Marine Primary Producers – In Class Slides

Coccolithophores

Olivia, Mary, Nicole

Me

What am I?

Unicellular eukaryotic phytoplankton

Size : range from 5- 50 µm across

- Live in large numbers throughout upper ocean

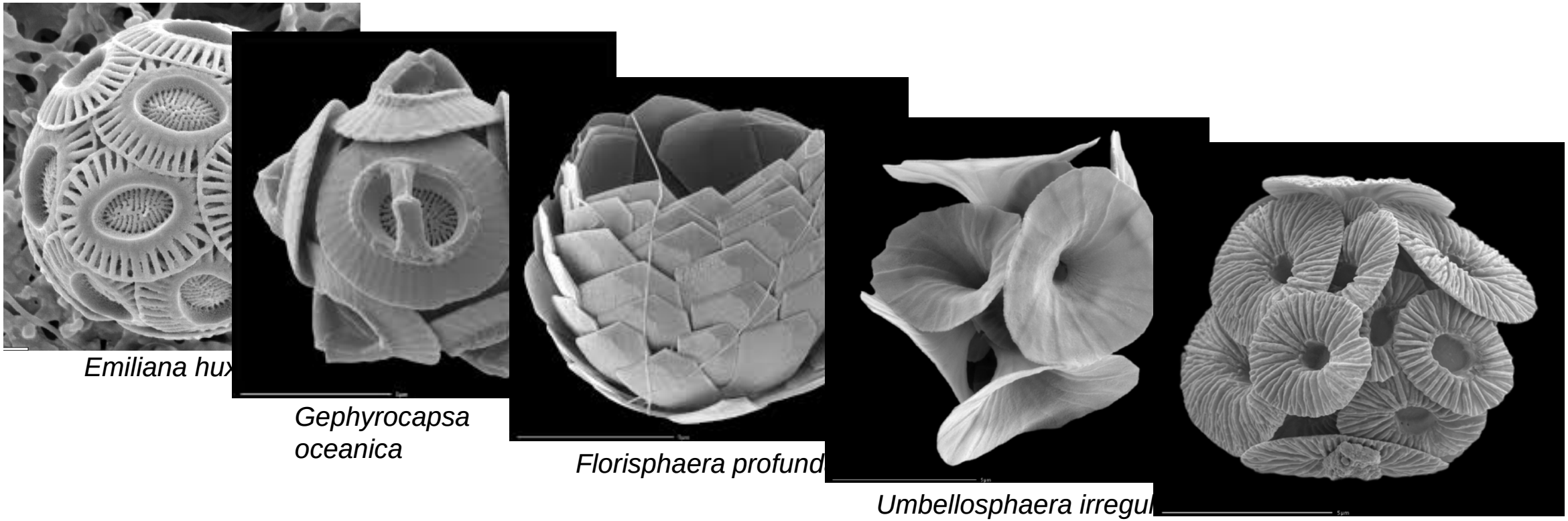
Shape: flagellated spherical cells covered with coccoliths

  - Coccoliths: protective microscopic disk shaped plates of calcium carbonate
  - Surround themselves with at least 30 of these “scales”
    - Scale size: three one-thousandths of a millimeter in diameter.
    - Color of Scales: white

Me in the ocean

Found in upper layers of ocean in still, nutrient-poor, mild temp waters

- Don’t live in areas of upwelling for nutrients like most phytoplankton



Emiliana hux

Gephyrocapsa oceanica

Florisphaera profund

Umbellosphaera irregul

Umbellosphaera tenuis

Me in the food web

Major primary producer

What eats me:

- zooplankton (*Calanus helgolandicus*, *elongatus*, *Centrapoges tonsa*)

Why am I important:

- major primary producer
- Leading calcite producer from dumping of coccoliths, dump more than 1.5 billion tons of calcite a year
- Dimethylsulfoniopropionate (DMSP)

Me when people write about me

Bach, W. M., Holligan, P. M., & Kilpatrick, K. A. (1992). Calcification, photosynthesis and growth of the bloom-forming coccolithophore, Emiliania huxleyi. *Continental Shelf Research, 12* (12), 1353-1374.

Coccolithophores. Retrieved from https://www.geo.uni-bremen.de/sedpal/page.php?pageid=643

Geisen, M., Young, J. R., Probert, I., Sáez, A. G., Baumann, K., Sprengel, C., . . . Medlin, L. K. (2004). Species level variation in coccolithophores. *Coccolithophores*,327-366. doi:10.1007/978-3-662-06278-4_13

Harris, R. P. (1994). Zooplankton grazing on the coccolithophore Emiliania huxleyi and its role in inorganic carbon flux. *Marine Biology, 119*, 431-439.

Honjo, S. (1976). Coccoliths: Production, transportation and sedimentation. *Marine Micropaleontology, 1*, 65-79. doi: 10.1016/0377-8398(76)90005-0

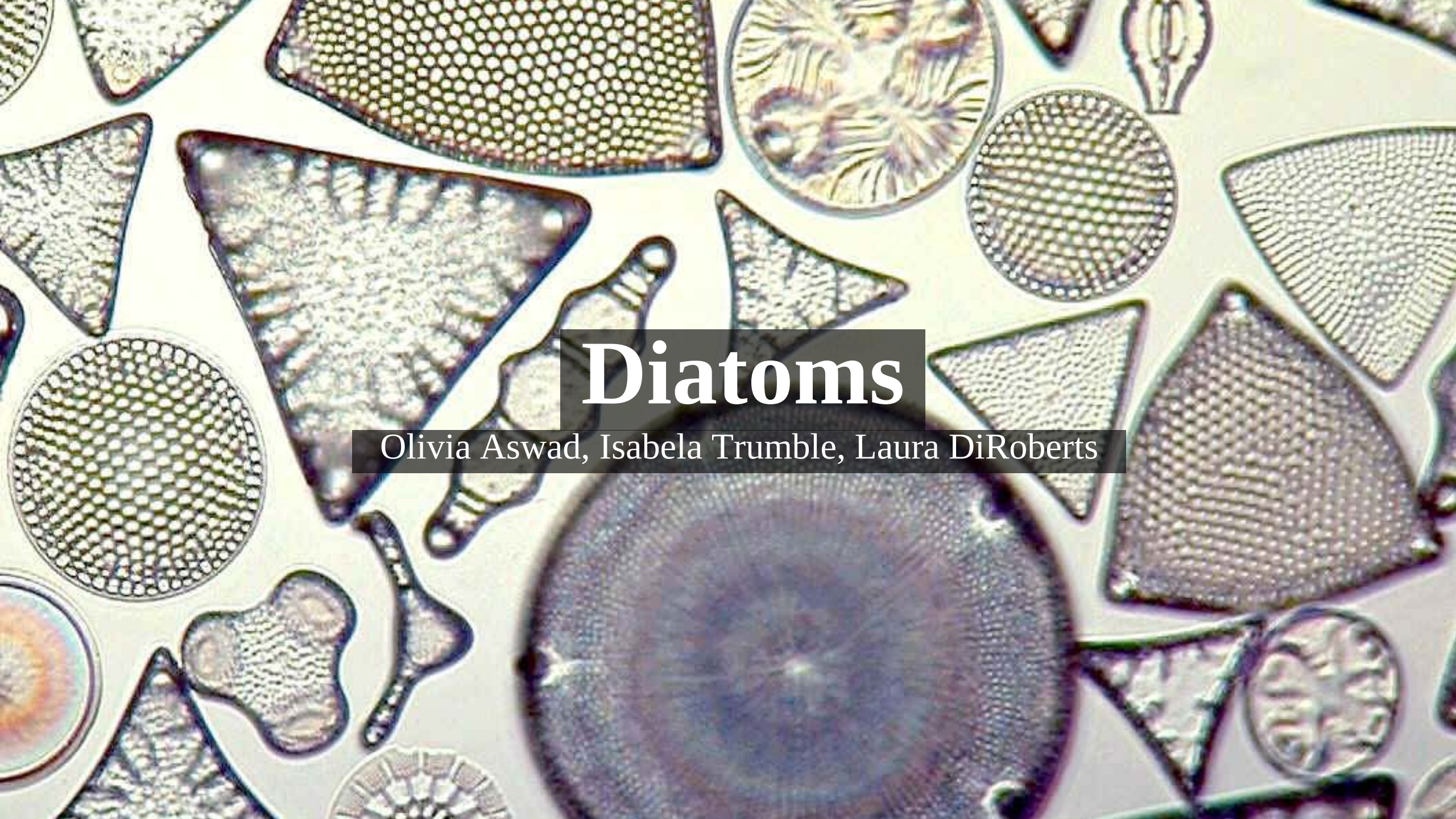
Shatto, Rahilla C C.A, and Niall C. Slowey (1997, September 1). "Survival of the Strangest Speculations on the Functions of Coccoliths." *Functions of Coccoliths, Quarterdeck 5.2*, web.archive.org/web/20040529042518/http://www-ocean.tamu.edu/Quarterdeck/QD5.2/shatto-slowey2.html.

University of Bremen. (n.d.). Coccolithophores. Retrieved from https://www.geo.uni-bremen.de/sedpal/page.php?pageid=643

Weier, J. (1999, April 26). What is a Coccolithophore? Fact Sheet : Feature Articles. Retrieved from https://earthobservatory.nasa.gov/Features/Coccolithophores/

Winter, A., & Siesser, W. G. (2006). *Coccolithophores*. Cambridge: Cambridge University Press.

Yoch, D.C. (2002). Dimethylsulfoniopropionate: Its Sources, Role in the Marine Food Web, and Biological Degradation to Dimethylsulfide. *Appl. Environ. Microbiol., 68* (12), 5804-5815.

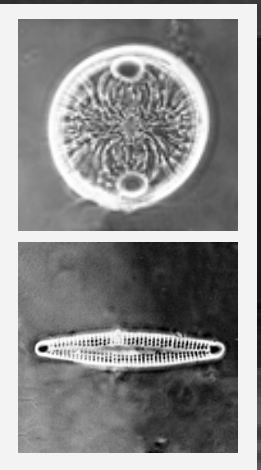


Diatoms

Olivia Aswad, Isabela Trumble, Laura DiRoberts

Characteristics

- Unicellular microalgae
- Most diatoms are between 2 microns to 500 micron
- Silicate Frustule
  - Epitheca and Hypotheca
- Bilateral (pennate) or Radial Symmetry (centrate)
- Solitary or colonial
- Sexual and Asexual Reproduction

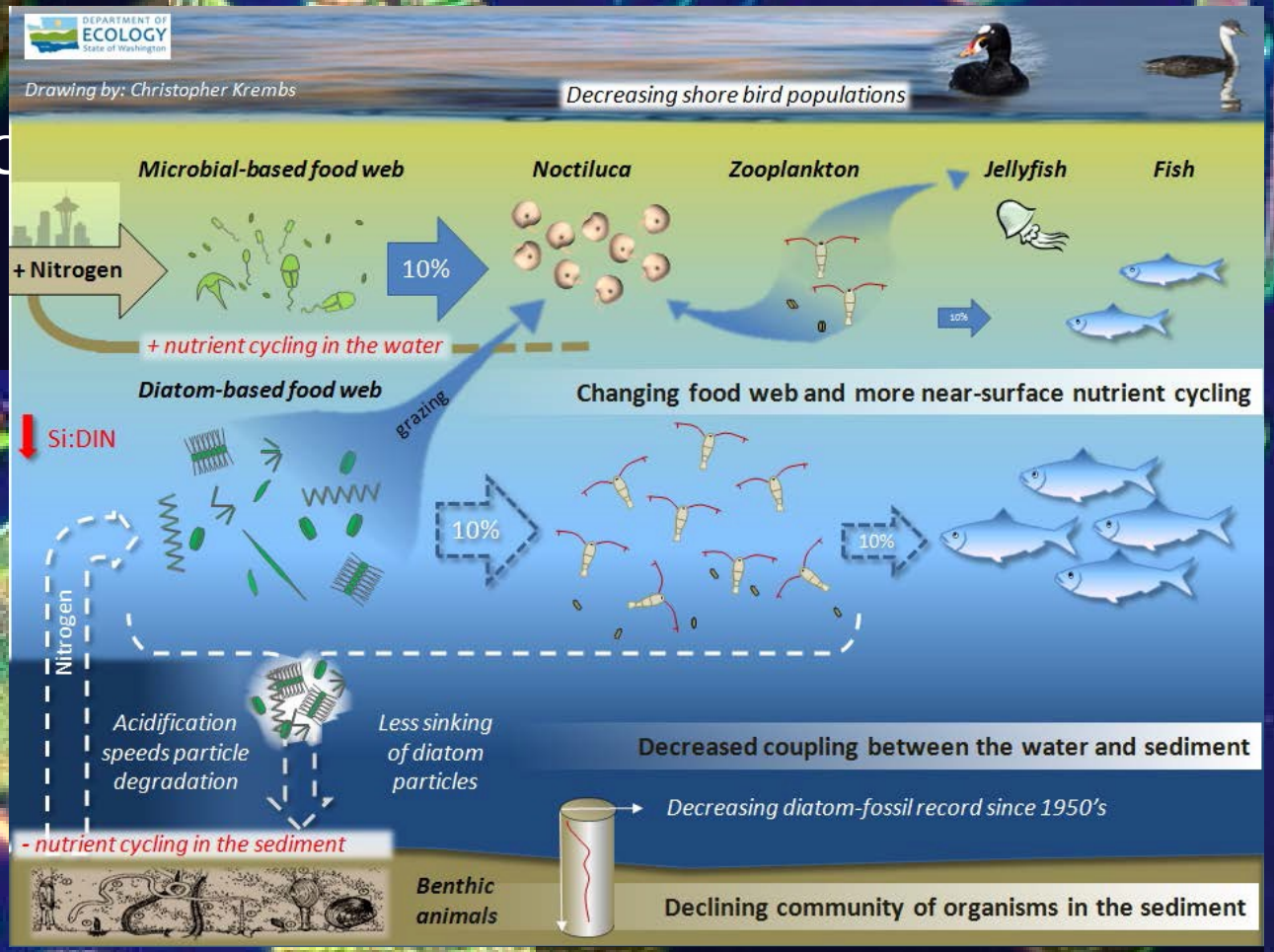


Role in the Environment

- 20%-25% of global carbon fixation (AKA 1˚ Production)
  - $CO_2 \rightarrow O_2$ (photosynthesis)
- Grazed by zooplankton and other 1˚ Consumers
  - Supply food for entire ocean food chain
  - Diatoms → Zooplankton → Fish → Whales
- Approximately 12,000-30,000 species worldwide

Why are they important?

- Provide basis for food chain
- Important to Global Carbon Fixation
  - Major source for atmospheric oxygen
- Siliceous Ooze
- Climate Change Models



Picture Credit (Encyclopedia of Puget

Works Cited

Bopp, L., Aumont, O., Cadule, P., Alvain, S., & Gehlen, M. (2005). Response of diatoms distribution to global warming and potential implications: A global model study. Geophysical Research Letters, 32(19), 1–4. https://doi.org/10.1029/2005GL023653

Hall, J. (2011). The Most Important Organism? http://www.ecology.com/2011/09/12/important-organism/

Introducing the Bacillariophyta. (1995). http://www.ucmp.berkeley.edu/chromista/bacillariophyta.html Accessed on 08 February, 2018.

Malviya, S., Scalco, E., Audic, S., Vincent, F., Veluchamy, A., Poulain, J., Wincker, P., Iudicone, D., De Vargas, C., Bittner, L., Zingone, A., & Bowlera, C. (2016). Proceedings of the National Academy of Sciences: Insights into global diatom distribution and diversity in the world's ocean. doi: 10.1073/pnas.1509523113

Mercado, J. M., Salles, S., & Cortés, D. (2011). Marine Diatom Communities: Taxonomical Variability,Physiological Plasticity and Role in the Carbon Cycling at Costal Upwelling Areas. In J. C. Compton (Ed.), *Diatoms: Ecology and Life Cycle* (p. 26). Malaga: Nova Science Publishers, Inc.

Olney, M. (2002). UCL Microfossil image recovery and circulation for learning and education. http://www.ucl.ac.uk/GeolSci/micropal/diatom.html Accessed on 08_February, 2018

Spaulding, S.A., Lubinski, D.J. and Potapova, M. (2010). Diatoms of the United States. http://westerndiatoms.colorado.edu Accessed on 08 February, 2018.

Yool, A., & Tyrrell, T. (2003). Role of diatoms in regulating the ocean's silicon cycle. Global Biogeochemical Cycles, 17(4). https://doi.org/10.1029/2002GB002018

Dinoflagellates

Who am I?

- Eukaryotic microplankton (20 – 200 µmol) made up of over 2,000 species and 125 genera
- Only half of dinoflagellates are photosynthetic.

How do I look?

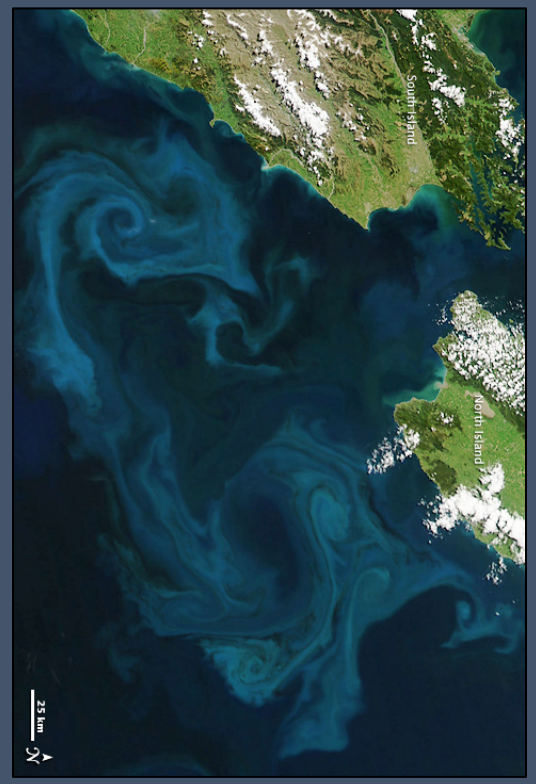
- Armor plates made up of cellulose
- 2 flagella for movement
- Some have chloroplast and/or bioluminescence

Where am I found?

- They can be found in both freshwater and marine environments.
- More significant component of the phytoplankton in warmer waters.
- Dominate nutrient-rich, surface, stratified, waters in temperate zones during the spring.

What do I eat?

- Autotrophs make their own food through photosynthesis making them the bottom of the food chain.
- Heterotrophs eat diatoms, fish eggs, algae, zooplankton even other dinoflagellates.



Role in global primary productivity

Half of the primary productivity on planet Earth occurs in the oceans and is conducted by phytoplankton.

Difficult to quantify primary productivity of dinoflagellates because:

1. Many types of phytoplankton.
2. Symbionts of dinoflagellates are also photosynthesizers.
3. Blooms cause for random spatial and temporal distribution of dinoflagellates.

Why am I important?

- Ocean disaster
  - Harmful Algal Blooms (HABs)
  - Coral bleaching
- Ecological value
  - Primary producers
  - Diverse ecological roles
- Economic value
  - Medical value
  - Impacts on aquaculture

Prochlorococcus and *Synechococcus*

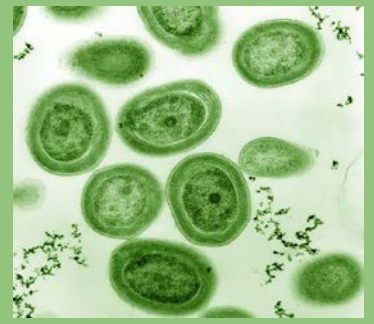
A review of two of the world's most abundant Cyanobacteria

By: Emma Chamberlain, John Sullivan, & Hayley Goss

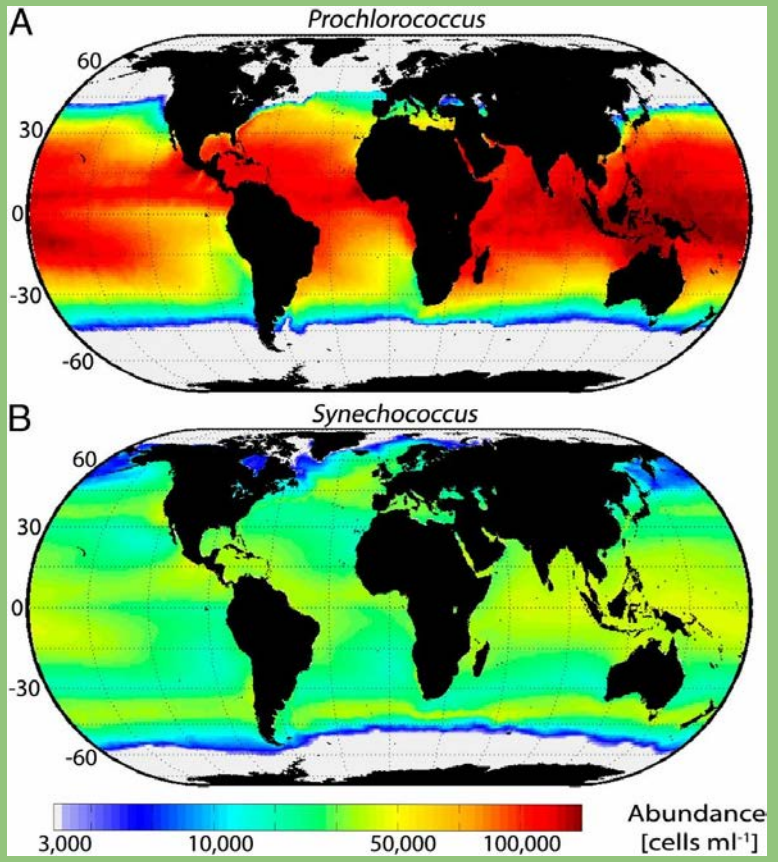
Prochlorococcus from the Joint Genome Institute

Synechococcus from Oceans at MIT

General Characteristics & Location

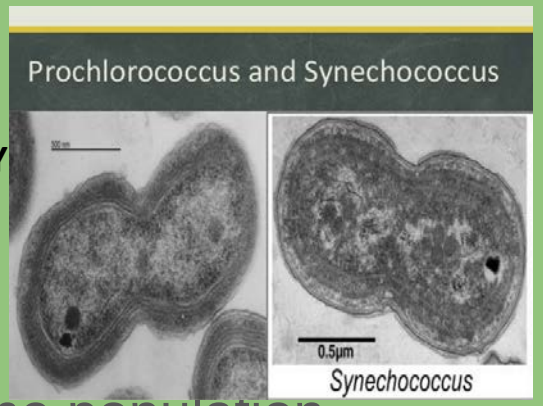


- *Syncechococcuss* size varies from 0.8 to 1.5µm
- Found to thrive in well lit oceanic surface waters, with concentrations ranging from 1,000 to 200,000 cells per ml. Most commonly found in the euphotic zone (except in Antarctica). Nutrient rich waters lead to higher numbers per ml.
- Unicellular, circular shape
- Being a simplistic organism; composed of a cell wall, cytoplasm and nucleic material.
- *Prochlorococcus* size ~0.6µm
- Most abundant photosynthetic organism, with a yearly count at about 2.8-3.0x10^27. These cyanobacteria thrive in oligotrophic regions of the ocean
- Possess a higher ratio of chlorophyll-b to chlorophyll-a.
- Part of the base of the marine food chain.
- Survives from 100 to 150 meters, with colder waters being the limiting factor.



Primary Production and contribution to the Food Web

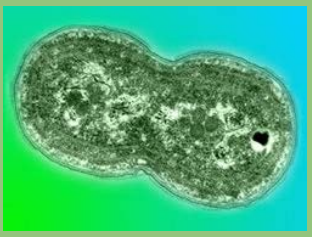
- Annual mean global abundances of Prochlorococcus and Synechococcus are 2.9 ± 0.1 × 10^{27} and 7.0 ± 0.3 × 10^{26} cells **(Flombaum)**
- Synechococcus thrives in a wider range of environments and can range from 5 x 10^{2} to 1.5 X 10^{6} cell whereas Prochlorococcus can occur at abundances of 10^{5} cells per ml throughout much of its distribution area. (**F. PARTENSKY)**
- In nutrient rich areas Prochlorococcus may be 100 times denser and account for 22 times more carbon than Synechococcus (**F. PARTENSKY**



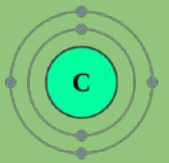
Rates of Grazing and Mortality

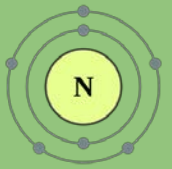
- Despite a rapid doubling time these species stay relatively stable, due to the population being controlled by both grazers and cell mortality due to viruses (**Flombaum) (Guillou)**
- Prochlorococcus and Synechococcus are the main food source for many grazers smaller than 5 micrometers, mainly protozoan (**Guillou) (Belnap)**
- It is currently hypothesizes that the preferential feeding rates of grazers on these organisms may be partially responsible for their distribution patterns (**F. PARTENSKY) (Guillou)**

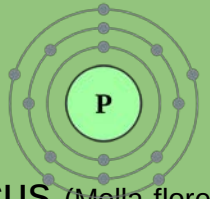
Why are these species important?

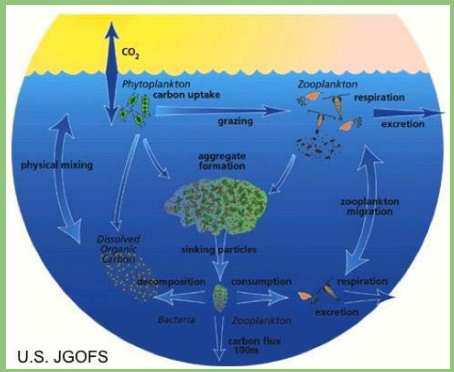


- **Most abundant phototrophs on Earth (Mella-flores 2012)**
  - Account for up to half of all primary production at any given location (Bagby 2015)
    - Provides oxygen and base for food web.
      - Cyanobacteria appeared 3.5 BYA -partially responsible for of oxygen in early atmosphere
      - Prochlorococcus currently provides 13-48% of oxygen in the atmosphere (Prochlorococcus)
- **Biogeochemical Significance**
  - Determine elemental composition of seawater and oceanic particulates (Bertillson 2003)
    - Create variations from Redfield ratio in low latitude marine biomes (Bertilson 2003)
    - Affect availability of N, P, and other limiting nutrients (Bertilson 2003)
    - P limited so they create higher than Redfield C:P and N:P ratios (Bertilson 2003)
  - Contribute to global carbon cycle
    - Responsible for **up to 50% of fixed C** in marine systems (Fu 2007)









Prochlorococcus produces Transparent Exopolymer Particles (TEP) (Iuculano 2017)

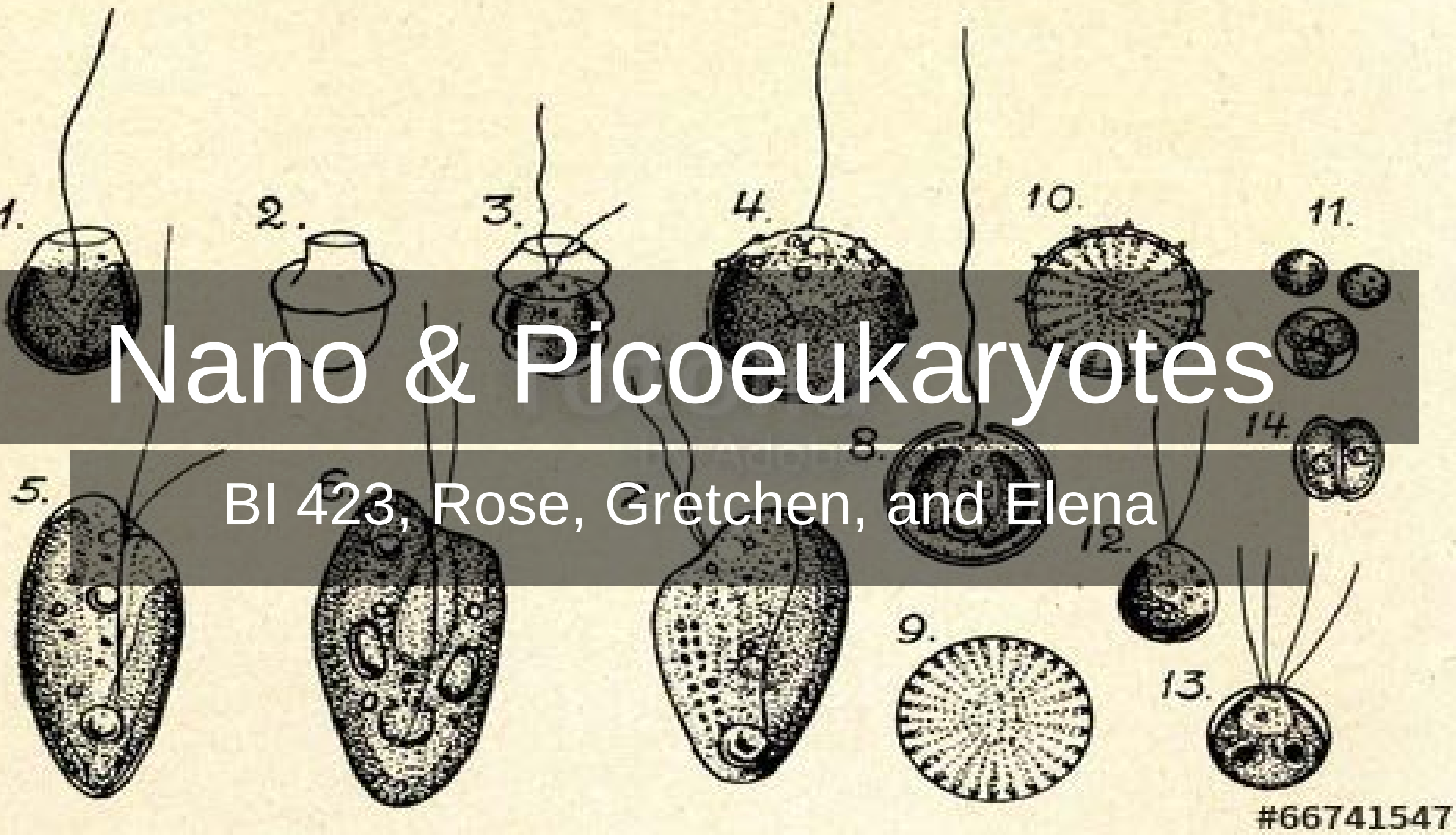
- Made up of acidic polysaccharides (Iuculano 2017)
- **Export carbon to deep waters** (Iuculano 2017)
- Stress from solar radiation promotes production of TEP (Iuculano 2017)
  - Prochlorococcus more prone to succumb to UV stress than Synechococcus (Mella-flores 2012)

Citations

1. Bagby, S. C. & Chisholm, S. W. Response of Prochlorococcus to varying CO2:O2 ratios. *ISME J.* **9,** 2232–2245 (2015).
2. Belnap, J. Microbes and Microfauna Associated with Biological Soil Crusts | SpringerLink.
3. Bertilsson, S., Berglund, O., Karl, D. M. & Chisholm, S. W. Elemental composition of marine Prochlorococcus and Synechococcus: Implications for the ecological stoichiometry of the sea. *Limnol. Oceanogr.* **48,** 1721–1731 (2003).
4. Earth's Most Abundant Phototroph: Prochlorococcus. *Earth's Most Abundant Phototroph: Prochlorococcus* (2015). Available at: http://davidson.weizmann.ac.il/en/online/maagarmada/life_sci/earths-most-abundant-phototroph- prochlorococcus.
5. Flombaum, P. *et al.* Present and future global distributions of the marine Cyanobacteria Prochlorococcus and Synechococcus. *Proc. Natl. Acad. Sci.* **110,** 9824–9829 (2013).
6. Fu, F.-X., Warner, M. E., Zhang, Y., Feng, Y. & Hutchins, D. A. Effects of Increased Temperature and Co2 on Photosynthesis, Growth, and Elemental Ratios in Marine Synechococcus and Prochlorococcus (cyanobacteria)1. *J. Phycol.* **43,** 485–496 (2007).
7. Guillou, L., Jacquet, S., Chrétiennot-Dinet, M.-J. & Vaulot, D. Grazing impact of two small heterotrophic flagellates on Prochlorococcus and Synechococcus. *Aquat. Microb. Ecol.* **26,** 201–207 (2001).
8. Iuculano, F., Mazuecos, I. P., Reche, I. & Agustí, S. Prochlorococcus as a Possible Source for Transparent Exopolymer Particles (TEP). *Front. Microbiol.* **8,** (2017).
9. Mella-Flores, D. *et al.* Prochlorococcus and Synechococcus have Evolved Different Adaptive Mechanisms to Cope with Light and UV Stress. *Front. Microbiol.* **3,** (2012).
10. Partensky, F., Blanchot, J. & Vaulot, D. (1) Differential distribution and ecology of Prochlorococcus and Synechococcus in oceanic waters: a review. *ResearchGate*
11. *Prochlorococcus.* Wikipedia (2018).
12. Structure of Cyanobacteria (Blue Green Algae). Available at: http://www.biologydiscussion.com/cytology/structure-of-cyanobacteria-blue-green-algae/36793.
13. *Synechococcus*. *Wikipedia* (2017).

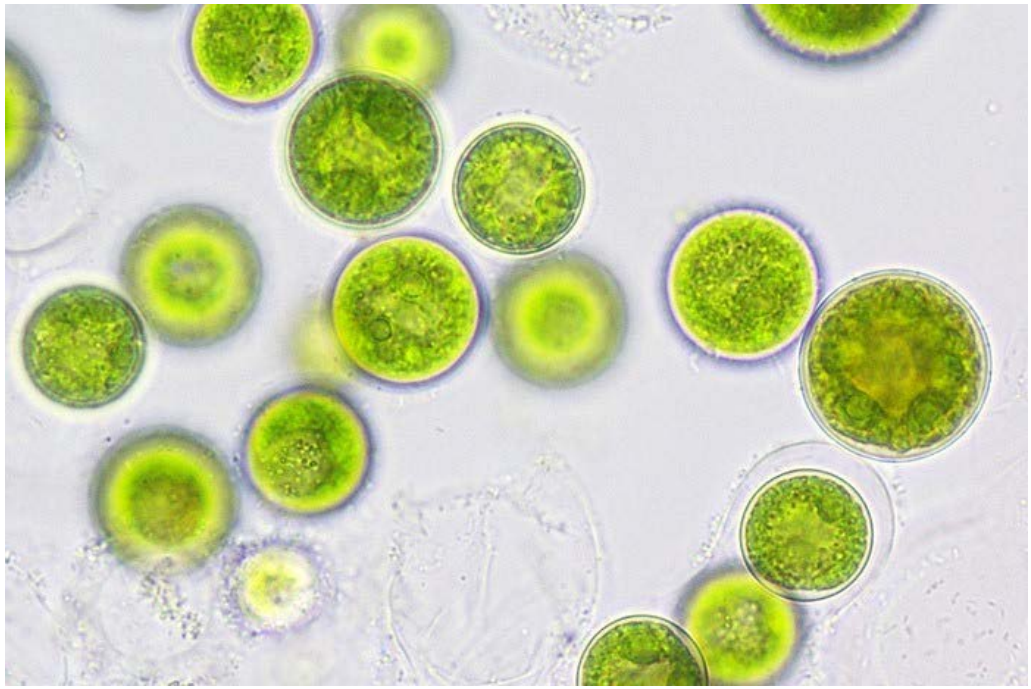
Nano & Picoeukaryotes

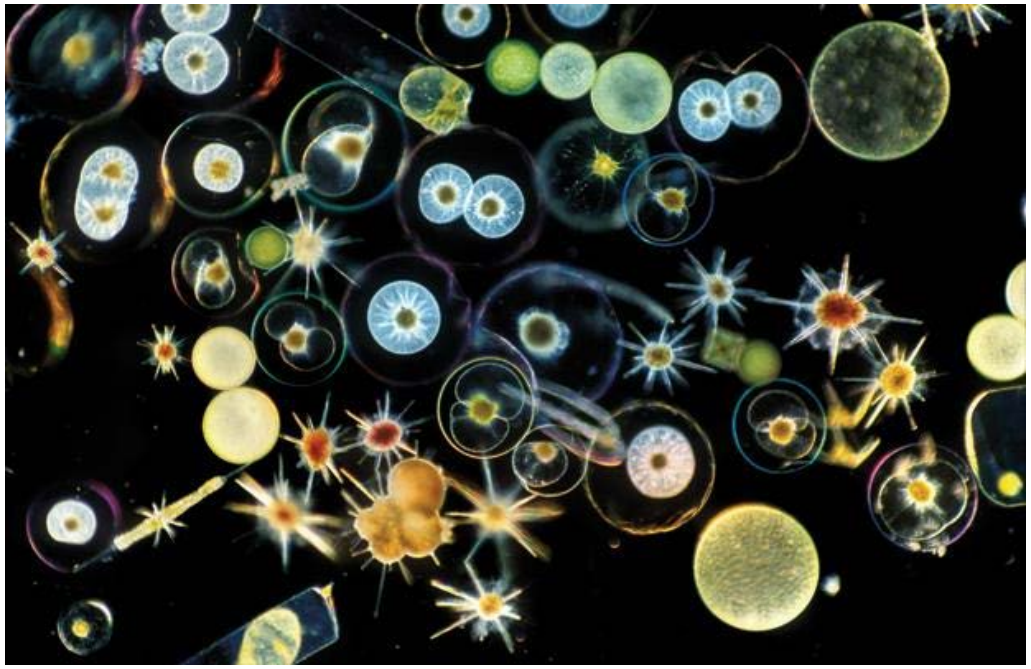
BI 423, Rose, Gretchen, and Elena



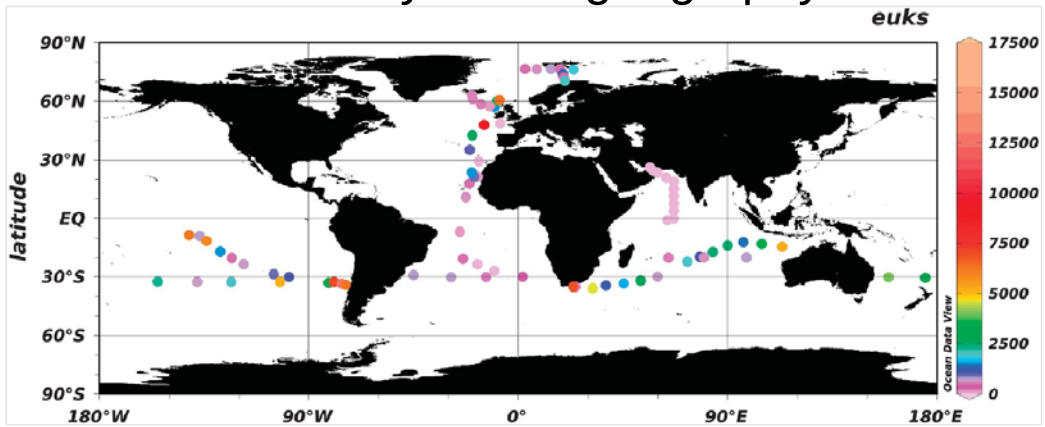
General Characteristics

- **Nano → 2-20µm**
  - Includes members from all the algal groups, as well as many diatoms, and flagellates.
- **Pico → 0.2-2.0 µm**
  - Although very small, they are commonly found in Prasinophyceae (a kind of green algae) and the Haptophyceae.
  - Cyanobacterial photosynthetic picoplankton are also a common group.
  - Picoeukaryotes are a common topic of interest in studying the evolution of larger eukaryotes as well as the evolution of green plants.
- Due to such large diversity and minimal work with these organisms, specifics on cell structure, cell walls, and life/reproductive characteristics regarding nano and pico plankton are understudied.





Picoeukaryote Biogeography



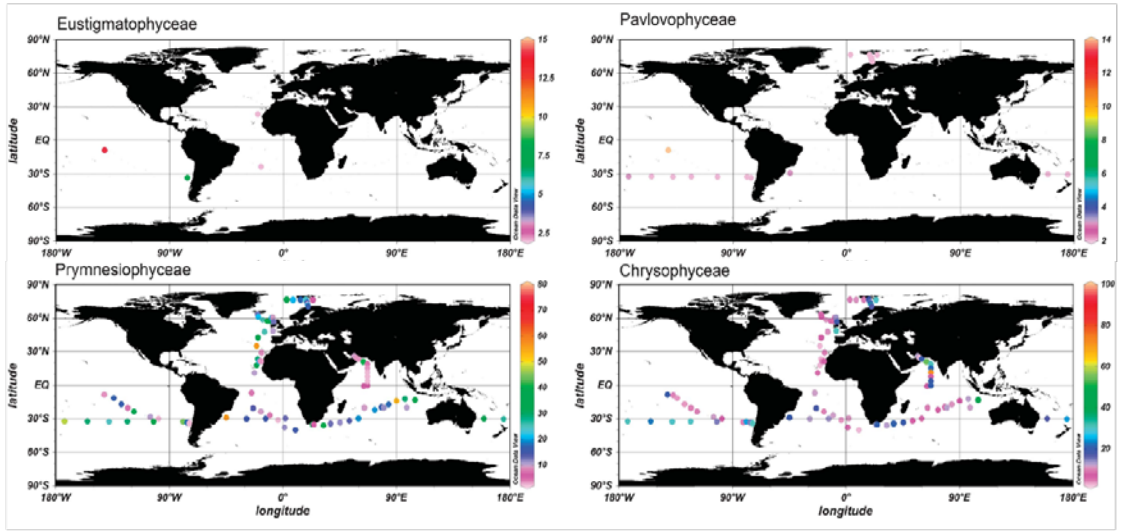
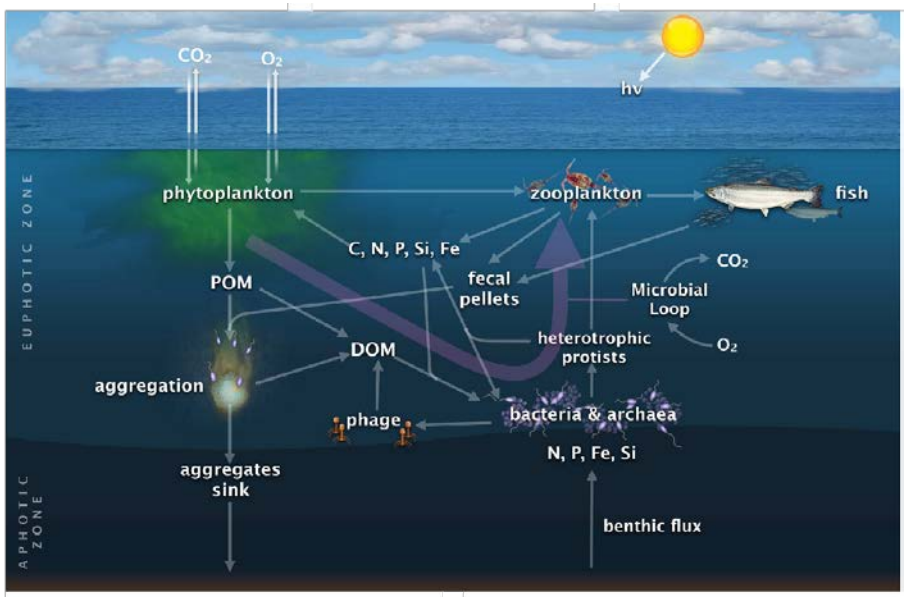


Figure 3 Global distribution patterns of specific PPE classes, at all depths sampled, as determined by dot blot hybridisation analysis.
Kirkham (2013) *The ISME Journal*

- Ubiquitous globally and throughout water column
- Variations in species abundance and richness
- Specific distribution patterns for PE classes

Integration into marine food web

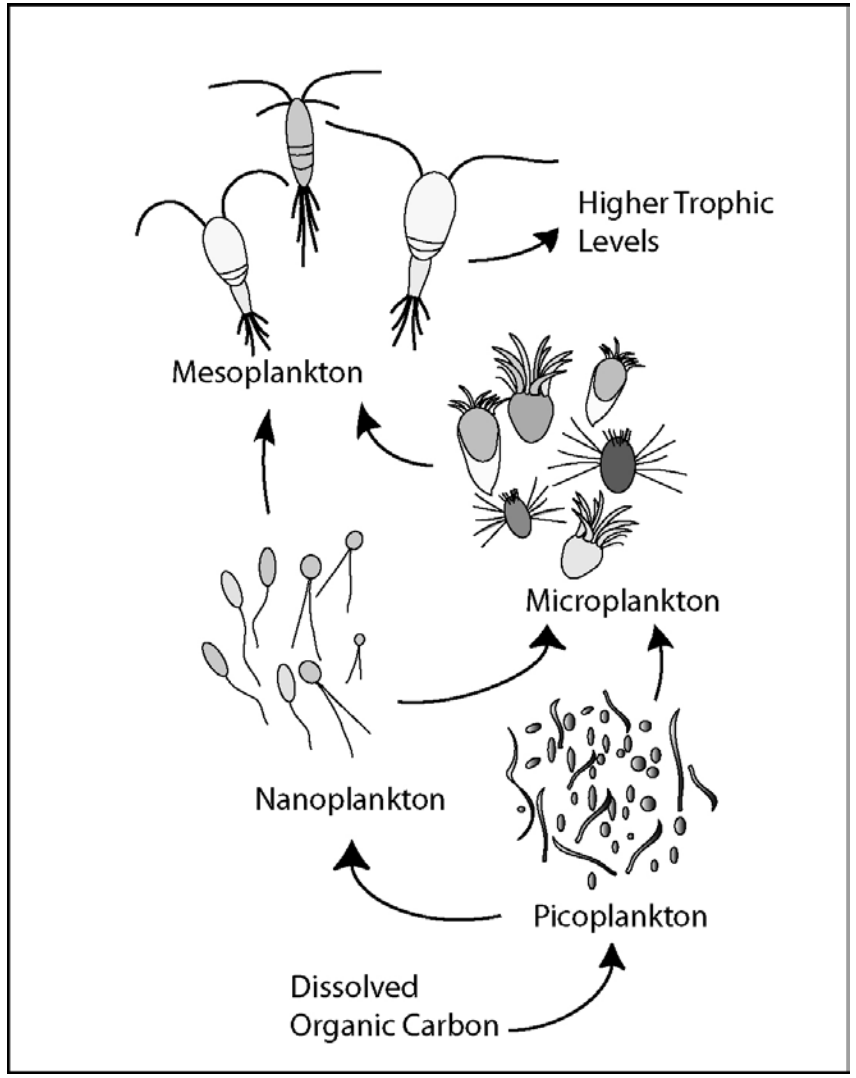


Worden (2015) *Science*

- Autotrophic PE
- Heterotrophic PE
  - Key bacteriovores
  - Prey on specific organism, not size class
  - Degrade organic matter
- PE Consumers, preferential = Zooplankton
  - Protists: Dinoflagellates, Ciliophora
- Population control mechanism depends on specific ecosystem

Primary Productivity and Importance

- Abundance doesn't directly imply large impact
- Phototropic Picoeukaryotes
  - Along with picoprokaryotes form picophytoplankton
  - 80-90% of phytoplankton biomass in open sea, ~ 10% in most productive systems
  - Dominate picophytoplankton: 60-80% biomass and primary production
- Heterotrophic Picoeukaryotes
  - Bacteriovores
  - Keep bacteria levels stable
  - transfer dissolved organic matter to higher trophic levels
  - Recycle nutrients



Sources:

- https://en.wikipedia.org/wiki/Nanophytoplankton
- https://en.wikipedia.org/wiki/Picoeukaryote
- Balzano, S., Marie, D., Gourvil, P., & Vaulot, D. Composition of the summer photosynthetic pico and nanoplankton communities in the Beaufort Sea assessed by T-RFLP and sequences of the 18S rRNA gene from flow cytometry sorted samples. *The ISME Journal* 6(8), 1480. (2012)
- Leliaert, F., Smith, D. R., Moreau, H., Herron, M. D., Verbruggen, H., Delwiche, C. F., &
- DeClerck, O. (2012). Phylogeny and molecular evolution of the green algae. Critical Reviews in Plant Sciences, 31(1), 1-46.
- Fouilland, E., Descolas-Gros, C., Courties, C., et al. Productivity and growth of a natural population of the smallest free-living eukaryote under nitrogen deficiency and sufficiency. *Microbial Ecology* 48:1, 103-110 (2004)
- Kirkham, A. R. et al. A global perspective on marine photosynthetic picoeukaryote community structure. *ISME J.* 7, 922–936 (2013)
- Massana, Ramon. Eukaryotic Picoplankton in Surface Oceans. *Annual Review of Microbiology* 65, 91–110 (2011)
- Orsi, W. D. et al. Identifying protist consumers of photosynthetic picoeukaryotes in the surface ocean using stable isotope probing. *Environ. Microbiol.* 0, (2018)
- Worden, A. Z., Lee, J. H., Mock, T., et al. Green evolution and dynamic adaptations revealed by genomes of the marine picoeukaryotes Micromonas. *Science* 324:5924, 268-272 (2009)
- Worden, A. Z. et al. Rethinking the marine carbon cycle: Factoring in the multifarious lifestyles of microbes. *Science* 347, (2015)
- Vallino, J. J. & Algar, C. K. The Thermodynamics of Marine Biogeochemical Cycles: Lotka Revisited. *Ann. Rev. Mar. Sci.* 8, 333–356 (2016)
- Wu, W., Huang, B., Liao, Y. & Sun, P. Picoeukaryotic diversity and distribution in the subtropical-tropical South China Sea. *FEMS Microbiol. Ecol.* 89, 563–579 (2018)

Trichodesmium

Alia Al-Haj and Kendal McPherson

Trichodesmium spp. (a.k.a sea sawdust)

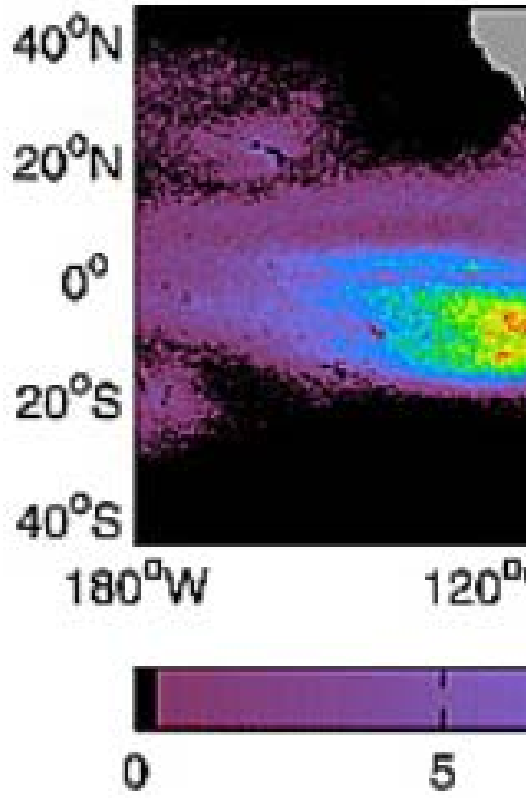
- Bloom forming cyanobacteria
- 5-8 species
- Filaments called trichomes

Capone, 1997

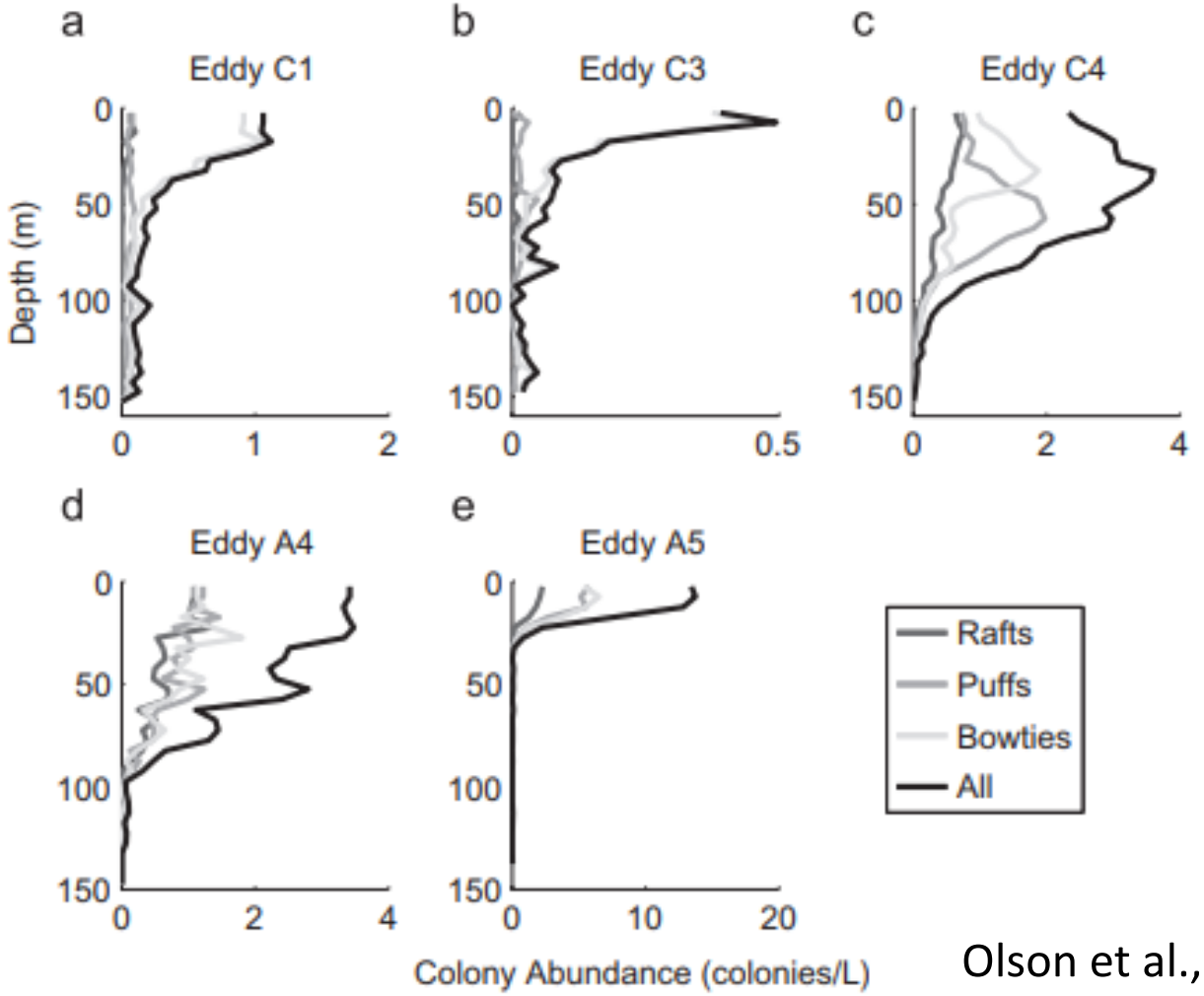
Kim, 2015

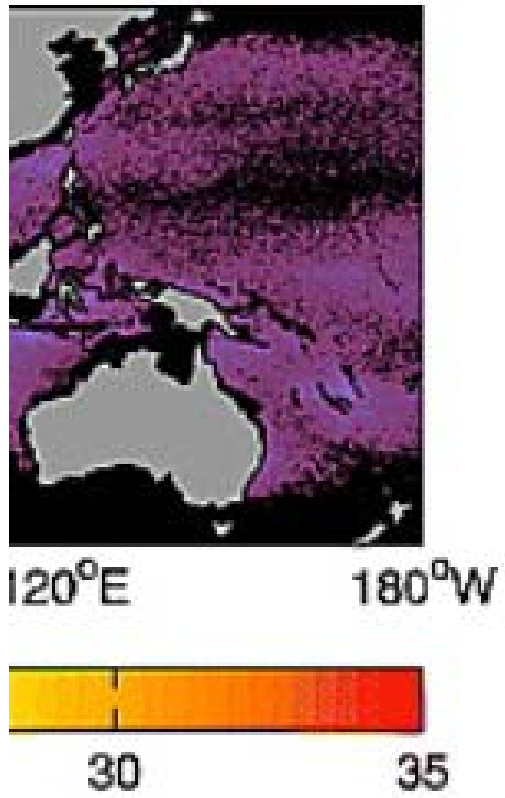
Range

- 20 °N and 20 °S in the eastern Pacific
- 40 °N and 40 °S in the Atlantic, western Pacific, and Indian Oceans
- Temp: 20 - 34 °C
- Depth: 0 - 100 m



Westberry and Siegel, 200

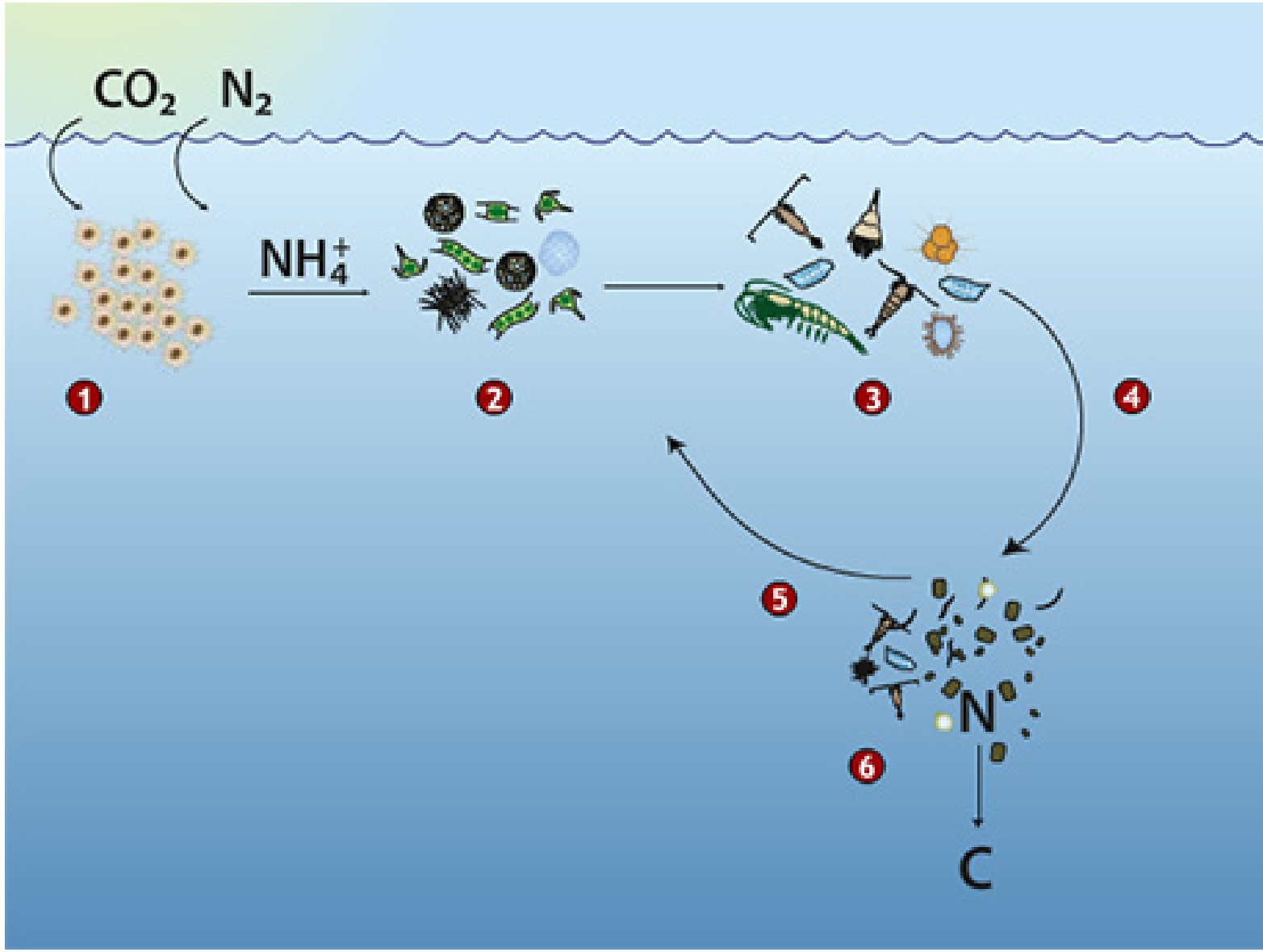




Olson et al., 2015

Ecological Importance

- Grazed by tunicates, copepods, and fish
- Blooms home to many organisms
- N-fixers (30-50% of global marine N-fix)
- 7.9-47% of primary production in the North Pacific and North Atlantic



http://www.whoi.edu/page.do?pid=110417&cid=45906&cl=32132&article=53146&tid=5782

Sargassum

Katherine Galeas, Shuhui Lui, and Yuhua Situ

My general characteristics

-highly branched thallus

-hollow berrylike floats (pneumatocysts)

-fronds (small and leaf-like)

Productivity

0·20 g Cfm 2/day or 72 g C/m2/yr

181-1, 234 C gdry /g h mass

Where am I found?

Abundant in the ocean

Shallow coastal tropical and temperate marine waters

In the north atlantic ocean

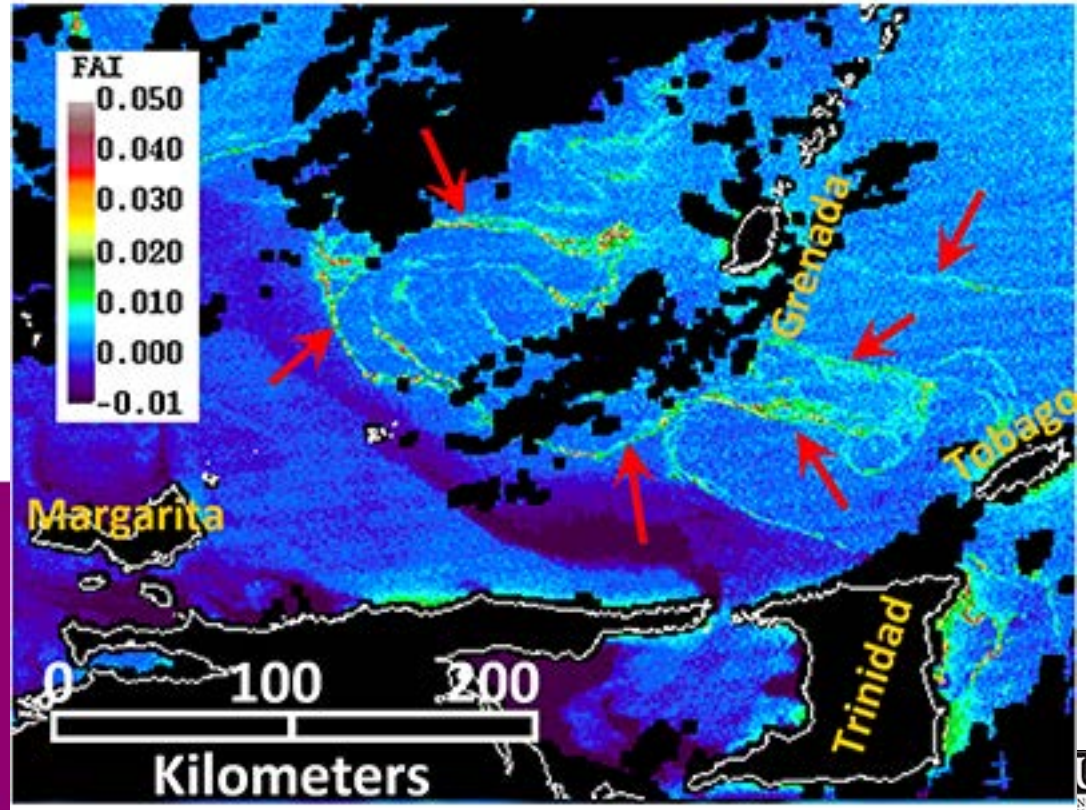
Temperate and Boreal waters

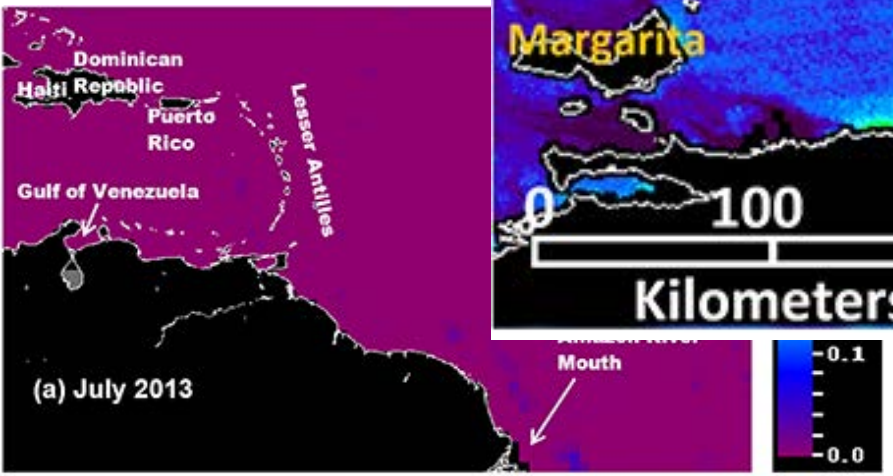
Histrio histrio
Sargassum fish

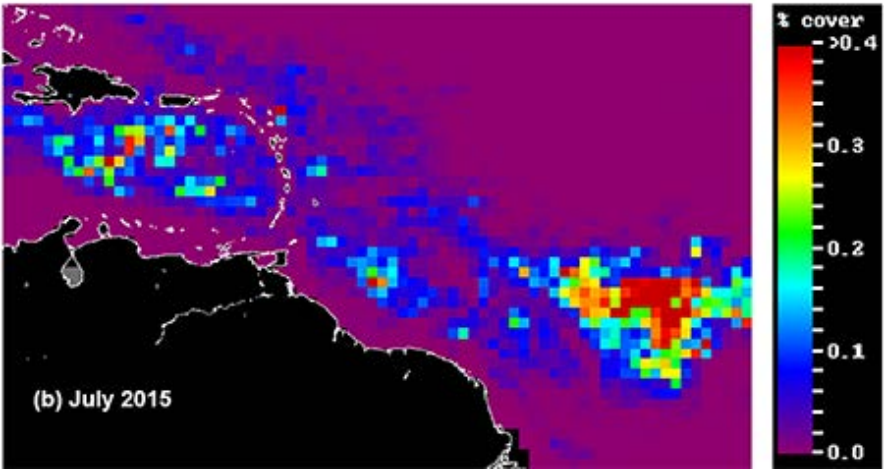
What eats me?
-herbivorous fishes
-echinoids
-human

Why am I important?
Carbon Sink
Provide homes for juvenile fish, camouflaging invertebrates, nurseries for many fish like mahi-mahi
Potential in the medical and pharmaceutical fields.Serves as biofuel and land fill.

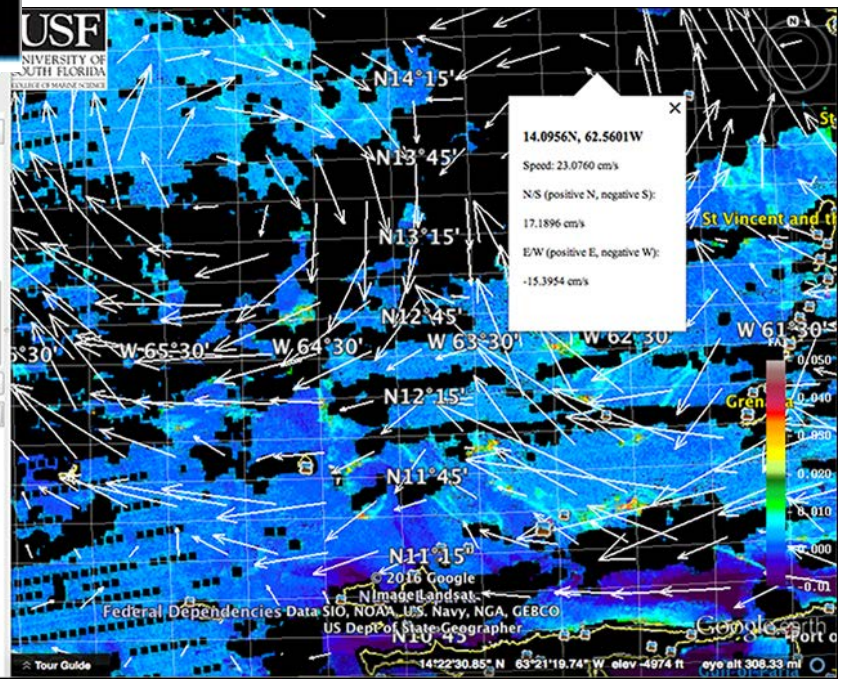
SaWS


FAI
0.050
0.040
0.030
0.020
0.010
0.000
-0.01
Grenada
Tobago
Margarita
Trinidad
0
100
200
Kilometers


Dominican
Haiti Republic
Puerto
Rico
Lesser Antilles
Gulf of Venezuela
Mouth
(a) July 2013
0.1
0.0


(b) July 2015
% cover
>0.4
0.3
0.2
0.1
0.0


Places
The Titanic
Located in the North Atlantic Ocean
The Forbidden City
Located in China
Mount Fuji
Located near Tokyo, Japan
Google Headquarters
Located in Mountain View, California
Temporary Places
5/26/2015 - PASS A
This is a AFAI MODISA map, you
Layers
Earth Gallery
Primary Database
Voyager
Borders and Labels
Places
Photos
Roads
3D Buildings
Ocean
Weather
Gallery
Global Awareness
More
Terrain
Tour Guide


USF
UNIVERSITY OF SOUTH FLORIDA
14.0956N, 62.5601W
Speed: 23.0760 cm/s
N/S (positive N, negative S):
17.1896 cm/s
E/W (positive E, negative W):
-15.3954 cm/s
N14°15'
N13°45'
N13°15'
N12°45'
N12°15'
N11°45'
N11°15'
W 65°30'
W 64°30'
W 63°30'
W 62°30'
W 61°30'
St Vincent and t
0.050
0.040
0.030
0.020
0.010
0.000
-0.01
© 2016 Google
Image Landsat
Federal Dependencies Data SIO, NOAA, US. Navy, NGA, GEBCO
US Dept Of State Geographer
Google Earth
14°22'30.85" N 63°21'19.74" W elev -4974 ft eye alt 308.33 mi

Works Cited

Boyd, P.W., S. Sundby, and H.-O. Pörtner, 2014: Cross-chapter box on net primary production in the ocean. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 133-136.

Bryant, Dennis. “Pelagic Sargassum Habitat Restricted Area.” *Maritime Logistics Professional*, Maritime Logistics Professional, 18 Sept. 2015, www.maritimeprofessional.com/blogs/post/pelagic-sargassum-habitat-restricted-area-14915.

Deane. “Sargassum Sea Vegetable.” *Eat The Weeds and Other Things, Too*, 9 Sept. 2017, www.eattheweeds.com/sargassum-not-just-for-breakfast-any-more-2/.

Dubbs et al. *An Examination of Pelagic Sargassum Community Primary Productivity and Nutrient Cycling in the Face of Gulf Stream Based Energy - IEEE Conference Publication*, ieeexplore.ieee.org/xpls/icp.jsp?arnumber=7404418&tag=1.

Gaskill, Melissa. “Significant Sargassum.” *Alert Diver | Significant Sargassum*, www.alertdiver.com/?articleNo=1108.

Menzel, D.w., and J.h. Ryther. “The Annual Cycle of Primary Production in the Sargasso Sea off Bermuda.” *Deep Sea Research (1953)*, vol. 6, 1959, pp. 351–367., doi:10.1016/0146-6313(59)90095-4.

“Notes on Sargassum (With Diagram) | Alage.” *Biology Discussion*, 4 Feb. 2016, www.biologydiscussion.com/algae/life-cycle-algae/notes-on-sargassum-with-diagram-alage/21227.

“Sargassum: A Complex 'Island' Community at Sea.” *NOAA Ocean Explorer Podcast RSS*, oceanexplorer.noaa.gov/explorations/03edge/background/sargassum/sargassum.html.

“Sargassum: The What, Where, and Why of This Seaweed.” *Akumal Dive Shop, Riviera Maya*, 22 Aug. 2016, akumaldiveshop.com/sargassum-the-what-where-and-why-of-this-seaweed/.

The Editors of Encyclopædia Britannica. “Sargassum.” *Encyclopædia Britannica*, Encyclopædia Britannica, Inc., 1 Feb. 2017, www.britannica.com/science/Sargassum.

US Department of Commerce, National Oceanic and Atmospheric Administration. “What Is Sargassum?” *NOAA Ocean Explorer Podcast RSS*, 16 July 2014, oceanexplorer.noaa.gov/facts/sargassum.html.

WoRMS - World Register of Marine Species - Scyllaea Pelagica Linnaeus, 1758, www.marinespecies.org/aphia.php?p=taxdetails&id=141425.

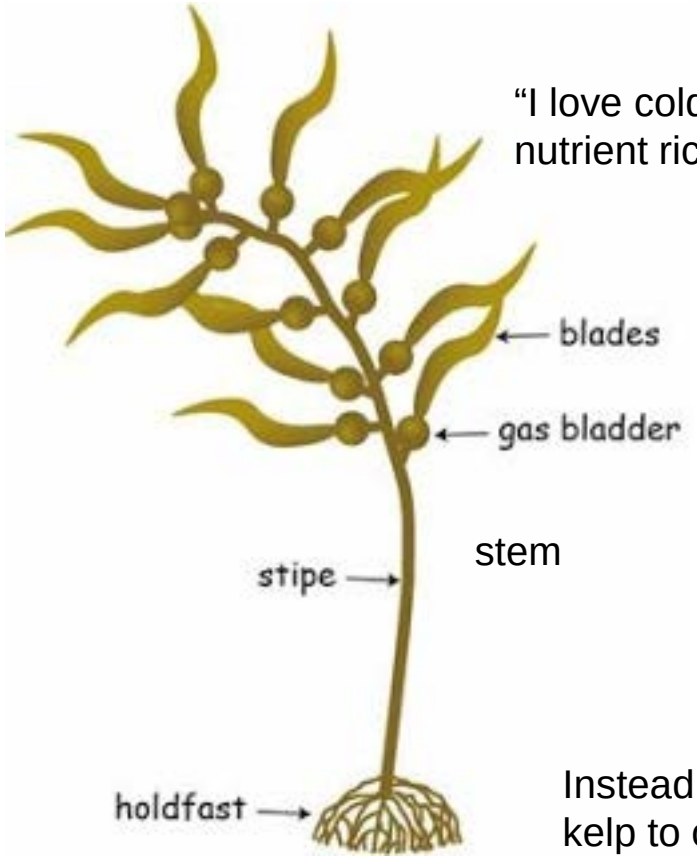
Pictures:
https://eos.org/features/sargassum-watch-warns-of-incoming-seaweed
http://optics.marine.usf.edu/projects/SaWS.html
http://www.alamy.com/stock-photo-loggerhead-turtle-hatchlings-taking-refuge-among-sargassum-weed-caretta-25159936.html

Underwater Solar City

(a.k.a. kelp)

- Found in a wide range of places but mostly in the pacific along rocky shore lines
  - Love cold and nutrient rich environments
- 2 - 30 meters (but can grow up to 175 feet!)
- 1 - few year lifespan
- Protista kingdom
- Laminariales order
- 30+ genera
- Brown algae
- Fastest growing boi
- Clear water only

so many people live in me



“I love cold nutrient rich”

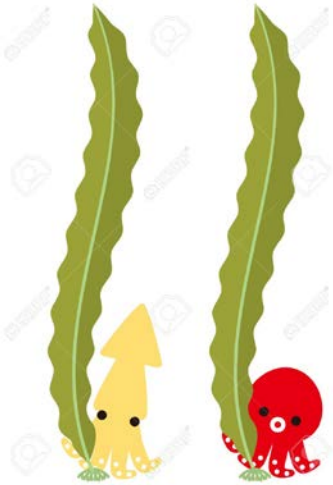
:protection

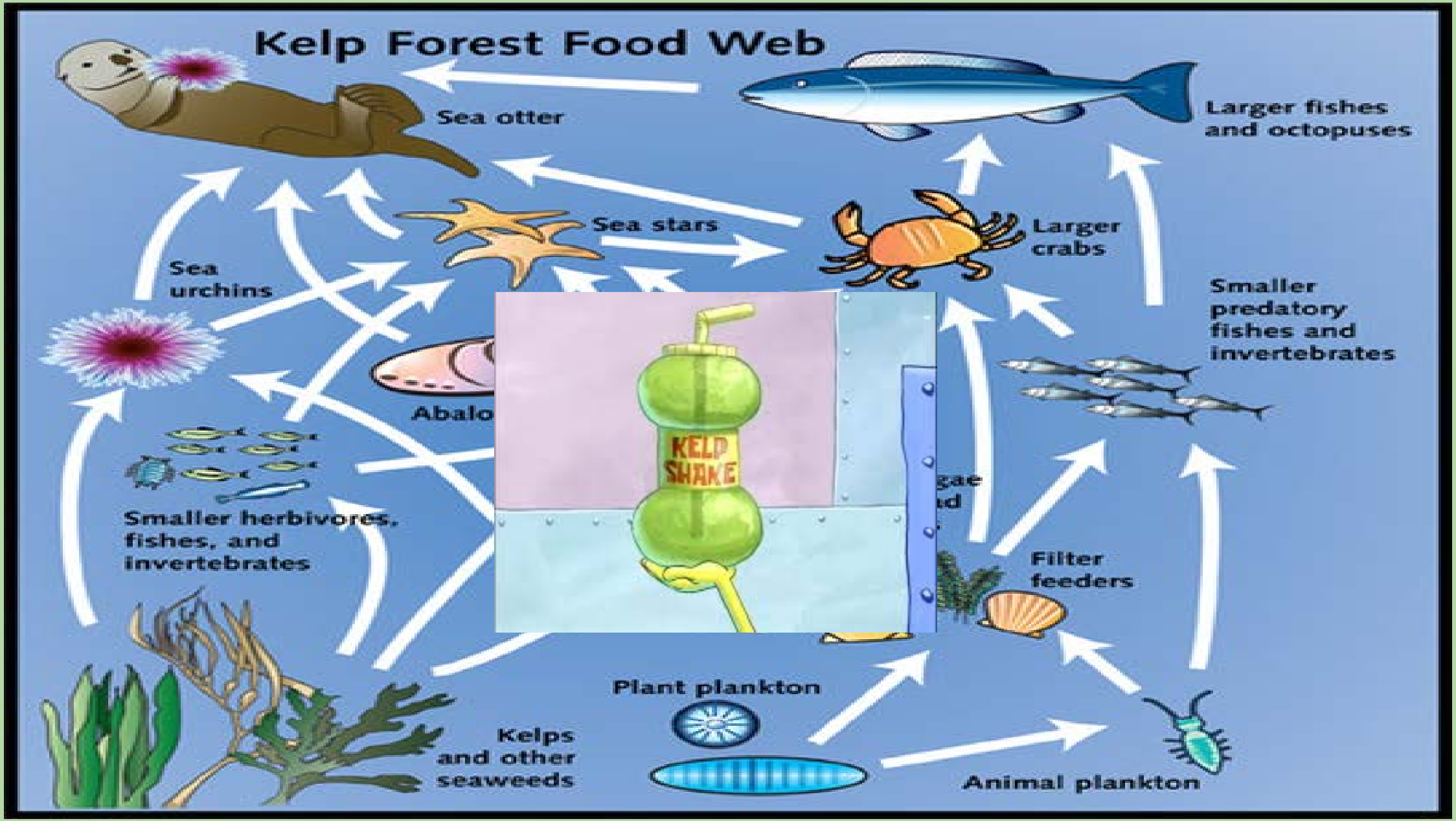
stem

“I would have scoliosis without my pneumatocyst”

Instead of roots, anchors kelp to ocean floor

“When I grow up, I’m gonna have so many kelp friends”




Kelp Forest Food Web
Sea otter
Larger fishes and octopuses
Sea stars
Larger crabs
Sea urchins
Smaller predatory fishes and invertebrates
Abalo
KELP SHAKE
Smaller herbivores, fishes, and invertebrates
Filter feeders
Plant plankton
Kelps and other seaweeds
Animal plankton

- Giant and bull kelp dominate the world
- Vitamin C, B5, K rich
- Inhabitants: invertebrates ~ brittleworms, sculp, snails, brittle stars, sea stars, anemonies, crabs, jellyfish
- In times of trouble: whales hide in it, sea turtles live in it, sea lions hunt in it;
    - Protection from storms and waves since kelp makes currents weaker
- Biodiverse af - almost more than any other ocean thing

Pics (in order of appearance):

http://www.surfscience.org/articles/kelp

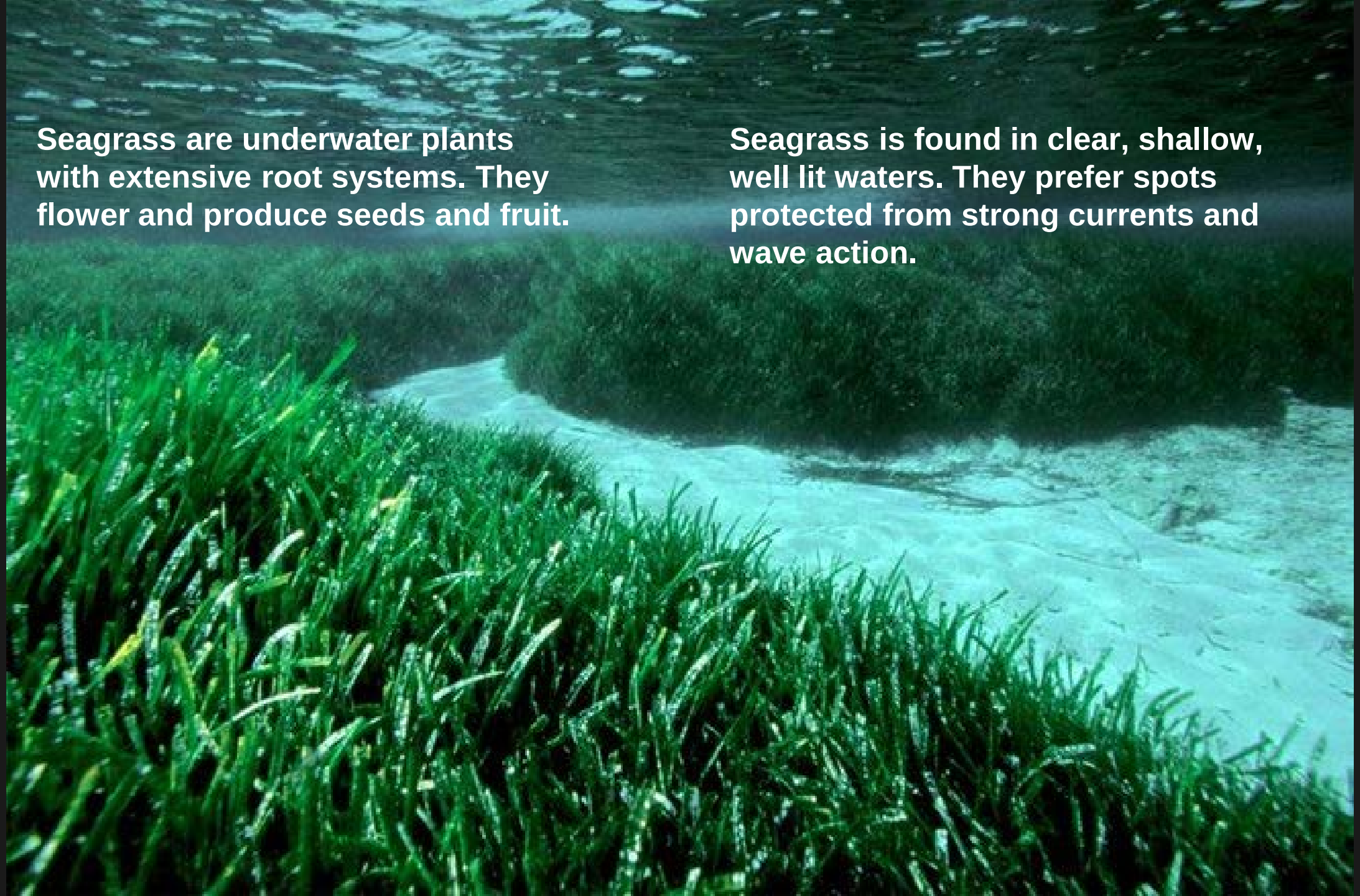
https://kelpforestwebsite.weebly.com/food-chain.html

http://spongebob.wikia.com/wiki/Kelp_Shake

http://www.conniemclennan.com/p/my-former-life.html

Seagrass

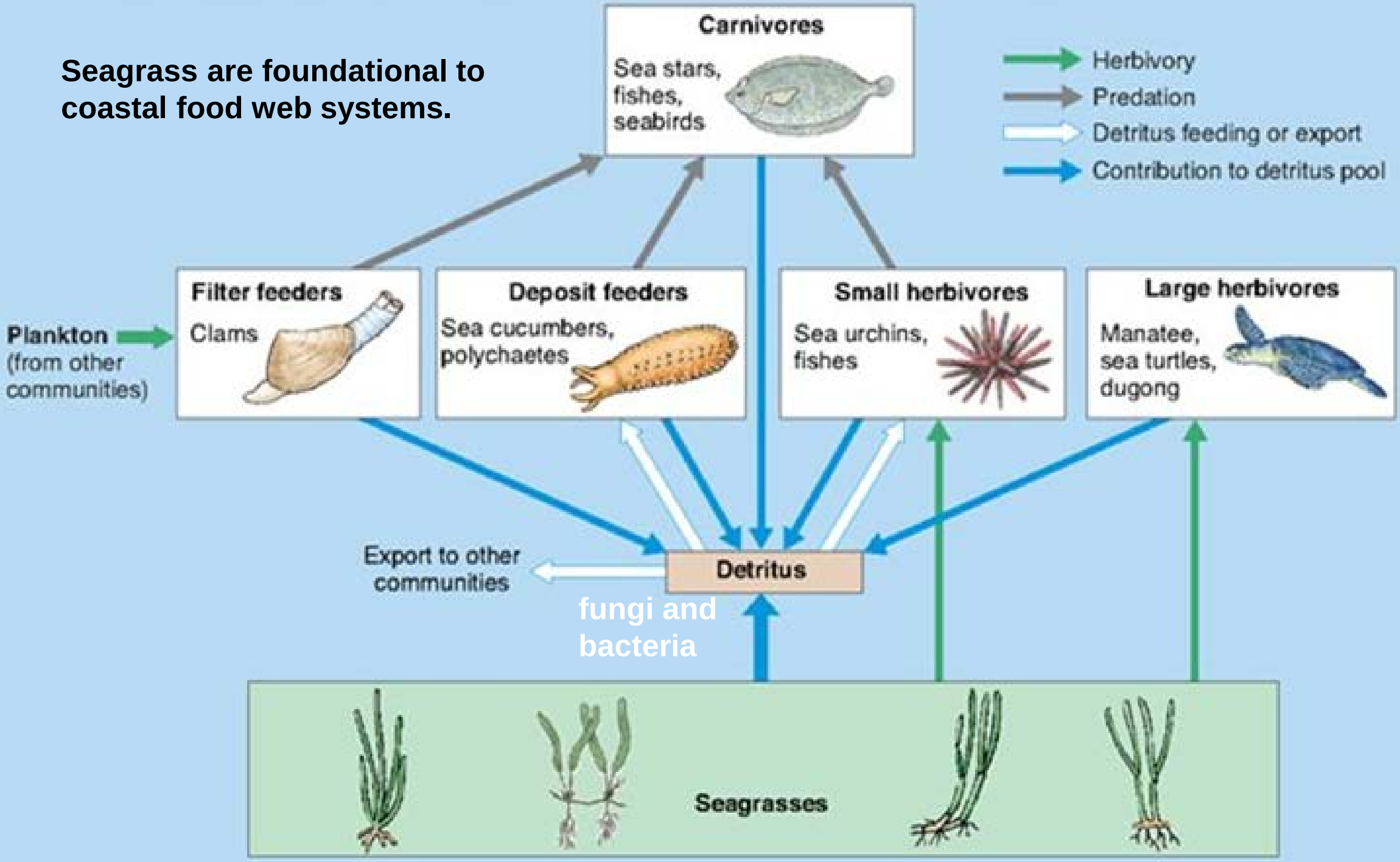
Beatrice Cheung, Saloni Shah, and Mackenzie Knox

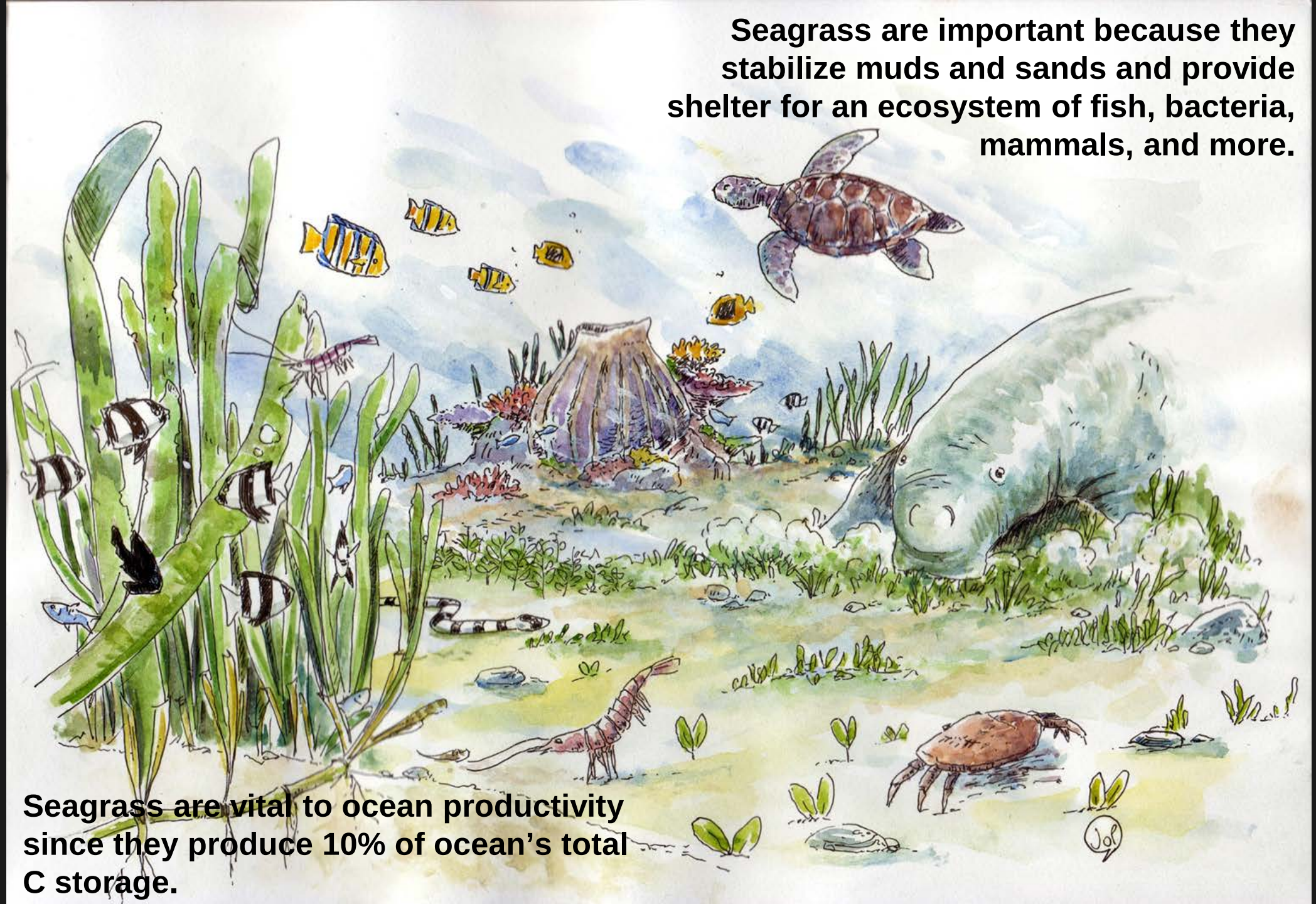


Seagrass are underwater plants with extensive root systems. They flower and produce seeds and fruit.

Seagrass is found in clear, shallow, well lit waters. They prefer spots protected from strong currents and wave action.

Seagrass are foundational to coastal food web systems.





Seagrass are important because they stabilize muds and sands and provide shelter for an ecosystem of fish, bacteria, mammals, and more.

Seagrass are vital to ocean productivity since they produce 10% of ocean's total C storage.

References:

Di maria,., De corso,L. *Seagrass animals and characteristics.* Retrieved from https://seagrassmeadow.weebly.com/sea-grass-animals-and-characteristics.html

Fourqurean J., Duarte M., Kennedy H., Marba N., *et al.* (2012, May 20). *Seagrass ecosystems as globally significant carbon stock.* Retrieved from https://www.nature.com/articles/ngeo1477

Mateo, M. (2012, May 21). *Seagrasses store as much carbon as forests*. Retrieved from https://www.livescience.com/20462-seagrasses-store-carbon-forests.html

Orth R., Carruthers T., Dennison W., Duarte M. *et al.* (2006, December 1). *Global Crisis for Seagrass Ecosystems*. Retrieved from https://academic.oup.com/bioscience/article/56/12/987/221654

Poovatchiranon, S. (2012). *Seagrasses.* Retrieved from http://www.ioseaturtles.org/Education/seagrassbooklet.pdf

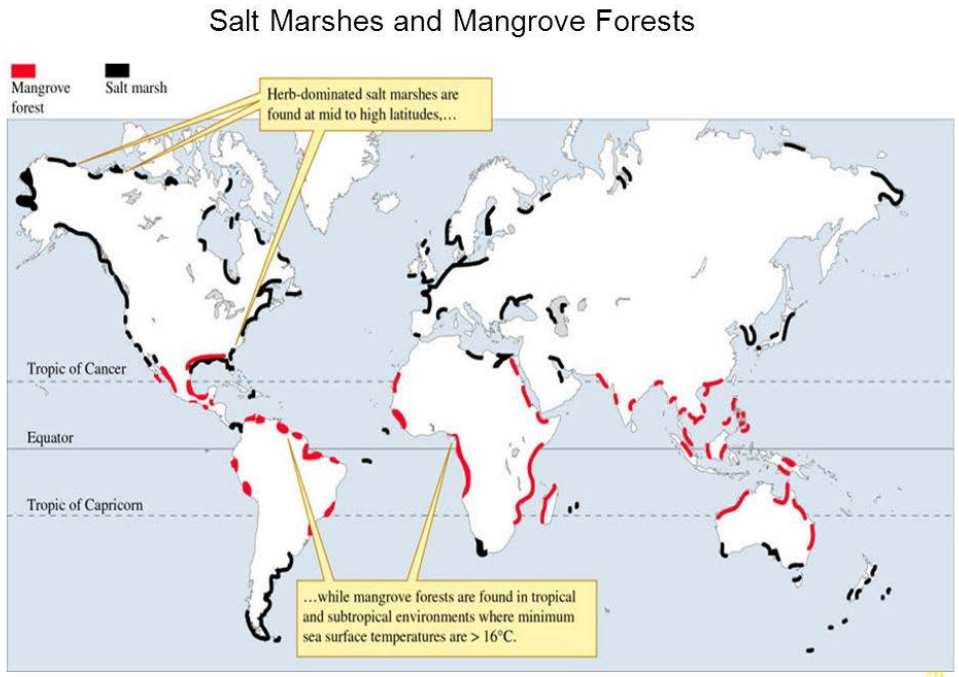
Reynolds P. (2017). *Seagrass and Seagrass Beds.* Retrieved from http://ocean.si.edu/seagrass-and-seagrass-beds

Salt Marshes

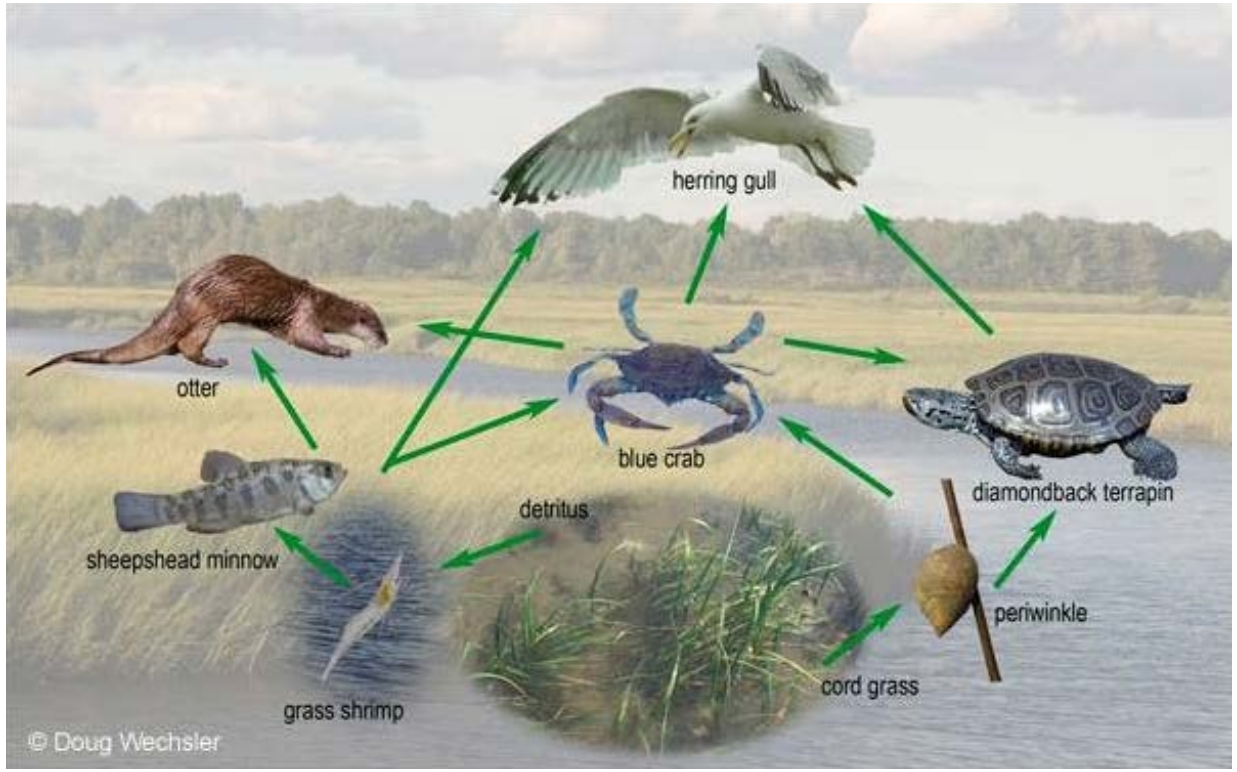
Amy Green, Christopher Reyes, and Grace Chu

General Characteristics

- Coastal wetlands
- Middle to high latitudes
- Diverse communities
- Productive ecosystems



Food Webs



Productivity

- High Productivity
  - Above ground
    - Marsh Grass and phytoplankton
  - Below ground
    - Mud algae
- Nitrogen is a limiting nutrient
- High productivity in low and intertidal marshes

Importance

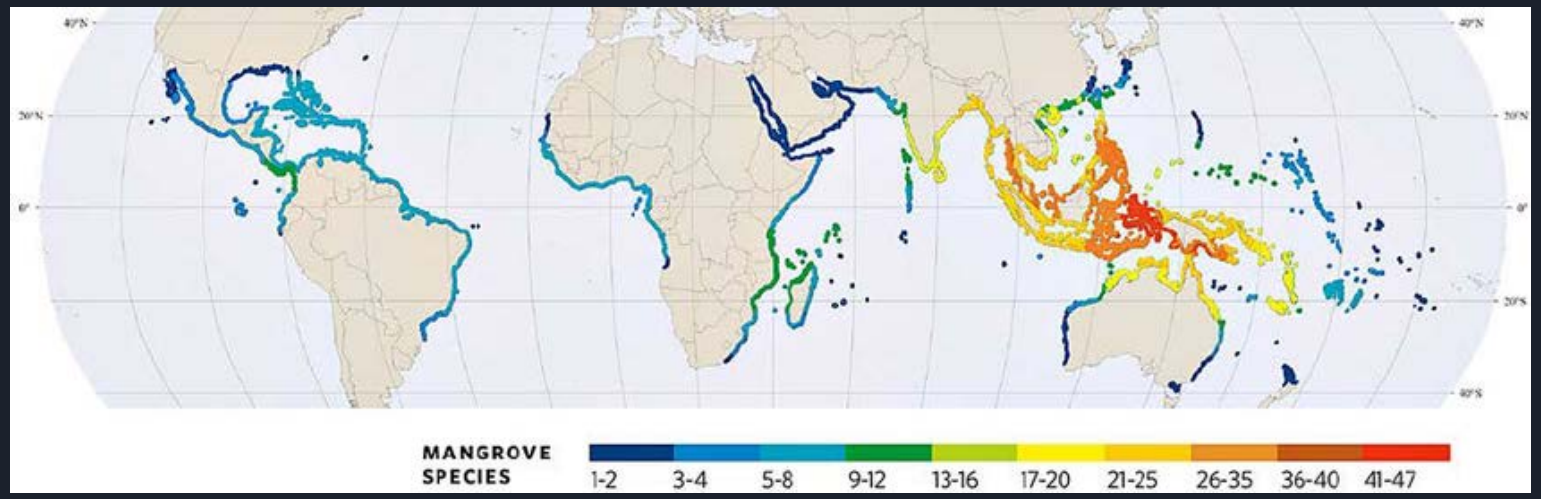
- Nursery for fish, crustacea, and insects
- Wave protection
- Protection against sea level rise
- Mosquito control

Mangroves

Ena Miculinic, Nicolas Colletier, Ellen Laaker

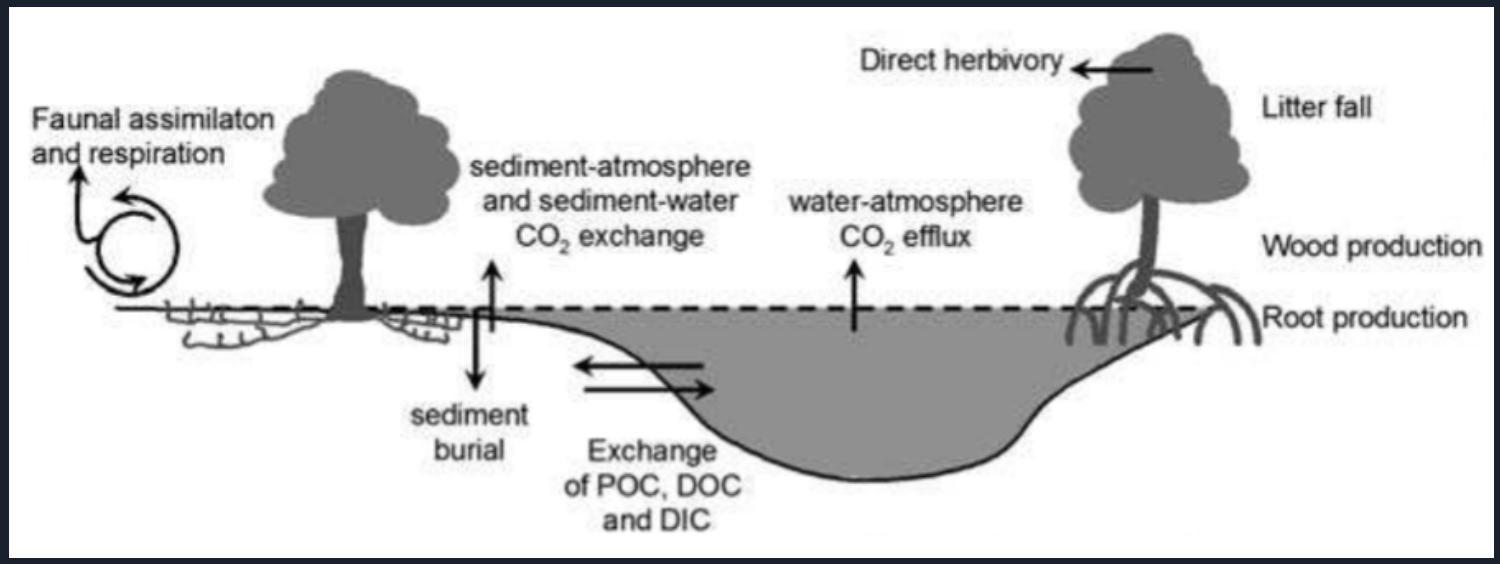
Mangrove Characteristics

- Three main types of mangroves: Red, Black, and White
- Found in tropical and subtropical regions around the world covering about 160,000 sq. km
- Thrive in low-oxygen soils and can tolerate wide ranges of salinity



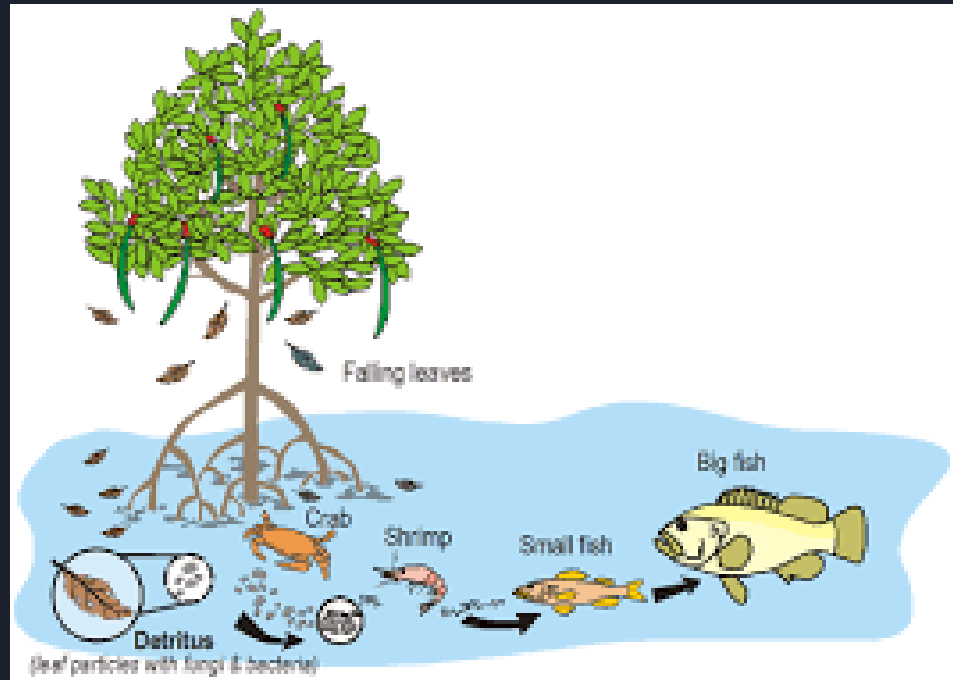
Mangrove Productivity

- Mangrove forests occupy only 2% of the world's coastal ocean area, yet they account for about 5% of net primary production
- Net primary production estimated to be 218 ± 72 Tg C a^{-1}
- Mean NPP rate is 11.1 Mg C ha^{-1} y^{-1}
  - Higher than salt marshes (8.34), seagrasses (1.04), macroalgae (3.8), and coastal phytoplankton (1.7)
  - Similar to that of coral reefs (10).



Mangrove Importance

- Coastal Protection- Mangrove trap sediments to stabilize coastlines and protect coral reefs and seagrass meadows from being smothered by sediment. They also protect coastlines from erosion by waves and storms
- Fisheries- Mangroves act as a nursery habitat for juvenile fish, crab, shrimp, and mollusc species, offering protection from predators
- Timber and plant products- used by indigenous communities
- Carbon Sinks



Citations

1. Bouillon, Steven, et al. "Mangrove Production and Carbon Sinks: A Revision of Global Budget Estimates." *Global Biogeochemical Cycles* 22.2 (2008): n/a-n/a. Print.
2. Alongi, Daniel M., and Sandip K. Mukhopadhyay. "Contribution of Mangroves to Coastal Carbon Cycling in Low Latitude Seas." *Agricultural and Forest Meteorology* 213 (2015): 266-72. Print.
3. N. C. DUKE, J.-O. MEYNECKE, S. DITTMANN, et al. *A World Without Mangroves?* . Science 06 Jul 2007: Vol. 317, Issue 5834, pp. 41-42
4. http://www.mesa.edu.au/aboutMESA.asp
5. http://wwf.panda.org/about_our_earth/blue_planet/coasts/mangroves/mangrove_importance/