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Coccolithophores

Coccolithophores are unicellular eukaryotic phytoplankton with flagellated spherical cells and are typically smaller than 30µm. While they are small in size, they congregate in large numbers throughout the upper ocean to make a large impact. Their name is derived from coccoliths which are tiny protective disk shaped plates of calcium carbonate that cover them. These coccoliths are similar to the shape of hubcaps (Weier 1999). While coccoliths' function continues to be researched, possibilities include defense against grazing by zooplankton, protection against diseases, and increased buoyancy (Shatto & Slowey, 1997).

Coccolithophores are found in the upper layers of still, nutrient-poor, mild temperature waters (Weier 1999). Unlike many other members of the phytoplankton family, coccolithophores do not live in areas of upwelling and often thrive in places where their competitors would starve. This is helpful because they are not a strong competitor (Weier 1999). They are located mostly in the photic zone of subpolar regions (Weier 1999). In the Atlantic Ocean, the primary species are *Emiliana huxleyi, Florisphaera profunda*, and different species of *Umbellosphaera* and *Gephyrocapsa*. There are over 90 different species of coccolithophores in the Pacific Ocean (Geisen et al. 2004). Coccolithophores are typically milky white in color and when they explode in massive blooms, they can brighten and discolor the water to a teal color. This brightening during blooms reflects light penetrating the ocean and increases the oceans albedo (Weier 1999).

Upon death, coccolith skeletons descend through the water column rapidly in marine snow, fecal pellets, and other aggregate particles and settle to sediment, preventing dissolution below calcite compensation depth (Winter & Siesser, 2006). Their calcite plates accumulate, forming calcareous ooze and, eventually, structures such as the White Cliffs of Dover (Honjo, 1976; Ghose 1).

Coccolithophores are a major primary producer, as they convert dissolved CO_2 in the ocean to $CaCO_3$ in the process of creating coccoliths. A bloom of coccolithophores in the Gulf on Maine in 1989 was responsible for 0.5% of all of the primary productivity in the area for that year (Bach, Holligan, & Kilpatrick, 1992).

As an incredibly abundant autotroph, coccolithophores are consumed by a variety of zooplankton, such as *Calanus helgolandicus*, *Pseudocalanus elongatus*, *Centrapoges typicus*, and *Acartia tonsa*, and support many food webs (Harris, 1994; Honjo, 1976). As NASA Earth Observatory states, "Each time a molecule of coccolith is made, one less carbon atom is allowed to roam freely in the world to form greenhouse gases and contribute to global warming" (Weier 1999). In the short term, however, the production of coccoliths also generates a molecule of CO_2, and therefore could contribute to the greenhouse gas problem (Weier 1999). Coccolithophores also release dimethylsulfoniopropionate (DMSP), which is an important step in the sulfur cycle (Yoch, 2002).

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What each member did:

- Olivia Calabrese researched coccolithophores’ primary production, what consumes them, and why they are important. She also created the slide for this information and wrote about it for the paper.
- Mary Liesegang took on researching and answering the questions of what the common species of coccolithophores are and where they live for both the powerpoint and the paper
- Nicole Velandia researched the general characteristics of coccolithophores (size/shape/etc) and the function of their coccoliths in both the powerpoint and the paper.

Marine Primary Producers - Diatoms

<u>Characteristics</u>

Diatoms are a variety of single celled microalgae which range in size from 2 microns to 500 microns. (Spaulding, 2010) They have a silicate frustule, or cell wall, which is comprised of two halves, the epitheca (larger) and the hypotheca (smaller). However, the frustrule does not grow during the diatoms life cycle so their size steadily reduces in size during asexual reproduction which creates a need for sexual reproduction. (Olney, 2002) Sexual reproduction allows for the creation of a zygote called an auxospore which expands to a larger size than its parent cells before forming a frustule. (Mann, Evans 2007)

Diatoms are found as either solitary organisms, or in chain-like colonies which are connected using mucus filaments. (UCMP, 1995) They also display either bilateral or radial symmetry. Radially symmetric diatoms, known as centrate diatoms, are comprised of three suborders; coscinodiscineae, rhizosoleniineae, and biddulphiineae. The first of which has a marginal ring, but no center of polarity. The second and third have no marginal ring but have either one (rhizosoleniineae) or two (biddulphiineae) centers of polarity. Bilaterally symmetrical diatoms fall into two subgroups. The first, bacillariineae, have a groove (raphe) that secretes mucus which allows them to attach to or move across substrate. The second, fragilariineae, do not have a raphe. (Olney, 2002)

<u>Role in the environment</u>:

Diatoms are accountable for 20-25% of global carbon fixation (UCMP, 1995) which emphasizes their influence as a primary producer. (Malviya, 2016) By converting carbon dioxide to oxygen in our atmosphere, diatoms prove to be even more efficient than trees. (Hopkinson, 2011) Diatoms can undergo cell division up to eight times per day. (Olney, 2002) Since diatoms have such a fast turnover, and 71% of Earth's surface is covered in ocean, phytoplankton produce more than half the planet's atmospheric oxygen (Hall, 2011).

Diatoms are at the base of the ecological food web and are eaten primarily by zooplankton as well as other primary consumers. (Hall, 2011) Since they provide energy for the zooplankton, it allows for small fish to eat the zooplankton, and small fish like Sand Lance are food for the Humpback whales, essentially feeding the entire ocean. Without diatoms, the ocean would be lacking a large piece of its autotrophic organisms, collapsing the food web. Furthermore, it is estimated that approximately 12,000-30,000 species of diatom exist globally, though some estimates go as high as 200,000 species. (Guiry, 2012) Diatoms have a huge impact on the biogeochemistry both as a primary producer, but also as a major player in the silica cycle (Yool, 2003).

<u>Why are they important</u>:

Diatoms are a ubiquitous organism in both fresh and saltwater, they are the major primary producer for the basis for the rest of the food web and are one of the biggest sources of carbon fixation in the world. (Spaulding, 2010) Their tests have a high silica content which is reintegrated into the environment via recycling in the bottom of the ocean when diatoms die and sink to the bottom creating siliceous ooze from which silica is redissolved and with upwelling is brought back into the photic zone. (Yool, 2003)

In a study done in 2005 using climate change models to observe changes in diatom populations they found that when CO_2 was four times its normal levels diatoms global abundance shrank by 10% but in some places like the North Atlantic and Subantarctic Pacific there were decreases as high as 60%. (Bopp, 2005) The implications of the microbiome shift from being high in diatoms to being high in other small phytoplankton would be huge in terms of the nutrient composition of detritus, which can change the available nutrients in deep water being brought to the photic zone by upwelling. (Mercado, 2011) Lower populations of Diatoms means less silica and higher Carbon and Nitrogen cycling which would shift the world's microbiome extensively.

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DINOFLAGELLATES

What are my general characteristics (e.g., size, shapes, component, etc.).

Dinoflagellates are a group of eukaryotic microplankton (20 – 200 µmol) made up of over 2,000 species and 125 genera, only half of which are photosynthetic (Taylor et al. 2008). Despite their small size, photosynthetic dinoflagellates are important contributors to global primary production, only second to diatoms as marine primary producers (Knoll et al. 2007). Dinoflagellates are covered by thecal plates made up of cellulose, which form a "shield" around the organism. The plates come in many different shapes and sizes with some species having unique crests or ridges (Margulis et al. 1990). Dinoflagellates have two independent flagella made up of clusters of protein that help them move throughout the water. This flagellum is where dinoflagellates get their name. They are also asexual, producing more dinoflagellates through cell division. Furthermore, dinoflagellates can produce their own light through chemical reactions resulting in bioluminescence (Schmitter et al. 1976).

Where am I found?

Dinoflagellates are found in both the ocean and freshwater ecosystems (Thornton, 2012) with 90% of them living in the ocean. Some have even been found in snow (Include citation). Overall, dinoflagellates tend to be found in, warmer, surface stratified waters. In temperate zones, dinoflagellates dominate over diatoms in nutrient rich, well-mixed, spring water columns. Additionally, photosynthetic dinoflagellates reside in sponges, corals, jellyfish and flatworms as symbionts providing carbohydrates to the host and receiving protection from the host (Abercrombie, 2017).

What do they eat?

Since half of dinoflagellates are photosynthetic and can produce their own food (i.e. autotrophic), making them the base of the food chain. This is because photosynthetic dinoflagellates contain chloroplasts, which absorb light energy to make food. However, not all dinoflagellates are autotrophic. The other half of dinoflagellate species do not photosynthesize, therefore are heterotrophic, meaning they cannot produce their own food (Stoecker, 1999). Non-photosynthetic dinoflagellates eat diatoms or other protests, even other dinoflagellates. Additional food sources include fish eggs or other protists. Some species will parasitize other organisms such as zooplankton, protists, algae or fish (Hansen, 1991).

How much of the ocean primary productivity do I account for?

Half of the primary productivity on planet Earth occurs in the oceans and is conducted by phytoplankton (Cloern, 2008). Phytoplankton is an overall term encompassing diatoms, dinoflagellates and cocolithophores (Knoll, 2007). There are a couple of factors that prevent us from getting the exact number for the amount of primary productivity accounted for by dinoflagellates. (1) Measurements of primary productivity by phytoplankton encompass all types of phytoplankton, making it difficult to piece out the specific contribution of dinoflagellates themselves. (2) Dinoflagellates are symbionts with other organisms such as cyanobacteria who also photosynthesize. Therefore, in these primary productivity measurements, separating the two is impossible (Gordn et al. 1994). (3) Finally, dinoflagellates have a patchy distribution throughout the season. Ten percent of dinoflagellates also experience periodic "blooms" that influence the amount they contribute to total primary productivity (Smayada & Reynolds, 2003; Thorton, 2008). Being that these blooms are unpredictable, dinoflagellate influence to global primary production can differ from year to year.

Why am I important?

- The primary role of dinoflagellates in ocean disaster
  - Harmful algal bloom

    The harmful algal blooms (HABs) can lead severe marine economic losses and the frequency of it is increasing (Hallegraeff, 1993). The major reason of HABs is the dinoflagellates, especially at the late spring bloom (Guo et al., 2014) and in the background of global warming (Xiao et al, 2018). About 75% of toxic phytoplankton species in HABs are dinoflagellates (Smayda and Reynolds, 2003). Even we usually call HABs as 'red tides', it could also be brown, yellow, green or blue, depending on the dominant species, concentration and depth (Food and Agriculture Organization of the United Nations, 1993).

  - Coral Bleaching

    The coral bleaching is threatening the tropical coastal ecosystem (Hoegh-Guldberg. 1999). In most cases, the rapid bleaching of corals, especially during mass bleaching events, is due to the loss of zooxanthellae (Hoegh-Guldberg and Smith, 1989), which is a kind of dinoflagellates.

- Ecological value of dinoflagellates
  - Primary producers

    Dinoflagellates possessing photosynthetic pigments play a major role as primary producers in freshwater and marine habitats (Hickman et al, 2008).

  - Diverse ecological roles

    Besides the role of energy provider, dinoflagellates' various nutritional strategies makes dinoflagellates playing multiple role in ecosystem and supporting diverse food chain. About half of dinoflagellates are phototroph (Gaines et al, 1987), the rest of them are mixotrophy (Gallardo-Rodríguez et al, 2012), and heterotrophy (Bralewska and Witek, 1995). Especially, the symbiotic relationship between some dinoflagellates and coral is the basis of tropical coastal ecosystem (Coffroth and Santos, 2005).

- Economic value of dinoflagellates
  - Economic value

    Dinoflagellates have been reported as potent natural bio-toxin producers (Wang, 2008). These bio-toxins display wide diversity and complexity (Blunt et al., 2018). As a result, some of them have great potential for use as pharmaceutical therapies and biological research probes (Assunca et al., 2018).

  - Impacts on aquaculture

    Besides their possible medical value, dinoflagellates also influence aquaculture deeply by providing food or killing fish and shellfish with bio-toxin (Turner and Tester, 1997). In addition, these toxins will accumulate in food chain and human body. Worldwide, close to 2,000 cases of food poisoning from consumption of contaminated fish or shellfish are reported each year, 15% of which will be proved fatal (Hallegraeff, 2010).

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CONTRIBUTION

Xiaohui Zhu: By reading the abstract of papers, Xiaohui filtered 100 highest cited paper and 100 newest paper under the topic of dinoflagellates to get related paper list for this group. In addition, he answered the question about the importance of dinoflagellates and then designed one page slide for the presentation. Because his presentation partner has to attend an academic conference, he will present the whole PowerPoint in class.

Claudia Mazur: Claudia contributed written answers for four out of the five answers for the written questions (ex: general characteristics, location, general importance and food web). She also created two out of the three slides addressing these questions. Since she was away at a conference during the week of presentation, she was unable to present these questions in class. As a result, she took more of an initiative on the written portion of the assignments, while Xiaohui focused more on the presentation to the class.

ES 423 Marine Primary Producers
Emelia Chamberlain, John Sullivan, & Hayley Goss

Synechococcus and Prochlorococcus Presentation Accompanying Text

Synechococcus is a cyanobacteria that thrives in temperate and tropical oceanic surface waters, where they photosynthesize with the plentiful sunlight. Depending on the amount of sunlight available, concentrations of up to 200,000 cells per milliliter have been observed. These cells can reach such high concentrations per ml due to their size, which ranges from 0.8 micrometers to 1.5 micrometers. They are most commonly found in the euphotic zone, which ranges from the surface to 260 feet deep. The only place where these microorganisms are not found Antarctica, as they prefer warmer waters. On the other hand, Prochlorococcus is a slightly smaller cyanobacteria, measuring at 0.6 micrometers. These organisms are the most abundant photosynthetic organism in the world, with a yearly count of 2.8 to 3 octillion cells (or 10^{27}). An interesting feature of Prochlorococcus is that they have a higher ratio of chlorophyll-b to chlorophyll-a, which allows them to absorb blue light. Blue light penetrates much deeper into the ocean than other colors in the spectrum, and in some locations can go deeper than 200 meters. This accompanies their preference for water temperatures of 10 to 33 degrees celsius. Being one of the largest populations of phytoplankton, this species forms part of the base of the marine food chain.

The populations levels of Prochlorococcus and Synechococcus remain relatively constant despite their fast doubling time of sixteen to thirty one hours due to grazing activities and cell death by viruses. It would appear that due to their relative size most meroplankton cannot feed on these organisms and they are primarily fed upon by grazers; micro-zooplankton smaller than 5 micrometers such as ciliates and flagellates. Protozoans are the primarily consumers that help link cyanobacteria to the higher trophic levels. Studies show that these organisms have preferential feeding tendencies. Flagellates appeared to grow at a much more substantial rate when feeding on Prochlorococcus, and saw limited population growth when dependent solely on Synechococcus for food. (Jacquet) A reverse pattern was observed in feeding preference of ciliates. When given a feeding choice these microscopic grazers preferred Synechococcus (Partensky). It is hypothesized that this preferential grazing, along with physiological constraints, may be responsible for the distribution and density patterns for these two species. (Partensky) In the regions where Prochlorococcus can be found it is extremely productive when compared to Synechococcus, which is less limited geographically but is found in lower densities. Because of its wider distribution Synechococcus does contribute to more biomass overall than Prochlorococcus. Cyanobacteria is responsible for raising the oxygen level in the atmosphere during its formation and the earliest fossilized cyanobacteria is over 3 million years old. (WHOI ocean us magazine)

Besides being the base of the food web and key contributors to primary production, these two species of Cyanobacteria are important because they are significant players in the cycling of the ocean's nutrients. Over evolutionary time, phytoplankton composition has played an important role in determining seawater elemental composition. They create variations from the Redfield ratio and affect the dynamics and availability of carbon (C) nitrogen (N), phosphorous (P) and other limiting nutrients. Prochlorococcus and Synechococcus, have been known to affect the elemental composition of oceanic particulates specifically in low latitude marine biomes. Since they are P limited phytoplankton they specifically tend to create higher than average C:P and N:P ratios in particulate matter than would be expected from the Redfield Ratio (Bertilsson et. al 2003). Being responsible for up to 50% of fixed carbon in marine systems, they perhaps contribute the most to the global carbon cycle (Fu et. al 2007). Prochlorococcus plays an especially important role in the global biological carbon pump by producing Transparent Exopolymer Particles (TEP). These particles, which consist mainly of acidic polysaccharides, from “marine aggregates”. These aggregates then export carbon to deeper waters by enhancing sedimentation of particles. In oligotrophic waters where prochlorococcus thrives, stress from solar radiation promotes the production of TEP by killing off phytoplankton blooms. (luculano 2017). In fact, Prochlorococcus is especially known for its poor reaction to UV induced oxidative stress. A niche specialist, Prochlorococcus reacts to this stress by simply shutting down key metabolic process until the stressful period is over. Synechococcus, on the other hand, is a generalist and is able to efficiently deal with UV radiation and oxidative stress by altering its photochemical processes. (Mella-Flores et. al 2012). Perhaps this is why Synechococcus contributes less TEP to the global carbon cycle. Either way, it is clear that both species play an important role in both oceanic primary production and biogeochemical cycles.

How each group member participated.

We separated the research into three categories and each tackled the questions regarding each. John created the first slide and answered the questions about general characteristics and location. Hayley created the second slide and answered the questions about productivity and predators. Emma created the third slide and answered the questions about importance as well as creating the citations page. We jointly compiled this document highlighting all of our individual research.

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Primary Producer Project

Katherine Galeas, Shuhui Lui, Yuhua Situ

Primary producer: Sargassum aka Gulfweed/Sea holly

1. General characteristics

Sargassum is a brown seaweed that floats in the ocean usually forming large islands (NOAA 2014). The structure of the plant consists of a highly branched thallus with fronds with edges that are toothy (NOAA 2014). The thallus also contains pneumatocysts which are hollow berry like cysts that allows this type of brown algae float (Britannica 2017) . The largest members of sargassum can reach up to several meters in length. The fronds are long and oval shaped. Usually, sargassum is yellow-brown to a chocolate brown color and the two most common types are Sargassum natans and Sargassum fluitans (Akumal Dive Shop 2016). It is really bothersome when it washes up on the shore because of how bad it stinks when it begins to deteriorates (Akumal Dive Shop 2016).

2. Location

Usually, sargassum is found in coastal tropical and temperate marine waters (Bryant 2015). It is very abundant in the ocean and the Sargasso Sea is found in the North Atlantic Ocean. The Sargasso sea is located directly in the North Atlantic Gyre and is 1,107km wide and 3,200km long, only bound by the ocean currents (Akumal Dive Shop 2016). The Gulf brings the sargassum and the currents bring it to the gyre (Gaskill 2013). When the Sargassum loses its buoyancy, it sinks to the seafloor and becomes part of the deep sea (NOAA 2014).

3. How much primary production?

According to a 1950s journal article by D. W. Menzel and J. H. Ryther, the average net productivity averaged 0·20 g Cfm 2/day or 72 g C/m2/year. The most recent estimates were 181-1, 234 μC gdry /g h mass (Dubbs et al 2015).

4. Food For…

In tropical areas, sargassum is consumed by herbivorous fishes and echinoids. Scyllaea pelagica is a nudibranch that eat sargassum (WoRMS 2004) . Humans can consume sargassum but harvesting this seaweed has to be done with great care because any blue/green algae on the fronds of sargassum is inedible (Deame 2017).

5. Importance

Sargassum is important because it provides so many things for the creatures living and visiting the floating islands. It provides food for herbivores and homes for them. The islands become nurseries for many big commercial fish like mahi-mahi and Jacks (NOAA 2014). The sargassum fish is a type of frog fish that exclusively lives among the fronds of the seaweed (Akumal Dive Shop 2016). In addition to providing on the surface of the ocean, the sargassum provides energy to the deep sea in the form of carbon when it sinks (NOAA 2004). Sargassum as the potential to help in the medical and pharmaceutical fields and is perfect for landfill and biofuels. It has been designated to be a essential fish habitat (NOAA 2014).

6. Group roles

Katherine: She did the research aspect of the project and used the information found to write the text.

Shuhui Lui: She cross referenced some of the research articles that she found with Katherine and did the powerpoint.

Yuhua Situ: Did not appear on Thursday and did not contribute to this project though it was shared with them.

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Kelp - what are my general characteristics (e.g., size, shapes, what am I made of?, etc.); Where am I found? How much of the ocean primary productivity do I account for? What eats me (i.e., what food webs do I support?). Why am I important?

Summary:

Slide 1: (Sand) Kelp is a nice brown algae that grows into a forest of many different kelps and organisms. Kelp comes in a wide range of sizes and types (most well known being Giant Kelp); they can grow up to 175 feet (Monterey Bay Aquarium) with an average of about 7 to 100 feet, 2-30 meters (National Park Service, 2015). Kelp likes to stay in the cool (5-20C), nutrient-rich waters of the Pacific in rocky shorelines (NOAA), which have clearer waters to allow photosynthesis and growth. Kelp are fairly short-lived, but they grow quickly, 18 inches/day (NOAA), so the forests stay full. Kelp don't have roots; so, they are technically not plants, but the holdfast keeps them rooted into the ground. Their stems are called stipes, and their leaves are blades. At the base of each blade, there is a gas bladder, or pneumatocyst, that keeps the kelp upright (CCBER). Without pneumatocysts, the very diverse organisms that live among kelp would not be able to take shelter within these forests. Kelp is endangered (ABC, 2012)!

Slide 2: (Siobhan) Kelp forests are one of the most productive ecosystems in the ocean (WERC). While it is difficult to place a exact amount of the primary productivity of kelp forests, it is estimated that the average kelp bed is responsible for 400-1900 gC/m^2/yr (Goetze). For example, a study in California among three kelp beds saw a range of 420-2380 gC/m^2/yr of NPP per bed (Reed et al., 2008). Kelp forests support a diverse ecosystem. Primarily, they are eaten by sea urchins as well as smaller herbivores, fish, and other inverts. These in turn are eaten by other organisms such as sea stars, crabs, and sea otters (National Park Service, 2015). Humans have also taken to using kelp for food products (NOAA).

Slide 3: (Daniel) A closer look into kelp sheds some light as to what makes it so important. Rich in Vitamin C, B5, and K, kelp is a high nutritional source for humans and marine organisms alike. Becoming so popular, that kelp is even used in shampoo and toothpaste. Kelp forests are also widely used as habitats and nurseries for multiple animal species. Because of this, they become feeding grounds for predators such as sea lions, and even birds, who hunt the insects and small marine organisms near the surface. From brittleworms and brittle stars, to jellyfish and sea turtles, kelp forests are one of the most diverse marine ecosystems to be found, close behind the coral reefs. Because of their massive size, kelp forest are also used as shelters from storms surges and rough weather, even by whales and dolphins (NOAA).

How each person participated: We all researched answers to the questions and created the slides together (team effort, equal participation). For the write-up, we each chose one slide to summarize.

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Fun facts:

“In fact, sea kelp is one of the fastest growing plants on the planet” (up to 18 inches/day) - national geographic but it’s not a real plant and it doesn’t have real roots

Sea dragons live in kelp forests

They can get up to 175ft long

Different types of kelp can live together in one kelp forest

Kelp is used in shampoos and toothpaste

High calcium and vitamin K

Kendall McPherson
Alia Al-Haj

Trichodesmium

Slide 1

-What is Trichodesmium?/Characteristics

- Also called “sea sawdust”[1]
- A type of planktonic marine cyanobacteria[2]
- 5-8 different species described in literature[3,4]
- **What does it look like?**
- Fusiform or Radial[5]
- 2-5mm[5]
- Made of Tiny filaments called trichomes[5]

Slide 2:

Where am I found?

- Largest blooms found in south pacific gyre and around equator[2]
- Blooms can form between 20 °N and 20 °S in the eastern Pacific and between 40 °N and 40 °S in the Atlantic, western Pacific, and Indian Oceans[2]
- *Trichodesmium* is found primarily in water between 20 and 34 °C and is frequently encountered in tropical and sub-tropical oceans in western boundary currents[5]
- Mostly found in surface waters, but has been found at up to 100 m depth in the Atlantic[6]

Slide 3:

Why am I important/How much of ocean primary productivity do I account for?

- Fixes Nitrogen[5]
- Grazed by tunicates, copepods, and fish[2]
- Aerobic, while most Nfixers are anaerobic or form heterocysts[2]
- N-fix occurs in diazocytes[2]
- Migrate in the water column to scavenge P and Fe from lower depths for N-fixation[2]
- Mostly made of C and N but limited by P and Fe[2]
- *Trichodesmium* introduces the largest fraction of new nitrogen to the euphotic zone in the tropical and subtropical North Atlantic[7]
- 60-80 Tg N/yr (Global marine N-fix is 100-200 Tg N/yr)[2]
- This is very important because it allows for further CO2 fixation by the remaining non-diazotrophic phytoplankton community[7]
- Trichodesmium are the most significant cyanobacteria primary producers (fixing ~165mg CO_2/m^2/day)[7]
- 7.9-47% of primary production in the North Pacific and North Atlantic[8]

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Work was split equally between Kendall and Alia. With both contributing to finding the information on the slides. Kendall typed up the word document and Alia made the powerpoint presentation and works cited. Kendall will present the shorter first two slides and Alia will present the final slide.

What are my general characteristics (e.g., size, shapes, what am I made of?, etc.);

Mangroves are woody shrubs and trees that vary in size from around 6 to 35 meters in height. They are the only woody plants that grow between land and sea in low latitudes, mostly on subtropical and tropical coastlines. Relative to other trees, they do well in salty and hypoxic conditions. They have a global mean biomass of 24.7 kg m^{-2} and cover about 160,000 km^2.

Most mangrove carbon is stored in dead roots in the soil below the plants. The "outwelling" hypothesis suggests that organic matter produced by mangroves is exported to the ocean, where it provides nutrients for coastal fisheries. Mangroves are able to store and transport large amounts of fixed carbon because of tides and waves, which provide added energy. Additionally, mangrove leaves allow for low transpiration and high carbon gain, making them highly productive.

Where am I found?

- Tropical and Subtropical regions all around the world. However, they are disappearing at an alarming rate.

How much of the ocean primary productivity do I account for?

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

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What eats me (i.e., what food webs do I support?).

Mangrove detritus is eaten by molluscs, small crustaceans and fish, but fungi and bacteria make it available to them.

http://www.mesa.edu.au/mangroves/mangroves04.asp

Why am I important?

They are disappearing worldwide by 1 - 2% per year, a rate greater than or equal to declines in adjacent coral reefs or tropical rainforests. Mangrove forests act both an atmospheric CO2 sink and an essential source of oceanic carbon. Due to deforestation, the support that mangrove ecosystems provide for terrestrial as well as marine food webs would be lost; could lead to declines in fisheries. Their decline impacts mangrove-dependent fauna with their complex habitat linkages, as well as p hysical benefits like the buffering of seagrass beds and coral reefs against the impacts of river-borne siltation, or protection of coastal communities from sea-level rise, storm surges, and tsunamis. Human communities living in or near mangroves would also lose access to sources of essential food, fibers, timber, chemicals, and medicines.

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Group Member Contribution:
Ena- Researched, worked on powerpoint and brief text section
Nico- Researched, worked on powerpoint and citation
Ellen- Researched, worked on powerpoint, and brief text, and citation
Each group member contributed equally

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.

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Salt Marshes

Amy Green, Christopher Reyes, and Grace Chu

Slide 2:

Salt marshes are "coastal wetlands flooded and drained by salt water brought by tides" (NOAA 2017). They are typically found worldwide, usually in middle to high latitudes in sheltered coastal areas between terrestrial and marine environments. Salt marshes are home to incredibly diverse communities of organisms, most of which are adapted for the harsh conditions present in salt marshes, such as desiccation, flooding, extreme temperature differences, and salinity fluctuations. The communities present in salt marshes are a result of a fast growth rate of vegetation and a high rate of incoming nutrients, which give way to highly productive ecosystems (Smithsonian Marine Station 2009).

Slide 3:

Salt marshes are composed of a diverse group of organisms ranging from detritivores, such as snails and amphipods, to filter feeders, such as mussels and oysters, to predators, including the blue crab and diamondback terrapin. Detritus serves as the base of the food web. Due to the low oxygen of sediments as a result of constant submergence, there exists a low diversity of plant species (Bertness 1998).

Salt marshes are one of the most productive areas globally. In some southern U.S. coastal salt marshes, productivity has reached 8000 gC/m^2/yr. Most low or intertidal salt marshes reach higher rates of productivity due to high hydrological fluxes. Salt marshes are often nitrogen limited, though they support diverse marsh grasses and phytoplankton species. Much of marsh production occurs below ground in the roots of plants and by mud algae in the peat (Coastal Carolina University).

Slide 4:

Salt marshes serve as nurseries for commercially and recreationally important fish and crustaceans (Deegan *et al.* 2002). They protect against waves and sea level rise (Florida Dept. of Environmental Protection 2017). Furthermore, organisms such as the mummichog (fish) aid in controlling of mosquito populations (New Hampshire Department of Environmental Services 2004).

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Group Member Participation

Grace Chu: Focused on gathering information about salt marsh general characteristics and location and contributed to the development of the presentation

Christopher Reyes: Focused on gathering information about food webs, the role of nitrogen, and the importance of salt marshes and contributed to the development of the presentation

Amy Green: Focused on gathering information about the productivity and importance of salt marshes and contributed to the development of the presentation

Gretchen McCarthy, Roseline Ewa, Elena Forchielli

BI 423

Marine Primary Producers

February 15, 2018

An Overview of Pico and Nanoeukaryotes

Nanoeukaryotes are marine organisms that are 2-20μm in size and includes members from all the algal groups, as well as many diatoms, and flagellates. Picoeukaryotes are marine organisms that are 0.2-2.0 μm in size. Although very small, picoplankton are commonly found in the groups Prasinophyceae, a kind of green algae, and the Haptophyceae (Sym and Pienaar, 1993, Massana, 2002). Cyanobacterial photosynthetic picoplankton are also a common group within picoplankton. Picoeukaryotes are a common topic of interest in studying the evolution of larger eukaryotes as well as the evolution of green plants (Leliaert et al. 2012). Due to such large diversity and minimal work with these organisms, specifics on cell structure, cell walls, life, and reproductive characteristics regarding nano and picoplankton are understudied.

Picoeukaryotes and nanoeukaryotes have a ubiquitous global distribution and are found throughout the water column (Kirkham 2013). There are variations in species abundance and richness in different parts of the ocean (Kirkham 2013). Picoeukaryotes have specific distribution patterns and are also autotrophic and heterotrophic (Kirkham 2013, Massana 2011). Heterotrophic picoeukaryotes are key bacteriovores that prey on specific organisms and degrade organic matter (Wu 2013). Picoeukaryote consumers have a preference for zooplankton. The population control mechanism for picoeukaryotes depends on the specific ecosystem (Massana 2011).

Despite their abundance, picoeukaryotes do not directly have a large impact on primary production. Phototrohpic picoeukaryotes along with picoprokaryotes form picophytoplankton, which accounts for 80-90% of phytoplankton biomass in open sea, and about 10% in most productive systems (Massana, 2011). However, picoeukaryotes dominate picophytoplankton, forming about 60-80% of biomass and primary production (Massana, 2011). Phototrophic picoeukaryotes make important contributions to algal biomass and primary production globally. For example, they account for roughly 38-50% of algal biomass in the Indian Ocean and about 34% of primary production in the North Atlantic (Massana, 2011). Heterotrophic picoeukaryotes, as a stated earlier, are bacteriovores. They play a vital role in the microbial loop by keeping bacteria levels stable, transfering dissolved organic matter to higher trophic levels, and recycle nutrients that help sustain regenerated primary production (Massana, 2011). In conclusion these organisms play a central role in the biogeochemical processes of marine ecosystems.

Group Roles

Gretchen: researched and made slide for general characteristics, edited text document

Elena: researched and made slide for biogeography and foods webs, edited text document

Rosline: researched and made slide for primary production and importance, typed text document

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