

Large variation around stock-recruitment relationship

Often poor fits to empirical data

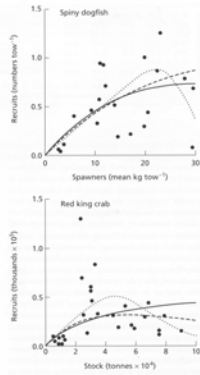


Fig. 4.8 Spawner-recruit relationships of Rebertus and Holt (1984), Becker (1981) and Shepherd (1981) fitted to data for the spiny dogfish *Squalus acanthias* of the north-west Atlantic (1968-83), and for the red king crab *Paralithodes cambricus* from Bristol Bay, Alaska (1968-80). Data from Myers et al. (1993b).

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 be referred to as Allee effect

Depensation may prevent stock recovery from exploitation

What types of species likely would be most affected?

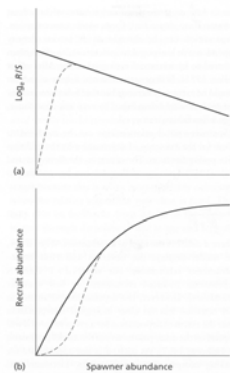
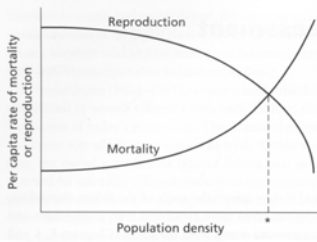
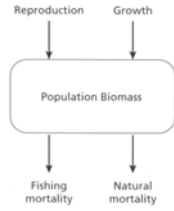


Fig. 4.13 Examples of (a) the relationship between recruits per spawner and spawner abundance when there is compensation (—) or depensation (---) and (b) the effects of depensation (---) on the mean spawner-recruit relationship.

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

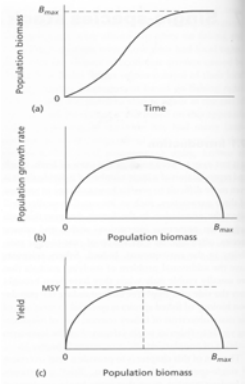
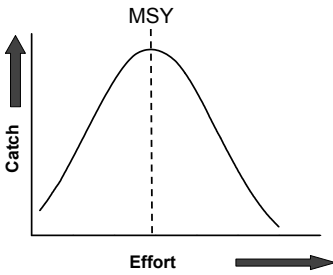


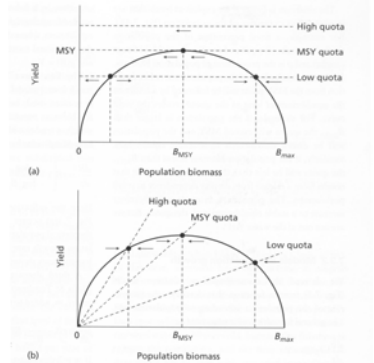
Fig. 7.1 (a) Logistic population growth. (b) Populations grow most quickly at intermediate sizes up to a maximum total biomass, B_{max} . (c) The maximum sustainable yield (MSY) in biomass occurs at a level of fishing mortality that places the population at an intermediate size.

Maximum sustainable yield:



Stability and surplus production models under different fishing quotas

- Constant biomass caught
- Constant proportion of biomass caught



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

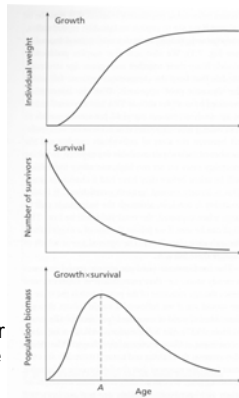


Fig. 7.11 The logic of yield-per-recruit models, based on the trade-off between growth and mortality of individuals. Here, the optimal age at which to catch the fish is at A.

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

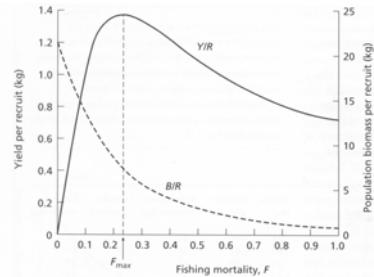


Fig. 7.12 Yield per recruit (Y/R) and population biomass per recruit (B/R) for a single cohort of fish, for various potential fishing mortalities, F . The results are for fish of ages 1–10, and natural mortality, $M = 0.2$ (see Box 7.6).

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

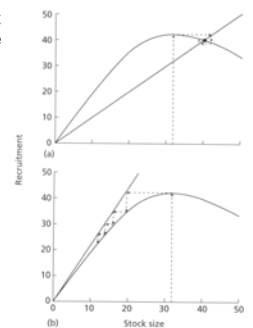


Fig. 7.14 Population trajectories for a Ricker spawner-recruitment relationship. (a) The replacement line intersects the spawner-recruit curve, leading to a stable equilibrium. (b) The replacement line corresponding to higher fishing pressure exceeds the spawner-recruit curve, leading to a population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

Fishing Effects on Populations and Communities

- Vulnerability to fishing -- predator-prey relationships (humans-target species)

Determined by:

- behavior (susceptibility to fishing gears)
- life history (evolution has made some fishes more vulnerable to fishing mortality and population declines than others)

Behavior

- schooling or aggregating may increase predation risk for humans
But...schooling or aggregating may decrease predation risk for natural predators
- aggregating species can be targeted despite low population size (e.g., spawning aggregations)
- net avoidance determined by swimming speed and escape responses
- migration routes – targeted by fishers
- habitat associations



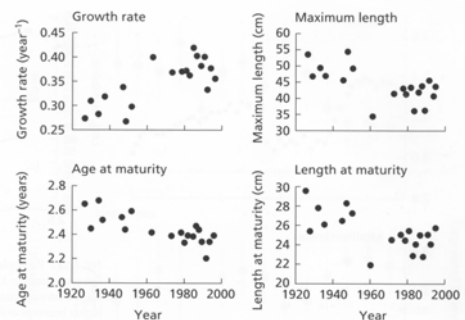
Life History

- larger, slow-growing, late-maturing species suffer greater population declines due to fishing
But... evolutionarily are buffered in population size against poor years of recruitment

Population Effects of Fishing

- fishing tends to change size and age structure
mean body size and age decreases as fishing mortality increases)
- egg production may decrease
- but growth rates and production may also increase following decreases in population density due to fishing
- change in sex ratio (hermaphrodites) when sex change dictated by size (becomes female-biased population when species is protogynous)
... also can change sex ratio by size limits of the fishery (dungeness crab)
- genetic structure may change (faster-growing individuals are removed from the population)

Population Effects of Fishing



Community Effects of Fishing

Diversity:

-- extinction (rare) vs. extirpation (giant sea bass, white abalone)

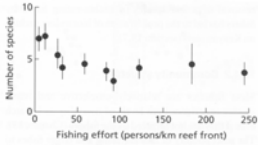


Fig. 12.9 The relationship between species richness (± 95 C.L.) and fishing intensity for groupers (Epinephelinae) on Fijian reefs. After Jennings and Polunin (1997).

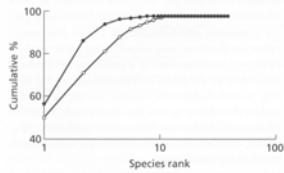


Fig. 12.7 A-dominance curves for the North Sea groundfish community off East Shetland from 1929 to 1953 (\circ) and 1980 to 1993 (\square). After Greenstreet and Hall (1996).

Community Structure:

-- fished community dominated by small individuals and smaller species
-- changes in trophic structure

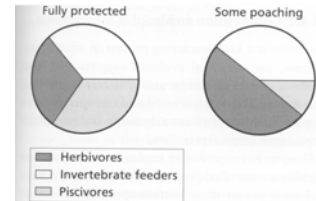


Fig. 12.11 Trophic structure (by biomass) of fish communities in Seychelles marine reserves that are either fully protected, or subject to a small amount of fishing and poaching. After Jennings and Kaiser (1998).