

Catchability and Selectivity in Stock Synthesis

Quick review

Catchability

Selectivity

Availability

Vulnerability

Catchability

- Catchability: The constant (q) between the abundance index (I) and the model abundance (B).

$$\hat{I}_t = q_t \hat{B}_t e^{\varepsilon_t} \quad \varepsilon_t \sim \text{N}\left(0, \sigma_\varepsilon^2\right)$$

$$q_t = q_{t-1} e^{\alpha_t} \quad \alpha_t \sim \text{N}\left(0, \sigma_\alpha^2\right)$$

Catchability (Q) in SS

- Q is not needed to get fishing mortality, it is needed only where there are CPUE, effort, or survey data to be analyzed
- Q can be specified as a simple, internally calculated scaling factor, or as a model parameter
- As a parameter, it can be:
 - Density-dependent (one additional parameter)
 - Linked to an environmental covariate (one additional parameter)
 - Have random deviations or random walk over time

Q units

$$\widehat{CPUE} = Q * B$$

- Where B is the model's estimate of population abundance (in biomass or numbers as appropriate) after accounting for selectivity.
- Catch = F*B
- F = Q*Effort, so:

$$\hat{E} = \frac{1}{Q} * F$$

- Note that SS reports this 1/Q as Q, so you'll need to invert to compare to the Q from CPUE data

Selectivity, Availability and Vulnerability

- **Selectivity**: The probability of catching an individual of a given age/length scaled to the maximum probability over all ages, given that all animals are available to be caught.
- **Availability**: The relative probability, as a function of age/length, of being in the area in which catching occurs.
- **Vulnerability**: The combination of selectivity and availability.

Selectivity in SS: Outline

- General notes
- Functional forms
 - Logistic
 - Double normal
 - Piecewise
 - Nonparametric
 - Splines
- Retention and discard mortality
- Male offsets
- Advanced topics (time-varying selectivity)

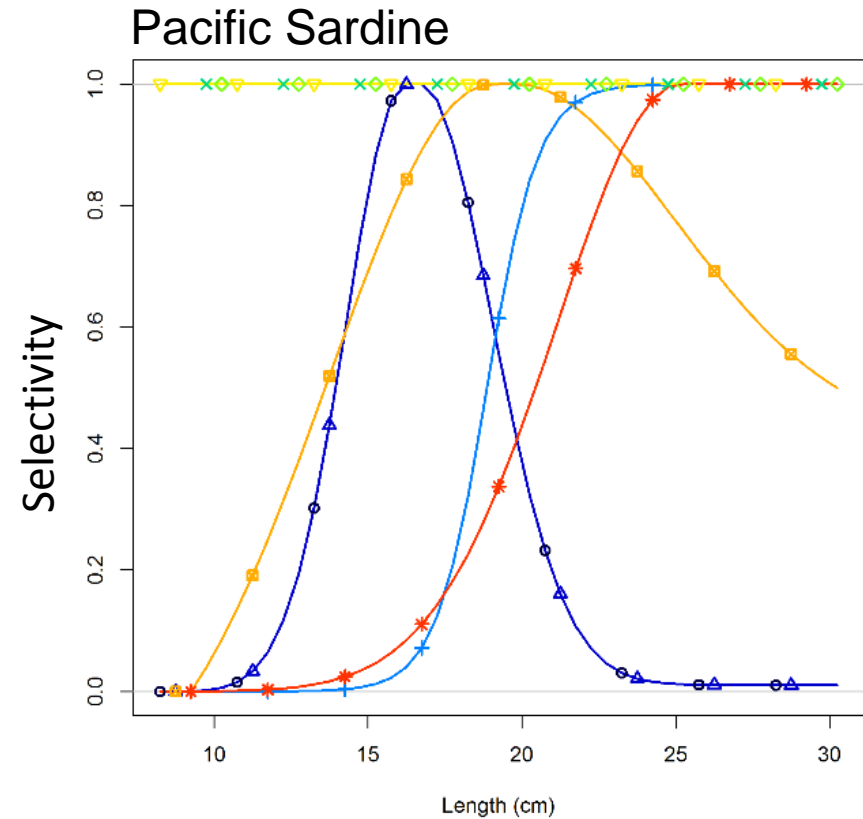
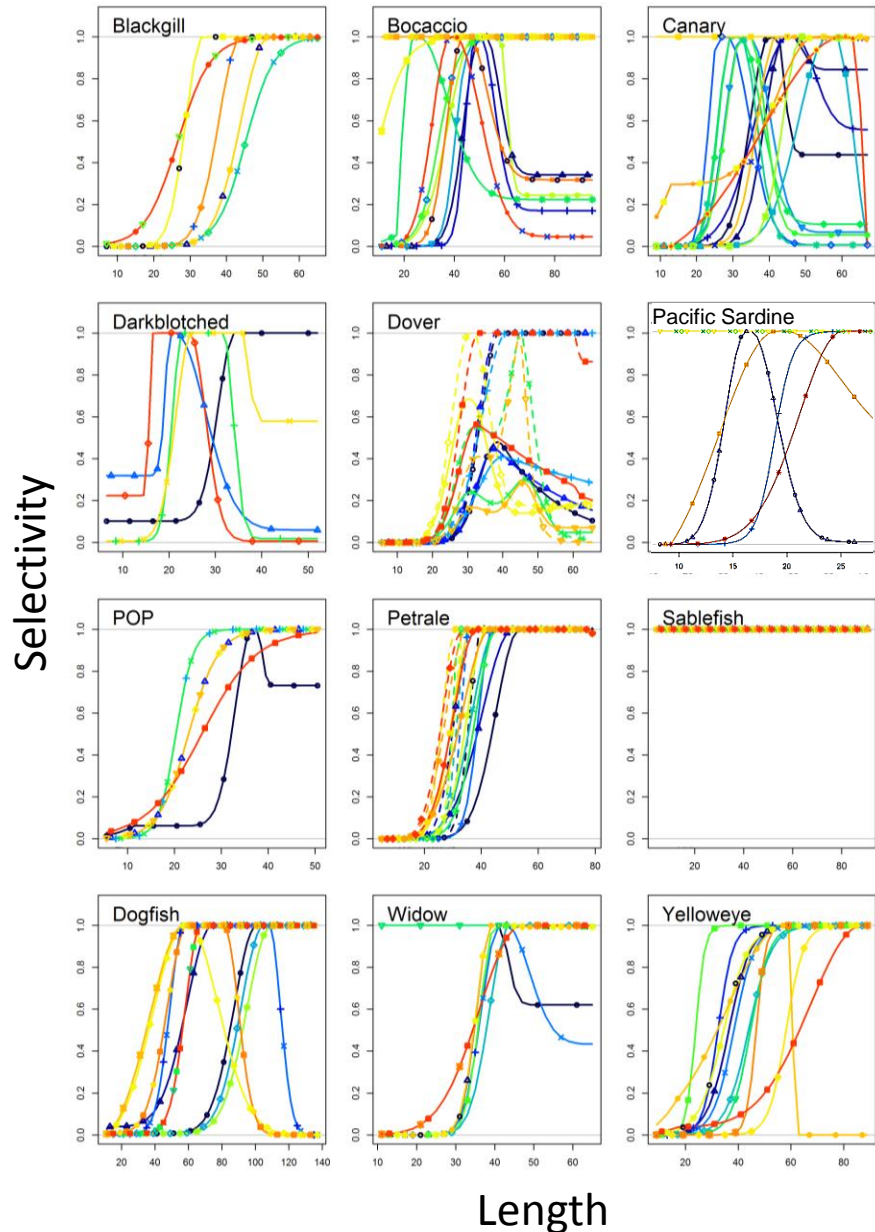
Notes on selectivity in SS

- Wide variety of options
- Selectivity can be a function of either age or length or a combination of both
- Parameters of the selectivity curves have all the functionality as other parameters:
 - time blocks, random variation, covariates, priors, etc.

Functional forms

- Full selectivity for all ages/lengths
 - typically used for age with length is also used and vice versa
- Logistic
 - commonly used for asymptotic selectivity
- Double logistic
- Double normal
 - most commonly used selectivity, allows a declining right limb
- Exponential-logistic
- Piecewise linear (in log space) function of length
- One value per age
- Random walk across ages
- Splines
- Selex = spawning biomass, recruitment, or rec dev
- Mirror selectivity of another fleet/survey
- others....

Selectivity in recent SS assessments

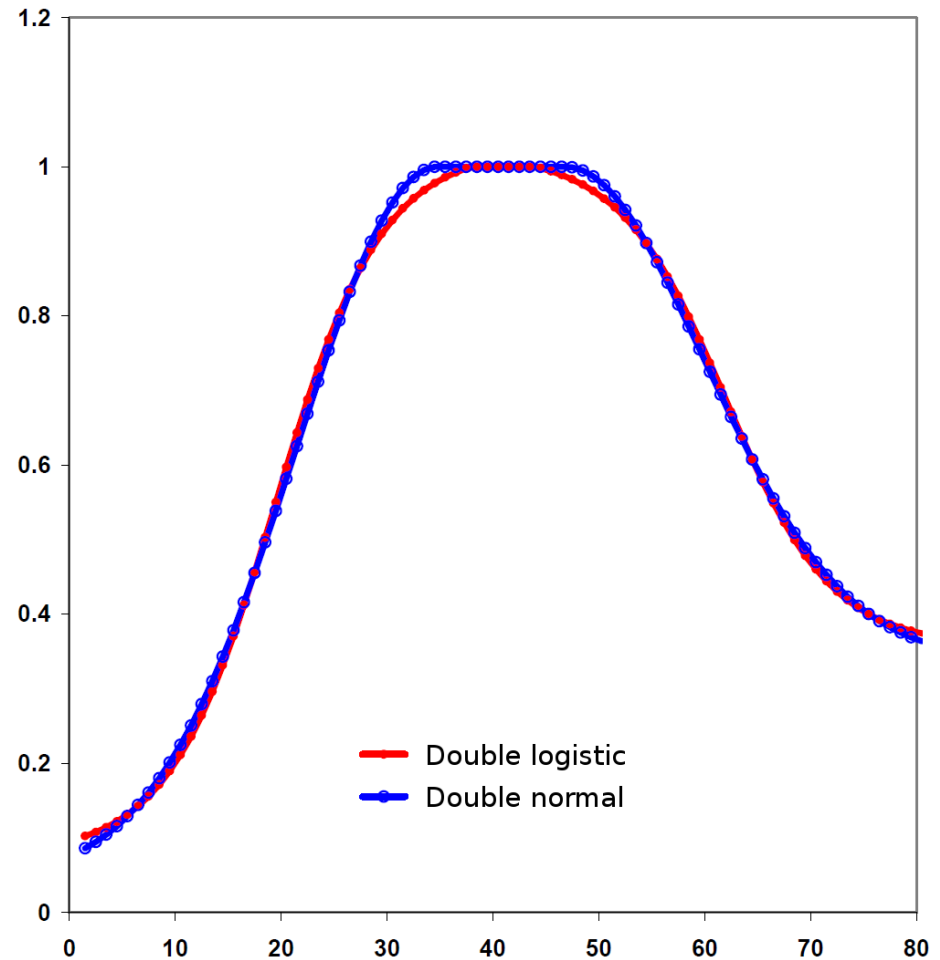
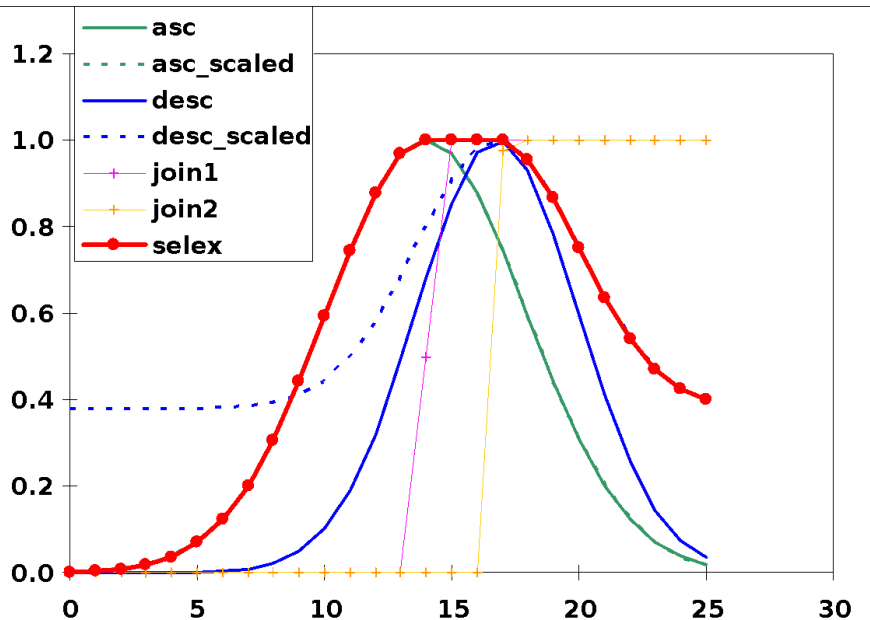


Double normal

- Comprised of the outer sides of two adjacent normal curves with separate variance parameters and peaks joined by a horizontal line.
- The parameters include
 - the selectivity at the smallest and largest ages/sizes,
 - the age/size where the selectivity first reaches full selectivity,
 - the length of the plateau, and
 - two parameters controlling the slope of the ascending and descending limbs.
- Can be made asymptotic by fixing some parameters
- Options for parameters representing selectivity at smallest and largest ages/sizes:
 - use, ignore, or ignore and make selectivity constant below/above specified bin

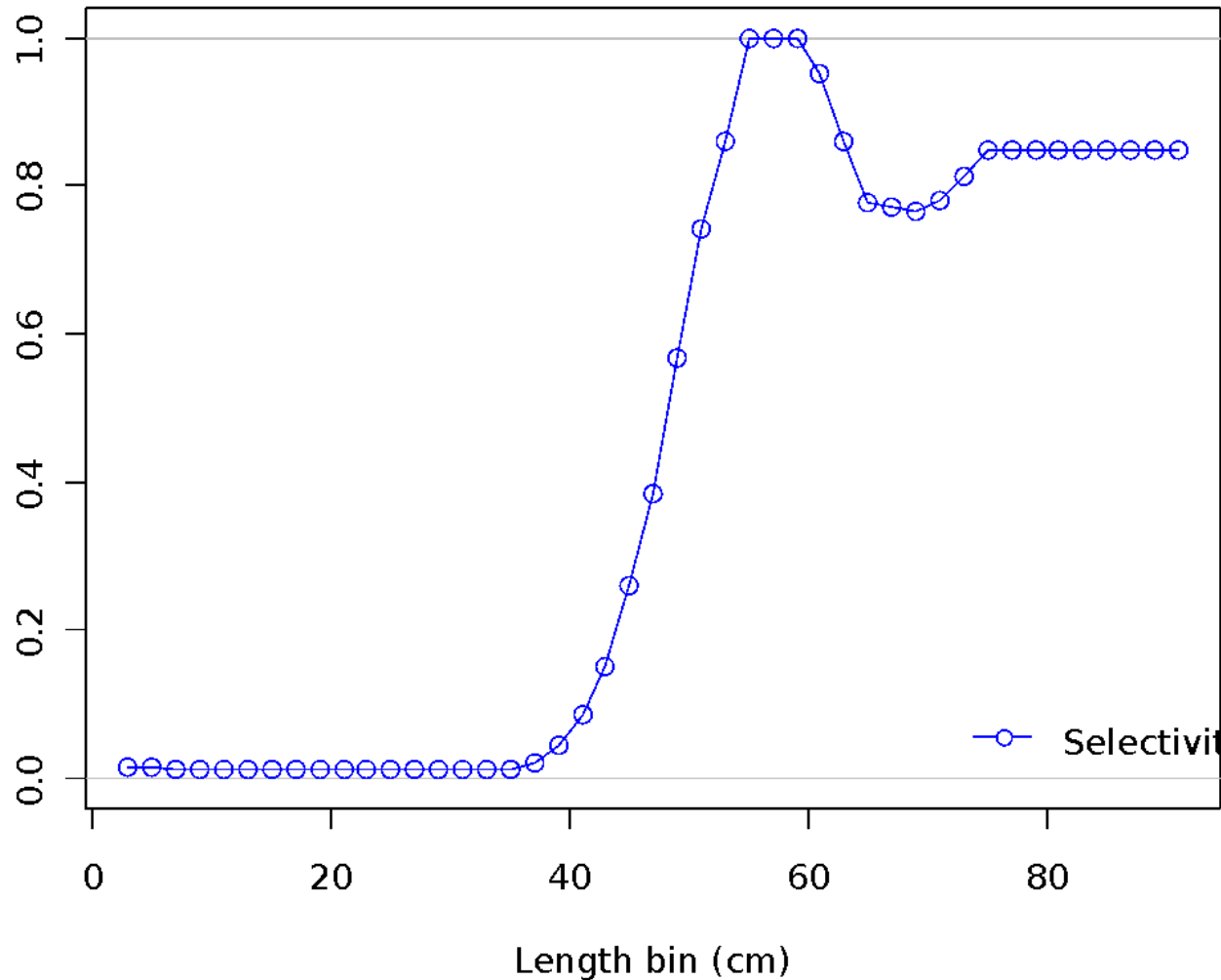
Double normal

- Can be similar to double logistic
- Simpler, better behaved function

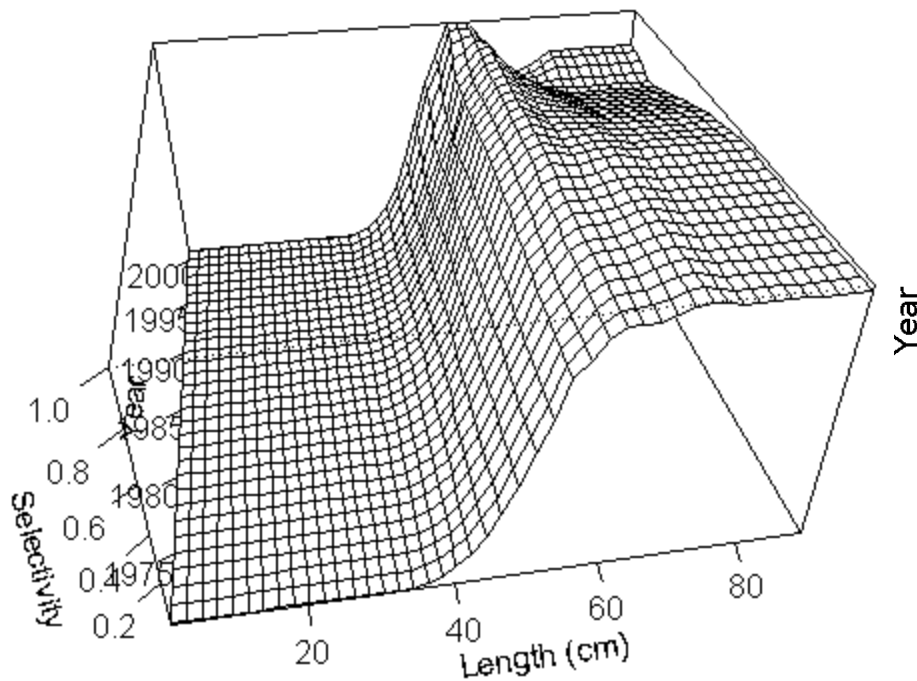


Piecewise linear selectivity

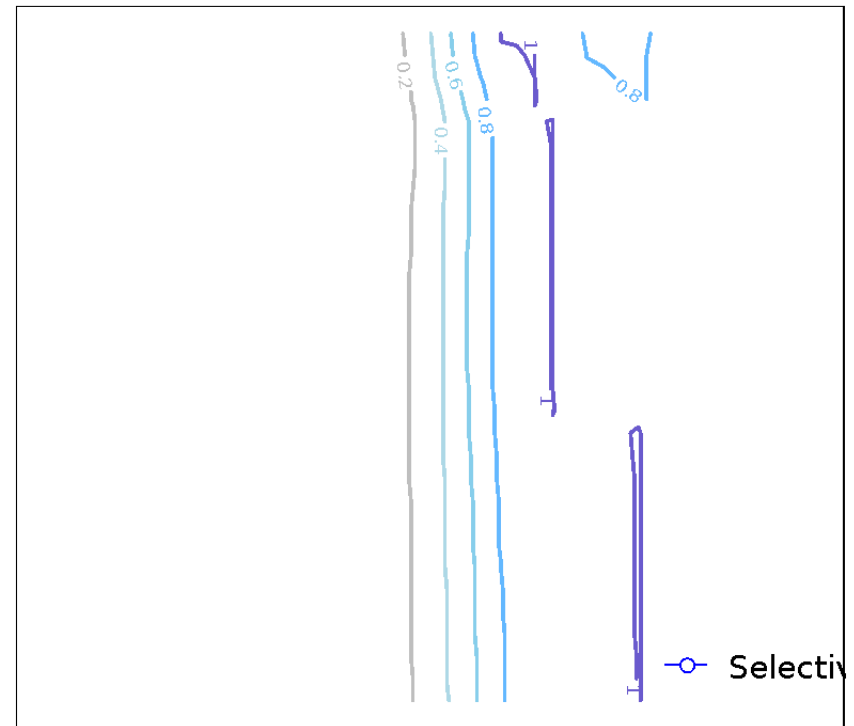
Female ending year selectivity for fishery1



Piecewise selectivity at length and with random walk over time



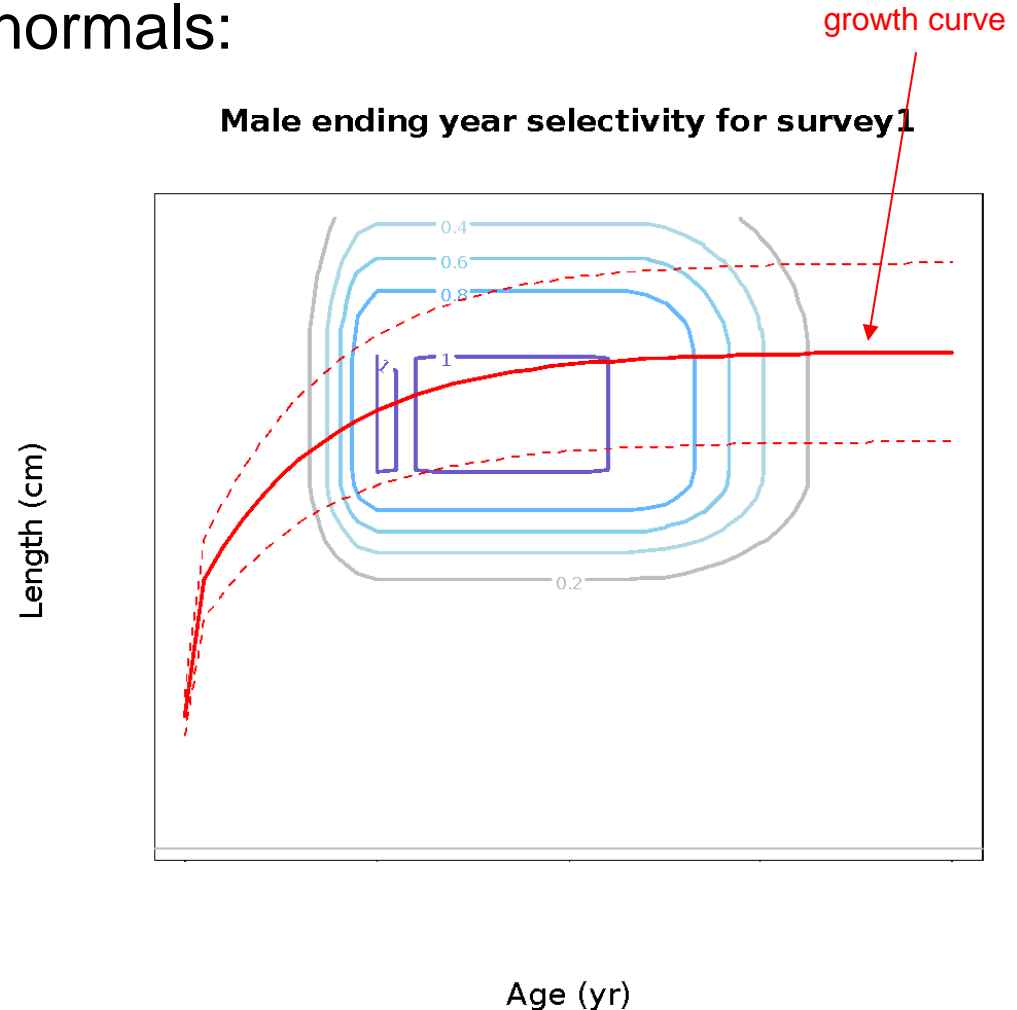
Female time-varying selectivity for fishery1



Length (cm)

Combining selectivity at length at age

- Independent functions
- Example with two double normals:

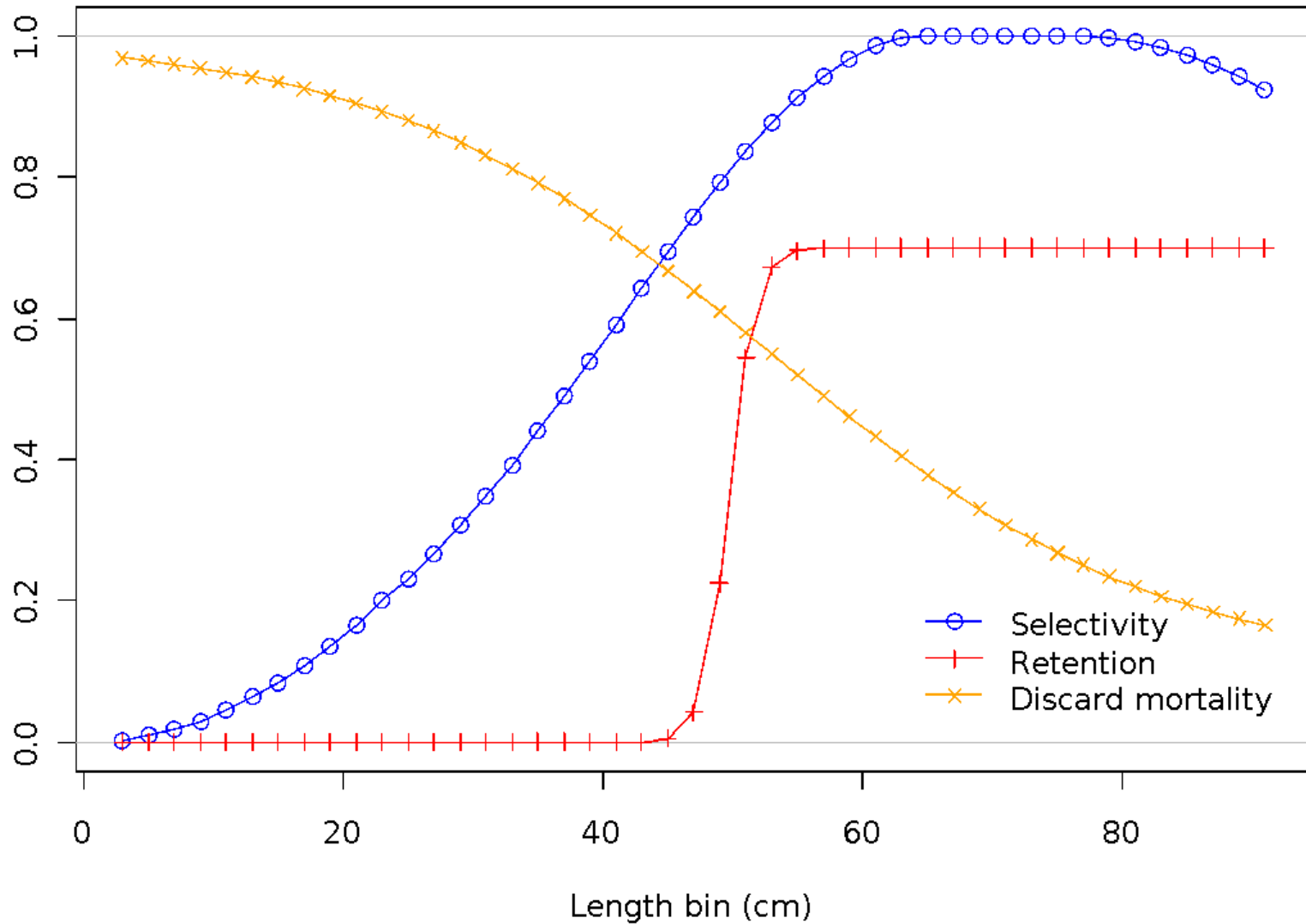


Retention and discard mortality

- Retention is a logistic function of size with parameter for asymptotic retention rate
- Offset from inflection parameter for males
- Discard mortality also logistic with asymptote and male offset
- $\text{dead fish} = \text{sel} \cdot (\text{ret} + (1 - \text{ret}) \cdot \text{disc})$

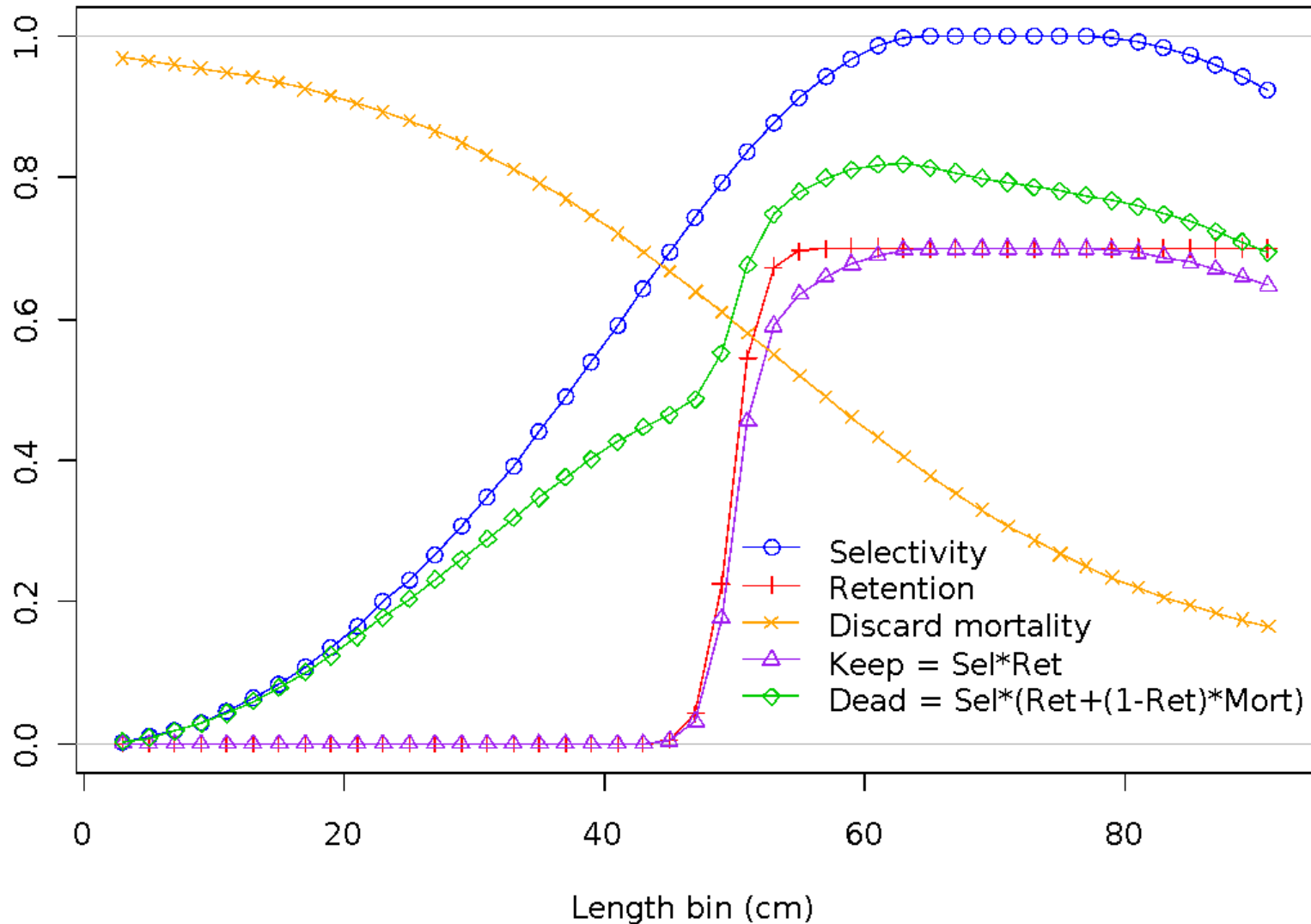
Retention and discard mortality

Male ending year selectivity for fishery1



Retention and discard mortality

Male ending year selectivity for fishery1



Male offset

Male (or female) selectivity is modeled two ways

1. Offset from female selectivity using a broken stick with parameters:

- age/size at the break point
- $\log(\text{male} / \text{female selectivity})$ at min, max, and break point

2. A function of parameters which are computed as offsets from parameters for other gender
(only available for logistic and double normal)

Male offset

