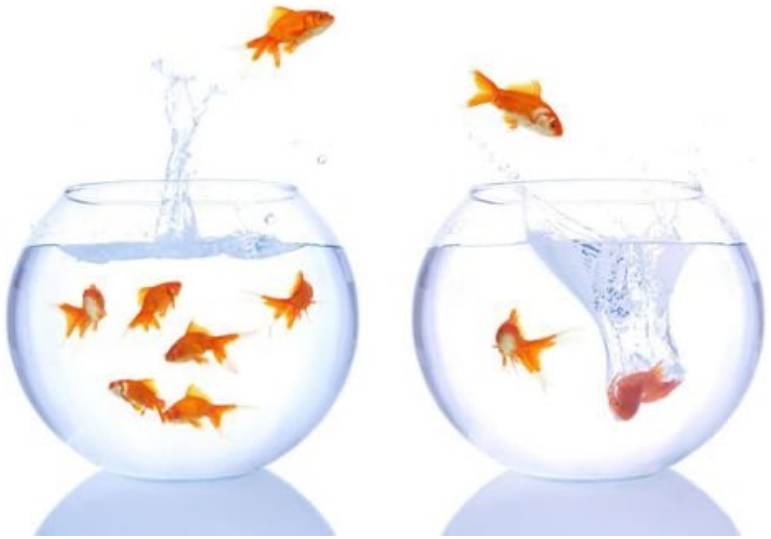


Recruitment

What is recruitment?

A more difficult question than you might imagine…

- When an organism "enters a" or "is available for" harvest
- When a young organism's survival is density dependent

Fish recruitment

Adults	->	Eggs
Eggs	->	Larvae
Larvae	->	Juveniles
Juveniles	->	Recruits
Recruits	->	Adults

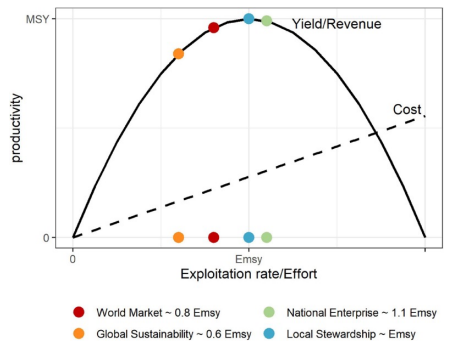
MSY vs. Recruitment

MSY

Simple

Based on biomass

Assumes equilibrium

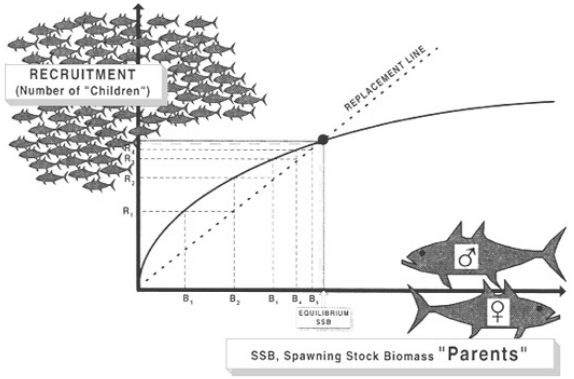


RECRUITMENT

More structured

Numbers/biomass

Dynamic and lagged



SALMON

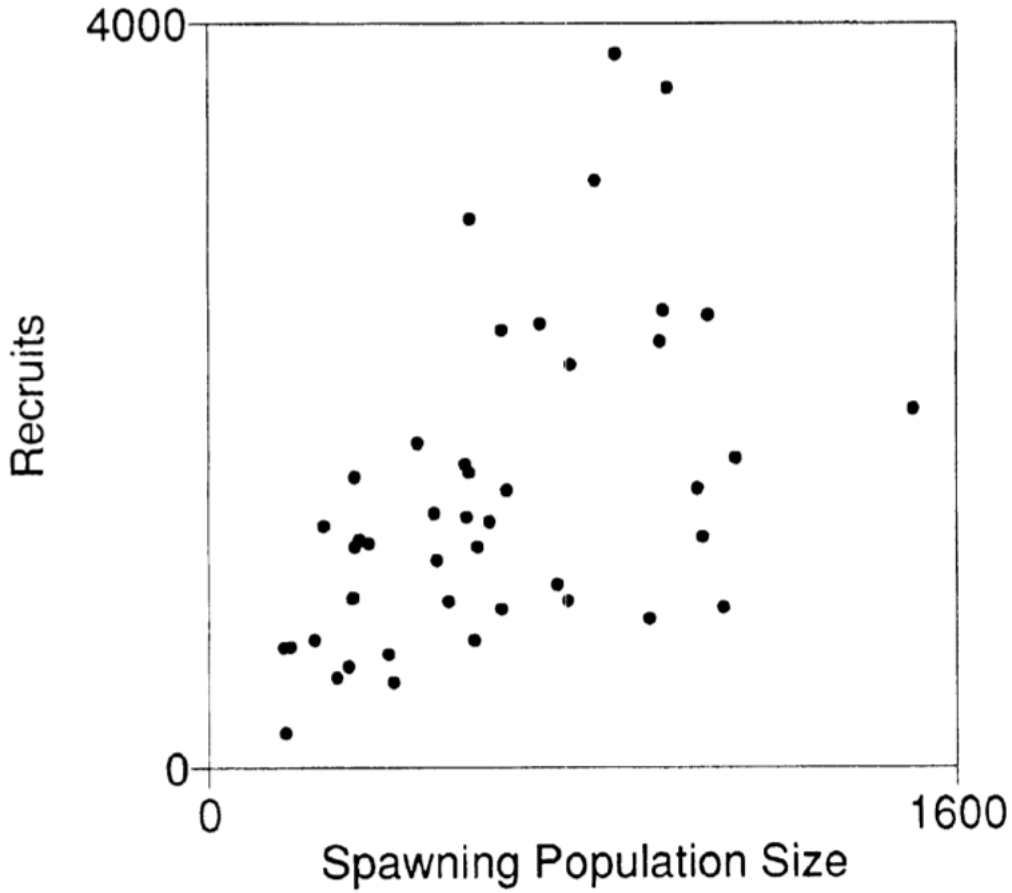


Figure 7.1. Stock-recruitment data for Skeena River sockeye salmon. Numbers in thousands. Data from Shepard and Withler (1958).

What do you notice about these data?

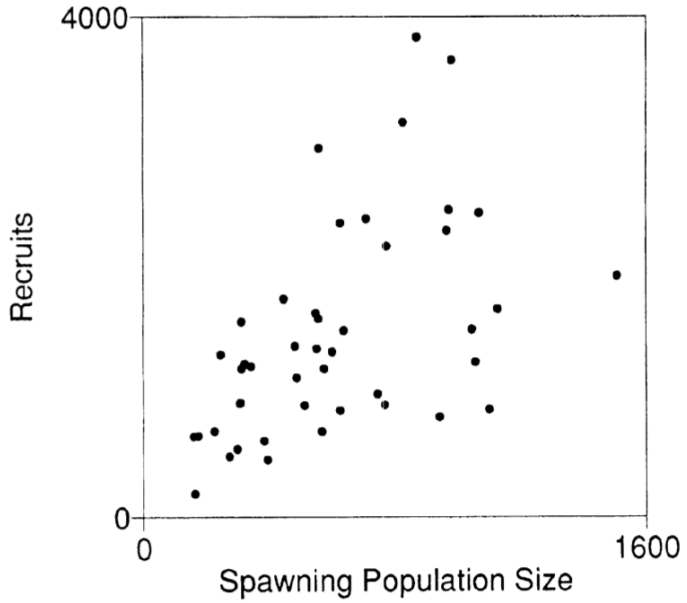


Figure 7.1. Stock-recruitment data for Skeena River sockeye salmon. Numbers in thousands. Data from Shepard and Withler (1958).

What do you notice about these data?

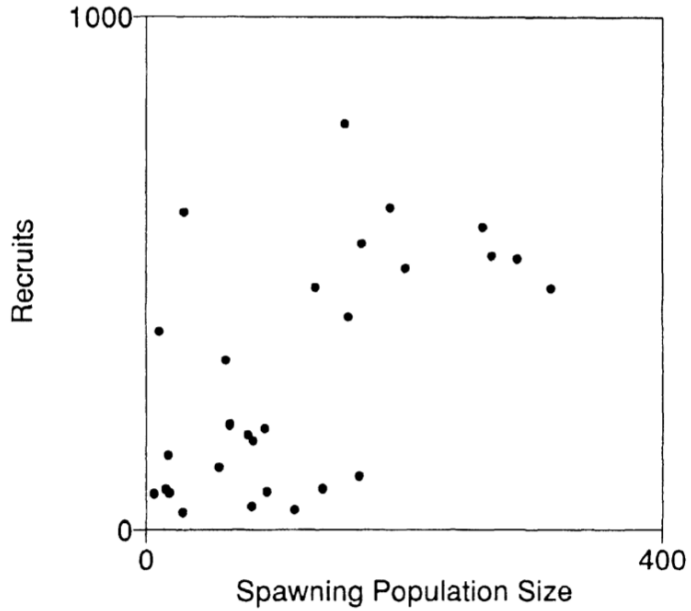


Figure 7.2. Stock-recruitment data for Icelandic summer spawning herring. Data from Jakobsson (1980).

What do you notice about these data?

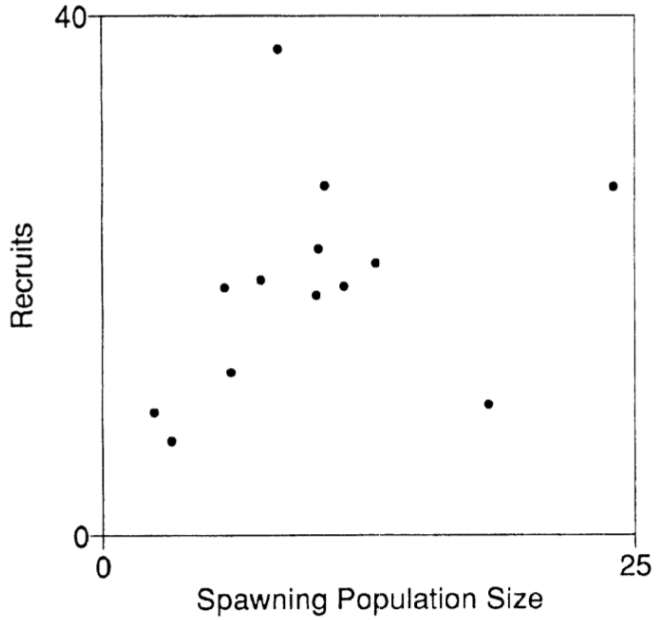


Figure 7.3. Stock-recruitment data for Exmouth Gulf tiger prawns. Data from Penn and Caputi (1985).

What do you notice about these data?

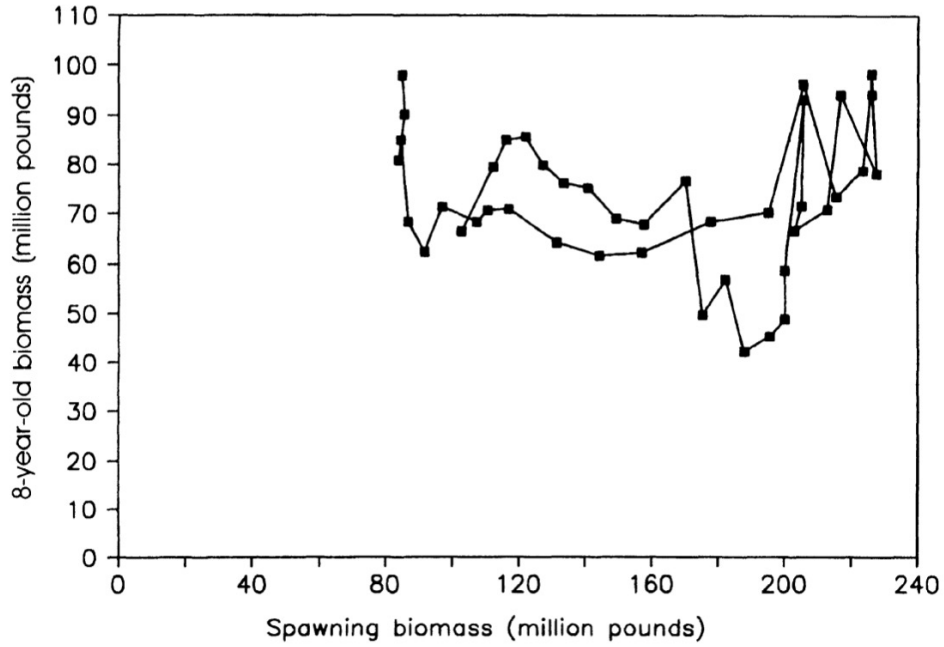
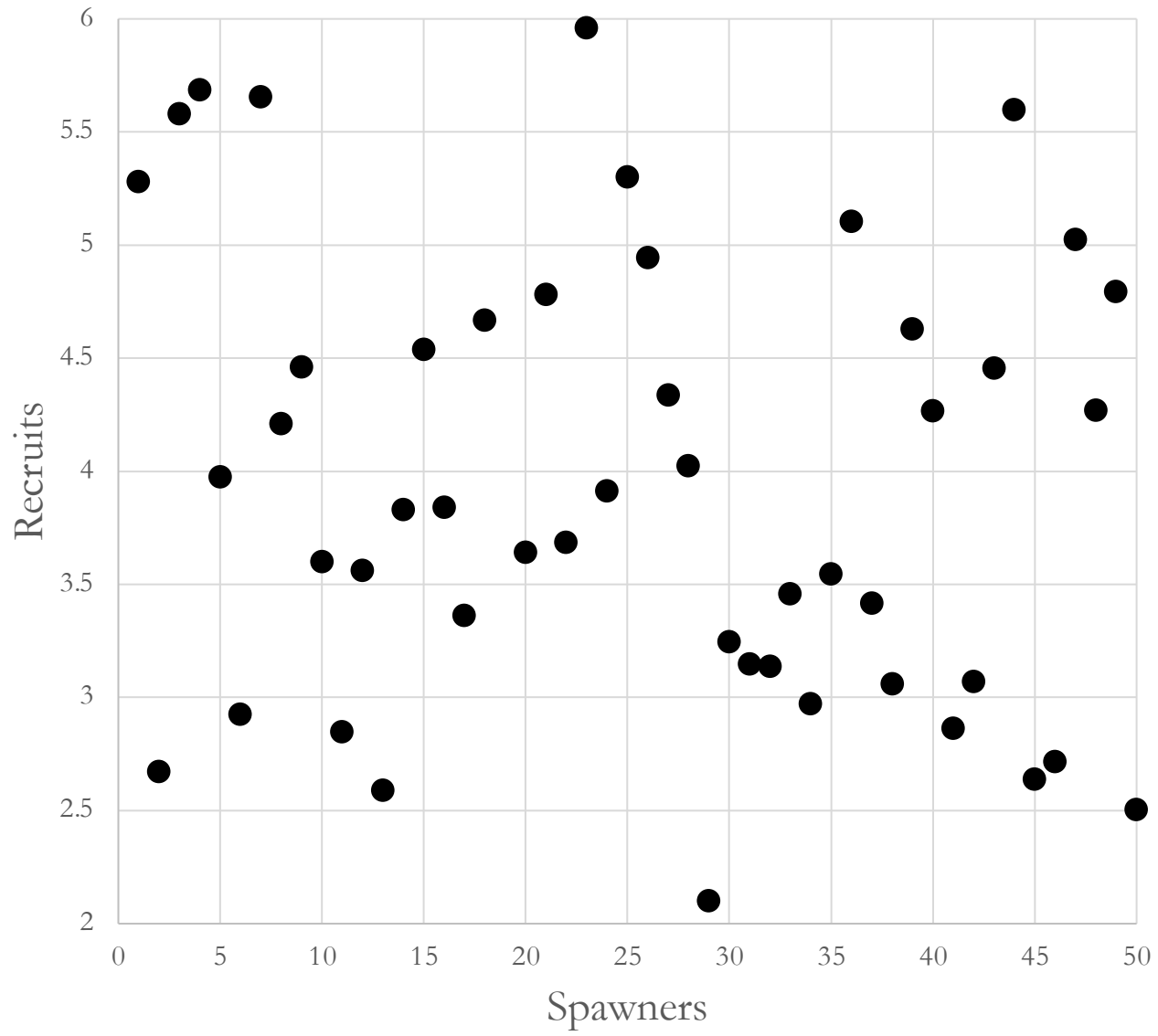


Figure 7.4. Stock-recruitment data for Pacific halibut (*Hippoglossus stenolepis*). Data from International Pacific Halibut Commission.

The most common pattern…



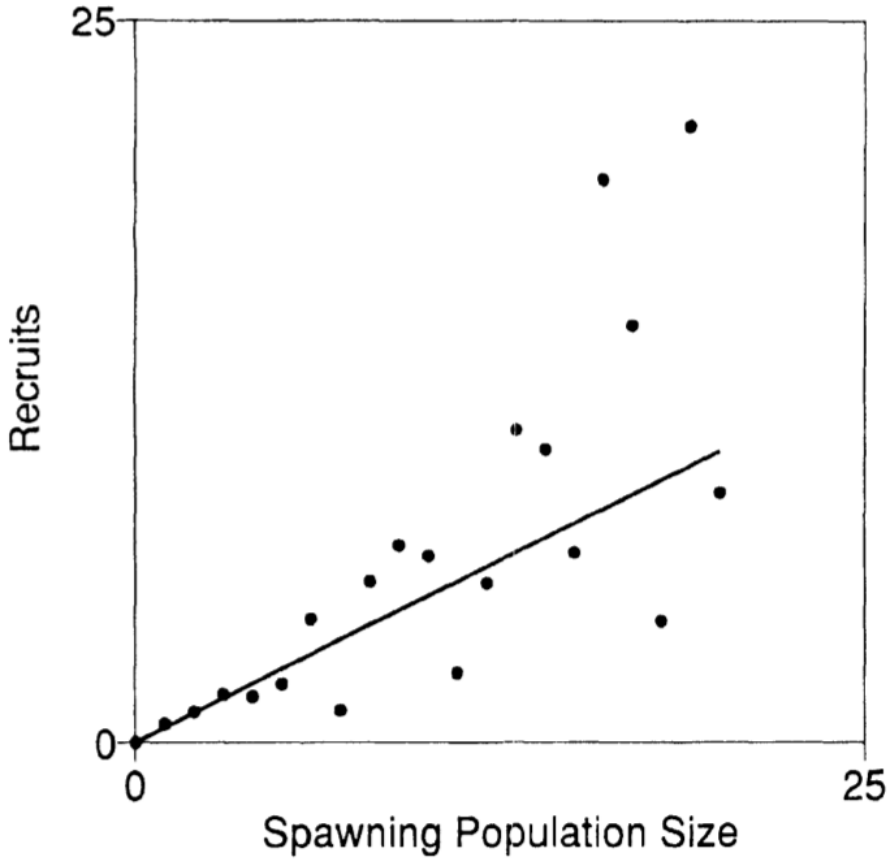


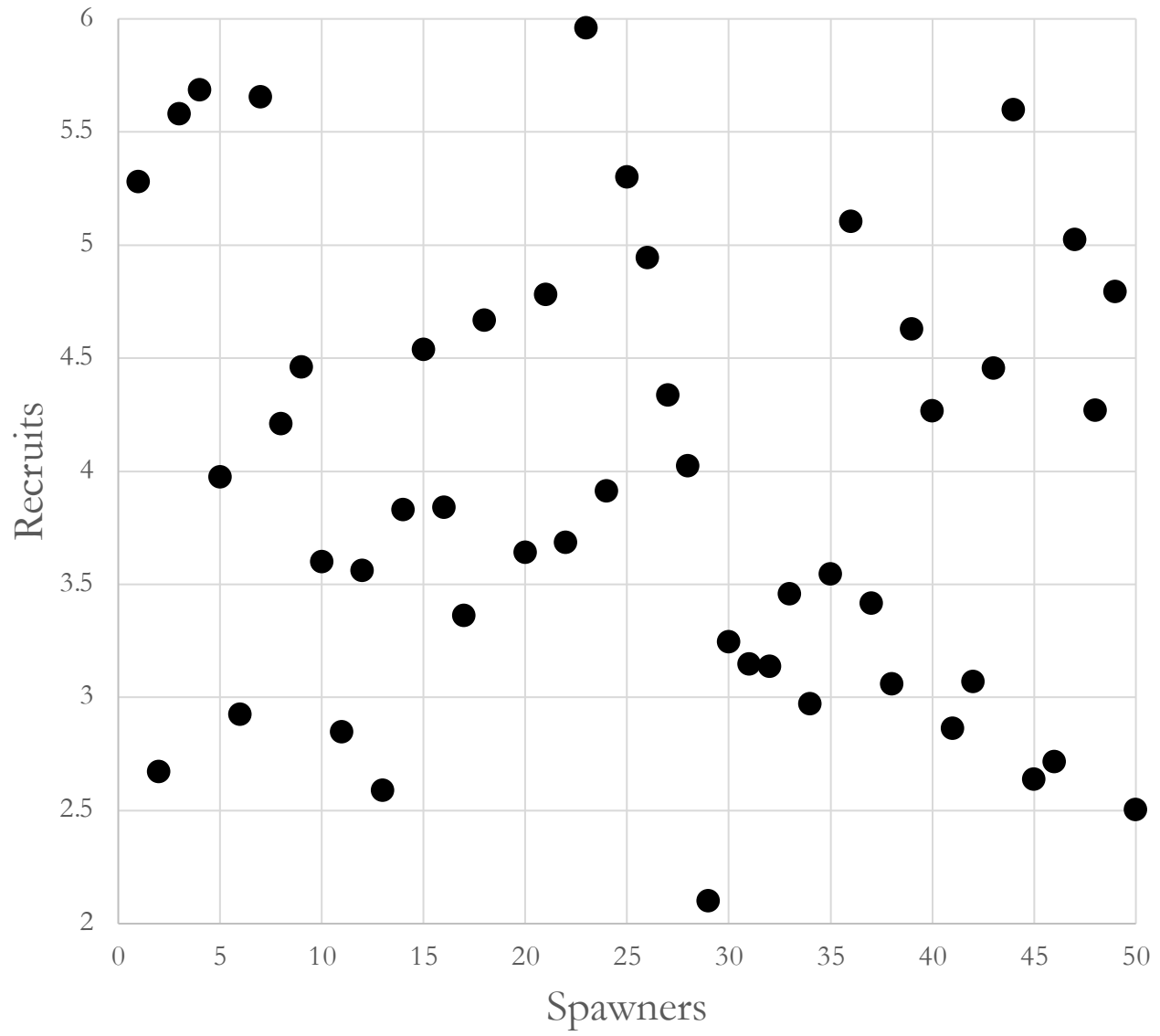
Figure 7.5. Stock-recruitment average relationship and sample data points for density-independent survival.

Why do stock-recruit patterns emerge?

Density-independent

- More reproductively active individuals means more young
- Each young has a given survival probability
- More young generally means more recruits
- A reasonable assumption, to a point

What about this pattern?



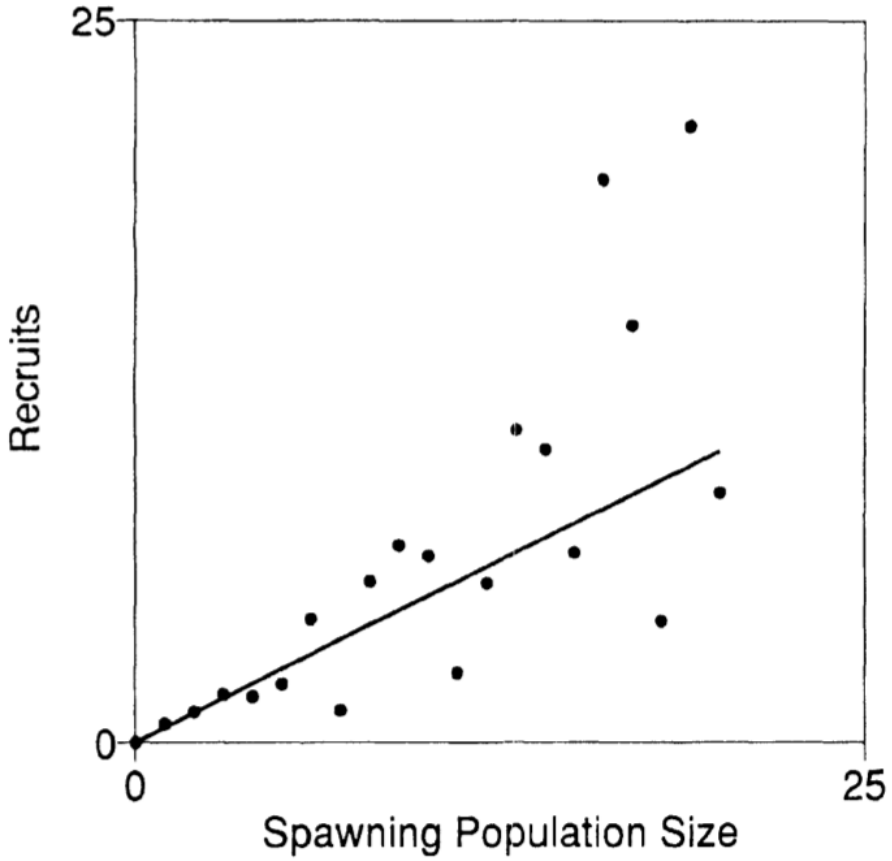


Figure 7.5. Stock-recruitment average relationship and sample data points for density-independent survival.

Why do stock-recruit patterns emerge?

Density-dependent

- Limited resources affects adult survival and growth
- Compensation: reduction in recruits-per-spawner as the number of spawners increase
- Stock-recruitment relationship may become flat

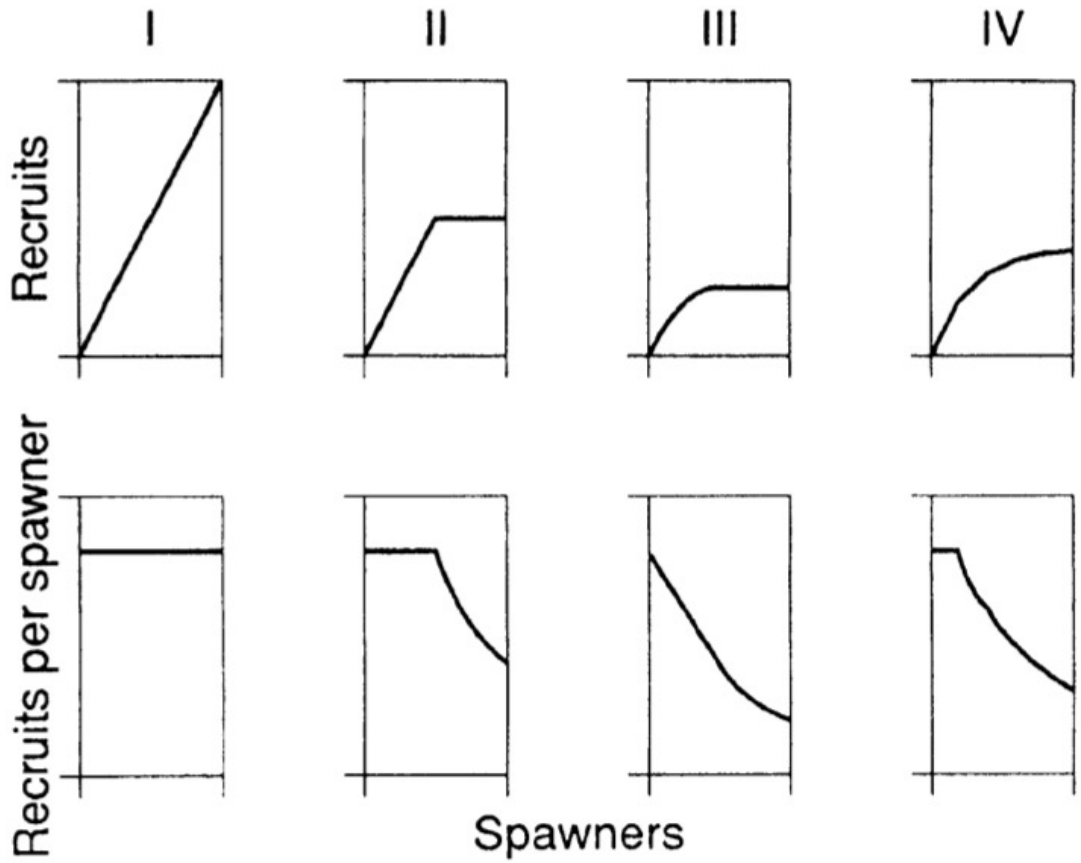
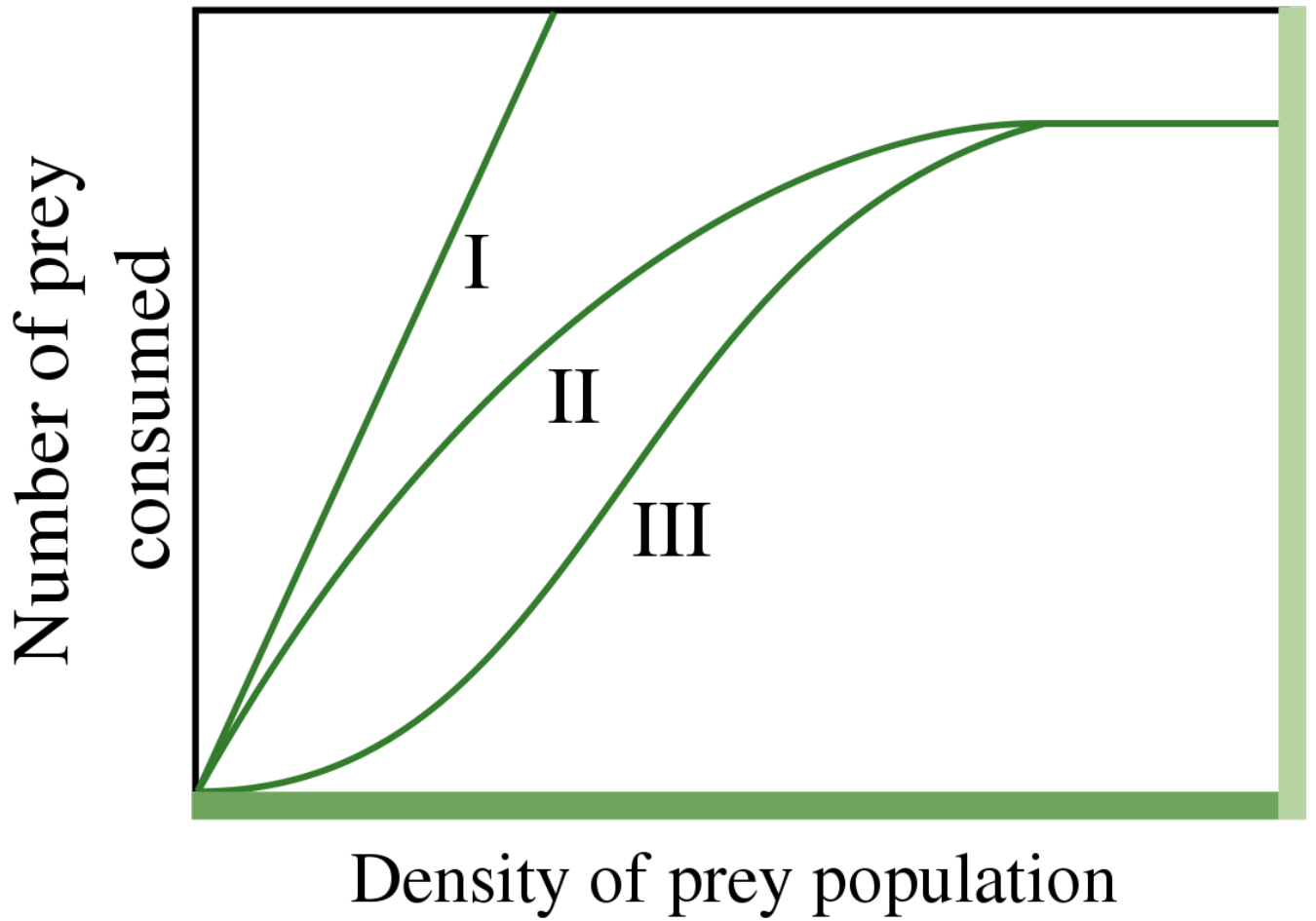


Figure 7.6. Stock-recruitment curves for alternative models of compensatory mortality.

Overcompensation

Mortality increases as density increases

- Cannibalism or infection
- Increasing density of young induces "prey switching"
- Increasing density of young limits resources
- Very large stock sizes produce a smaller number of recruits



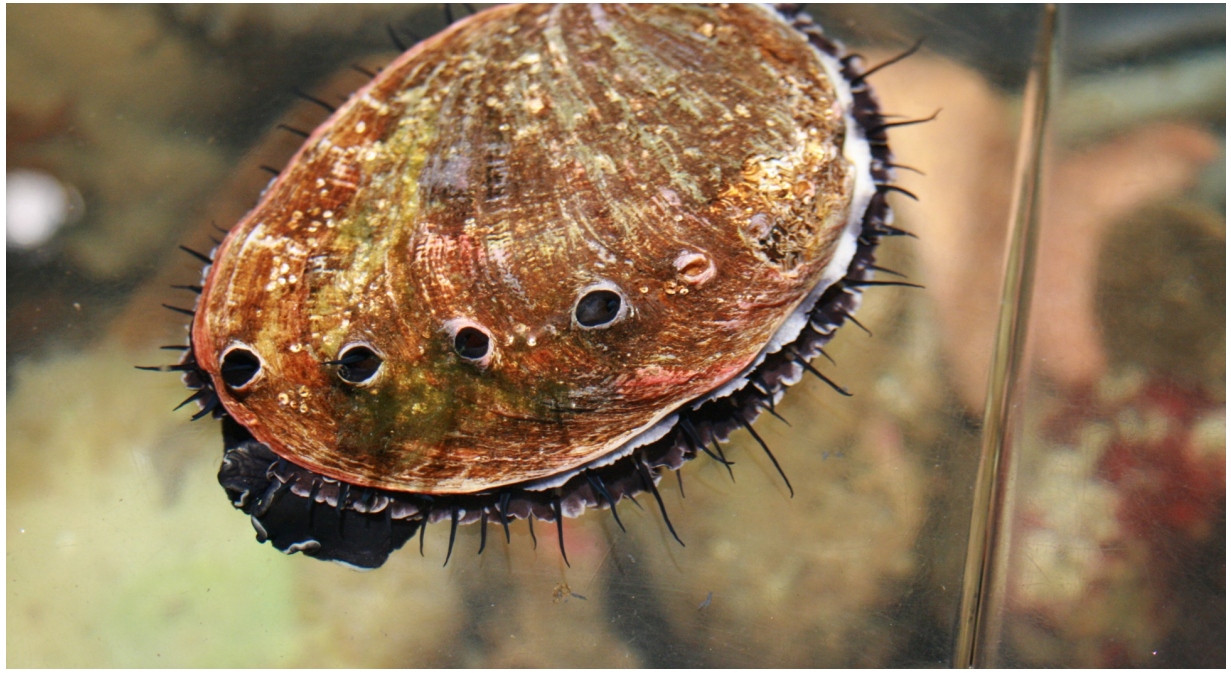
Compensation vs. depensation

Compensation: decrease in recruits-per-spawner with an increase in spawning stock size

- Limiting resources
- Increasing predation on young

Depensation: increase in recruits-per-spawner with an increase in spawning stock size

- Constant predation
- Difficulty finding mates with low stock size (Allee effect)



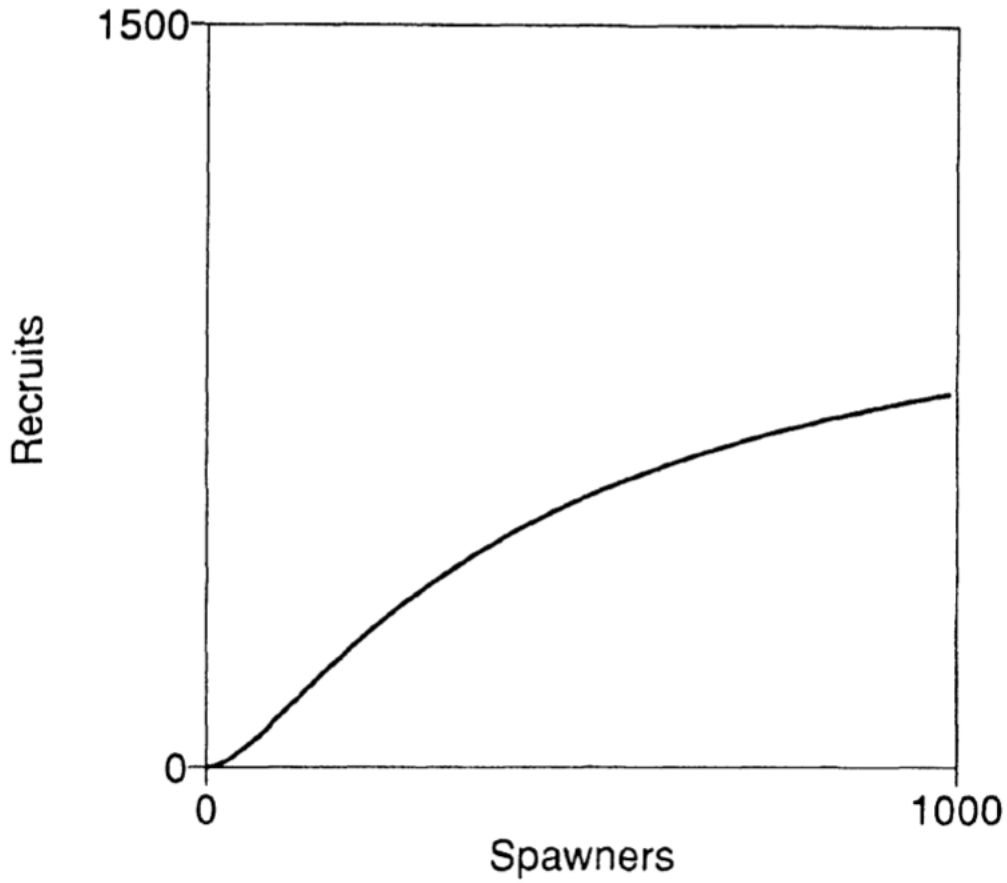


Figure 7.7. Stock-recruitment relationship with depensatory mortality.

Spatial structure

Spatially separated stocks

Some stocks are more or less productive

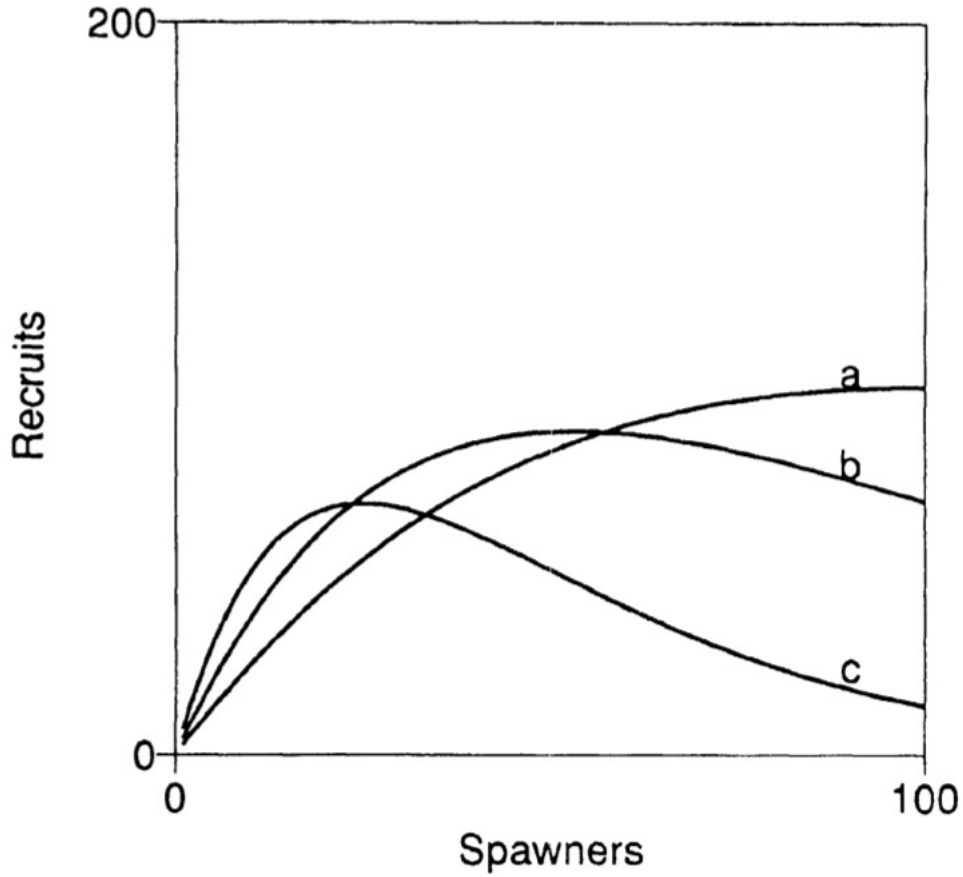


Figure 7.8. Stock-recruitment relationships for a stock that consists of spatially separated substocks when all substocks are present (a) and when less productive substocks have been eliminated by overexploitation (b and c).

Measurements

STOCK SIZE

Number of females/individuals alive by age*fecundity by age

Total biomass above maturation size

Abundance index in the year young were produced

RECRUITMENT

Number of individuals alive at a given time after reproduction

For fish, usually occurs when fish are old enough to enter the fishery

Models

Range or distribution of recruits produced for a given range of spawners

Stock-recruitment curves WITH VARIANCE

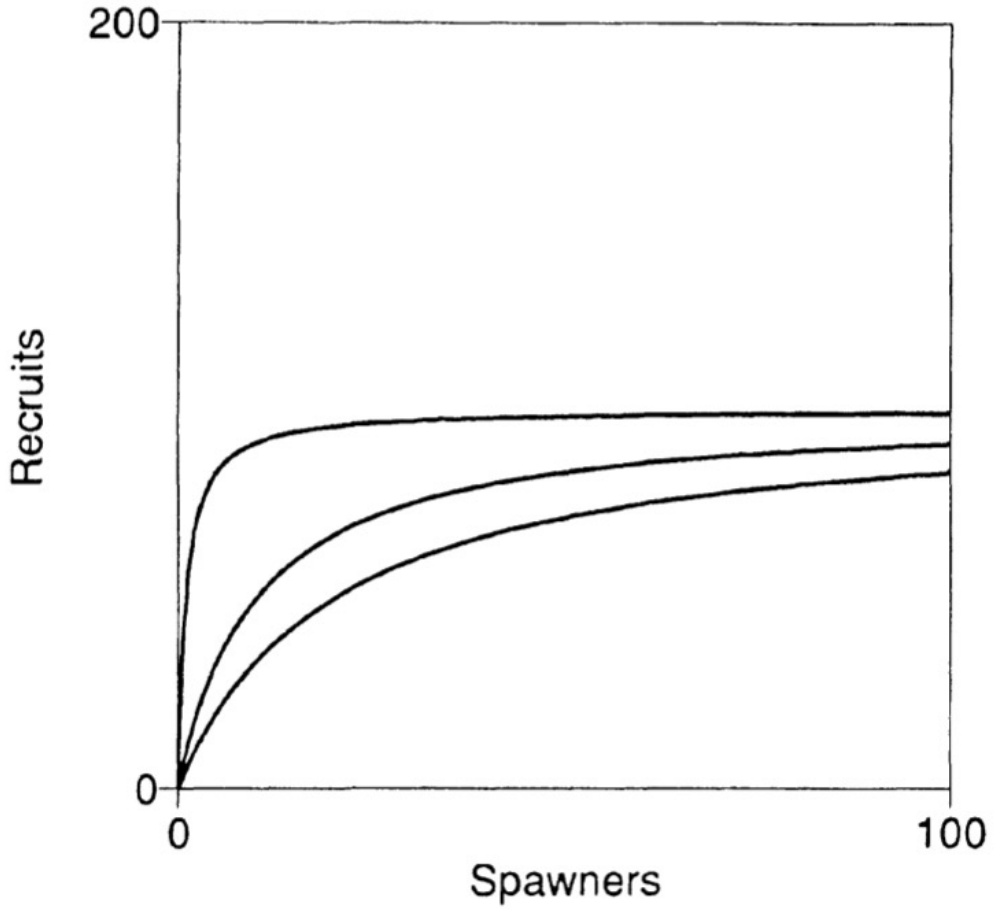


Figure 7.9. Beverton-Holt stock-recruitment curves.

Beverton-Holt

$$R = \frac{aS}{b + S}$$

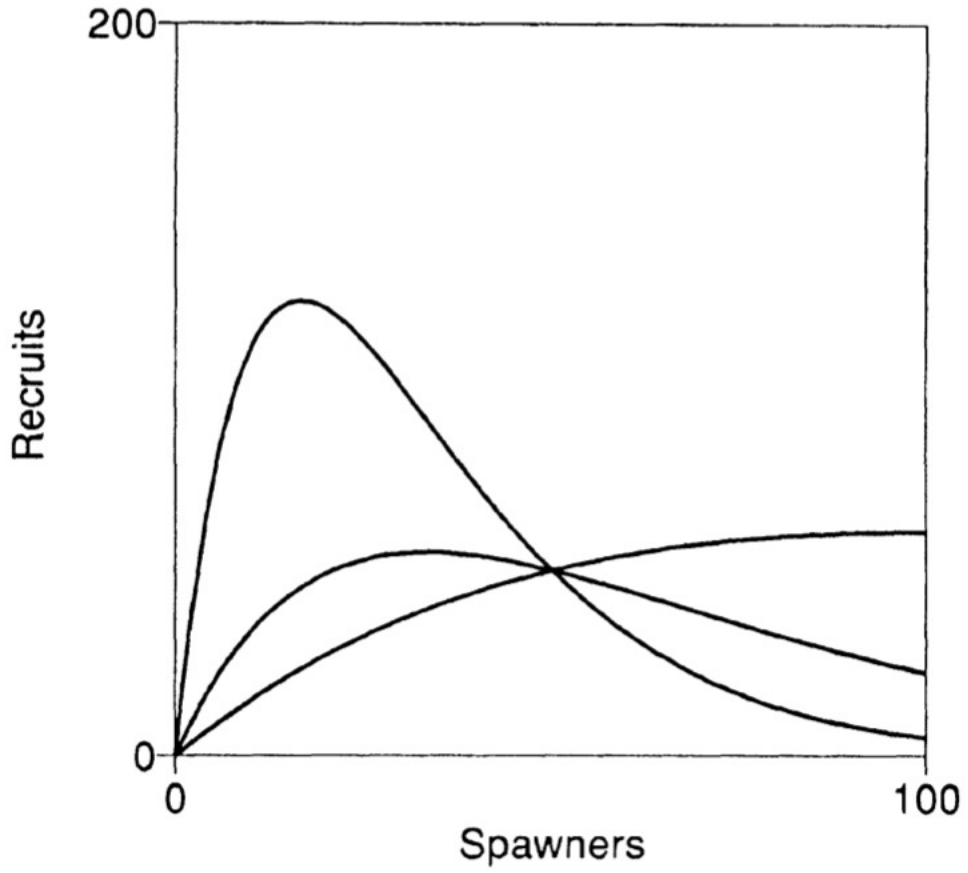


Figure 7.10. Ricker curves with different *a* values.

Ricker

$$R = aSe^{-bS}$$

Deriso

$c = -\infty$	$R = aS$
$c = -1$	$R = aS/(1 + bS)$
$c = 0$	$R = aSe^{-bS}$
$c = 1$	$R = aS(1 - bS)$

$$R = aS(1 - bcS)^{1/c}$$