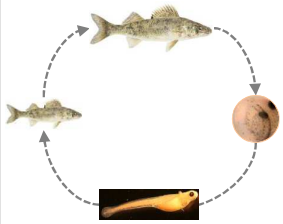
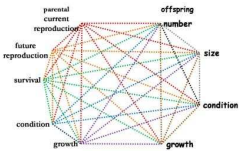
Life histories of fishes

Presented by Nikolai Klibansky





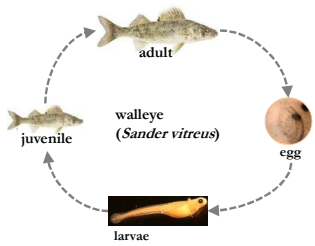
Outline

I. What is a life history?
II. Life history events and traits
III. Life history information in fisheries
IV. Trends in empirical data
V. Life history theory

What is a life history?

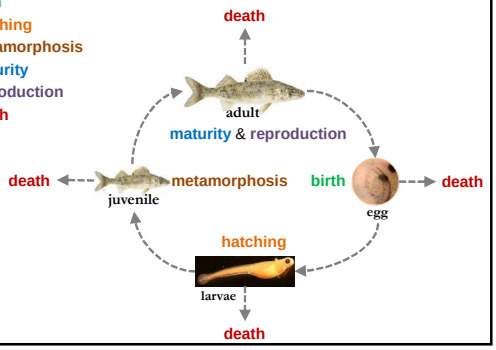
life history – the set of events and traits that define the life cycle of a species

Typical life cycle of an oviparous species



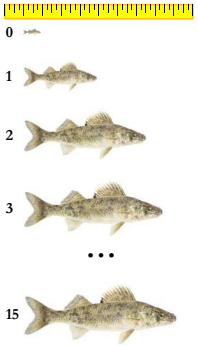
Life history events

1. birth
2. hatching
3. metamorphosis
4. maturity
5. reproduction
6. death



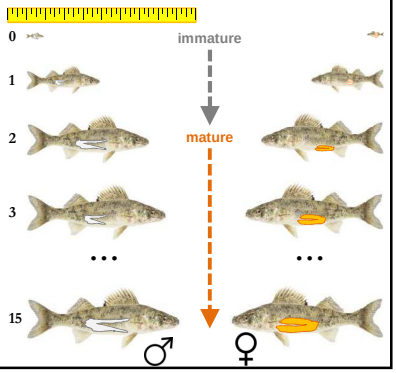
Traits we measure in individuals

1. Size
2. Age



Traits we measure in individuals

1. Size
2. Age
3. Sex
4. Maturity stage
5. Fecundity



Major life history in fisheries

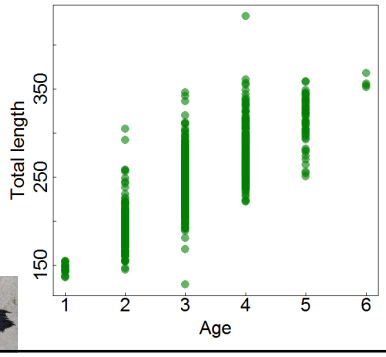
Traits we measure in individuals

1. Sex
2. Age
3. Size
4. Maturity stage
5. Fecundity

Major life history traits we calculate in populations

1. Size at age (growth)
2. Death and age
   A. survivorship
   B. mortality
3. Size at maturity
4. Age at maturity
5. Fecundity at size
6. Fecundity at age
7. Size at sex transition
8. Age at sex transition

Growth

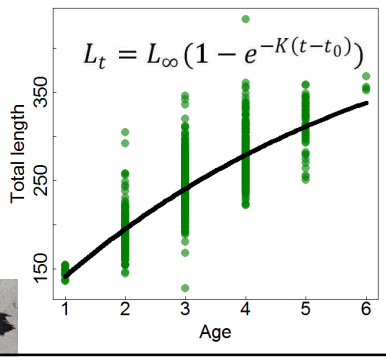


Growth

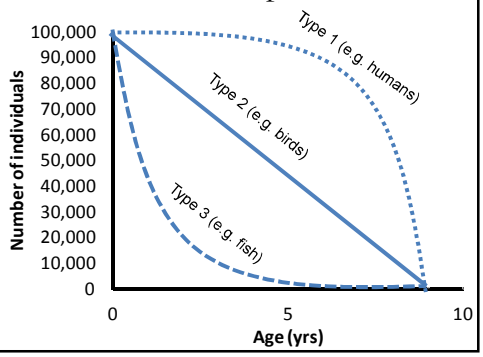
Von Bertalanffy growth equation

$$L_t = L_\infty(1 - e^{-K(t-t_0)})$$

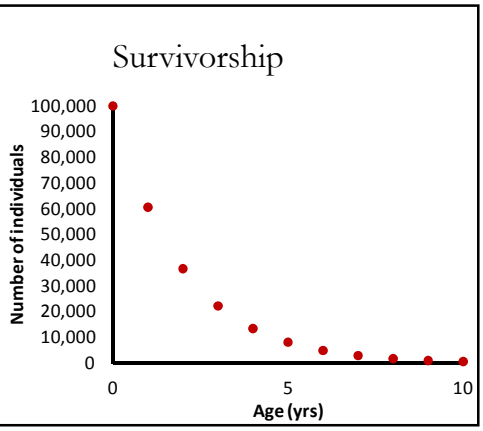
t = age
L_t = length at age t
L_∞ = asymptotic length
K = growth rate
t_0 = age when: $L_t = 0$



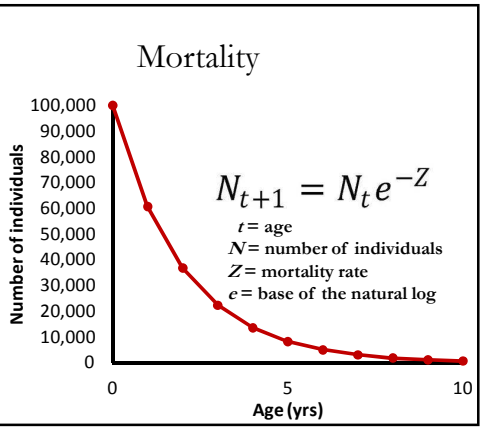
Survivorship



Survivorship

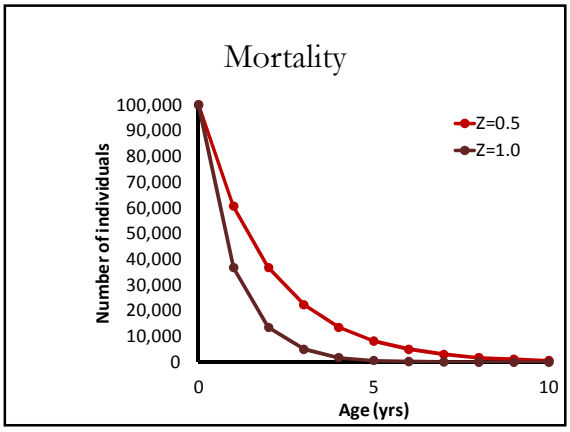


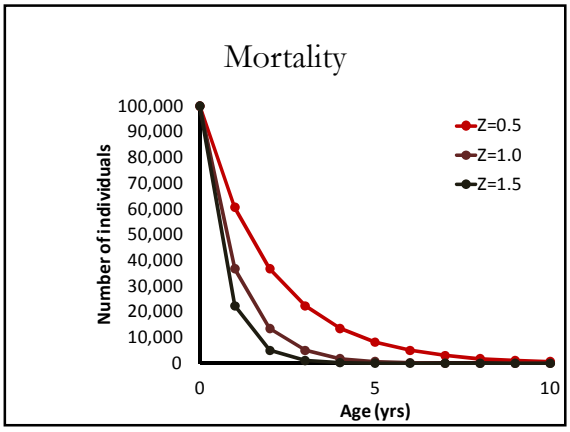
Mortality



$$N_{t+1} = N_t e^{-Z}$$

t = age
N = number of individuals
Z = mortality rate
e = base of the natural log


Mortality
Number of individuals
100,000
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
0
5
10
Age (yrs)
Z=0.5
Z=1.0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20,000
10,000
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5
10
Age (yrs)
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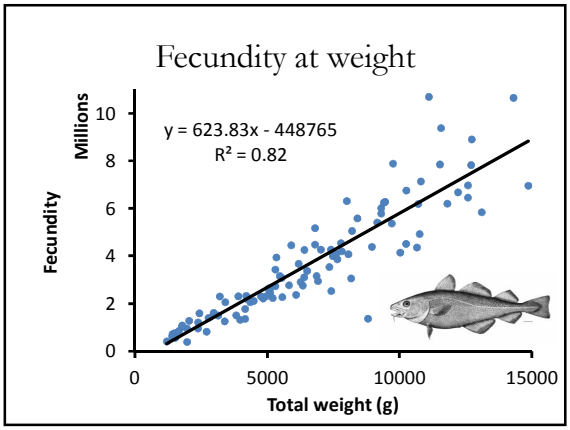
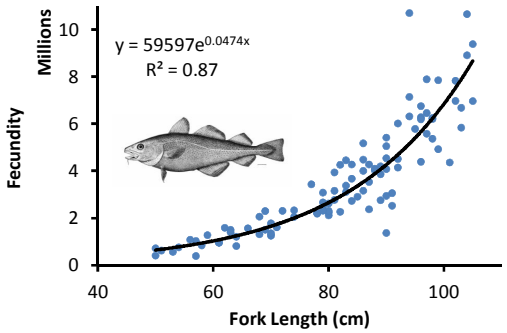
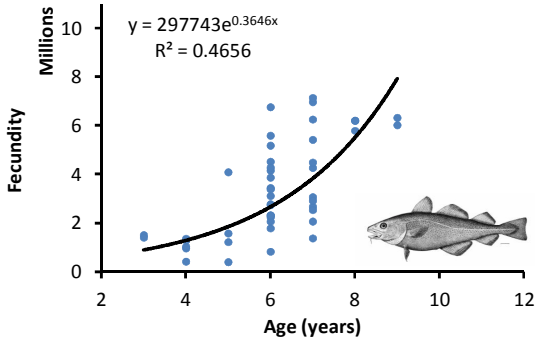

Fecundity at weight
Fecundity
Millions
10
8
6
4
2
0
y = 623.83x - 448765
R² = 0.82
0
5000
10000
15000
Total weight (g)

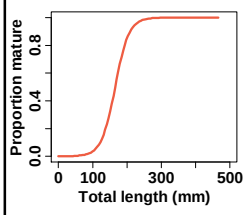
Fecundity at length

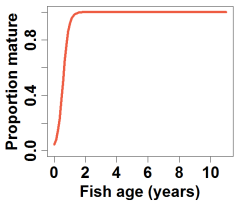


Fecundity at age

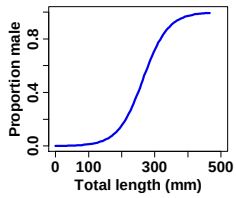


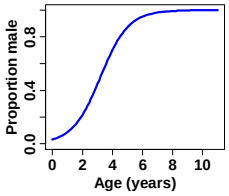
Size and Age at Maturity



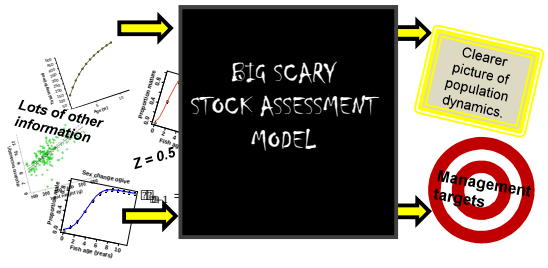


Size and Age at Sex Change

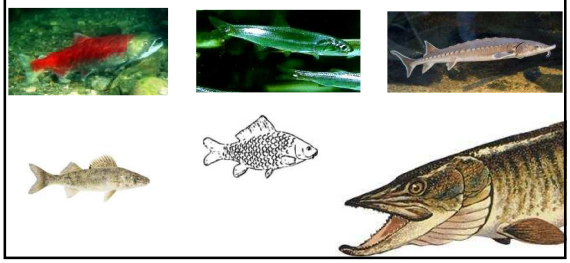




Life history data and fisheries management



Trends in empirical data



Teleost orders in Winemiller and Rose (1992)

216 teleost species


12 Clupeiformes


30 Cypriniformes


71 Perciformes


11 Pleuronectiformes


28 Salmoniformes

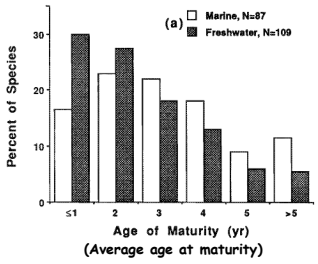

16 Scorpaeniformes


12 Siluriformes

Winemiller, K.O., and Rose, K.A. 1992. Patterns of life history diversification in North American fishes - implications for population regulation. Canadian Journal of Fisheries and Aquatic Sciences **49(10): 2196-2218.**

Age at maturity

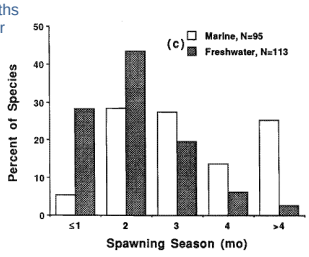
-age at maturity usually <6
-a little higher in marine species
-mean overall = 3 years



Winemiller, K.O., and Rose, K.A. 1992. Patterns of life history diversification in North American fishes - implications for population regulation. Canadian Journal of Fisheries and Aquatic Sciences **49(10): 2196-2218.**

Spawning season length

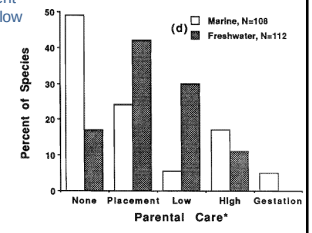
-spawning season usually < 4 months
-more marine species spawn longer
-mean overall = 2.7 months



Winemiller, K.O., and Rose, K.A. 1992. Patterns of life history diversification in North American fishes - implications for population regulation. Canadian Journal of Fisheries and Aquatic Sciences **49(10): 2196-2218.**

Parental care

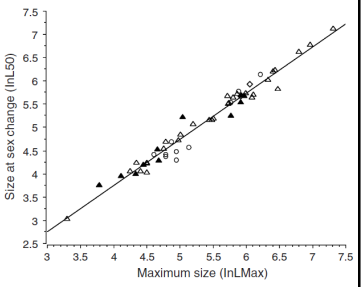
-marine: usually no care, or placement
-fresh: many with placement and/or low care



Winemiller, K.O., and Rose, K.A. 1992. Patterns of life history diversification in North American fishes - implications for population regulation. Canadian Journal of Fisheries and Aquatic Sciences **49(10): 2196-2218.**

Size at sex change vs. maximum body size

-strong relationship
-Fish change sex at:
80% maximum size
2.5 times size at maturity

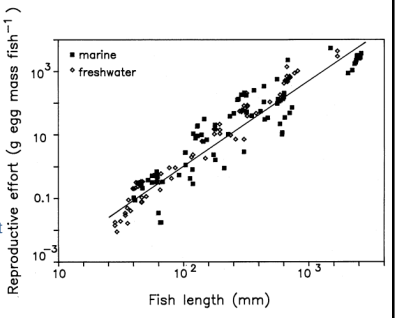


Allsop, D.J., and West, S.A. 2003. Constant relative age and size at sex change for sequentially hermaphroditic fish. Journal of Evolutionary Biology **16: 921-929.**

Reproductive investment vs. body size

-NOTE: reproductive investment is more correct in this case because we're only dealing with the mass put into reproduction, which does not include energy spent on reproductive behaviors

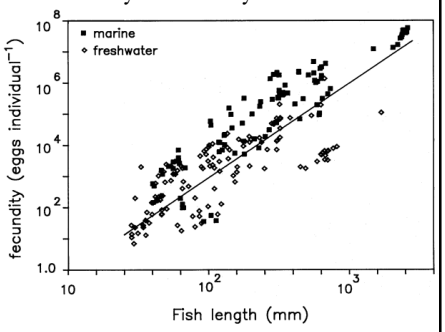
-Across species reproductive investment increases with fish length



Duarte, C.M., and Alcaraz, M. 1989. To produce many small or few large eggs: a size-independent reproductive tactic of fish. Oecologia **80(3): 401-404.**

Fecundity vs. body size

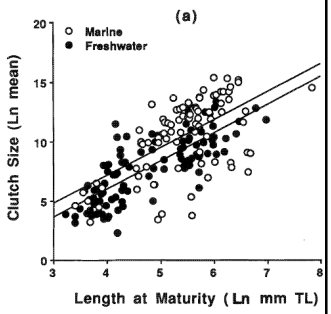
-Across species fecundity increases with fish length



Duarte, C.M., and Alcaraz, M. 1989. To produce many small or few large eggs: a size-independent reproductive tactic of fish. Oecologia **80(3): 401-404.**

Clutch size vs. length at maturity

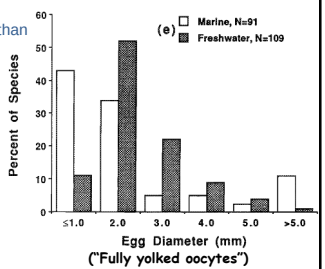
-clutch size = batch fecundity
Across species number of eggs per clutch increases with length at maturity
-Generally higher in marine than freshwater



Winemiller, K.O., and Rose, K.A. 1992. Patterns of life history diversification in North American fishes - implications for population regulation. Canadian Journal of Fisheries and Aquatic Sciences **49(10): 2196-2218.**

Egg size

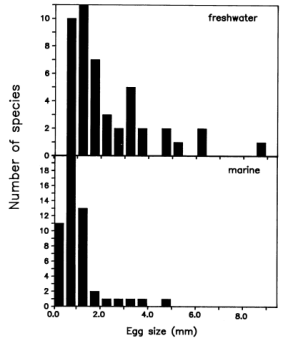
-Eggs usually < 6mm
-Marine eggs tend to be smaller than freshwater eggs
-mean overall = 2.14 mm



Winemiller, K.O., and Rose, K.A. 1992. Patterns of life history diversification in North American fishes - implications for population regulation. Canadian Journal of Fisheries and Aquatic Sciences **49(10): 2196-2218.**

Egg size

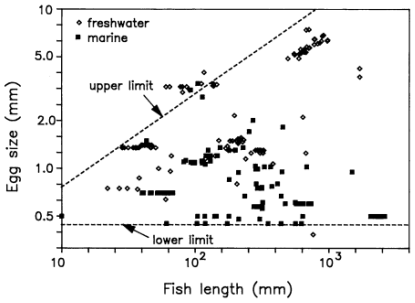
-Eggs usually < 6mm
-Marine eggs tend to be smaller than freshwater eggs
-mean overall = 2.3 mm



Duarte, C.M., and Alcaraz, M. 1989. To produce many small or few large eggs: a size-independent reproductive tactic of fish. Oecologia **80(3): 401-404.**

Egg size vs. body size

-Mean egg size doesn't increase with fish size
-Egg size range seems to increase with fish size



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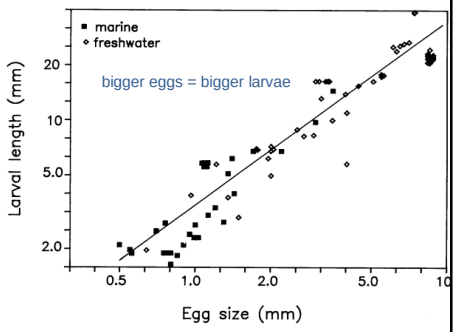
Egg size vs. offspring size



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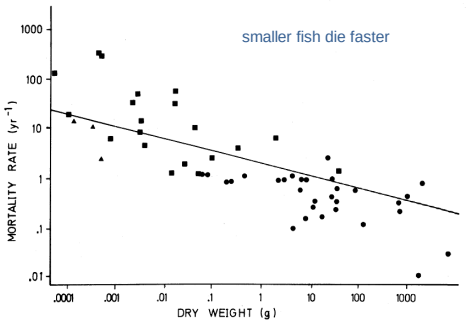
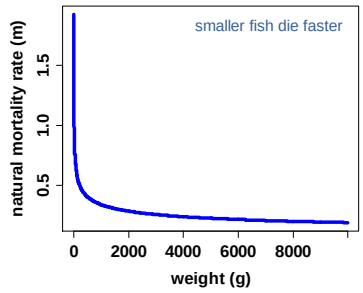
Mortality rate and body size



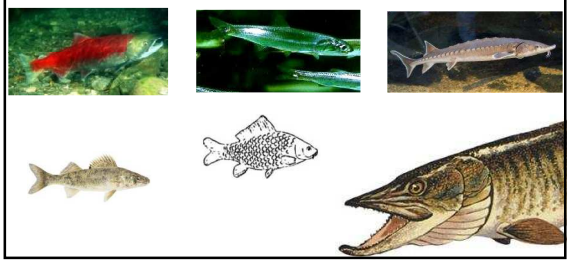
Peterson, I., and Wroblewski, J.S. 1984. Mortality rate of fishes in the pelagic ecosystem. Canadian Journal of Fisheries and Aquatic Sciences **41(7): 1117-1120.**

Mortality rate and body size



Peterson, I., and Wroblewski, J.S. 1984. Mortality rate of fishes in the pelagic ecosystem. Can. J. Fish. Aquat. Sci. **41(7): 1117-1120.**

Life history theory



Big questions

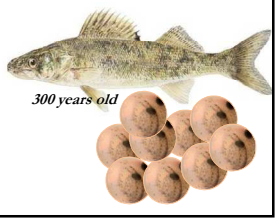
Why do we see patterns in life history traits?

Why do we see the specific patterns that we see?

Why don't we see certain patterns?

e.g. **DARWINIAN DEMONS**

-born mature
-grow extremely fast
- massive eggs
- high fecundity
-long life



Key concepts

1. Fitness
2. Phenotype
3. Genotype
4. Quantitative traits
5. Phenotypic plasticity
6. Reaction norms
7. Constraints
8. Tradeoffs
9. Life history strategy (pattern)

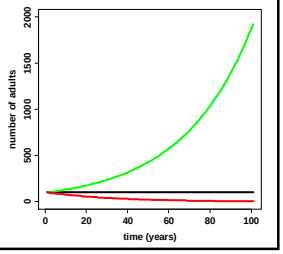
Key concepts

fitness

– the expected contribution of an allele, genotype, or phenotype to future generations (*Stearns, 1992*)
– often called reproductive success (*Futuyma, 2005*)
– average per capita rate of increase in numbers (*Futuyma, 2005*)

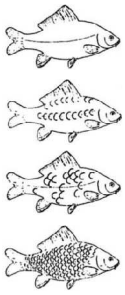
- Imagining 3 populations of squid which differ only in one life history trait (fecundity)

- **High fecundity**
- **Medium fecundity**
- **Low fecundity**



Key concepts

phenotype | **genotype**



TTGCGAATC
AACGCTTAG

GTGCGATTC
CACGCTAAG

TTGAGATTC
AACTCTAAG

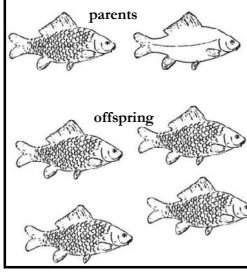
TTGCGATCA
AACGCTAGT

Scale pattern in carp (*Cyprinus carpio*)

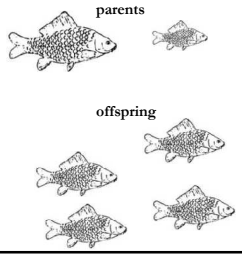
Key concepts

quantitative traits

Scale pattern in carp is a Mendelian genetic trait

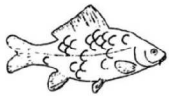


Traits like size are quantitative genetic traits



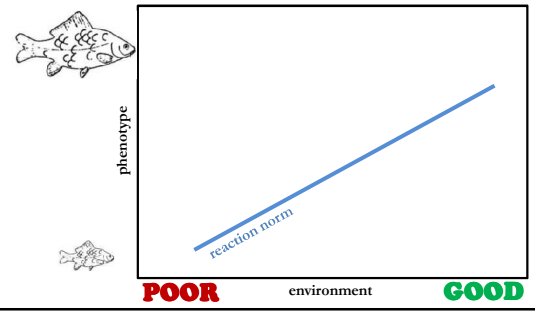
Key concepts

phenotypic plasticity

identical genotypes	+	different environments	=	different phenotypes
TTGAGATTC AACTCTAAG		POOR		
TTGAGATTC AACTCTAAG		FAIR		
TTGAGATTC AACTCTAAG		GOOD		

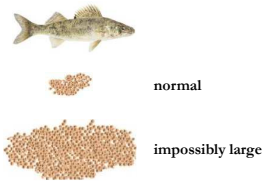
Key concepts

reaction norm



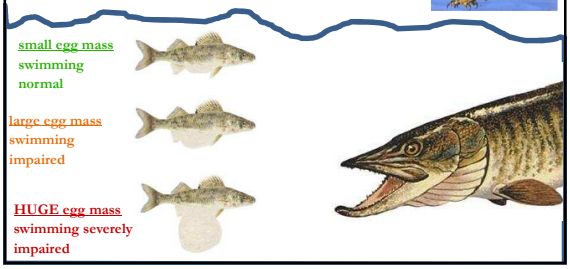
Key concepts

- constraints – limitations on traits
- Two main types
  1. internal – imposed by genetic, phylogenetic, physiological, or mechanical factors



Key concepts

- constraints – limitations on traits
- Two main types
  1. internal – imposed by genetic, phylogenetic, physiological, or mechanical factors
  2. external – imposed by ecological factors

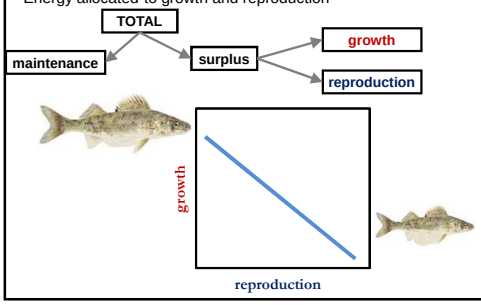


Key concepts

tradeoff – relationship where an increase in one thing implies a decrease in another (Stearns, 1992)

EXAMPLE

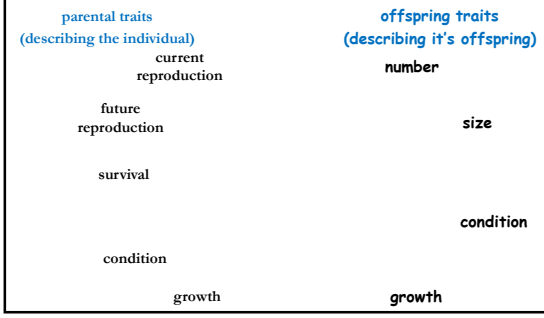
Energy allocated to growth and reproduction



Key concepts

tradeoff

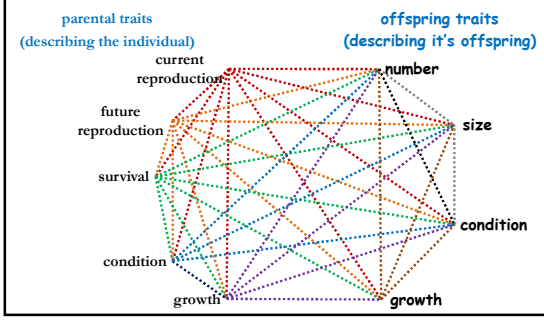
- Many life history traits make up the phenotype of each individual fish
- Major life history traits according to Stearns (1992)



Key concepts

tradeoff

- Any two traits may exhibit a tradeoff resulting, in a complex network of tradeoffs (Stearns, 1992)

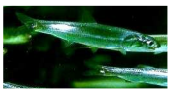


Key concepts

life history strategy (pattern) - the pattern of life history traits that make up the entire phenotype of an individual or species

coho salmon
Oncorhynchus kisutch

-fast adult growth in ocean
-delay maturity, grow large
-migrate upriver for high offspring survival but no future reproduction
-larger, thus fewer eggs



northern anchovy
Engraulis mordax

-mature early and small
-don't grow large, high adult mortality
-multiple reproductive events
-more, smaller eggs
-high offspring mortality

Atlantic sturgeon
Acipenser oxyrinchus

-very late maturity
-grow very large
-long livespan
-many reproductive events
-MANY small eggs
-high offspring mortality