1 **CHAPTER 13**
Biological Productivity and Energy Transfer

2 **Chapter summary in haiku form**

Primary produce
Sunlight and phytoplankton
Ocean is garden

3 **Chapter Overview**

- Productivity is the same as photosynthesis, which is affected by sunlight and nutrients.
- Productivity is globally and seasonally variable.
- Feeding relationships are represented by food chains and food webs.
- Oceans are being overfished.

4 **Primary Productivity**

- Primary productivity is the rate at which energy is stored in organic matter.
- Photosynthesis uses solar radiation.
- Chemosynthesis uses chemical reactions.
- 99.9% of the ocean's biomass relies directly or indirectly on photosynthesis for food.
-

5 **Photosynthesis**

6 **Measurement of Primary Productivity**

- Directly – capture plankton in plankton nets
- Measure radioactive carbon in seawater
- Monitor ocean color with satellites
  - Green pigment chlorophyll
  - SeaWiFS
-

7 **Ocean Chlorophyll – SeaWiFS**

8 **Factors Affecting Primary Productivity**

- Nutrient availability
  - Nitrate, phosphorous, iron, silica
  - Most from river runoff
  - Productivity high along continental margins
  - *Redfield ratio* – C:N:P

9 **Factors Affecting Primary Productivity**

- Solar radiation
  - Uppermost surface seawater and shallow seafloor
  - Compensation depth – net photosynthesis becomes zero
  - Euphotic zone—from surface to about 100 meters (330 feet)
-

10 **Light Transmission in Ocean Water**

- Visible light of the electromagnetic spectrum
- Blue wavelengths penetrate deepest
- Longer wavelengths (red, orange) absorbed first
-

11 **Transmission of Light in Seawater**

12

13

14 **Color in the Ocean**

- Color of ocean ranges from deep blue to yellow-green
- Factors
  - Turbidity from runoff

  - Photosynthetic pigment (chlorophyll)
    - Eutrophic
    - Oligotrophic
- Secchi Disk – measures water transparency
-

15 **Upwelling and Nutrient Supply**
- Cooler, deeper seawater is nutrient-rich.
- Areas of coastal upwelling are sites of high productivity.
-

16
17 **Upwelling and Nutrient Supply**
18 **Types of Photosynthetic Marine Organisms**
- Anthophyta
  - Seed-bearing plants
- Macroscopic (large) algae
- Microscopic (small) algae
- Photosynthetic bacteria
-

19 **Anthophyta**
- Only in shallow coastal waters
- Primarily grasses and mangroves
-

20 **Anthophyta**
- Only in shallow coastal waters
- Primarily grasses and mangroves

21 **Macroscopic Algae**
- "Seaweeds"
- Brown algae
- Green algae
- Red algae
  - Most abundant and most widespread
  - Varied colors
-

22
23
24
25
26 **Microscopic Algae**
- Produce food for 99% of marine animals
- Most planktonic
- Golden algae
  - Diatoms – tests made of silica
  - Coccolithophores – plates of calcium carbonate
- Dinoflagellates
  - Red tide (harmful algal bloom)
  - Toxins
  - Fish kills
  - Human illness
-

27 **Microscopic Algae**
28

29
30
31
32 **Photosynthetic Bacteria**
- Extremely small
- May be responsible for half of total photosynthetic biomass in oceans
- Exert critical influence on marine ecosystems
-

33 **Regional Primary Productivity Variations**
- Values range from 1 gC/m^2/year to 4000 gC/m^2/year based on:
  - Uneven distribution of nutrients
  - Changes in availability of sunlight
- 90% of biomass from euphotic zone decomposes before descending

34 **Regional Primary Productivity Variations**
- Only 1% of organic matter is not decomposed in the deep ocean.
- Biological pump – moves material from euphotic zone to sea floor
- Subtropical gyre thermoclines and pycnoclines prevent the resupply of nutrients to the surface.
-

35 **Polar Ocean Productivity**
- Winter darkness
- Summer sunlight
- Phytoplankton (diatoms) bloom
- Zooplankton (mainly small crustaceans) productivity follows
- Example: Arctic Ocean's Barents Sea

36 **Polar Ocean Productivity**
- Antarctic productivity slightly greater than Arctic
- North Atlantic Deep Water upwells near Antarctica
- Productivity decrease from UV radiation – ozone hole

37 **Polar Ocean Productivity**
- Isothermal waters – little mixing
- Plankton remain at surface
- Blue whales migrate to feed on maximum zooplankton productivity.
-

38 **Productivity in Tropical Oceans**
- Permanent thermocline is barrier to vertical mixing
- Low rate of primary productivity – lack of nutrients
-

39 **Productivity in Tropical Oceans**
- High primary productivity in areas of
  - Equatorial upwelling
  - Coastal upwelling
  - Coral reefs
    - Symbiotic algae
    - Recycle nutrients within the ecosystem

40 **Temperate Ocean Productivity**
- Productivity limited by
  - Available sunlight
  - Available nutrients
-

41 **Temperate Ocean Productivity**
- Highly seasonal pattern
- Winter low
  - Many nutrients, little sunlight
- Spring high
  - Spring bloom
- Summer low
  - Few nutrients, abundant sunlight
- Fall high
  - Fall bloom
-

42 **Temperate Ocean Seasonal Cycle**

43 **Comparison of Global Productivities**

44 **Energy Flow in Marine Systems**
- Biotic community – assemblage of organisms in definable area
- Ecosystem – biotic community plus environment
- Energy flow is unidirectional based on solar energy input.

45 **Energy Flow in Marine Systems**
- Three categories of organisms:
- Producers
  - Nourish themselves with photosynthesis or chemosynthesis
  - Autotrophic
- Consumers
  - Eat other organisms
  - Heterotrophic
- Decomposers – break down dead organisms or waste
-

46 **Energy Flow in Marine Systems**

47 **Consumers in Marine Ecosystems**
- Herbivores – eat plants
- Carnivores – eat other animals
- Omnivores – eat plants and animals
- Bacteriovores – eat bacteria

48 **Nutrient Flow in Marine Ecosystems**
- Biogeochemical cycling
-

49 **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
  - Capture and eat other animals
-

50 **Feeding Strategies**

51 **Trophic Levels**
- Feeding stage
- Chemical energy transferred from producers to consumers
- About 10% of energy transferred to next trophic level
- Gross ecological efficiency

52 **Trophic Levels**

53 **Ecosystem Energy Flow and Efficiency**

54 **Food Chains**
- Primary producer
- Herbivore
- One or more carnivores
-

55 **Food Webs**
- Branching network of many consumers
- Consumers more likely to survive with alternative food sources
-

56 **Biomass Pyramid**
- The number of individuals and total biomass decreases at successive trophic levels.
- Organisms increase in size.
-

57 **Marine Fisheries**
- Commercial fishing
- Most from continental shelves
- Over 20% from areas of upwelling that make up 0.1% of ocean surface area
-

58 **Overfishing**
- Fish from standing stock – the mass present in the ecosystem at any given time
- Overfishing – fish stock harvested too rapidly, juveniles not sexually mature to reproduce
- Reduction in Maximum Sustainable Yield (MSY)

59 **Exploitation Status of Marine Fish**

60 **Overfishing**
- 80% of available fish stock fully exploited, overexploited, or depleted/recovering
- Large predatory fish reduced
- Increased fish production, decreased stocks

61 **Incidental Catch or Bycatch**
- Non-commercial species are taken incidentally by commercial fishers.
- Bycatch may be up to 8 times more than the intended catch.
  - Birds, turtles, dolphins, sharks

62 **Tuna and Dolphins**
- Tuna and dolphins swim together
- Caught in purse seine net
- Marine Mammals Protection Act addendum for dolphins
- Driftnets or gill nets banned in 1989

63 **Purse Seine Net**

64 **Fisheries Management**
- Regulate fishing
- Conflicting interests
- Human employment
- Self-sustaining marine ecosystems
- International waters
- Enforcement difficult

65 **Fisheries Management**
- Many large fishing vessels
- Governments subsidize fishing
- 1995—world fishing fleet spent $124 billion to catch $70 billion worth of fish
-

66 **Fisheries Management**

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

67 **Fisheries Management Effectiveness**

68 **Fisheries Management**

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

69 **Seafood Choices**

70 **End of CHAPTER 13**

Biological Productivity and Energy Transfer