Northeast Fisheries
Science Center

Basics of Fisheries Science

GMRI Marine Resources Education Program

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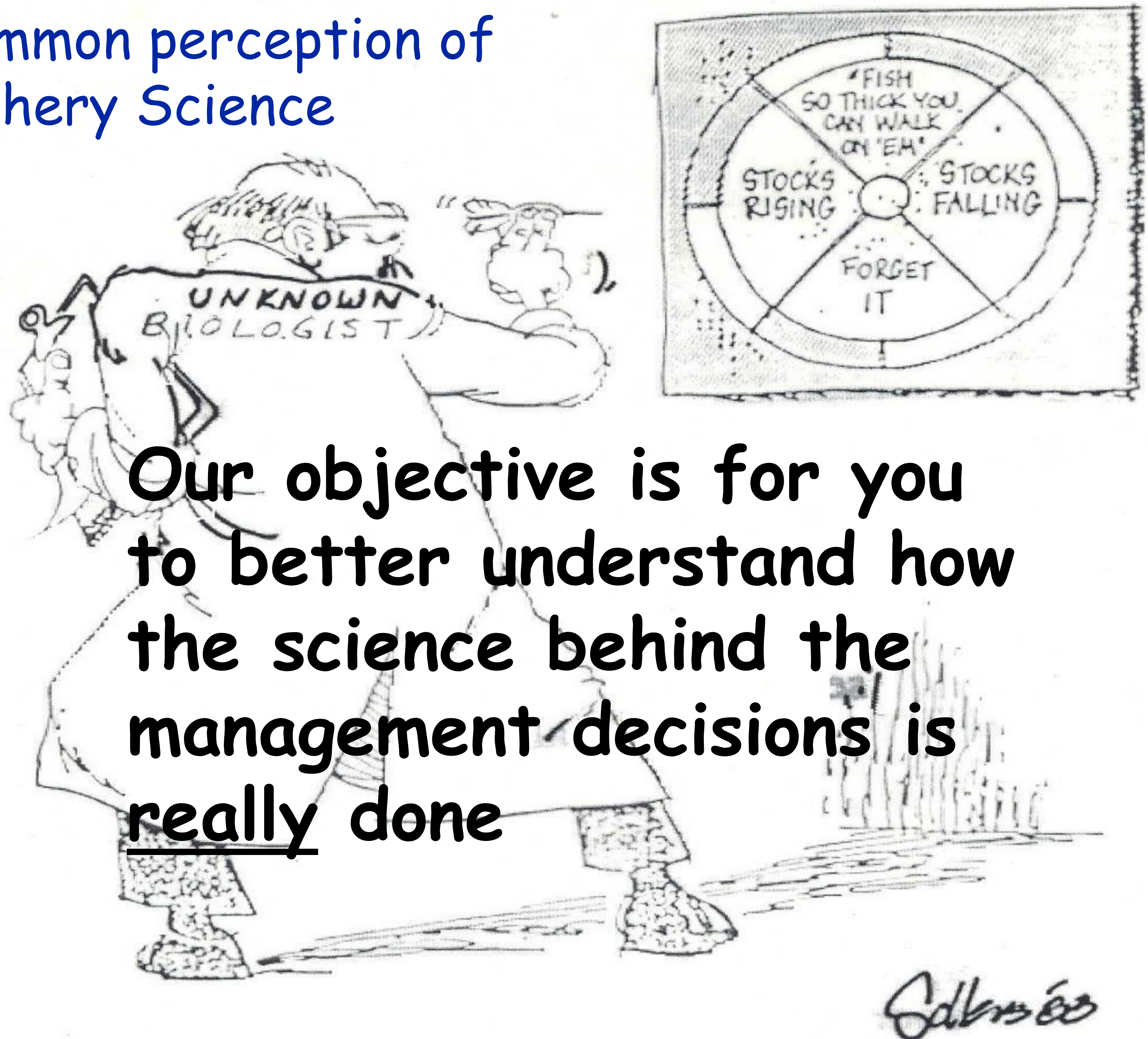
Research Institute
Science. Education. Community.

Common perception of Fishery Science



Our objective is for you to better understand how the science behind the management decisions is <u>really</u> done

Definitions:

Population: all the individuals of a species living in a given area. Populations can grow but are limited by space, food, etc. A **stock** is a sub-group within the larger population.

Rates: Similar to a proportion but can also refer to the change of value between two points in time (e.g. Rate of increase). Examples: Tax rate, interest rate, exchange rate, etc.

Cohort: members of the population all born in the same year (all the same age). Also referred to as a year class.

Definitions:

Biomass: combined weight of all the individuals in a population

Models: the mathematical representation of some system or process

e.g. $Y = a + bX$ is a model of a straight line

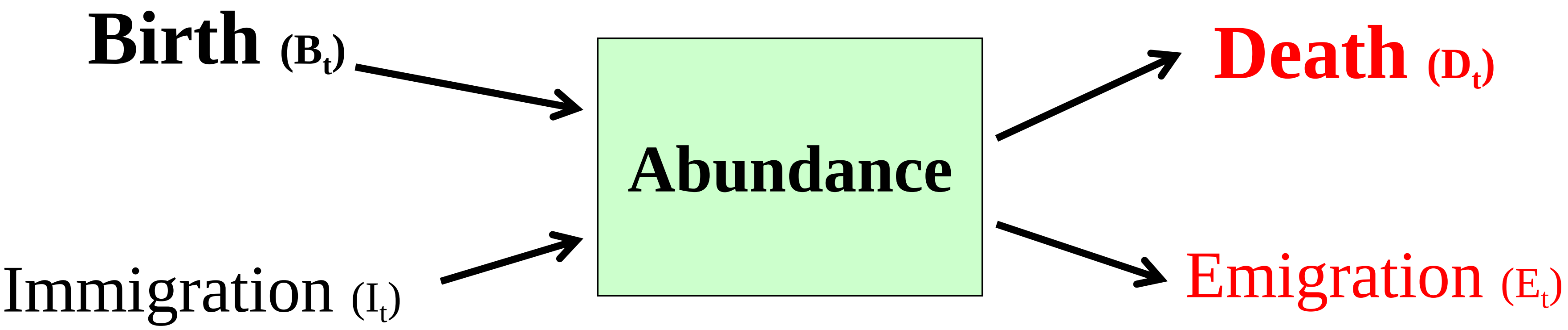
Population Dynamics: the processes and factors involved in the maintenance, decline, or expansion of populations

Concepts in Population Biology

Biological populations (humans, fish, trees, bacteria...) are regulated by four primary factors:

- rate of death (d),
- rate of immigration (i, coming from some other place),
- rate of emigration (e, going to some other place),
- rate of birth (b).

any given point in time:



In order for population to be stable then:

$$B_t + I_t = D_t - E_t$$

Populations can be stable at different abundances.. as long as the numbers entering equal the number leaving.

If start with a stable population and

Births ↓ and removals ↑ then abundance ↓

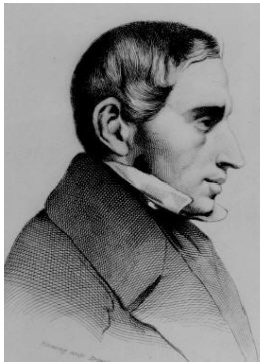
likewise

Births ↑ and removals ↓ then abundance ↑

Populations do not have unlimited growth but are regulated by available resources such as food, habitat, etc.

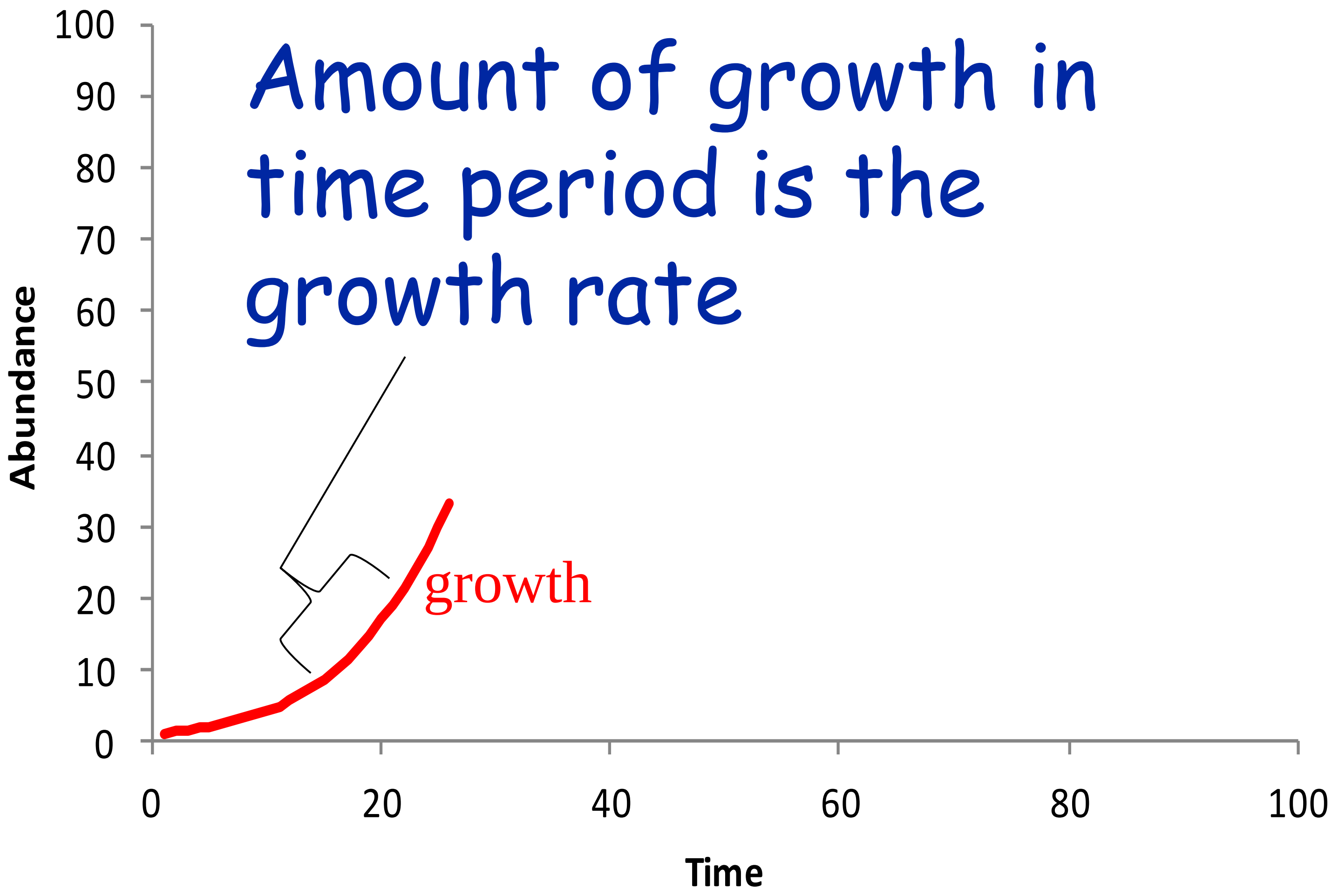
(Malthus 1798)

Described mathematically as Logistic growth

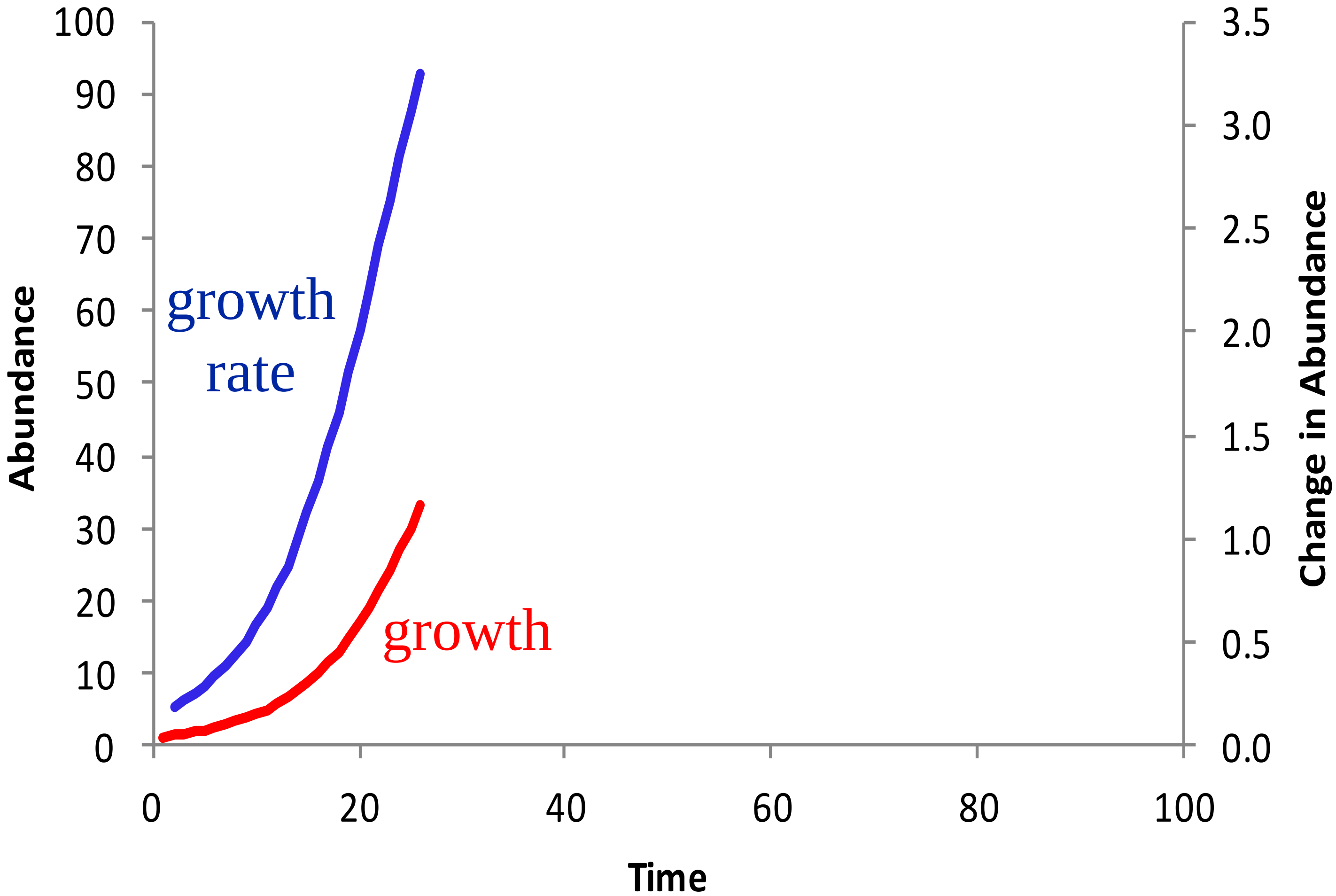


(Verhulst 1838)

Logistic growth

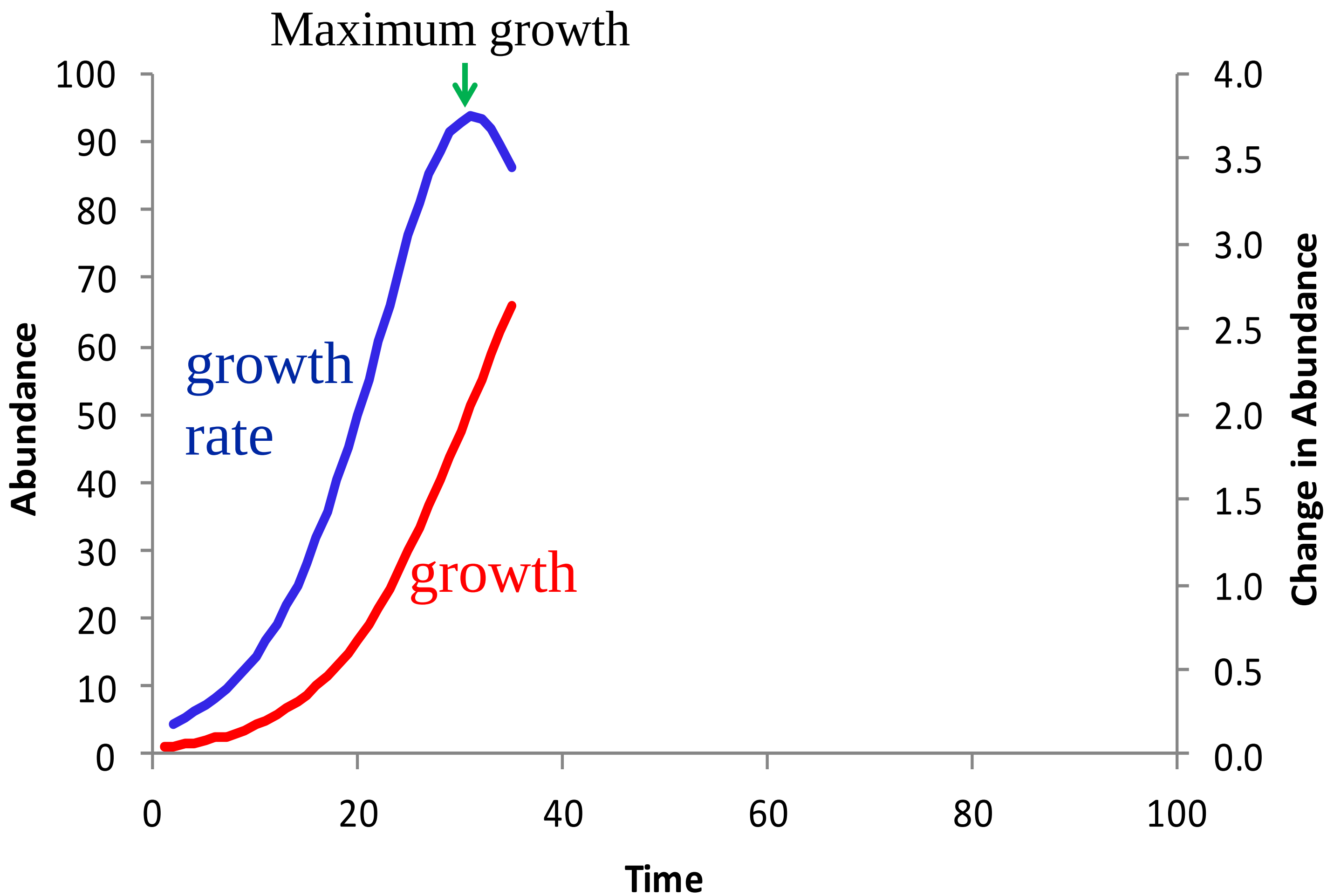


Logistic growth



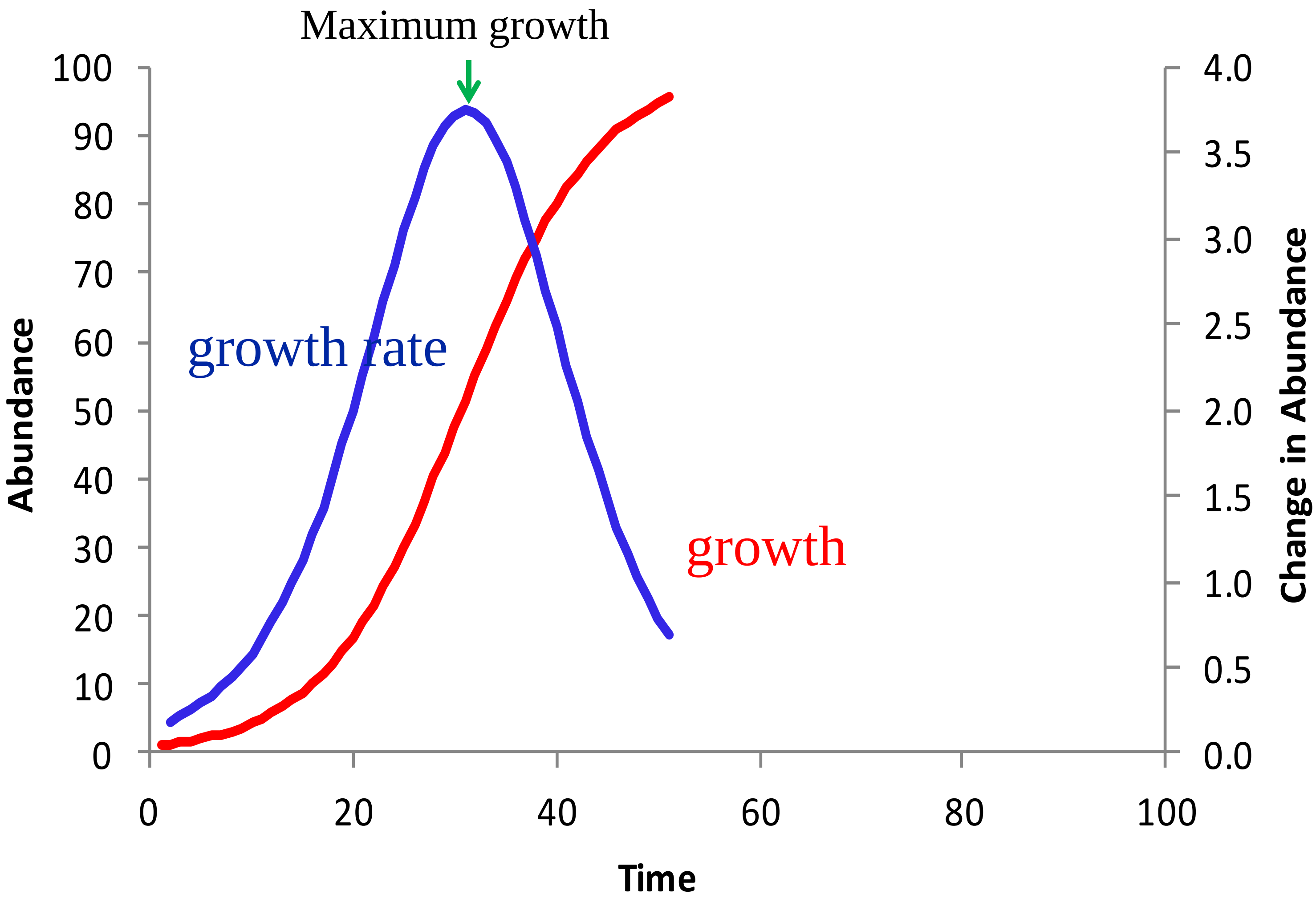
Early phase

Logistic growth



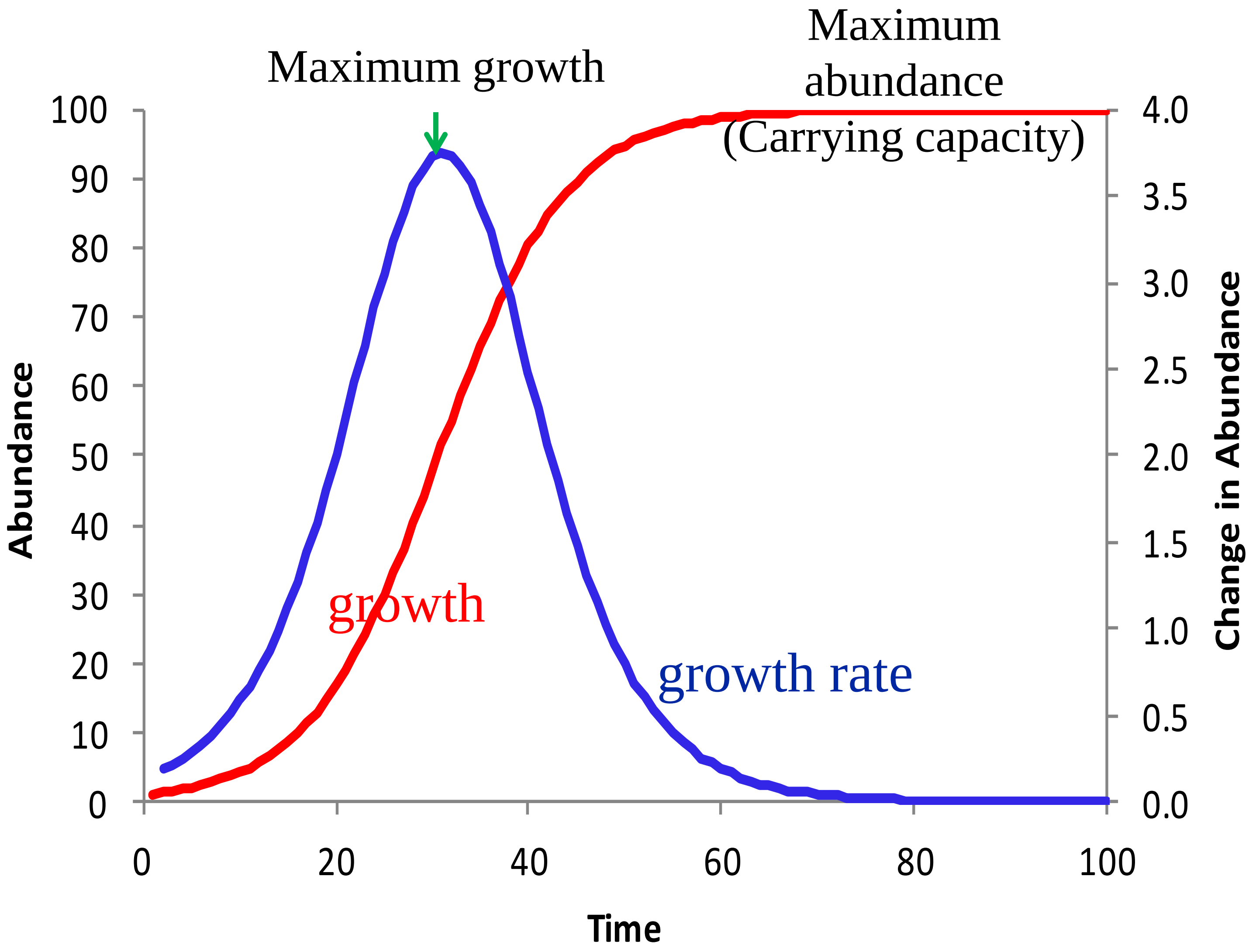
maximum growth phase

Logistic growth

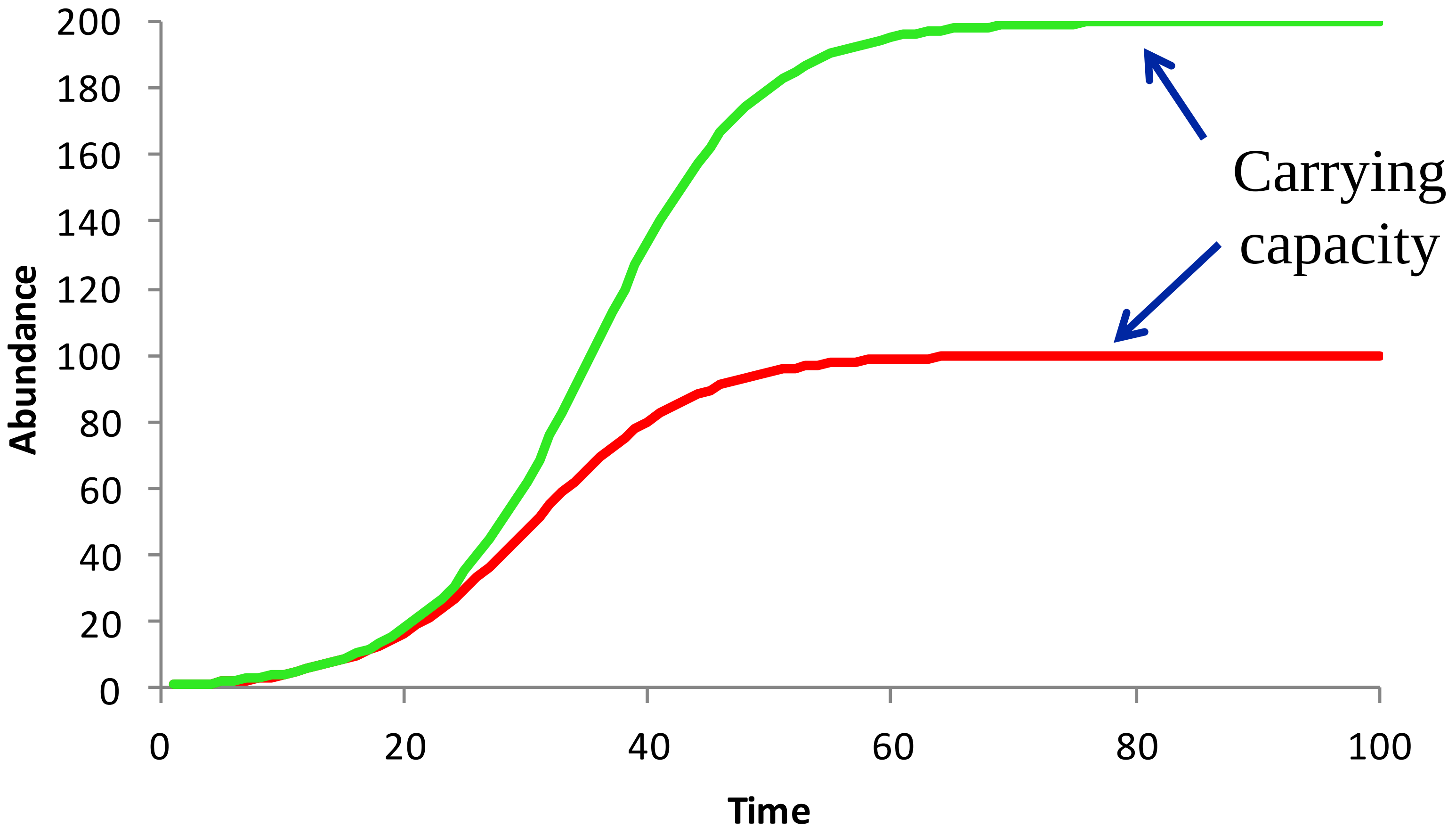


late growth phase

Logistic growth

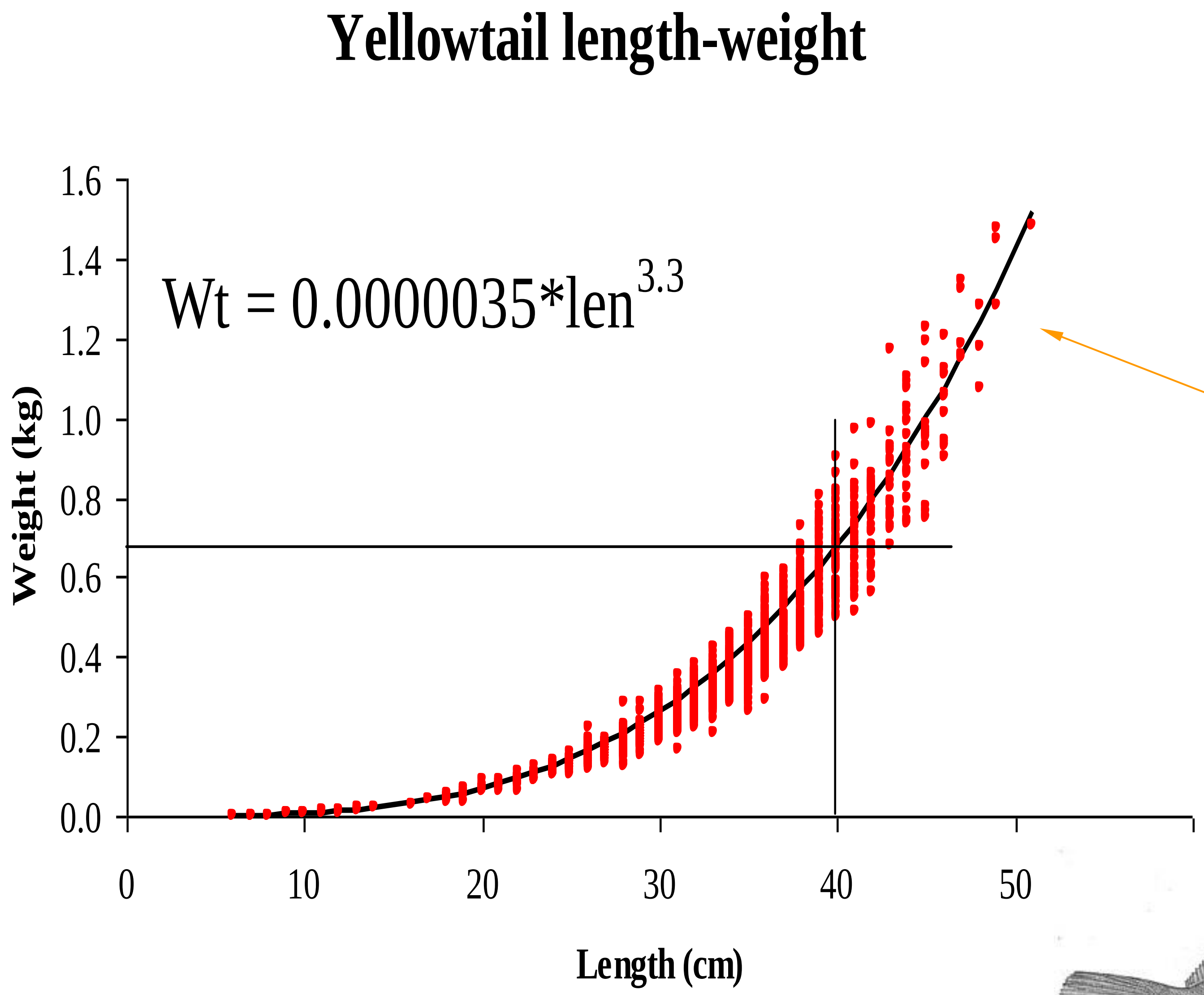


Carrying capacity will vary among populations or with changes within populations



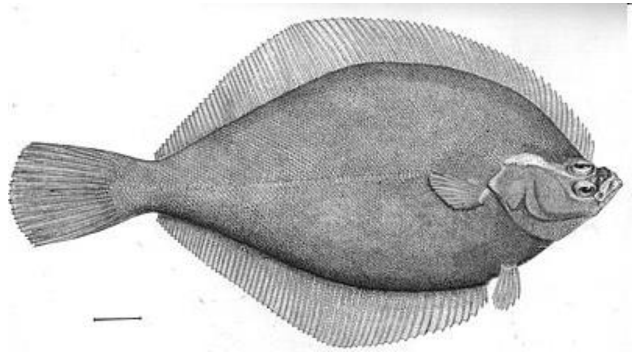
Population growth

Populations abundance increases by increasing the number of individuals in the population but total biomass of the population also grows by increase in the size of the individuals.



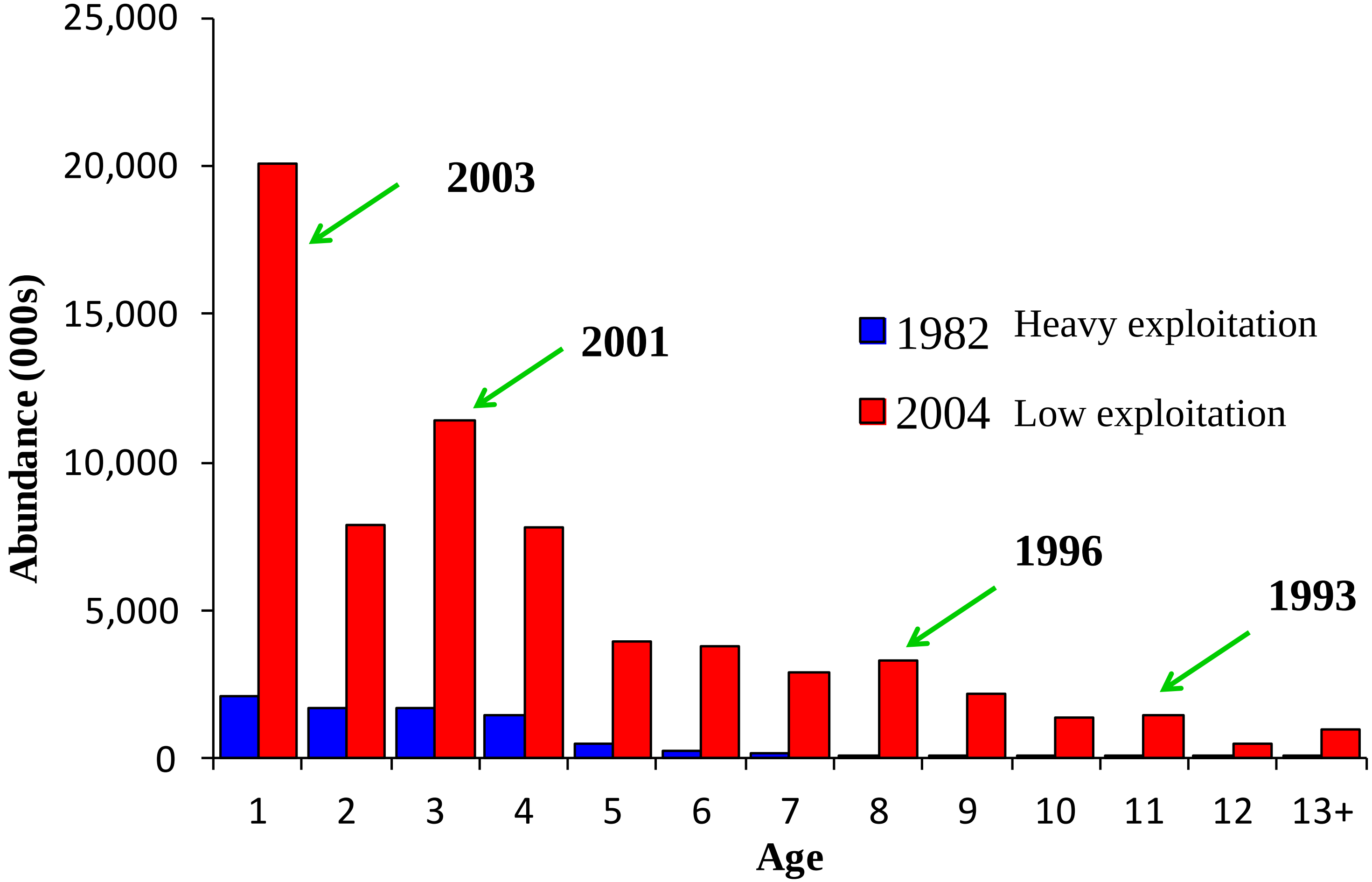
Weight is roughly a cubic function of length $wt = aL^3$

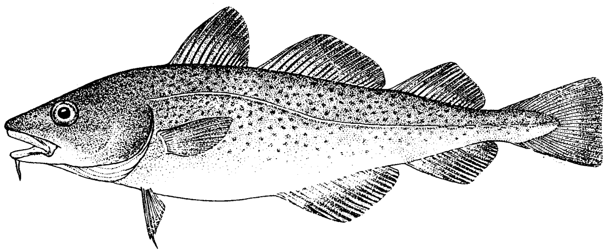
We can convert length to weight easily



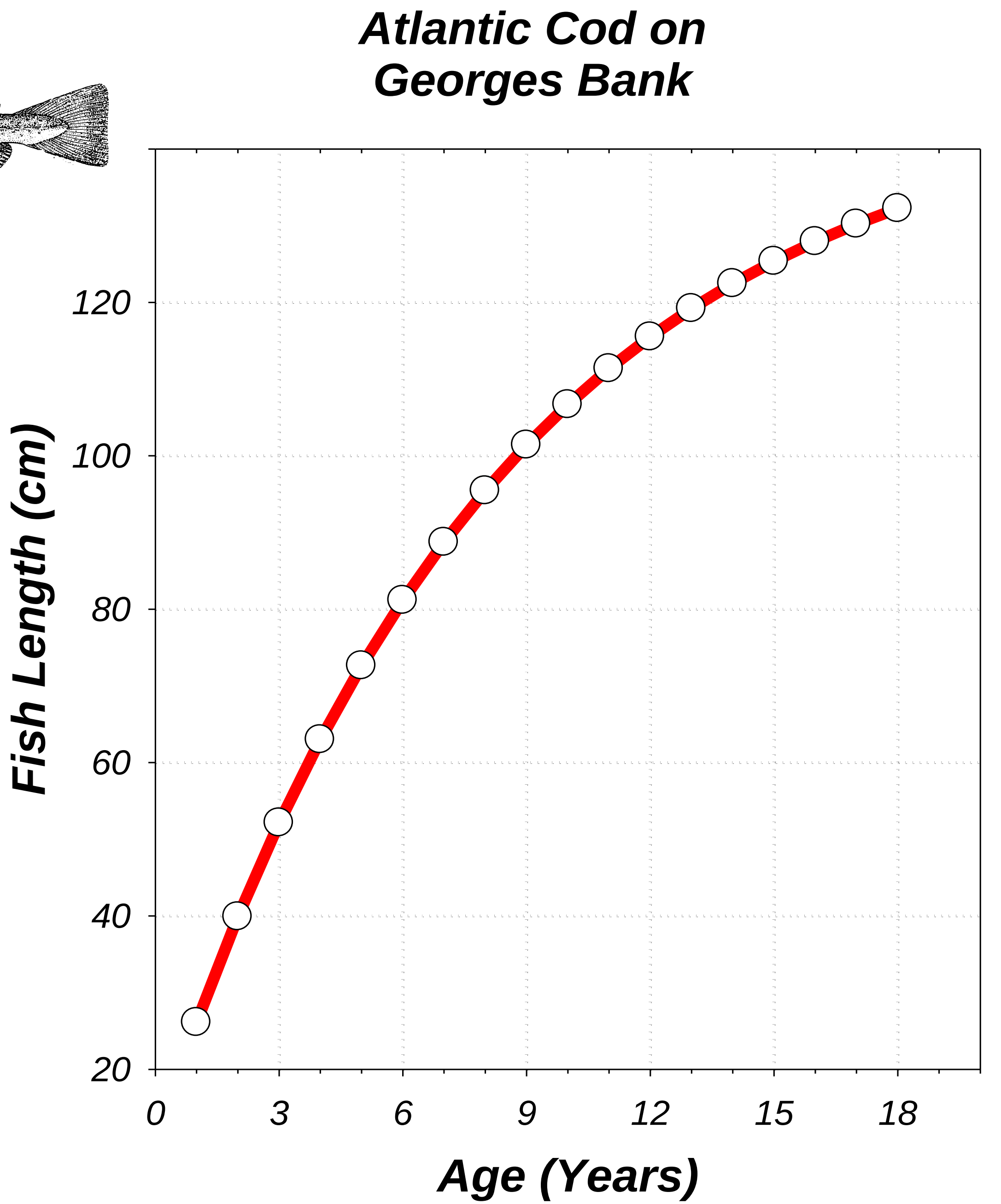
Dividing the information into age categories provides further insight into a populations dynamics

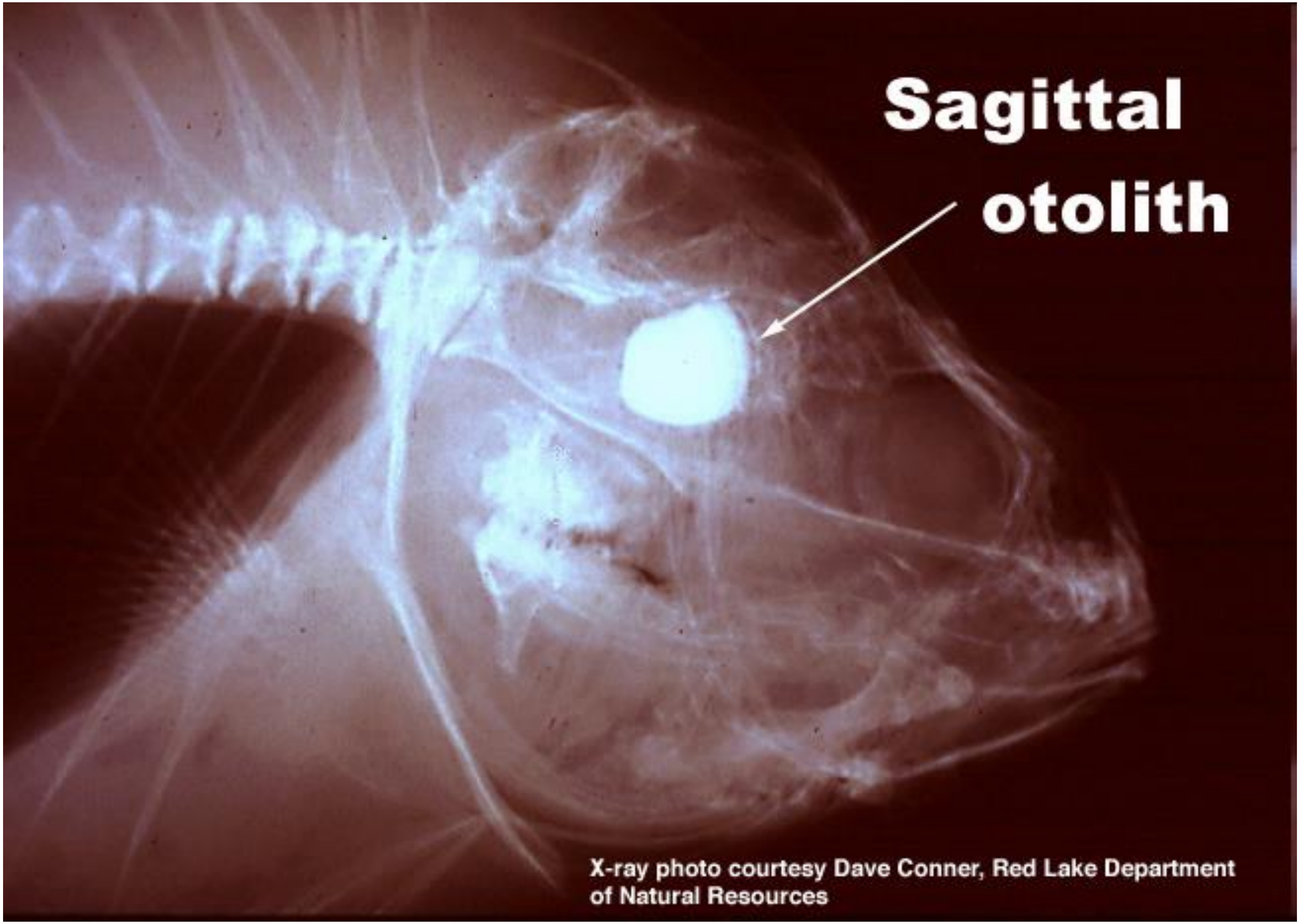
Striped bass age structure



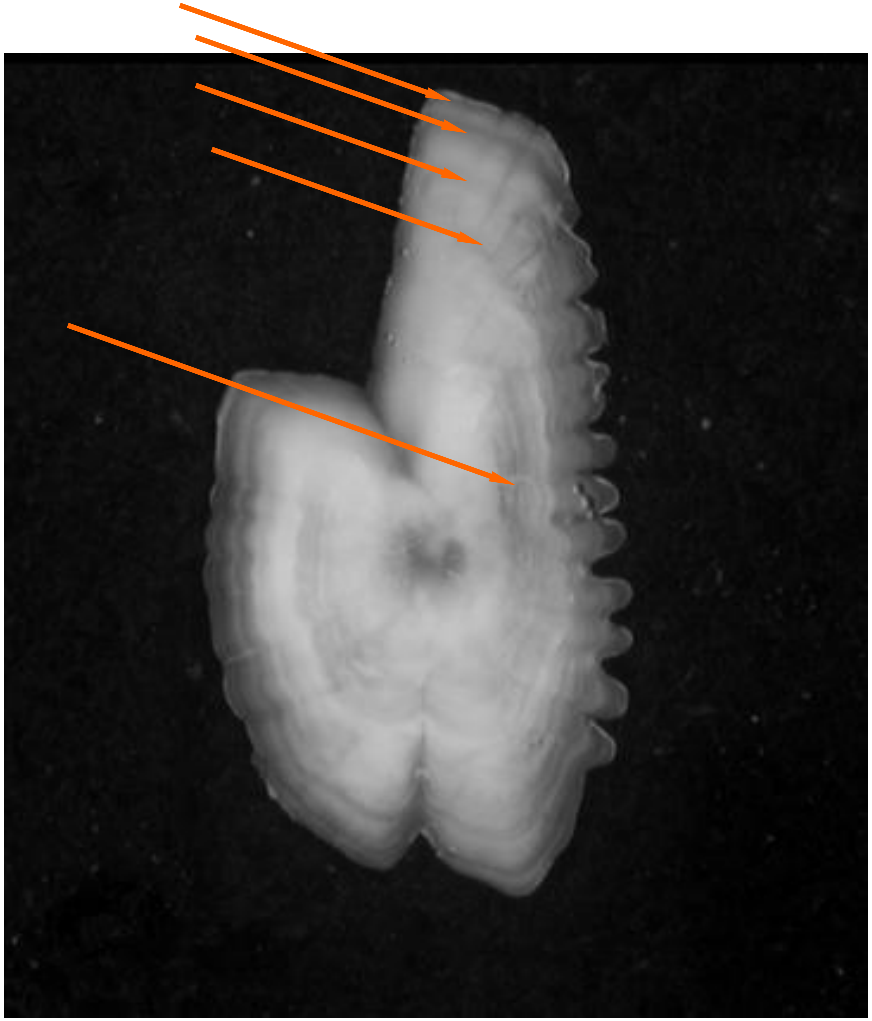


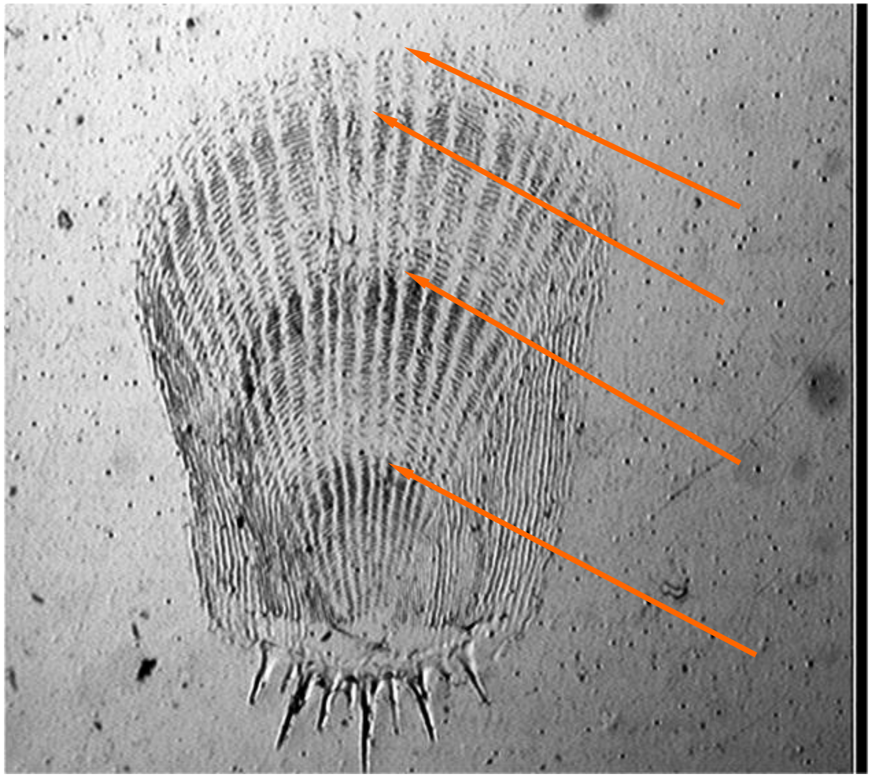
Growth curve




Sagittal
otolith
X-ray photo courtesy Dave Conner, Red Lake Department
of Natural Resources

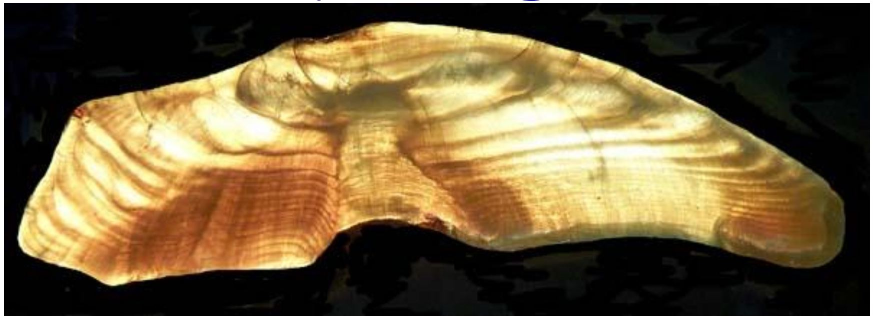
How do we age fish?

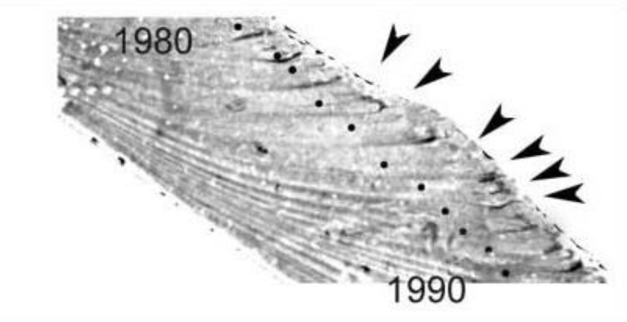




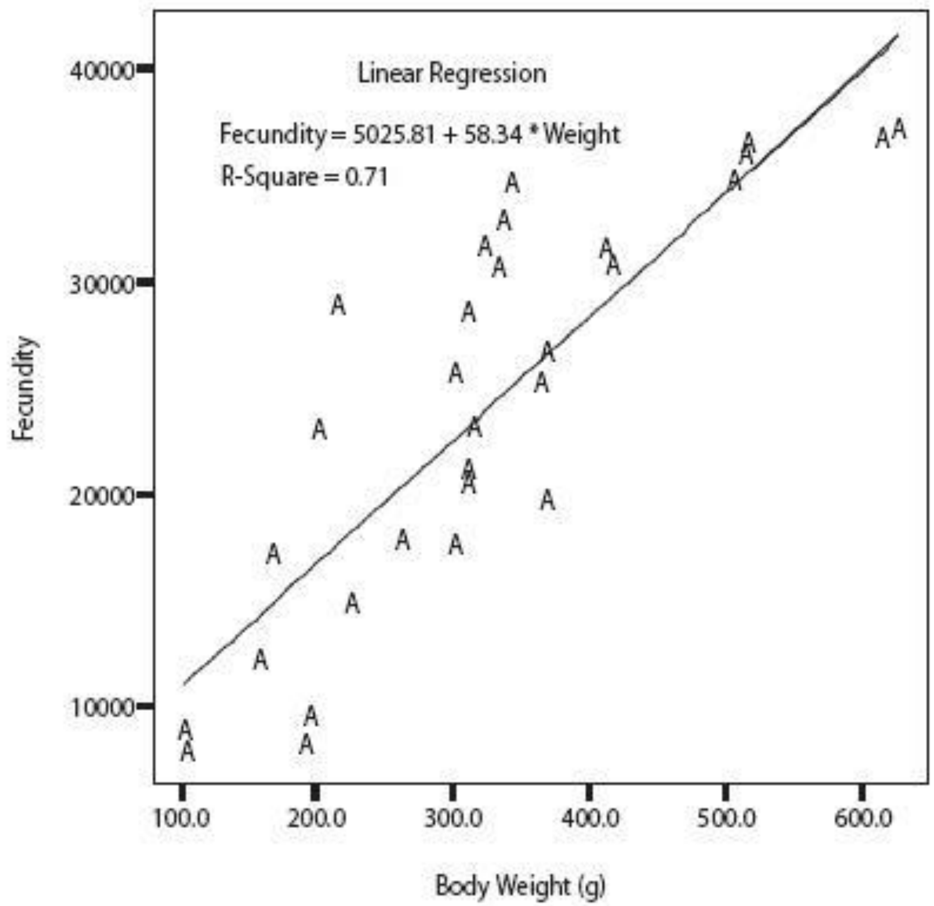
How long do marine species live?

- Most in our region live 10-15 years
- Striped bass live 25-30 years
- Sand eels live 3-5 years
- Squids live about 18 months
- Ocean quahogs estimated at 200+ !





Reproductive Biology

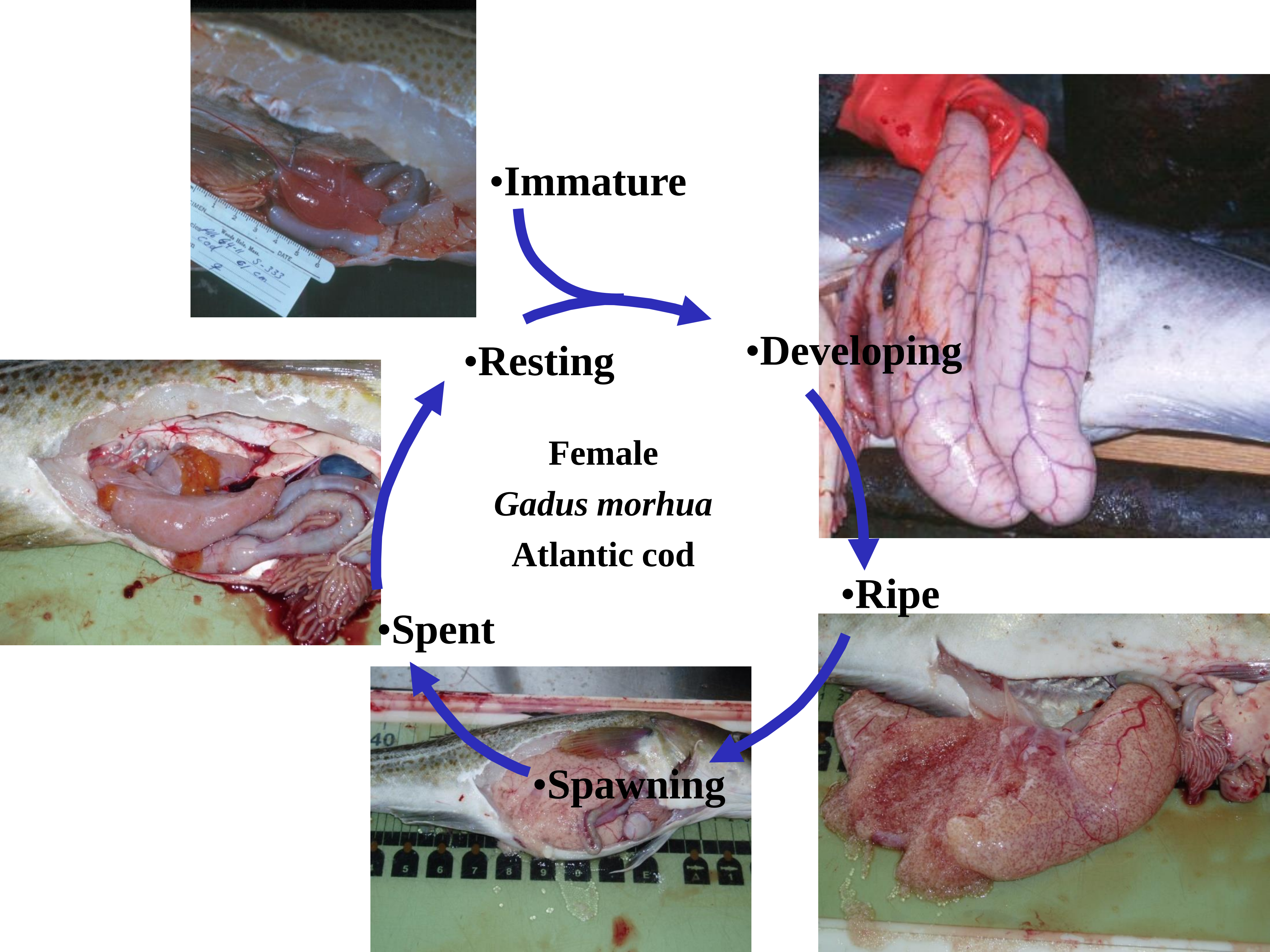


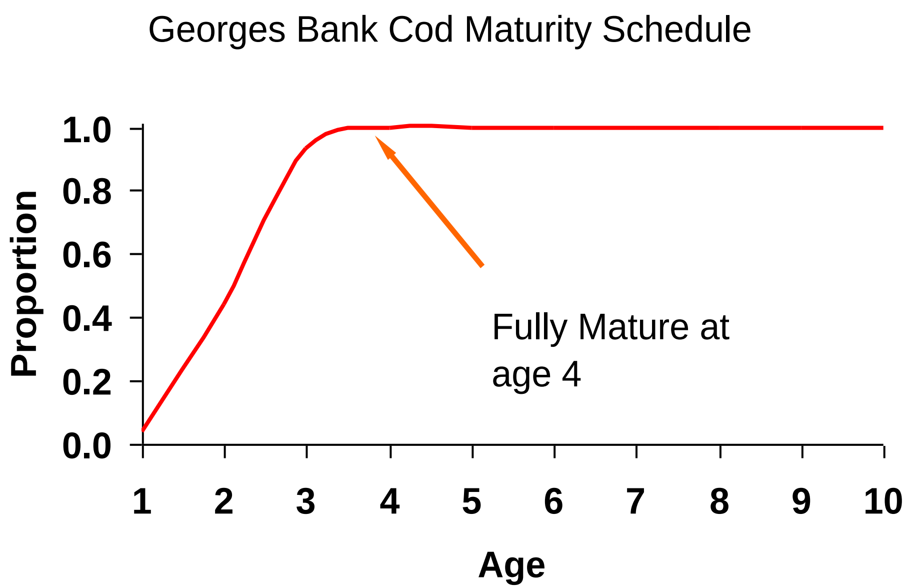
. Regression line showing relationship between Fecundity and Body weight of *C. nigrodigitatus*.

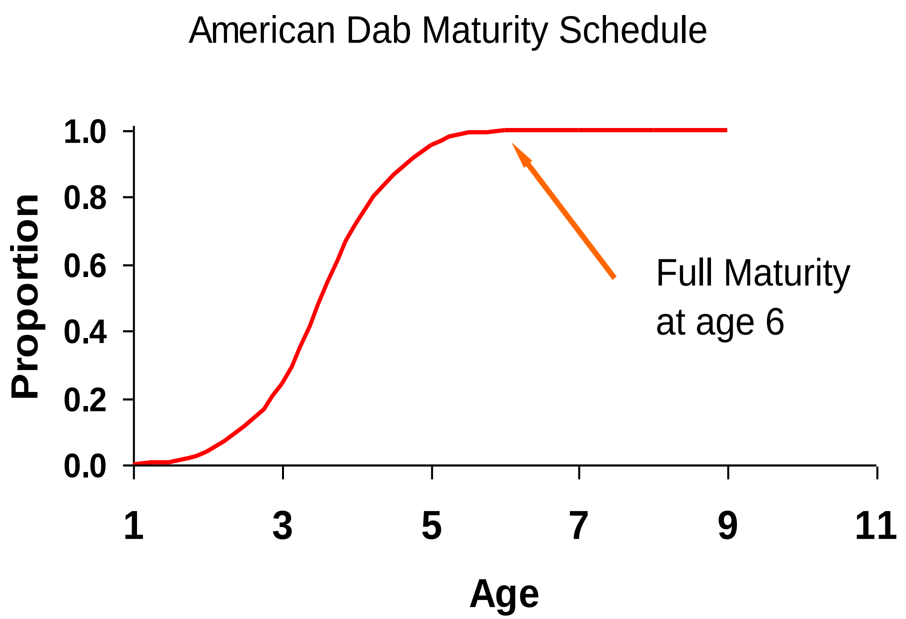
Egg production in fishes is directly related to body weight. Therefore total biomass of mature females is equivalent to total egg production.

So we need female biomass and maturity information to calculate spawning stock biomass (SSB)

Maturity information collected annually on surveys


•Immature
•Developing
•Ripe
•Spawning
•Spent
•Resting
Female
Gadus morhua
Atlantic cod





Maturation varies by species and region

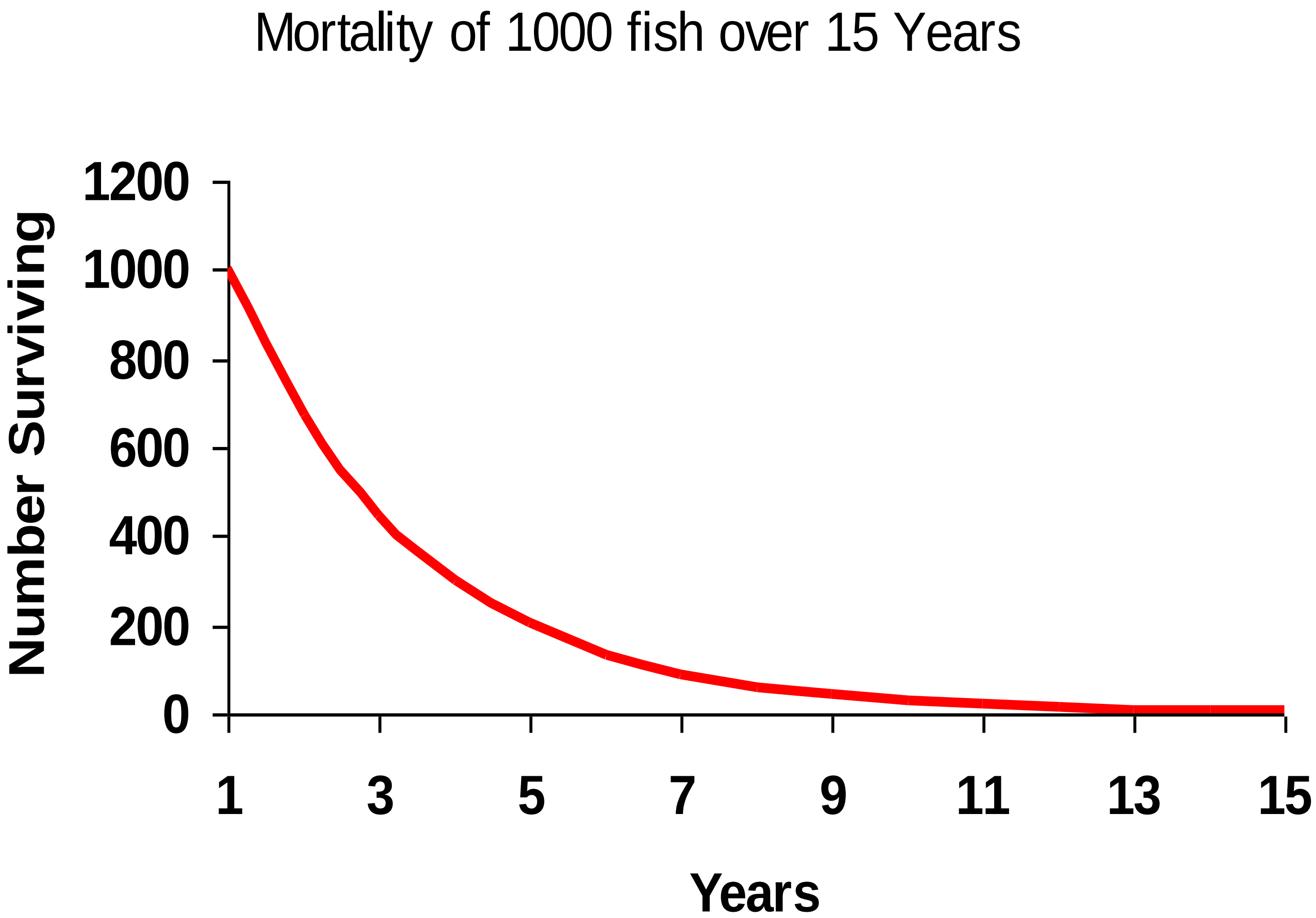
Maturation is also sensitive to density, temperature, food resources.

Mortality

What is it?

- The loss of fish from the population by natural and fishing related causes.
- Estimating the <u>rate</u> of decline or the number of fish that die during some time period, usually 1 year.

Mortality in a population describes a decay process

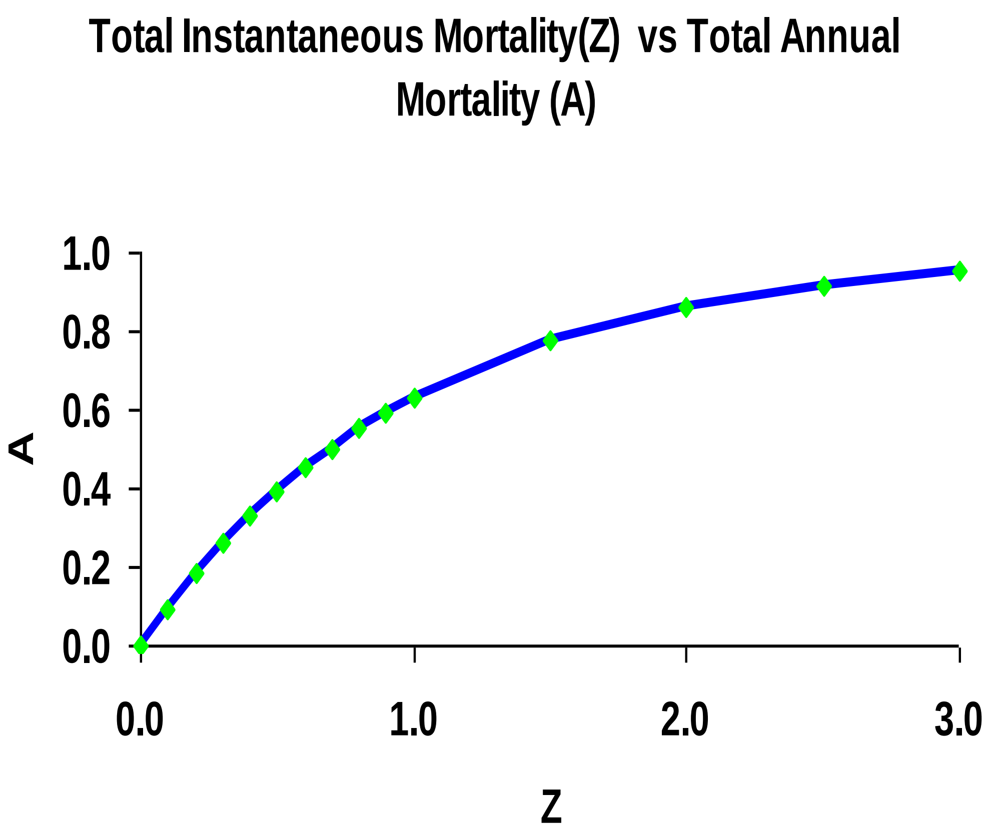


Mortality of a fish population is a combination of natural mortality (M) and fishing mortality (F)

Total mortality (Z) is the combination of both.

It is a rate not a percentage. So can exceed 1.0 (not the same as 100%)

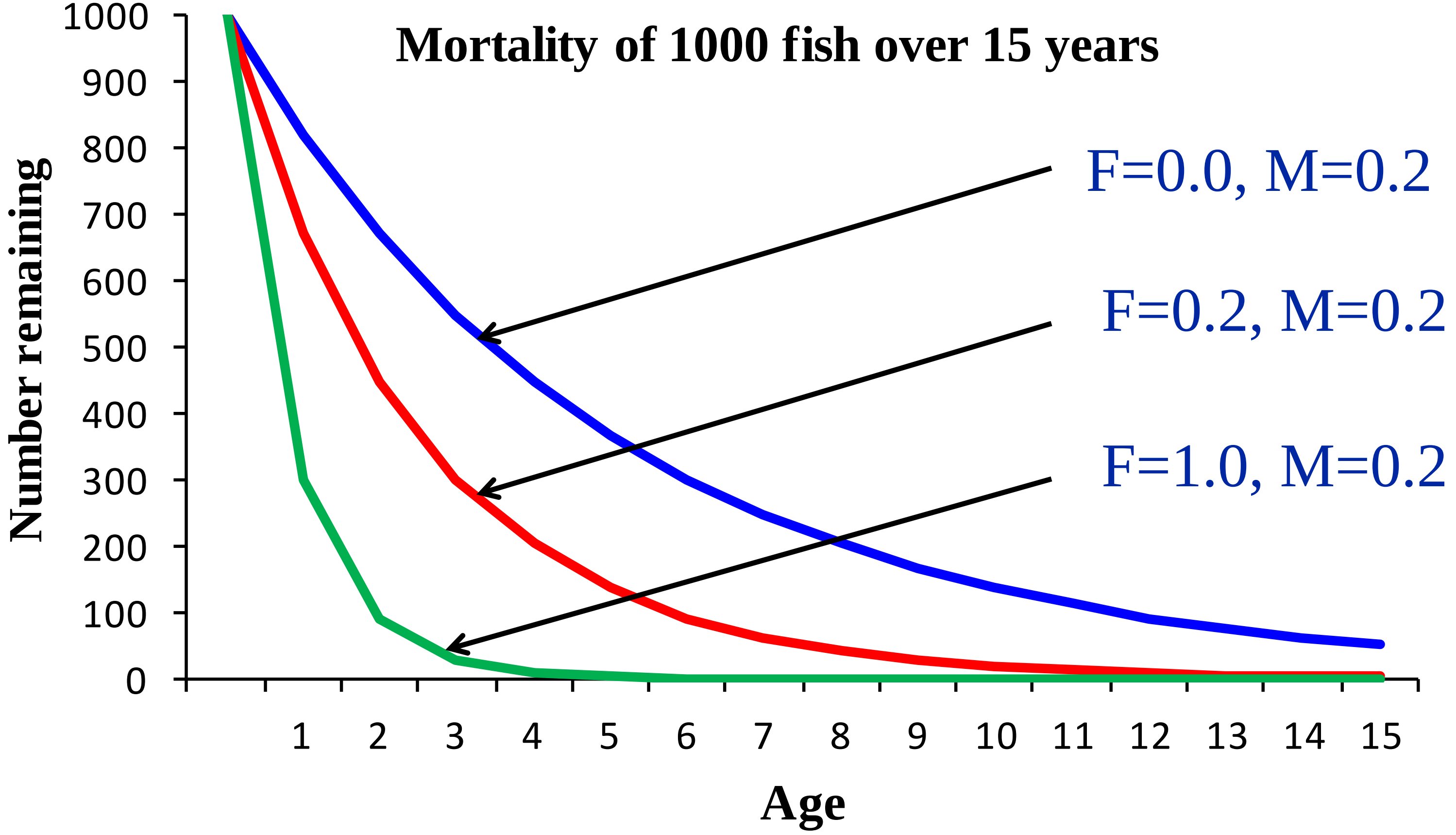
Mortality Rates Relating the two Types



•*Important Points*

- Annual Rates are Percentage Rates
- Instantaneous Rates are Exponential Rates
- *A Z of 1 = an A of 63%*
- Instantaneous rates are handy because they can be added, subtracted, multiplied, etc.
- *Z = F + M*
- Annual rates cannot be manipulated this way

Effects of Different Fishing Rates



Why are mortality rates so important?

With them we can:

- Determine the historical size of a stock.
- Estimate current biomass.
- Estimate next years biomass.
- Determine maximum sustainable yields.

Recruitment

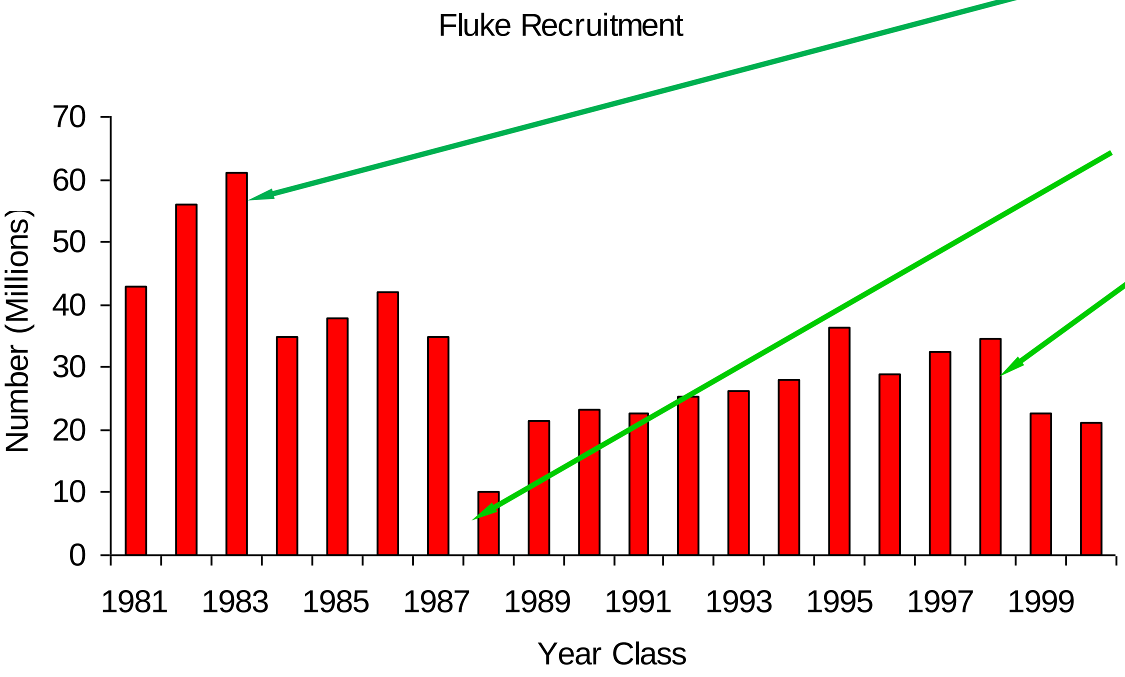
What is Recruitment?

New fish entering the population from a previous annual spawning event.

Why is Recruitment Important?

- It is the engine that drives a fishery
- Provides the new fish that sustains the catch in the future!
- If we can estimate it, we can predict future stock status.
- It changes annually based on spawner biomass and environmental factors.

Fluke Recruitment-age 1



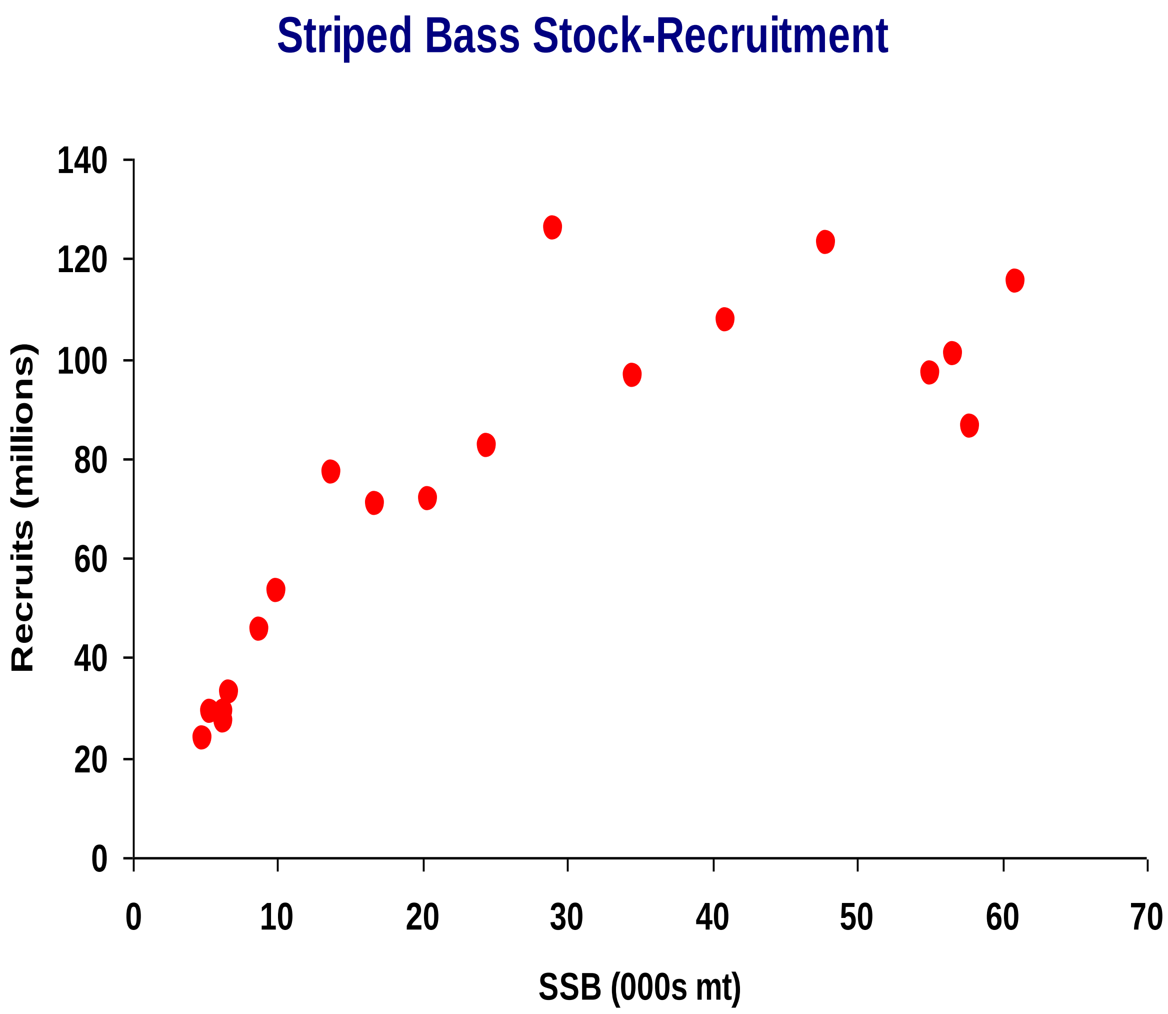
New recruits

Different each year, related to spawning stock size and environmental factors

Stock - Recruitment

The relationship between the number of mature adult spawners and the number of juvenile fish entering the population

Stock Recruitment Data



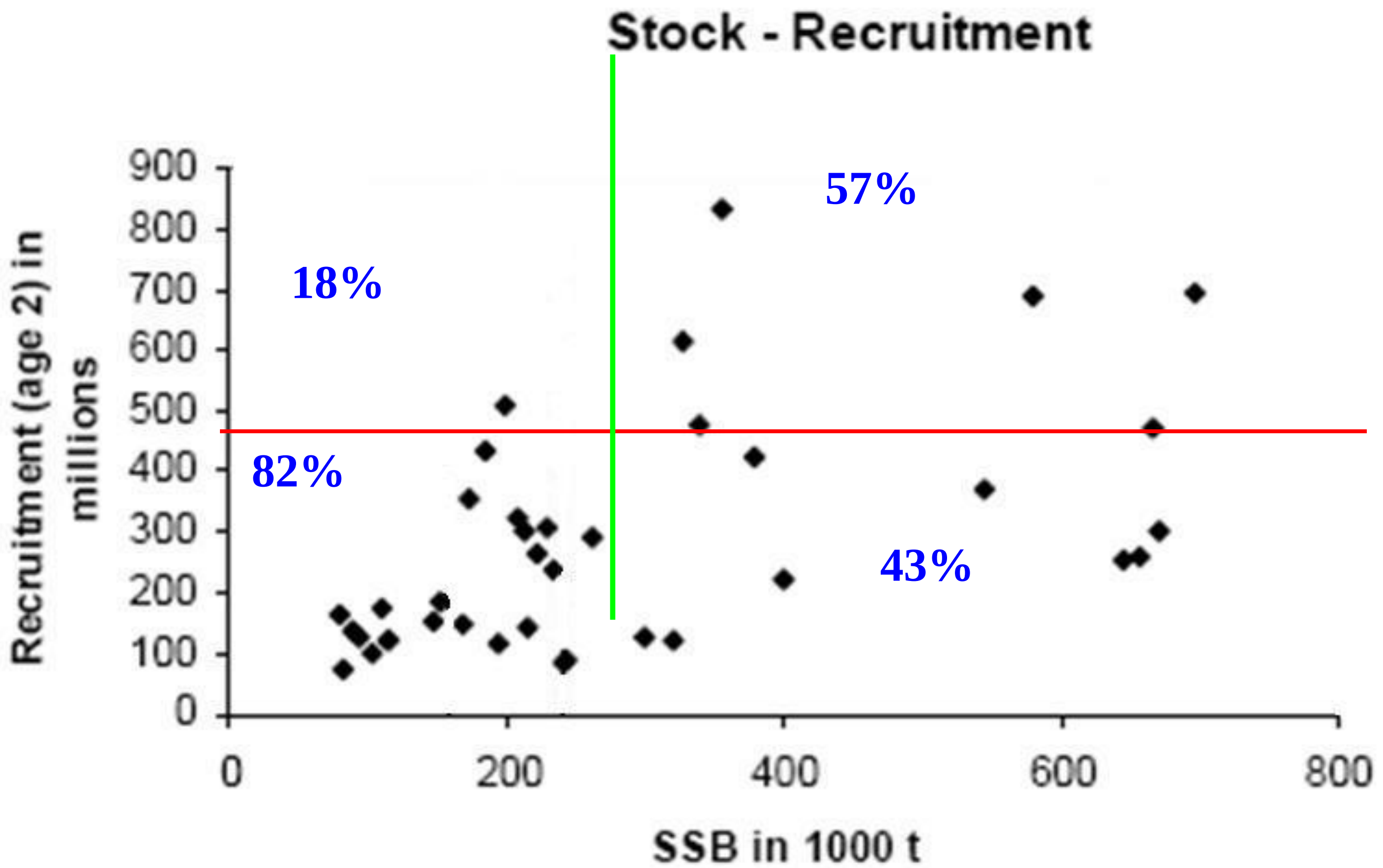
Not a one to one relationship!
A maximum of average recruitment regardless of SSB

Why is the Study of Stock-Recruitment So Important

- Used to forecast potential recruitment
- Understand level of spawning biomass necessary to produce large sustainable catches
- Calculate key values (reference points) for the stock

Often highly variable but still useful.

Low SSB results in reduced chance of average recruitment



Baltic cod 25-32

Population Dynamics

Population Dynamics: ***Study of the Vital Rates of Populations***

- **Growth** – change in size of the individuals in the population
- **Mortality** – change in the number of individuals in the population from death
- **Recruitment** – change in the number of individuals in the population from births

The Basic Fish Population Model

change in population biomass =

$$\underbrace{(G + R)}_{\text{additions}} - \underbrace{(M + C)}_{\text{subtractions}}$$

G = growth

R = births (recruitment)

M = natural mortality (deaths)

C = catch (deaths)

Which of these can management control?

Productivity = (Growth + Recruitment) –

(natural Mortality + Catch)

Can only control catch directly. In theory, can influence recruitment growth, and natural mortality

Density dependence

Key concept in population dynamic models

Density Dependence-

the basis for fishery management

What happens with too many fish?

Growth (yield per fish) declines.

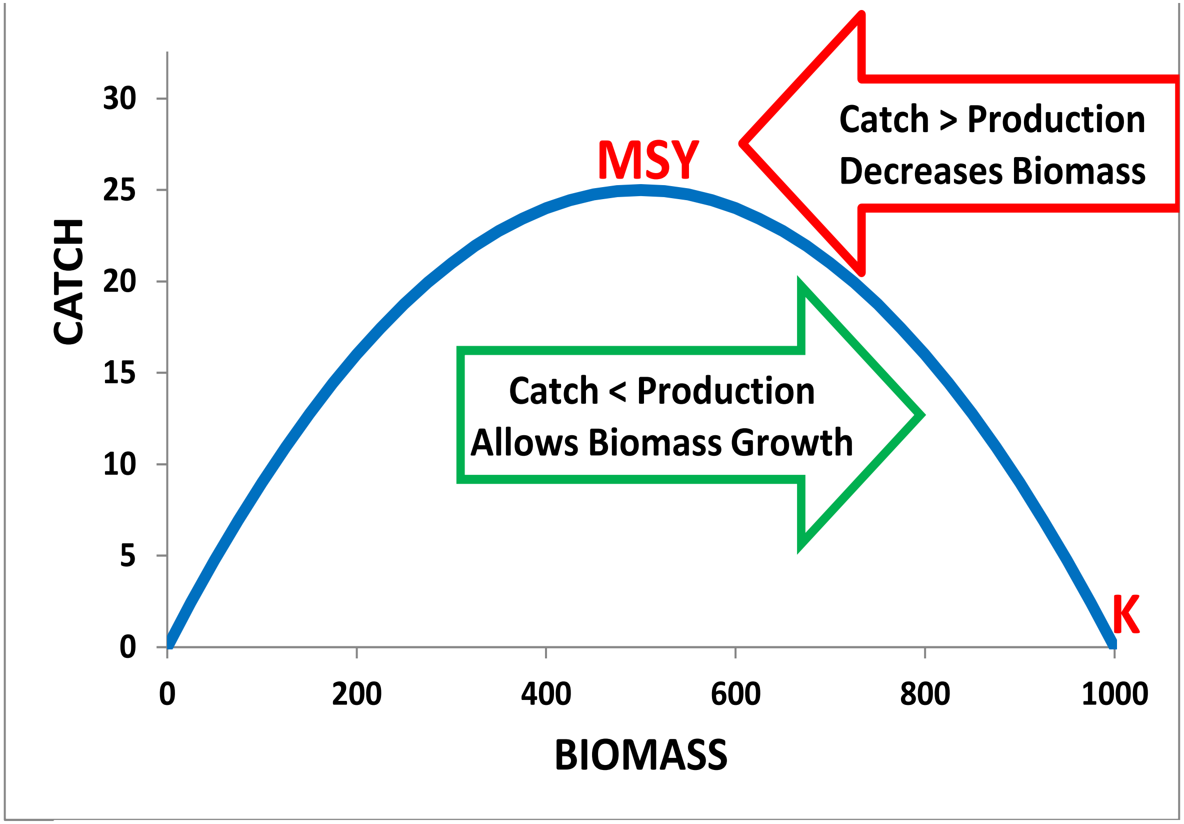
Habitat saturated. Run out of room.

Food can become limiting.

What happens if not enough fish?

Can have too few for mating success.
May increase predation risk.
May reduce feeding efficiency.
Yield to fisheries is very low.

Density processes important in yield models



- **Maximum Population is carrying capacity (K). Productivity low.**
- **Production is greatest if stock size at half its carrying capacity.**
- **Associated catch is maximum sustainable yield (*MSY*).**

- **If removals can be replaced by production each year, on average, the fishery is sustainable at that level.**