Cholla Bay trip (extra credit) March 28-30

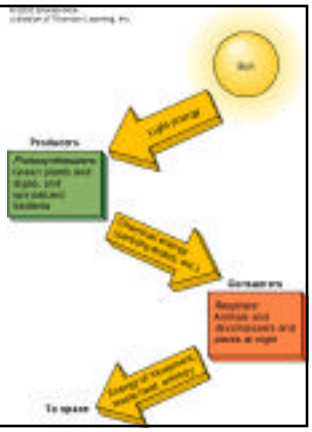
- Sign-up March 13 starting at 7:00 AM in front of GS 208. **Spaces limited**. In person only. Bring:
  - $50 cash or check (to U of A)
  - Proof of US citizenship required (passport, original birth certificate, notarized copy of birth certificate, voter registration, military ID)
- Not a US citizen? Must have valid US visa; may need Mexican visa, check with Mexican consulate.
- Signed form from website (linked on home page)

Primary production

- Capturing energy and using energy
- Who does it?
  - Phytoplankton
    - Detour: harmful algal blooms (killer algae!)
  - Seaweeds, mangroves, sea grass,
- Primary productivity: where and why
- Trophic (feeding) relationships and efficiency -- food webs
- Kelp forests - otters, urchins and kelp

Most primary productivity in the ocean comes from photosynthesis.

Therefore, most primary productivity comes from the photic zone.



Photosynthesis

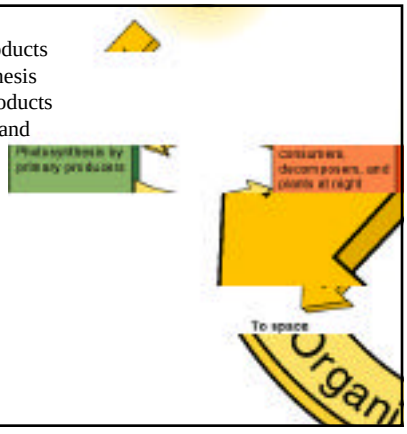
$$6\ CO_2 + 6\ H_2O \xrightarrow{\text{sunlight}} C_6H_{12}O_6 + 6\ 0_2$$

glucose

Respiration

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6\ CO_2 + 6\ H_2O + \text{Energy}$$

Beginning products for photosynthesis are the end products of respiration and vice versa.



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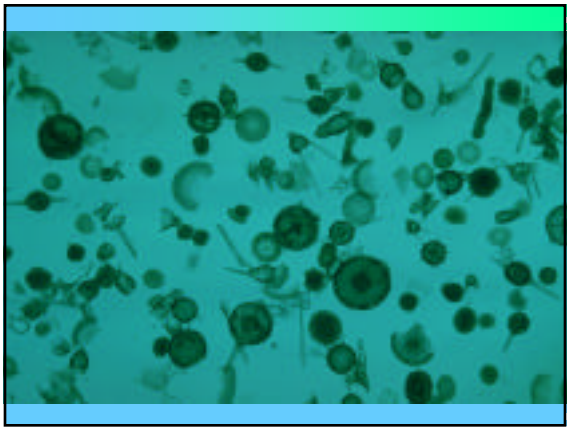
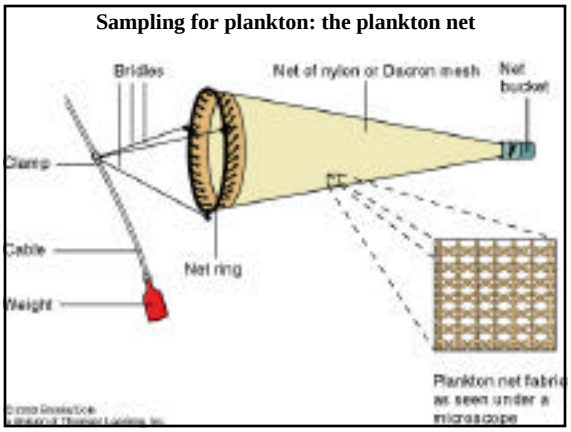
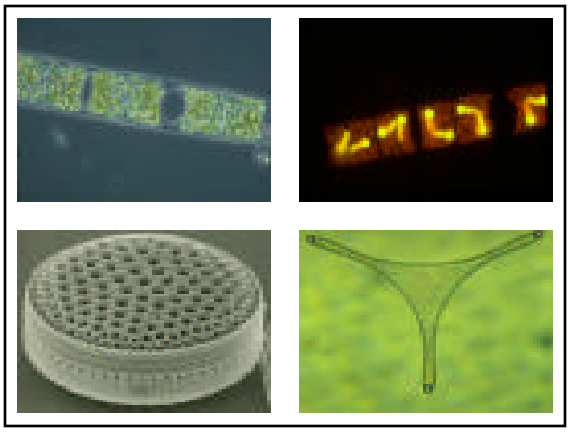


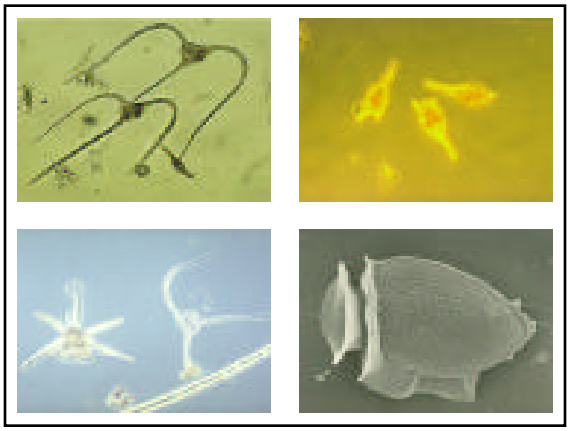
Phytoplankton

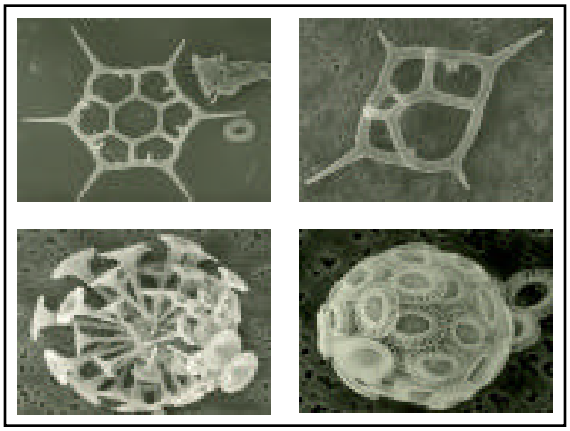
- One-celled, planktonic autotrophs
- Small (microscopic) organisms
- Four major groups:
  - Diatoms
  - Dinoflagellates
  - Silicoflagellates
  - Coccolithophores

Sampling for plankton: the plankton net





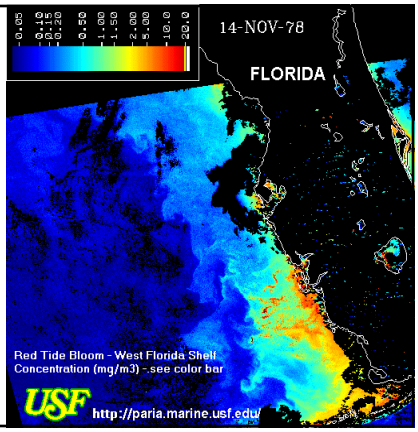




The attack of the killer algae

- Harmful algal blooms (HABs),
- or “red tides”: but not always red, and not related to tides
- Mostly from dinoflagellates, a few diatoms
- associated with high supply of nutrients and high light (summer)

Florida HAB



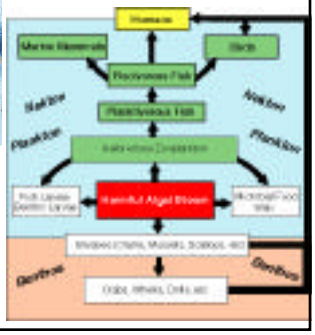
The attack of the killer algae

- Toxins (poisons) a byproduct of metabolism
- indirect poisoning thru food web:

  people eat fish that eat the dinoflagellates

  people eat shellfish that eat the dinoflagellates
- toxins can be: neurotoxins, paralytic, diarrhetic, amnesic
- sometimes fatal!

Humans and HABs



Victims of killer algae

Victims of killer algae

Manatees

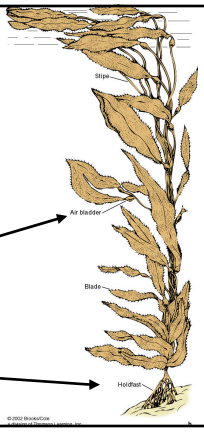
Pelican

Larger marine plants

- Multicellular autotrophs
  - Attached to substrate (bottom, or something else)
- Examples:
  - Seaweeds (fleshy algae)
  - Encrusting algae
  - Sea grasses
  - Mangroves

Macrocystis, or kelp, a brown fleshy alga

Floats because of air bladders, or pneumatocysts

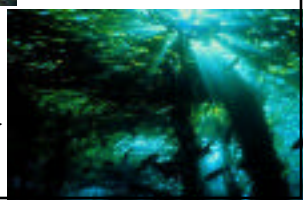


Attaches to bottom with "holdfast" - not roots

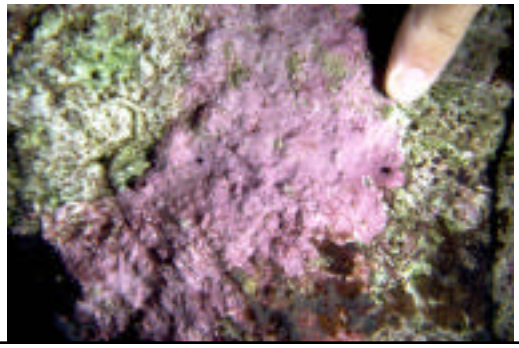
The kelp forest: productivity plus habitat

The canopy from above

The canopy from below



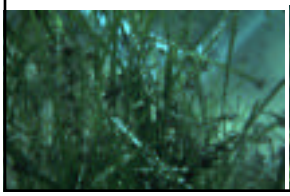
Encrusting red algae: encrusts rocks, shells, any hard bottom



Sea grasses: food and habitat

Zostera, or eel grass

Thalassia, or turtle grass



Mangroves - roots in the water

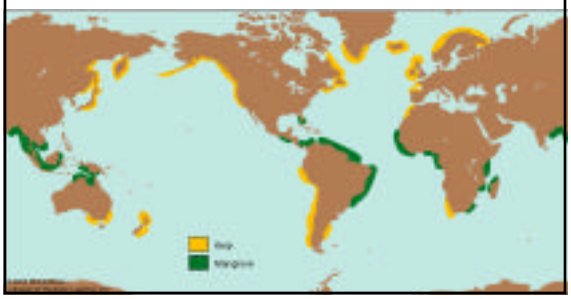
Mangroves

- tropical and subtropical muddy coasts
- roots can extract freshwater from seawater
- 50 species worldwide
- create habitat for fish and invertebrates
- provide food for fish and invertebrates
- protect coastlines from storms

Distribution of mangrove and kelp

Kelp - mostly high latitude

Mangrove - mostly low latitude



Primary production in the oceans

- **Define**: Primary production is the formation of organic from inorganic materials
  - –Photosynthesis
    - •Phytoplankton: 90 – 96%
    - •Seaweeds: 2 – 5%
  - –Chemosynthesis: 2 – 5%
    - (we'll describe in a later lecture)
- Importance: base of the food web!
  - Also regulates atmospheric O_2 and CO_2 - more later on this

Factors that limit photosynthesis

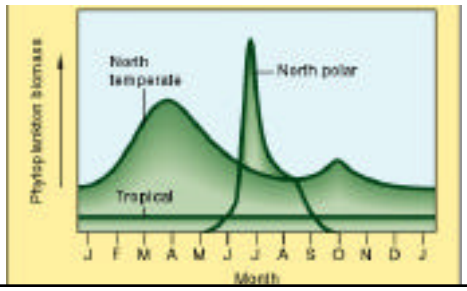
- Light
  - Changes from place to place due to depth, clarity of water; seasonal cycle of solar radiation
- Nutrients
  - Highest nearshore and in areas of upwelling
  - Most important:
    - Phosphates
    - Nitrates
    - Silica, iron (in certain regions)

Productivity and the seasons: light and nutrients

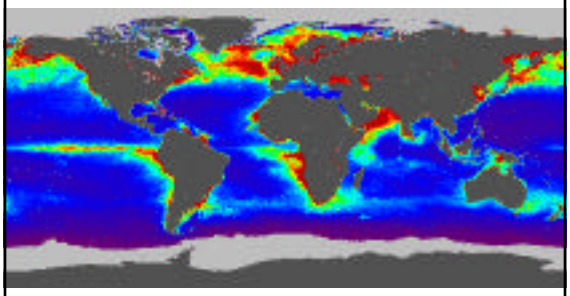
tropical - constant thru year, but low nutrients = low productivity

temperate - two seasons, high nutrients in spring, greatest total productivity

polar - light limited; spike when light first hits ocean



Global primary productivity: Northern latitude summer



Highest along coasts and in areas of upwelling (why?)

Lowest in central parts of oceans - oceanic “deserts”

Measuring primary production

- Measure one component of the chemical equation

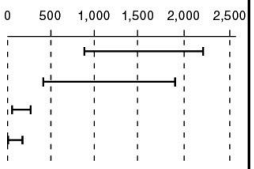
$$6CO_2 + H_2O + \text{energy} \rightarrow C_6H_{12}O_6 + 6O_2$$

- Usually expressed in units of weight carbon produced/area/time
  (grams $C/m^2/yr$)

Primary production: Which ocean ecosystems are most productive?

(fig. 12.2)

COMMUNITY	NET PRIMARY PRODUCTION ($gC/m^2/yr$)
OCEAN COMMUNITIES	
Coral reef	880–2,200
Kelp bed	400–1,900
Shelf plankton	90–270
Open ocean	1–180



So who eats this stuff?

Primary producers/autotrophs/phytoplankton

are eaten by

herbivores/heterotrophs/zooplankton

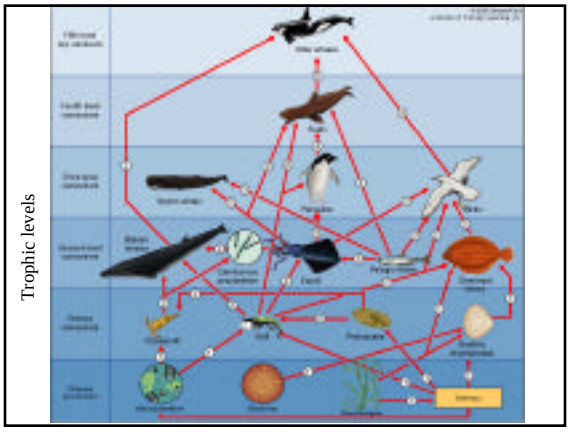
are eaten by

carnivores or omnivores

are eaten by

other carnivores

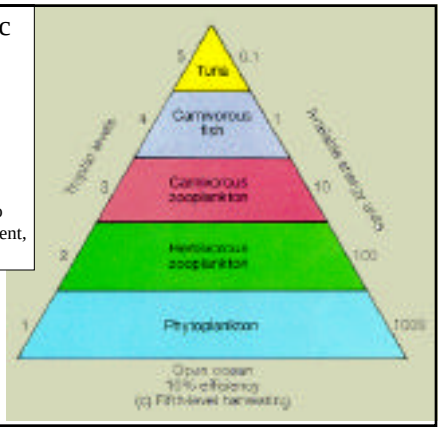
etc.



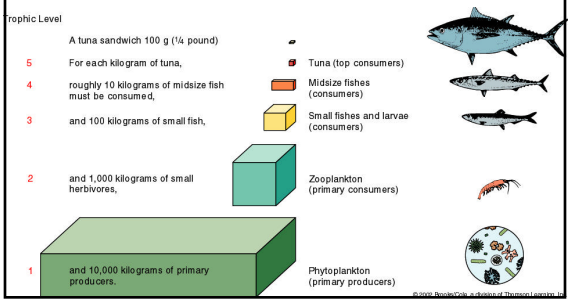
The trophic pyramid

90% of food energy is lost at each step.

Energy is lost to growth, movement, heat.

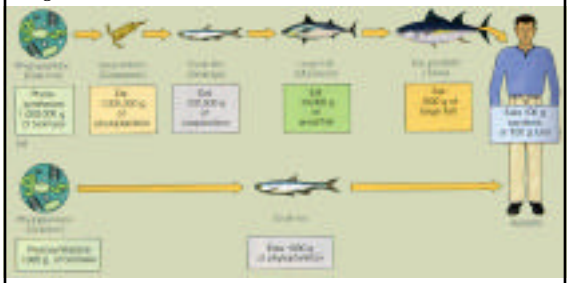


The trophic pyramid and trophic efficiency



Which fish can support the most people?
Tuna (5th trophic level)
or sardines (2nd trophic level)?

One million grams of phytoplankton needed for 100 grams of tuna



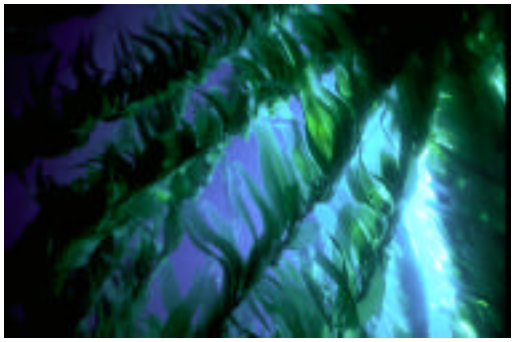
One thousand grams of phytoplankton needed for 100 g of tuna

One million grams of phytoplankton could produce 100,000 g of sardines

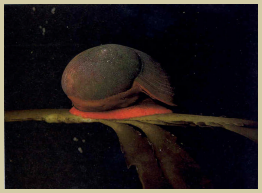
Kelp forests

- 30 – 40 m water depth
  - – determined by light availability
- found almost exclusively at areas of upwelling
  - – require high nutrient concentrations
- water temperatures cooler than 20°C

The kelp forest: benthic macro-algae



- supports diverse community
- provide
  - Protection/ hiding place from predators
  - Substrate for encrusting organisms
  - Food for grazers
  - Detritus (decay releases nutrients for phytoplankton productivity)

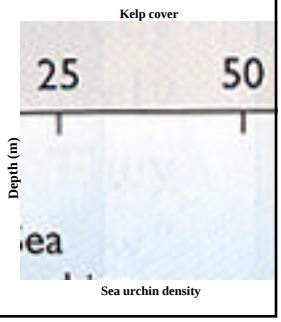



The role of sea otters in kelp communities

- a ‘keystone’ predator
- sea urchins graze kelp beds
- otters keep sea urchin populations under pressure
  - keep the sea urchin populations from growing too large

What happens if otters are removed? By hunting for pelts, for example.

Sea urchin populations increase and kelp cover decreases.



What happens when otters are abundant?

Sea urchin populations decrease and kelp cover increases.