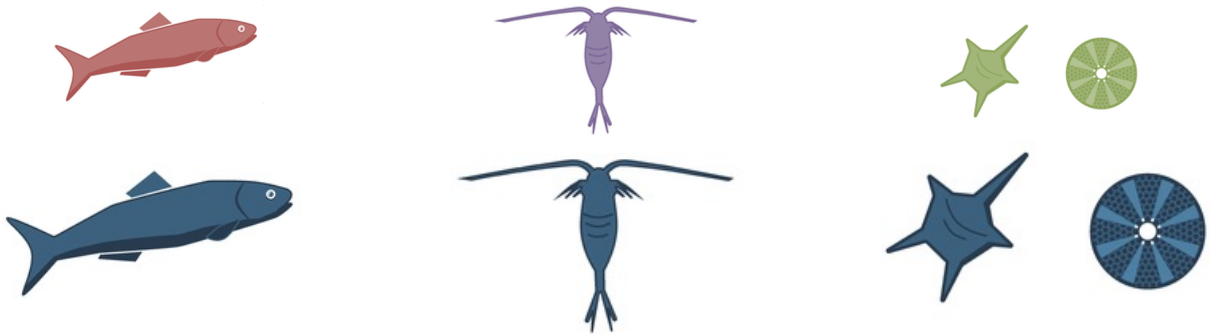
KÜNO 2021 Trait Workshop

Traits across taxa

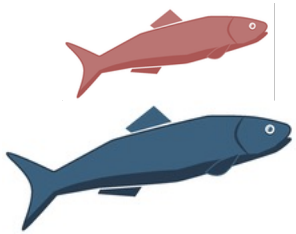


Kai Wirtz, Carsten Lemmen, et al

Helmholtz-Zentrum hereon

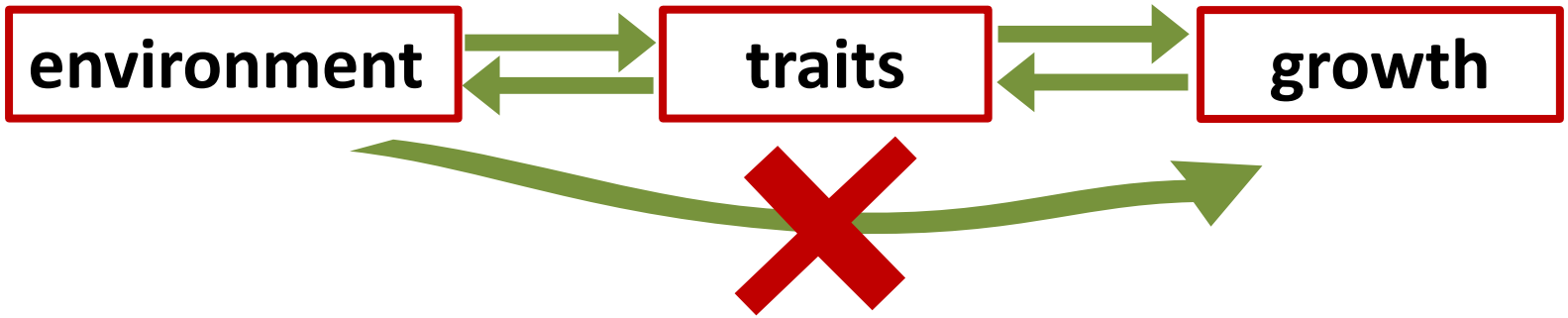
“trait”

adjustable property of a biological entity that affects its fitness



- **traits characterize single organisms, populations, species (genotypes), communities, groups**
- **traits can be quantified (value)**
- **trait values alter due to behavior, sorting, selection, …**
- **all traits change over time**

traits are key for understanding and modeling the response of ecosystems to environmental change



traits can be further categorized

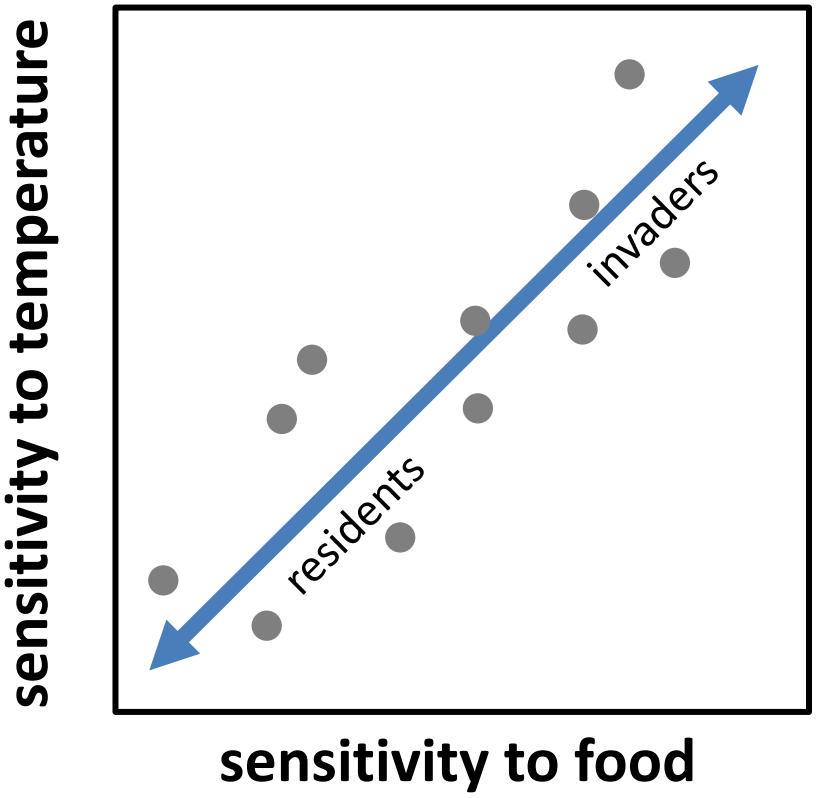
effect vs. response

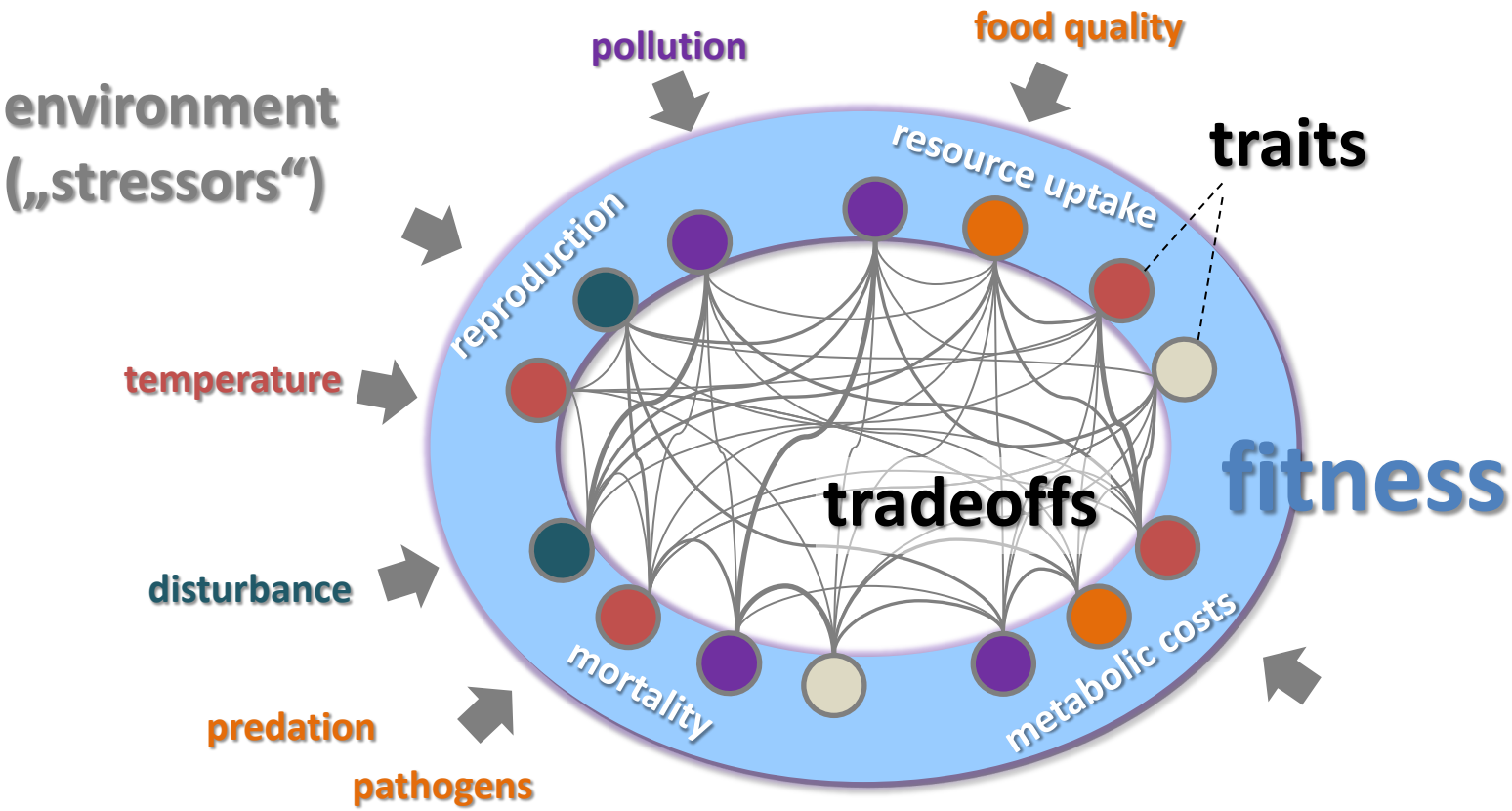
genetic • morphological • physiological • life-history • behavior

BUT THIS MAY NOT BE HELPFUL

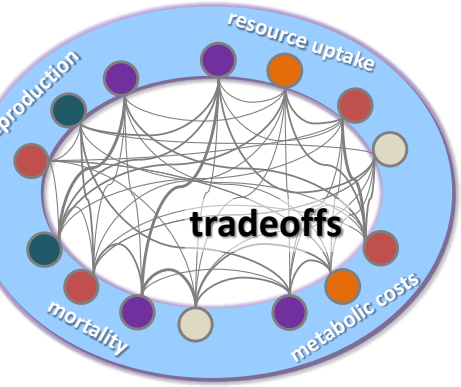
“trade-off”

(statistical) relationship between traits, often due to physical or chemical constraints



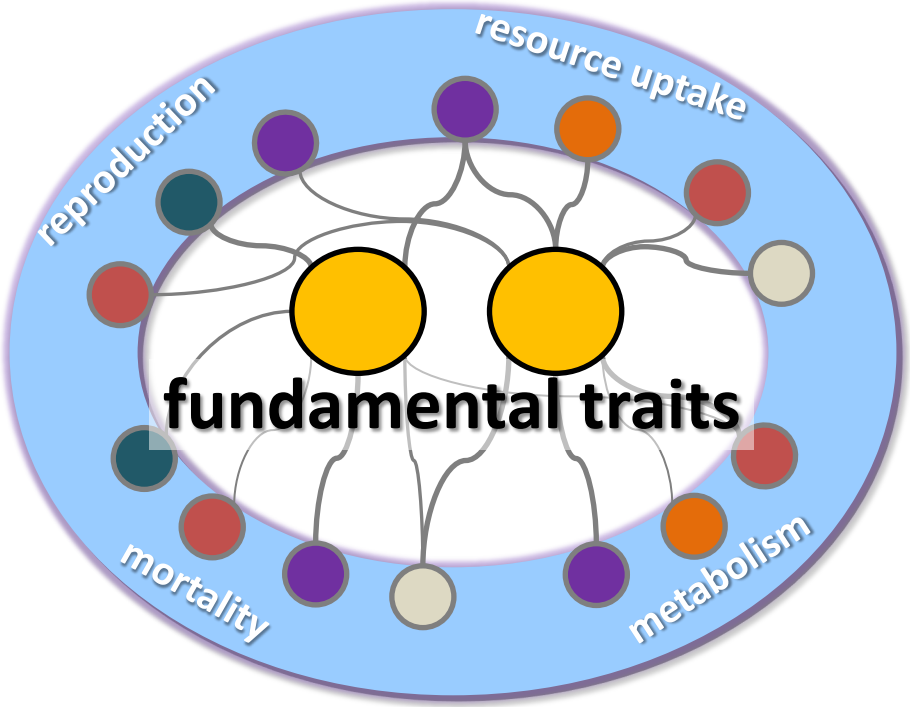

environment
(„stressors“)
pollution
food quality
traits
resource uptake
reproduction
temperature
tradeoffs
fitness
disturbance
mortality
metabolic costs
predation
pathogens

"Fundamental" ("master", "key") traits entail many trade-offs



$N * (N - 1)/2$

$N = 14 \rightarrow 91$

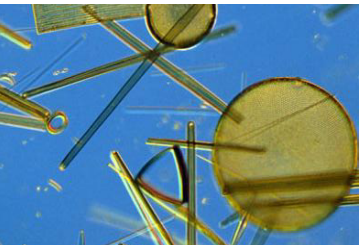


$N * n$

$N = 14, n = 2 \rightarrow 28$

fundamental traits strongly vary in time and space and determine many aspects of growth

→ mechanistic modeling and indicator definition



trait hierarchy and trade-offs in phytoplankton

carboxy-lation

maximal photosynthesis

light harvesting

exudation

hetero trophy

cell size

protein partitioning

edibility

max. nutrient uptake

activity

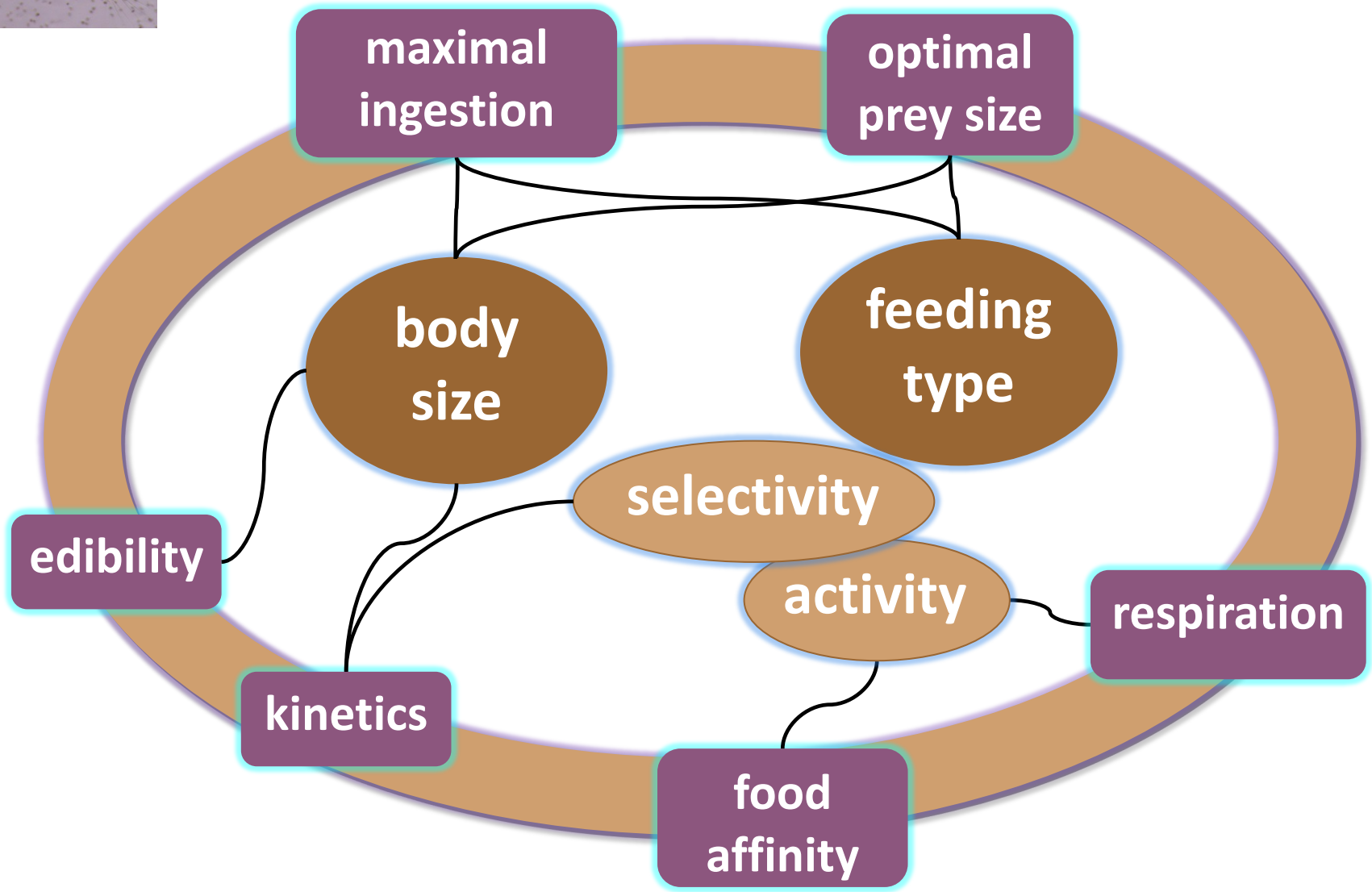
buoyancy

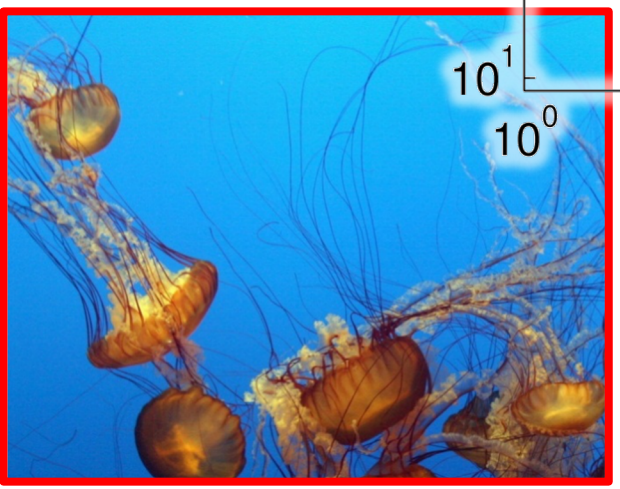
nutrient affinity

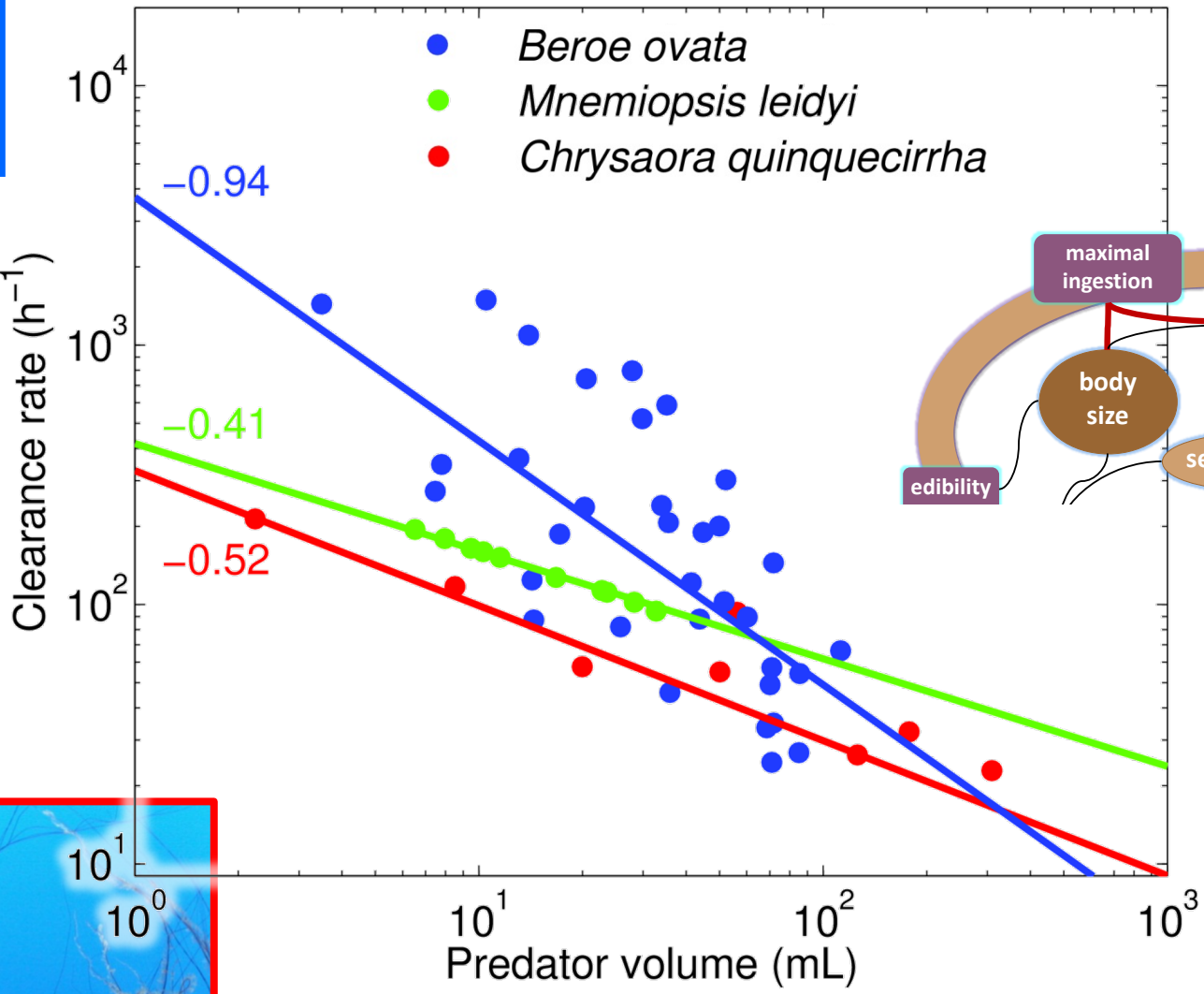
respiration

Wirtz *MarBiol* 2012, Wirtz & Sommer *MarBiol* 2012
Wirtz & Kerimoglu *FrontEcolEvol* 2016

trait hierarchy and trade-offs in zooplankton



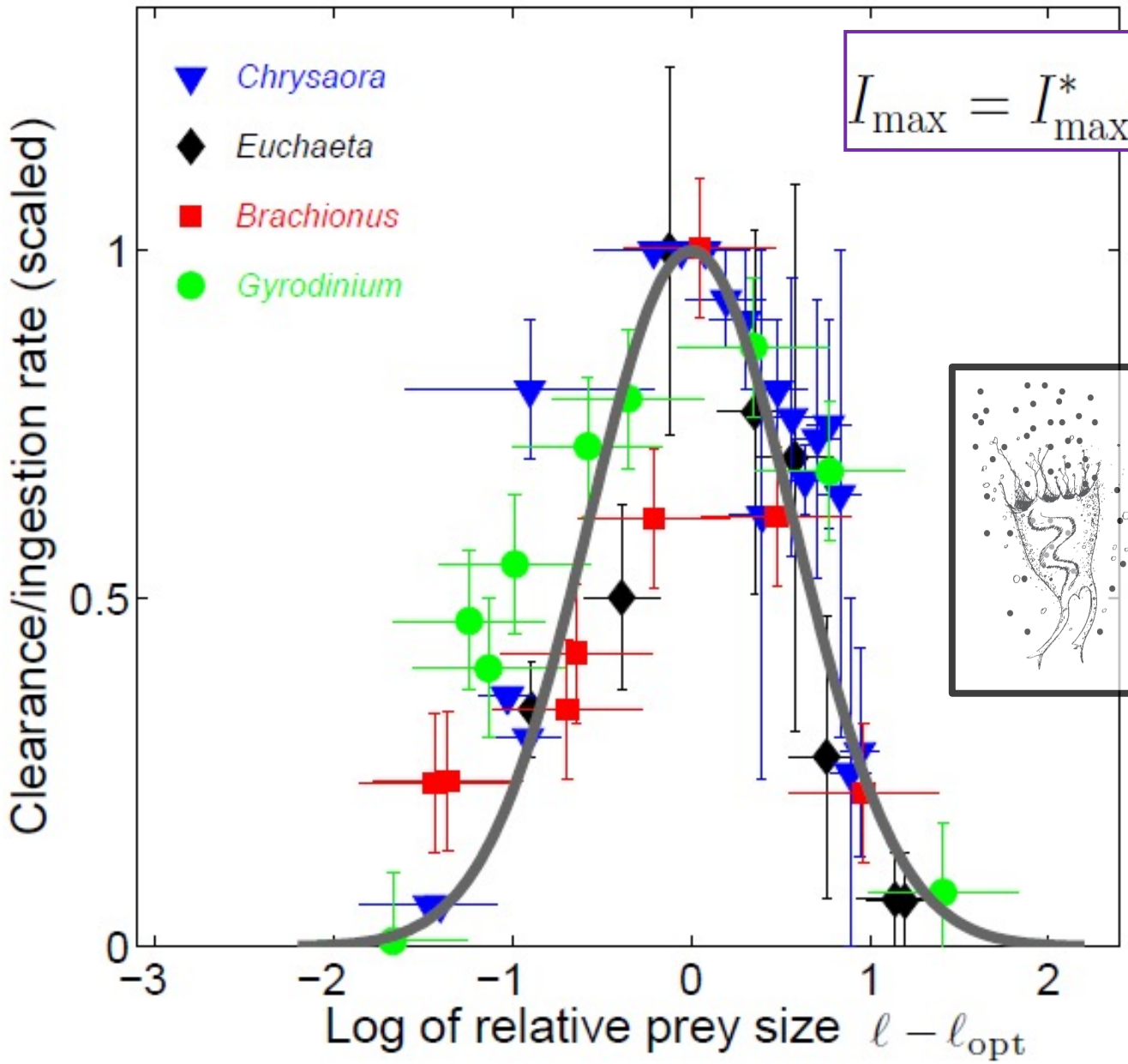




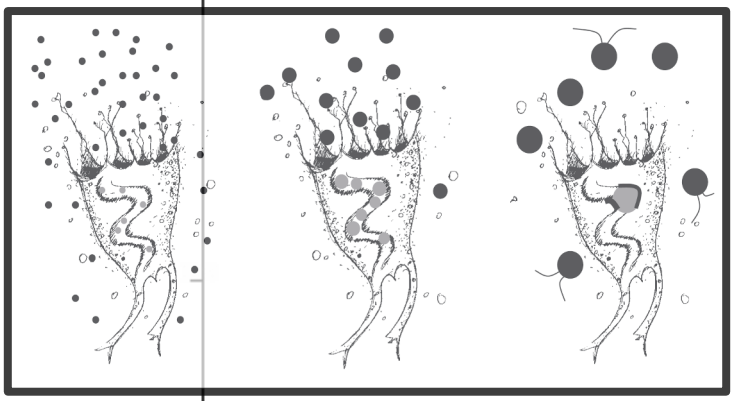
Scaling laws derive from biomechanics

Wirtz JPR 2013

Universal feeding kernel and breadth



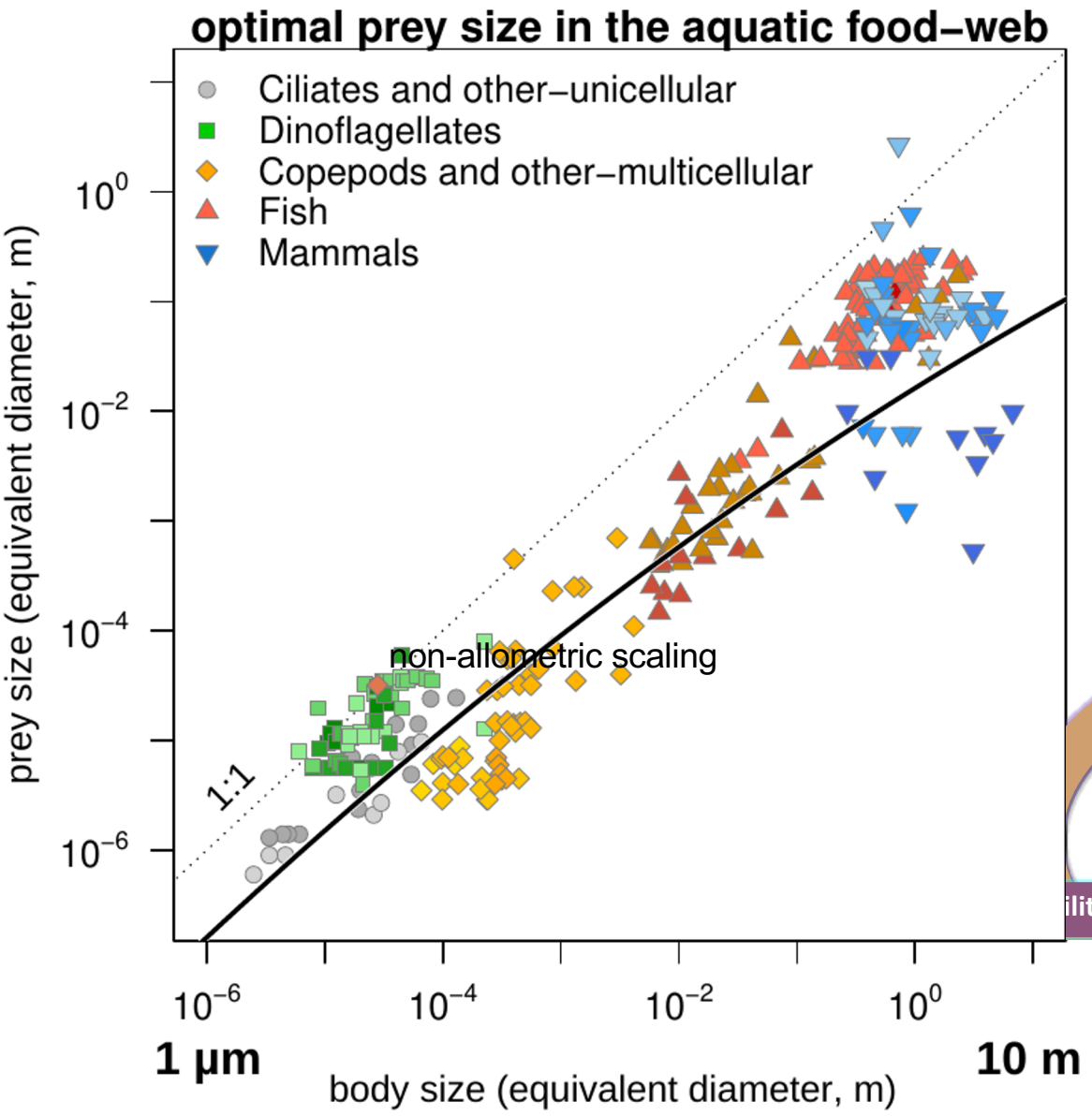
$$I_{\max} = I^*_{\max} \cdot \mathrm{e}^{-3/2(\ell - \ell_{\mathrm{opt}})^2}$$



biomechanical modeling

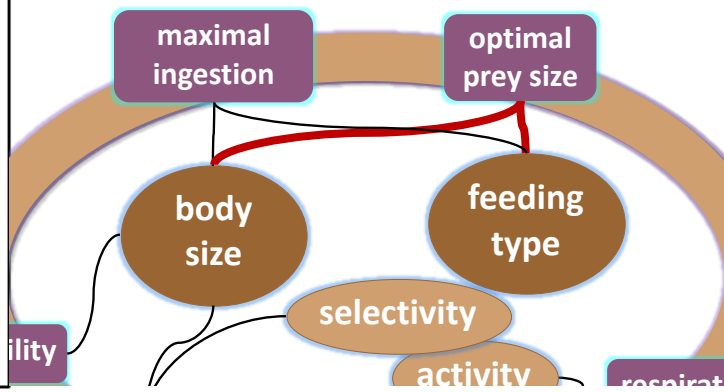
Wirtz *MEPS* 2014

Predator-prey size-scaling across (aquatic) taxa



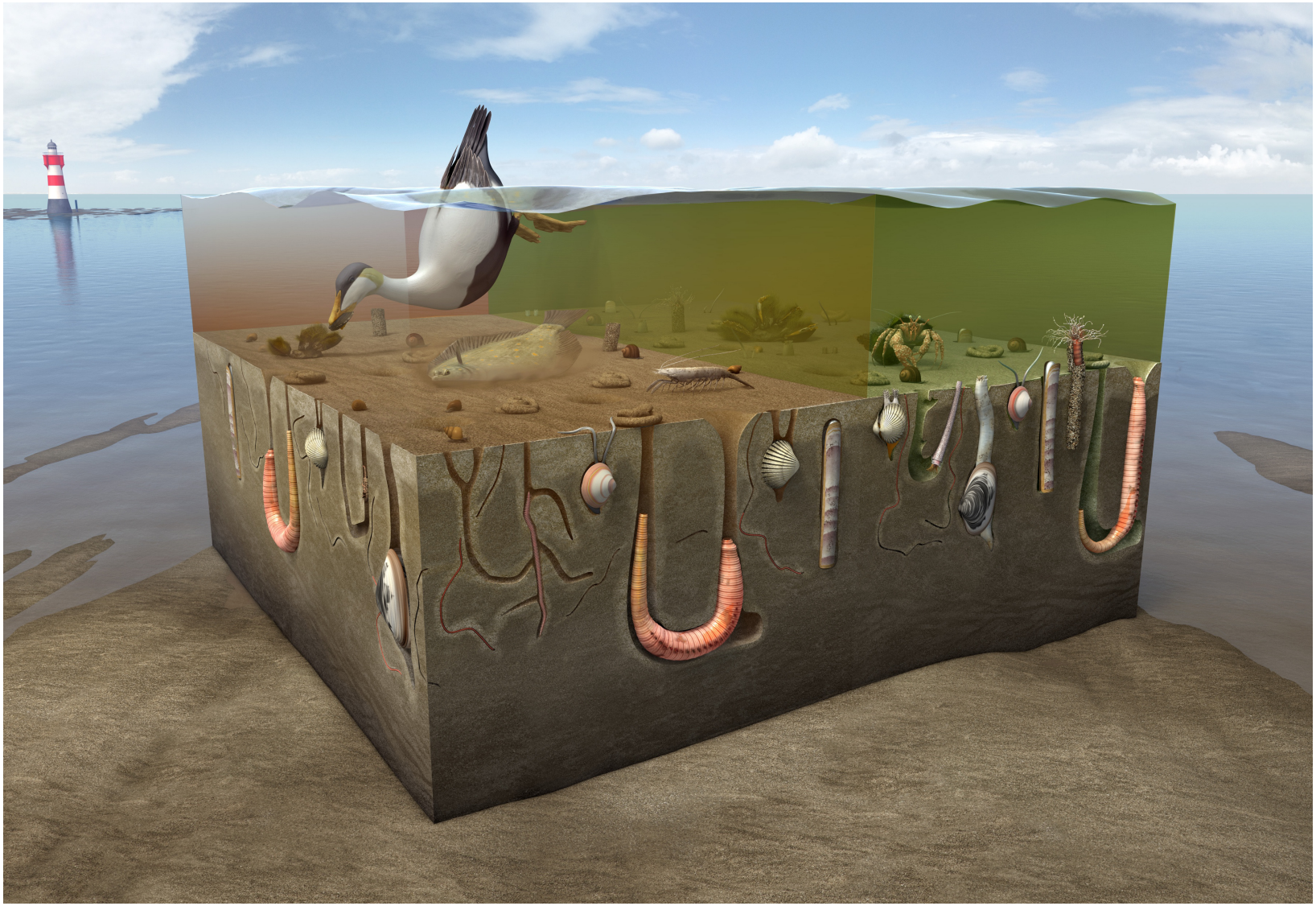
biomechanics:
non-allometric scaling

reference line for feeding type
(e.g., below: suspension feeding; above: ambushing)



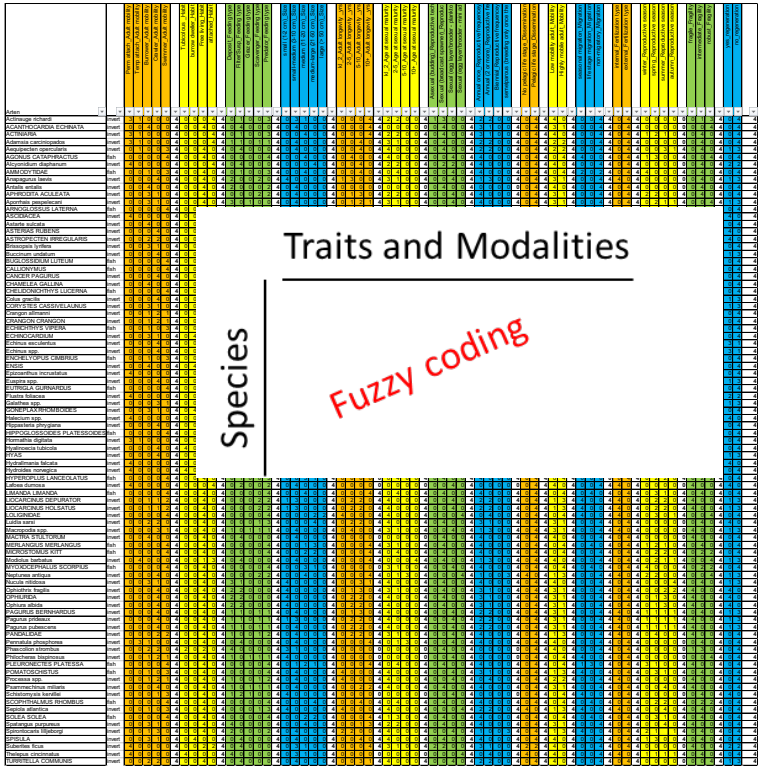
(García-Oliva and Wirtz, in prep.)

traits in macrozoobenthos



from species to traits

trait database for epibenthic invertebrates and demersal fish by classifying each species into **categories (modalities)** using **Fuzzy Coding**



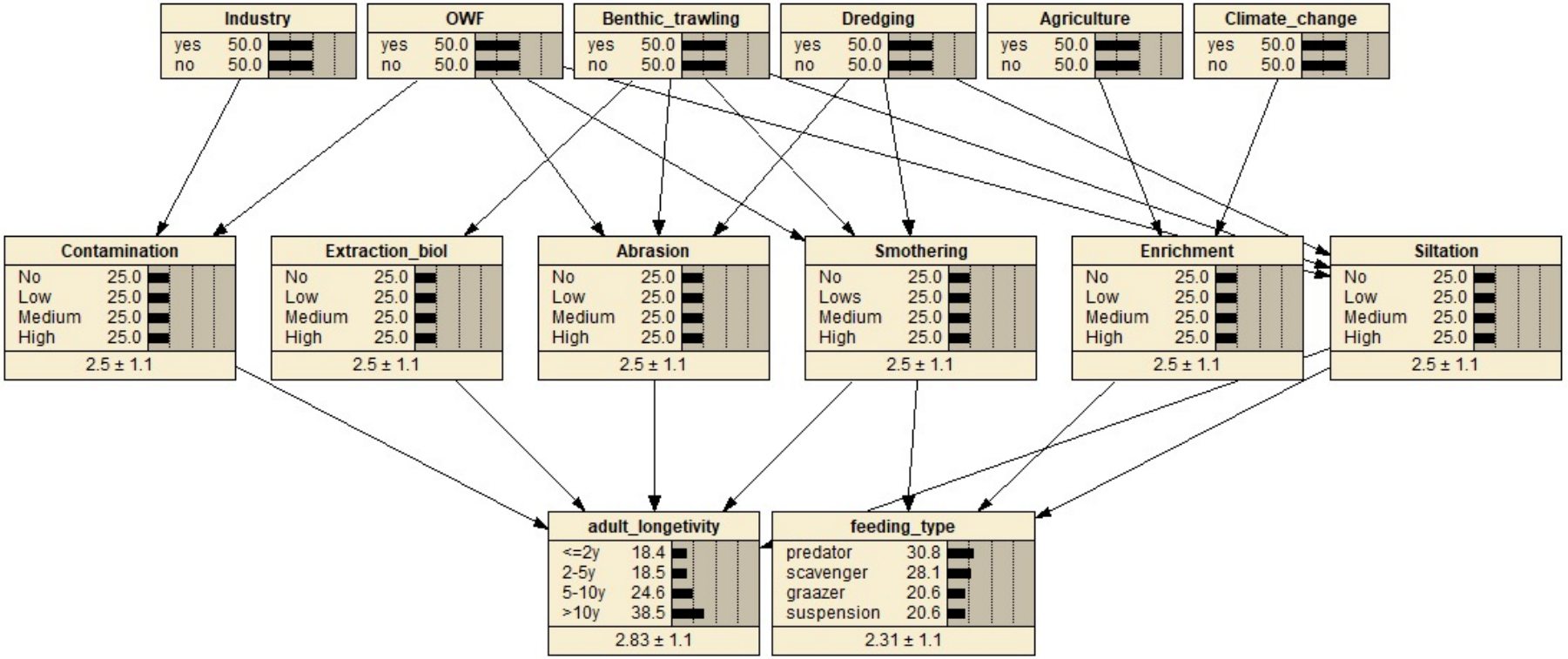
87 Species and 15 Traits (53 Modalities)

34 Species and 8 Traits (34 Modalities)

Trait	Categories
Mobility	Perm. attached; Temp. attached; Burrower; Crawler; Swimmer
Habitat	Infauna; Epifauna; Epizoic
Feeding type	Deposit; Filter/suspens.; Grazer; Scavenger; Predator
Food type	Algae; Invertebr./Vertebr.; Carrion; Detritus; Plankton; Suspend. org. matter; Microorg.
Size (cm)	small (1–2); small-medium (3–10); medium (11–20); medium-large (11–20); large (> 50)
Adult longevity (yr)	< 2; 2–5; 5–10; 10+
Age sexual maturity (yr)	< 2; 2–5; 5–10; 10+
Reprod. technique	Asexual; Sexual (spawner); Sexual (egg lay/brood - mini adults); Sexual (egg lay/brood - plankt. larvae)
Reprod. frequency	Annual once; Annual (2 or more); Biennial; Semelparous
Reprod. season	Winter; Spring; Summer; Autumn
Dissemination	No pelagic life stage; Pelagic life stage; Low mobility adult; Highly mobile adult; Migratory
Fertilization type	Internal; External
Migration	**Seasonal; life stage; non-migratory**

Neumann, Gimpel, Rehren, Probst, Stelzenmüller; *Thünen Institut*

Bayesian Networks: cumulative effect of pressures on traits

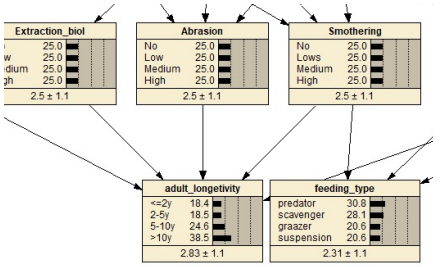


Bayesian network:
assess the effects of **management scenarios** and the risk **of cumulative effects** on the **functional traits of** demersal fish and epibenthic invertebrates

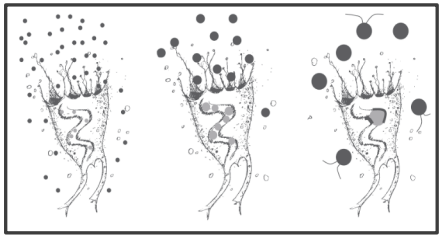
MUSSEL
MULTIPLE STRESSORS ON NORTH SEA LIFE

Stelzenmüller, Gimpel, Rehren, Probst, Neumann; *Thünen Institut*

statistical vs. mechanistic trait models



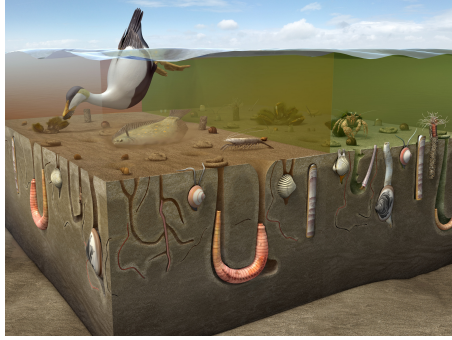
- relatively easy set-up of statistical approaches
- but: limited prediction range
  (e.g., invasive species, new environmental relation of previously sub-dominant species, …)
- mechanistic models require knowledge about major traits and trade-offs and wider modeling expertise

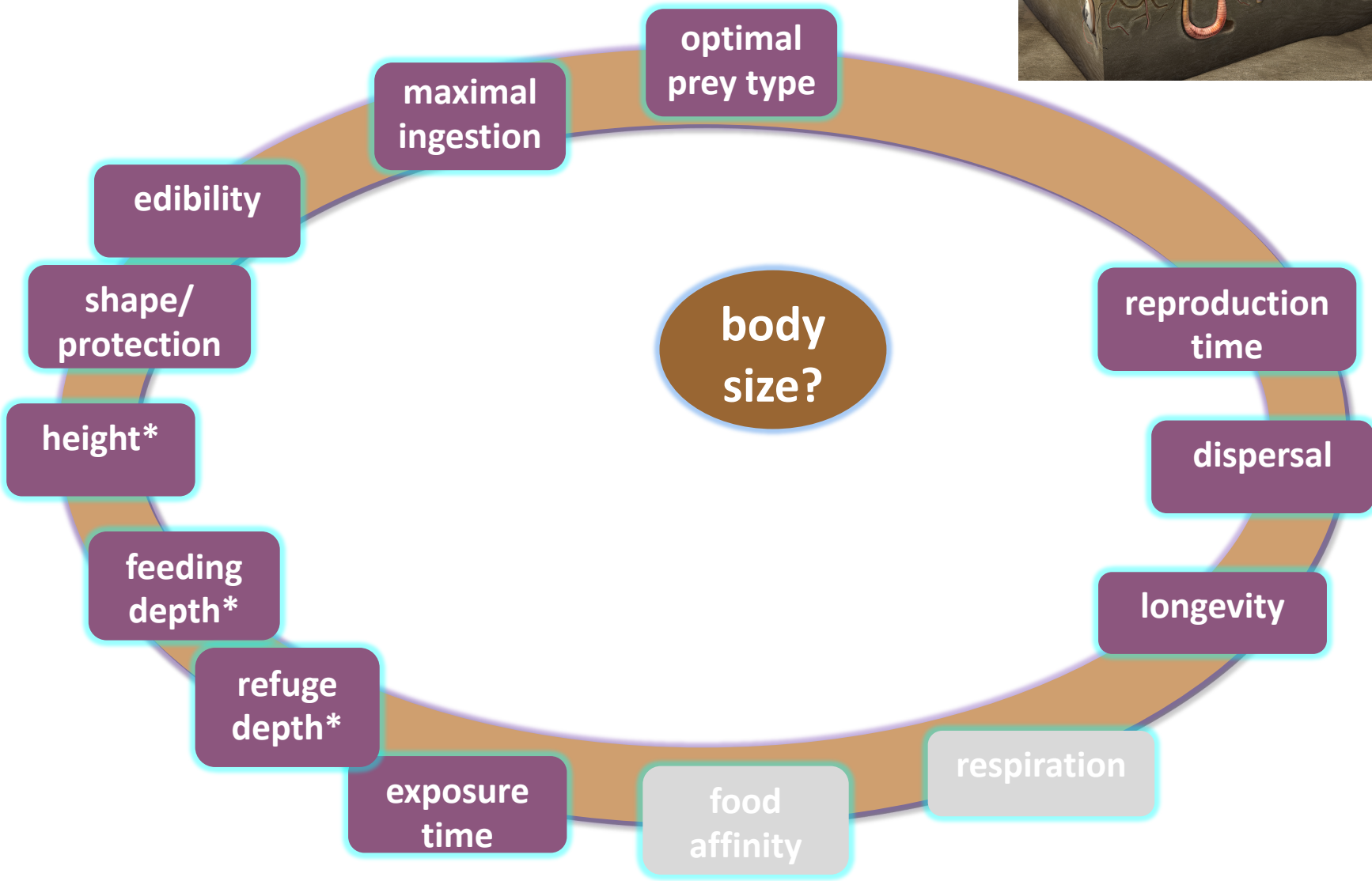


- solution (?): combination of both approaches

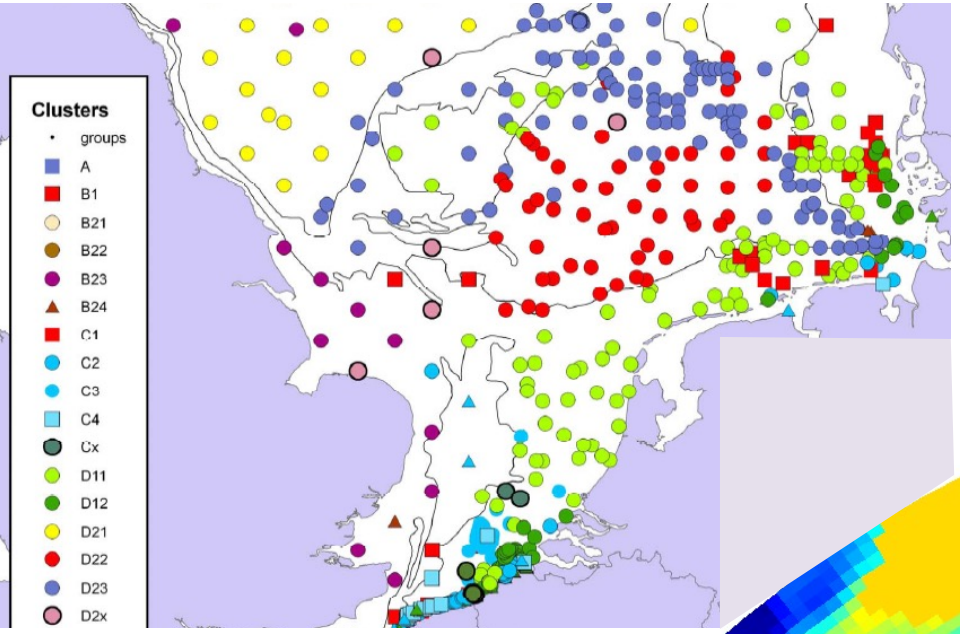
MUSSEL
MULTIPLE STRESSORS ON NORTH SEA LIFE

Conceptual trait-based model for macrozoobenthos

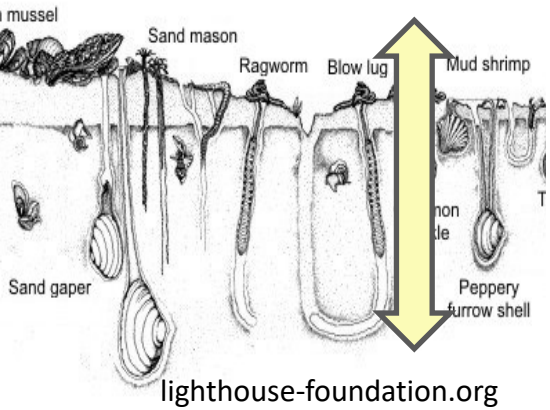




Vertical positioning by macrozoobenthos

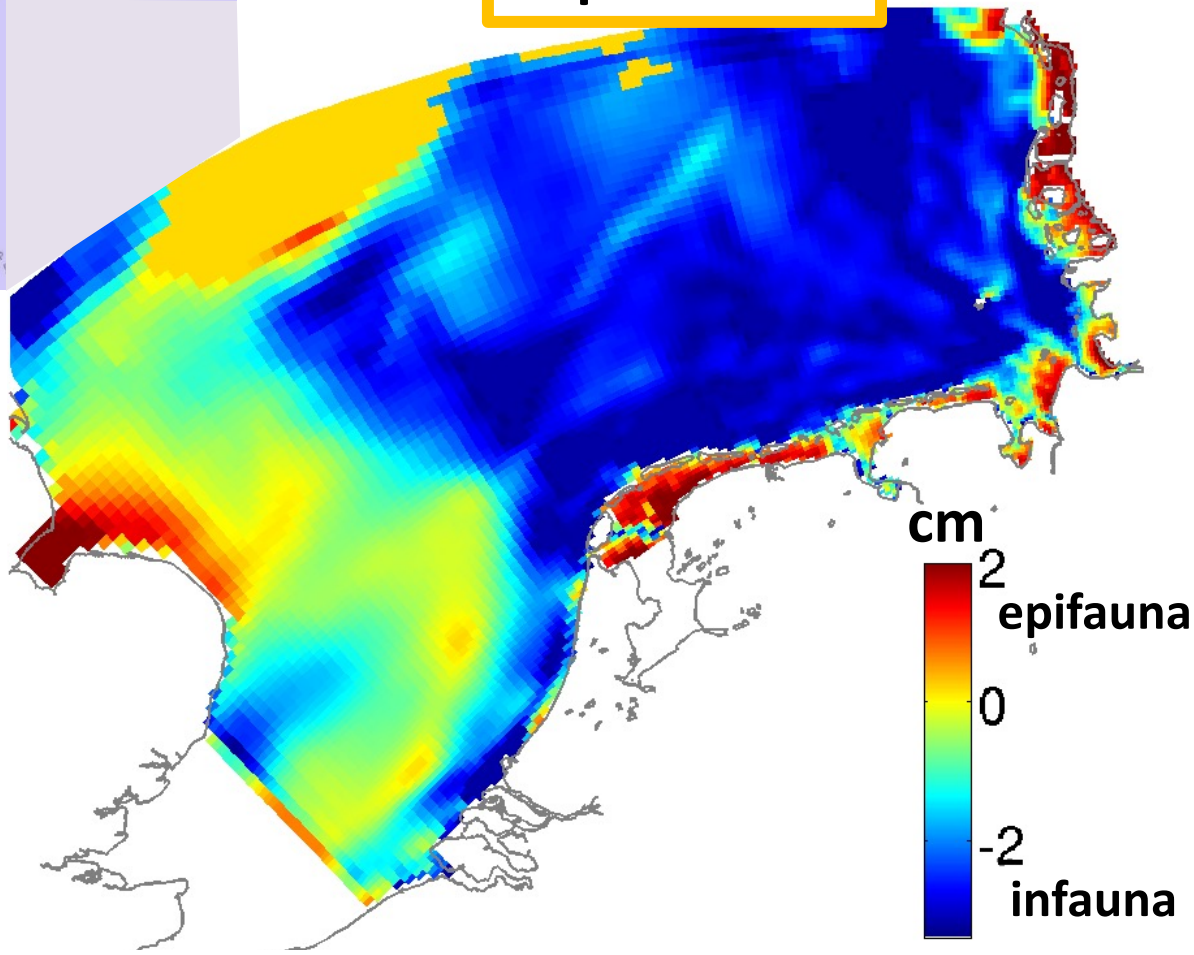


Rachor et al. 2007(ICES)

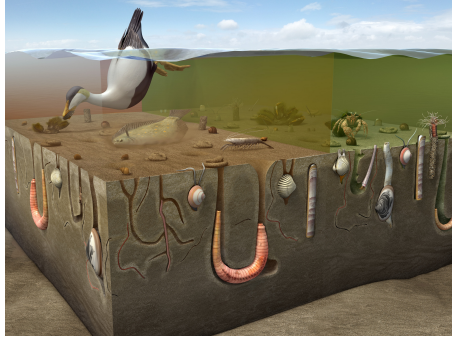


lighthouse-foundation.org

mean vertical position



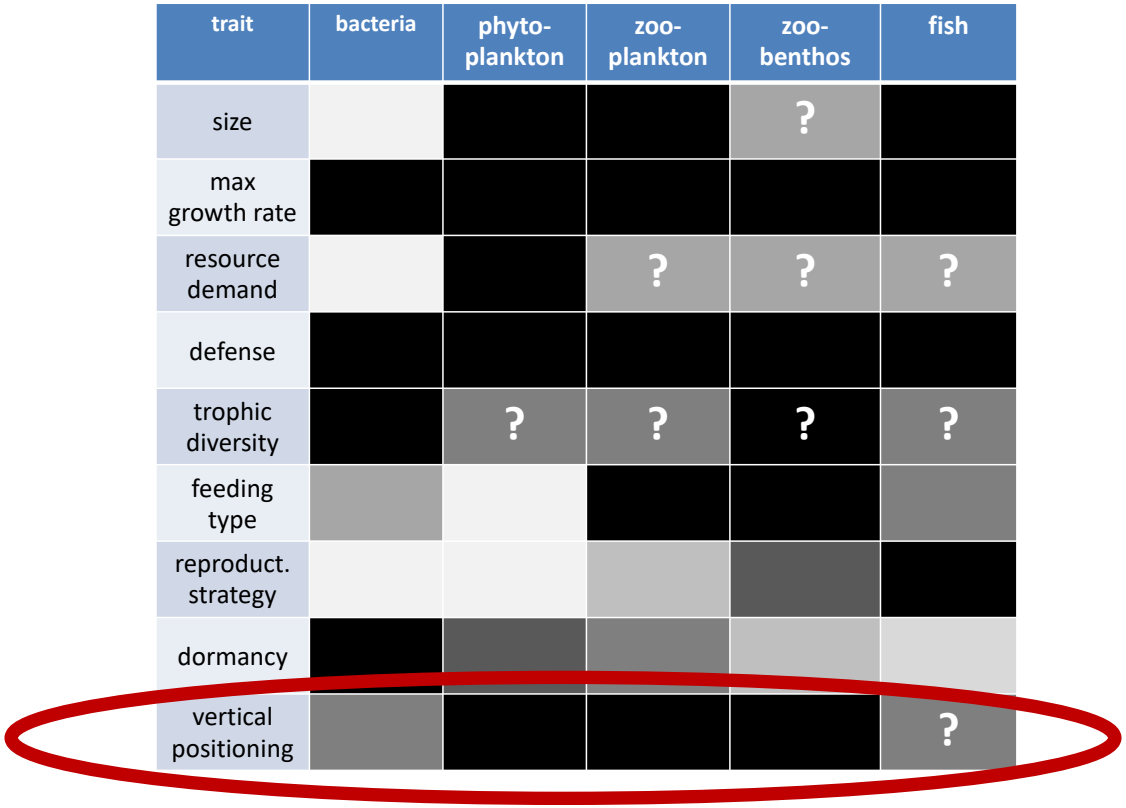
Conceptual trait-based model for macrozoobenthos



optimal prey type
maximal ingestion
edibility
body size?
shape/ protection
reproduction time
height*
?
dispersal
vertical position
feeding depth*
bottom roughness
longevity
activity
refuge depth*
(de)stabil-ization
respiration
exposure time
food affinity
bio-turbation

trait	bacteria	phyto-plankton	zoo-plankton	zoo-benthos	fish
size				?	

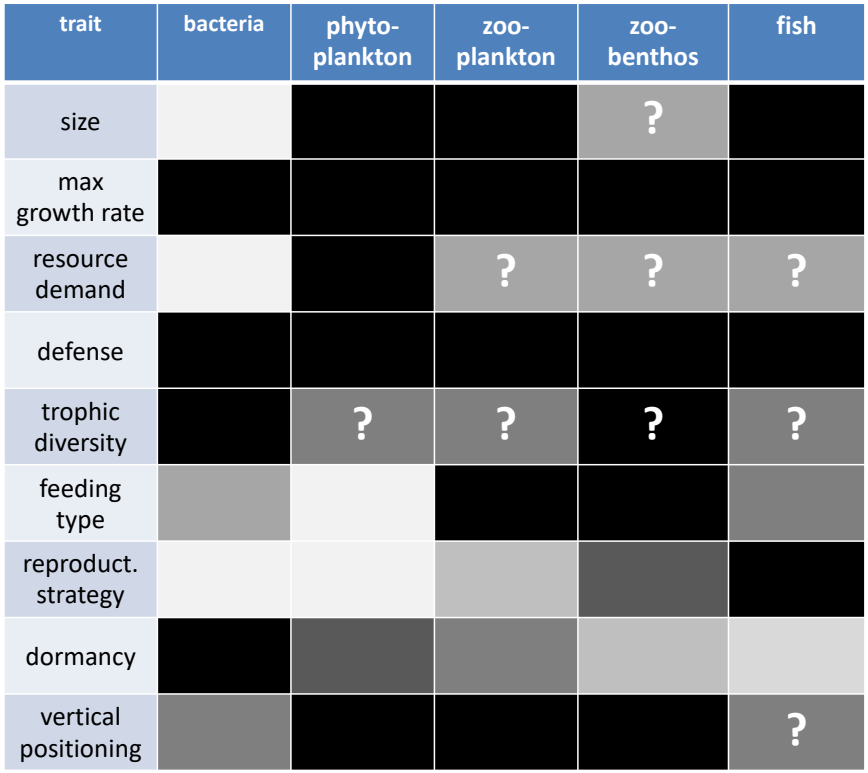
trait	bacteria	phyto-plankton	zoo-plankton	zoo-benthos	fish
size				?	
max growth rate					
resource demand			?	?	?
defense					
trophic diversity		?	?	?	?
feeding type					
reproduct. strategy					
dormancy					
vertical positioning					?



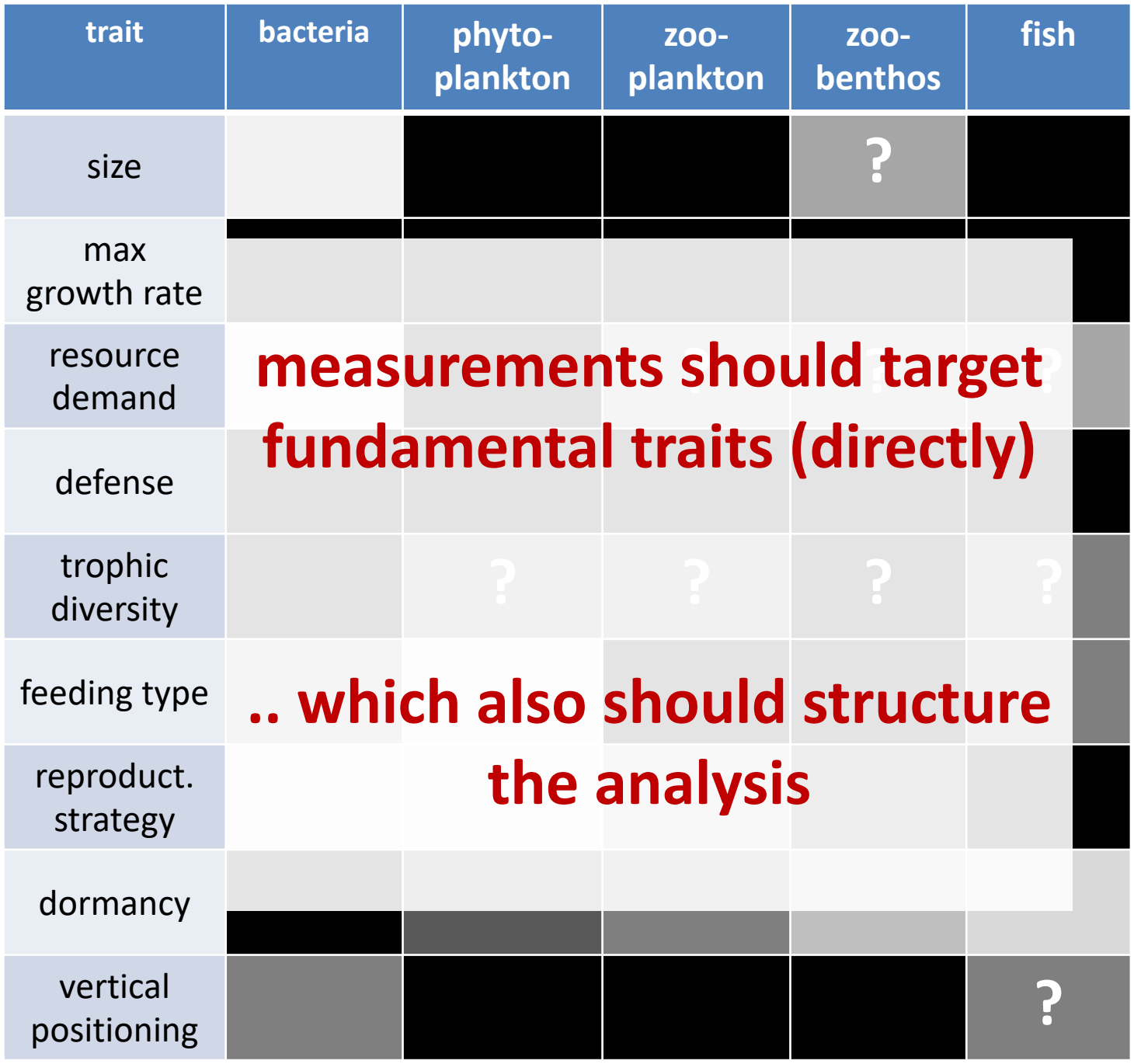
Identification of relevant fundamental traits (and related mechanisms) overlooked so far:

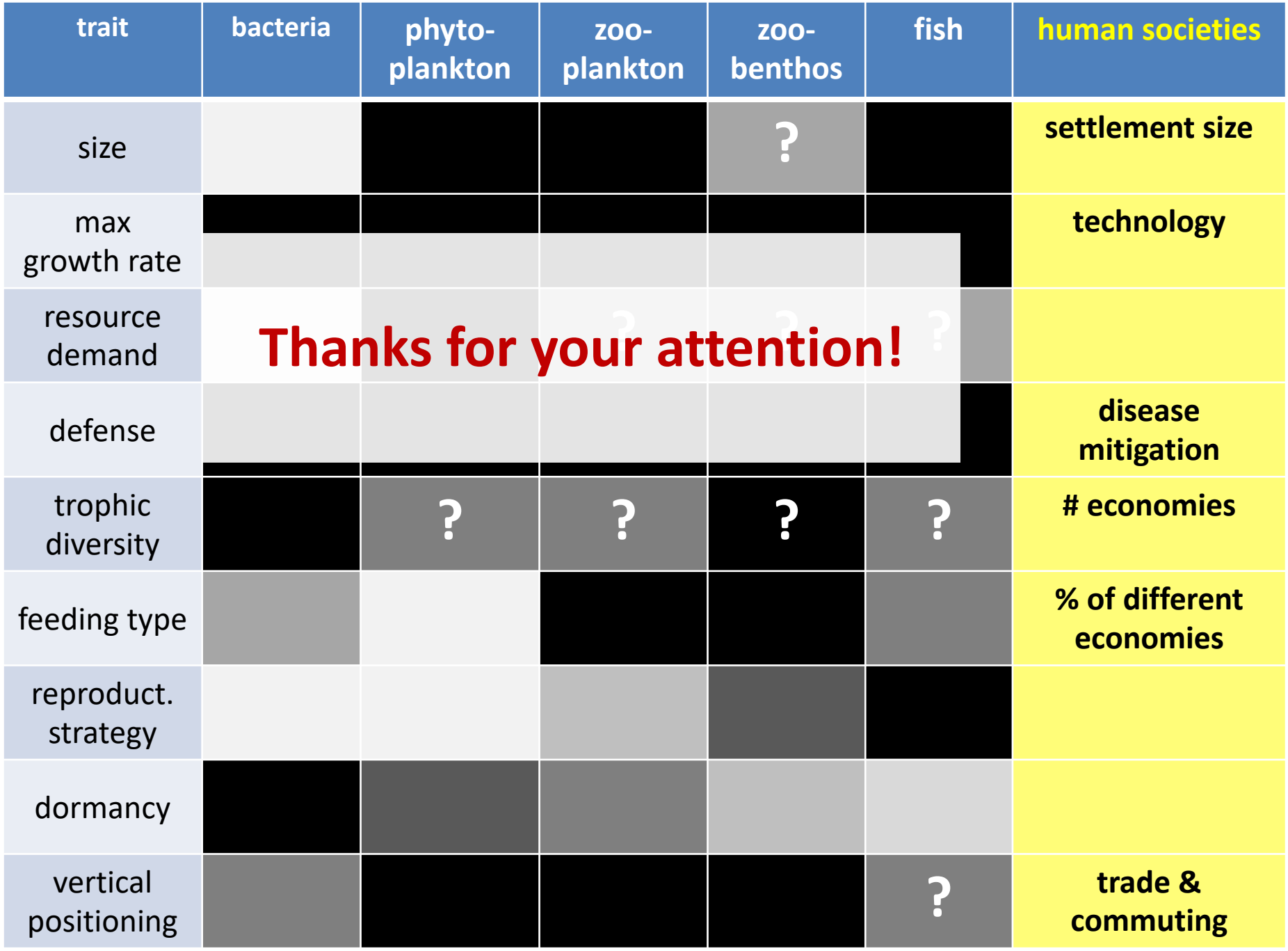
Example:

Vertical positioning in phytoplankton and zoobenthos



- **similarity in fundamental traits across taxa: general principles in the organization of (marine) life ?**
- **dissimilarity: identifies borders of functional groups**
- **trends in the relevance of key traits with organismal size**
- **trait changes in one group relate to trait changes in trophically linked group (motility - positioning, defense, feeding type of prey and predator)**


trait
bacteria
phyto-plankton
zoo-plankton
zoo-benthos
fish
size
max growth rate
resource demand
defense
trophic diversity
feeding type
reproduct. strategy
dormancy
vertical positioning
?
measurements should target fundamental traits (directly)
.. which also should structure the analysis


trait
bacteria
phyto-plankton
zoo-plankton
zoo-benthos
fish
human societies
size
?
settlement size
max growth rate
technology
resource demand
Thanks for your attention!
defense
disease mitigation
trophic diversity
?
?
?
?
economies
feeding type
% of different economies
reproduct. strategy
dormancy
vertical positioning
?
trade & commuting