Comparison between Preliminary Stock Synthesis Models for the 2019 WCNPO Striped Marlin Stock Assessment.

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Abstract

This document summarizes preliminary Stock Synthesis model runs for the Western Central North Pacific Ocean (WCNPO) striped marlin stock assessment. Three models are presented here, and they are as following; Model 1) Initial base case model containing data from 1975-2017; Model 2) Similar parameterization from Model 1 however containing data from 1994-2017; and model 3) Similar parameterization from Model 1 however containing partially data from 1975-1993. Model results were compared using the R package recently developed *Kaputils*. All the three models converged, and fits to CPUE and length composition data were reasonable. Ending year (2017) stock status relative to maximum sustainable yield (MSY) reference points obtained from the three preliminary SS3 model indicated that the fishing mortality rate in 2017 was above the fishing mortality rate at maximum sustainable yield. The SS3 model runs also indicated that stock spawning biomass, was below the stock spawning biomass at maximum sustainable yield.

Introduction

This document summarizes three Stock Synthesis (SS; Methot and Wetzel, 2013)) model runs for the WCNPO striped marlin. Results from the preliminary base case model were compared to two alternative scenarios.

Methods

Definition of Fisheries

Catch, CPUE and size composition data available for the three models are detailed on Table 1 and Figure 1.

Catch

The series of catch were divided into early and late periods to coincide with divisions of the CPUE indices (Table 1).

Relative Abundance Indices

The CPUE indices available for inclusion in the three models are detailed in Table 1. The CPUE indices were assumed to be linearly proportional to biomass where catchability (q) occur in the first month of the quarter assigned. The CVs for each CPUE index were assumed to be equal to their respective calculated SEs on the log scale. The minimum CV was scaled to a minimum of 0.20. If the input SE was greater than these values, it was left unchanged.

Length Composition

Length composition data were available for the three models (Figure 1). These data were available in quarterly time steps. Data were fit using a multinomial error structure.

Model Description

The models were set up as a single area and sex and four seasons (quarters). Age at recruitment was calculated based upon the model estimated average selectivity at age based upon the quarterly selectivity at length. The maximum age of striped marlin was set to 15 years. Sex aggregated specific biological parameters were used, with age-specific natural mortality (Table 2). The model used a Beverton-Holt spawner-recruit relationship with steepness (h) fixed at 0.87 and sigmaR (σ_r) fixed at 0.6.

For Models 1 and 3 the population was assumed to be in equilibrium prior to 1975, with an estimated equilibrium exploitation catch of 2500 mt per quarter (5000 mt annual total). For Model 2 initial conditions were freely estimated from the data in the main model period.

The population model and the fishery length data had one cm length bins from 50-230+ cm. The population had 16 annual ages from age 0 to 15+. There were no age data. Fishery length data were used to estimate selectivity patterns, which controlled the size distribution of the fishery removals. All fleets with length data were estimated as six parameter double normal (dome-shaped) selectivity patterns except for Japan drift gillnet length data, which was estimated as a two parameter asymptotic logistic selectivity pattern. Survey selectivity patterns mirrored their respective catch fleets (Table 3

Table).

Model estimated time series of total biomass (B in metric tons, mt = 1000 kg), age 1+ total biomass (B_{1+} mt), female spawning biomass (SSB mt), and recruitment (R in 1000s of fish) were tabulated on an annual basis. Annual exploitation rate (F) was calculated as Catch/B_{1+}. Stock status indicators were calculated based upon MSY-based reference points as proxies.

Three models are presented here, and they are as following; Model 1) Initial base case model containing data from 1975-2017; Model 2) Similar parameterization from Model 1 however containing data from 1994-2017; and model 3) Similar parameterization from Model 1 however the historic indices from Japan (1975-1993; S6 and S7) were excluded.

Models results were compared using the recently developed R package *Kaputils*. A set of custom plots were produced to facilitate comparison between the three models. *Kaputils* is available at the GitHub platform: https://github.com/mkapur/kaputils

Profiling the likelihood on R_0, where the R_0 is fixed at a range of values around the maximum likelihood estimate and then the likelihood is estimated, was used to identify influential data components (Lee *et al.,* 2014).

Results

All three models ran in less than 25 minutes. The inverse Hessian was positive definite, which allowed for the estimation of parameter standard deviations and suggests that the models converged.

Profiling on R_0 showed that the length composition data and CPUE indices showed different minimum likelihood solution in all three models (Figure 2). Model estimates of age 1+ SSB/SSB_{MSY} and F/F_{MSY} for all three models are shown in Figure 3. Estimates of recruitment deviations as well as R0 are shown in Figures 4 and 5, respectively. Overall, the models showed similar trends in biomass and fishing mortality during the late period (1993-2017), however the trends differed in scale.

Literature Cited

Lee, H.-H., K. R. Piner, R. D. Methot Jr and Maunder, M. N. (2014). Use of likelihood profiling over a global scaling parameter to structure the population dynamics model: An example using blue marlin in the Pacific Ocean. Fisheries Research 158: 138-146.

Methot Jr, R. D. and Wetzel, C. R. (2013). Stock synthesis: A biological and statistical framework for fish stock assessment and fishery management. Fisheries Research 142: 86-99.

Tables

Table 1. List of fleets with Catch and CPUE indices provided for the 2019 Western Central North Pacific Ocean Striped Marlin Stock Assessment.

Catch Index	Abundance Index	Fleet Name	Time Series
F1	S1	JPNLL_Q1A1_Late	1994-2017
F2	-	JPNLL_Q1A2	1975-2017
F3	-	JPNLL_Q1A3	1975-2017
F4	-	JPNLL_Q2A1	1975-2017
F5	S2	JPNLL_Q3A1_Late	1994-2017
F6	-	JPNLL_Q4A1	1975-2017
F7	-	JPNLL_Q1A4	1975-2017
F8	-	JPNLL_Q2A2	1975-2017
F9	-	JPNLL_Q3A2	1975-2017
F10	-	JPNLL_Q4A2	2000-2016
F11	-	JPNLL_Q4A3	1975-2017
F12	-	JPNLL_Others	1975-2017
F13	-	JPNDF_Q14	1975-2017
F14	-	JPNDF_Q23	1975-2017
F15	-	JPN_Others	1975-2017
F16	S3	US_LL	1987-2017
F17	-	US_Others	1987-2017
F18	S4	TWN_DWLL	1967-2017
F19	S5	TWN_STLL	1958-2017
F20	-	TWN_Others	1958-2017
F21	-	WCPFC_Others	1975-2017
F22	S6	JPNLL_Q1A1_Early	1975-1993
F23	S7	JPNLL_Q3A1_Early	1975-1993

Table 2. Key life history, recruitment, and selectivity parameters used in the striped marlin stock assessment model. The column labeled "Estimated ?" identifies if the parameters are expected to be estimated within the assessment model (Estimated), fixed at a specific value, i.e., not estimated (Fixed).

Parameter (units)	Value	Estimated?
Natural mortality (M, age-specific yr)	M_0 = 0.54, M_1 = 0.47, M_2 = 0.43, M_3 = 0.40, M_{4+} = 0.38	Fixed
Length_at_min_age (EFL cm)	$L(A_{min})$ = 104	Fixed
Length_at_max_age (EFL cm)	$L(A_{max})$ = 214	Fixed
VonBert_K	k = 0.24	Fixed
$W=aL^b$ (kg)	a = 4.68 ×10-6	Fixed
	b = 3.16	
Size at 50-percent maturity (EFL cm) and maturity ogive slope parameter	Female: L_{50} = 161, β = -0.08	Fixed
Stock-recruitment steepness (h)	h= 0.87	Fixed
Unfished log-scale recruitment (Ln(R_0))	-	Estimated
Standard deviation of recruitment (σR)	σR = 0.6	Fixed
Initial age structure	-	Estimated
Recruitment deviations	-	Estimated
Selectivity	-	Estimated
Catchability	-	Estimated

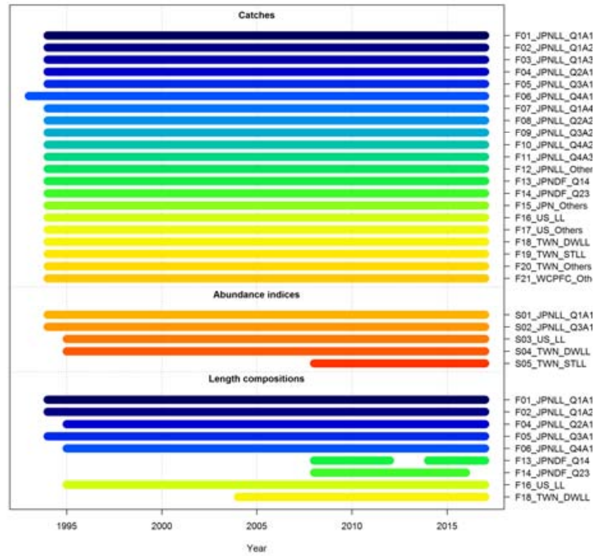
Table 3. Table of selectivity functions for each catch and abundance time series.

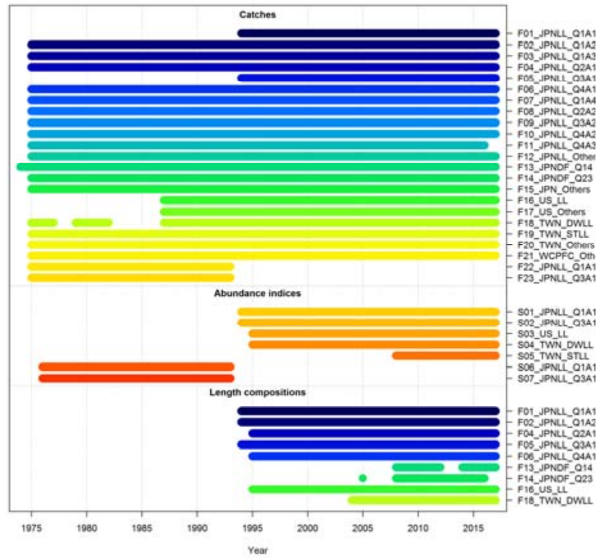
Fleet	Selectivity Function
F1	Double-normal
F2	Double-normal
F3	Mirror F2
F4	Double-normal
F5	Double-normal
F6	Double-normal
F7	Mirror F2
F8	Mirror F4
F9	Mirror F5
F10	Mirror F6
F11	Mirror F6
F12	Mirror F4
F13	Asymptotic lognormal
F14	Asymptotic lognormal
F15	Mirror F4
F16	Double-normal
F17	Mirror F16
F18	Double-normal
F19	Mirror F18
F20	Mirror F14
F21	Mirror F4
F22	Mirror F1
F23	Mirror F5
S1	Mirror F1
S2	Mirror F5
S3	Mirror F16
S4	Mirror F18
S5	Mirror F18
S6	Mirror F1
S7	Mirror F5

Figures

Model 1

Model 2





Model 3

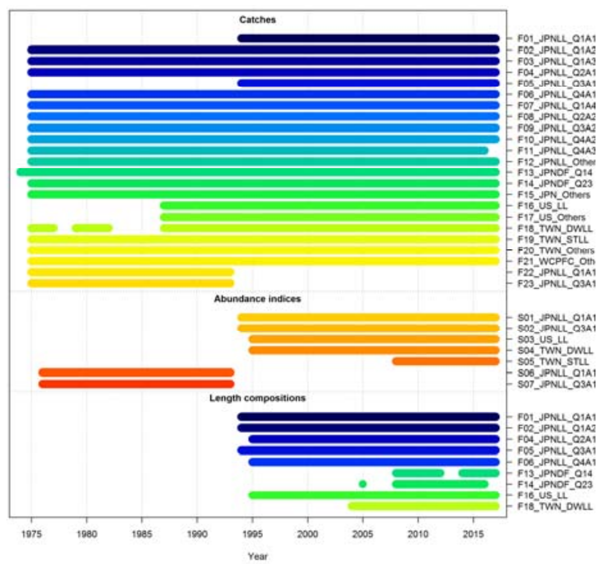


Figure 1. Catch, abundance, and length composition data available for the WCNPO Stock Synthesis striped marlin assessment models 1-3.

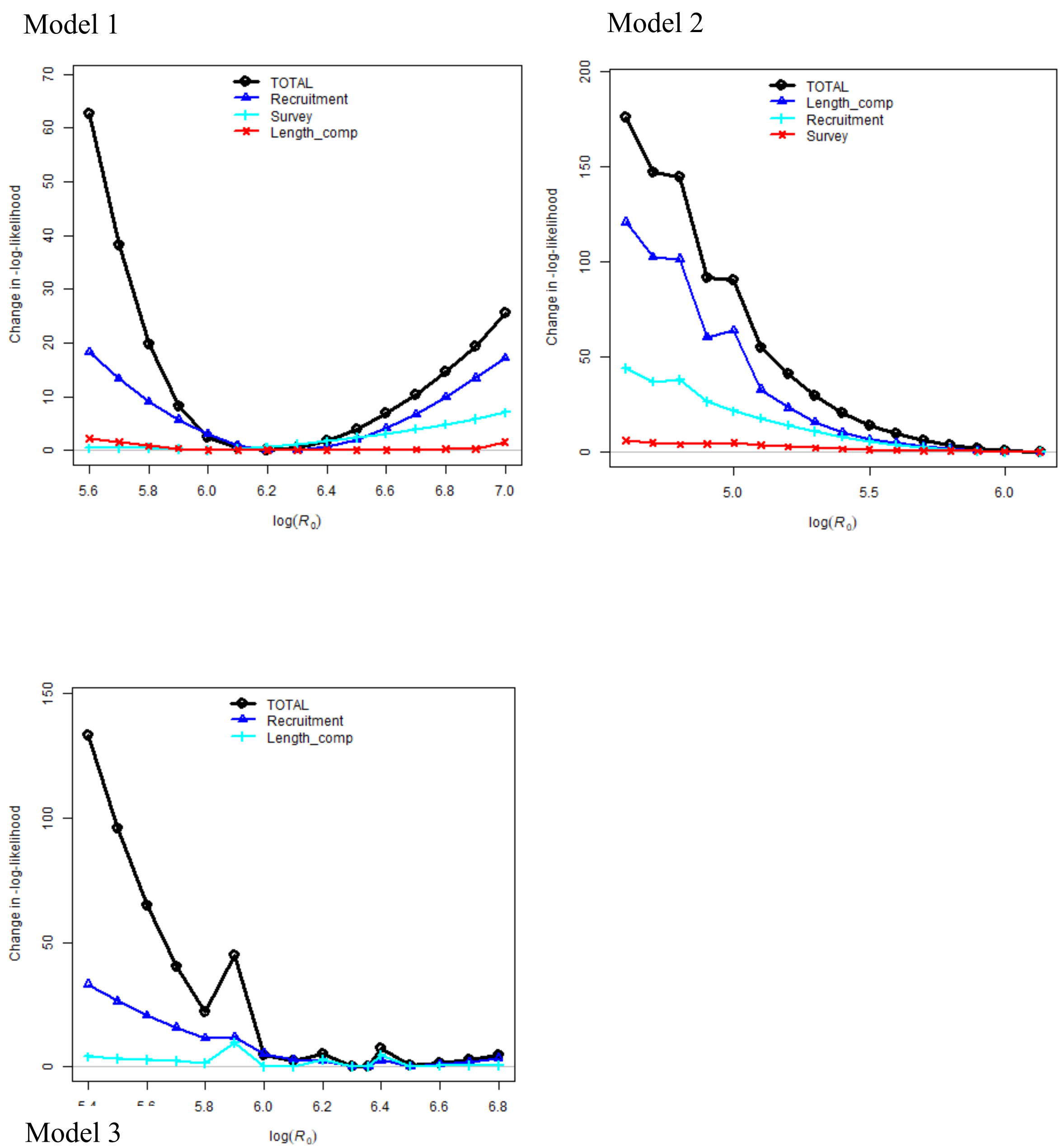


Figure 2. Likelihood profile on log(R_0) by likelihood component from models 1-3.

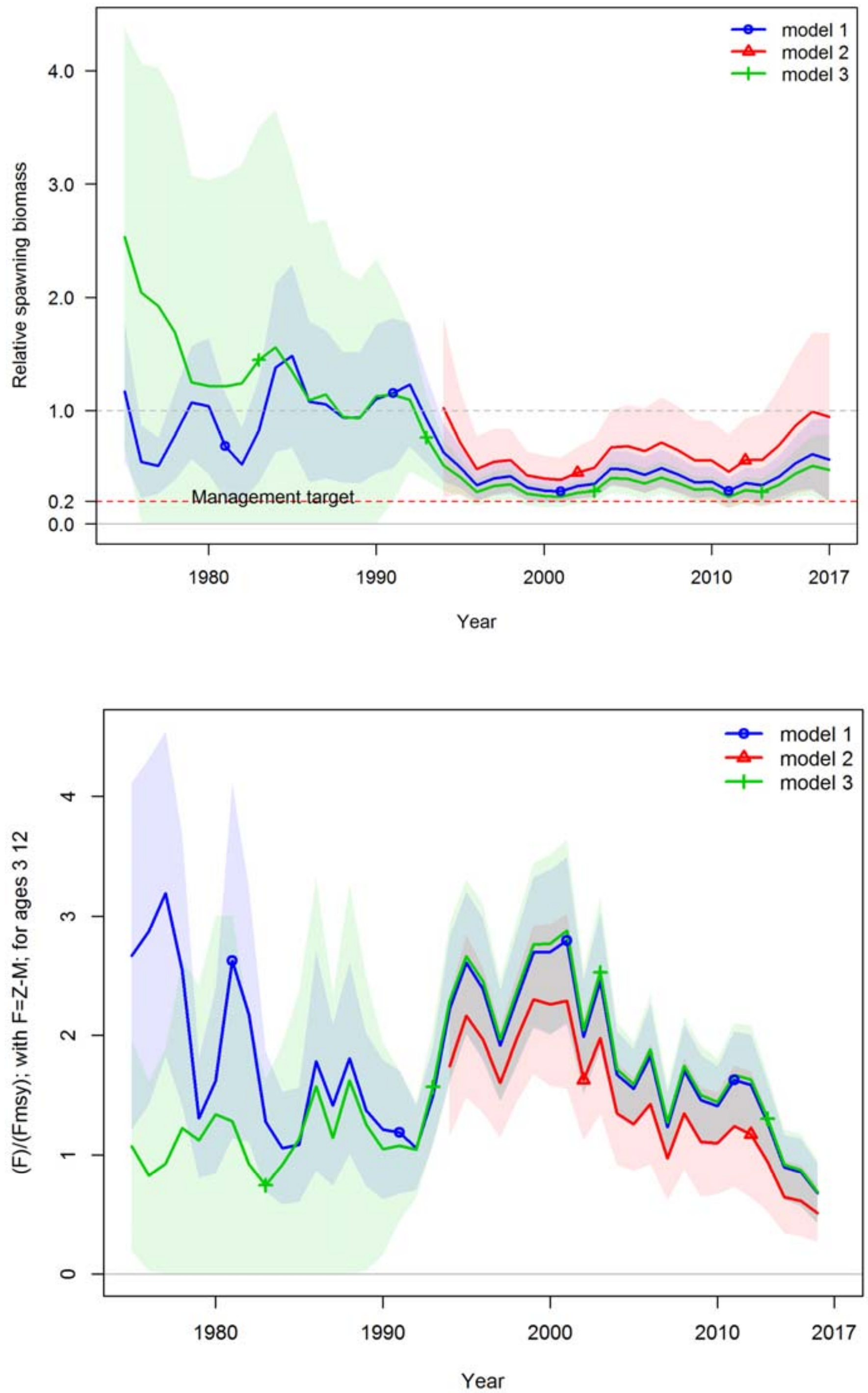


Figure 3. Relative spawning biomass and fishing mortality for models 1-3.

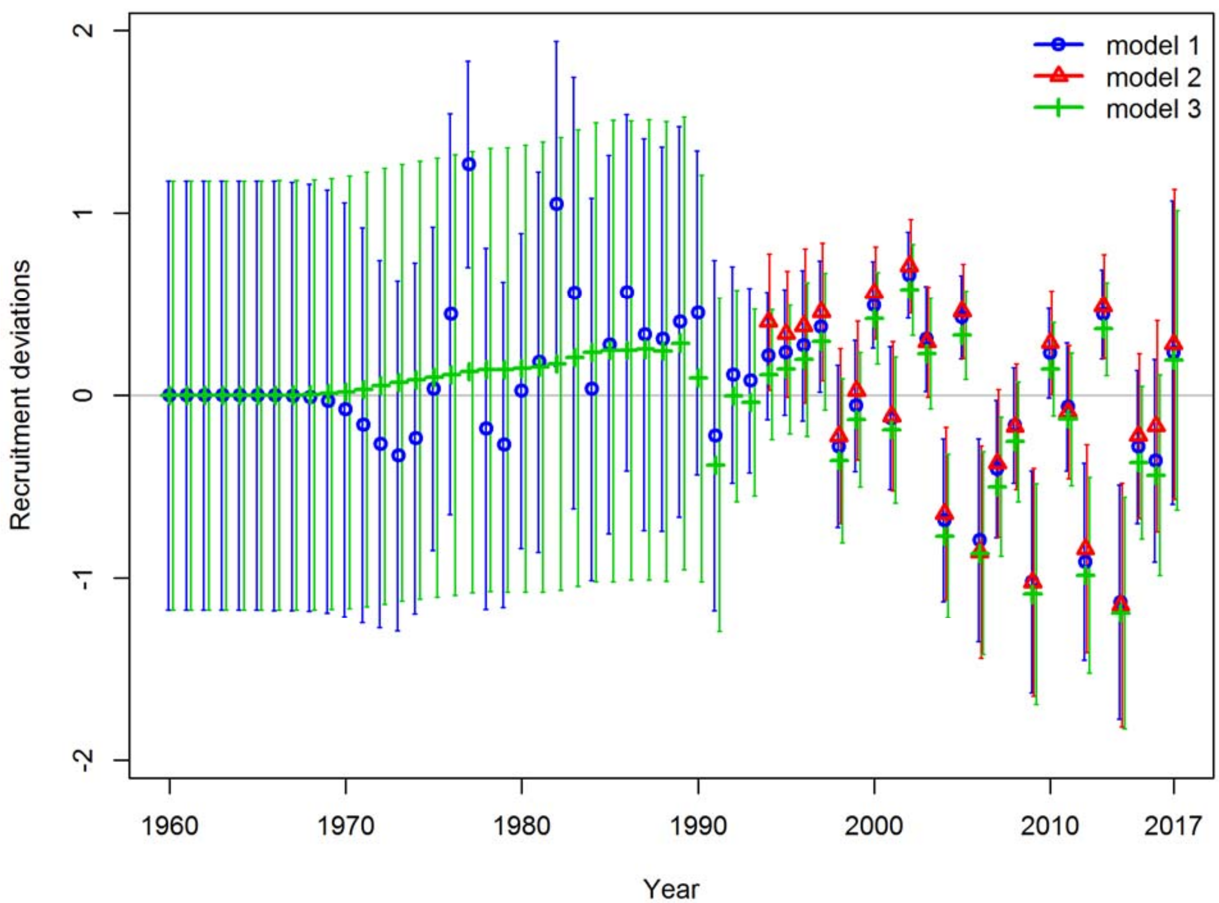


Figure 4. Residual recruitment deviations estimated from Models 1-3. Information prior 1975 indicate early recruitment deviations.

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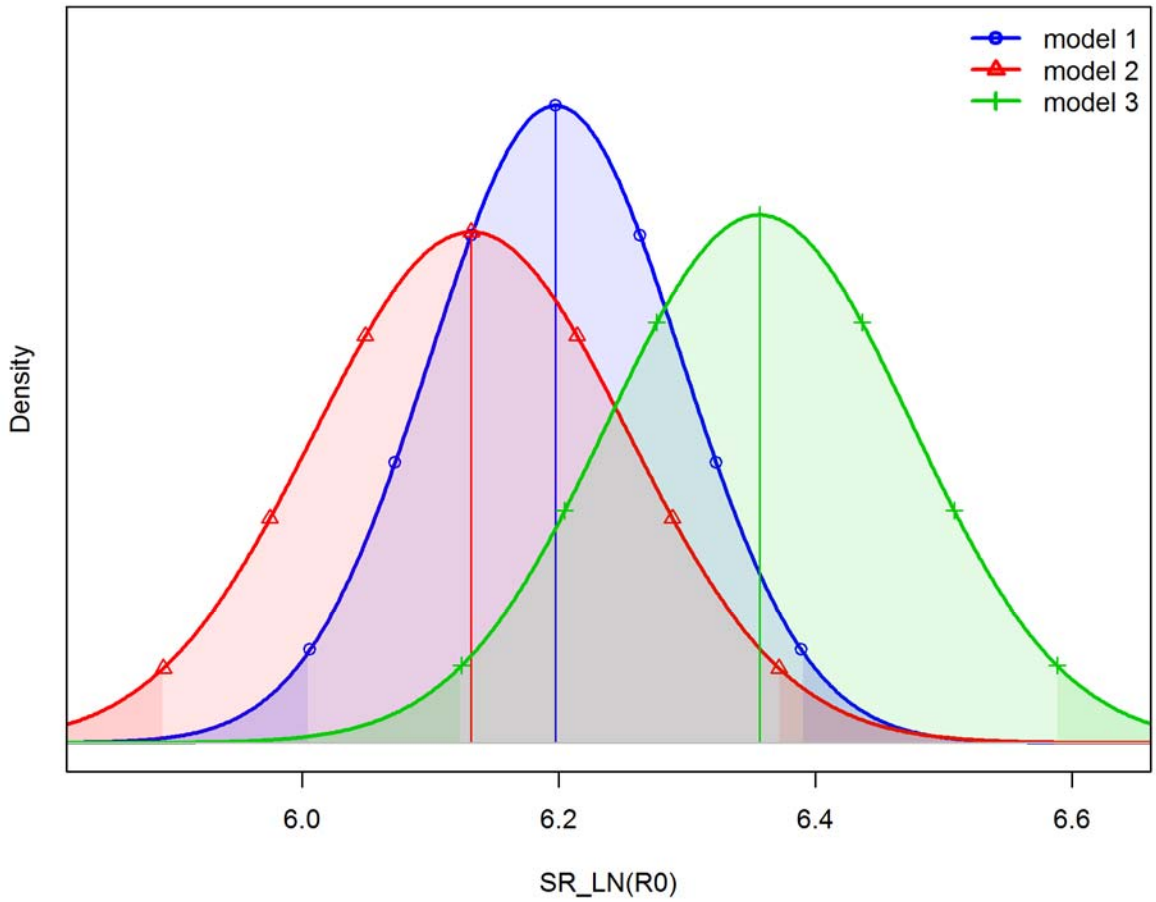

Figure 5. Density plots for the main scaling parameter in the model (equilibrium recruitment; SR_ln(R0)) for models 1-3.