

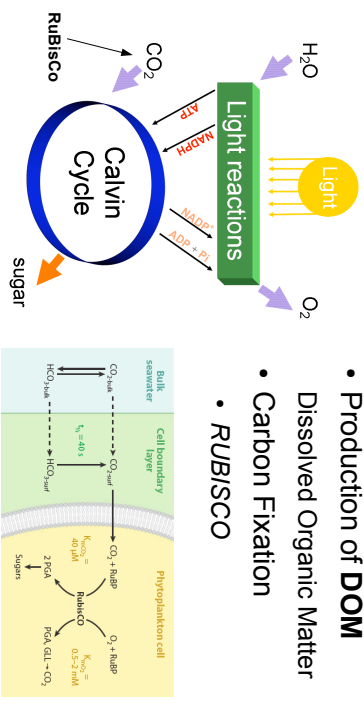


Microbial Ecology of the Sea

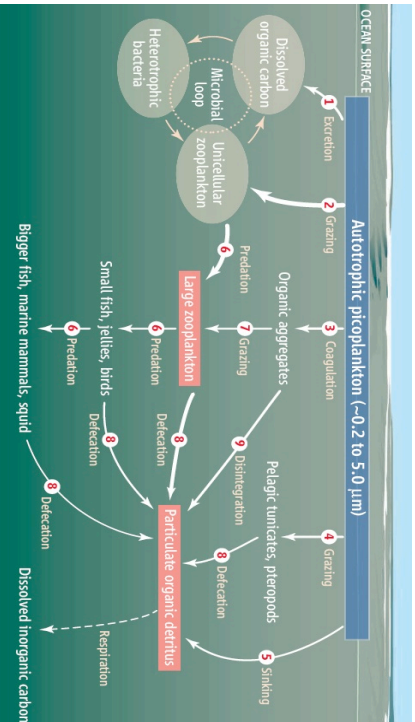


Consequences of Photosynthesis

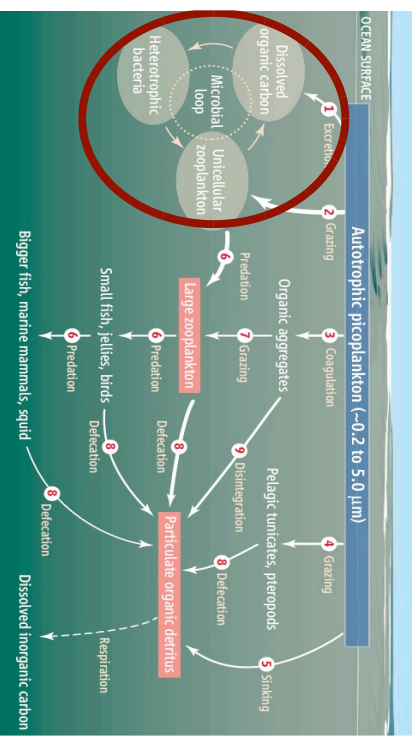
- Production of **DOM**
- Dissolved Organic Matter
- Carbon Fixation
- **RUBISCO**



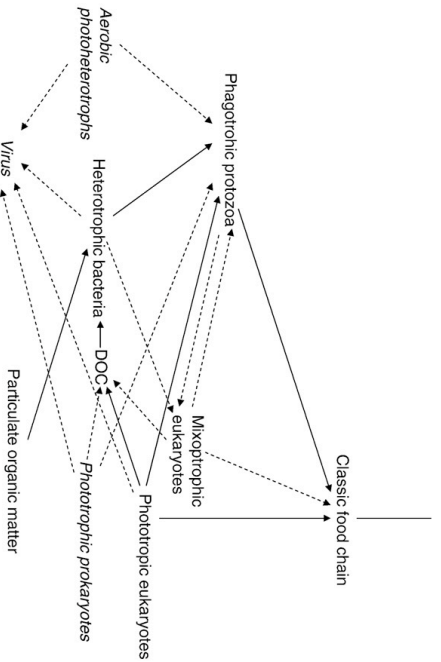
What is DOM?



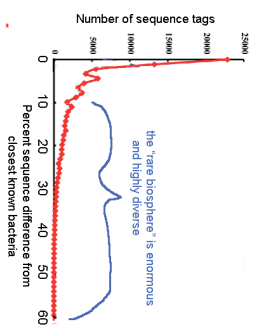
The Microbial Loop



The Microbial Loop



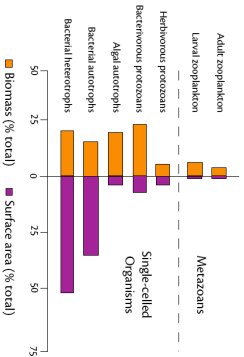
Marine Microbes



- Microbial Diversity
- 100 x diversity w/in last 10 years
- Most microbes known from sequences
 - Rare Biosphere
- Archaea, bacteria, fungi, single-celled eukaryotes

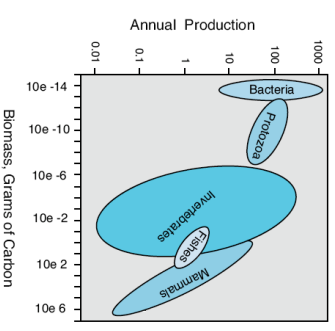
Marine Microbes

- Small size, but big biomass!
- Billions of microbes in each ounce of water
- 10^{29} cells in ocean



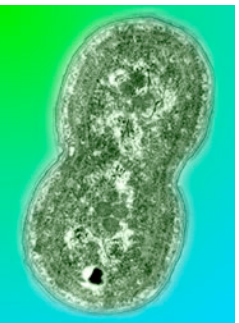
Marine Microbes

- High metabolism
- Heterotrophic bacteria can divide each 10-20 min.
- Metabolism per unit biomass related to surface area: volume



- $SA=4\pi r^2$
 - $V=(4/3)\pi r^3$
 - $SA/V=3/r$
- For a sphere

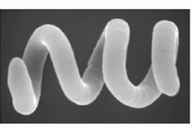
Phototrophs



- Phytoplankton = Diatoms, algae cyanobacteria
 - Eukaryote and Prokaryote
- *Synechococcus* & *Prochlorococcus*—very abundant and account much ocean productivity

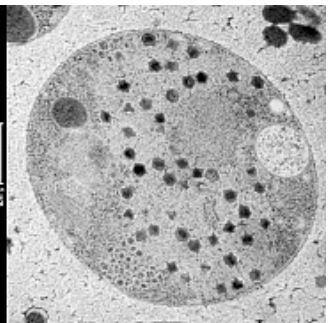
Aerobe Photoheterotrophs

- Roseobacter
- Does not perform photosynthesis
- Uses light energy to generate ATP
- Rapidly metabolizes DMSP (produced by dinoflagellates)



Viruses

- Very common, 10^9 /mL
- Infect prokaryotes AND eukaryote algae
- Nearly all bacteria have 1 host-specific virus
- Induces lysis, recycling the DOM in bacteria



Viruses

- Viral attacks \approx grazing pressure
- Host specificity drives succession changes in bacterial biota
- Bacteria-Virus arms race may be driving bacterial diversity in the ocean

Mixotrophy

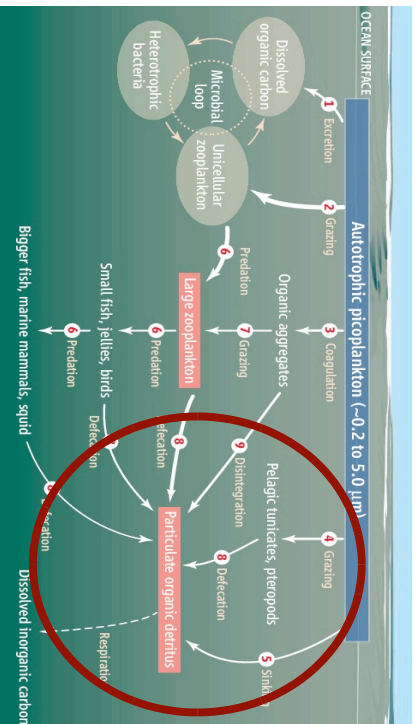
- Protists that phagocytose particles AND is phototrophic
- Ciliates can ingest algae and use chloroplasts for several days
- Dinoflagellates and Heterokonts contain chloroplasts and can still phagocytose
- May hold important role in balancing energetics of the water column

Chemolithotrophs

- Archaea that may detoxify sulfidic waters

$$2\text{NO}_3^- + 5\text{HS}^- + 7\text{H}^+ \rightarrow \text{N}_2 + 5\text{S}^0 + 6\text{H}_2\text{O}$$
- Can rapidly form blooms and provide a buffer between the oxic and toxic sulfidic zones
- Other archaea may oxidize CH_4 or NH_4^+

Particulate Organic Matter



Sources

- Rain of marine snow
- Remains of plankton, fecal pellets, moults
- Plant debris and animal carcasses
- Refractory DOM derived from POM
- Small particles (eg Bacteria) remain suspended

Particulate Organic Matter

Particulate Organic Matter

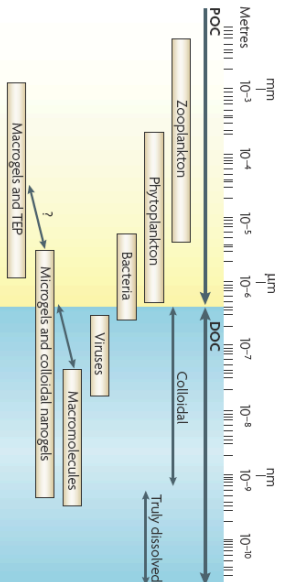
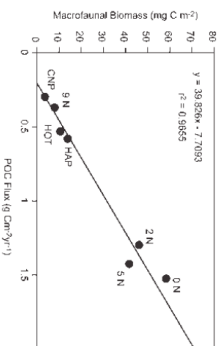


Figure 2 | The size range of organic matter and microbial interactions in the ocean.

Food Supply to the Deep

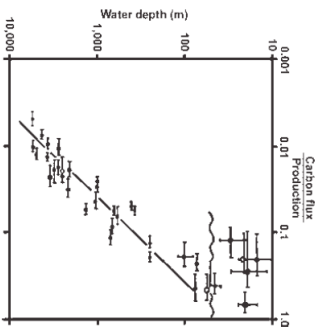
- More biomass per area = more carbon flux
- Carbon Flux = mass of Carbon per area per year
- Benthic biomass correlated with rate of POM rain from euphotic zone



Food Supply to the Deep

2 controls on POM flux

- Annual rate of Productivity in Euphotic Zone
- Water Depth



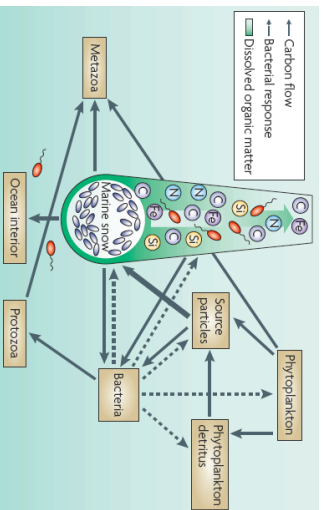
Food Supply to the Deep

Table 6.2
Measured organic-carbon inputs and respiratory demands¹ on the floor of the 1300 m deep Santa Catalina Basin, along the California margin

	Flux, $(\text{g C m}^{-2} \text{y}^{-1})$	Percentage of total	Ref.
Measured carbon inputs			
Vertical rain of small particles (from sediment traps)	5-10	70-84	1,2
Neckton falls	1.6	13-23	3
Kelp falls	0.1	-1	4
Total carbon input	7-12	100	
Respiratory demands			
Sediment community	5-10	37-45	5,6
Epibenthic megafauna	0.9	3-9	5
Benthic-boundary-layer plankton	5-11	40-45	5
Total carbon outflow	11-27	100	

- Rain of POM falls enough to sustain to minimum respiratory demands of sediment community
- Small particles make up majority of carbon input to the deep
- Nekton (fish falls, macrofauna, whales) contribute too

Microbial Transformation of POM



- Bacteria intensively colonize marine snow (up to 10^9 cells/mL)
- High hydrolytic activity of bacteria leave plume of nonsinking DOM in water column

Particulate Organic Matter



Nekton Falls

- Larger organisms – fish, marine mammals and reptiles, wood (think old shipwrecks, trees), plant matter (kelp falls)
- Large organic enrichment to the deep sea
- Can occur haphazardly, channeled or seasonally
- Deep Sea scavenger communities
- Common along migratory pathways?

Nekton Falls

Baited Camera Traps <http://www.youtube.com/watch?v=9Tr89-Z90cU>



Nekton Falls

Time-lapse Camera experiments <http://www.youtube.com/watch?v=1QbGk4sFR0g>



Nekton Falls

Parting thought – Through fishing and whaling activities we have removed a portion of the available carbon input to the deep sea.

How does this also affect the microbial loop?

Do you think that deep sea communities respond to this or is the amount of marine snow raining down on the deep sea enough?