Behavior in Marine Plankton: mechanisms, tradeoff and population implications

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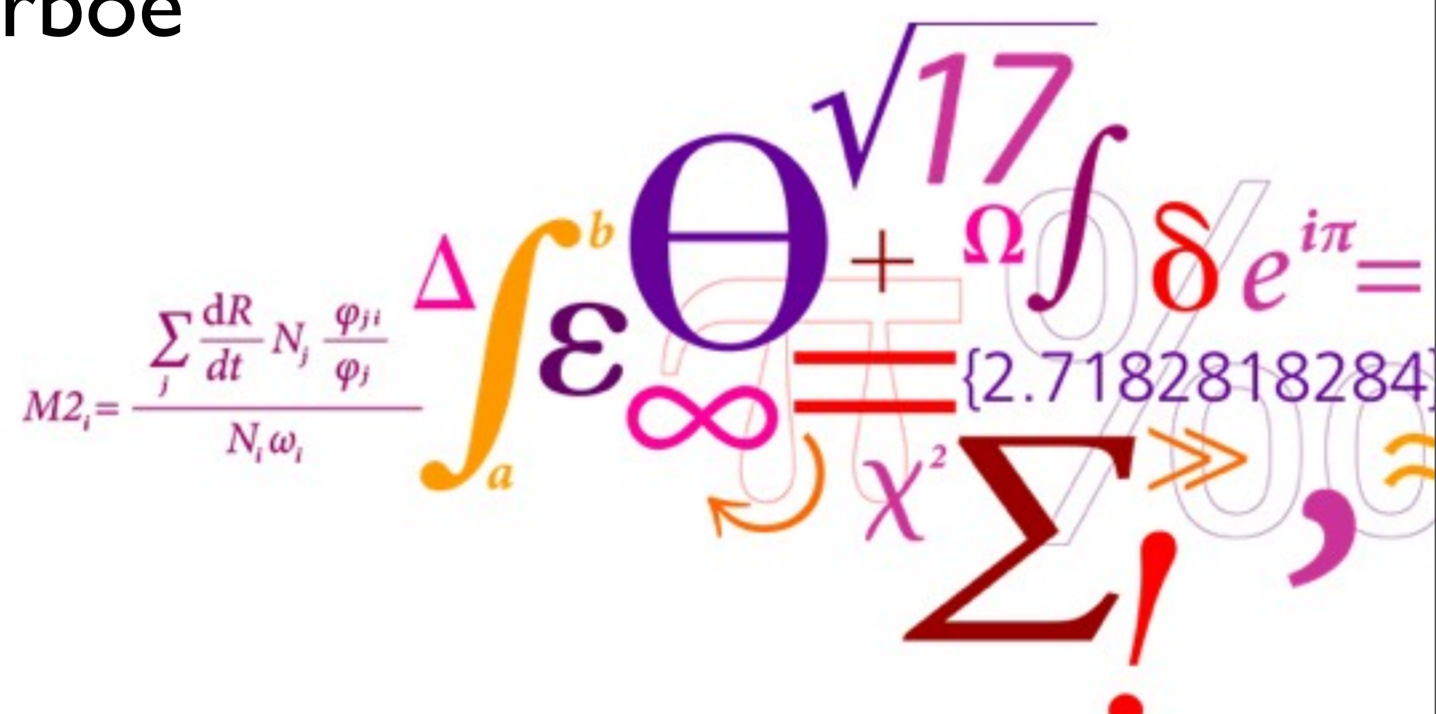


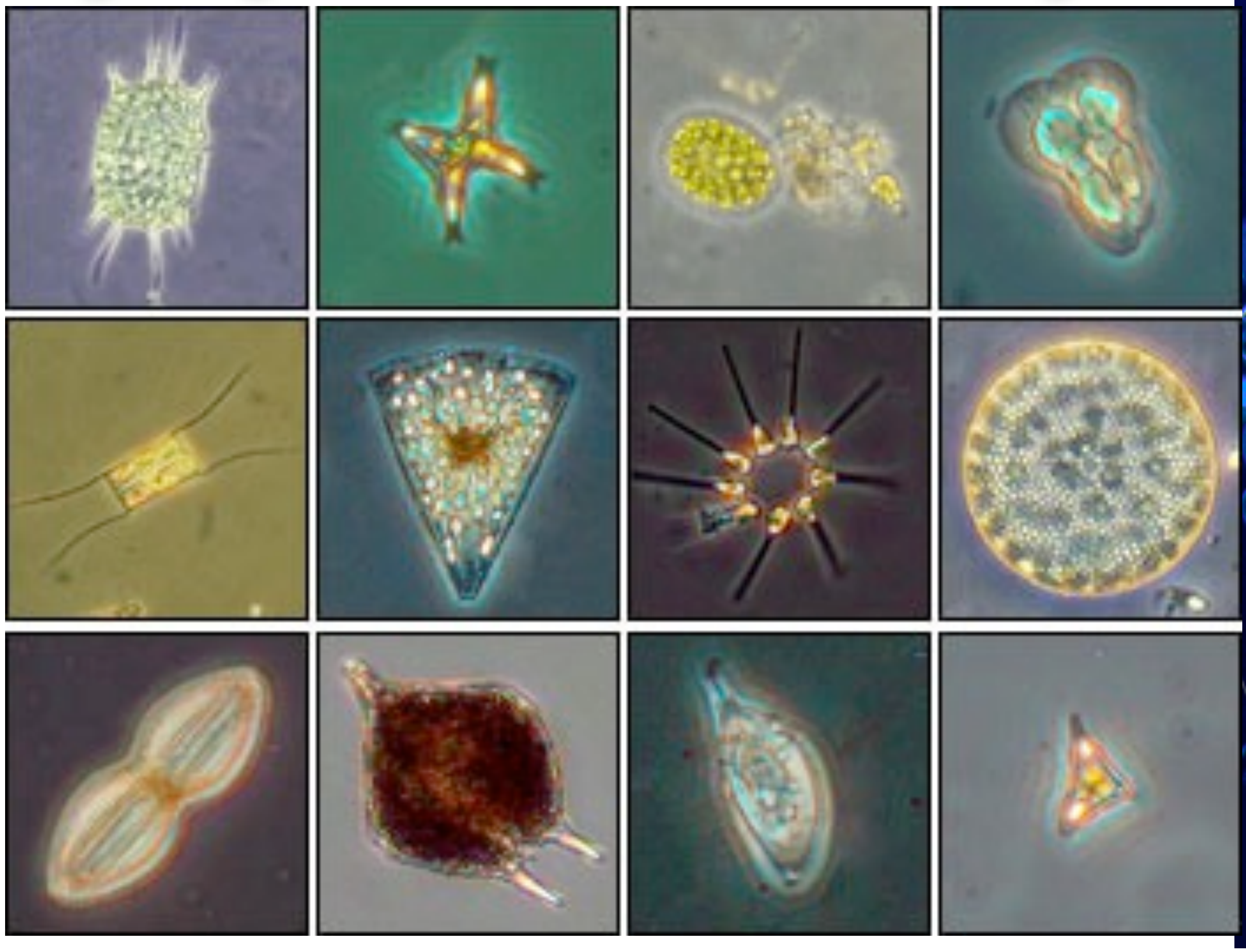
Outline

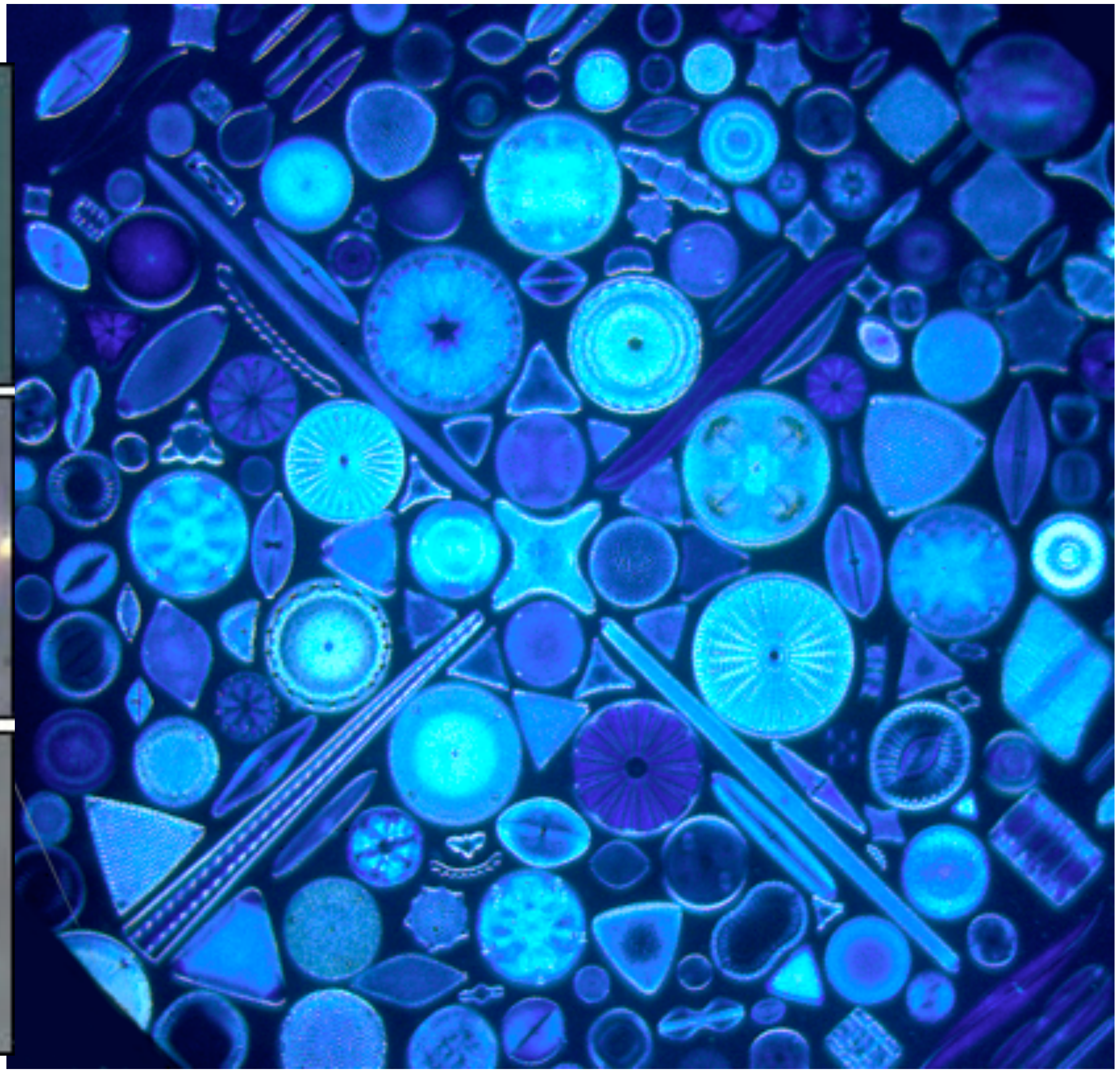
- Plankton life forms and diversity
- Zooplankton behavior (observations, and implications)
- Consequences of behavior in plankton communities

Phytoplankton diversity

Image Credit: *Smithsonian Environmental Research Center*

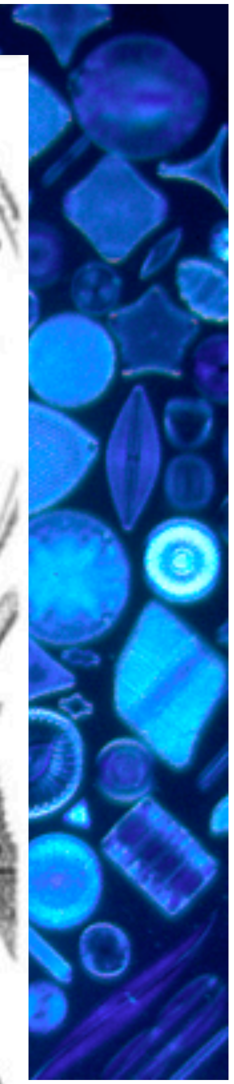
Phytoplankton diversity





Crawford/Hinz

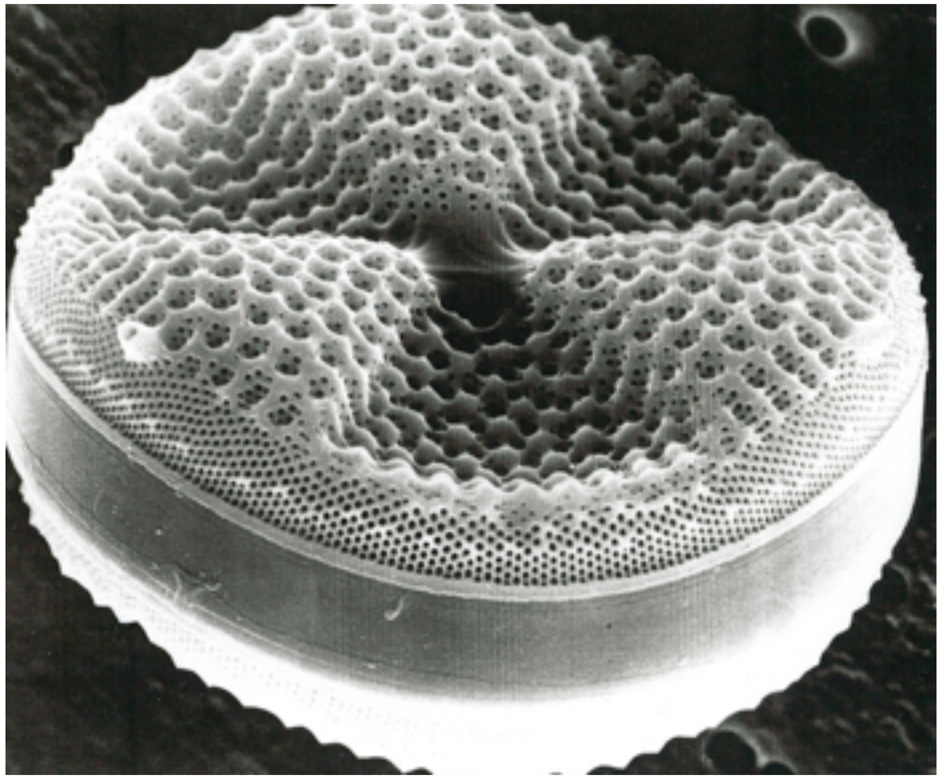
Phytoplankton diversity



Crawford/Hinz

Haeckel "*Art forms of* Nature", 1904 From: Hamm & Smetacek 2007 - Armor : Why, When and How

Co-evolution of attack and defense systems
"Plankton arms race"



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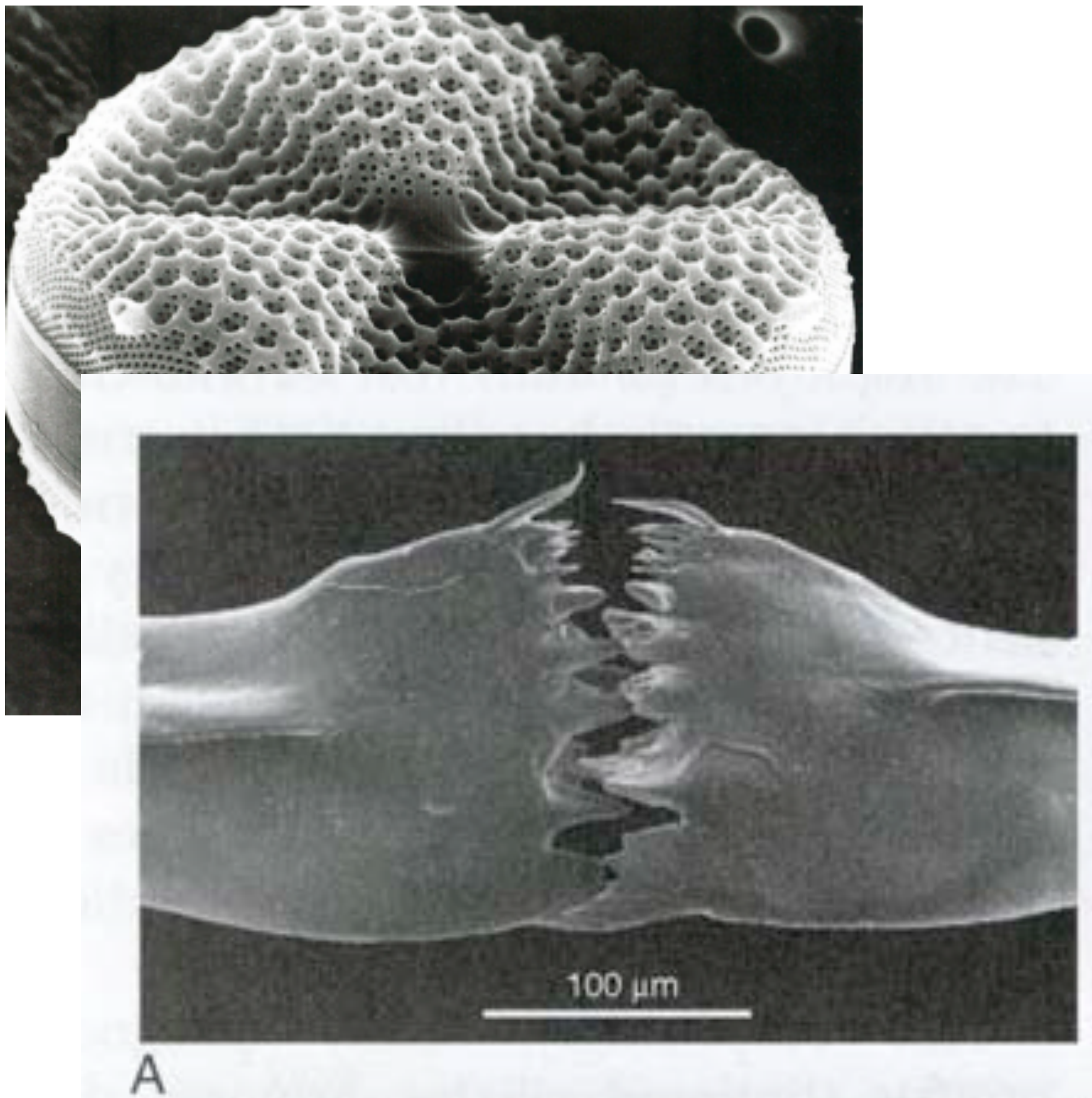

Co-evolution of attack and defense systems
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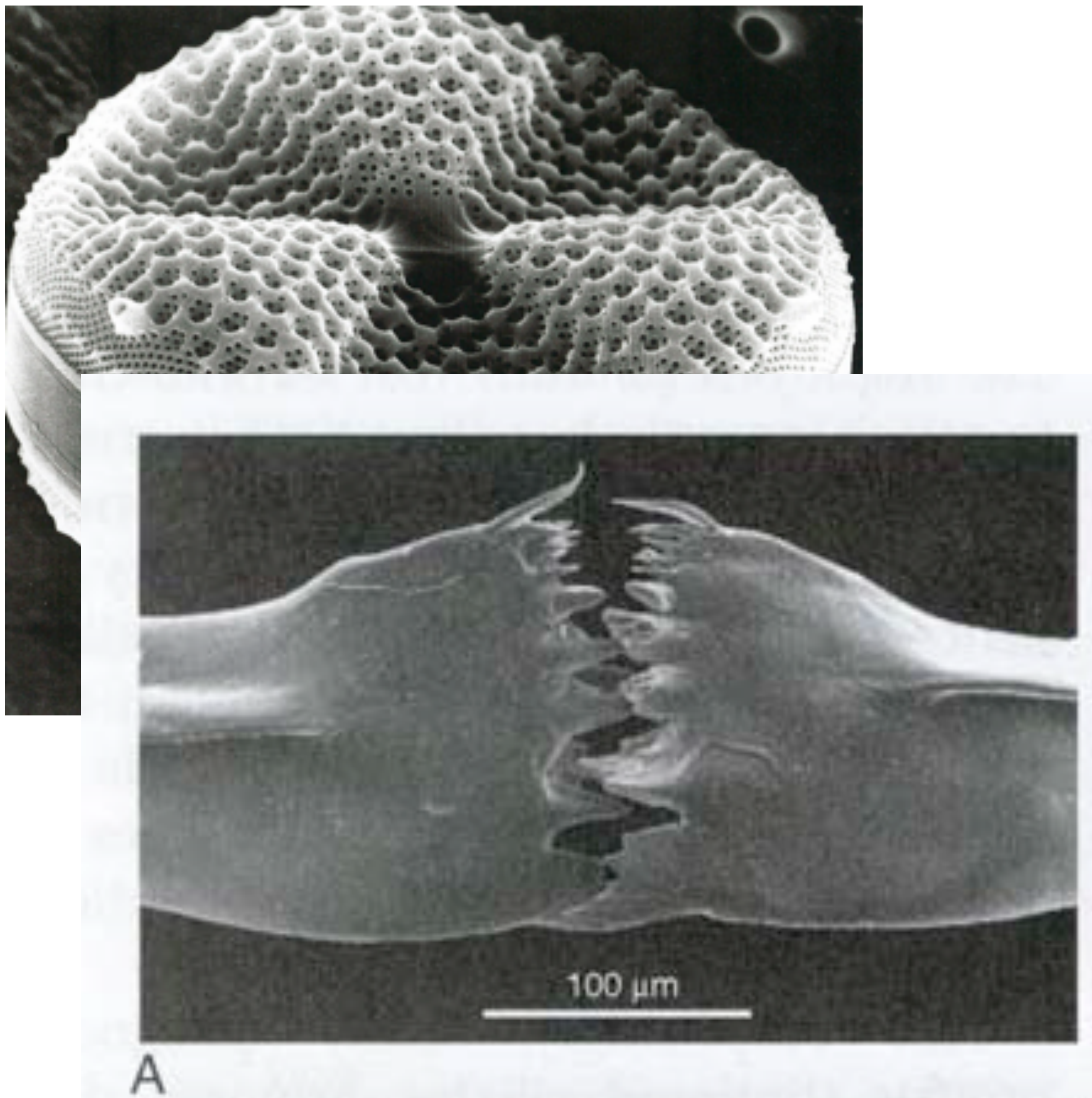
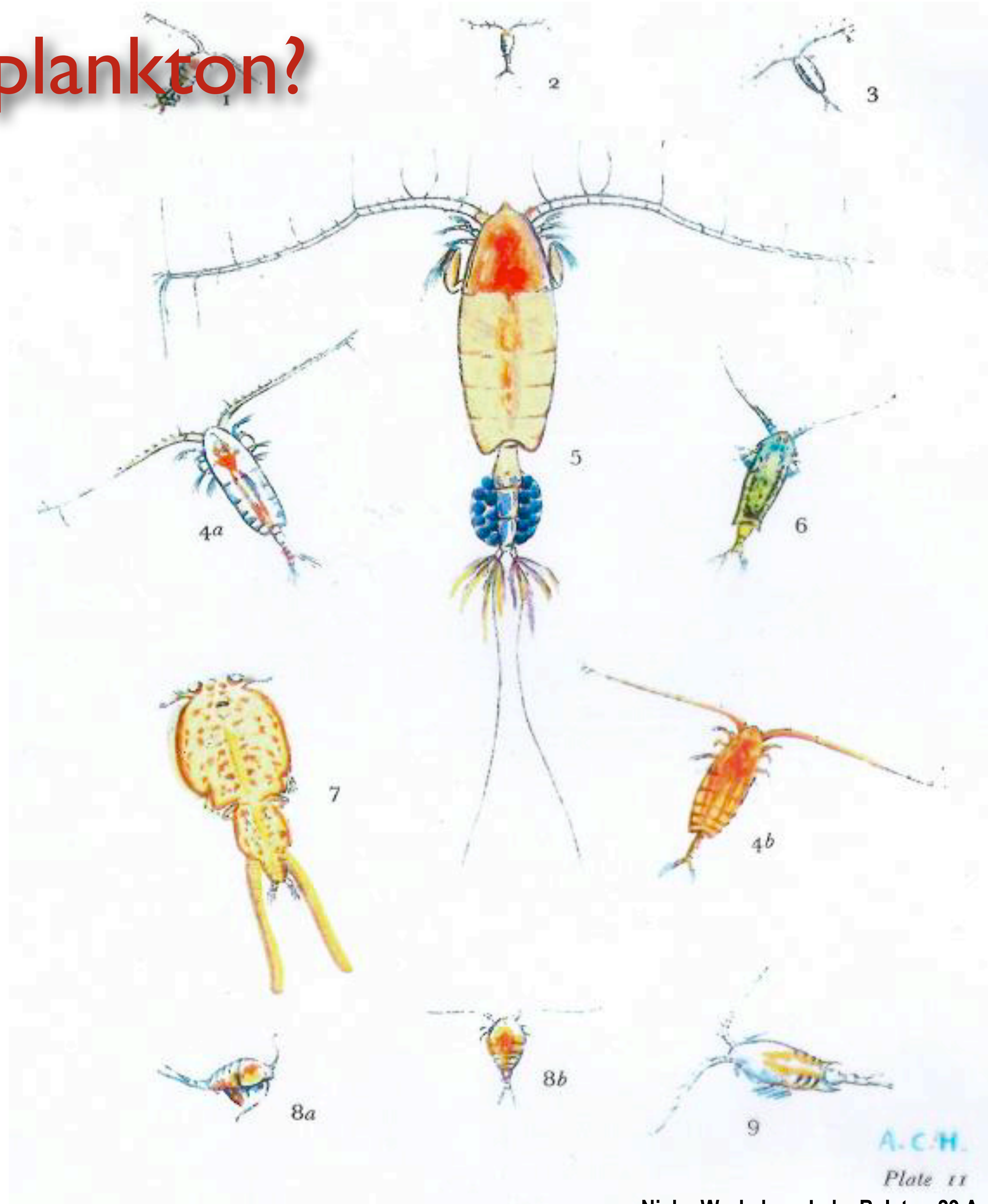


Plankton evolution is mainly ruled by protection.
The many shapes of plankton reflect defense responses to specific attack systems ranging from pathogens, parasitoids to predators. (Smetacek, 2001 - Nature 411: 745)

What about zooplankton?



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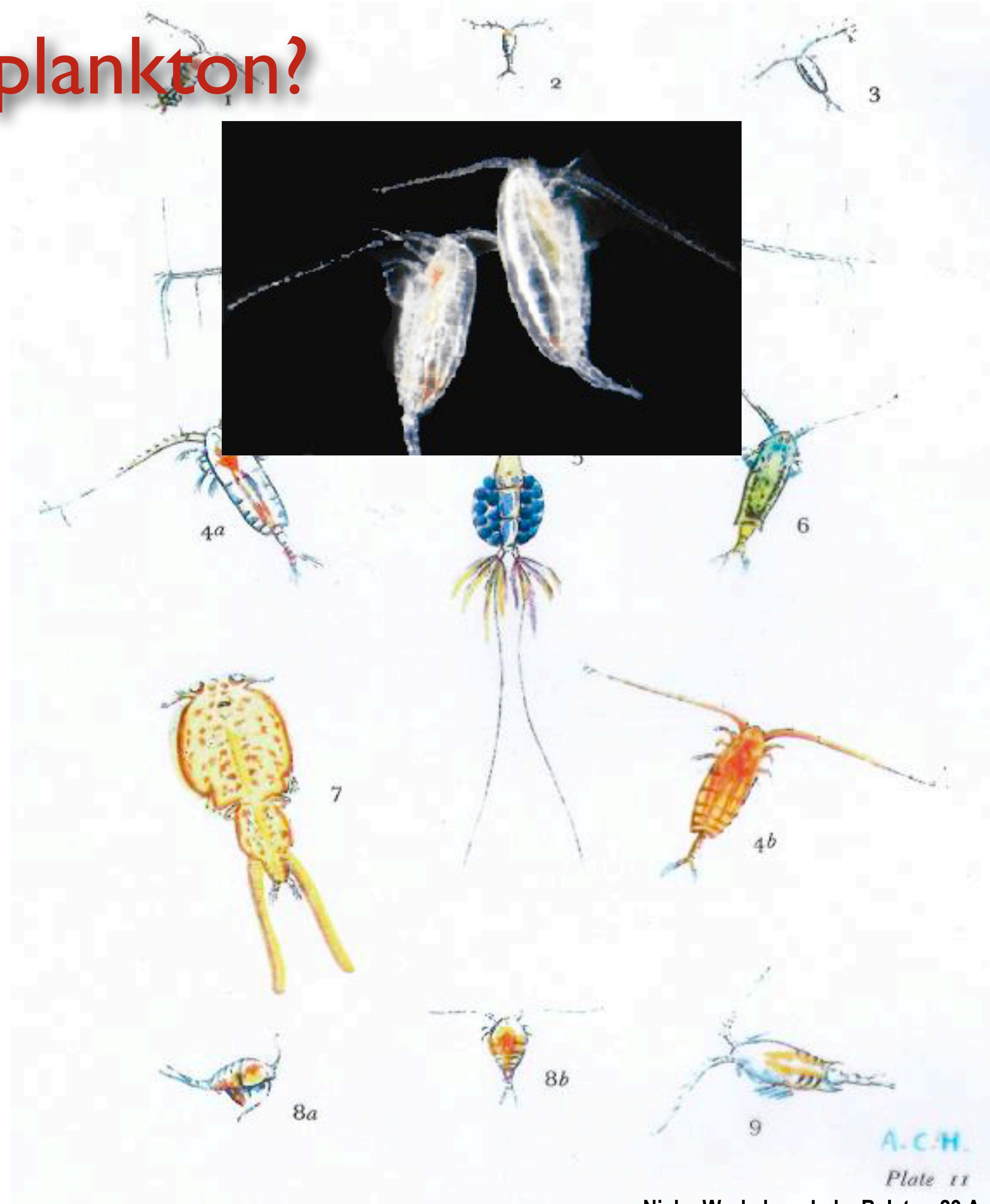

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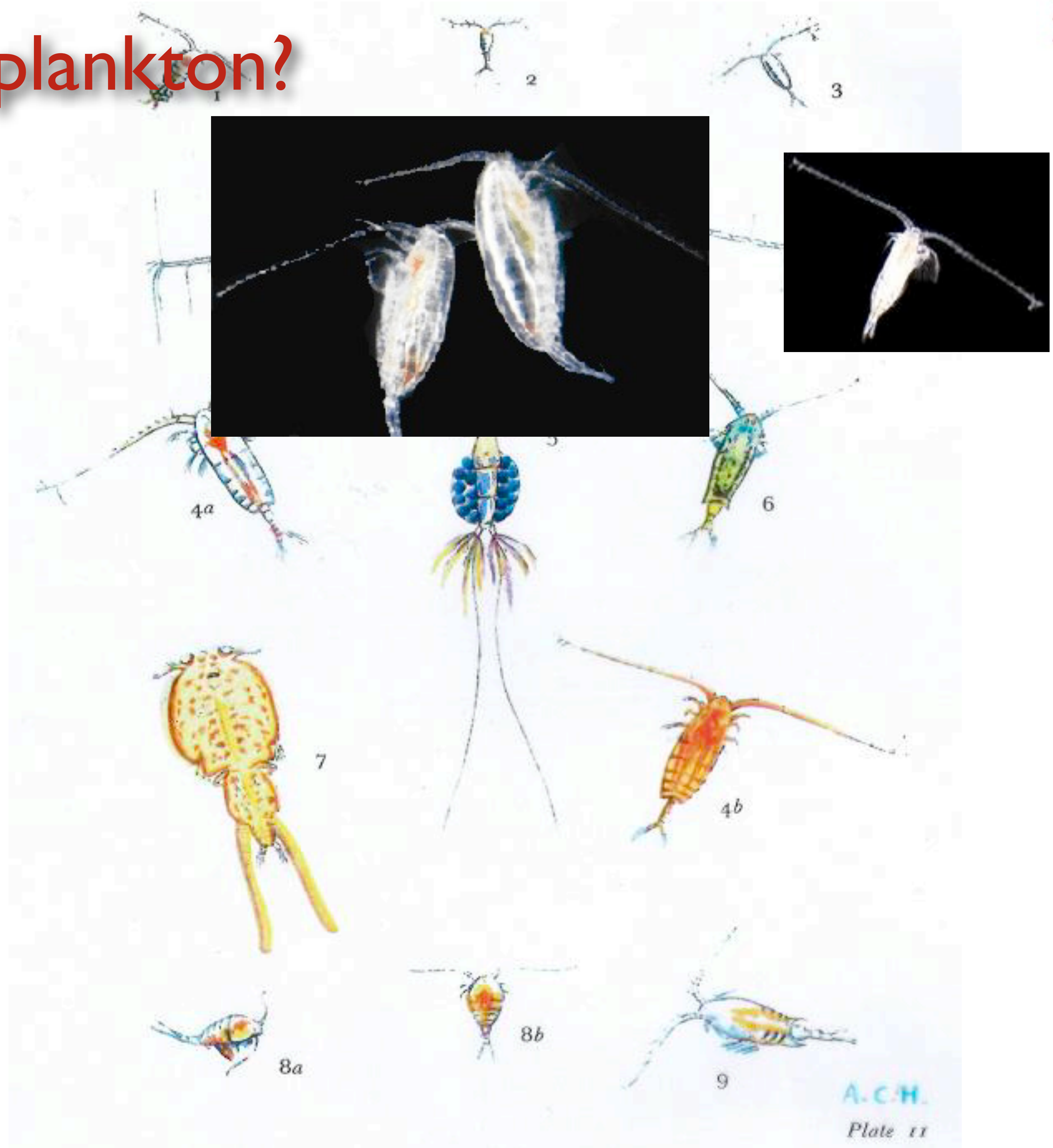

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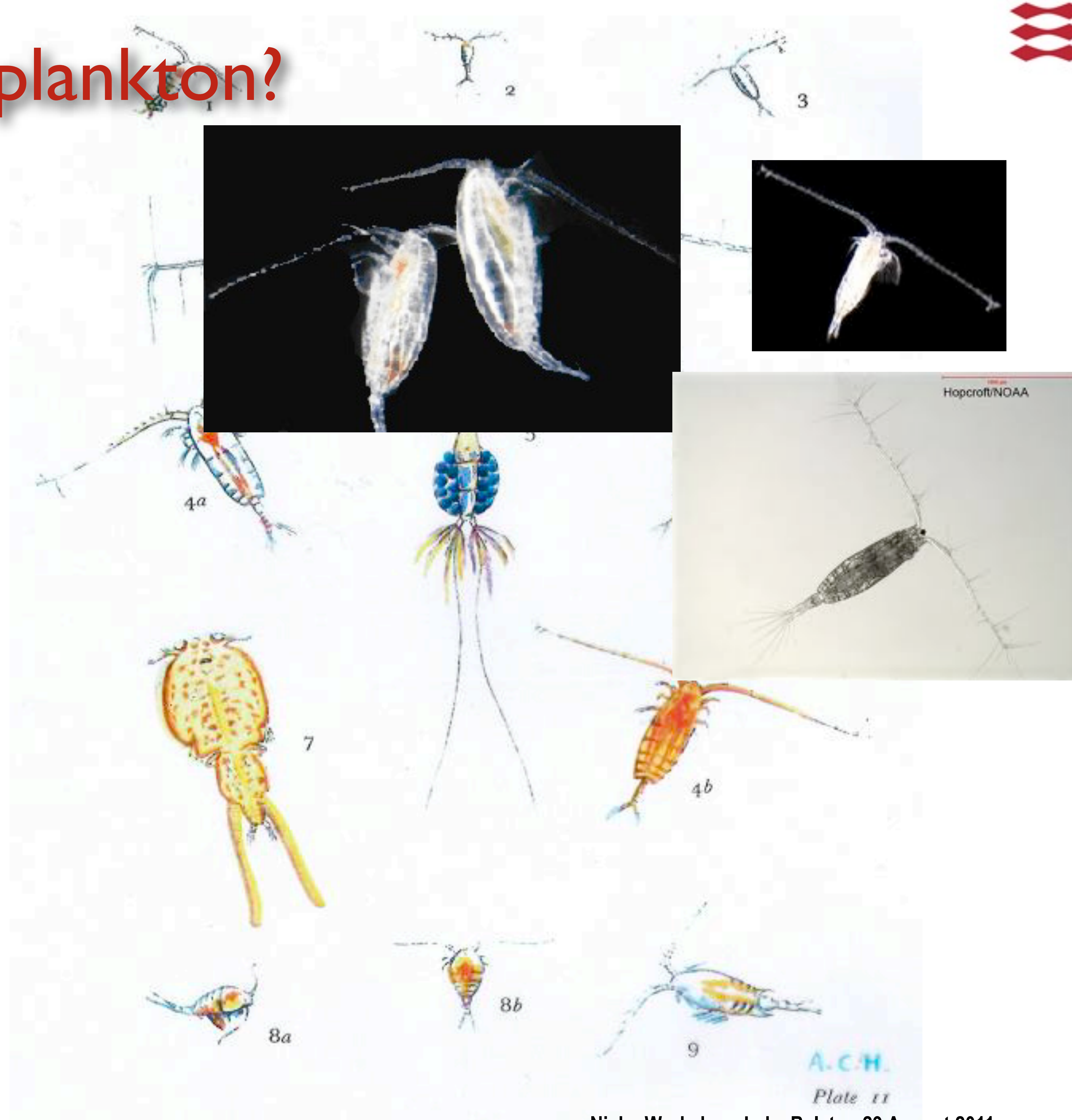
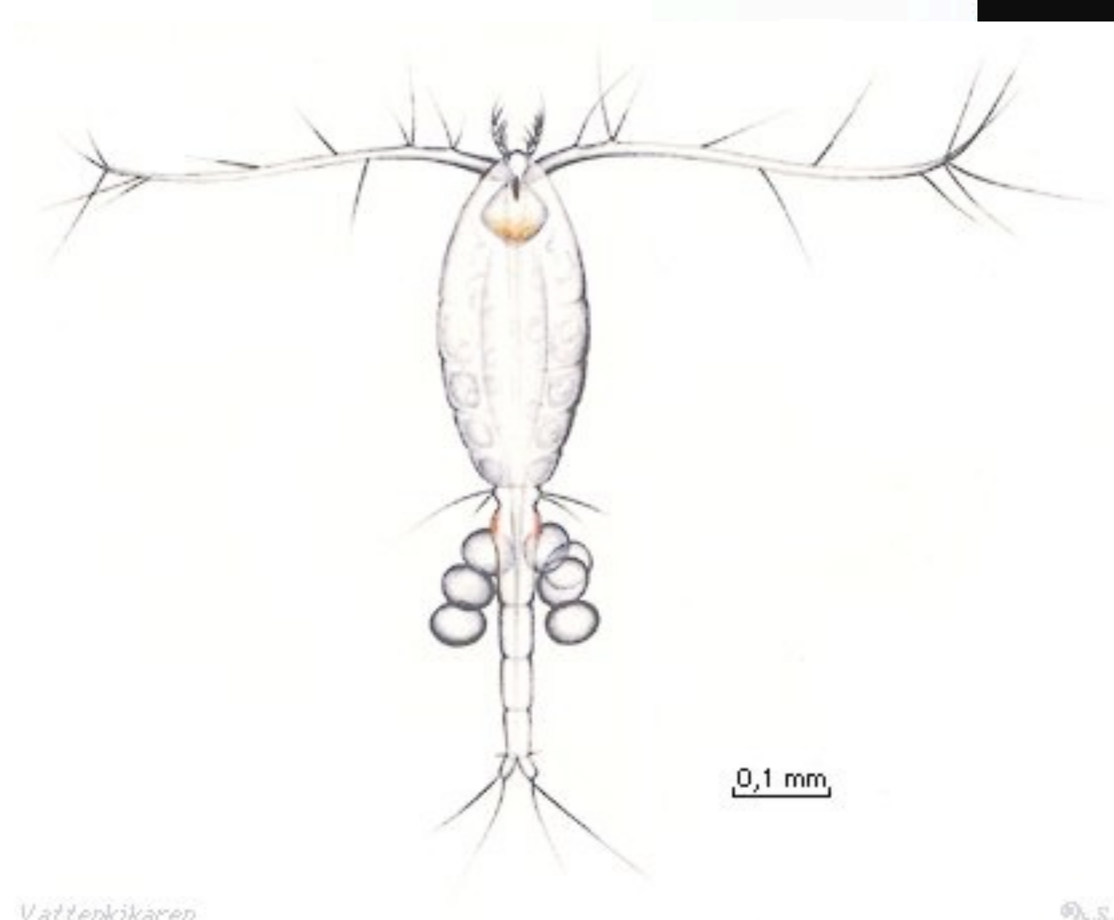
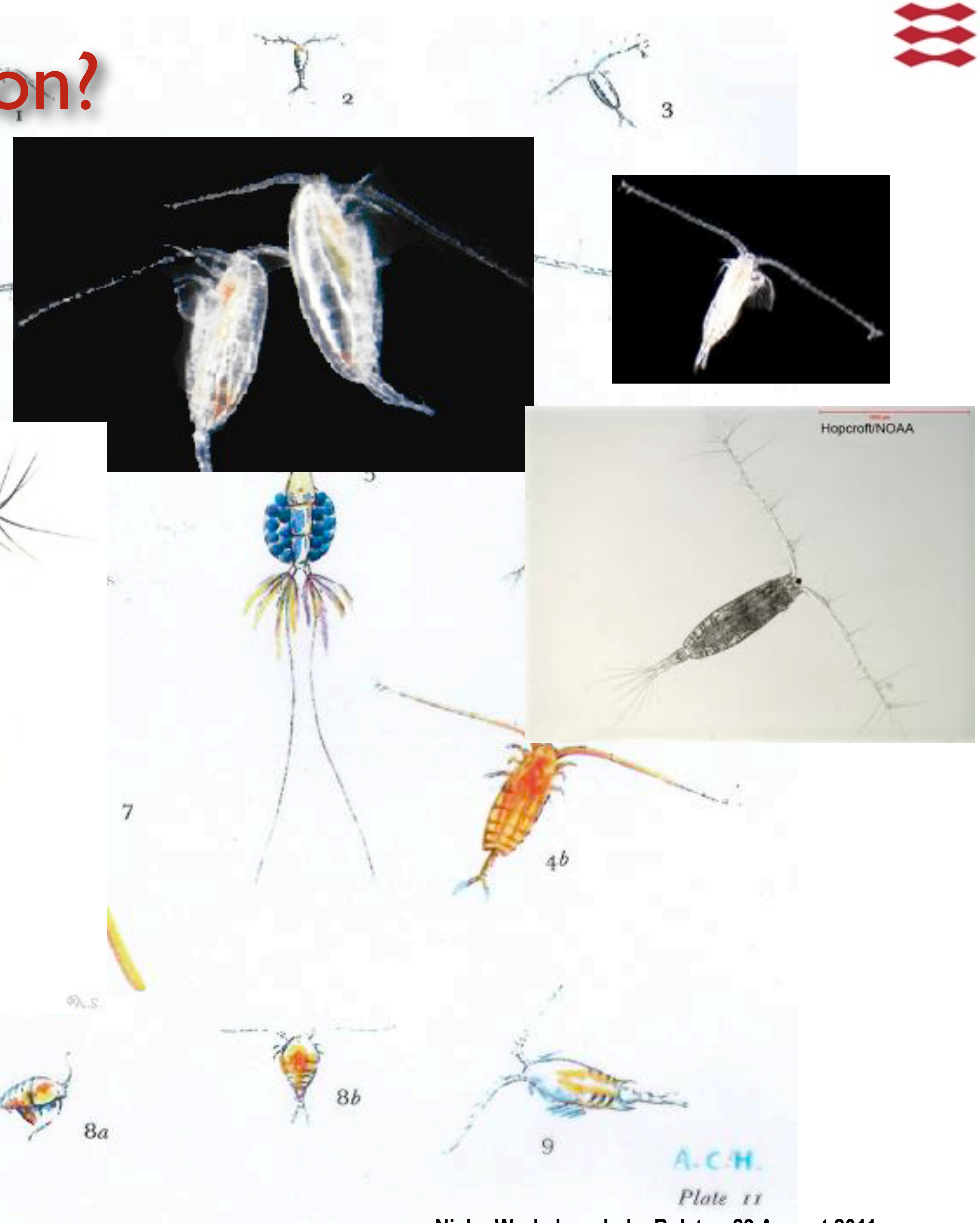
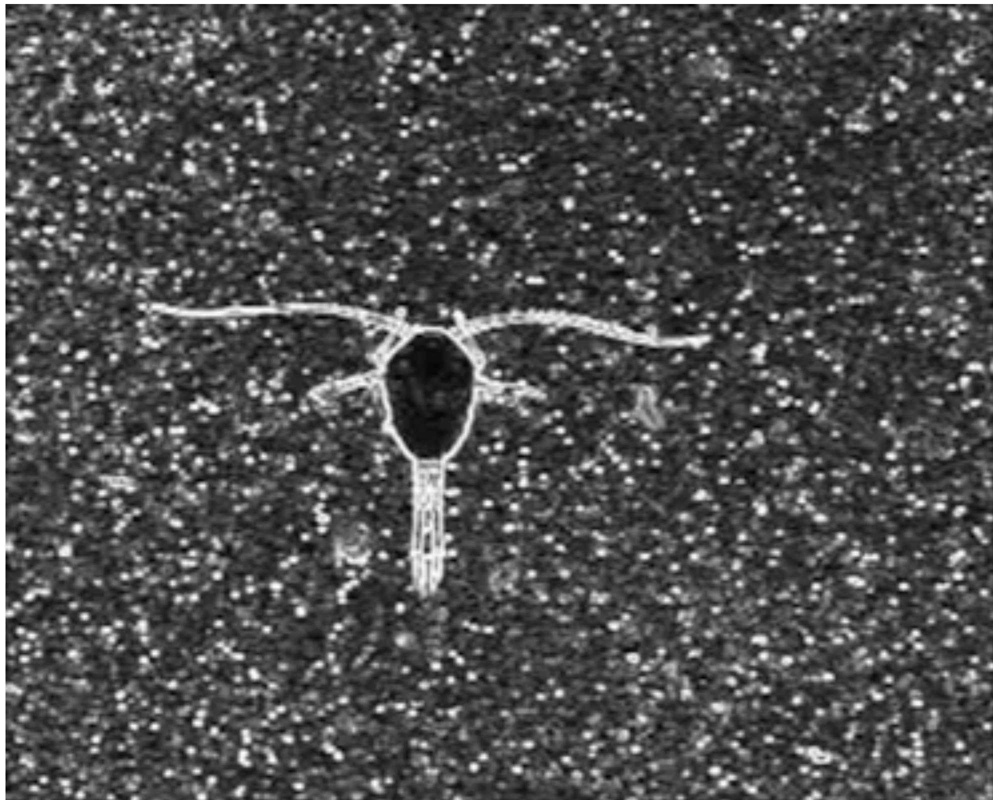


What about zooplankton?

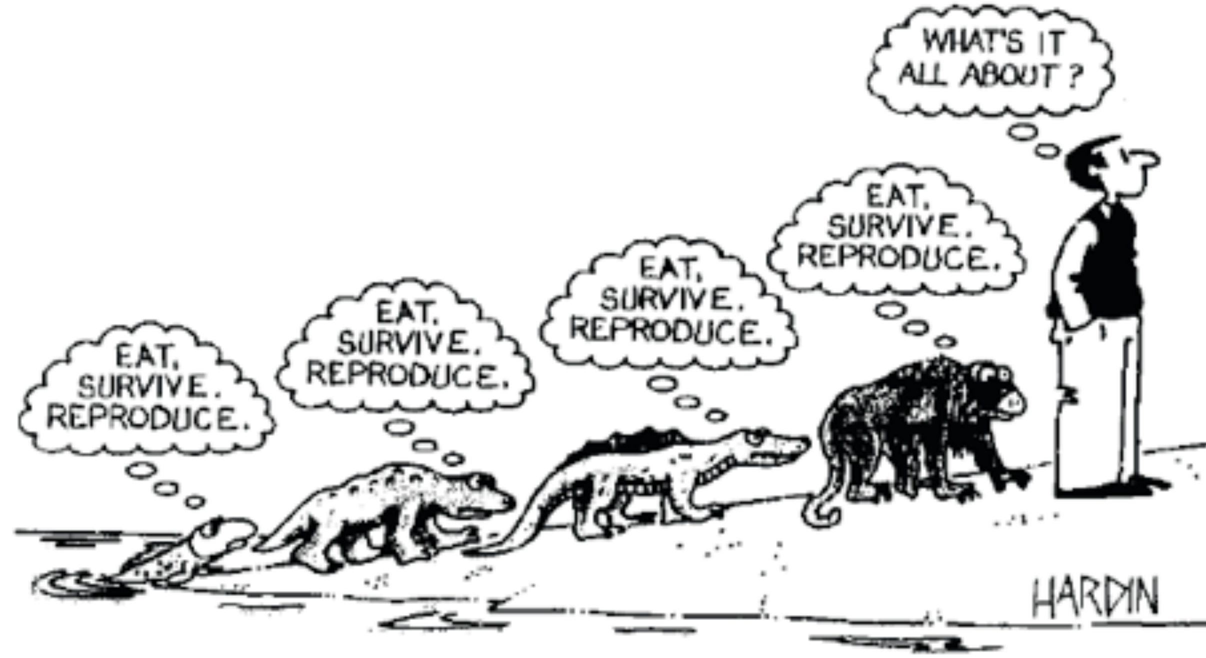
Many different zooplankton species appear to have evolved a very similar body plan.







Feed

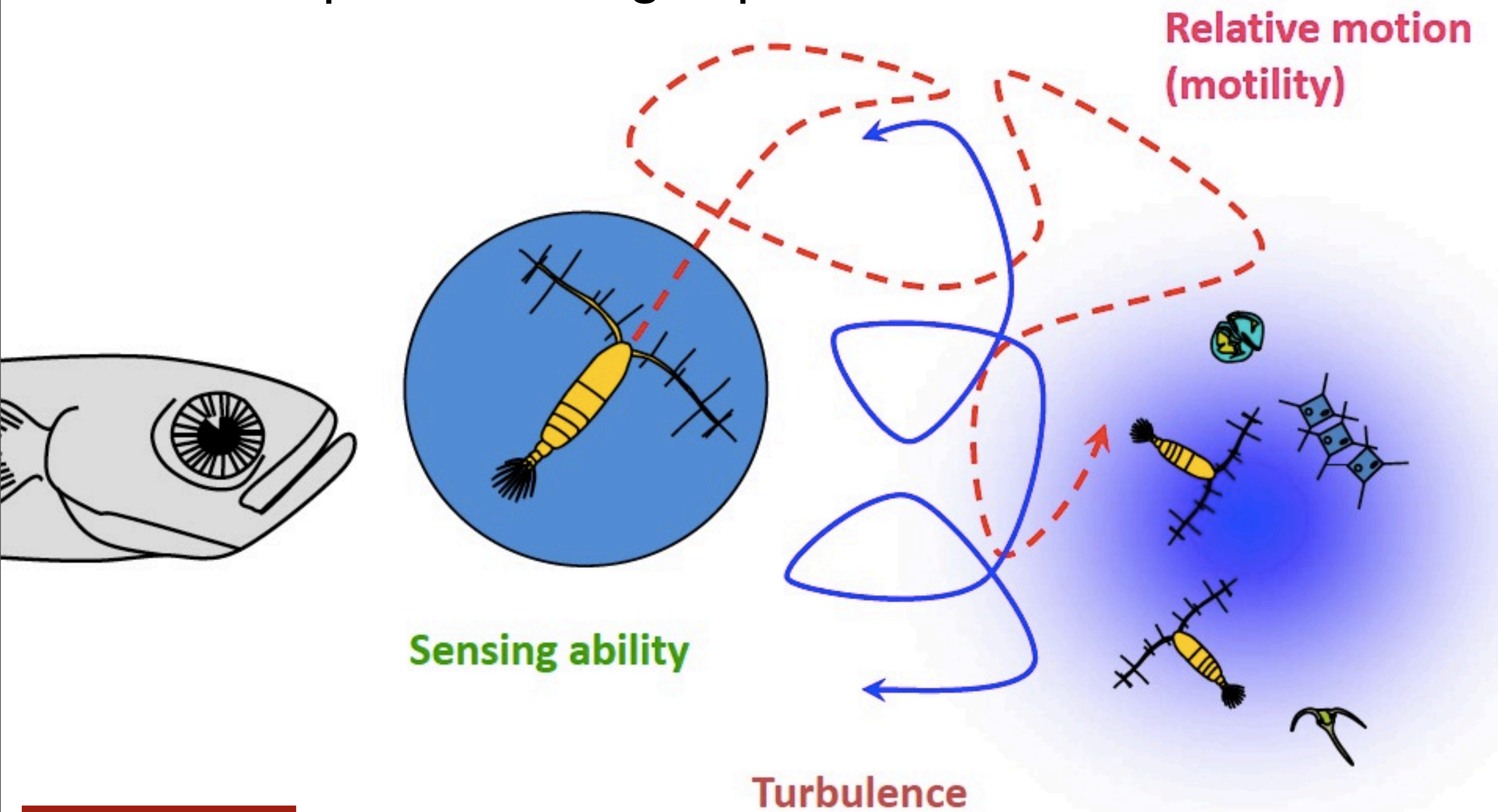


Survive

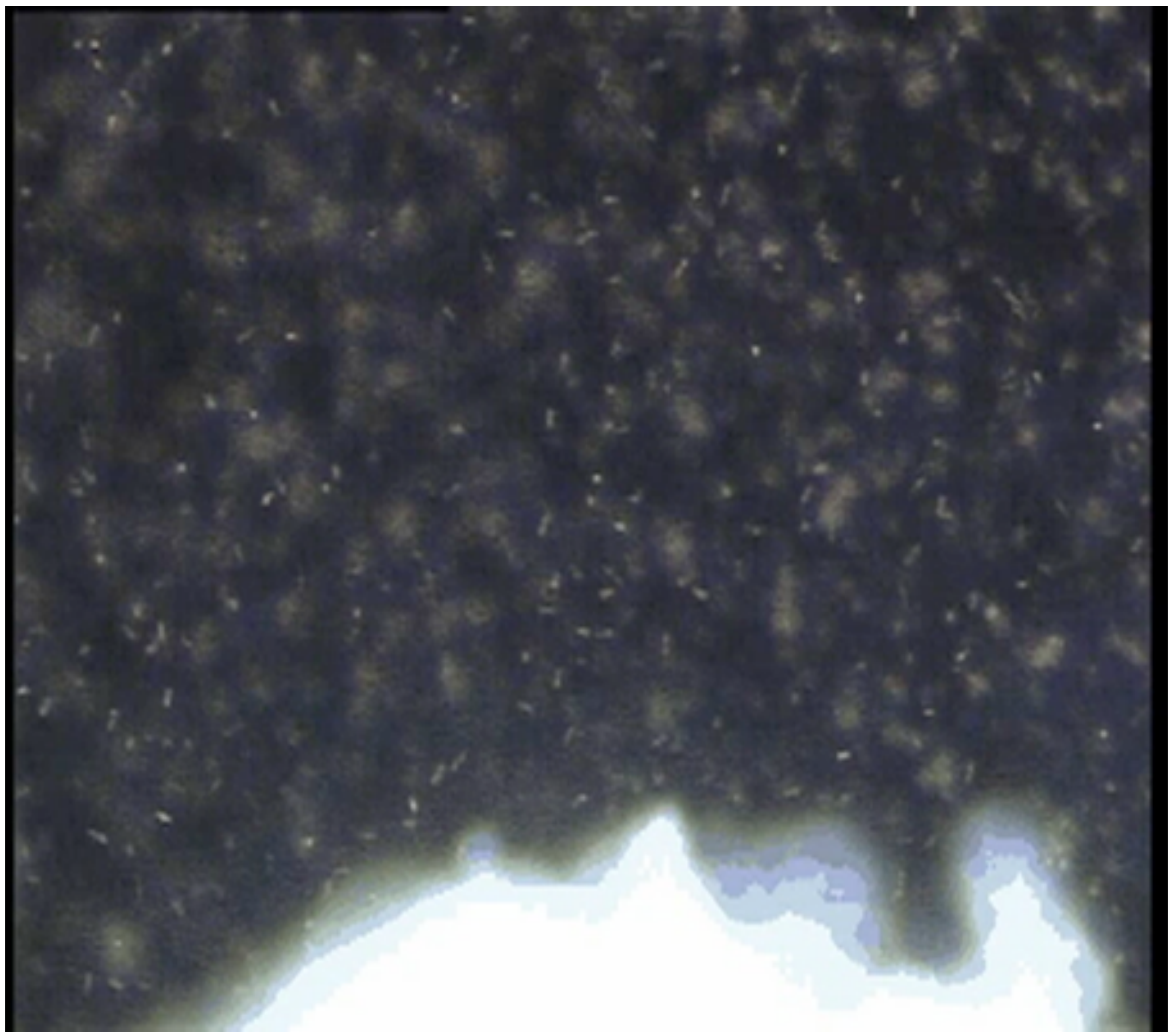
Reproduce

What about zooplankton?

I argue here that **behavior** is one of the most important trait that characterize species in this group.



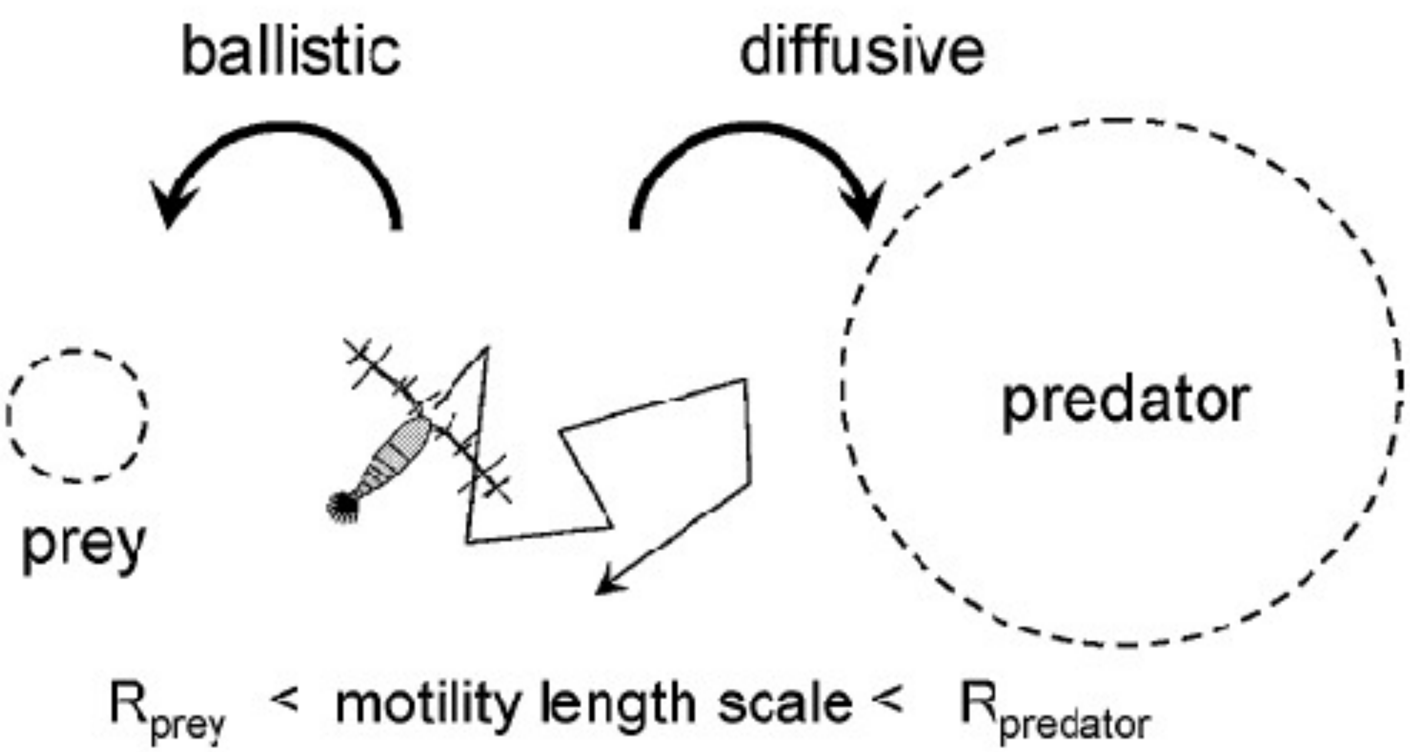
Encounter rate: balistic vs. diffusive



Pelagic bacteria swim
Their motility can be describe as a diffusion process with *Diffusion rate*~ $10^{-5} cm^2 s^{-1}$

Temora longicornis
Cruising feeding behavior

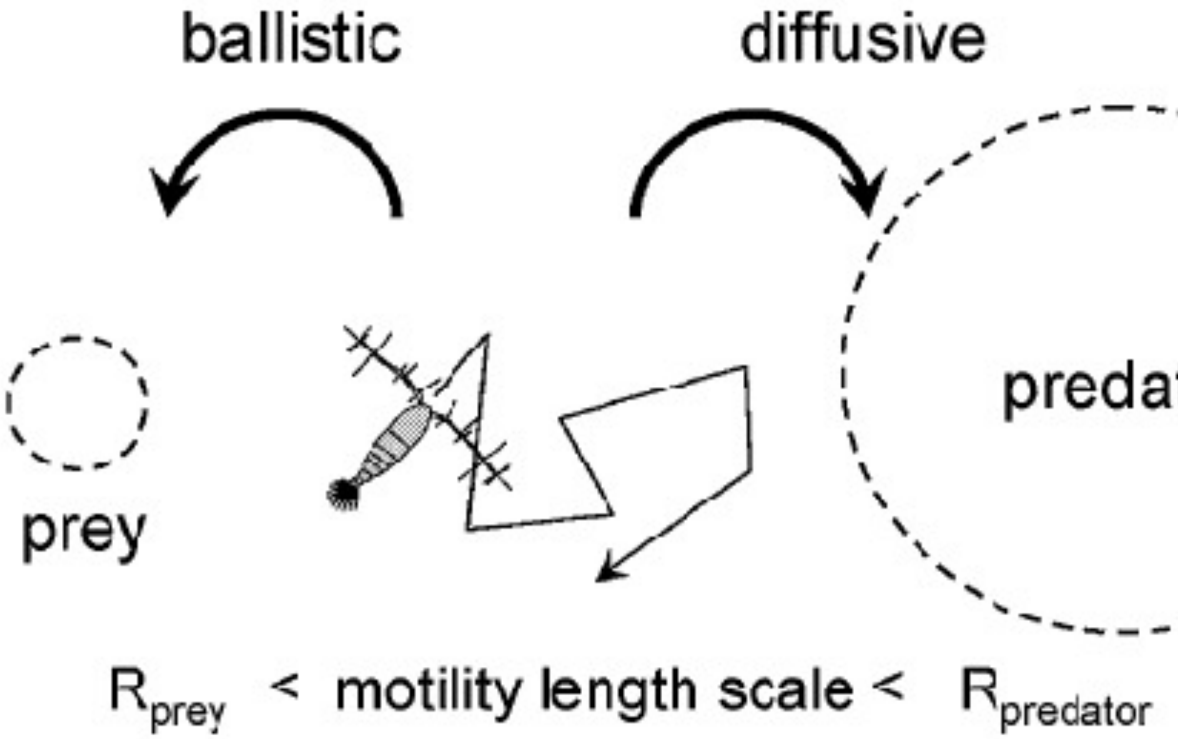
Evolutionary constraints on the behavior



$\lambda \approx 6$ * size of organism

Visser & Kiørboe 2006

Evolutionary constraints on the behavior



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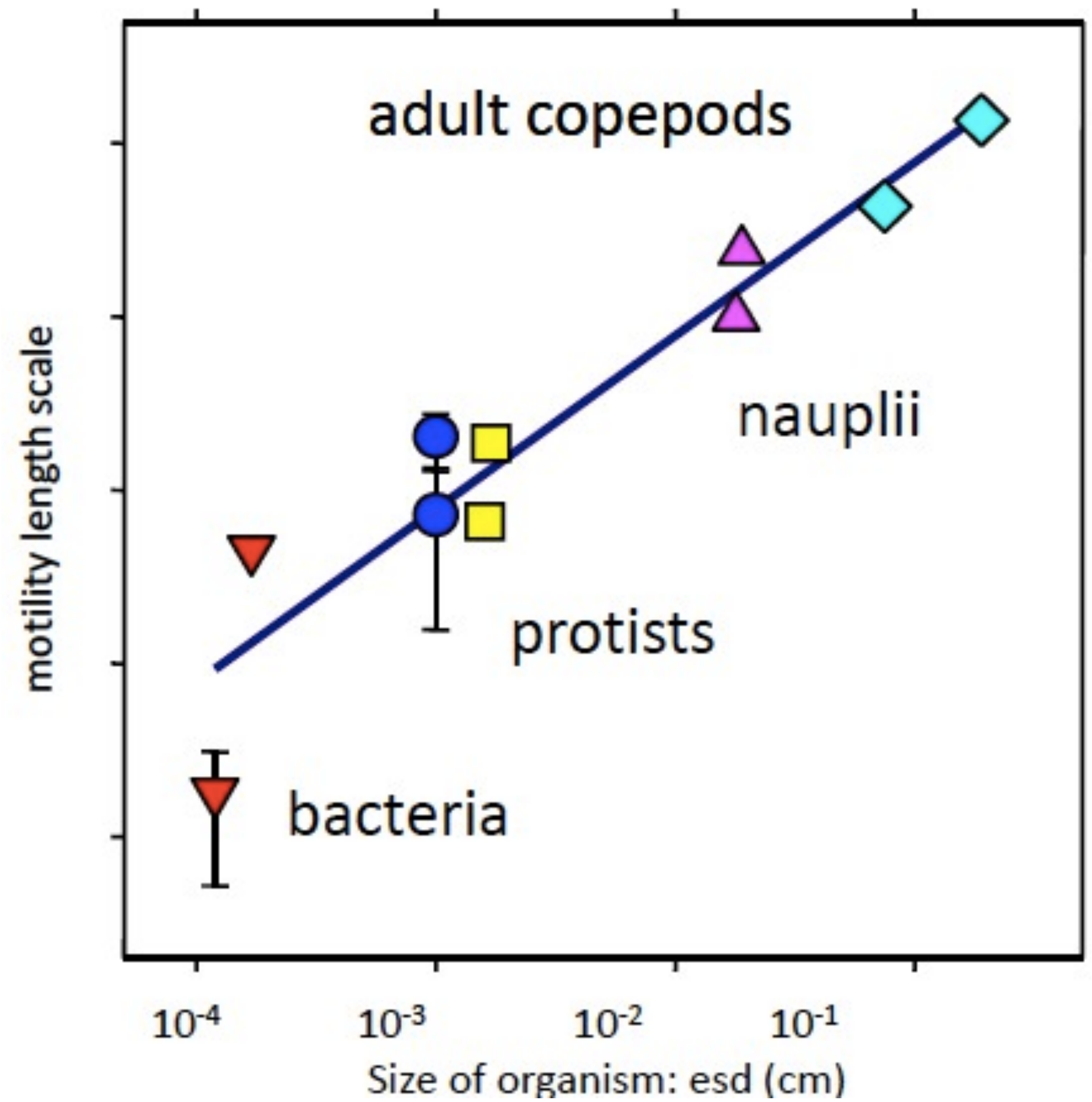
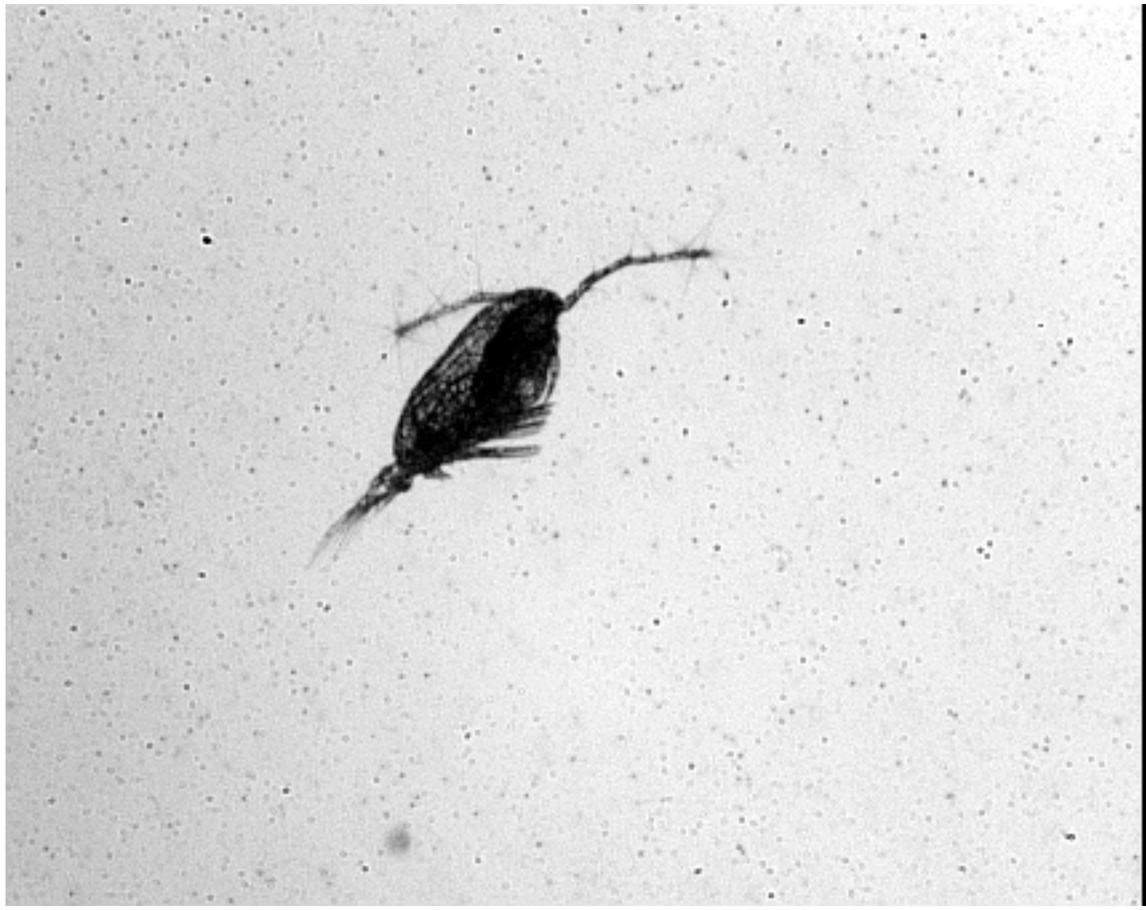
Observations



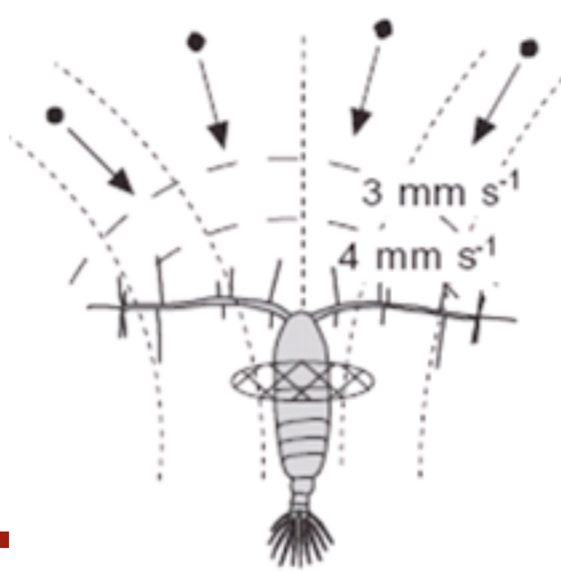
$\lambda = 7d$ (r^2=0.90)

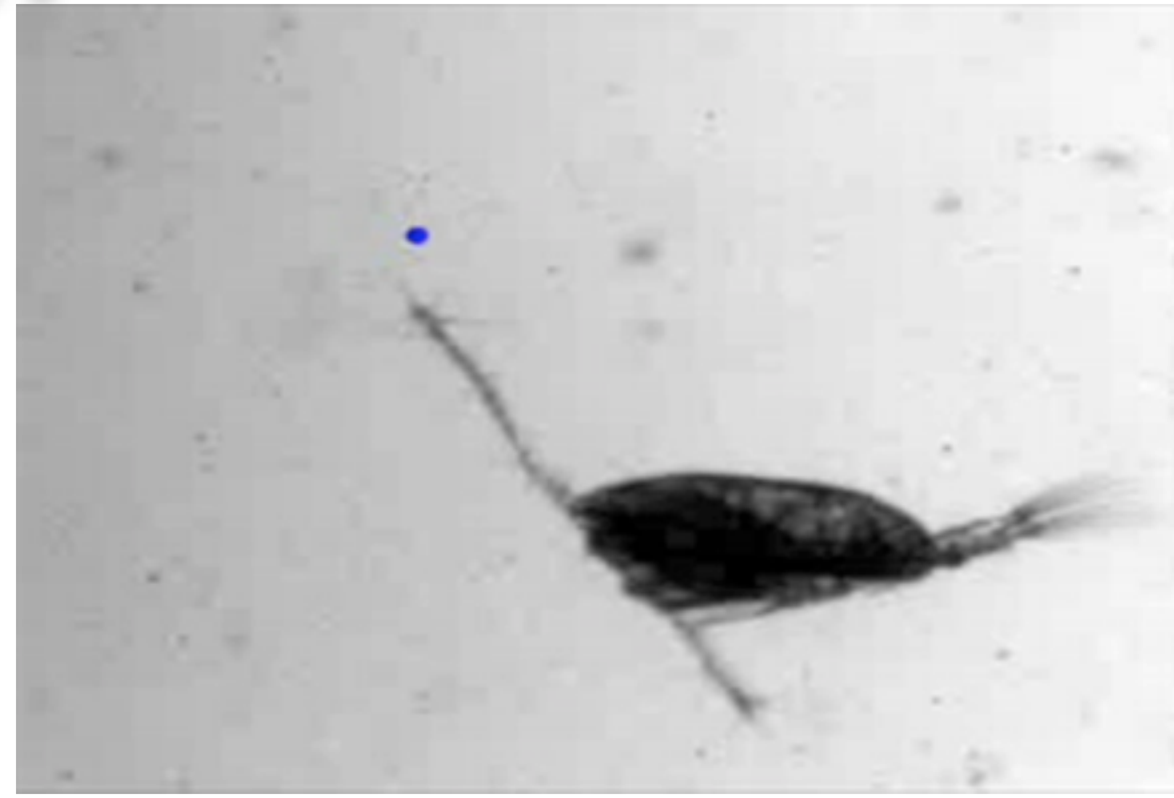
Visser & Kiørboe 2006

Can we model the behavior?

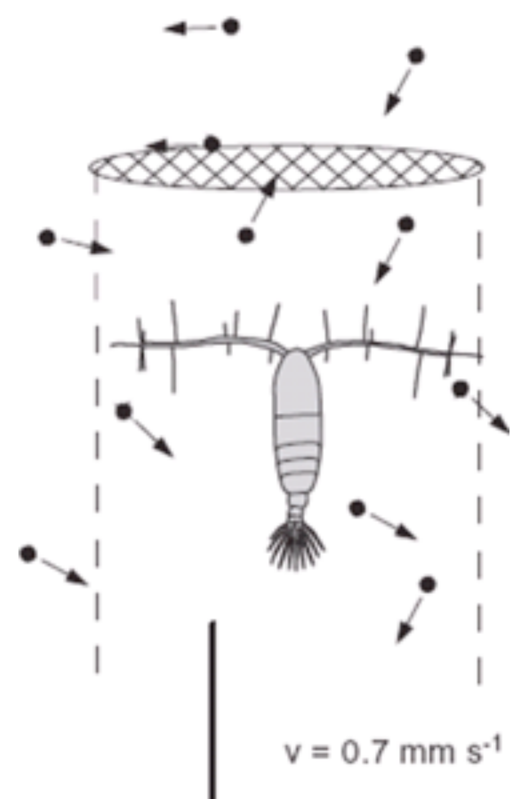


SUSPENSION FEEDING





AMBUSH FEEDING



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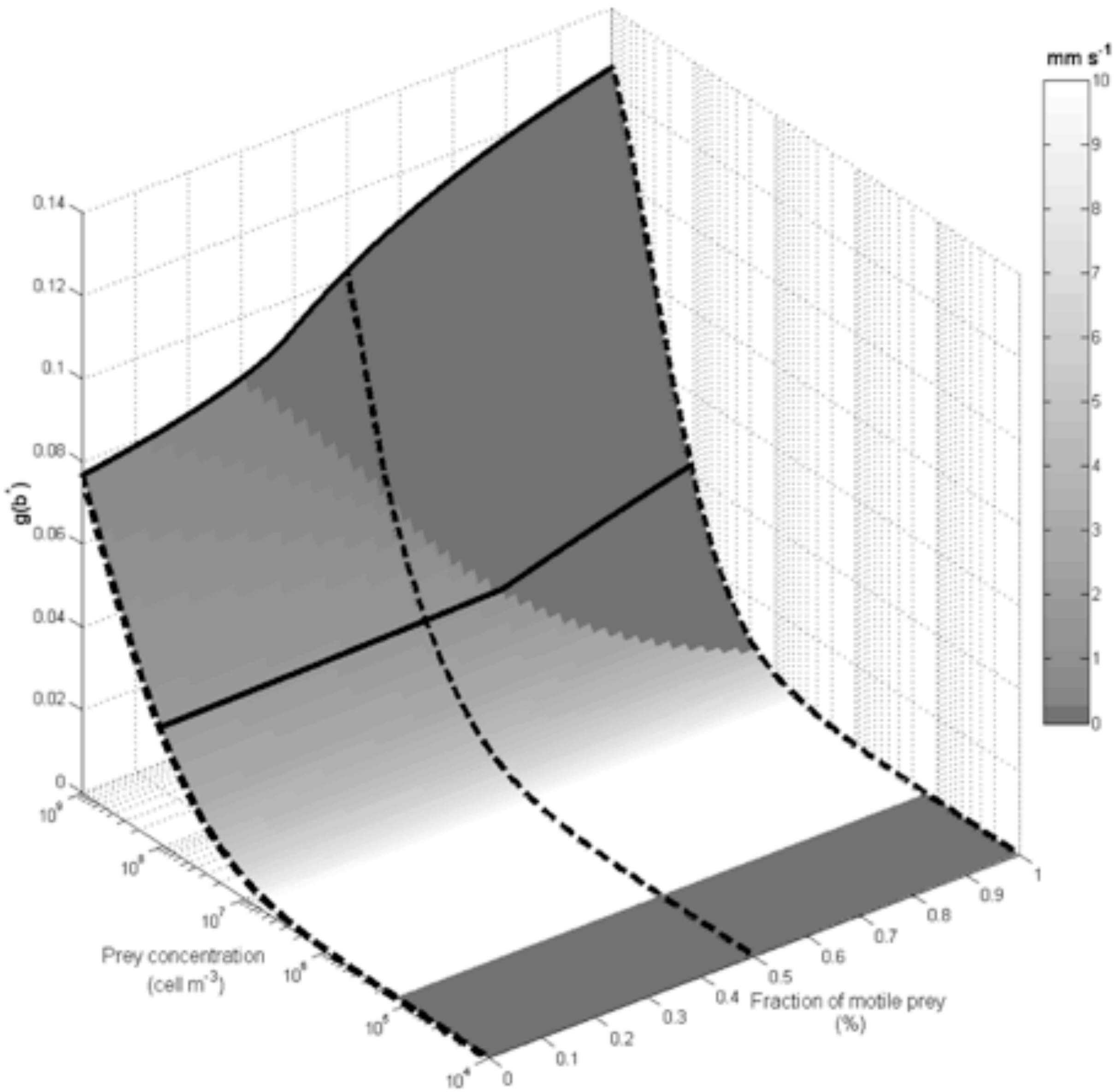

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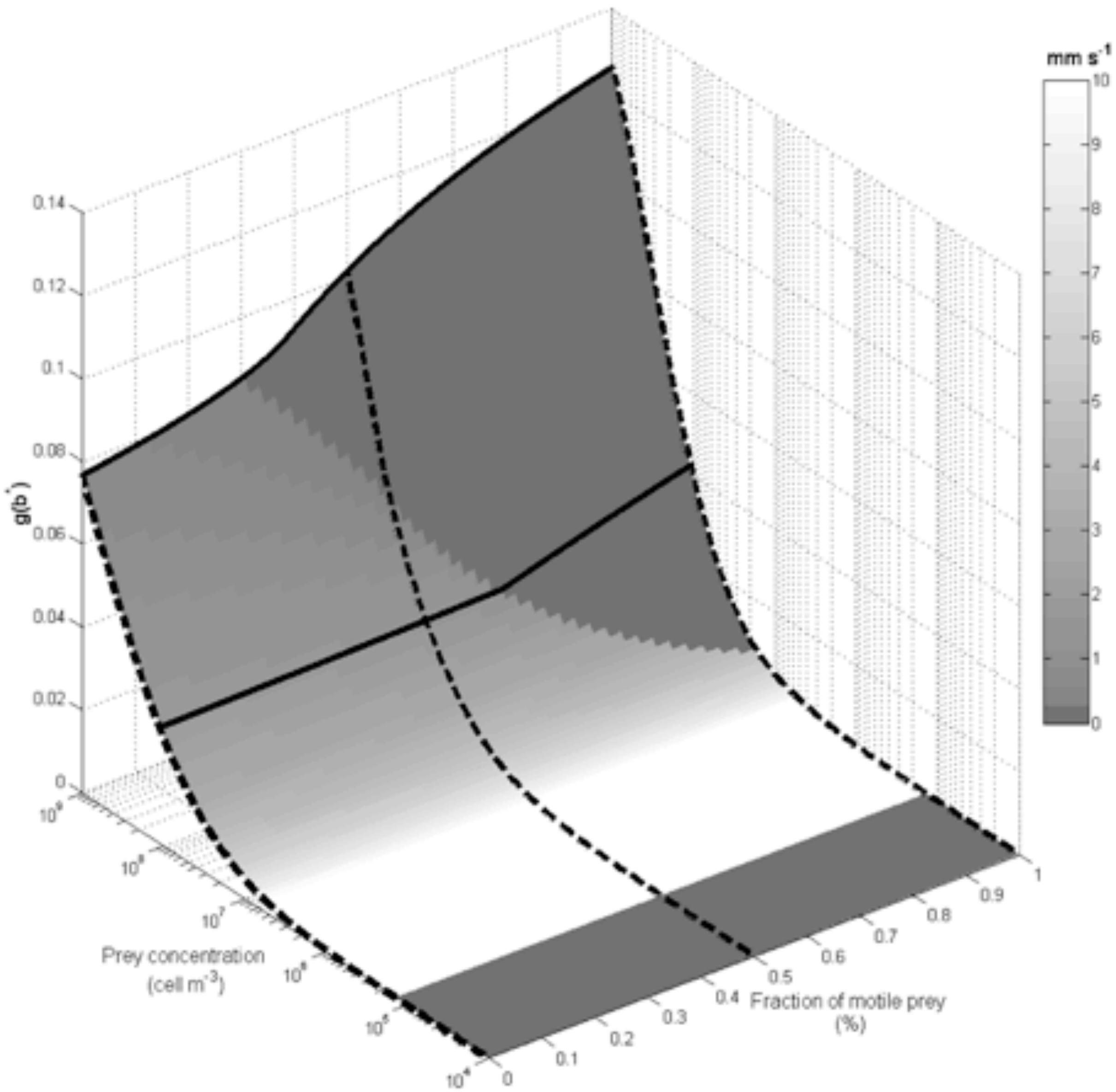

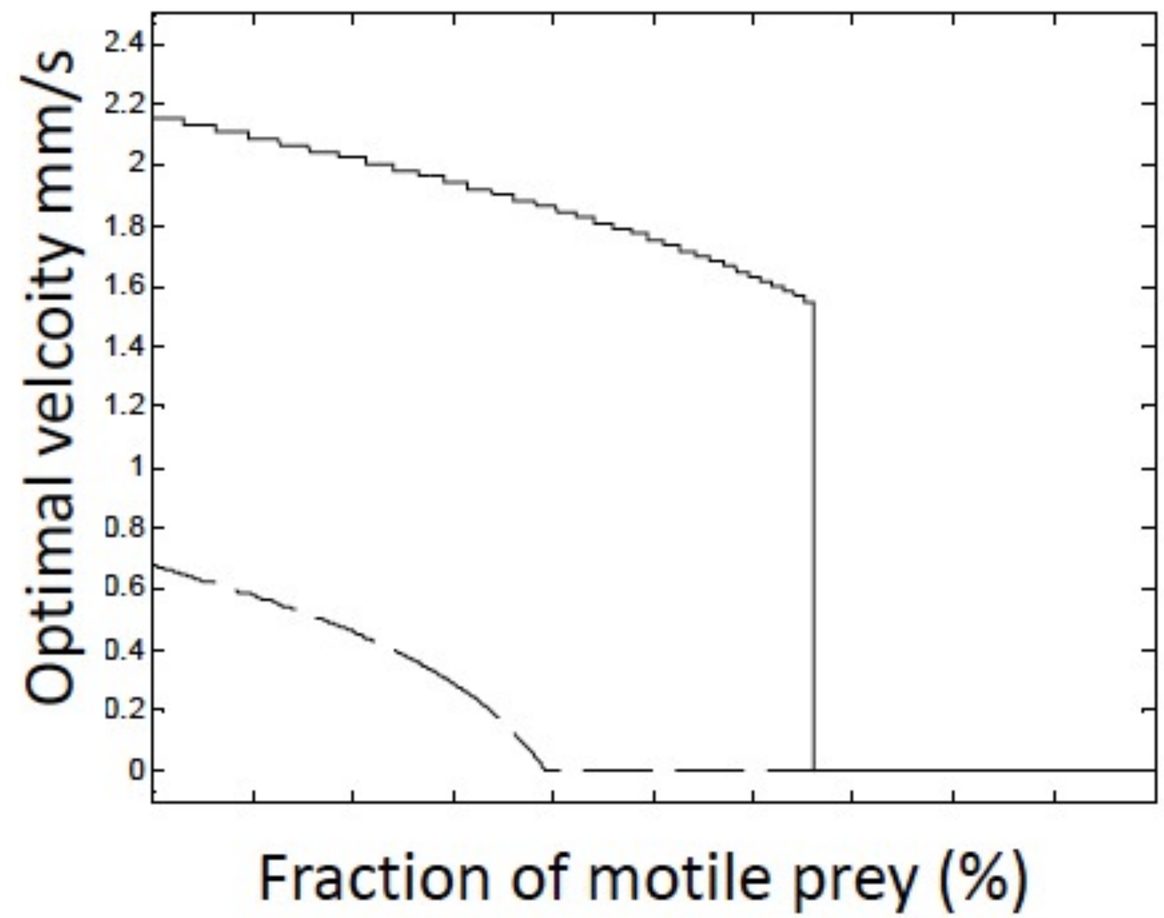

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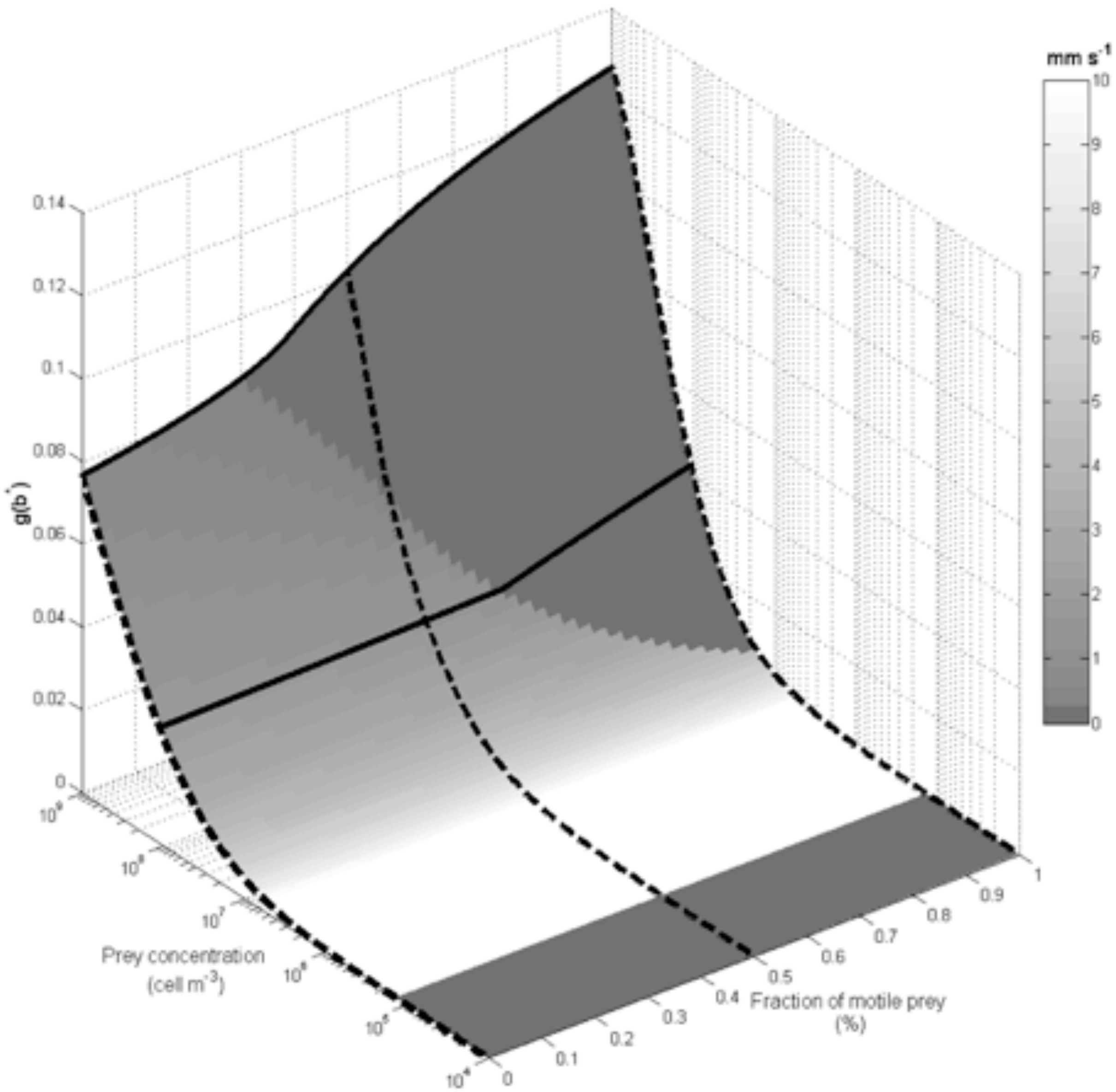
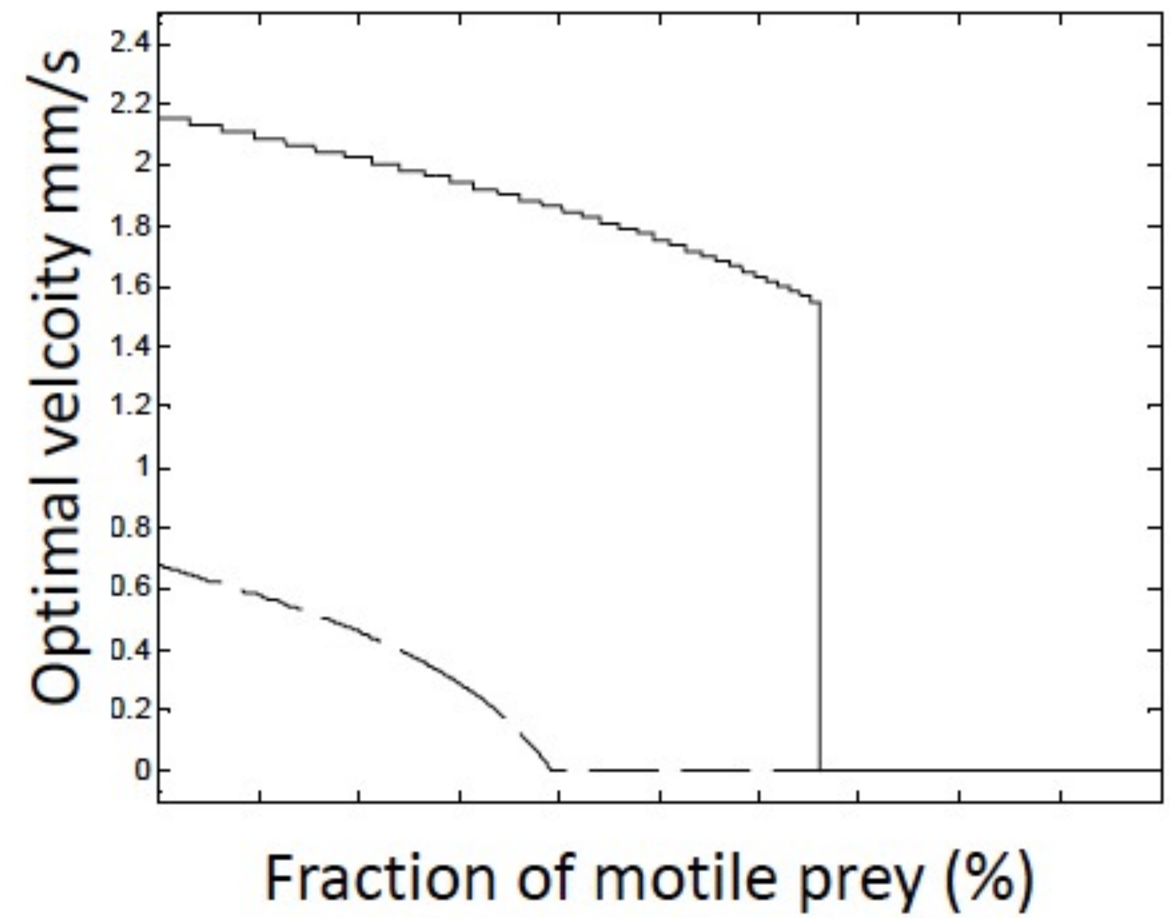




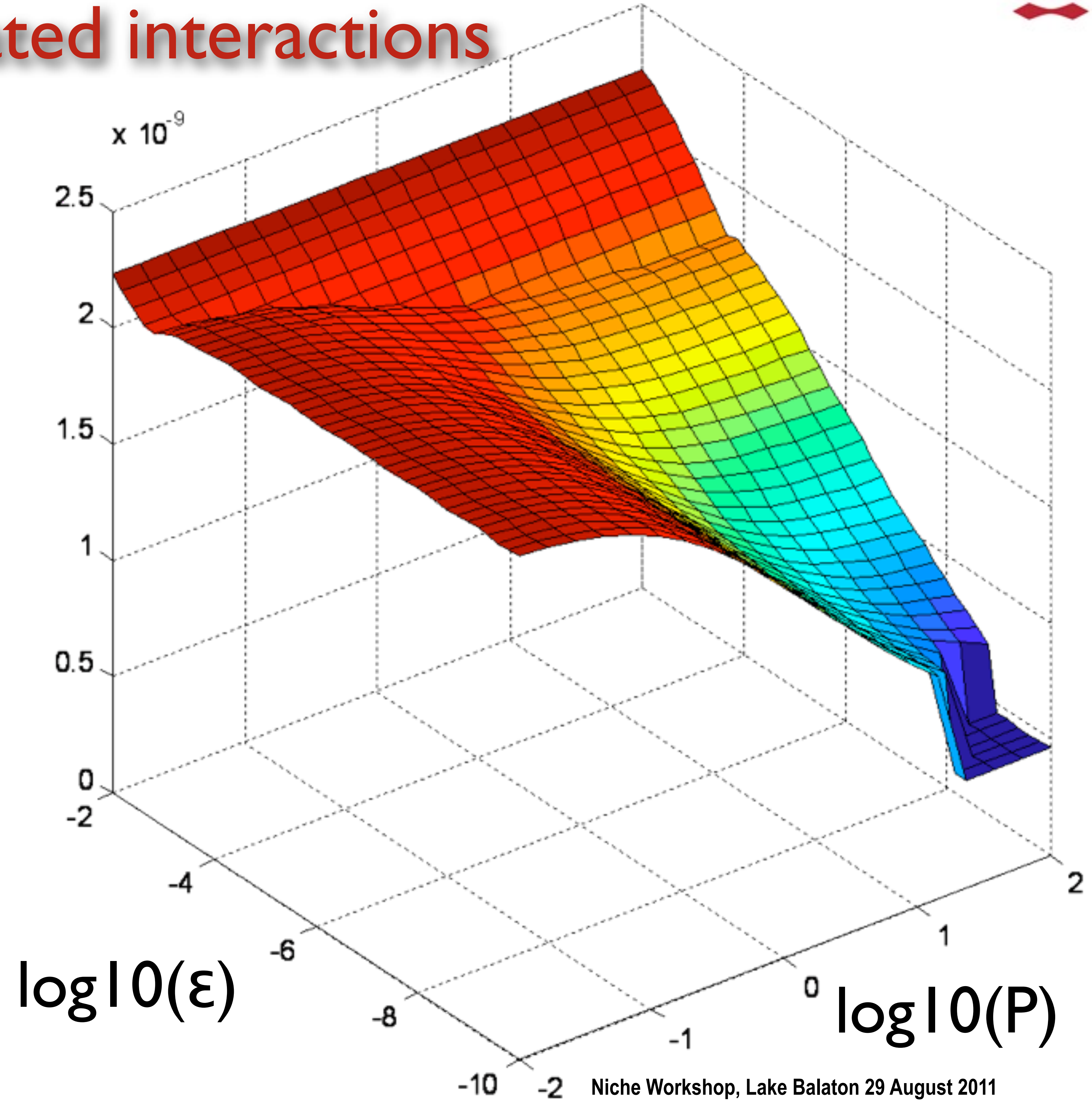
Our estimate of maximum fitness is an increasing function of both prey type and prey concentration. However, an increase in **prey abundance does not always correspond to higher ingestion rate since behavioral switching effects can emerge** when predation risk is considered at intermediate and high prey concentrations.

Behavioral mediated interactions

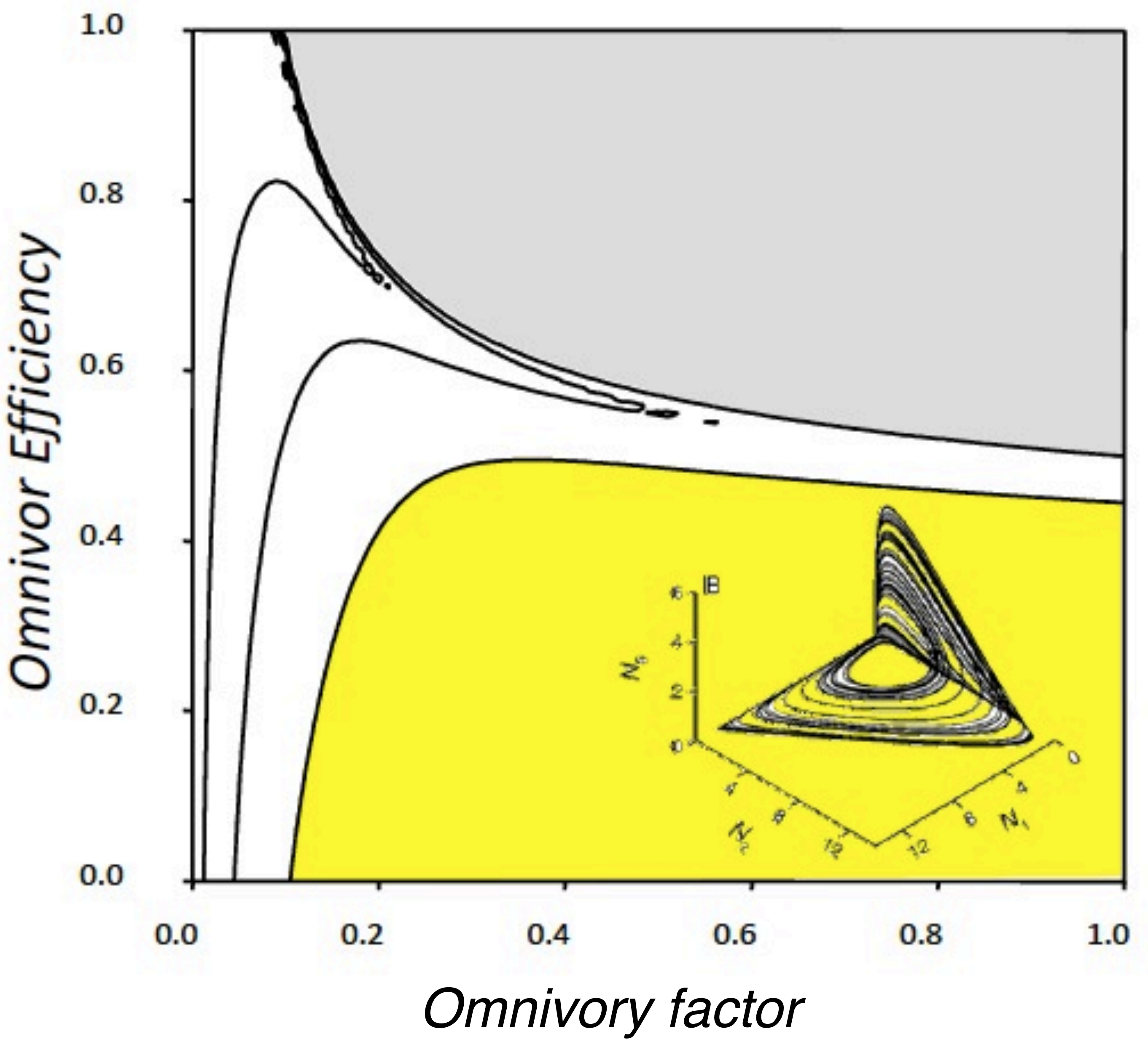
5-fold decrease in clearance rate from low to high predator abundance.

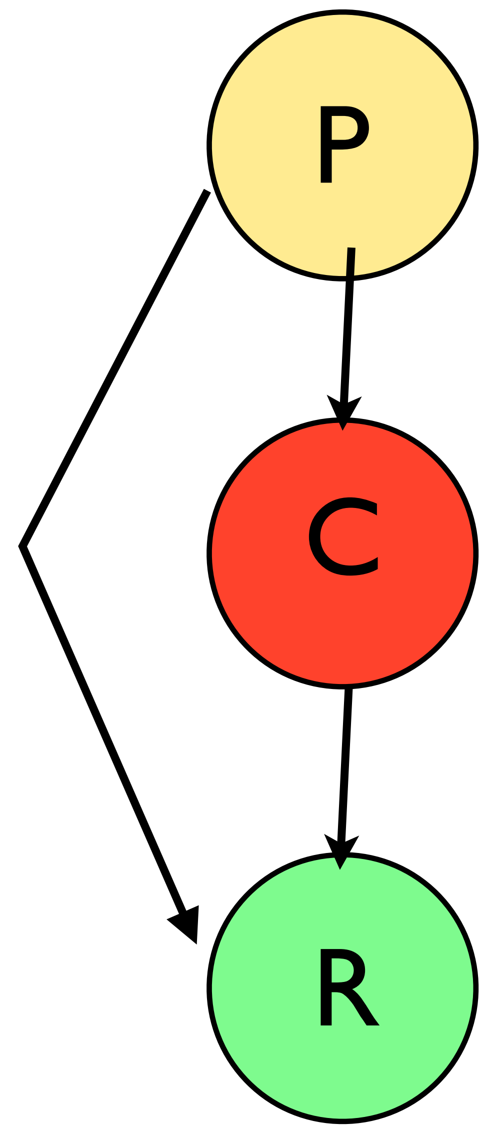
This effect is more pronounced at low ε

$$\frac{dN_i}{dt} = \sum_{j=1} a_{ij} N_i N_j$$



Consequences on population dynamics





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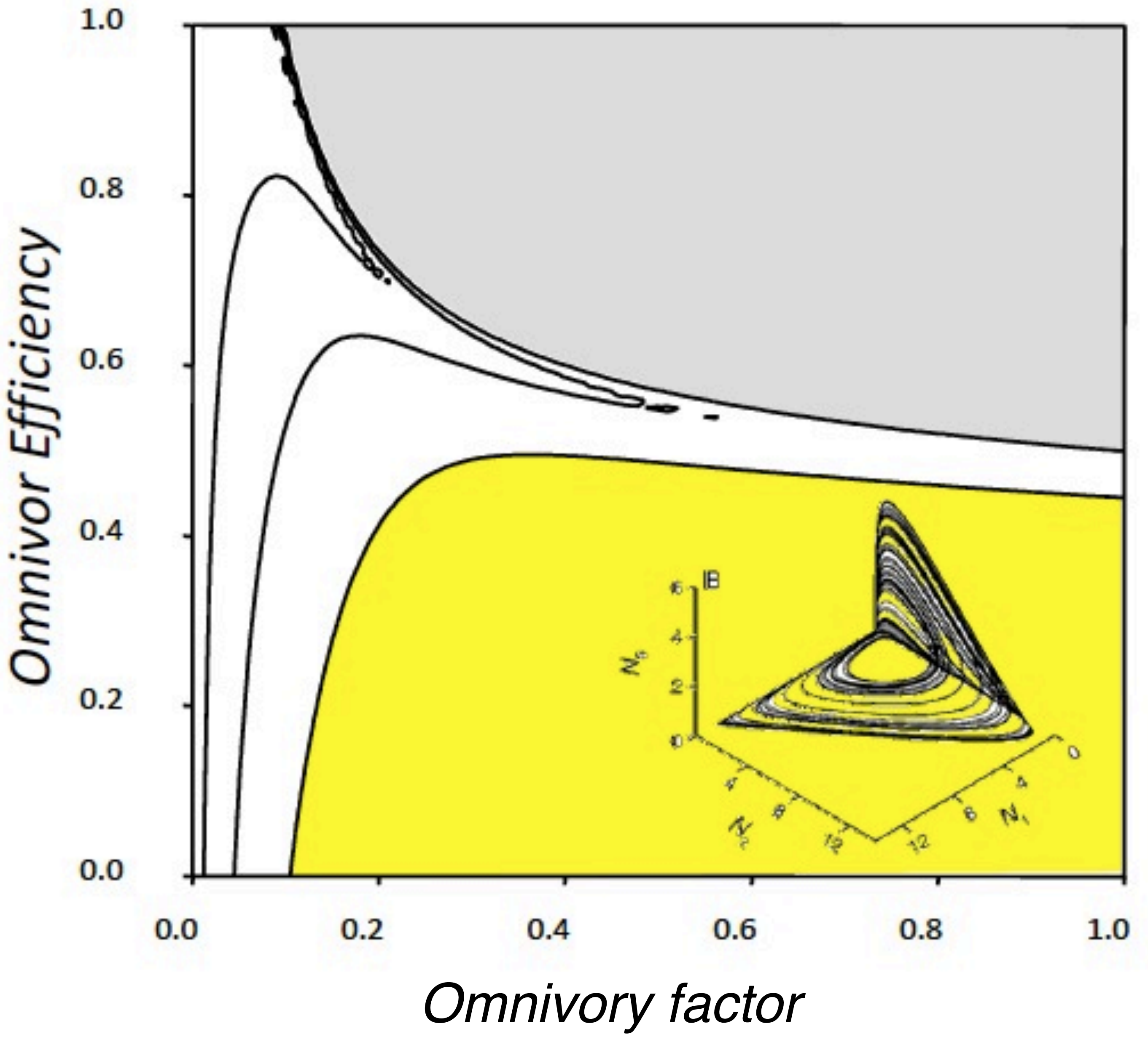

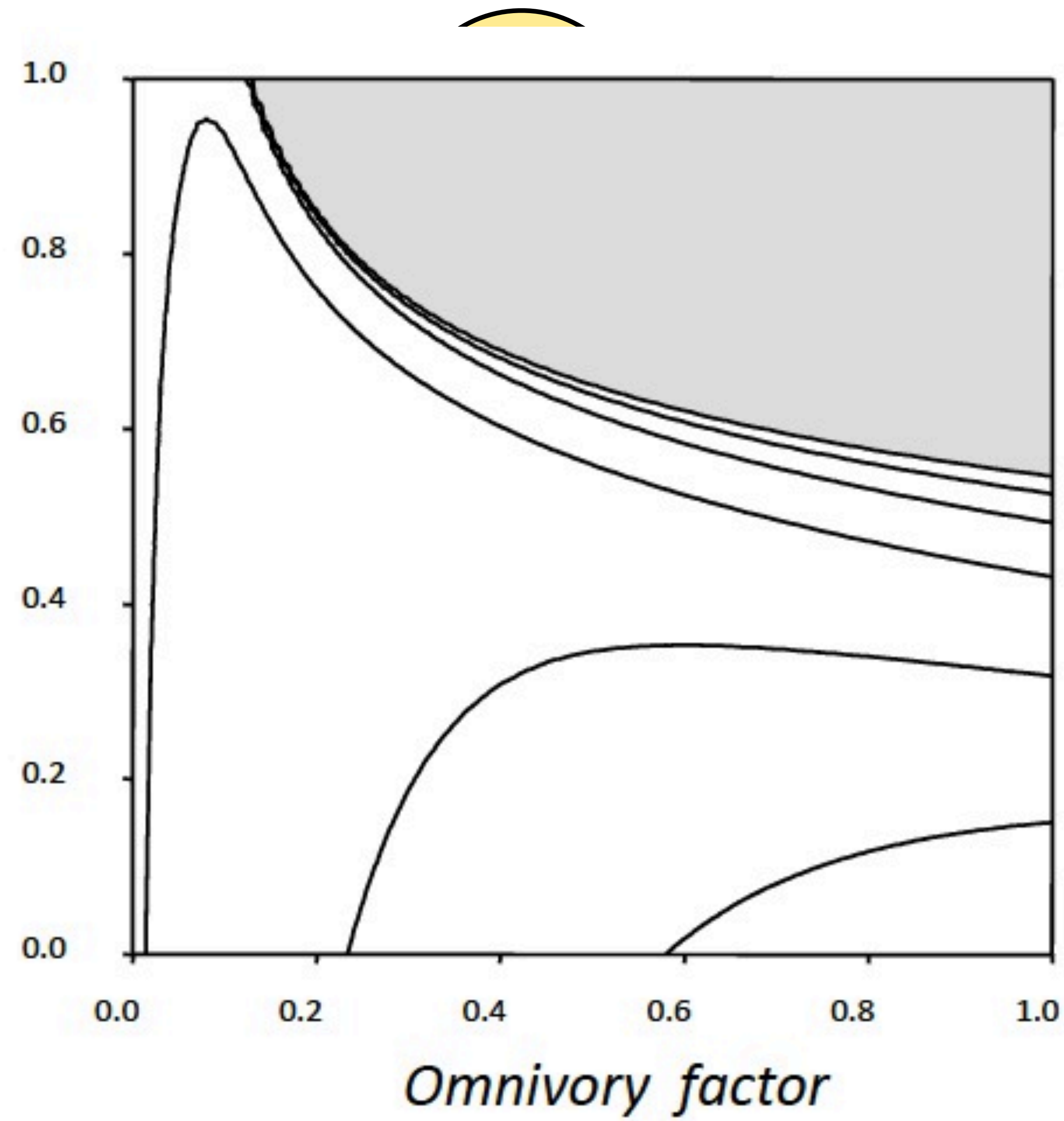

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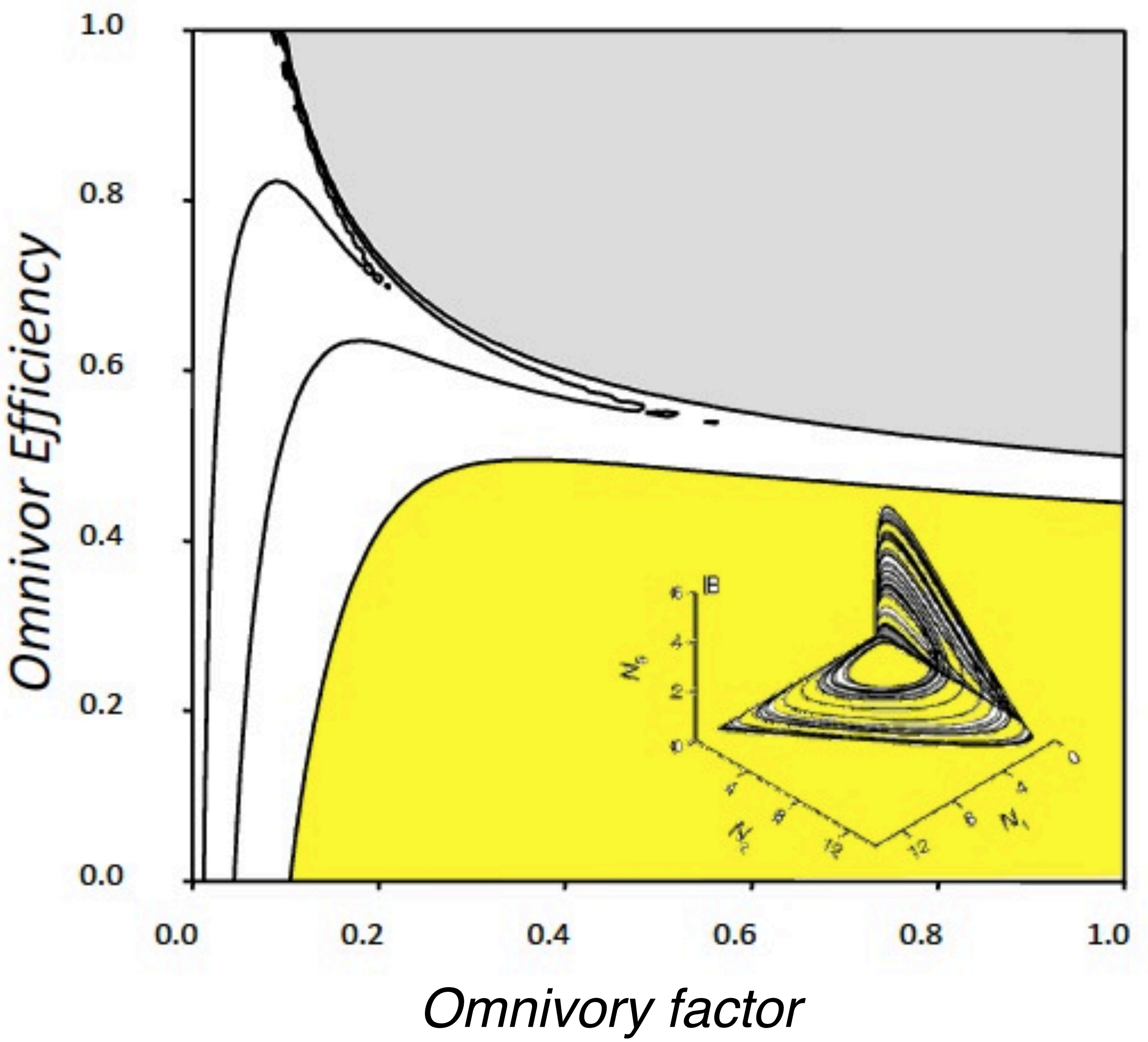

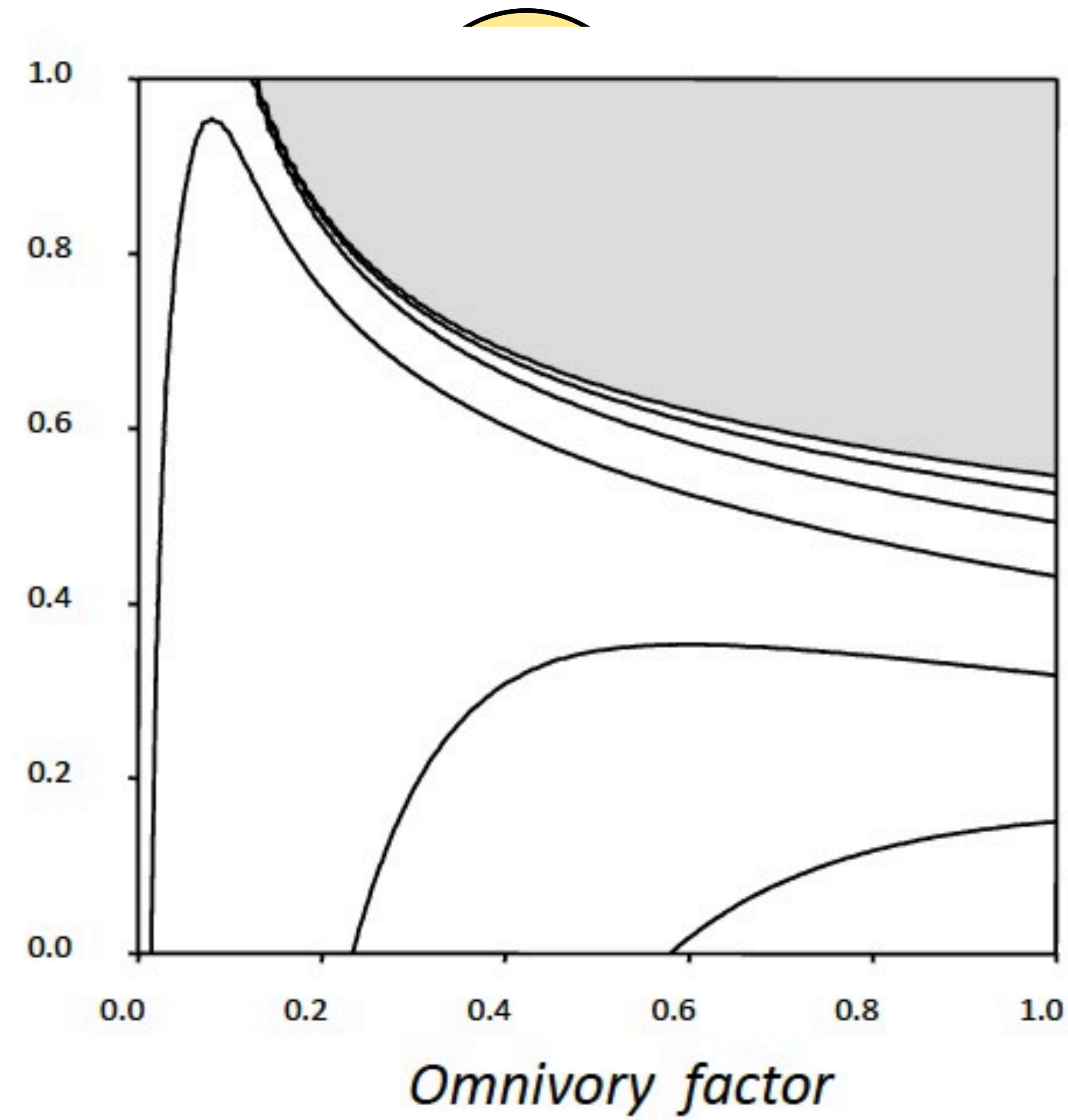

Adaptative behavior greatly expand the region of stable species coexistence in omnivor system

Conclusions

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3) Copepods' behavior can be described by simple model in which the trade off between encounters with prey and predators is made explicit (optimal approach appears to work)

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1) Co-evolution of attack and defense systems is a driving force in natural selection of marine plankton leading to speciation

2) In zooplankton behavior is a major trait that can be used to distinguish different species and ecological functions

3) Copepods' behavior can be described by simple model in which the trade off between encounters with prey and predators is made explicit (optimal approach appears to work)

4) Adaptive behavior in zooplankton favors coexistence of interacting species that would otherwise be driven to extinction and has profound effects on the dynamics of the *population*

Thanks!
and thanks to:

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Ken Andersen