Productivity and fisheries

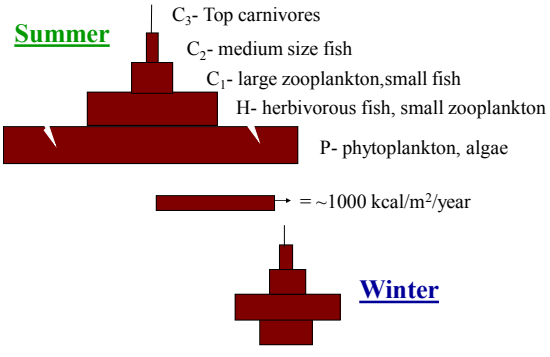
Why study production processes?

- Fisheries strongly tied to spatial and temporal variation in primary productivity
- Better understanding of distribution of fishery resources
- Interpret population dynamics

Energy flow

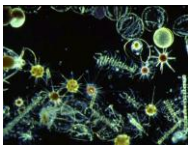
- Production begins with plants
- Fix carbon and transfer to higher trophic levels
- Energy flows through trophic interactions
- Food chains of various lengths (affects transfer efficiency)

Biological pyramids



Sources of marine production

About 90% of net primary production from phytoplankton (oceanic and coastal)



Macroalgae accounts for about 5%

Remaining from several sources (mangroves, reef algae, seagrasses, marsh plants)

Variation in marine production

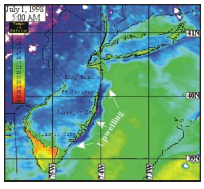
Fine scale processes

- sinking
- swimming
- turbulence
- Generate nutrient diffusion

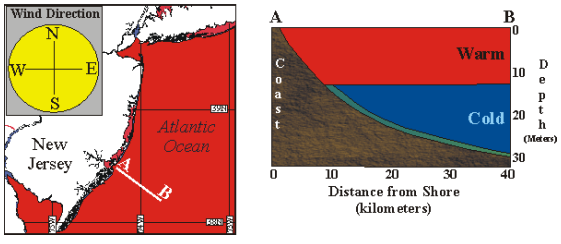
Ceratium

Large scale processes

- wind and mixing
- ocean circulation
- upwelling



The Basics of Coastal Upwelling
No Wind



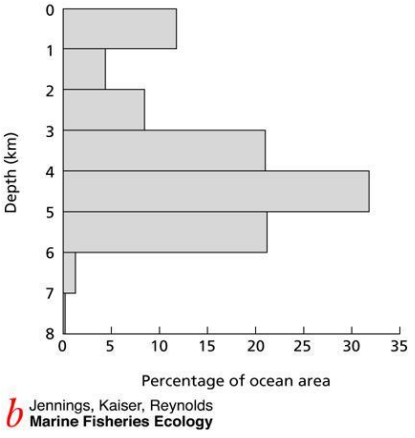
What are the limiting factors for primary productivity?

1) Light
2) Nutrients
   a. Phosphorous-phosphates
   b. Nitrogen- ammonia, nitrate, nitrite
   c. Potassium
3) Temperature
4) Dissolved gases - carbon dioxide and oxygen

What are the limiting factors for primary productivity?

Light limitation:

- The sea covers 71% of earth's surface, but most of it is at depths >1km
- Most production occurs over continental shelf waters < 200m deep (only 7-8% of ocean)



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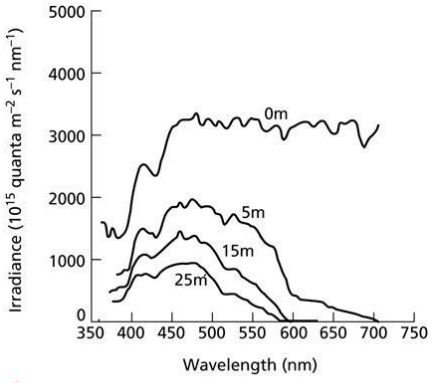
What are the limiting factors for primary productivity?

Light limitation:

- Available light levels fall rapidly with depth
- Longer wavelengths absorbed at surface
- Photosynthesis restricted to upper water column in turbid coastal areas



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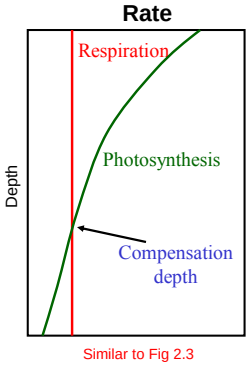
Compensation depth

Depth at which respiration rate equals photosynthetic rate

- shallow waters contain ample light, thus photosynthesis exceeds respiration
- deeper waters have less light penetration, thus respiration exceeds photosynthesis



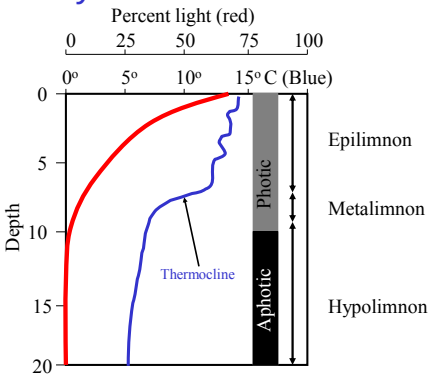
Similar to Fig 2.3

What are the limiting factors for primary productivity?

Temperature limitation:

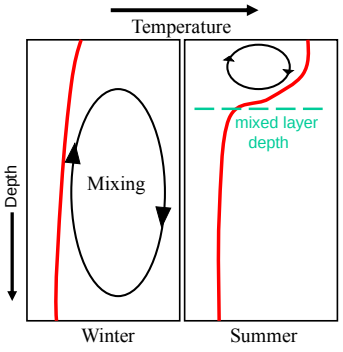
- In addition to light levels, temperature also decreases with depth
- Formation of thermocline
- Thermocline shifts seasonally depending on wind stress

Physical structure



Seasonal variation

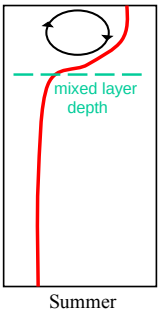
Differences in mixing among seasons changes the position of the thermocline



What are the limiting factors for primary productivity?

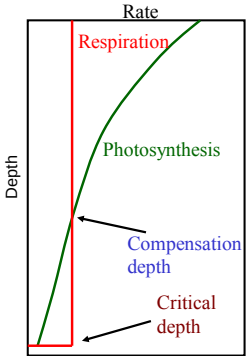
Nutrient limitation:

- Stratification prevents plankton from sinking below compensation depth, but also prevents nutrient transfer up from deep waters
- Leads to seasonal and spatial variation in production

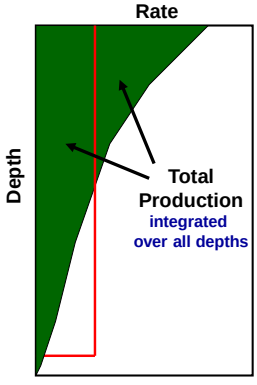


What causes the spring bloom?

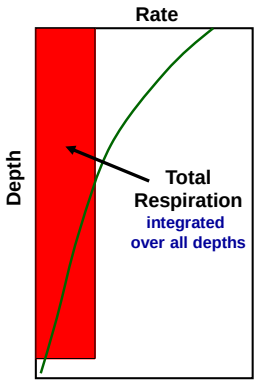
- Mixing followed by stratification
- Shallower mixed layer
- Plankton held in euphotic zone
- Population growth?



What causes the spring bloom?

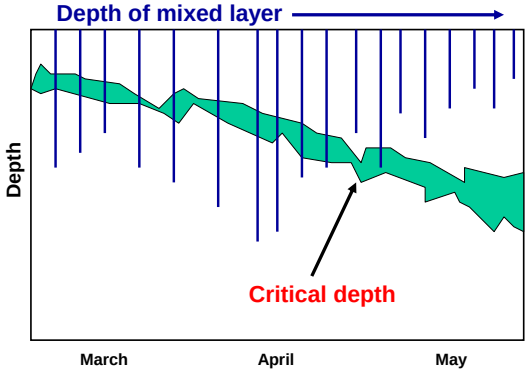


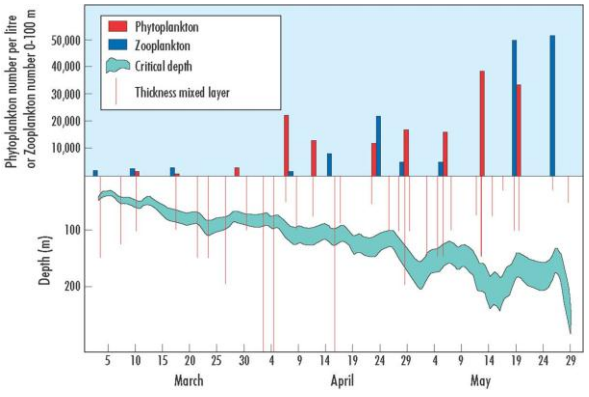
What causes the spring bloom?



What causes the spring bloom?

- Total production must be **>** total respiration for population growth to occur
- Respiration increases with depth, relative to production
- Critical depth (of mixed layer) exists where total production = total respiration
- Known as Gran effect or Sverdrup mechanism





Plankton Dynamics and Spatial Structure

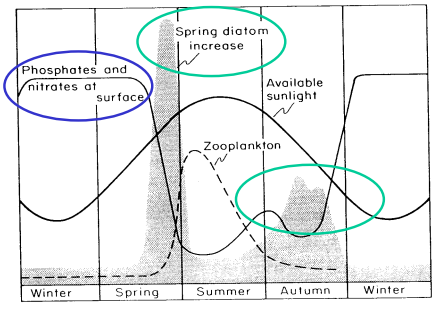
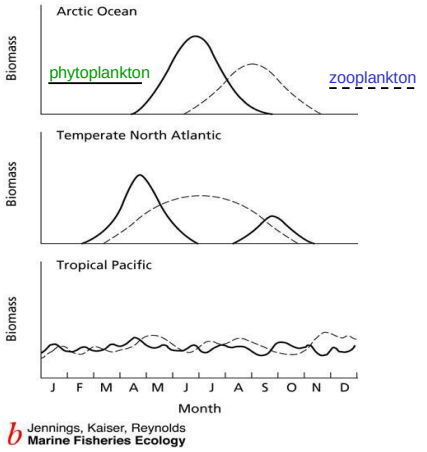


Figure 10-2 Idealized diagram tracing changes in plankton, light, and nutrients during the year in a temperate-boreal inshore body of water. (Modified after Russell Hunter, 1970)

Spatial and temporal variation in primary productivity

- Climate variation (temp, winds) leads to latitudinal variation in production
- Different seasonal patterns at temperate, polar, and tropical latitudes



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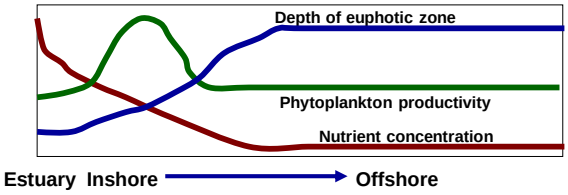
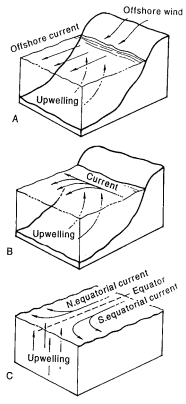
Change in structure offshore



Global scale variation in primary productivity

- Upwelling affects production by surfacing nutrients
- Generates global patterns of productivity

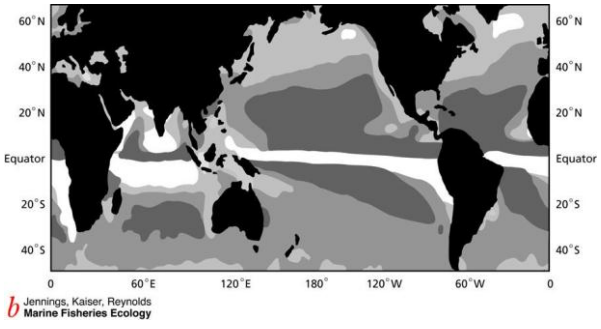


offshore winds

longshore currents

diverging currents

Figure 1.46 Conditions causing upwellings.



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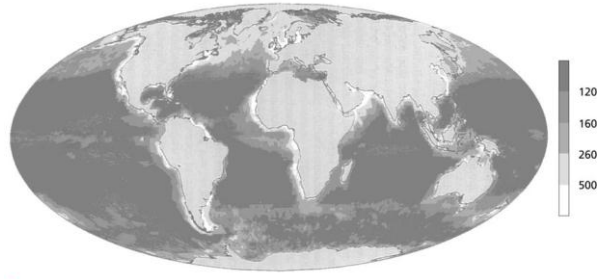

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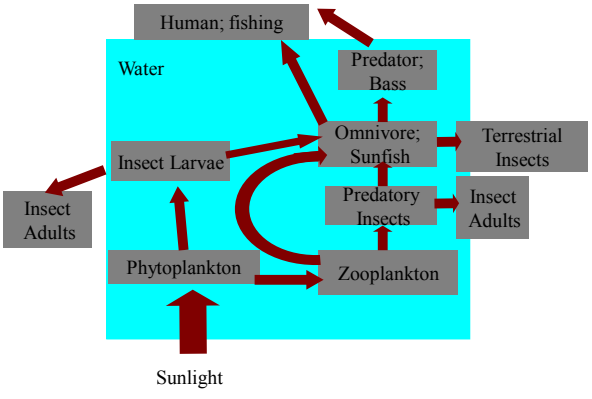
Transfer of energy (Food webs)

- **All organisms ultimately rely upon energy captured by primary producers**
- **Each step = 1 trophic level**
- **Carbon lost at each step, based on gross growth efficiency (GGE)**
- **Transfer Efficiency = GGE X % of prey eaten**

Lake food web



Production and fisheries

- Fish production thus depends on:
  1) levels of primary production
  2) length of the food chain
  3) transfer efficiency
- Highest catches (fish production) come from coastal and shelf areas

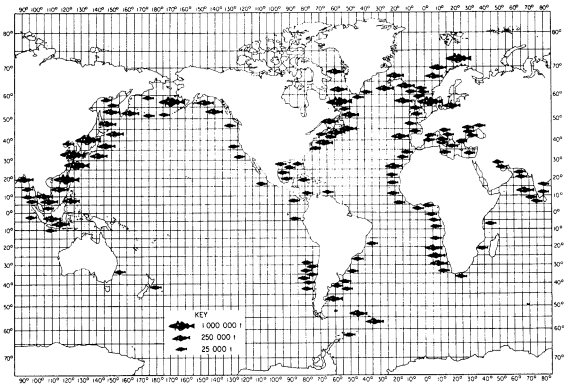
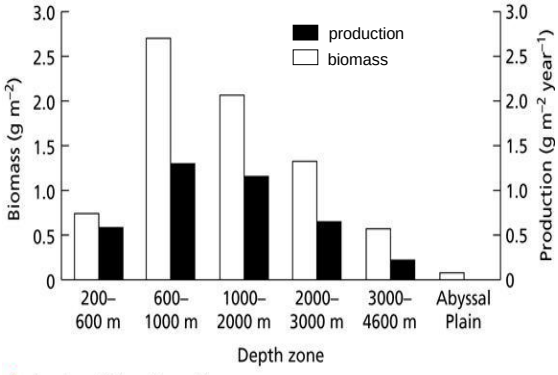


Fig. 15.3. Distribution of catches of demersal catches; note the concentrations of catches in certain areas, noticeably the North Pacific and North Atlantic. (from FAO 1972)



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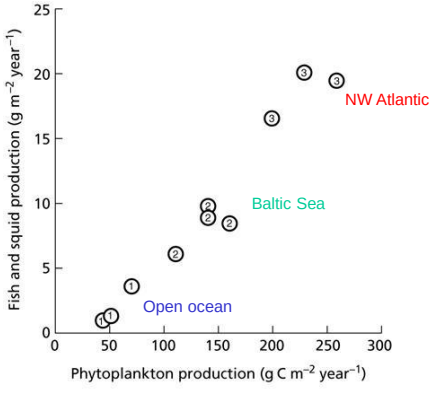

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Table 1.1 Possible mean yields (t/km^2/year)

Open ocean (temperate)	0.5
Open ocean (tropical)	0.02
Shallow banks (temperate)	3
Reefs (tropical)	4
Continental shelf (temperate)	2
Continental shelf (tropical)	6
Estuaries (temperate)	10
Estuaries (tropical)	15
Upwellings	18

Production and fisheries

- Five major coastal currents associated with upwelling areas
  - California current (US west coast)
  - Peru current (west coast of South America)
  - Canary current (NW Africa)
  - Benguela current (SW Africa)
  - Somali current (Indian ocean)
- Highly productive clupeid fisheries of major social and economic importance