Seeking Sustainability with Both Eyes Open

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p_i ~ A measure of presence of event *i*

$0 \leq p_i \leq 1$

$(1 - p_i)$ ~ Conventional measure of absence of *i*

$-\log(p_i)$

Boltzmann's measure of absence

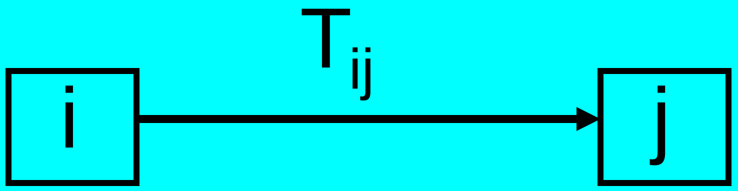
$h_i = -p_i \log(p_i)$

A joint measure of presence *and* absence

$$H = \sum_i h_i = -\sum_i p_i \log\left(p_i\right) \geq 0$$

The variety inherent in the system

T_{ij} ~ Arc originating in *i* and ending in *j*



$$T = \sum_{i,j} T_{ij}$$

Total magnitude of system

Estimate of $p_{ij} \sim \left(\frac{T_{ij}}{T} \right)$

Whence,

$$H = -\sum_{i,j}\left(\frac{T_{ij}}{T}\right)\log\left(\frac{T_{ij}}{T}\right) \geq 0$$

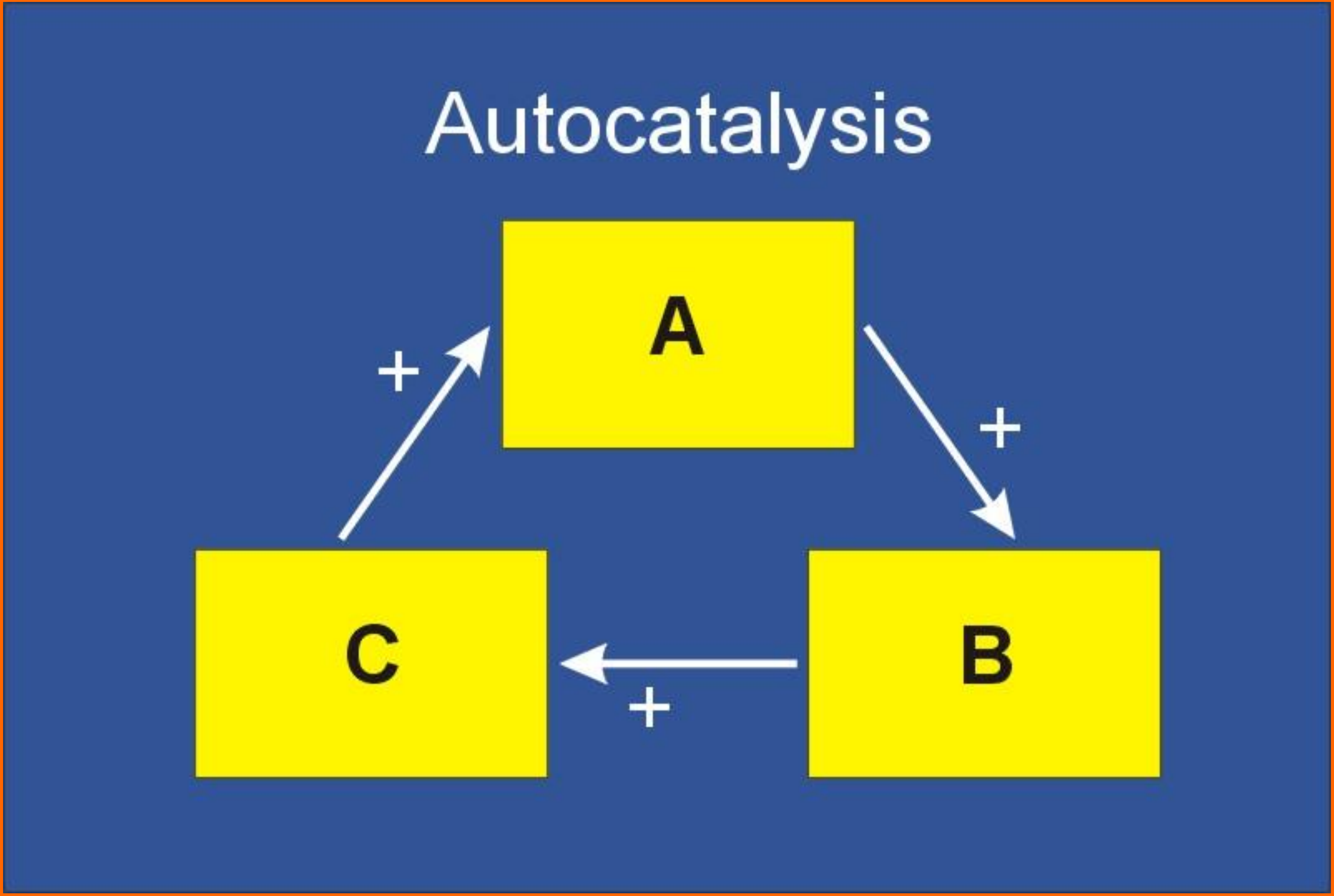
An admixture of presence and absence for the system as a whole.

Decomposition of H

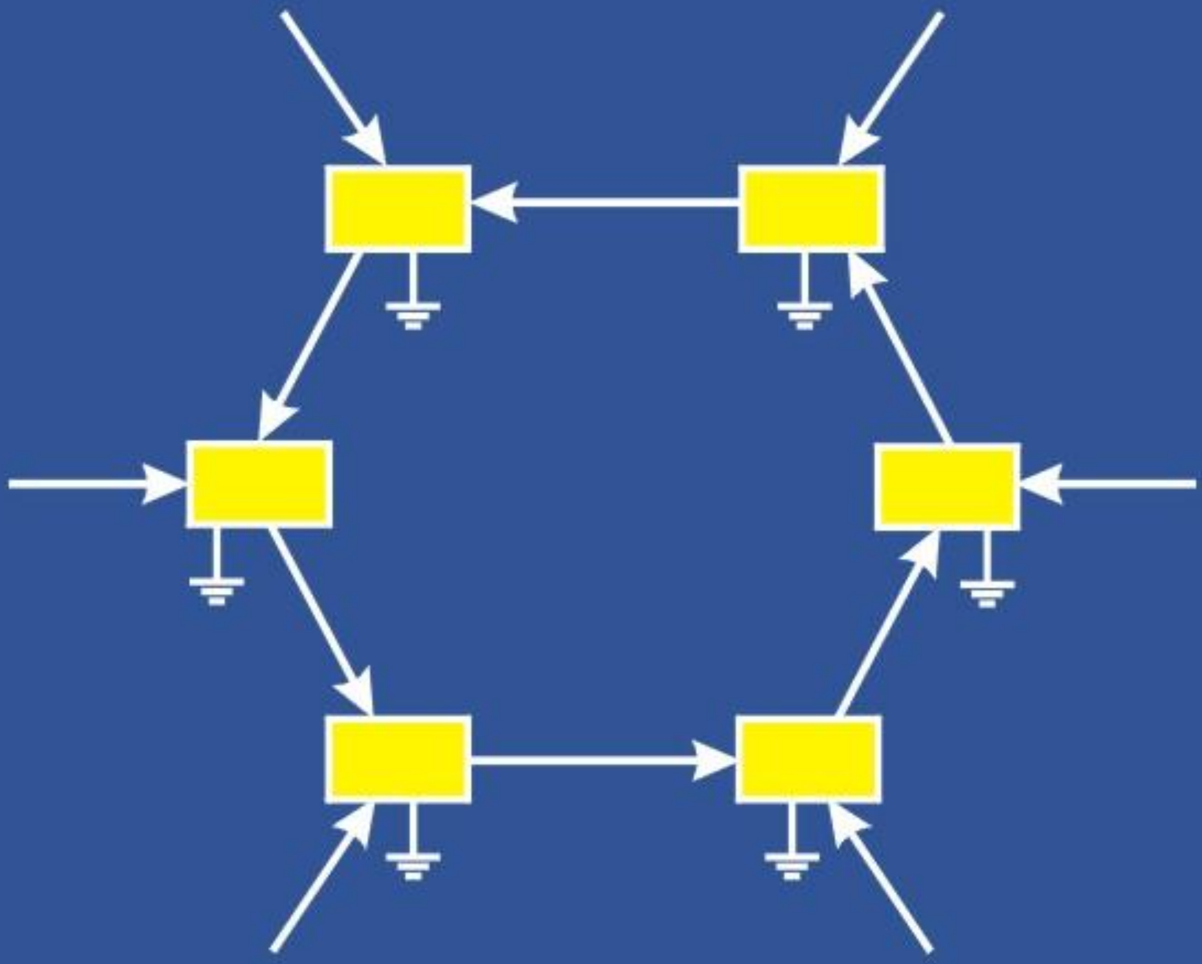
H = A + Φ

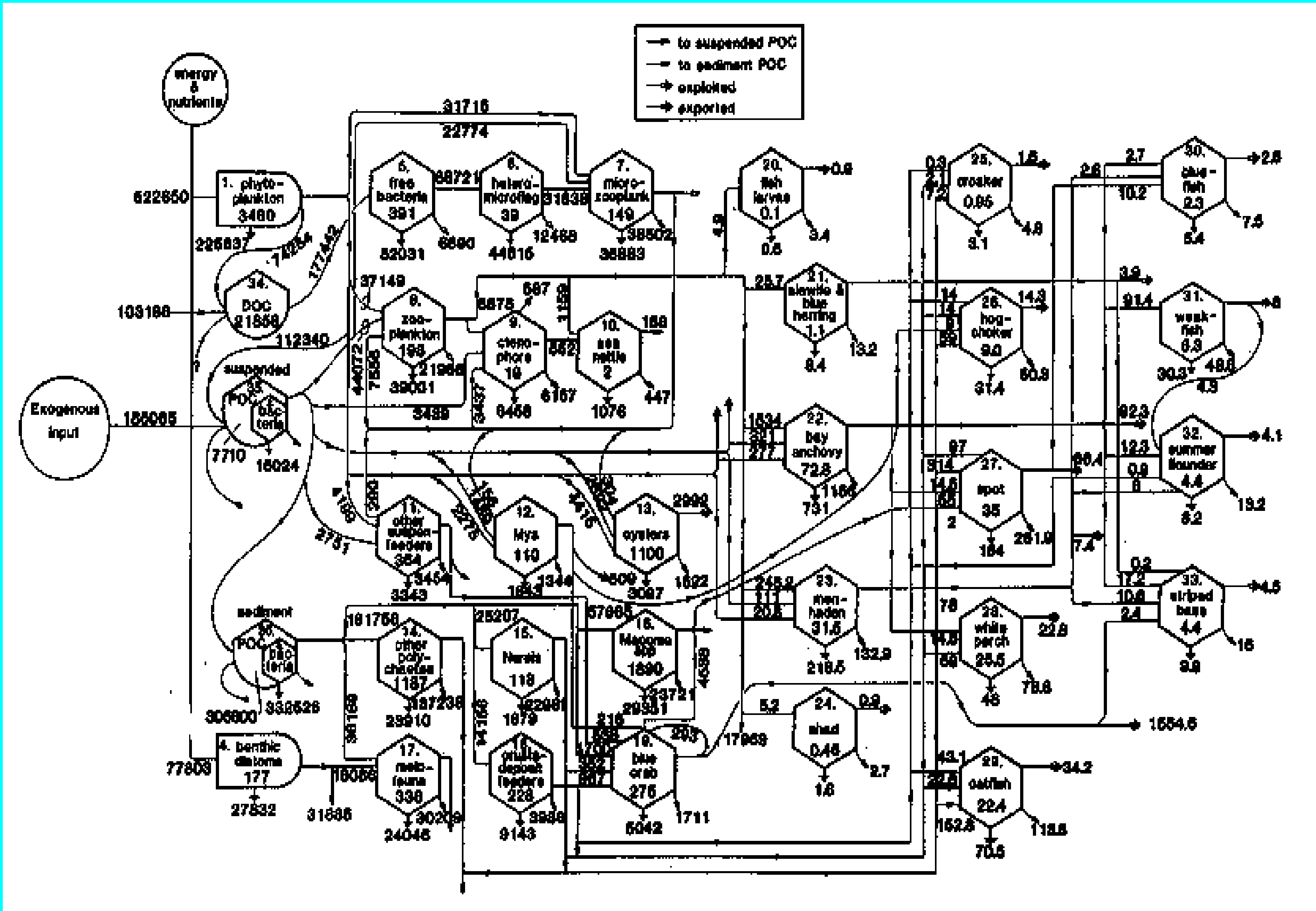
where
$$A = \sum_{i,j} \left(\frac{T_{ij}}{T} \right) \log \left(\frac{T_{ij} T}{\sum_p T_{ip} \sum_q T_{qj}} \right) \geq 0$$

and
$$\Phi = -\sum_{i,j} \left(\frac{T_{ij}}{T} \right) \log \left(\frac{T_{ij}^2}{\sum_p T_{ip} \sum_q T_{qj}} \right) \geq 0$$


Autocatalysis
A
B
C
+
+
+

Centripetality





Chesapeake Mesohaline Ecosystem

Degree of organization, a = A/H

Normalized freedom, $\phi = \Phi$/H

So that,

$$a + \phi = 1$$

With succession, $a \rightarrow 1$ (?)

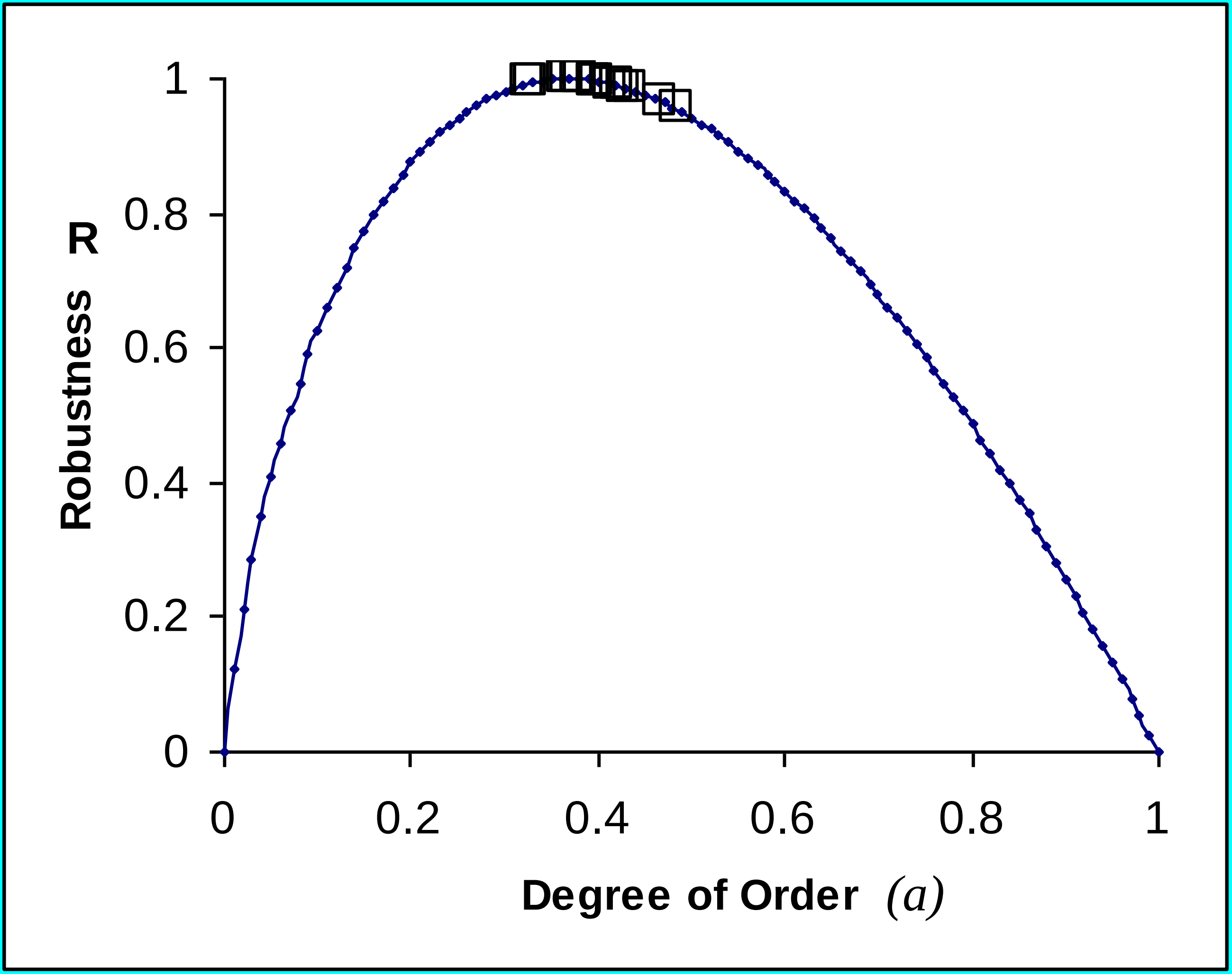
After Boltzmann,
instead of ϕ, use

$$-\log(a)$$

to denote disorganization.

Define system robustness as,

$$R = -a\log(a)$$



Robustness R
1
0.8
0.6
0.4
0.2
0
0
0.2
0.4
0.6
0.8
1
Degree of Order (a)

Contributions of each T_{ij} to robustness, R

$$\frac{\partial R}{\partial T_{ij}} = F + \frac{T_{..}F'}{C}\left\{\log\left[\frac{T_{ij}T_{..}}{T_{i.}T_{.j}}\right] + a\log\left[\frac{T_{ij}^{2}}{T_{i.}T_{.j}}\right]\right\}$$

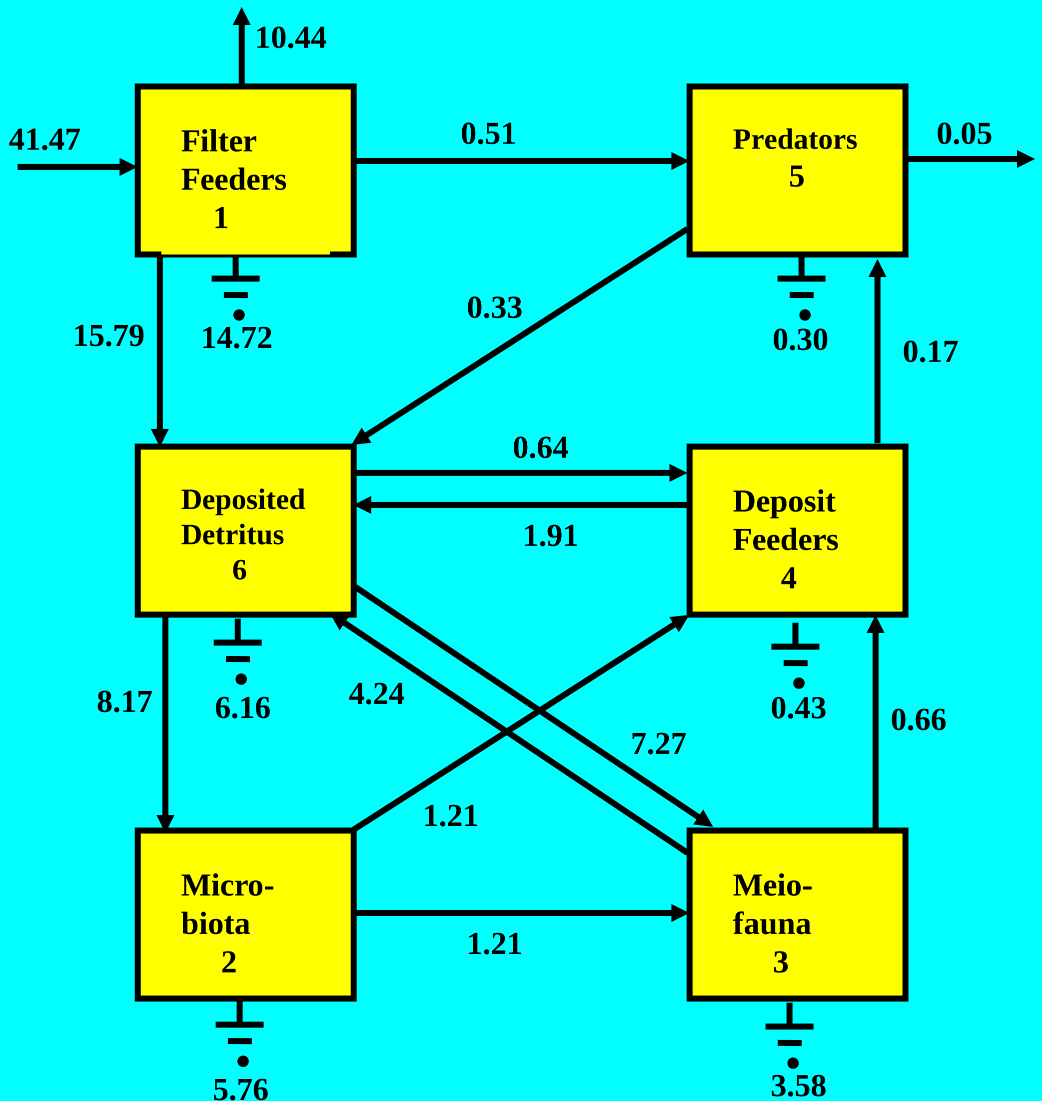
F'

a

where $$F' = -e\left[\frac{\log(a\ )}{\log(e)} + 1\right]$$

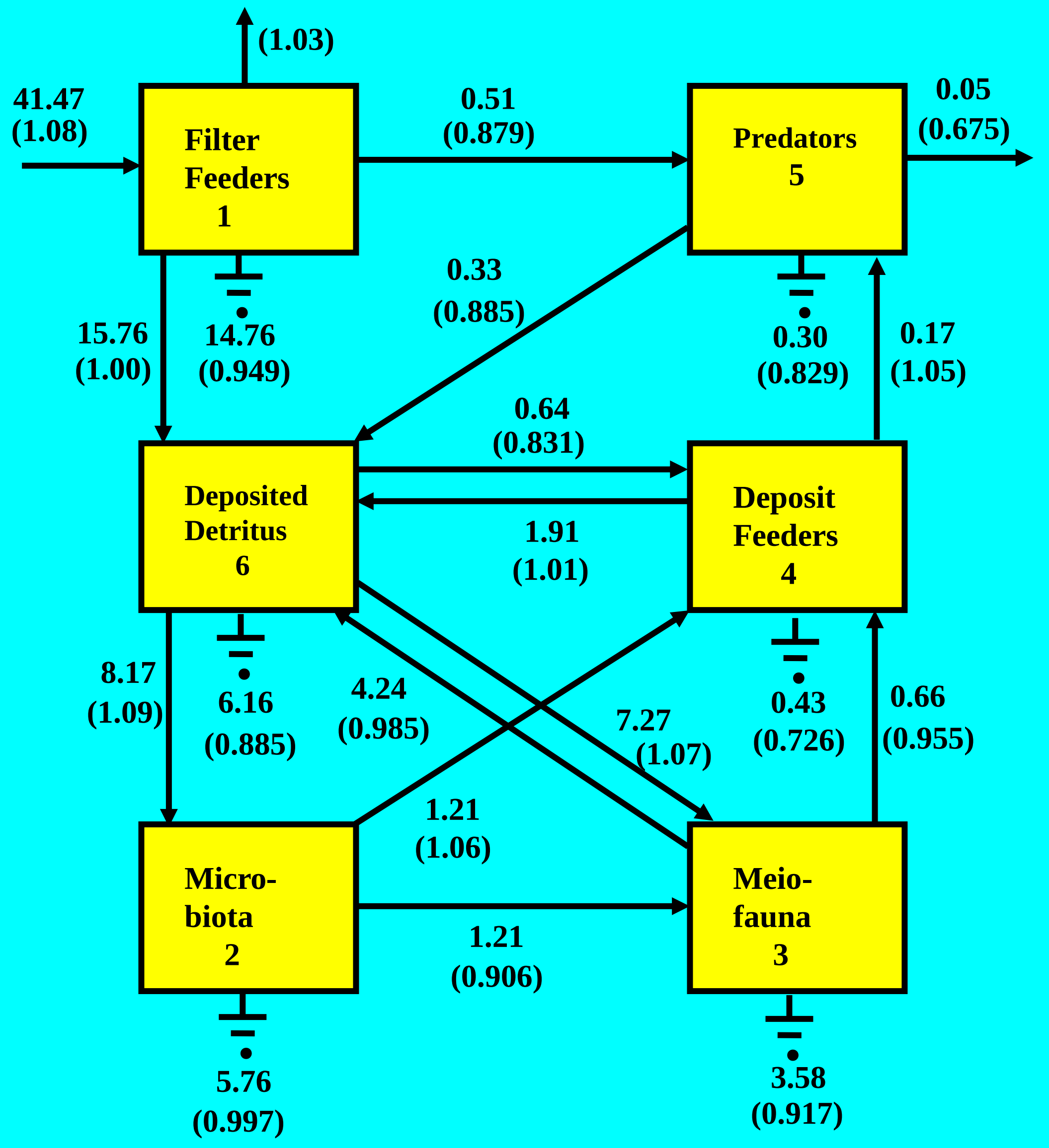
Marginal Contribution of T_{ij}

$\frac{\partial R}{\partial T_{ij}}$ is the marginal contribution of T_{ij} to the robustness of the system. That is, it is the amount that each unit of T_{ij} contributes toward the robustness. It is equal to unity for all i and j when R is maximal (at a = [1/e]).



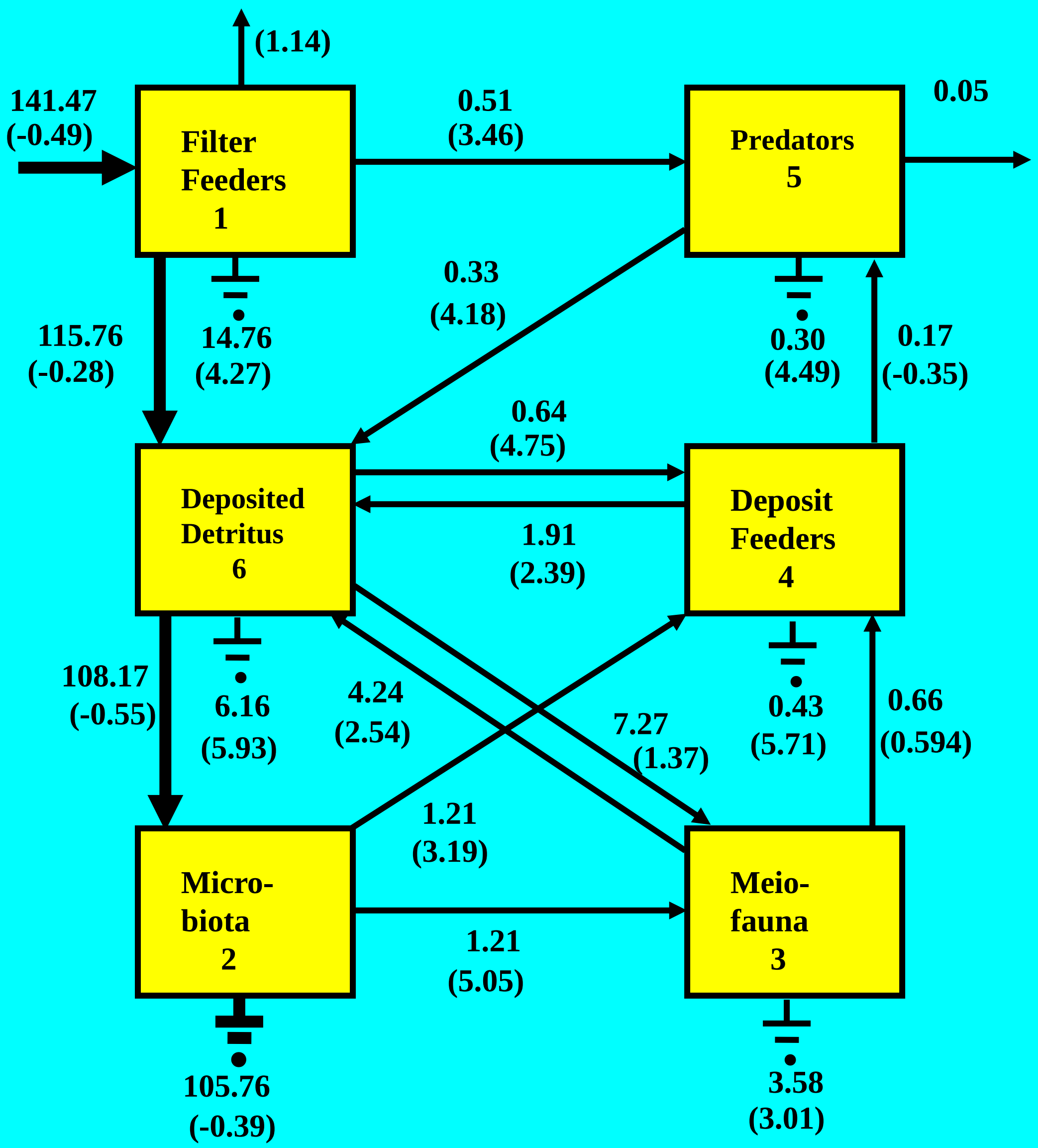
Oyster Reef Network, Dame & Patten 1981

(Flows in kcal/m^2/d)



Oyster Reef Network, Marginal contributions in parentheses.

$a = 0.436$



Hypothetically Eutrophic Oyster Reef

$a = 0.683$

Templeton Foundation Press, 2009

This talk:

<http://www.cbl.umces.edu/~ulan/EyesOpen.pdf>