Bloom in a Bottle

SMILE August 6th 2018

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NASA earth observatory (July 18 2018)
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Outline

01 Introduction

1.1 What is a Phytoplankton Bloom?

1.2 Why is it important to the carbon cycle?

1.3 Carbon cycle, climate change and ocean microorganisms

02 Experiment

2.1 Bloom in a Bottle: Goals and relevance

2.2 Materials and methods

2.3 Designing your own experiment

03 Closing remarks

3.1 Bloom in a Bottle: Questions

What is a Phytoplankton Bloom?

“Dense aggregations of phytoplankton cells of one or more species.”

‘Algal bloom’ is a term applied to an outbreak of phytoplankton cells well above the average for a given region or water body.

“... ephemeral phenomena that arise when growth rates of one or more species of the phytoplankton assemblage exceed their mortality rates”

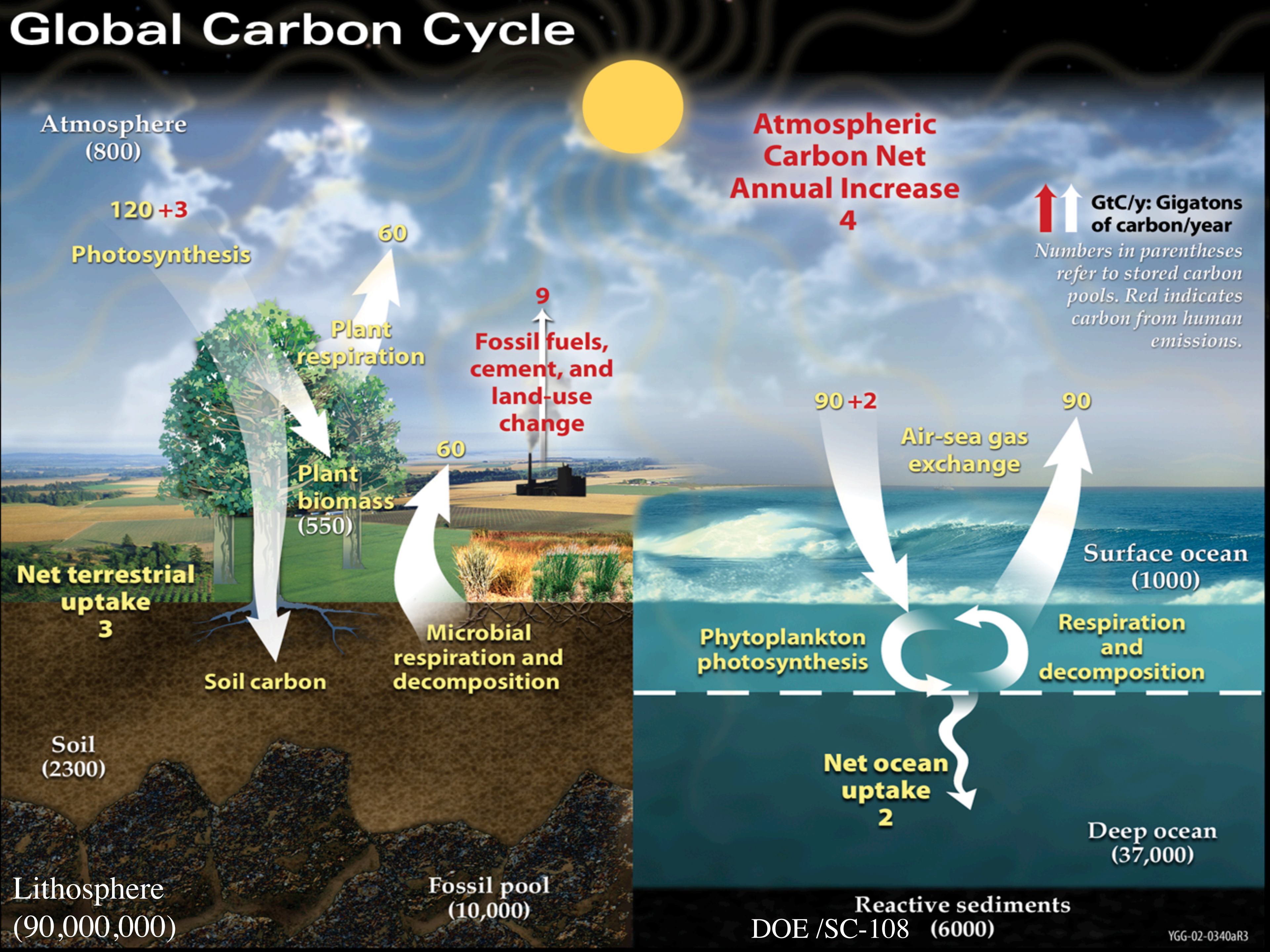
Eukaryotic Microbes, Elsevier 2012

Lake Erie Fresh water bloom, July, 2007

Coastal bloom St. Johns River, Florida summer, 2005

Cyanobacterial surface bloom in the Baltic Sea

Perl & Paul 2012


Global Carbon Cycle
Atmosphere
(800)
120 +3
Photosynthesis
60
Plant
respiration
9
Fossil fuels,
cement, and
land-use
change
Atmospheric
Carbon Net
Annual Increase
4
GtC/y: Gigatons
of carbon/year
Numbers in parentheses
refer to stored carbon
pools. Red indicates
carbon from human
emissions.
90 +2
90
Air-sea gas
exchange
60
Plant
biomass
(550)
Net terrestrial
uptake
3
Soil carbon
Microbial
respiration and
decomposition
Surface ocean
(1000)
Phytoplankton
photosynthesis
Respiration
and
decomposition
Net ocean
uptake
2
Soil
(2300)
Deep ocean
(37,000)
Lithosphere
(90,000,000)
Fossil pool
(10,000)
Reactive sediments
(6000)
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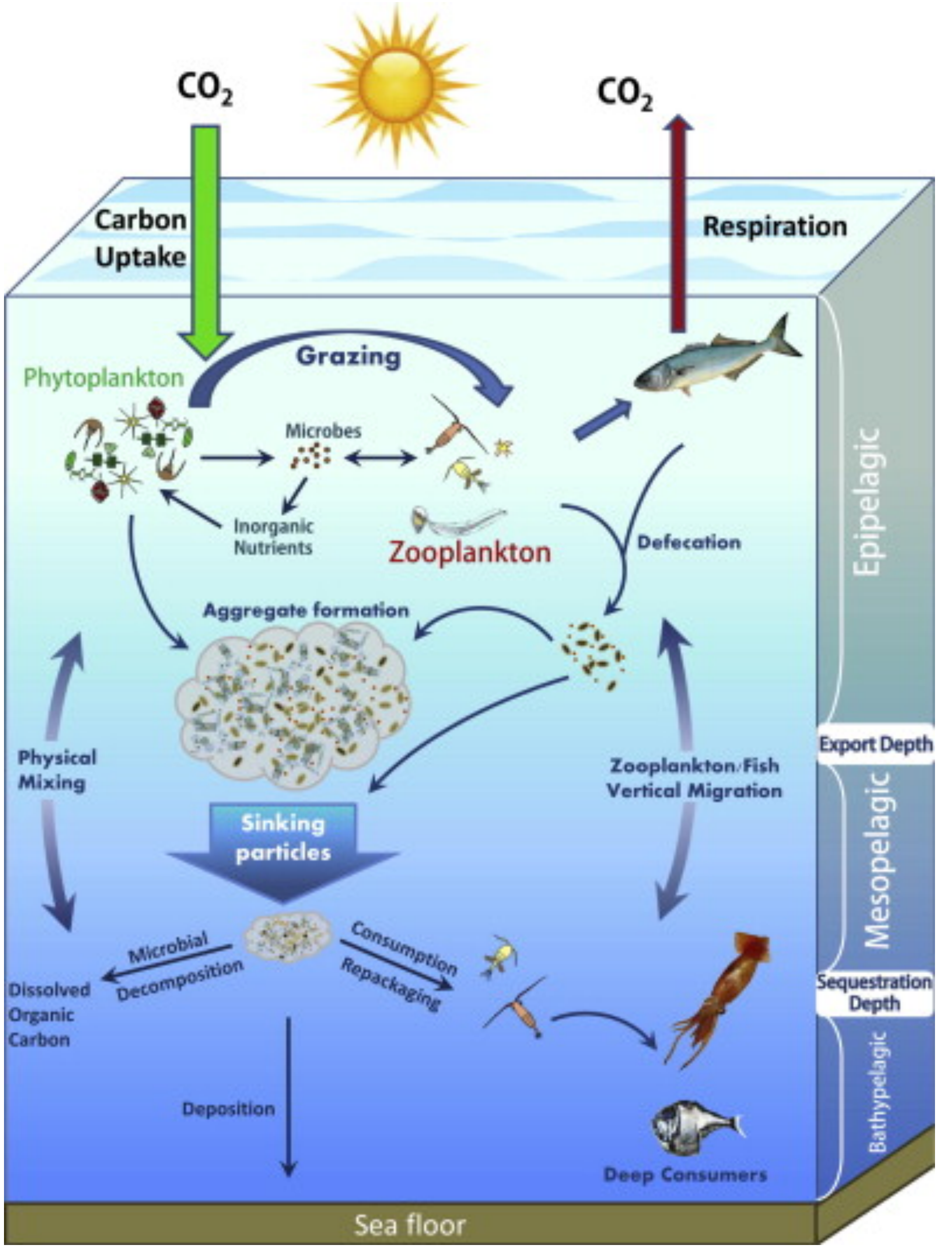
Carbon cycle and the Phytoplankton Blooms



Carbon Fates in the ocean

a) CO_2 dissolves - constant exchange

b) Phytoplankton Biomass

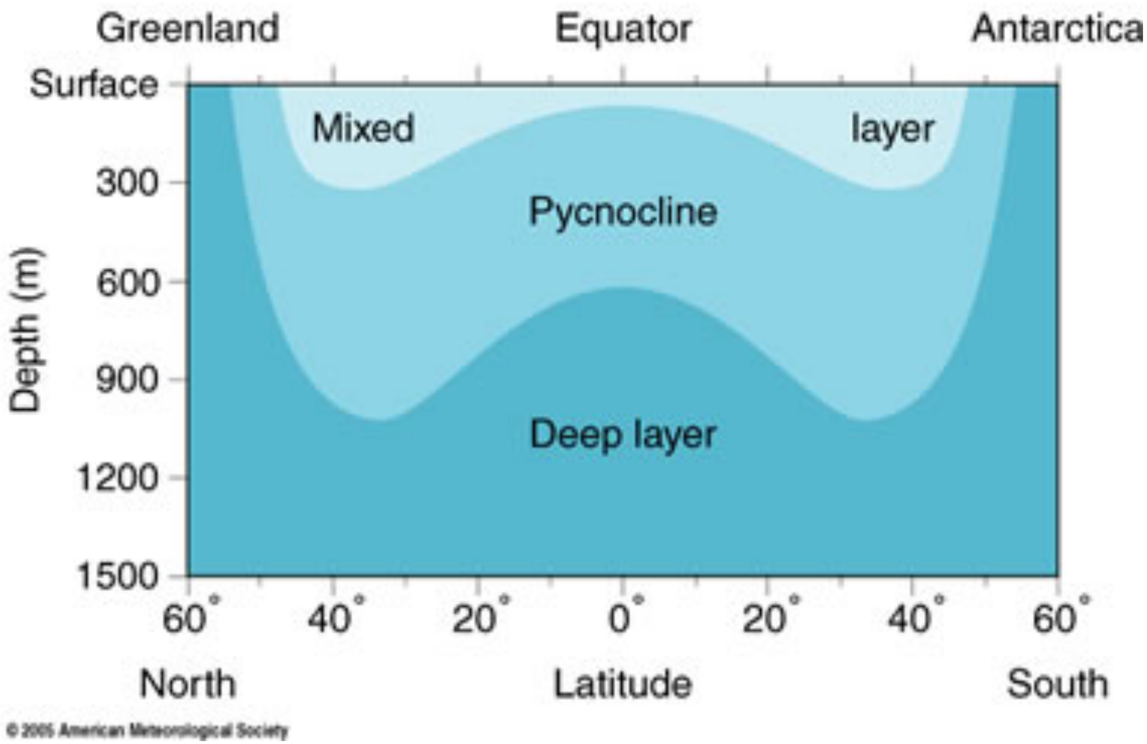
b1) Trophic web
- respiration
- remineralization

b2) Sinks

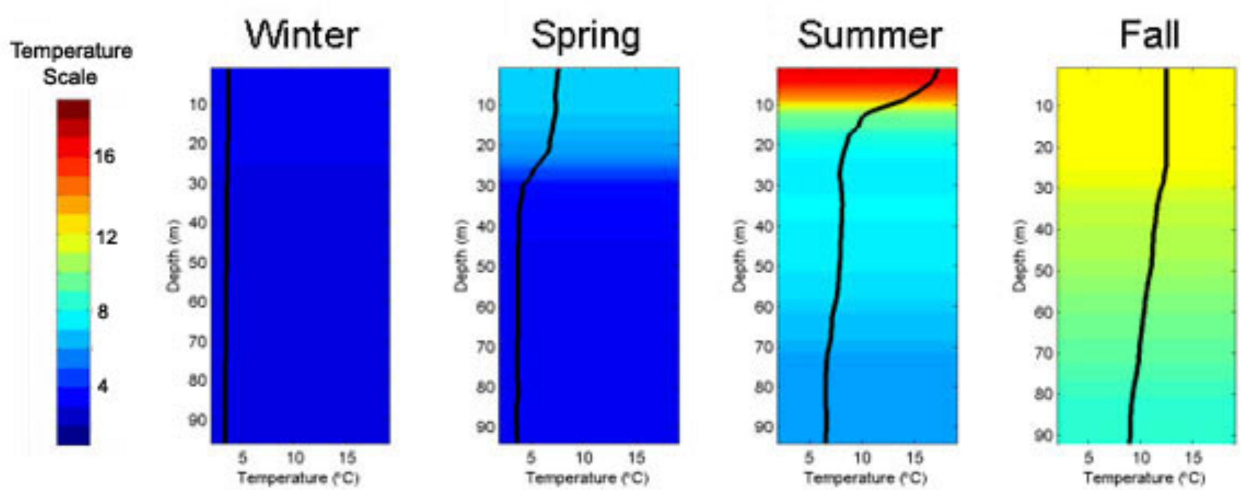
Ocean = Carbon 'sink'
Carbon Uptake > Carbon Release

https://www.sciencelearn.org.nz/resources/689-the-ocean-and-the-carbon-cycle

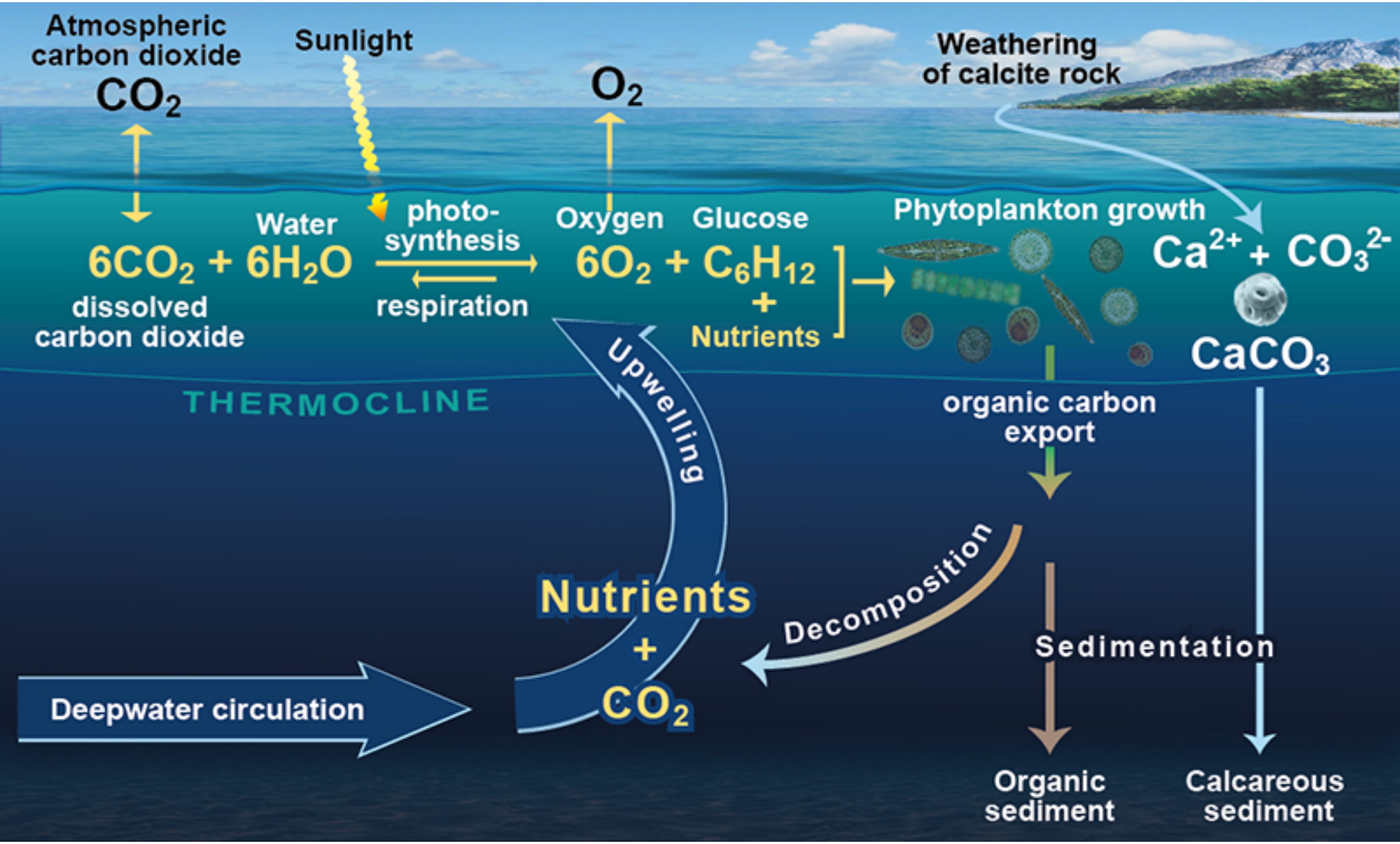
Ocean Phytoplankton Bloom : a complex recipe



High latitude water stratification



Ocean Phytoplankton Bloom: a complex recipe



Credit: NOC/V.Byfield

Background info: Redfield Ratios

- Phytomass displays an average C:N:P of 106:16:1
- This is similar to the C:N:P of dissolved matter in the ocean

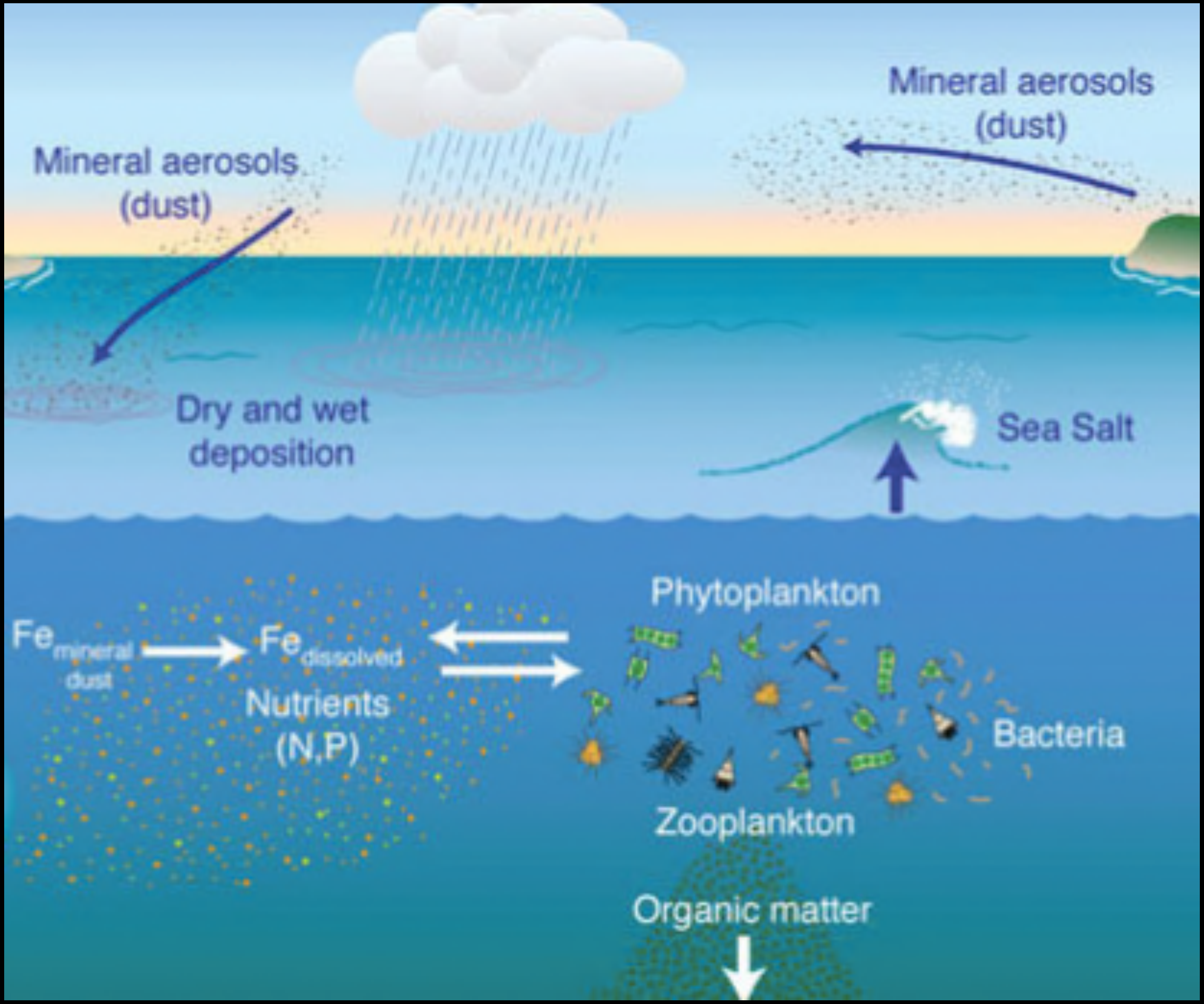
TABLE 1

ATOMIC RATIOS OF ELEMENTS IN THE BIOCHEMICAL CYCLE

	P	*N*	*C*	*O*
Analyses of plankton	1	16	106	–276
Changes in sea water	1	15	105	–235
Available in sea water	1	15	1000	200–300

Redfield, American Naturalist, 1958

Ocean Phytoplankton Bloom : a complex recipe



Blooming microbes

Why does blooming organisms cell size matters?

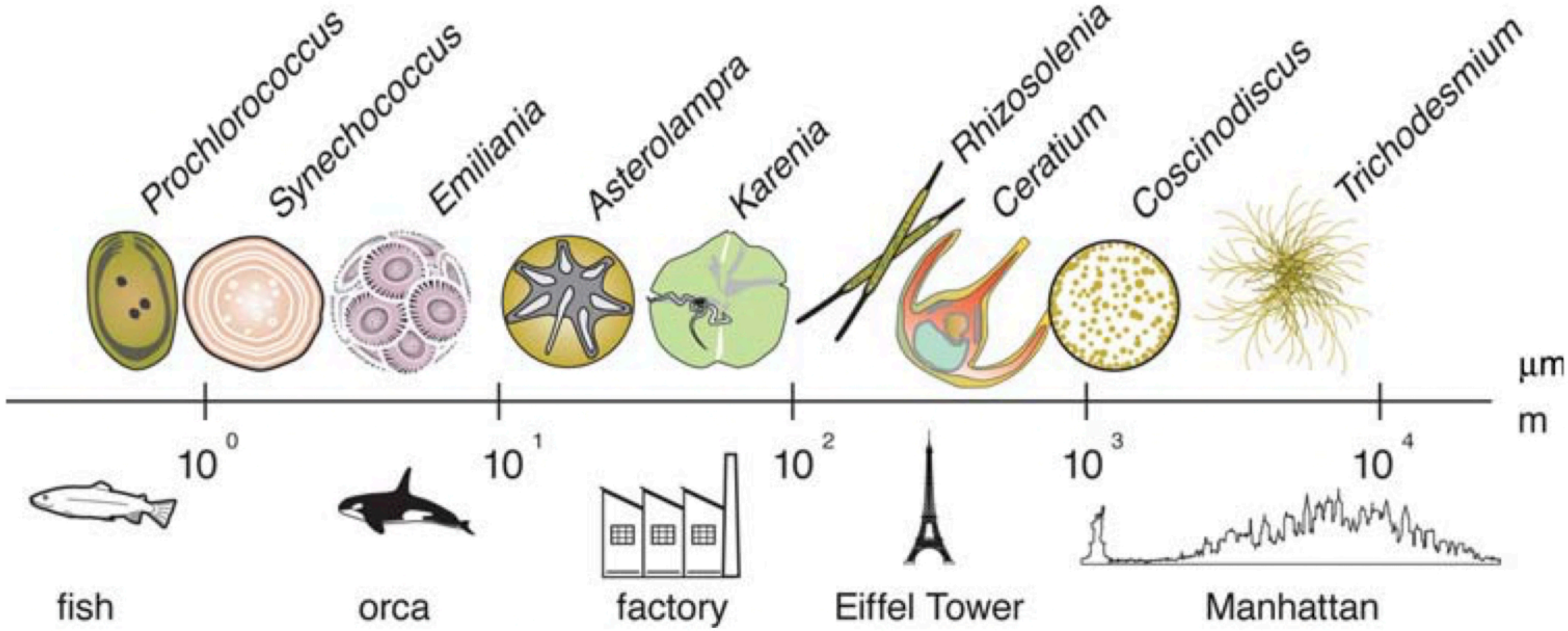
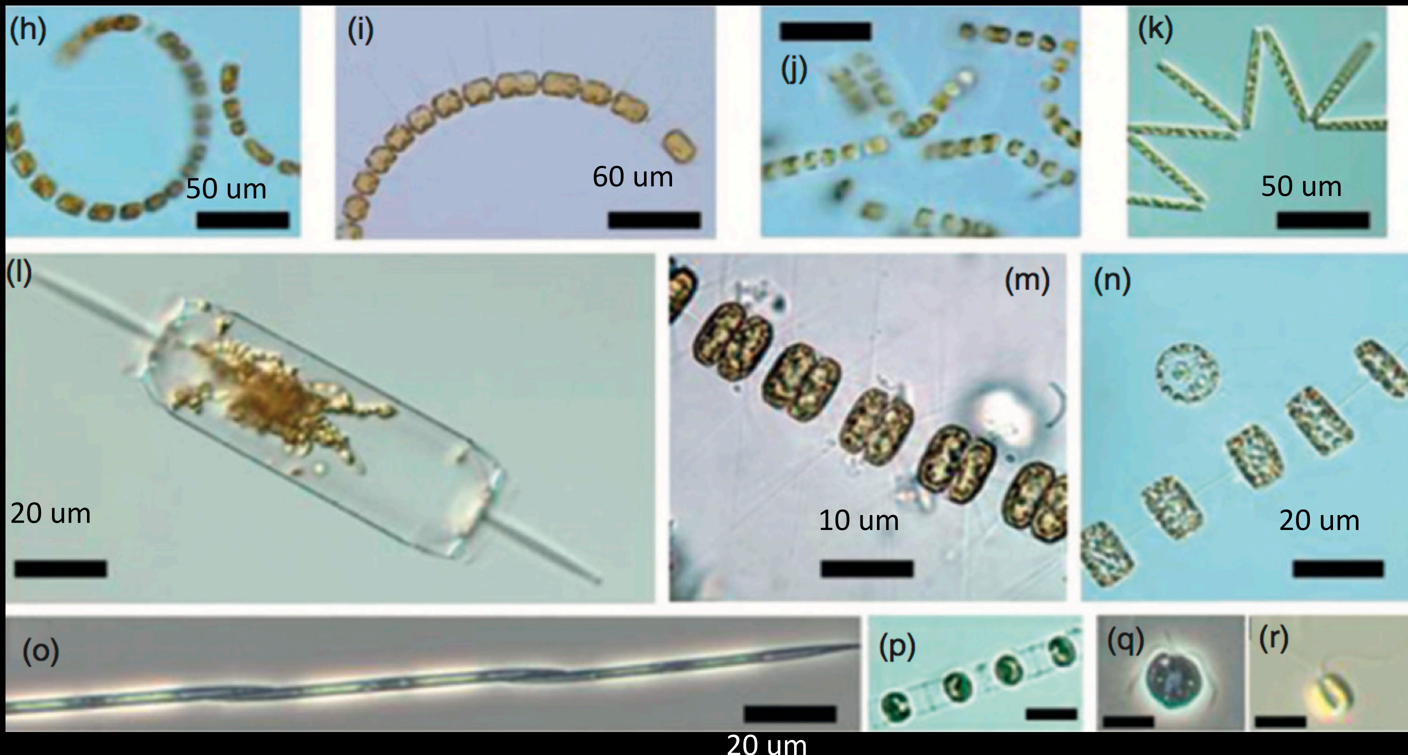


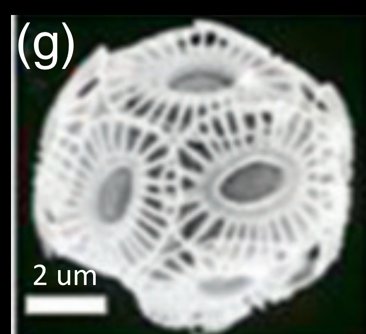
Fig. 2. A comparison of the size range (maximum linear dimension) of phytoplankton relative to macroscopic objects.

Finkel et al., 2010

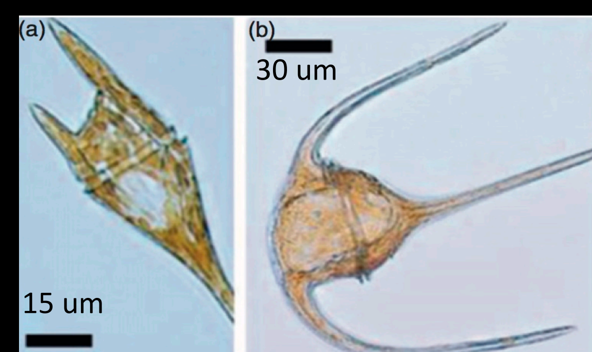
Diatoms



Haptophytes



Dinoflagellates

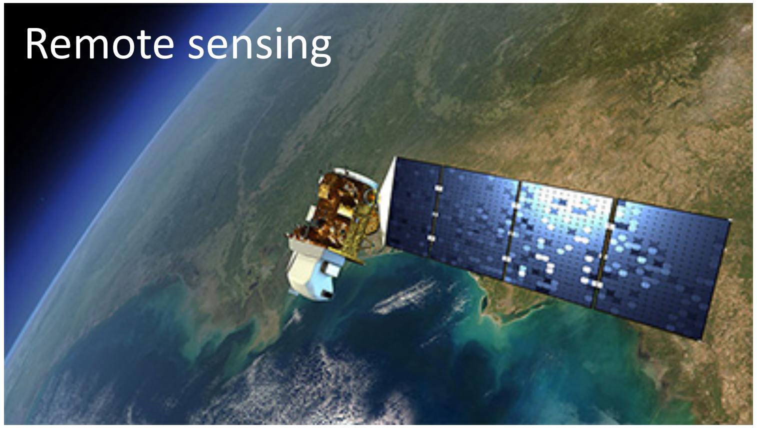


Measuring a Phytoplankton Bloom

What do we want to measure?

How do we measure it?

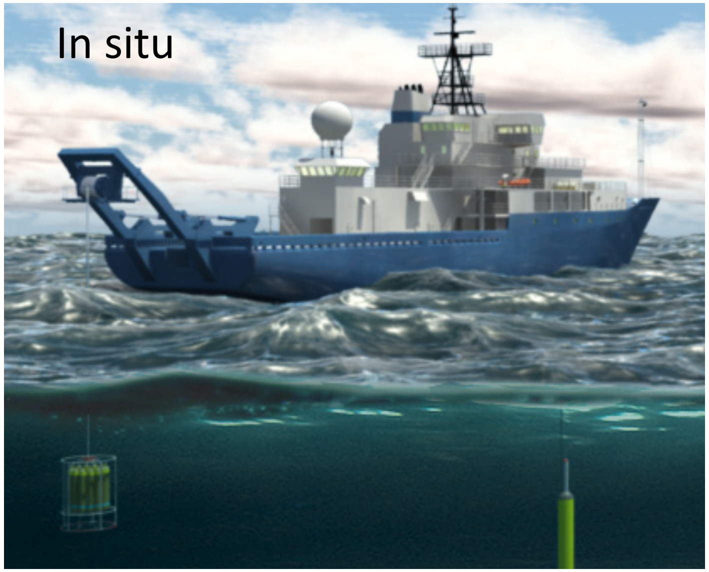
Measuring a Phytoplankton Bloom



Color: Biomass, type of bloom (cyano/ coccolithophores /diatoms)

Spatial distribution at global scale

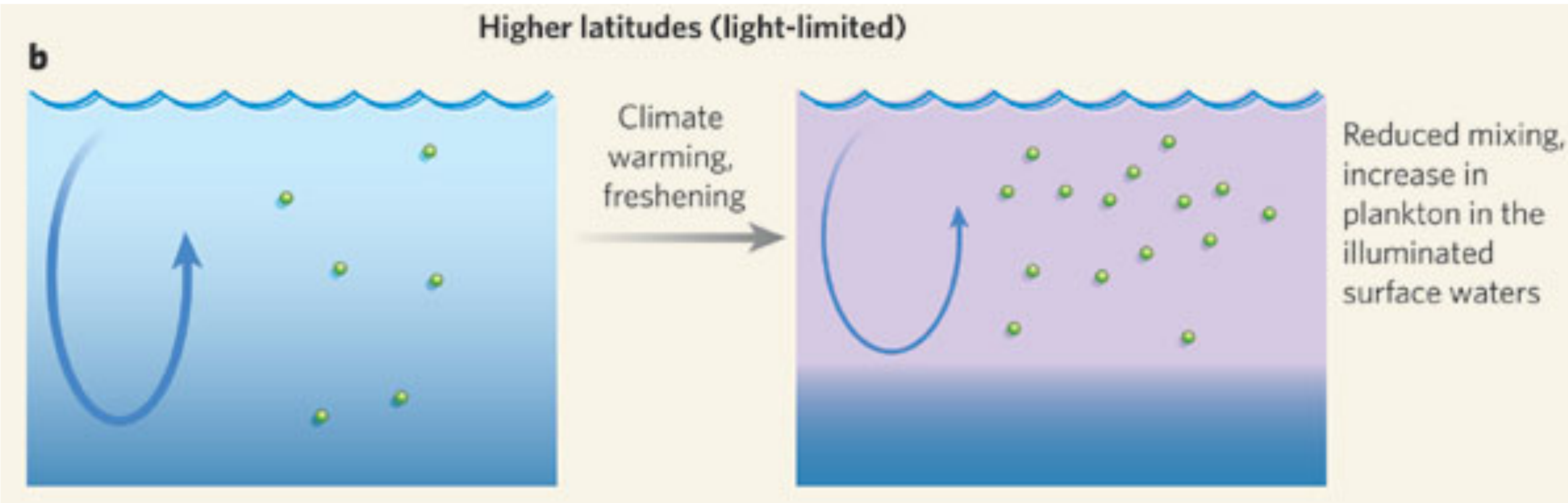
Time series



Species composition: High definition measurements.

Distribution through the water column: Biomass, species, etc.

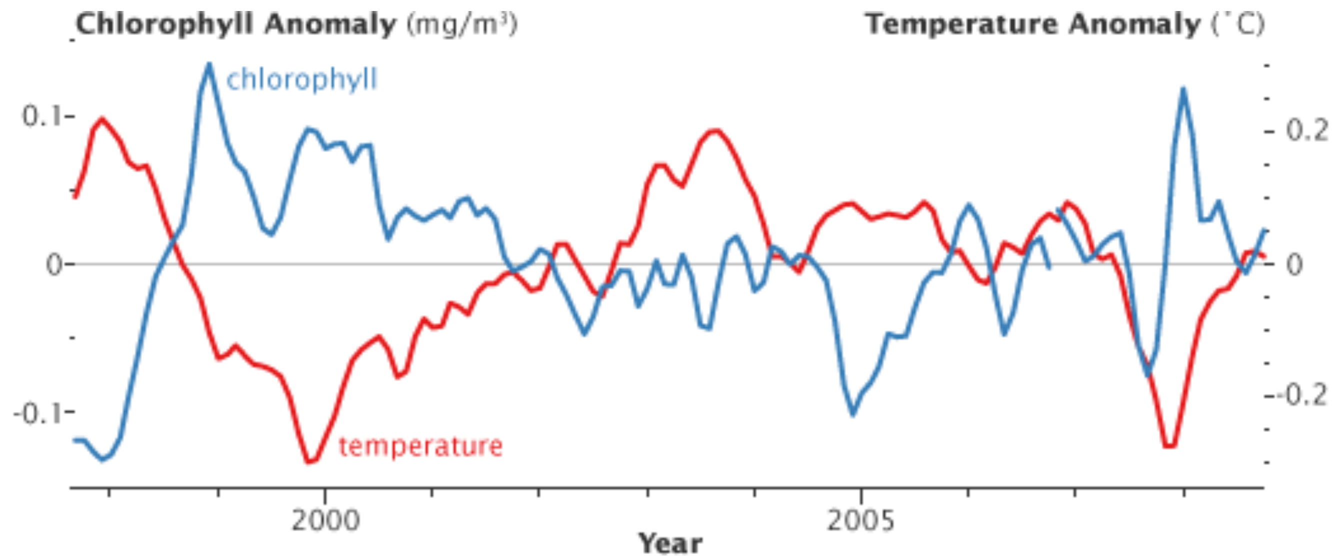
What's the relationship between carbon cycle, climate change and ocean microorganisms?

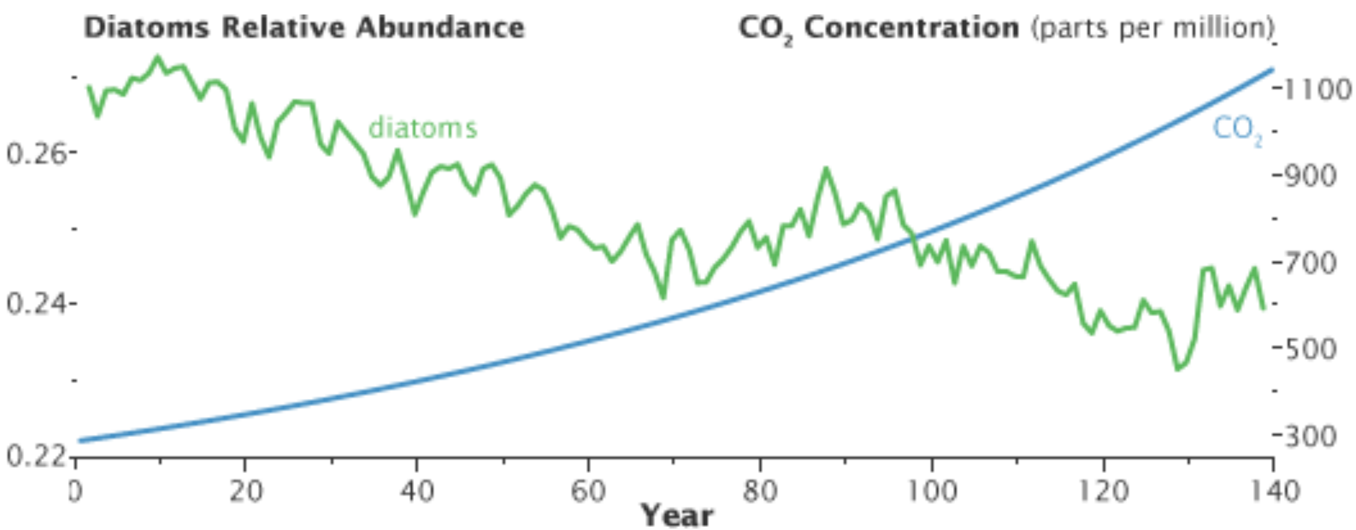


Climate change effects in phytoplankton blooms

- Chlorophyll decreases
- Shifts in species composition
- Bloom initiation timing
- Bloom magnitude

What's the relationship between carbon cycle, climate change and ocean microorganisms?





Bopp 2005, Behrenfeld et al. 2009, earthobservatory.nasa.gov

Bloom in a Bottle Activity

Scientific Method in Action!!

Giovannoni Lab
August 6th, 2018

Oregon State University

Purpose: This is an inquiry-based learning exercise, implementing the steps of the scientific method to investigate processes in microbial community ecology.

Scientific Method: Preparation

- Observation
- Question
- Hypothesis
- Design Experiment

Scientific Method: Experimentation

- Set up Experiment
- Run Experiment
- Gather Data

Scientific Method: Conclusions

Analyze Data

Use data to draw conclusions

Refine hypothesis based off conclusions

Repeat!

Observation

"I see no more than you, but I have trained myself to notice what I see." - Sherlock Holmes

http://www.seos-project.eu/modules/oceancolour/oceancolour-c03-p04.html
https://www.geolsoc.org.uk/ks3/gsl/education/resources/rockcycle/page3824.html

Define a Question

- Ask broad questions that seek to explain the root or causes for the initial observations.
- Questions should be open ended
- Questions should stimulate initial research (online), which should drive further refinement of the question

Example:

- Why is this bloom occurring?
- What is required for a bloom to form?
- What nutrients are needed to sustain a bloom?

Define a Question

Question Examples:

- What **nutrients** do phytoplankton need to grow?
- What **ratio** of these nutrients is required to stimulate a bloom?
- Does phytoplankton growth mirror the **amount of nutrients** added?
- How does **surface area** of the bottle affect bloom formation?
- Do phytoplankton blooms form in all **seasons** of the year?
- How deep can phytoplankton grow; how does **light color** affect growth?
- How does **salinity** affect the growth of algae in freshwater?
- How **diverse** are phytoplankton? Are there different types of phytoplankton in different types of water?

Testable Hypothesis

- A specific, focused question with a yes/no answer derived from broad questions in previous step.
- Research is designed to test the hypothesis, providing an answer the “yes/no” question

Example:

- A refined question would then be: what nutrients are required to stimulate phytoplankton growth?
- Focused, testable, hypotheses would be:
  - ***The phytoplankton community found in the seawater in Newport Oregon is nitrogen limited.***

Testable Hypothesis

The phytoplankton community found in the seawater in Newport Oregon is nitrogen limited.

In order to confirm this hypothesis, the following conditions need to be met:

- The nitrogen treatment had more growth than the phosphorus treatment
- The nitrogen treatment had more growth than the negative control.

Experimental Design

- Design an Experiment to test your hypothesis.
- If necessary refine your hypothesis to match the realities of your experimental abilities.
- Add additional specificity to your hypothesis to match experiential conditions

What are some important factors to include in an experiment?

Experimental Design

- Only manipulate one variable
- Negative Control
- Positive Control
- Replicates

Experimental Design: Make a Table

The phytoplankton community found in the seawater in Newport Oregon is nitrogen limited.

Bottle #	Label	Replicate	Water Type	Water Volume	Treatment
1	Negative Control	A	Seawater	500ml	None
2	Negative Control	B	Seawater	500ml	None
3	Negative Control	C	Seawater	500ml	None
4	Positive Control	A	Seawater	500ml	Miracle-Gro 0.5ml
5	Positive Control	B	Seawater	500ml	Miracle-Gro 0.5ml
6	Positive Control	C	Seawater	500ml	Miracle-Gro 0.5ml
7	Nitrogen	A	Seawater	500ml	1ml NH_4Cl
8	Nitrogen	B	Seawater	500ml	1ml NH_4Cl
9	Nitrogen	C	Seawater	500ml	1ml NH_4Cl
10	Phosphorus	A	Seawater	500ml	1ml NaH_2PO_4
11	Phosphorus	B	Seawater	500ml	1ml NaH_2PO_4
12	Phosphorus	C	Seawater	500ml	1ml NaH_2PO_4

Call a Scientist!

Email Chris to set up call! suffridc@oregonstate.edu

Scientific Method: Experimentation

Set up Experiment

Run Experiment

Gather Data

Set up Experiment:

DEMO TIME!

Set up Experiment

- Collect water from a creek, river, lake, or ocean.
- Determine experimental treatments based off scientific method steps discussed above. For this example:
- Create a table outlining your experiment.
- Add 500ml of raw water into each container
- Label each bottle with the Number, Label, and Replicate from the table.
- Add the treatments to each container based on the table above. E.g., add 1ml of NH_4Cl to bottle 7. **See Appendix 2 for details about stock concentrations and making dilutions.**
- After adding the treatment, loosely cap the container (to allow air exchange), and place near a window where each bottle will receive natural light

Gather Data

- Microscopy
- Quantify Color
- Filtering

Scientific Method: Conclusions

1. Analyze Data
2. Use data to draw conclusions
3. Refine hypothesis based off conclusions
4. Repeat!

Use Data to Determine Conclusions

- Look back on the course of the experiment and determine if your hypothesis was supported. Did the positive control have more growth than the negative control? Did the experimental treatments have more growth that the negative control? How much more?

- Did nitrogen or phosphorus produce more growth? We hypothesized that the system was nitrogen limited, so in order to confirm that hypothesis, the following conditions need to be met:
  - The nitrogen treatment had more growth than the phosphorus treatment
  - The nitrogen treatment had more growth than the negative control.

- At this stage please feel free to contact the Giovannoni Lab again, we’d be happy to talk with your groups about their results

Final Thoughts

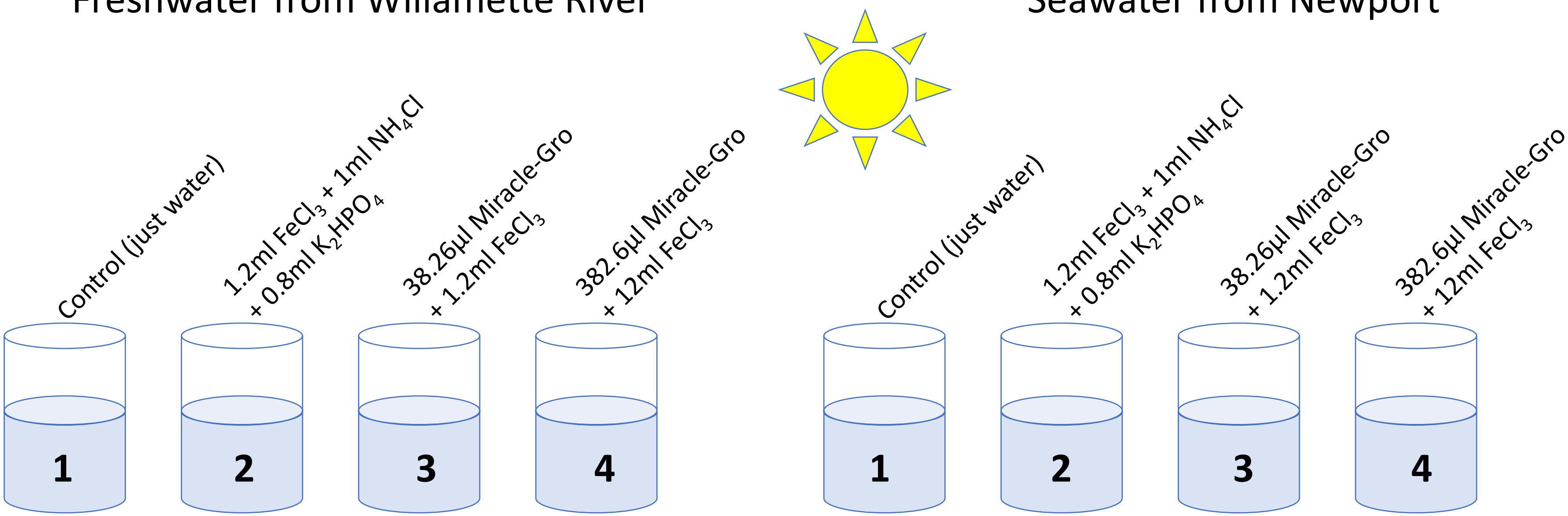
- If the data supports the hypothesis, GREAT! You have used the scientific method to determine the likely cause of an observed event.

- If the data does not support the hypothesis, GREAT! You have determined what is not going on using the scientific method! Repeat the process to investigate further

Experimental setup

Freshwater from Willamette River

Seawater from Newport

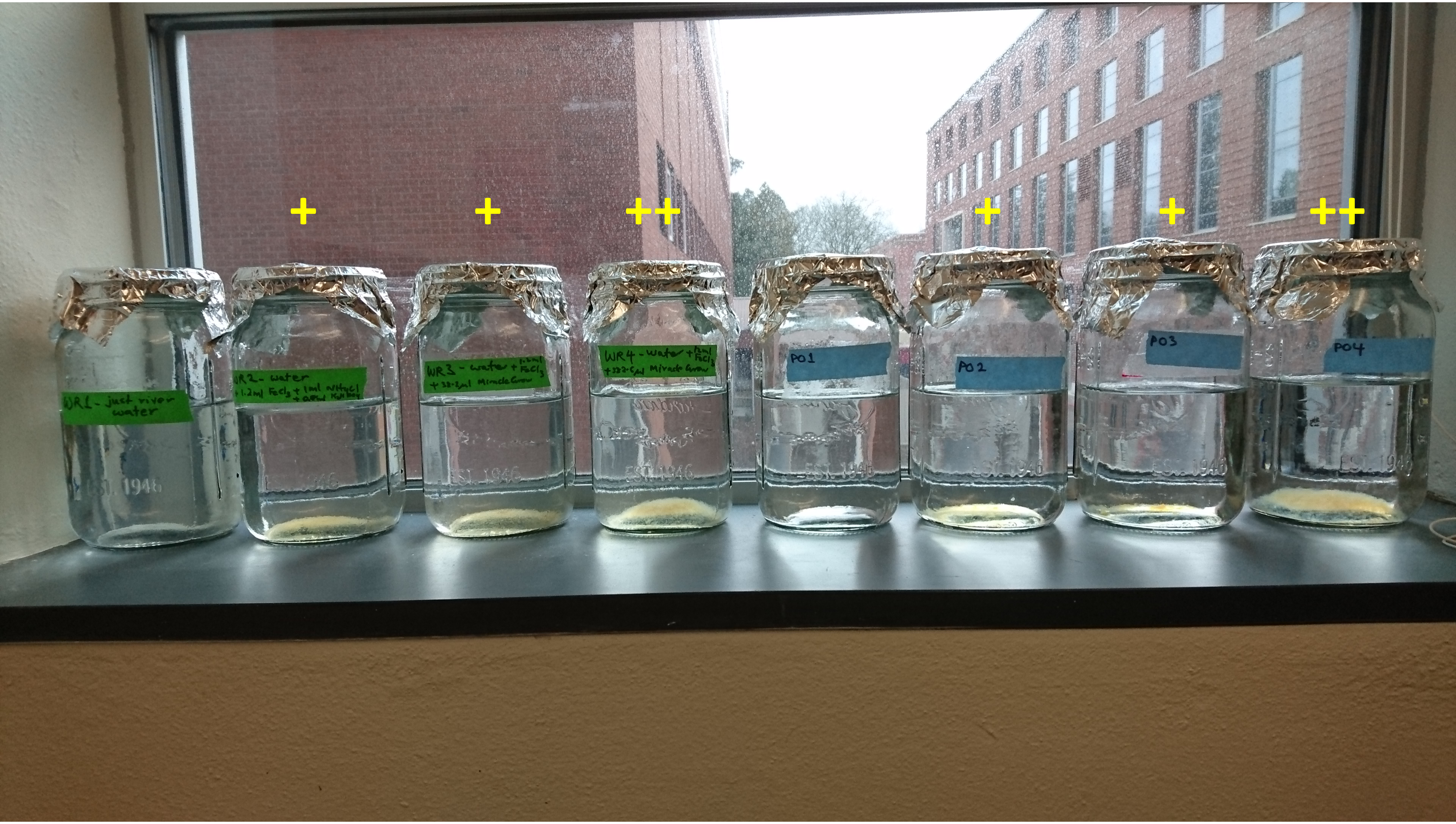


500ml of **river water** in each bottle

500ml of **seawater** in each bottle

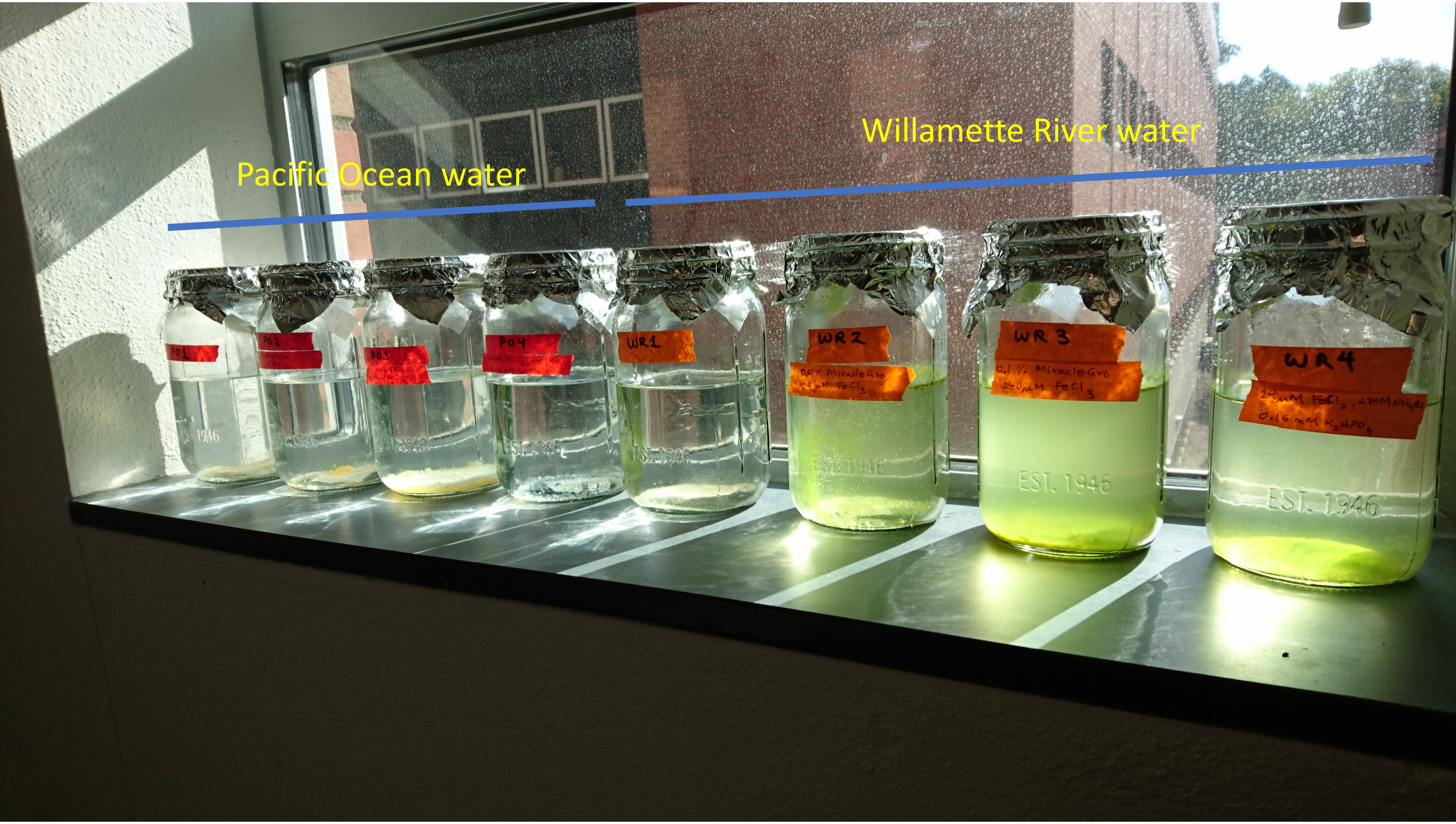
Results: Day 1 (01/18/2017)

Results: Day 8 (01/26/2017)



Results from last year

After 3 months



Results from last year

After 3 months