Dynamic Pool models

- Yield-per-recruit
  - Beverton-Holt
  - Ricker
- SSB-per-recruit
- eggs-per-recruit
- Section 7.7 in text

Dynamic pool models

Primary difference from surplus production models:

- ➢ Dynamic pool models account for variable growth, mortality, and reproductive potential by age

- ➢ Currently used to examine reproduction and recruitment potential

Dynamic pool models

<u>How they work</u>:

- **Consider explicitly how growth and mortality affect stock biomass and reproductive potential**
- **First, stock biomass is separated into age-specific components,**
- **The model then calculates effects of growth and mortality on each age-specific component,**
- **Last, all age-specific component effects are summed**

Yield-per-recruit models

- Examine trade-off between capturing many small fish early in their life vs. less larger fish later in life
- If F is set too high, many fish will be harvested before they have had a chance to grow to large body sizes
- This is termed ‘growth overfishing’

Yield-per-recruit models

- If F is set too low, large fish will be captured but total yield will be low due to low numbers of fish harvested

Thus, age at harvest must be traded-off against harvest rate because growth and mortality vary with age differently

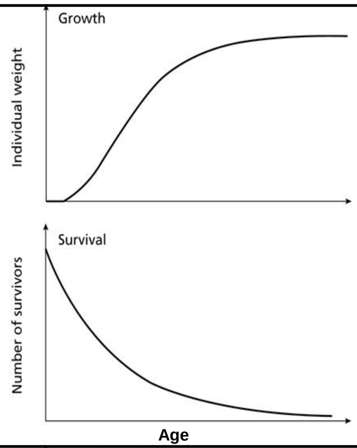


Fig. 7.11

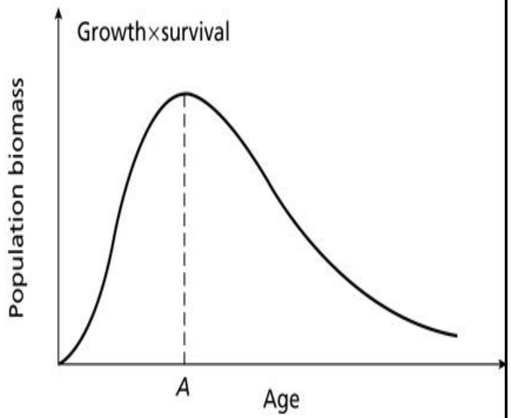


Fig. 7.11

Yield-per-recruit models

- Yield assumed to depend on growth, age at first capture and fishing mortality
- Effects of recruitment added later

Yield-per-recruit models

- Consider the biomass of a stock (N × average wgt) present at any time,
- The yield from that stock at a given time is the biomass (B) × the instantaneous fishing mortality rate (F)

So we have:

$$Y_t = F_t N_t W_t$$

Yield-per-recruit models

$$Y_t = F_t N_t W_t$$

Over the course of a time period,

$$Y = \sum_{t_c}^{t_{max}} F_t N_t W_t$$

Where t_c and t_{max} are ages at first capture and maximum age respectively

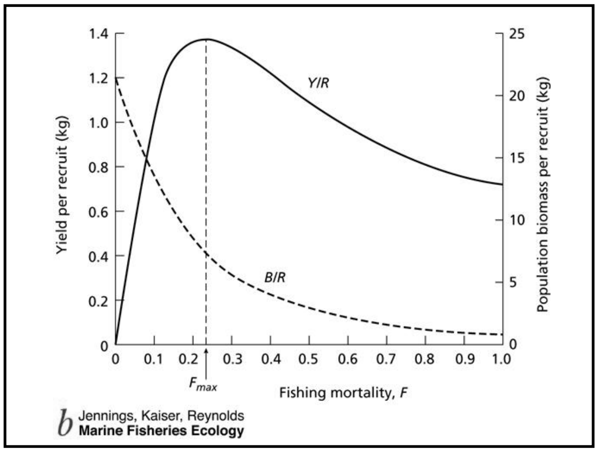
Yield-per-Recruit Calculations

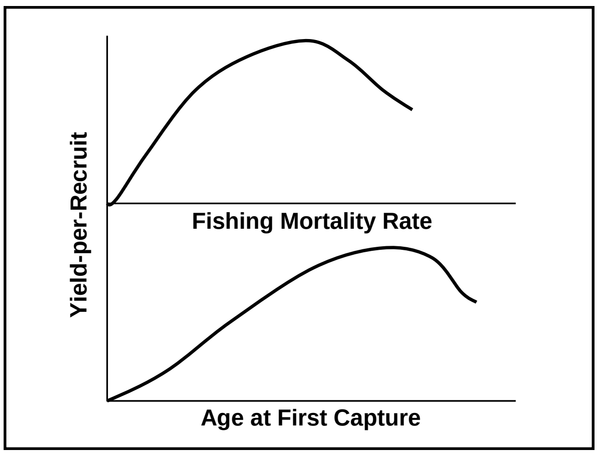
Age	Wgt	N alive	Biomass (kg)	Catch (n)	Yield (kg)
1	0.6	100	60	41	25
2	0.9	45	40	19	17
3	2.1	20	42	8	17
4	4.1	9	37	4	15
5	6.3	4	26	2	11
6	8.4	2	15	1	6
7	10.0	1	8	0.3	3
8	11.2	0.4	4	0.2	2
9	12.6	0.2	2	0.1	1
10	13.5	0.1	1	0.0	0
Sum			237		98
Sum/R			**2.37**		**0.98**

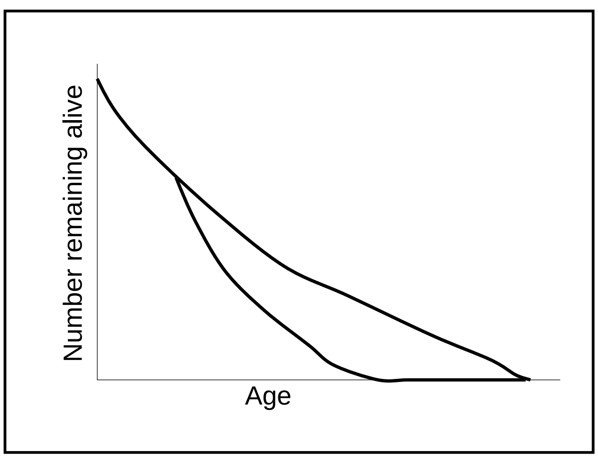
With F = 0.6 and M = 0.2

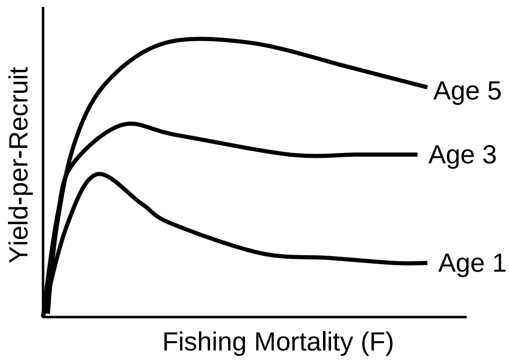
Yield-per-Recruit Calculations

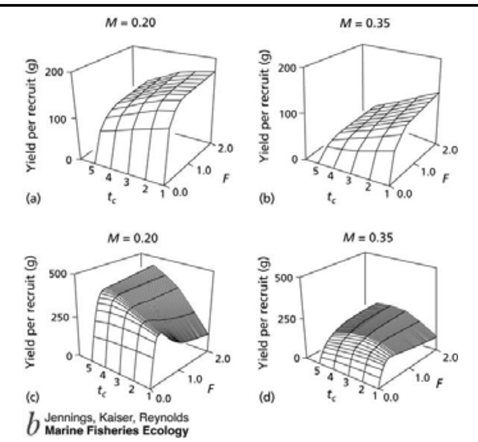
F	Y/R	B/R
0.0	0	21.46
0.1	1.12	12.94
0.2	1.36	8.27
0.3	1.32	5.60
0.4	1.2	4.00
0.5	1.08	3.01
0.6	0.98	2.37
0.7	0.89	1.93
0.8	0.83	1.63
0.9	0.77	1.42
1.0	0.73	1.26


1.4
1.2
1.0
0.8
0.6
0.4
0.2
0
Yield per recruit (kg)
25
20
15
10
5
0
Population biomass per recruit (kg)
Y/R
B/R
0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0
F_{max}
Fishing mortality, F
Jennings, Kaiser, Reynolds
Marine Fisheries Ecology


Yield-per-Recruit
Fishing Mortality Rate
Age at First Capture


Number remaining alive
Age





Yield-per-recruit models

Advantages:

- Both F and M are explicit in the model
- Increased biological realism
- Avoid having to address year-to-year variation in recruitment
- Can see effects of F and Age of Entry on age and size in the catch

Yield-per-recruit models

Limitations/Assumptions:

- Constant recruitment is assumed
- This assumes age-structure remains stable
- Ignore any temporal variation in F and M
- Stable environment
- No density-dependence in growth and mortality

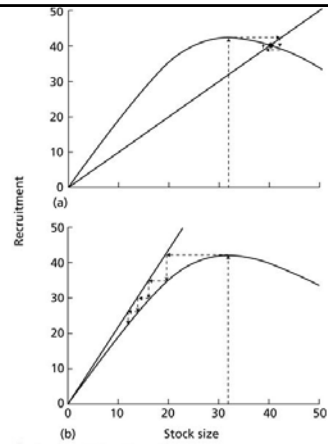
Yield-per-recruit models

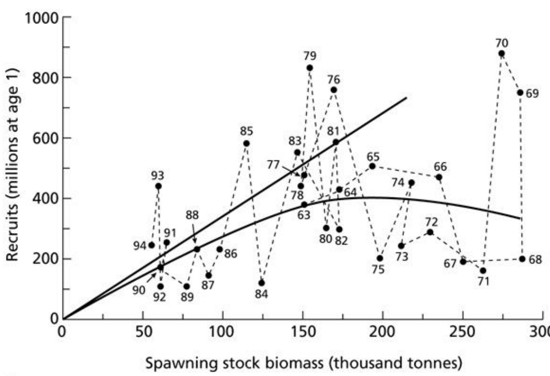
- **Yield-per-Recruit is good for determining if 'growth overfishing' is occurring**
- **But, since the models assume constant recruitment, they can't detect 'recruitment overfishing'**

  This is when the fish population is fished so hard that an adequate number of recruits is not produced

Yield-per-recruit models

- **In order to deal with the potential for 'recruitment overfishing':**
- **We need to incorporate stock-recruitment relationships**
- **Remember, our replacment line (SSB per R) is a function of F**
  - **High F = low SSB per R**
  - **Low F = high SSB per R**





b Jennings, Kaiser, Reynolds
Marine Fisheries Ecology

Reproductive Potential models

- **Examine changes in other life parameters from effects of fishing mortality rate**
- **Yield may be fine, but stock could be overfished in terms of its ability to replenish itself**
- **These models examine effects of fishing on reproductive potential of remaining stock**

Reproductive Potential models

Spawning Stock Biomass per Recruit (SSB/R)

- **Examine stock biomass remaining after fishing and estimate fraction mature**
- **Sum contribution to SSB at each age**
- **Max SSB/R occurs at F = 0 (virgin population) and SSB/R evaluated in terms of fraction of Max**
- **SSB/R at each F results in replacement line with slope of R/SSB**

Reproductive Potential models

Eggs per Recruit (EPR)

- **Examine stock biomass remaining at each age, percent maturity, and fecundity**
- **Sum lifetime egg production at each age**
- **Max EPR occurs at F = 0 (virgin population) and EPR evaluated in terms of fraction of Max**
- **Often used to evaluate variable age-0 survival by altering the seed number of age-1 recruits**
- **Does increased age-0 survival offset higher F?**