Equations

Page 76 Eqn. (1): apportionment by area i is equal to the exponential of proportions of recruits to area i divided by the aggregate sum of each of the exponential or proportions of recruits by each area i.

Page 79 Eqn. (2): the rate of movement by area i is equal to the exponential of movement rate for area i divided by the aggregate sum of each of the exponential of movement rates by each area i.

Page 87 Eqn. (3): the expected catch is equal to the ratio of the observed catch to the catch multiplier.

Page 97 Eqn. (4): the seasonal parameter is equal to the input parameter P multiplied by the exponent of the season value.

Page 98 Eqn. (5): the recruits in year y is equal to the product of 4 times steepness times unfished equilibrium recruitment times spawning biomass in year y divided by unfished spawning biomass in equilibrium times open parenthesis 1 minus steepness close parenthesis plus spawning biomass in year y times open parenthesis 5 time steepness minus 1 closed parenthesis. Variation in recruitment generated by multiplying that ratio by the exponent of open parenthesis negative 0.5 time bias in year y times the recruitment sigma squared plus the recruitment variation in year y closed parenthesis. The recruitment variation by year is distributed normally zero centered with standard deviation of the recruitment sigma squared.

Page 99 Eqn. (6): the recruits in year y are equal to the product of unfished recruitment in equilibrium times spawning biomass in year y divided by unfished spawning biomass in equilibrium all multiplied by the exponent of steepness times open parenthesis 1 minus spawning biomass in year y divided by the unfished spawning biomass in equilibrium closed parenthesis times the exponent of negative 0.5 times bias adjustment in year y times recruitment sigma squared plus recruitment variation in year y. The recruitment variation by year is distributed normally zero centered with standard deviation of the recruitment sigma squared.

Page 99 Eqn. (7): the recruits in year y are equal to the joiner function times open parenthesis the minimum recruitment level predicted at a spawning biomass of zero times the unfished recruitment in equilibrium plus the unfished recruitment in equilibrium times spawning biomass in year y divided by steepness times unfished spawning biomass in equilibrium multiplied by open parenthesis 1 minus minimum recruitment closed parenthesis closed parenthesis plus unfished recruitment in equilibrium times open parenthesis 1 minus the joiner function closed parenthesis times exponential of negative 0.5 times bias adjustment in year y times recruitment sigma squared plus recruitment variation in year y. The recruitment variation by year is distributed normally zero centered with standard deviation of the recruitment sigma squared.

Page 99 Eqn. (8): the joiner function is equal to open parenthesis 1 plus the exponent of 1000 plus open parenthesis unfished spawning biomass in equilibrium minus steepness times unfished spawning biomass in equilibrium closed parenthesis divided by unfished spawning biomass in equilibrium closed parenthesis all raised to negative 1.

Page 99 Eqn. (9): z-naught equals negative natural logarithm of survival-naught.

Page 99 Eqn. (10): z-min equals the negative natural logarithm of survival-max which equals the z-naught times open parenthesis 1 minus z-frac.

Page 100 Eqn. (11): recruits in year y equal the spawning biomass in year y times the exponent of open parenthesis negative z-naught plus open parenthesis z-naught minus z-min closed parenthesis times open parenthesis 1 minus open parenthesis spawning biomass in year y divided by unfished spawning biomass in equilibrium closed parenthesis raised to beta closed parenthesis times the exponent of recruitment deviation in year y. The recruitment variation in year y is distributed normally zero centered with standard deviation of recruitment sigma squared.

Page 100 Eqn. (12): z-frac is equal to the natural logarithm of open parenthesis survival-max closed parenthesis minus the natural logarithm of open parenthesis survival-naught closed parenthesis both divided by the negative natural logarithm open parenthesis survival-naught closed parenthesis. This is approximately equal to survival-max minus survival-naught divided by 1 minus survival-naught.

Page 101 Eqn. (13): steepness is equal to 0.2 times the exponent of z-naught times z-frac time open parenthesis 1 minus 0.2 raised to beta closed parenthesis. This is less than 0.2 times the exponent of z-naught which is equal to 1 divided by 5 times survival-naught which is equal to unfished spawning biomass in equilibrium divided by 5 times unfished recruitment in equilibrium.

Page 101 Eqn. (14):

Figure 1. (page 185-jitter)  Illustration of the jitter algorithm. The initial parameter value "Input init" is shown on the x-axis and is transformed by a cumulative normal distribution with 0.001 and 0.999 quantiles set to the "Min" and "Max" parameter bounds. This distribution is illustrated by a black curve with a sigmoidal shape increasing from the lower left (with x, y values of Min, 0.001) to the upper right (with values Max, 0.999). The transformed initial value is about 0.17 on the y-axis. A uniform distribution in the transformed cumulative normal distribution space is used to sample a new jittered initial value and is represented by a histogram on the y-axis. This uniform distribution has bounds determined by the transformed initial value plus or minus the "jitter" input, which in this example is 0.2, resulting in a range of about -0.03 to 0.37 centered around the transformed initial value of 0.17. A second histogram on the x-axis shows how these jittered samples are mapped back into the parameter space. This second histogram shows a skewed distribution, where the mode is larger than "Input init" but the lower tail is longer reflecting the same number of values spread over a larger range. This distribution of back-transformed values shows a spike in the lower tail associated with values from the uniform distribution below 0.001 that get mapped back to one-tenth of the way from the bound to the original initial value. In addition to the histograms showing the distribution of values , the figure shows a single realization using red arrows, where the 0.17 transformed value is jittered to 0.06 by a uniform random value which is then mapped back to a "New init" value partway between the Min value and the "Input init" value.

Figure 2. (page 187-beta prior) The shape of the symmetric beta prior across alternative standard deviation values and the change in the negative log-likelihood. The shape of symmetric beta prior is relatively flat across values with limited increases in the change in the negative log-likelihood at the low and high parameter bounds if the standard deviation value is a low value (>0.5). As the standard deviation of the distribution increases more of the distribution weight is shifted to the center of the parameter bounds, with sharp increases in the negative log-likelihood value at the lower and upper bounds.

Figure 3. (page 196 Input vs Eff N) The relationship between the observed sample size (the input sample number) versus the effective sample size for the McAllister-Ianelli data-weighting approach. The effective sample size is the product of the input sample size and the data weighting applied to the data set. The harmonic mean of the effective sample sizes is a horizontal line with the arithmetic mean of the observed sample sizes is a vertical line. The relationship between the observed and effective sample size for each year is indicated on the figure. Tuning these data using the McAllister-Ianelli data-weighting approach will result in the one-to-one line between the observed and effective sample size will cross the harmonic and arithmetic mean lines where they intersect.

Figure 4. The mean length of the length samples for each year from Fleet 1 (called the MexCal S1 NSP fleet) with 95% confidence intervals based on current samples sizes using the Francis data weighting method (referred to as TA1.8). Thinner intervals with capped ends show result of further adjusting sample sizes based on suggested multiplier, 0.2739, with 95% interval (0.1661-0.6305) for length data from Fleet 1. The blue line shows the expected variation of the mean length across years.

Figure 5. Spawner-recruitment relationship for darkblotched rockfish (Gertseva and Thorson, 2013). Red points represent estimated recruitments, the solid black line is the stock-recruit relationship and the green line represents the adjustment to this relationship after adjustment to account for the lognormal distribution associated with each year. The "+" symbol labeled 1915 near the right side represents both the virgin and initial equilibrium of the model. The numerous red points close to the initial conditions correspond to the early years of the model with low harvest rates. The estimates of annual recruitment in the later years of the model, where composition data are informative, are distributed above and below the stock-recruit relationship. The highest estimated recruitment years are 1981, 1995, and 2000 and the lowest estimated recruitments occurred in 1993, 1998, and 2001.

Figure 6. Time series of log recruitment deviations for darkblotched rockfish with 95% uncertainty intervals. The start year of the model is 1915, but recruitment deviations are estimated starting in 1870. The 45 deviation estimates for 1870–1914 inform the age structure used in the start year. The black color for the years 1960–2011 indicates the "main" recruitment deviation vector, while the blue color for the years 1870–1959 and 2012–2024 indicates the "early" and "late/forecast" recruitment deviation vectors, respectively.

Figure 7 Time series of standard error estimates for the log recruitment deviations for darkblotched rockfish with 95% uncertainty intervals. As in Figure 10, the black color indicates the main recruitment period. This period with lower standard error is associated with higher variability among deviations (Figure 10). The red line at 0.75 indicates the value in this model.

Figure 12 (page 204 bias adjustment)

Figure 13 (page 210 timeseries)