

Geographical variations in productivity

Introduction

- The environmental factors such as light , temperature and nutrients interact with each other in the marine environment and play a major role to produce the geographical and latitudinal variations in productivity.

TEMPERATE SEAS

- In the temperate zone seas, the amount of light varies seasonally.
- As a result, the amount of solar energy entering the water varies, which alters the temperature in the upper water layers.
- The thermal structure of the water column, therefore, changes seasonally. In the summer months, the sun is high, days are long, and the upper layers heat up and become less dense than underlying layers.
- In contrast to the tropics, all the major factors that affect productivity change seasonally in temperate seas.

- 
- In the spring, the increased light and solar energy increase the temperature of the upper layers.
 - With increasing temperature come increasing differences in density between upper and lower layers.
 - Under such conditions the wind cannot mix the water to as great a depth as in winter; at some point, algal cells are no longer carried below the critical depth.

- Since nutrients in upper layers have been replenished during the winter mixing, conditions are good for phytoplankton growth, and we observe the spring bloom.
- As spring passes into summer, the water column becomes more thermally stratified, mixing with lower levels ceases, and light conditions reach optimal levels.
- Because mixing ceases due to stratification, nutrient replenishment ceases and production falls, even though light levels are optimal.

TROPICAL SEAS

- In the tropical seas, the upper waters are well lighted throughout the year because the sun does not show marked changes in height above the horizon.
- This means there is a great difference in density between surface and deep waters; hence, mixing does not occur.
- This **thermal stratification** extends throughout the year.

- 
- In the tropical seas, the light conditions are optimal for high productivity.
 - Tropical seas are very clear and have the deepest compensation depths, but they are that way because there are few phytoplankton in the water column due to the low nutrient content.

POLAR SEAS

- In Polar areas, productivity is restricted to a single short period in the polar summer, usually July or August in the Arctic.
- At this time, the snow cover on the ice has disappeared, allowing sufficient light to enter the water through the ice to permit phytoplankton growth.
- Following this single burst of growth, the production quickly declines.

- 
- Nutrients are not limiting and the water column is never strongly stratified.
 - The reason for the lack of production at other times is due primarily to lack of light.
 - Light intensity is insufficient for a fall bloom, and during the long winter, light is either absent or prevented from reaching the water column by a layer of snow over the ice pack.

PRODUCTIVITY IN INSHORE AND COASTAL WATERS

- The situation in the water masses adjacent to land is somewhat different. There are several factors that contribute to this difference.
- First factor is, inshore waters tend to receive a considerable input of the critical nutrients, PO_4^{-3} and NO_3^{-1} , due to runoff from the adjacent land.
-
- Because of this input, inshore waters usually do not show nutrient depletion.

- A second factor contributing to the difference is the water depth. Most inshore waters are shallower than the critical depth; thus, the phytoplankton cannot be carried below this depth in any kind of weather.
- A third factor is that shallow inshore waters rarely have a persistent thermocline; hence, no nutrients are locked up in bottom waters
- A final influencing factor is the presence of large amounts of terrigenous debris in the water,
- which may act to restrict depth of the photic zone and counteract the high nutrient concentration and shallow depth.

- Nutrients are not limiting due to runoff from land and lack of a permanent thermocline.
- Yearly average production in inshore temperate waters is higher than in offshore waters due to the greater nutrient concentrations and lack of critical depth problems.
- The production is not even higher inshore probably is due to the presence of large amounts of light-absorbing debris in shallow water, and the fact that in offshore water, production can occur to a greater depth.

PRODUCTION FOR SEVERAL DIFFERENT GEOGRAPHICAL AREAS

- **Location: Productivity in g C/m²/year**
- Long Island Sound (temperature inshore): 380
- Continental shelf: 100 - 160
- Tropical oceans: 18 - 50
- Temperate oceans: 70 - 120
- Antarctic oceans: 100
- Arctic Ocean: <1