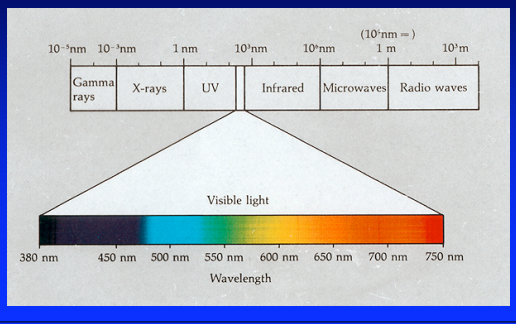
Environmental Factors Affecting Corals and Coral Reefs

ENVIRONMENTAL FACTORS CORRELATED WITH HEALTHY REEF CORAL GROWTH

Warm Tropical Water
Normal Seawater Salinity
Appropriate Solar Radiation
Low Inorganic Nutrients
Low Turbidity
Low Sedimentation
Vigorous Water Motion

The Electromagnetic Radiation Spectrum



PAR

Photosynthetically Active Radiation

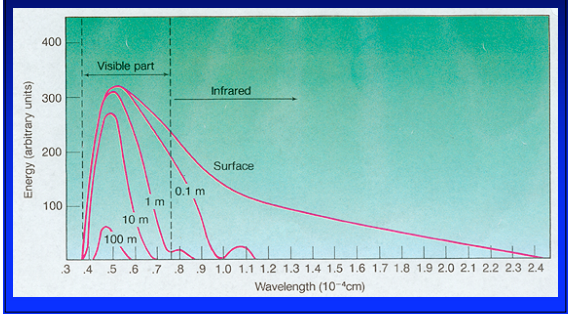
Light Absorption in the Ocean

- Light Intensity
  - decreases with depth
  - 100 meter = depth limit of hermatypic corals primarily a result of the overall reduction in light
  - many studies have focused upon how changing light intensities with depth affect the photosynthesis of zooxanthellae of corals

Light Absorption in the Ocean

- Spectral Characteristics
  - red wavelengths absorbed more readily by water than blue wavelenths
  - blue light penetrates deepest in the oceans
  - the change in the spectral characteristics of light with depth likely to influence plant photosynthesis
  - less work has been done to understand the influence of the spectral distribution of light on zooxanthellae photosynthesis in corals

Light Penetration in the Ocean



Primary Productivity

The rate of production of organic matter by autotrophs

Photosynthesis

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

Measuring Primary Productivity in the Ocean

- Standing Crop Estimates
  - weigh out total plant material
  - measure concentration of chlorophyll in the water
  - use satellite imagery
- Measure Actual Rates of Primary Productivity
  - measure oxygen production and consumption by plants (e.g., light-dark bottle technique)

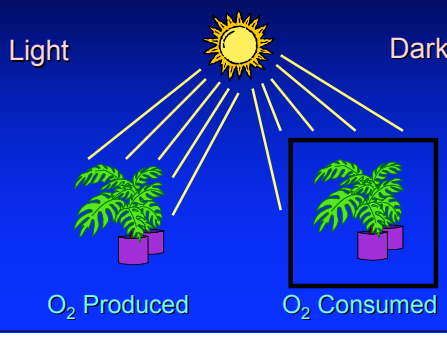
Photosynthesis

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

Aerobic Respiration

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

Light-Dark Bottle Technique



Using the Oxygen Light-Dark Bottle Technique to Measuring Primary Productivity

O_{2start} = Starting Oxygen Concentration

O_{2end} = Ending Oxygen Concentration

$O_{2end} - O_{2start} = \Delta O_2$

Relationships Between Gross Production, Respiration, and Net Production

Gross Production (GP)
The total amount of oxygen (or organic matter) produced due to photosynthesis

Respiration (R)
The total amount of oxygen (or organic matter) consumed due to aerobic respiration

Net Production (NP)
The net amount of oxygen (or organic matter) produced (or consumed) due to the combined effects of respiration and photosynthesis

Symbols Used

ΔO_2 due to **RESPIRATION** = ΔO_{2R}

ΔO_2 due to **GROSS PRODUCTION** = ΔO_{2GP}

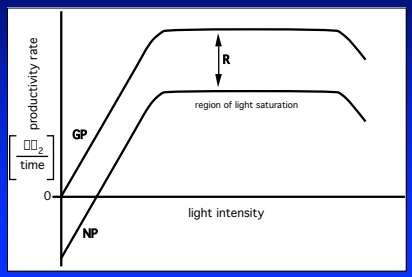
ΔO_2 due to **NET PRODUCTION** = ΔO_{2NP}

Calculating GP from NP and R

$$\Delta O_{2GP} = \Delta O_{2NP} - \Delta O_{2R}$$

assumption:
respiration continues at a constant rate regardless of whether the light is on or off

Photosynthesis as a Function of Light Intensity



Photoadaptation in Corals

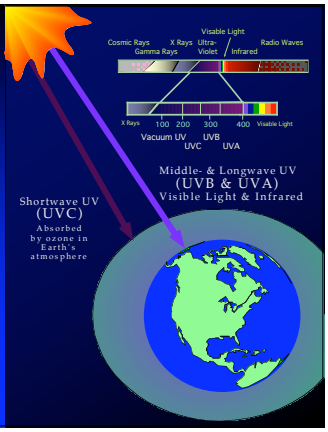
Changes in pigment concentrations and algal densities in response to light intensity

Colony Morphology Responses to Irradiance

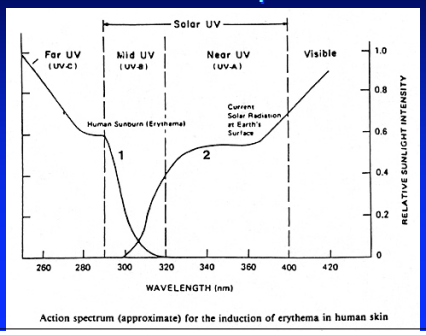
Hemispherical Branching Colonies

Plate-Forming Colonies

Absorption of Ultraviolet Radiation by the Earth's Atmsophere



Types of UV and Human Sunburn Responses



Action spectrum (approximate) for the induction of erythema in human skin

Effects of UV on Living Things

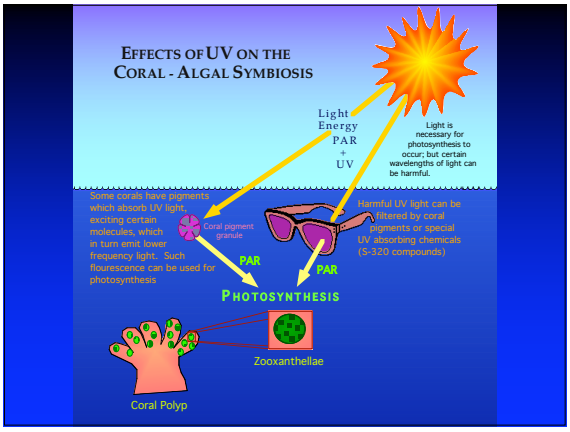
- damage to DNA resulting in mutations
- damage to other biological molecules
  - proteins: enzyme inactivation
  - lipids: disruption of cell membranes and membrane transport systems

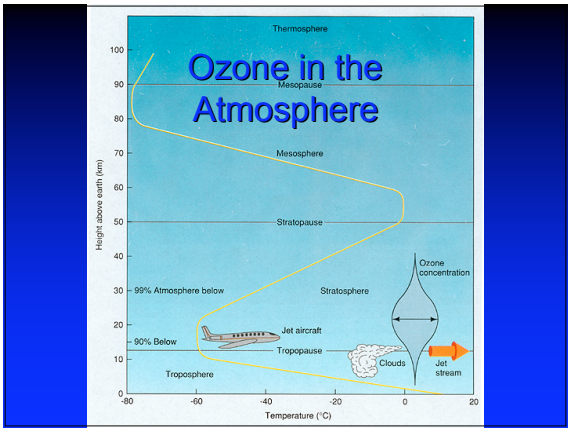
Corals and UV Radiation

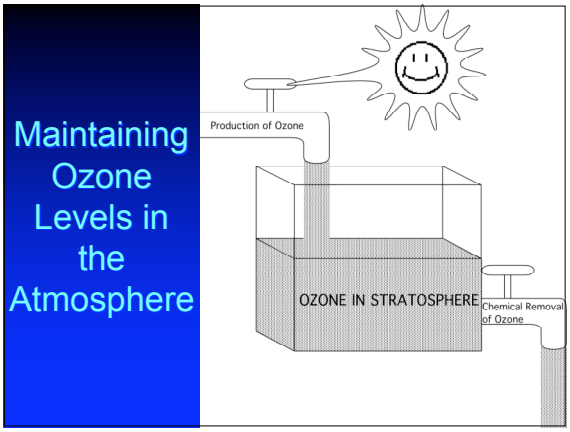
- decreased growth and increased reproductive output
- decreased rates of calcification
- transplantion experiments (deep corals brought to the surface) demonstrate corals may be UV-sensitive (exhibit bleaching and increased mortality)
- coral sperm appears to be UV-sensitive (note spawning normally takes place at night)

Ultraviolet Absorbing Compounds in Corals

- mycosporine-like amino acids (MAA's)
- MAA's apparently produced by zooxanthellae but stored in the animal tissues
- concentrations greater in shallow water corals than in deeper ones
- transplation experiments demonstrate adaptional changes in pigment concentrations
- positively buoyant eggs exhibit higher concentrations of pigments than do negatively buoyant eggs

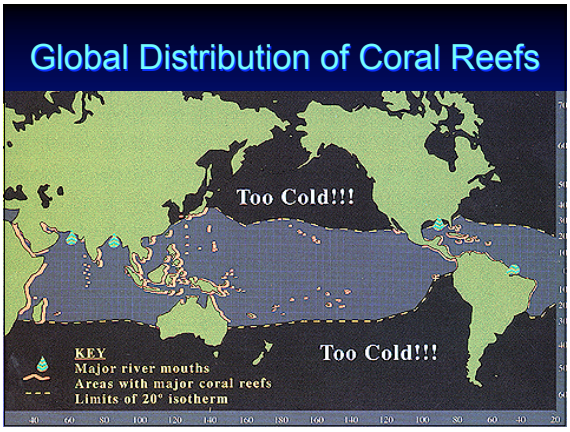




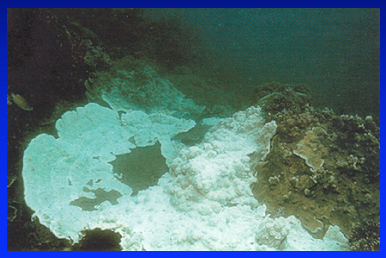


Temperature

- Lethal Limits
  - 5 - 36°C
  - physiological effects = bleaching (expulsion of zooxanthellae from coral tissues)
- Ecological Limits
  - 18 - 29°C (low limit correlates with 20° N & S latitude limit of reef corals)
  - some exceptions exist
  - reasons for differences between lethal and actual limits
    - secondary effects of temperature on feeding or on reproduction
    - synergistic effects of other environmental factors (e.g., UV irradiance)



Bleaching

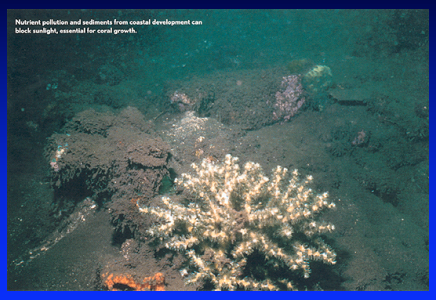


Global Climate Change

Other Factors

Salinity
Sedimentation
Aerial Exposure at Low Tide
Water Motion
Inorganic Nutrients
Currents

Sediments



Nutrients and Algae Growth