Figures

Model species

Gummy shark
Mustelus antarcticus

M = 0.1970, A_{MAX} = 16 yrs

School shark
Galeorhinus galeus

M = 0.1075, A_{MAX} = 54 yrs

Vary reproductive frequency (1/P_{MAX})

Annual
Biennial
Triennial
Quadrennial

P_{MAX} =
{1, 3/4, 2/3, 1/2, 1/3, 1/4}

Simulate length data

Equilibrium population model

F = 0.25 M

Maternal

Low selectivity for females in maternal condition

High selectivity for females in maternal condition

Catch at length, N =
{50, 100, 250, 500, 1000, 2500}

Simulate maternal condition

$$\Psi' \sim B(P) \quad P = P_{Max}\left(1 + e^{-ln(19)\left(\frac{l - L'_{50}}{L'_{95} - L'_{50}}\right)}\right)^{-1}$$

Estimate Maternity Parameters

True relationship (---)

3PLF - Estimated

Three parameter logistic, P_{MAX} estimated

3PLF - Fixed

Three parameter logistic, P_{MAX} fixed

2PLF - Maternity

Two parameter logistic, ignore P_{MAX}

2PLF - Maturity

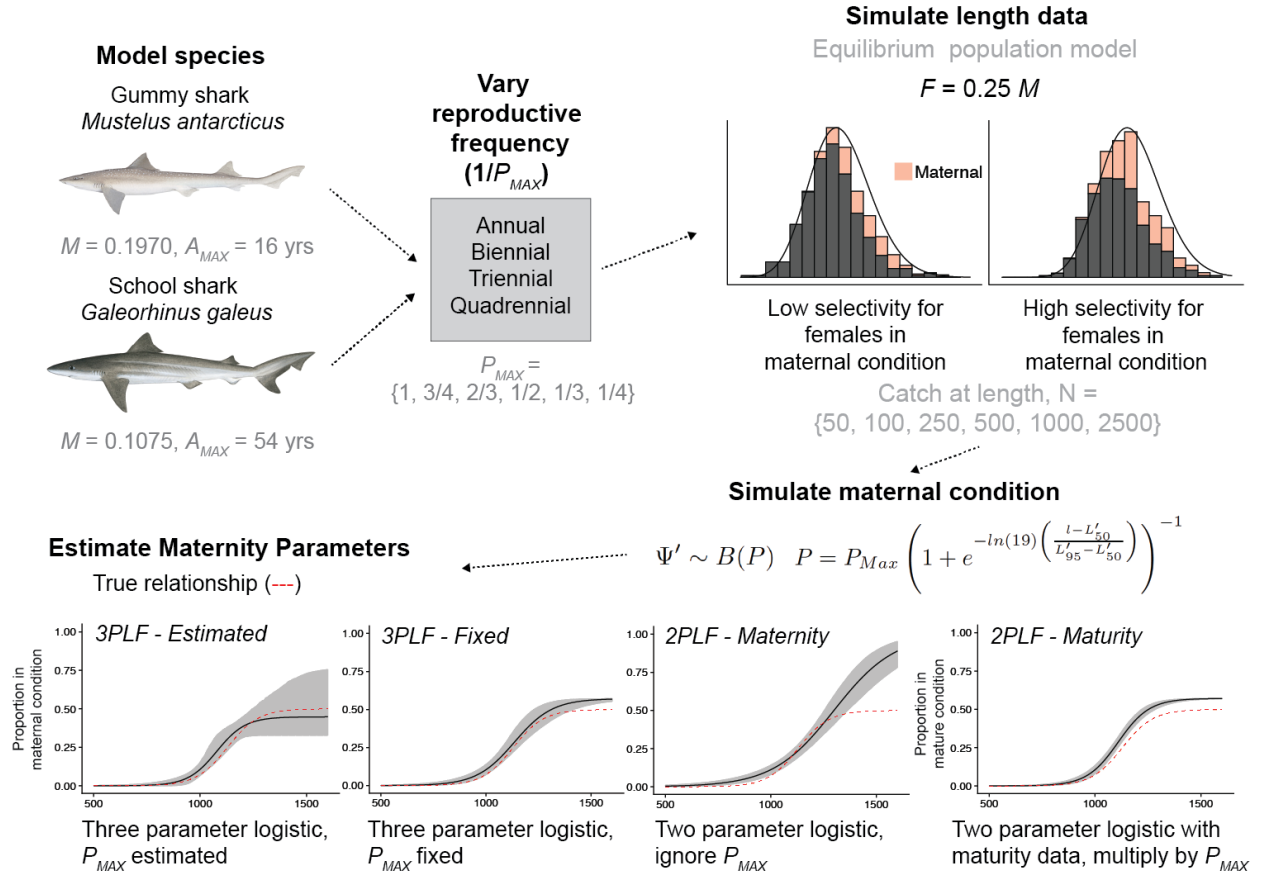Two parameter logistic with maturity data, multiply by P_{MAX}

Figure 1. Approach used to generate simulated data and test the performance of four methods for calculating maternity parameters. Illustrations © R.Swainston/www.anima.net.au
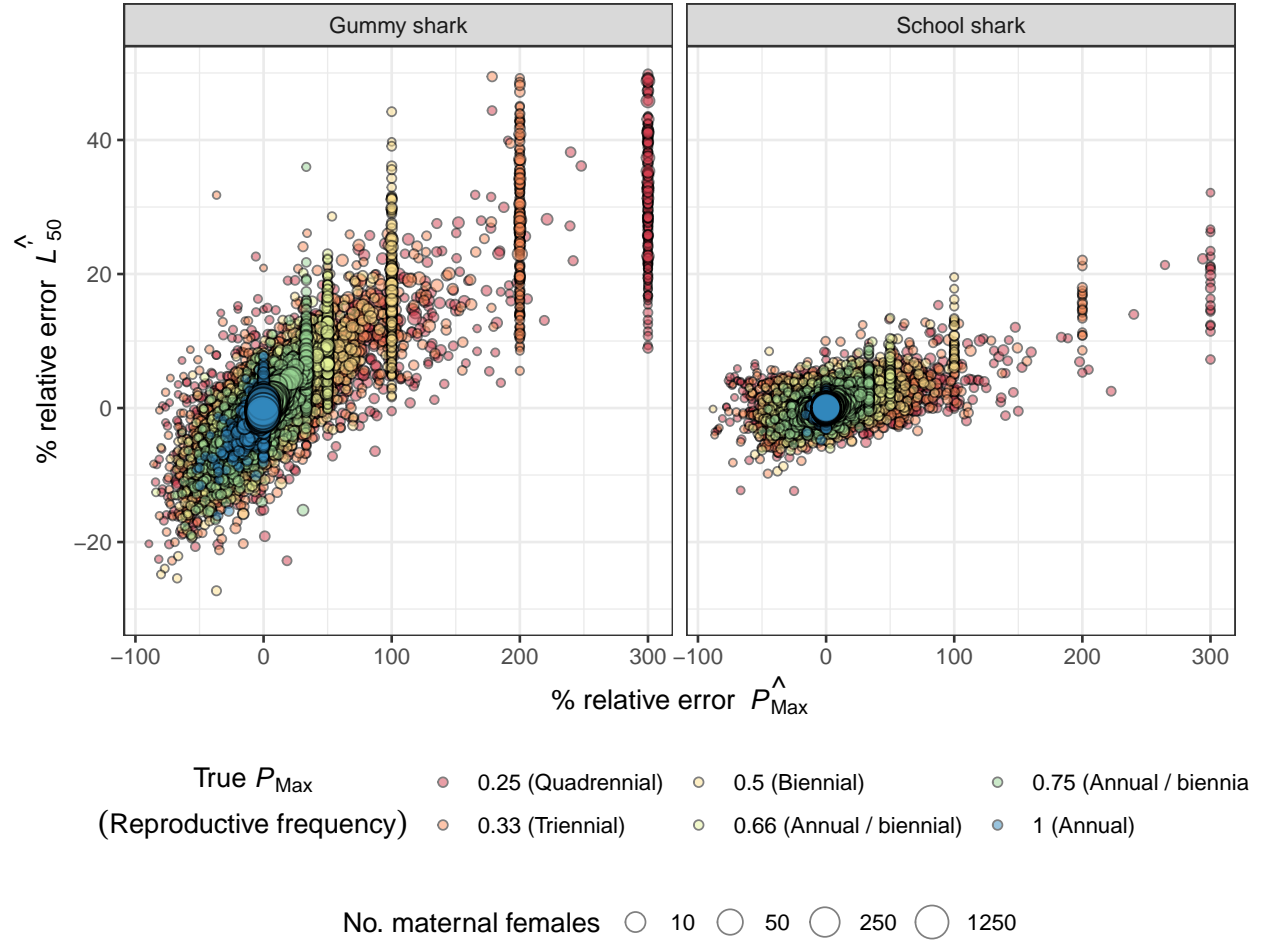
Figure 2. Bias (per cent relative error) in parameter estimates for $\hat{L_{50}}$ and $\hat{P_{Max}}$ for the 3PLF maternity function with P_{Max} estimated. Each point represents parameter estimates from one iteration of simulated data, including all combinations of variables. Simulations with longer reproductive cycles and fewer maternal females were associated with higher bias in both parameters $\hat{L_{50}}$ and $\hat{P_{Max}}$. Note: 0.09% of data points (n = 42) were cropped to aid with data visualization (see Figure S12 for uncropped figure).
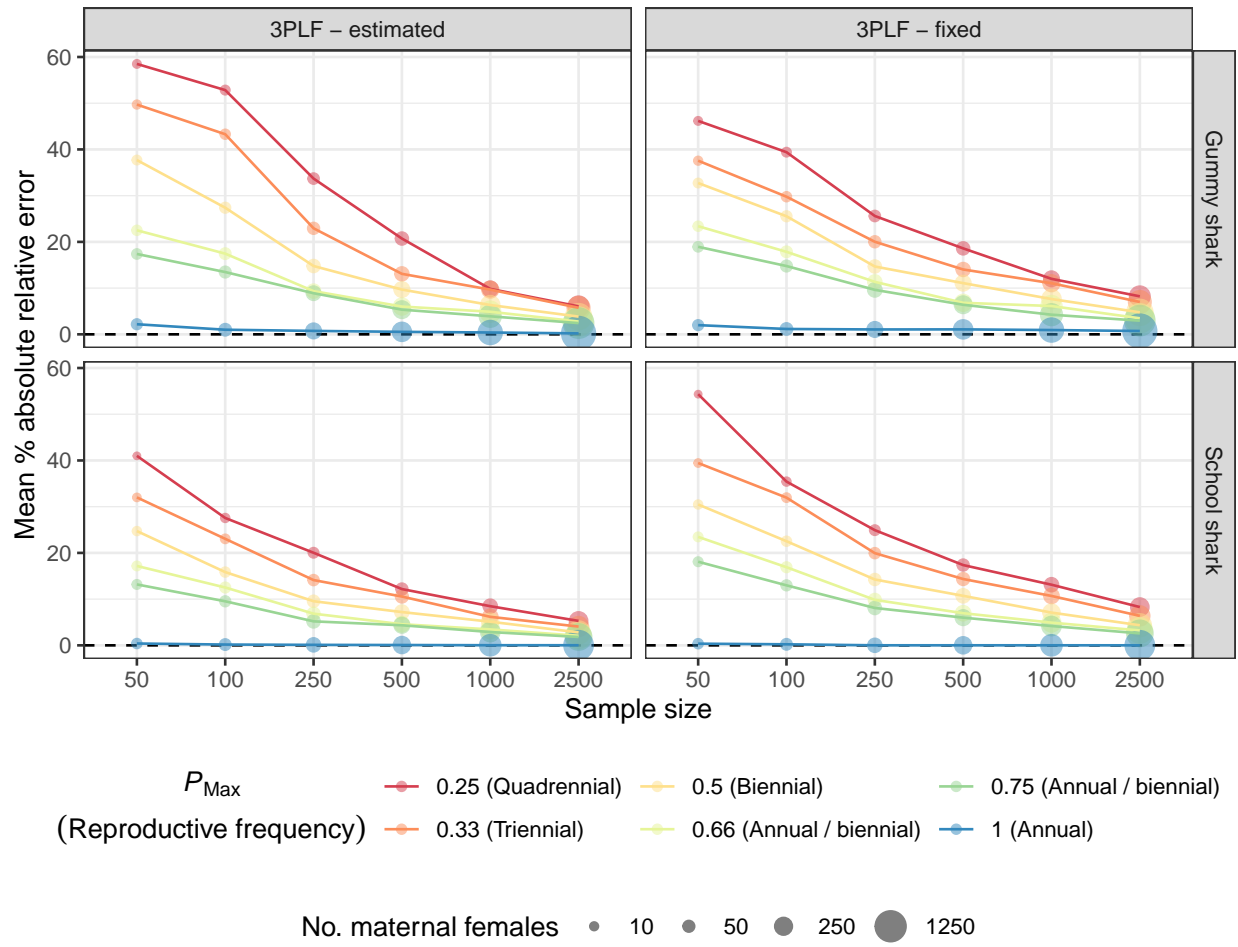
Figure 3. Accuracy (per cent absolute error) in parameter estimates of $\hat{P_{Max}}$ for 3PLF methods. Large sample sizes were needed to accurately estimate $\hat{P_{Max}}$ and accuracy decreased as the duration of the reproductive cycle increased. Each point reflects a mean value from 300 simulated data sets.
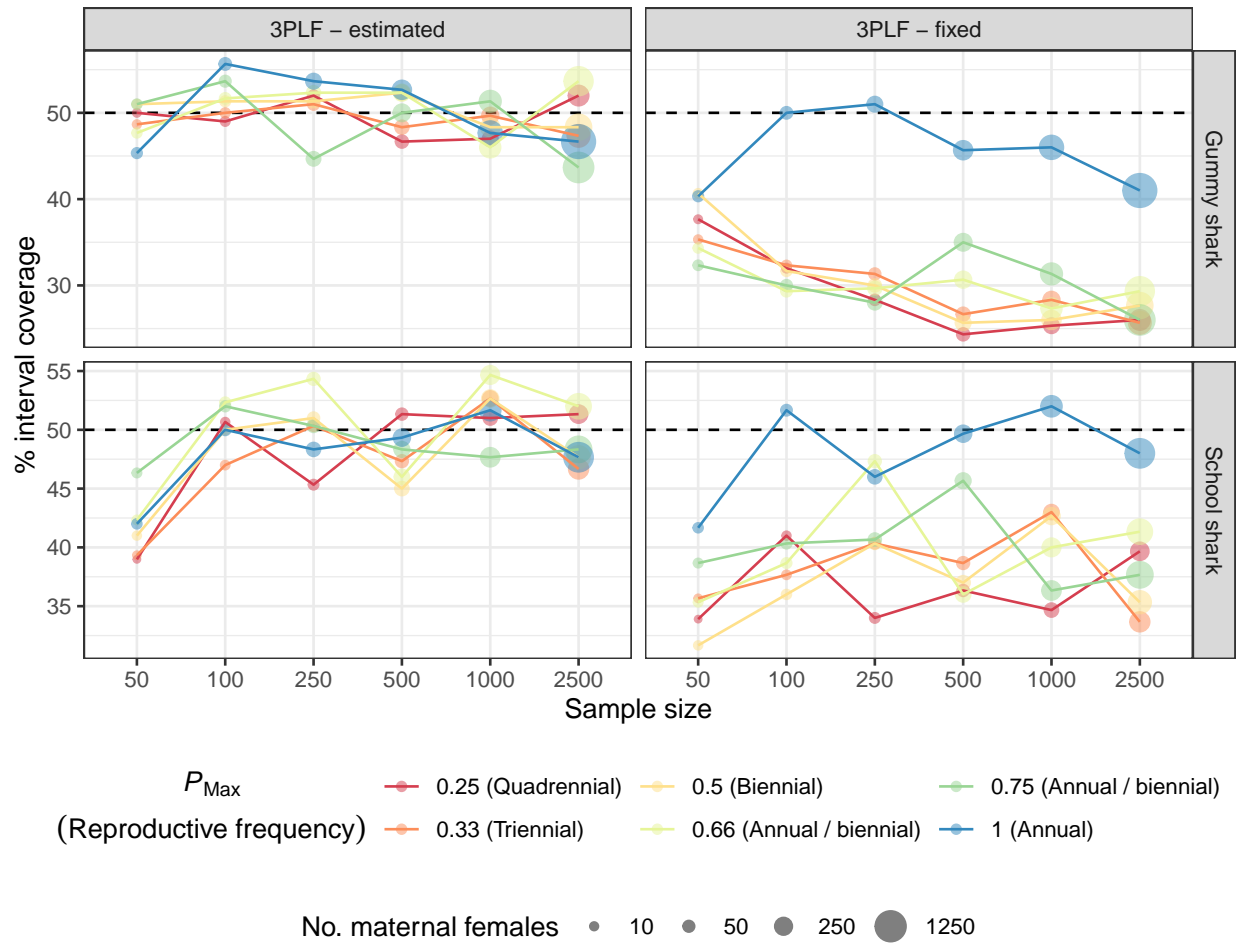
Figure 4. Confidence interval coverage for $\hat{L^i_{50}}$ for 3PLF methods (high selectivity scenarios). Figure shows the percentage of simulations (n = 300) where the true parameter value fell within the 50% bootstrap confidence interval.
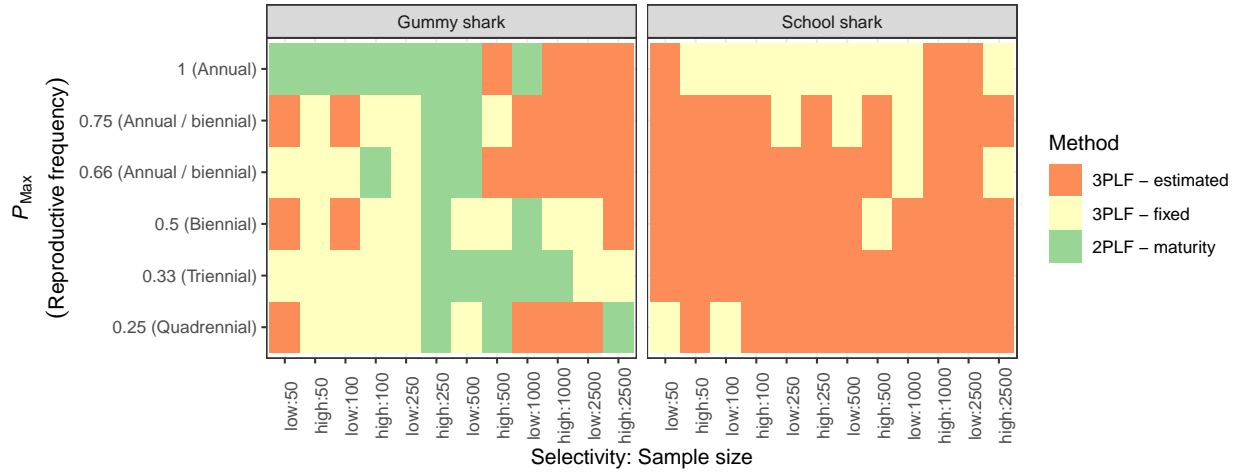
Figure 5. Performance of alternative maternity functions in minimising bias in calculations of R_0. The preferred method was that which minimised bias, |relative error| across 300 simulated datasets. Note 2PLF-maternity (Annual) scenarios were excluded for this comparison.
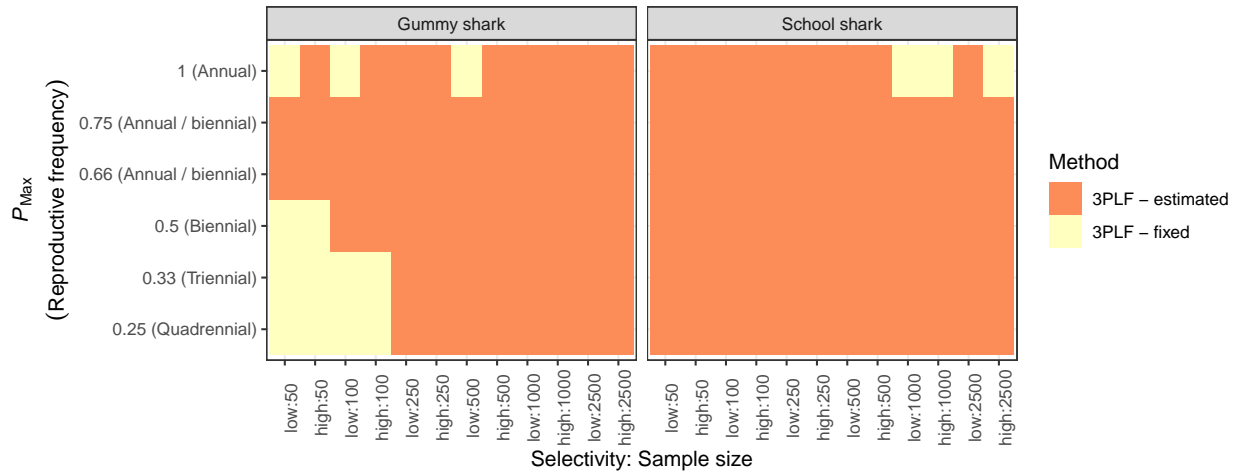
Figure 6. Performance of alternative maternity functions in accurately calculating R_0. The best performing method was that which minimised mean absolute error across 300 simulated datasets. Note 2PLF-maternity (Annual) scenarios were excluded for this comparison.
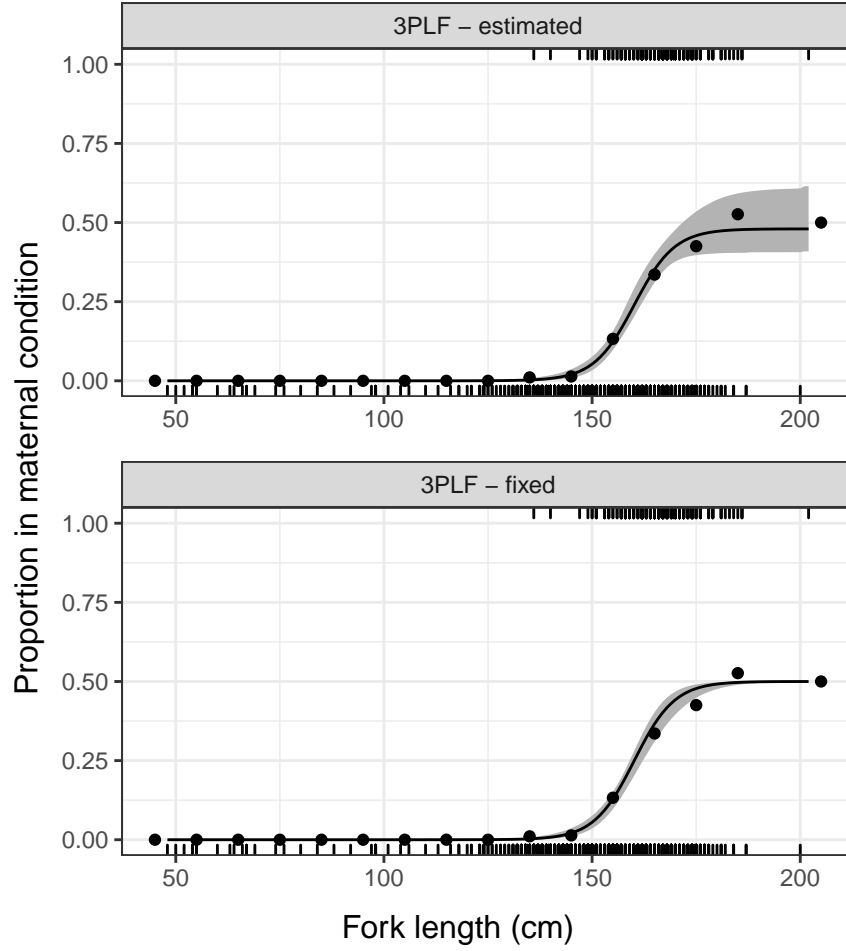
Figure 7. Comparison of 3PLF-estimated and 3PLF-fixed methods used to estimate maternal parameters for sandbar shark, *C. plumbeus*, in the Gulf of Mexico and Western North Atlantic. Solid line is the expected proportion in maternal condition at length, $\Psi'(L)$. The grey shaded region denotes 95% confidence intervals based on bootstrap resampling. Black points show proportion in maternal condition in 10cm length intervals. Marginal rug plots denote raw data that models were fit to. P_{Max} was fixed at 0.5 in the lower panel.