Marine Phytoplankton: A Brief Overview

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Training Course
On "Fundamentals of Remote Sensing & GIS and Oceanographic Applications"

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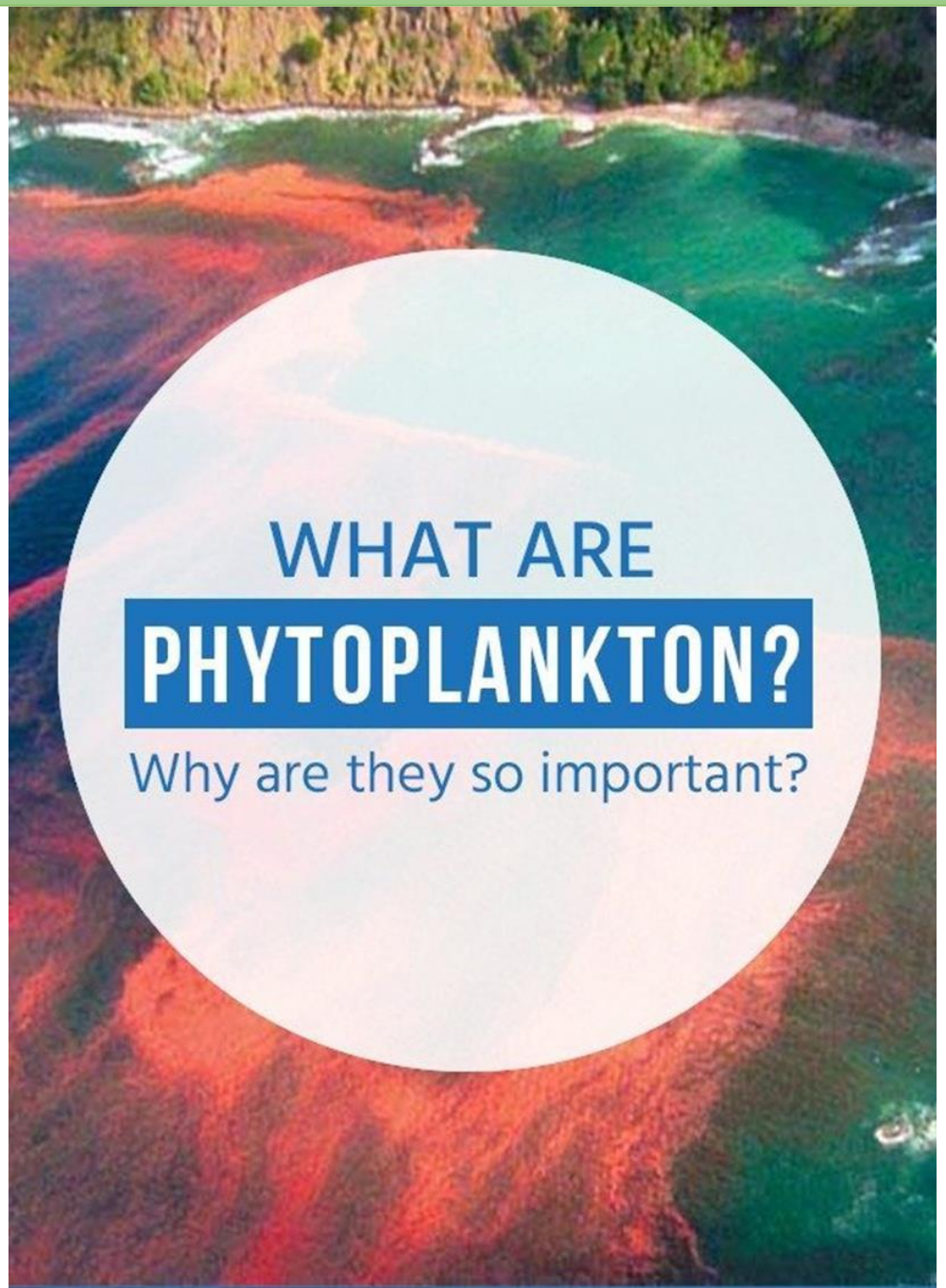
Phytoplankton???



Plankton

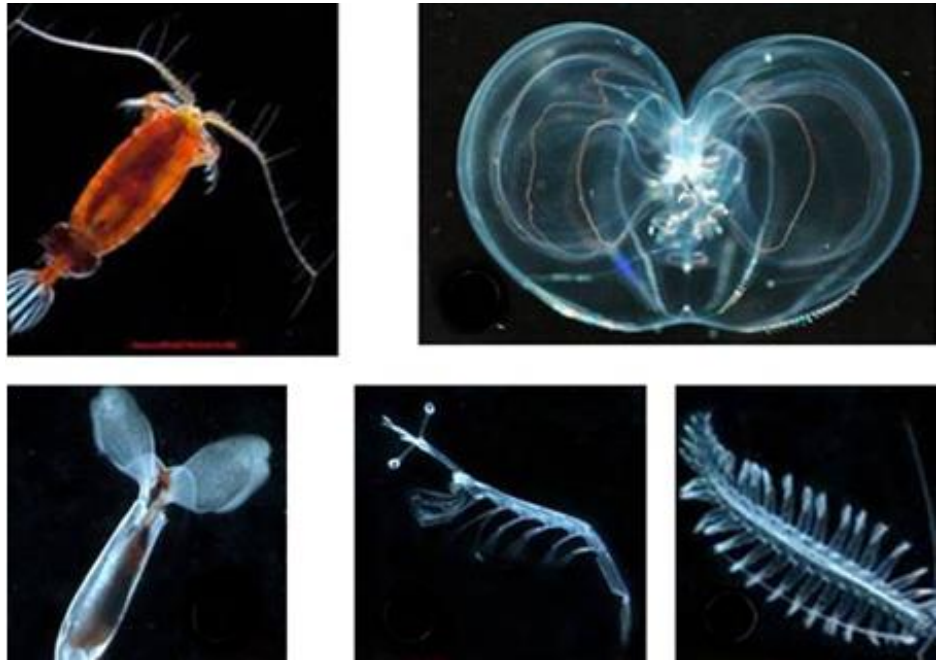
Nekton

Benthos

Source: https://en.wikipedia.org/wiki/Victor_Hensen

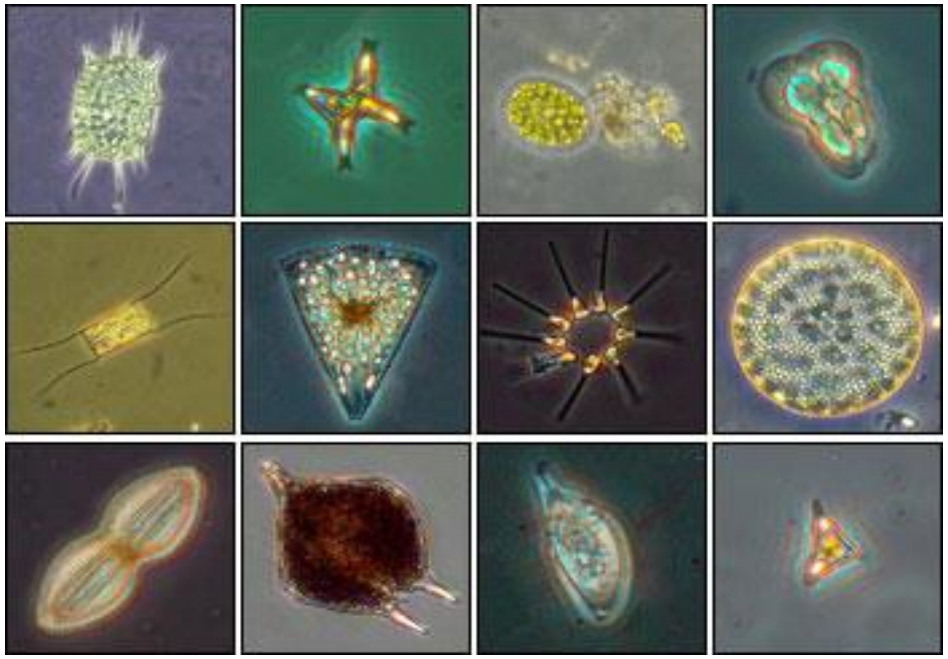
Plankton: Types

Zooplankton



Source: http://www.aori.u-tokyo.ac.jp/research/topics/2009/2009_ORI13.html

Phytoplankton



Source: http://www.earthweek.com/2010/ew100730/ew100730a.html

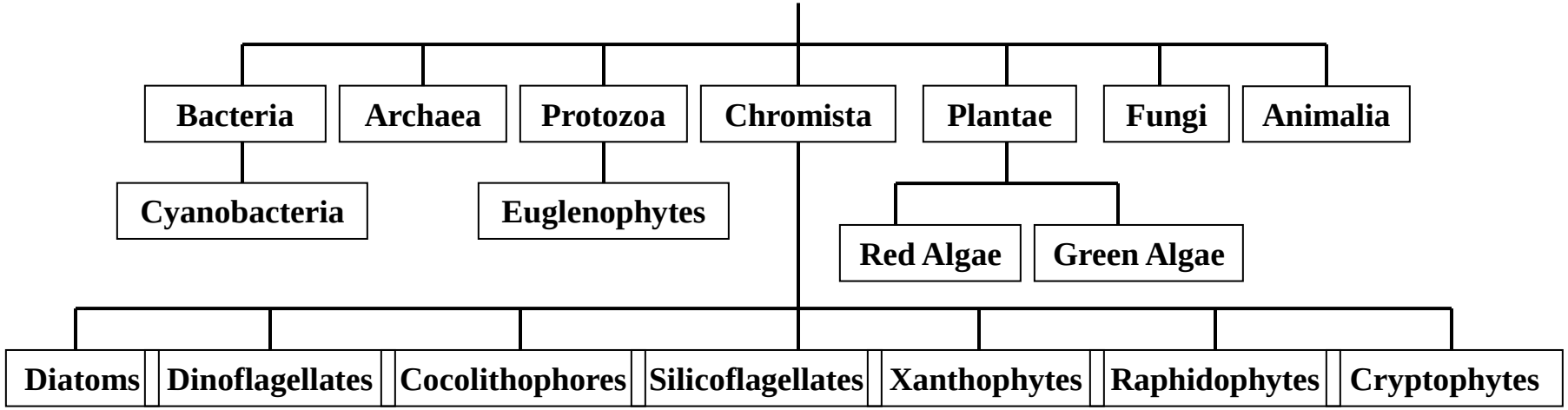
Phytoplankton: Taxonomic Tree

Linnaeus 1735	Haeckel 1866	Chatton 1925	Copeland 1938	Whittaker 1969	Woese et al. 1990	Cavalier-Smith 1998	Cavalier-Smith 2015
2 kingdoms	3 kingdoms	2 empires	4 kingdoms	5 kingdoms	3 domains	2 empires, 6 kingdoms	2 empires, 7 kingdoms
(not treated)	Protista	Prokaryota	Monera	Monera	Bacteria	Bacteria	Bacteria
					Archaea		Archaea
		Eukaryota	Protoctista	Protista	Eucarya	Protozoa	Protozoa
						Chromista	Chromista
Vegetabilia	Plantae		Plantae	Plantae		Plantae	Plantae
				Fungi		Fungi	Fungi
Animalia	Animalia		Animalia	Animalia		Animalia	Animalia

Source: https://en.wikipedia.org/wiki/Taxonomy_(biology)

Biological Taxonomy

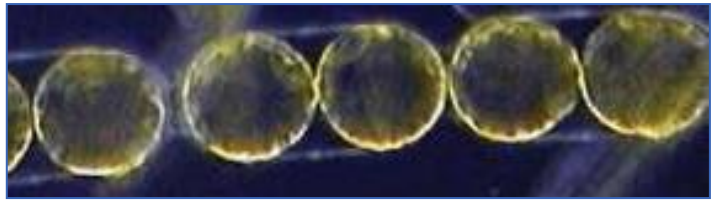
(*Cavalier-Smith 2015*)



Phytoplankton: Facts

Plant-like Plankton = Phytoplankton

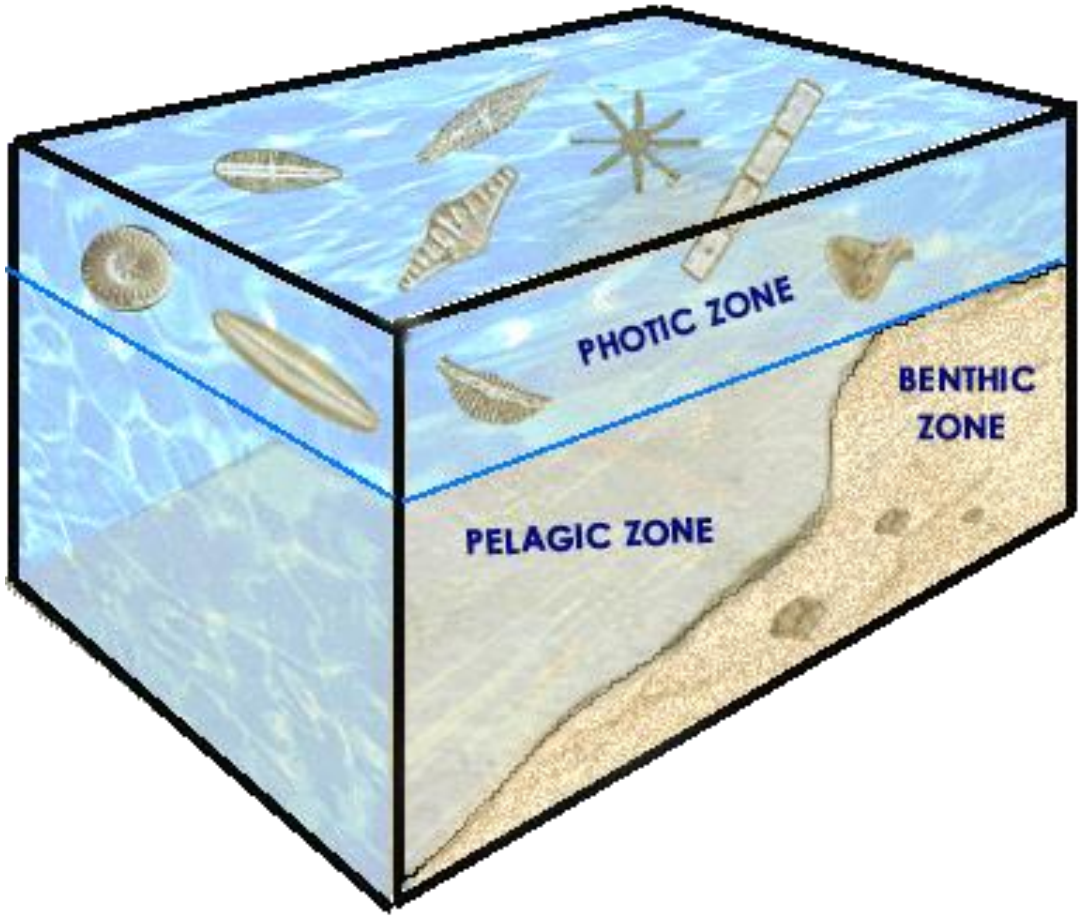
Single cell or chain of cells



Over a million phytoplankton in a teaspoon!

Phytoplankton: Facts

Ubiquitous in coastal and open ocean



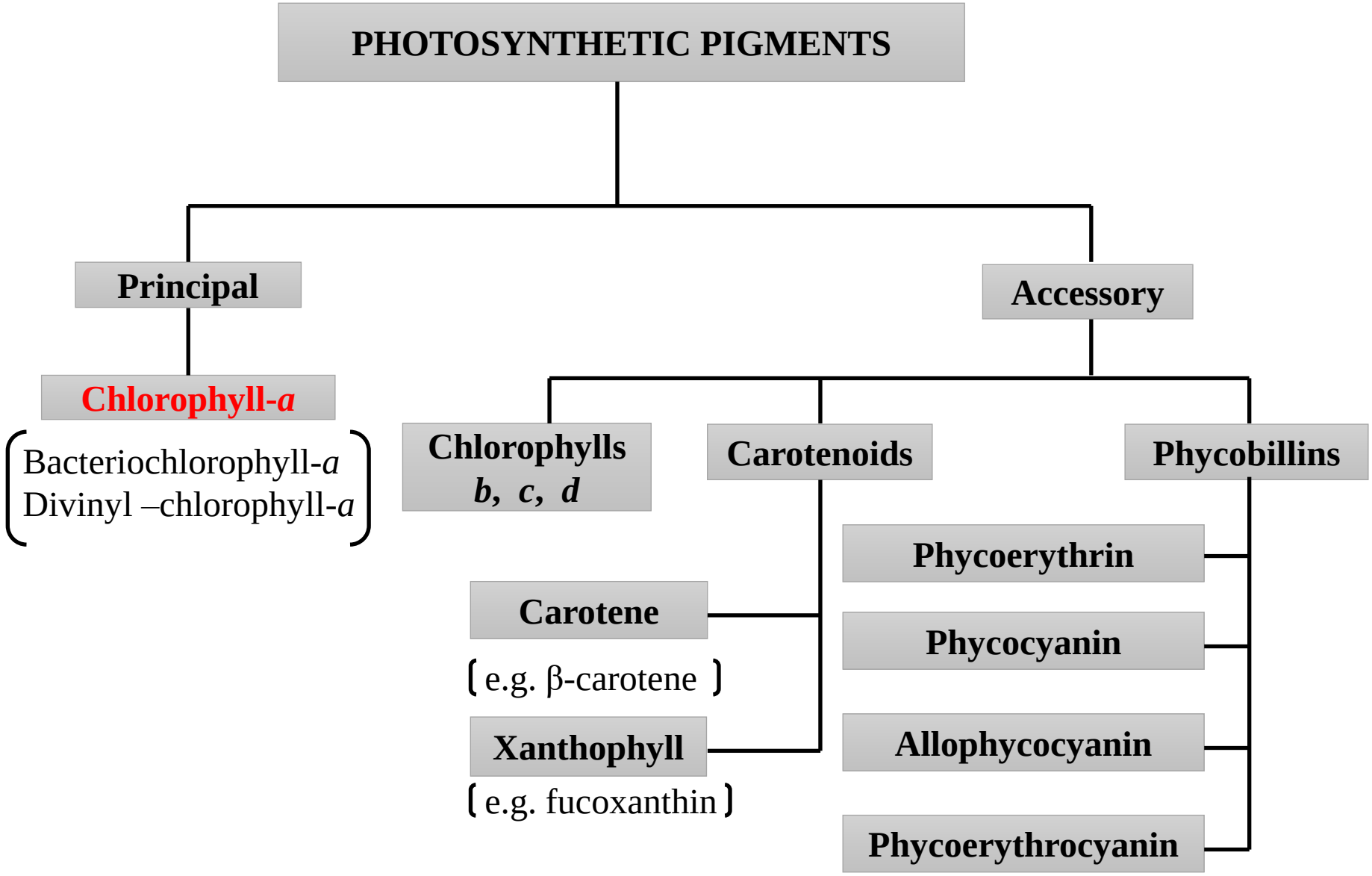
***Small size**:* *Quick diffusion & frictional drag*

Structure: *Disks & chains*

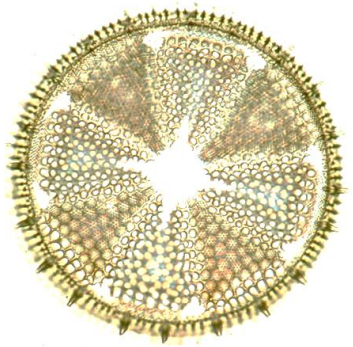
Low density: *Light ions & lipid by-products*

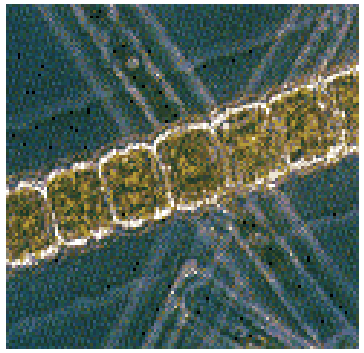
Source: https://www.slideshare.net/nagat122/microbial-marine-ecology

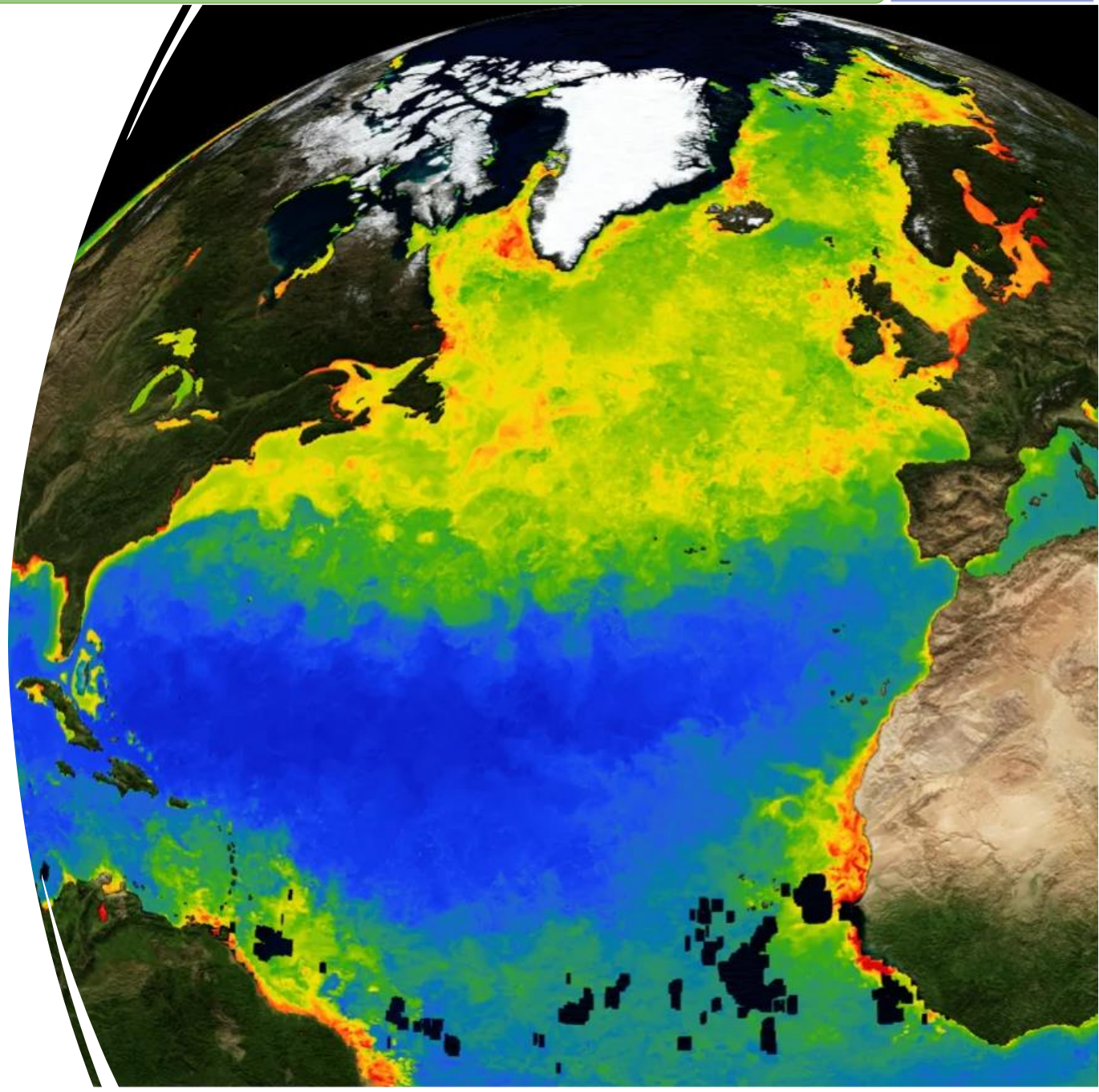
Phytoplankton: Pigments



Phytoplankton: Ocean Colour

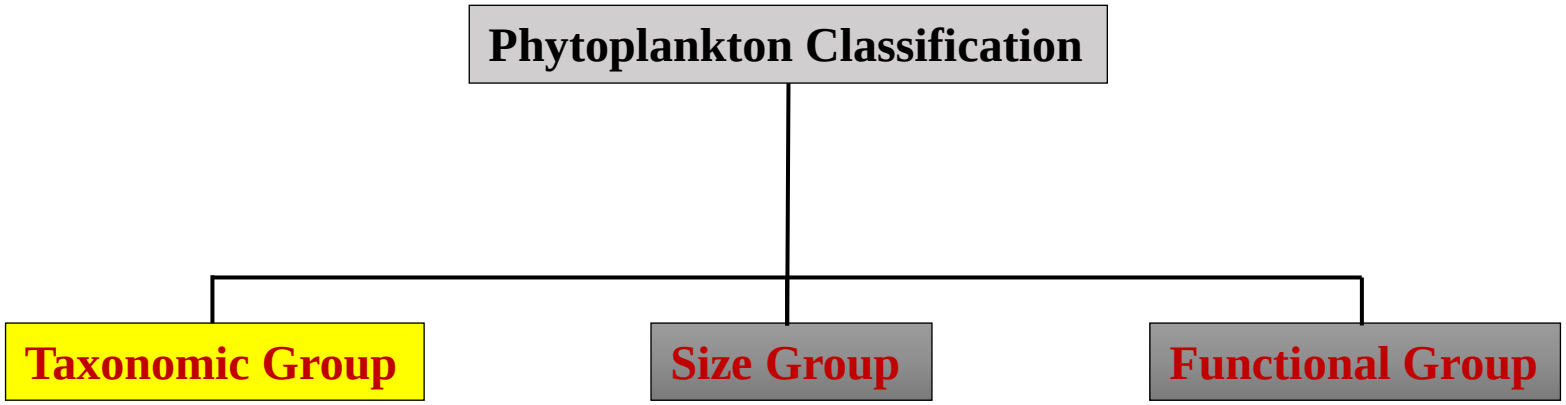






For most regions of the world, the colour of the ocean is determined primarily by the abundance of **phytoplankton** and associated photosynthetic pigments.

Phytoplankton: Classification



Phytoplankton: Taxonomic Group

Biological Taxonomy
(*Cavalier-Smith 2015*)

- **Bacteria**
  - **Cyanobacteria**
- **Archaea**
- **Protozoa**
  - **Euglenophytes**
- **Chromista**
  - **Diatoms**
  - **Dinoflagellates**
  - **Cocolithophores**
  - **Silicoflagellates**
  - **Xanthophytes**
  - **Raphidophytes**
  - **Cryptophytes**
- **Plantae**
  - **Red Algae**
  - **Green Algae**
- **Fungi**
- **Animalia**

Cyanobacteria

Diatom

Dinoflagellate

Green Algae

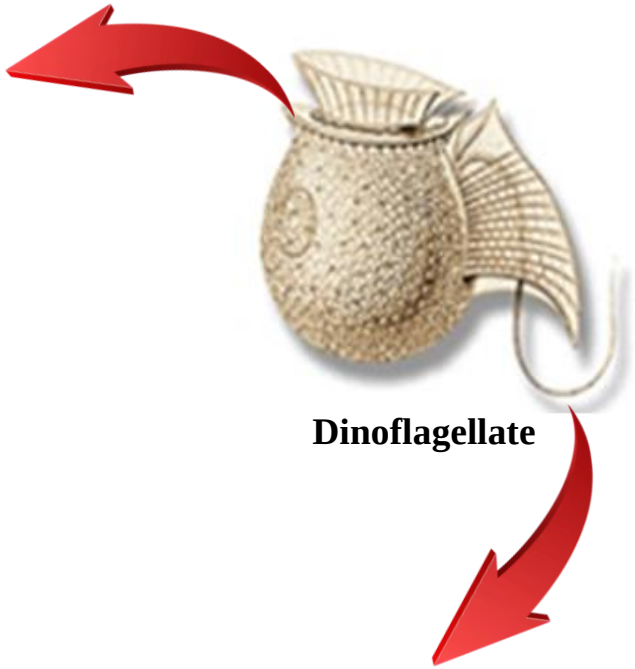
Cocolithophore

Phytoplankton: Taxonomic Group

- Unicellular, can form colonies
- Major group of marine microalgae
- Siliceous ornate shell
- Forms diatomaceous earth
- Ubiquitous in distribution

Diatom

- A large group of flagellate eukaryotes
- Autotrophic, mixotrophic
- Forms bloom (Red Tide)
- Some species exhibits bioluminescence



Dinoflagellate

Firefly (green)

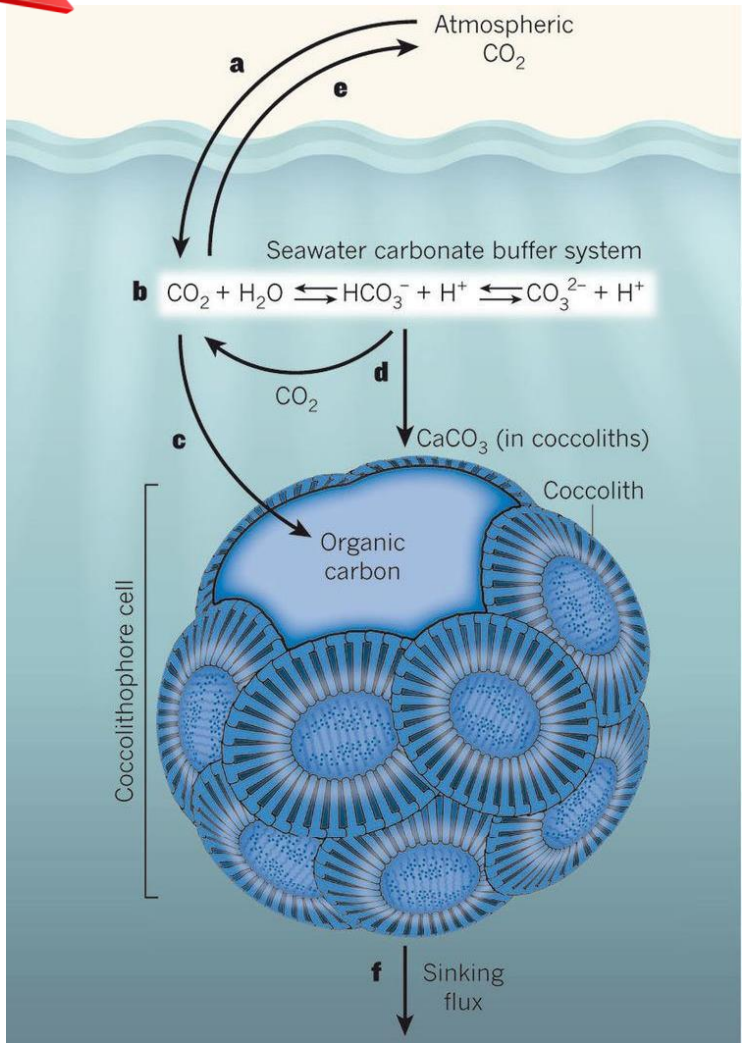
Luciferin + Oxygen → Luciferase → Bioluminescence

Dinoflagellates (blue-green)

Phytoplankton: Taxonomic Group

Cocolithophore

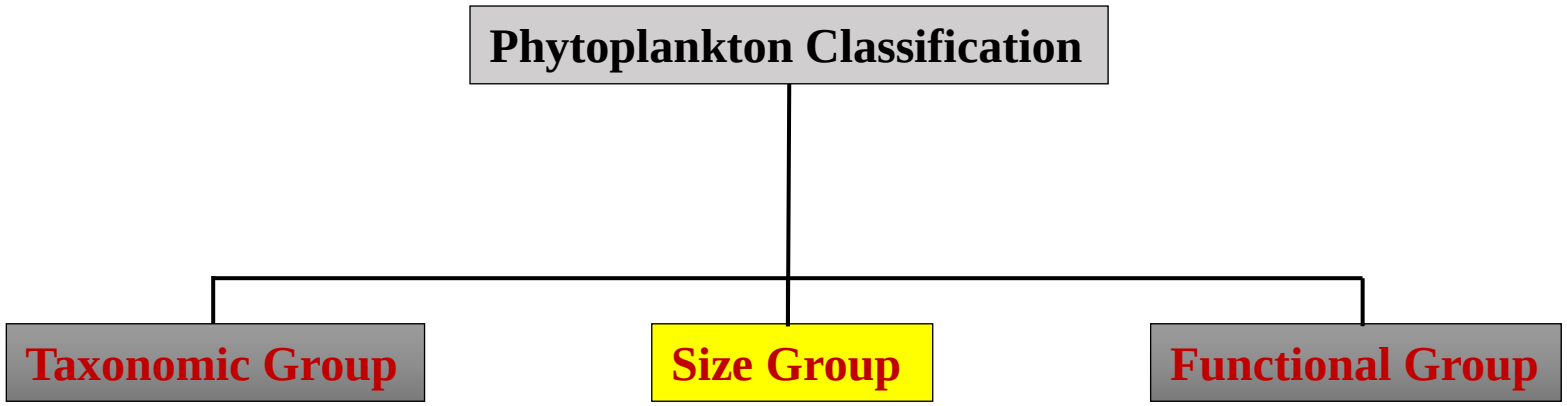
- ❑Calcifying phytoplankton
- ❑Exhibits “coccoliths”
- ❑Prefer low to moderate nutrient
- ❑Exclusively marine
- ❑Forms bloom



- ❑Also known as Blue Green Algae
- ❑Evolution of earth’s oxidizing atmosphere
- ❑ Only photosynthetic prokaryotes able to produce oxygen
- ❑Can fix atmospheric nitrogen through heterocysts
- ❑Exists as isolated cells or form colonies
- ❑Forms bloom

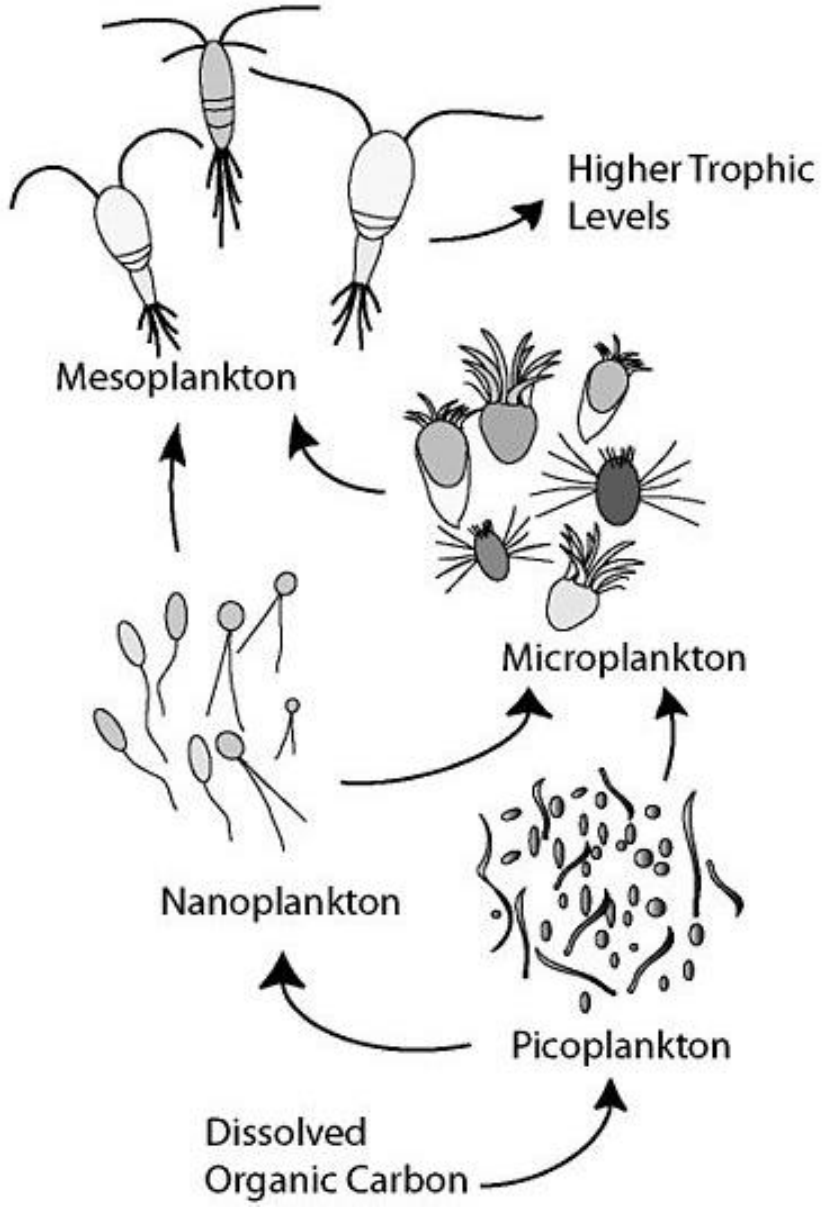
Cyanobacteria

Phytoplankton: Classification



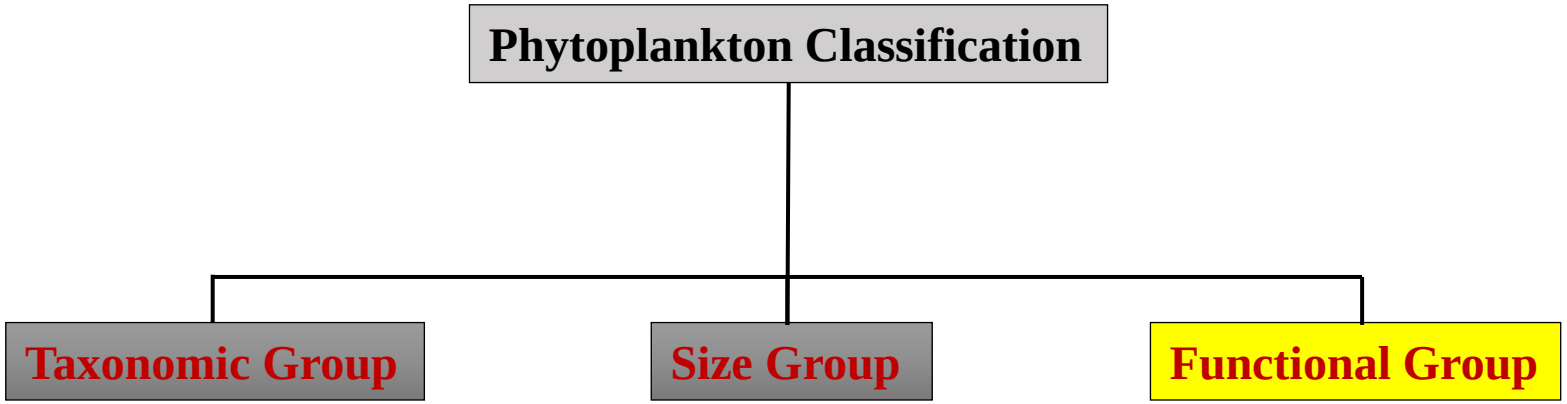
Phytoplankton: Size group

0.2 – 2 µm	→	Picophytoplankton
2 – 20 µm	→	Nanophytoplankton
20 – 200 µm	→	Microphytoplankton
200 – 2 mm	→	Mesophytoplankton
> 2 mm	→	Macrophytoplankton



Source: The Ecology of Phytoplankton Book by Colin S. Reynolds
Source: https://en.wikipedia.org/wiki/Microbial_loop

Phytoplankton: Classification

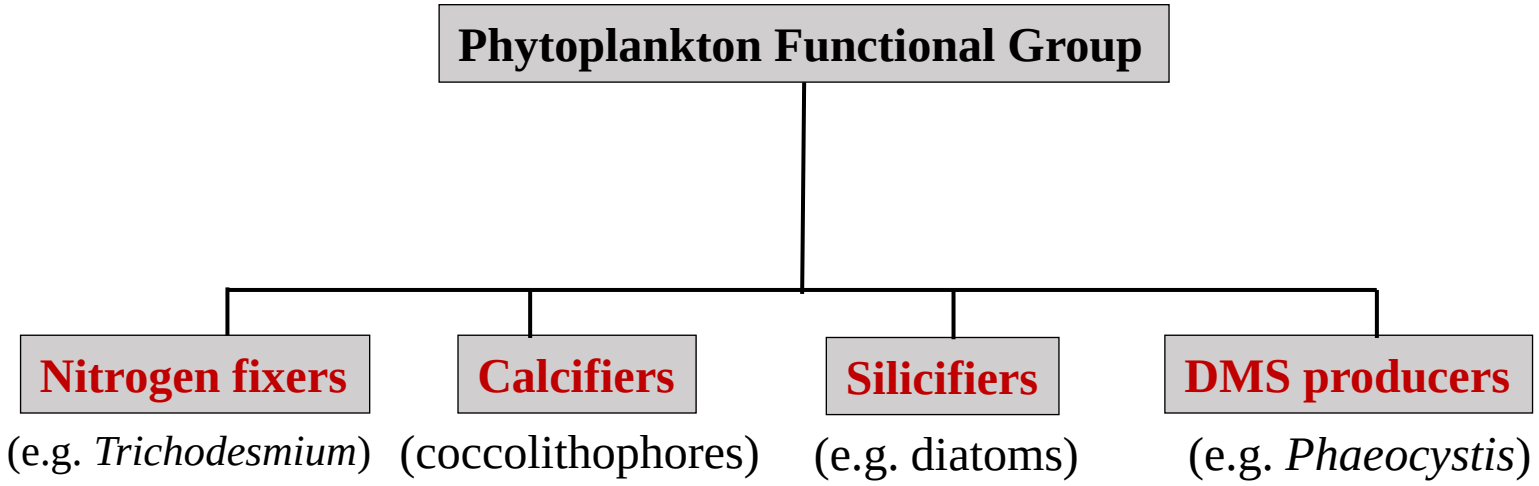


Phytoplankton: Functional group

➢Also known as Phytoplankton Functional Types (PFTs)

➢Conceptual groupings of phytoplankton species exhibiting similar **ecological functionality**

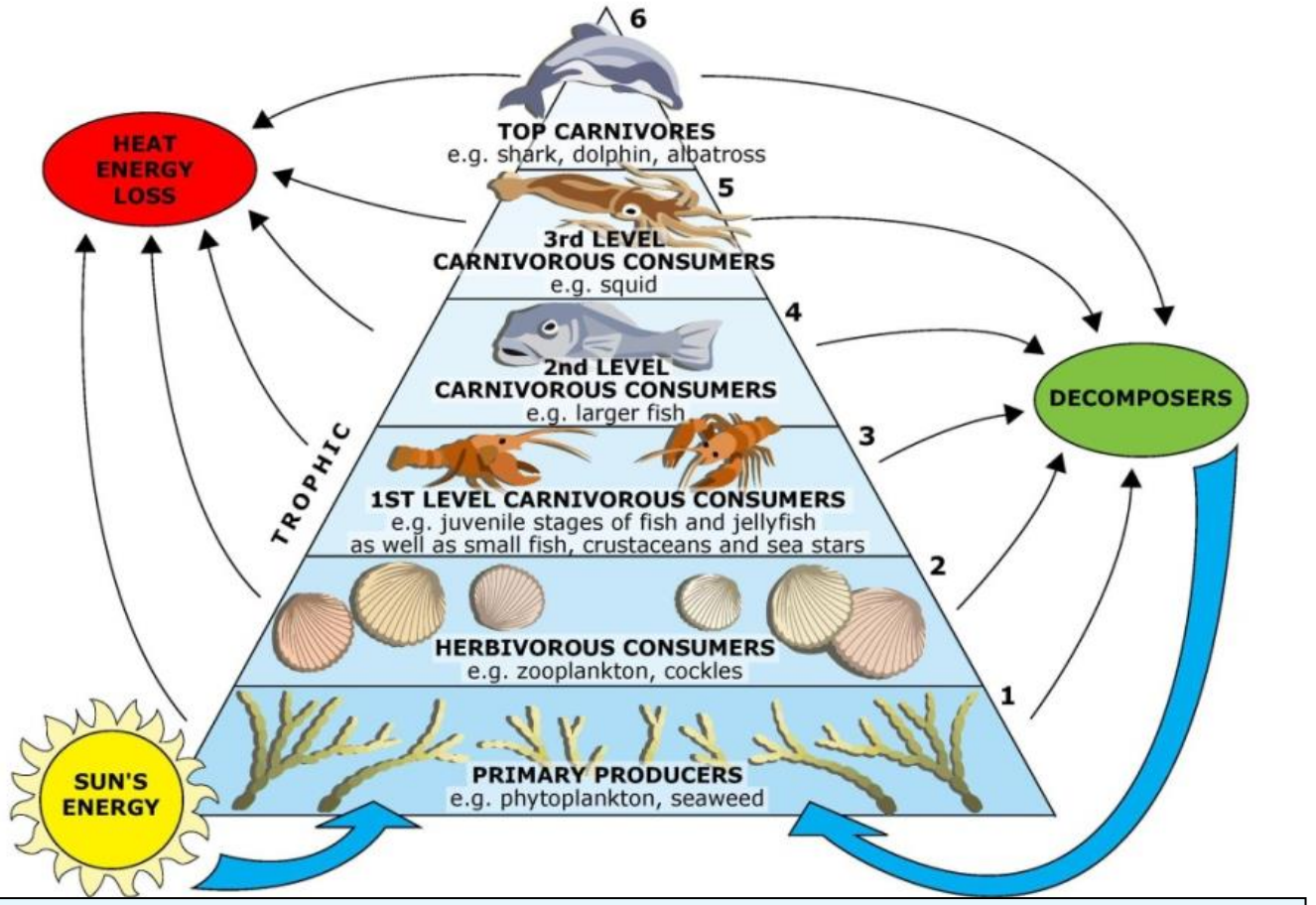
Food web / Biogeochemical cycles

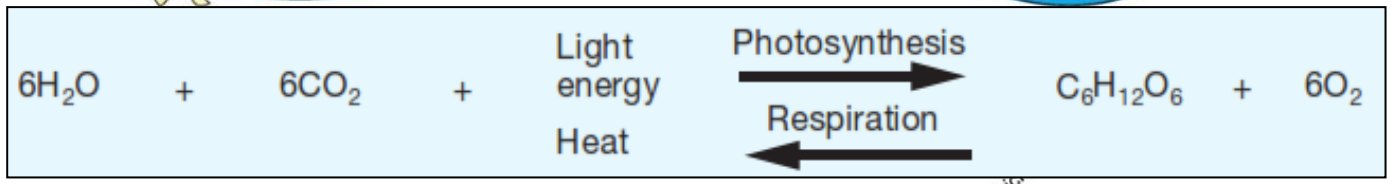


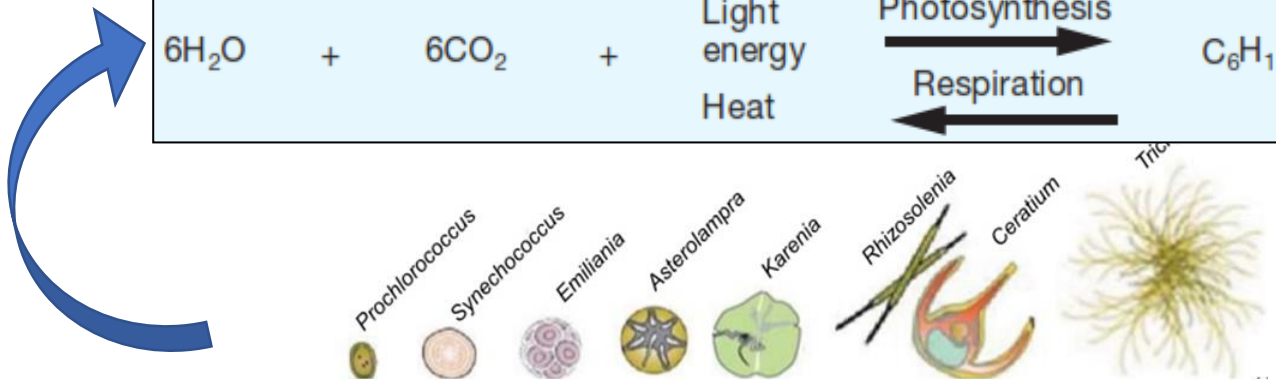
➢Relevant proxies of ecosystem functioning & climate change

➢Improves predictive capabilities of biogeochemical models

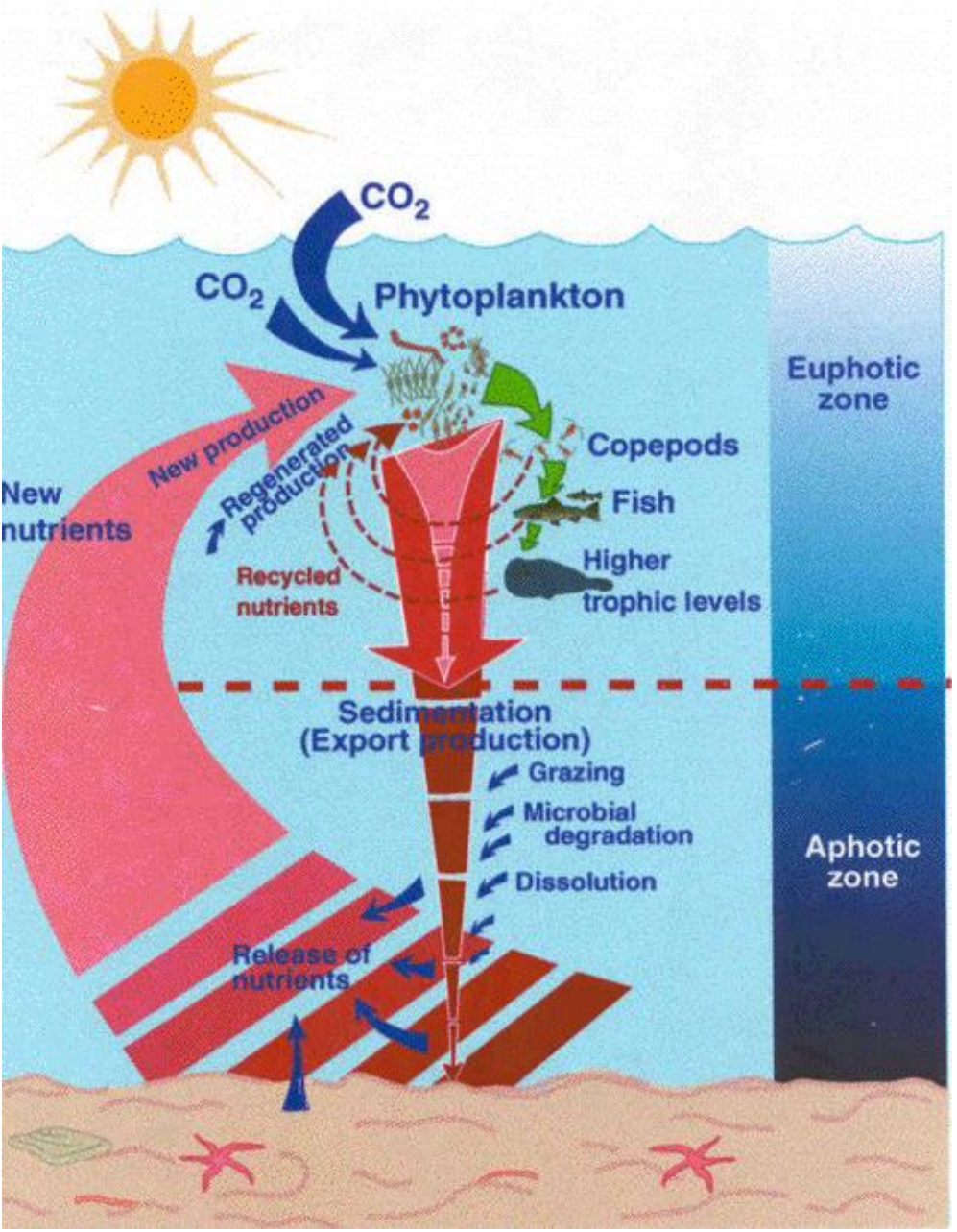
Phytoplankton: Facts







Phytoplankton: Production >>>> Packer & Mover of Carbon



Source: http://kodu.ut.ee/~olli/eutr/html/htmlBook_64.html

Transfer of Organic Carbon

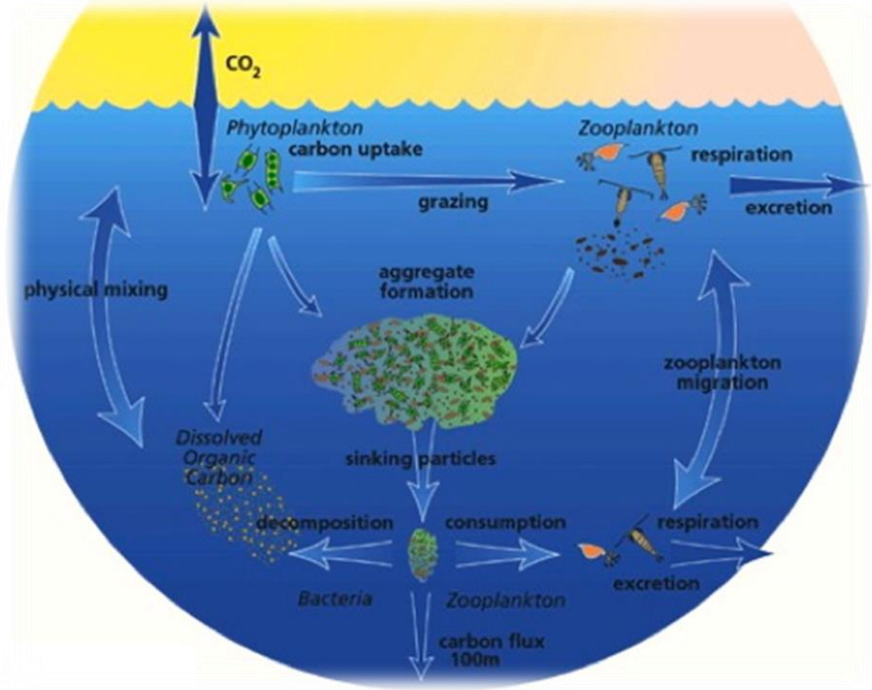
Surface carbon removal

Global C Export

~ 4 – 12 GtCy^{-1}

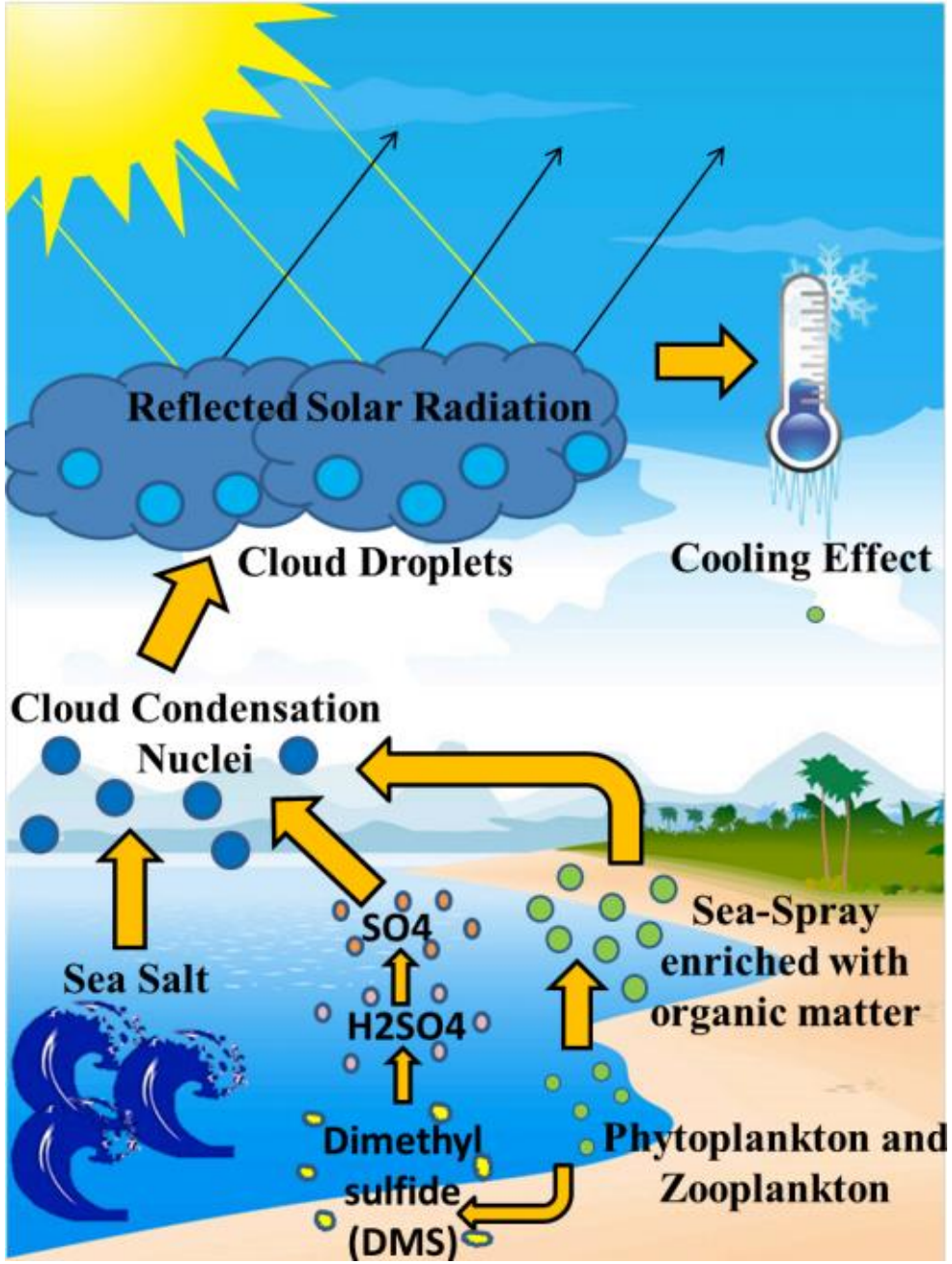
Carbon sequestration pathway

Deep



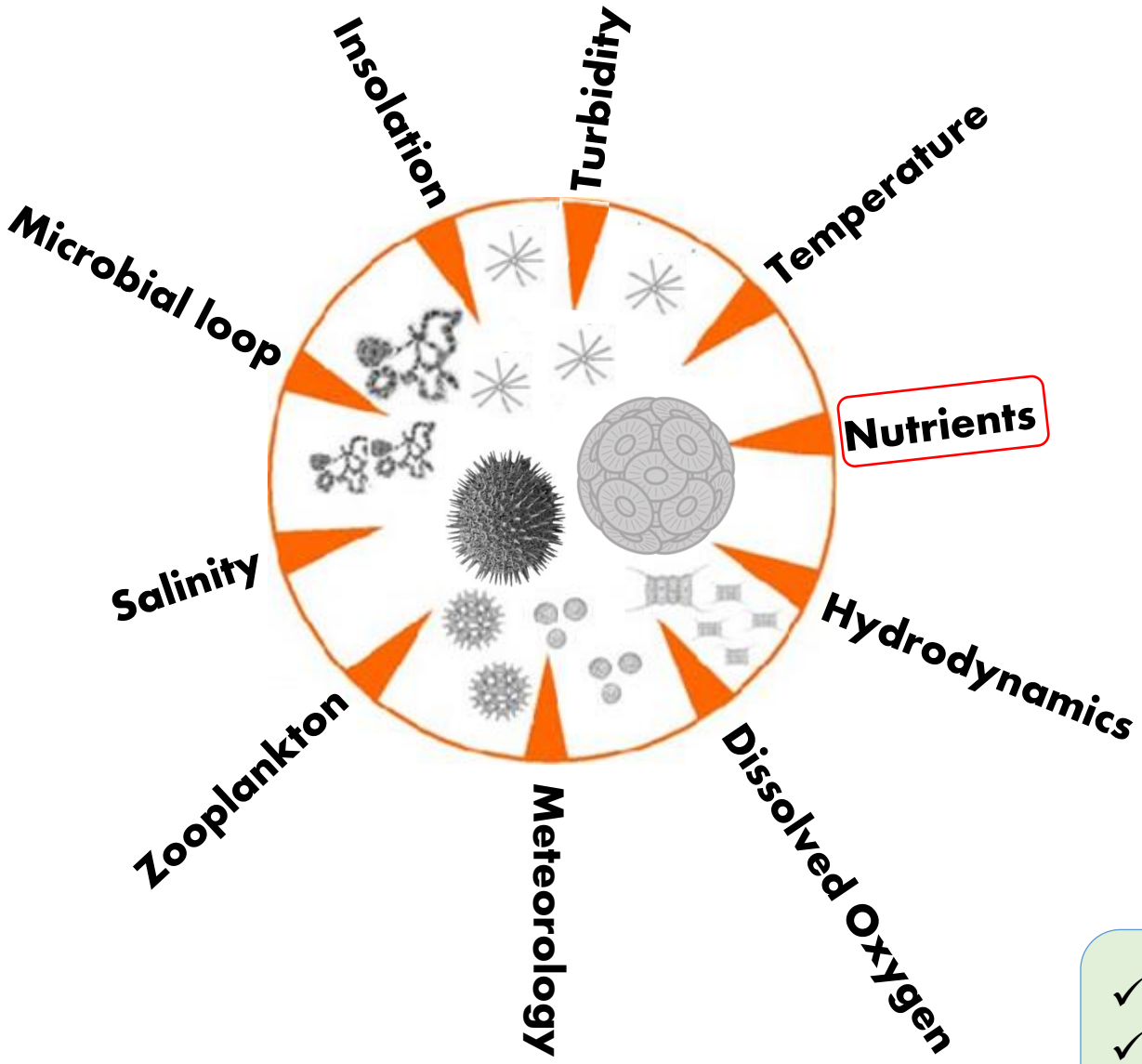
Source: https://www.sciencedaily.com/releases/2014/03/140311141536.htm

Phytoplankton: Climate Driver

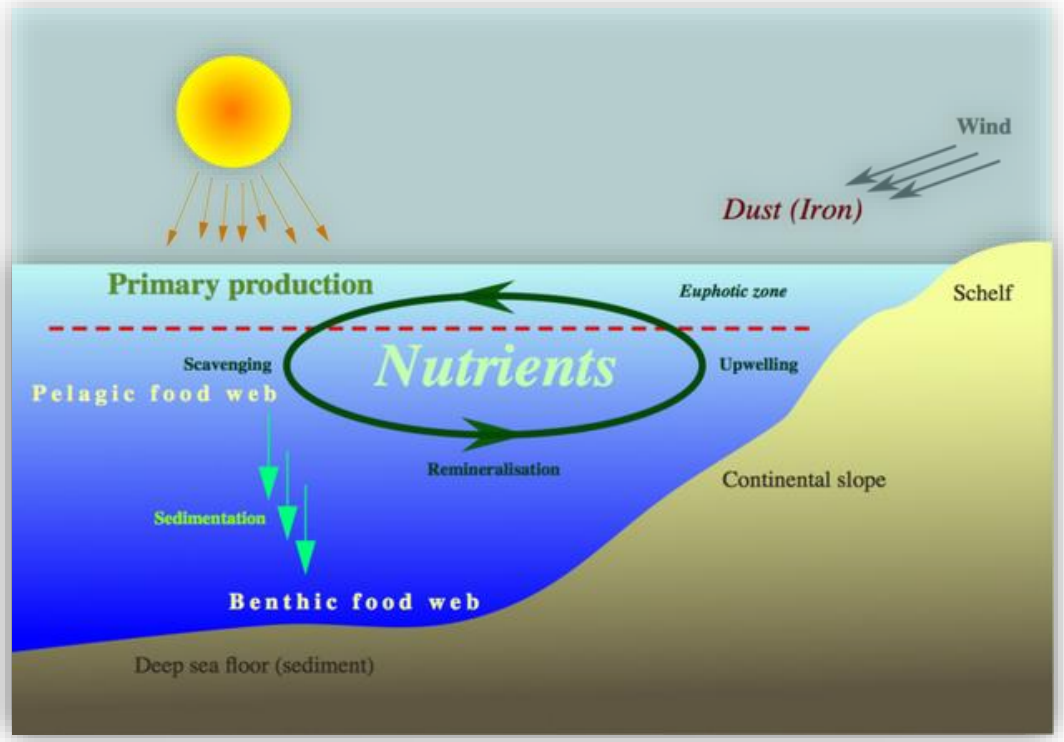


Source: Nichols, M. A. (2016). *Spatial and Temporal Variability of Marine Primary Organic Aerosols over the Global Oceans: A Review*

Phytoplankton: Controlling Factors

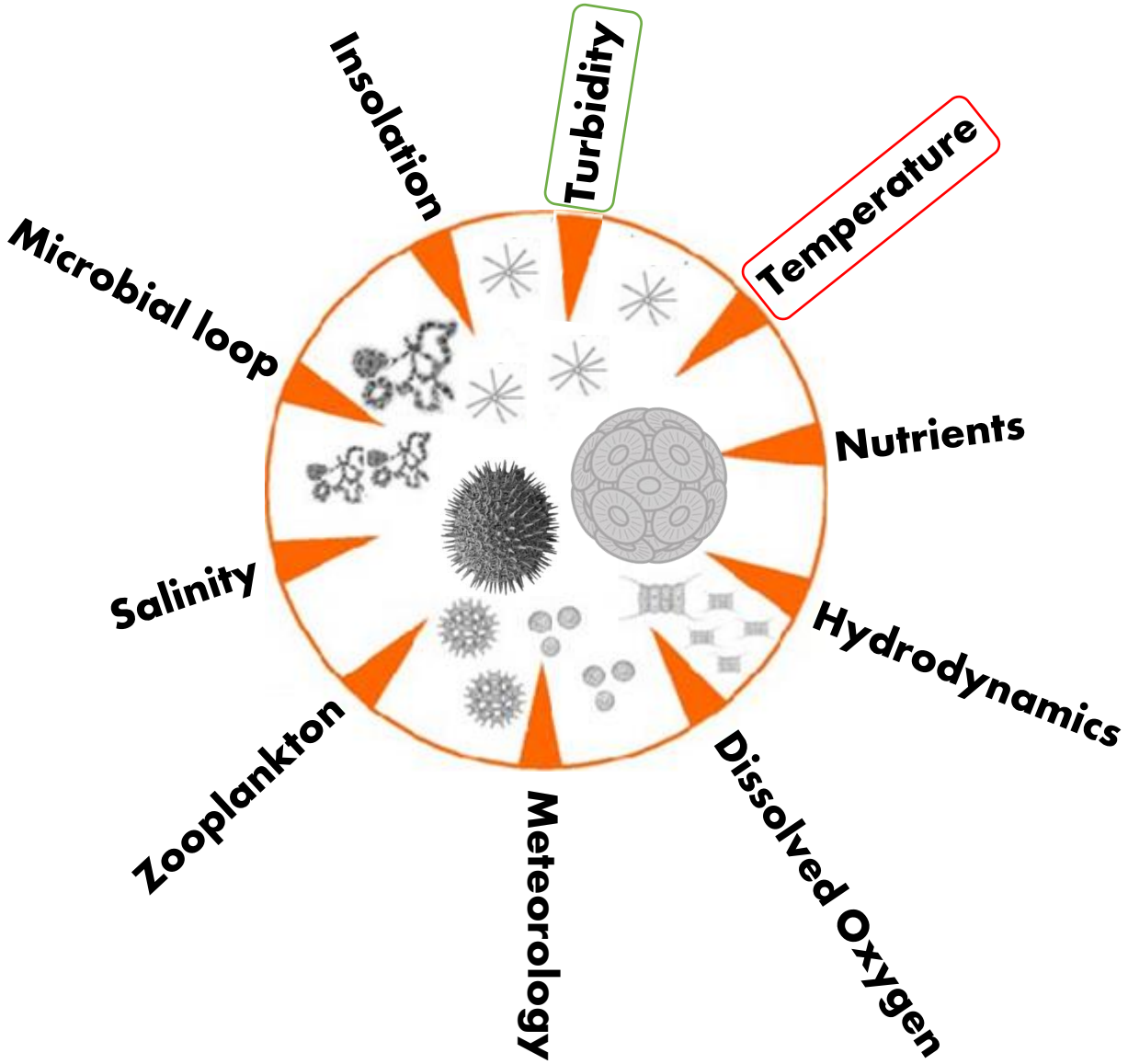


Environmental forcing factors of phytoplankton



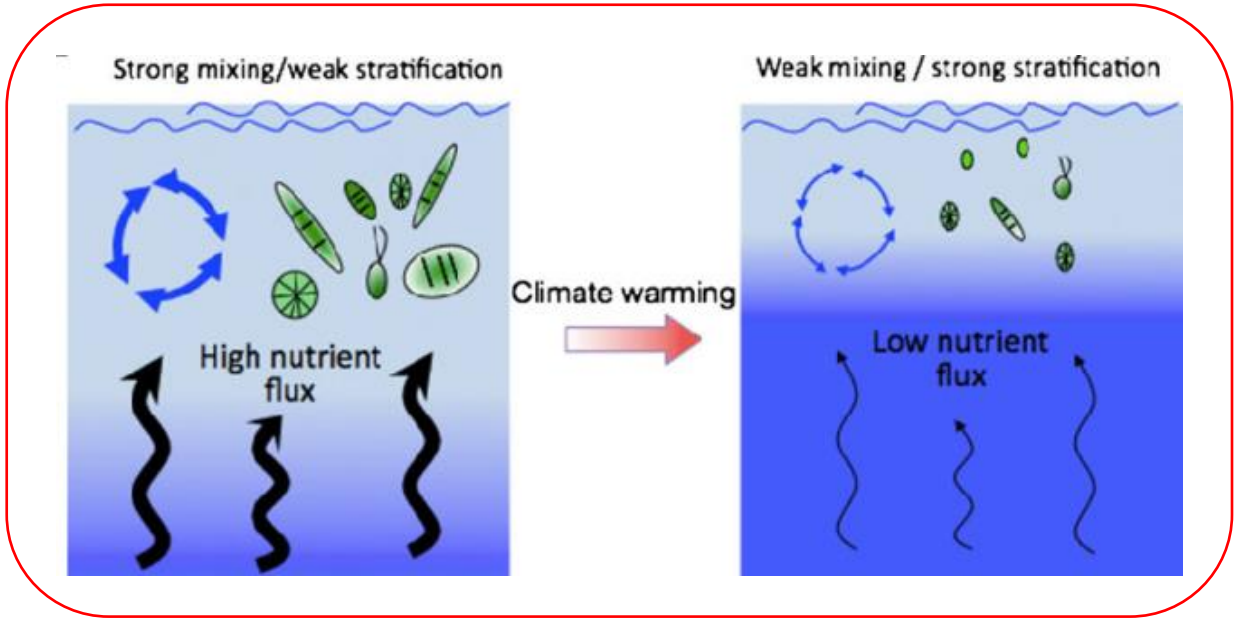
✓Nutrient availability → **Adequate growth**
✓Nutrient shortage → **Growth retards**
✓Single nutrient run out → **Unbalanced growth**

Phytoplankton: Controlling Factors



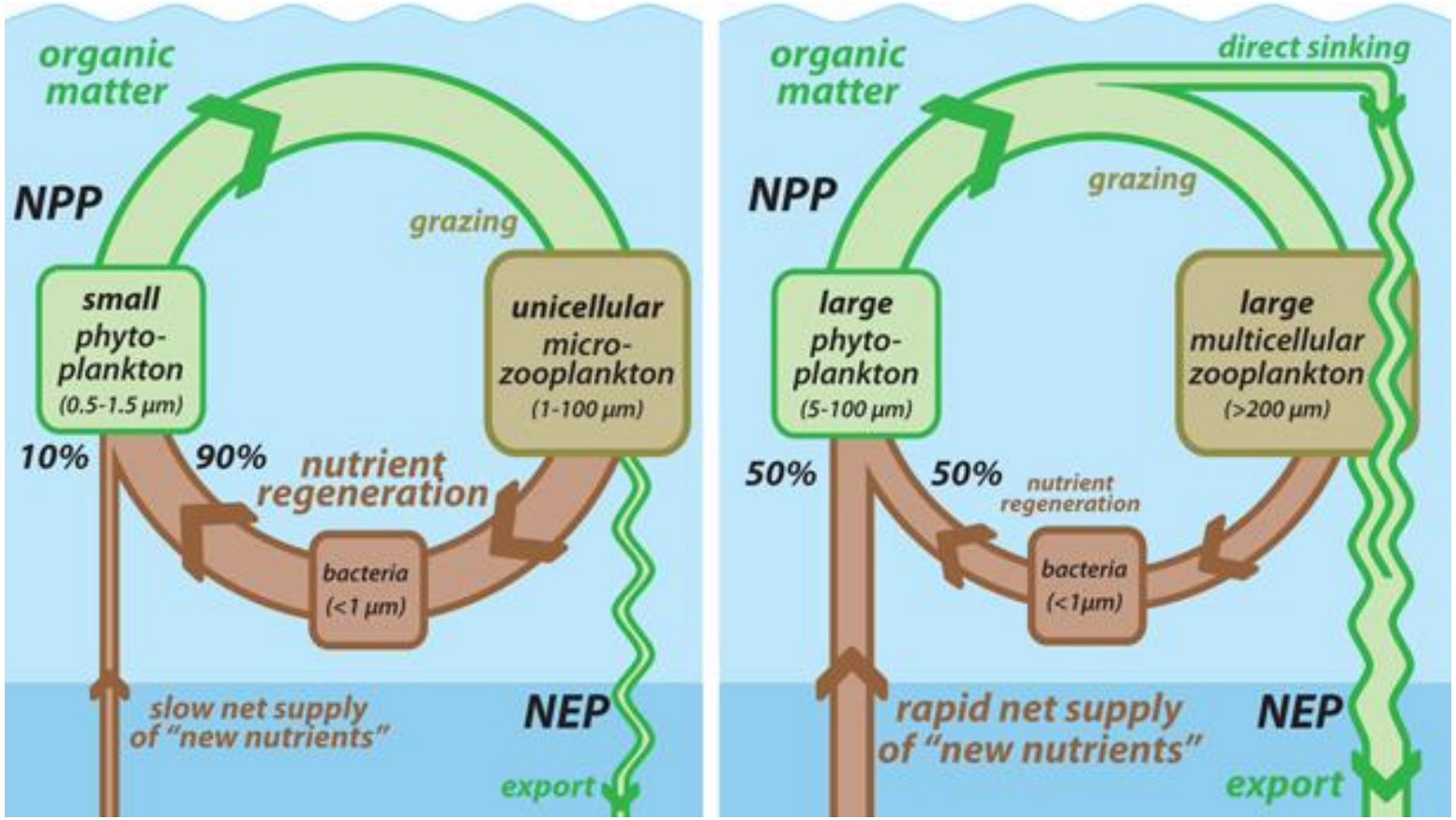
✓High turbidity→ Reduce light penetration → Inhibit growth

✓High turbidity (suspended solid)→ Trap solar energy→ Increase temperature →Decrease DO



Phytoplankton: Controlling Factors

Efficient Recycling — **Inefficient Recycling**

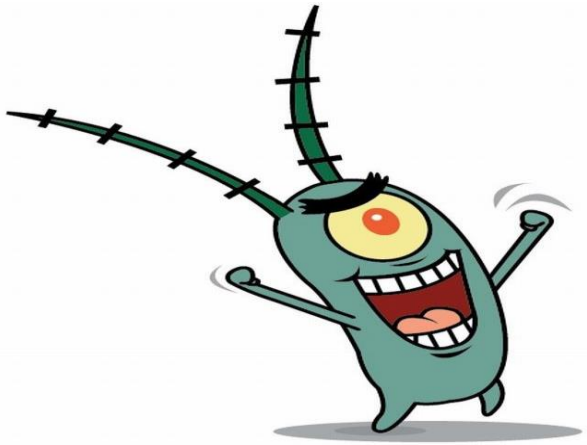


Sigman D.M. & Hain M.P. (2012). The biological productivity of the ocean. *Nature Education Knowledge*,*3*(10), 21.

Phytoplankton: Take home message

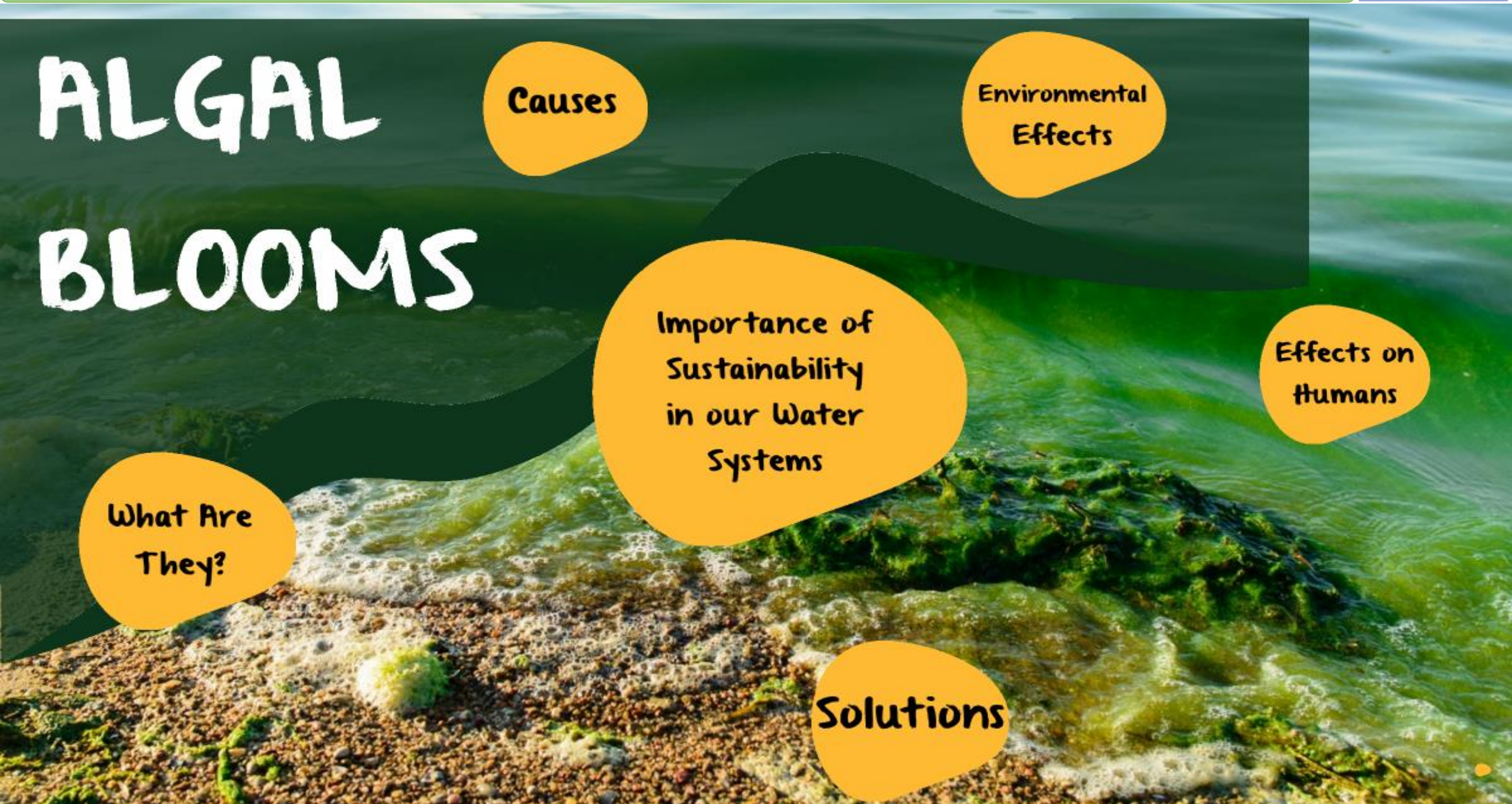
- ✓ **Major Primary Producer** : Contributes to more than 50% of global primary production
- ✓ **Trophic Energy Modulator** : Forms the base of the aquatic food chain
- ✓ **Climate Driver** : Regulates temperature and produces CCN forming DMS
- ✓ **Packer & Mover of carbon** : Controls levels of atmospheric CO_2 through photosynthesis
- ✓ **Oxygen Producer** : Responsible for ~ 50% of atmospheric oxygen production
- ✓ **Commercial Product** : Food, high optical quality glass, space shuttle tile, medicine etc.
- ✓ **Petroleum Oil Source** : Contain tiny oil droplet that accumulates in the seafloor

Phytoplankton: Bloom: A rapidly expanding problem of the present century……



https://carriegillaspie.com/red-tide-florida/

Phytoplankton: Bloom: A rapidly expanding problem of the present century……



Phytoplankton: Bloom

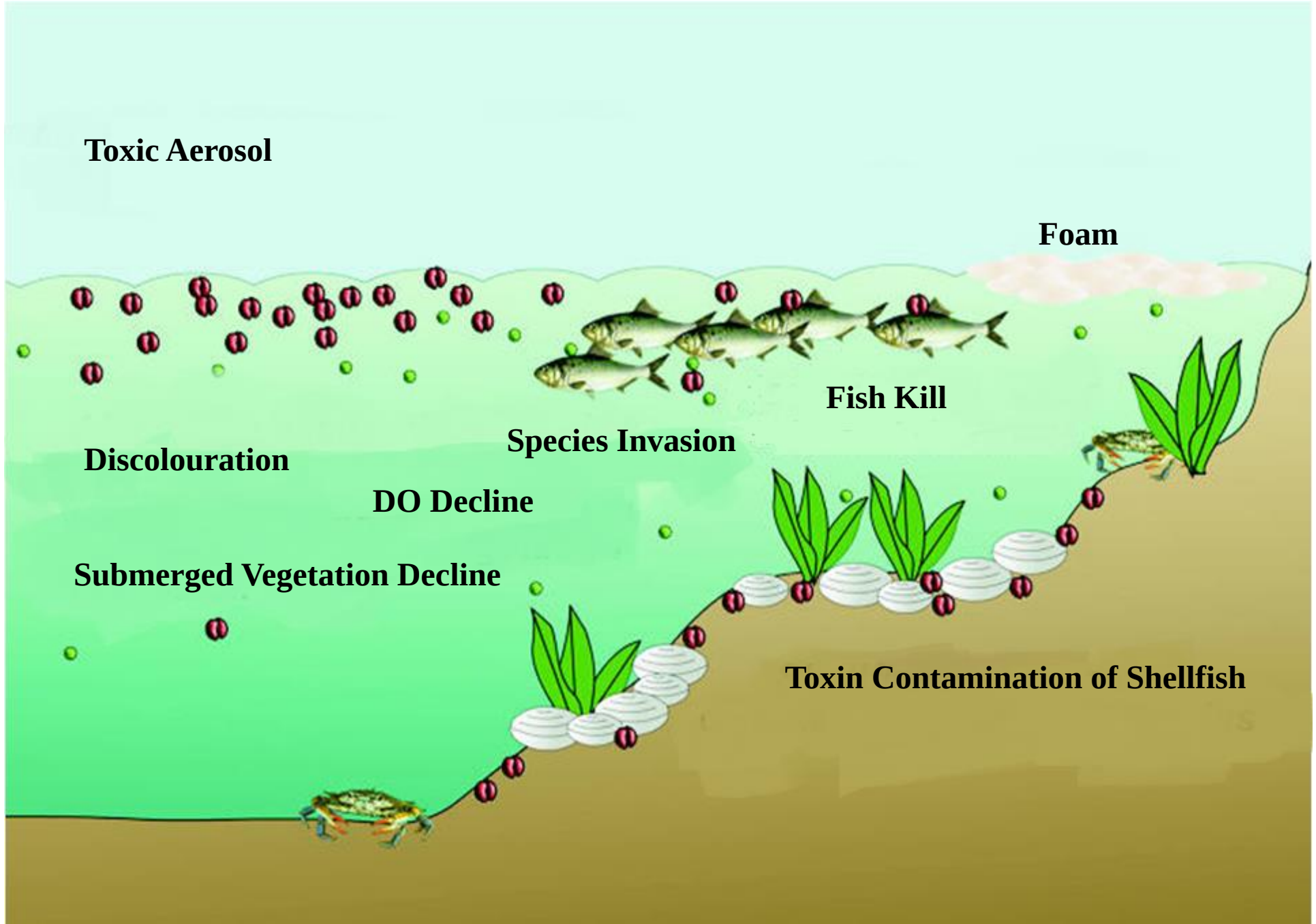
Optimum physico-chemical condition

Cell numbers: 10^3-10^6 cells/L: 96hrs

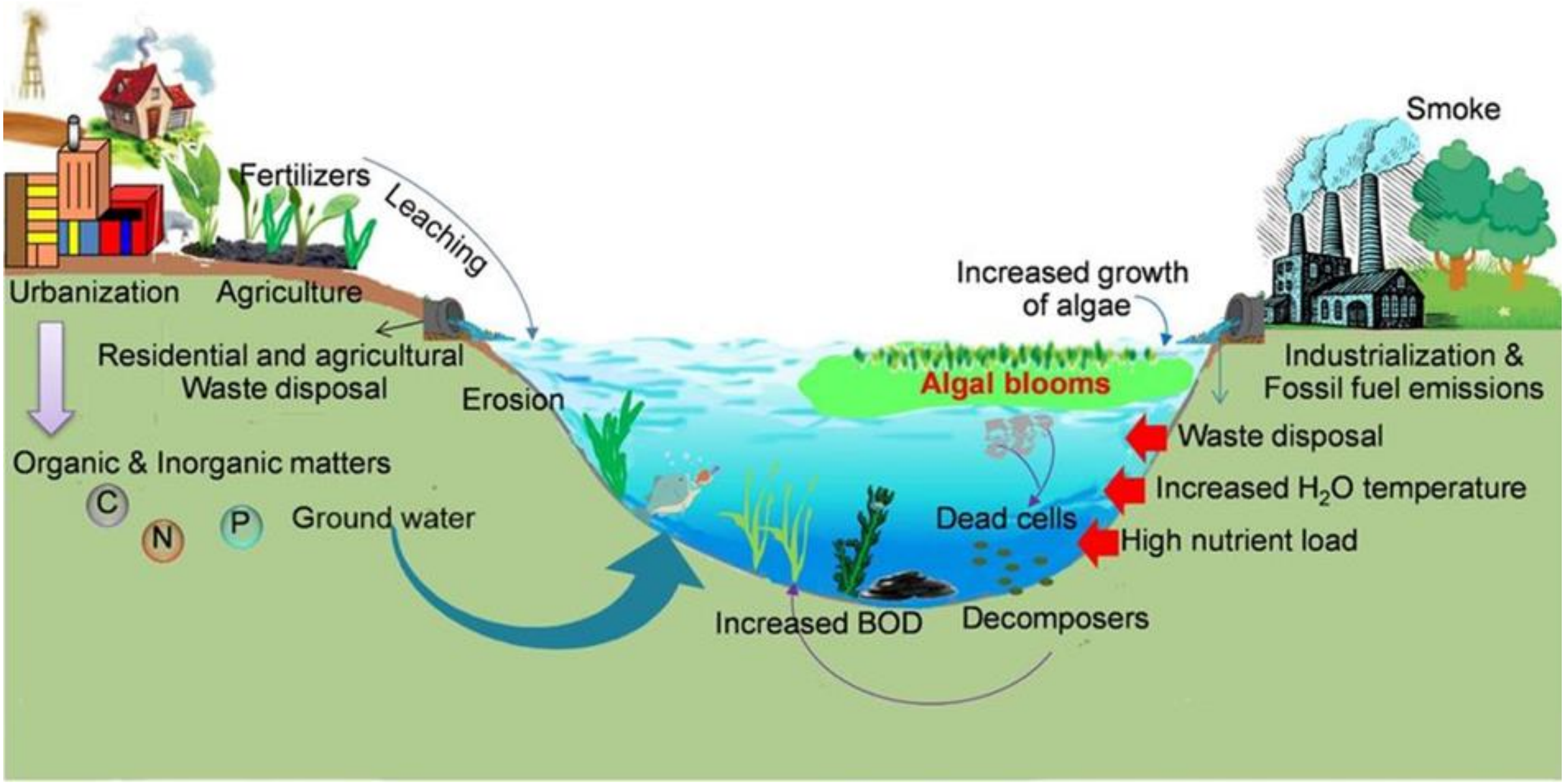
Biomass: ~ 10 mg-m^{-3}

Source: Harrison, et al. 2017.

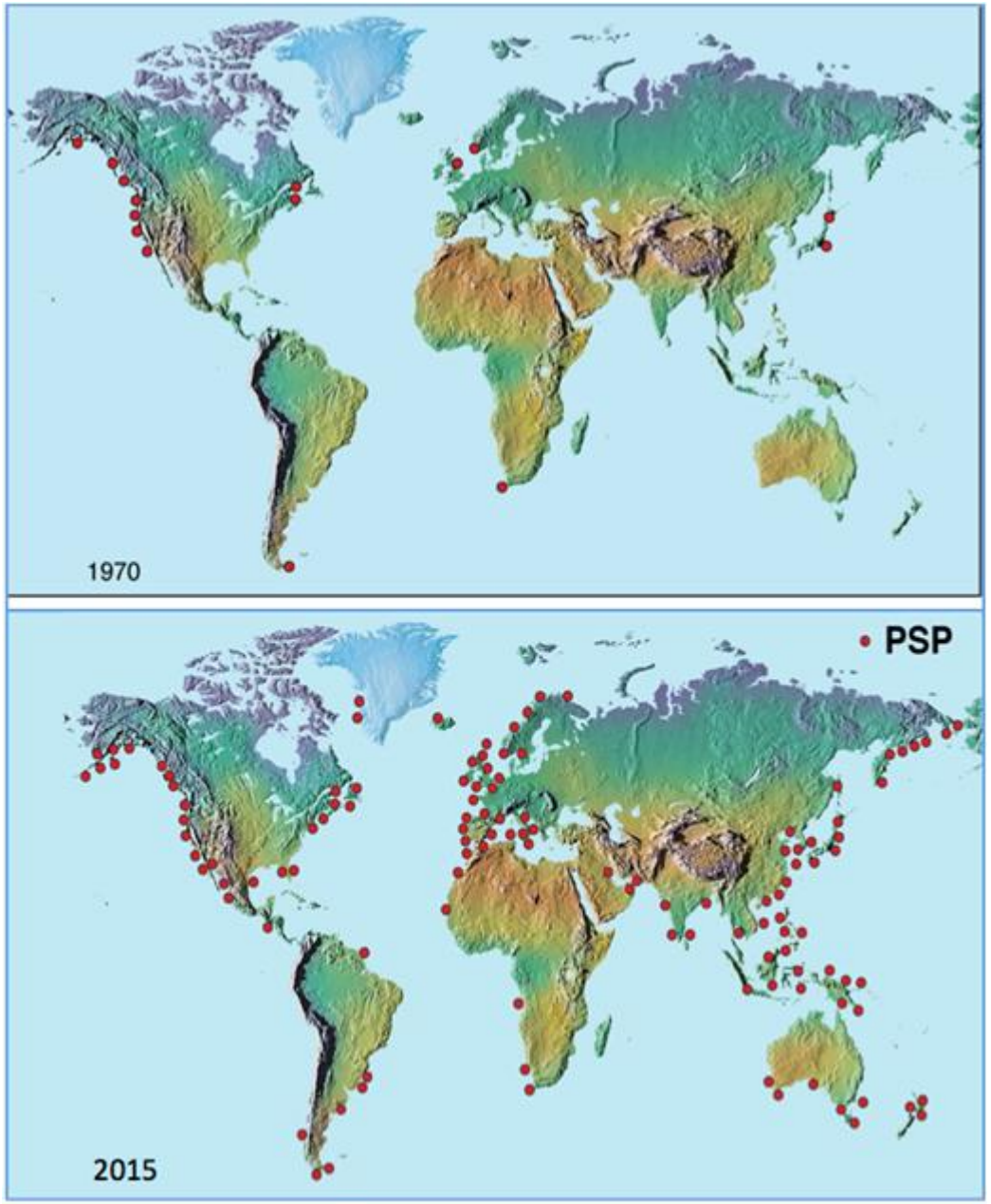
Phytoplankton: Bloom: Impacts



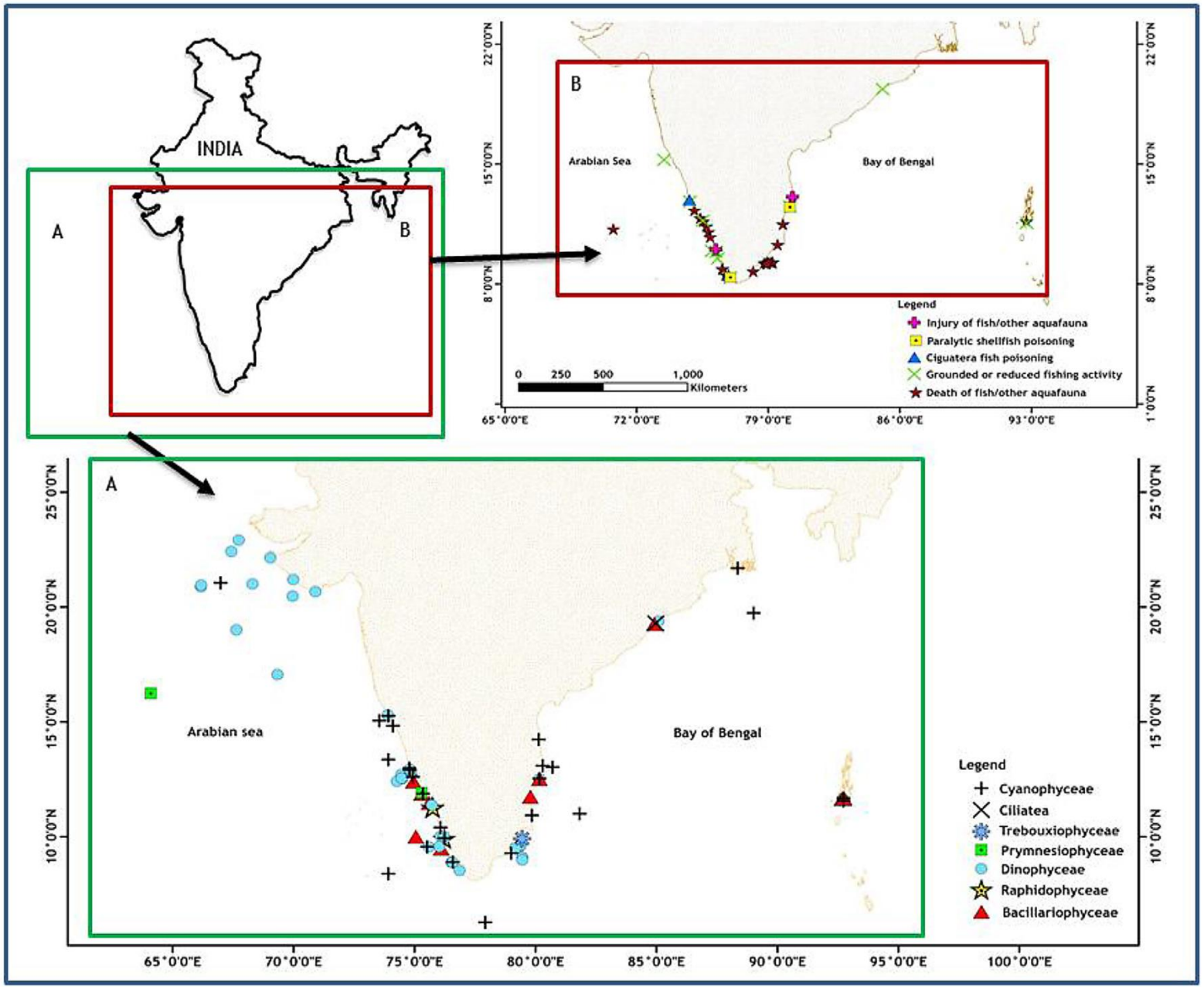
Phytoplankton: Bloom: Potential Factors



Phytoplankton: Bloom: Global Phytoplankton Toxicity Events

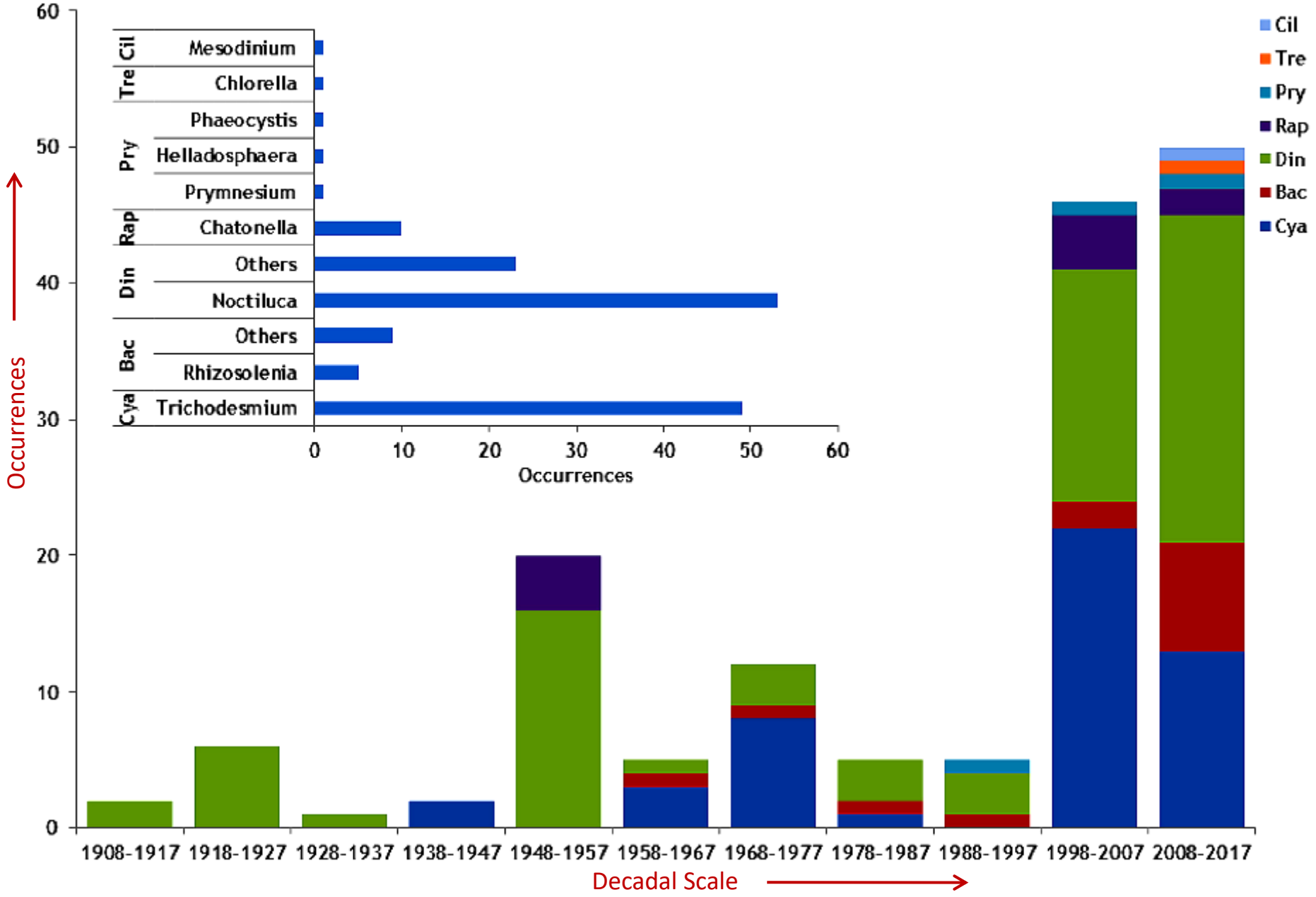


Phytoplankton: Bloom: Scenario of Indian Coastal Waters



Source: Oyeku & Mandal (2020) Oceanologia.

Phytoplankton: Bloom: Scenario of Indian Coastal Waters



Source: Oyeku & Mandal (2020) Oceanologia.

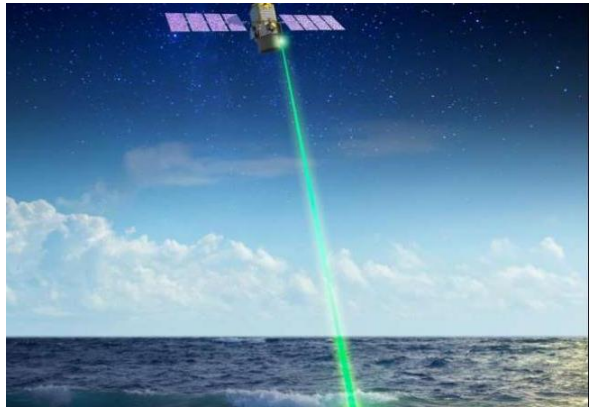
Phytoplankton: Observation

Phytoplankton Monitoring

- ***In situ***
- **Automated Observatory**
- **Remote Sensing**

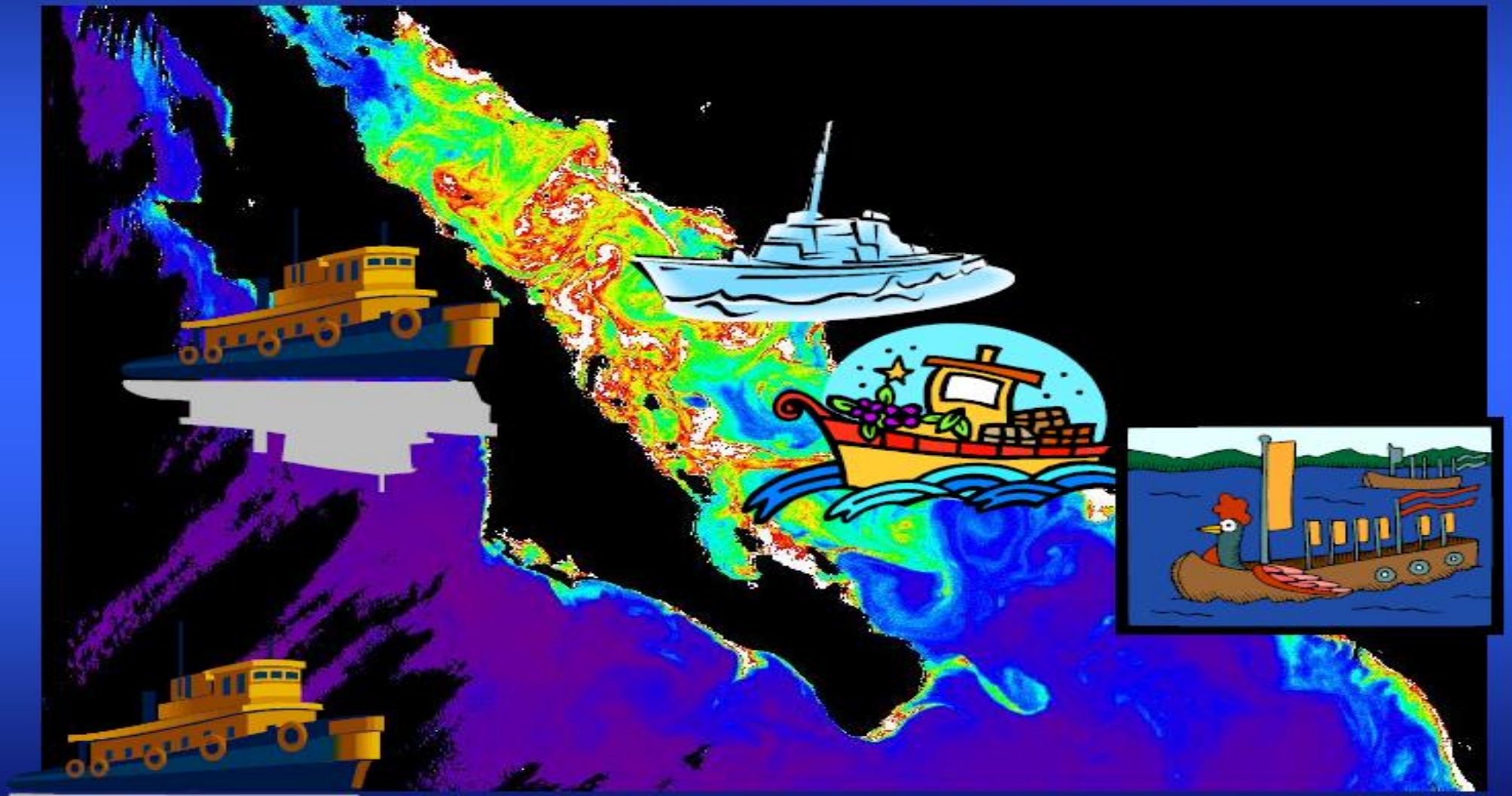
Source: https://microcosmos.foldscope.com/?p=17431

Source: https://www.pml.ac.uk/

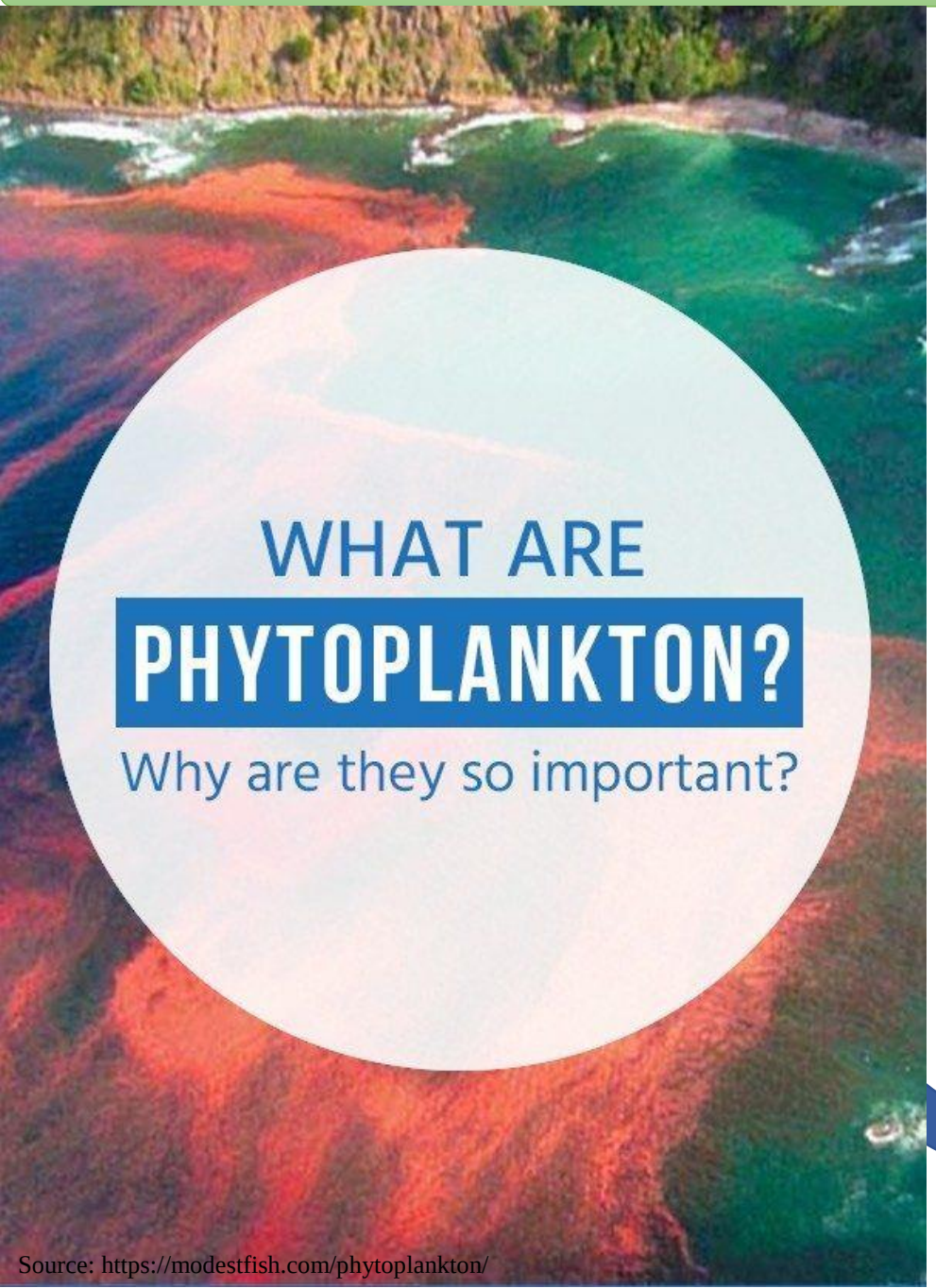


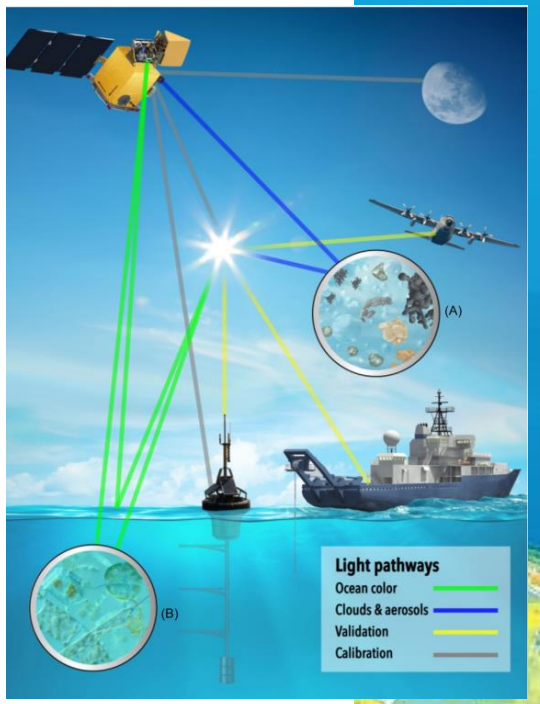
Source: Deccan Chronicle

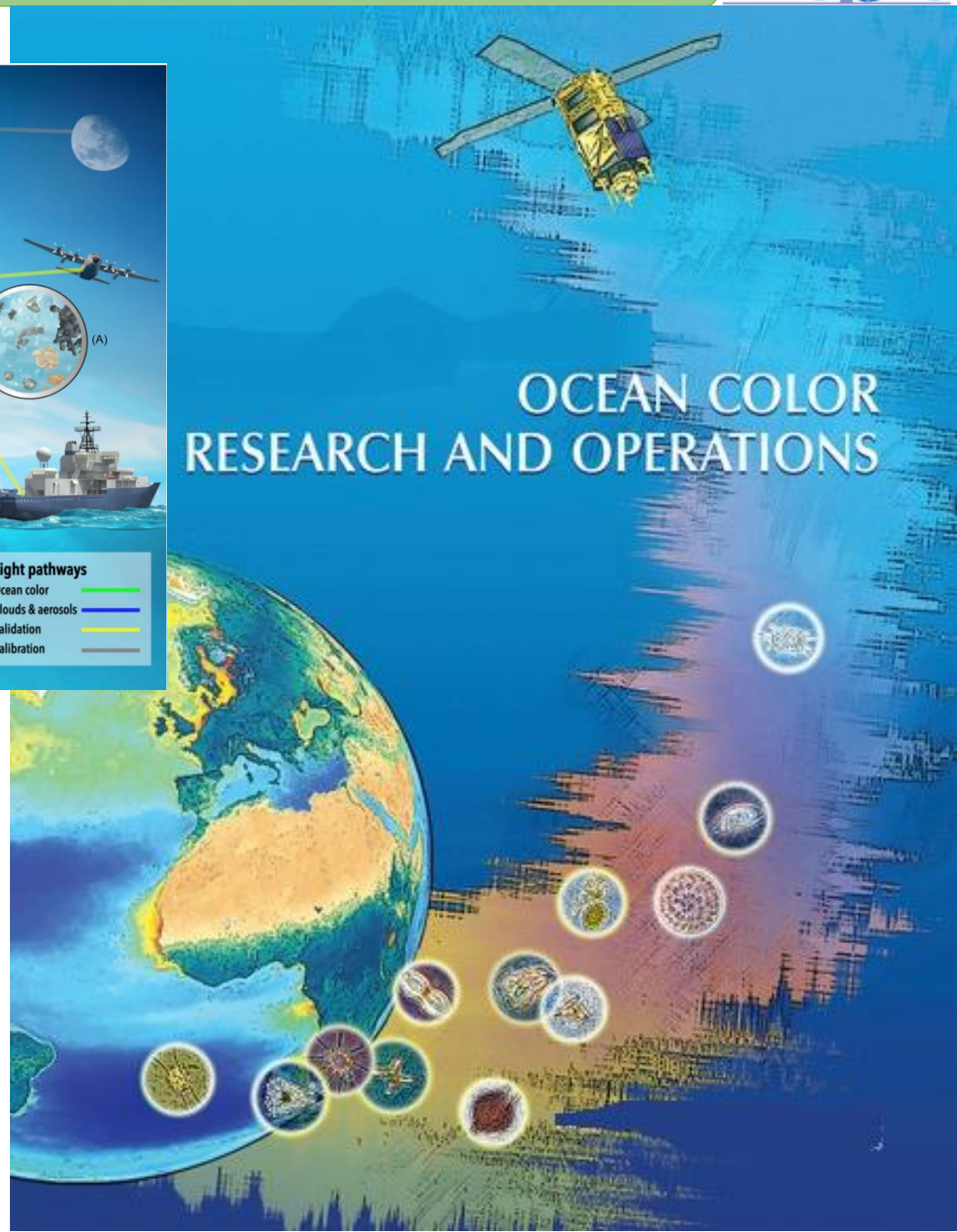
Not enough ships to sample the oceans!



Phytoplankton: Hope It's Clear Now!!!







Source: https://modestfish.com/phytoplankton/

THANK YOU