New insights into the Weddell Sea ecosystem applying a network approach

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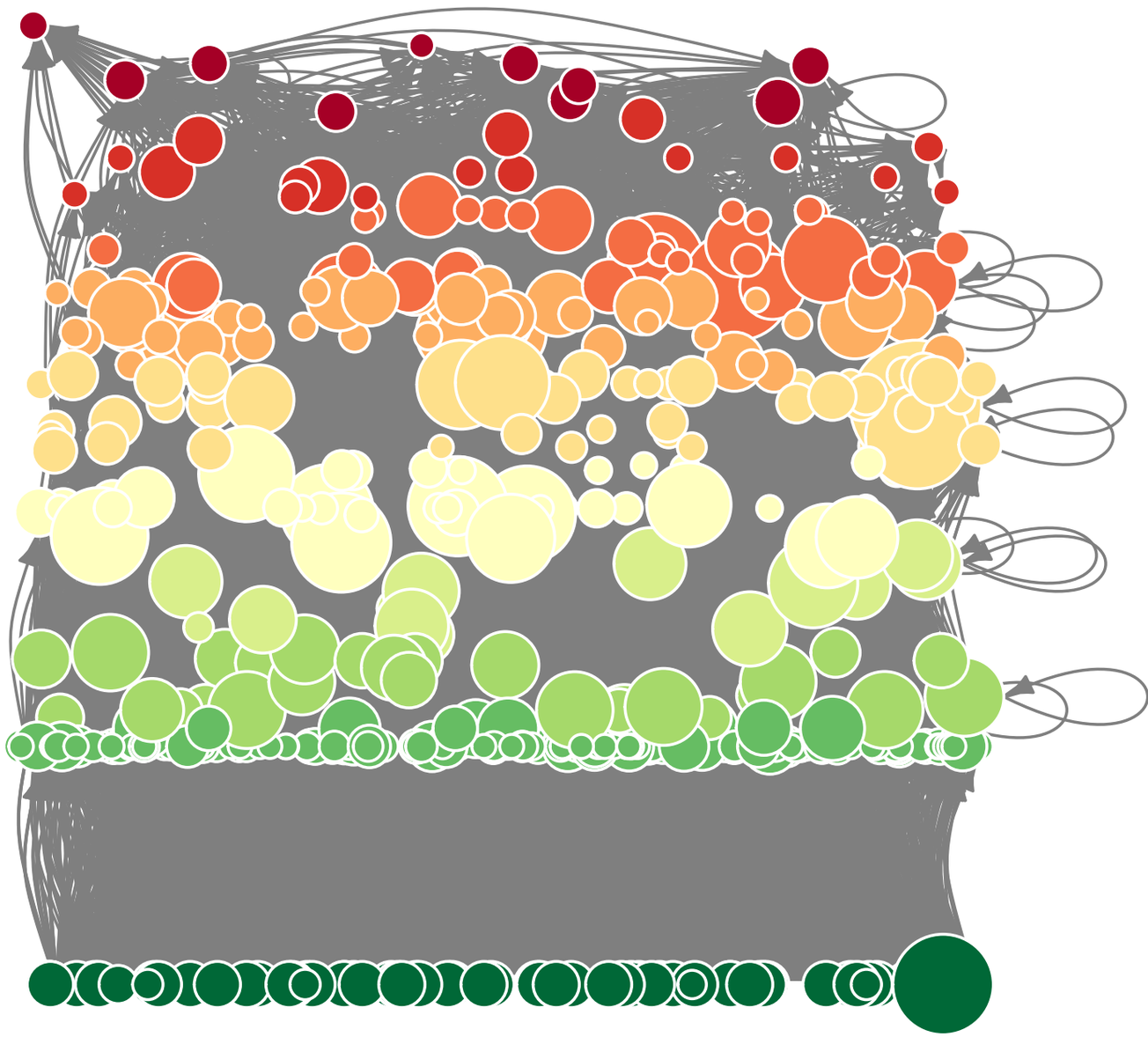
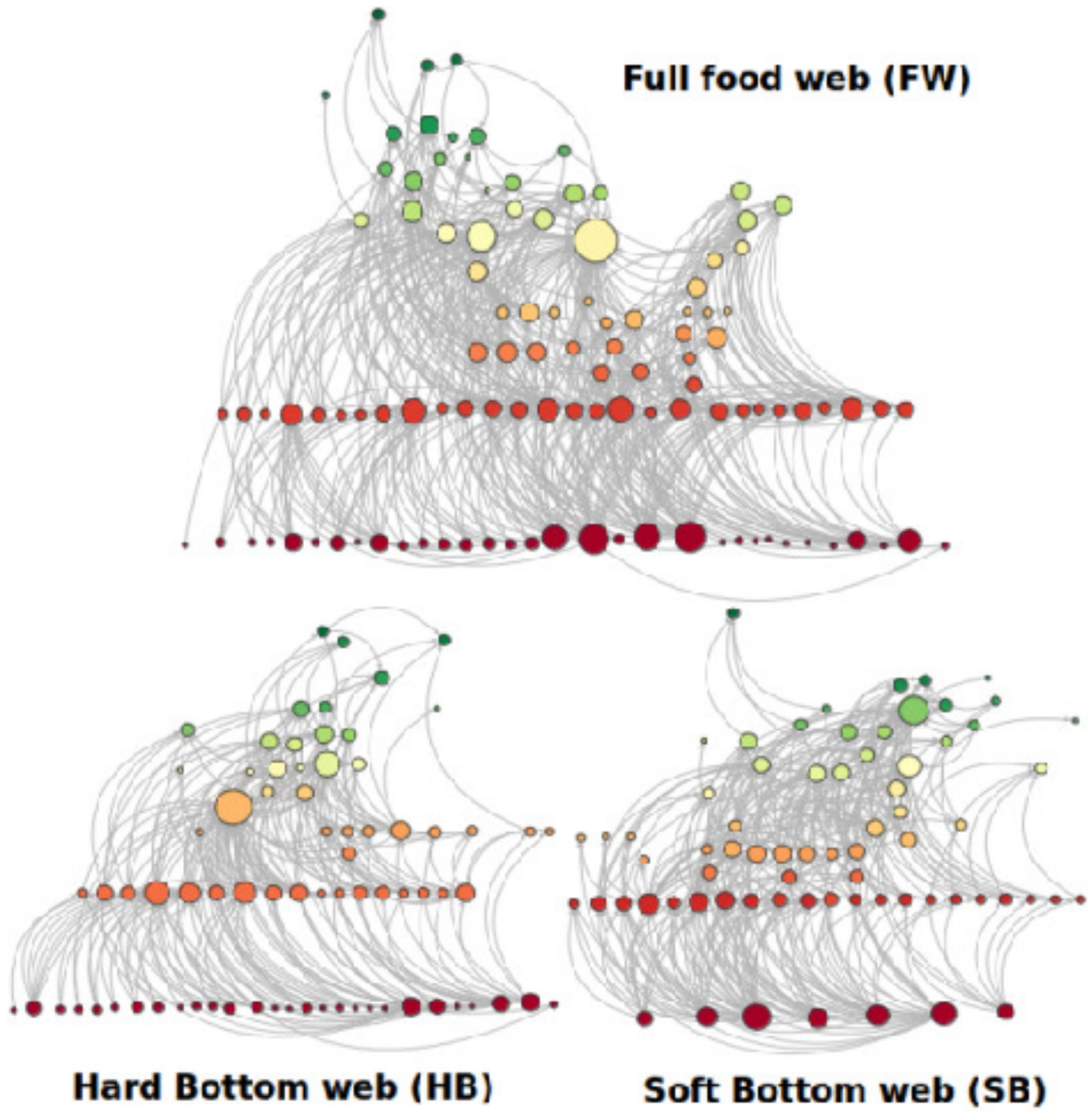


Marine antarctic ecosystems call for a complex approach

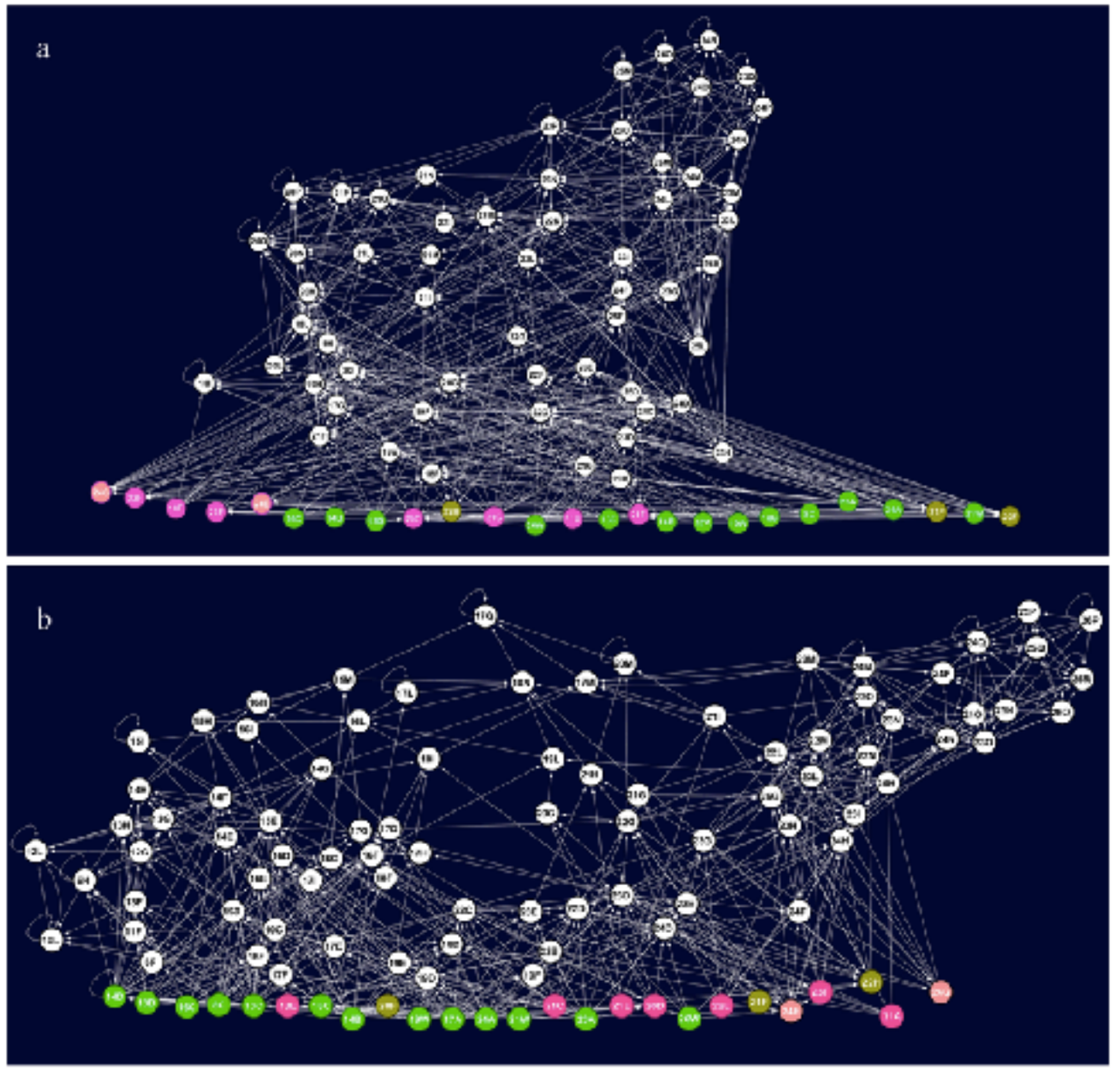
More and more researches are showing the complexity of the network formed by prey and predator interactions, the so-called food web, in different Antarctic ecosystems.

Antarctic Peninsula



Potter Cove (South Shetland Is.) food webs by habitat type.

Ross Sea



Benthic food web structure in Terra Nova Bay, Antarctica.

Cordone et al. 2020, Rossi et al. 2019

The Weddell Sea food web describes a complex system

The Role of Body Size in Complex Food Webs: A Cold Case

UTE JACOB,[1,*] AARON THIERRY,[2,3] ULRICH BROSE,[4] WOLF E. ARNTZ,[5] SOFIA BERG,[6] THOMAS BREY,[5] INGO FETZER,[7] TOMAS JONSSON,[6] KATJA MINTENBECK,[5] CHRISTIAN MÖLLMANN,[1] OWEN L. PETCHEY,[8] JENS O. RIEDE[4] AND JENNIFER A. DUNNE[9,10]

https://doi.org/10.1016/B978-0-12-386475-8.00005-8

"…species body size and species classification in terms of trophic or functional roles are one key to understanding why certain species are abundant while others are rare, and how species functional roles may change in response to species loss."

nature ecology & evolution ARTICLES

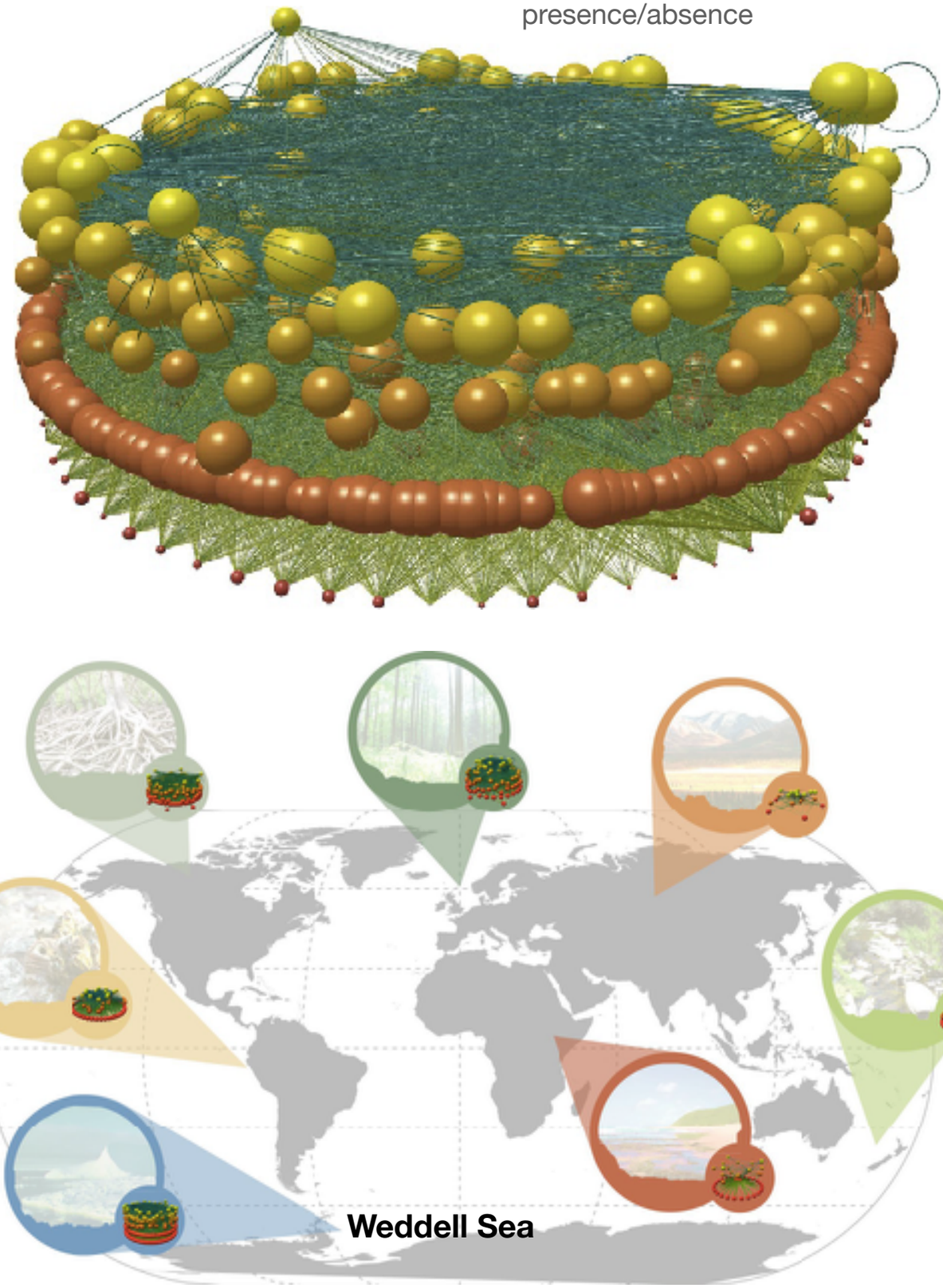
Predator traits determine food-web architecture across ecosystems

https://doi.org/10.1038/s41559-019-0899-x

Ulrich Brose, Phillippe Archambault, Andrew D. Barnes, Louis-Felix Bersier, Thomas Boy, João Canning-Clode, Eoinla Conti, Marta Dias, Christoph Digel, Awantha Dissanayake, Augusto A. V. Flores, Katarina Fussmann, Benoit Gauzens, Clare Gray, Johanna Häussler, Myriam R. Hirt, Ute Jacob, Malte Jochum, Sonia Kéfi, Orla McLaughlin, Muriel M. MacPherson, Ellen Latz, Katrin Layer-Dobral, Pierre Legagneux, Yuanhang Li, Carolina Madeira, Neo D. Martinez, Vanessa Mendonça, Christian Mulder, Sergio A. Navarrete, Eoin J. O'Gorman, David Ott, José Paula, Daniel Perkins, Denise Piechnik, Ivan Pokrovsky, David Raffaelli, Björn C. Rall, Benjamin Rosenbaum, Remo Ryser, Ana Silva, Esra H. Sohlström, Natalia Sokolova, Murray S. A. Thompson, Rose M. Thompson, Fanny Vermandele, Caterina Vinagre, Shaopeng Wang, Jori M. Wefer, Richard J. Williams, Evie Wieters, Guy Woodward and Alison C. Iles

"With only three species traits (body mass, metabolic and movement type), our models could predict which 25% of the predators possess the highest average body-mass ratios with surprisingly high accuracy in most ecosystem types."

Species = 488
Trophic interactions = 16200
presence/absence



METHODOLOGY

General objective, study area and data source

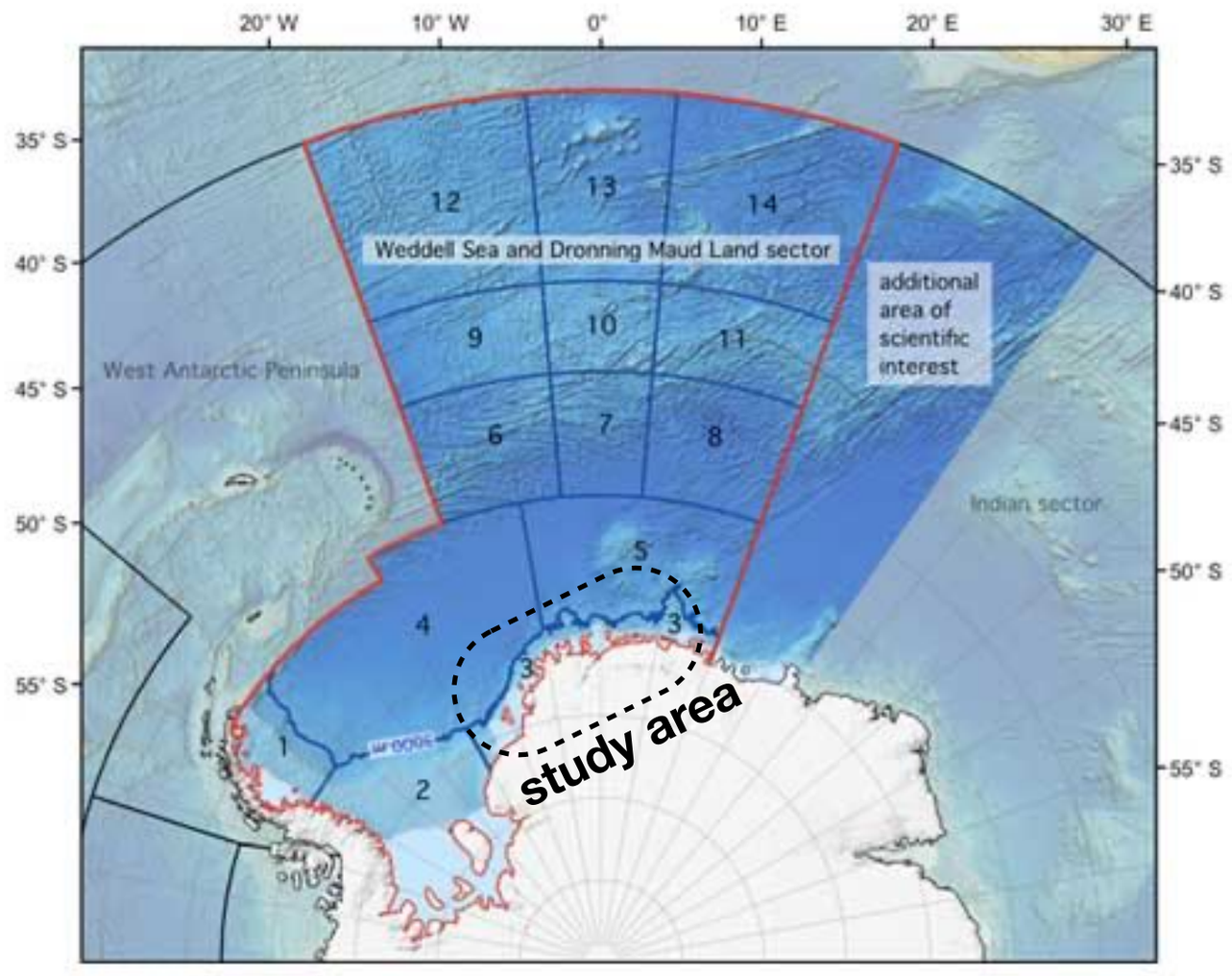
General objective

Estimate the interaction strength of the Weddell Sea food web and determine key trophic species considering unweighted and weighted network approach.

presence/absence interaction strength

Study area

High Antarctic Weddell Sea shelf (74-78° S), length ~ 450 km.



Taken from www.soos.aq

Data source

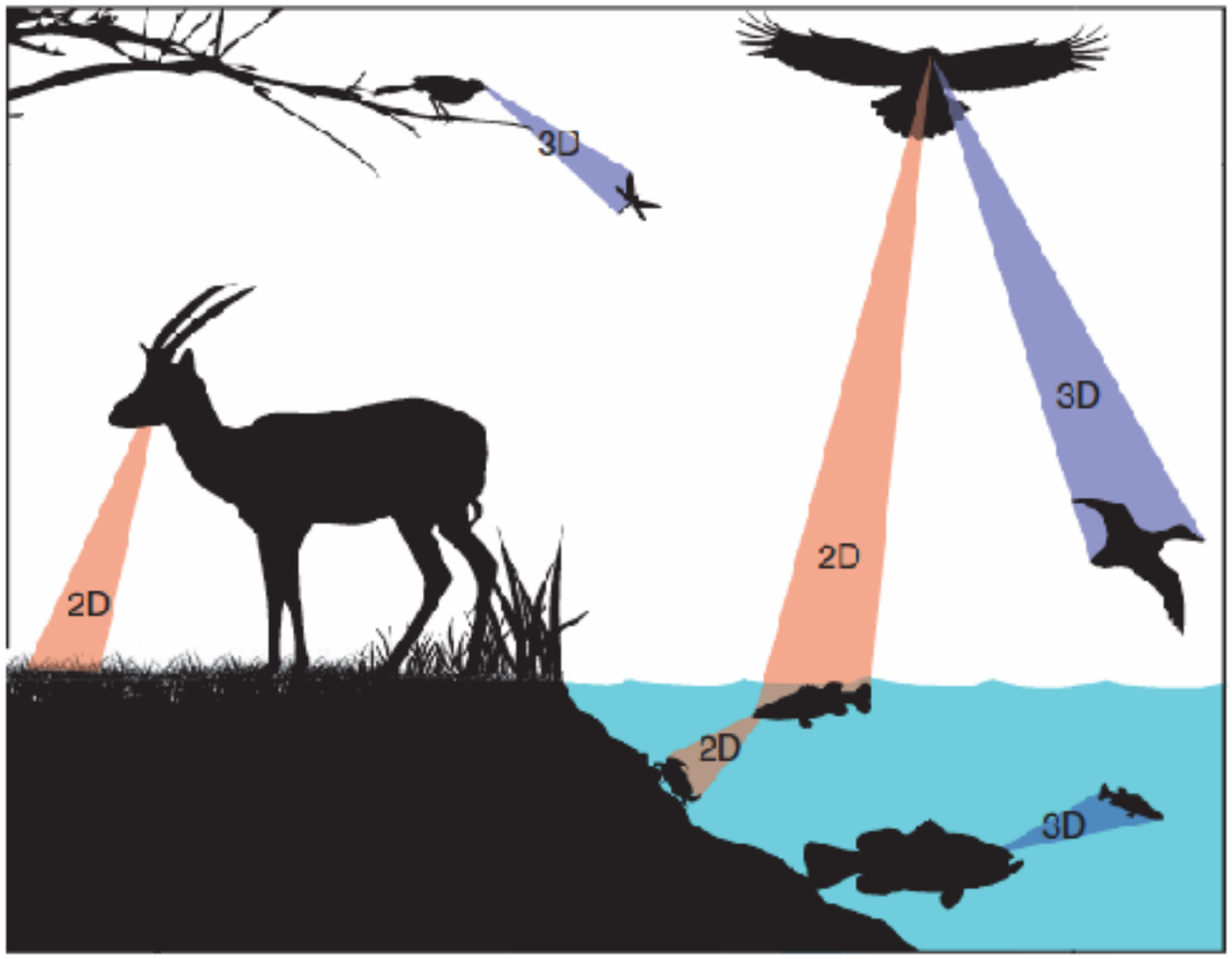
https://doi.org/10.25829/IDIV.283-3-756

Estimation of interaction strength

We estimated the interaction strength *IS* by considering the body mass and the interaction dimensionality of the prey and predator.

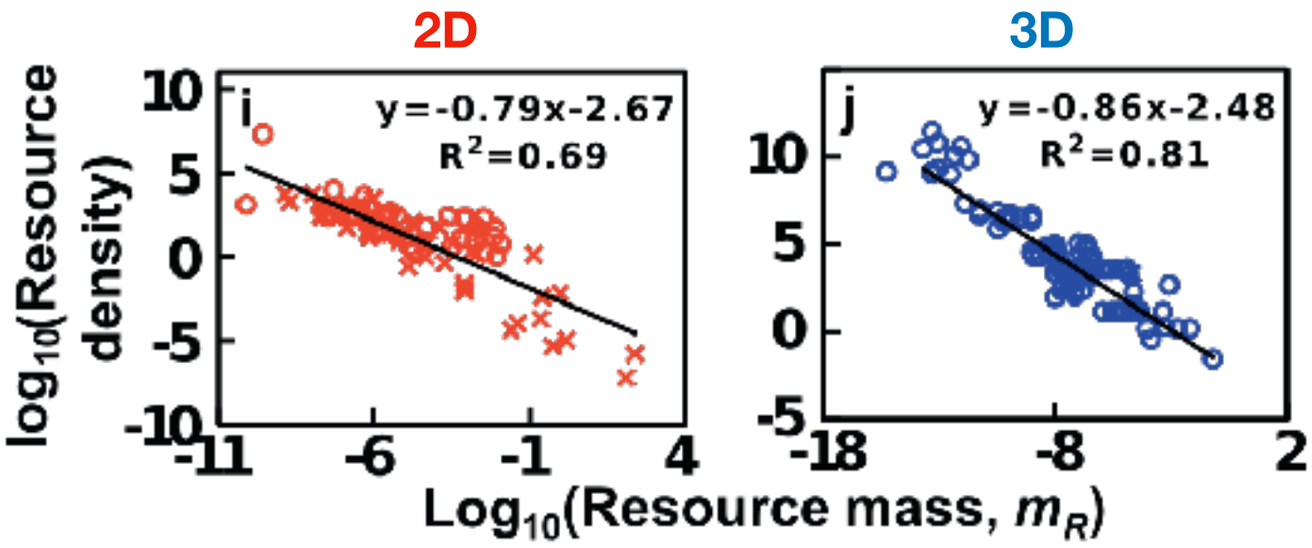
$$IS = \alpha x_R m_R / m_C$$

where α is the search rate, x_R is the density of the resource, and m_R and m_C are the body mass of the resource and the consumer, respectively.

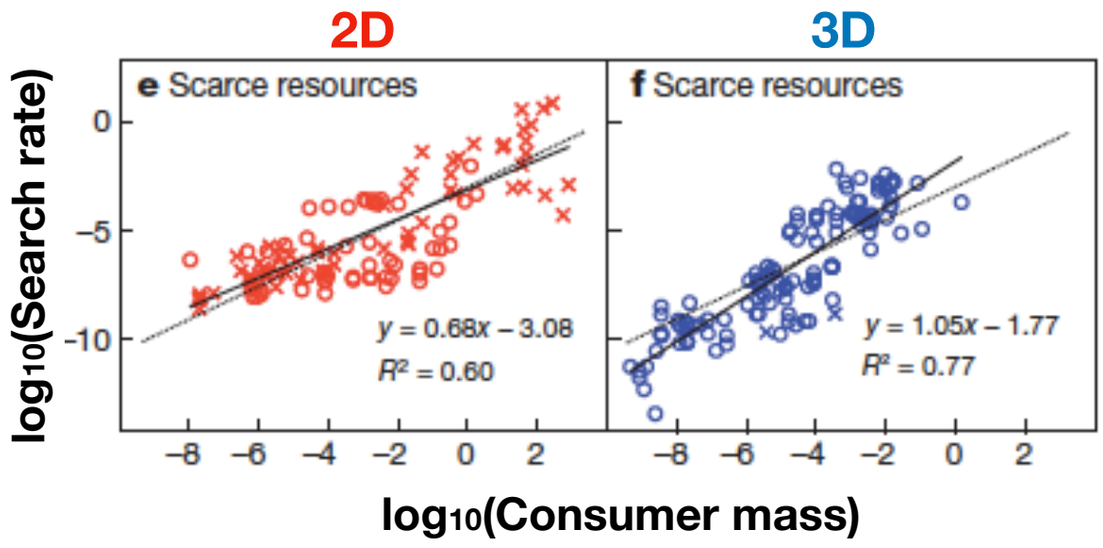


Taken from Pawar et al. (2012). https://doi.org/10.1038/nature11131

Estimation of resource density x_R



Estimation of search rate α



Key trophic species

Unweighted

Trophic level:
position of a species in the food web considering the set of prey and predators.

Trophic similarity (*TS*):
measures the similarity/uniqueness of a species based on shared (*c*) and unique (*a*) resources and consumers with other species (*c*). $TS = c / (a + b + c)$

Degree:
number of total interactions, in- (predator role) plus out-interactions (prey role).

Weighted

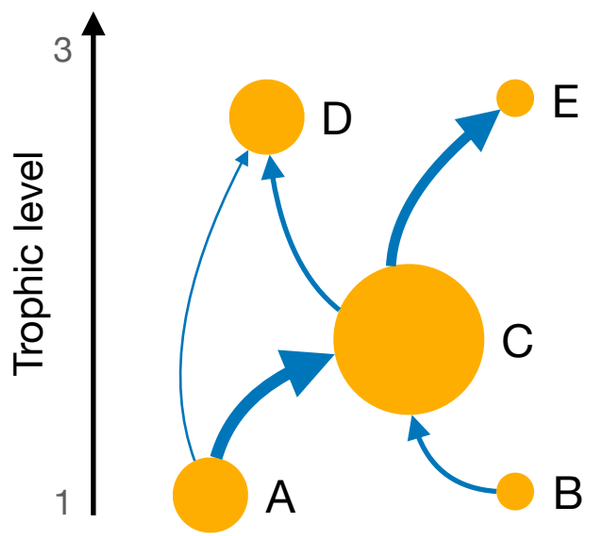
Interaction strength:
total effect of a species, as a prey and/or predator, in the other species of the food web.

UNWEIGHTED

Trophic level
spp A and B are basal
sp C is intermediate
spp D and E are top predators

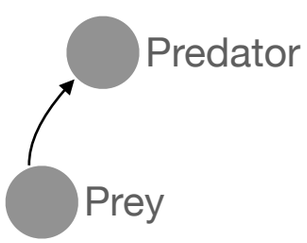
Trophic similarity
spp A and B share predator C
sp C shares predators D and E
spp D and E share prey C

Degree (node diameter)
spp A and D = 2
sp C = 4
spp B and E = 1



WEIGHTED

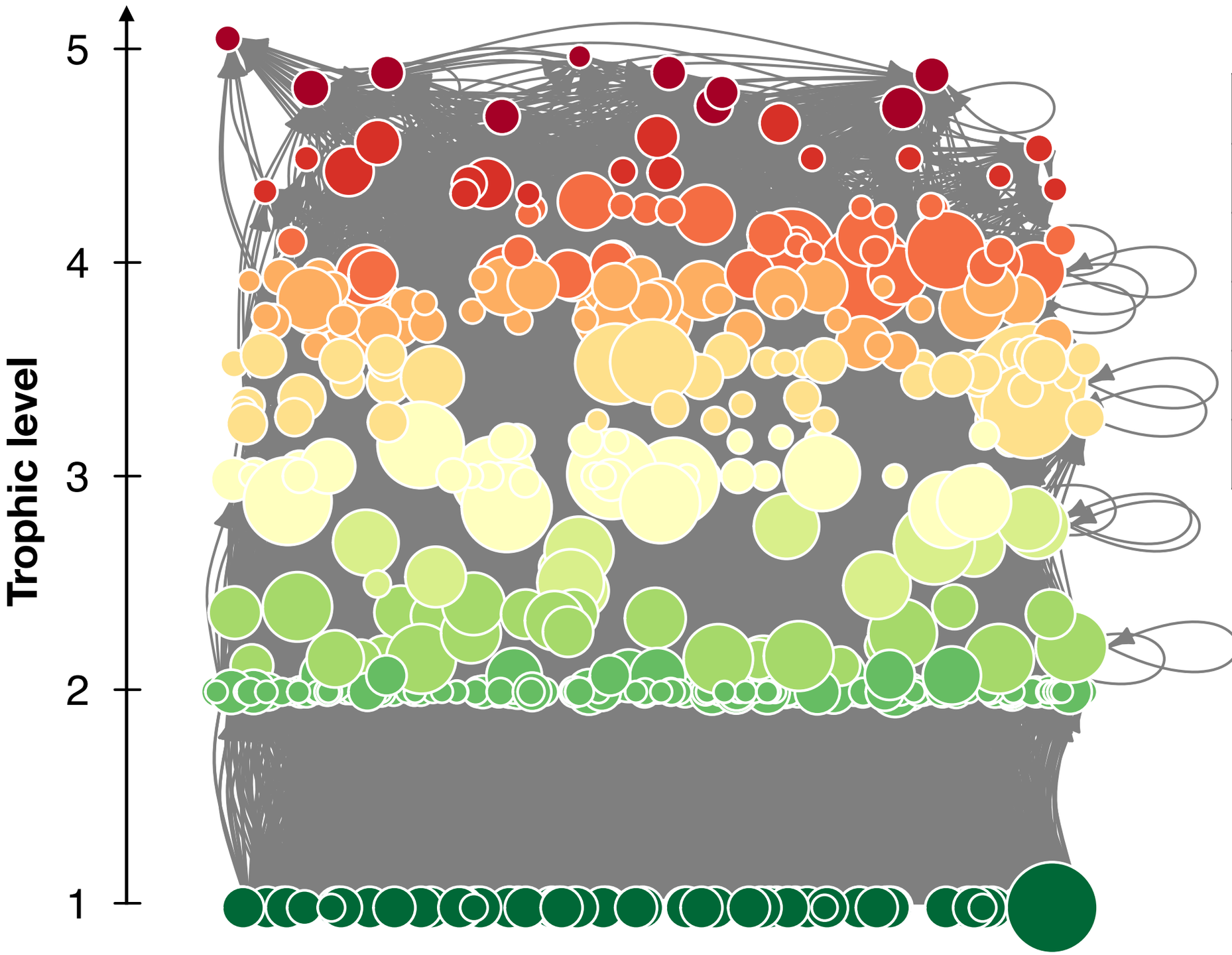
Interaction strength
A —> C is the strongest
A —> D is the weakest
sp C has the greatest strength



RESULTS

Food web generalities

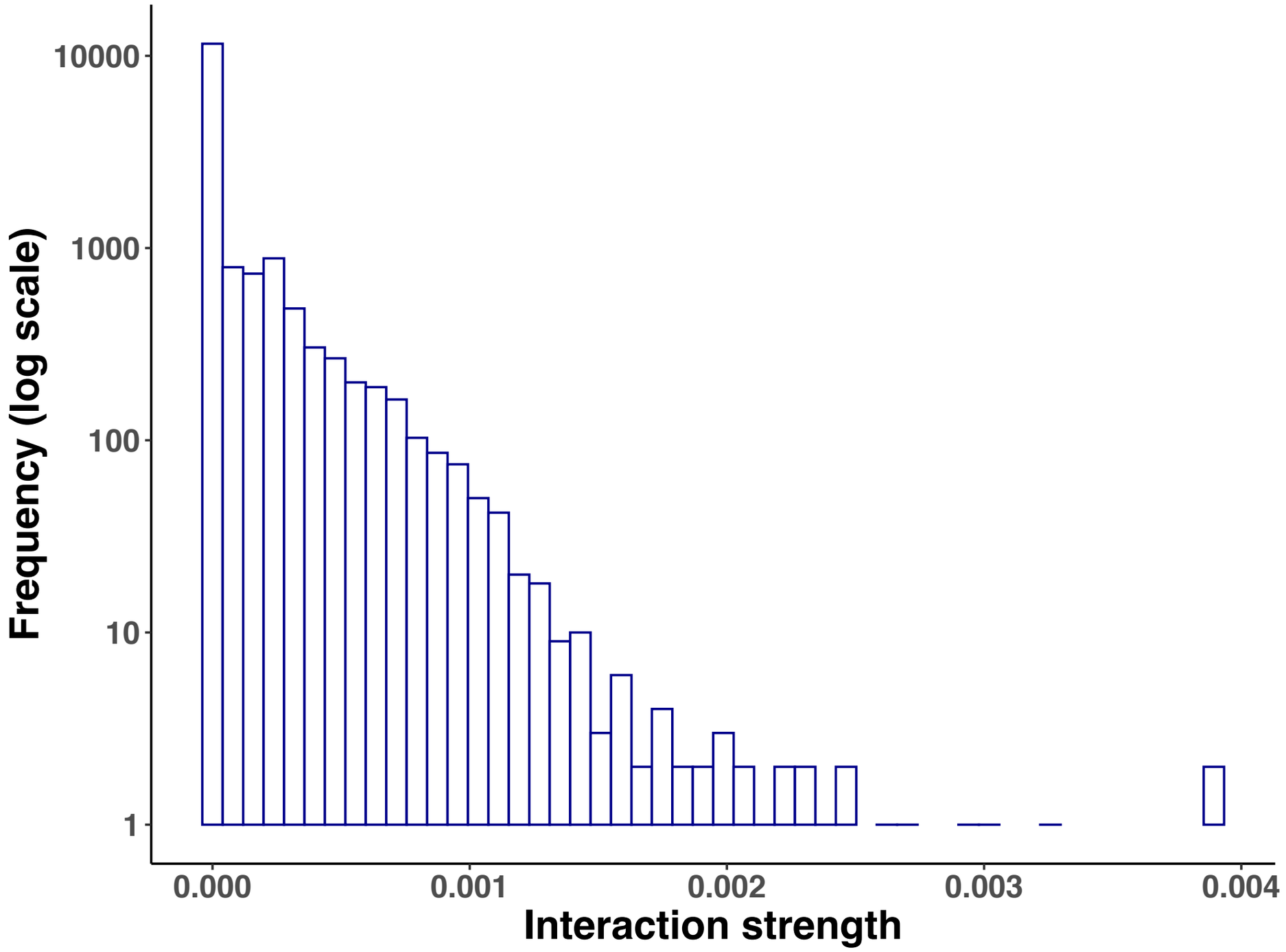
The Weddell Sea food web describes an ecosystem of **490 trophic species** and **16041 predator-prey interactions**



# species	490
# interactions	16041
Linkage density	32.74
Connectance	0.07
Omnivory (%)	51
Cannibalistic int.	52

Interaction strength distribution

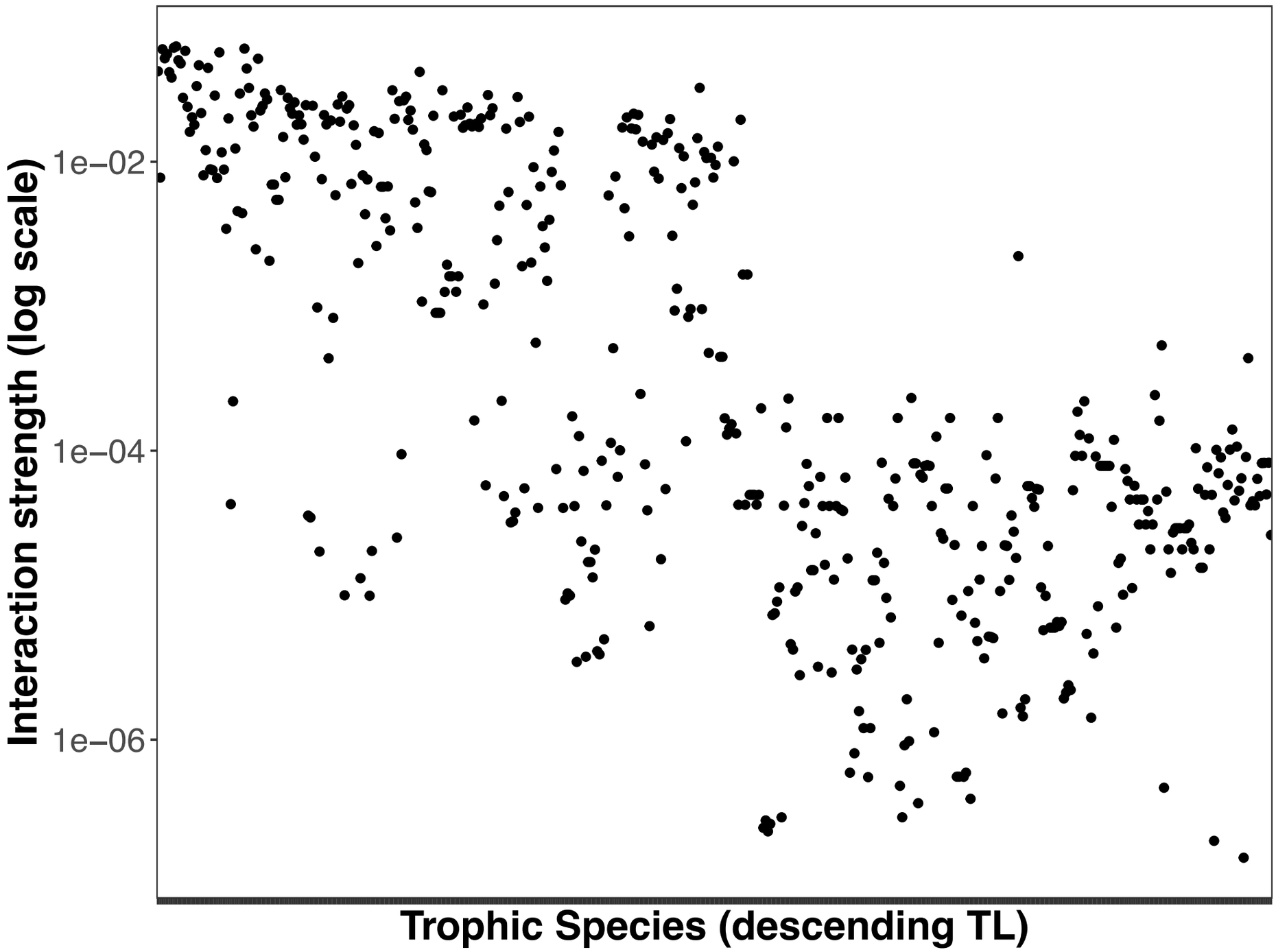
Asymmetric distribution of the interaction strength:
many weak interactions, **few strong**



Interaction strength = in + out interactions

Interaction strength - trophic level (TL)

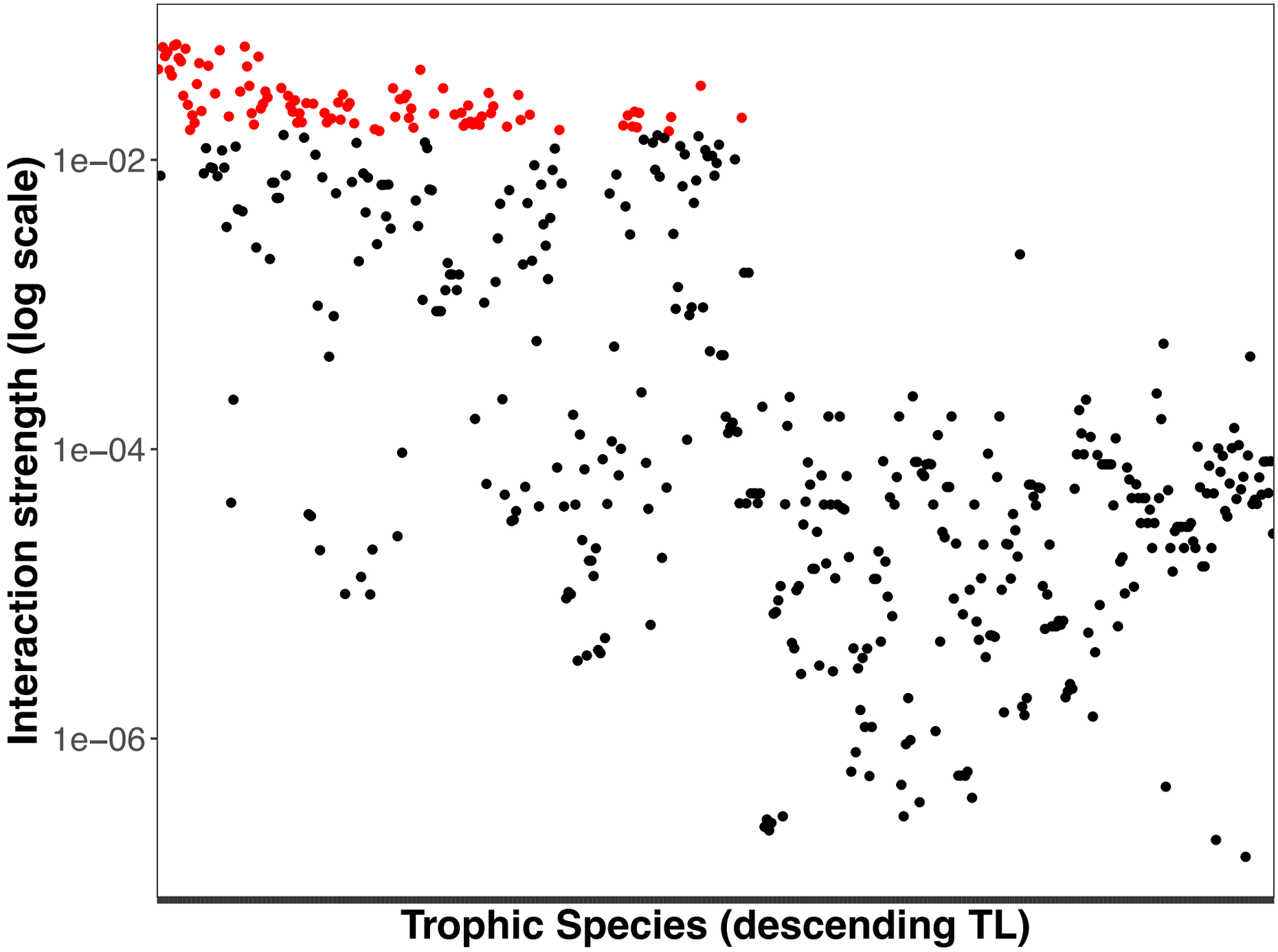
Evident relationship btw **interaction strength** and **TL**:
strong interactions in **high-trophic level** species



Interaction strength - trophic level (TL)

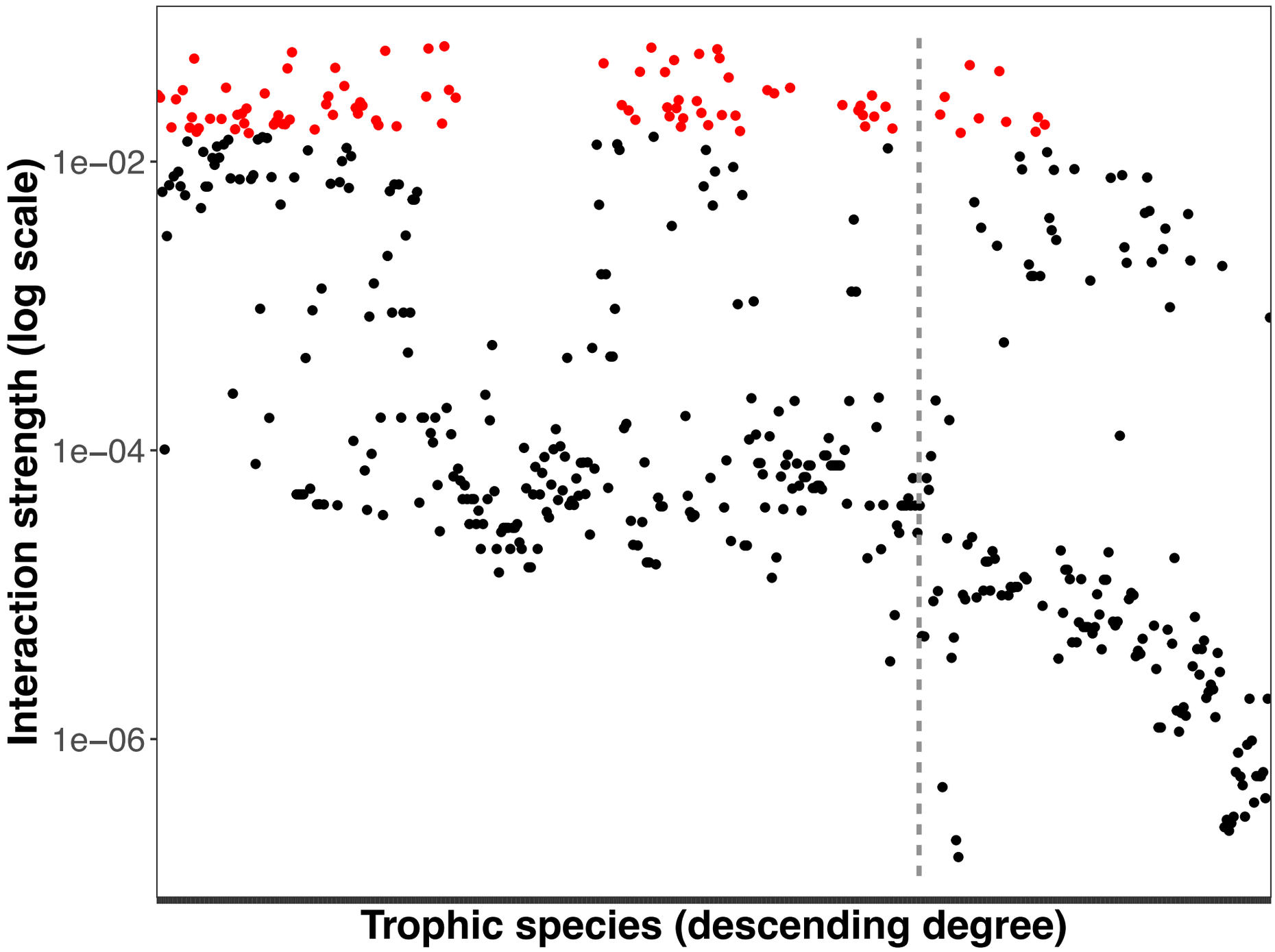
20% of the **species**

80% of the **total interaction strength** of the food web



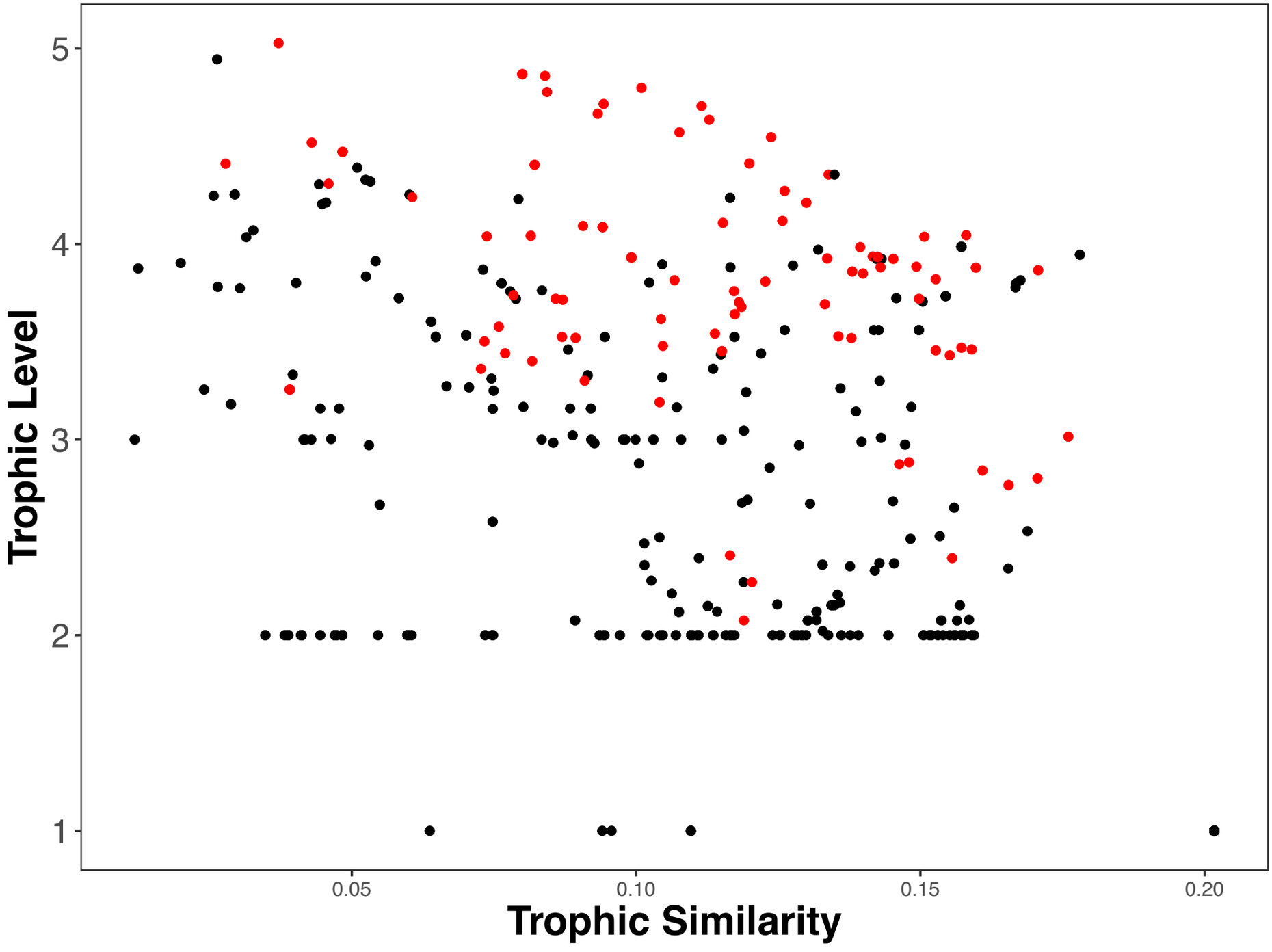
Interaction strength - Degree

Relationship btw **interaction strength** and **degree**: **uniform** until a **degree threshold**, when it **decreases**



Interaction strength - trophic similarity - trophic level (TL)

The species with **strongest interaction strength** (80%) are **distributed all** along the **trophic similarity range** in **TL > 2**



CONCLUSION

✓ Few species, 20%, hold most of the interaction strength of the food web, meaning that they are important to the stability of the ecosystem.

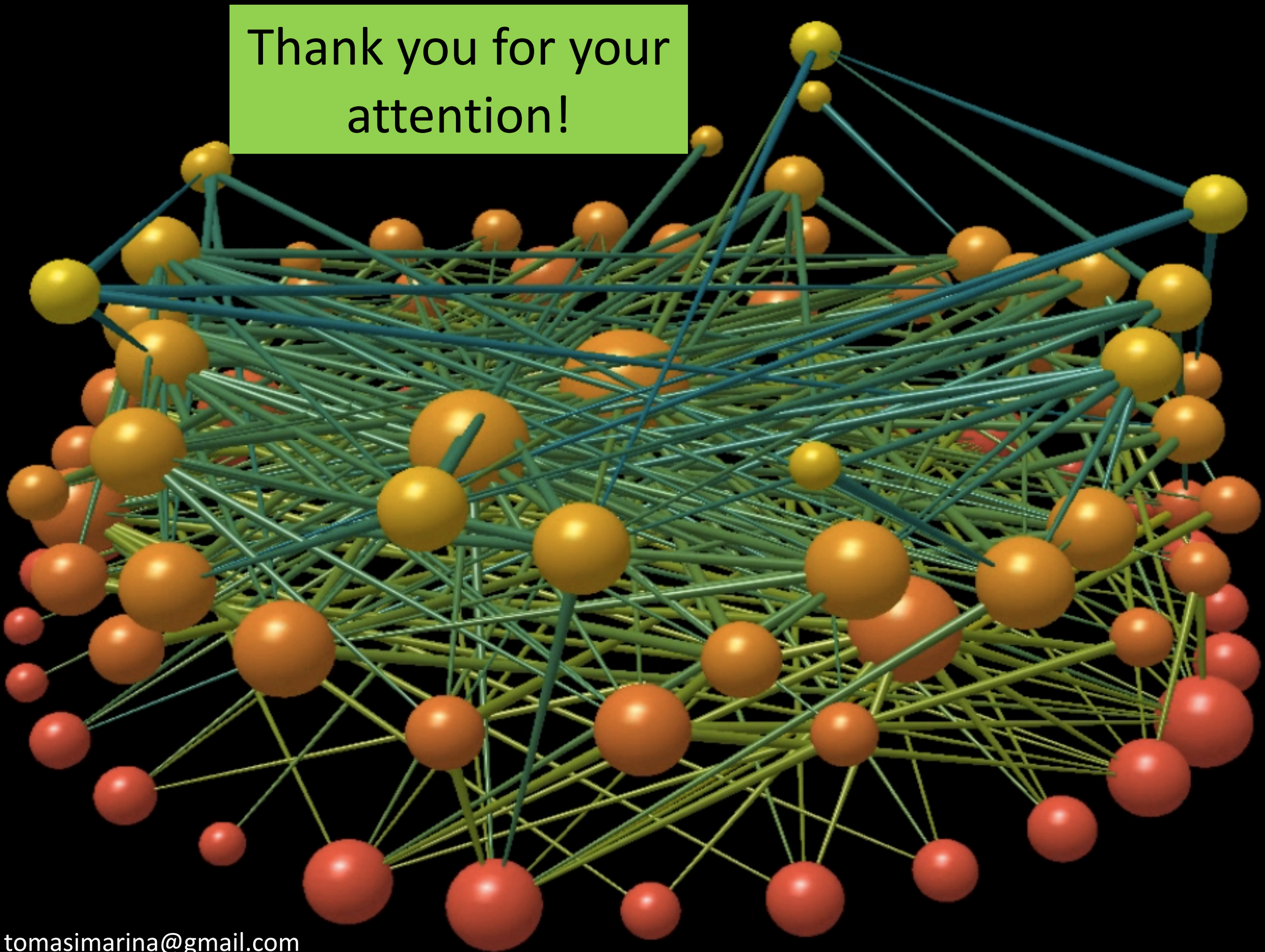
✓ Most of these important species are in high trophic levels (top predators), such as marine mammals and sea birds.

✓ These species may have many or few interactions, meaning that this parameter (degree) is not a good predictor of species importance to the stability of the ecosystem.

✓ Only few of these important species are unique in terms of trophic similarity, most of them present mid to high similarities.

The Weddell Sea food web presents a high functional redundancy, where the most important species (strong interactions) are "replaceable", suggesting stability to perturbations.

Thank you for your attention!



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