Overfishing of planktivorous fishes may result in smaller plankton and less efficient energy flow to higher trophic levels

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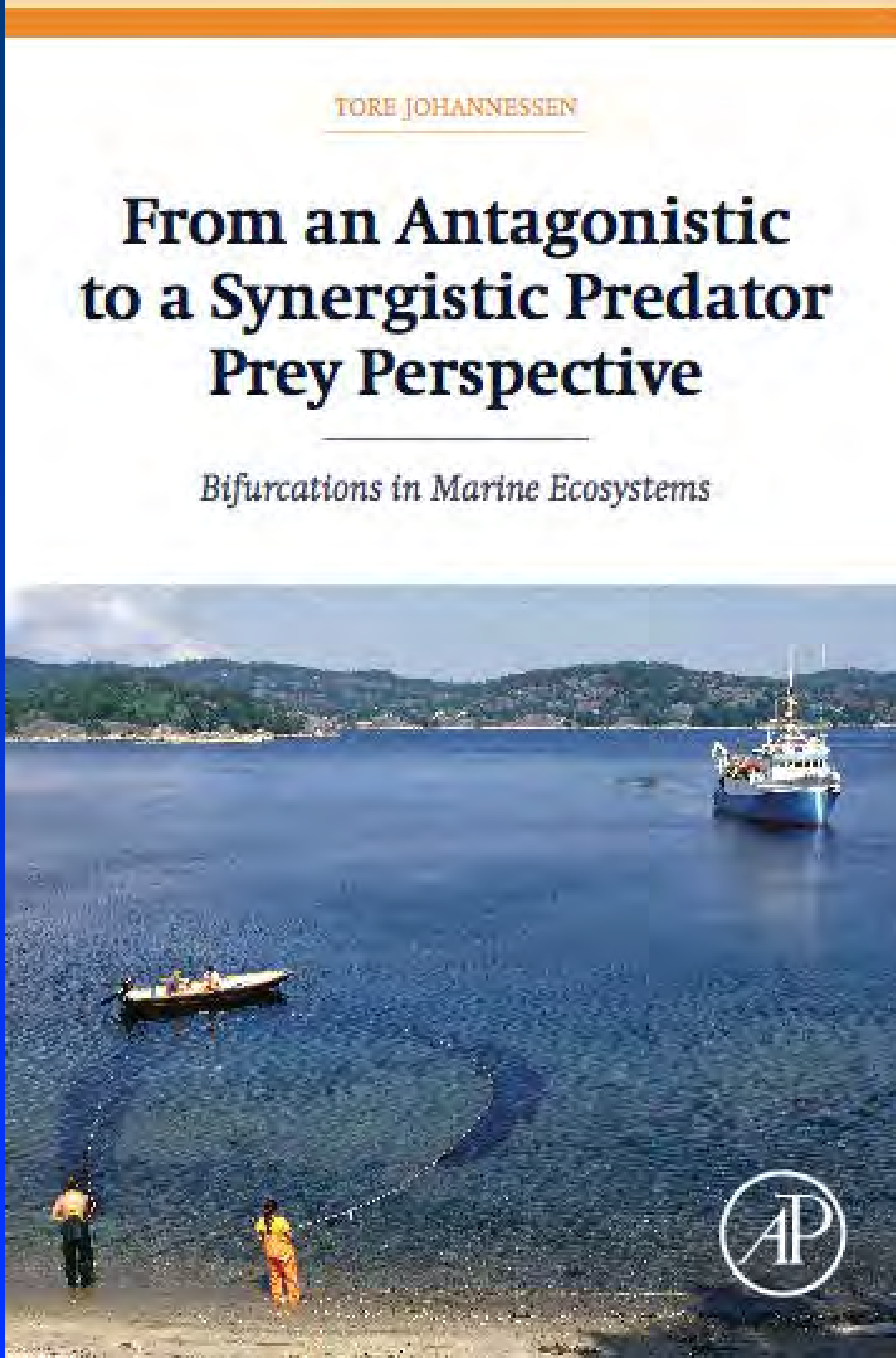
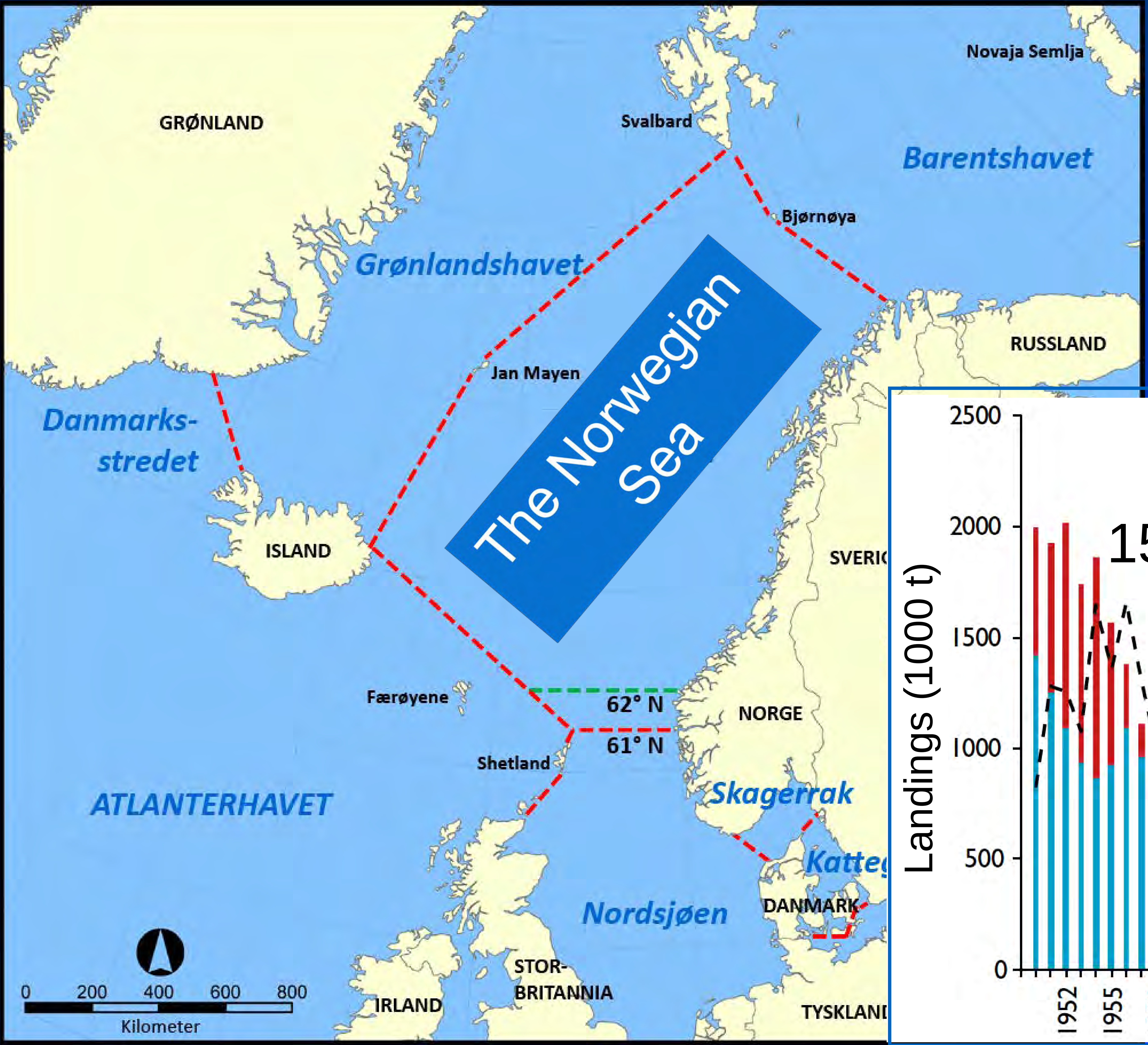
Presentation of some results and speculations from the book “From an Antagonistic to a Synergistic Predator Prey Perspective: Bifurcations in Marine Ecosystems” (Elsevier 2014)

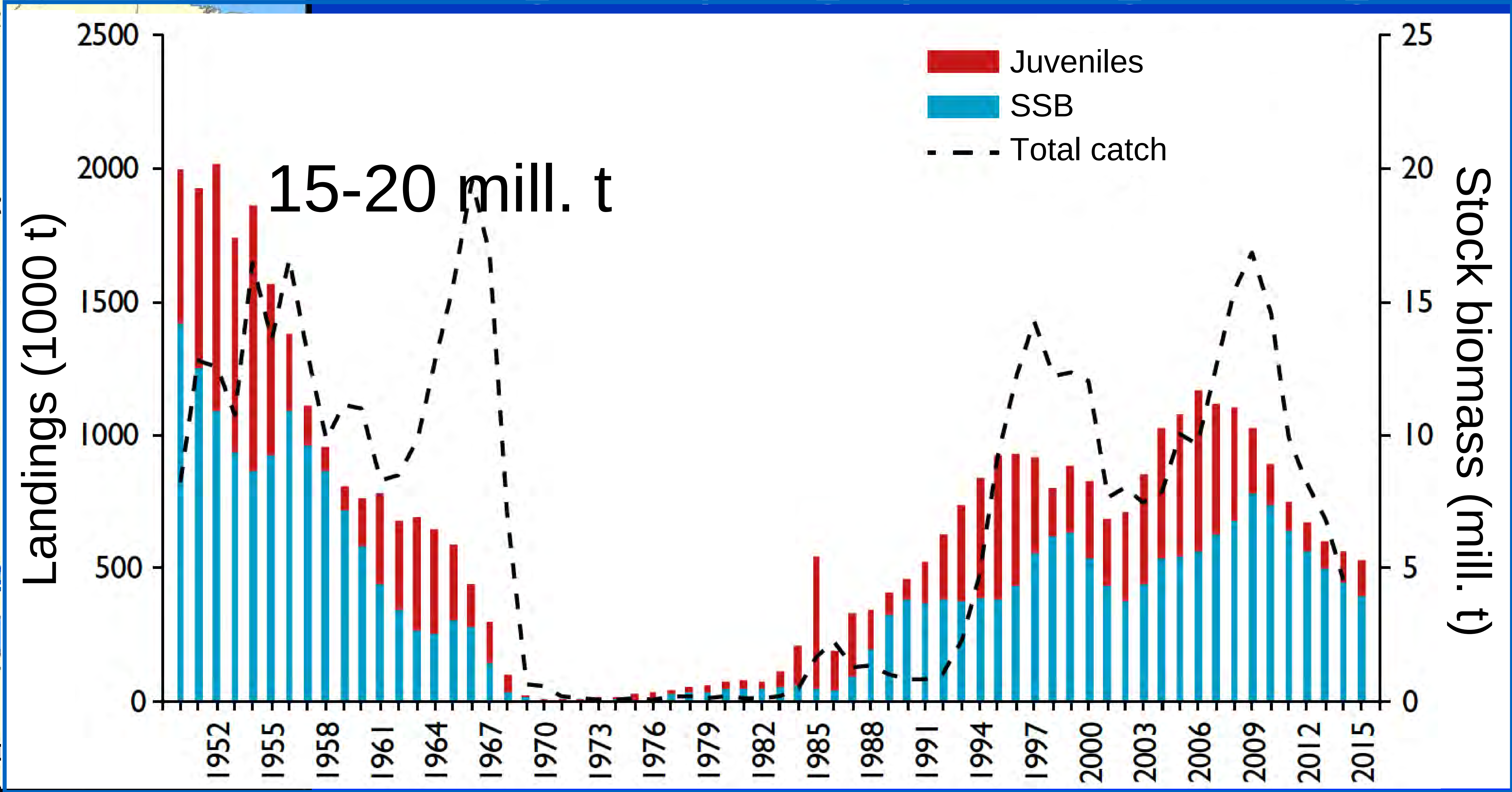


The Norwegian Sea



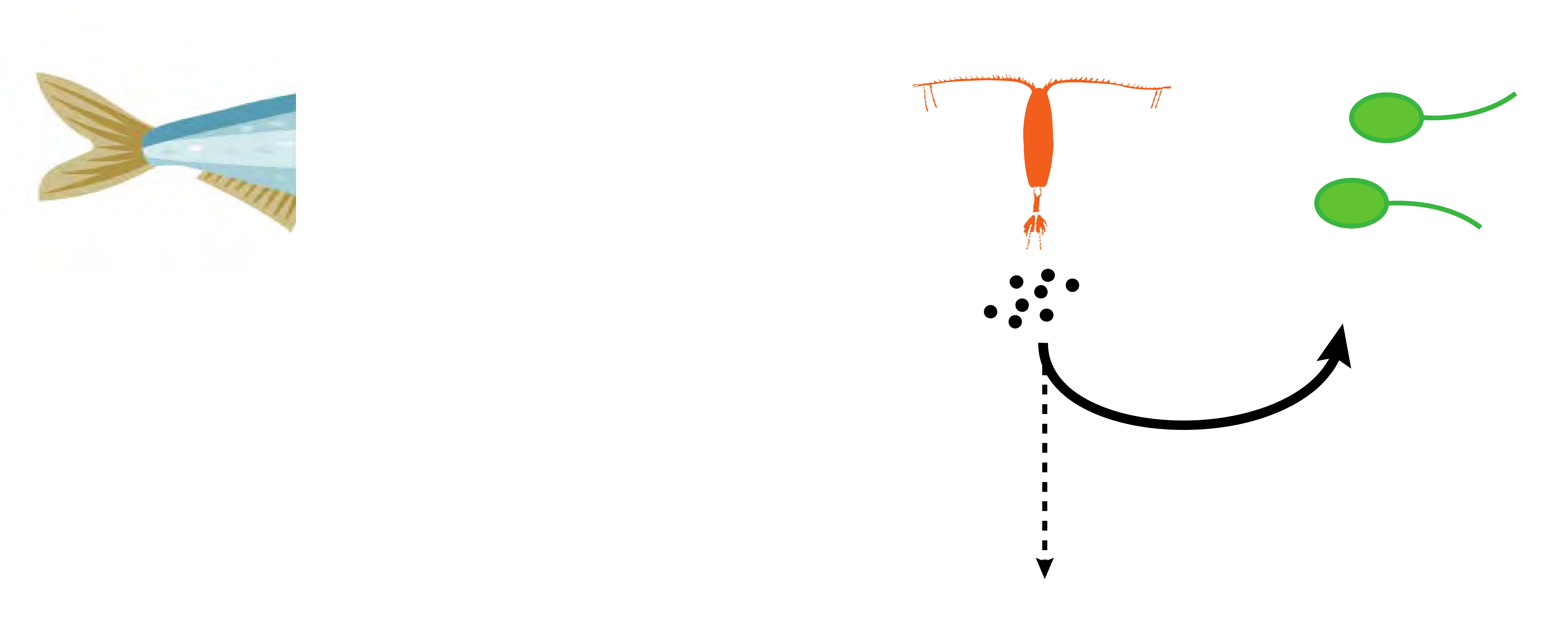
What were the consequences of removing 15-20 mill. t of herring?

Norwegian spring spawning herring



Impact of overexploiting planktivorous fishes with focus on the plankton community

Fait of faecal pellets of fish and zooplankton



- zooplankton faecal pellets
- phytoplankton
- fish faecal pellet
- zooplankton

Large stocks of planktivorous fish will contribute to export of nutrients to deeper waters and thereby lower primary productivity (PP)

What is the prevailing theory of the relationship between PP and the structure of the plankton community?

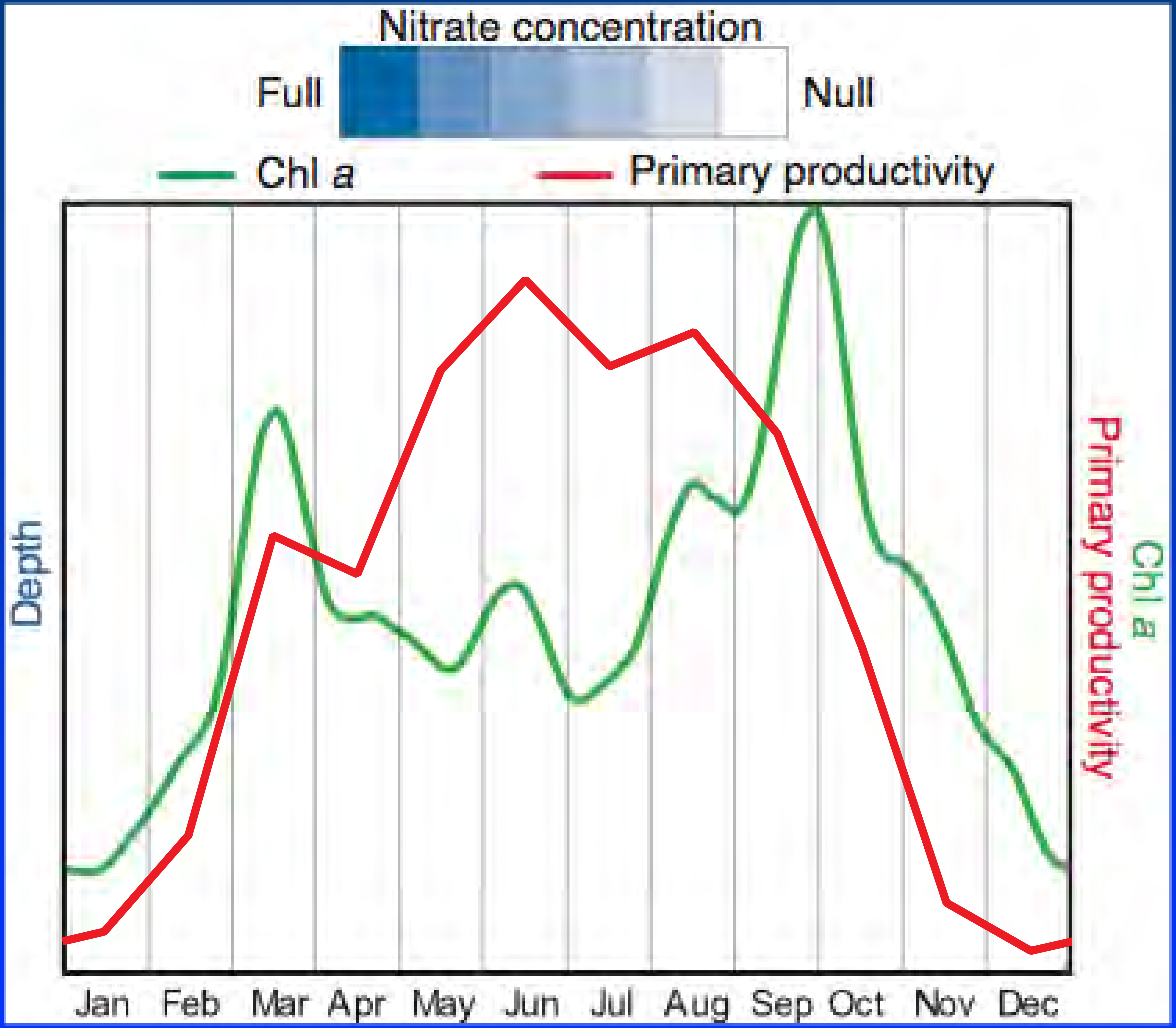
To my knowledge there is none

PP is rarely measured

Luckily there are exceptions. On the west coast of Sweden Odd Lindahl has measured PP since 1984 (C14 method)


Norwegian Sea
Sweden
Finland
Norway
Skagerrak
Denmark
United Kingdom
Ireland
Belarus
Poland
Germany
Ukraine
Austria
France
Romania
Italy
Spain
Greece
Portugal
Google

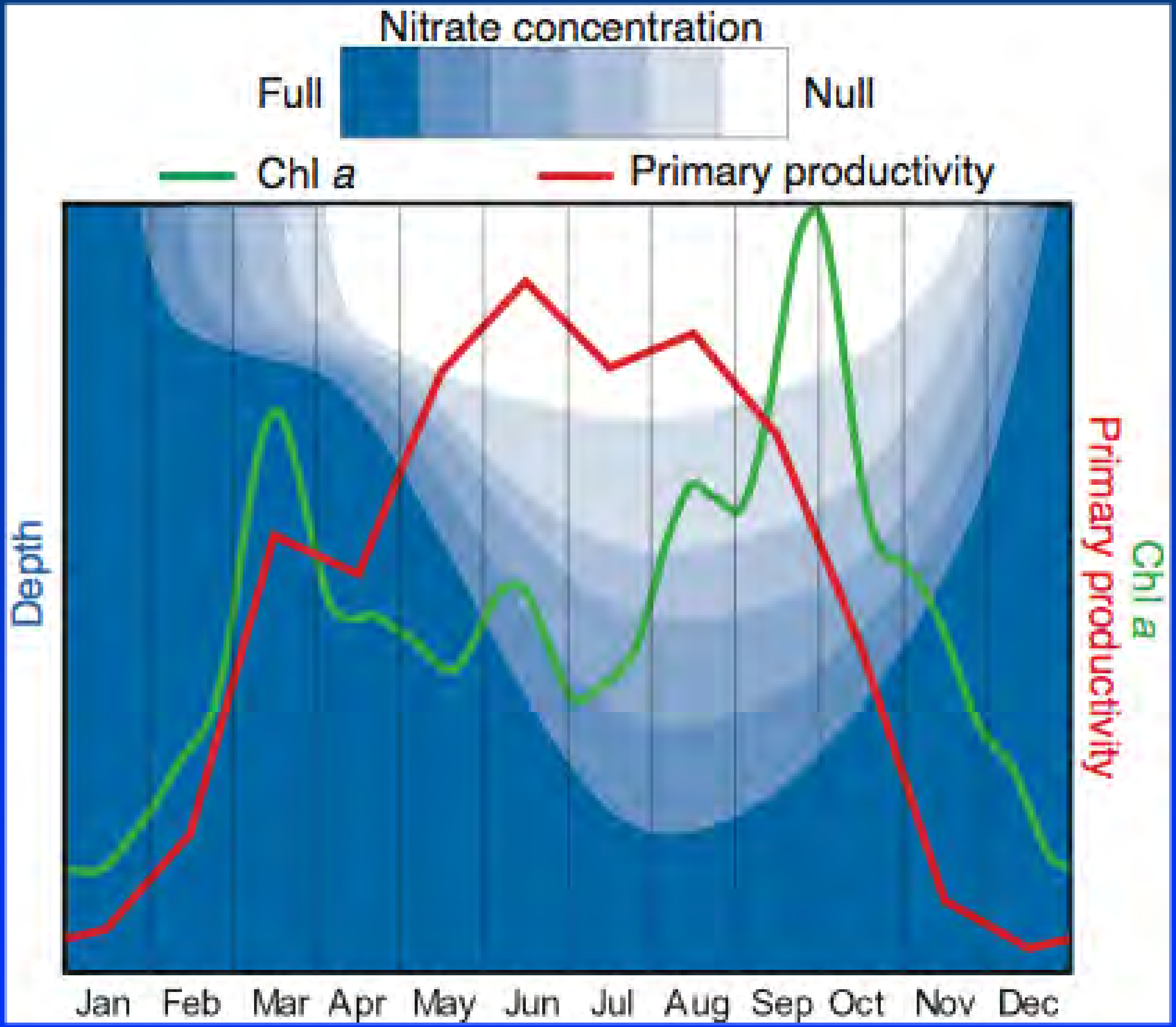
Algal biomass (Chl *a*) and primary productivity (10 years)



Primary productivity = Algal biomass + grazing (simplified version)

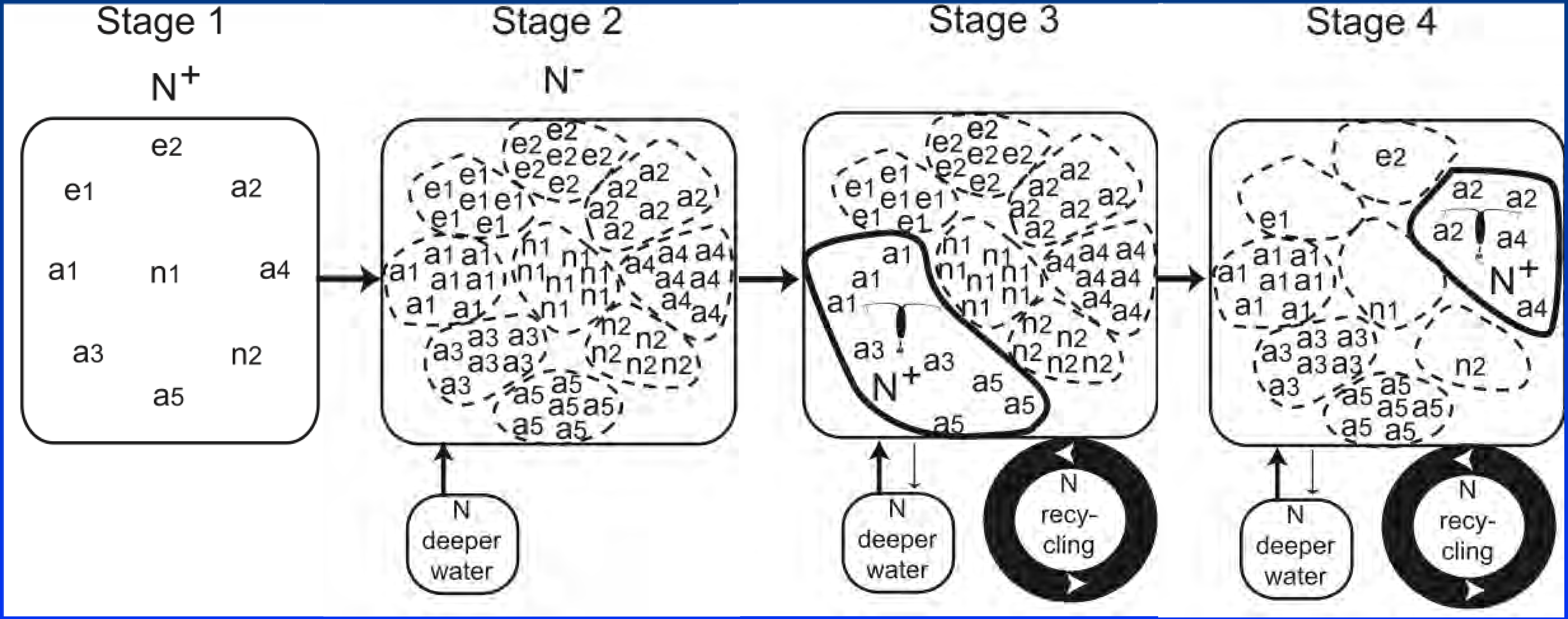
Zooplankton biomass follows the same seasonal pattern as PP

Algal biomass (Chl *a*) and primary productivity (10 years)



Edible algae dominate during summer when the grazing pressure is high and nutrients mainly recycled - there must be an advantage of being eaten

The advantage of being eaten



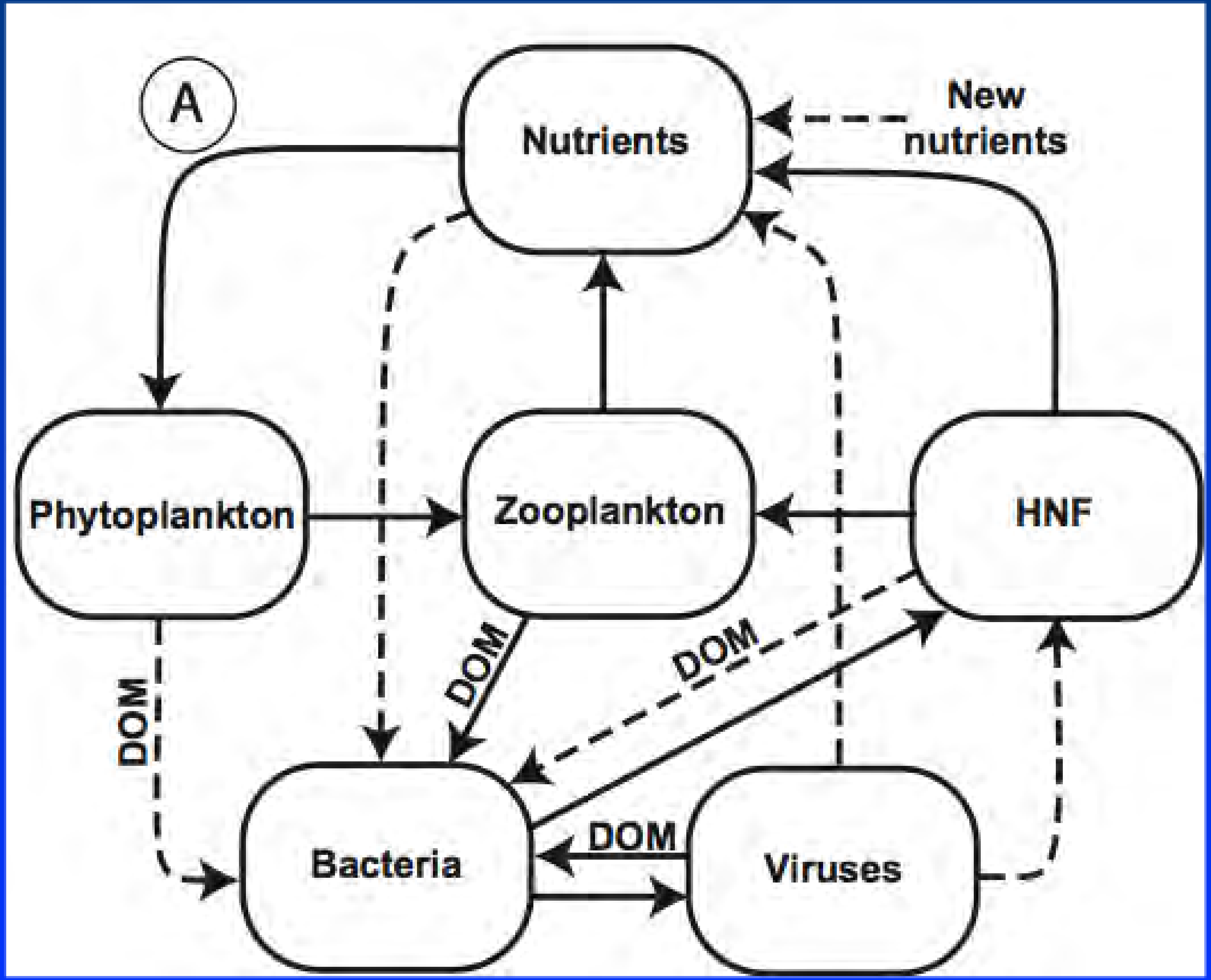
a – preferred algal prey

e – edible but not preferred algae

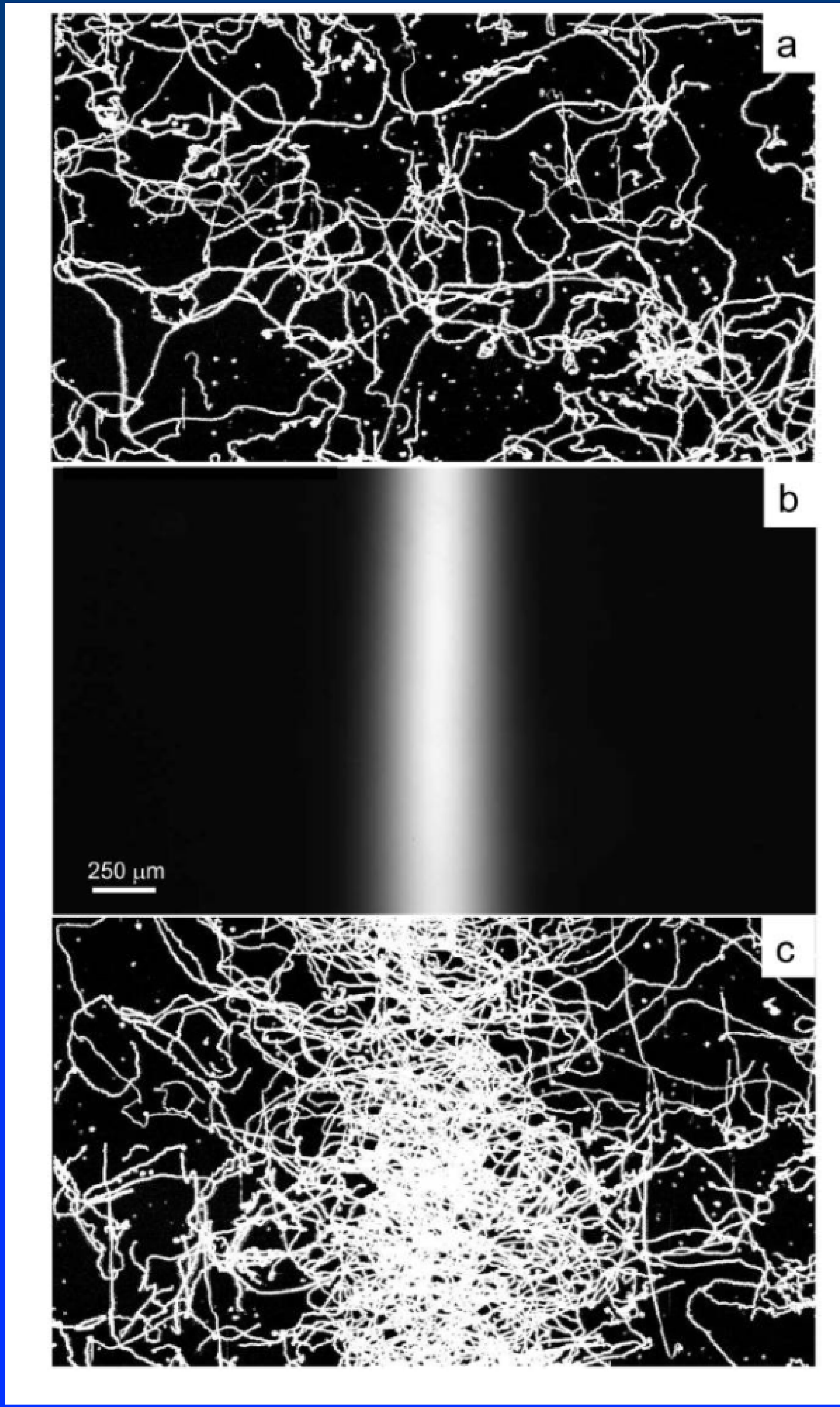
n – inedible algae

The advantage of being eaten

Cycling og nutrients



The winners are those that are eaten at the same rate as they grow
Inedible organisms loose because cycling of nutrients is impeded



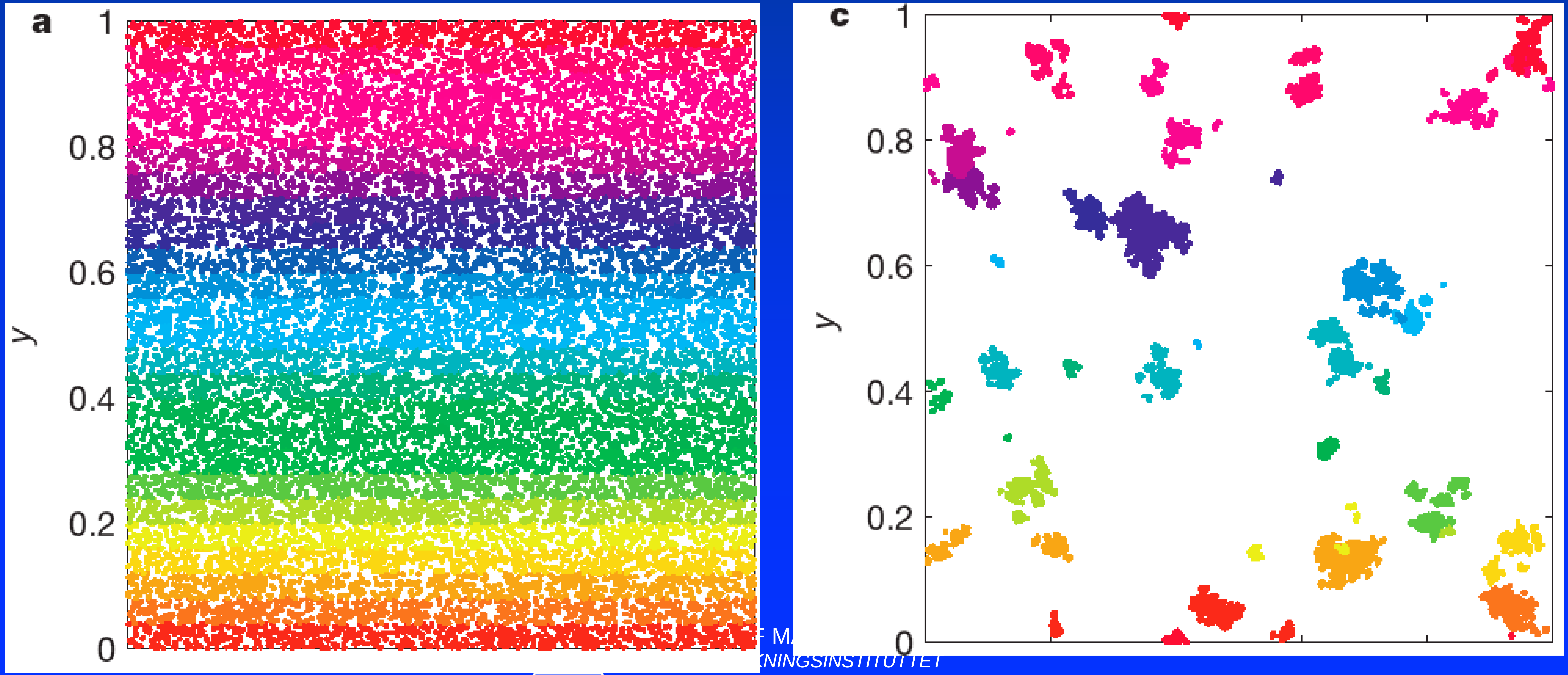
Evidence of motile algae, bacteria and HNF utilizing micro-patches of their resources

Seymour, J. R., Marcos, and R. Stocker. 2009. Resource Patch Formation and Exploitation throughout the Marine Microbial Food Web. Am. Nat. 173: E15–E29.

Evidence of patchiness
Theoretical study

Young, WR, AJ Roberts, and G Stuhne. 2001. Reproductive pair correlations and the clustering of organisms. Nature 412: 328-331.

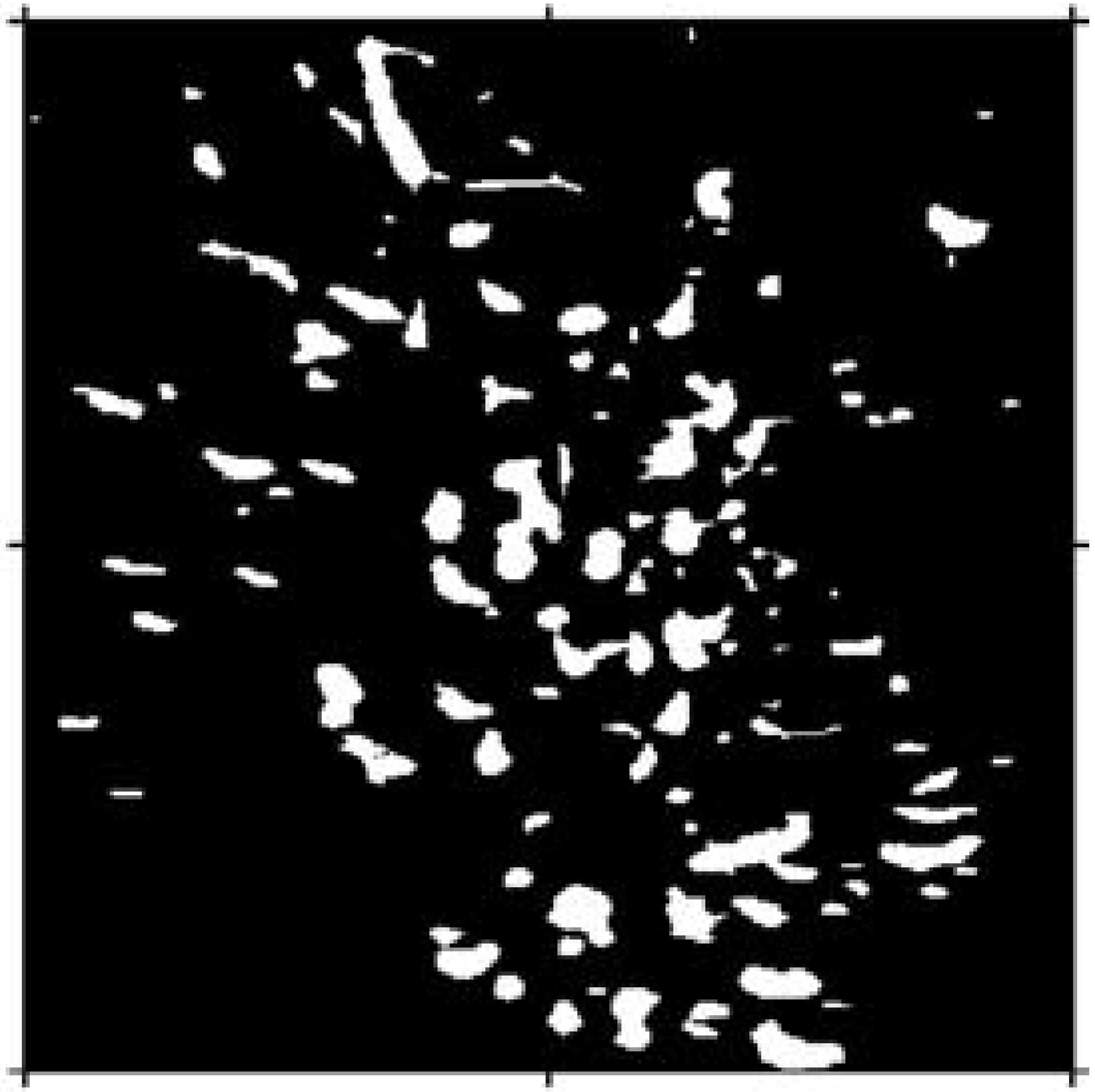
IBM study of algal reproduction and grazing



Evidence of patchiness
Empirical study

Doubell, M J, H Yamazaki, H Li, and Y Kokubu. 2009. An advanced laser-based fluorescence microstructure profiler (TurboMAP-L) for measuring bio-physical coupling in aquatic systems. Journal of Plankton Research 31: 1441-1452

2x2 cm

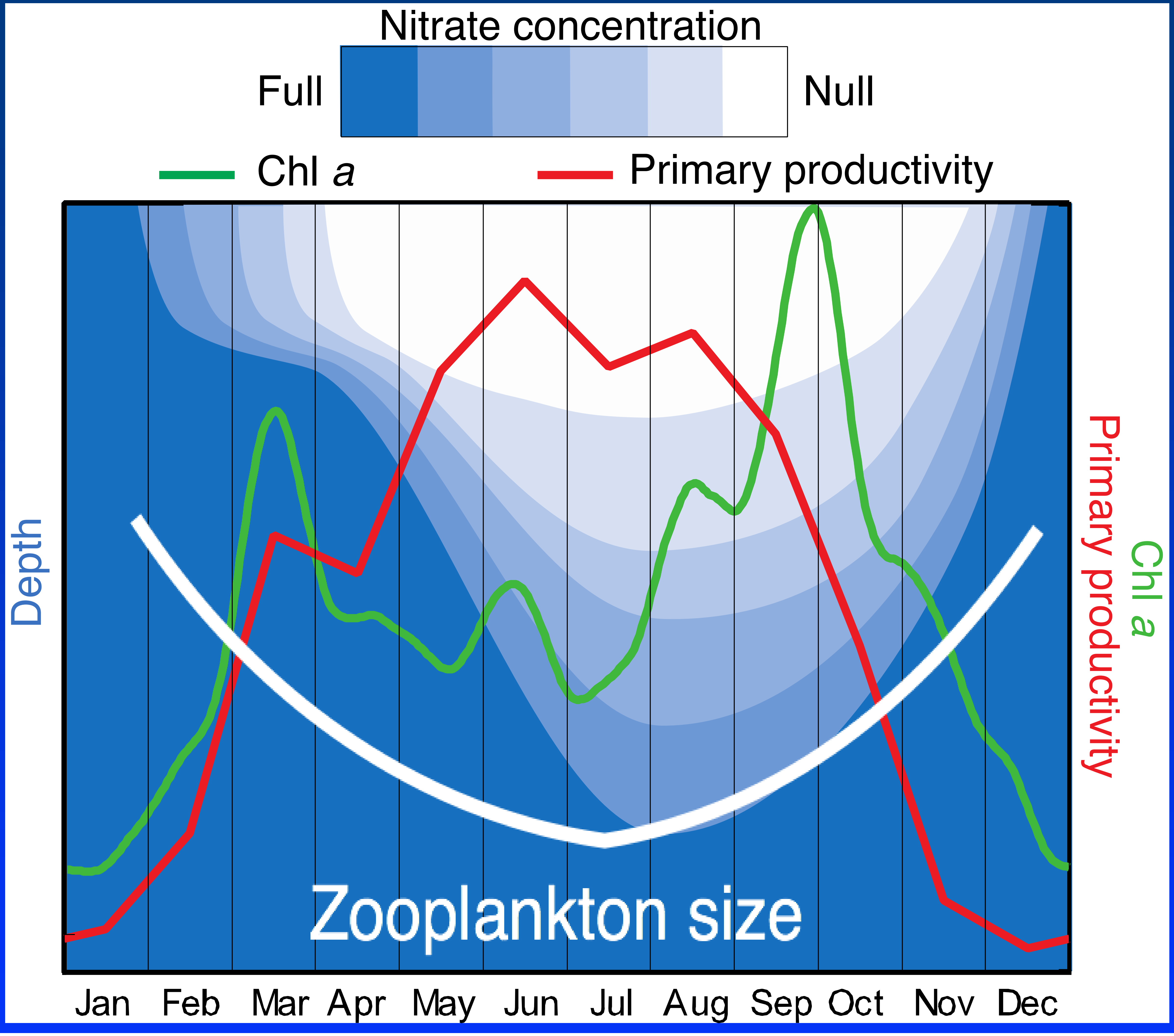


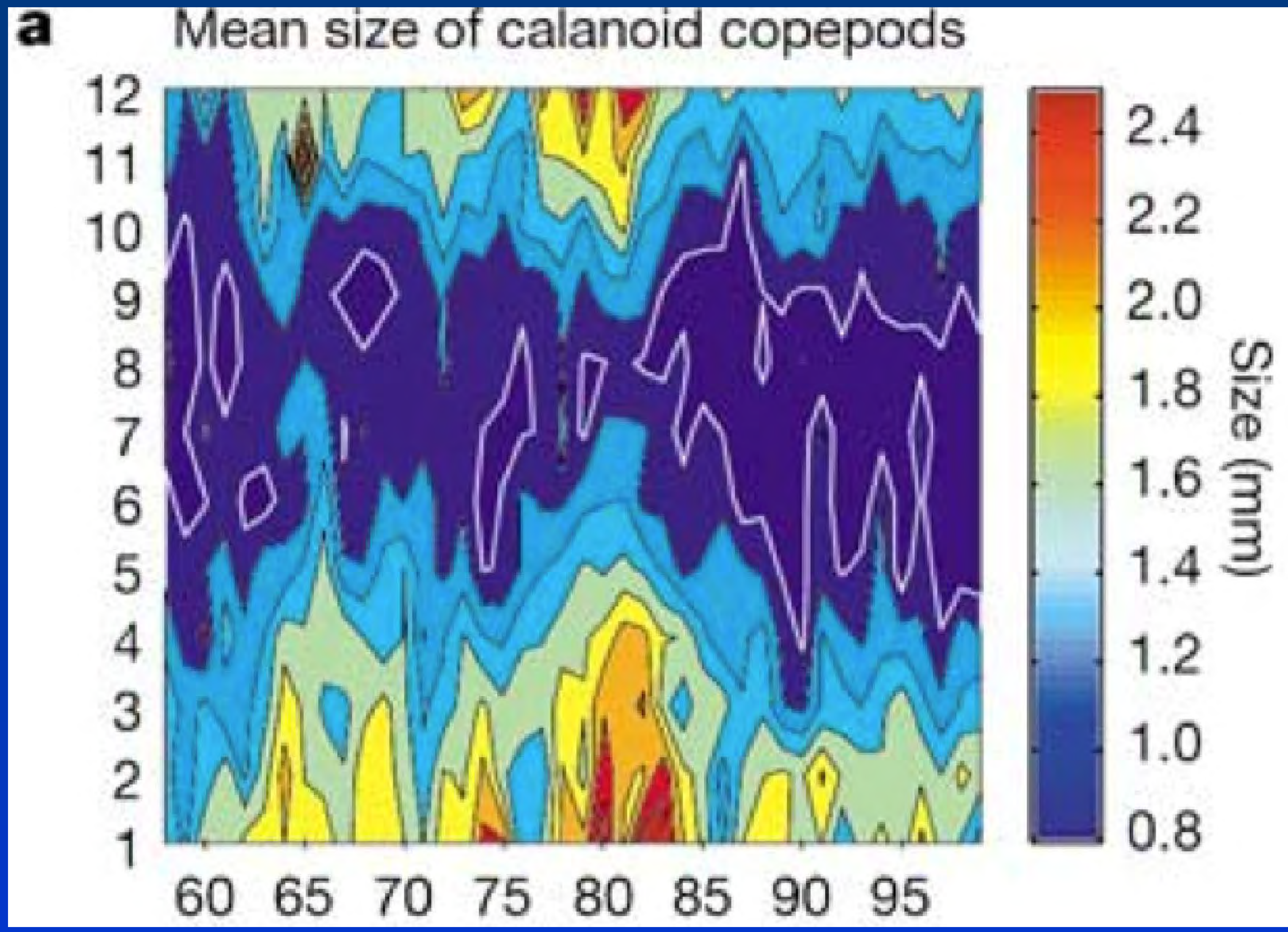
Microscale patchiness in recycled nutrients and DOM will also contribute to patchiness in motile phytoplankton, bacteria and heterotrophic nanoflagellates (HNF)

Algal biomass (Chl *a*) and primary productivity (10 years)

During summer growth rates in phytoplankton balance grazing rates

Grazing rates ~double from April-June. This favours small and fast-growing algal cells





Beaugrand, G., Brander, K. M., Alistair Lindley, J., Souissi, S., & Reid, P. C. (2003). Plankton effect on cod recruitment in the North Sea. Nature, 426(6967), 661–664.

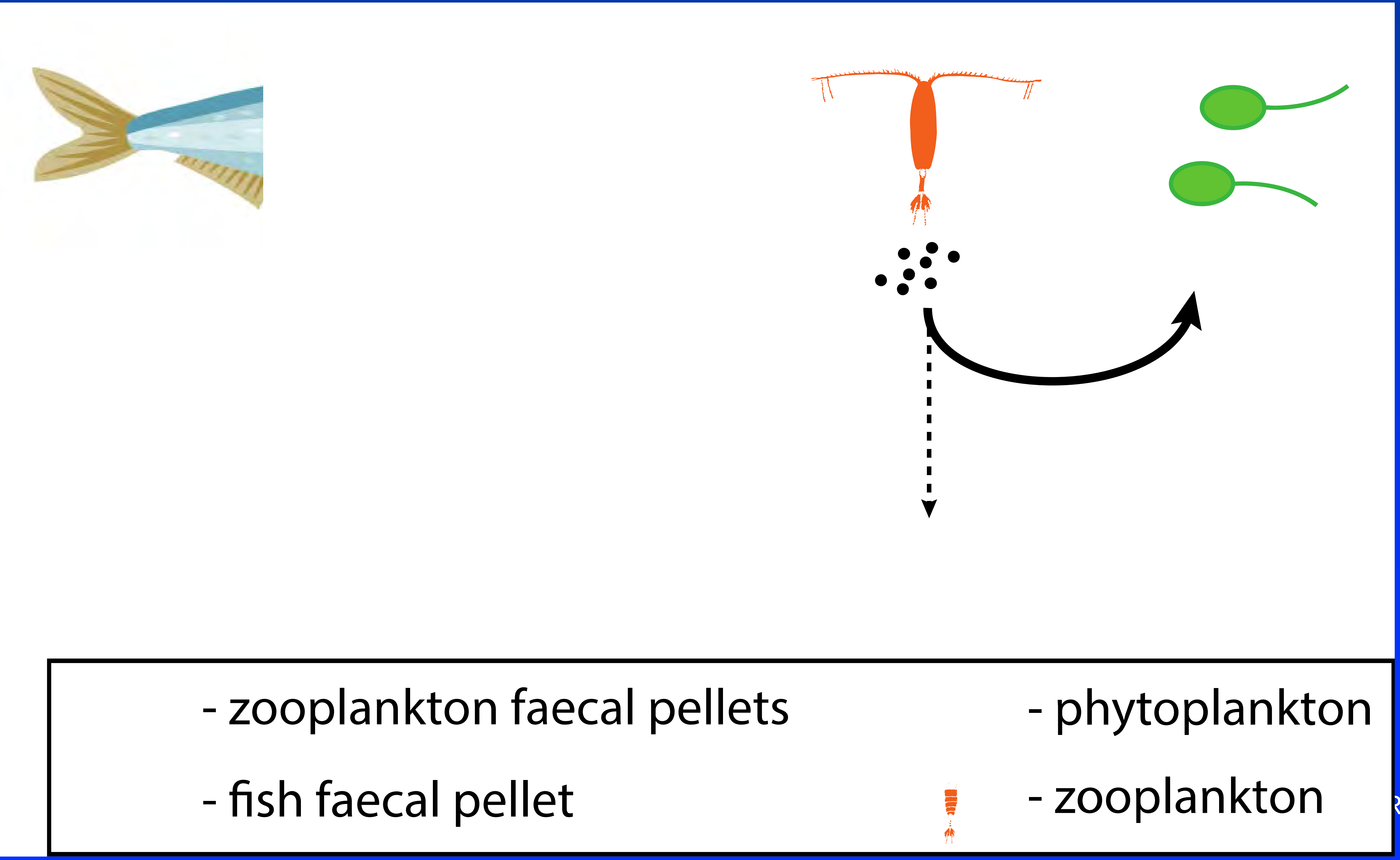
Conclusion:

High PP - small plankton due to competitive advantages

Low PP - large plankton due to competitive advantages

Impact of overexploiting planktivorous fishes

Fait of faecal pellets of fish and zooplankton



Large stocks of planktivorous fish will contribute to export of nutrients to deeper waters and thus lower primary productivity

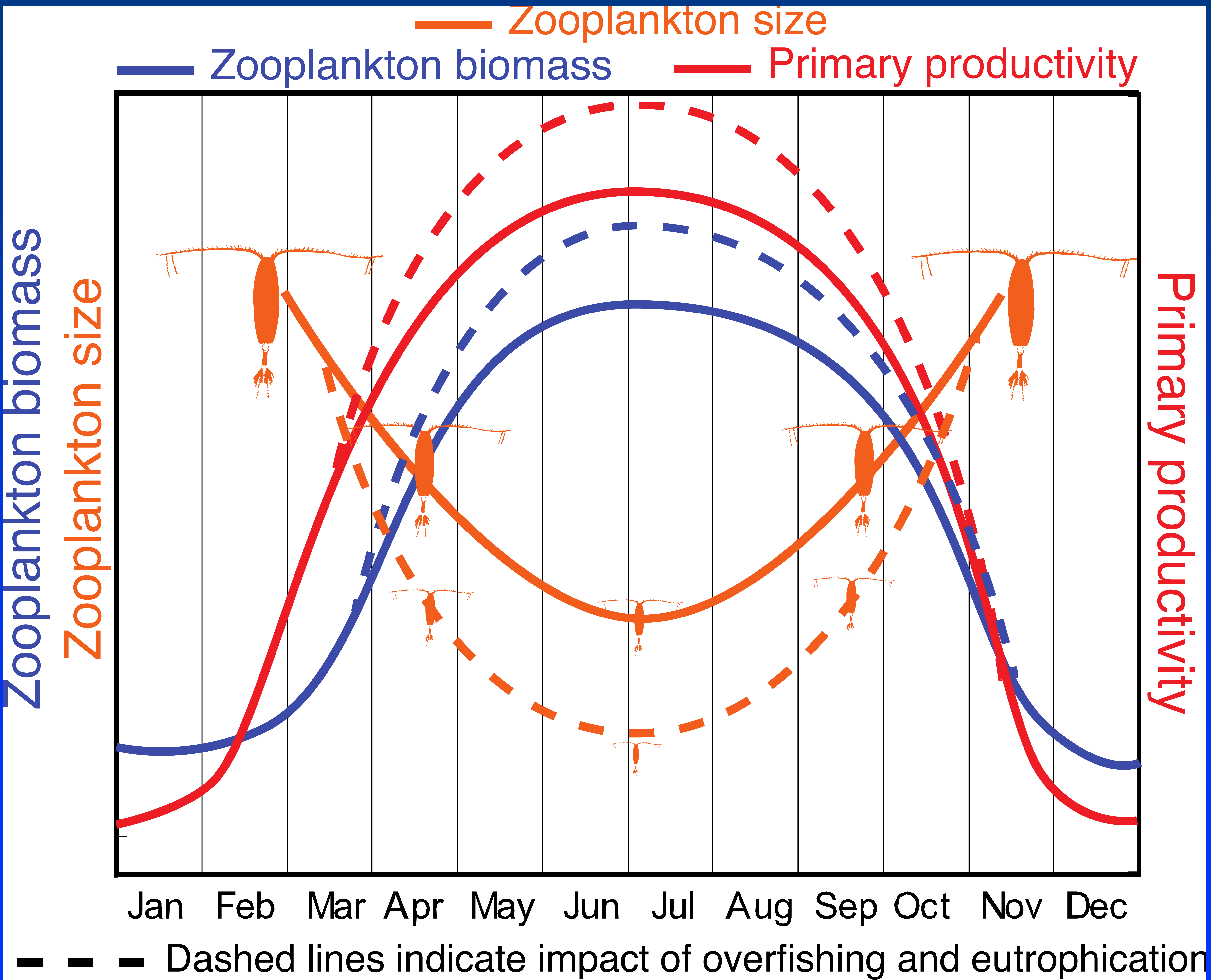
RCH

Impact of overexploiting planktivorous fishes

Overexploiting planktivorous fish stocks will result in increased primary productivity,

increased zooplankton biomass,

but reduced size in plankton and thus reduced energy flow to higher trophic levels (planktivors are clever!)



Summary

1. PP is suggested to be an important structuring variable in marine planktonic communities
2. High PP – small plankton
3. Low PP – larger plankton
4. Overfishing of planktivorous fishes and eutrophication will have the same impact on the plankton community by causing increased PP and thereby smaller plankton
5. There is a synergistic relationship between planktivores and their zooplankton prey, i.e. both predator and prey increase in abundance by coexisting
6. There is also a synergistic relationship between zooplankton, their algal prey and organisms that contribute to cycling of nutrients

Thank you for your attention!