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- 2  **Biological Productivity and Energy Transfer**
- 3  **Chapter summary in haiku form**  
Primary produce  
Sunlight and phytoplankton  
Ocean is garden
- 4  **Primary productivity**
  - Rate at which energy is stored in organic matter
  - Photosynthesis using solar radiation
  - Chemosynthesis using chemical reactions
  - 99.9% of marine life relies directly or indirectly on photosynthesis for food
- 5  **Photosynthetic productivity**
  - Chemical reaction that stores solar energy in organic molecules
- 6  **Photosynthetic productivity**
  - Gross primary production
    - Total amount of organic carbon produced by photosynthesis per unit time in certain area
  - Net primary production
    - Gross primary production minus cellular respiration (growth, reproduction)
  - New production
    - Nutrients added to local ecosystem (e.g., upwelling)
  - Regenerated production
    - Recycling of nutrients within ecosystem
- 7  **Measuring primary productivity**
  - Capture plankton
    - Plankton nets
  - Ocean color
    - Chlorophyll colors seawater
    - SeaWiFs on satellite
- 8  **Factors affecting primary productivity**
  - Nutrients
    - Nitrate, phosphorous, iron, silica
    - Most from river runoff
    - Productivity high along continental margins
  - Solar radiation
    - Uppermost surface seawater and shallow seafloor
    - Euphotic zone surface to about 100 m (330 ft)
    -
- 9  **Upwelling and nutrient supply**
- 10  **Light transmission**
- 11  **Light transmission**
  - Visible light of the electromagnetic spectrum
  - Blue wavelengths penetrate deepest
  - Longer wavelengths (red, orange) absorbed first
- 12  **Light transmission in ocean**
- 13  **Light transmission in ocean**
  - Color of ocean ranges from deep blue to yellow-green
  - Factors
    - Turbidity (suspended sediment) from runoff
    - Photosynthetic pigment (chlorophyll)
      - Eutrophic
- 14 

- High chlorophyll
- Oligotrophic
- Low Chlorophyll
- 15  **Light transmission in ocean**
  - SeaStar satellite/SeaWiFS view of ocean chlorophyll and land vegetation (productivity)
- 16  **Types of photosynthetic marine organisms**
  - Anthophyta
    - Seed-bearing plants
  - Macroscopic (large) algae
  - Microscopic (small) algae
  - Photosynthetic bacteria
- 17  **Anthophyta**
  - Only in shallow coastal waters
  - Primarily grasses and mangroves
- 18  **Macroscopic algae**
  - "Seaweeds"
  - Brown algae
  - Green algae
  - Red algae (most abundant and most widespread)
    - Varied colors
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- 23  **Microscopic algae**
  - Produce food for 99% of marine animals
  - Most planktonic
  - Golden algae
    - Diatoms (tests of silica)
    - Coccolithophores (plates of calcium carbonate)
  - Dinoflagellates
    - Red tide (harmful algal bloom)
    - Toxins
    - Fish kills
    - Human illness
    - 
    -
- 24
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- 28  **Photosynthetic bacteria**
  - Extremely small
  - May be responsible for half of total photosynthetic biomass in oceans
- 29  **Regional primary productivity**
  - Varies from very low to very high depending on
    - Distribution of nutrients
    - Seasonal changes in solar radiation
  - About 90% of surface biomass decomposed in surface ocean
  - About 10% sinks to deeper ocean
  - Only 1% organic matter not decomposed in deep ocean
  - Biological pump (CO<sub>2</sub> and nutrients to sea floor sediments)

- 30  **Polar ocean productivity**
- Winter darkness
  - Summer sunlight
  - Phytoplankton (diatoms) bloom
  - Zooplankton (mainly small crustaceans) productivity follows
  - Example
    - Arctic Ocean
- 31  **Polar ocean productivity**
- Availability of sunlight and
  - High nutrients due to upwelling of North Atlantic Deep Water
    - No thermocline
    - No barrier to vertical mixing
  - Blue whales migrate to feed on maximum zooplankton productivity
- 32  **Tropical ocean productivity**
- 33  **Tropical ocean productivity**
- Permanent thermocline is barrier to vertical mixing
  - Low rate primary productivity (lack of nutrients)
  - High primary productivity in areas of
    - Equatorial upwelling
    - Coastal upwelling
    - Coral reefs
      - Symbiotic algae
      - Recycle nutrients within the ecosystem
- 34  **Temperate ocean productivity**
- 35  **Temperate ocean productivity**
- Limited by both available sunlight and
  - Available nutrients
  - Highly seasonal pattern
    - Winter low (lots of nutrients, little sunlight)
    - Spring high (spring bloom)
    - Summer low (little nutrients, lots of sunlight)
    - Fall high (fall bloom)
- 36  **Regional productivity summarized**
- 37  **Energy flow in marine ecosystems**
- Ecosystem includes living organisms (biotic community) and environment
  - Solar energy converted to chemical energy by producers (mainly photosynthesis)
  - Consumers eat other organisms
    - Herbivores
    - Carnivores
    - Omnivores
    - Bacteriovores
  - Decomposers breaking down dead organisms or waste products
- 38  **Algae-supported biotic community**
- 39  **Nutrient flow in marine ecosystems**
- Nutrients cycled from one chemical form to another
  - Biogeochemical cycling
  - Example, nutrients fixed by producers
  - Passed onto consumers
  - Some nutrients released to seawater through decomposers
  - Nutrients can be recycled through upwelling

- 40  **Biogeo-chemical cycling**
- 41  **Feeding strategies**
- Suspension feeding or filter feeding
    - Take in seawater and filter out usable organic matter
  - Deposit feeding
    - Take in detritus and sediment and extract usable organic matter
  - Carnivorous feeding
    - Organisms capture and eat other animals
    -
- 42  **Feeding strategies**
- 43  **Trophic levels**
- Chemical energy is transferred from producers to consumers
  - Feeding stage is trophic level
  - About 10% of energy transferred to next trophic level
- 44  **Passage of energy between trophic levels**
- 45  **Food chain**                      **Food web**
- Primary producer
  - Herbivore
  - One or more carnivores
- 46 
- 47  **Biomass pyramid**
- Number of individuals and total biomass decrease at successive trophic levels
  - Organisms increase in size
- 48  **Symbiosis**
- Organisms associate in beneficial relationship
  - Commensalism
    - One benefits without harm to other
  - Mutualism
    - Mutually beneficial
  - Parasitism
    - One benefits and may harm the other
- 49  **Marine fisheries**
- 50  **Overfishing**
- Taking more fish than sustainable
  - Remaining fish young, small
  - About 30% of fish stocks depleted or overfished
  - About 47% fished at biological limit
- 51  **Incidental catch or bycatch**
- Non-commercial species taken incidentally by commercial fishers
  - Bycatch may be 25% or 800% of commercial fish
    - Birds, turtles, dolphins, sharks
    - Dolphin-safe tuna
  - Driftnets or gill nets banned in 1989
- 52  **Fisheries management**
- Regulate fishing
  - Conflicting interests
  - Human employment
  - Self-sustaining marine ecosystems
  - International waters
  - Enforcement difficult
- 53  **Fisheries management**


- Many large fishing vessels
- 1995 world fishing fleet spent \$124 billion to catch \$70 billion worth of fish
- Governments subsidize fishing

54  **Fisheries management**

- Northwest Atlantic Fisheries such as Grand Banks and Georges Bank
- Canada and U.S. restrict fishing and enforce bans
- Some fish stocks in North Atlantic rebounding
- Other fish stocks still in decline (e.g., cod)

55  **Fisheries management**

- Consumer choices in seafood
- Consume and purchase seafood from healthy, thriving fisheries
  - Examples, farmed seafood, Alaska salmon
- Avoid overfished or depleted seafood
  - Examples, tuna, shark, shrimp

56  **End of CHAPTER 13**

**Biological Productivity and Energy Transfer**