Human Impacts on Populations

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- Humans have always exploited natural populations
  - Humans = top predators and ultimate competitors on Earth
  - Conflict → humans exploit populations while simultaneously attempting to manage them
  - Many natural populations have high $ value
  - So what can we do?
- Can we exploit them wisely by maintaining an equilibrium between recruitment and harvest?

Sustained Yield

- → Yield per unit time from an exploited population equal to production per unit time
- Yield = the amount removed when harvested from the standing crop
- Initially developed for managing fisheries by (E.S. Russell):

$$B_{t+1} = B_t + [A_{br} + G_{bi} - (C_{bt} + M_b)]$$

Sustained Yield

$$B_{t+1} = B_t + [A_{br} + G_{bi} - (C_{bf} + M_b)]$$

- B_{t+1} → exploitable stock pre-harvest
- B_t → exploitable stock after last harvest
- A_{br} → gains from new recruits (young)
- G_{bi} → gains from growth of individuals not harvested + new recruits
- C_{bf} → losses from harvest period
- M_b → losses from natural causes (mortality)

Sustained Yield

$$B_{t+1} = B_t + [A_{br} + G_{bi} - (C_{bf} + M_b)]$$

- Thus, to maintain SY, one must account for:
  - GAINS (recruitment + growth)
  - LOSSES (exploitation + mortality)
  - In relation to the initial population (or population leftover)
- Highly simplified! Why?

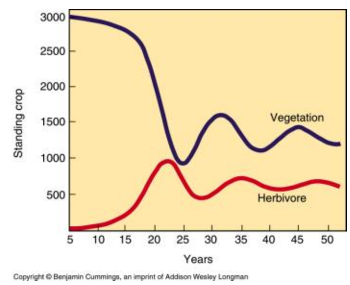
Sustained Yield

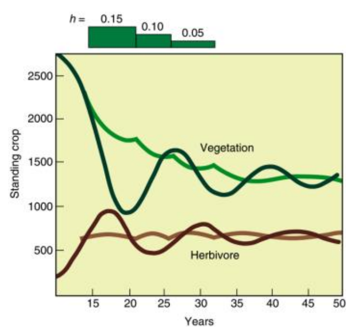
- In an undisturbed population A_{br}, C_{bf}, and M_b are interdependent
  - As populations are exploited significant changes occur (remember density-dependent effects)
  - To compensate for exploitation, population may exhibit changes in growth rates, age of sexual maturity, numbers of offspring produced and mortality rates (all affecting a population rate of increase *r*)
- Thus SY depends heavily on *r*
- So at what level should harvest take place?
- Should the population be kept at K?

Sustained Yield

- In order to achieve SY we must raise *r*
- How can this be done?
  - Increase K (increase resources, improve fecundity, survival, etc.)
  - Reduce and stabilize population at lower density
- The idea is to have the rate of harvest (*H*) equal the rate of increase
- What effects could *H* have on natural communities? What about population interactions?

Remember the interaction between herbivores and vegetation. What if we started harvesting the herbivore population? What would happen to the plant population?

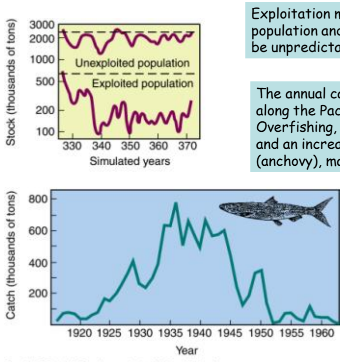




As a result of management the fluctuations are reduced and the system moves to equilibrium. Rate of harvest must be maintained until plant density levels off and begins to increase. Will vary with population *r*

Sustained Yield

- SY is not a particular value for a given population
  - Values may vary with different population levels and diff. management techniques
- Maximum Sustained Yield → level of SY at which the population declines if harvest exceeded
- Optimum Sustained Yield → the level of SY determined by consideration of other factors affecting the population (species interactions, land use problems, etc.)

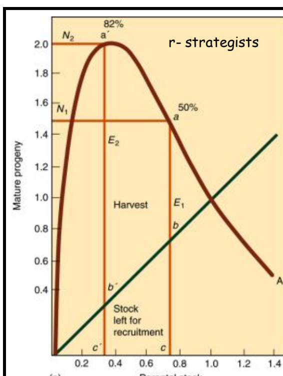


Exploitation may add instability to a population and the effects can often be unpredictable

The annual catch of the Pacific sardine along the Pacific coast of NA. Overfishing, environmental changes, and an increase in a competing fish (anchovy), made the population collapse

The role of management can be increasingly difficult considering the different reproductive strategies of populations being harvested:

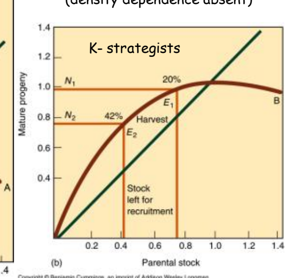
- r – strategists
- K - strategists



Low parental stock → very productive

Harvesting r- vs. K-strategists

45 line represents the replacement level of the stock (density dependence absent)

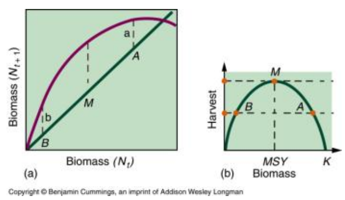


Low parental stock → not very productive

A Sustained Yield model for a population of K-strategists

Three harvesting regimes: A, B, M

Maximum Sustained Yield is at M, where the diagonal line and the curve have maximum separation



Maximum Sustained yield is approximately at K/2

At A the equilibrium is stable at high density (above MSY)

At B the population is at unstable equilibrium (vulnerable to chance extinction)

Problems with SY management

- Often fails to consider the following:
  - Size and age classes
  - Differential rates of growth among them
  - Sex ratio
  - Survival
  - Reproduction
  - Environmental uncertainties
- Data difficult to obtain

Problems with SY management

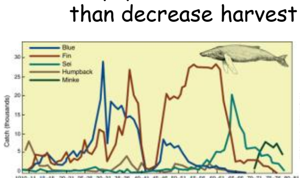
- Management approaches in current use:
  - Fixed quota → certain % removed each harvest period based on MSY estimates
  - Dynamic pool model → animals removed replace those that would eventually be lost due to density-dependent mortality
  - Harvest effort → the numbers removed controlled by manipulating exploitative effort (i.e., hunting seasons, bag limits, etc)

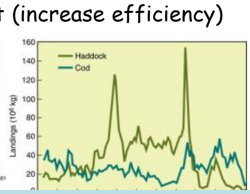
Problems with SY management

- These models are biological, based on logistic growth and have a major flaw
- They fail to incorporate the most important component of population exploitation
- $$$$ -- Economics -- $$$$
- Exploitation = $$$ (food, licenses, permits, equipment, employment, etc)
- Attempts to reduce the rates meets strong opposition

Problems with SY management

- What are the consequences?
  - Increased collapse of overexploited pops'
  - As pops declined, efforts increased rather than decrease harvest (increase efficiency)





Up to certain rate of exploitation, stock can replace itself, beyond this point?

Problems with SY management

- Other major flaws of population management
  - Considers stocks of individual species as single biological units
  - Fails to consider larger ecological systems
  - Seeks maximum economic return without leaving behind portion that maintains integrity (predator-prey; by-catch; trophic relations & interactions; food web structure)
  - Emphasizes the economic revenue for which they depend on (i.e., recreational opportunities)
  - Depends too much on crisis management with little steps to rescue a species until it's too late

Alternatives?

- Reserves (refuges) → provide a source for rescue
  - The excess population would flow out and restock and enhance the productivity or abundance of game on the surrounding area
  - Not only terrestrial (also in marine and freshwater environments)
- Size and shape an issue…large vs. small…
- Need for data on life history, reproductive strategies, home range, etc.

Forest Exploitation

- Initially → clear land for agriculture and supply for building materials
- Gilford Pinchot (1892) introduces forest management practices in NC
- The goal of SY in forestry is to achieve a balance btw net growth and harvest
  - Cut old mature forest to promote regeneration (increase *r*) → need to think in diff time scales
  - Problems with approach still the same:
    - Growing trees as crop rather than ecosystem

Habitat Loss and Fragmentation

- Affects species at both geographical and local scales
  - Increased growth of human population and demand for space = compress and fragment species natural range
  - Endemic and ecologically specialized sp most affected (limited distribution)
  - Migratory species also vulnerable (corridors eliminated)
  - Not just terrestrial - Aquatic habitats (dams, water extraction, increased pollution)
- Need for protection and management
  - Refuges; Management practices; Need for data

Wildlife Restoration

- Success vs. Conflicts
  - White-tailed deer, Wild turkey
  - Conflict with humans?
  - Translocations and transplants (genetic considerations?)
- Management of Restored Populations
  - If restoration successful, species may reach a point where population exceeds the ability of the habitat to support it
  - Lead to habitat deterioration

Pollution

- Chemical
  - Pesticides, sedimentation, excessive nutrients, toxic wastes, etc.
- Bio-invaders
  - The accidental or intentional introduction of exotic species, through intense competition and predatory pressures
  - Results in the displacement and often extinction of many native species
  - Compromise the integrity of ecosystems and at times cause extensive economic damage

Pest Populations and Control

- Chemical Control
  - Long-term effects
  - Non-target species
  - Resistance
- Biological Control
  - Predator-prey relations
- Genetic Control
  - Crossing → preserve genes w/ defenses
  - Example: Bt corn
- Mechanical and Cultural Control
  - Can be costly at larger scales

Integrated Pest Management

- Developed by entomologists
  - Considers the biological, ecological, economic, social, and even aesthetic aspect of pest control
  - Employs variety of techniques
  - Deal with pests at point when it is easier to control rather than at point of major outbreak