WLF 201
Maximum Sustainable Yield

Harvest of fish and wildlife population is a complex web of social, political, and biological principles. At times, social or political demands may be at odds with biological principles that govern harvest management. Managers must balance these competing interest.

We will focus on the biological principles behind sport harvest (hunting, fishing, and trapping), although some of these principles have applications in commercial harvest and we will consider some social and political issues. The biological goals of harvest management are:

- sustained harvest of populations such that the current yield (harvest) will not affect future harvest
- reducing abundance of overabundant species

We will investigate 3 practices for accomplishing these objectives.

1. Maximum sustainable yield (MSY)
   - Most commonly used in big-game (Carnivora and Artiodactyl) and fisheries management
   - maximize yield that can be sustained

2. Additive and Compensatory
   - The effects of exploitation on survival
   - Unify theory, but most commonly applied to bird populations

3. Adaptive Harvest Management
   - Approach to harvest management that embraces uncertainty
   - Harvest is an experiment
   - Feedback loop between harvest and monitoring

Maximum Sustainable Yield

The theory MSY is quite simple for populations that exhibit geometric population growth (e.g., muskox on Nunivak Island).

- Harvest the population at rate equal to the rate of increase

? = 1.2

$H = 0.2$
$N_0 = 1000$

Year	**N_{t+1} w/ harvest**	**Harvest**	**N_{t+1} w/o harvest**
1	1000	200	1200
2	1000	200	1440
3	1000	200	1728
...			
n	1000	200	$N_0 1.2^n$

This is obviously simplistic

- ignoring density dependence
- environmental stochasticity
- uncertainty (structural, partial observability, partial controllability)

How can we maximize sustainable yield when populations are subject to density dependent regulation?

If you recall, the relationship between

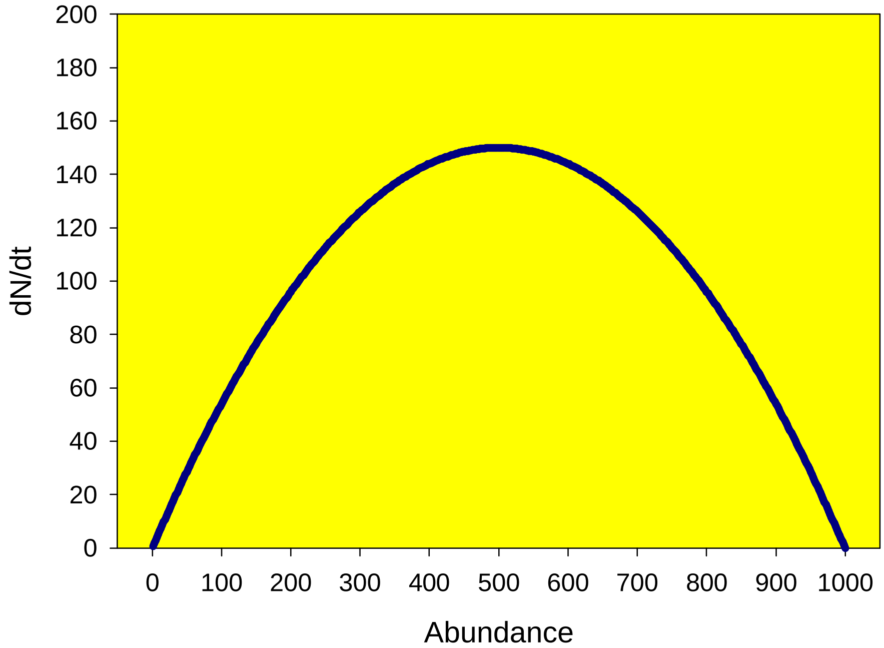
5 time and population size (N),
5 population growth rate (dN/dt) and abundance,
5 and per capita growth rate (1/N dN/dt) and abundance

looks like this for logistic growth:

remember
$N_{t+1} = N_t e^{r(1 - N/K)}$
$dN/dt = N r(1-N/K)$

5 Given these relationships, at what population size could you have a sustainable harvest that is maximized?

5 At what population size could you have the highest harvest (number of animals) and still have a stable population size?



dN/dt = N x 0.6 (1 - N/1000)

5 Where is dN/dt maximized?

5 Therefore, where can harvest be maximized?

5 What is maximize sustainable rate of harvest?

- the rate of harvest (H) is maximized at ½ r_d
- ½ rd x K/2 = 0.3 x 500 = 150

Scenarios:

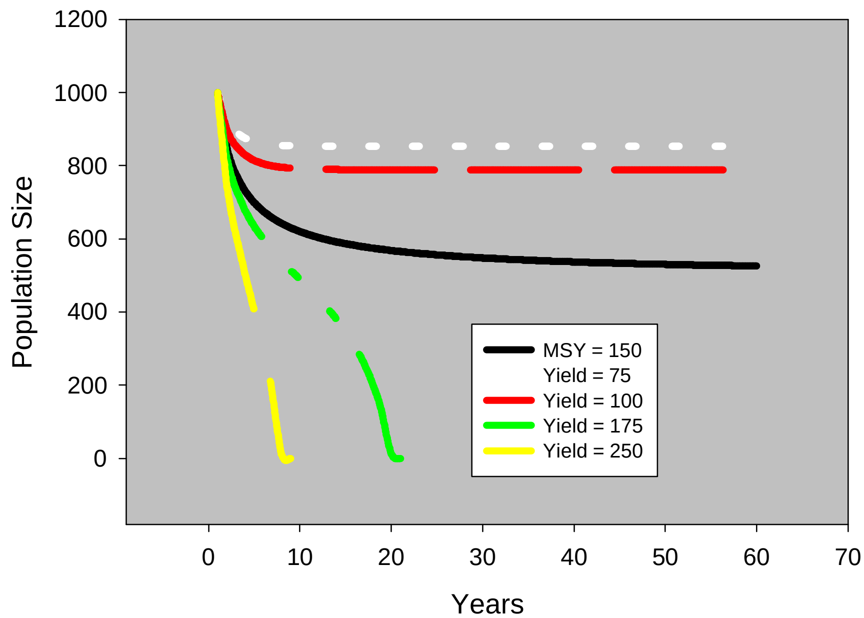
5 Start with 1,000 animals

5 Harvest:

- a constant yield of MSY
- constant >MSY
- and constant <MSY

$N_{t+1} = N_t + N_t \times 0.6 (1 - N_t/K) - \text{yield}$

Relationship between population size and yield where MSY = 150.



Lessons:

- Constant harvest > MSY can be disasterous
- Change in population size is similar for MSY, <MSY, and >MSY in the initial years
- Constant effort harvest (H = N * effort *efficiency) can also push harvest beyond MSY (ratchet effect)
    - Harvest tracks population size

Furthermore:

We assumed:

1. Constant Birth and Death
2. Constant K
3. No Age Structure

5 Harvest exceeding MSY may have caused the collapse of many commercial fisheries. Example: North Sea Cod, Cook et al. (1997) Potential collapse of North Sea cod stocks. Nature 385:521-522.

5 Do we want to manage populations near MSY?

5 Let’s look at harvest theory from another angle.