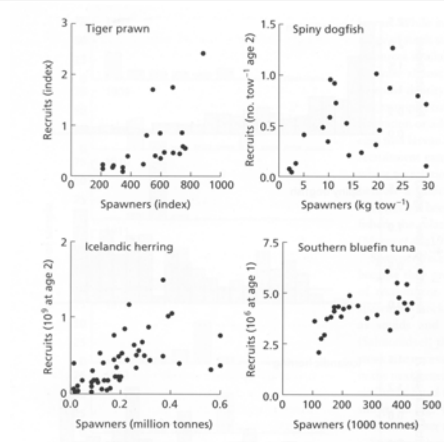
## Spawner and recruit relationships

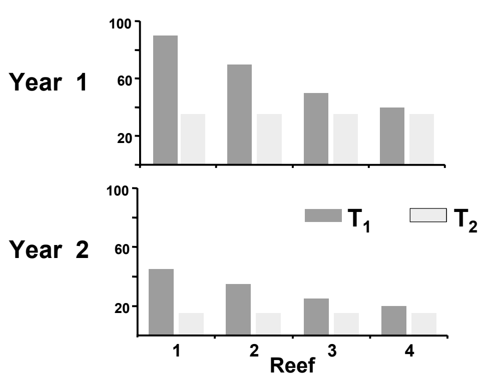
**Expectation**: positive relationship between spawner and recruit relationship (known as stock-recruitment relationships)

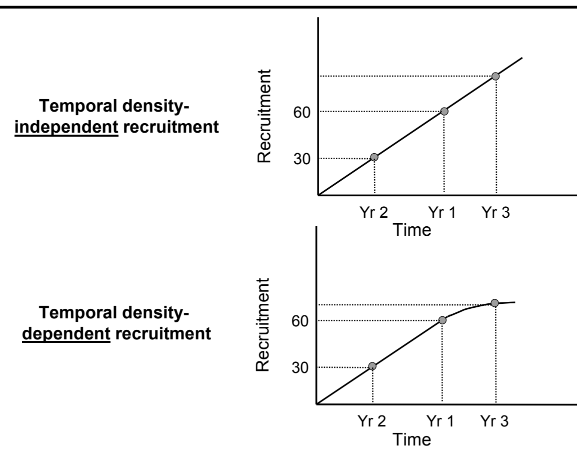
**If mortality in early life stages was density-independent, then predation, starvation, and oceanographic processes would act independently from number of eggs spawned**

**If this were true all of the time, what would a graph of spawner to recruit abundance look like?**




## When spatial ≠ temporal density dependence



**Stock-recruitment relationships are important because…**

**-- they provide a basis for predicting a range in recruitment that is expected for a given size of spawning stock**
**-- spawner abundance often used an an index of total egg production (egg production per unit stock of biomass may decrease as fishing intensity increases)**

**…but spawner abundance not directly proportional to egg production (small females produce few eggs per unit body weight)**

**Theoretical relationships have been used to describe spawner and recruit abundance (stock-recruitment models)**

**An ideal model should provide**
**-- a reasonable fit to empirical data**
**-- pass through the origin**
**-- not fall to the spawner axis**

**<u>Assumption</u>: spawner-recruitment relationship constant over time**

**<u>Problem</u>: Relationships help in understanding how exploitation affects populations but they have been misrepresented. Variance around the mean of the relationship drives short-term stock dynamics**

**Beverton-Holt model (1957):**

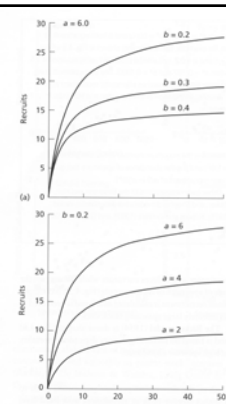



*Fig. 4.5* Beverton and Holt (1957) spawner–recruit relationships indicating the effects of (a) changing parameter $b$ when $a = 6$, and (b) changing $a$ when $b = 0.2$.

**Ricker model (1954)**

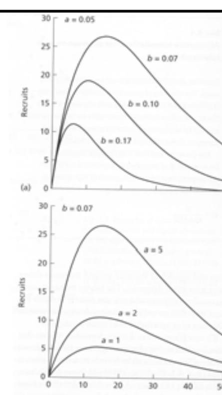



*Fig. 4.6* Ricker (1954) spawner–recruit relationships indicating the effects of (a) changing parameter $b$ when $a = 0.05$, and (b) changing $a$ when $b = 0.07$.

**Shepherd model (1982)**

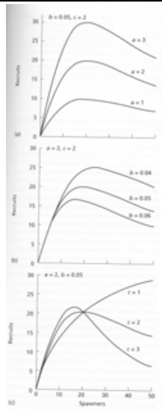



Fig. 4.7 Shepherd (1982) spawner–recruit relationships indicating the effects of (a) changing parameter a when b = 0.05 and c = 2; (b) changing b when a = 2 and c = 2; and (c) changing c when a = 2 and b = 0.05.

## What is the "recruitment problem?"

Despite the importance of the stock-recruitment relationship in pop. regulation, a striking relation between the magnitude of recruitment and spawning stock is not usually reflected in the body of empirical data

**Large variation around stock-recruitment relationship**

**Often poor fits to empirical data**

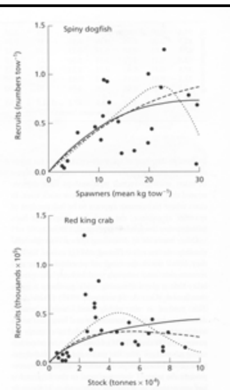



*Fig. 4.8* Spawner–recruit relationships of Beverton and Holt (——), Ricker (- - -) and Shepherd (. . . .) fitted to data for the spiny dogfish *Squalus acanthias* of the north-west Atlantic (1968–88), and for the red king crab *Paralithodes camtschatica* from Bristol Bay, Alaska (1968–88). Data from Myers *et al.* (1995b).

## Depensation (inverse density dependence)

**Lower than expected recruitment success at low population levels**

**-- could occur if predators ate larvae at a constant rate**
**-- females fail to find mates when stock size is low**
**-- fertilization rates of broadcast spawners dependent on sperm concentration**

**Can also referred to as Allee effect**

**Depensation may prevent stock recovery from exploitation**

**What types of species likely would be most affected?**

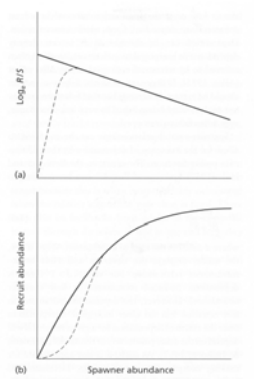


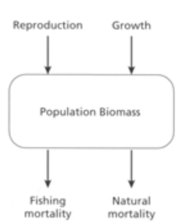

*Fig. 4.13* Examples of (a) the relationship between recruits per spawner and spawner abundance when there is compensation (——) or depensation (- - -) and (b) the effects of depensation (- - -) on the mean spawner–recruit relationship.

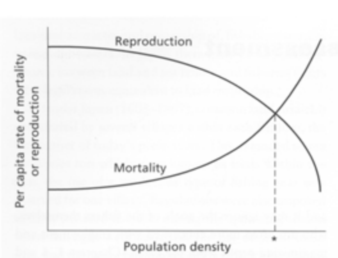
## Stock assessment

- Single and multi-species assessment
- MSY a starting point for understanding exploitation
- Sustainability = balance between mortality and reproduction/growth
- Mortality, reproduction, growth due to abiotic and biotic factors

  (balance through density dependence – "compensatory effects")

What determines population biomass?




Density-dependent per capita rates of reproduction and mortality

## Surplus production models

- Find largest fishing mortality rates that can be offset by increased population growth

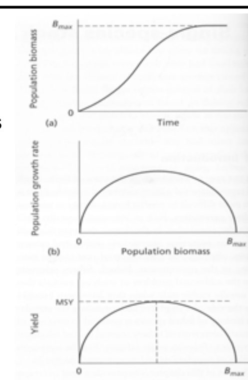
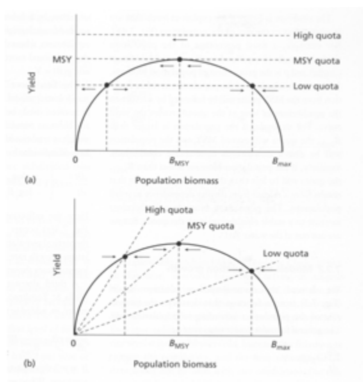



*Fig. 7.3* (a) Logistic population growth. (b) Populations grow most quickly at intermediate sizes up to a maximum total biomass, $B_{max}$. (c) The maximum sustainable yield (MSY) in biomass occurs at a level of fishing mortality that places the population at an intermediate size.

## Surplus production models under different fishing quotas




## Yield-per-recruit models

- "Dynamic pool" approach – models that keep components separate (reproduction, growth, natural mortality, fishing mortality)
- Assumes that recruitment is constant
- Trade-off between the sizes of individuals caught and the number of individuals available for capture

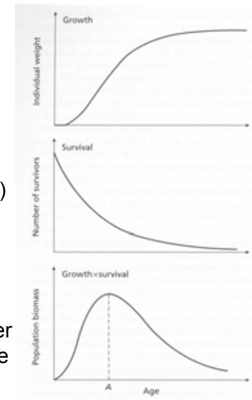



*Fig. 7.11* The logic of yield-per-recruit models, based on the trade-off between growth and mortality of individuals. Here, the optimal age at which to catch the fish is at *A*.

**Calculate yield per recruit and population biomass per recruit to balance desire to maximize yield against need to ensure sufficient reproduction to minimize recruitment overfishing**

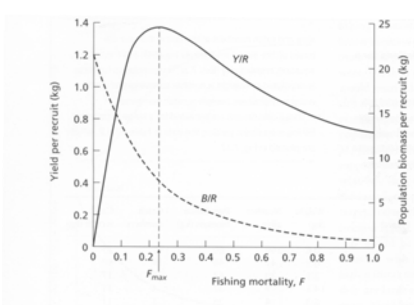



*Fig. 7.12* Yield per recruit (*Y/R*) and population biomass per recruit (*B/R*) for a single cohort of fish, for various potential fishing mortalities, *F*. The results are for fish of ages 1–10, and natural mortality, $M = 0.2$ (see Box 7.6).

## Incorporating recruitment into yield-per-recruit models

- Recruitment ignored in yield-per-recruit models (assumed constant)
- Yield-per recruit models address **growth overfishing**, they need to be incorporated with stock-recruitment models to avoid **recruitment overfishing**
- Replacement lines used to understand how changes in fishing mortality affect recruitment rates of exploited stocks

Replacement line of slope 1.0 means that recruitment balances spawning stock size

Can predict trajectory of a population from any stock size

used to understand how changes in fishing mortality affect recruitment rates of exploited stocks

- Upper graph, population approaches stable equilibrium

- Lower graph, steeper replacement line to accommodate higher fishing mortality

-- recruitment is not high enough to sustain the population and it will crash

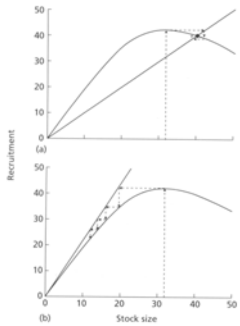



*Fig. 7.14* Population trajectories for a Ricker spawner–recruitment relationship. (a) The replacement line intersects the spawner–recruit curve, leading to a stable equilibrium. (b) The replacement line corresponding to higher fishing pressure exceeds the spawner–recruit curve, leading to a population collapse.