Review of Operating Model Parameters for SEDAR 49: Lane Snapper

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SEDAR49-AW-02

Submitted: 12 July 2016
Updated: 12 August 2016

Please cite this document as:

Sagarese, S. R., J. J. Isely, and M. W. Smith. 2016. Review of Operating Model Parameters for SEDAR 49: Lane Snapper. SEDAR 49-AW-02. SEDAR, North Charleston, SC. 17 pp.

Review of Operating Model Parameters for SEDAR 49: Lane Snapper

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The first step in a DLMtool data-limited assessment is the development of an operating model (OM) that describes the "true" simulated population dynamics covering the stock and fishing fleet of interest. Within a simulation framework, the operating model represents the biological components of the system to be managed, fisher behavior in response to management actions, how data are collected from the management system, and environmental conditions as well as interactions (Kell et al. 2007; Carruthers et al. 2014; Punt et al. 2014).

During the SEDAR 49 Data Workshop, multiple working groups were convened to review available data and provide recommendations of appropriate life history, stock dynamics and fleet characterizations to aid in parameterizing the OMs. Substantial efforts were also undertaken prior to the workshop which enabled discussion of available literature, data sources, and their reliability at the workshop. A comprehensive literature review of life history parameters was conducted prior to the workshop, with details provided in Adams et al. (2016). A critical component to the Data Workshop was the participation of federal, state, and industry experts in characterizing both stock and fleet dynamics for each of the eight species selected for SEDAR49. Fishermen provided keen insight into potential issues including species misidentification, selectivity patterns, discard mortality, and ecosystem considerations (see SEDAR 49 DW Report, Section 10).

In this working document we describe the parameters recommended and justifications for representing both stock and fleet dynamics within the operating model for Lane Snapper (*Lutjanus synagris*). Although a range of data limitations were discussed at the Data Workshop, our simulation analyses should be able address whether applied data-limited methods perform well under the specified life history type, which is expected to represent Lane Snapper. It is assumed that the operating model under development, as specified in this document, represents reality and reflects the best available science at this point in time (Table 1). Figures 1 through 8 reveal parameters and their respective distributions, which are provided in Table 2.

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Table 1. Operating model parameters for Lane Snapper. Decisions made at the Data Workshop are color coded for ease of interpretation (red = Life History Working Group recommendation; green = Commercial/Recreational Working Group recommendation; blue = Index Working Group recommendation). Parameters with no color indicate decisions made by the analysts.

OM input	**Description**	**Value or CV**	**Source**
Life-history			
MaxAge	Maximum age of individuals that are simulated (no plus group)	19 y	Maximum age observed in meta-analysis (Luckhurst et al. 2000)
R0	Magnitude of unfished recruitment (scaling factor). Normally fixed to some arbitrary value since it simply scales the simulated numbers. Typically can be set to 1000. (Carruthers and Hordyk 2016)	1000	Default value
M	Natural mortality rate	0.330 – 0.366 y^{-1}	Range calculated using Then et al. (2014) based on plausible values of Maximum Age (17 – 19 y) in reliable literature (Johnson et al. 1995; Luckhurst et al. 2000)
Msd	Inter-annual variability in M expressed as a coefficient of variation	c(0,0)	Turned off for now
Mgrad	Mean temporal trend in M, expressed as a percent change in M per year	c(0,0)	Turned off for now
h	Recruitment compensation (steepness)	0.5 – 0.99	Range considered in past SEDARs/FWC assessments for Lutjanids (Adams et al. 2016)
Srrel	Type of stock-recruitment relationship (1=BH, 2=Ricker)	1	Adams et al. 2016
Linf	Von Bertalanffy asymptotic size	42.2 – 49.3 cm FL	95% Confidence intervals from SEDAR 49 analysis for FL

Linfsd	Inter-annual variability in Linf expressed as a coefficient of variation	c(0,0)	Turned off for now
Linfgrad	Mean temporal trend in Linf, expressed as a percent change in M per year	c(0,0)	Turned off for now
K	Von Bertalanffy maximum growth rate	0.116 − 0.219	95% Confidence intervals from SEDAR 49 analysis for FL
Ksd	Inter-annual variability in K expressed as a coefficient of variation	c(0,0)	Turned off for now
Kgrad	Mean temporal trend in K, expressed as a percent change in M per year	c(0,0)	Turned off for now
vbt0	Von Bertalanffy theoretical age at length zero	-4.16 − -1.51	95% Confidence intervals from SEDAR 49 analysis for FL
a	Length-weight parameter a	5.92E-05	Value from SEDAR49 data analysis from FL (cm) to W Wt (lbs)
b	Length-weight parameter b	2.86	Value from SEDAR49 data analysis from FL (cm) to W Wt (lbs)
D	Current level of stock depletion (Bnow / Bunfished)	c(0.12,0.31)	Estimates of depletion over last three years for Vermilion Snapper (SEDAR45) and Red Snapper (SEDAR31) range from 0.28-0.31 and 0.12-0.15, respectively
L50	Length at which individuals are 50% mature	23.5 − 24.5 cm FL	Range of reported values for sexes in Luckhurst et al. (2000)
L50_95	Length increment from 50% to 95% maturity (L95-upper L50,L95-lower L50)	c(2.5, 3.5)	Expert opinion based on size of ages 2-3 fish (27.0 cm FL)
recgrad	Mean slope in recruitment deviations	c(0,0)	Turned off for now

Perr	Process error in recruitment deviations	0.3 − 0.75	Range considered in past SEDAR assessments for Lutjanids (Adams et al. 2016)
AC	Autocorrelation in recruitment deviations	c(0.11,0.76)	Range derived from SEDAR45 Vermilion Snapper and SEDAR31 Red Snapper assessments. Autocorrelation was investigated between: (1) estimated recruits; (2) recruitment deviations, and (3) index of recruitment (if available). Range for Red Snapper covers 0.46 to 0.72
Frac_area_1	Fraction of unfished biomass in area 1 at start of simulation	c(0.095, 0.105)	Default value
Prob_staying	Probability that individuals in area 1 stay there in year	c(0.5, 0.6)	Default value
Fleet			
nyears	Number of years for historical simulation. Should be set as close as possible to the length of time that the fishery has been exploited.	100	Coincident with train to Key West (completed 1912)
Spat_targ	Distribution of fishing in relation to spatial biomass. 1 = fishers are indiscriminate in where they fish (e.g., bycatch species); > 1 indicates targetting areas of higher biomass	c(1,1)	Default value
LFS	Length at full selectivity (LFS/L50) for representative fleet	c(0.98, 1.02)	24.0 cm; DW Report, Section 8.2
L5	Length at 5% selectivity (LFC/L50) for representative fleet	c(0.82, 0.85)	20.0 cm; DW Report, Section 8.2
Vmaxlen	Vulnerability of oldest age class to representative fleet (controls extent of dome-shaped selectivity)	c(1,1)	Asymptotic (DW Report, Table 8.5.2)

Fsd	Interannual variability in F - determines how much F fluctuates from year to year	c(0.00,0.92)	Range of interannual variability in annual F for the dominant fleet ("representative") from SEDAR45 for Vermilion snapper (0,0.09) and SEDAR31 for Red Snapper (0,0.92)
qinc	Mean percentage change in fishing efficiency	c(0,0)	Turned off for now
qcv	Interannual variability in fishing efficiency	c(0,0)	Turned off for now
EffYears	Index of effort	Recreational Private	DW Report, Section 6.2.2
Observation			
LenMcv	Bias in length at 50% vulnerability	0.2	Default value for biased, imprecise
Cobs	Log-normal catch observation error	c(0.103, 0.103)	DW Report, Section 5.2.2
Cbiascv	CV controlling the sampling of bias	0.103	DW Report, Section 5.2.2
CAA_nsamp	Number of catch-at-age observations per time step	c(150, 200)	General range of annual composition samples desired; or could use default for biased, imprecise (50,100)
CAA_ESS	Effective sample size	c(10,20)	Default for biased, imprecise
CAL_nsamp	Number of catch-at-length observations per time step	c(150, 200)	General range of annual composition samples desired; or could use default for biased, imprecise (50,100)
CAL_ESS	Effective sample size	c(10,20)	Default for biased, imprecise
CALcv	Lognormal variability in length at age	c(0.27,0.27)	Maximum CV derived from length data for the representative fleet by year

Iobs	Observation error in relative abundance index expressed as a CV	c(0.064,0.064)	Maximum CV for the Headboat survey; DW Report, Section 7.5.2
Icv	Observation error in relative abundance index expressed as a CV	0.064	Maximum CV for the Headboat survey; DW Report, Section 7.5.2
Mcv	Bias in M sampled from a log-normal distribution with a CV	0.32	Cross-validation prediction error of updated Hoenig (Then et al. 2014); Carruthers et al. (2014) used 0.5
Linfcv	Bias in Linf sampled from a log-normal distribution with a CV	0.04	SEDAR49 analysis for FL: mean = 449 mm FL, SE = 17.221
Kcv	Bias in K sampled from a log-normal distribution with a CV	0.16	SEDAR49 analysis for FL: mean = 0.166, SE = 0.027
t0cv	Bias in t0 sampled from a log-normal distribution with a CV	0.26	SEDAR49 analysis for FL: -2.59, 0.668 SE
LFCcv	Bias in length at first capture sampled from a log-normal distribution with a CV	0.11	DW Report, Section 10.4
LFScv	Bias in length at full selection sampled from a log-normal distribution with a CV	0.27	DW Report, Section 10.4
B0cv	Bias in unfished biomass sampled from a log-normal distribution with a CV	4	Default for biased, imprecise
FMSYcv	Bias in FMSY sampled from a log-normal distribution with a CV	0.2	Default for biased, imprecise
FMSY_Mcv	Bias in FMSY/M sampled from a log-normal distribution with a CV	0.11	From meta-analysis (Zhou et al. 2012); Carruthers et al. (2014) used 0.2
BMSY_B0cv	Bias in BMSY/B0 sampled from a log-normal distribution with a CV	0.14	From meta-analysis (Thorson et al. 2012); Carruthers et al. (2014) used 0.2 (default for biased, imprecise)

rcv	Bias in intrinsic rate of increase sampled from a log-normal distribution with a CV	0.5	Default for biased, imprecise (used in Carruthers et al. 2014)
Dbiascv	Bias in stock depletion sampled from a log-normal distribution with a CV	1	Carruthers et al. (2014) used 1.0
Dcv	Imprecision in stock depletion among years expressed as a CV	c(0.05,0.20)	Default for biased, imprecise
Btbias	Bias in current stock biomass sampled from a log-normal distribution with a CV	c(0.2,5.0)	Default for biased, imprecise
Btcv	Imprecision in current stock biomass expressed as a CV	c(0.2,0.5)	Default for biased, imprecise
Fcurbiascv	Bias in current F sampled from a log-normal distribution with a CV	0.75	Default for biased, imprecise
Fcurcv	Imprecision in current F among years expressed as a CV	c(0.5,1.0)	Default for biased, imprecise
hcv	Bias in knowledge of steepness	0.47	Maximum value of: abs[(range estimate-point estimate)/point estimate]
maxagecv	Bias in maximum age (not currently used)	0.11	Maximum value of: abs[(range estimate-point estimate)/point estimate]
Reccv	Bias in recent recruitment strength	c(0.1,0.3)	Default for biased, imprecise
Irefcv	Bias in relative abundance index at BMSY	0.3	Default for biased, imprecise
Crefcv	Bias in MSY	0.3	Default for biased, imprecise
Brefcv	Bias in BMSY	0.5	Default for biased, imprecise
beta	Parameter controlling hyperstability (< 1)/hyperdepletion (>1)	c(0.33, 3.0)	Default for biased, imprecise

Table 2. Summary of distributions assumed for parameters within the stock, fleet, and observation subclasses within the operating model. Input parameters are as defined in Table 1.

Input	Distribution	Input	Distribution
Stock subclass		**Observation subclass**	
MaxAge	-	LenMcv	Log-normal
R0	-	Cobs	Uniform
M	Uniform	Cbiascv	Log-normal
sd	Uniform	CAA_nsamp	Uniform
grad	Uniform	CAA_ESS	Uniform
h	Uniform	CAL_nsamp	Uniform
SRrel	-	CAL_ESS	Uniform
Linf	Uniform	CAL_cv	-
sd	Uniform	Iobs	Uniform
grad	Uniform	Mcv	Log-normal
K	Uniform	Kcv	Log-normal
sd	Uniform	t0cv	Log-normal
grad	Uniform	Linfcv	Log-normal
t0	Uniform	LFCcv	Log-normal
a	-	LFScv	Log-normal
b	-	B0cv	Log-normal
D	Uniform	FMSYcv	-
L50	Uniform	FMSY_Mcv	Log-normal
L50_95	Uniform	BMSY_B0cv	Log-normal
recgrad	Uniform	rcv	-
Perr	Uniform	Dbiascv	Log-normal
AC	Uniform	Dcv	Uniform
Frac_area_1	Uniform	Btbias	Uniform
Prob_staying	Uniform	Btcv	Uniform
		Fcurbiascv	-
Fleet subclass		Fcurcv	-
nyears	-	hcv	-
Spat_targ	Uniform	Icv	-
LFS	Uniform	maxagecv	-
L5	Uniform	Reccv	Uniform
Fgrad	-	Irefcv	Log-normal
qinc	Uniform	Crefcv	Log-normal
qcv	Uniform	Brefcv	Log-normal
Vmaxlen	Uniform	beta	Uniform

Figure 1. Sampled parameters in the operating model for life history. Parameters include: M = natural mortality, Linf = von Bertalanffy asymptotic size, K = von Bertalanffy growth rate, t0 = von Bertalanffy theoretical age at length zero, ageM = age at 50% maturity (derived from length at 50% maturity), lenM = length at 50% maturity, len95 = length at 95% maturity, Steepness = steepness of the stock recruitment curve, Recr Devs= recruitment deviations.

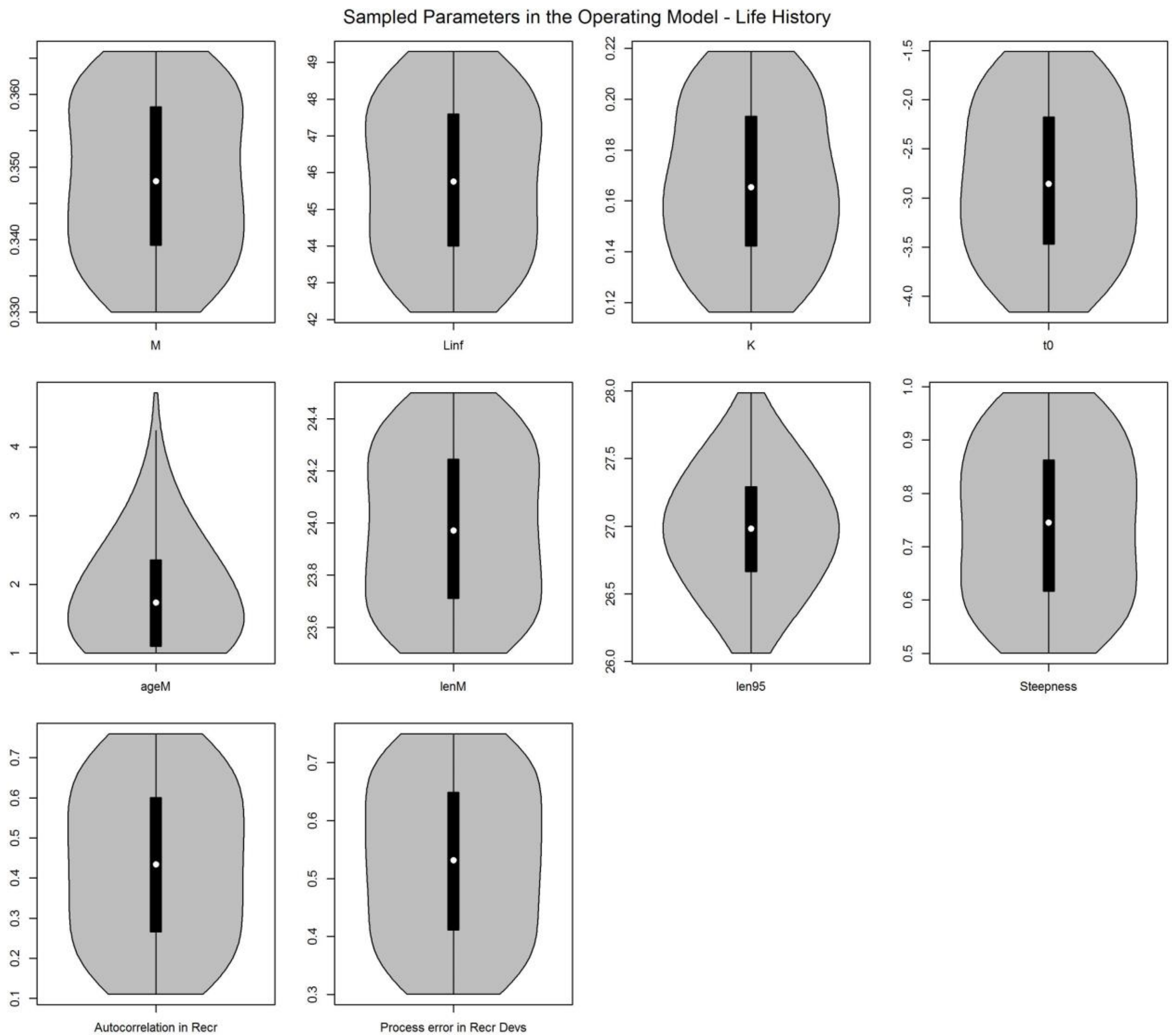

Figure 2. Sampled parameters in the operating model for the fishery. Parameters include: L5 = shortest length corresponding to 5% vulnerability, LFC = length at first capture, LFS = length at full selection, Frac_area_1 = fraction of individuals found in area 1 of a generic two-area model of the simulation framework, Prob_staying = probability that individuals in area 1 remain in that area, F = fishing mortality, Recr Devs = recruitment deviations.

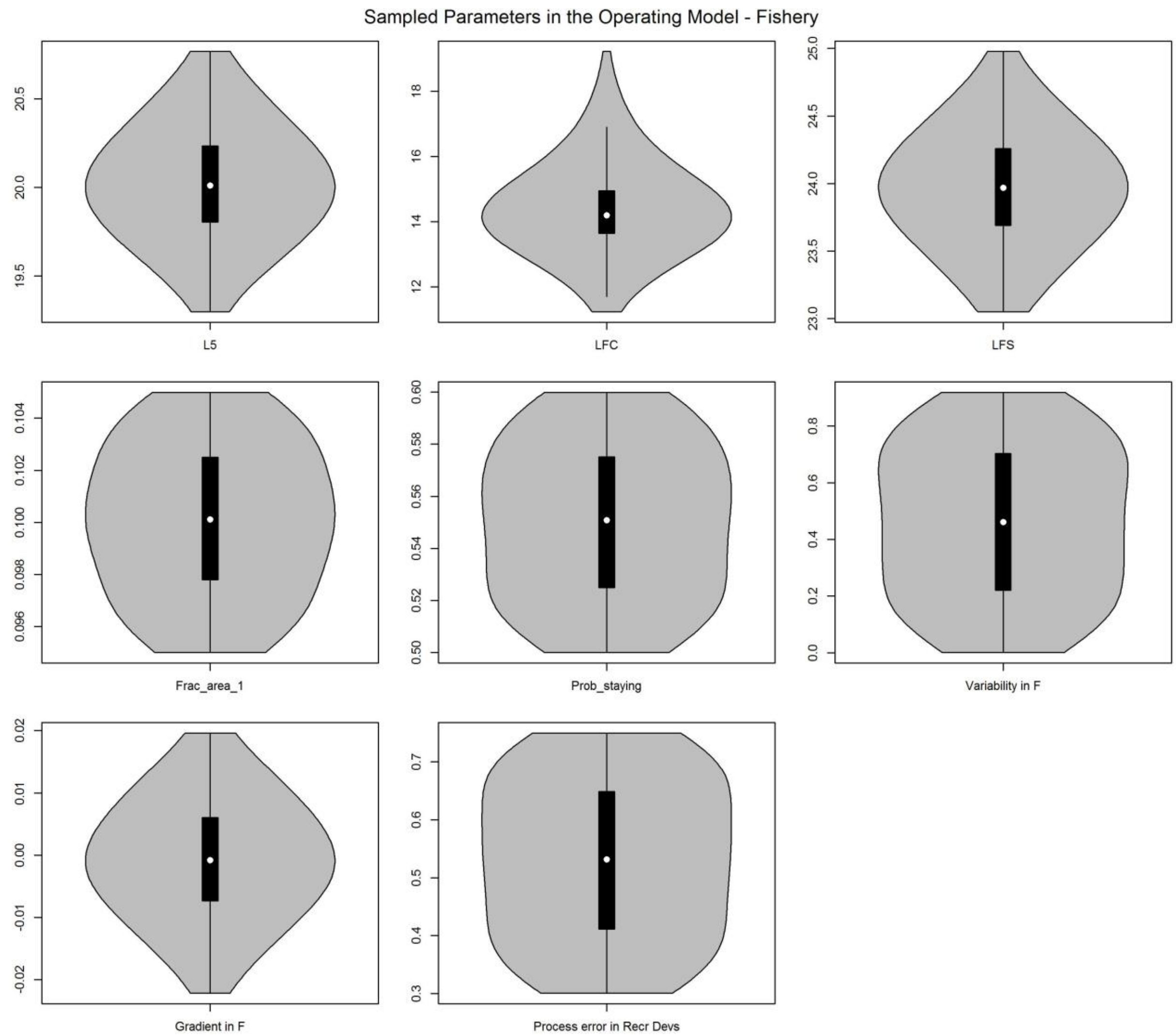

Figure 3. Sampled parameters in the operating model for the reference parameters. Parameters include: RefY = Reference yield (highest long-term yield obtained from fixed F strategy), MSY = maximum sustainable yield, OFLreal = true simulated overfishing limit, BMSY_B0 = most productive stock size relative to unfished, FMSY = fishing mortality rate at maximum sustainable yield, FMSY_M = fishing mortality rate divided by natural mortality rate.

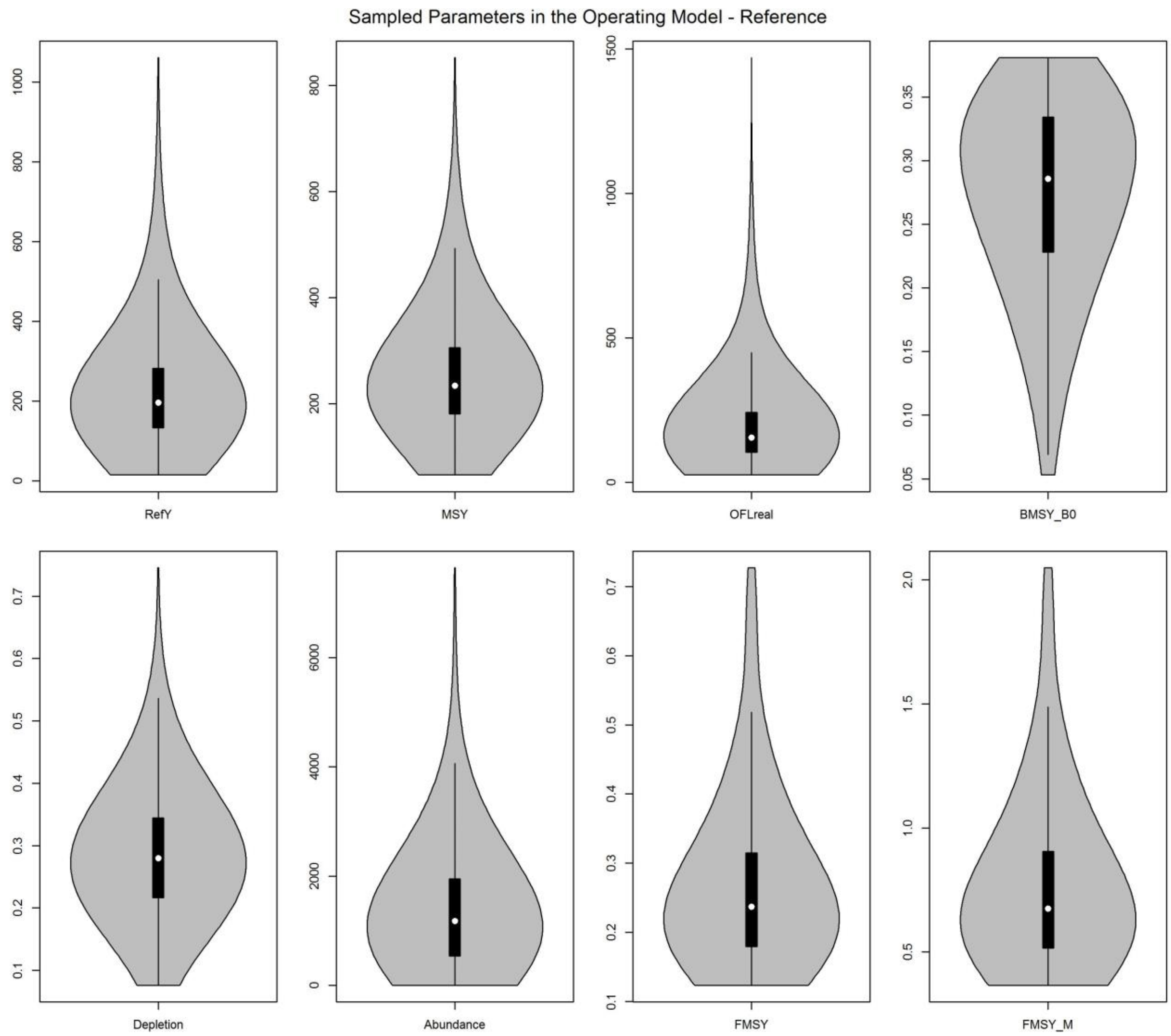

Figure 4. Sampled parameters in the observation model for life history. Parameters as defined in Figure 1 caption, with exception of hbias = bias in steepness parameter. Bias refers to an inaccuracy in an observed parameter that occurs for the duration of a simulation.

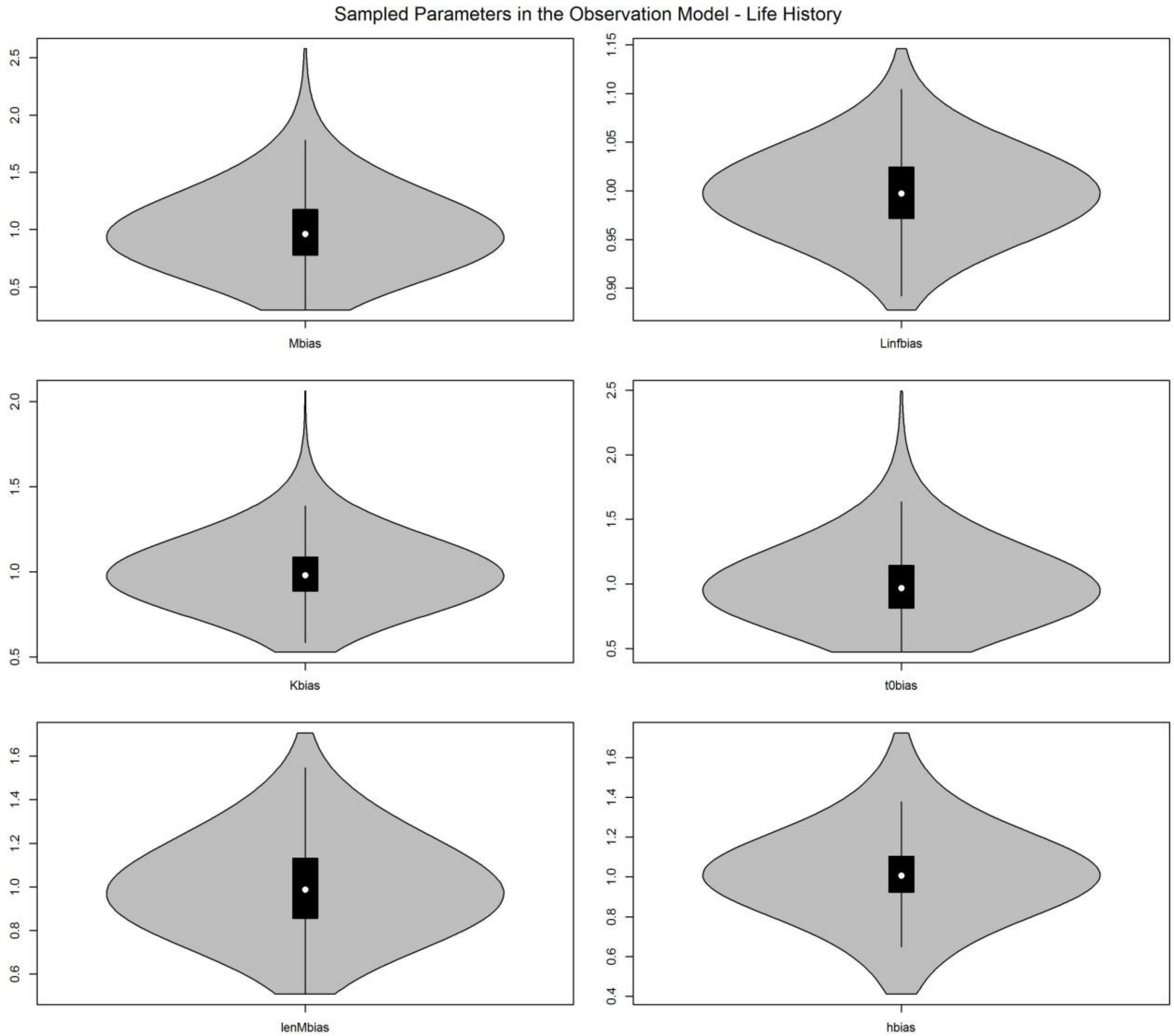

Figure 5. Sampled parameters in the observation model for fishery. Parameters as defined in Figure 2 caption, with exception of Cbias = bias in observed catches. Bias refers to an inaccuracy in an observed parameter that occurs for the duration of a simulation.

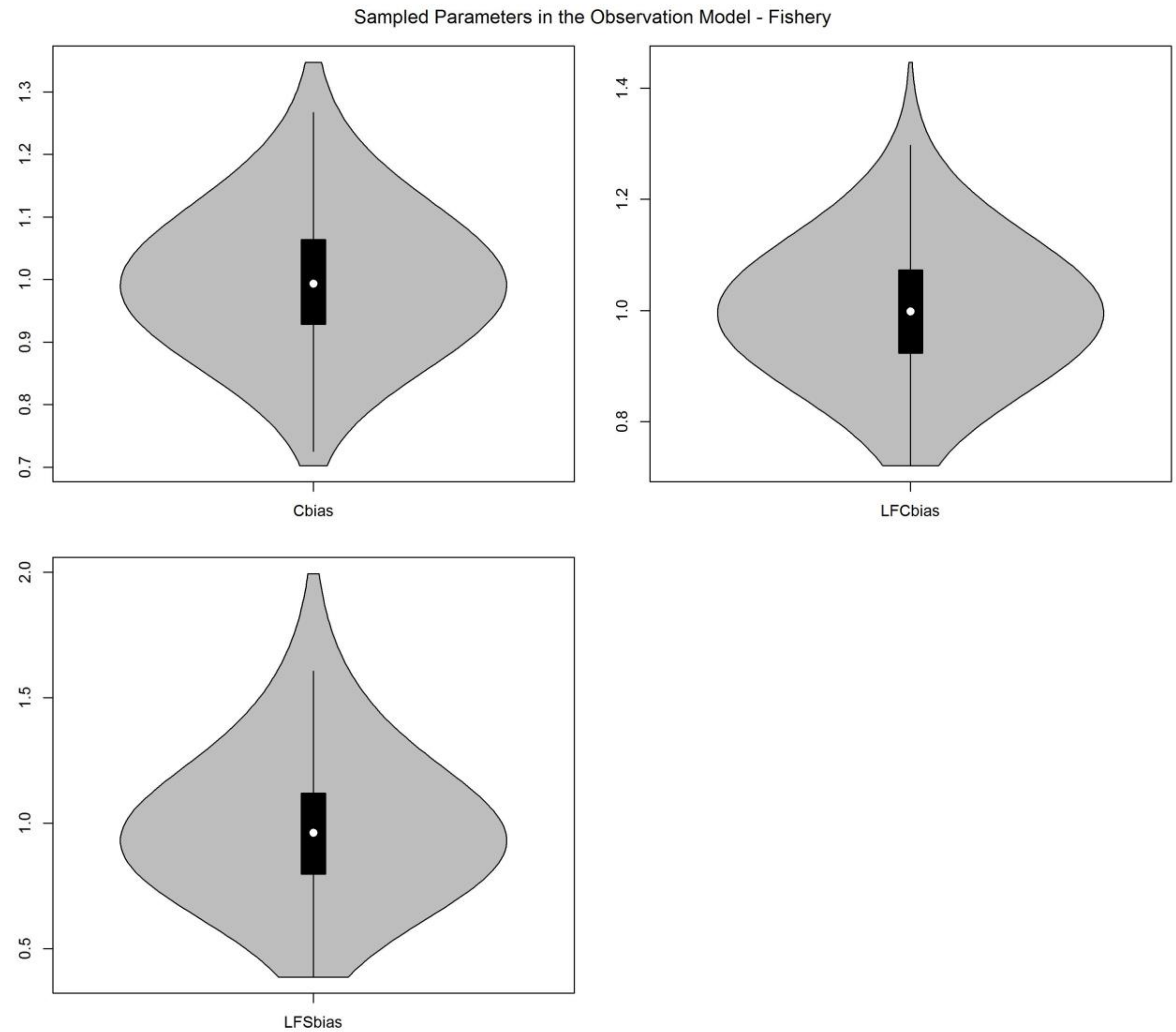

Figure 6. Sampled parameters in the observation model for the index of abundance. Betas is a parameter controlling hyperstability/hyperdepletion.

Figure 7. Sampled parameters in the observation model for the size and composition. Parameters include: CAA_nsamp = number of catch-at-age observations per time step, CAA_ESS = effective sample size (independent age draws) of the multinomial catch-at-age observation error model, CAL_nsamp = number of catch-at-length observations per time step, and CAL_ESS = effective sample size (independent age draws) of the multinomial catch-at-length observation error model.

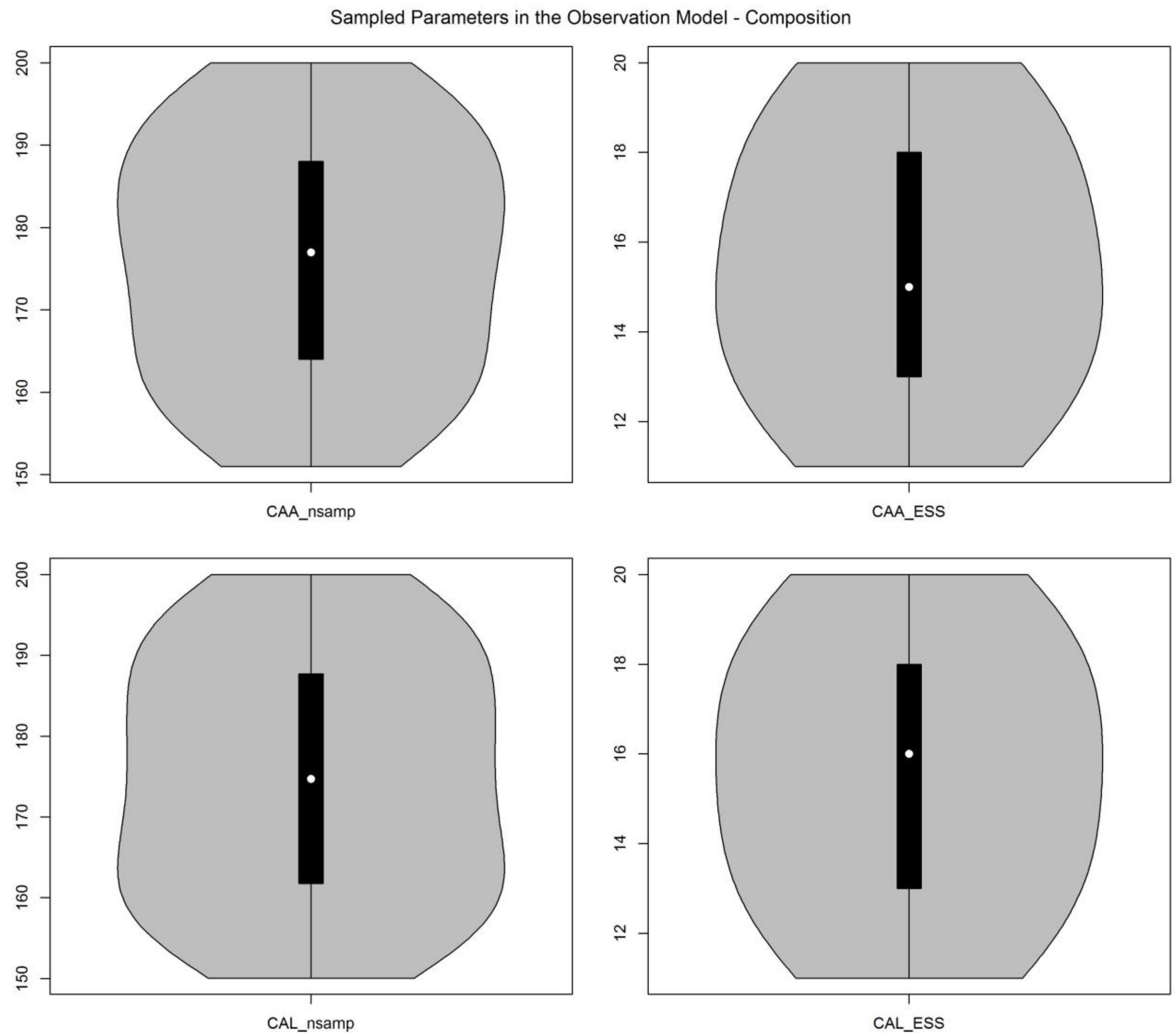

Figure 8. Sampled parameters in the observation model for the reference. Parameters as defined in Figure 3 caption, with exception of D = Depletion, A = abundance, Iref = reference index level, Cref = reference catch level, and Bref = reference biomass level. Bias refers to an inaccuracy in an observed parameter that occurs for the duration of a simulation.