Population Ecology (part 2)

I. Types of Density Dependence
II. Population Structure - Closed vs. Open
III. Metapopulation Dynamics
IV. Intrapopulation Structure
V. Life History Strategies

I. Types of Density Dependence

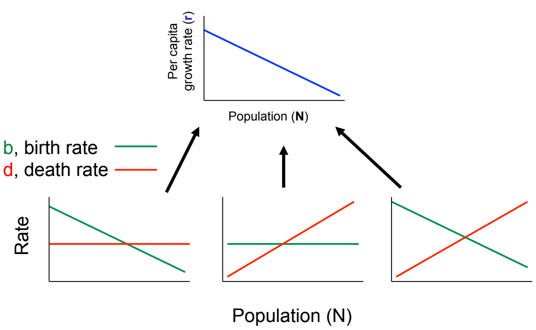
1. Density Independent

2. Density Dependent

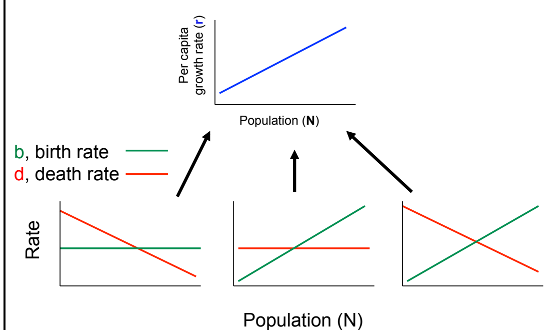
A. Direct (Negative) Density Dependence

B. Inverse (Positive) Density Dependence

Direct (negative) density dependence



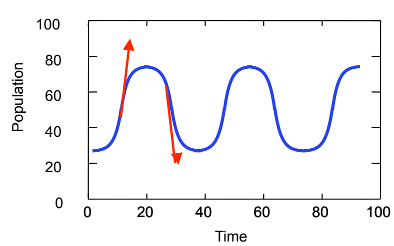
Inverse (positive) density dependence



Inverse (positive) density dependence

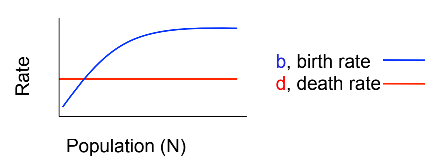
Does **not** regulate populations

- makes them more…
  - **- susceptible to extinction**
  - **- prone to explosion**



Inverse density dependence -- The Allee Effect

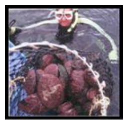
(W.C. Allee 1931. *Animal Aggregations: A study in General Sociology*)

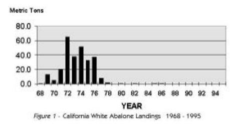


Inverse density dependence -- The Allee Effect

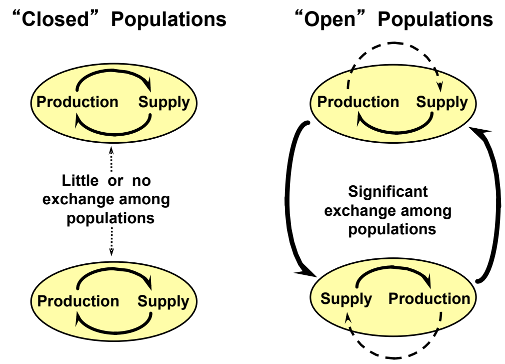
Example: white abalone (*Haliotis sorenseni*)

- first marine invertebrate to be listed as an endangered species
- male and female need to be within ~ 1 m to reproduce
- current densities in good habitat ~ 1 hectare (100 x 100 m)





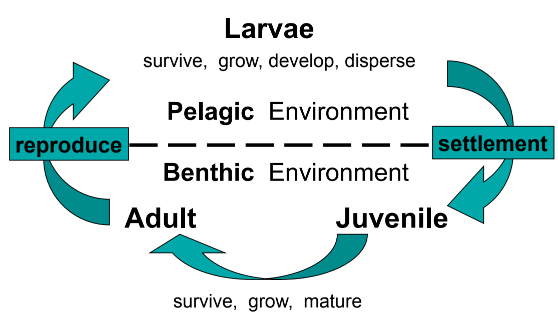
II. Population Structure -- Closed vs. Open



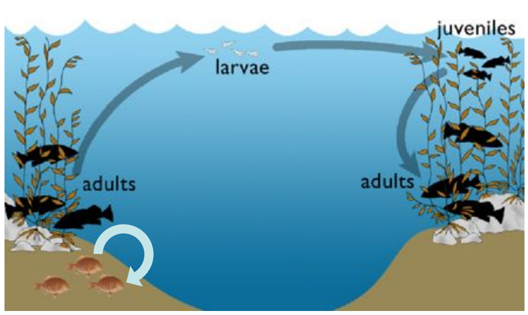
Most benthic marine organisms live in open populations because...

- adult habitat is patchy
- adults are relatively sedentary
- there is dispersal of planktonic larvae

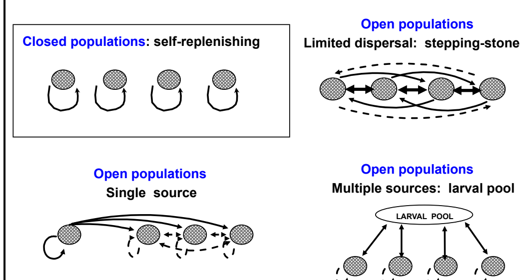
"Bipartite" life cycle of benthic marine organisms with pelagic larvae



"Bipartite" life cycle of benthic marine fishes with pelagic larvae



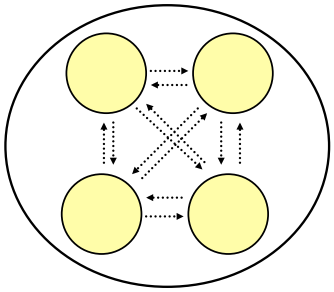
Spatial structure of populations can affect gene flow, genetic diversity, population dynamics, and population persistence



III. Metapopulation Dynamics

Metapopulation: a collection of open subpopulations

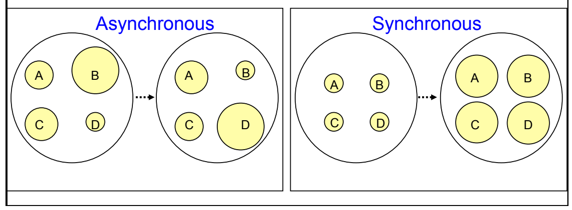
- i.e., a population composed of spatially isolated subpopulations that are connected by dispersal among them



- the **metapopulation** is a closed population
- at a large enough spatial scale, all populations are closed

Regulation in Metapopulations

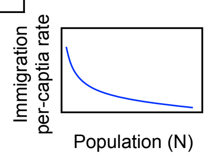
- can get regulation in a metapopulation without "biological" density dependence in the subpopulations
  - — must have dispersal among subpopulations
  - — must have asynchronous fluctuations in abundance in subpopulations
  - — get "mathematical" density dependence



Regulation in Metapopulations

- can get regulation in a metapopulation without "biological" density dependence in subpopulations

Subpopulation density	# immigrants (settlers)	per-capita rate of immigration
10	5	0.50
20	5	0.25
50	5	0.10
100	5	0.05



IV. Intrapopulation Structure

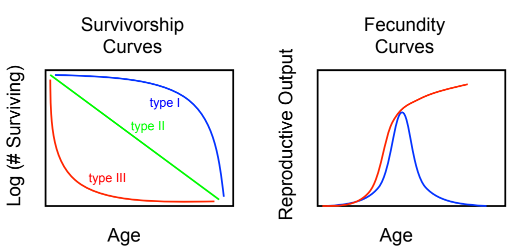
Contrary to assumptions of simple mathematical models (e.g., Logistic Growth), not all individuals in a population are the same!

Intrapopulation Structure is the relative abundance of individual traits among individuals in a population:

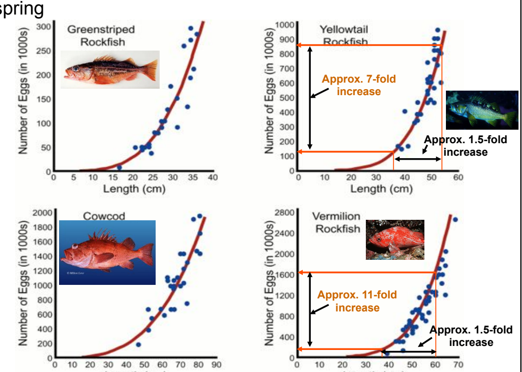
- **age**
- **size**
- **stage (e.g., larvae, juveniles, adults)**
- **sex**
- **genetic (genotypes)**
- **spatial**

All of these can influence per-capita rate of mortality (d) and reproduction (b)

For example, the probability of survival and fecundity chage with age

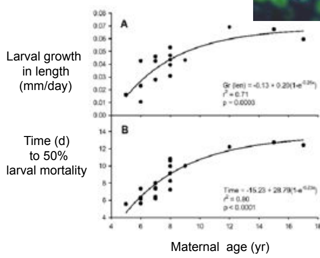


For example, size matters -- bigger fish produce far more offspring



Age matters, too:
older females produce higher quality larvae with a higher likelihood of surviving

black rockfish (*Sebastes melanops*)



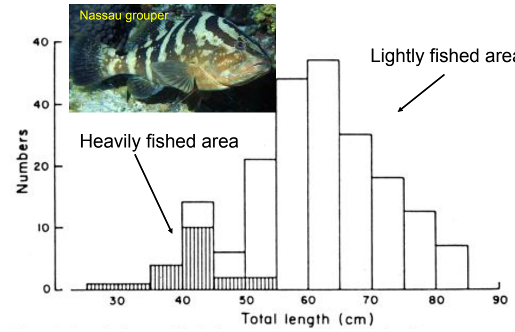
Berkeley et al. 2004
Fisheries 29: 23-32

Berkeley et al. 2004
Ecology 85:1258-1264

AND… Different aged fish spawn at different times

Bobko, S. J. and S. A. Berkeley. 2004. Fishery Bulletin 102:418-429

Fishing changes the size (& age) structure
(Thompson & Munro 1978)



V. Life History Strategies

Live fast, die young?

Evolution can affect many basic attributes of the life history of an organism:

- **age at maturity**
- **reproductive pattern** (repeated vs. "big bang")
- **fecundity** (offspring per bout)
- **lifespan**

Reproductive Pattern

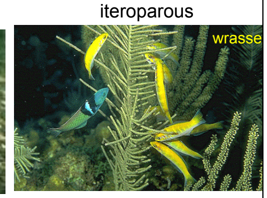
Semelparity ("Big Bang") — reproduce once

Iteroparity — reproduce multiple times

Why do one instead of the other?

semelparous

iteroparous

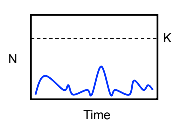


Different life history strategies have evolved in response to different patterns of environmental variability

r-selection vs. K-selection

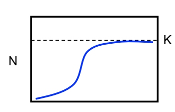
- **r-selection**

⇒ unstable environments
- — low densities relative to K
- — highly variable densities (in response to environmental variation)
- — **selects for high r** to utilize unlimited resources



- **K-selection**

⇒ stable environments
- — near K
- — relatively constant densities
- — **selects for low r**, but high competitive ability to garner resources



Pressures that cause r- or K-selection and attributes of r- and K-selected species

Selective Pressures	r-selection	K-selection
Climate	unpredictable	constant
Mortality	density-independent	density-dependent
Density	variable, low relative to K	constant, near K
Competition	weak	strong
Expected attributes		
r	high	low
maturity	early	late
ontological development	rapid	slow
brood size	high	low
size of offspring relative to parents	small	large
lifespan	short	long