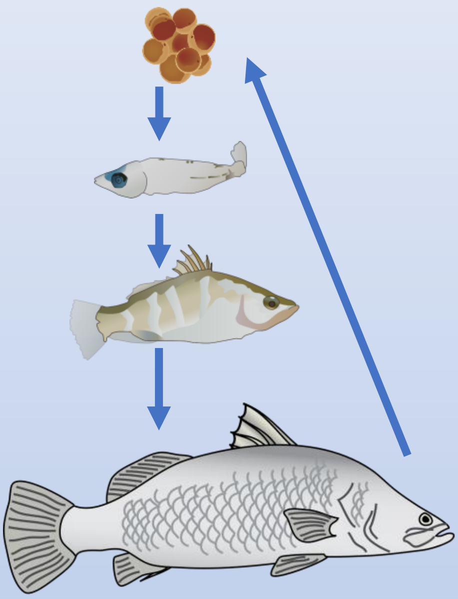
Recruitment

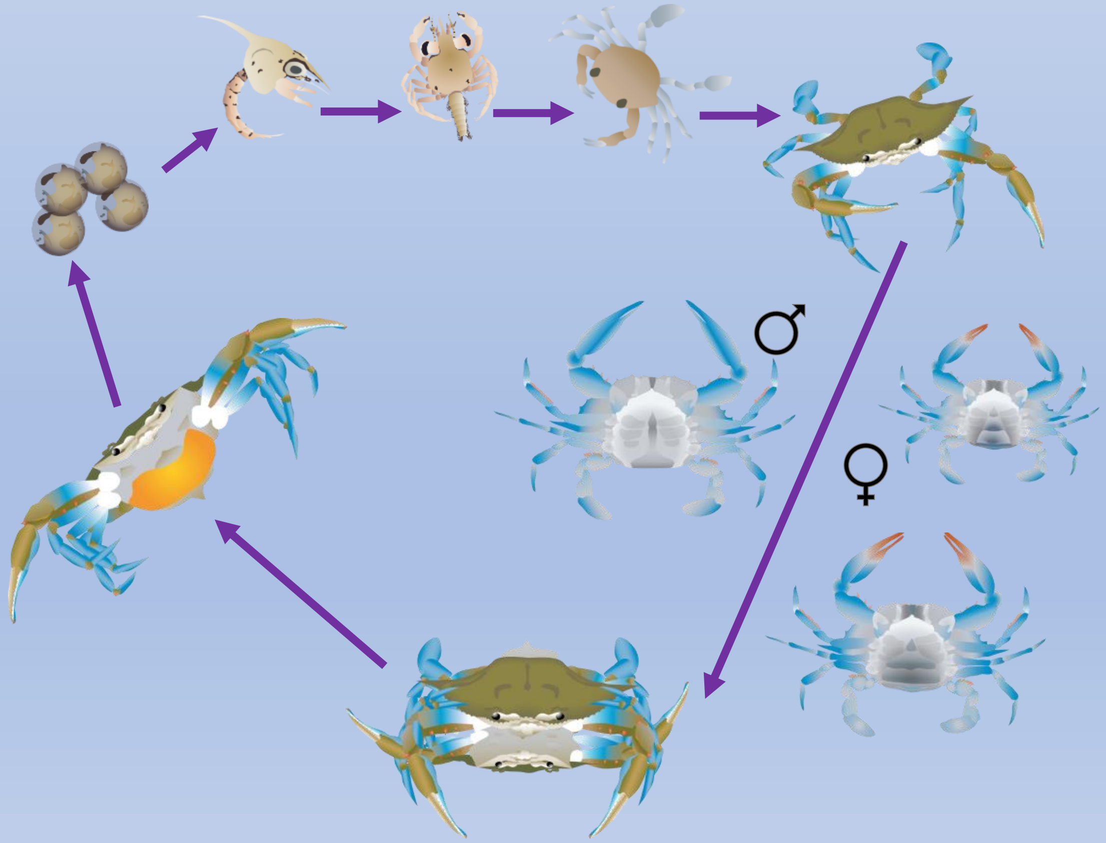
— Life cycle —

Meaning: The changes in form that an animal undergoes throughout its life.

There is a large variability of different life cycles but they often include:

- Egg
- Larvae – live off yolk sac, may drift in the plankton or swim
- Juvenile – feeding, but sexually immature
- Adult – sexually mature
- Spawning – reproduction usually occurs multiple times
- Death





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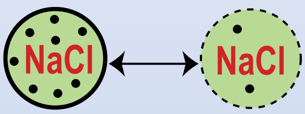
Recruitment

— Vulnerability at each stage —

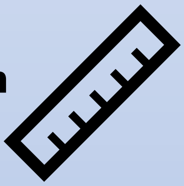
At each stage of their lives, fish are vulnerable (growth and mortality) to different factors.

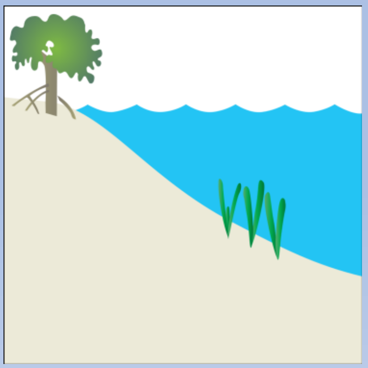
- Egg stage: predation, water temperature, currents, predation, salinity, disease, sedimentation, oxygen levels
- Larvae: predation, water temperature, currents, predation, salinity, disease, oxygen levels
- Juveniles: predation, water temperature, predation, disease, bycatch
- Adults: predation, predation, disease, fishing mortality

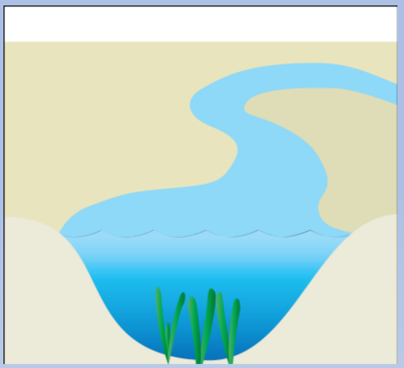


Protecting species throughout the life cycle:

- A common fisheries management tool is legal **minimum size limits**. These are usually set to a size that will let the majority of the population spawn at least once.
- Fishery regulations might also include larger size hooks or nets with big enough mesh that smaller fish can escape.
- Fishery closures protect areas when spawning occurs or specific nursery habitats important for recruitment.







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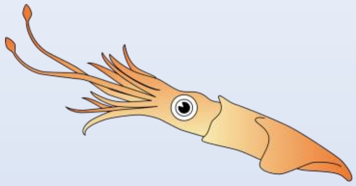
Recruitment

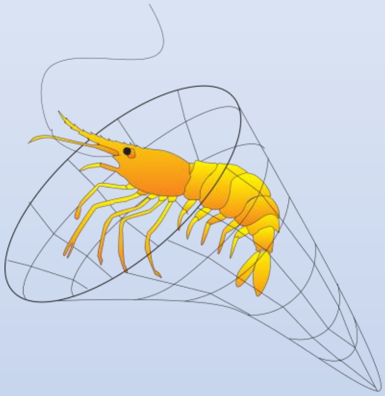
— Diversity of life cycles —

Fish have a wide variety of life history cycles and reproductive effort.



Gould’s Squid live for about a year. They die shortly after spawning and laying floating egg masses that hatch into juveniles 1-2 months later, which then grow into adults.

Banana Prawns live for a year and have a mixed life cycle. Adults live and spawn offshore. They lay eggs, which emerge as a pelagic nauplius. Larval prawns use the tides to move to nursery estuaries and rivers, living in the mud near mangroves about 10 days after hatching and then returning to the ocean after 6-8 weeks. Banana prawns have a risky life cycle, subjected to many environmental conditions. Rain, tides, river flows, temperatures, currents and winds will affect banana prawn catches from year to year.



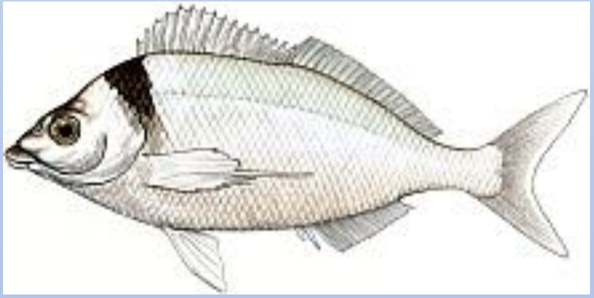


Illustration *Peter Gouldthorpe*

Jackass Morwong live up to 40 years, but usually closer to 16. They can reproduce after 3 years, laying pelagic eggs, which develop into a pelagic larval stage, followed by an extended pelagic post-larval stage known as ‘paperfish’. After 9-12 months, juveniles will settle in shallower reefs before eventually moving offshore as adults.

Life history strategies:

r-selected species: Most fish and shellfish reproduce quickly, produce large numbers of eggs, have fast growth rates, early maturation, lower survivor rates and the ability to disperse widely.

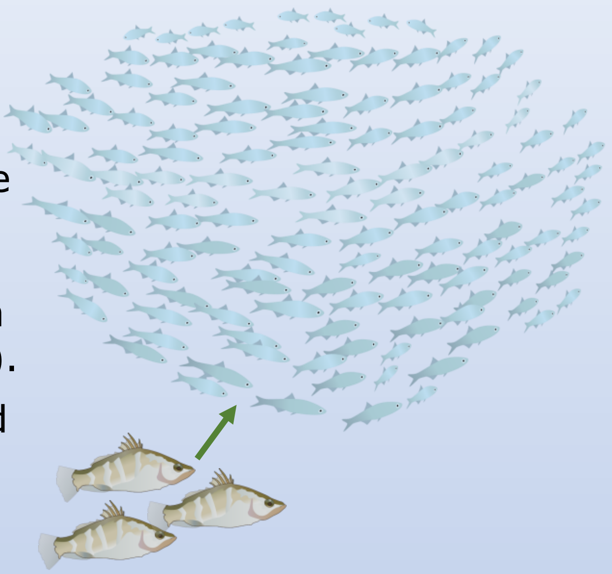
K-selected species: Species that tend to have stable populations that fluctuate near the environmental carrying capacity. These species typically have longer lifespans, low numbers of larger offspring, longer gestation, older age at maturity and more parental care.

Illustrations courtesy of the Integration and Application Network, University of Maryland Center for Environmental Science (ian.umces.edu/symbols/)

— Recruitment —

Meaning: Recruitment is the entry of young fish into the fished component of the stock through growth or movement.

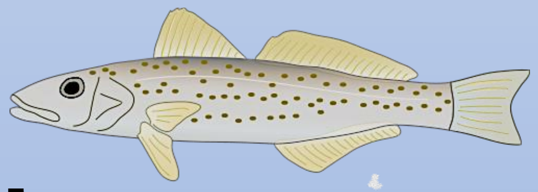
Symbol: ***R***

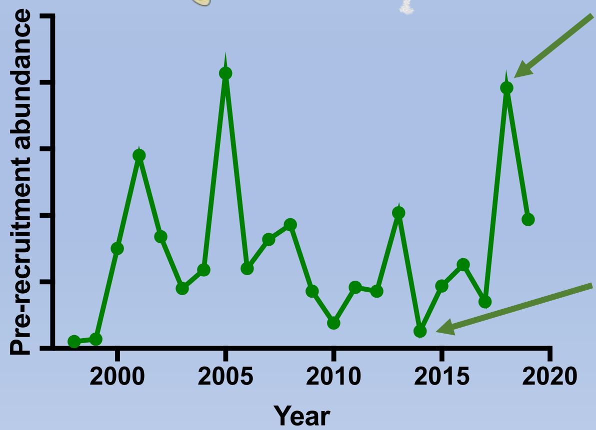


Fish recruit into a fishery either by growing to a size at which they can be caught by the fishing gear, or by moving into an area where fishing takes place (for example moving from a nursery area to the fishing grounds).

The level of recruitment is determined by:

- How many eggs are laid
- Mortality rates at all stages
- Pre-recruitment life cycle stages
- Growth rates
- Environmental or behavioural factors that affect the distribution of pre-recruit stages





King George Whiting caught in Victoria originate from South Australia and are carried by the currents as larvae to settle in Victoria’s bays and inlets.

These currents are driven by winds. When the wind blows in the right direction at the right speeds and at the right times of the year, recruitment of 3 year old fish into the fishery is good.

When the wind blows in the wrong direction at the wrong speeds, recruitment is bad.

Illustrations courtesy of the Integration and Application Network, University of Maryland Center for Environmental Science (ian.umces.edu/symbols/)

Recruitment

— Variable recruitment—

Recruitment of many species can be highly variable from year to year.

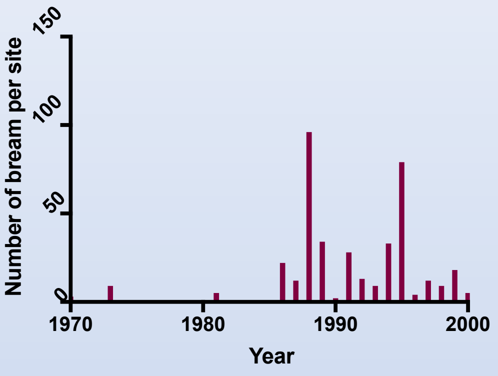


Illustration by R. Swainston

The Goldilocks effect

Stocks that have extreme recruitment patterns rely on environmental conditions being just right for some or many parts of their life cycle – not too hot, not too cold, but *juuuuuust right*.

Some estuaries have layers of water that vary in temperature and salinity with depth. These change with the freshwater that flows from the rivers into the estuary.

Black Bream show high recruitment variability. Bream move from estuaries into feeder rivers to spawn. Certain conditions create the right episodes for higher recruitment.

Strong recruitment for that species depended on:

- The salinity gradient (halocline)
- Higher flows during the juvenile period
- Nursery seagrass habitat and water quality

Local recruitment or population connectivity?

Some fish stocks rely on self-recruitment (i.e. recruitment largely depends on the local population) while other stocks may be connected to nearby populations, either through larval dispersal or adult migration.

Fishery Management

It is important to consider the biology of the species, the dispersal potential of life cycle stages, and recruitment variability for appropriate management strategies.

One of the tools of fisheries management is legal minimum size limits. These are often set at a size that will let the majority of the population spawn at least once.

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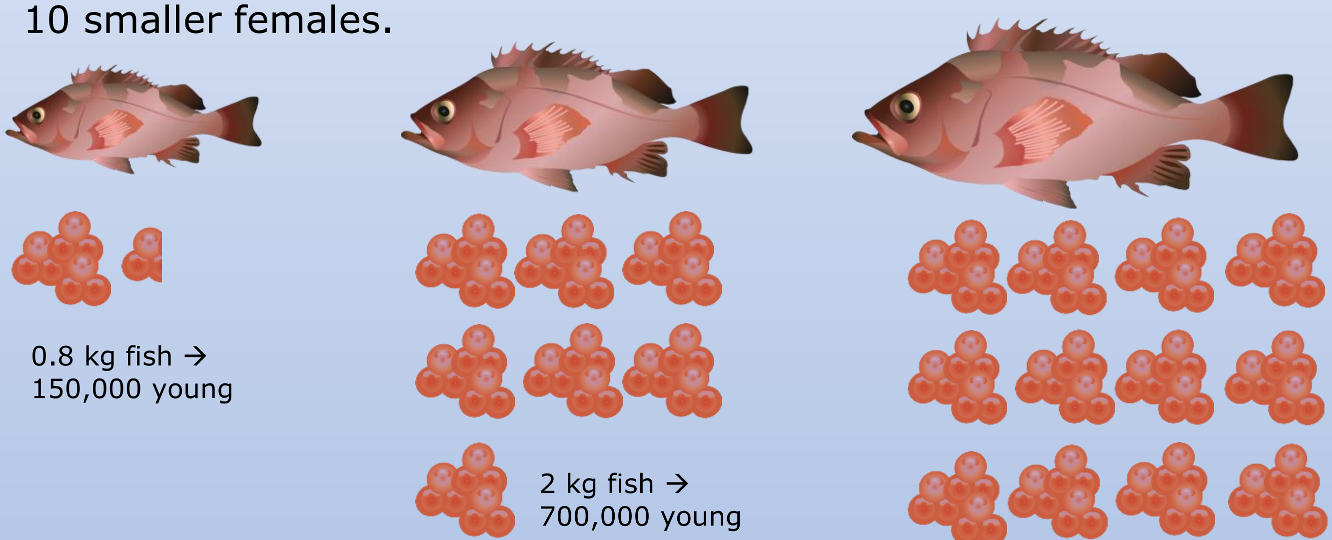
Reproduction

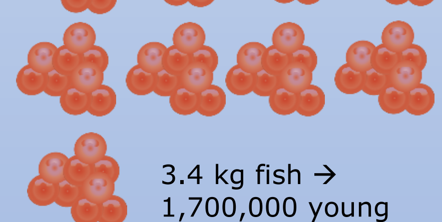
— Fecundity —

Meaning: The number of eggs produced on average by a female of a given size/age.

Knowing approximately how many eggs a fish can produce, or its reproductive potential, can be really important to the long-term goals of a fishery.

For instance, some species have **Big Old Fat Fecund Female Fish**. At larger sizes, these older females can lay many more eggs than younger females. One large female might produce as many eggs as 10 smaller females.





The fish from those eggs produced by larger fish also generally grow faster and have better survival.

This is the case for many species, including groupers and lobsters. While it might be tempting to catch the bigger fish, BOFFFF are more valuable. They make a greater contribution to following generations and successful recruitment to the fishery.

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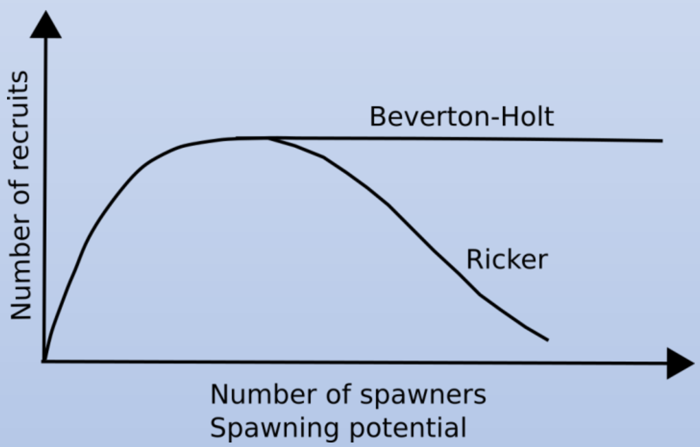
Recruitment

Stock-recruitment relationships

Natural changes in fish populations are largely due to differences in recruitment. **Stock-recruitment relationships** estimate how recruitment might change, depending on **biomass** of mature female breeders — the **spawning stock biomass (SSB)**. The shape of this relationship is used as an input into **quantitative stock assessments**.

Stock-recruitment relationships are different for each stock because it is largely dependent on the **life history strategy** of the species. The number **recruits** depends on the **biomass** of reproductively - active fish (spawners) and environmental conditions.



In theory, with few spawners, there are fewer recruits expected. As the number of spawners increases, we expect recruitment to also increase. However, as the spawning stock increases, there may be more competition for food amongst recruits or increased susceptibility to disease, resulting in reduced numbers of recruits.

Two of the classic stock-recruitment models are:

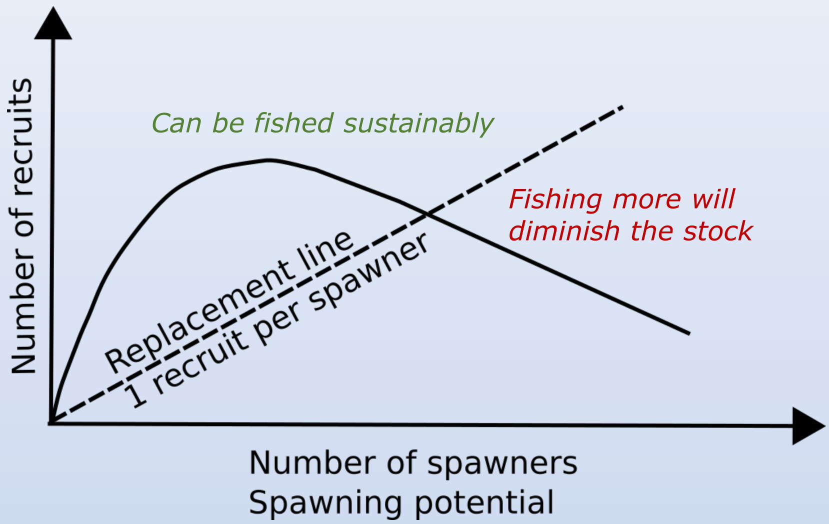
1. Beverton-Holt model where the number of recruits flatlines at some maximum level of recruitment; and
2. Ricker model where mortality of recruits is proportional to the initial spawning stock size, and recruitment levels can decline at large spawning stock biomasses.

Recruitment

Stock-recruitment relationships

A few important concepts:

- The **replacement line** is where the number of spawning stock = the number of recruits. Recruits above this line are can be fished without negatively impacting the population.

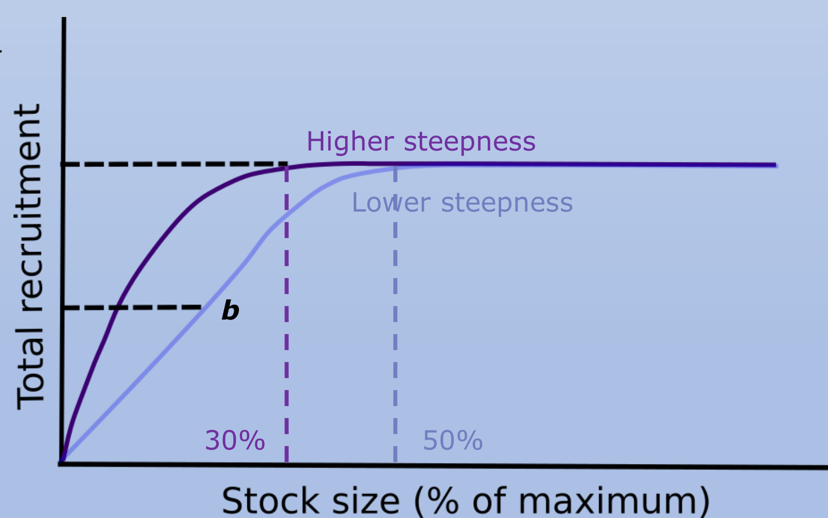


The **steepness (*h*)** of the stock-recruitment line is the fraction of unfished recruitment (***R_0***) when the ***SSB*** is at 20% of unfished levels. Steepness relates to fishery **productivity** and **yield** of the stock.

- If steepness is 0.7, then reducing the spawners to 20% of unfished levels will reduce recruitment to 70% of unfished levels
- If steepness is 0.5, then reducing the spawners to 20% of unfished levels will reduce recruitment to 50% of unfished levels

At higher steepness a stock can be fished more before recruitment is effected. When 70% of this stock has to be fished its recruitment will decline. This stock can recover more quickly if overfishing is stopped.

At lower steepness a stock will recover more slowly from overfishing. If this stock is fished to only 50% of its unfished biomass, its recruitment will decline.



- Steepness is often a source of uncertainty in stock assessment models.
- These theoretical models do not account for environmental conditions, so the stock-recruitment relationship is one input in the stock assessment model.

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