# Harvest Control Rules (The “Tier System”)

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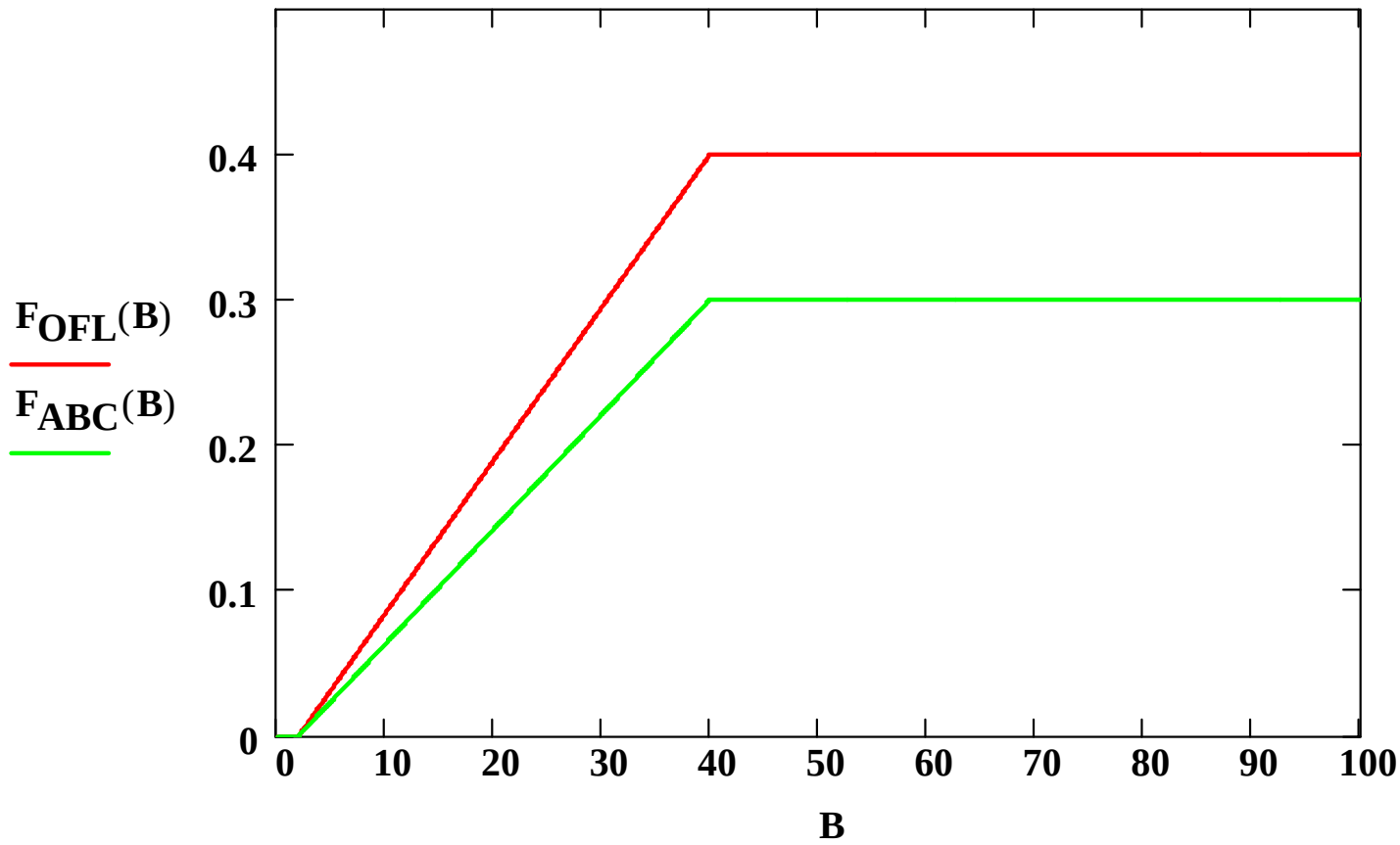
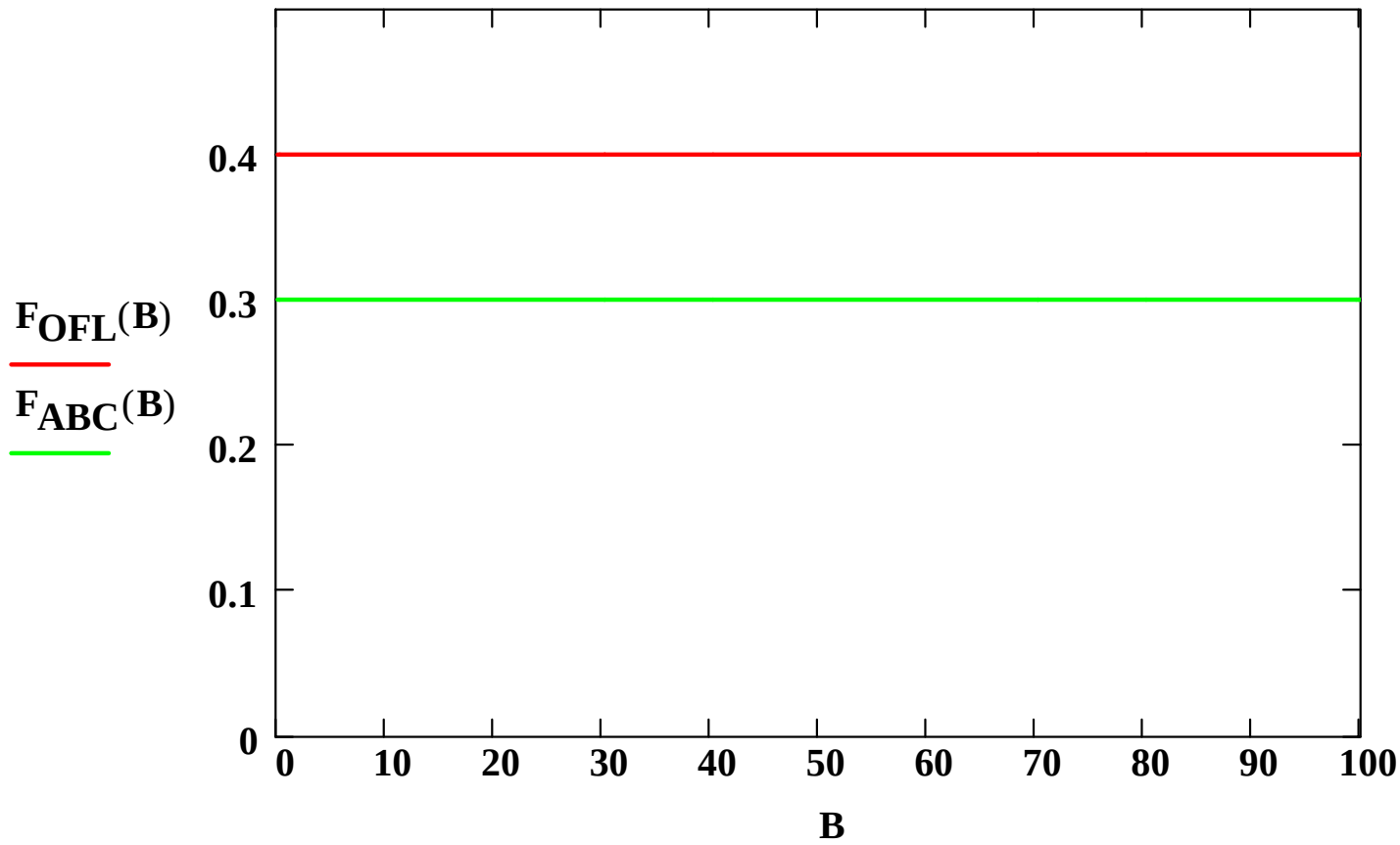
# Tiers Grouped by HCR Shape

- Control rules in Tiers 1-3 have similar shape
  - Constant F if biomass above the reference level
  - F varies with B below the reference level
  - F=0 if biomass extremely low
- Control rules in Tiers 4-5 have similar shape
  - Constant F regardless of biomass
- Control rules in Tier 6 are unique
  - Constant catch regardless of biomass
  - Unless the SSC has a better idea

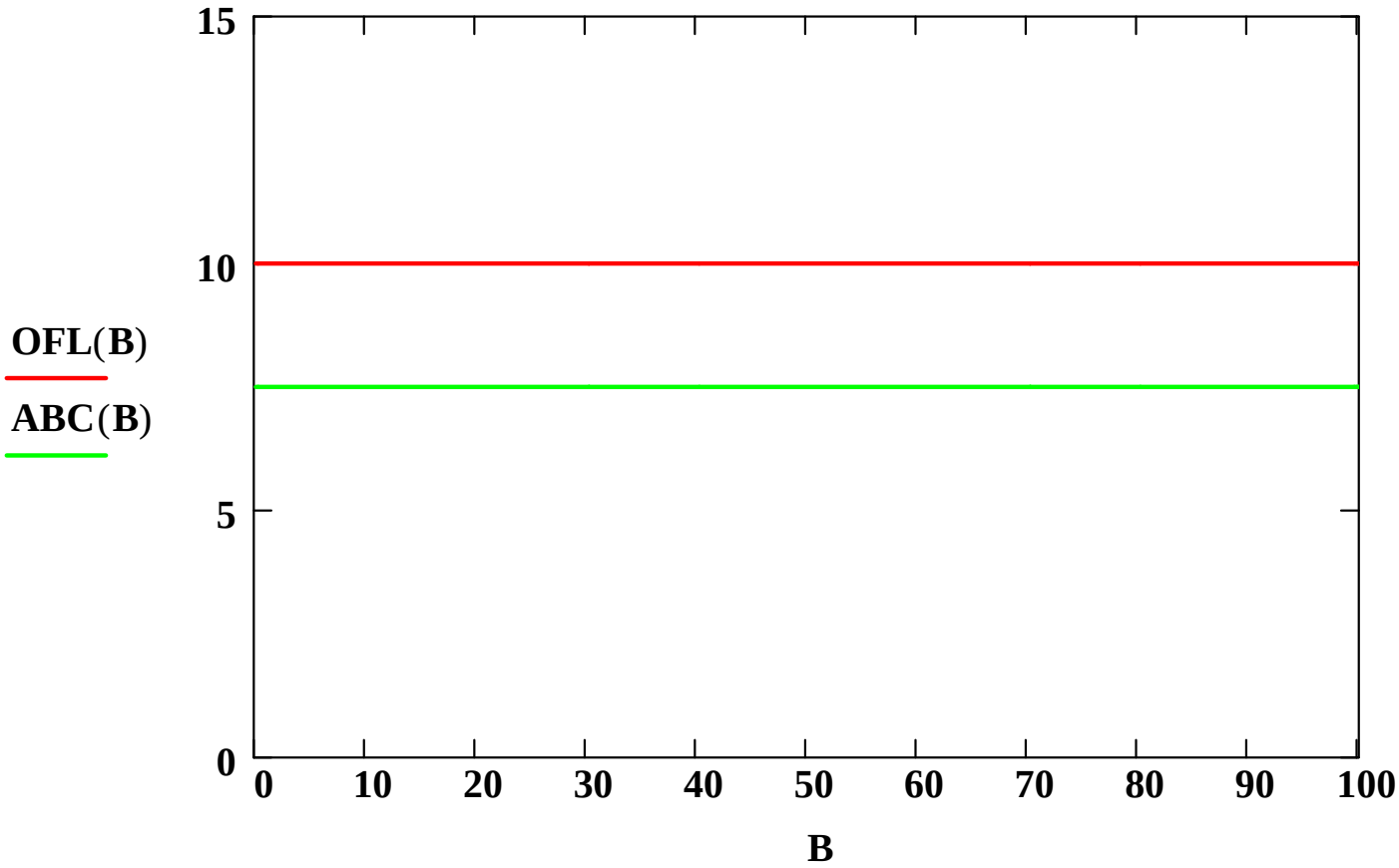
# Shape of Control Rules in Tiers 1-3



# Shape of Control Rules in Tiers 4-5



# Shape of Control Rules in Tier 6



# Tiers Grouped by Basis

- Tiers 1-2 based on MSY directly
  - Tier 1: use when uncertainty *can* be estimated
  - Tier 2: use when uncertainty *can't* be estimated
- Tiers 3-4 based on spawning per recruit
  - Tier 3: use when recruitment *can* be estimated
  - Tier 4: use when recruitment *can't* be estimated
- Tier 5 based on natural mortality rate
- Tier 6 based on average catch

# Spawning Per Recruit

- Usually expressed in relative (%) terms
- Ratio between two lifetime egg productions
  - Numerator: assume the cohort is fished
  - Denominator: assume cohort is *not* fished
- Ranges between 0 and 1, depending on F
  - Numerator is small if F is large
  - Numerator = denominator if F=0

# Example SPR Calculations

| Age | Nos. | Expl. | Catch | Wt. | Yield | Surv. | Mat. | Spawn. | Mort. | Deaths |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1,000 | 0.00 | 0 | 0.8 | 0 | 1,000 | 0 | 0 | 0.2 | 200 |
| 2 | 800 | 0.00 | 0 | 1.8 | 0 | 800 | 0 | 0 | 0.2 | 160 |
| 3 | 640 | 0.19 | 122 | 2.8 | 340 | 518 | 0 | 0 | 0.2 | 104 |
| 4 | 415 | 0.19 | 79 | 3.8 | 299 | 336 | 0 | 0 | 0.2 | 67 |
| 5 | 269 | 0.19 | 51 | 4.8 | 245 | 218 | 1 | 1,045 | 0.2 | 44 |
| 6 | 174 | 0.19 | 33 | 5.8 | 192 | 141 | 1 | 818 | 0.2 | 28 |
| 7 | 113 | 0.19 | 21 | 6.8 | 146 | 91 | 1 | 622 | 0.2 | 18 |
| 8 | 73 | 0.19 | 14 | 7.8 | 108 | 59 | 1 | 462 | 0.2 | 12 |
| 9 | 47 | 0.19 | 9 | 8.8 | 79 | 38 | 1 | 338 | 0.2 | 8 |
| 10 | 31 | 0.19 | 6 | 9.8 | 57 | 25 | 1 | 244 | 1.0 | 25 |
| Sum | 3,562 | | 335 | | 1,467 | 3,227 | | 3,528 | | 665 |

| Age | Nos. | Expl. | Catch | Wt. | Yield | Surv. | Mat. | Spawn. | Mort. | Deaths |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1,000 | 0.00 | 0 | 0.8 | 0 | 1,000 | 0 | 0 | 0.2 | 200 |
| 2 | 800 | 0.00 | 0 | 1.8 | 0 | 800 | 0 | 0 | 0.2 | 160 |
| 3 | 640 | 0.00 | 0 | 2.8 | 0 | 640 | 0 | 0 | 0.2 | 128 |
| 4 | 512 | 0.00 | 0 | 3.8 | 0 | 512 | 0 | 0 | 0.2 | 102 |
| 5 | 410 | 0.00 | 0 | 4.8 | 0 | 410 | 1 | 1,966 | 0.2 | 82 |
| 6 | 328 | 0.00 | 0 | 5.8 | 0 | 328 | 1 | 1,901 | 0.2 | 66 |
| 7 | 262 | 0.00 | 0 | 6.8 | 0 | 262 | 1 | 1,783 | 0.2 | 52 |
| 8 | 210 | 0.00 | 0 | 7.8 | 0 | 210 | 1 | 1,636 | 0.2 | 42 |
| 9 | 168 | 0.00 | 0 | 8.8 | 0 | 168 | 1 | 1,476 | 0.2 | 34 |
| 10 | 134 | 0.00 | 0 | 9.8 | 0 | 134 | 1 | 1,315 | 1.0 | 134 |
| Sum | 4,463 | | 0 | | 0 | 4,463 | | 10,077 | | 1000 |

# Recruits don’t matter in SPR% (so long as they’re the same)

$$\frac{\left(\frac{3528}{1000}\right)}{\left(\frac{10077}{1000}\right)} = \left(\frac{3528}{1000}\right) \cdot \left(\frac{1000}{10077}\right) = \frac{3528}{10077} = 0.35$$

# What is B40%?

- 40% of biomass that would result from an average cohort if fishing were eliminated
  - "average cohort" computed over current regime
  - product of SPR(F40%) and average recruitment
- *Not* 40% of historic biomass
  - historic regime may differ from current
- *Not* 40% of equilibrium biomass
  - equilibrium recruitment may differ from average

# Example SY Calculations

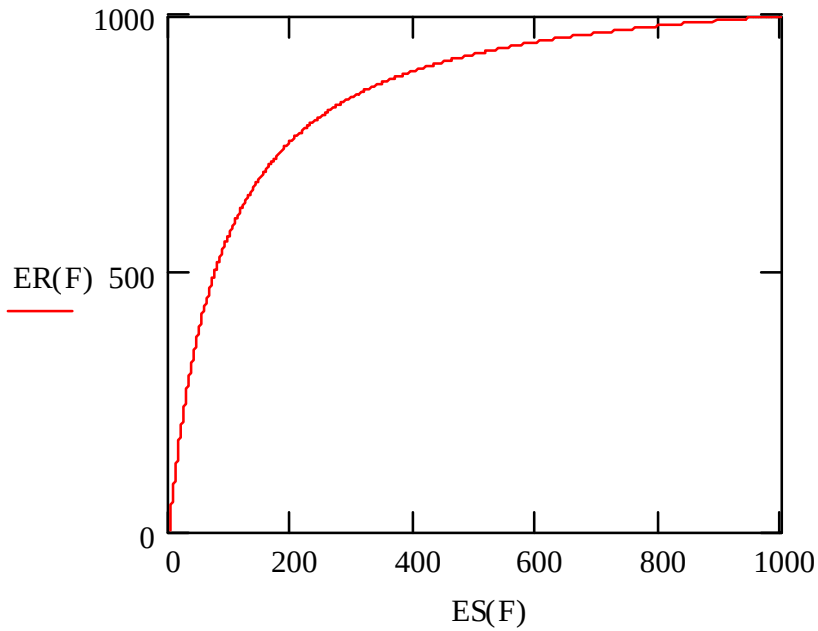
| Age | Nos. | Expl. | Catch | Wt. | Yield | Surv. | Mat. | Spawn. | Mort. | Deaths |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 809 | 0.00 | 0 | 0.8 | 0 | 809 | 0 | 0 | 0.2 | 162 |
| 2 | 648 | 0.00 | 0 | 1.8 | 0 | 648 | 0 | 0 | 0.2 | 130 |
| 3 | 518 | 0.21 | 109 | 2.8 | 305 | 409 | 0 | 0 | 0.2 | 82 |
| 4 | 327 | 0.21 | 69 | 3.8 | 261 | 259 | 0 | 0 | 0.2 | 52 |
| 5 | 207 | 0.21 | 43 | 4.8 | 209 | 163 | 1 | 785 | 0.2 | 33 |
| 6 | 131 | 0.21 | 27 | 5.8 | 159 | 103 | 1 | 599 | 0.2 | 21 |
| 7 | 83 | 0.21 | 17 | 6.8 | 118 | 65 | 1 | 444 | 0.2 | 13 |
| 8 | 52 | 0.21 | 11 | 7.8 | 86 | 41 | 1 | 322 | 0.2 | 8 |
| 9 | 33 | 0.21 | 7 | 8.8 | 61 | 26 | 1 | 229 | 0.2 | 5 |
| 10 | 21 | 0.21 | 4 | 9.8 | 43 | 16 | 1 | 162 | 1.0 | 16 |
| Sum | 2,829 | | 288 | | 1,241 | 2,541 | | 2,541 | | 521 |

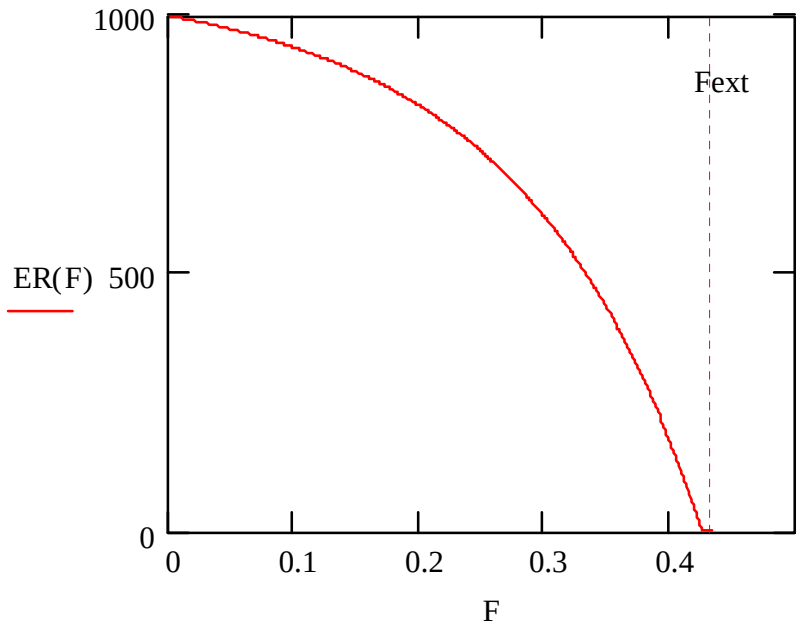
| Age | Nos. | Expl. | Catch | Wt. | Yield | Surv. | Mat. | Spawn. | Mort. | Deaths |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1,000 | 0.00 | 0 | 0.8 | 0 | 1,000 | 0 | 0 | 0.2 | 200 |
| 2 | 800 | 0.00 | 0 | 1.8 | 0 | 800 | 0 | 0 | 0.2 | 160 |
| 3 | 640 | 0.00 | 0 | 2.8 | 0 | 640 | 0 | 0 | 0.2 | 128 |
| 4 | 512 | 0.00 | 0 | 3.8 | 0 | 512 | 0 | 0 | 0.2 | 102 |
| 5 | 410 | 0.00 | 0 | 4.8 | 0 | 410 | 1 | 1,966 | 0.2 | 82 |
| 6 | 328 | 0.00 | 0 | 5.8 | 0 | 328 | 1 | 1,901 | 0.2 | 66 |
| 7 | 262 | 0.00 | 0 | 6.8 | 0 | 262 | 1 | 1,783 | 0.2 | 52 |
| 8 | 210 | 0.00 | 0 | 7.8 | 0 | 210 | 1 | 1,636 | 0.2 | 42 |
| 9 | 168 | 0.00 | 0 | 8.8 | 0 | 168 | 1 | 1,476 | 0.2 | 34 |
| 10 | 134 | 0.00 | 0 | 9.8 | 0 | 134 | 1 | 1,315 | 1.0 | 134 |
| Sum | 4,463 | | 0 | | 0 | 4,463 | | 10,077 | | 1000 |

# Recruits *do* matter in SY (because they're *not* equal)

$$\frac{\left(\frac{2541}{809}\right)}{\left(\frac{10077}{1000}\right)} = \left(\frac{2541}{809}\right) \cdot \left(\frac{1000}{10077}\right) = 0.312$$

# Equilibrium Recruitment



# Per-Recruit and Equilibrium