Mass cycling in weighted real-world food webs and economic networks

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Data: 245 weighted food webs

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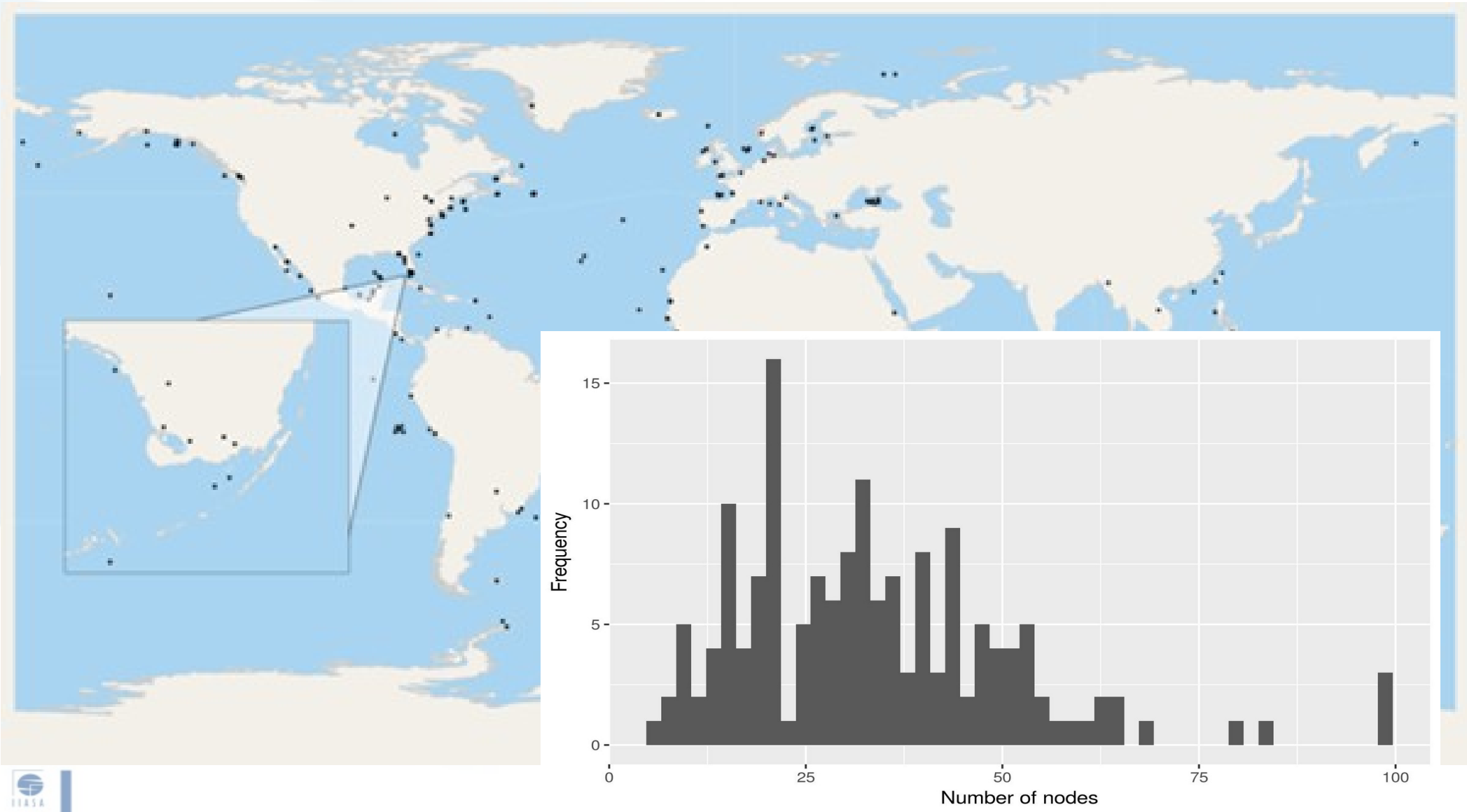


Alaska, Prince William Sound

Trophic level 5

Trophic level 4

Trophic level 3

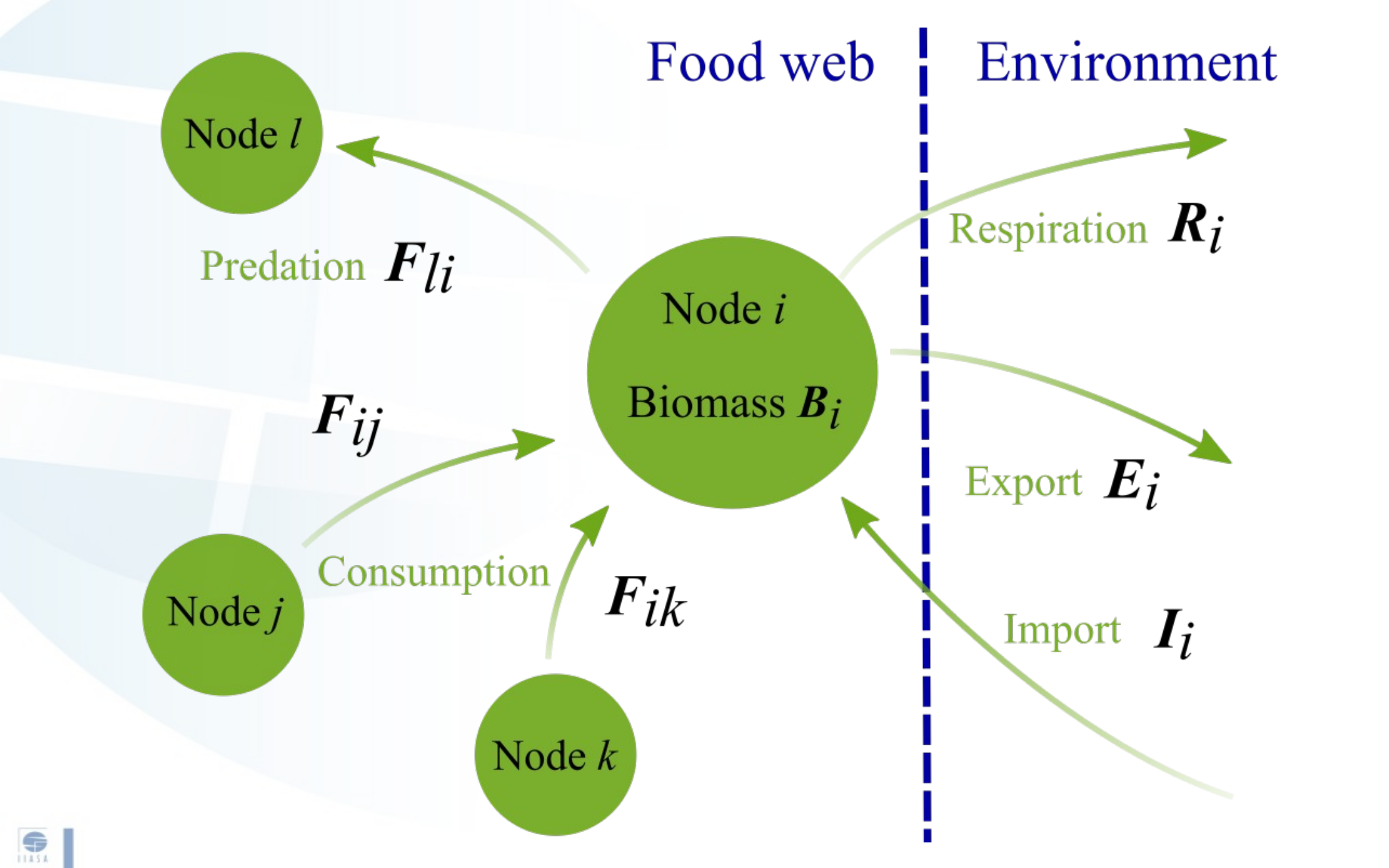
Trophic level 2

Trophic level 1

Pinnipeds
Res. mammals
Salmon
Trans. mammals
Demersal fish
Birds
Small pelagics
Herring
Wild salmon fry
Sea otters
Hatch. salmon fry
Epi. zoobenthos
Macrozooplankton
Intertidal inv.
Inf. zoobenthos
Mesozooplankton
Phytoplankton
PrimProd
Detritus
Macroalgae
PrimProd

Biomass ■ loss ⊞ gain

Detritus – dead organic matter

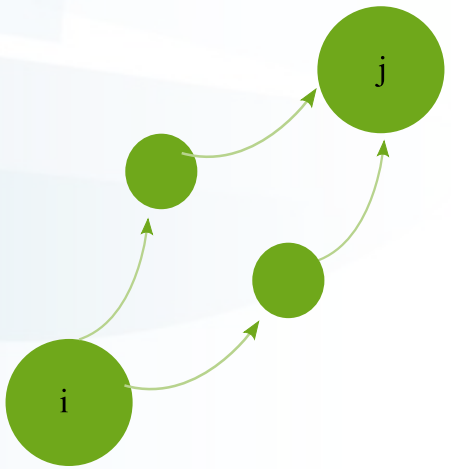

Food web
Environment
Node l
Predation F_{li}
Node i
Biomass B_i
Respiration R_i
F_{ij}
Export E_i
Node j
Consumption
F_{ik}
Import I_i
Node k

Indirect effects in flow network

$$G_{ij} = \frac{F_{ij}}{\sum_{k=1}^{n} F_{ik}} = \frac{F_{ij}}{F_{i.}}$$

Probability of biomass unit following this link

G^2



Final effects matrix:

$$N = I + G + G^2 + \ldots = (I - G)^{-1}$$

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Probability of biomass unit following this link

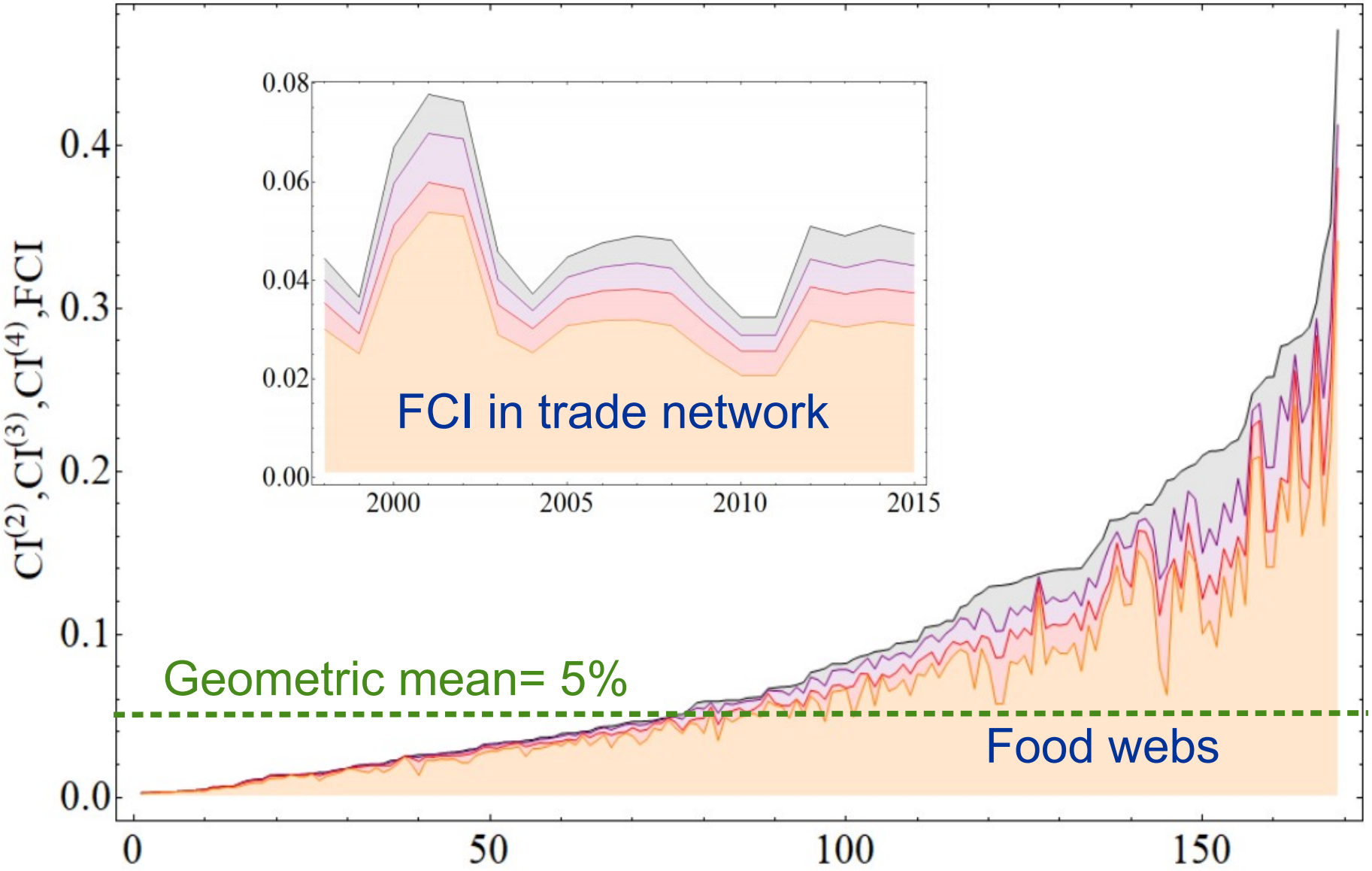
$$N = I + G + G^2 + \ldots = (I - G)^{-1}$$

Final effects matrix:

$$\sum_{i=1}^{n} \frac{N_{ii} - 1}{N_{ii}} \frac{F_{i.}}{F_{..}}$$

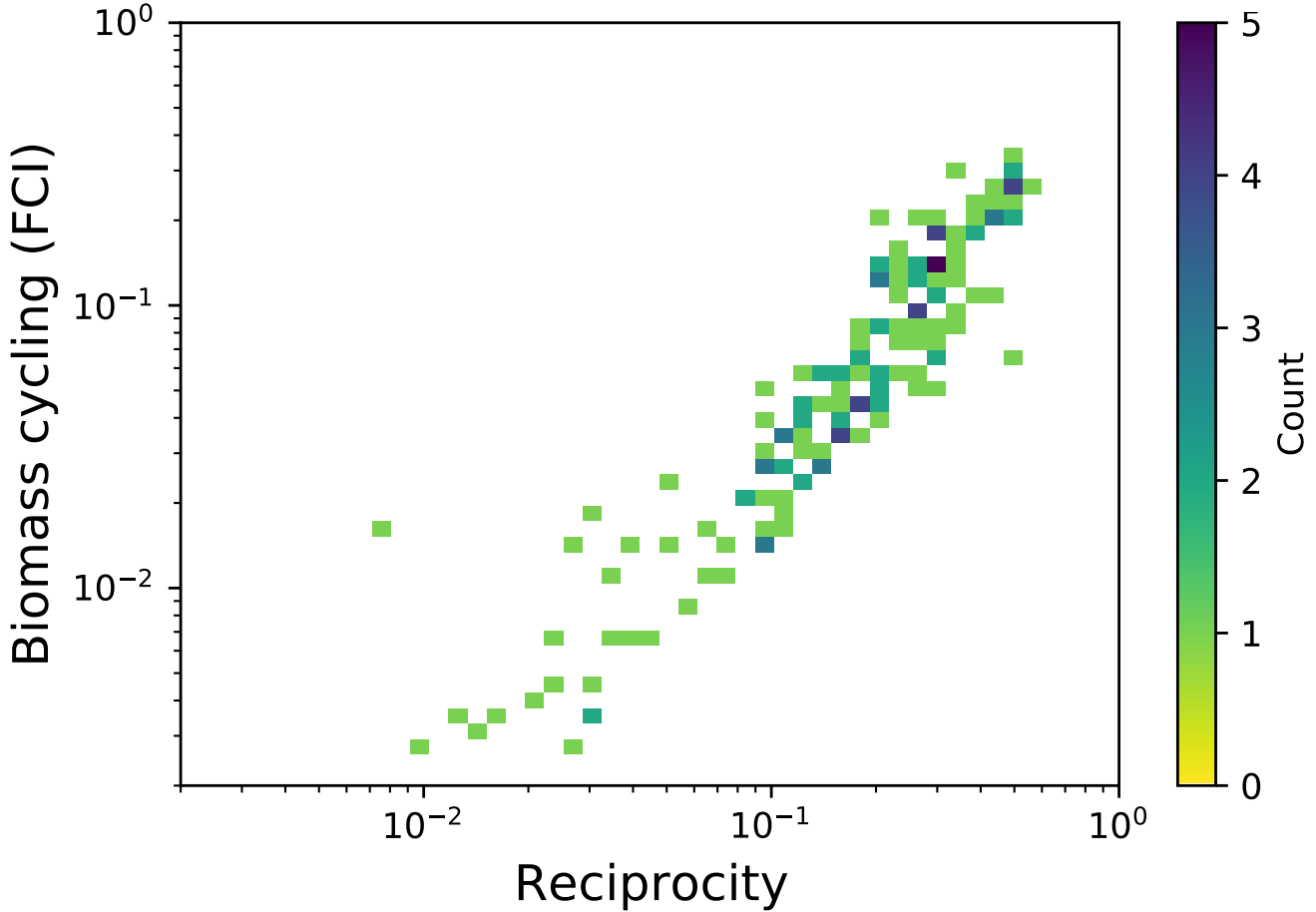
Finn Cycling Index (FCI)

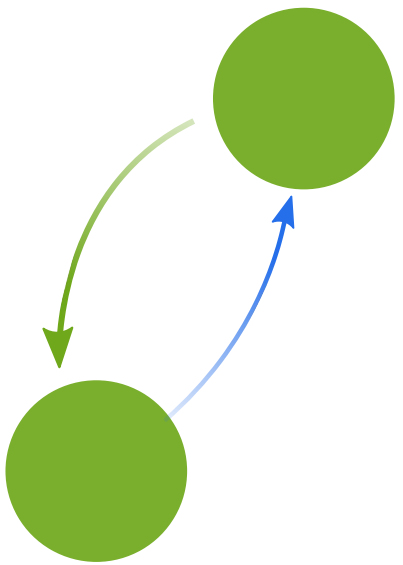
2-step cycling $CI^{(2)}$ dominates cycling in food webs



Biomass cycling and reciprocity

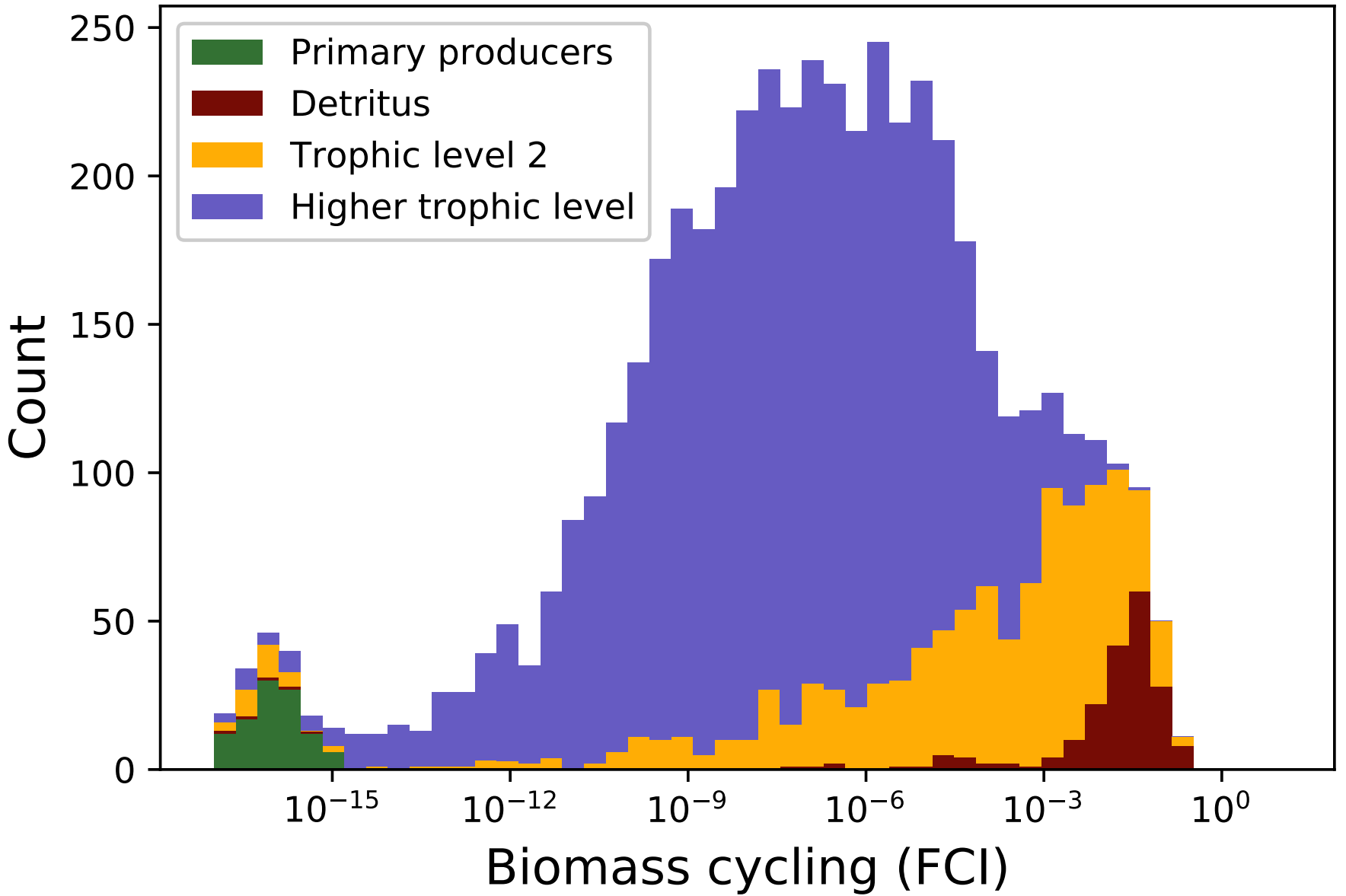
$$r = \frac{\sum_i \sum_j \min[F_{ij}, F_{ji}]}{\sum_i \sum_j F_{ij}}$$



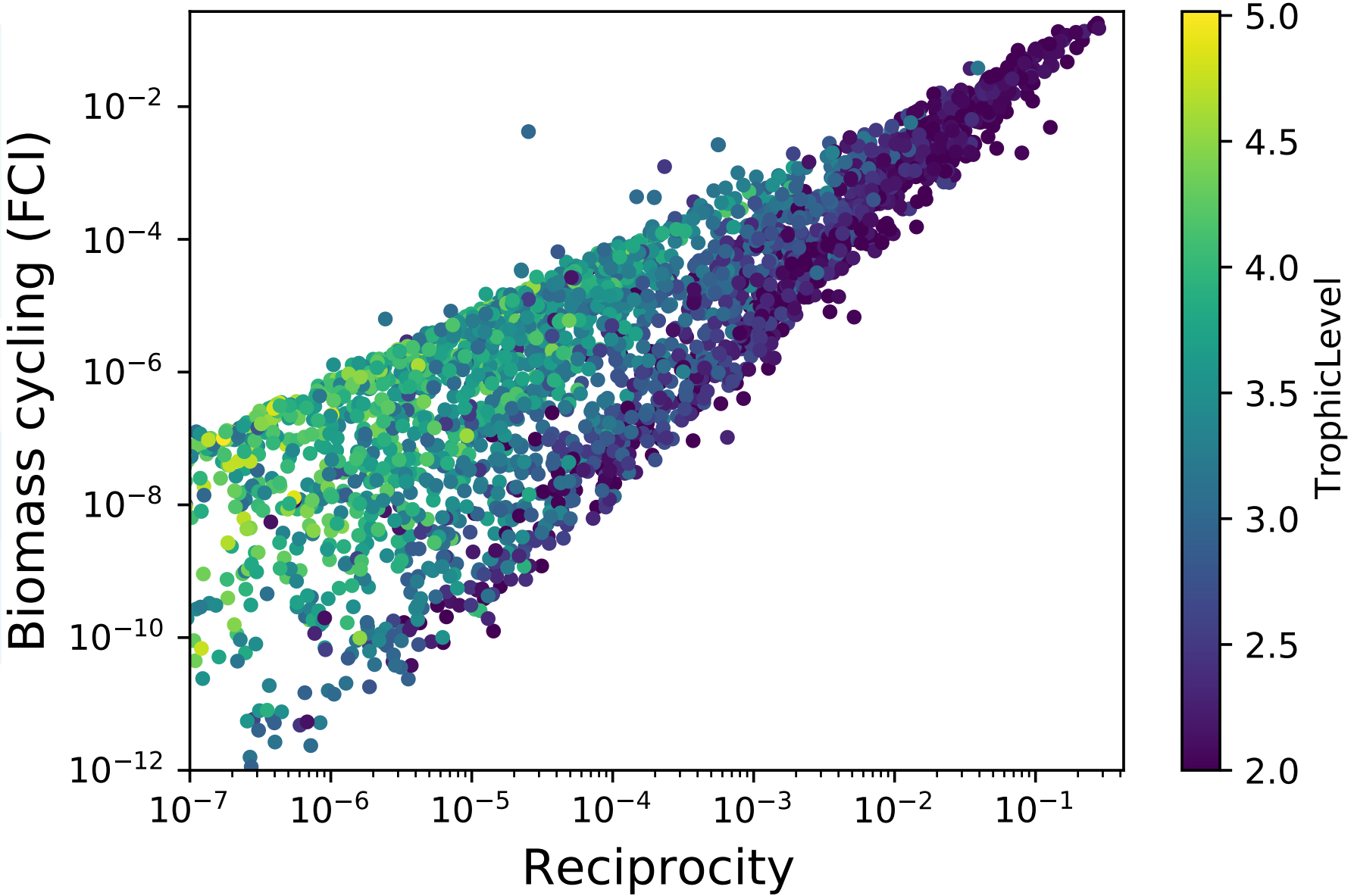


$$FCI \propto r^{1.209 \pm 0.040}$$

Recycling of dead organic matter in food webs



Biomass cycling and reciprocity at node level



Biomass cycling and reciprocity at node level

Biomass cycl

10^{-6}
10^{-8}
10^{-10}
10^{-12}

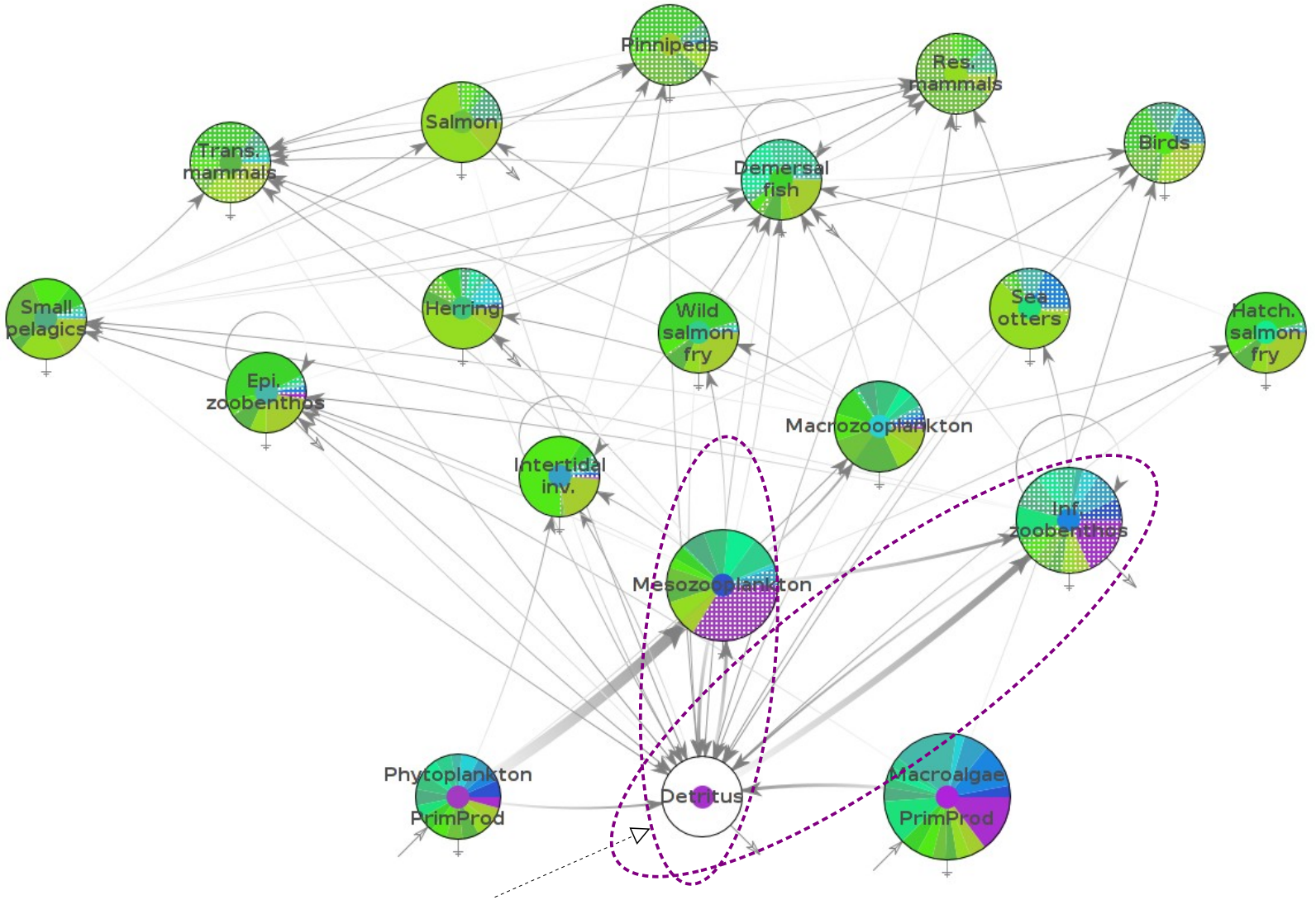
10^{-7} 10^{-6} 10^{-5} 10^{-4} 10^{-3} 10^{-2} 10^{-1}

Reciprocity

TrophicLevel

5.0
4.5
4.0
3.5
3.0
2.5
2.0

Alaska, Prince William Sound



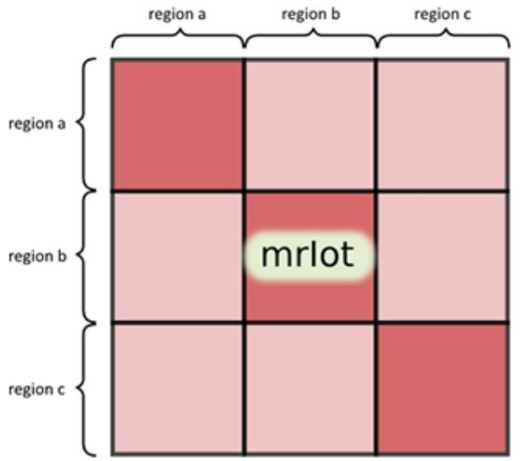
Detritus – dead organic matter

Decomposition can be a tough job

Jagiełło's Oak in
Białowieża NP
1524 - 1974

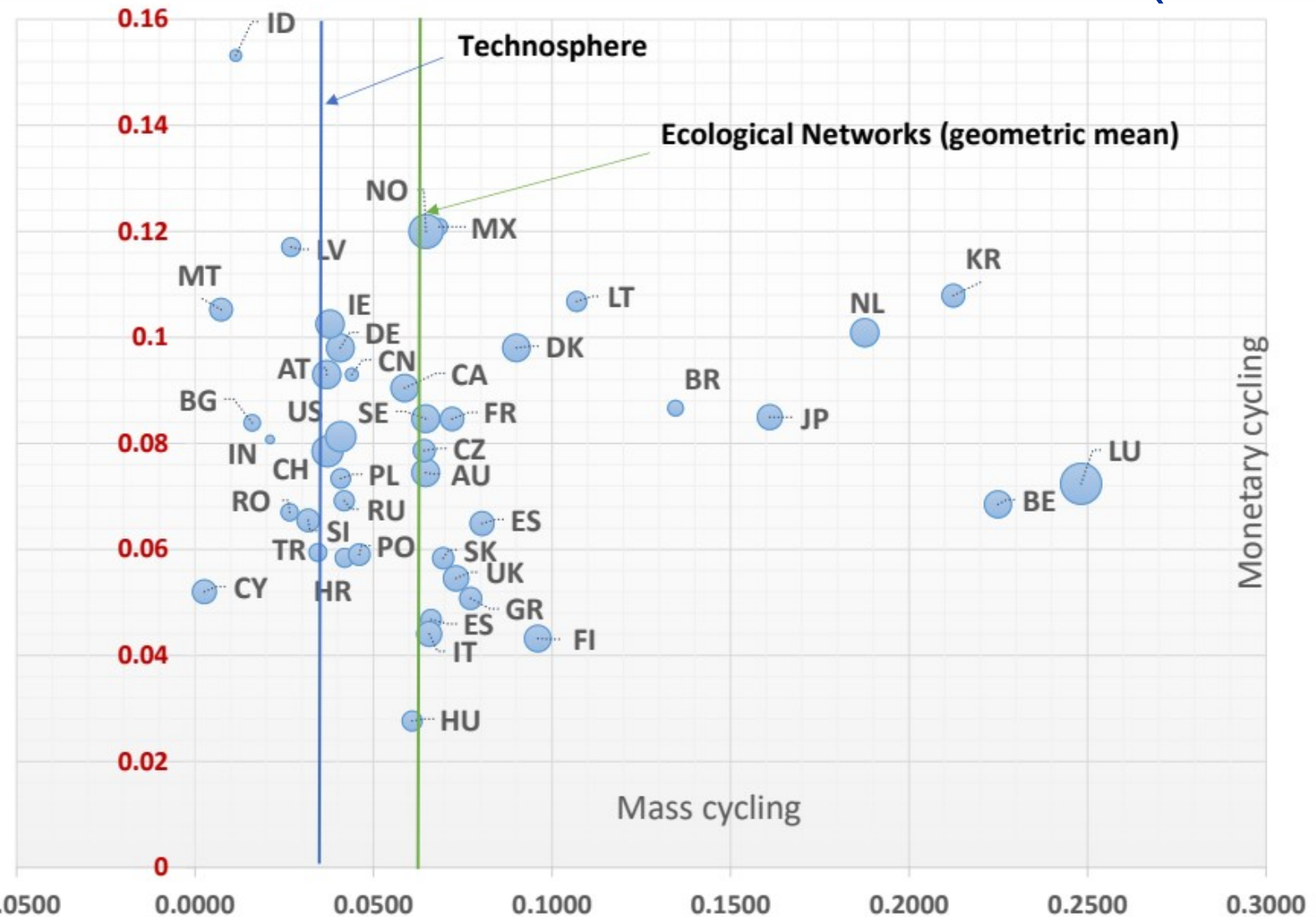
Current state

Economic networks



	Year	Networks	FCI	r^w
Food Webs		169	.091 ± .085	.22
Exiobase (world)	2011	1	.037	.02
Exiobase (countries)	2011	48	.066 ± .056	.01
PIOT, various	1990, 2015	4	.13 ± .021	.06
World Trade	1998-15	1	.05 ± .004	.36
Wolrd Trade, CO^2	2000-16	1	.06* ± .01	.02
China MRIO, CO^2	2012	1	.26	.25
China PIOT, CO^2	2012	30	.32 ± .09	.28

The world achieved 3.7% mass cycling in 2011 (EXIOBASE)



Summary

- Cycling and reciprocity are related through a power-law in food webs and their correlation is very high in industrial networks.
- Inspiration: promote reciprocity and collaboration among network's compartments

  Avantages:Simple, incremental, local, bottom-up: no detailed global knowledge of the system required

- Analogy to detritivores – technology, necessity (regulation) might be the prerequisites.

Circularity and reciprocity in ecological and economic flows

Mateusz Iskrzynski[1,2], *Freek Janssen*[2,3], *Francesco Picciolo*[4], *Brian Fath*[2,5,6] & *Franco Ruzzenenti*[2,3⋆]

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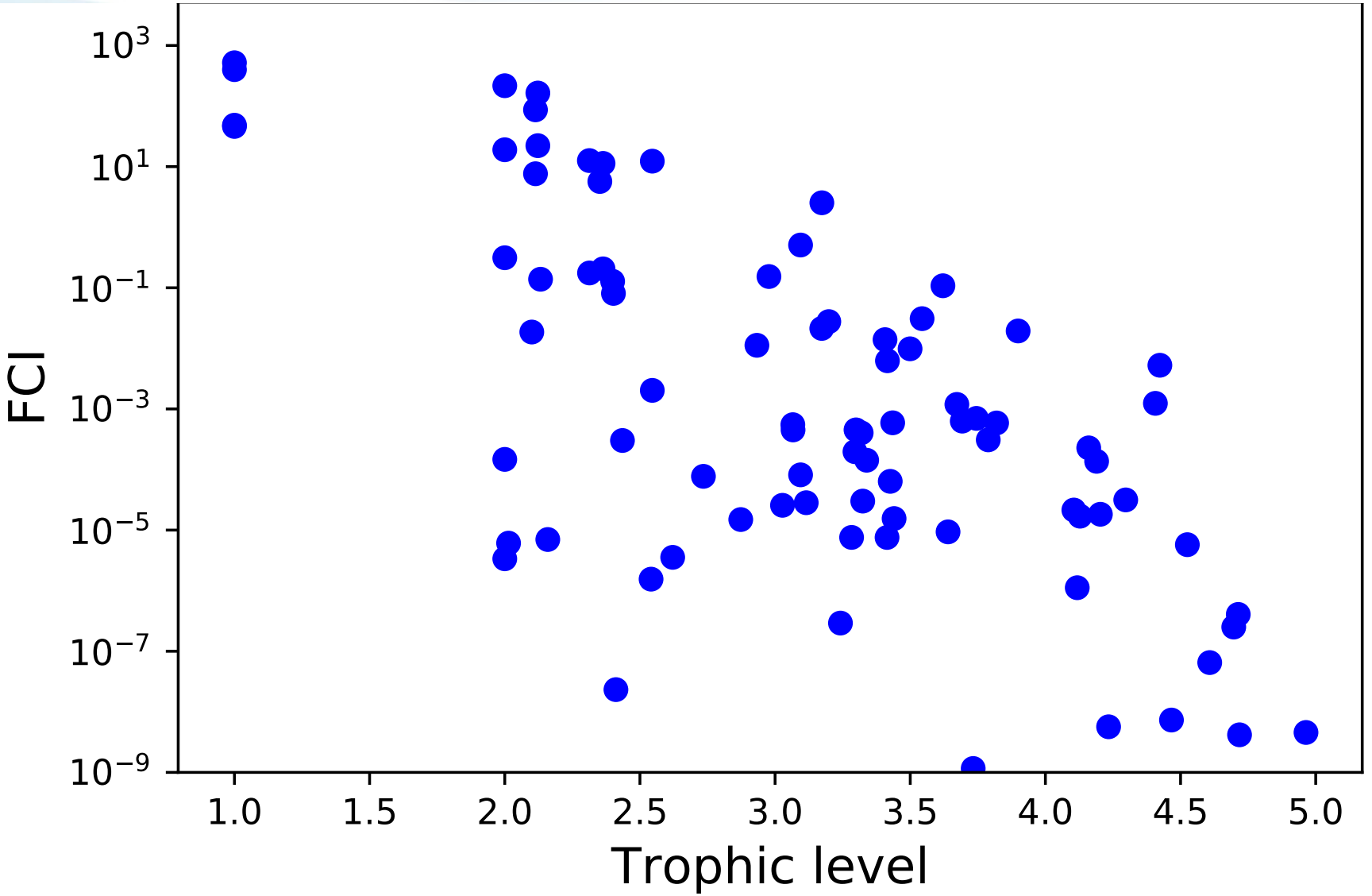
Thank you!

Biomass cycling (Albatross Bay)



Data Sources

- Robert Ulanowicz website:

  https://www.cbl.umces.edu/~ulan/ntwk/network.html

- EcoBase: a database of Ecopath with Ecosim models: http://sirs.agrocampus-ouest.fr/EcoBase/#discoverytools

- Networks published by Ursula Scharler and her students