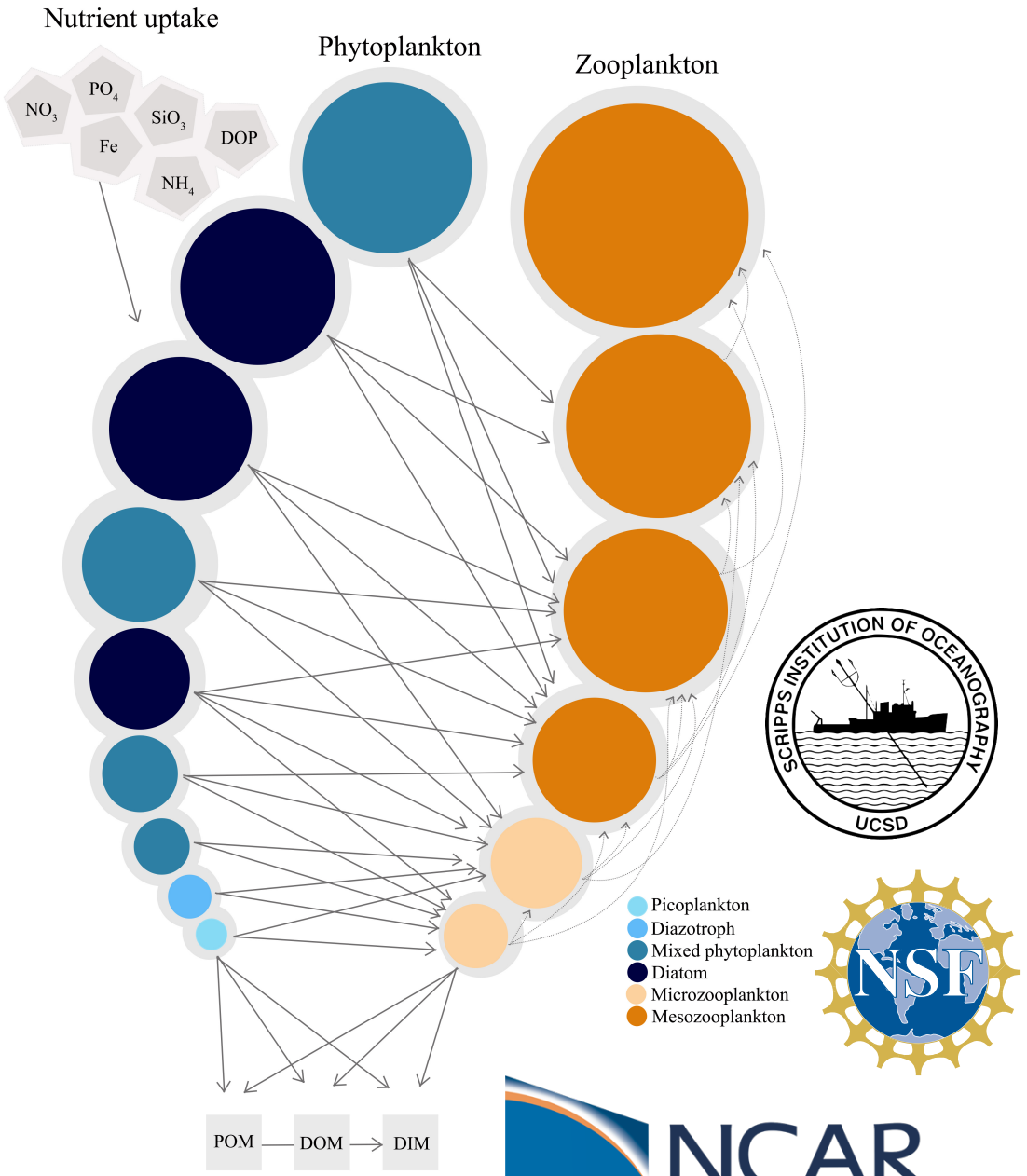
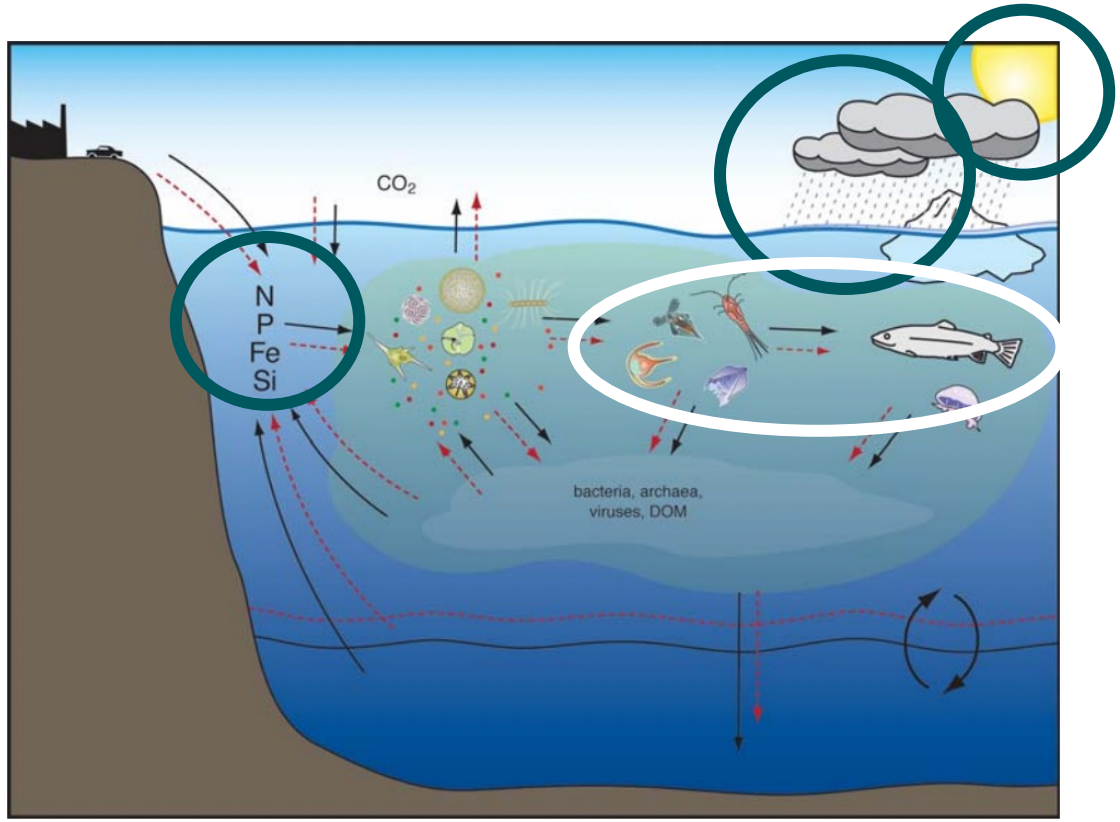
PLANKTON ENERGY FLOWS USING A GLOBAL SIZE-STRUCTURED AND TRAIT-BASED MODEL

Gabriela Negrete García, Jessica Y. Luo, Matthew C. Long, Keith Lindsay, Michael Levy, Andrew D. Barton



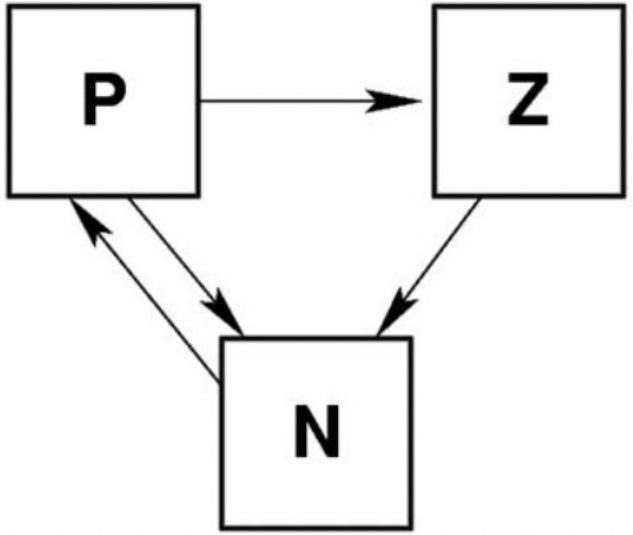
PHYTOPLANKTON



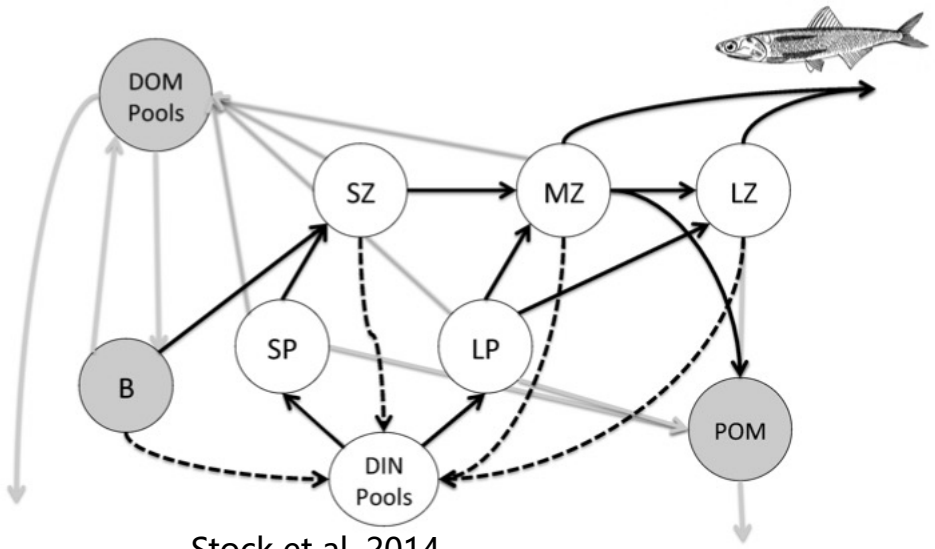
Finkel et al. 2007

- Major primary producers in the Ocean
  - Produce ~ 50% of oxygen we breathe
  - Building blocks of the marine food web
- Influenced by bottom-up processes
  - Nutrients, temperature, and light
- Dependent on top-down processes
  - Grazing by zooplankton and higher trophic levels
- Determine the exchange of carbon from the surface ocean, atmosphere, and ocean depths

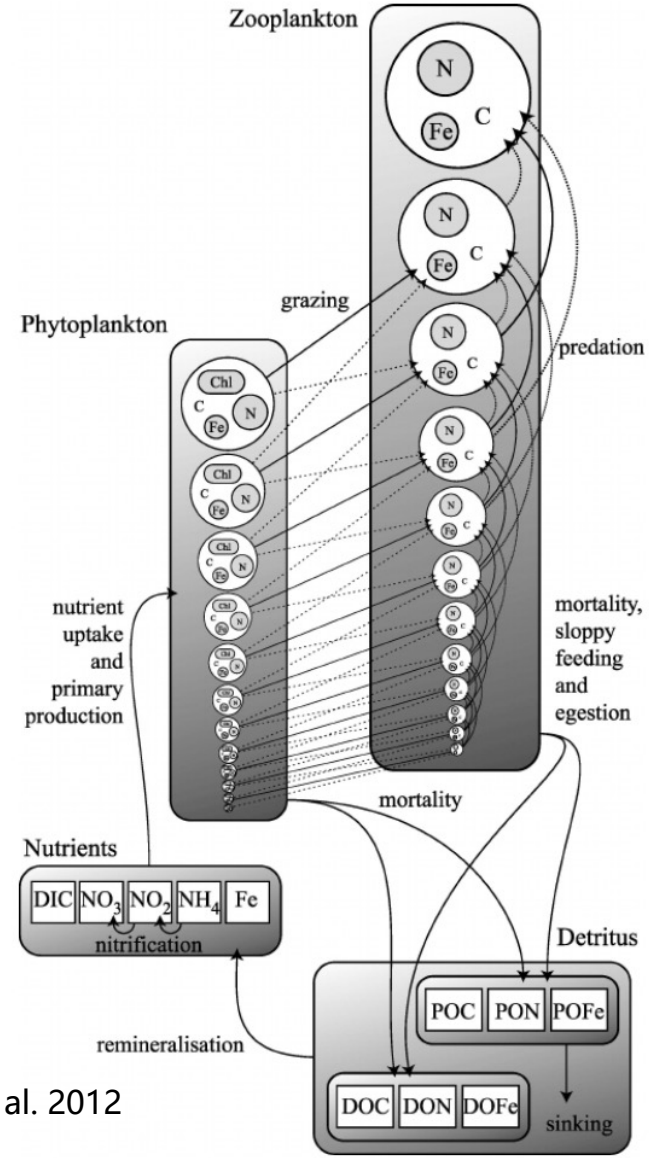
MODELING PHYTOPLANKTON COMMUNITIES



Franks et al. 1986

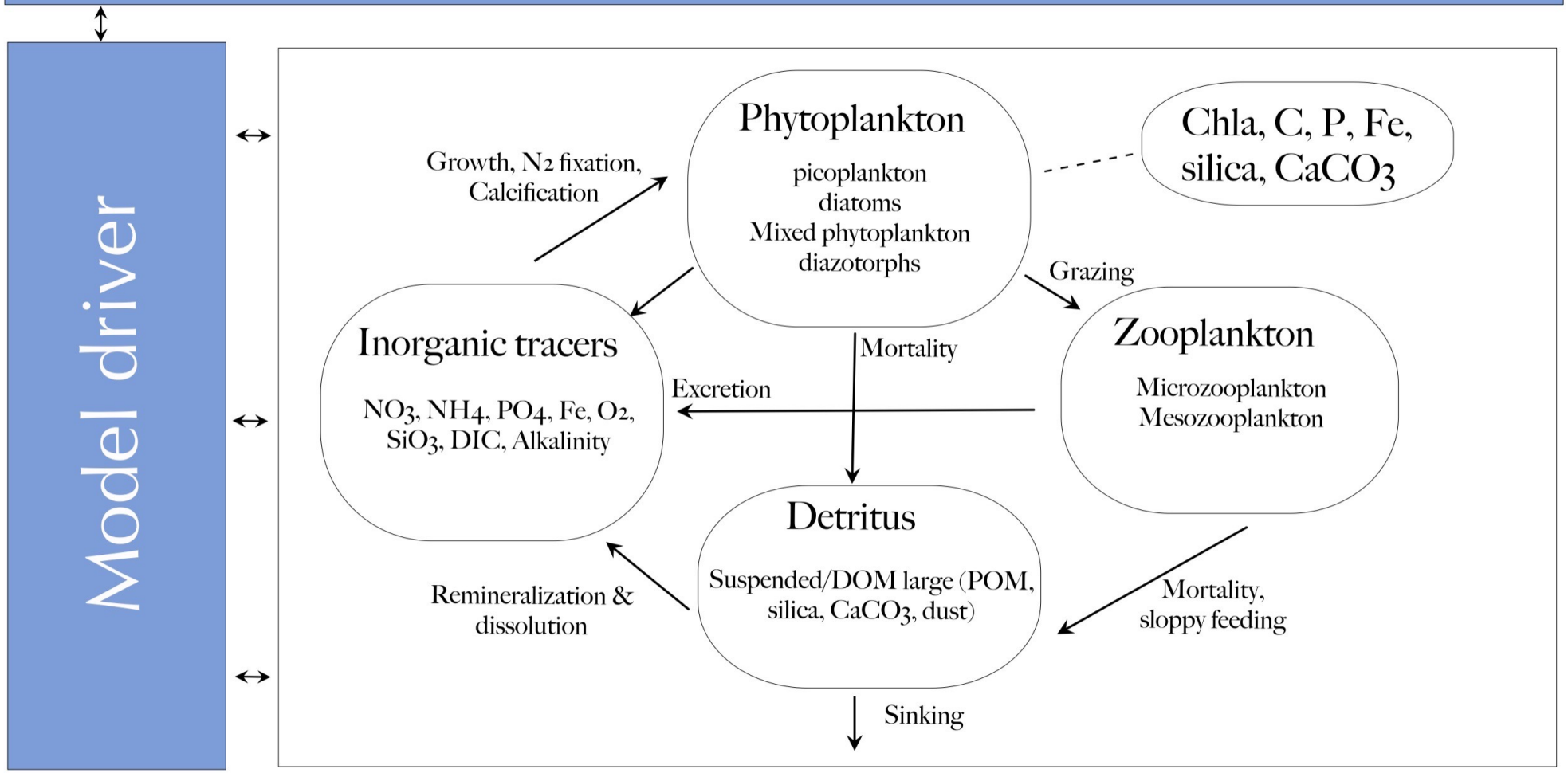


Stock et al. 2014



Ward et al. 2012

Community Earth System Model (CESM2)



MARBL-SPECTRA

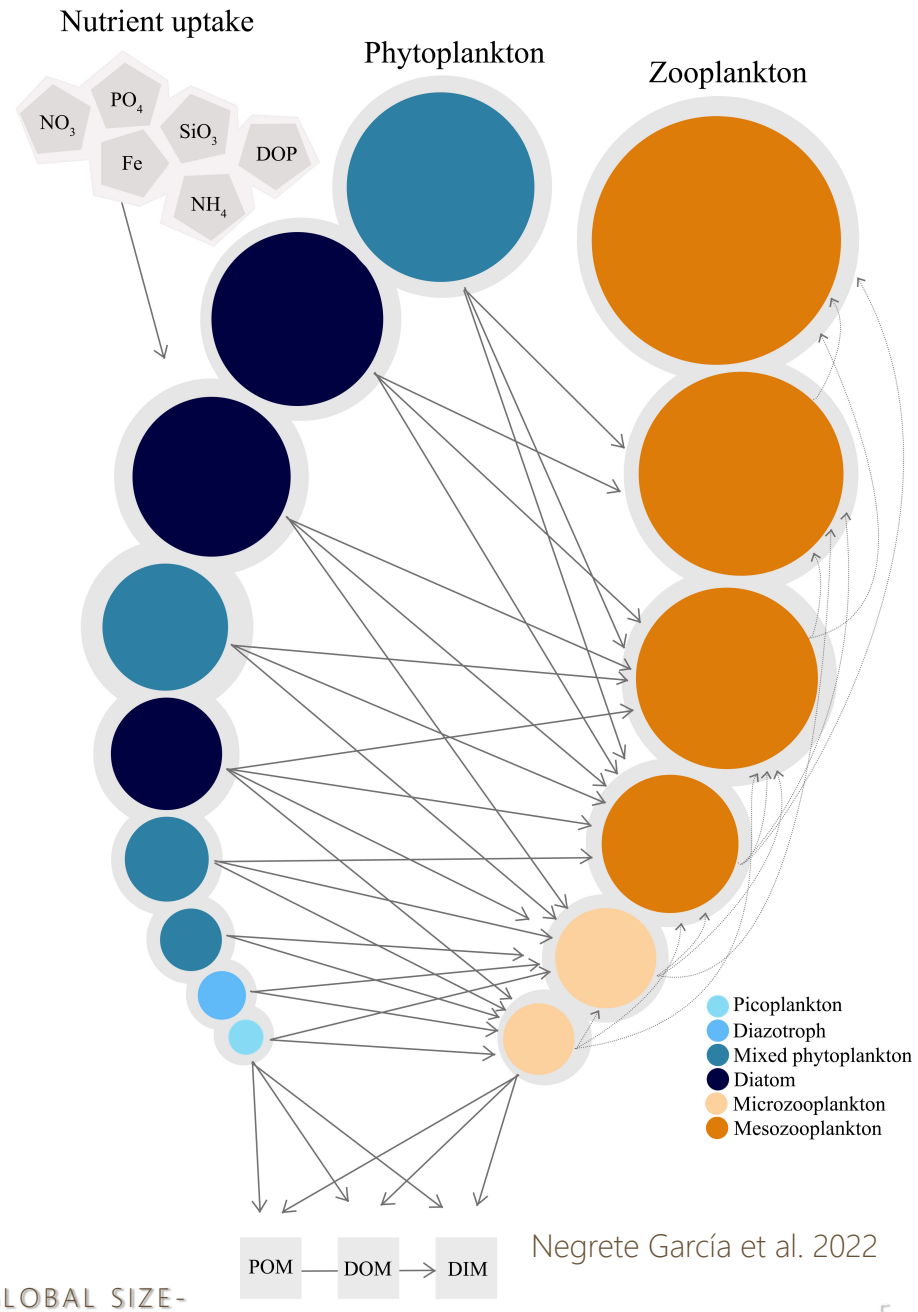
Plankton community model within Community Earth System Model.

9 phytoplankton

- Picoplankton
- Diazotroph
- 4 Mixed phytoplankton (includes calcifies)
- 3 Diatoms

6 zooplankton

- 2 Microzooplankton
- 4 Mesozooplankton



Negrete García et al. 2022

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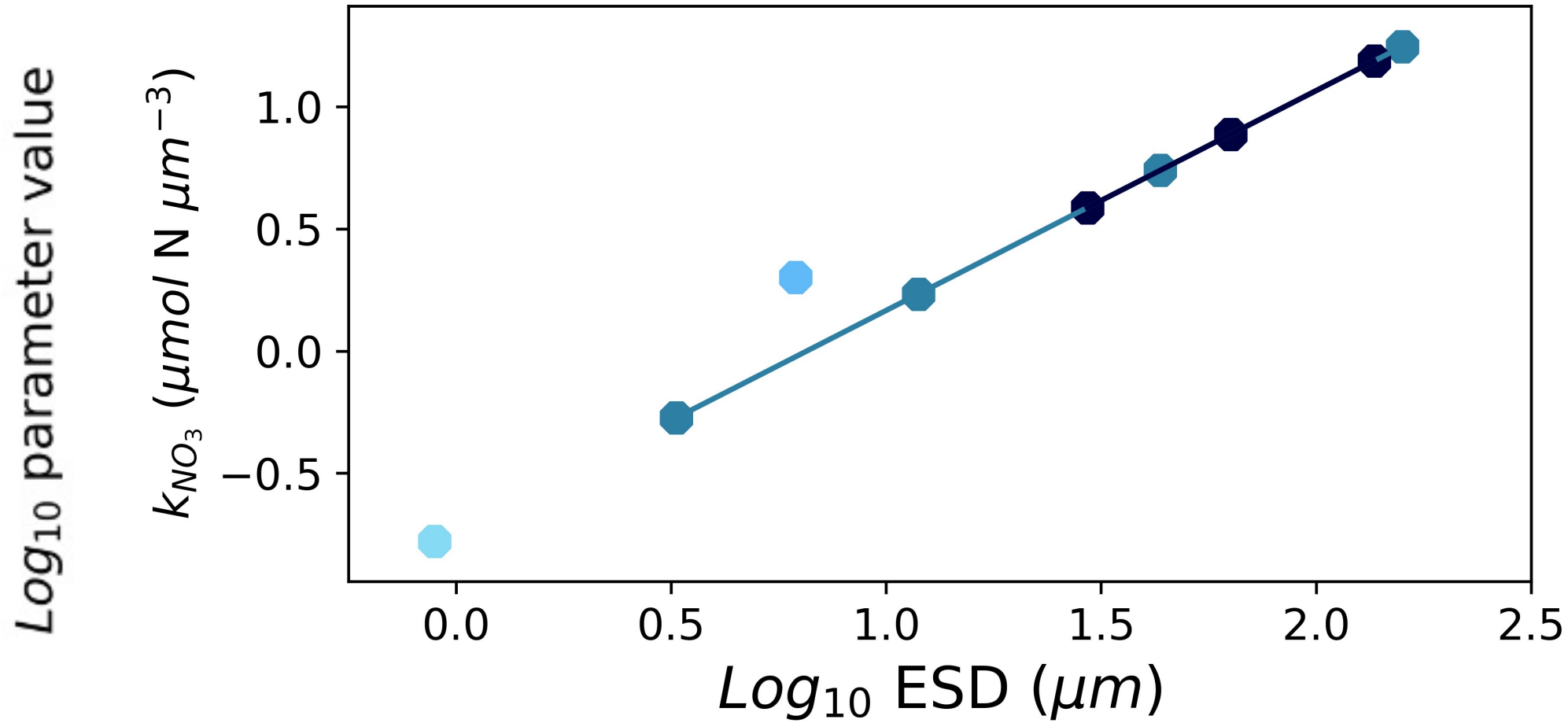
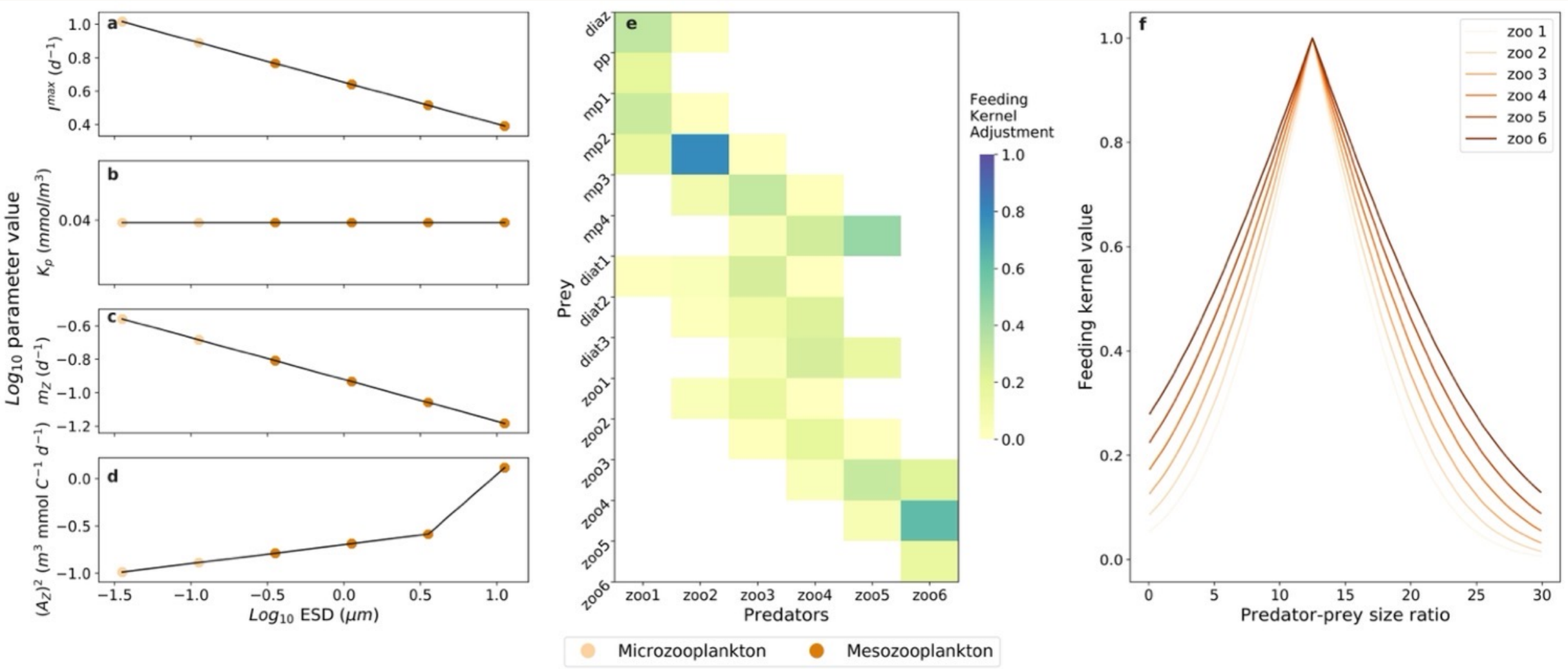
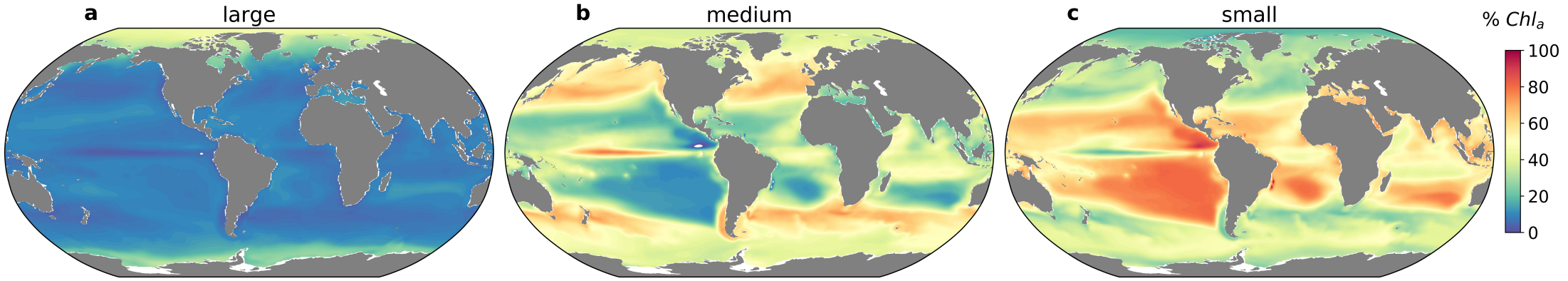
PHYTOPLANKTON ALLOMETRIC SCALING

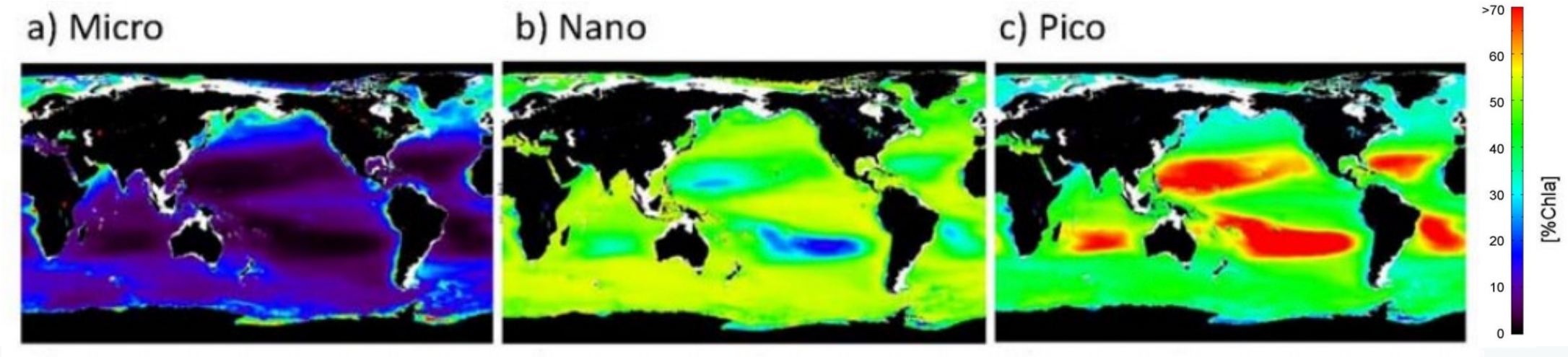


Picoplankton Diazotroph Mixed phytoplankton Diatoms

ZOOPLANKTON ALLOMETRIC SCALING



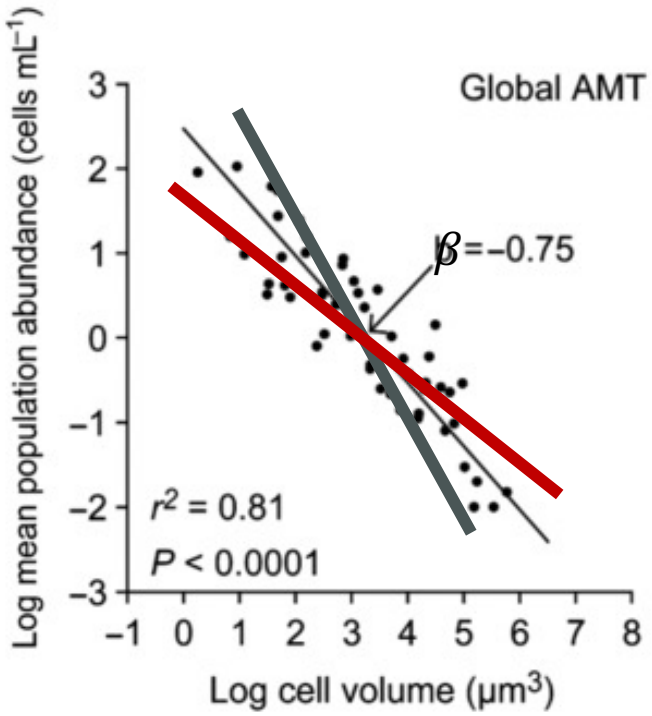




Hirata et al. 2011

- Small phytoplankton dominate oligotrophic regions
- Medium phytoplankton dominate coastal and productive regions
- Large phytoplankton dominate polar regions

PHYTOPLANKTON SIZE STRUCTURE

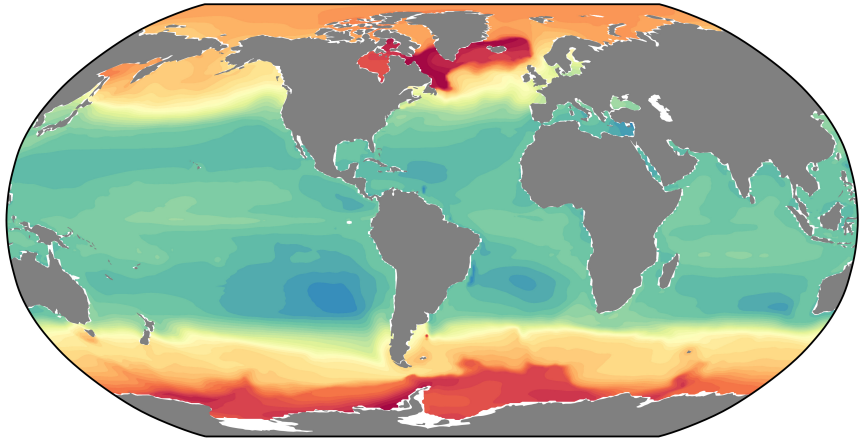


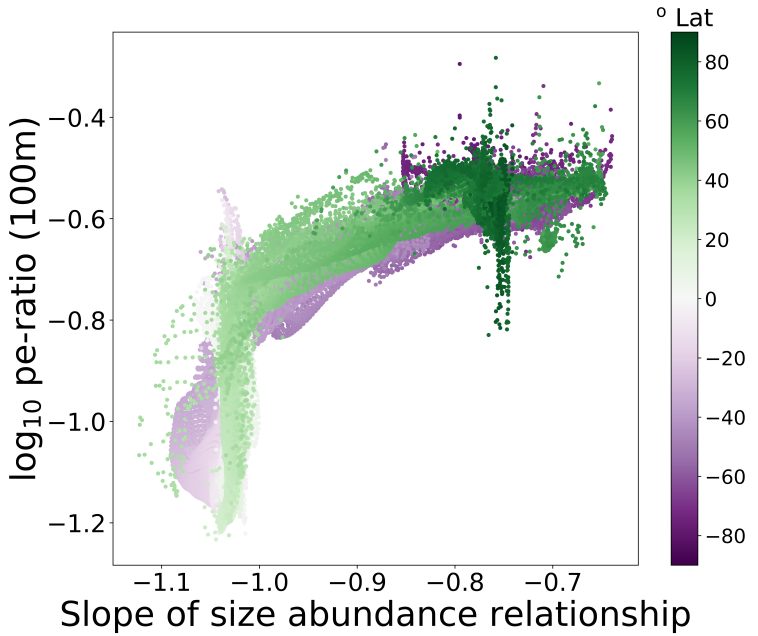
$$N = \alpha V^{\beta}$$

Slope of size-abundance relationship

- More negative slope (steeper) = dominance of smaller cells
- less negative slope (less steep) = larger phytoplankton dominance

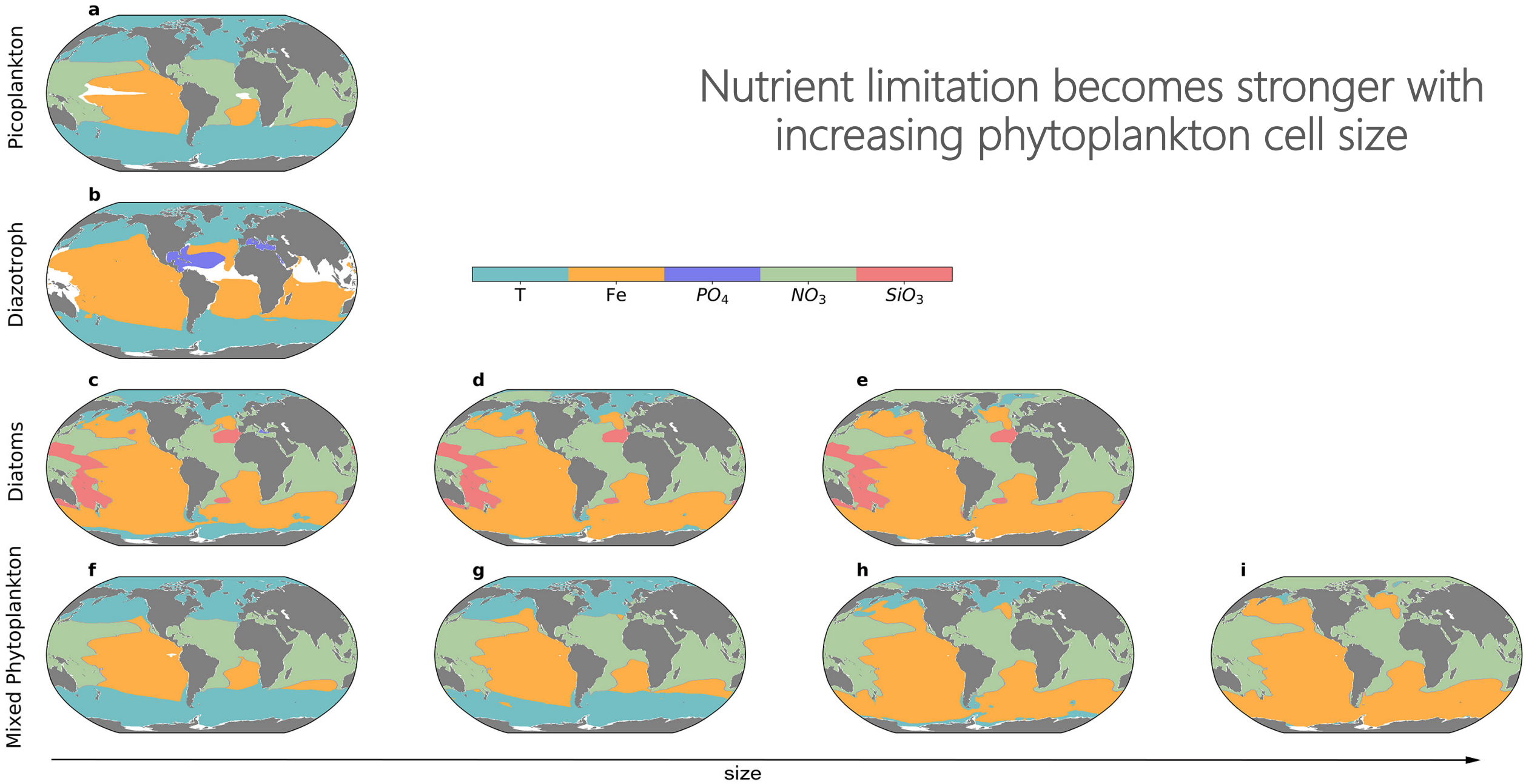
POSITIVE RELATIONSHIP BETWEEN SLOPE OF THE SIZE ABUNDANCE RELATIONSHIP AND EXPORT EFFICIENCY



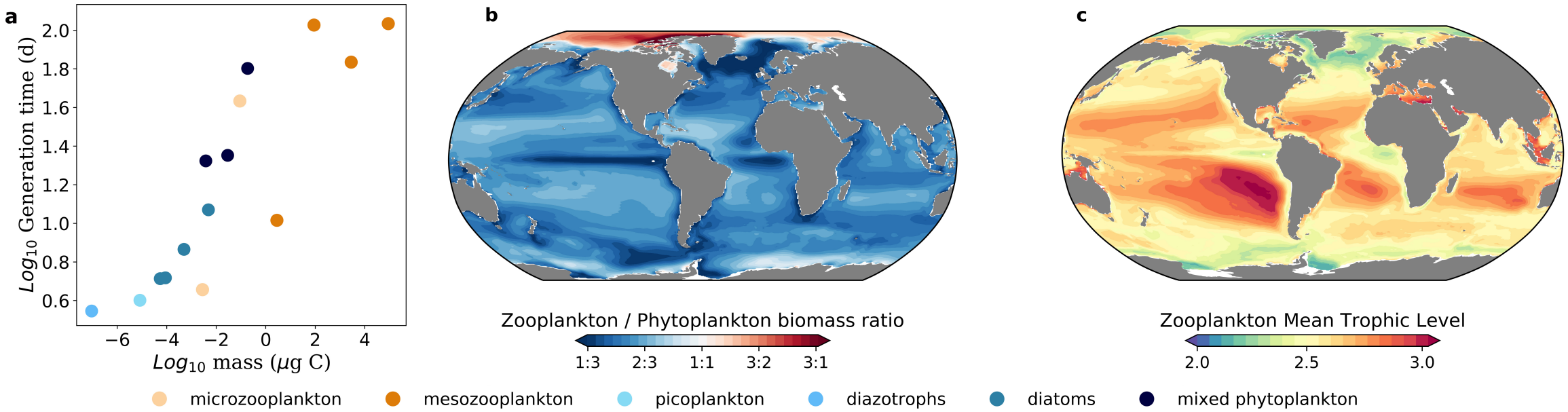


Pe-ratio = fraction of depth-integrated NPP exported as sinking particles at 100m.

Nutrient limitation becomes stronger with increasing phytoplankton cell size

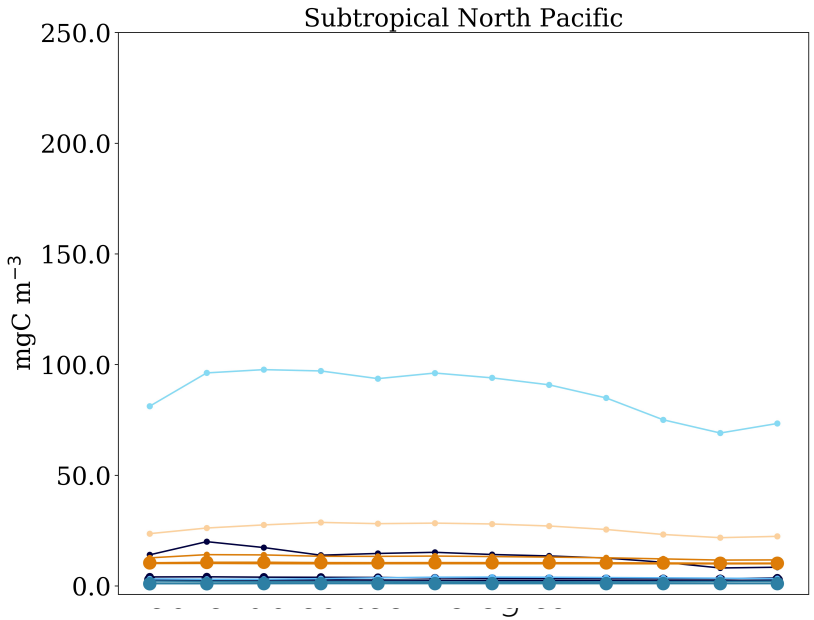


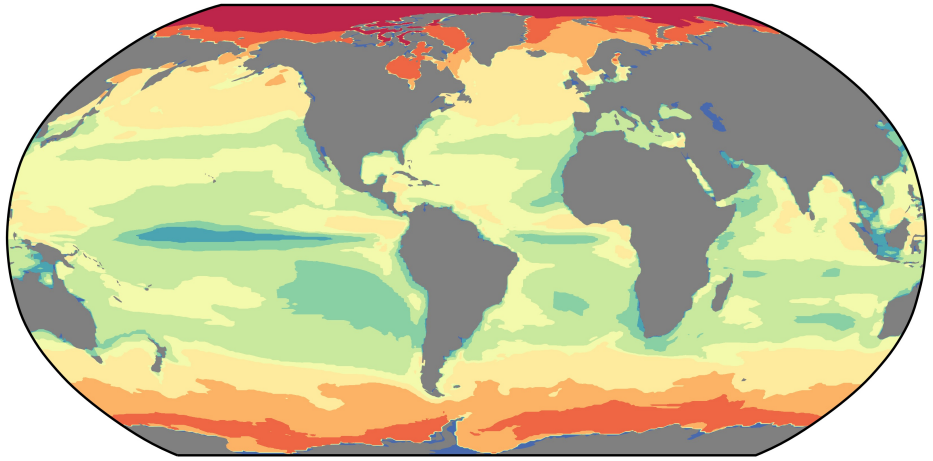
GENERATION TIMES, Z:P RATIOS & MEAN TROPHIC LEVELS

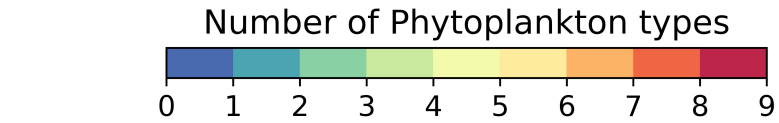


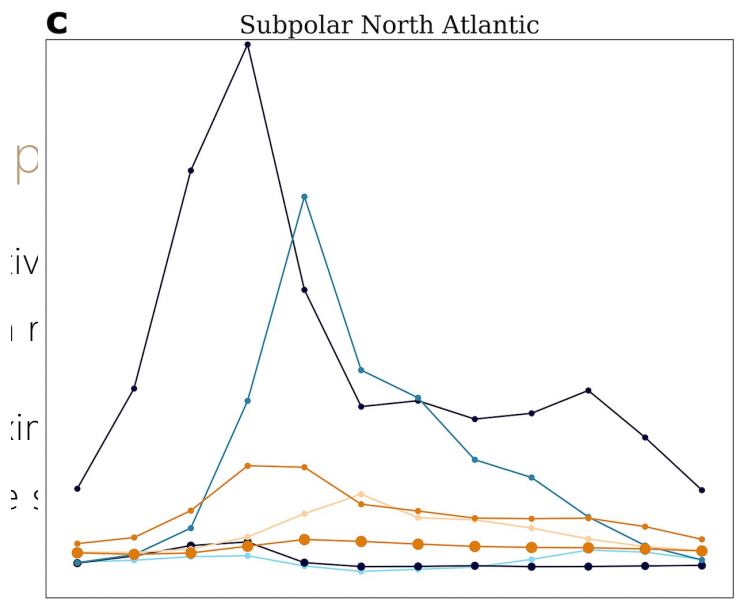
- Generation time increases with increasing cell size
- Z:P generally decrease with biomass gradient
- Longer, less efficient food chains in unproductive regions

PHYTOPLANKTON SUCCESSION







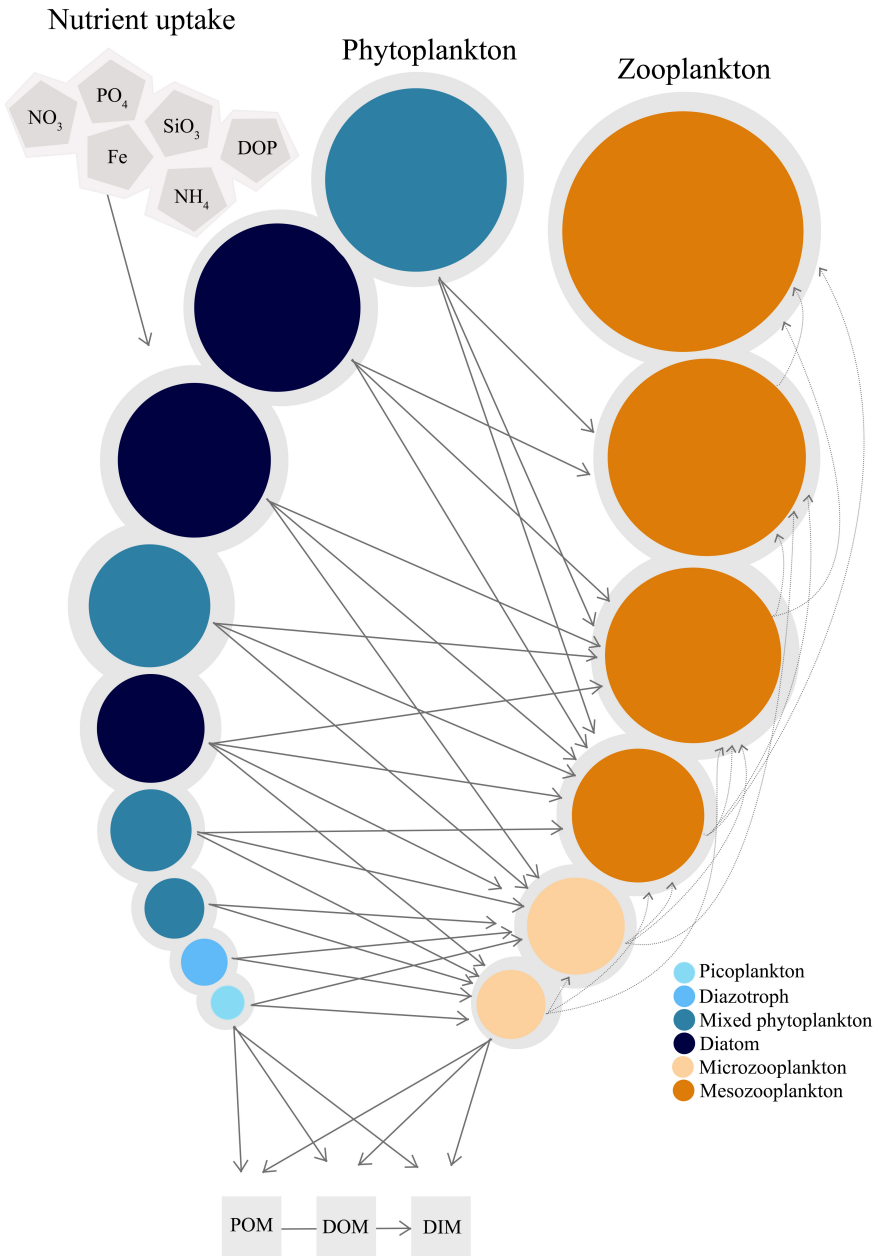


- Low phytoplankton succession in subtropical North Pacific
  - Strong grazing pressure from small microzooplankton & low nutrient delivery
- Higher phytoplankton succession in the subpolar North Atlantic
  - Balance between high nutrient availability and strong grazing pressure

SUMMARY

- MARBL-SPECTRA can simulate seasonal and regional changes in plankton phenology and succession and their roles in ecosystem functioning and biogeochemical processes.
- The incorporation of MARBL-SPECTRA in CESM2, enables mechanistic projections of how plankton communities are responding to seasonal and interannual changes in the environment, as well as how they might respond to future environmental change.

THANK YOU


Nutrient uptake
Phytoplankton
Zooplankton
NO3
PO4
SiO3
Fe
DOP
NH4
Picoplankton
Diazotroph
Mixed phytoplankton
Diatom
Microzooplankton
Mesozooplankton
POM
DOM
DIM