Reproduction

Reading: Chapter 9 (9.3)

- Fecundity
- Reproductive potential
- Maturity
- Sex ratio
- examples

Reproduction

- 96% of marine fish have pelagic eggs/larvae
- Fecundity from a few to millions of eggs per year
- Variation in maturity schedules:
  - Some fish born mature (dwarf perch)
  - Some mature in first year (anchovy, silversides)
  - Some mature many years after hatching (sturgeon)

Fecundity and maturity schedules have profound effects on stock dynamics and response to harvest

Reproduction

- Gonads (testes and ovaries) have long inactive periods
- Spawning occurs when fully developed gametes are released
- Spawning often takes place in particular habitats at particular times
- Stimulus may be internal (endogenous) or external (exogenous)

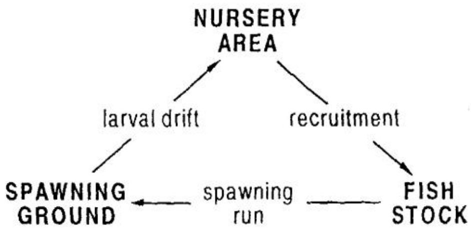


Figure 3.44 A generalized life history triangle for marine species; not all species have geographically separate spawning and nursery areas.

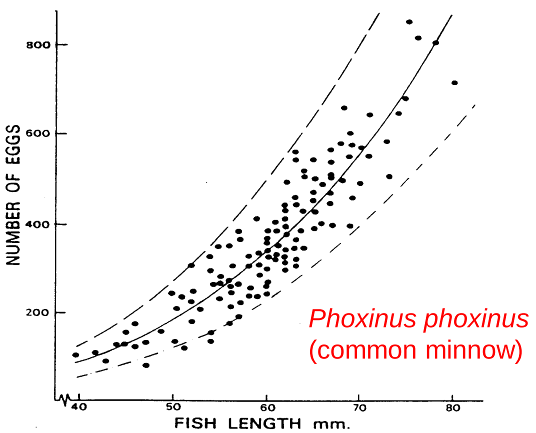
Fecundity

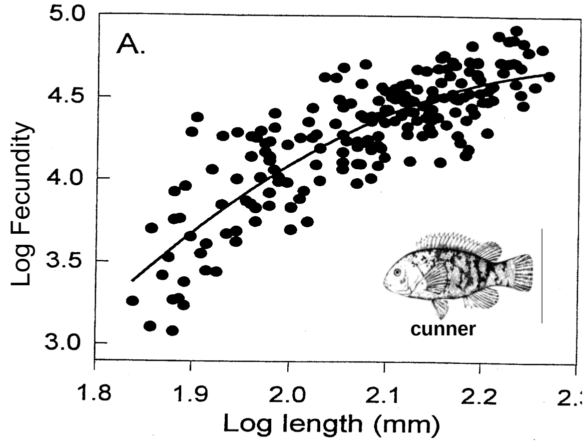
- Total count of ova in both ovaries
- Increases with age/size in teleost fishes
- Related to a power of length or weight

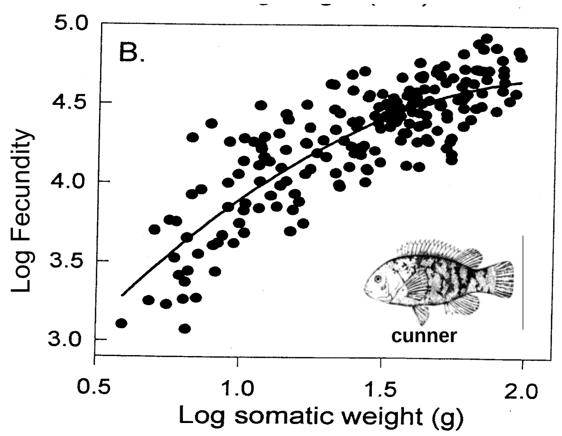
$$F = aL^b$$

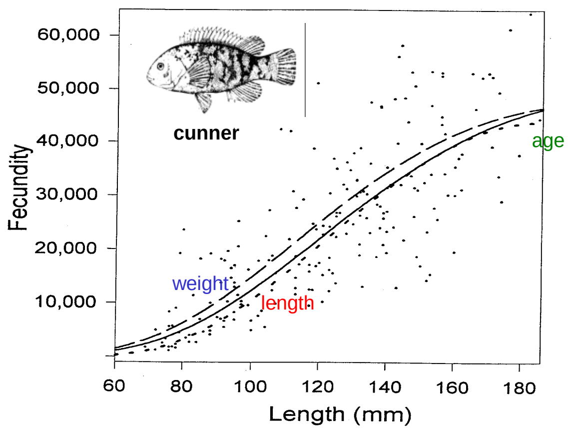
after ln transformation:

$$\ln F = \ln a + b \ln L$$




A.
Log Fecundity
Log length (mm)
cunner


B.
Log Fecundity
Log somatic weight (g)
cunner


cunner
Fecundity
Length (mm)
age
weight
length

Fecundity

True fecundity
– total number of eggs produced

Functional fecundity
– actual production of viable oocytes

Fecundity

Functional fecundity vs. True fecundity

Differences due to:
– **incomplete spawning**
– **atresia (degeneration)**
– **resorption of oocytes**

Fecundity

Total spawners vs. Batch spawners

Total spawners release 1 batch of eggs per breeding season (e.g., brown trout)

Batch spawners release multiple batches of eggs per breeding season (e.g., Atlantic cod)

Fecundity

Batch spawners can be either determinate or indeterminate spawners

determinate

– all eggs to be spawned are present as oocytes in ovary prior to spawning

indeterminate

– eggs to be spawned are not all present as oocytes in ovary prior to spawning (some develop later)

Fecundity

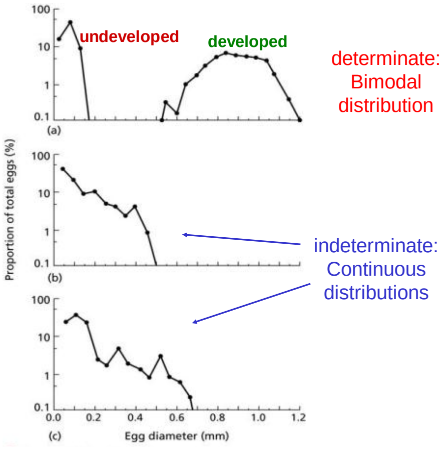
determinate vs. indeterminate spawners

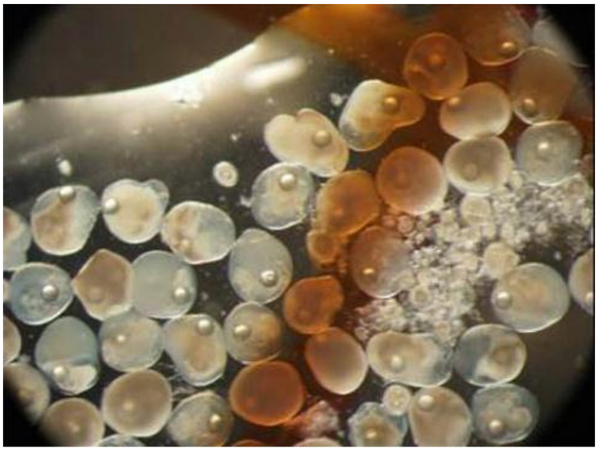
Implications for fecundity estimation?

indeterminate spawners:

– Counts of eggs do not indicate annual fecundity
  - Continuous new batches (size distribution)
  - Protracted season
  - Need to calculate Batch Fecundity X # of batches

– Keep in mind, spawning in multiple batches does not necessarily indicate indeterminate status!





Fecundity
Estimation Methods

A sub-sample of the ovary is used to extrapolate to total egg counts

This avoids total counts but introduces error

- How representative is the sample?
  - sub-sample location
  - egg size variability
  - egg quality variability

Fecundity
Assumptions

Using population fecundity as a measure of reproductive potential assumes:

- constant annual sex ratio
- no annual variation in egg #-fish size relationship
- no annual variation in age/size at maturity
- egg # is a function of fish size independent of age
- no annual variation in proportion of eggs retained by the female during spawning

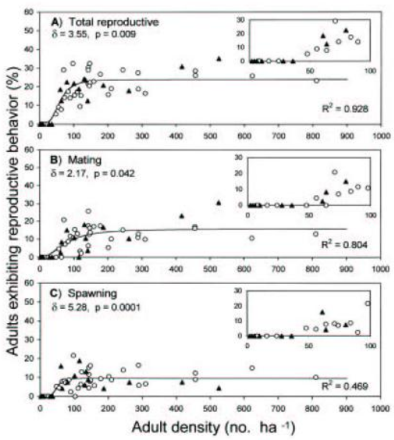
Fecundity
density-dependence

- At high population densities females can retain eggs
- At low densities females may become more fecund
- Each are examples of density-dependent compensatory responses

Fecundity
density-dependence

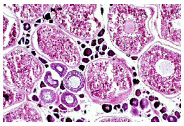
- At low population densities, females may also retain eggs if proper stimulus is absent
- This is an example of a density dependent response, but it is depensatory
- A decrease in reproductive success at low population density is an example of an Allee effect

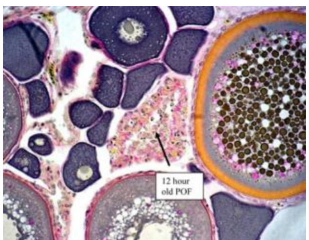
Queen conch in the Caribbean



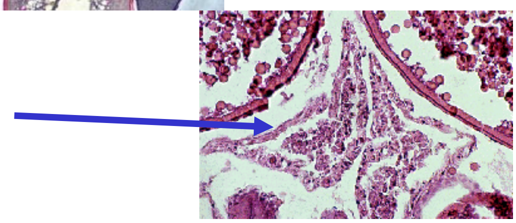
Maturity

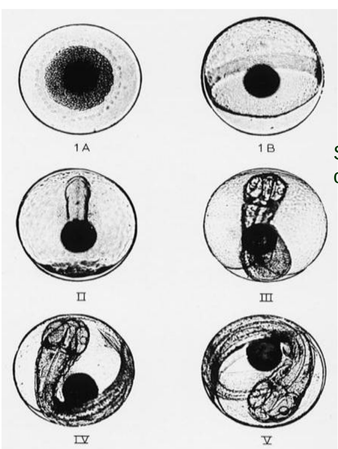
- Maturity schedules are generally age- and size-dependent
- Determined by classifying ovaries into developmental stages
  - Macroscopic examination of morphology, color, size, presence of visible oocytes
  - Microscopic (histologic) examination of gonadal tissue for presence of secondary oocytes and postovulatory follicles





Spotted seatrout that had spawned the previous night





Staged development of mackerel eggs

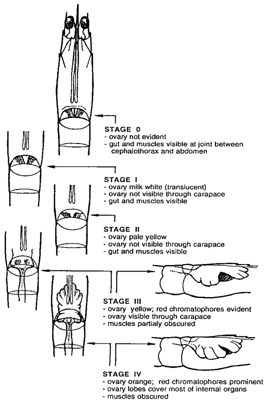


Figure 3.46 Stages in ovary development based on macroscopic criteria for the penaeid prawn *Penaeus latisulcatus*; dorsal and lateral views of prawns and ovaries are shown (adapted from King 1979).

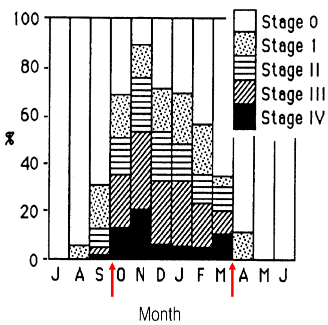


Figure 3.45 Percentage of female penaeid prawns *Penaeus latisulcatus* in five differen development stages (data combined from two succesive years).

Maturity

gonadosomatic indices

- GSI used to track reproductive seasonality
- Assumes ovary size increases with egg development due to increases in egg size
- Function of gonad mass (GM) relative to total body mass (TM)

GSI = 100* (GM/TM)

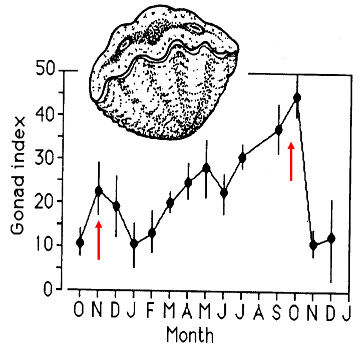
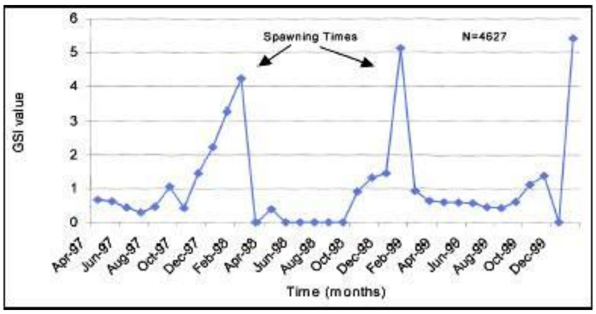
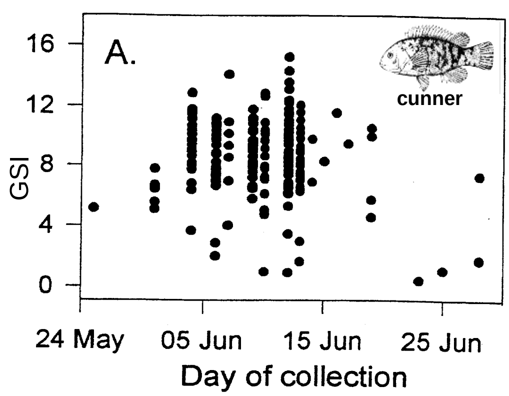


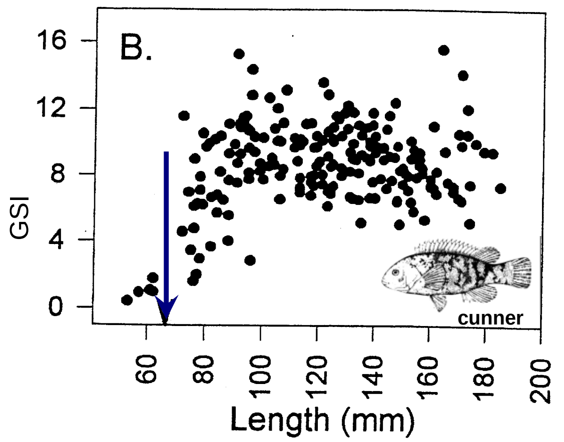
Figure 3.47 Gonad indices for the giant clam *Tridacna crocea*. The vertical bars indicate ±1 standard deviation (adapted from Shelley & Southgate 1988).

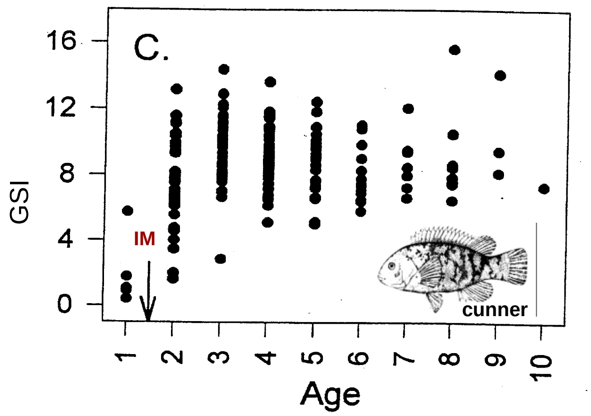
GSI



Common flatfish off Ireland coast







Maturity
length at maturity

- Length (L_m) or age (T_m) at maturity is length/age when 50% of population is mature
  - Estimate %mature in each size class
  - Fit a logistic curve (binomial response)

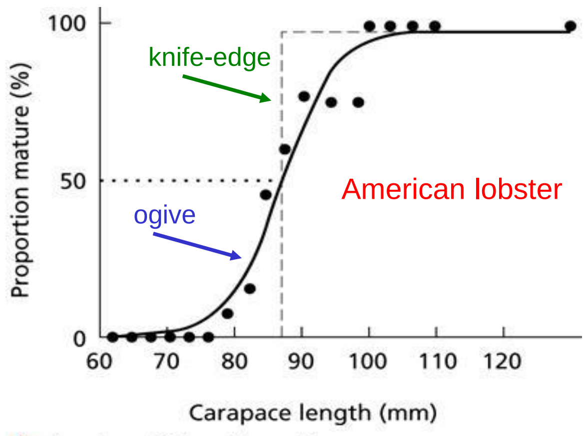
    $$P = 1 / (1 + e^{[-r(L - L_{mat})]})$$

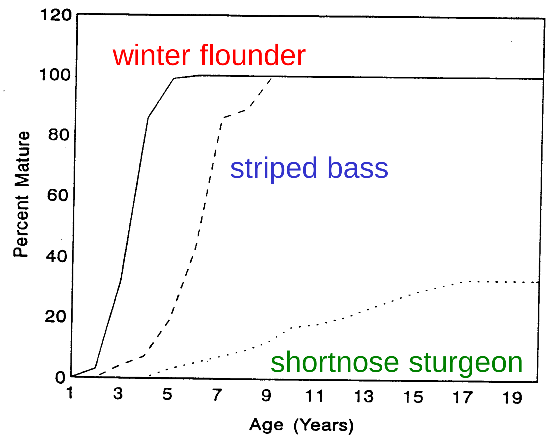
  - Or when linearized:

$$\ln ((1 - P)/P) = rL_{mat} - rL$$

with: b = -r

a = rLmat so Lmat = a/r





Maturity
life histories

- Maturity schedules are species-specific
- Density-dependence may cause advance or delay
- Semelparity vs. Iteroparity
- Hermaphroditism
  - Protogyny-female 1st vs. Protandry-male 1st
- Sex ratios
  - females usually modeled
  - important if spawning biomass is needed, or if males are limiting to reproductive success
  - distinguishing sexes externally often difficult