Class 40
FOOD RESOURCES OF THE OCEANS
World Fish Catch
Dynamics of fish populations and fishing
Over-exploited fisheries
Potential harvest of fish
Increasing fish production

**Recent history of marine food production:**
World fish catch increased 4-fold from 1950 to 1990
- 1953: 23 Million Metric Tons
- 1970: 68 Million Metric Tons
- 1990: 86 Million Metric Tons

Increase is leveling out, despite more technology and greater intensity of fishing.

**Types of animals harvested:**
- 88% fin fish
- 8% shell fish
- 4% crustaceans

**Use of the harvest:**
- 60% for human consumption
- 40% for oil, fishmeal for livestock and fish farms (!)

**Importance to human diet (not huge):**
- 1% of total food production
- 16% of total animal protein

**Distribution of fishing areas: Controlled by:**
1. Primary productivity -- nutrient availability
2. Trophic structure. More fish produced if...
   - number of trophic levels is low
   - efficiency of energy transfer in food chain is higher

**Open Ocean Areas- Small Harvest**
- Fisheries in upwelling zones: equatorial and polar -- moderate nutrient supply
- But the harvest is fin fish (e.g., tuna) from high atop an inefficient food chain.

**Coastal Areas: Large Harvest**
- Nutrient supply and regeneration is good-
  - runoff from land
  - Shallow water- nutrients retained, recycled
- Harvest both pelagic fish (herring) and bottom fish (cod, hake, haddock in northern waters)
- Shorter, more efficient food chain -- less energy expended by consumer organisms because of the higher population density of phytoplankton.

**Upwelling Areas -- West coasts of Americas and Africa**
- Very high primary productivity.
- Harvest small, fast-growing, phytoplankton-eating species that travel in dense schools, and are easy to catch: anchovies, sardines.
- Short, very efficient food chains.
DYNAMICS OF FISH POPULATIONS AND FISHERIES MANAGEMENT

Recent history of marine food production:
- 4-fold increase in past four decades.
- Increase is leveling out, despite more technology and greater intensity of fishing.
- Declines in many traditional fisheries.

Important questions to address:
- What controls the size of fish stocks?
- Effect of fishing on the population of fish stocks?
- Effects of over-fishing?

Steady-state biomass of a population of fish: Gains = Losses
- Without human impact (balance):
  - Growth of individuals + reproduction (new members) = deaths + natural predation
- Effects of fishing: add human predation --> decrease steady-state population

Harvesting decreases the average age and size. This leads to decrease in harvest, but not immediately…
  1. Older, larger fish taken first --> increased growth of younger fish --> net growth of population.
  2. To maintain yield, smaller & younger fish (breeding population) are taken.
  3. Reproduction decreases, yield decreases; population may not rebound even if fishing stops -- Over-fishing!

Important question: What is the "maximum sustainable yield?"
- Not known for most commercial fish stocks.
- Estimates range from 1/3 to 2/3 of total production

EXAMPLES OF OVER-EXPLOITATION
1. Peruvian anchovies.
   - Over-fished at peak harvest (1970; 12 million metric tons)
   - Devastating 1972 El Nino
   - Decrease to 2 million metric tons per year
   - Recent recovery…
     - 9.7 million metric tons in 1994
     - Dropped after 1997 El Nino
     - Rapid Recovery in 1999 and 2000

2. Pacific Salmon -- Overfishing and environmental degradation.
   - Degradation of spawning streams:
     - dams
     - altered stream banks (reduced shade)
     - water quality

3. Atlantic Cod, see: http://www.nefsc.nmfs.gov/sos/spsyn/pg/cod/
   - Baleen Whales -- Overfishing.
   - Harvest and populations of many species have declined markedly since 1960's

4. Whales -- Harvest and populations of many species declined markedly since 1960's
**POTENTIAL HARVEST OF FISH FROM THE OCEANS**

<table>
<thead>
<tr>
<th>Zone</th>
<th>Net Primary Prod. [million metric tons / yr.]</th>
<th>Trophic level harvested</th>
<th>Trophic efficiency(%)</th>
<th>Max. fish production [million metric tons / year]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open Ocean</td>
<td>209,000</td>
<td>5</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>Coastal</td>
<td>68,000</td>
<td>3</td>
<td>15</td>
<td>230</td>
</tr>
<tr>
<td>Upwelling</td>
<td>1,000</td>
<td>1.5</td>
<td>20</td>
<td>120</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>278,000</strong></td>
<td></td>
<td><strong>352</strong></td>
<td></td>
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</tbody>
</table>

Current fish yield about 90 Million metric tons, ~25% of maximum production.

Are we approaching the maximum sustainable yield for many commercial fish species? **Probably so.**

**WAYS TO INCREASE PRODUCTION FROM THE OCEANS.**

1. **Mariculture / Aquaculture.** > 20% of fish consumed
   - (a) salmon raised in near-shore pens
     - Fish meal used as feed!
     - Recent ecological worries
   - (b) molluscs and crustaceans raised in ponds.
   - (c) Ocean "ranching."
     - release eggs/young, harvest adults later
     - Genetic "engineering" to improve harvest (?)

2. **Development of new and underexploited fisheries.**
   Pollock and whiting populations of the northeast Pacific
   - Abundant
   - Oily, smelly -- not very appealing
   - Processing -- remove oils, process flesh to artificial crab and shrimp meat.

3. **Harvest lower on the food chain**
   - Antarctic krill?
   - Harvest phytoplankton directly?

4. **Proper regulation and management of currently fished stocks.**

But... Even if we were able to double the current yield of fish from the oceans, we would not add substantially to total global food production.