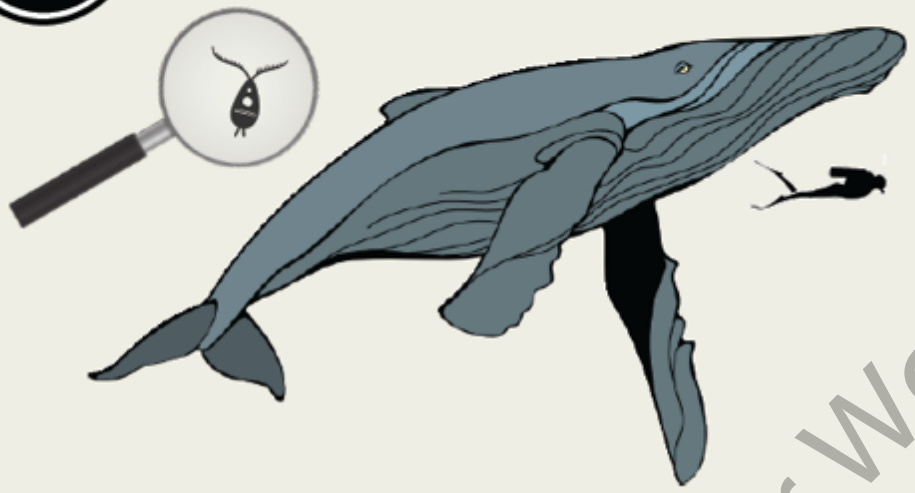
Allometric Scaling!

1

Works across a wide range of species!



2

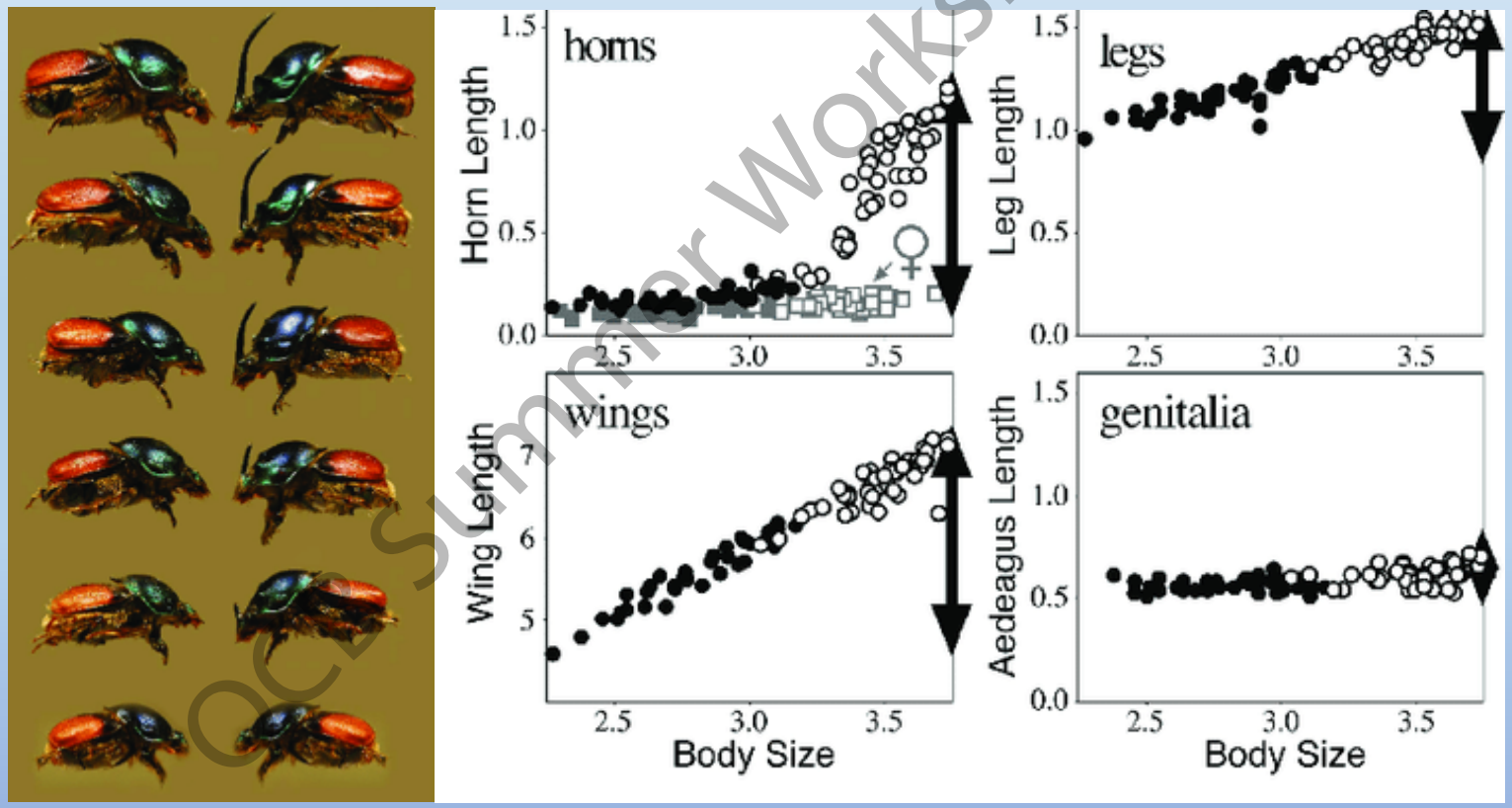
Easy to calculate!

3

Insufficient to adequately capture all important physiological variability

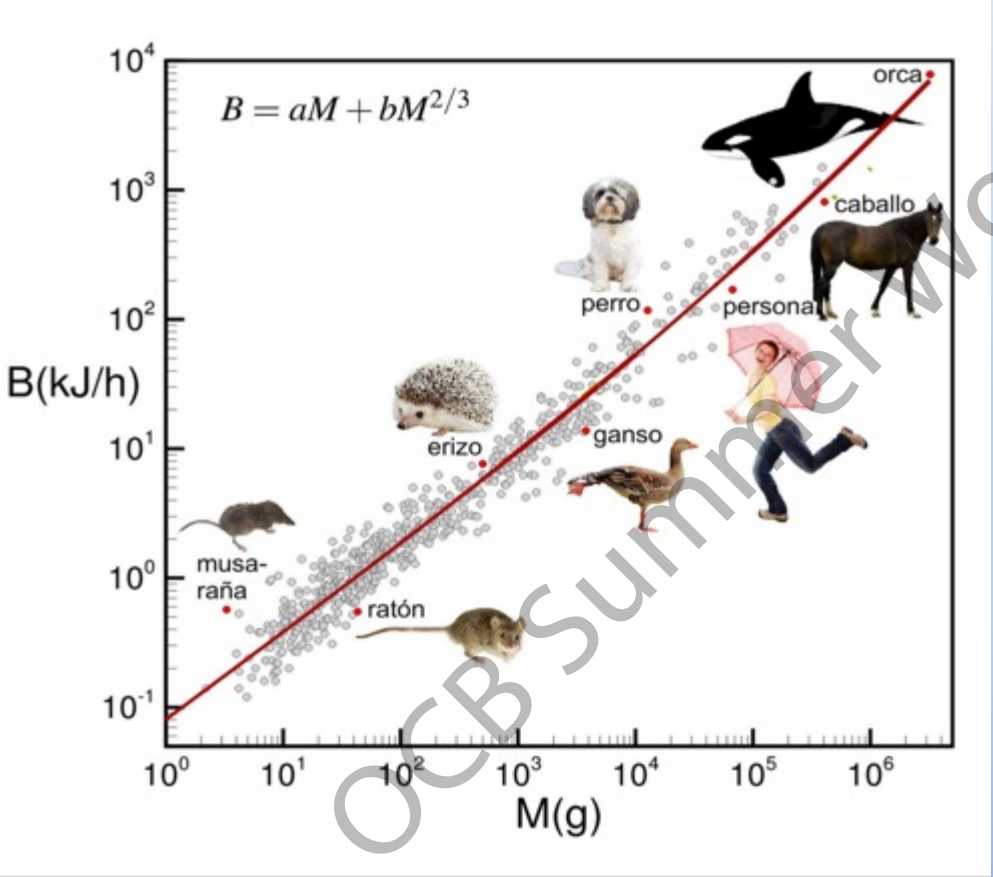
Allometry

When a trait relates (scales) in a predictable way to size. Often not linearly.



Allometric Scaling

$$Metabolic\ Rate = constant\ (Mass^{scaling\ exponent})$$



Kleiber-Ballesteros et al (2018)

There is debate about the exponent and about how many parameters the function should have.

This is not what this session is about. 😊

Why it works

For metabolism we think (argue amongst ourselves) that allometric scaling is due to:

- the physics of nutrient delivery/diffusion as limited by Surface Area to Volume constraints
- resource-transport network limitations
- energy loss due to entropy and system complexity.

What we use it for

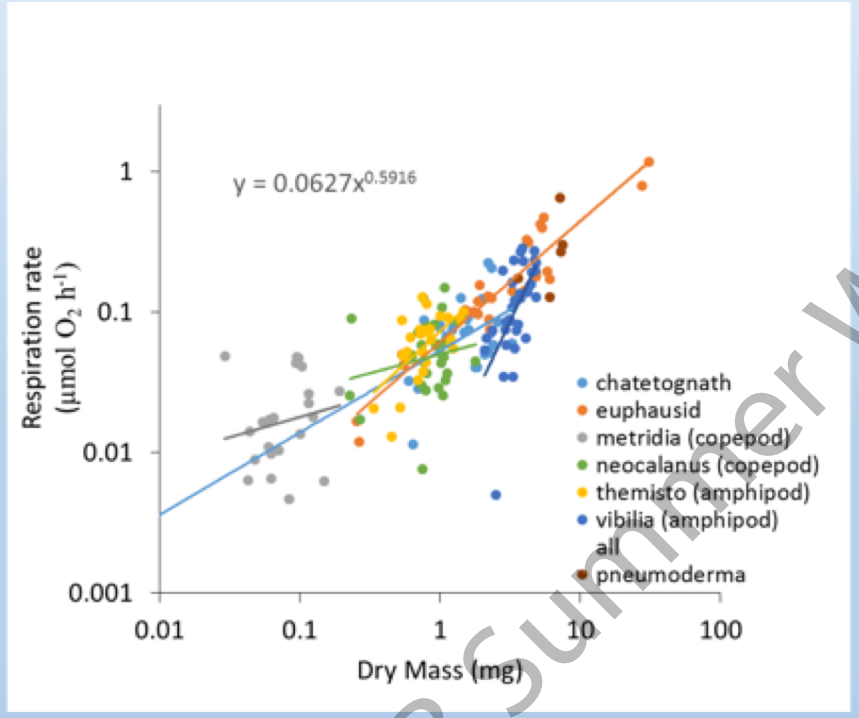
Scaling up!

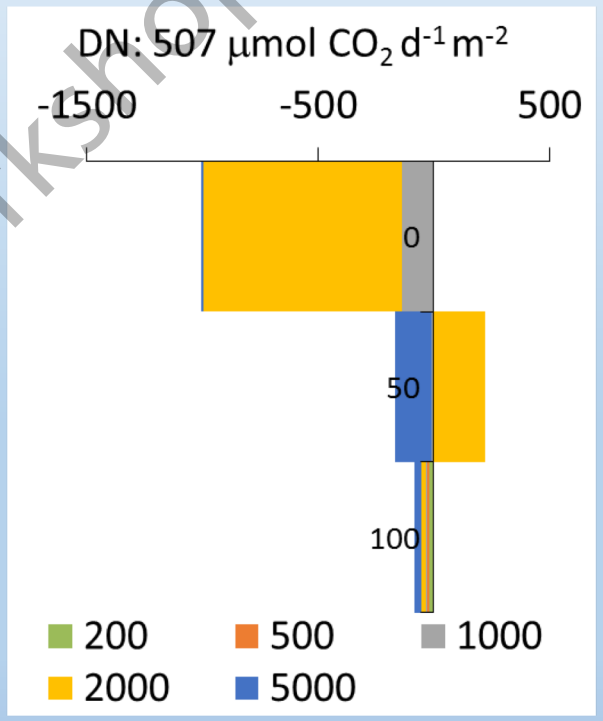
We have limited time and money to make measurements and we want to predict complex patterns.

Allometry helps us do this

What we use it for

Metabolism (O_2 use, CO_2 excretion)



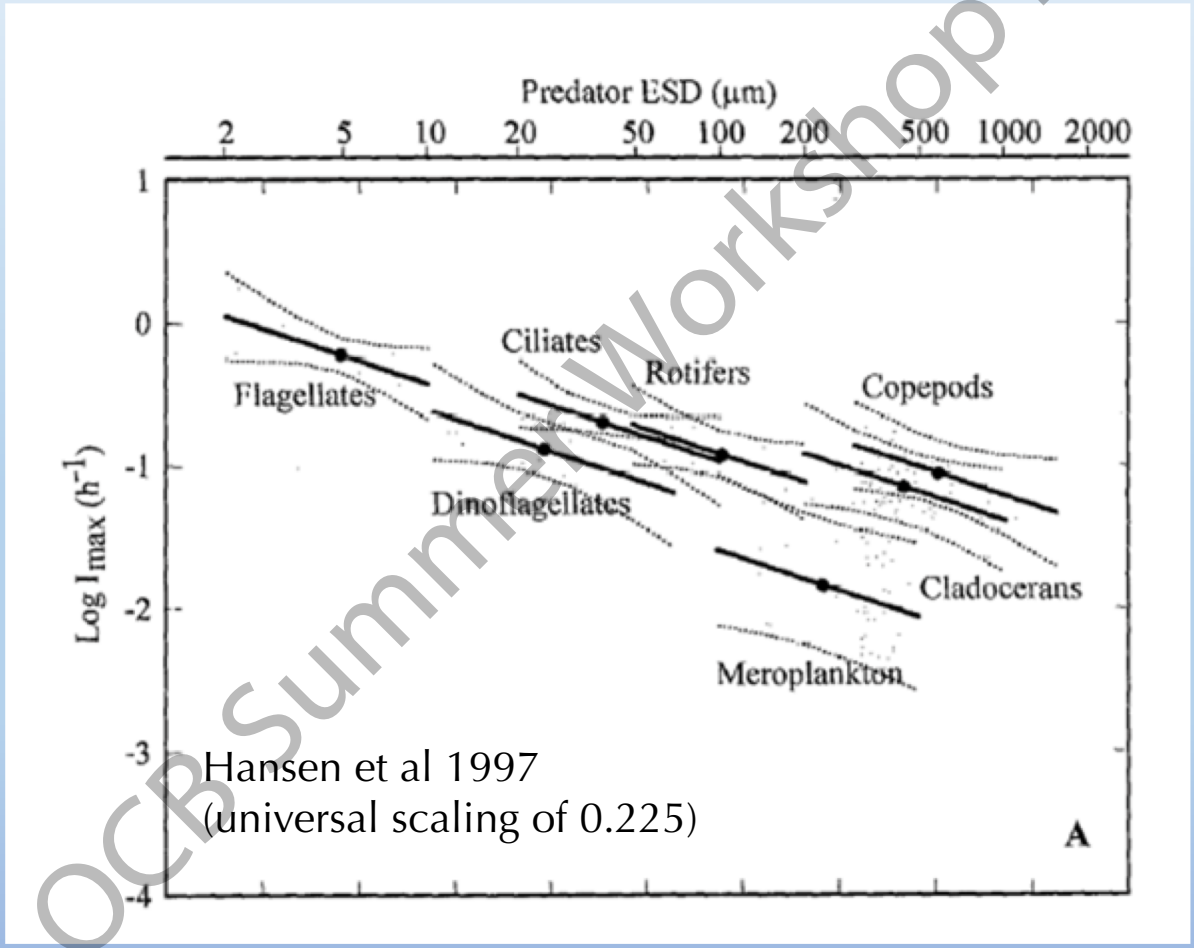


Maas et al (in prep)

EXPORTS

What we use it for

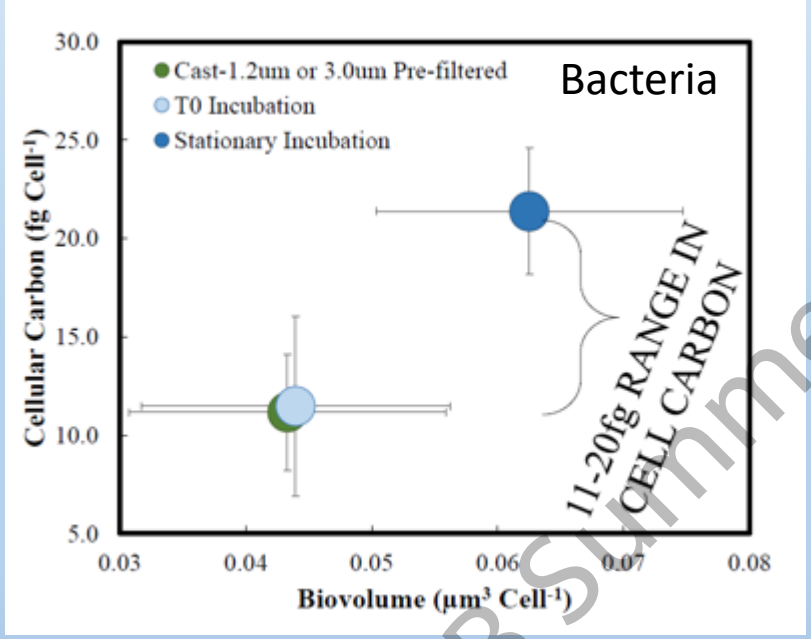
Grazing Rates



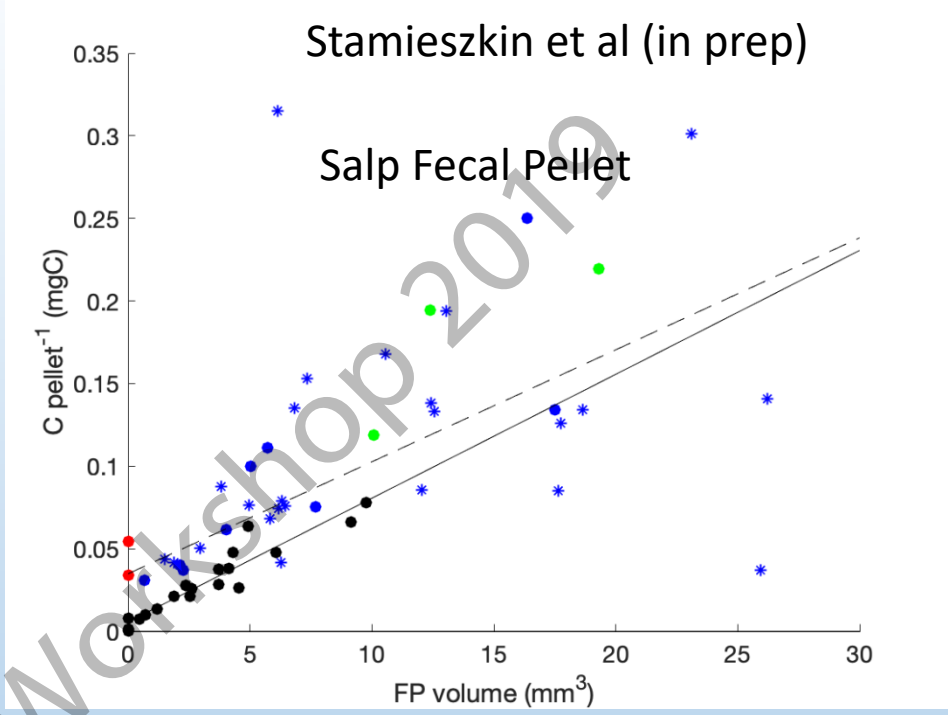
Hansen et al 1997
(universal scaling of 0.225)

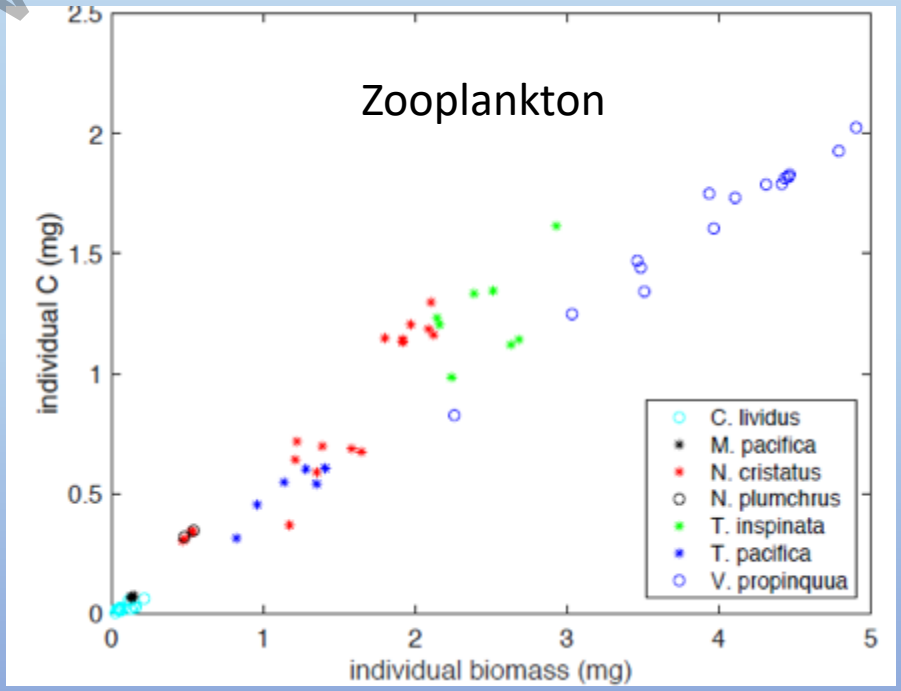
What we use it for

Carbon Content



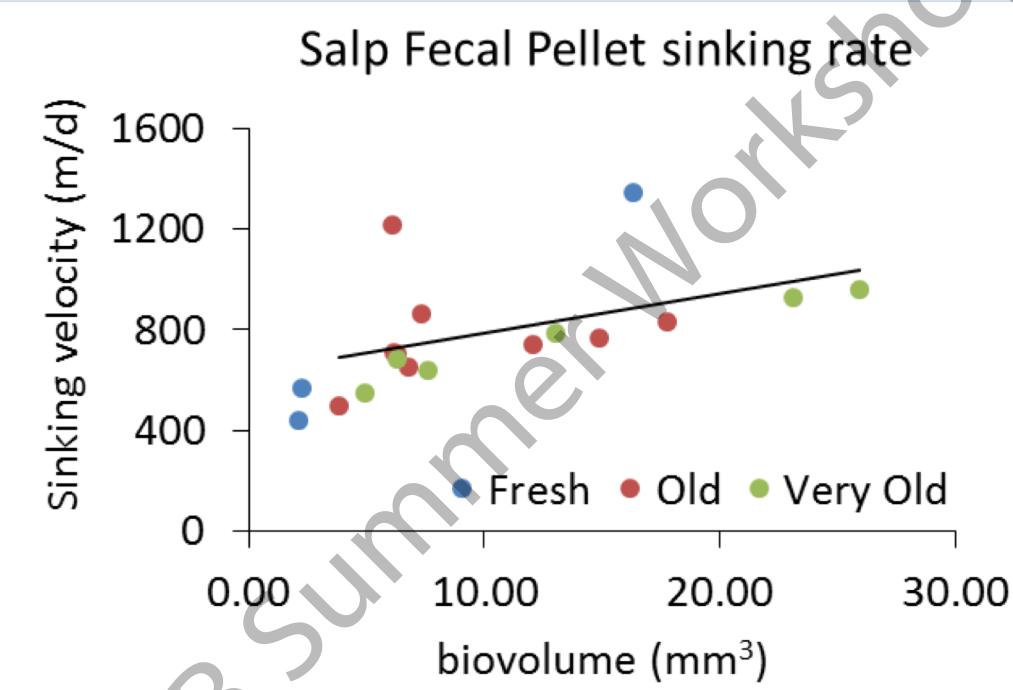
Stephens and Carlson (in prep)





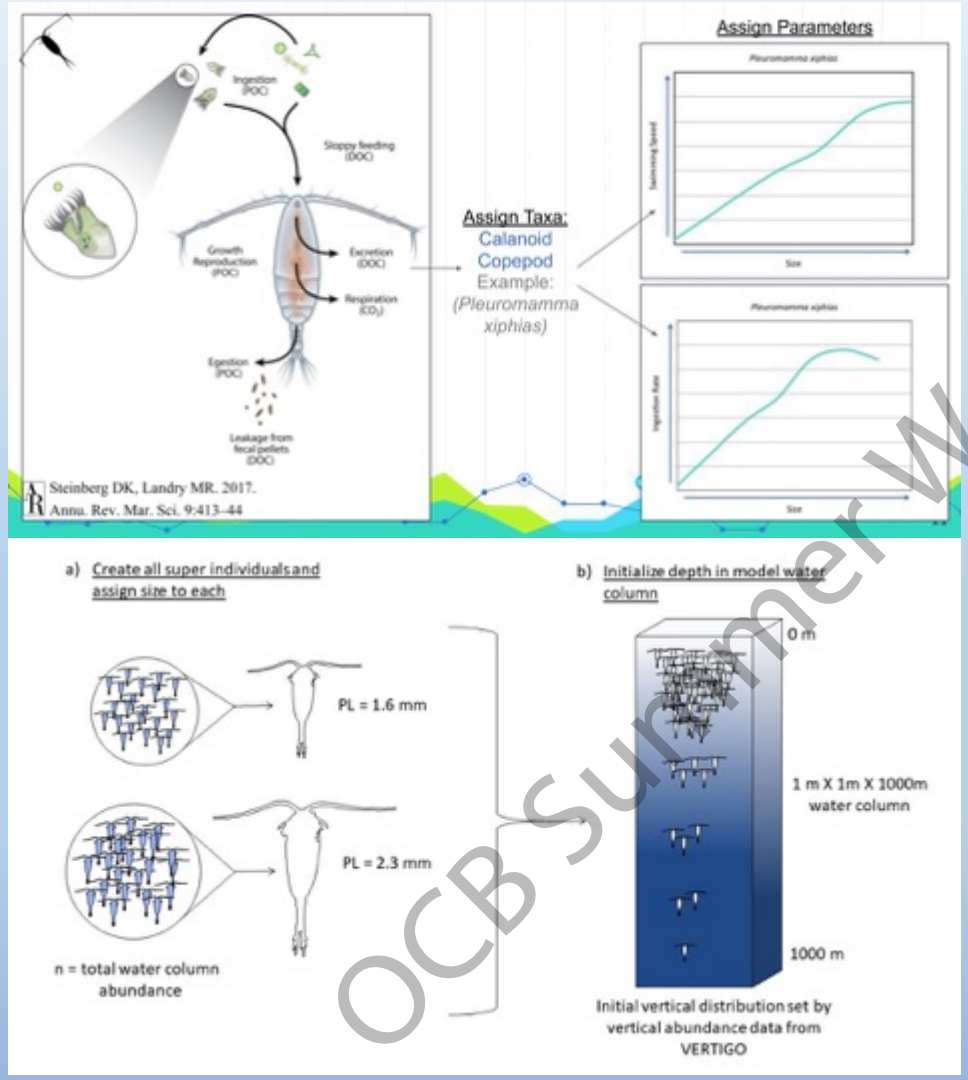
What we use it for

Sinking Rates

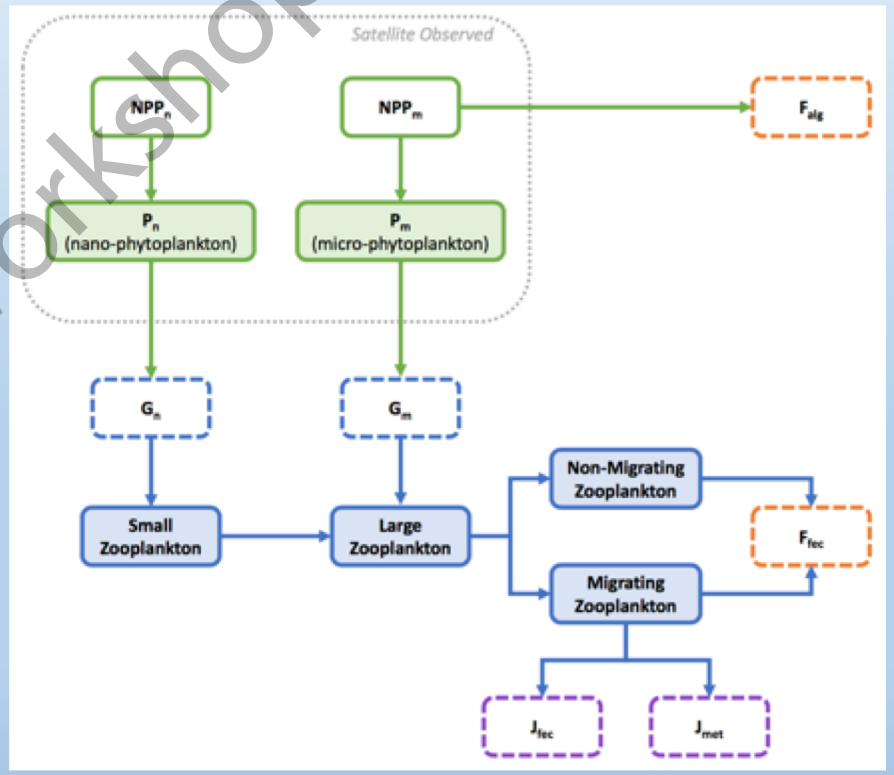


Passow et al (in prep)

Then we use it to model



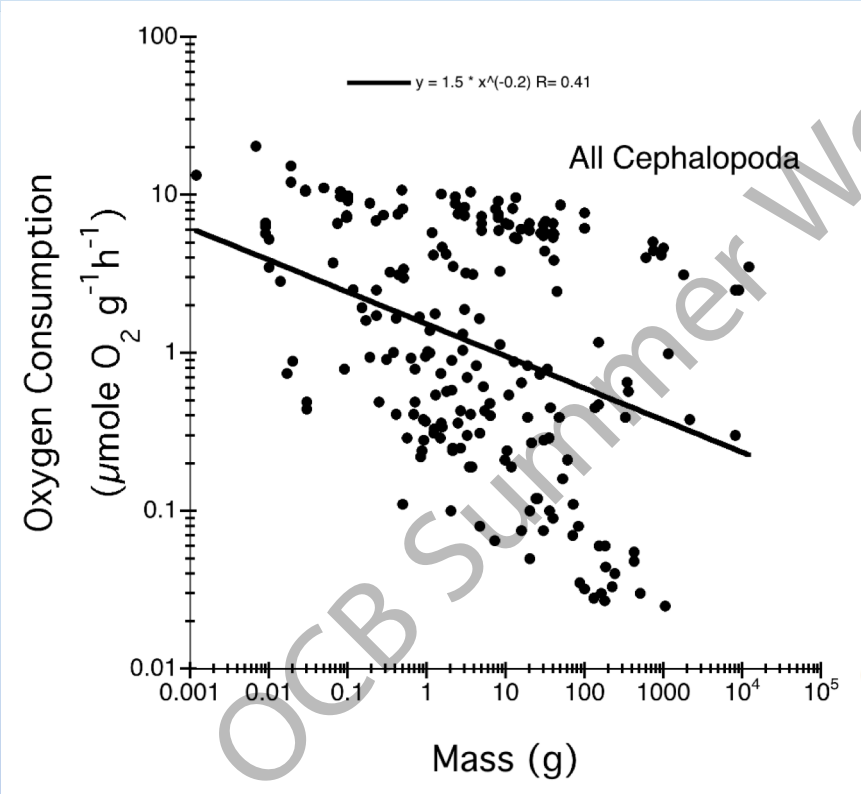
Countryman et al. in prep.



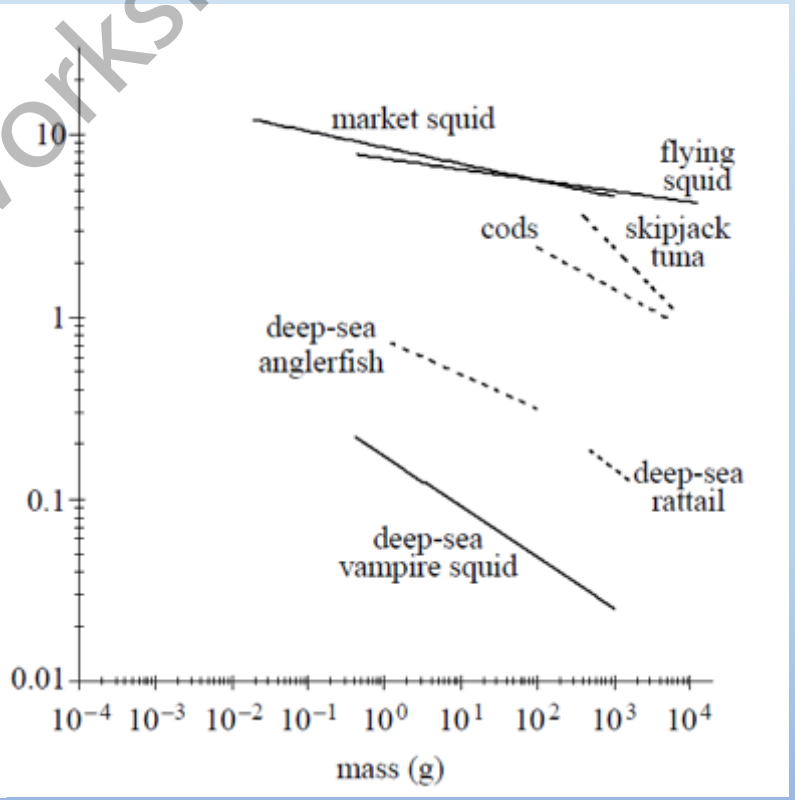
Archibald et al. 2019

Why (we think) it needs more thought

Ecosystem level deviations due to: taxonomy and habitat.



Seibel (personal comm)



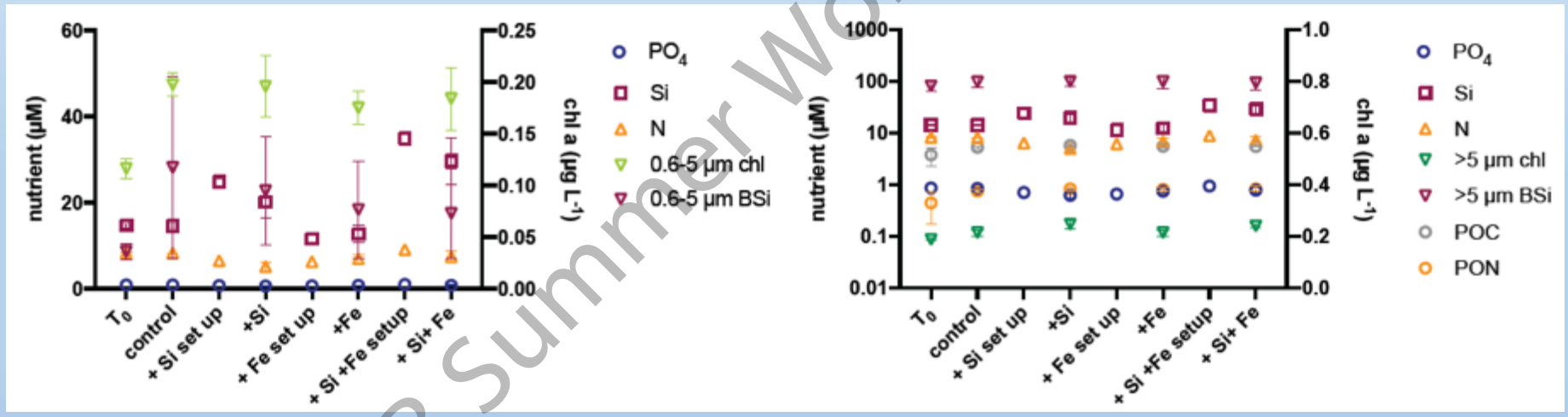
Seibel and Drazen (2007)

Why (we think) it needs more thought

Individual level deviations due to:
Developmental stage, substrate stress, etc.

0.6-5 µm fraction

> 5 µm fraction



Changes in phytoplankton due to nutrient additions

Brzezinski, Jenkins, et al (in prep)

Might size sometimes just be a covariate?

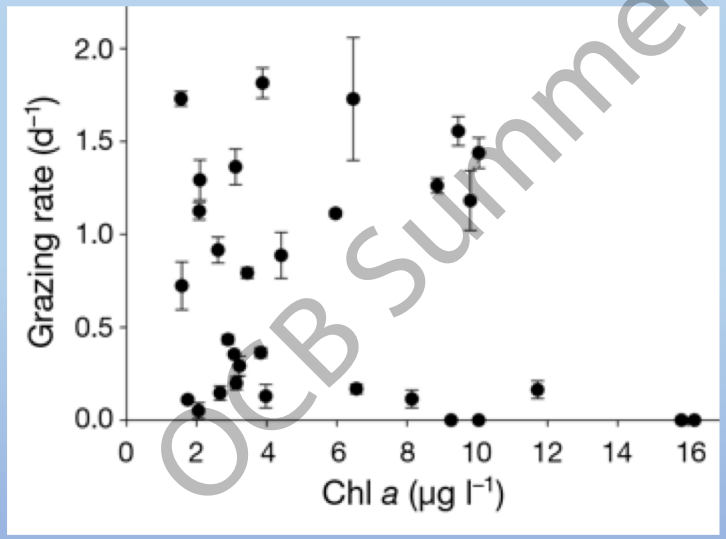
Size versus Grazing Rate - feeding type matters

The “apparent” size of a larvacean (its house) is much bigger than the animal itself.

Why this is still a conversation

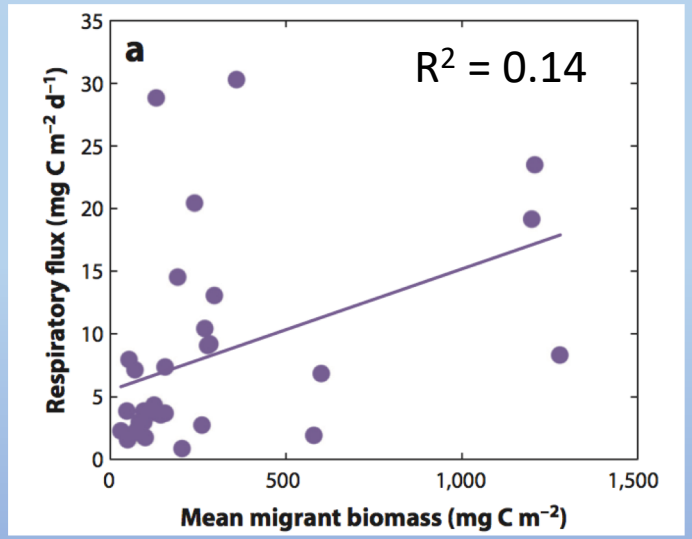
We use the simplest explanation describing our data, and then try to scale to the future earth system. And it does not work (based on broader observed data).

Phytoplankton "biomass" to grazing rate



Lawrence & Menden-Deuer 2012

Zooplankton biomass to export flux



Steinberg & Landry 2017

Why this is Important Now

Lots more optical sampling devices (and informatics processing pipelines) which lets us rapidly measure size class in the ocean

IFCB

Flow Cam

In-Line Flow Cytometry

UVP

Zooscan

OTZ Deep-See

Why this is Important Now

Recent large field campaigns whose sampling design and objectives are to link observations to models providing ecosystem scale products (NAAMES, EXPORTS).

These are opportunities to really test how much allometry actually captures and to determine which other traits best improve our predictions AND to implement them.

Traits

Any character that can be used to describe an important life history, ecological or biogeochemical niche

Examples:

- Size
- Depth Range
- Trophic Position/Type

Going Forward

Goals:

Expand the usefulness of allometry to other applications

Capture more of the variability that contributes to ecosystem function using traits

Understand when size is a “nuisance variable” (covariate) rather than driving the observed patterns

Going Forward

Methods:

Explore real world cross talk between model, experimental and in situ observations

Understand the mechanisms driving the covariation with size to apply them more broadly when the work or add the underlying trait when they don't

Your Job

Test your assumptions about allometry! Where can we use it more and where SHOULD we use it less?

Think about interesting alternative traits or applications.