NEREUS
PREDICTING THE FUTURE OCEAN

Nereus Program:
Predicting the Future Ocean

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PRINCETON UNIVERSITY
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Stockholm University
UNEP WCMC
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Will there be fish for coming generations?

- Fisheries have collapsed across the globe linked to overcapacity of fishing fleets
- Predictions of future fisheries are contradictory, and build on very incomplete science
- The NF-UBC Nereus program is an international, interdisciplinary, research network designed to analyze the global ocean and improve predictions, linking science - policy - people

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NF-UBC Nereus Program

- The Nereus program is a long-term (2010-2019, US$13M) cooperation between The Nippon Foundation and The Univ. of British Columbia, conducted in partnership with Princeton, Duke, Stockholm universities, and UNEPs World Conservation Monitoring Centre / University of Cambridge

- Working across disciplines to predict the future of the global ocean and evaluate how we can develop policies that offer resilience against climate change and exploitation

- Capacity building is key – 30 fellows to be involved

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Nereus?

- The original god of the sea
- Son of Pontius, the Sea and Gaia, the Earth
- The old gentleman of the sea
- Protector of fishermen –
- and he could predict the future!

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The Nereus model(ing complex): integrates many models and data

Policy & awareness

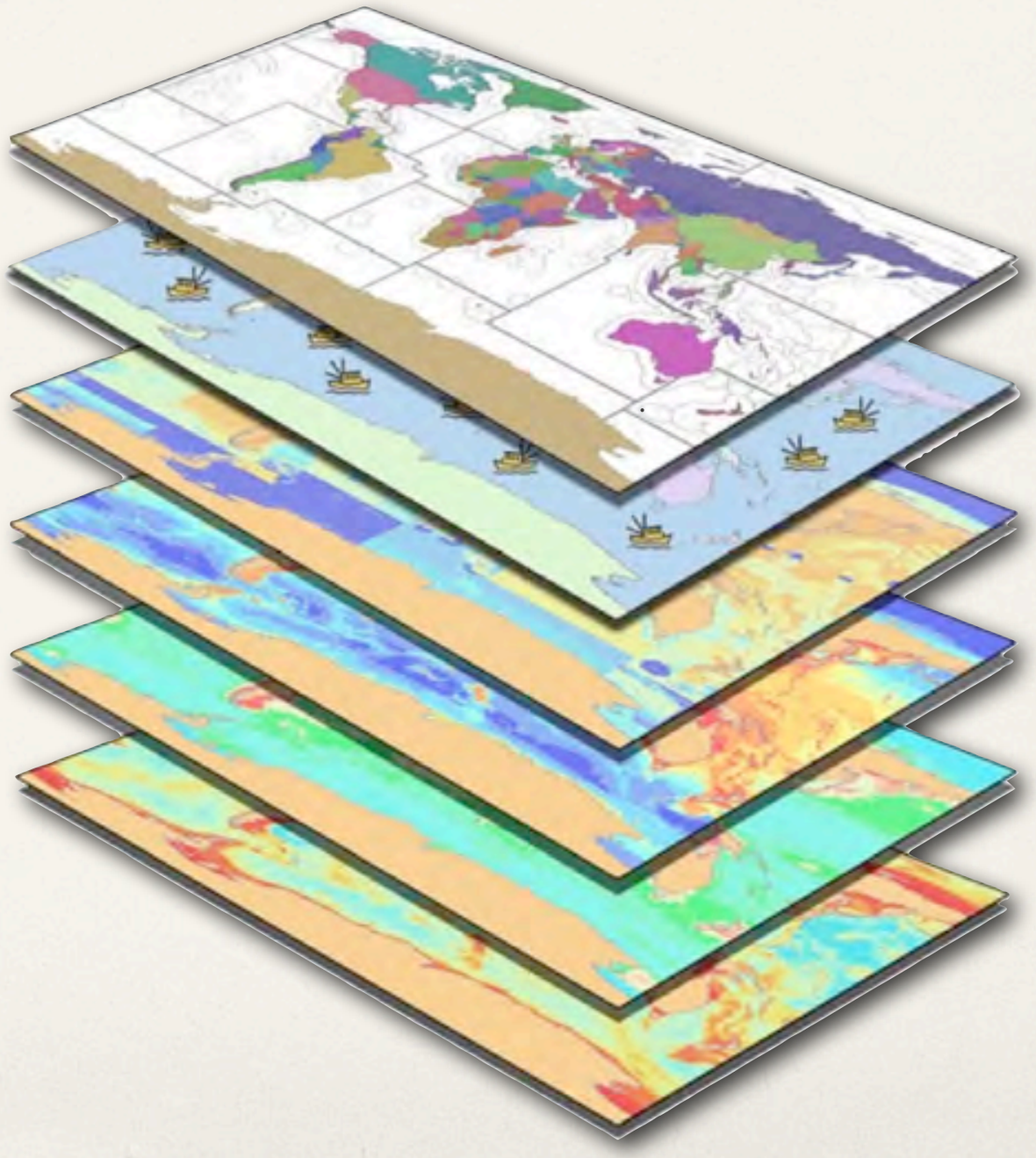
Economy & social

Seafood production

Biodiversity

Productivity

Climate & currents



SEA AROUND US PROJECT

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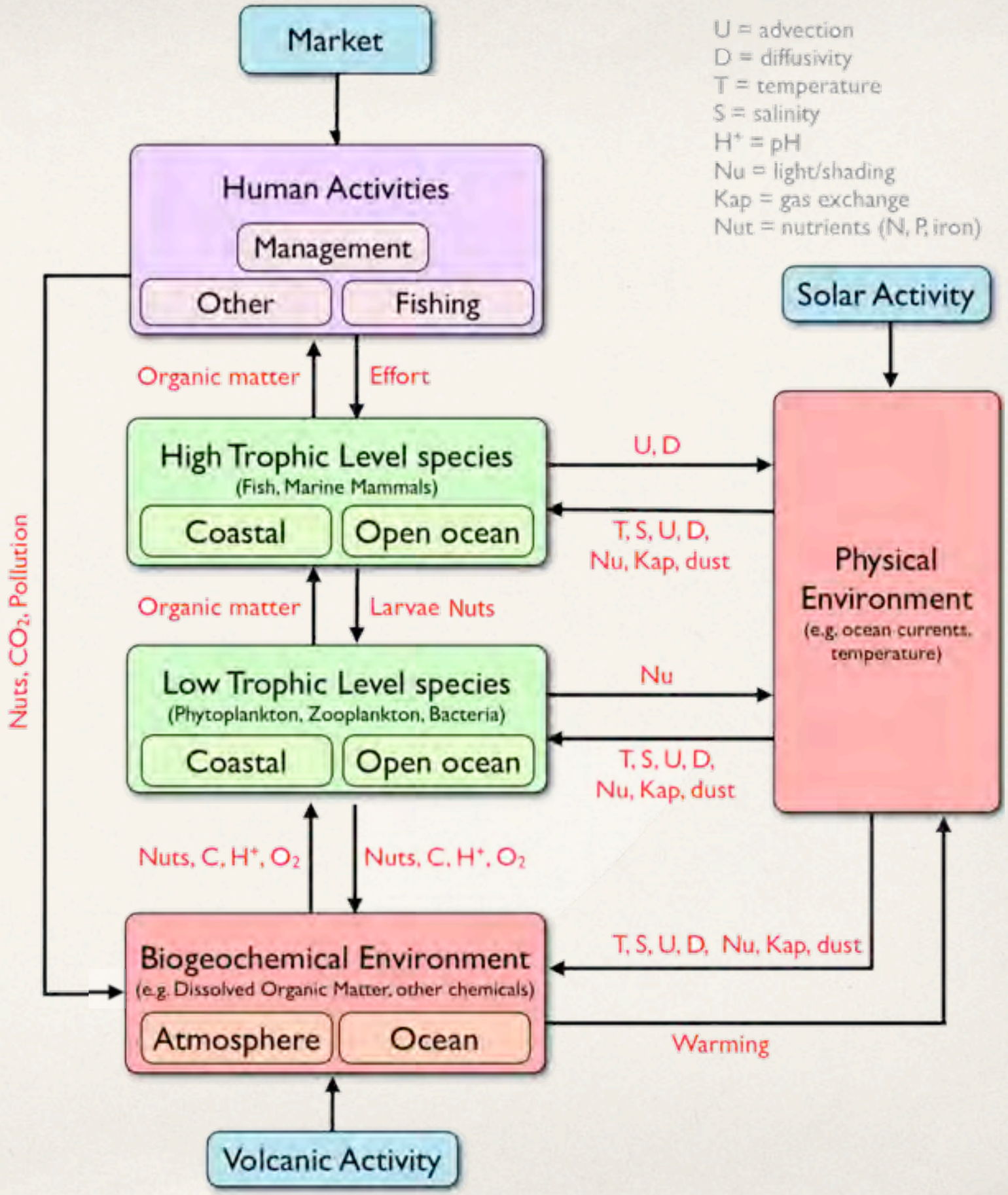
The Nereus model(ing complex)



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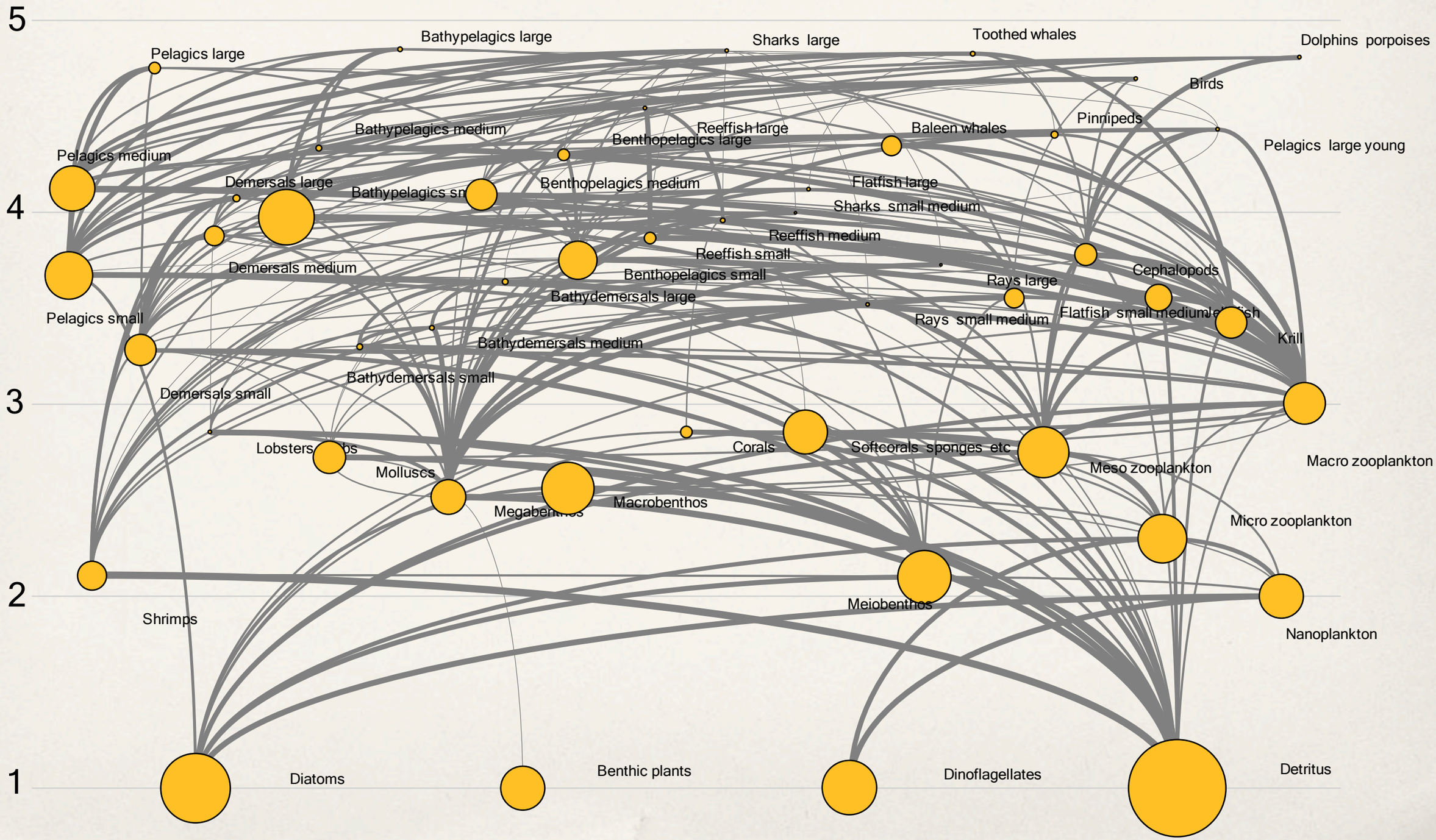
Upper trophic levels: food web & size distribution

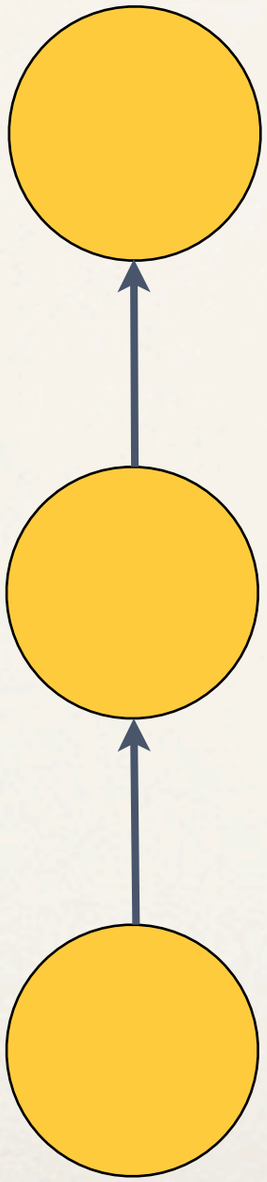


In the box: biodiversity

Group A

Group B

Group C



For each spatial cell & group:

Species 1

Species 2

...

Species N

← Vulnerability to fishing

← Temperature

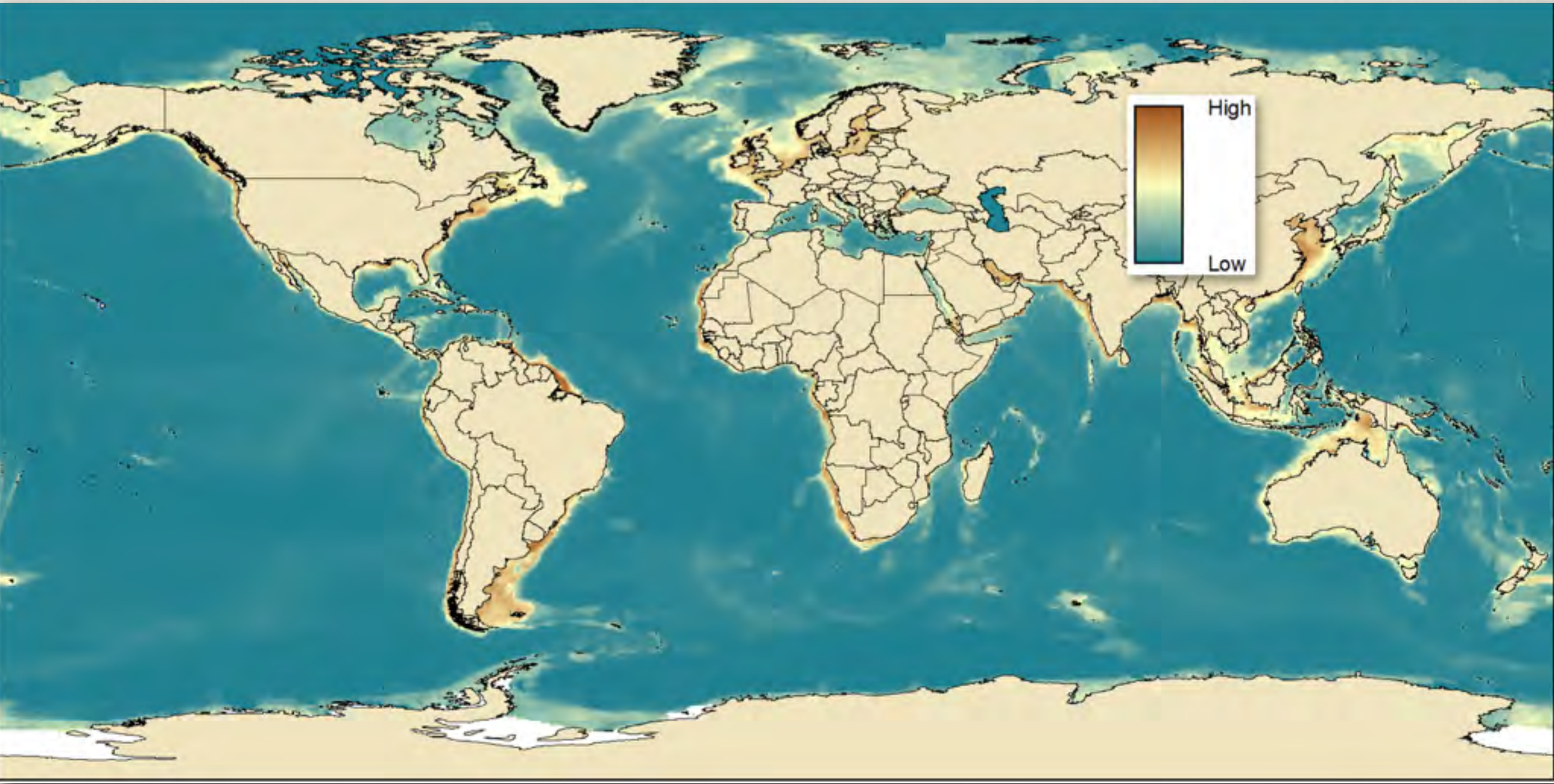
← Oxygen

← pH

Early results

- The first version of the Nereus model is operative
  - The first food web model of the world ocean
- Examples of early results
  - Based on 245 fishing fleets
  - Incorporates ~1000 species
- Major additions to come as the Nereus program develops

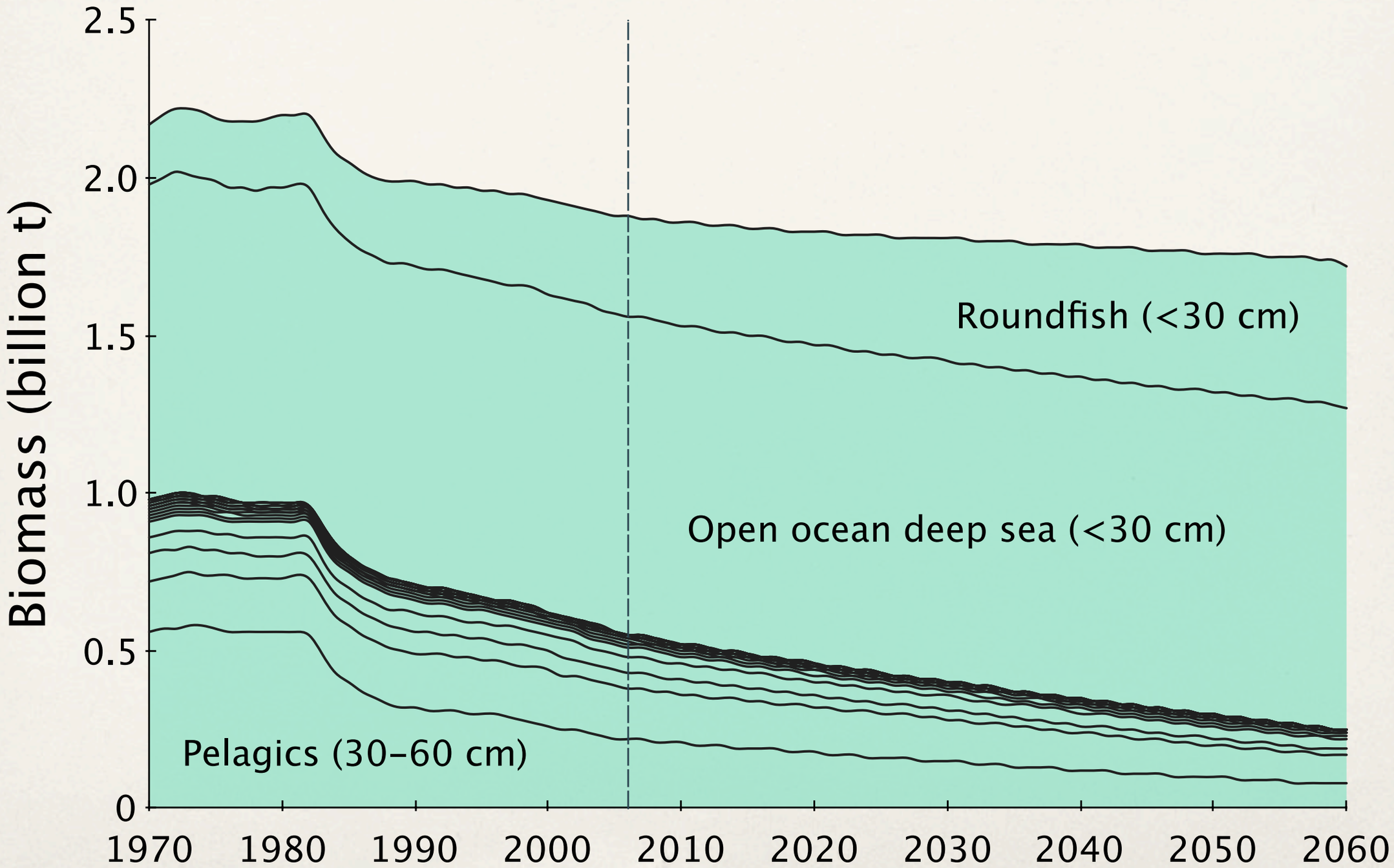
Fish biomass distribution: spatial model 252,000 cells



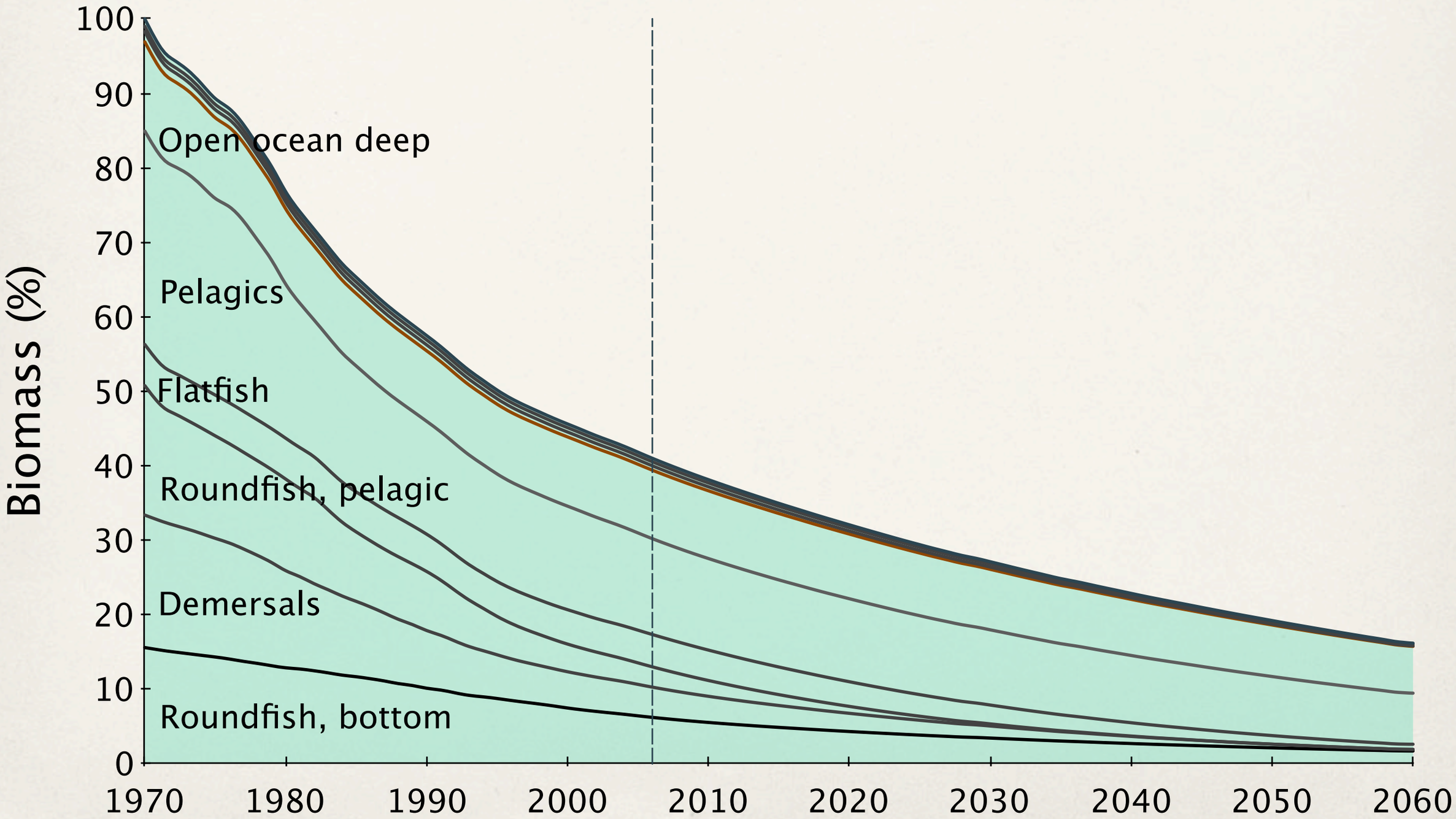
How much fish in the ocean?

- Only two previous attempts at estimating this, both much less comprehensive
- Total fish biomass ~2 billion t, >300 kg/person on earth
- Total biomass has decreased only little in the last 40 years.

Total fish biomass



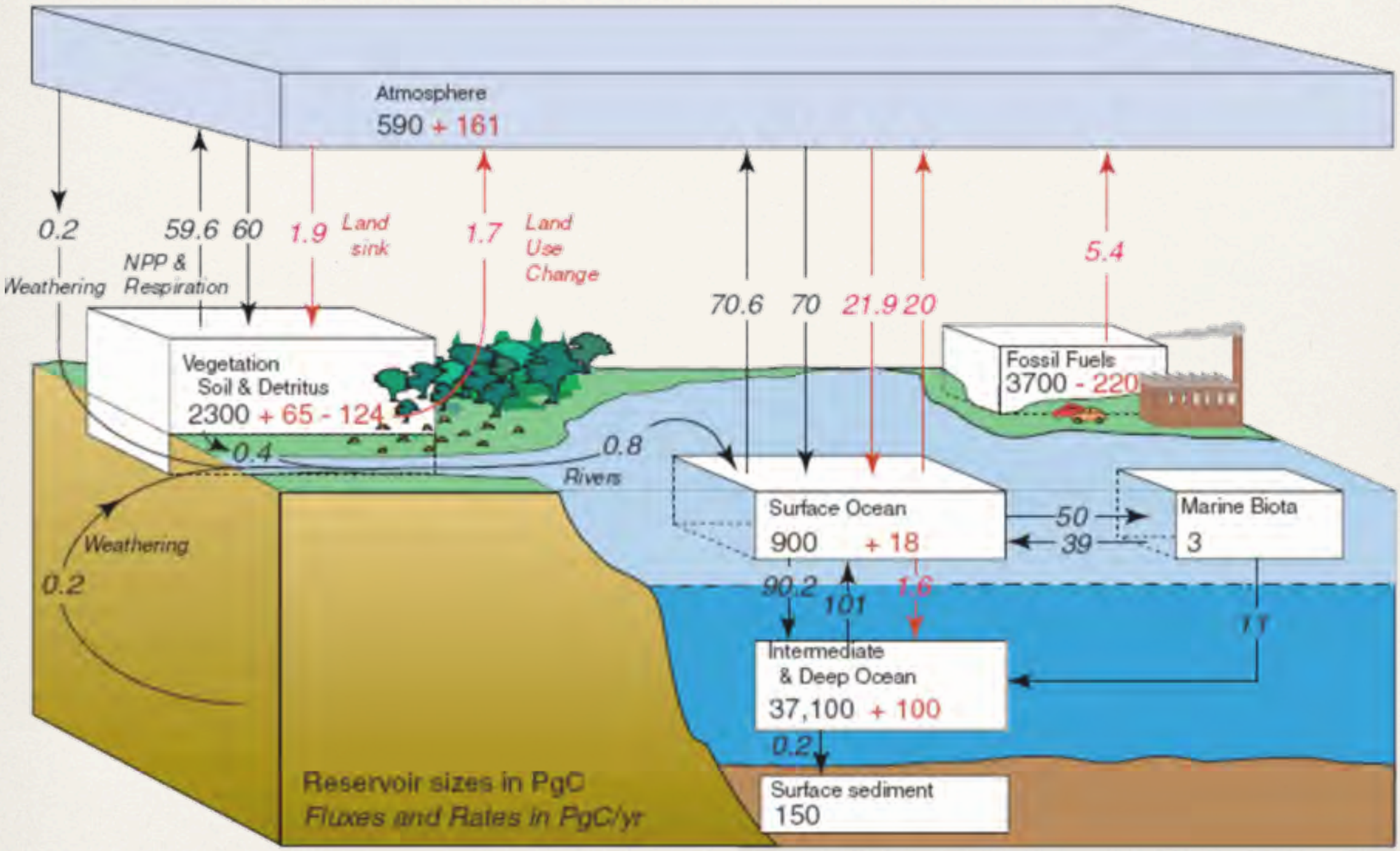
Large fish biomass



Adding life to the carbon cycle

- IPCC has focused on the physical environment – up to now
- Increasing effort on evaluating impact on life in the ocean (such as this conference is an expression of)
- Impact of ocean life on the carbon cycle?
  - "Higher levels of the food chain such as fish are not of importance in controlling the surface chemical composition in most regions of the ocean"

The carbon cycle: marine biota



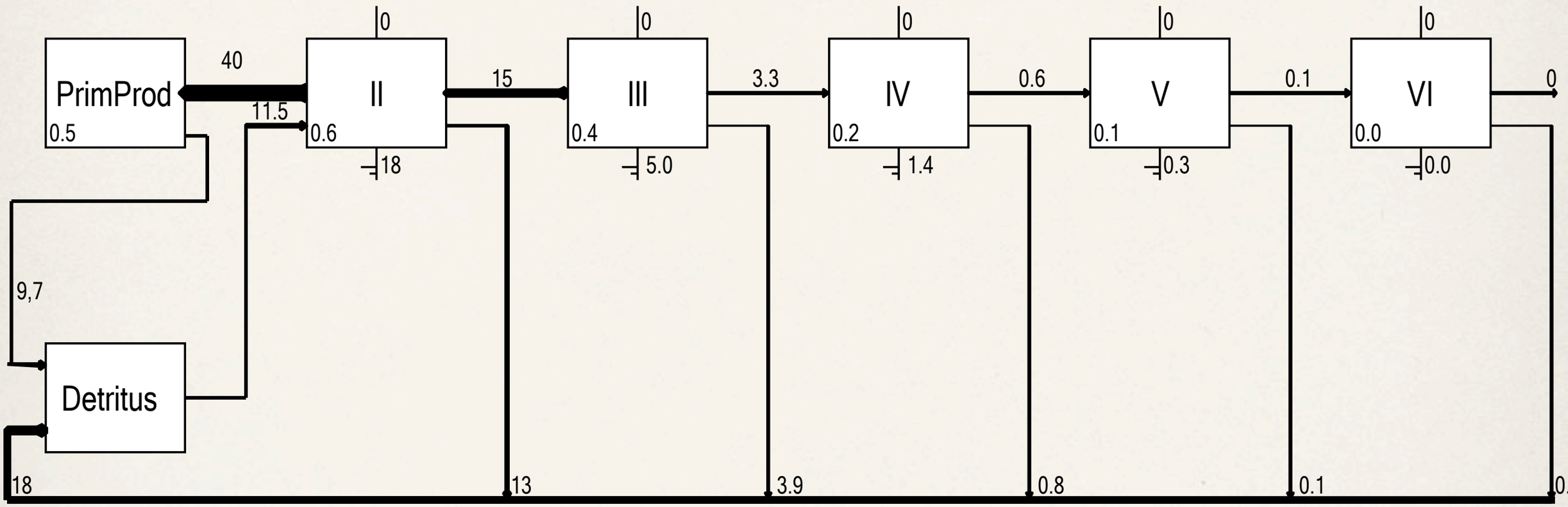
The marine biota act as a carbon pump ... provides a deep source of inorganic carbon and creates a deficit of about 10% of $\sum CO_2$ in surface waters ... The size of the export fluxes is not well known.

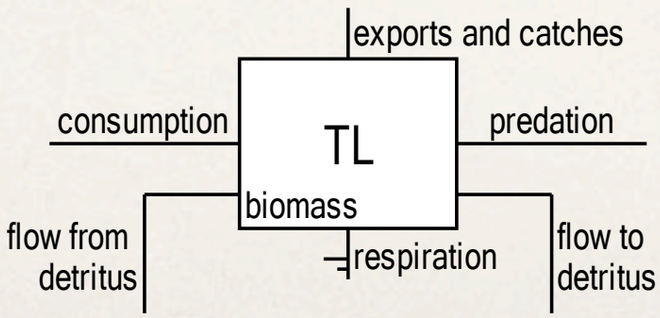
Sarmiento and Gruber, 2002

Nereus model is designed to describe interactions, but

- Flow to deep layers?
  - Not (currently) built to answer that
- Impact of nutrient recycling by biota
  - Not currently included (but neat project)

Global pools and fluxes: Nereus



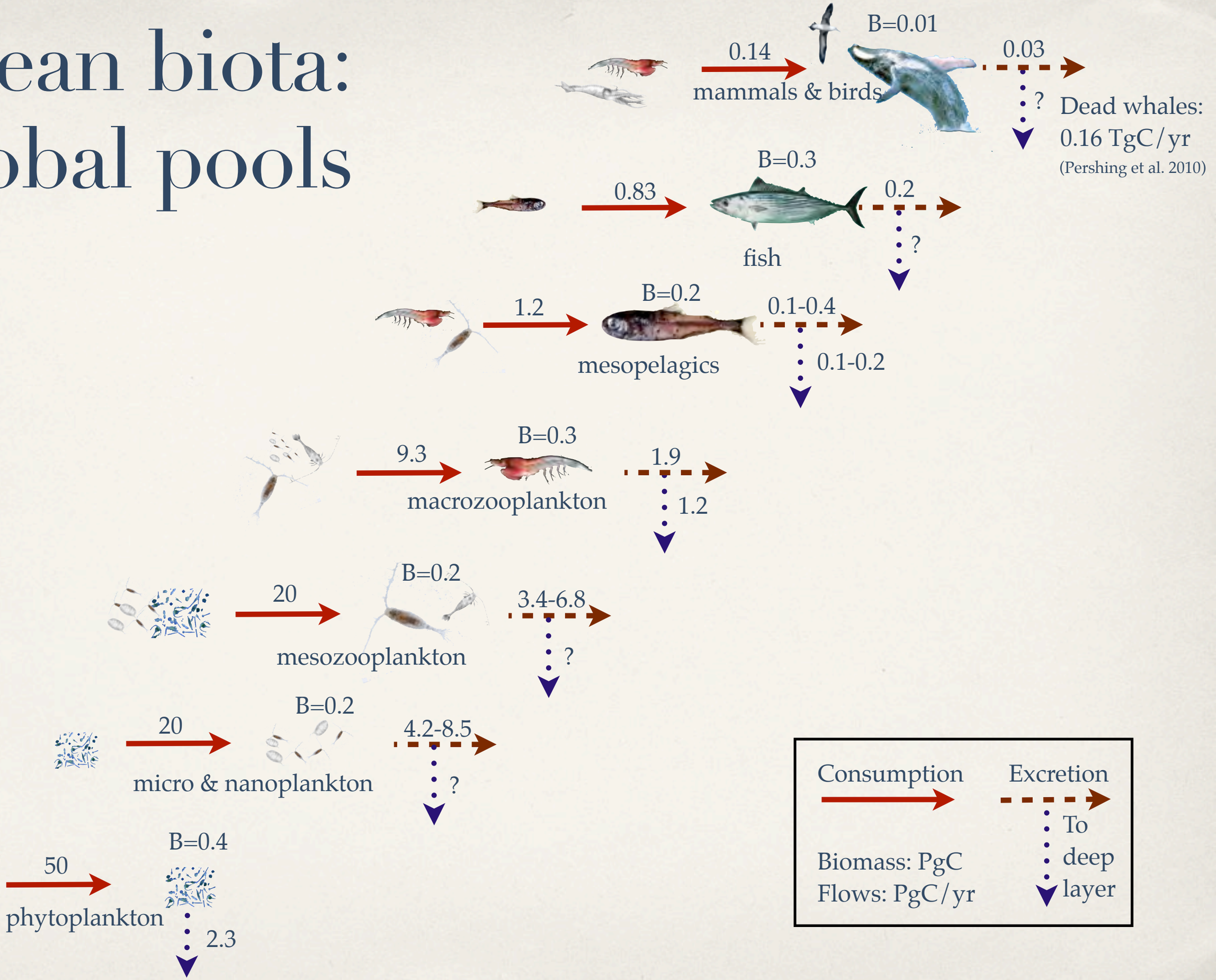


Totals:

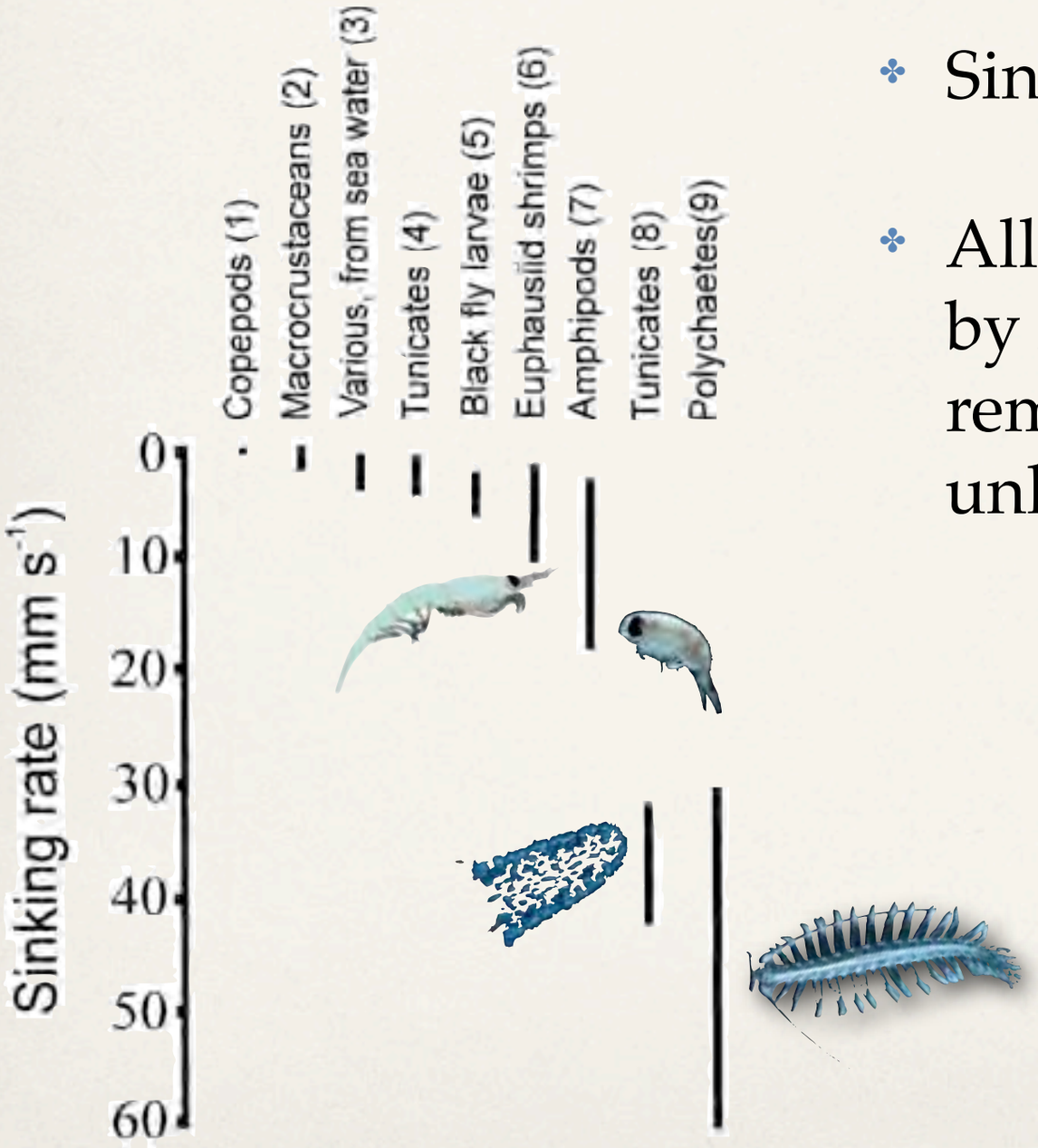
Biomasses: 2.0 PgC

Consumption: 85 PgC/yr

Ocean biota: Global pools



Suspension feeder excretion



- Sinking rates are a.o. size-dependent
- All small pellets (like those produced by zooplankton > 200 µm) are likely to remain within stratified photic zones, unless in aggregates

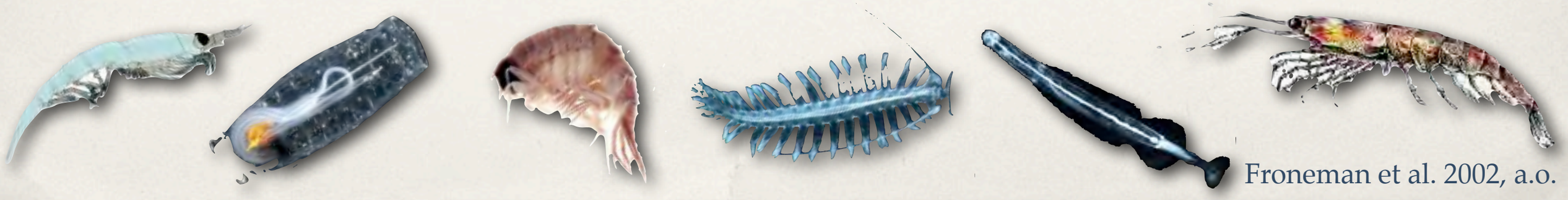
Wotton and Malmqvist 2001

Macrozooplankton excretion

- Froneman et al. (2002) evaluated predation impact of carnivorous macrozooplankton in the Southern Ocean during austral autumn, and found that macrozooplankton may contribute a downward flux of carbon equivalent to 0.3-9% of the total mesozooplankton stock per day

- Assuming that this rate is representative for half the year (or half the global mesozooplankton biomass of ~0.14PgC):

  - Flow to deep ocean: 1.2 PgC/yr (range 0.08–2.35)



Froneman et al. 2002, a.o.

Mesopelagic fish: live fast die young

- Global biomass: 0.16 PgC
- Consumption: >1 PgC/yr
- Excretion 16% of consumption
- 75% of excretion to deep layer
- Global sequestration of 0.05-0.22 PgC/yr

Gjösaeter and Kawaguchi 1980, Radchenko 2007, a.o.

Communicating the science

- We seek policies that are resilient to climate change impacts and secures future food protection

- Public support is important for changing how we manage the oceans

Nereus will contribute to global assessments

- We need capacity for predicting climate change impact on life in the ocean
- We fisheries scientists have been saying for forty years: cut fishing effort and all will be fine
  - But that is easier said than done
- We need to develop policies that can actually be implemented
- Calls for interdisciplinary work – for which Nereus is a poster child

Nereus will evaluate and visualize alternative future scenarios

- Should the World Trade Organization ban subsidies? Which?
- Should the UN limit FAD-tuna fishing? Shark finning?
- At UNDP: will there be alternative livelihood for fishers in coastal, tropical areas?
- At UNEP: how will the scenarios impact the ocean environment
- What types of aquaculture should be developed?
- How much of the world ocean should be protected?
- Are there policies that are resilient to change?
- ...

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