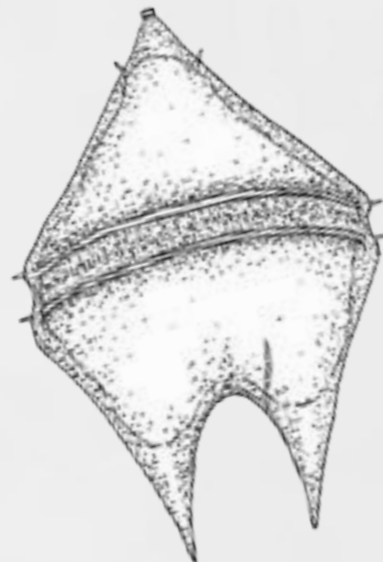


Adding complex trophic interactions
to a size-spectral plankton model:

Emergent diversity patterns and
limits on predictability

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Oceanography / Applied Physics Lab
Univ of Washington (Seattle)



support:
River Influences on Shelf Ecosystems (RISE: NSF)
Pacific Northwest Toxins (PNWTOX: NOAA Ecohab, NSF)

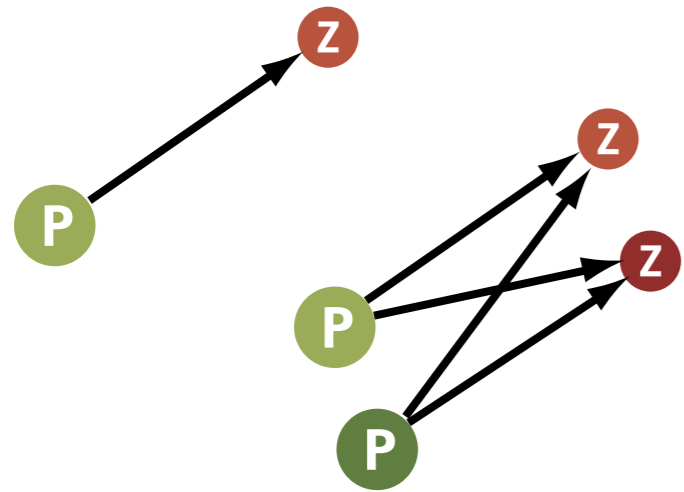
Hawkins and Sutton (*BAMS*, 2010)

uncertainty in regional climate models =

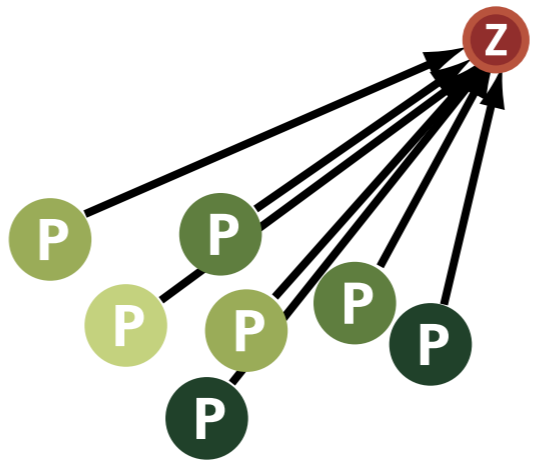
internal variability + model uncertainty + scenario uncertainty;
all three are important for some timescale of prediction.

transient blooms
= predator-prey oscillations
= ecosystem weather

In biogeochemical models, we usually **suppress** internal variability in order to make bottom-up linkages clear and clean.

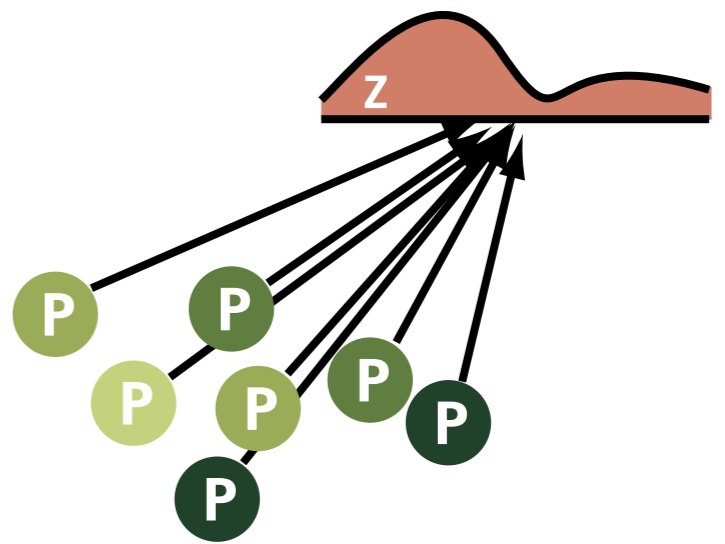


omitting diversity
(the standard NPZ approach)



including phytoplankton diversity
but omitting zooplankton diversity

(Follows et al., *Science*, 2007;
Bruggeman and Kooijman, *L&O*,
2007)

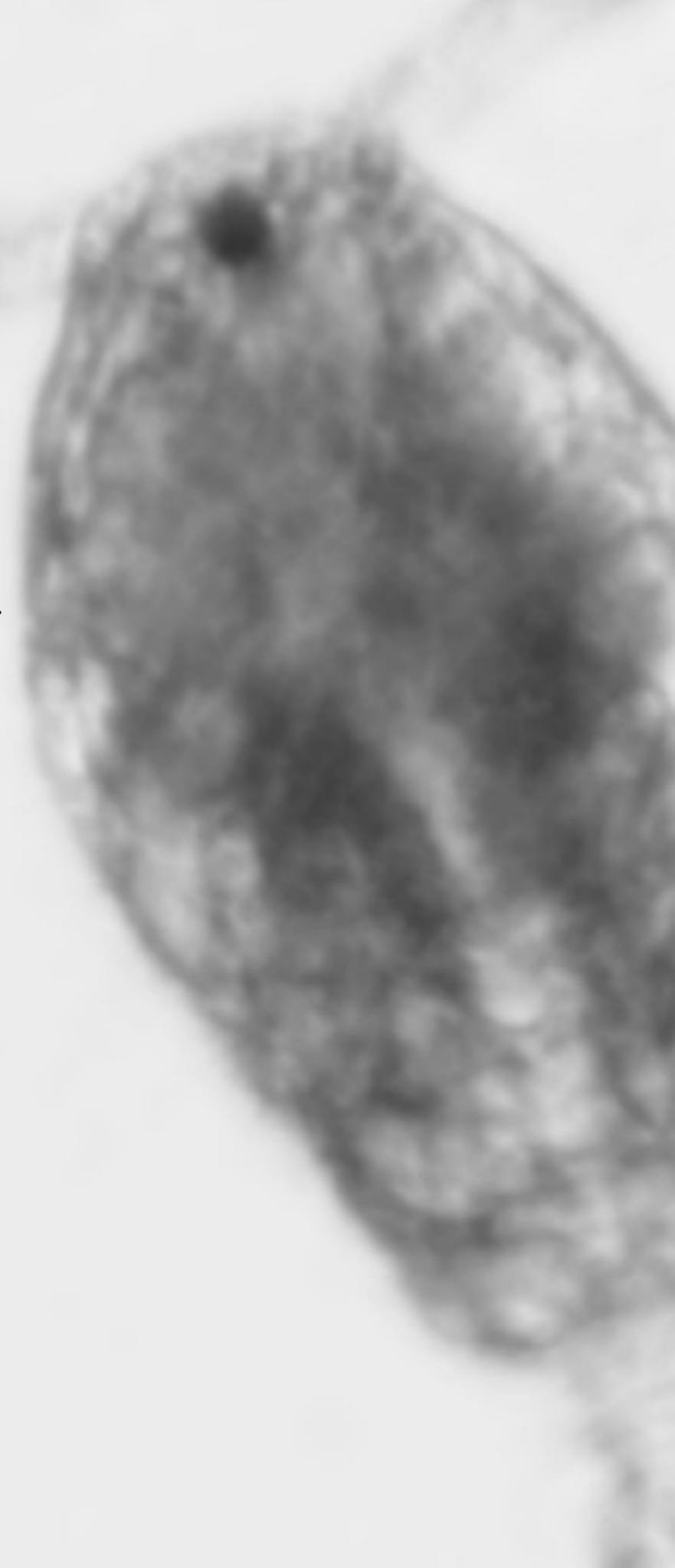
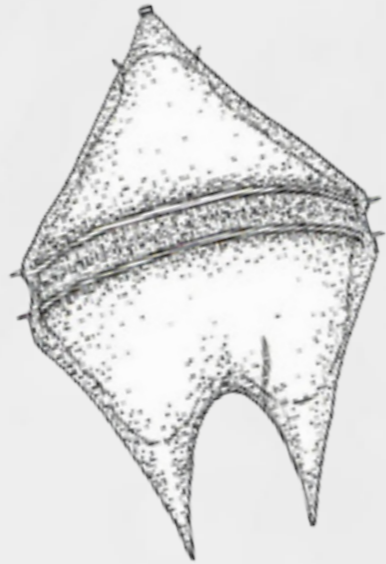
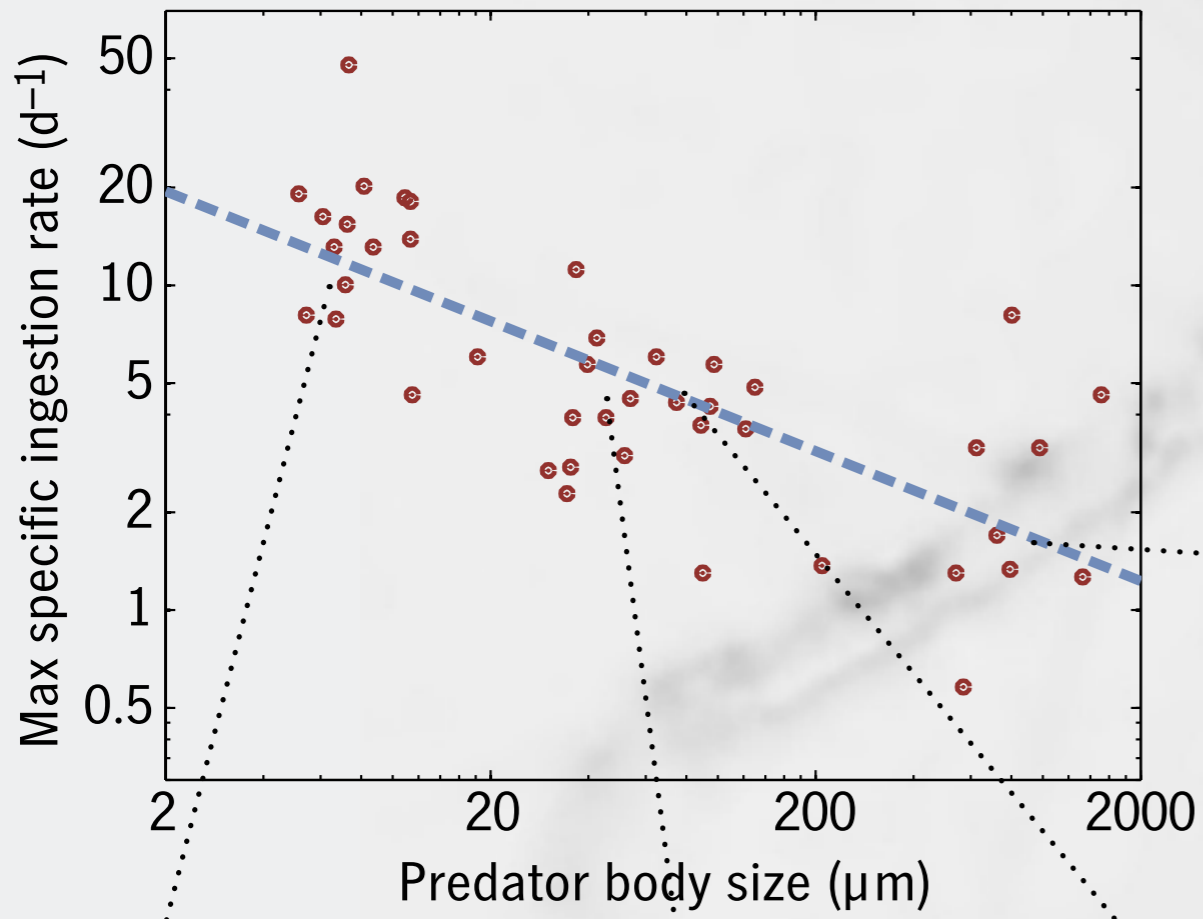


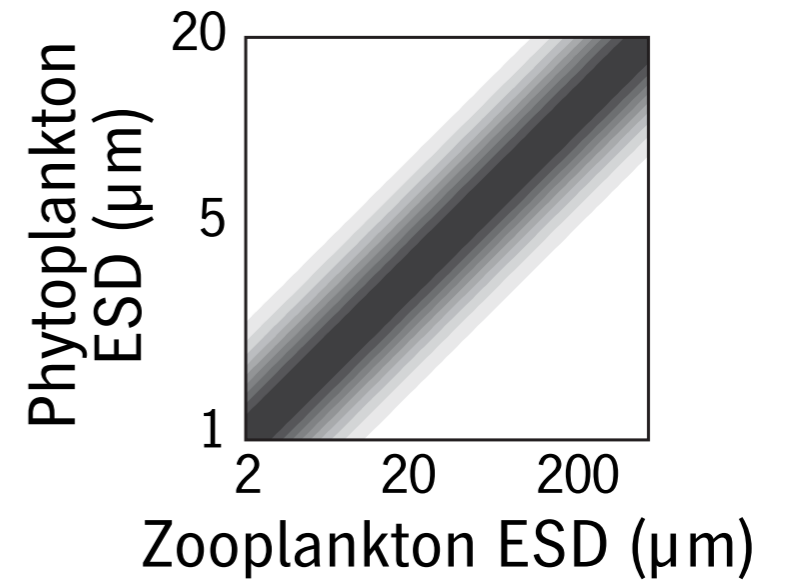
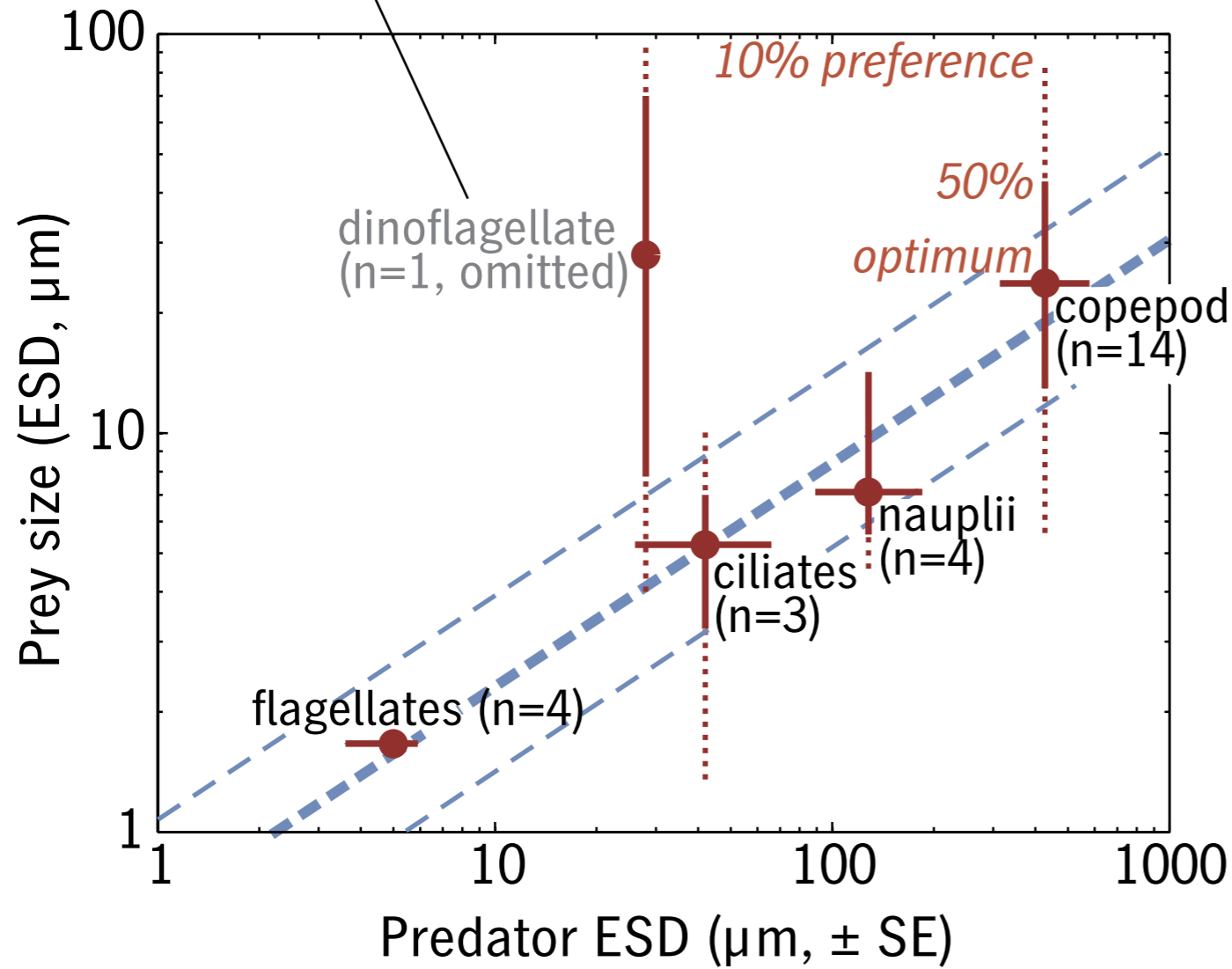
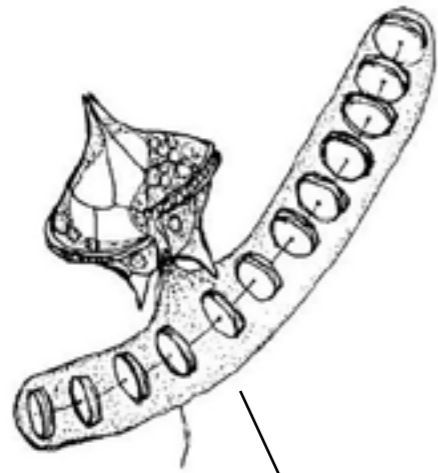
constructing a grazer field
that eliminates predator-prey
instabilities

(Armstrong, *DSR*, 2003)

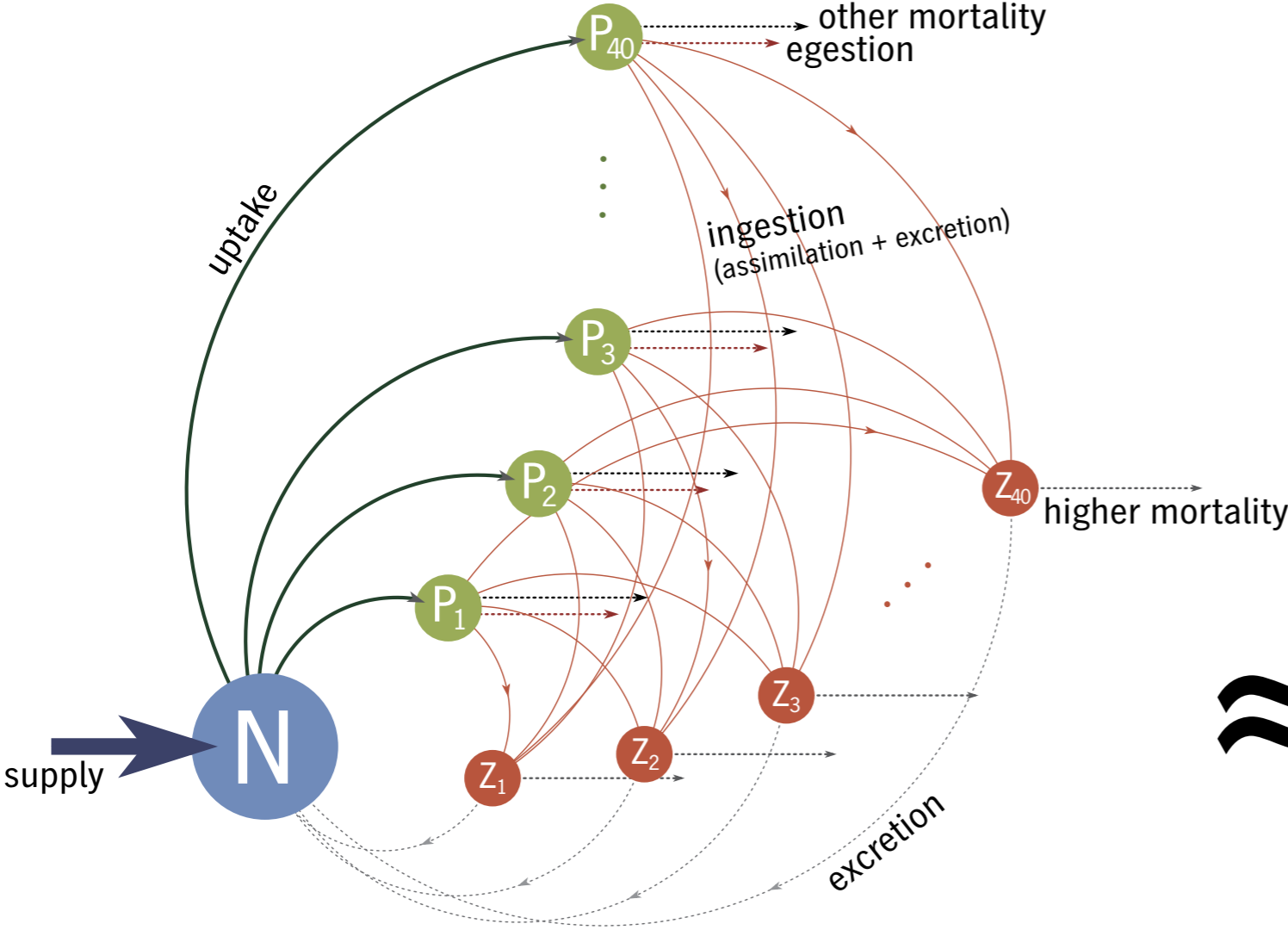
What if we **resolve** and **quantify** the internal variability instead?

Zooplankton ingestion rate (d^{-1}) (Hansen et al., *L&O*, 1997)

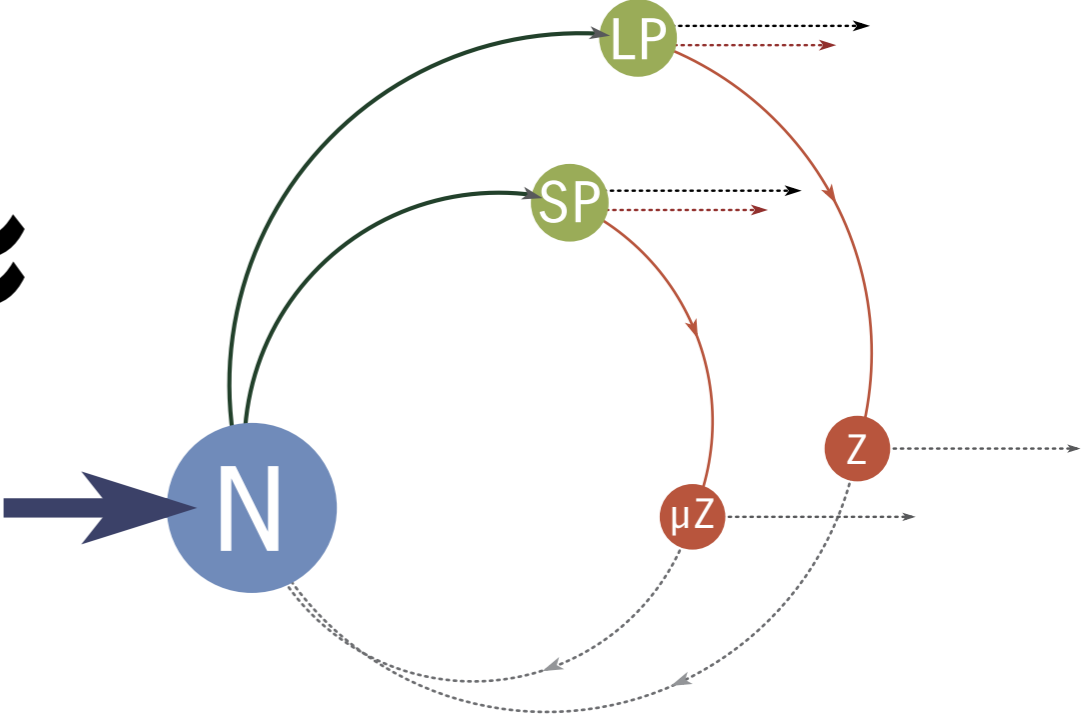




Relative prey preference
(Hansen et al., *L&O*, 1994)

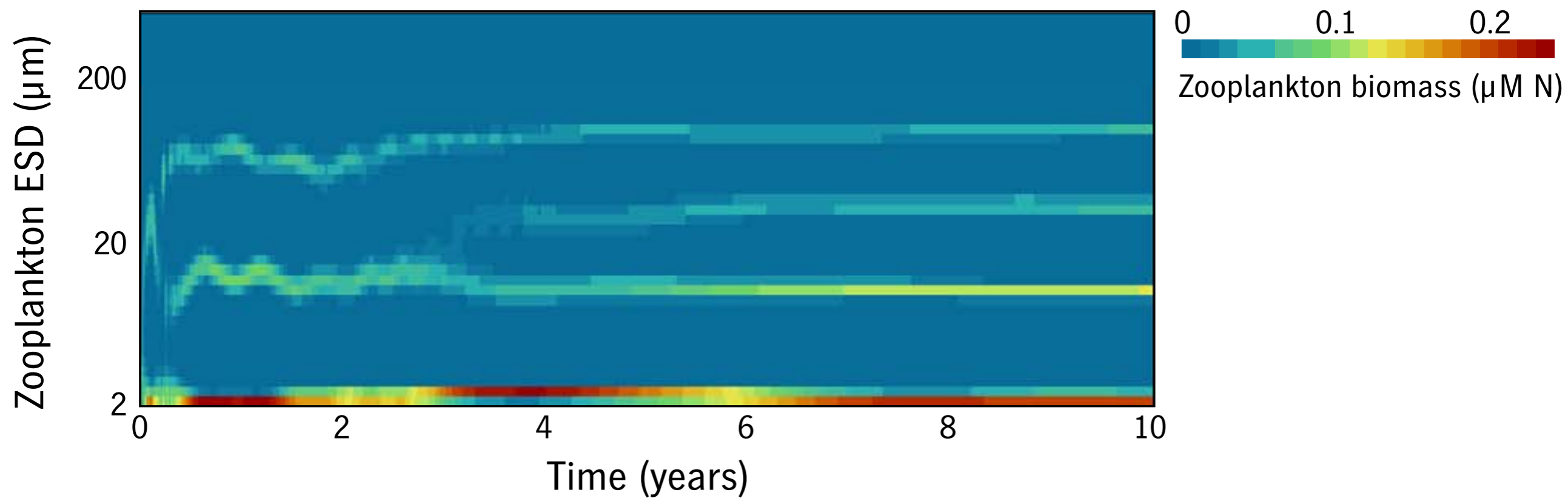
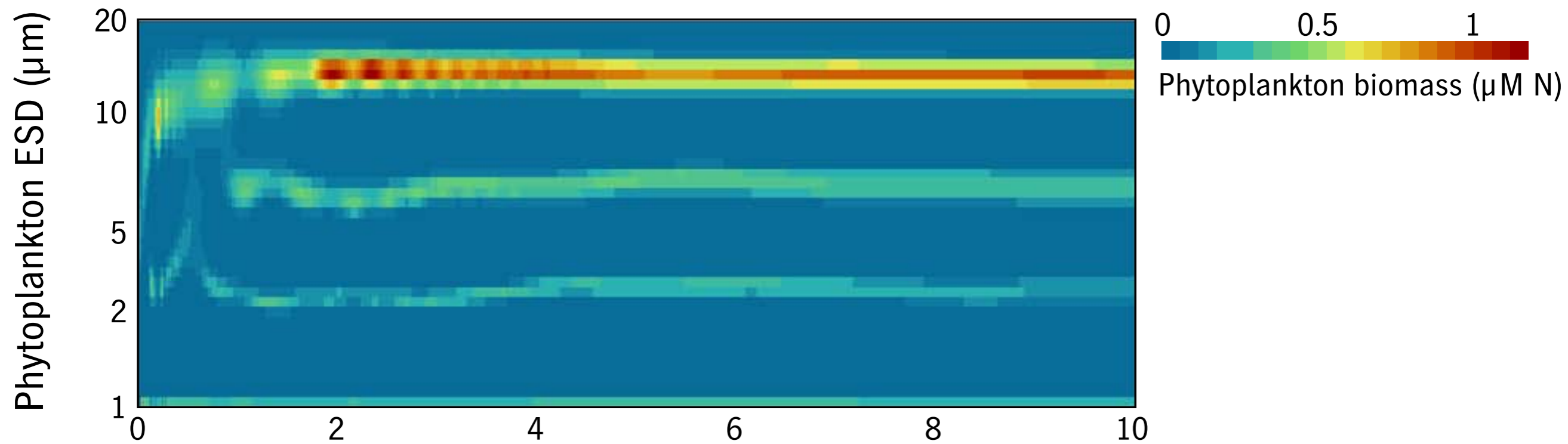


\approx

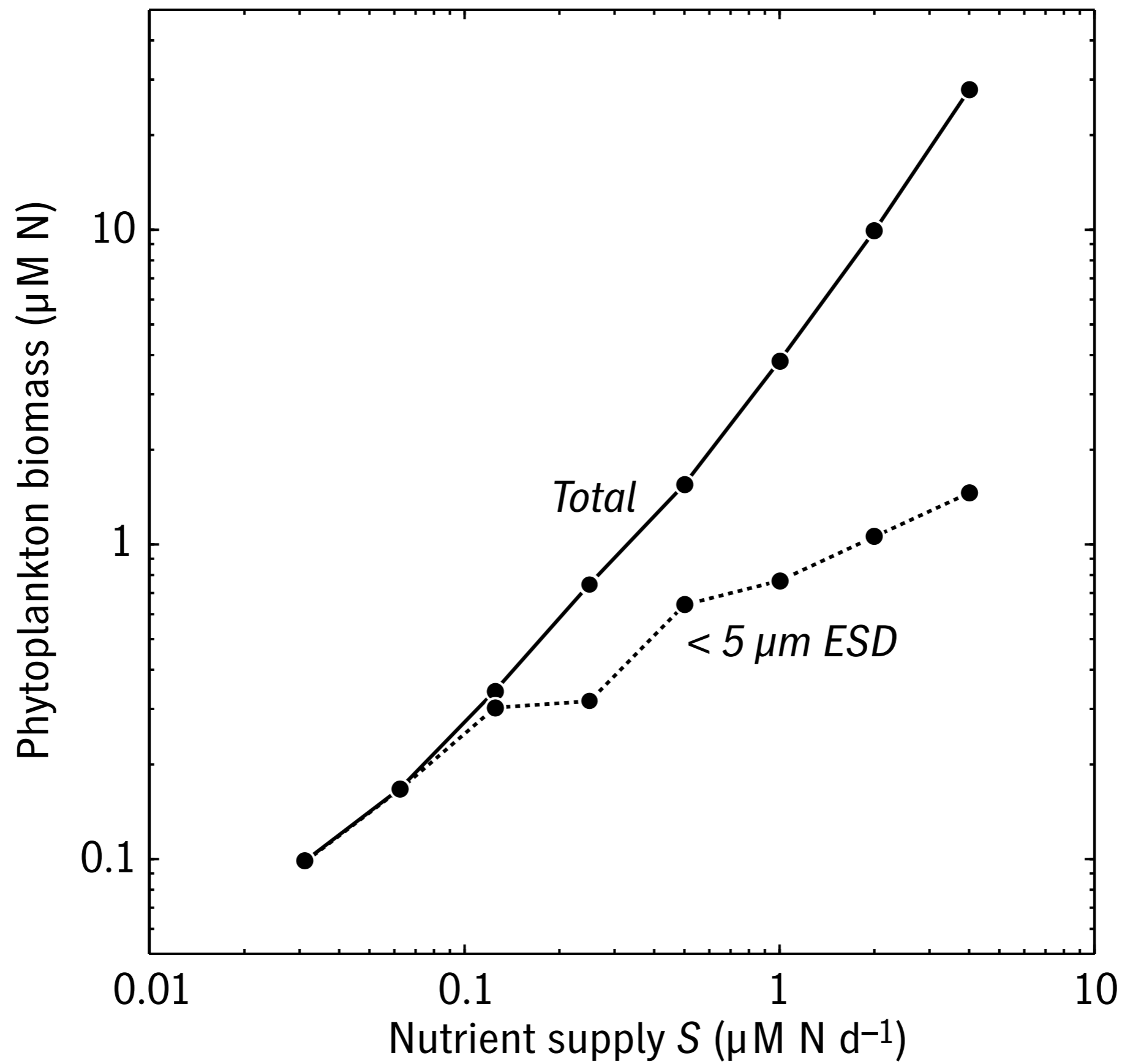


equivalent functional-group model

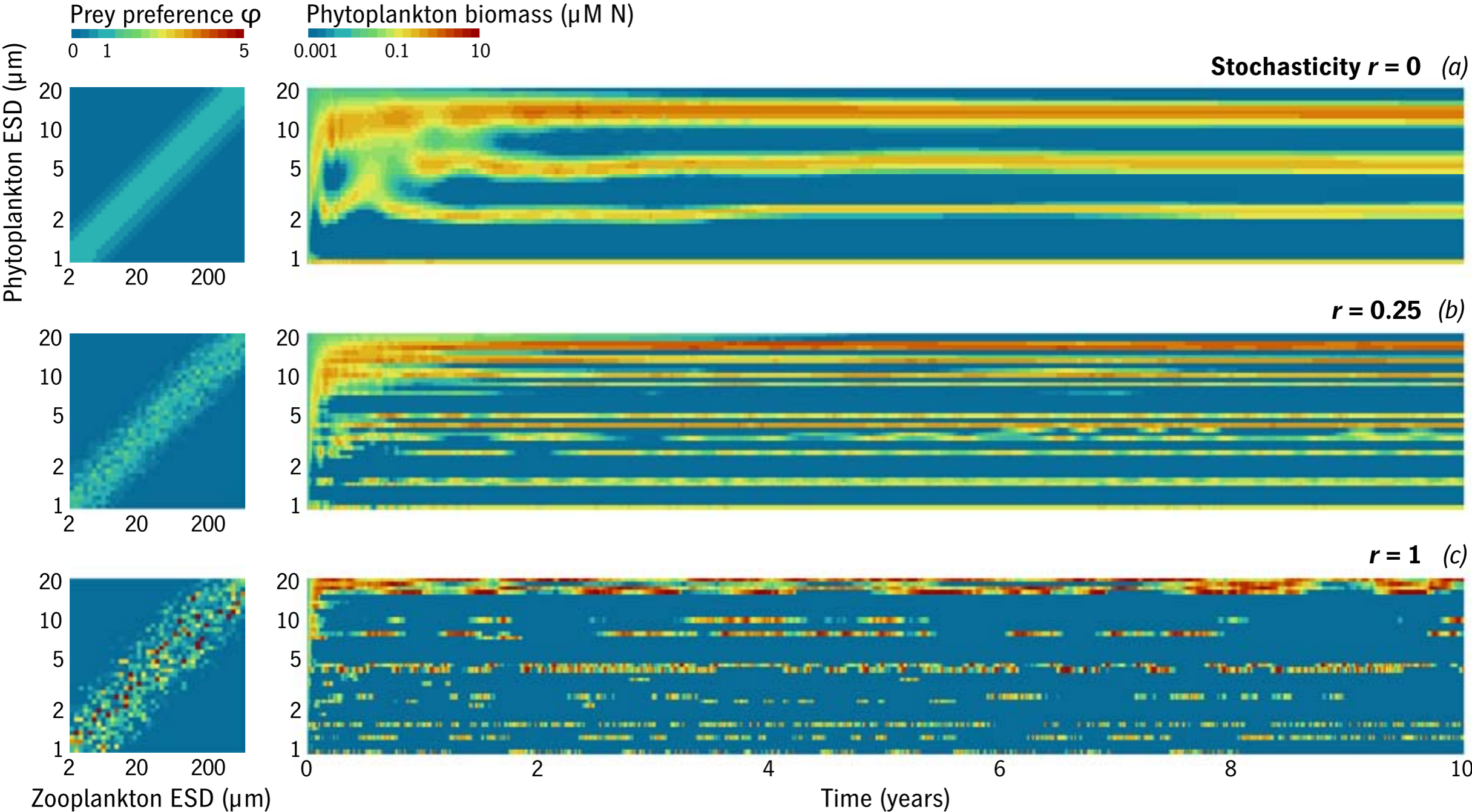
(small P have lower nutrient requirements but fast grazers; large P grow faster relative to their grazers but are N limited)

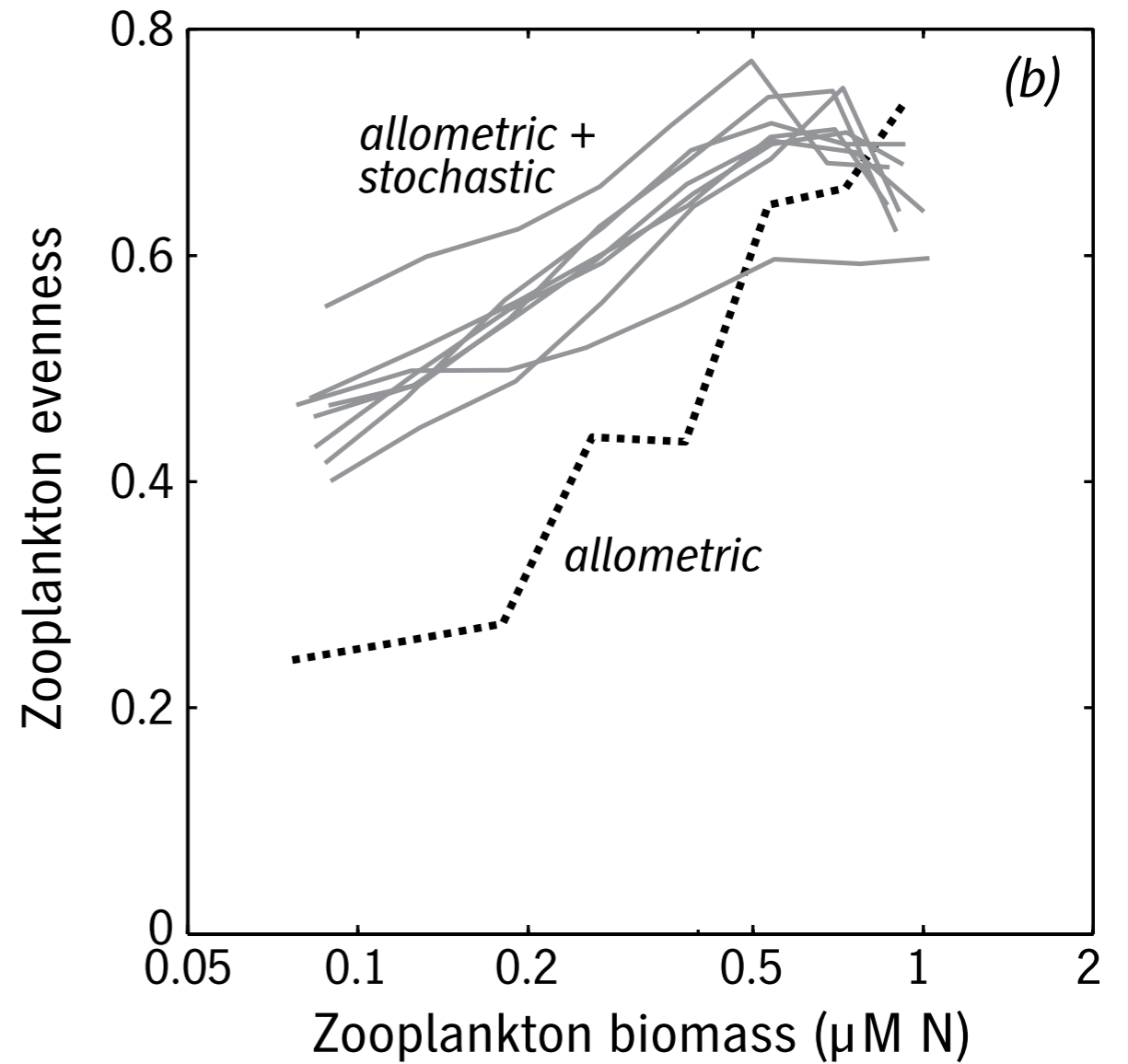
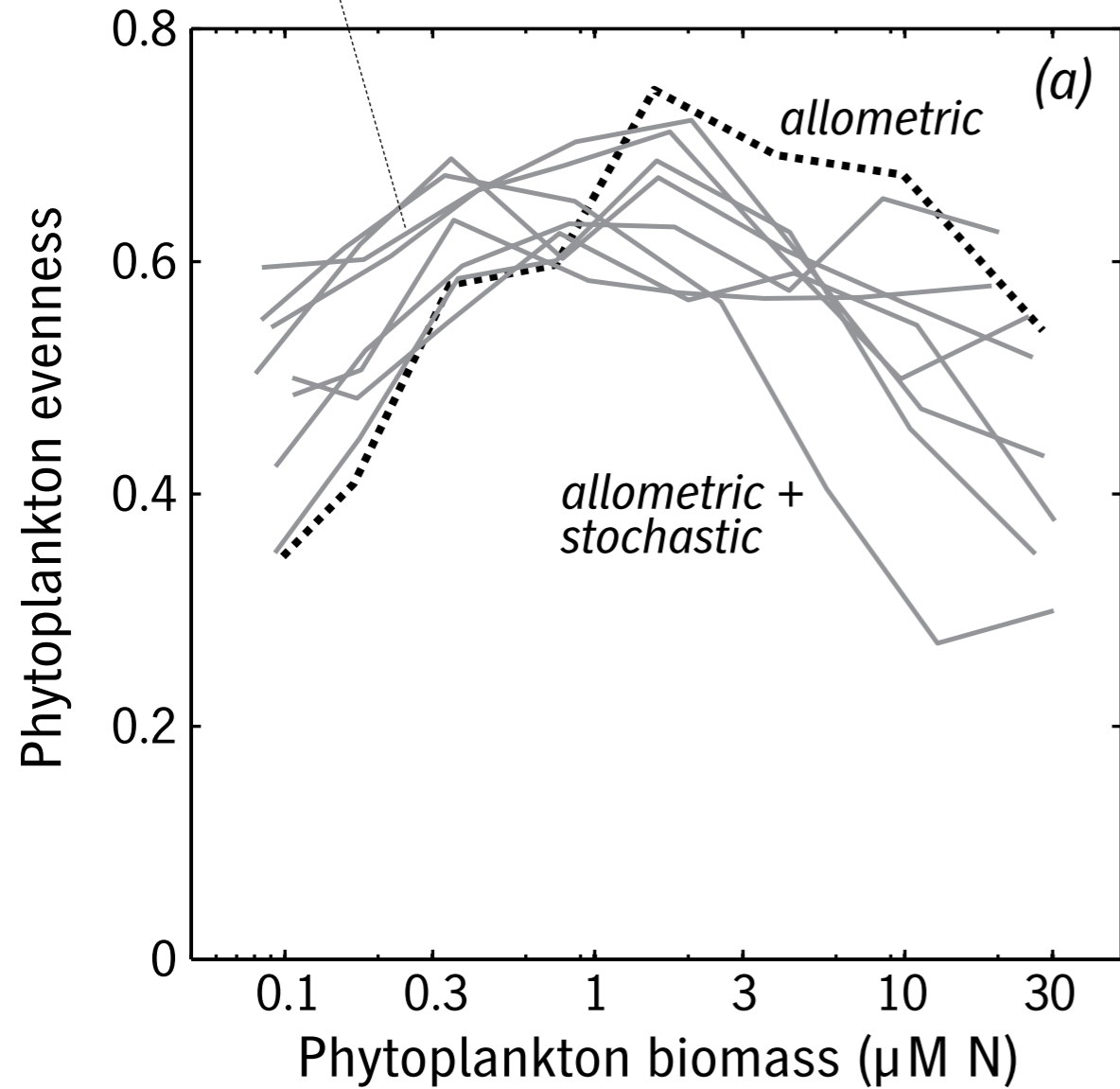
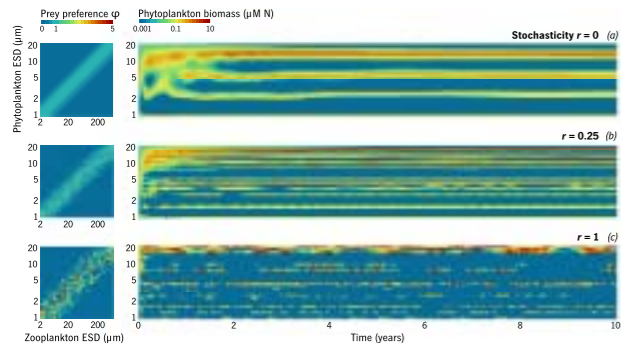


Under steady nutrient forcing



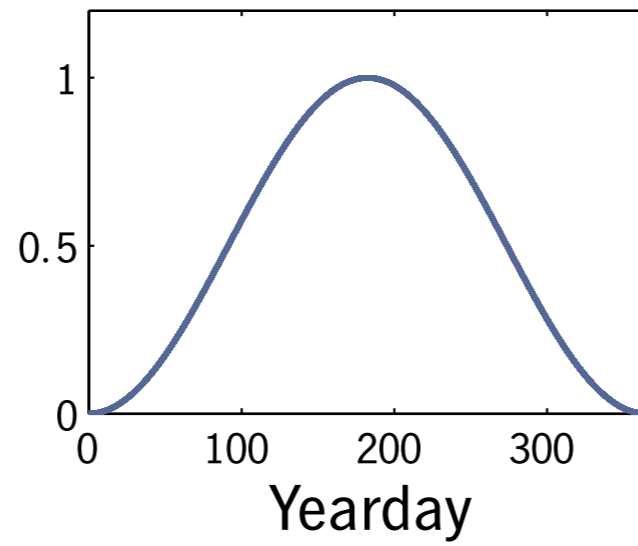
What about species-specific interactions?



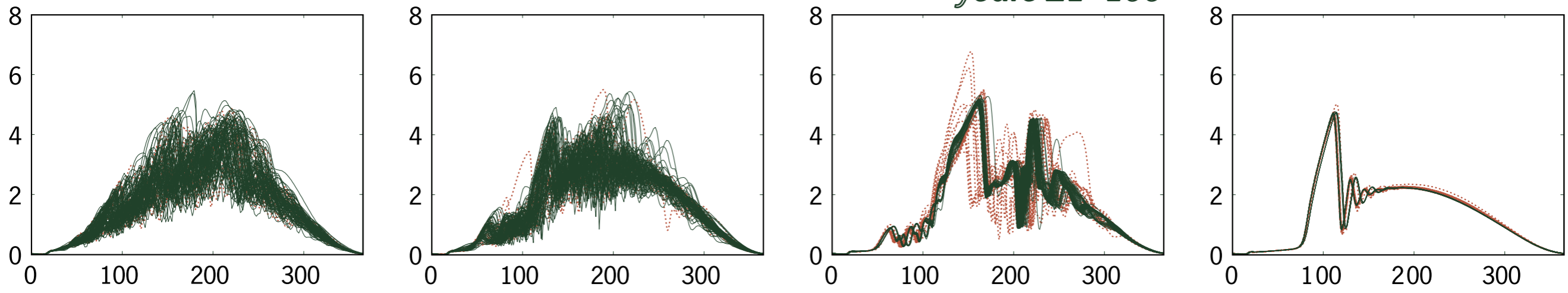


as in global marine observations
(Irigoien et al., *Nature*, 2004)

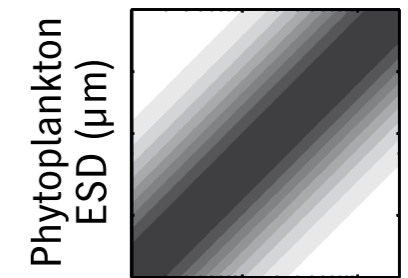
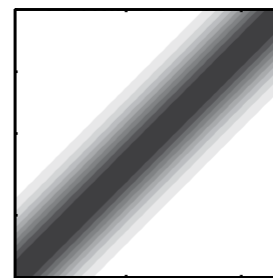
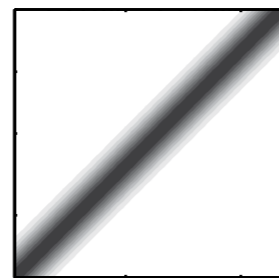
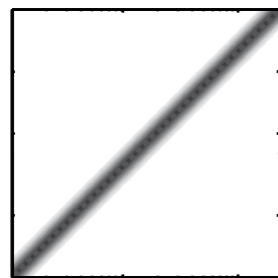
Nutrient supply S ($\mu\text{M N d}^{-1}$)



Phytoplankton biomass ($\mu\text{M N}$)



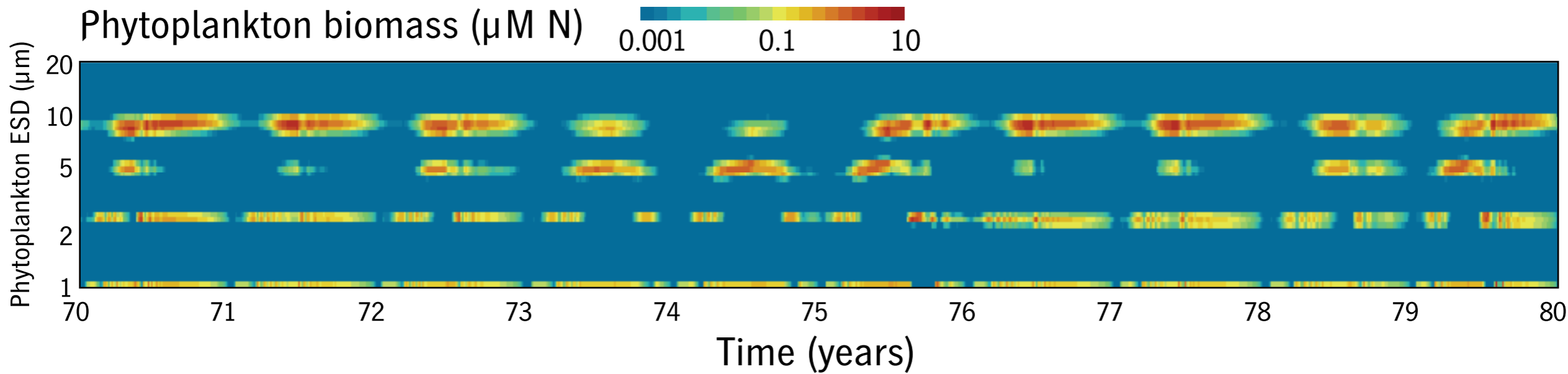
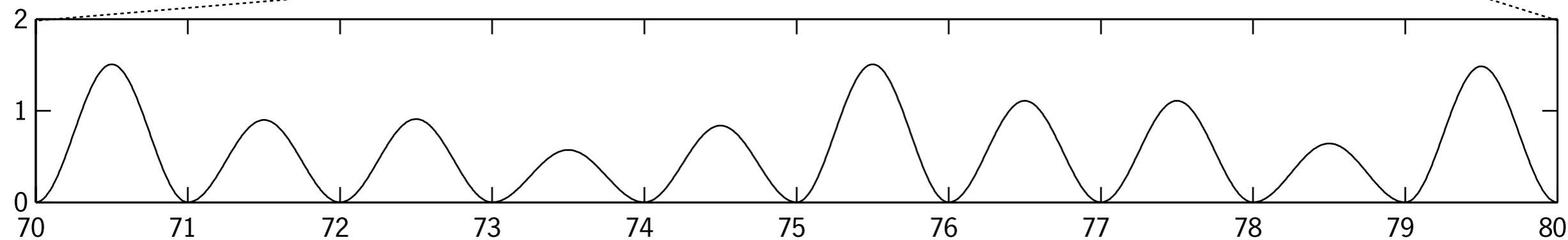
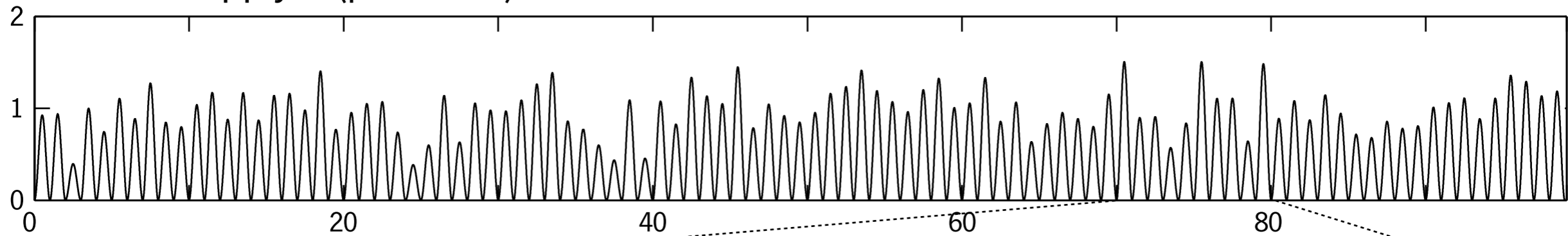
Prey preference φ

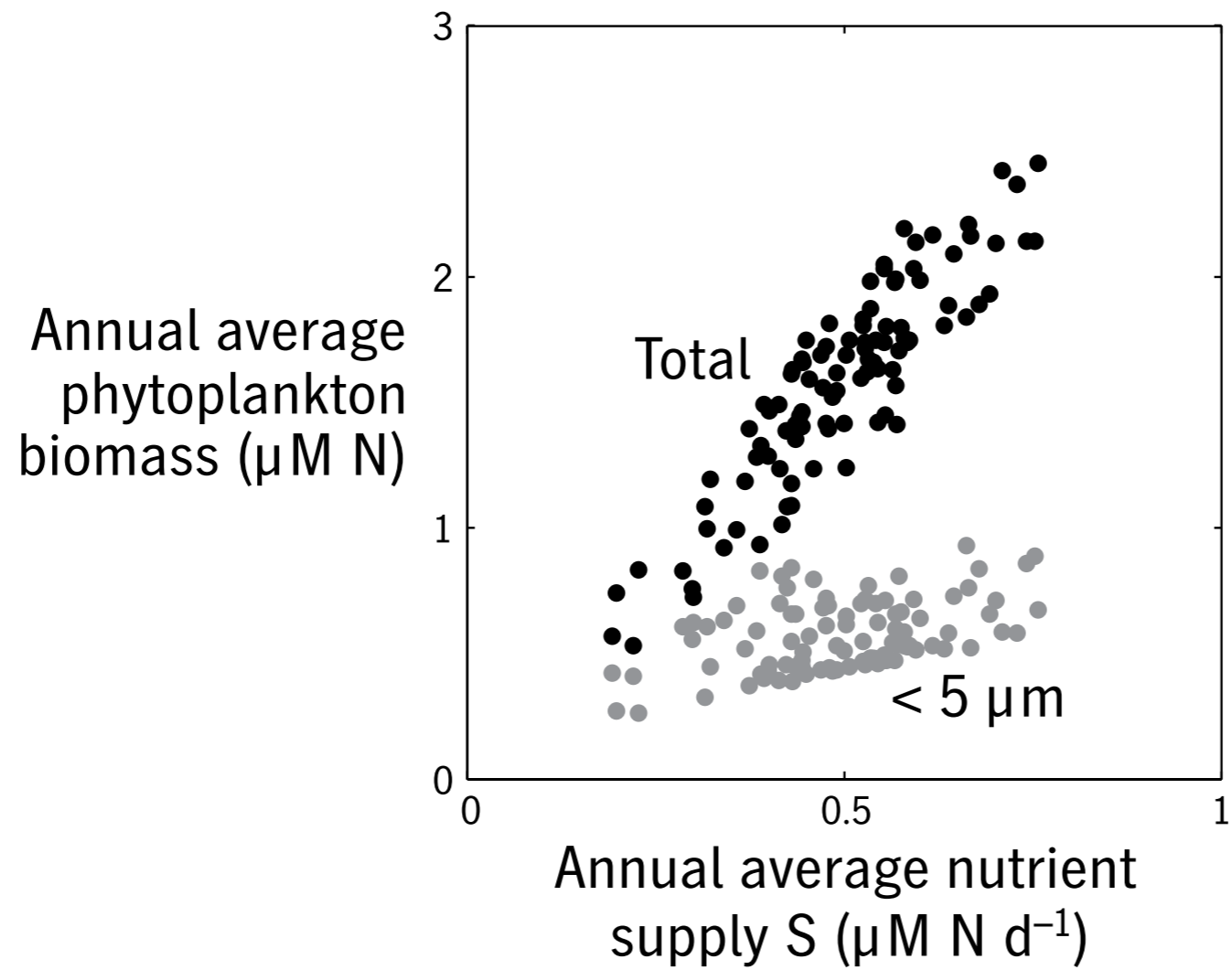
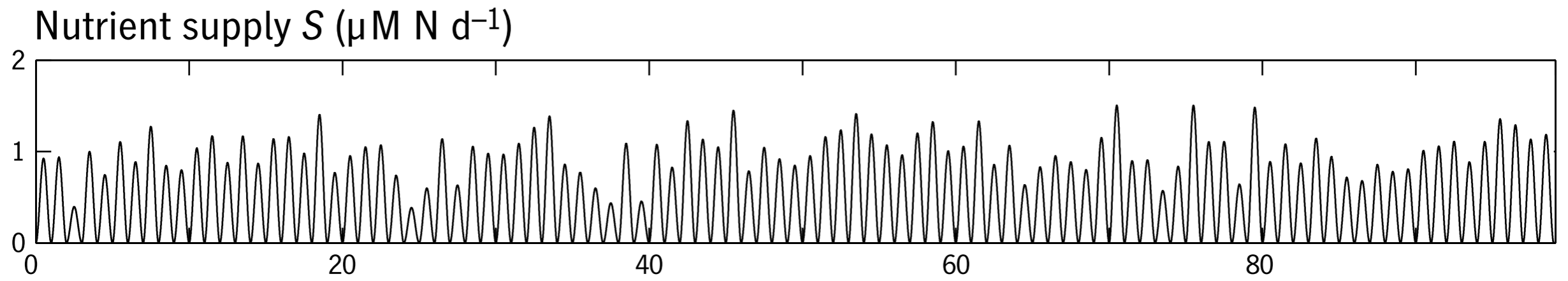


Phytoplankton ESD (μm)

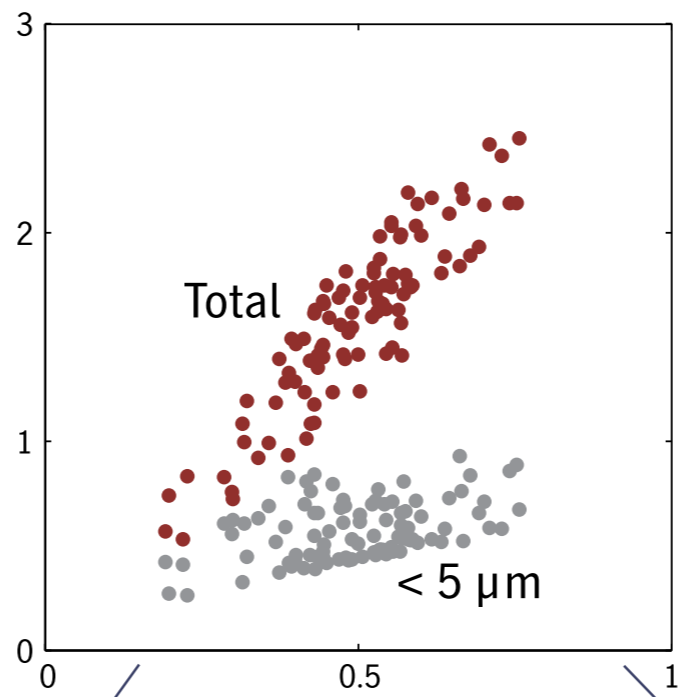
Zooplankton ESD (μm)

Nutrient supply S ($\mu\text{M N d}^{-1}$)

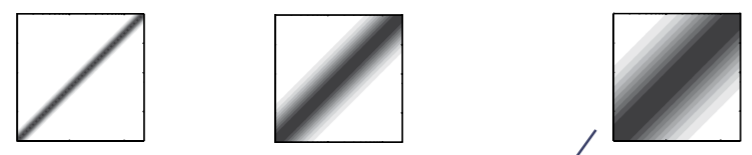




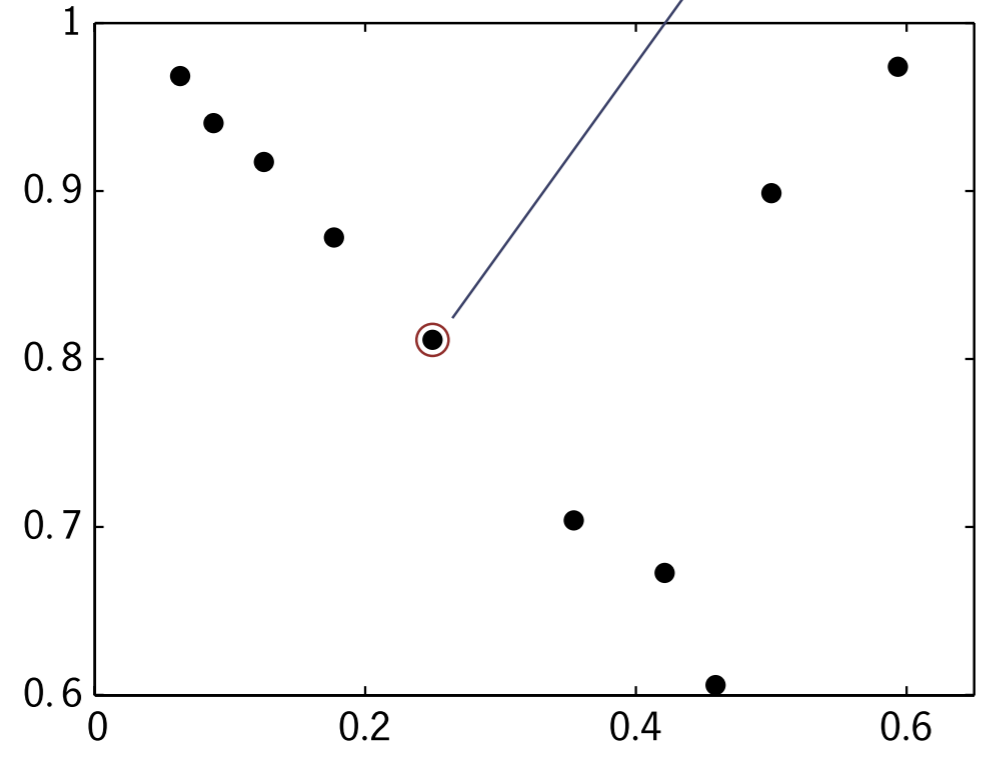
Annual average phytoplankton biomass ($\mu\text{M N}$)



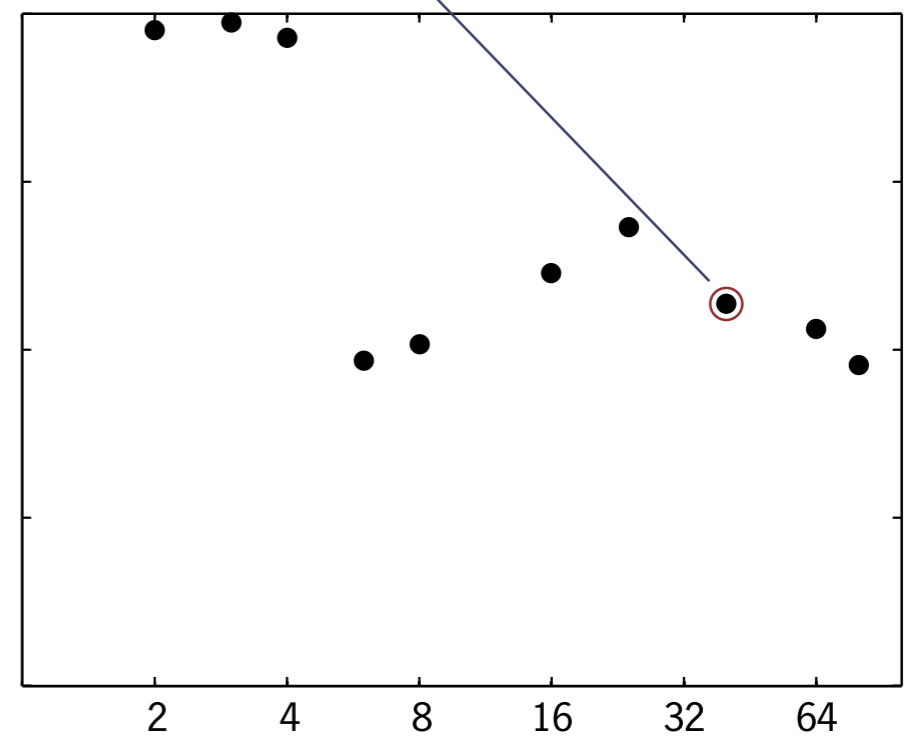
Annual average nutrient supply S ($\mu\text{M N d}^{-1}$)



r^2



specialist grazers Prey size tolerance *generalists*



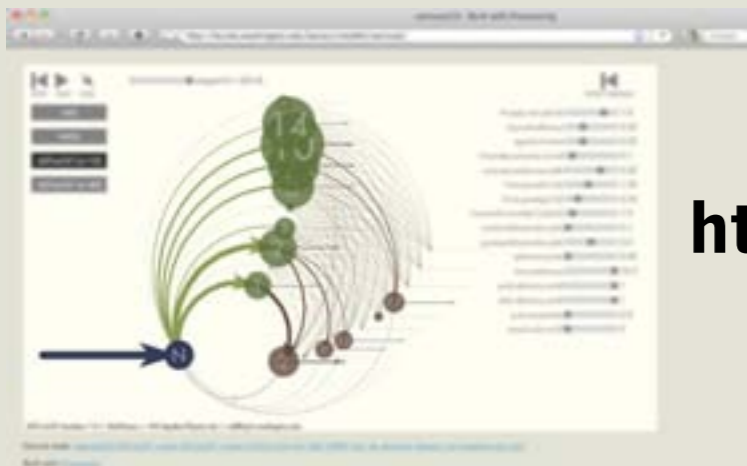
functional-group models Number of size classes *diversity-resolving*

Conclusions

Including diverse grazing preferences in a size-spectral NPZ model leads to **inherent unpredictability** in the response of total biomass to slow changes in nutrient supply: up to 40% of interannual variance.

Changing food-web complexity (making grazers more specialized or generalist) affects predictability differently at different timescales. **Bloom-timescale predictability and interannual predictability are anticorrelated** in this model.

These dynamics can be resolved with only **a moderate increase in the number of P, Z classes** (6–8 where a conventional NPZ model would have 2). Doing so in a realistic biophysical model would allow for **a new dimension of ensemble uncertainty estimation**, analogous to quantifying decadal variability in a GCM.



<http://faculty.washington.edu/banasn/models/astrocat>