**Marine Resources**

- The oceans provide modern society with numerous resources.
- These resources include mineral deposits, oil and gas, electrical energy, food from marine animals and plants, transportation, and recreation.
- Resources must be properly managed to be sustainable for ourselves and future generations.
- Unfortunately, many types of marine resources have been mismanaged and over-exploited, and their future sustainability is uncertain.
- Choices we make can help protect marine resources!

**Some Important Concepts**

- Marine resources may be categorized as:
  1. Physical resources include *petroleum and natural gas*, which form from the buried remains of marine plankton. This category also includes many kinds of *minerals*, as well as *fresh water* extracted from seawater by desalination.
  2. Other energy resources include several methods of generating electrical power from waves and currents, wind, tides, and thermal gradients in the oceans.
  3. Biological resources are marine animals and plants harvested for food and other uses. The commercial fishing industry has fished many commercial fish stocks beyond their maximum sustainable yield.
  4. Nonextractive resources include use of the oceans for transportation and recreation.
- Renewable resources are replaced by natural processes, while nonrenewable resources are present in fixed amounts and are not replaced (or at least are replaced extremely slowly, much more slowly than humans are extracting and using them).
- *Laws of the Sea* govern the rights of countries in using the ocean and its resources.
1a. Petroleum & Natural Gas

Petroleum (crude oil) and natural gas pumped from offshore drilling platforms contributes substantially to the world supply of these products.

- Offshore drilling currently accounts for ~30% of total world production
- This is likely to increase in future...
- Deeper ocean to be exploited...

Petroleum & Natural Gas

Crude oil and gas form from the decomposition and chemical transformation of organic material in marine sediments. They are, literally, FOSSIL FUELS.

The first step in oil formation is for large amounts of plankton to accumulate on the sea floor in areas of low oxygen (so there are few scavengers to consume the accumulating organic matter). The plankton-rich deposits gradually get buried to greater and greater depths, and over time the increasing heat and pressure transform this organic material into crude oil. Further heat and pressure cause natural gas to form. Most oil forms at depths within two miles from the surface; most gas forms at slightly greater depths.

Oil and gas, being lighter than rock or sediment, naturally migrate upward once formed deep underground. Therefore, once oil and gas form, they must be trapped in some way, or they will leak upward and escape.

Petroleum & Natural Gas

As they migrate upward, oil and gas may become trapped under impermeable rock layers, called cap rock. The oil and gas accumulate in these traps, forming a reservoir. Locating such reservoirs and extracting the oil and gas contained there is the goal of oil companies.

The oil in a reservoir occurs not in large underground pools, but in small spaces (called pores) within the underground rock formations.
1b. Mineral Resources

In dollar value, oil and natural gas are currently the most valuable physical resources we get from the ocean. But many mineral resources are also important.

- Sand and gravel - second in economic value to oil and gas
- Methane hydrate - potentially important future source of gas
- Metallic sulfides - source of zinc, copper, lead, silver, cadmium
- Manganese nodules - source of manganese, cobalt, nickel
- Salts - from evaporation ponds; used in food & manufacturing
- Etc!
Methane Hydrates

See Fig. 15.5, p. 352

Divergent & Convergent Plate Margins:
Metallic Sulfides

Manganese Nodules
Manganese Nodules

- Halite = table salt
- Gypsum = building material
- Chemical industrial uses

Evaporative Salts
Desalination - removal of dissolved salts from sea water - provides a critical source of fresh water in many arid countries of the world. There are several methods of desalination. The figure above shows one simple and low-cost method. Solar energy heats the seawater, causing water molecules to evaporate (form water vapor), leaving salt behind. The fresh water condenses on the insides of the covers and is collected.

Reverse Osmosis

See Fig. 15.8, p. 354
2. Other Energy Resources

The oceans represent a potentially huge source of electrical power. There are several sources of energy that can be harnessed for electrical power:

- The movement of waves and currents
- The wind
- Local tides
- The thermal gradient (the temperature difference between shallow water and deep water), known as ocean thermal energy conversion or OTEC

2a. Waves & Currents

Waves and currents are primarily caused by winds, and winds are caused by uneven solar heating of Earth’s surface. Trapping this “stored solar energy” can be done in number of ways.

One example is shown in this figure: Waves hitting the breakwater cause trapped water to rise and fall, like a piston, forcing air through a shaft and turning a turbine, generating electricity.
2b. Wind

See Fig. 15.9, p. 355
Bay of Fundy, Nova Scotia, Canada
(NASA image)

Highest tides on Earth occur here - Tidal range can reach 16 meters!

“Like a father pushing his daughter on a swing, the gentle Atlantic tidal pulse pushes the waters of the Bay of Fundy—Gulf of Maine basin at nearly the optimum frequency to cause a large to-and-fro oscillation.”

2d. Thermal Gradient

While waves and currents represent the most obvious source of electrical power from the oceans, far more potential power output is represented by the thermal gradient between deep and shallow water.

An ocean thermal energy conversion (OTEC) plant consists of circulating ammonia. The warm surface water vaporizes the ammonia, which causes it to expand and create pressure to turn a turbine generator. The vaporized ammonia is then condensed by cold water from below the thermocline, and pumped back to the vaporizer.

3. Biological Resources

Biological resources represent all the animals and plants that we harvest from the sea, primarily for food.

Marine sources of food provide a significant proportion of the human population’s protein intake. Fish, crustaceans, and mollusks constitute the majority of the world’s commercial marine harvest.

Commercial fishing is a multi-billion dollar industry, and is the most dangerous job in the U.S., having the highest death rate of any profession! Highly technological equipment is employed in an ever-increasing effort to catch an ever-dwindling resource.

Biological Resources

Major types of commercially harvested fish, mollusks, and crustaceans.
http://www.mbayaq.org/cr/seafoodwatch.asp

**Fisheries Management**

- **Difficulties**
  - Regulation of fishing vessels
  - Catch limits
  - Many countries
  - Migrating fish
  - Weather/climate
  - Human activities in one area impact another
  - Economic concerns of fishers

**Primary Productivity & Fisheries**

- **Relationship to nitrogen influx**
  - More nitrogen at upwelling
  - Duration of upwelling
  - Rates of upwelling
    - Moderate
    - Too slow
    - Too fast
Evidence that people have pushed fisheries beyond their limits is suggested by this graph. It shows that the average per capita world fish catch reached a peak in the late 1980s, and has been declining ever since. This decline is occurring in spite of increasing population growth and ever-increasing efforts to catch more fish! Simply put, fishermen (and women) are working harder than ever to catch fish, but are catching less. This decline is projected to continue in this century.

Fisheries Management

Excessive harvesting of many commercial fish stocks means that today we may be close to the catastrophic collapse of many fisheries.

Some key concepts relating to fishery management:
- Maximum sustainable yield - the maximum amount of any species that can be harvested without affecting future yields.
- Overfished - a status assigned to fish stocks that have been harvested so thoroughly that there are not enough individuals left to provide breeding stock to replenish the species.
- Commercial extinction - the depletion of a species to the point where it is no longer profitable to harvest.
- By-kill - animals unintentionally killed when other species are being harvested during commercial fishing.
Fisheries Management

By-kill refers to animals unintentionally killed during commercial fishing. Tremendous amounts of by-kill occur during many fishing operations. One of the main causes of by-kill are drift nets: large, vertically suspended floating nets that snare nearly anything that runs into them. Turtles, seals, dolphins, and many non-commercial fish species are killed by the thousands in these nets each year.

See Figs. 15.16&15.17, p. 360
Whaling

Commercial fishing also includes whaling. The whaling industry has pushed most of the species of great whales to the brink of extinction. 8 of the 11 species of large whales once hunted are now commercially extinct.

This graph shows the serial decline in whales caught during a 50-year span beginning in 1940. As one species was hunted to commercial extinction, whalers switched to hunting another species, then another...

Pharmaceuticals from the Sea

Research on marine sources of new drugs is a vital and growing industry.

Researchers estimate that 10% of marine species may contain useful medical compounds!

Examples:

Acyclovir, the first anti-viral compound approved for humans, is derived from a Caribbean Sea sponge.

Pseudopterosins, a class of anti-inflammatory drugs, is derived from marine species.

A number of chemicals that show promise as anti-cancer drugs have been extracted from marine species.

4. Nonextractive Resources

“Nonextractive” resources refer to various uses that do not involve physically taking something out of the oceans.

- Transportation - Millions of tons of goods, and nearly half of the world’s crude oil, is transported across the oceans in ships. Oil, iron, coal, and grain make up about 80% of the total value of materials transported by ships.

- Recreation - Tourism, sport fishing, surfing, beach-going, scuba diving, aquariums and marine parks represent billions of dollars in commerce.

The Law of the Sea

Through human history the oceans were traditionally viewed as open territory (Mare Liberum), belonging to no one and available to all for transportation and resource extraction.

The International Law of the Sea, an international agreement to which most nations are now bound, currently governs use of the oceans. The Law recognizes the following regions for any nation:

- Territorial waters - coastal jurisdiction - extending 12 miles from shore, over which a nation has exclusive control.

- Exclusive economic zone (EEZ) - extending 200 miles from shore, in which a nation has control over all resources, but cannot limit transportation and passage.

- High seas - areas beyond EEZs, which are the common property of all countries.
World Exclusive Economic Zones are shown in blue. The United States EEZs are shown in red. The United States EEZ covers 10.3 million square kilometers -- an area about 1/3 larger than the land area of the entire USA!
“5-Minute Write”

Summarize the main points of today’s lecture.
List 3 to 5 questions you have, based on today’s lecture.
What did you find most interesting about today’s lecture?
How was the lecture relevant to you?
Table 17.1 World Commercial Catch of Aquaculture Yield for 2001

<table>
<thead>
<tr>
<th>Species Group</th>
<th>Millions of Metric Tons, Live Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Herring, sardines, anchovies</td>
<td>20.5</td>
</tr>
<tr>
<td>Carps, barbels, cyprinids</td>
<td>17.0</td>
</tr>
<tr>
<td>Cod, hakes, haddocks</td>
<td>9.2</td>
</tr>
<tr>
<td>Tunas, bonitos, billfishes</td>
<td>5.8</td>
</tr>
<tr>
<td>Salmons, trouts, smelts</td>
<td>2.6</td>
</tr>
<tr>
<td>Tilapias</td>
<td>2.1</td>
</tr>
<tr>
<td>Other fishes</td>
<td>44.9</td>
</tr>
<tr>
<td>Shrimps, crabs, lobsters, krill</td>
<td>5.7</td>
</tr>
<tr>
<td>Mollusks (oysters, scallops, squid, etc.)</td>
<td>18.6</td>
</tr>
<tr>
<td>Sea urchin, other echinoderms</td>
<td>0.1</td>
</tr>
<tr>
<td>Total for all marine sources, excluding marine mammals, marine algae, and aquatic plants</td>
<td>130.2</td>
</tr>
</tbody>
</table>

© 2006 Thomson - Brookes/Cole

Fig. 15.6, p. 353
See Fig. 15.19, p. 361
Fig. 15.20, p. 361
Seaweed Harvesting