Life in the Ocean: Marine Plants and Animals

Energy Transfer

Food Web Dynamics

Reading:

13.2-13.4, 13.6-13.8

14.2, 14.4, 14.7-14.9, 14.11- 14.12

Graphics: (top) "Mystery Squid", NOAA and Science, (middle) Lima sea star, K.Evans, photographer. Courtesy of National MarineSanctuaries Photo Gallery. (bottom) Red shrimp. National Ocean Service Photo Gallery.

Flows of Energy

Energy flows from the sun to organisms and is ultimately lost

Producers - build organic material from sunlight (photosynthesis)

Consumers - use organic material for energy (respiration)

Graphic: Garrison, Fig. 13.3.

Cycles of Matter

Matter cycles between producers and consumers

Products of photosynthesis are used for respiration

Products of respiration are used for photosynthesis

Graphic: Garrison, 4th Ed., Fig. 14.2.

Photosynthesis

Photosynthesis binds energy into large organic molecules:

sunlight

$6\ CO_2\ +\ 6\ H_2O$ $C_6H_{12}O_6\ +\ 6\ O_2$

carbon dioxide **water** **glucose (carbohydrate)** **oxygen**

- Done by <u>plants during sunlit hours</u>

- The basis for most life on Earth

Graphics: Top: Marsh plant, South Carolina. NOAA National Estuarine Reserve Collection. Bottom: Red algae. National Museum of Natural History and the Smithsonian Institution.

Respiration

Respiration converts organic matter to energy:

$C_6H_{12}O_6\ +\ 6\ O_2$ $6\ CO_2\ +\ 6\ H_2O$ + chemical energy

glucose oxygen carbon dioxide water

- Energy used for metabolism, movement, maintaining body heat

- Done by both plants and animals

Graphic: Top: Emperor penguins ,
M. Van Woert, photographer.
Bottom: Moonrise on Hobart Bay,
Cmdr. J. Bortnaik, photographer.
Courtesy of NOAA.

Terrestrial (Land) and Marine Plants

Both need sunlight, CO_2, nutrients and water, but...

- Land plants access water and nutrients via roots (favors large plants)

- Most ocean plants need to float to remain within the sunlit zone (favors very small plants)

Graphic: Pinet, Fig. 14.9.

Comparison of Marine and Land Plants

Property	Land Plants	Marine Plants
Obtaining nutrients	roots	exchange across cell walls
Obtaining sunlight	expansive leaves	float in euphotic zone
Structural support	trunks, stems	little or none required
Size	usually large	usually small

Graphics: (left) Coastal forest, courtesy of NOAA, (right) C.Wighamii, National Ocean Service Photo Gallery.

Phytoplankton - Small Marine Plants

- Small and free-floating

- Energy obtained via photosynthesis

- Very abundant, 90-96% of total ocean primary productivity

Small size allows:

- diffusion of nutrients into cells and transfer of wastes out

- efficient use of cellular material

Graphic: Phytoplankter. Courtesy of NASA Goddard Space Flight Center.

Diatoms - Phytoplankters Living in Glass Houses

- Dominant type of phytoplankton

- Forms silica "shells"

- Store energy as oils (floatation)

- Free floating (no locomotion)

- Can live singly or form long chains

Graphic: Diatom morphology, courtesy of the SeaWiFS project, NASA/GSFC and ORBIMAGE.

Coccoliths

Single-celled plants covered with calcium carbonate disks

Turn seawater "milky" during blooms

Shells can form thick sedimentary deposits

Graphics: Coccoliths, courtesy of the SeaWiFS project, NASA/GSFC and ORBIMAGE.

Dinoflagellates

Single-celled plants that use flagella

(whiplike appendedges) to adjust position and orientation

Many species are

toxic and can

cause harmful

algal blooms

Graphics: (top) Dinoflagellate.

Courtesy NASA Goddard Space

Flight Center, (center) Garrison, pg 391, (bottom) courtesy of the

SeaWiFS project and

NASA/GSFC.

Primary Productivity

Primary productivity = synthesis of organic matter from inorganic substances

Expressed in grams of carbon per unit area per unit time (grams/meter^2/day or grams/meter^2/year)

Graphic: Garrison, Fig. 13.5a.

Variations in Primary Productivity

Primary productivity is regionally variable

Some of the most productive ecosytems on Earth are marine

Graphic: After Garrison, Fig. 13.5c.

Marine Plants – Limited by Light

The <u>vertical</u> distribution of marine plants is controlled by the availability of light

Below the euphotic zone, there is not enough light for photosynthesis

The depth of the euphotic zone depends on water clarity (the amount of suspended material in the water)

Graphic: Garrison, Fig. 13.14.

Marine Plants – Limited by Nutrients

The <u>geographic</u> distribution of marine plants is controlled by the availability of

nutrients

Regions with low nutrients have few phytoplankton

High nutrients:

- polar regions

- upwelling zones

Graphic: Distribution of phosphate (a nutrient) in the surface ocean.

Seasonal Patterns of Primary Productivity Are Controlled by Light and Nutrients

Tropical regions have nearly constant production through the year

Mid-latitudes (temperate regions) have fall and spring blooms

Polar regions have short summer growing seasons

Graphic: (left) See Garrison, Fig. 14.13 (green lines), (right) plant pigment concentration in the ocean, provided by the SeaWiFS Project, NASA/Goddard Space Flight Center and ORBIMAGE, see Garrison Fig. 13.6.

The Spring Bloom

The shift from winter to spring is marked with an explosion in the abundance of marine phytoplankton

Conditions needed:

- abundant light, nutrients

- warm, calm conditions

- low grazing rates by animals

Graphics: Ocean color (top) Feb 2001, (bottom) May 2001. Images courtesy of SeaWiFS and Orbimage. (animation)

Marine Food Webs

Graphic: Garrison, Fig. 13.9.

Trophic Transfers

Only about 10% of food is stored in consumers as flesh

- each trophic step is about 10% of the mass of the step below

- large organisms are less common than small organisms

- most marine communities depend on plants for their “base”

Graphic: Garrison, Fig. 13.8.

Phytoplankton and Zooplankton

"Plankton" – drifting or weakly swimming organisms, can be plants or animals

<u>Phytoplankton</u>

- marine plants

- primary producers (photosynthesizers)

- the base of many marine food webs

<u>Zooplankton</u>

- marine animals

- primary consumers (plant eaters)

- the 1st animal link in many marine food webs

Graphics: (top) C. Wagami, courtesy of NOAA, (bottom) copepod with eggs, photo by R.Hopcroft, Univ. Alaska, Fairbanks, courtesy of NOAA.

Suspension Feeders

Suspension ("filter") feeders eat particles that are suspended in the water column

Typical foods: phytoplankton, small bits of dead organic matter

Require flow-through of water in order to filter out food

- active pumping (sponges)

- natural water motion due to waves or currents

- swimming (zooplankton)

Graphics: (top) Christmas tree worms Spirobranchus giganteus photo by J. Guttuso, courtesy of NOAA, (bottom) Garrison, Fig. 15.3b.

Scavengers and Deposit Feeders

Consumers (Predators)

Many medium-size and large organisms hunt for food

Predation strategies:

- foraging (actively moving in search of prey)

- ambushing ("sit and wait" –works best when metabolism is low or prey is abundant)

- cooperative hunting (hunting as a group)

Predators can exert strong pressure on lower levels of the food web

Graphic: (top) Nurse shark, (bottom) Moray eel, courtesy of NOAA Photo Library.

Apex Predators at the Top of the Food Web

Apex predators have evolved very effective hunting strategies

Sharks have excellent sensory systems

- smell

- vision

- lateral line (detects vibrations)

- electroreceptors (detect small variations in electrical currents)

Orcas ("killer whales") are very intelligent and hunt cooperatively in groups

Graphics: (top) White shark, photo by S. Anderson, (bottom) Orcas, courtesy of NOAA.

Apex Predators - Vulnerable to Predation by Humans

Because most apex predators produce few and infrequent young, populations of these animals can be depleted by overfishing

Example – sharks:

- many years to maturity

- have few young

- many sharks need specific habitats for their young which are different from adult habitats

Graphics: White shark, photo by S. Anderson, courtesy of NOAA.

Abyssal Giants

Preview of Next Lecture

Ecological Interactions in Coastal and Open-Ocean Marine Communities

Reading: 16.2-16.13, 16.16- 16.17, 16.20, 15.25, 9.12

Graphic: Black rockfish in a kelp bed. Photograph by Kip Evans. Monterey Bay Naional Marine Sanctuary Colllection. Courtesy of NOAA
Kelp forest, S. Fisher courtesy of National Marine Sanctuaries and NOAA.