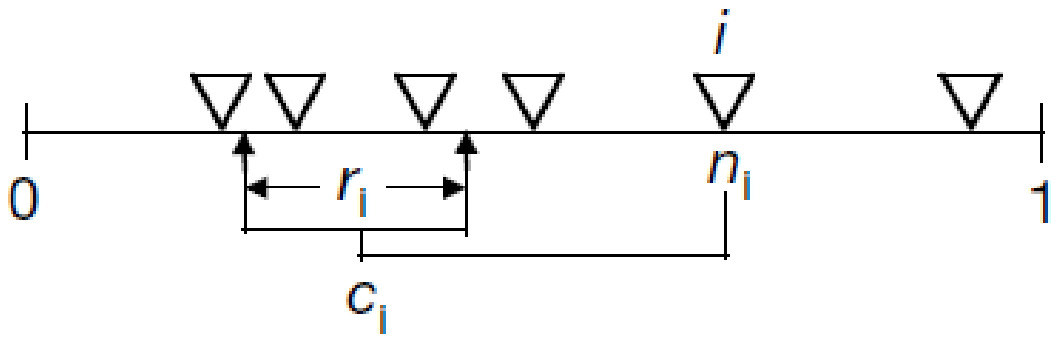
Patterns in food web

Elena Leonelli, mat. 2028635

The Niche model

How to simulate a food web?



1. assign to S_i his trophic niche n_i by sampling in $[0, 1]$
2. for each i, select x randomly from pdf $p_x(x) = b(1-x)^{b-1}$, where $b = \frac{S}{2z} - 1$
3. choose a position a at randomly in the interval $[\frac{xn_i}{2}, n_i]$
4. if n_j is inside a segment xn_i centered in a, i preys j

[+ basal, trophical identical and disconnected species]

Williams, R. J., & Martinez, N. D. (2000). Simple rules yield complex food webs. Nature, 404(6774), 180-183.

Distributions of preys/predators

$$P_{\text{prey}}(k) = \exp\left(-\frac{k}{2z}\right) - \frac{k}{2z} E_1\left(\frac{k}{2z}\right)$$

$$P_{\text{pred}}(m) = \frac{1}{2z} \sum_{m'=m}^{\infty} \gamma(m' + 1, 2z)$$

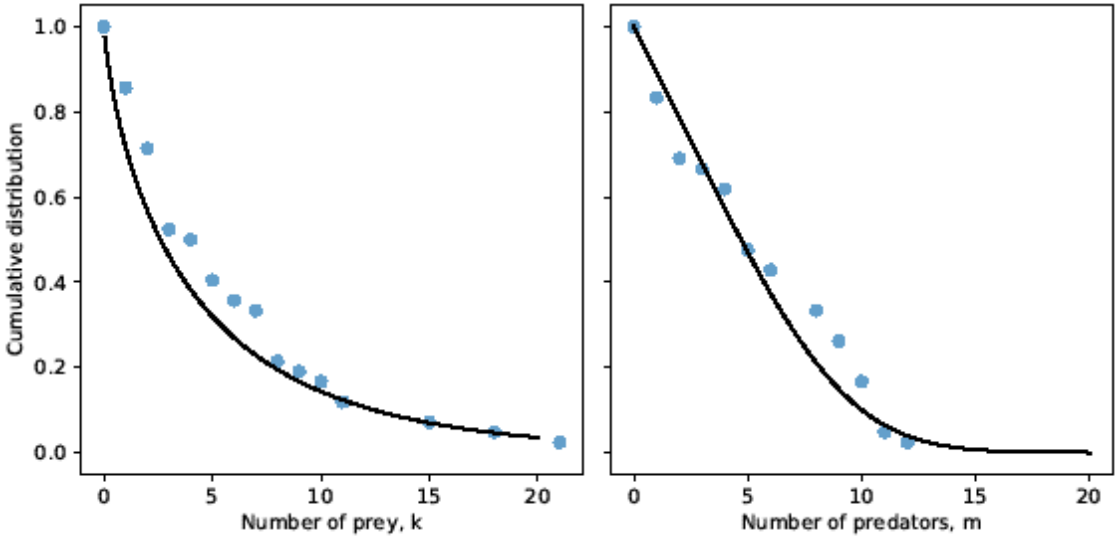
Limit of large web size ($S \gg 1$) and small connectance ($C = \frac{L}{S^2} \ll 1$)

NB: cumulative distribution decreases linearly as $1 - m/z$ for m<z and decays as the error function for m~2z (pdf ~step function)

Camacho, J., Guimera, R., & Amaral, L. A. N. (2002). Analytical solution of a model for complex food webs. Physical Review E, 65(3), 030901.

Empirical data

	Trophical species S	Linkage density z
Bridge Brook Lake	25	4.3
Chesapeake Bay	37	4.5
Coachella Valley	29	9.0
Lake Rock Lake	93	11.1
Skipwith Pond	25	7.9
St. Martin Island	42	4.9
Ythan Estuary	78	4.8

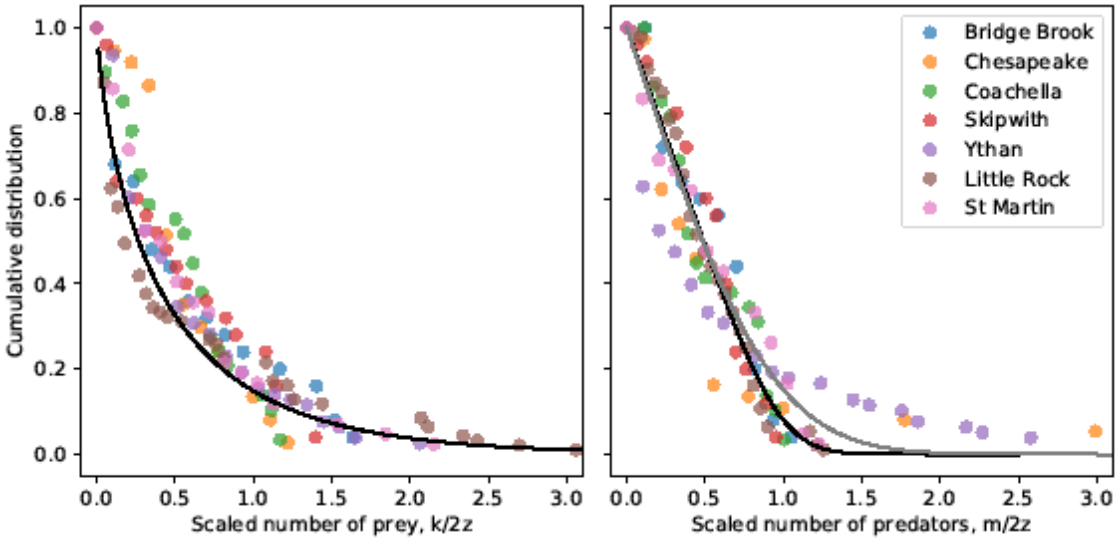


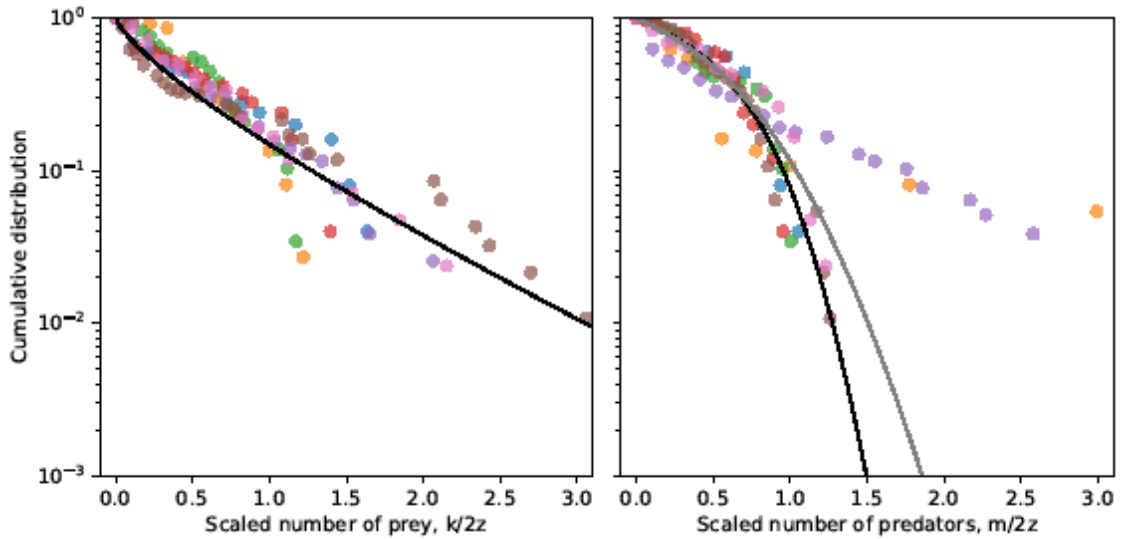
Analytical cumulative distributions compared with St. Martin data

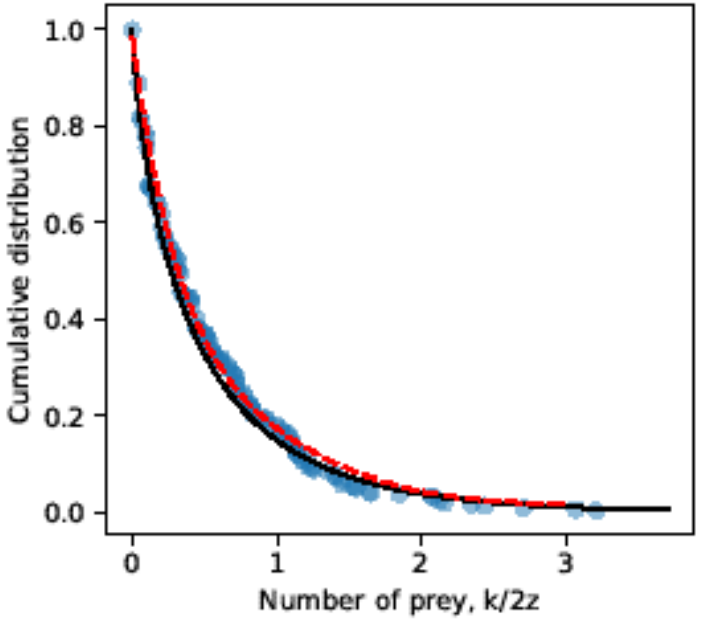
universal functional forms depending only on z

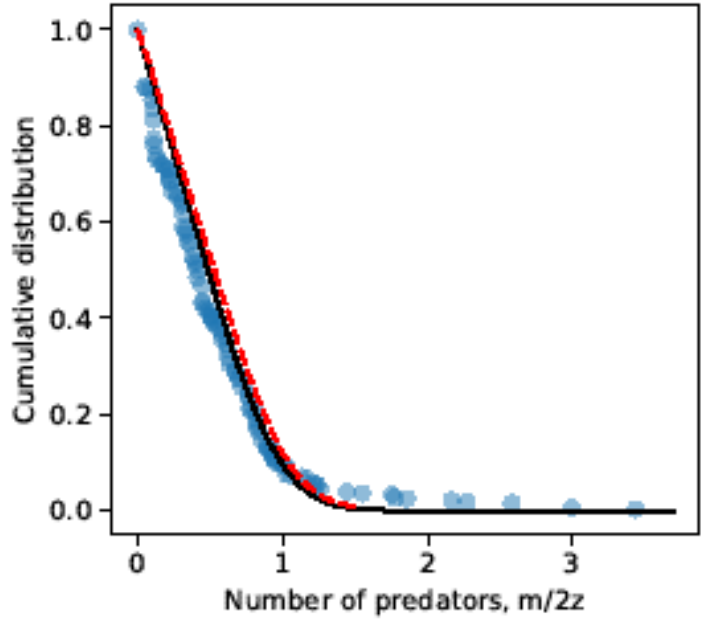
Ythan belongs to a different universality class? Or is incomplete?

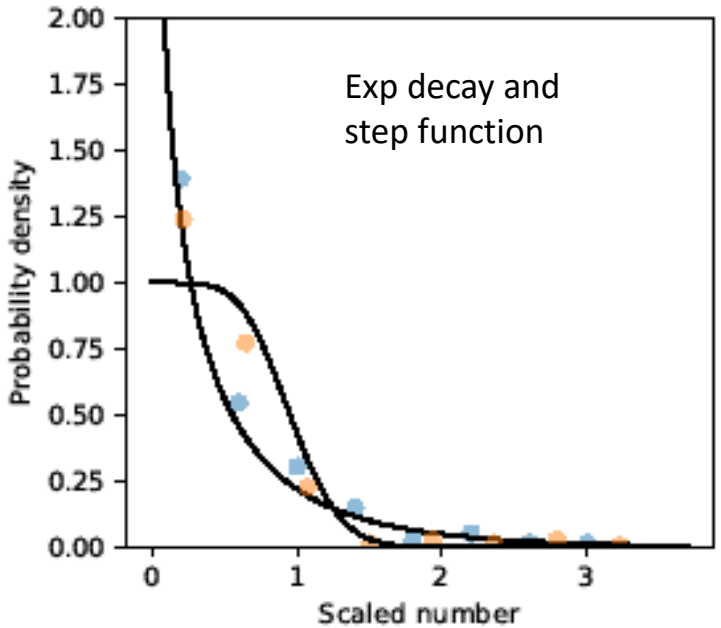
The “true” scaling holds only for m/2z < 1/2: the data collapse for m/2z < 0.7, then gaussian tail with explicit dependence on z

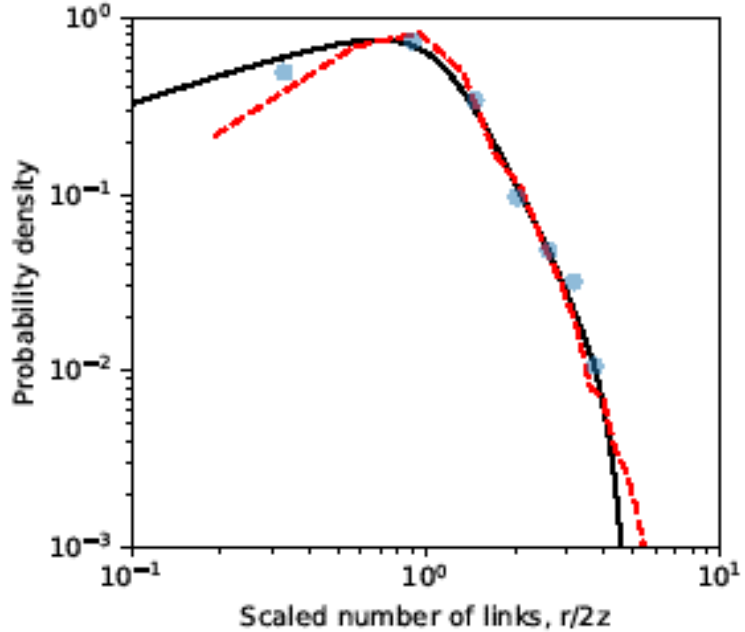




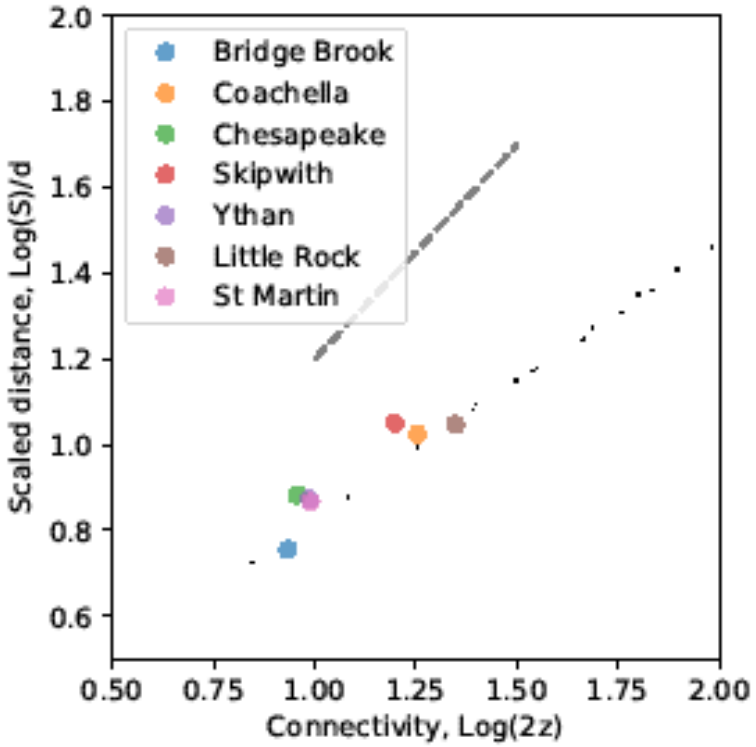






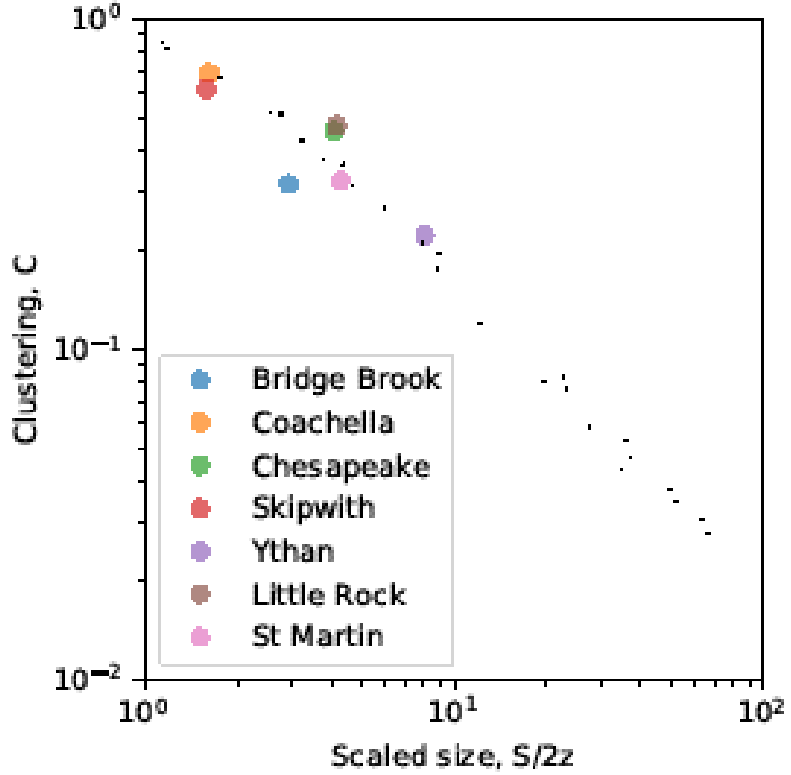


Exponential decay for r/2z >> 1: characteristic scale for z => food webs do not have a scale-free structure (power law)



d is the average trophic distance between species, i.e. the number of species needed to trophically connect two given species

-> may also follow a unique functional form for different food webs.

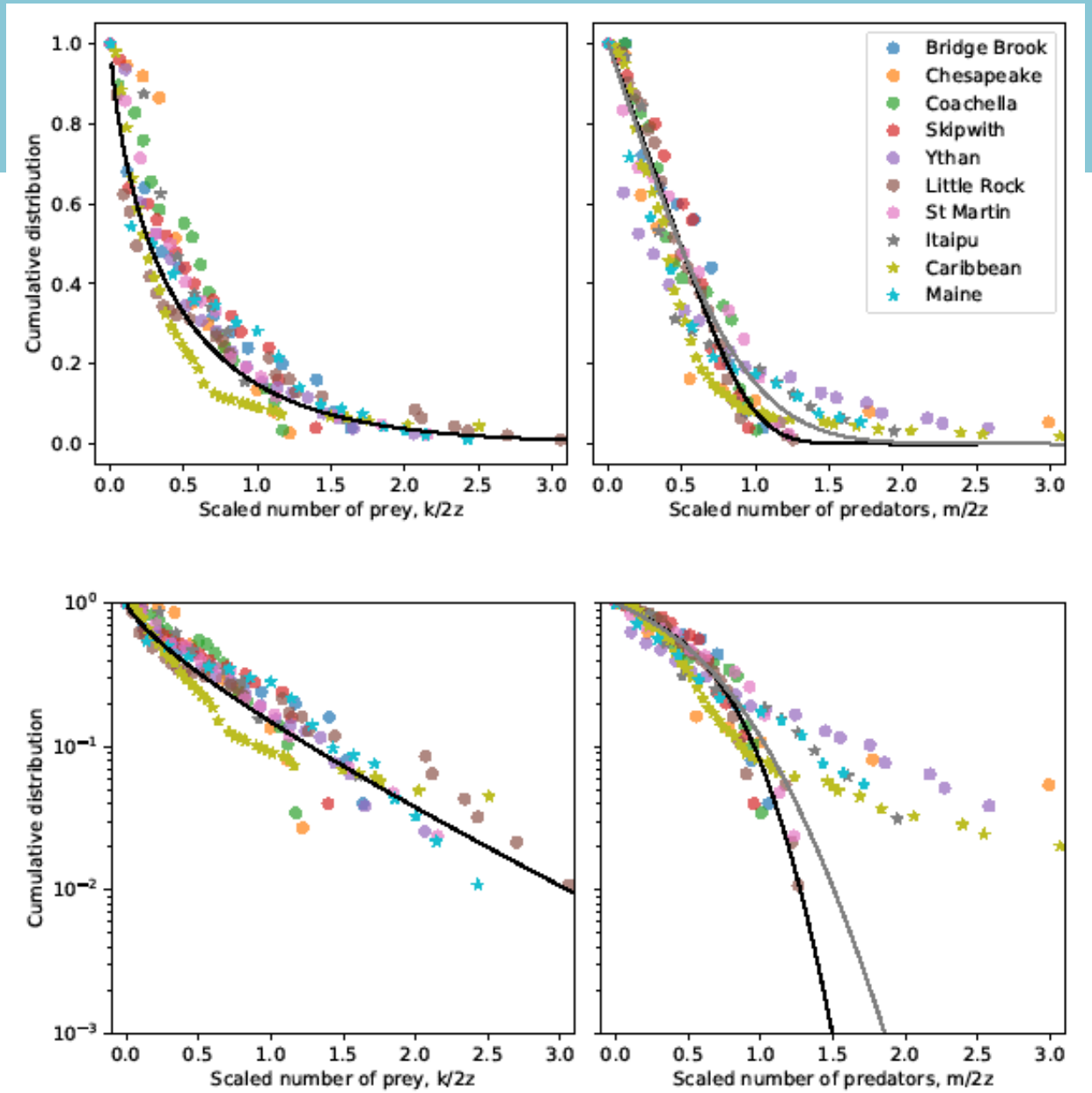


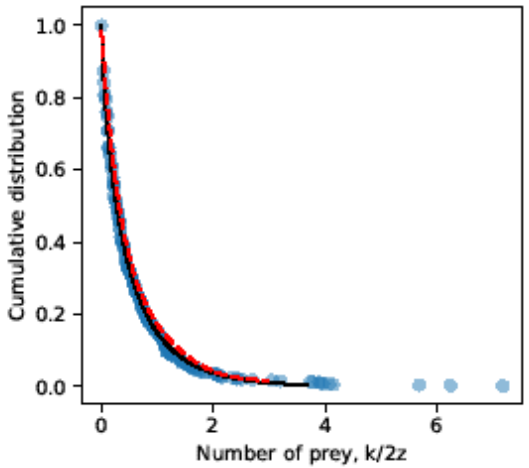
C is the clustering coefficient, i.e. the fraction of species' triplets that form fully connected triangles

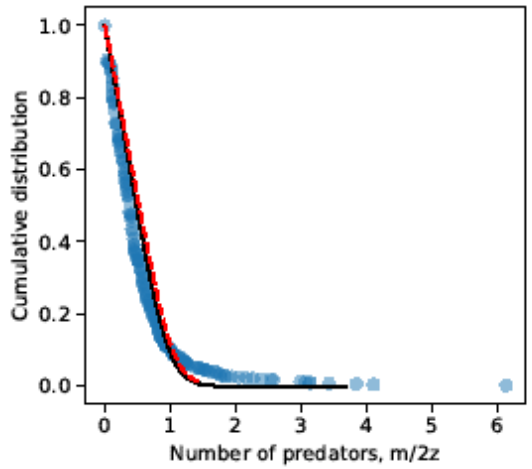
-> low compartmentalization: high interconnectance?

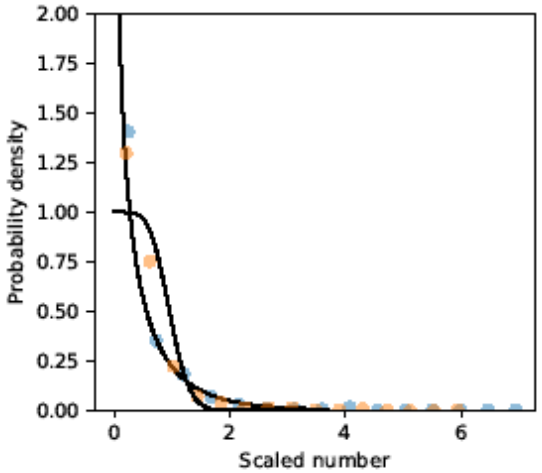
New data

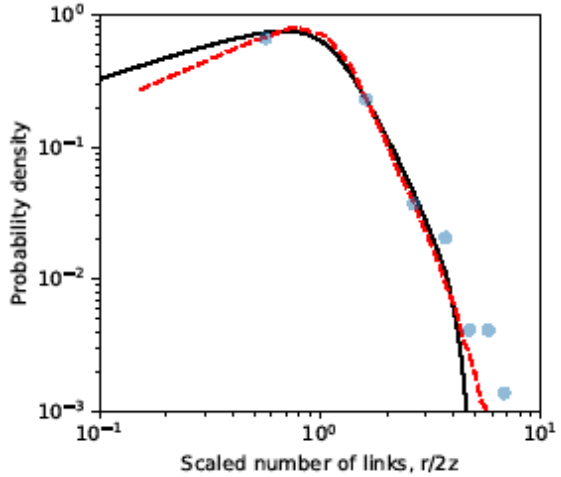
	Trophical species S	Linkage density z
Itaipu Reservoire	32	4.4
Caribbean Sea	245	13.4
Maine	92	3.5

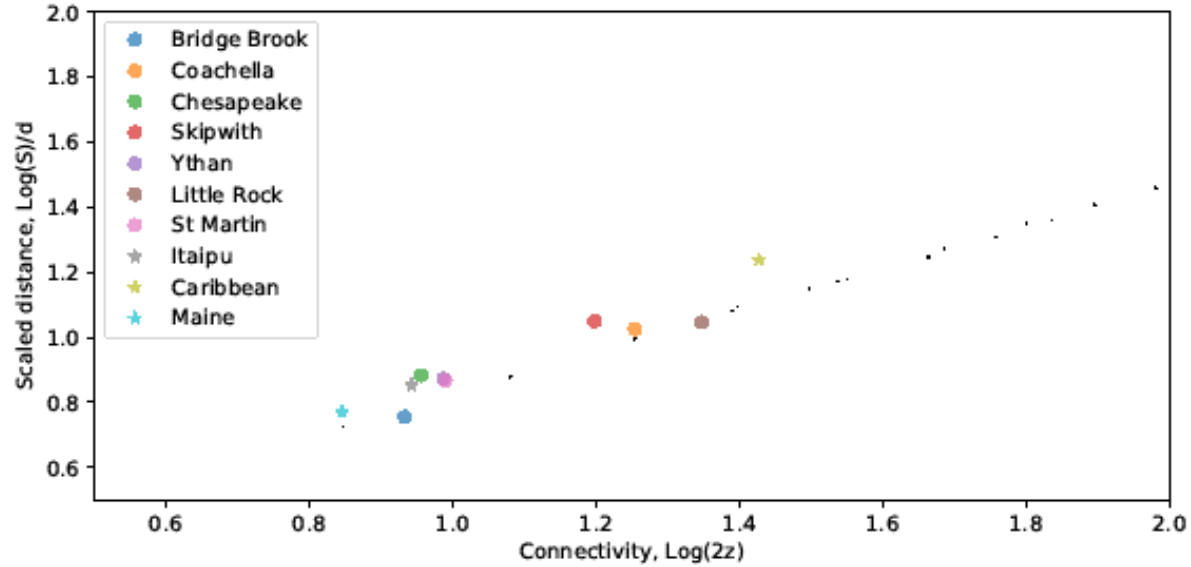


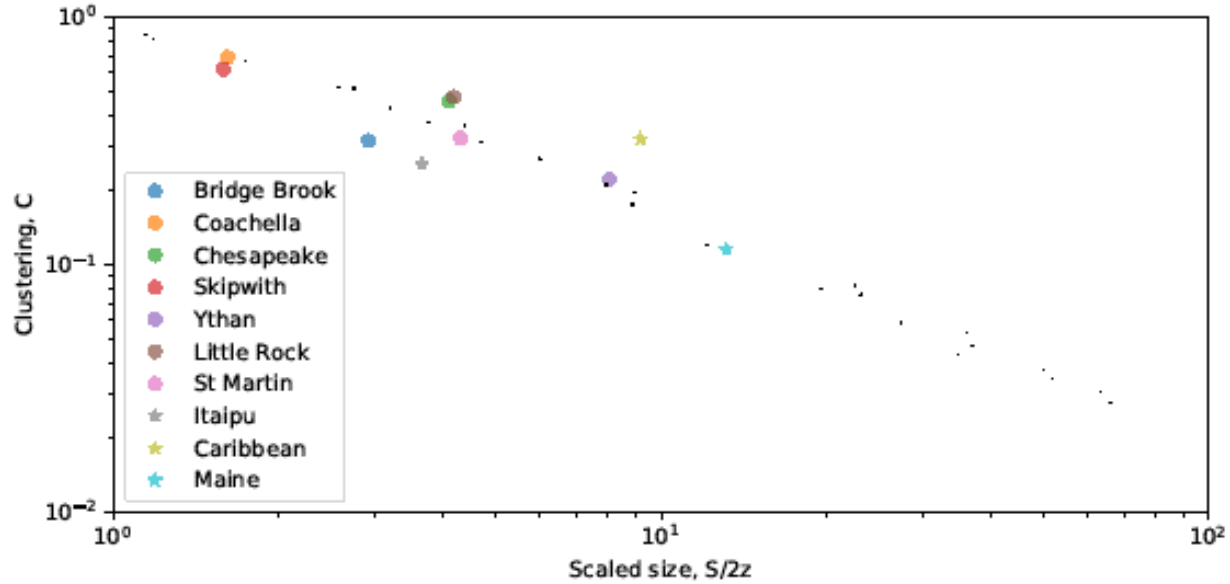

Cumulative distribution
Number of prey, k/2z


Cumulative distribution
Number of predators, m/2z


Probability density
Scaled number


Probability density
Scaled number of links, r/2z


Bridge Brook
Coachella
Chesapeake
Skipwith
Ythan
Little Rock
St Martin
Itaipu
Caribbean
Maine
Scaled distance, Log(S)/d
Connectivity, Log(2z)


Bridge Brook
Coachella
Chesapeake
Skipwith
Ythan
Little Rock
St Martin
Itaipu
Caribbean
Maine
Clustering, C
Scaled size, S/2z

Conclusions

- The cumulative distributions for the number of preys and predators collapse onto the same curves after a rescaling by z
- Food webs display universal patterns in the way trophic relations are established despite apparently “fundamental” differences in factors such as the environment and the size
- Niche model captures the behaviour found in real food webs
- New data validate the approach, but: incomplete? Different universality class?

Camacho, J., Guimerà, R., & Amaral, L. A. N. (2002). Robust patterns in food web structure. *Physical Review Letters*, *88*(22), 228102.