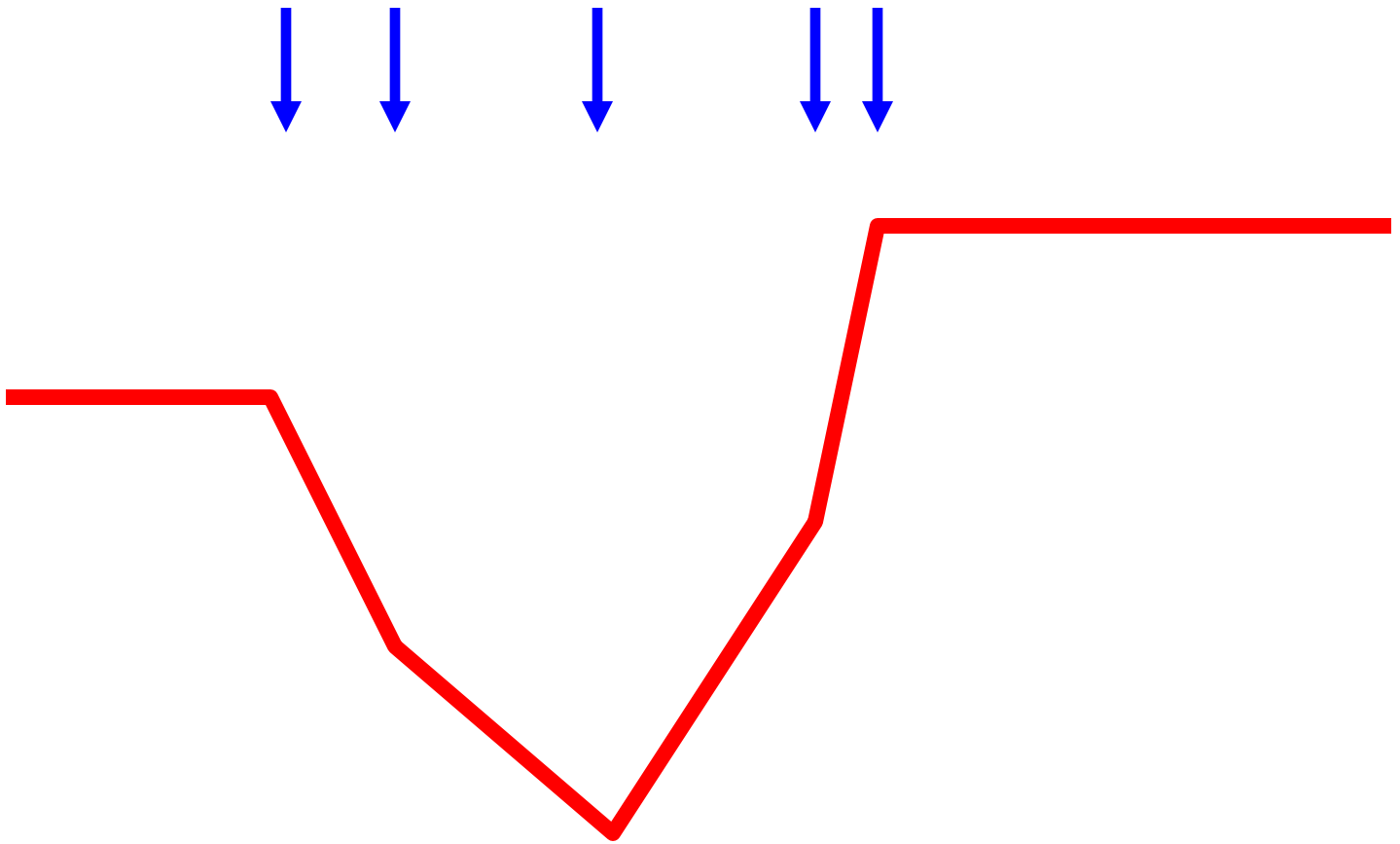
Modeling Natural (M) and Fishing (F) Mortality in Stock Synthesis

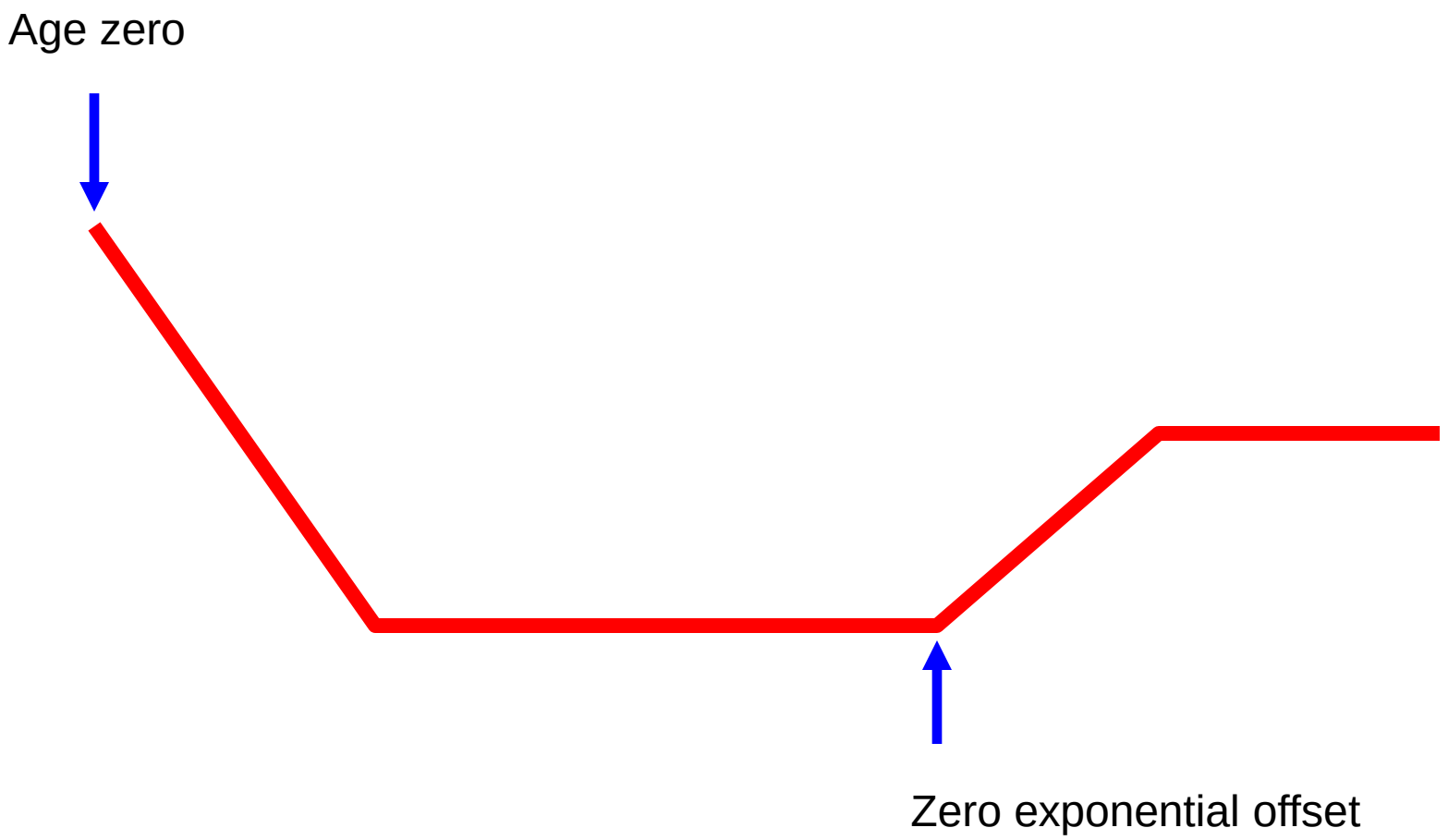
M options in Stock Synthesis v3

1. Single value for all ages
2. Broken stick (piecewise linear) where the number of breakpoints can be set
3. Scaled Lorenzen curve where the curve is scaled to an estimable value at a given age
4. Age-specific vector of user-specified fixed values
5. Age- and time-specific by using environmental link

Broken stick



Broken stick

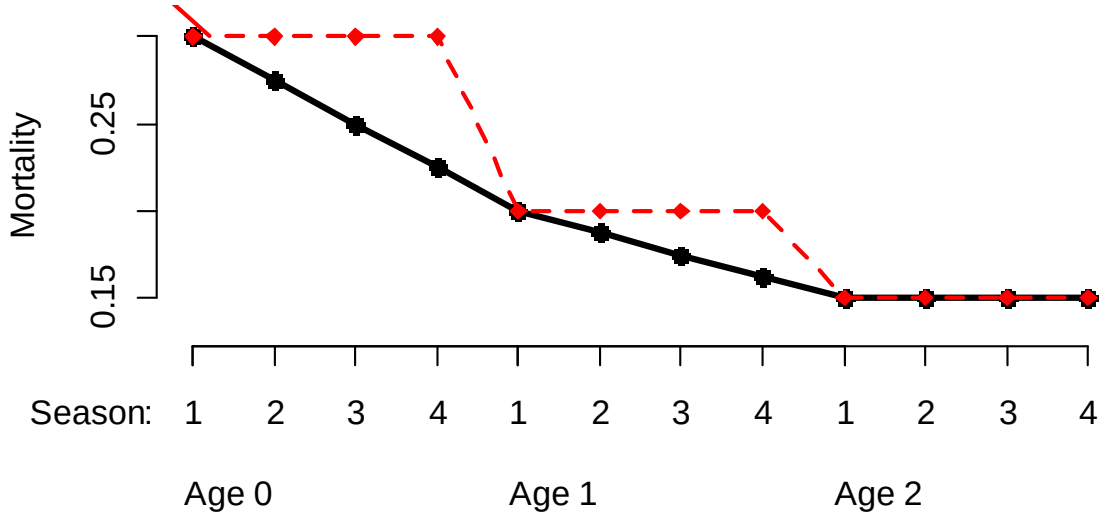


More on Mortality

- Value for males offset from females
- Can be time-varying like other parameters
- If broken stick is used (piecewise linear), values before and after range of breakpoints are constant at first/last value

Mortality in seasonal models

- Mortality is function of real age based on birth season, not calendar age
- User-specified values have choice of same value for each season within year, or interpolated values for each season



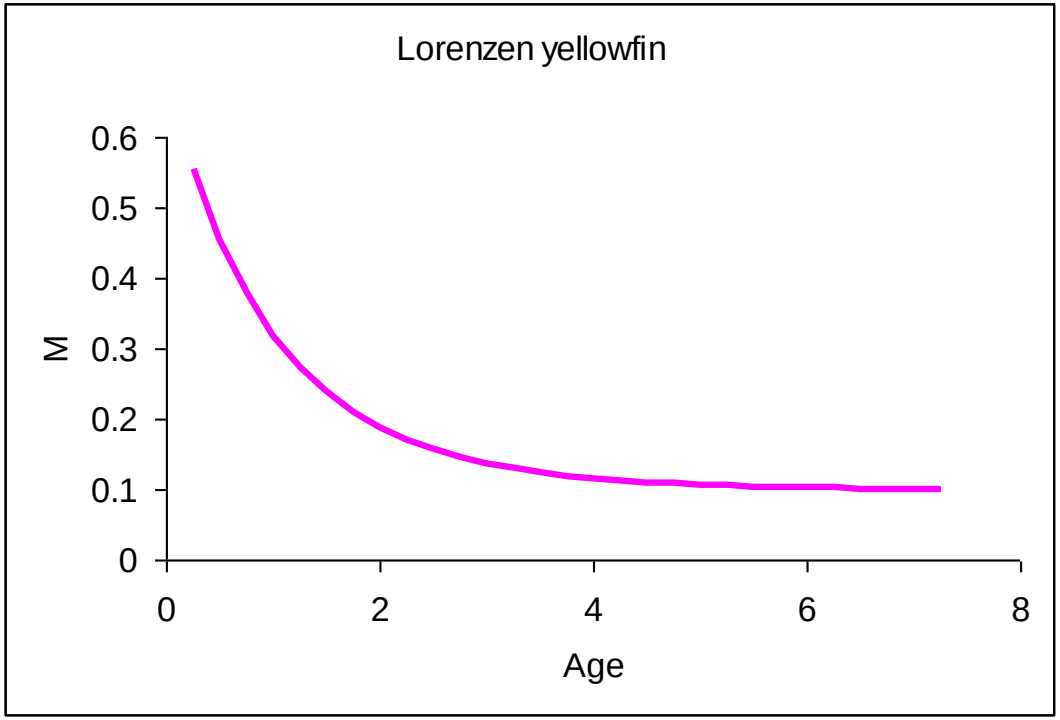
Lorenzen mortality

- Mortality is a function of mean size at age
- Parameter for M at user-specified reference age
- Based on initial growth curve, so does not work well with time-varying growth

Lorenzen mortality

$$S = \left(\frac{L(a-1, t-1)}{L(a-1, t-1) + L_\infty(B)(e^k - 1)} \right)^{\frac{M_{1,I}}{L_\infty K}} \qquad (2.10)$$

Lorenzen, K. (2005) Population dynamics and potential of fisheries stock enhancement: practical theory for assessment and policy analysis. Philosophical Transactions of the Royal Society Series B, 360:171-189.



Fishing mortality (F)

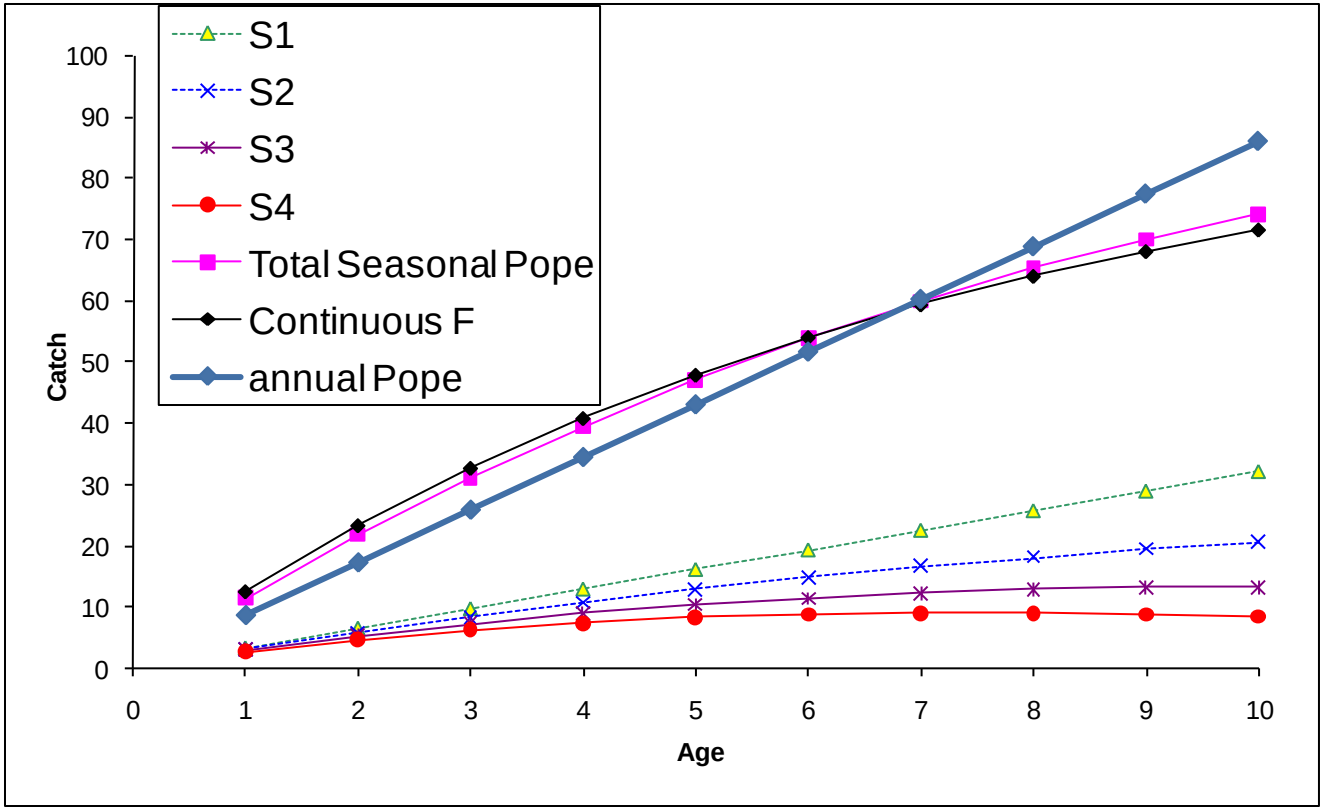
Continuous F vs. Pope's Approx.

- **With Pope's**
  - Decays N-at-age to midyear using M
  - Removes catch instantaneously using Hrate and selectivity, with Hrate calculated to exactly match the observed landed catch
  - Decays fishery survivors to end or year using M
  - Survey timing allows a specified fraction of M and catch to occur before the survey
  - New option now allows sampled agecomp to equal catch agecomp

- **With continuous F**
  - Uses M + F to calculate Z at age
  - Uses Z to decay N-at-age to time of survey

  Implications of selectivity differ between the two approaches

Selectivity issue



With N-at-age constant (100) and linear ramp in selectivity, we need multiple seasons for Pope's to approximate continuous F if F is high (here, 1.8)

Hybrid F

- Start by doing a Pope's calculation of mid-season exploitation rate:

  Hrate = catch_ret_obs(f,t)/vbio

- Then convert to an estimate of equivalent F

  F=-log(1.-Hrate);

- Then tune the F values in a fixed number (3-5) of iterations to approximate the observed catch

Hybrid F comparison

	Fmethod		
	1	2	3
	Pope's	parameters	hybrid
N_iter:	458	846	469
runtime(sec):	85	130	95
LIKELIHOOD	1327.64	1327.68	1327.68
endspbio	6017.21	5797.93	5798.08
se(endspbio)	1331.46	1293.99	1293.93

Reporting total F

- The complexities of multiple fleets, areas, growth patterns, seasons, dome-selectivity, etc. wreck havoc with calculation of a single annual total “F” statistic
- Initially, SS focused on reporting an annual value for equilibrium SPR and the total exploitation rate (catch/summary biomass).
- Sum of the apical F values across fleets is also available, but it is easily misleading in complex setups.
- New option gets age-specific total F from Z-M, where:
  - $Z=\ln(N_{t+1,a+1} / N_{t,a})$ on annual not seasonal basis, and
  - $M=\ln(N_{t+1,a+1} / N_{t,a})$ with fishery turned off
- With the fishery on and then off, SS reports:
  - Spawning biomass by area and GP
  - Numbers at age by GP and gender (combines areas)
  - Z at age by GP and gender
  - Up to output processors to do the F=Z-M calculations