Class 39 -- Food Webs

MATTER AND ENERGY TRANSFER IN MARINE ECOSYSTEMS

- **Ecosystems (Producers, Consumers, Decomposers)**
- **Food chains and food webs**
- **Efficiency of energy flow (Trophic pyramid)**

FACTORS CONTROLLING PRIMARY PRODUCTIVITY

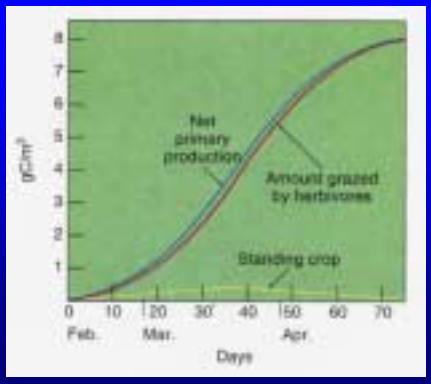
1. Sunlight- in two different ways

- **Photosynthesis**
- **Summer stratification, Winter mixing**
  - **–Summer: Warm surface waters- less dense, do not sink**
  - **–Winter: convection brings up nutrients**

3. Grazing by herbivores: Affects...

Phytoplankton biomass ("standing crop")

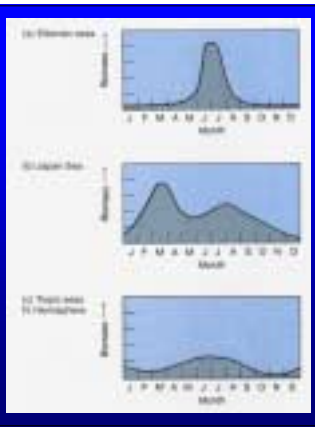
Rate of photosynthesis (i.e., productivity)



SEASONAL PRODUCTIVITY AND BIOMASS AT DIFFERENT LATITUDES

1. Polar oceans -- intense mid-summer "bloom"

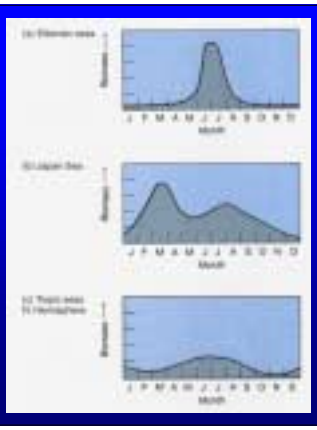
Productivity controlled by sunlight



Tropical oceans

Relatively constant but low productivity throughout the year

Productivity controlled by nutrient availability



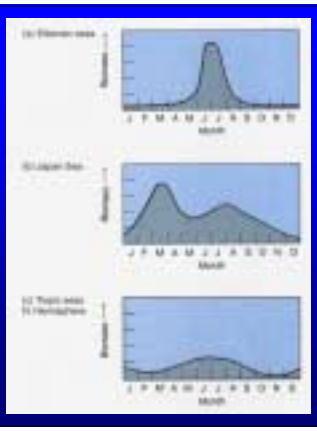
Mid-latitude oceans

Spring and autumn "blooms"

Winter:
- Nutrients are available, but sunlight is limiting

Spring:
- Increased sunlight and density stratification
- intense bloom

Summer:
- Zooplankton grazing reduces phytoplankton
- Nutrients are released --> second, less intense bloom

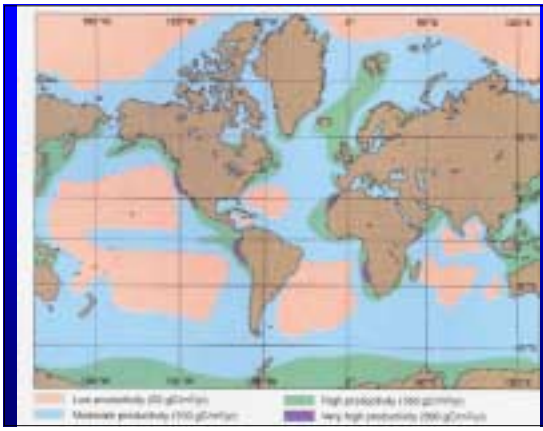


GLOBAL DISTRIBUTION OF PRIMARY PRODUCTIVITY (PP)

Open oceans
Low nutrients --> low PP

Polar and equatorial upwelling zones in open ocean
Good nutrient supply

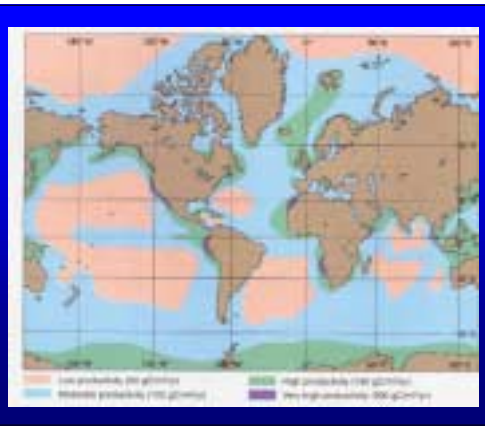
Continental shelves
High nutrient supply

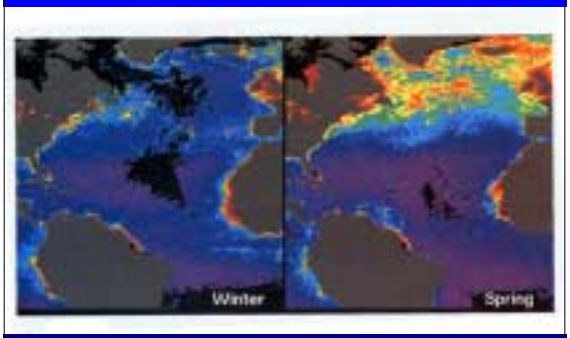


GLOBAL DISTRIBUTION OF PRIMARY PRODUCTIVITY (PP)

Coastal zones of intense upwelling at low latitudes
High nutrient supply

Estuaries and shallow coastal waters
Nutrients abundant
Photic zone extends to bottom: benthic algae





FOOD WEBS & MARINE ECOSYSTEMS

Food required for two separate needs:
- **Matter (for growth and reproduction)**
- **Energy (for metabolic processes)**

Ecosystem: **Community of plants and animals ... interactions between organisms and environment permit matter and energy transfer.**

Producers, Consumers, Decomposers

Primary Producers: . phytoplankton

Consumers: . heterotrophic animals
- –Primary consumers: herbivores
- –Secondary and higher-level consumers (carnivores, predators)

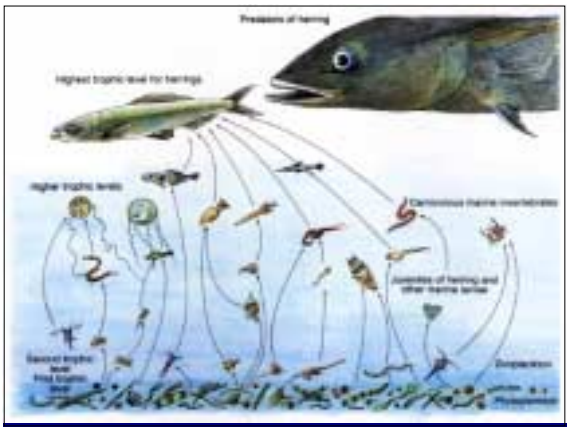
Decomposers: . bacteria (and fungi)
Completes the cycle

Energy and matter "flows" in a simple *food chain*

Trophic level	Name
4	Top carnivore
3	Carnivore
2	Herbivore
1	Autotroph

Example: food chain of herring in coastal oceans:

Trophic level	Name
4	Herring
3	Carnivorous Zooplankton
2	Herbivorous Zooplankton
1	Phytoplankton



Energy and matter pathways actually form a more complex *food web.*

Adult herring -- feeds on more than one level

Food webs more stable than simple food chains

-- greater variety of food organisms.

ENERGY + MATTER TRANSFER BETWEEN TROPHIC LEVELS

- Matter (organic substances, CO_2, O_2, nutrients) are cycled continuously between producers, consumers and decomposers.
  - –Examples: Cycles of P and N

- Energy flows in one direction:
  - -- Sun --> producers --> consumers --> decomposers

Energy utilization is not very efficient

- **1% of available solar energy is utilized by marine phytoplankton**
- **Most of the energy stored by producers (70-90%) is used by them**
- **Most of the energy in food eaten by consumers (70-90%) is used by them**
- **Remainder (10-30%) is available to consumers at next highest trophic level.**

Biomass at each trophic level is controlled by efficiency of energy transfer

--> Trophic Pyramid

- Lowest trophic level: high biomass; many small producers
- Highest trophic level: low biomass; few, large animals
- Examples of trophic-level efficiencies:
  - –Anchovy in coastal upwellings- 20%
  - –Tuna in open ocean- 10% + high level

Implications for harvesting marine fish as food resource:

Size of harvest depends on trophic efficiency and trophic level harvested.

FOOD RESOURCES

World fish catch increased 4-fold from l950 to l990

1953 - $23*10^6$ metric tons
1970 - $68*10^6$
1990 - $86*10^6$

Types of animals harvested:

88% fin fish
8% shell fish
4% crustaceans

Use of the harvest:

60% for human consumption
40% for oil, fishmeal for livestock and poultry

Importance to human diet:

1% of total food production
12% of total animal protein

Distribution of fishing areas controlled by:

1. Primary productivity -- rapid nutrient replenishment

2. Trophic structure ...
   ... number of trophic levels is low
   ... efficiency of energy transfer in food chain is high

Open Ocean Areas

Fisheries in upwelling zones in equatorial and polar oceans -- nutrient supply to surface waters.

But the harvest is fin fish (e.g., tuna) from high atop an inefficient food chain.

Coastal Areas

Nutrient supply and regeneration is good -- vertical mixing, runoff.

Harvest both pelagic fish (herring) and bottom fish (cod, hake, haddock in northern waters)

Shorter, more efficient food chain -- less energy expended by consumer organisms because of the higher population density of phytoplankton.

Upwelling Areas **-- west coasts of Americas and Africa**

High primary productivity.

Harvest small, fast-growing, phytoplankton-eating species that travel in dense schools, and are easy to catch: anchovies, sardines.

Short, very efficient food chains.