OCEANOGRAPHY

13. Biological Productivity and Energy Transfer

part 2:
Photosynthetic Marine Organisms

Notes from the textbook, integrated with original contributions

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Surf grass (filaments) *Phyllospadix* and brown algae *Macrocystis*
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What Kind of Photosynthetic Marine Organisms Exist?

- Many type of marine organisms, mostly microscopic, photosynthesize
  - Seed-bearing plants
  - Macroscopic algae
  - Microscopic algae
  - Bacteria

Seed-Bearing Plants

- The only plants found in ocean waters are members of the phylum Anthophita
  - Eelgrass (*Zostera*)
  - Surf grass (*Phyllospadix*)
  - Spartina (found in salt marshes)
  - different genera of Mangroves (found in salt marshes)

Surf grass and brown algae

Macroscopic Algae

- Various types of marine macro algae are typically found in shallow waters along the ocean margins
- Most of them are attached to the bottom, but a few species float
- While algae classification is based on more advanced concepts, algae color is a useful mean to describe them
  - Green algae
  - Red algae
  - Brown algae

Macroscopic Algae: Green

- Green algae (Chlorophyta) are more common in freshwaters
- Most species are intertidal or grow in bays
- Rarely exceeding 30 cm in size , they range from branched filaments to thin sheets
- Sea lettuce (*Ulva*) are typical of cold waters, while sponge weed (*Codium*) are more common in warm waters, and can actually reach a size of 6 m

Macroscopic Algae: Green

Sea lettuce (*Ulva*), left, is typical of cold waters

Sponge weed (*Codium*), right, is more common in warm waters, and can actually reach a size of 6 m

Macroscopic Algae: Red

- Red algae (Rodophyta) are the most abundant and widespread of marine macroscopic algae (rare in freshwaters)

- Over 400 species identified from intertidal to inner sublittoral zone

- Many are attached to the ocean bottom, either as branching forms or as encrusting organisms

Macroscopic Algae: Red

Red algae range in size from barely visible to beyond 3 m long

Found in both cold and warm waters, but warm waters species are very small

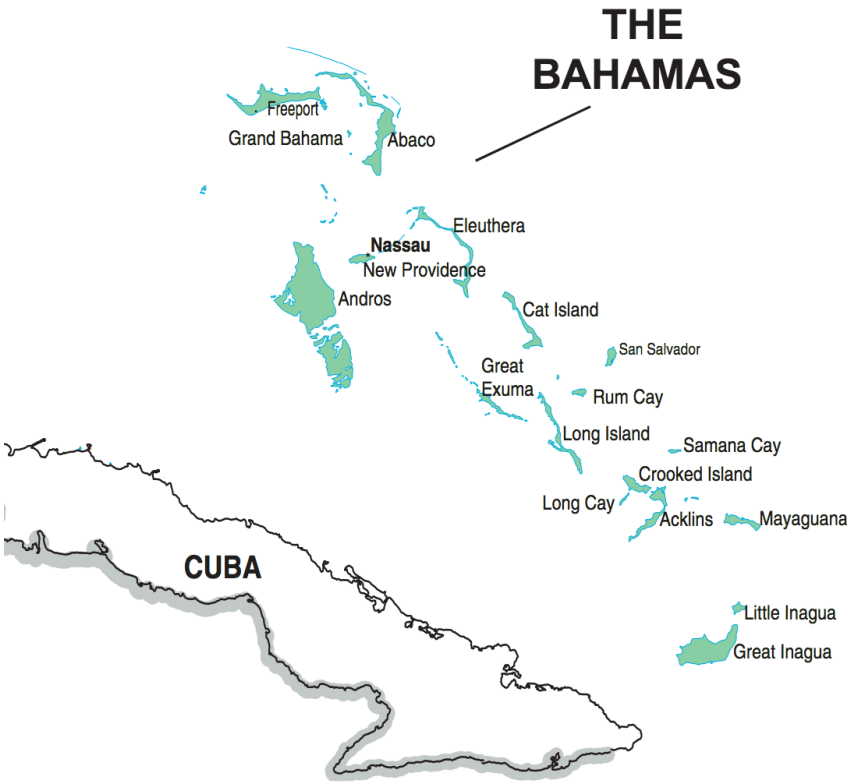
If living in upper, well-lighted zones, red algae tend to be.. Green, black, or purplish

Only deeper water varieties are brownish to actually pink-red in color

A red alga that thrives at -268 m

- Studies from a seamount off San Salvador (Bahamas) revealed a diverse multilayered macrophyte community of algae

- Their net productivity levels are comparable to shallow water seaweeds, although they receive only 1 to 2% of the light energy available at the surface and, at the bottom of the tier, only 0.0005%



The red algae *Neogonolithium strictum*, a crustose coralline form thrives (between -189 and -268 m from sea level)

Macroscopic Algae: Brown

- Brown algae (Phaeophyta) include the largest members of the attached species of marine algae
- Colors range from very light brown to black
- These algae prefer cold waters of mid-latitudes
- They include small *Ralfsia* (a dark and brown intertidal encrusting patch) and the very large bull kelp (*Pelagophycus*), which may grow from -30 m to the surface
- Other brown algae include *Sargassum* and *Macrocystis*

Clockwise from top left:

Ralfsia verrucosa

Sargassum filipendula

Macrocystis sp.

Pelagophycus porra

Microscopic Algae

- Microscopic algae make up, directly or indirectly, the source of food for more than 99% of marine animals

- Most are phytoplankton

- A few are “phytobenthos”, that is they live on the bottom in the nearshore environment, where sunlight reaches the shallow ocean floor

Microscopic Algae: Golden

- Golden algae (Chrysophyta) are so called because they contain the orange-yellow pigment carotene

- They include coccolithophorids and diatoms
  - Seen in Chapter 4 (review!)
  - Phytoplankton

Microscopic Algae: Golden

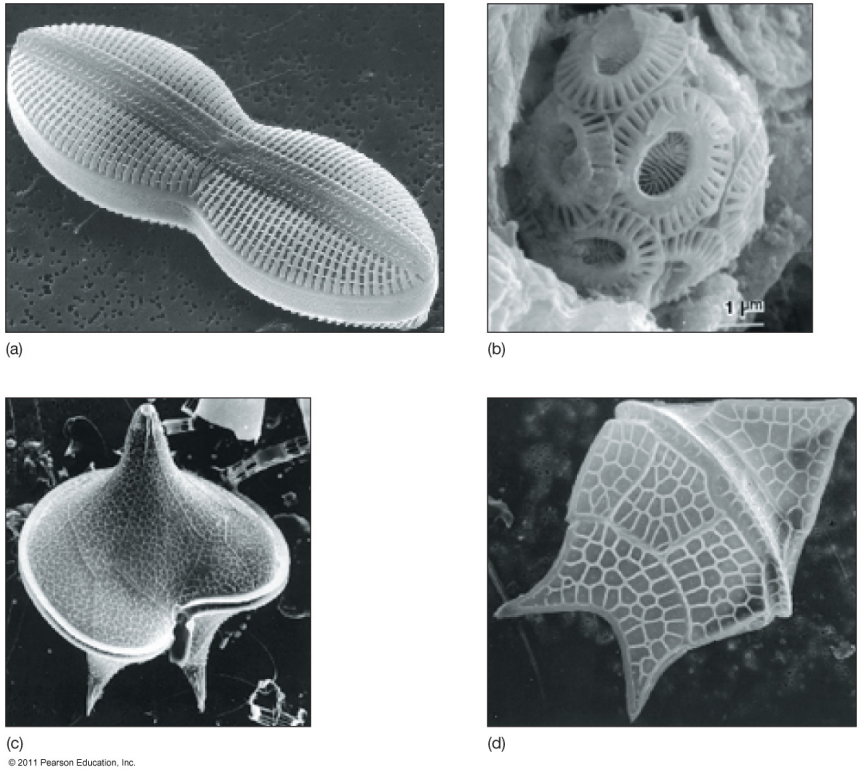
- Coccolithophores
  - They are extremely small (they will escape plankton nets)
  - Covered by small calcite plates called coccoliths (caCO3)
  - They live in temperate and warmer surface waters and are a major contributor to deep marine limestones (calcareous oozes, chalk)

- Diatoms
  - Algae with a silica (SiO2) shell (test)
  - Produce diatomaceous earth, chert
  - Most productive of marine algae
  - All have a pillow-box test

Microscopic Algae: Dinoflagellates

- Dinoflagellates (Pyrrophyta) are characterized by the presence of flagella (whip-like structures) used for (limited) motion

- Abundant, but not important geologically because their shell is made of organic, and hence biodegradable, cellulose



GOLDEN ALGAE and DINOFLAGELLATES

a. Diploneis (diatom)
b. Emiliana huxleyi (coccolithophore)
c. Protoperidimium divergens (dinoflagellate)
d. Heterodinium whittingae (dinoflagellate)

Dinoflagellates and Red Tides

- Dinoflagellates contain a red pigment that can stain surface waters in red (red tides)
- This (and any) kind of harmful algal bloom can produce toxins that are detrimental to marine life (and humans that eat contaminated species)
- Algal blooms are related to abundance of nutrients in the ocean

Dinoflagellates Toxins

- Many red tides are not poisonous but can still kill marine animals because decomposition uses a lot of oxygen

- Some red tides release toxins that are absorbed by marine animals. Some are killed, some are not, but who eats them also gets poisoned

- Humans who eat affected shellfish, or swim in algal blooms can get *paralytic shellfish poisoning* which can lead to death in 15% of the cases

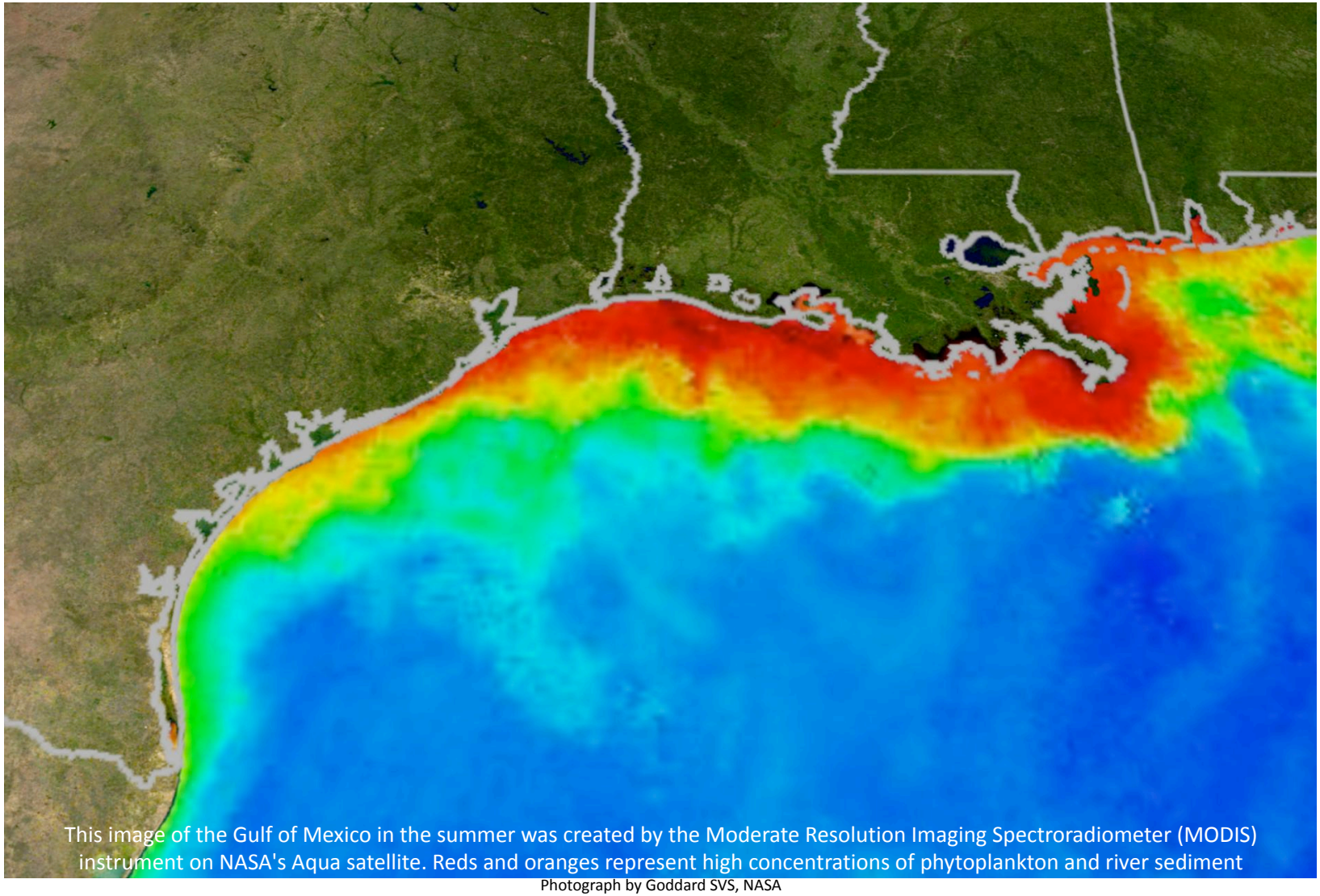
Dinoflagellates Toxins

- Certain tropical fish can also accumulate dinoflagellates toxins in their bodies
- Humans eating those fish can be poisoned by ciguatera
- Ciguatera is a sickness that is rarely fatal but it may take up to four weeks to clear
- Ciguatera is the most common kind of food poisoning in the world

Ocean Eutrophication and Dead Zones

- Ocean eutrophication is the enrichment of waters by a previously scarce nutrient that can trigger an overabundance of algae such as a HAB (Harmful Algal Bloom)
- While eutrophication can be natural, human waste, fertilizers, phosphates from detergents can cause algal blooms
- Algal blooms cause a drop in oxygen level upon death, because of the decomposition
- Waters can become *hypoxic* (or *anoxic*), and for animals that cannot move away it is death by asphyxiation
- Common in the Baltic Sea, at the mouth of the Mississippi River, Japan and Korea, U.S. east coast, English Channel, Adriatic Sea

Mississippi River Delta Eutrophication



This image of the Gulf of Mexico in the summer was created by the Moderate Resolution Imaging Spectroradiometer (MODIS) instrument on NASA's Aqua satellite. Reds and oranges represent high concentrations of phytoplankton and river sediment

Photograph by Goddard SVS, NASA

Photosynthetic Bacteria

- We only recently realized the role of bacteria in marine photosynthesis
- New sampling techniques and genome sequencing studies have revealed bacteria's incredible abundance and importance in the oceans
- Some bacteria, such as *Synechococcus*, may be responsible for half of total photosynthetic biomass in oceans

Photosynthetic Bacteria

- *Prochlorococcus* can even be more abundant, arriving to make up at least half of the world's total photosynthetic biomass

- This implies that *Prochlorococcus* is probably the most abundant photosynthetic organism on Earth

- Recent gene-sequencing of bacteria from the Sargasso Sea revealed an unexpectedly high oceanic microbial diversity

Prochlorococcus, the most abundant and smallest of marine phytoplankton

Biological Productivity and Energy Transfer

part 2: Photosynthetic Marine Organisms

The end