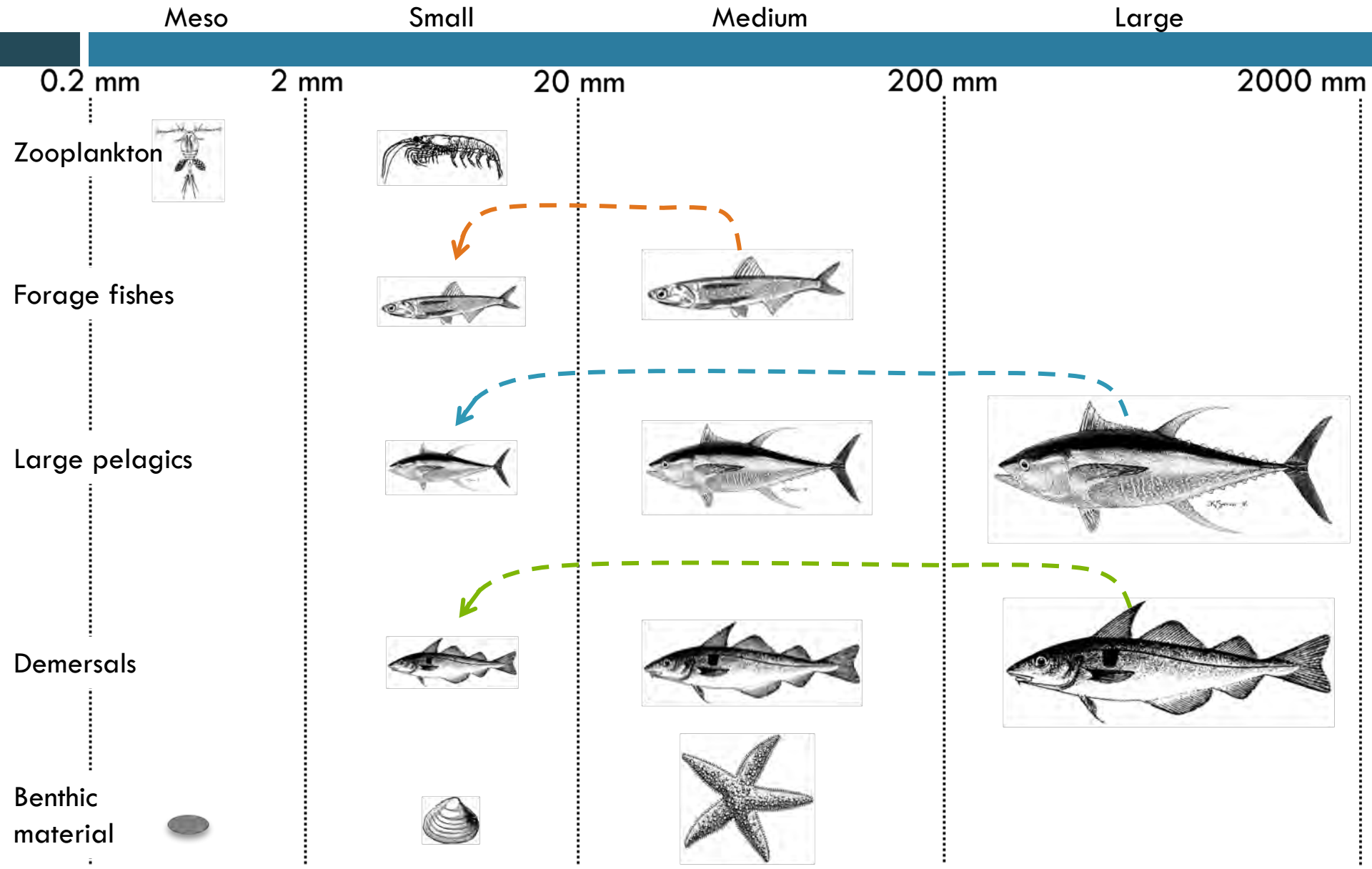
Structured by:

- Feeding & habitat "functional type"
  - forage fishes
  - large migratory pelagics
  - demersals
- Maturity stage
  - larvae
  - juveniles
  - adults
- Size
  - small
  - medium
  - large

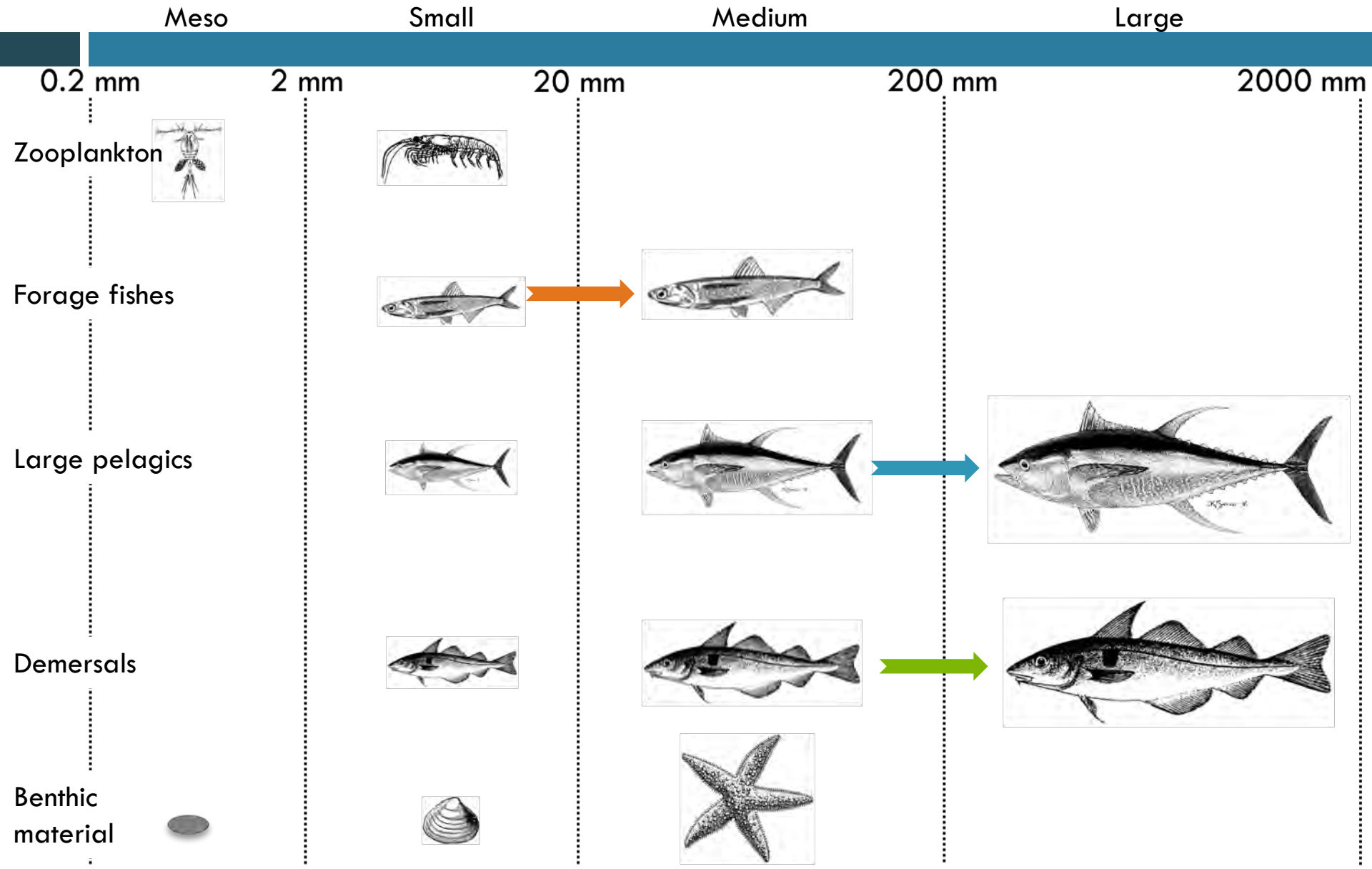
Functional types and sizes



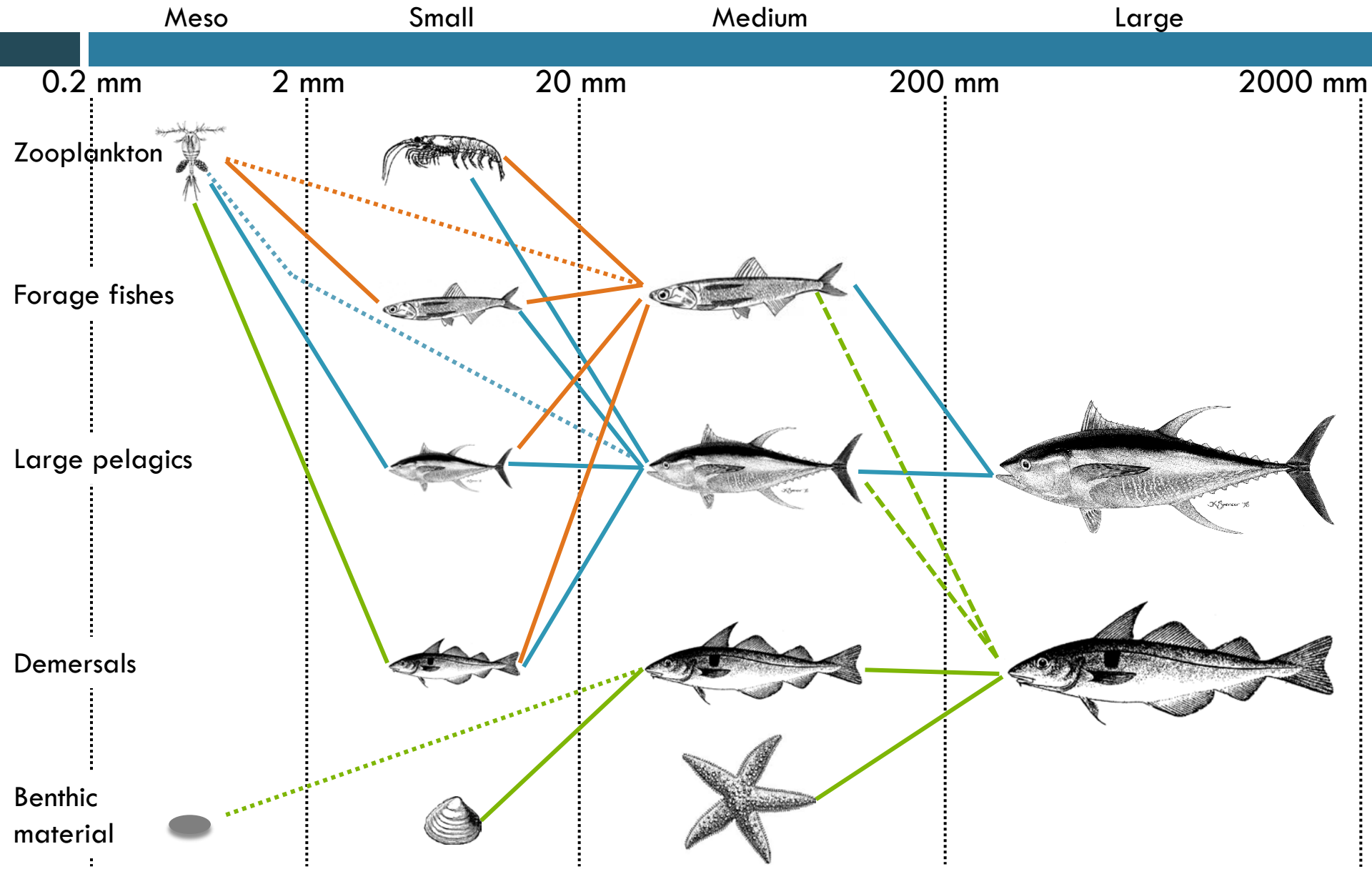
Life cycle dynamics - reproduction



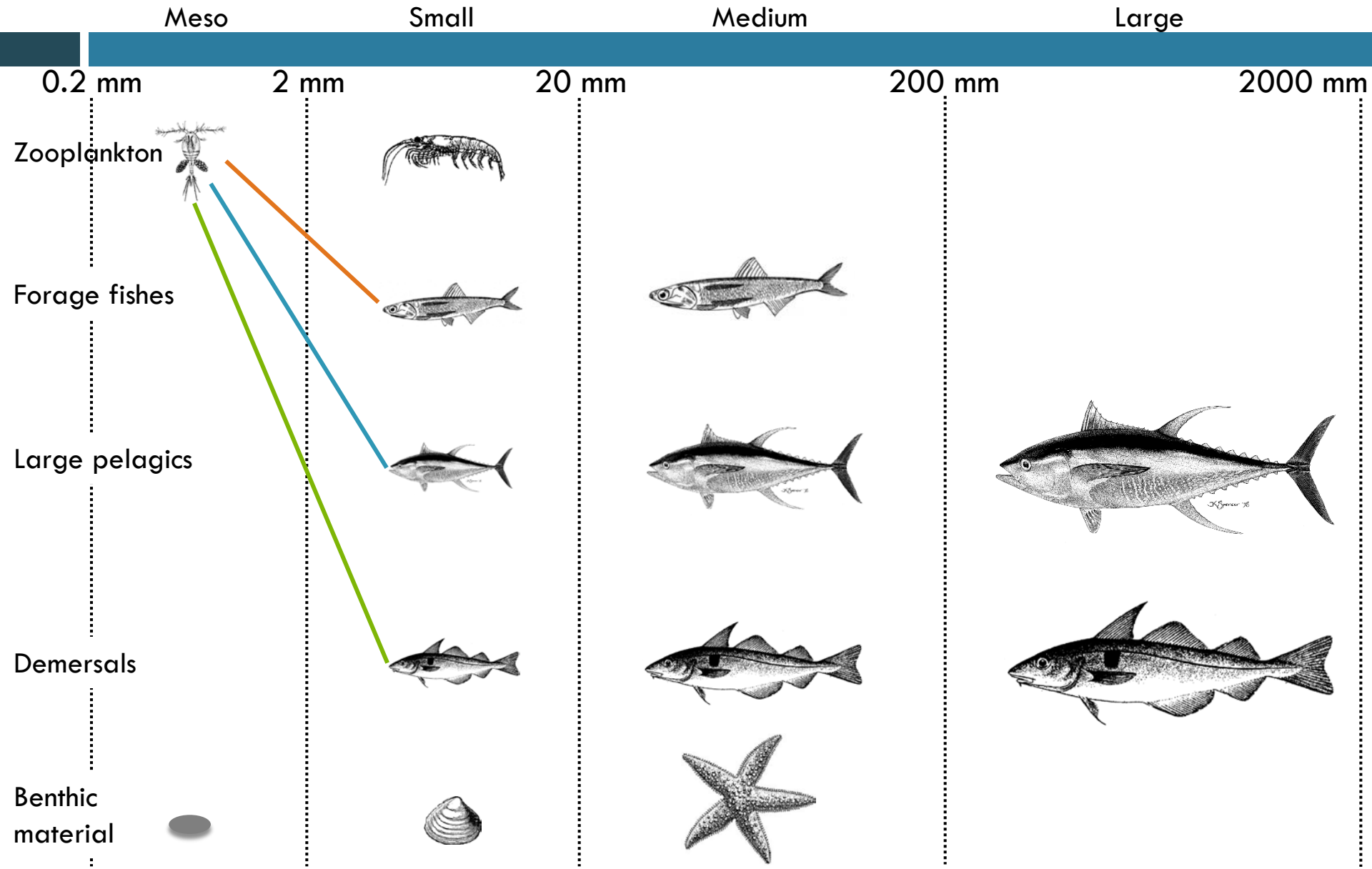
Life cycle dynamics - recruitment



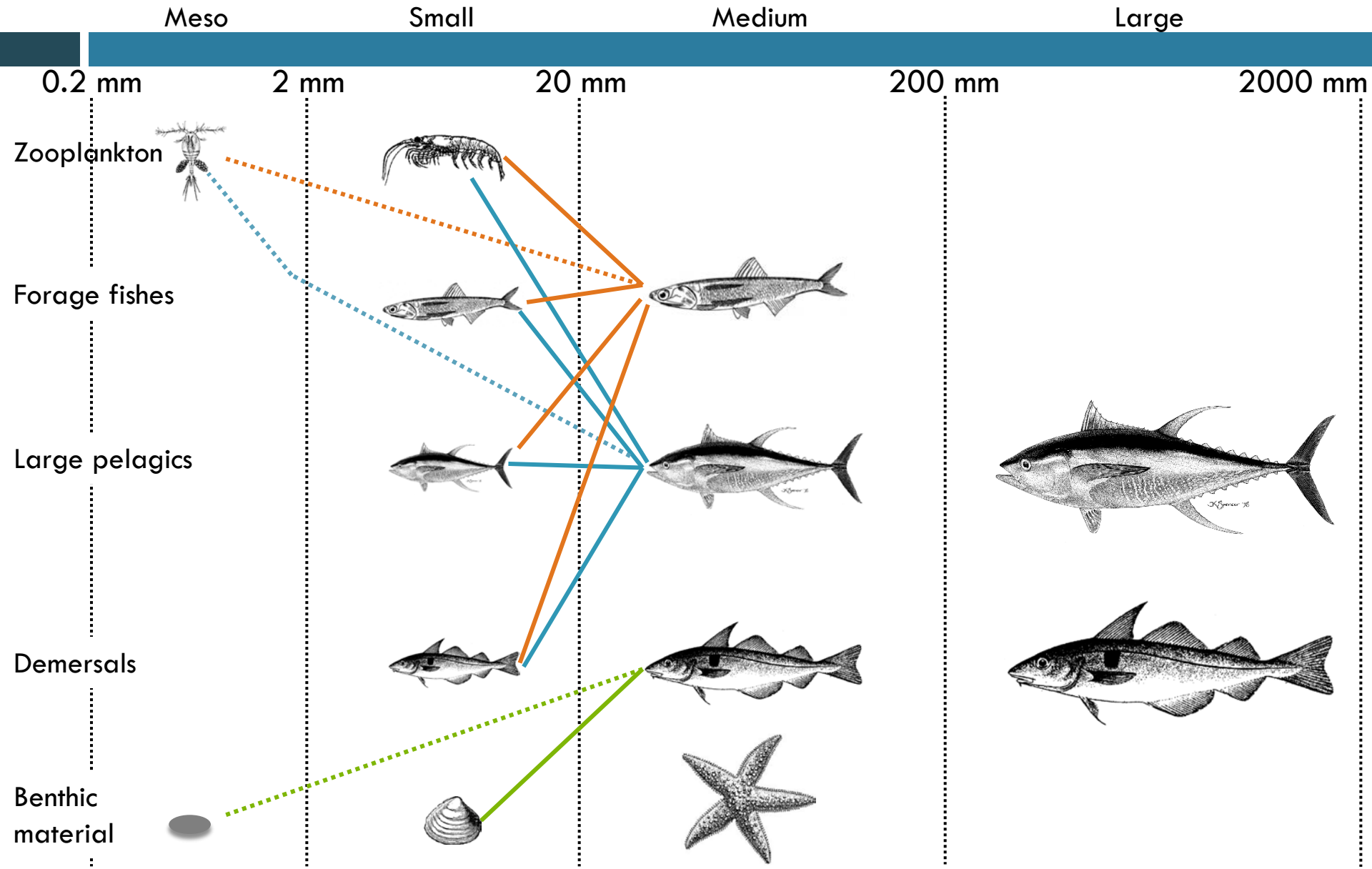
Size-based trophic interactions



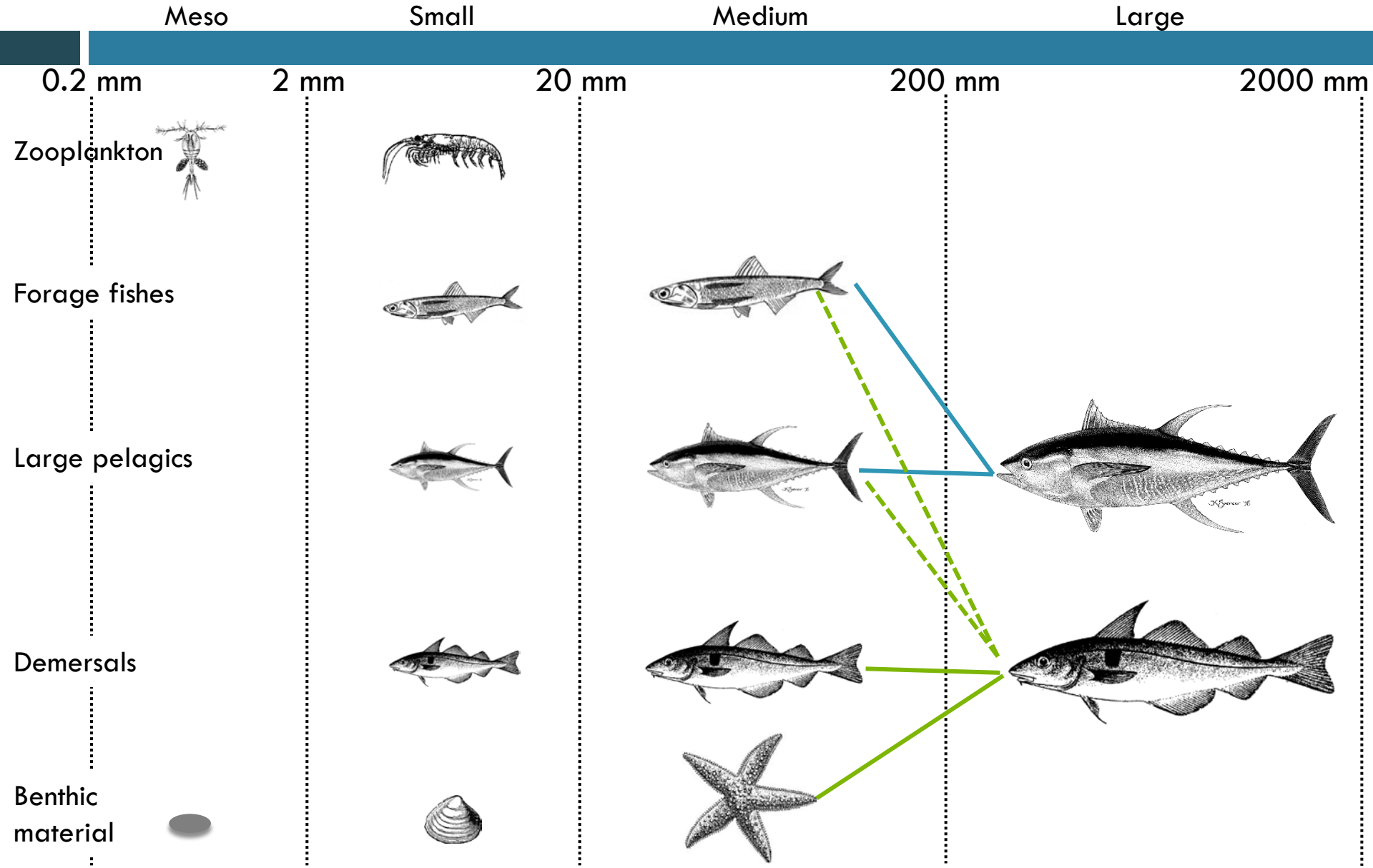
Small eats medium zooplankton



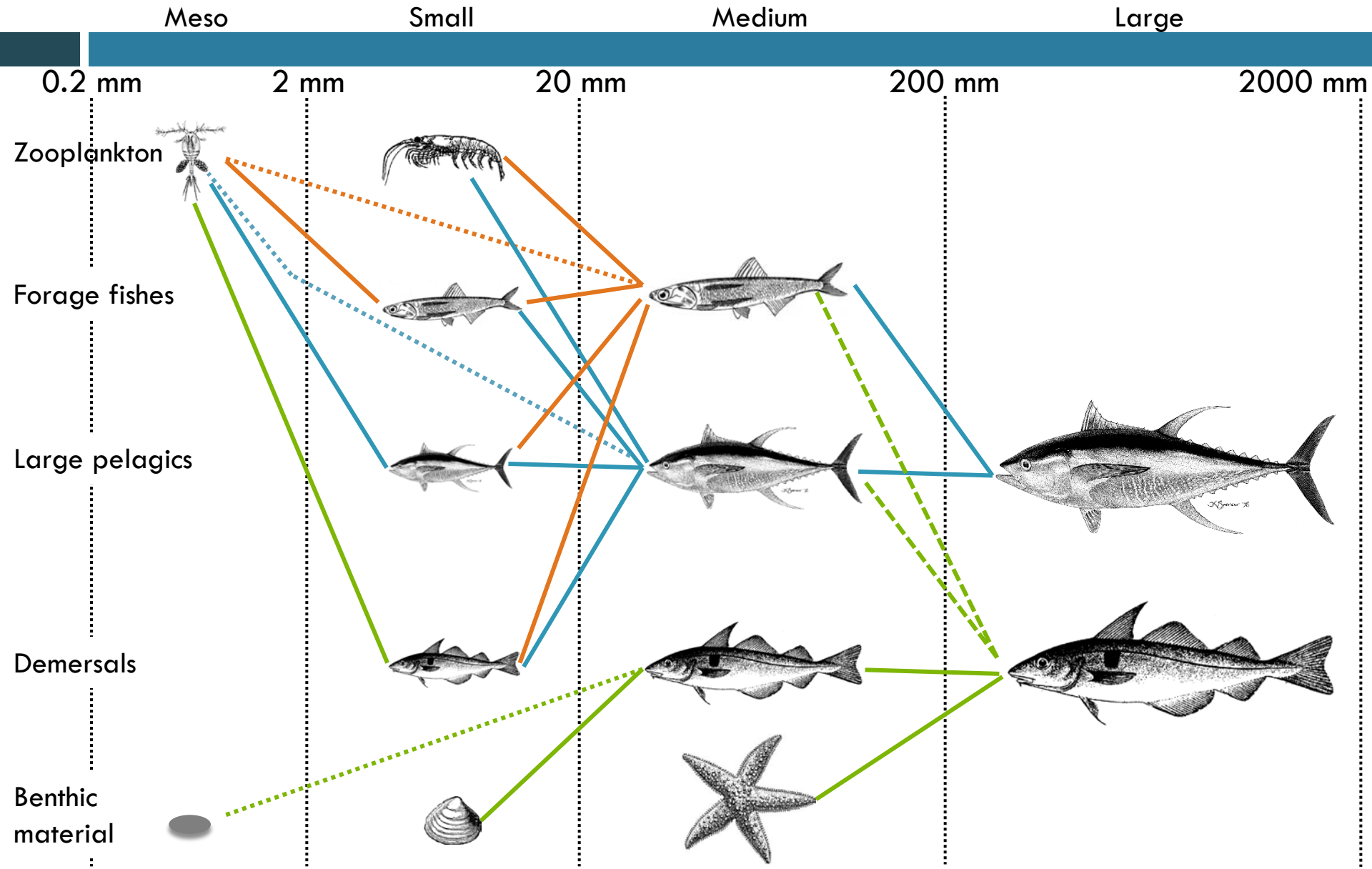
Medium eats small animals



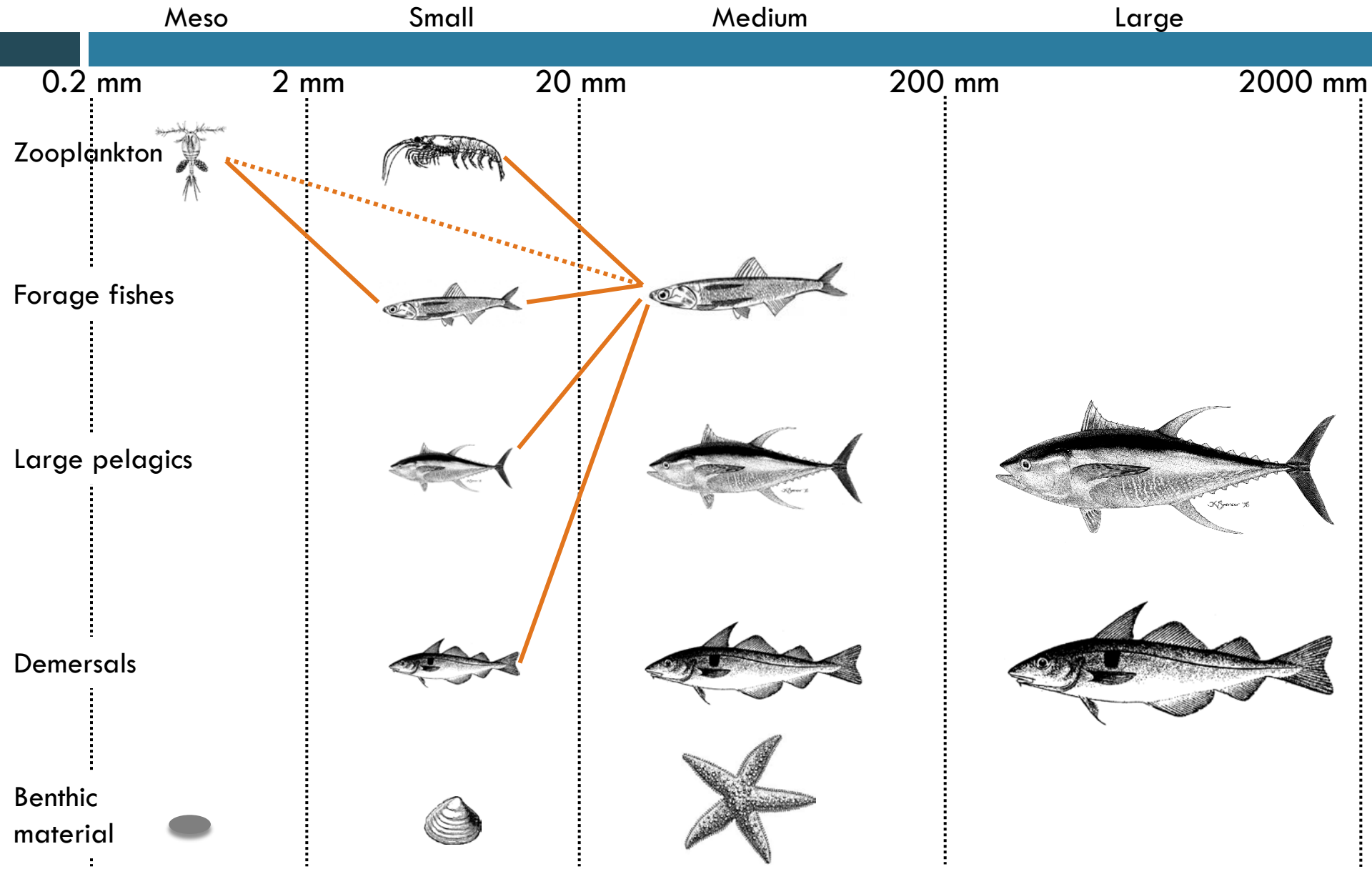
Large eats medium animals



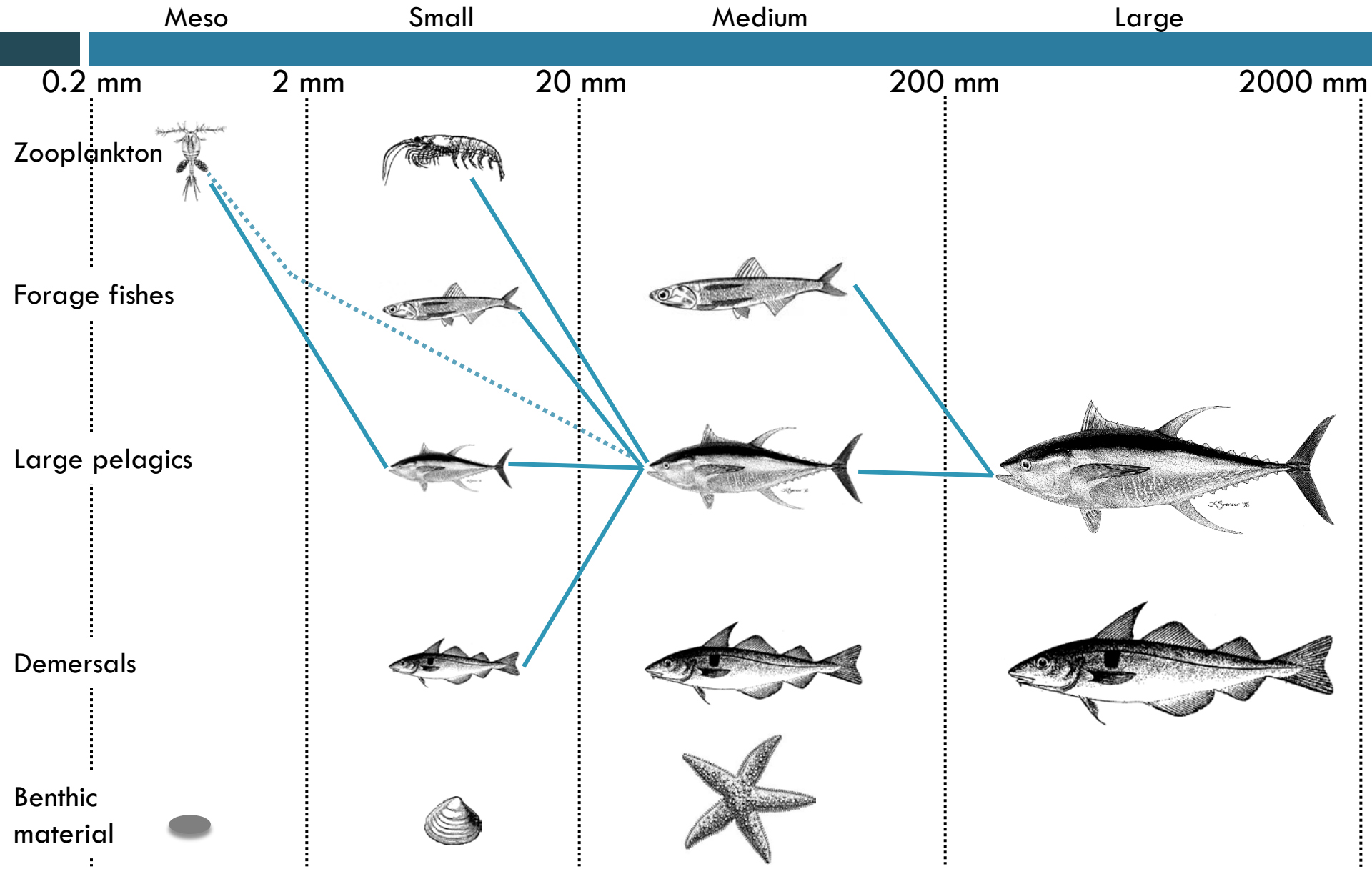
Type-based trophic interactions



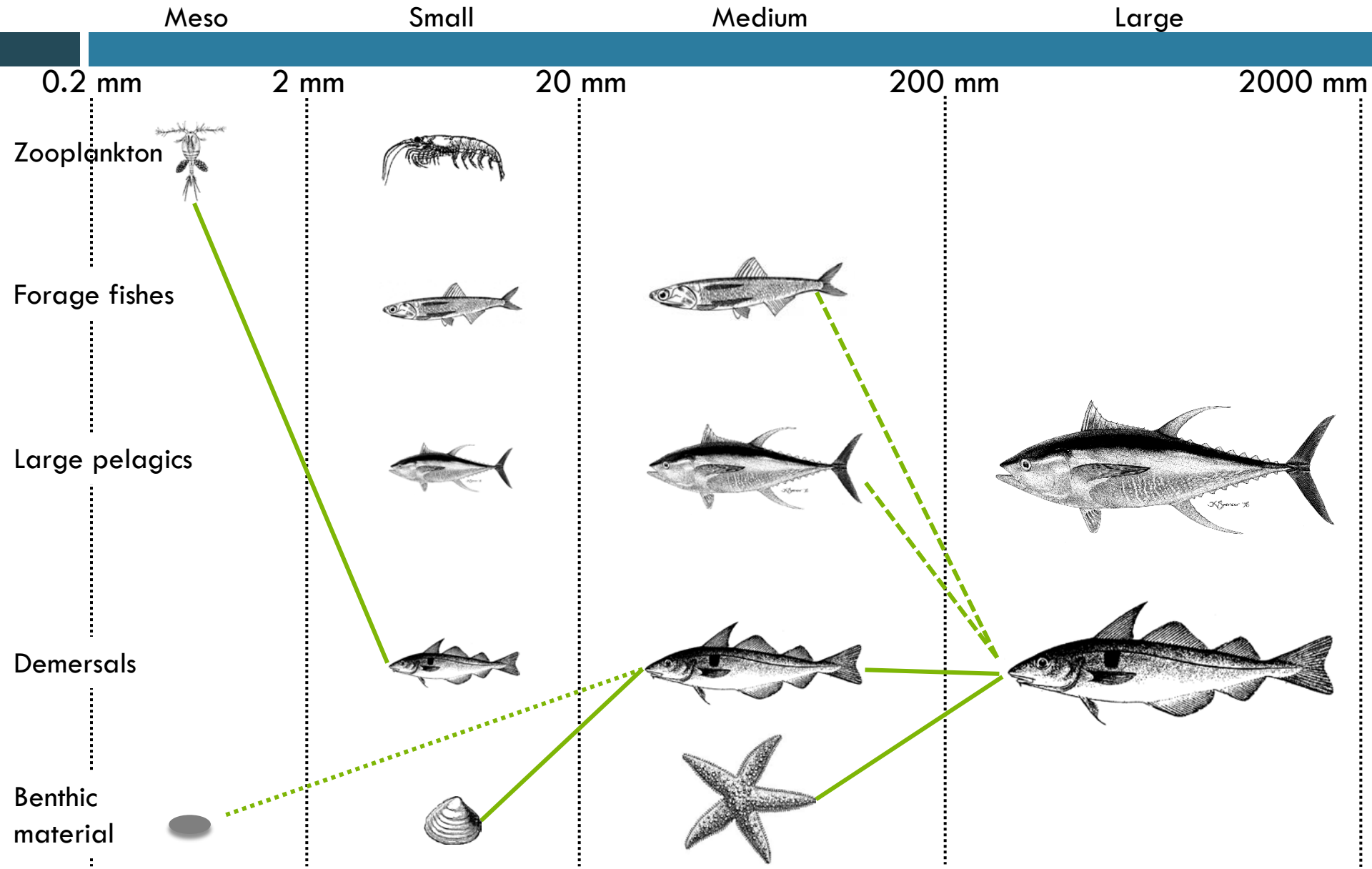
Forage fishes eat plankton



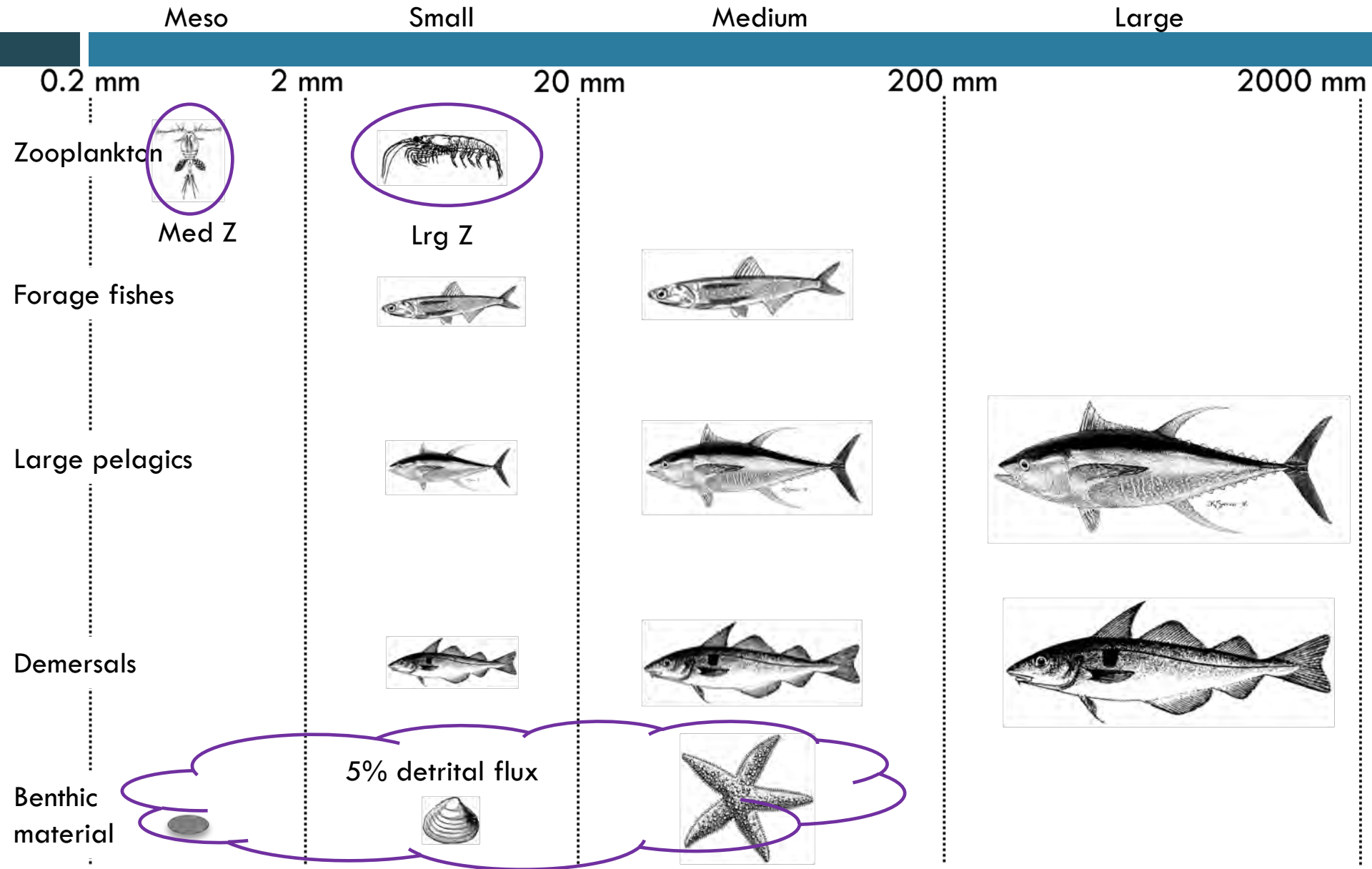
Large pelagics eat pelagic animals



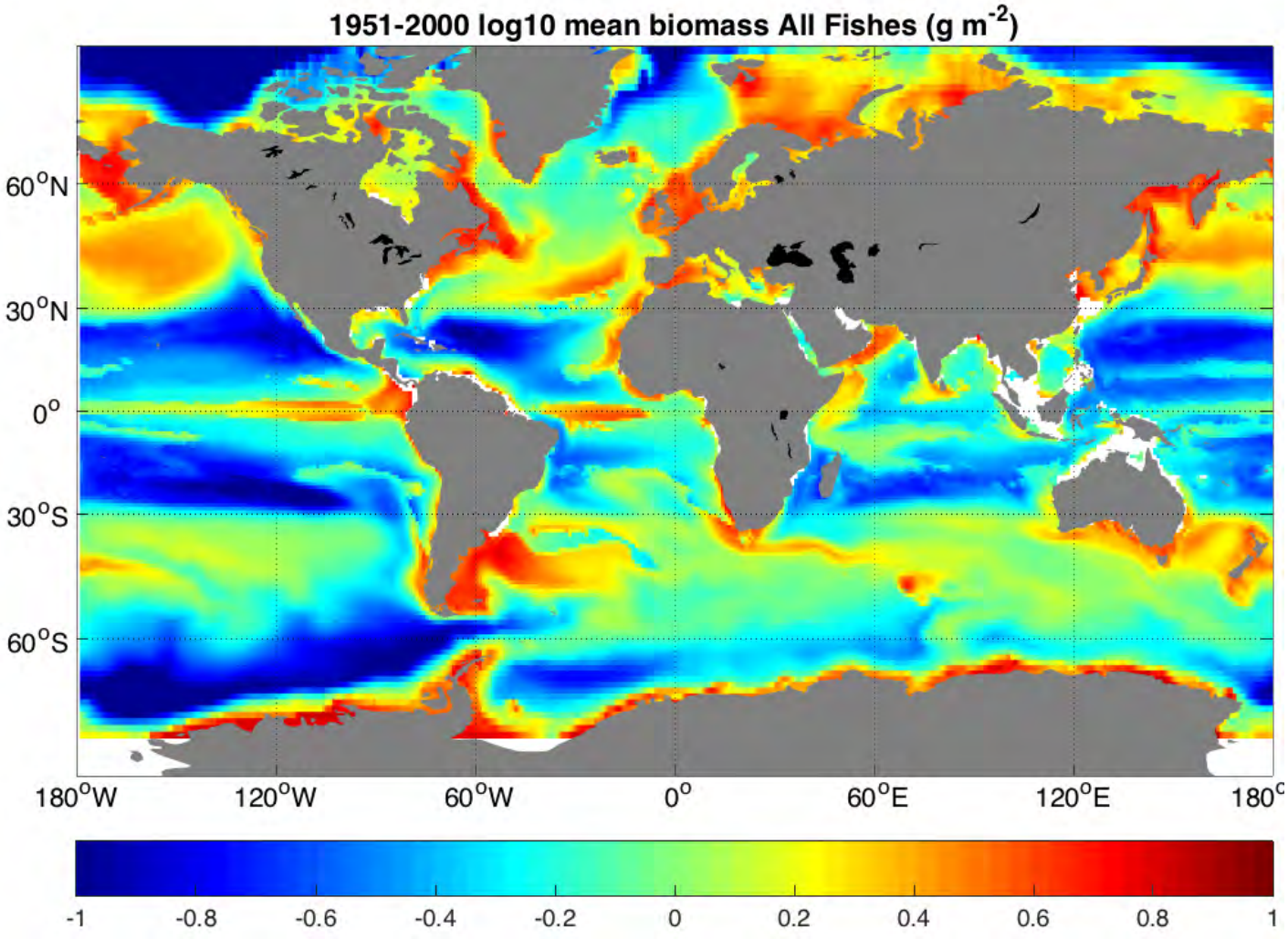
Demersals eat … it depends



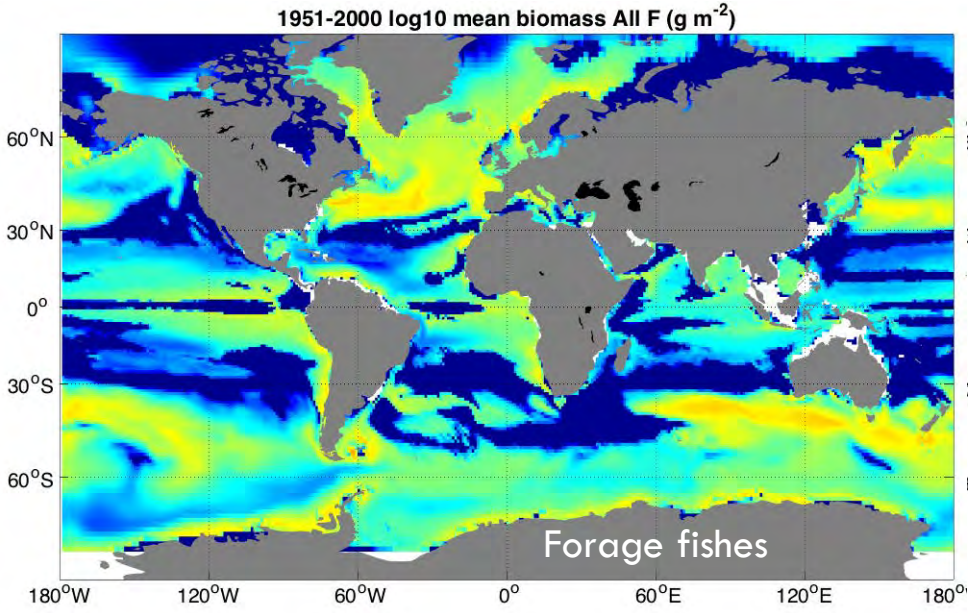
ESM-COBALT linkage

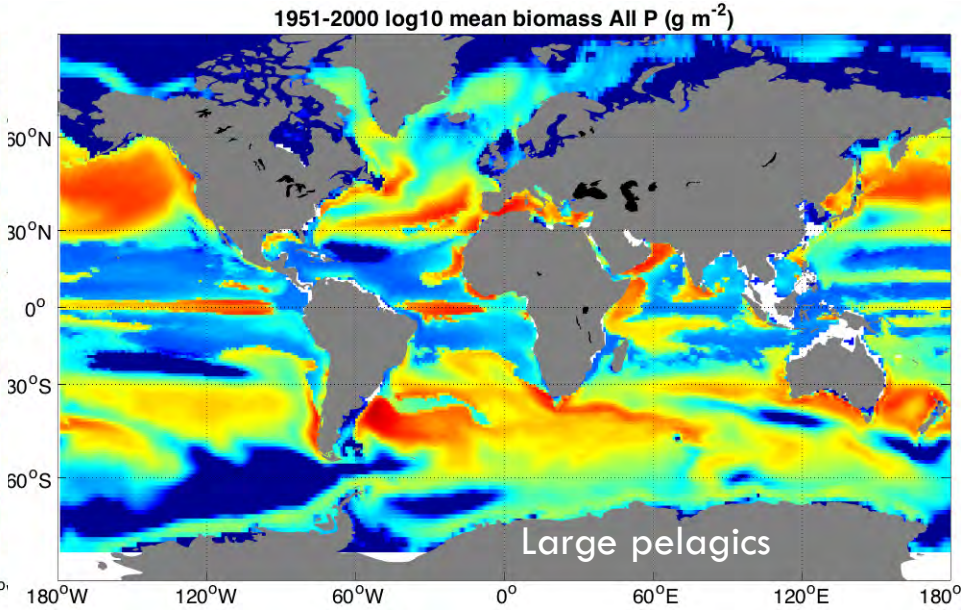


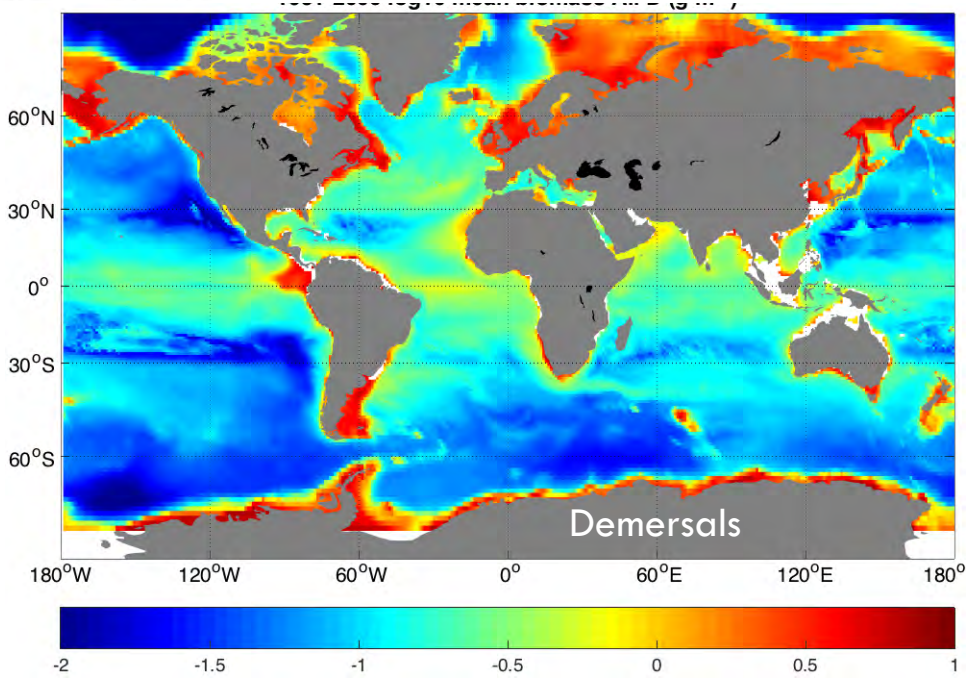
Unfished historic global fish distribution



Unfished historic global fish distribution

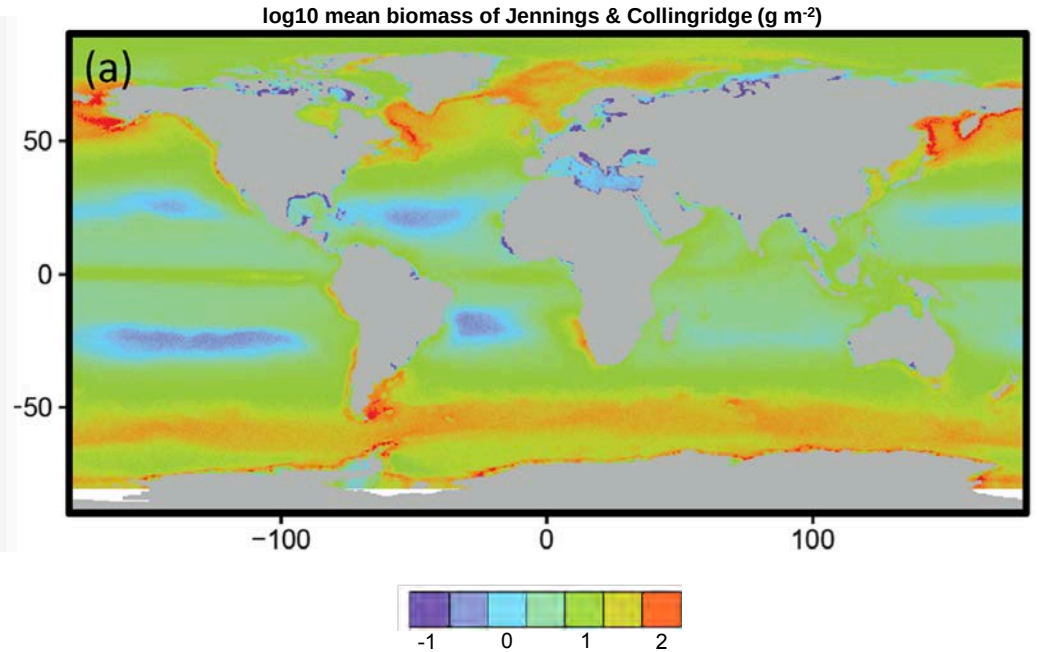




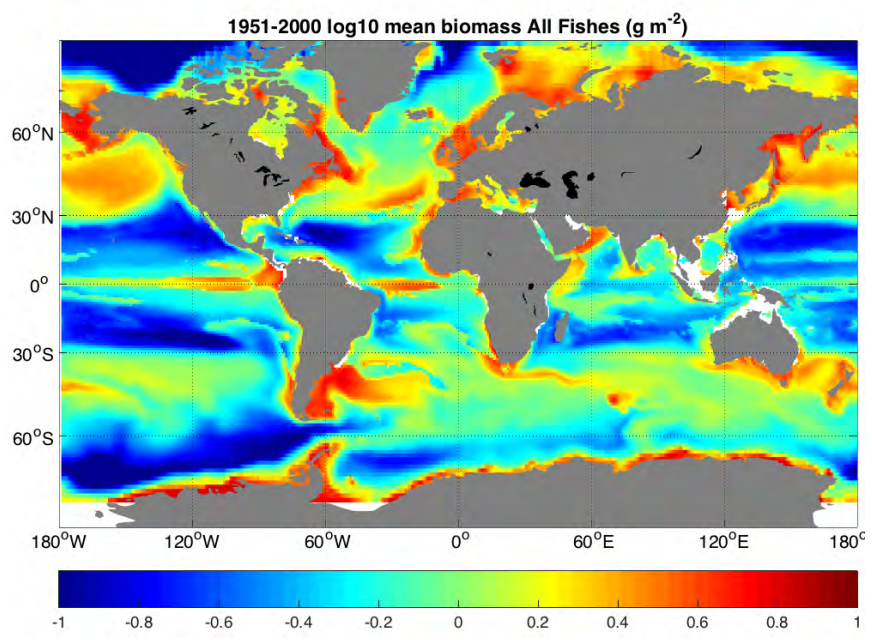


Comparisons to other estimates

All consumers



Size-based model



Size- and type-based model

weight = $10^2 – 10^4$ g

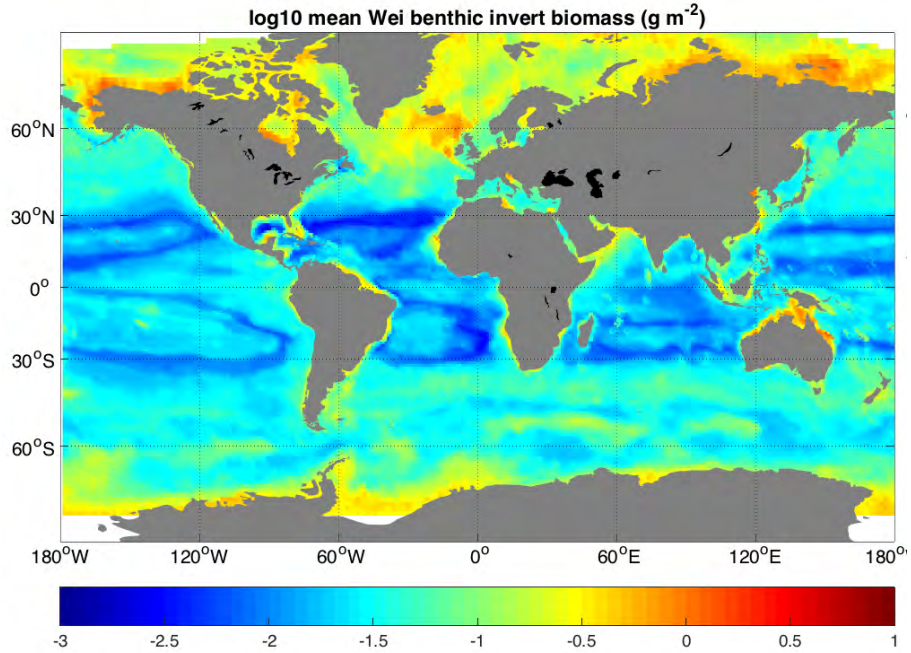
0.09 – 8.89 10^9 MT

0.35 10^9 MT

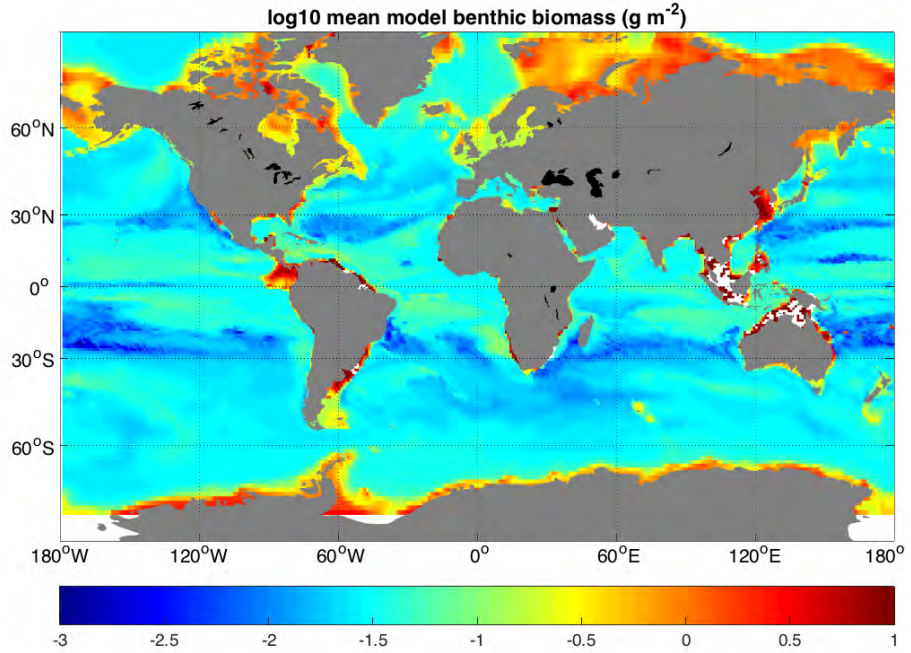
Jennings & Collingridge 2015

Comparisons to other estimates

Benthic invertebrates > 1mm



Statistical model

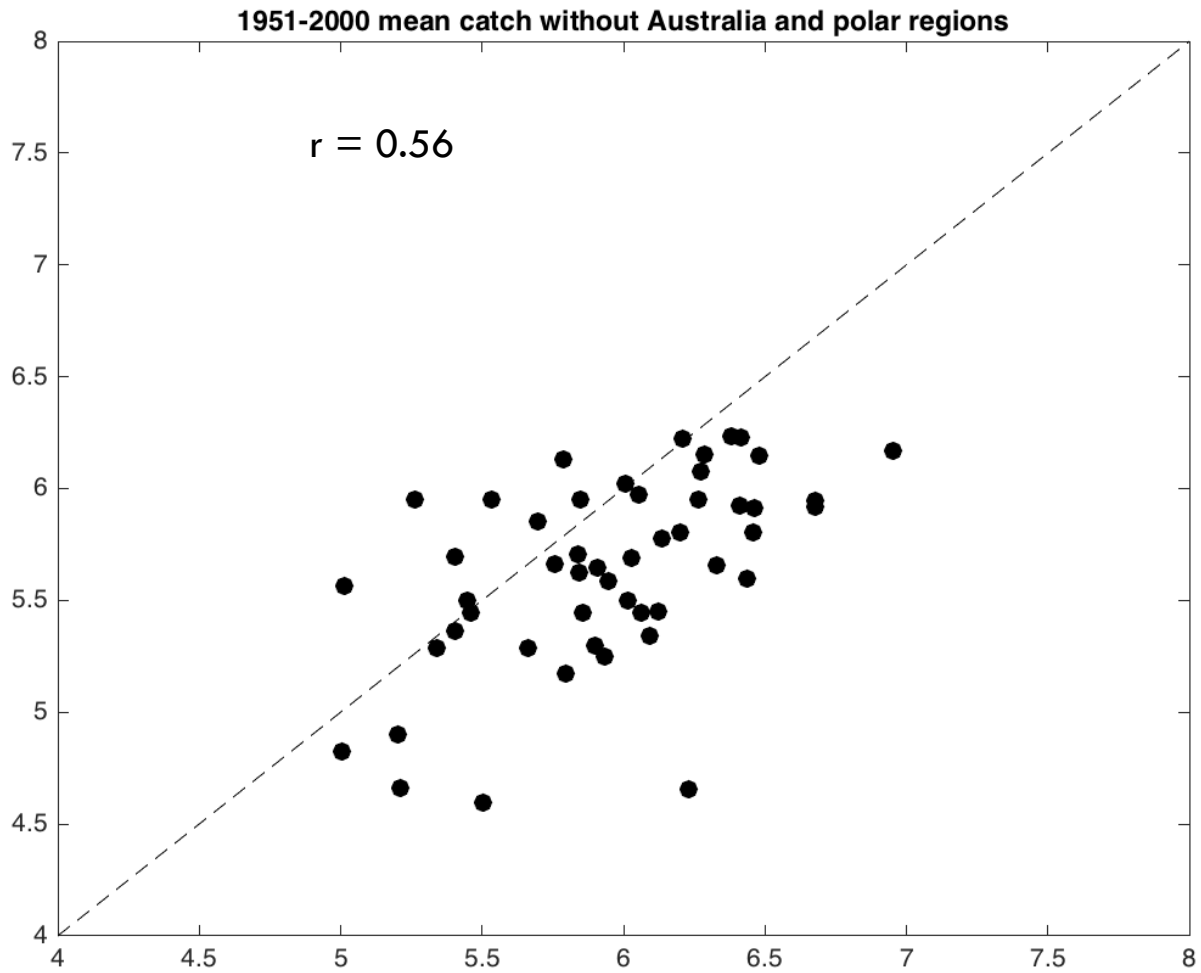


Mechanistic model

Wei et al. 2011

Comparisons to other estimates

Commercial fish catch



F=0.3

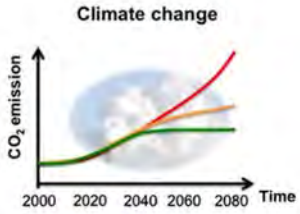
~MSY

4 comparisons to highlight drivers

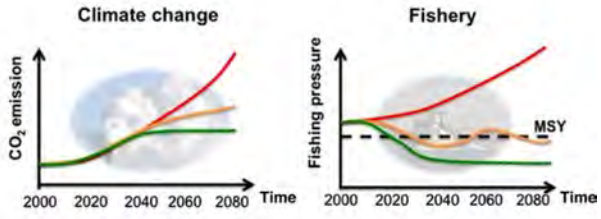
- Historic unfished vs. Pre-industrial
  - Industrial CO_2

- Historic fished vs. Historic unfished
  - Contemporary Fishing

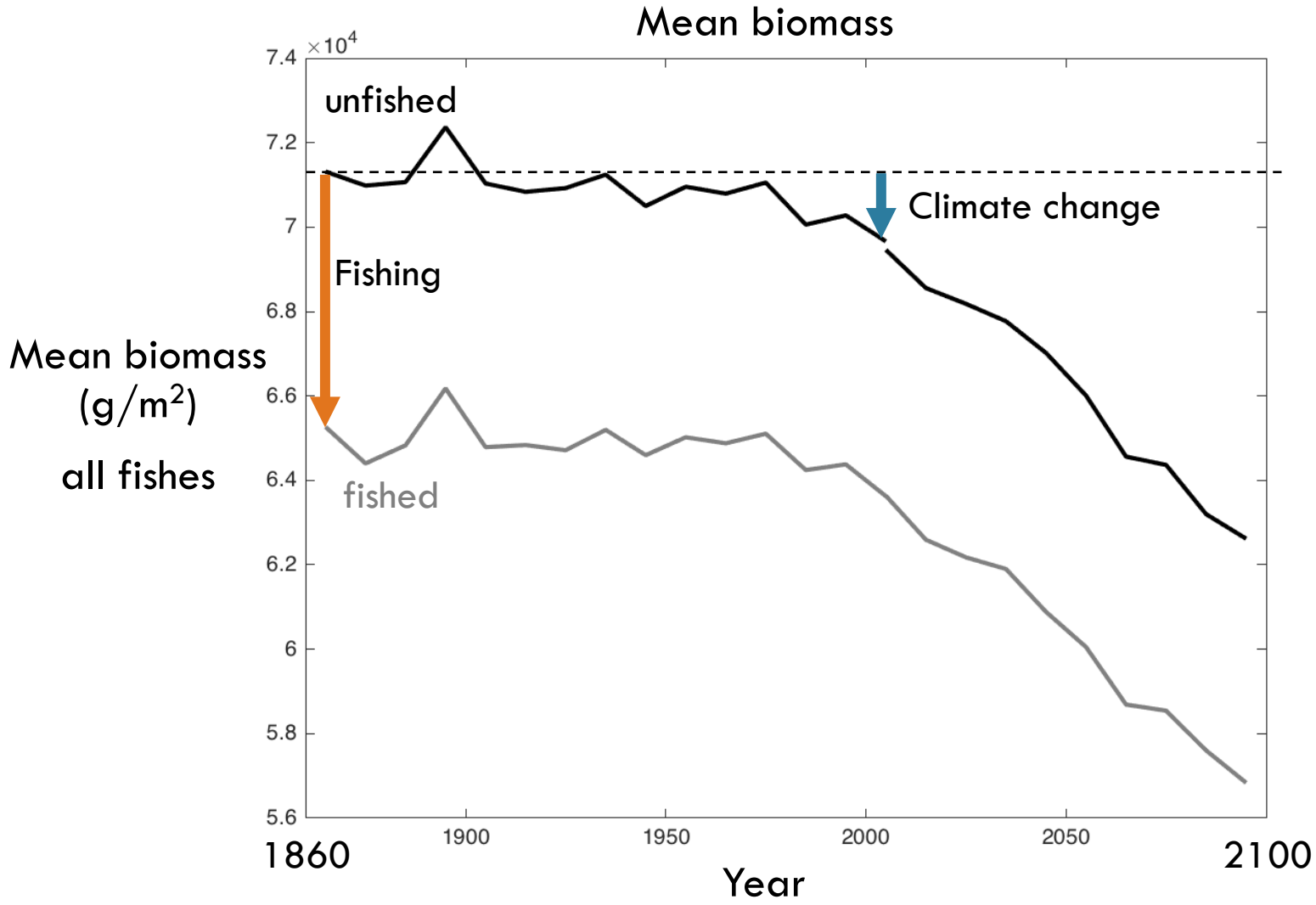
- Future unfished vs. Historic unfished
  - Climate change (RCP 8.5)



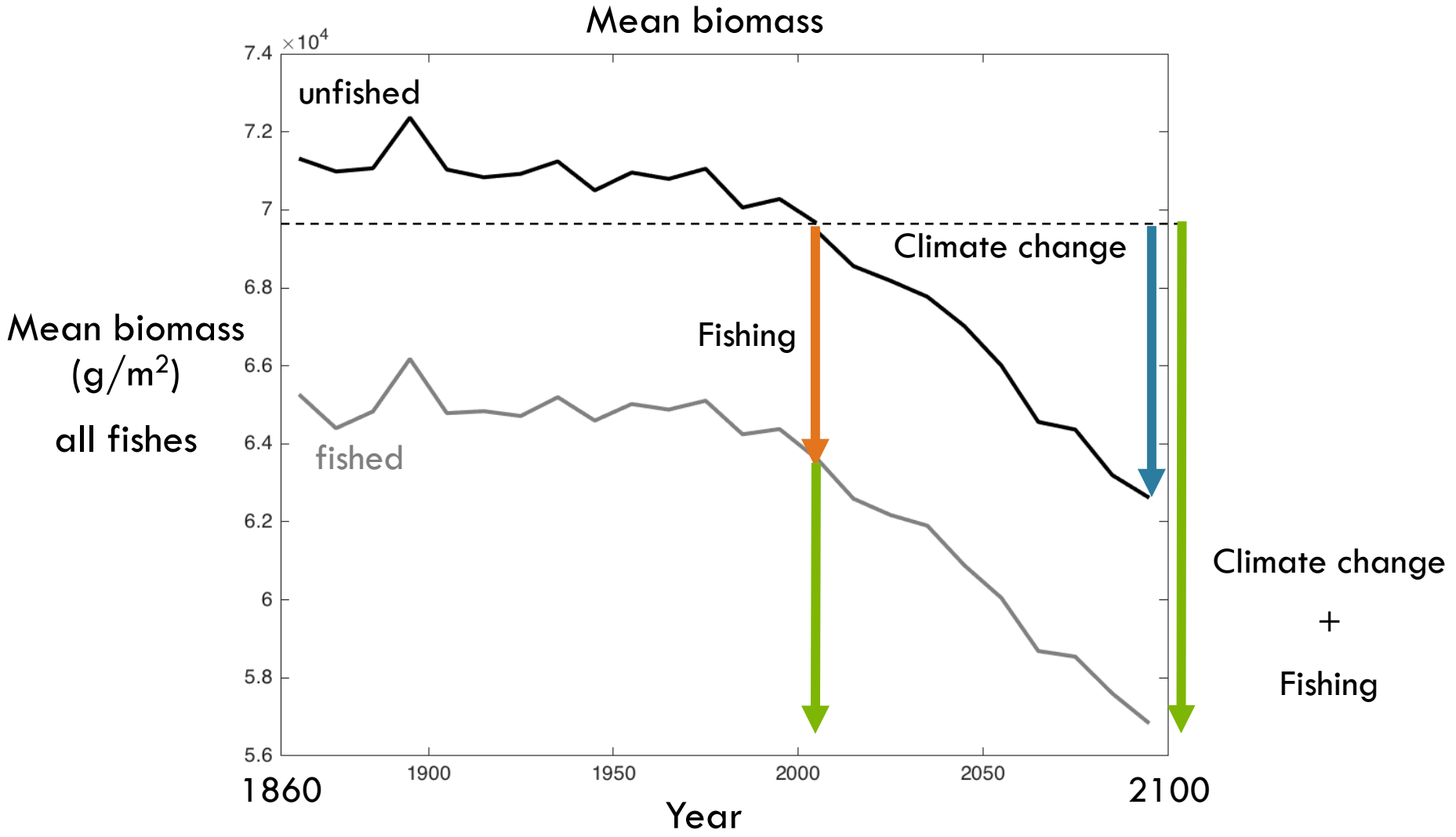
- Future fished vs. Historic fished
  - Climate change + Future Fishing



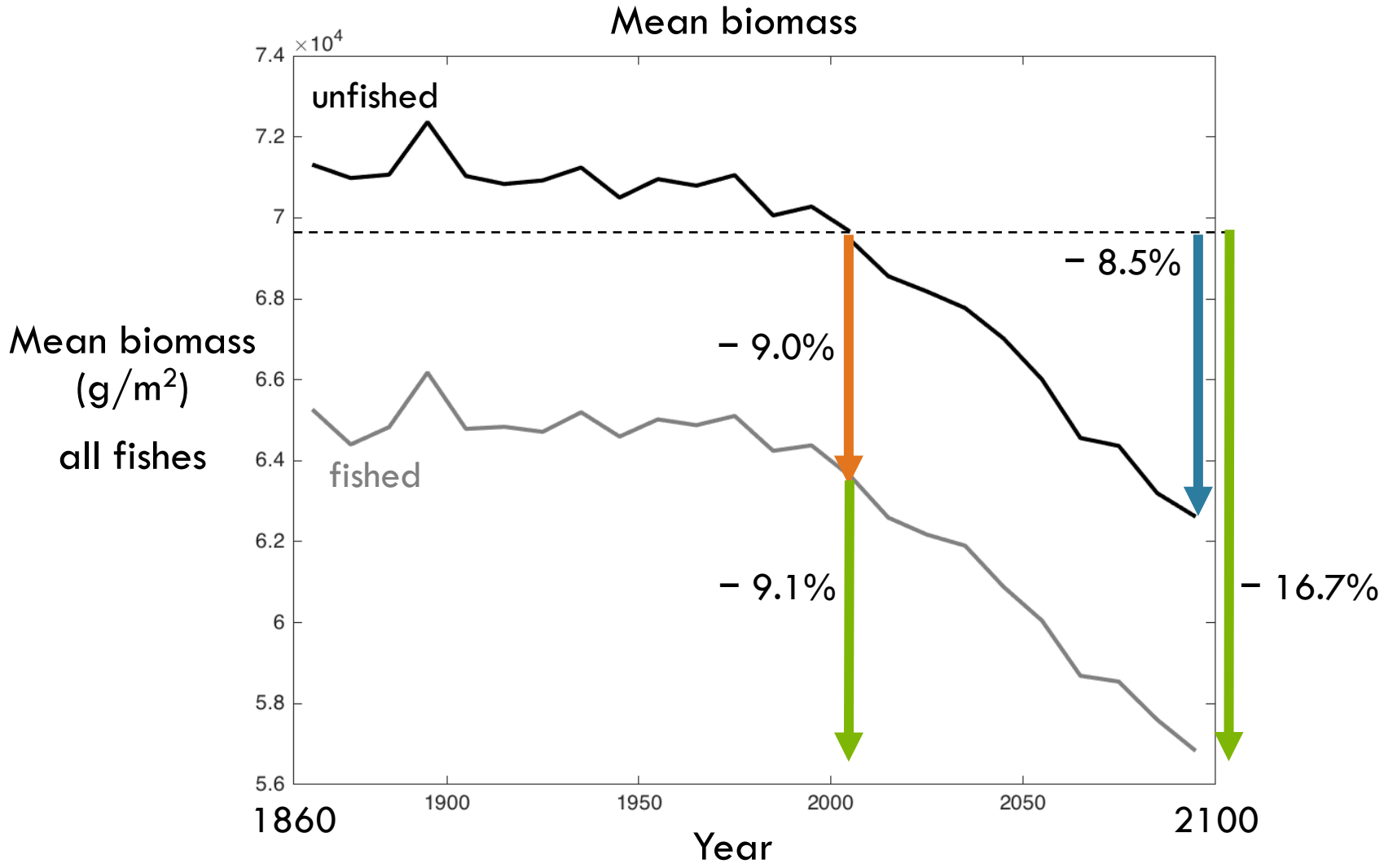
Nominal changes from climate change to date



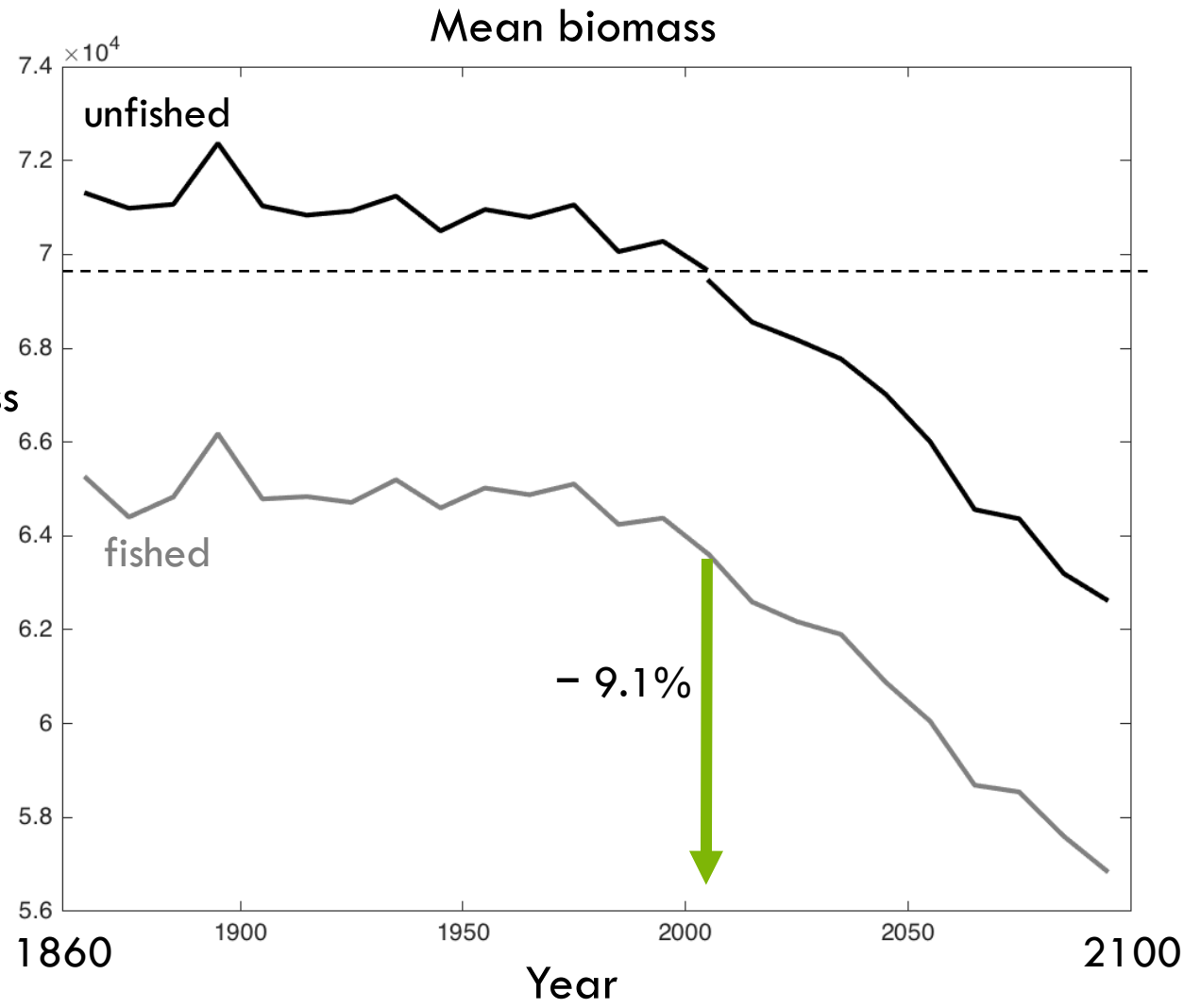
Future climate change similar magnitude as fishing



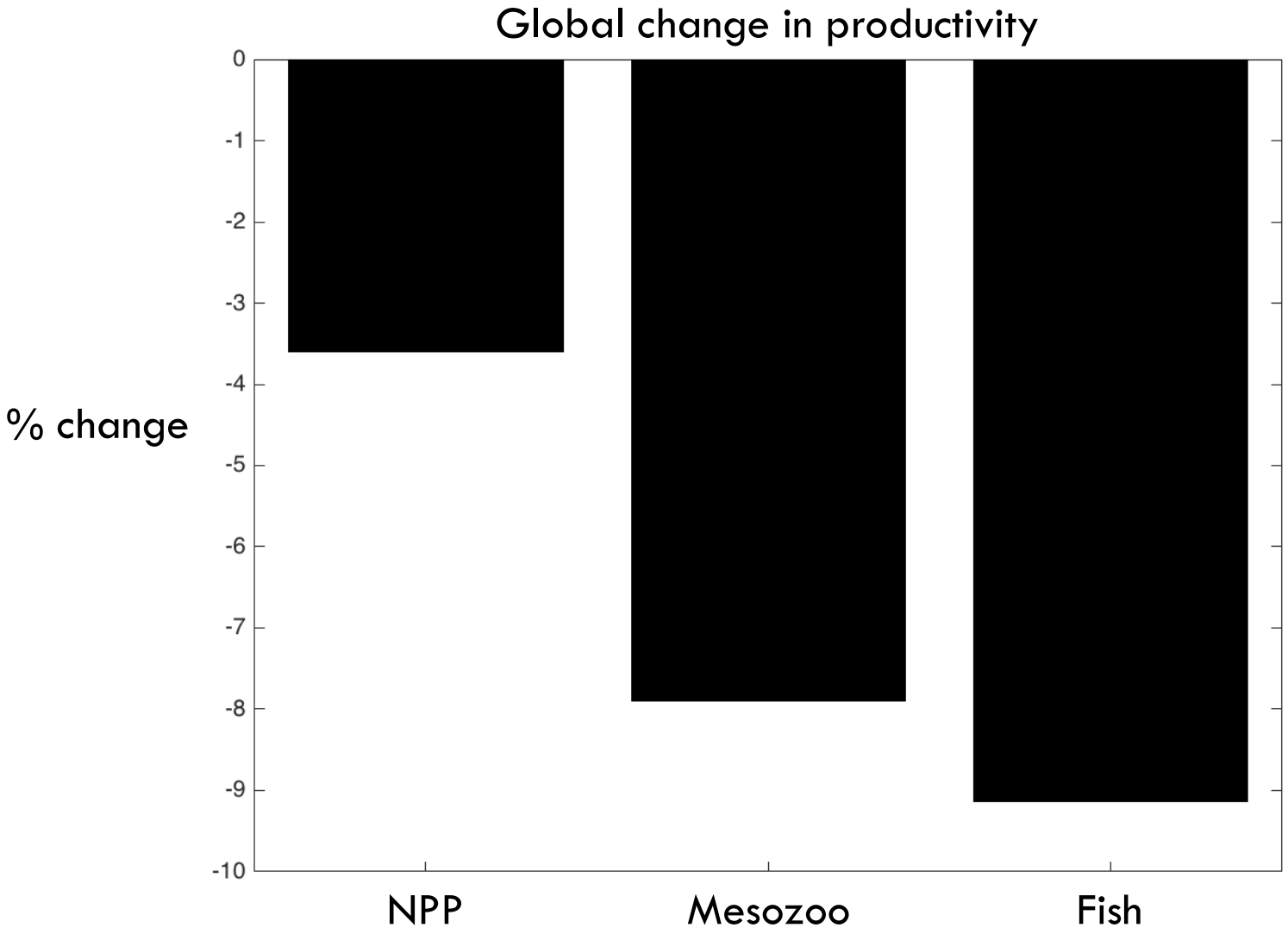
Future climate change similar magnitude as fishing



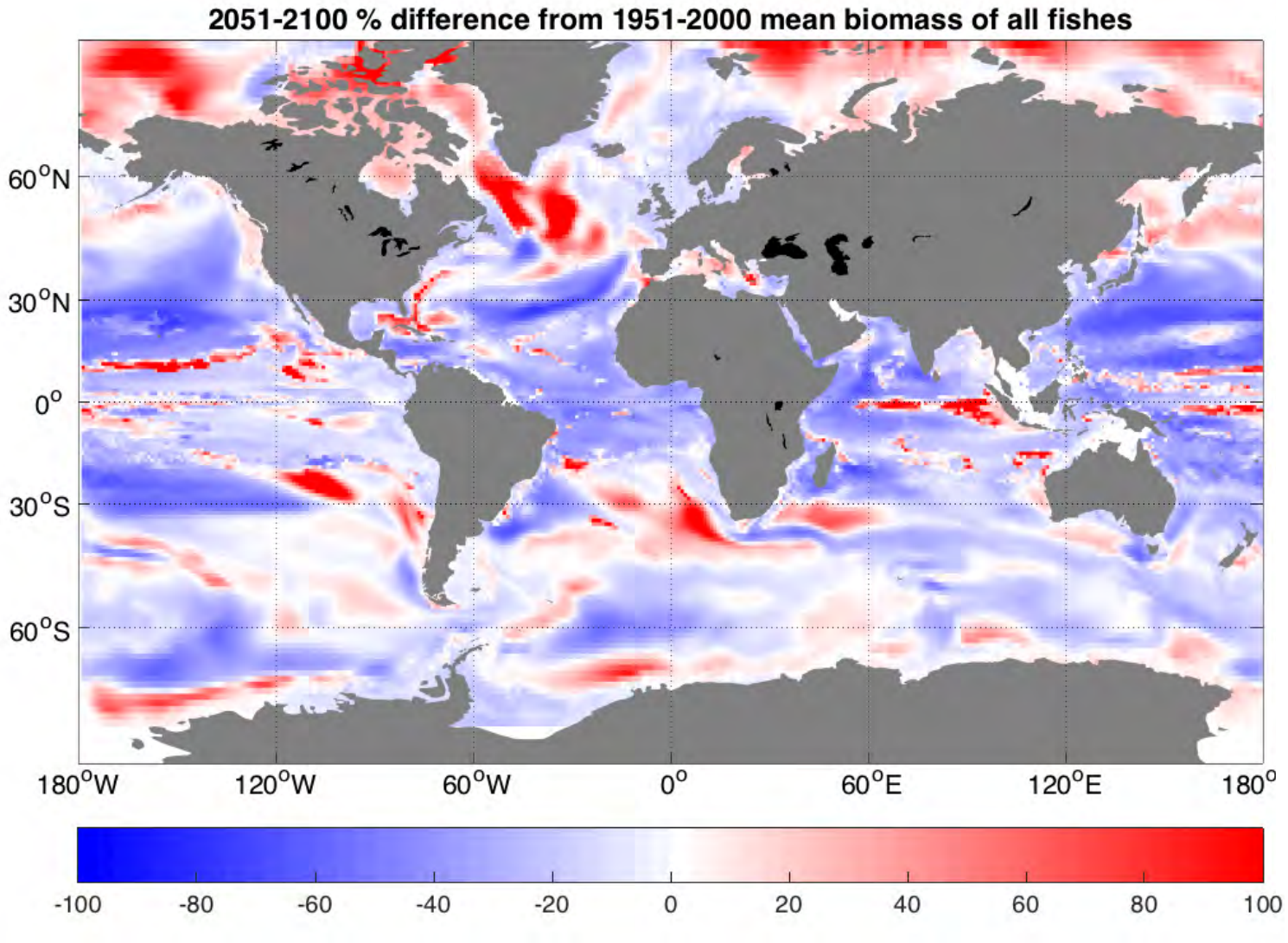
Future climate change similar magnitude as fishing



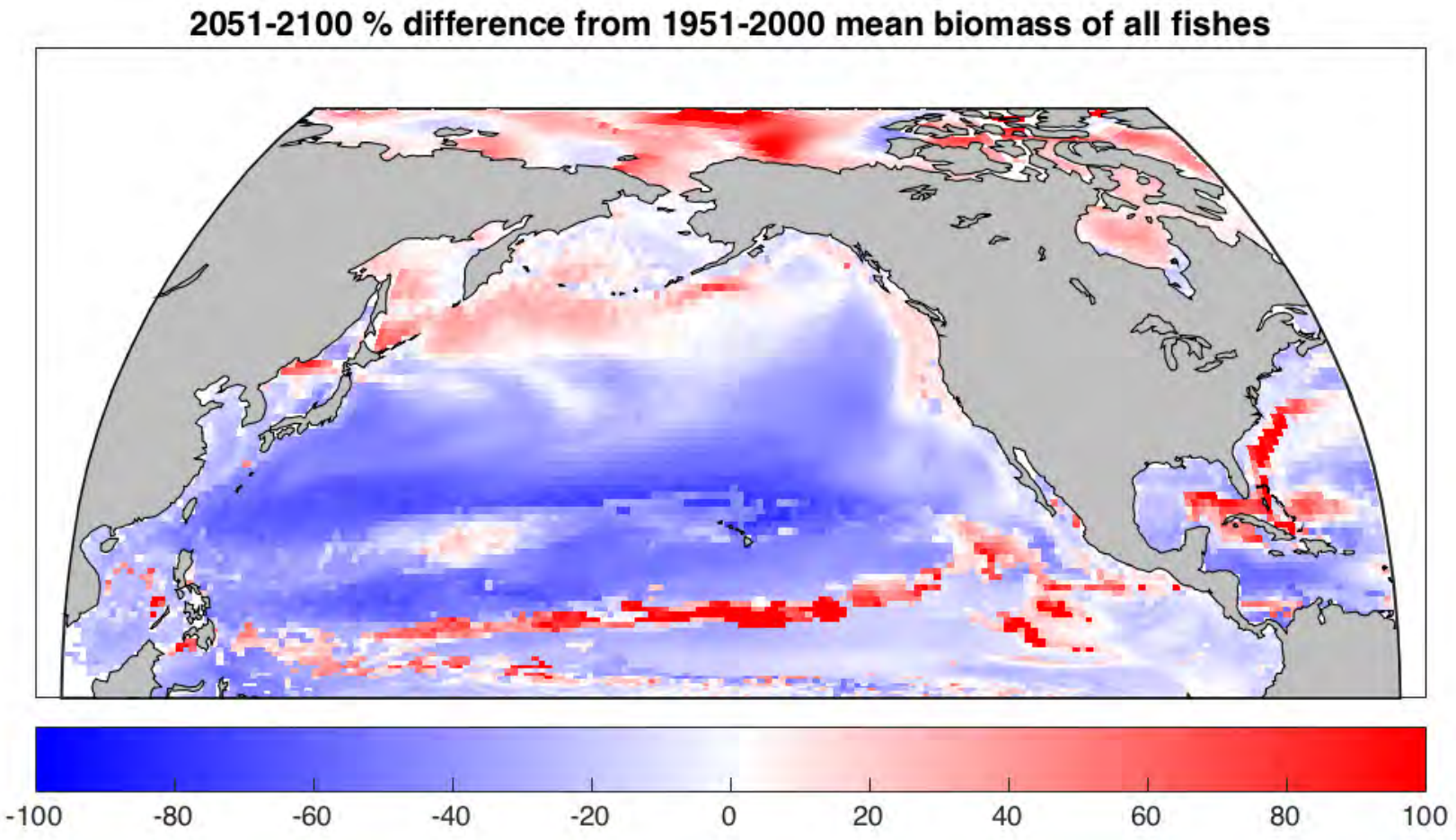
Trophic amplification



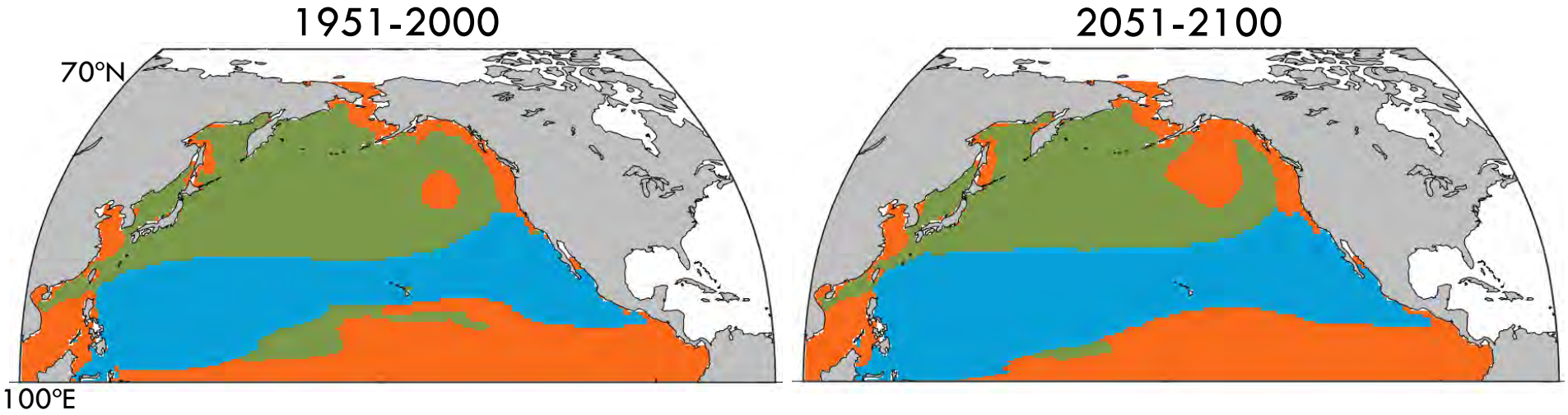
Huge regional variations in % change



N Pac regional variations % change



N Pacific changes in biomes

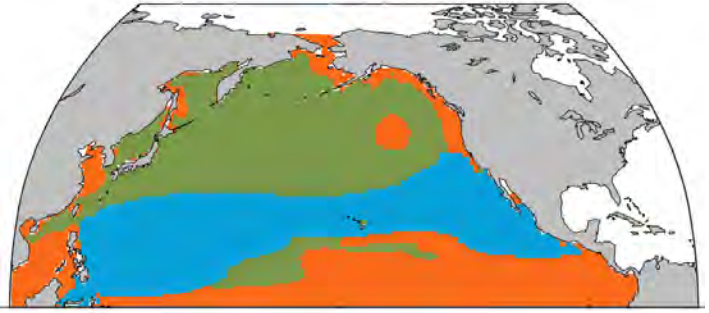


LC – Low Chl	+0.23
ECCS – Elevated Chl, Cont Strat	+0.03
ECSS – Elevated Chl, Seas Strat	−0.25

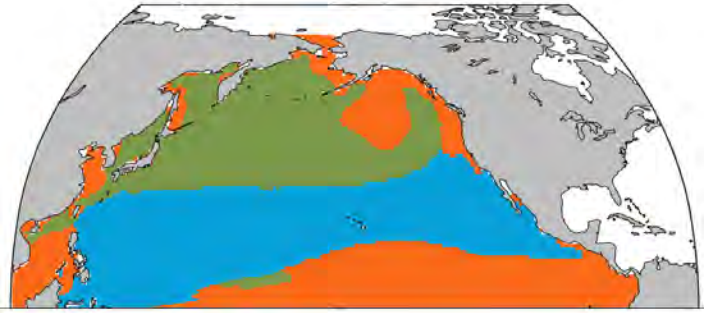
c.f. Polovina et al. 2011; Stock et al. 2014

N Pacific % change in fish by biome

1951-2000

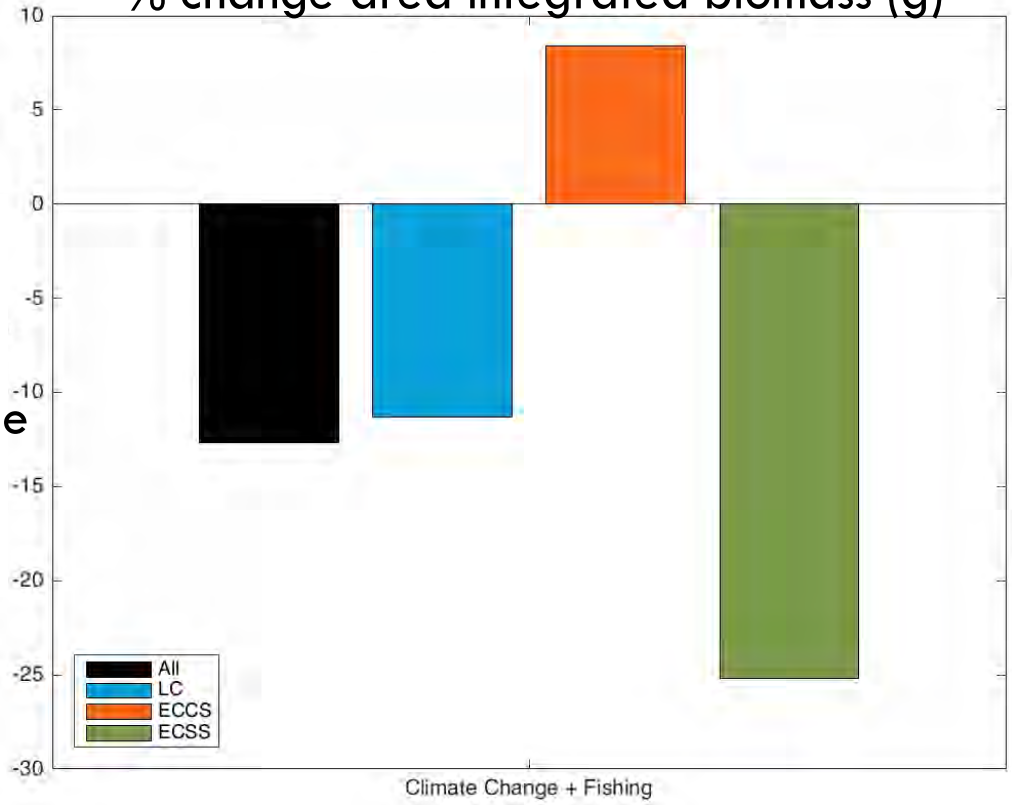


2051-2100



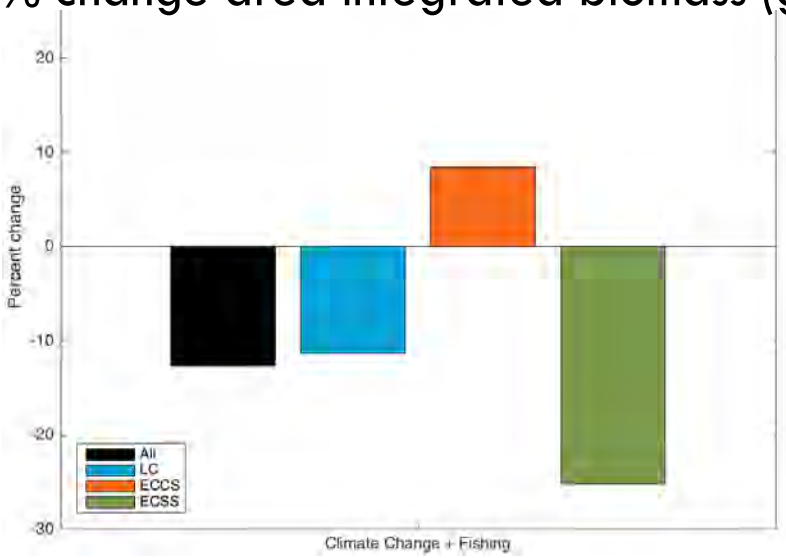
% change

% change area integrated biomass (g)



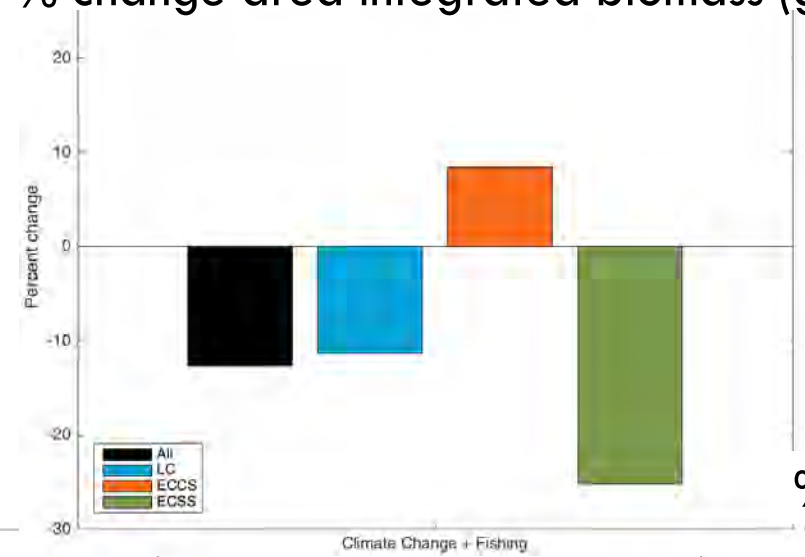
N Pacific % change by biome

% change area integrated biomass (g)

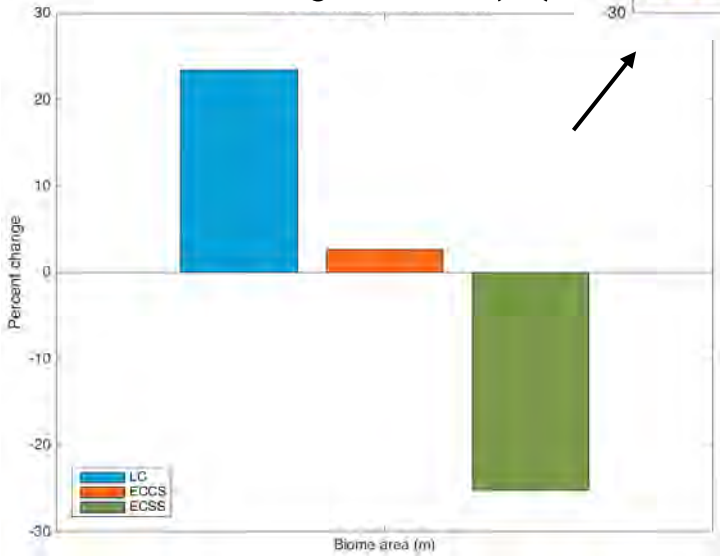


N Pacific % change by biome

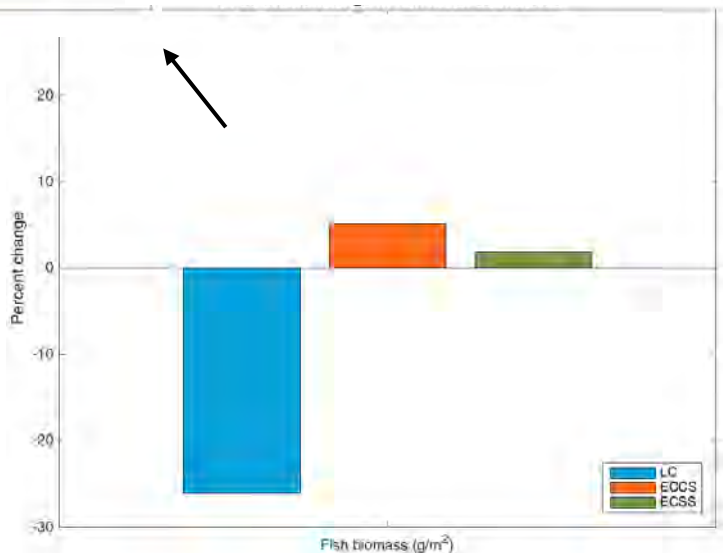
% change area integrated biomass (g)



% change area (m)



% change biomass (g/m^2)



Conclusions

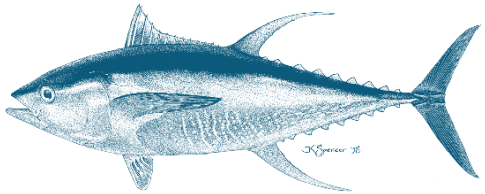
- Amplifying effects from anthropogenic forcing
  - Δ area + Δ abundance $\neq$ Δ biomass
  - Δ fished $>$ Δ unfished
  - trophic amplification of Δ productivity

Future directions

- Effect of movement
- Recruitment dynamics
  - Spawning phenology (Rebecca Asch)
  - Predation by zooplankton
- Jellyfish as competitors and predators (Natasha Henschke)
- Fisheries management scenarios

Acknowledgments

- Ken Andersen, Charlie Stock, Jorge Sarmiento, James Watson
- Nereus Program (Nippon Foundation)
- NOAA Geophysical Fluid Dynamics Laboratory
- Princeton University
- Sea Around Us Project



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