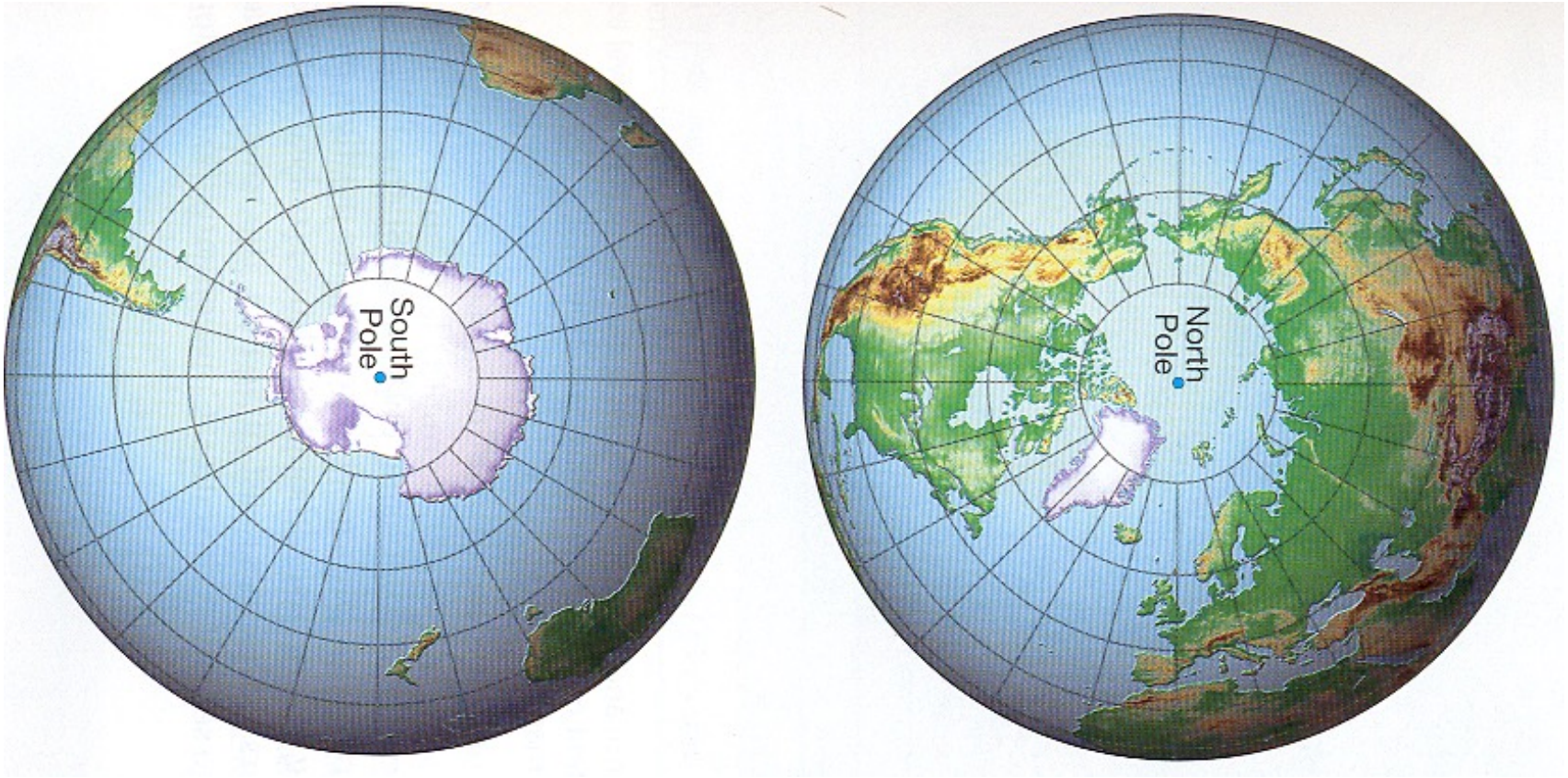
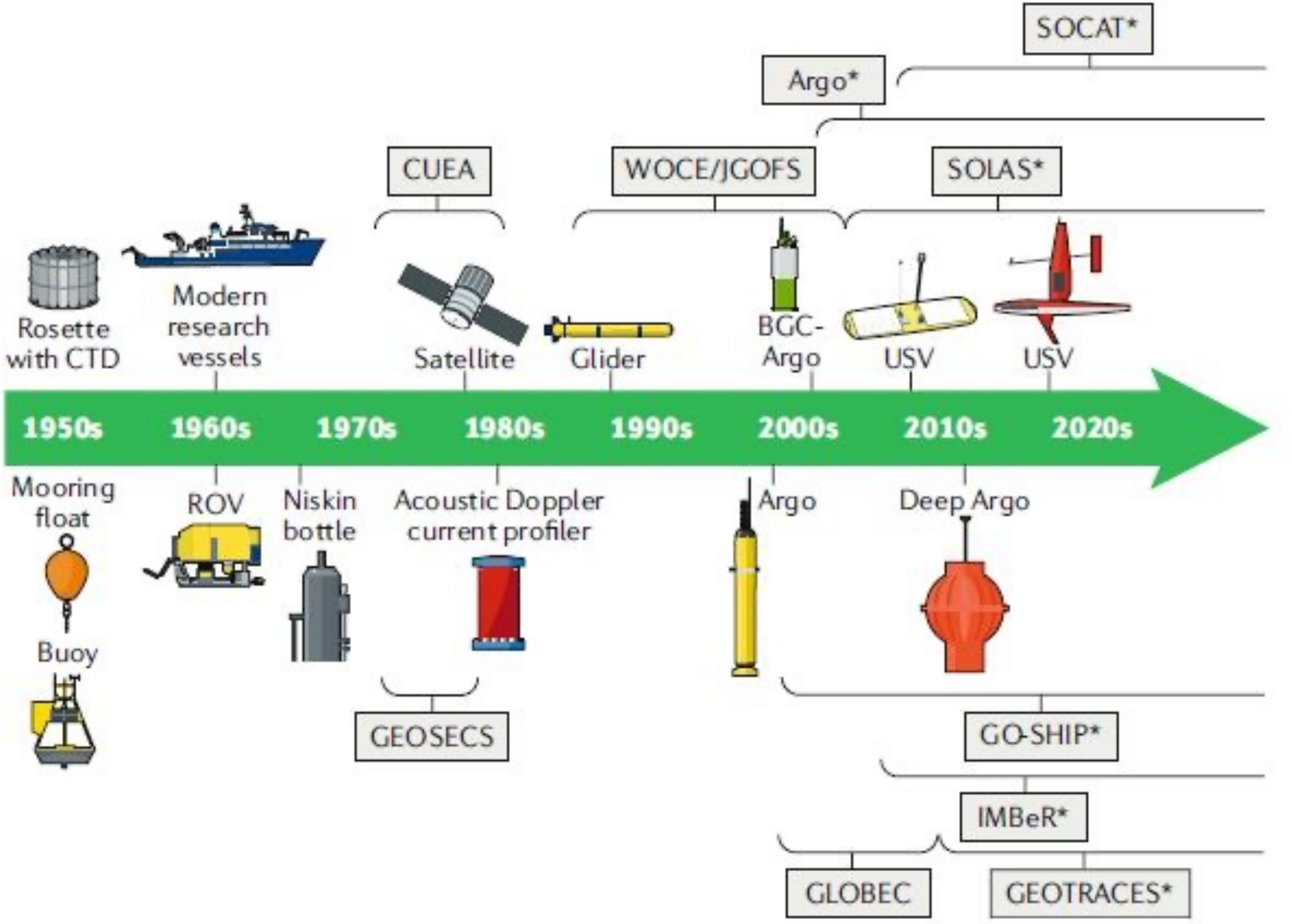
What is the color of phytoplankton ecology?



Aurea Maria Ciotti – ciotti@usp.br
Centro de Biologia Marinha da USP (CEBIMar – click to find me)

Plataforms to observe the biogeochemistry of the oceans

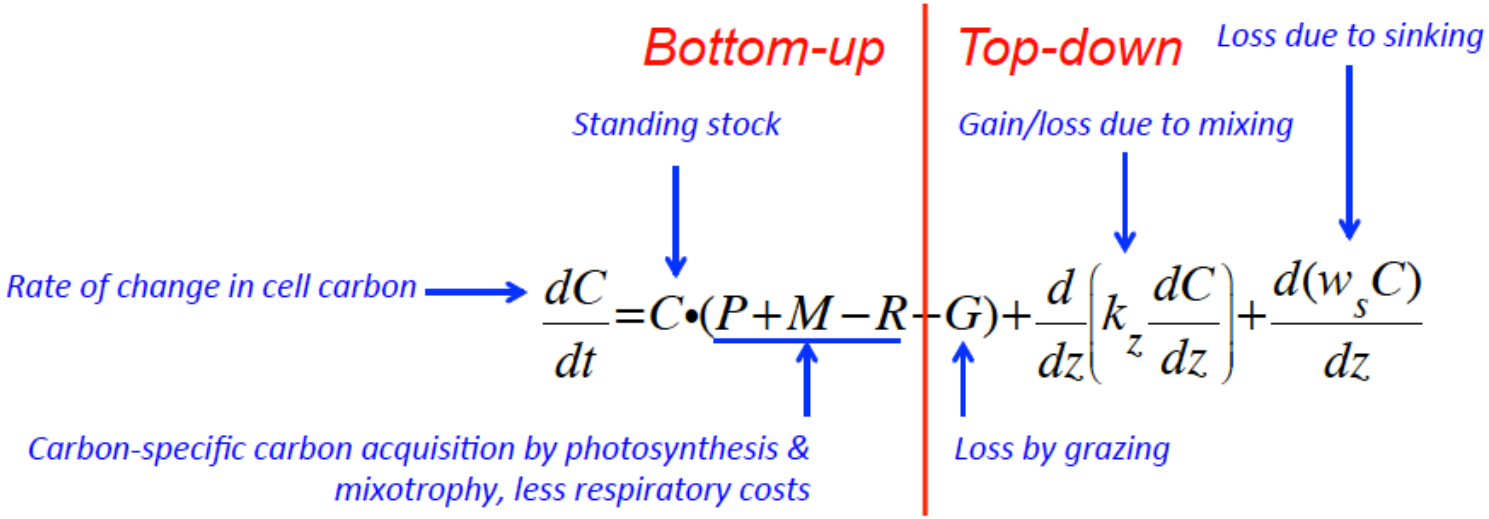


Chai et al., 2020 DOI: 10.1038/s43017-020-0053

Changes in ocean color by "*phytoplankton*"

- *O2 -50%-, m*ajor global biogeochemical player, climate, HABs
- Base of marine food webs.
- VIP – very importante processes / products

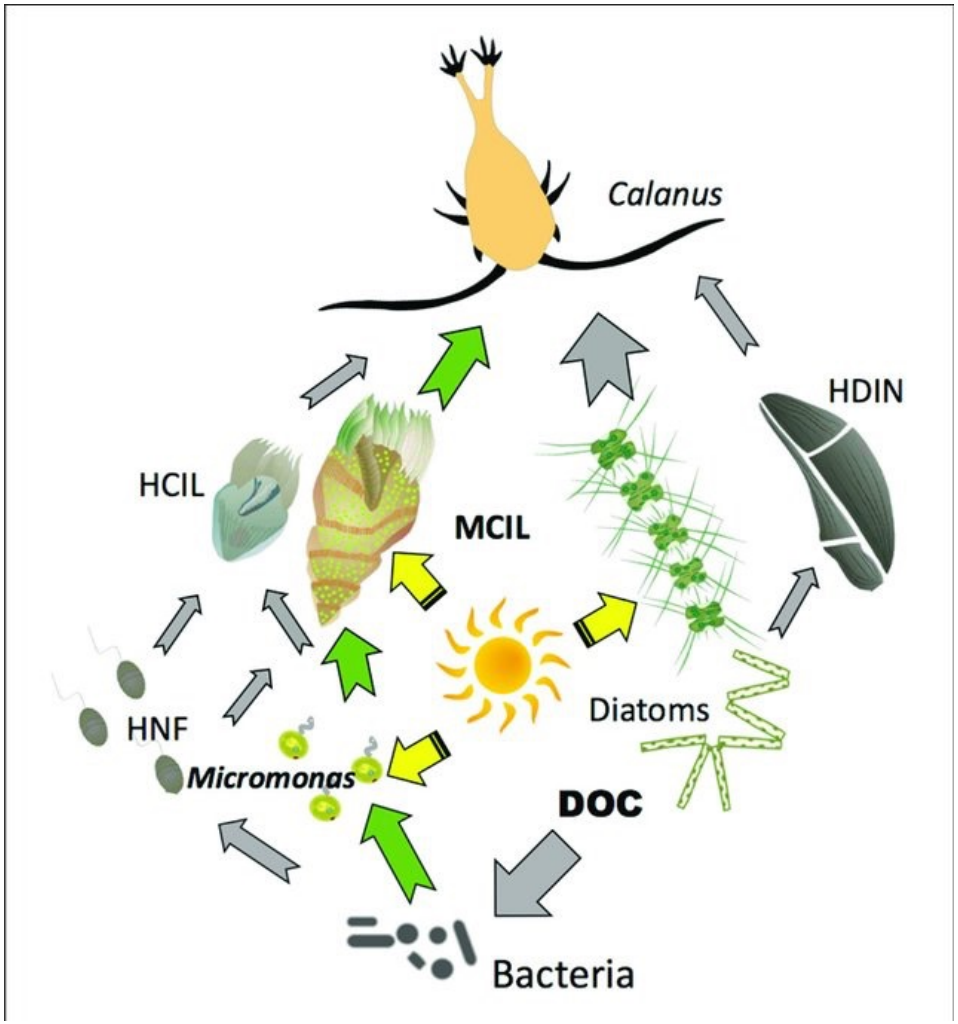
Typical values 10 to 60 mg C m^{-3} or 1 to 2 g C m^{-2}



Modified of Riley, Stommel and Bumpus (1949)

Typical values 10 to 100 mg C m^{-3} d^{-1} or 100 to 1000 mg C m^{-2} d^{-1}

Dichotomy “phytoplankton” and “microzooplankton”

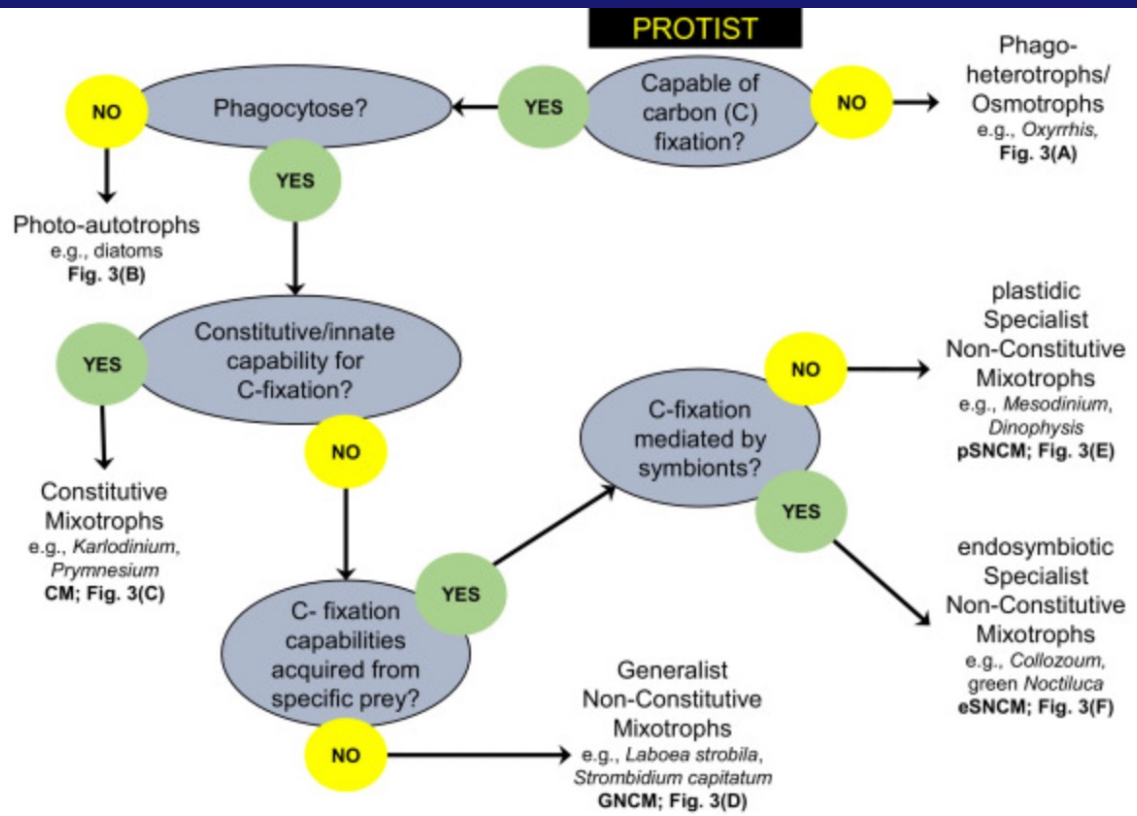


Microbial loop

FIGURE 3 | Conceptual model of Arctic food web with mixotrophy. Yellow arrows indicate flow of energy from the sun to photosynthetic organisms (autotrophs and mixotrophs); Gray arrows indicate flow of carbon to heterotrophs; Green arrows indicate major pathways of carbon flow to or from mixotrophs. HCIL, Strictly heterotrophic ciliates; MCIL, Mixotrophic ciliates; HNF, Heterotrophic nanoflagellates; DOC, Dissolved organic carbon; HDIN, Heterotrophic dinoflagellates.

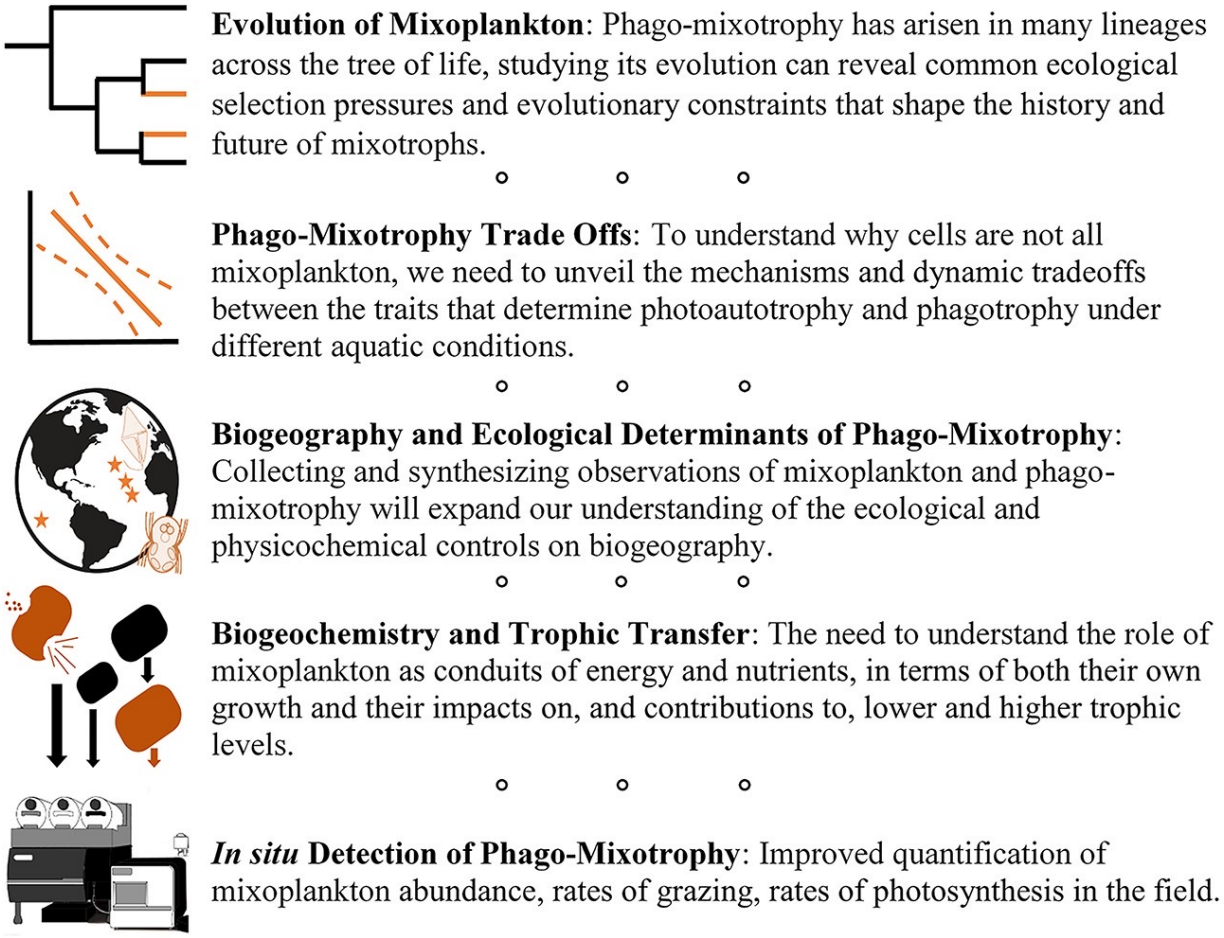
Mixotrophy

Stoecker and Lavrentyev2018 DOI: 10.3389/fmars.2018.00292



Mitra et al., 2016 10.1016/j.protis.2016.01.003

Fig. 1 Summary of our outlined mixoplankton and phago-mixotrophy research priorities. Icons by Holly Moeller.



Millette et al., 2023

J Plankton Res, fbad020, https://doi.org/10.1093/plankt/fbad020

Diazotrophic cyanobacteria

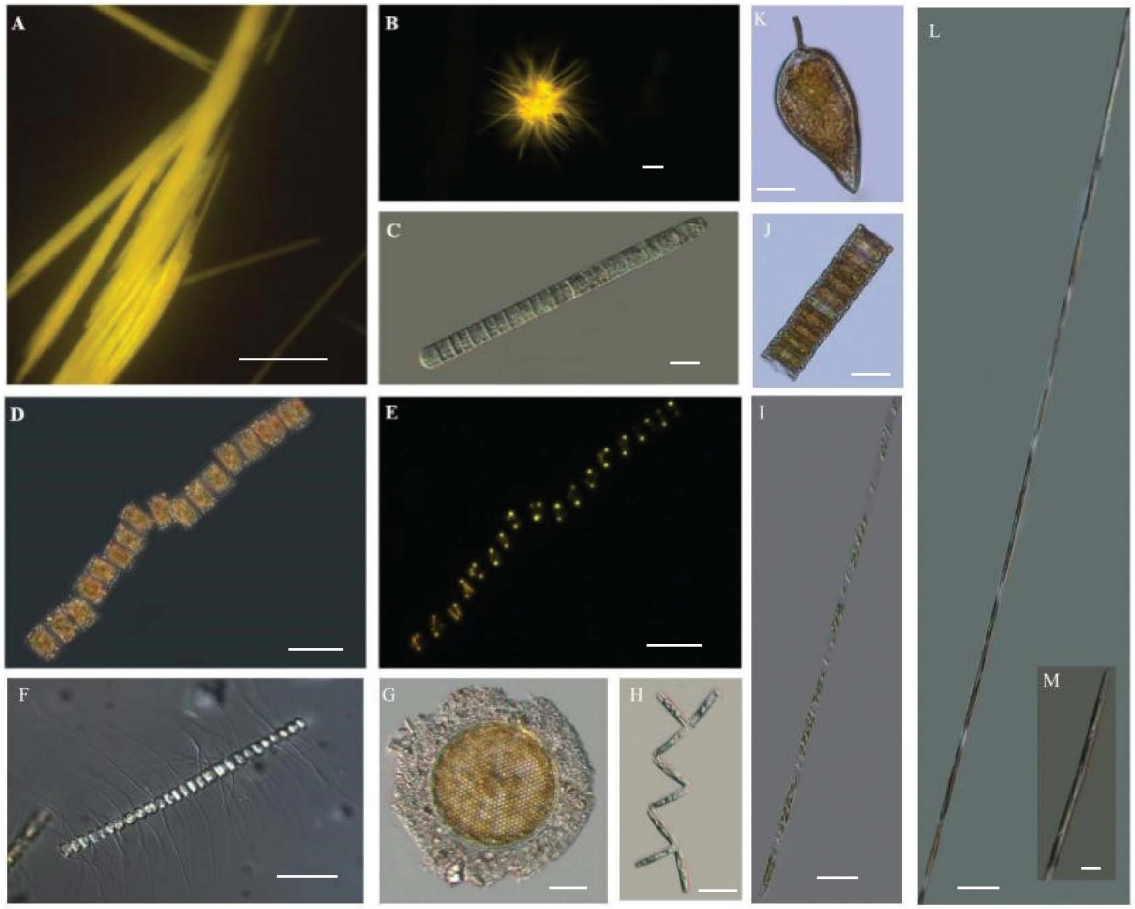
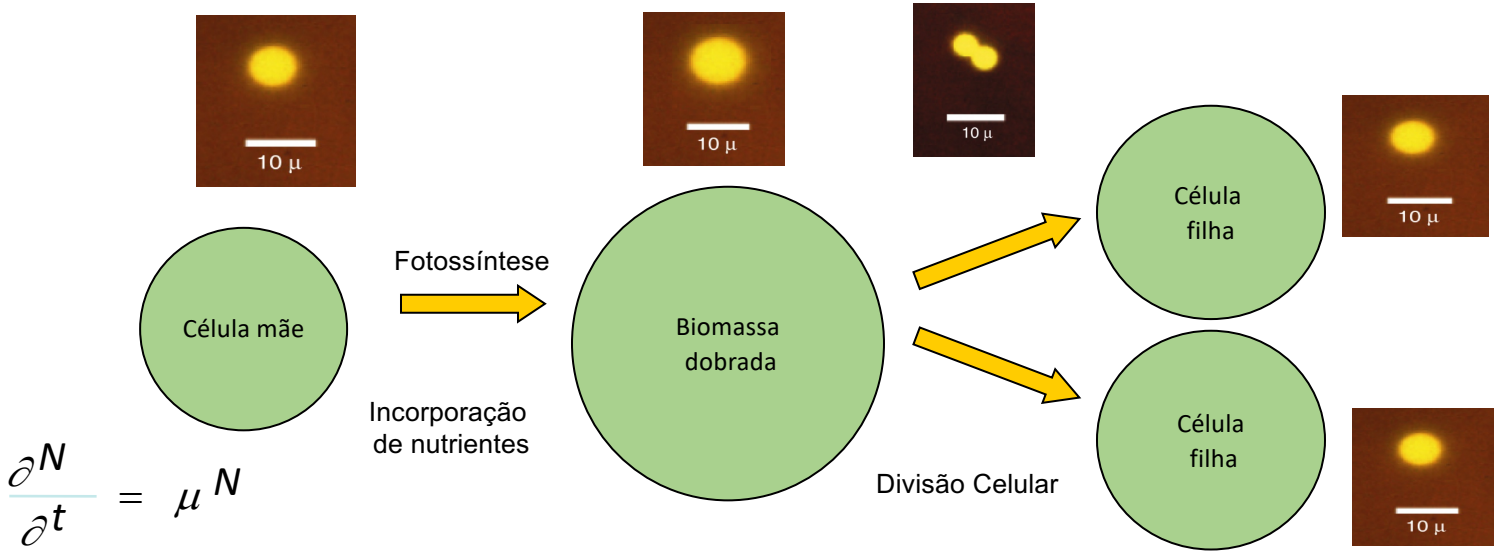


Figure 3. Diazotrophic cyanobacteria of the genus *Trichodesmium,* aggregates in bundles know as “tuffs” (**A**), in spherical “puffs” (**B**) and as a single trichome (**C**). Diatom *Hemiaulus membranaceus* (**D**) and diazotrophic cyanobacteria *Richelia intracellularis* (**E**) within it. Diatoms *Chaetoceros* cf. *debilis* (**F),** *Thalassiosira* sp.1 (**G**), *Leptocylindrus danicus* (**I**) and *Paralia sulcata* (**J**). Diatoms *Thalassionema nitzschioides* (**H**), *Pseudo-nitzschia* “*seriata*complex” sp.1 (see methods for definition) (**L, M**). Armored Dinoflagellate *Prorocentrum micans* (**K**). **A, B**epifluorescence microscopy image at 10x magnification; **E** epifluorescence microscopy image at 20x magnification; **I, L**DIC microscopy image at 200x magnification and **C, F, G, H, M** at 40x magnification; **D, K, J** phase-contrast microscopy image at 400x magnification. Scale bar: **A, B, D, E, F =** 50 µm; **C, G, H, I, J, K, L =** 10 µm; **M =** 05 µm.

Tocci et al., 2023 DOI:10.1590/1676-0611-BN-2021-1260

“Phytoplankton” growth – cell division – studies in cultures - drivers



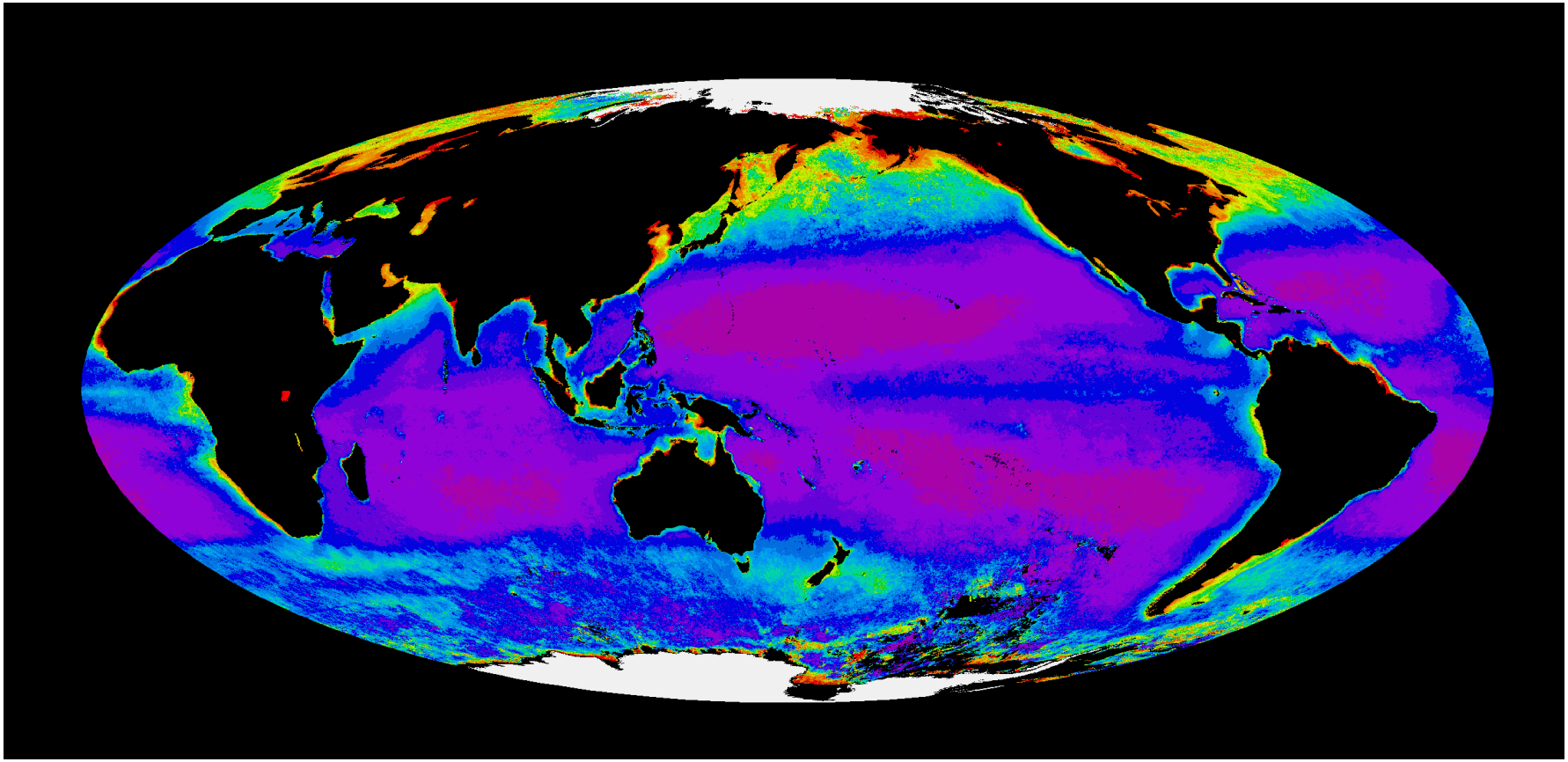
$$\frac{\partial N}{\partial t} = \mu N$$

Measurements in cultures (ml)

- Increase in cell density, chlorophyll, particulate carbon
- Decrease in nutrients (N, P, Si)

Thalassiosira pseudonana [Algaebase](#) *click for nomenclature checks*

Costal to open ocean gradients of faster loss of blue compared to green ligth (Rrs) has been documented as a global feature (CZCS)

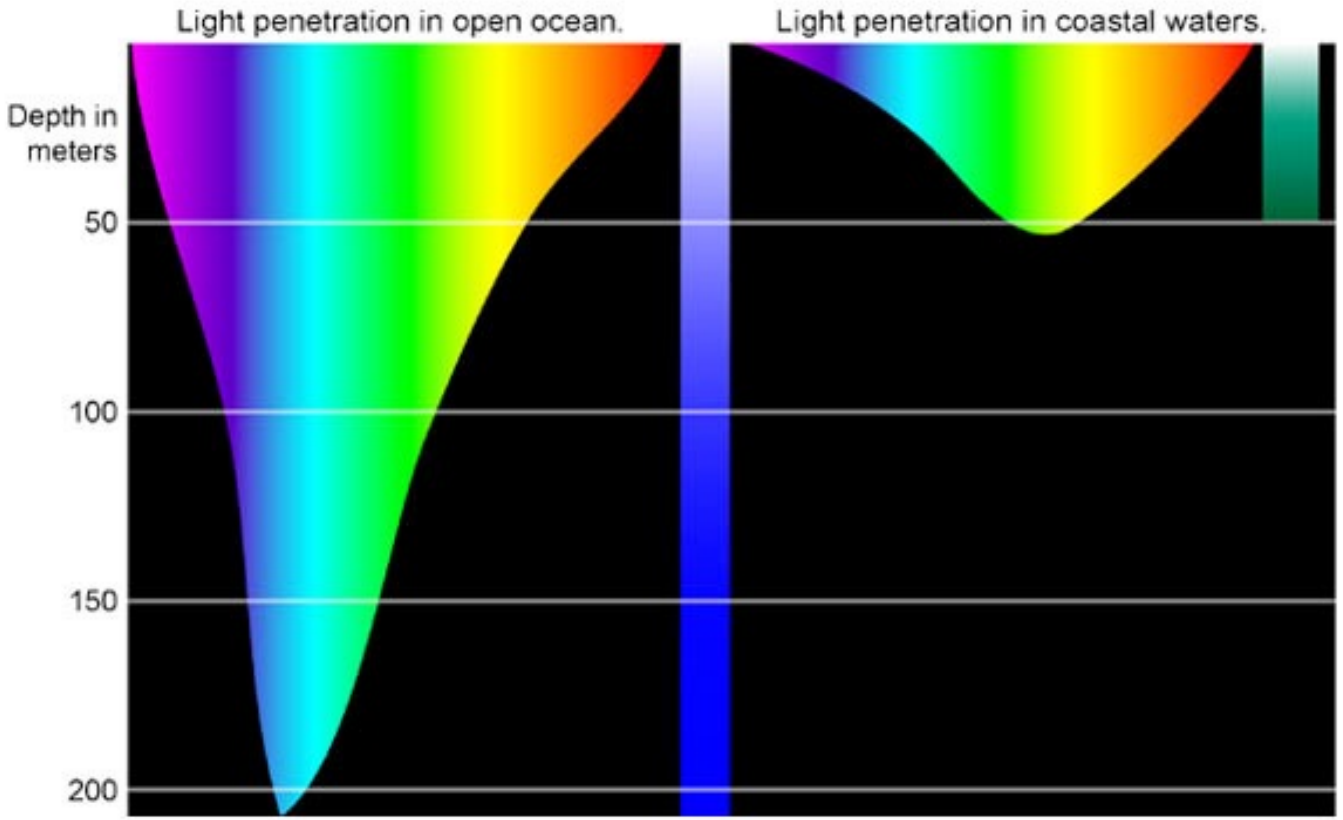


Bulk measurements/estimates
-chlorophyll / HPLC
-Phytoplankton carbon

$$\frac{\partial C}{\partial t}$$

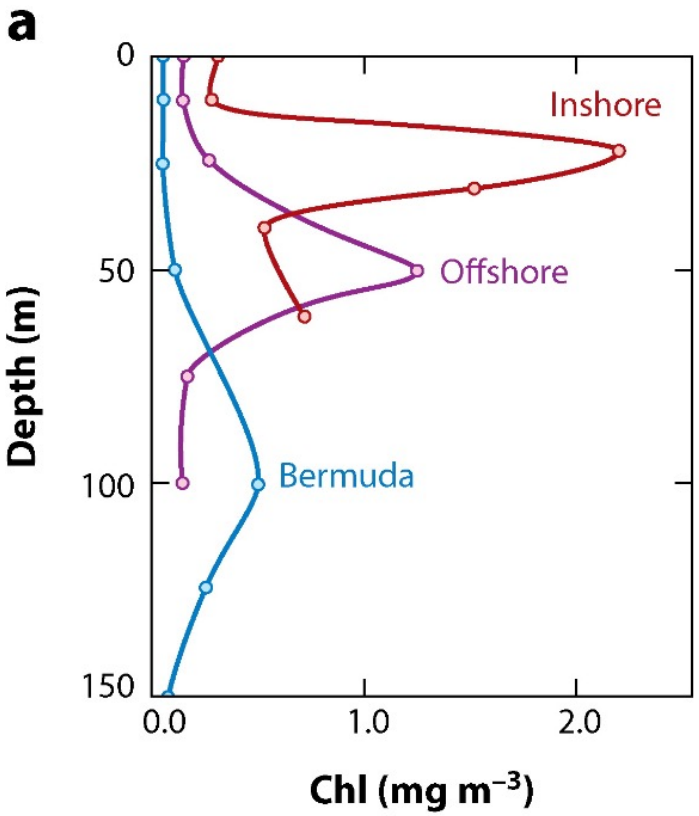
- C^{14} incorporation; O2 production;
- Estimation of ETR – variable fluorescence

Oligotrophic to Eutrophic Environment – more chlorophyll , larger cells

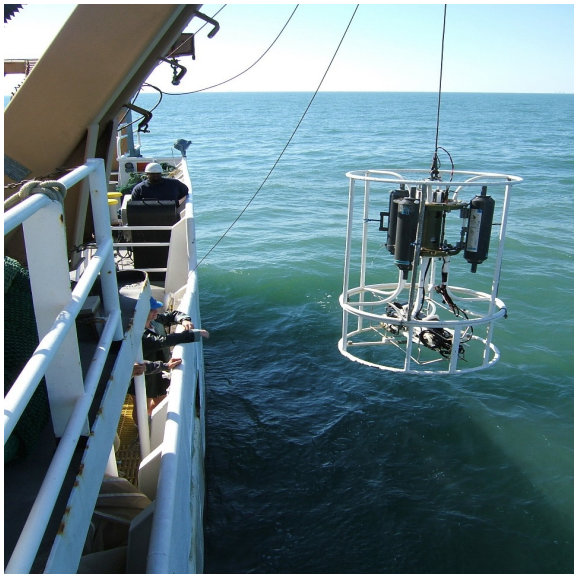


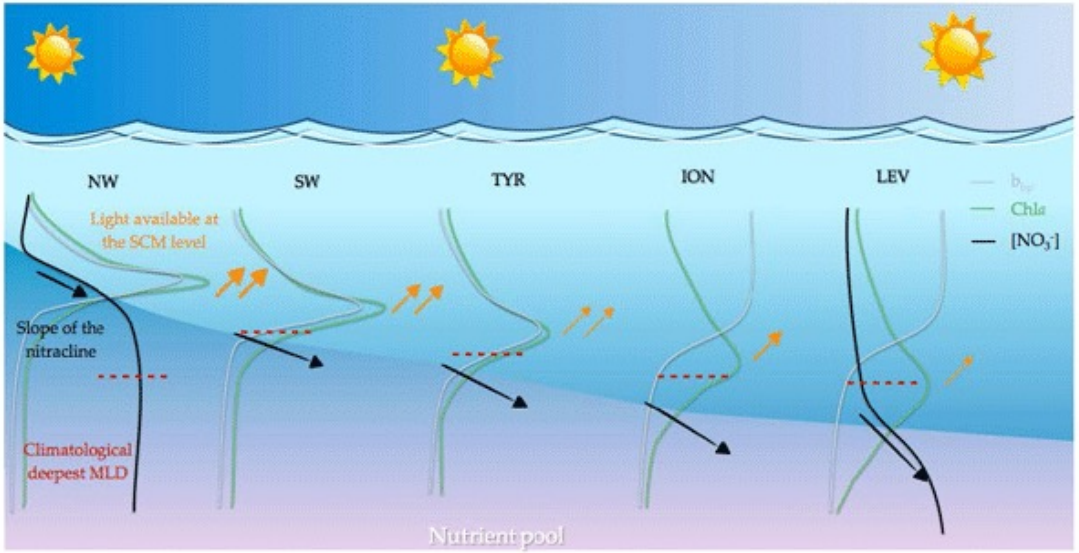
Bulk light absorption by communities –
Does it vary linear with chlorophyll concentration (?)

Optical measurements – physics and biology observed in similar scales

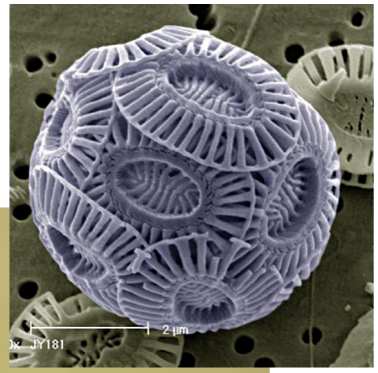


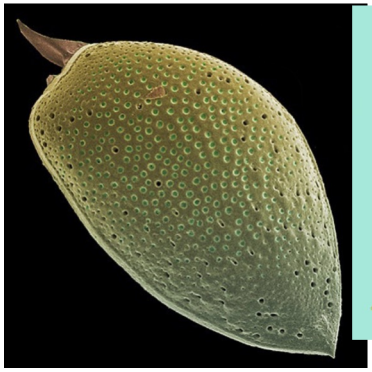
[Cullen 2015 Doi: 10.1146/annurev-marine-010213-135111]

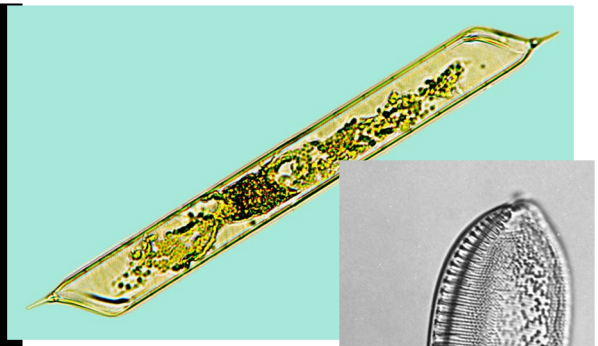


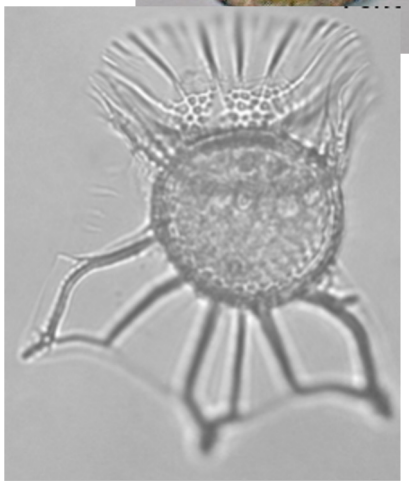


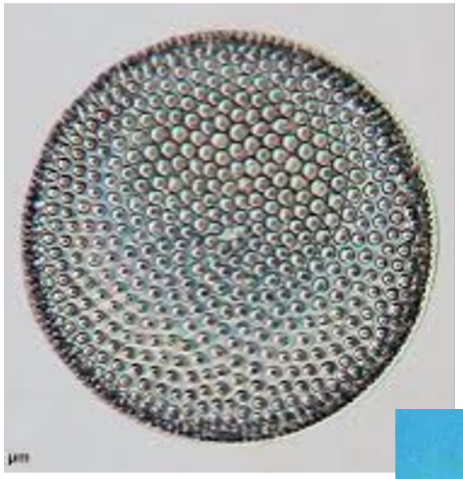
Barbieux et al. DOI: 10.5194/bg-16-1321-2019

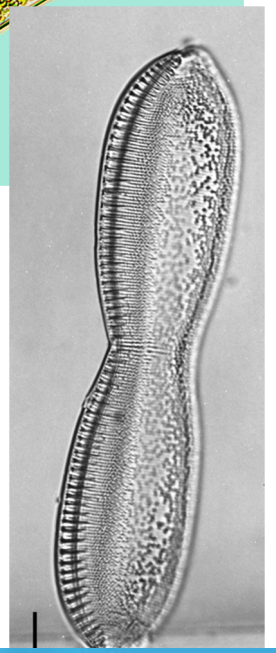

2 µm

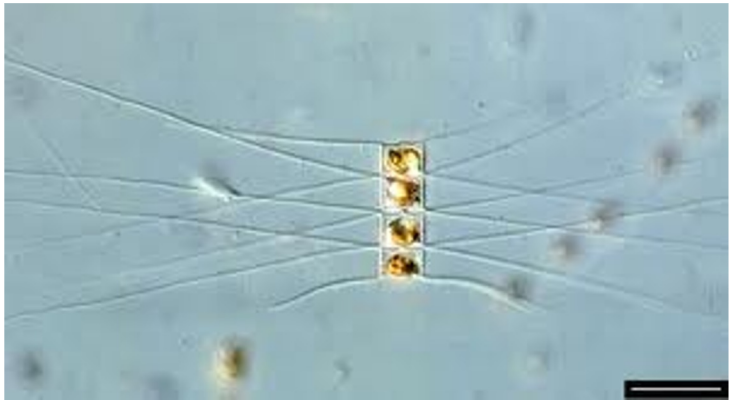


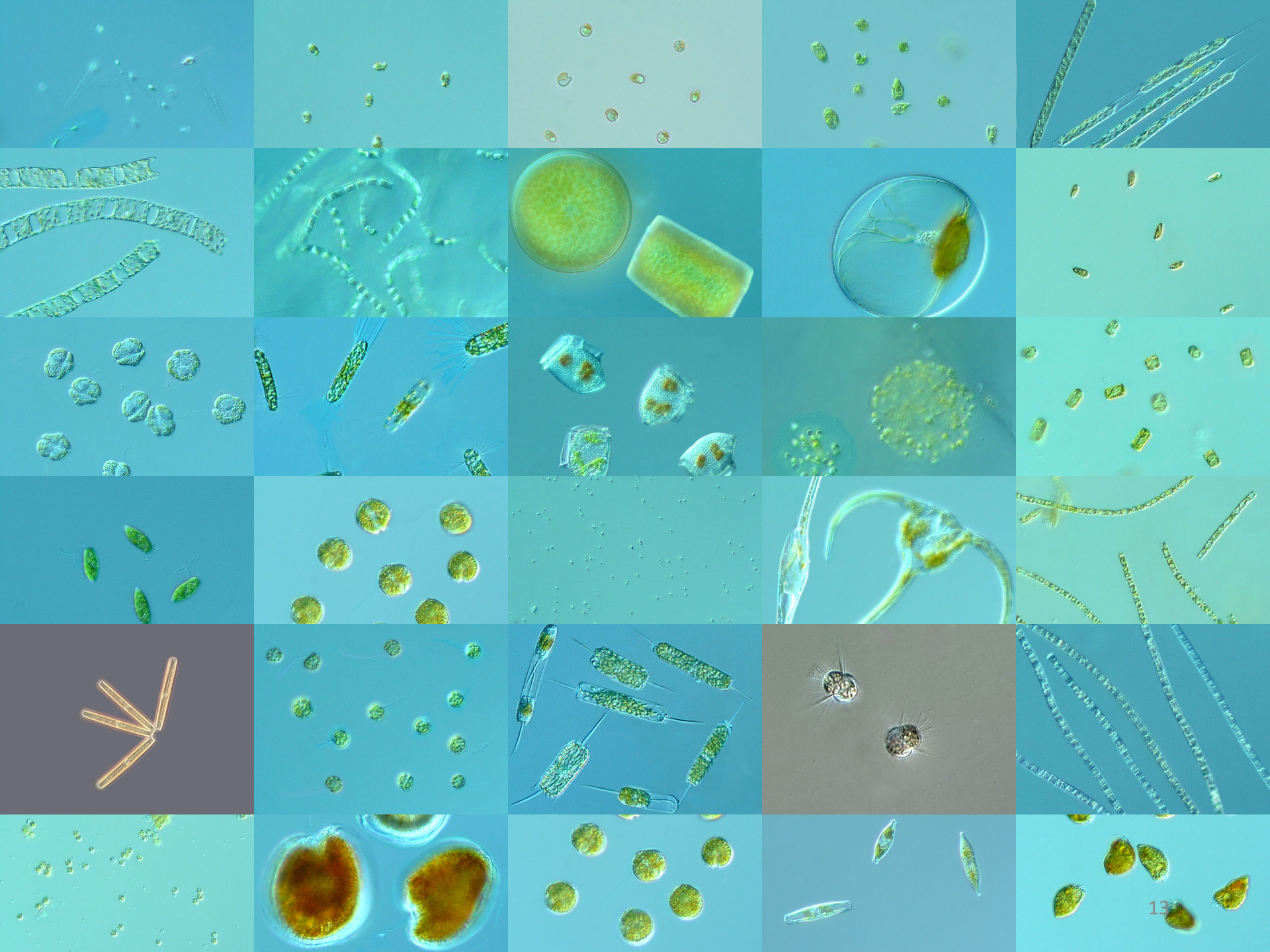


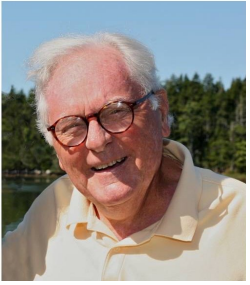












Charles Yentsch

[Yentsch and Phinney DOI:10.4319/lo.1989.34.8.1694]

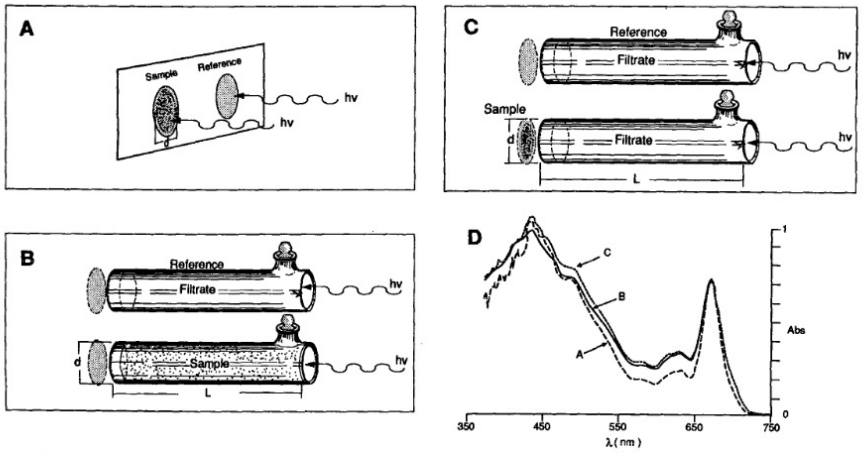
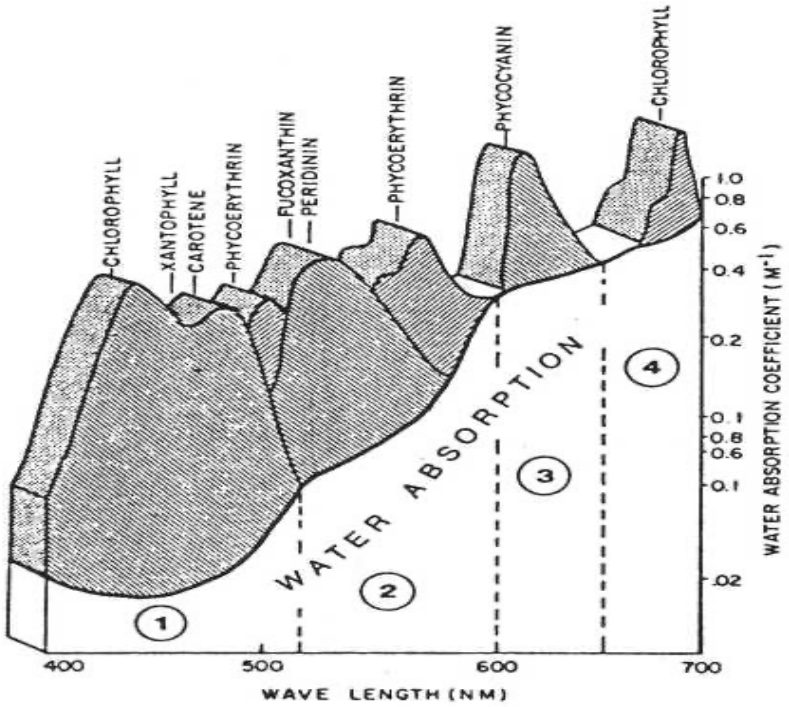


Fig. 2. Cuvette calibration for the filter technique. A. Filter technique used at sea. B. Cells in a 10-cm cuvette, 1.9-cm i.d., with blank filters (GFF) for diffusers. C. Cells on filter at exit of cuvette; blank filter is diffuser reference. D. Absorption spectra of panels A–C for *Phaeodactylum tricornutum*. Filtered media used in reference cuvette.



HPLC system

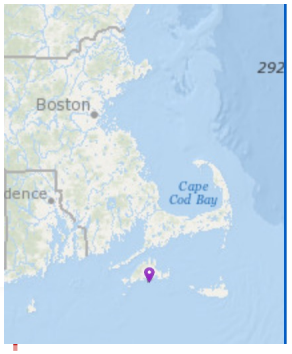
http://www.shsu.edu/~chm_tgc/sounds/sound.html

Please, remember Sasha's class

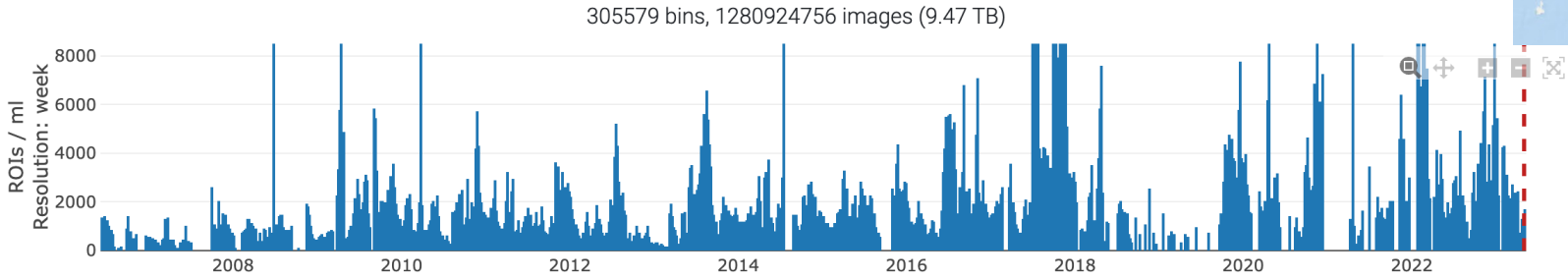
Sasha J. Kramer (MBARI)

Heidi Sosik

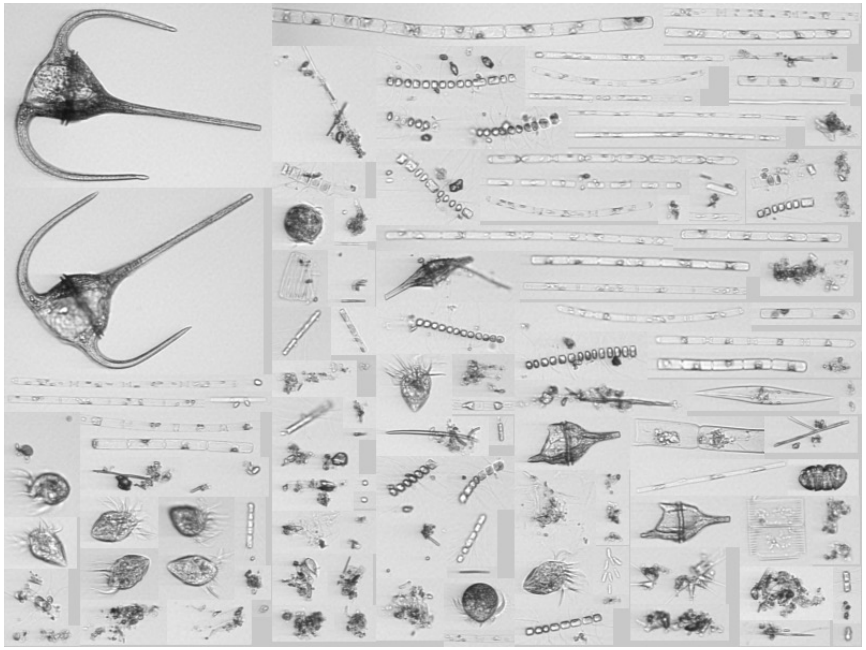
We can compute $\frac{\partial N}{\partial t}$ in nature now



https://ifcb-data.whoi.edu/timeline?dataset=mvco



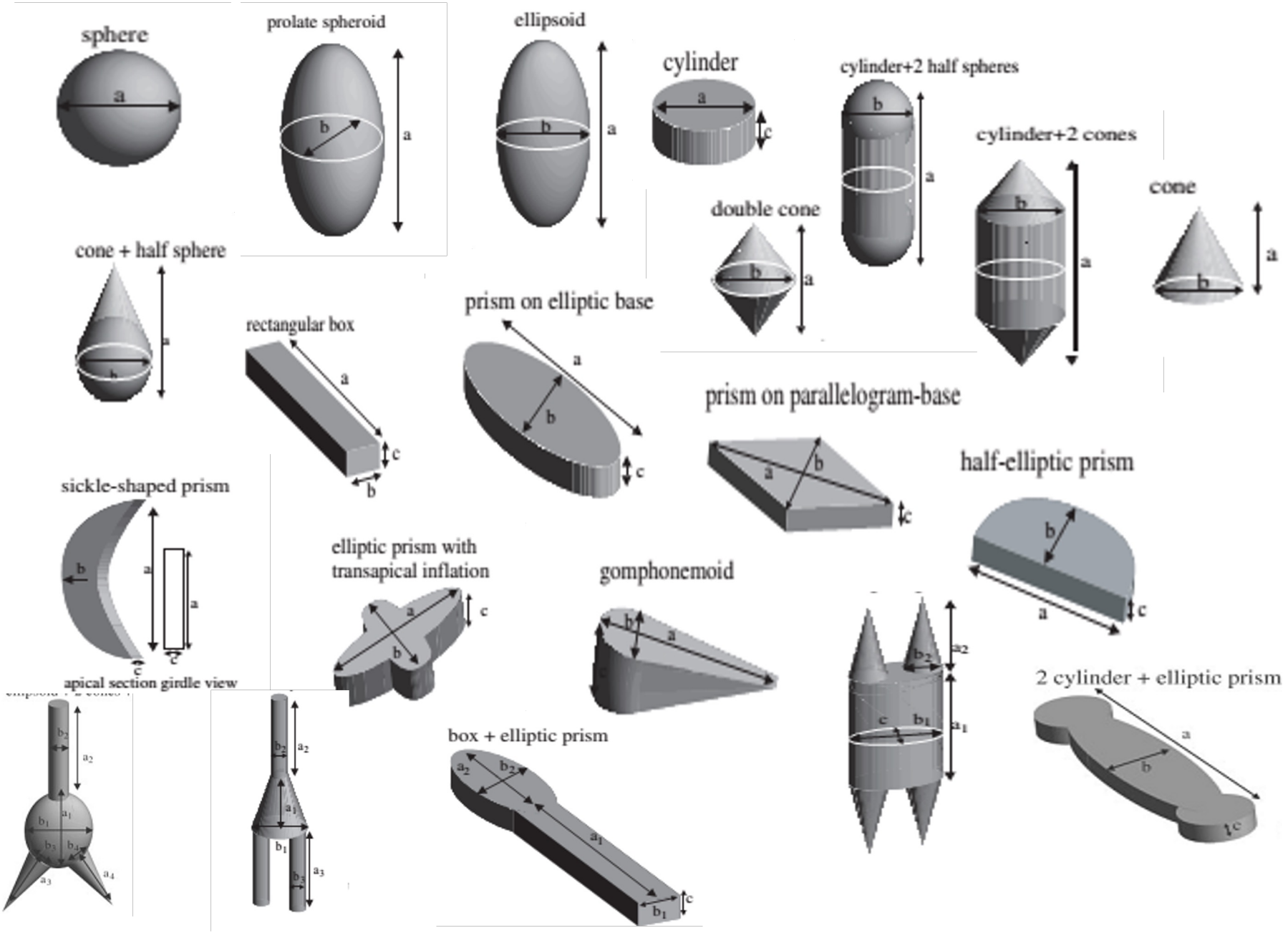
How does the cell C compare here?



Basic Info

Date/Time: 2023-05-03 18:12:31 UTC
(an hour ago)
Instrument: IFCB10
Triggers: 7550
Images: 6597
Triggers / s: 6.308
Volume Analyzed: 2.689 ml
ROIs / ml: 2452.969
Size: 34.35 MB
Latitude: 41.325
Longitude: -70.5667
Depth: 4

Sun and Liu, 2003 doi:10.1093/plankt/fbg096



Dealing with phytoplankton diversity

Community structure : species richness, number of individuals per specie (uniformity/ stability)

Reynolds et al.,2002 doi:10.1093/plankt/24.5.417

Groups (dominance)
Association (different groups co-occurring)
Functional Groups or Types (objective oriented)

Anderson 2005 DOI: 10.1093/plankt/fbi076

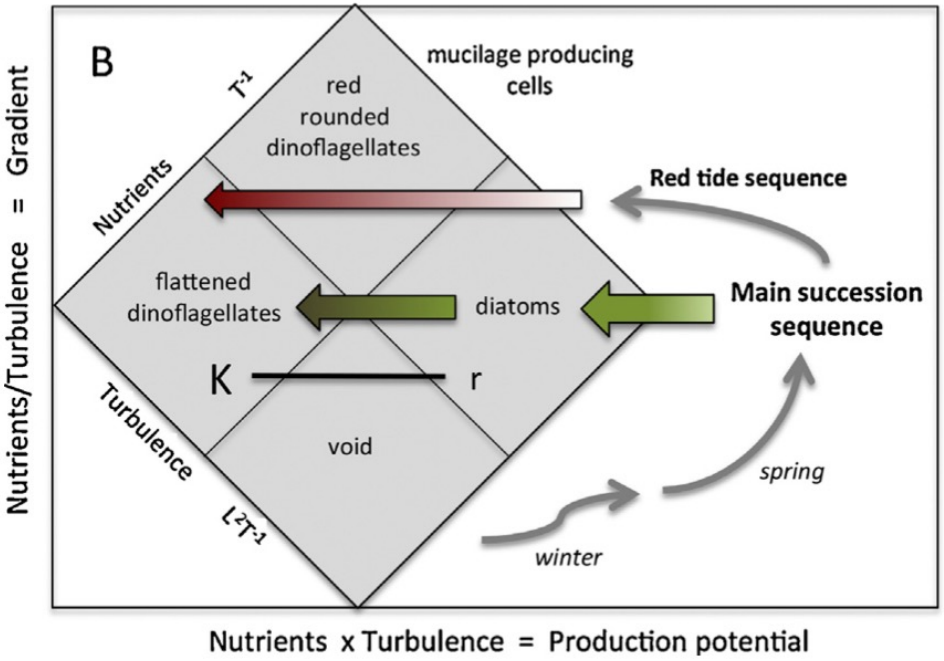
IOCCG (2014). Phytoplankton Functional Types from Space.

Trait	Pico-autotrophs	Nitrogen-fixers	Calcifiers	Silicifiers	DMS-producers
Cell size (μm)	0.7-2.0	Variable	5-10	20-200	5
Light	High	High	Low	Low	High-Low
Nutrient required		N_2 gas	Calcium	Silica	
Iron	Low	High	High	High	High
Loss	Grazing	Viral lysis	Sinking	Sinking	Lysis, grazing
Bio-optical properties	High a_B^*	a_B^* high in UV, High b_{bB}^*	High b_{bB}^*	Low, flat a_B^*	?
Remote sensing	Yes	Yes	Yes	Yes	No

Bracher et al., 2017 10.3389/fmars.2017.00055

Ramon Margalef

Mandalas- representation of recurring order



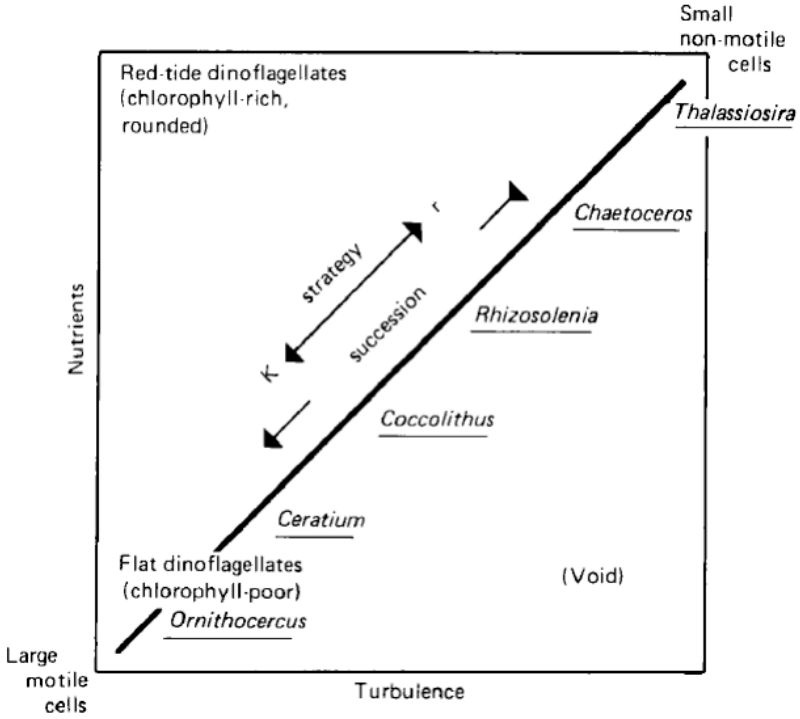


Fig. 1. Margalef's mandala. The mandala (B) was developed from the original conceptual understanding of the trajectory of phytoplankton responses to nutrients and turbulence (A). Note that the mandala illustrates both a generalized winter- spring bloom sequence and a ''red tide'' sequence. (A) Redrawn from Margalef et al. (1979); (B) reproduced from Smayda and Reynolds (2001) with permission of the Journal of Plankton Research.

Traits Nutrient acquisition , size and motility

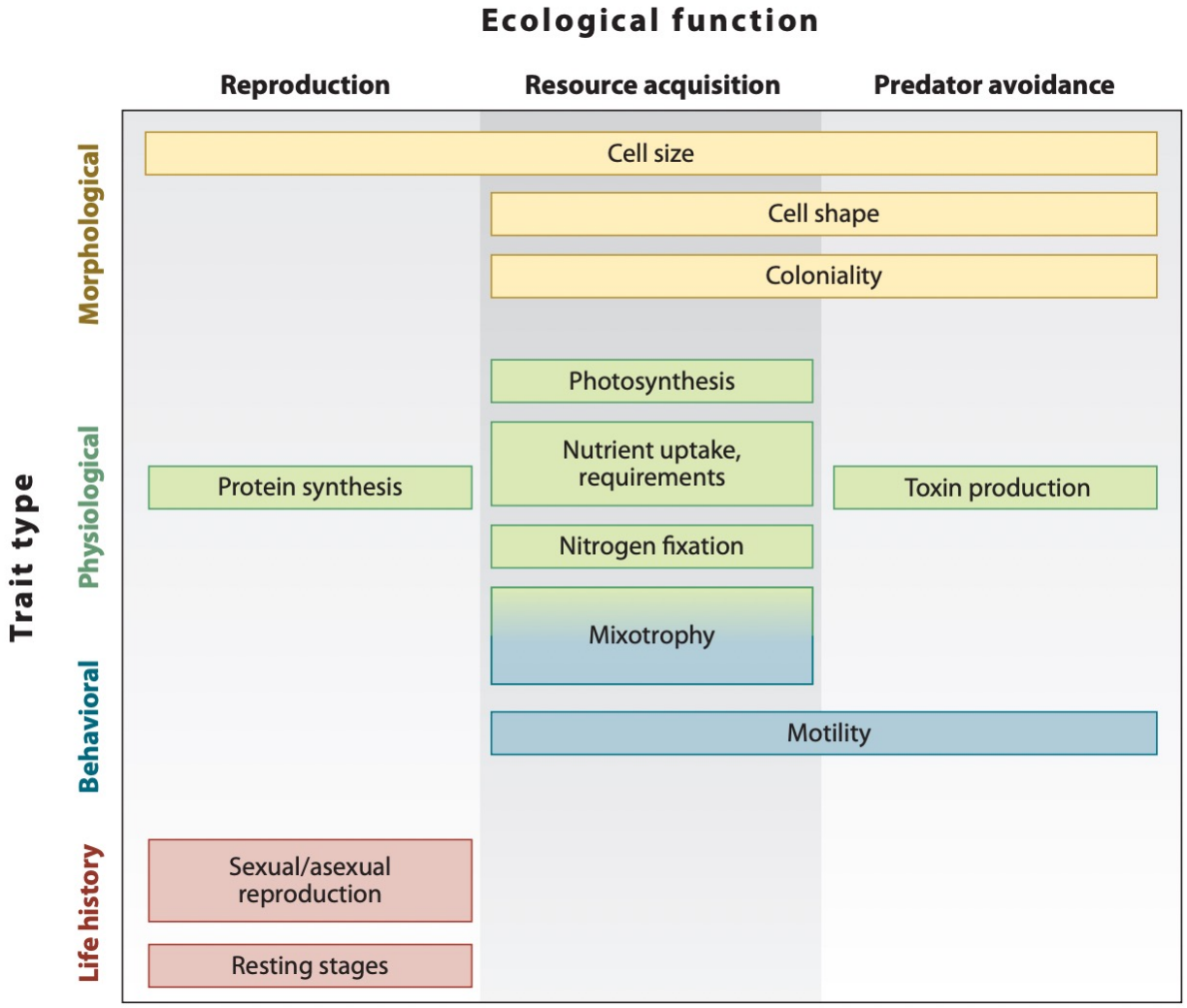
Glibert, 2016 DOI:10.1016/j.hal.2016.01.008

Patricia Glibert

Fig. 2. Revised phytoplankton mandala. Phytoplankton functional types are depicted along 12 axes (shown by the small numbers in the corner of each axis). The axes include: (1) the gradient of N forms preferentially used by the phytoplankton, from NH4+ to NO3⍰ and/or from organic to inorganic forms; (2) the gradient of dissolved inorganic N:P available to the phytoplankton (the tic mark on the gradient arrow represents the Redfield proportion); (3) adaptation to high vs low light and the tendency to be autotrophic vs mixotrophic (herein generally meaning phagotrophic); (4) motility of the cells, ranging from no motility to swimming (flagellated) to cells with sink/float vertical migration strategy; (5) turbulence from low to high; (6) pigmentation of the cells, from higher relative proportion of carotenoids to higher relative proportion of phycobiliproteins and/or chlorophylls; (7) temperature, plotted on inverse scale from high to low; (8) cell size, from small to large; (9) growth rate from low to high; (10) propensity of the cells to be toxic or to produce other bioreactive compounds such as reactive oxygen, plotted on inverse scale from high to low; (11) ecological strategy along the K to r spectrum; and (12) propensity for the resulting production to cycle through either the microbial loop (regenerated production) or to constitute new production. Note that all scales are relative and no dimensions are implied. All responses within relative space are representative and not meant to imply that all species or individuals within a given response surface will respond similarly. Icons of the organisms are from the University of Maryland Center for Environmental Science Integration and Application Network symbol library.

Litchman et al 2007 Doi: 10.1111/j.1461-0248.2007.01117.x

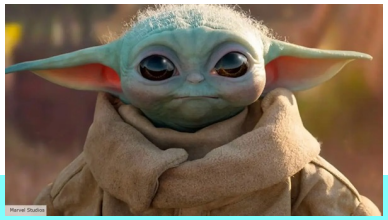
Elena Litchman



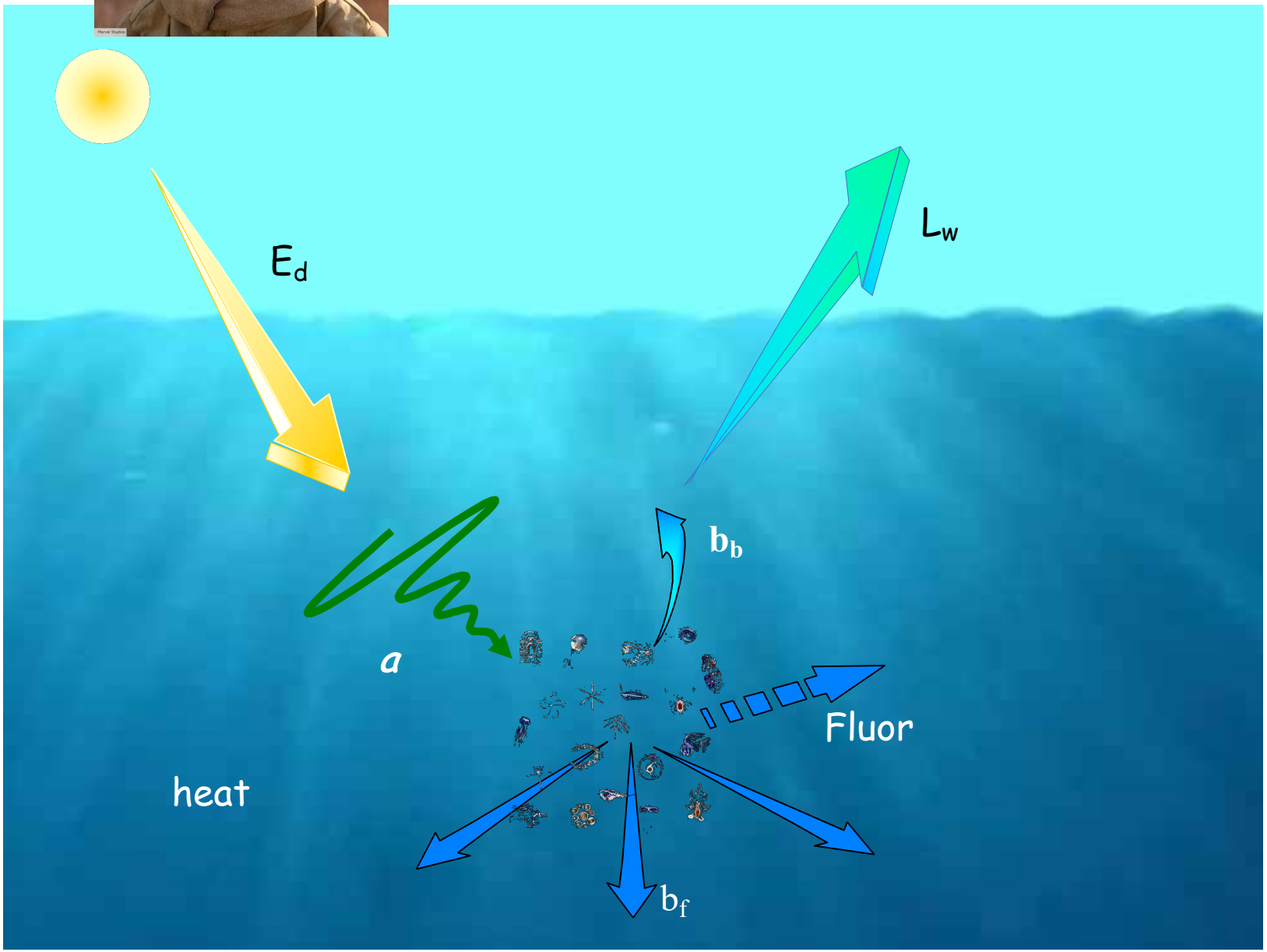
Litchman and Klausmeier DOI: 10.1146/annurev.ecolsys.39.110707.173549

Kruk et al 2009 DOI:10.1111/j.1365-2427.2009.02298.x

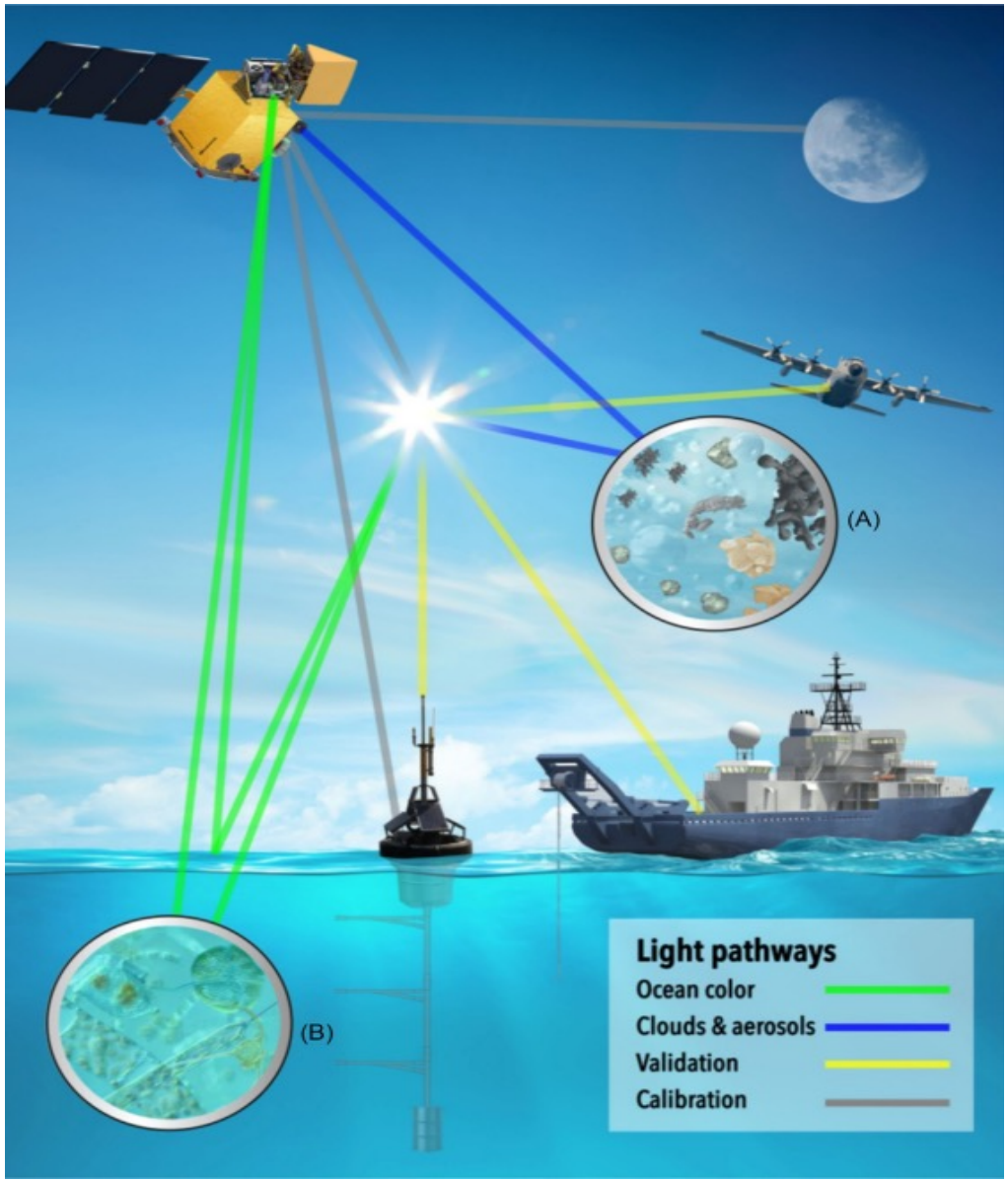
Yoda



Teach you will. The machine will learn.



https://pace.oceansciences.org/docs/werdell_and_mcclain_2019_eos3.pdf



My appeal to you: use size fractions, traits and PFTs responsibly

Fanly Fungyi Chow Ho

Click for Diatoms (literaly) growing in the lab

Welschmeyer DOI:10.4319/lo.1994.39.8.1985