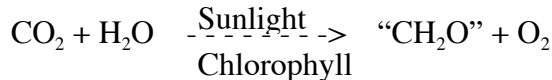


Class 33: PRIMARY PRODUCTIVITY (PP) IN THE OCEANS

Photosynthesis and Chemosynthesis
Gross and Net Primary Production
Cycling of organic matter
Controlling factors
Seasonal variations at different latitudes
Global distribution

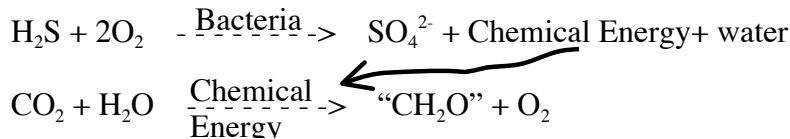
PP = Synthesis of organic matter by autotrophs

1. Photosynthesis by phytoplankton is most important



“CH₂O” represents the most basic building block of sugars, lipids, etc.

2. Chemosynthesis, e.g., by sulfur bacteria at hydrothermal vents



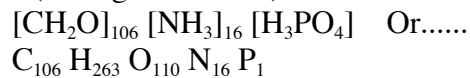
3. Biosynthesis: Builds essential molecules for life

Energy must be expended to do this.

CH₂O + nutrients (N, P, S) - - - - > proteins, lipids, DNA, etc.

How much N and P are needed per gram of biomass produced?

"Redfield ratio" (average for all PP)



Energy and Biomass are transferred through a food web. More on this later...

- Nutrients/Biomass recycled
- Energy derived from sunlight, is passed through the food web, but then eventually ends of “lost” as heat to the ocean

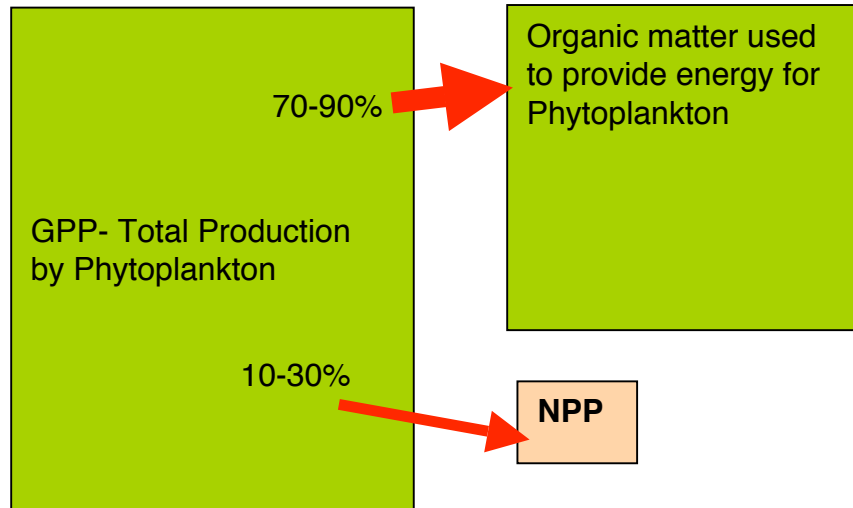
FATE OF ORGANIC MATTER -- HOW PP IS UTILIZED & CYCLED

Gross Primary Production . . (GPP) = Total amount of organic matter produced by primary producers (phytoplankton)

Net Primary Production . . (NPP) = GPP minus energy utilized (organic matter respired) by phytoplankton for life processes

GPP and NPP are expressed as carbon uptake rates, g C / m² – yr

Biomass, or "standing crop" is "density," g C / m²



NPP-Phytoplankton Biomass available to fuel the rest of the food web

ORGANIC MATTER "CYCLING"

Global balance:

- Almost complete recycling of the organic matter produced by PP
- Tiny amount of deposition of OM in sediments (~0.1% of GPP)
- Eventually returned to ocean-atmosphere system (Tectonic uplift or subduction)

FACTORS CONTROLLING PRIMARY PRODUCTIVITY

1. Sunlight- ...in two different ways

- a) Photosynthesis
- b) Seasonal heating -- stratification of surface waters
 - Warm top layer- less dense
 - Sits on top (w/ phytoplankton)
 - vs. Winter mixing- convection
 - Cooling of top layer—denser, sinks to perhaps 100m
 - Phytoplankton get less light

2. Nutrients: Removed from surface waters by PP + sinking of organic matter

Can be replenished by:

1. Winter mixing ...

- Nutrients mixed up from below
- vs. Summer stratification - no mixing

2. Upwelling brings up nutrients

3. Land-derived nutrients (rivers, dust)

3. Grazing by herbivores: Reduces...

- Amt. of living Phytoplankton, and thus...
- Rate of primary production

SEASONAL PRODUCTIVITY PATTERNS AT DIFFERENT LATITUDES

(For areas away from coasts and upwelling areas)

1. High-latitude: One intense mid-summer "bloom"

- Nutrients abundant from winter mixing
- Bloom initiated by summer sunlight
- Warming --> water stratification
 - ➔ phytoplankton remain in photic zone

Productivity controlled mostly by **sunlight**

2. Tropical oceans: Relatively low productivity throughout the year

- High-intensity sunlight all year
- Density-stratified surface waters
- Little vertical mixing, thus low nutrient levels

Productivity controlled by **nutrient** availability

3. Mid-latitude: Spring + Late Summer "blooms"

Sequence of events:

Winter:

- Mixing: Nutrients available
- But sunlight is limiting

Spring:

- Increased sunlight + water stratification
- Intense bloom

Late Summer or Fall:

- Grazing reduces phytoplankton biomass
- Nutrients released --> second, less intense bloom

Productivity controlled by **both** sunlight and nutrient availability

GLOBAL DISTRIBUTION OF PRIMARY PRODUCTIVITY (PP)

1. Open oceans- non-upwelling areas
 - Low nutrients --> low PP rates
2. Open ocean: Upwelling zones
 - Upwelling: Ekman transp.- equatorial + High-Lat.
 - Moderate to high PP rates
3. Continental shelves
 - High nutrients (runoff, some upwelling areas)
 - high PP rates
4. Coastal upwelling at low latitudes
 - High nutrient supply + low-latitude sunlight
 - ➔ very high PP rates
5. Estuaries and some shallow coastal waters
 - Nutrients abundant: vertical mixing, land runoff
 - Photic zone extends to bottom: benthic plants and algae
 - very high PP rates