



- Review Session: Tonight, 5PM in 100 Gregory
- Exam: Tuesday 7PM
- Last Names A - G 213 Greg, else 2 Education
- Format: Same as exams 1 to 3, but longer (75 questions)
- Study Outline is on the web. Major points only. Will be updated as I am able or get questions.
- Conflicts?

Lecture 40 -- The Oceans

FOOD RESOURCES OF THE OCEANS

World Fish Catch
 Dynamics of fish populations and fishing
 Over-exploited fisheries
 Potential harvest of fish
 Increasing fish production

Implications for harvesting marine fish as food resource:

Size of harvest depends on trophic efficiency and trophic level harvested.



FOOD RESOURCES

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

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 poultry

Importance to human diet:

- 1% of total food production
- 12% of total animal protein

Distribution of fishing areas

Controlled by:

1. Primary productivity -- rapid nutrient replenishment
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 in equatorial and polar oceans -- moderate nutrient supply to surface waters.

•But the harvest is fin fish (e.g., tuna) from high atop an inefficient food chain.



Coastal Areas

•Nutrient supply and regeneration is good -- vertical mixing, runoff.

•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**

- 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 FISHING YIELDS**

- Recent history of marine food production:
- 4-fold increase in past four decades.
 - Increase is leveling out or even decreasing, despite more technology and greater intensity of fishing.
 - Declines in many traditional and valuable 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 size (biomass) of a
population of fish :**

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

Fishing (over-fishing) decreases the age and size of individual fish. This leads to decrease in yield (harvest in tons per year)

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!

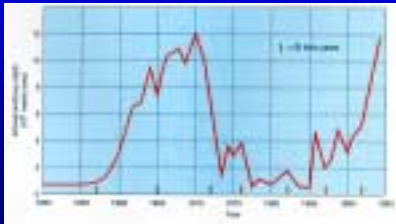
What is the "maximum sustainable yield?"

- Not known for most commercial fish stocks.
- Estimates range from 1/3 to 2/3 of total production

EXAMPLES OF OVER-EXPLOITATION

Peruvian anchovies.

- Over-fished at peak harvest in 1970 (12 million metric tons)
- Devastating 1972 El Nino.
- Decrease to 2 million metric tons per year
- Recent recovery?



EXAMPLES OF OVER-EXPLOITATION

Pacific Salmon -- Overfishing and environmental degradation.

Degradation of spawning "home" streams:

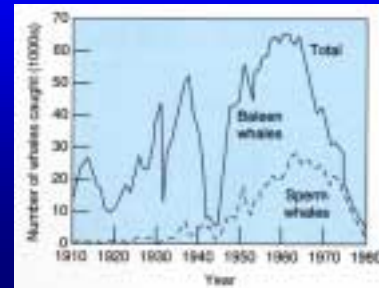
- dams
- alter stream banks (reduce shade)
- water quality

The "right to fish" and logging rights versus long-term health of the fish population



EXAMPLES OF OVER-EXPLOITATION

Whales -- Harvest and populations of many species have declined markedly since 1960's



POTENTIAL HARVEST OF FISH FROM THE OCEANS

J. A. Ryther (1969), Sumich, Table 15.2, p. 402

Province	Net Primary Prod. [million metric tons (live weight) / year]	Trophic level harvested	Trophic efficiency (%)	Maximum fish production [million metric tons / year]
Open Ocean	209,000	5	10	2
Coastal	68,000	3	15	230
Upwelling	1,000	1.5	20	120
Total	278,000			352

Current fish yield \approx 25% of maximum production.

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

INCREASING PRODUCTION FROM THE OCEANS

1. Mariculture / Aquaculture.

Will account for 20% of fish consumed by year 2000.

(a) salmon raised in near-shore pens

(b) molluscs and crustaceans raised in ponds.

(c) Open-ocean "ranching."

–Strategy: release eggs, larva, and fry to the oceans, then harvest the adults

–Molluscs and crustaceans -- best suited.

–Fish -- less promise (although it is being done)

•Genetic "engineering" to improve harvest



2. Development of new and underexploited fisheries.

Pollock and whiting populations of the northeast Pacific

–Not very appealing - no market as caught

–Processing -- artificial crab and shrimp meat.

Incidentally caught "trash fish" and deep-water fish

–Now dumped (dead)

–Process to fish-protein concentrate.

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 food from the oceans, we would not add substantially to total global food production