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Simulation testing of Stock Indicators [1]

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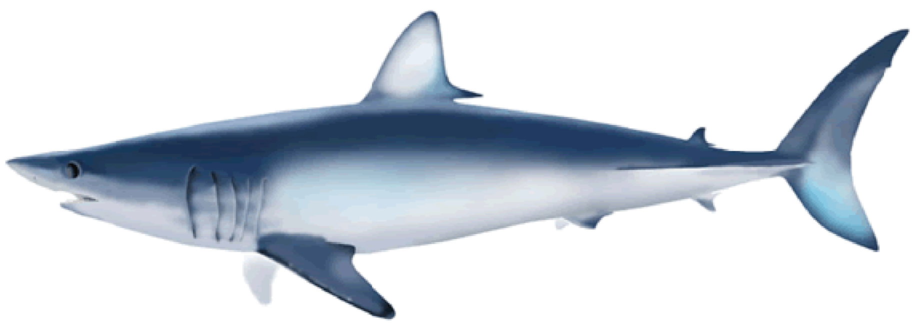

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Simulation testing of Stock Indicators

ABSTRACT

Fishery indicator analysis is one of several data-poor methods used to provide general stock status advice when the data needed to produce traditional population dynamics models are unavailable. We define fishery indicators to be simple metrics characterizing a temporal change in the data streams (CPUE and length compositions). For pelagic sharks, fishery indicators should consider spatial aspects of life history and fisheries from which the indicator information is drawn. This working paper used simulation methods to evaluate the reliability of CPUE and size indictors' prediction of stock status by comparing indictors against spawning stock biomass and fishing mortality. We simulate synthetic populations with a variety of life histories and exploitation scenarios that are consistent with the biological and fisheries properties of mako-like sharks. We further evaluate which potential indicators (CPUE and average size) provide the most reliable information about the stock status. The simulations results suggest that (1) indices of CPUE are better indicators for representing the stock status (in terms of both biomass status and fishing status) than average length; (2) longer or closer to virgin CPUE series are better indicators than shorter series; (3) precise CPUE indices are better indicators than imprecise indices; (4) adults CPUE indices are better indicators than recruits indices; and (5) conclusions about not being overexploited ($B/B_{MSY} > 1$) are more robust to the length and precision of CPUE indices than conclusions about a crashed status ($B/B_{MSY} < 0.2$).

INTRODUCTION

Data poor methods exist for situations when the data needed to produce traditional population dynamics models (e.g. Methot and Wetzle 2013) are unavailable. In some regional management arenas, data poor dynamic models such as catch free (Porch *et al.* 2007; Trenkel 2008) and index free models (Dick and MacCall 2010) have been developed to address data limitations. Such data-free models require strong assumptions that may not be fully tested. Alternatively, some regional management arenas have used simpler fishery indicator analyses to provide general stock status advice (Carruthers *et al.* 2012) and ecosystem health (Ault *et al.* 2005; Babcock *et al.* 2013).

The ISC Shark Working Group plans to use fishery indicator analyses to provide information about North Pacific shortfin mako shark status. We define fishery indicators to be simple metrics characterizing the data sources that may provide information about stock status. Usually, each metric characterizes a temporal change in the data stream. The most common indicators come from CPUE (Maunder *et al.* 2006; Probst and Oesterwind 2014), length compositions (Ault *et al.* 2008; Cope and Punt 2009) and catch data. Indicators have been used in the Pacific for pelagic fishes (Clarke *et al.* 2011; Aires-da-Silva *et al.* 2014; Hinton *et al.* 2014).

North Pacific pelagic sharks are candidates for fishery indicator analyses because of a lack of complete data to construct traditional population dynamics models. The lack of data available is due in part to shark being a bycatch or non-targeted catch, often not recorded. In the case of mako shark this has resulted in relatively short time series of CPUE and compositions as well as missing catch (both retained catch and discards). It is primarily the missing catch that prevents the development of a traditional dynamic model. Thus, the Working Group has decided to perform fishery indicator analyses in lieu of the dynamic modelling approach.

Fishery indicators for pelagic sharks should consider important aspects of the life history that may be relevant to interpretation of the indicators. The spatial aspects of life history interact with the complex spatial pattern of the fisheries from which the indicator information is drawn. Factors examined could include spatial patterns of both size/age and potentially sex ratio (e.g. Sippel *et al.* 2014). Spatial patterns include not only the latitudinal and longitudinal patterns but also depth structure. The picture is complex because fleets operate differently both in location (latitude/longitude) and depth of fishing.

The objective of this study is to evaluate the reliability of CPUE and size indictors' prediction of stock status using simulation methods. We simulate populations that are consistent with the biological properties of large pelagic sharks (i.e. mako-like sharks). In light of the importance of spatial patterns of both sharks and fleets, we further evaluate what properties of the fisheries (spatial) and data (data timespan and precision) as well as biological characteristics affect the indicator reliability. The study evaluates which potential indicators (CPUE and average size) provide the most reliable information about the stock status in terms of stock biomass and fishing mortality.

We intend to address five key questions: (1) What indicators can provide more information on the stock condition?; (2) Is the reliability of the indicator dependent on the duration of its time series?; (3) What is the impact of data precision on the reliability of the indicators?; 4) Which geographic area provides the most informative indicators?; and 5) What is the effect of assuming different mixing rates of fish among areas in the indicators?.

MATERIALS AND METHODS

1. Simulation Method

We simulated synthetic populations using stochastic population dynamics to evaluate potential fishery indicators for prediction of stock status. The approach is explained starting with 1) the simulation of the synthetic populations to derive fishery data used to calculate indicators, 2) calculation of fishery indicators, and 3) finally how we compared indicators to true stock status.

2. Settings of Simulation

We used the structure of the commonly used stock assessment model, Stock Synthesis (Methot and Wetzle 2013), to create the 10,000 simulated populations with a variety of shark life histories and exploitation histories over a 61 year time period. Stock Synthesis is a widely used forward simulating integrated population dynamics model capable of fitting a wide variety of data types. The model keeps track of both numbers at age, numbers at length as well as age at length. However, we did not use Stock Synthesis to fit to data, but instead used it to create synthetic populations based on stochastically generated parameters controlling the systematic and fishery processes governing the population dynamics.

A set of system process parameters for the simulations were generated at random from distributions described in Table 1 and Figure 2. To account for the spatial patterns, the dynamic model was developed as a spatially explicit model with 3 areas (Figure 1). Area 1 is recruitment settlement area and contains only ages 0-$A_{\text{max\_juvenile}}$. Areas 2 and 3 contain adults ages $A_{\text{max\_juvenile}}$ and above with Area 2 having a high relative abundance and Area 3 being a low abundance area. We assume age-0 fish all stay in area 1 and start moving out from age 1 until $A_{\text{max\_juvenile}}$, where $A_{\text{max\_juvenile}}$ was varied at random.

Movement rates between Area 1 and Area 2 were determined as the fraction of fish out of area 1 to area 2 (large adult area). Area 2 fraction was generated stochastically. Movement rates between Area 1 and Area 3 were determined as the fraction of fish out of area 1 to area 3, which is one minus the Area 2 fraction. We incorporated 5% random noise around the movement rate from Area 1 to Areas 2 & 3 at $A_{\text{max\_juvenile}}$ to allow movement rate to vary over the year. Movement rates between age 1 and age $A_{\text{max\_juvenile}}$ were linearly interpolated after logarithmic transformation.

Movement rates from the large adult area (Area 2) to the small adult area (Area 3) were determined as the fraction of fish out of area 2 to area 3. Two scenarios were modeled, a low mixing rate sampled from a normal distribution with mean at 0.05 indicating that area 2 retained 95% of small adults and 95% of large adults, and a median mixing rate sampled from a normal distribution with mean at 0.3 indicating that area 2 retained 70% of small adults and 70% large adults.

Important process parameters included recruitment, which was determined by a low fecundity spawner-recruit relationship (Taylor *et al.* 2013) with the parameters: log of unfished recruitment, ln(R_0), shape of the mortality-depletion relationship (*Beta*), and compensation parameter (*Sfrac*) that controls potential decrease in pre-recruit mortality as spawning output is reduced, as well as annual standard deviations for recruitment in log space (σ_R). The ln(R_0) was fixed at 8.7, *Beta* was fixed at 2, and *Sfrac* and σ_R were generated stochastically. Growth of fish in the simulation was assumed to follow the von Bertalanffy (VB) growth function with size at age 0 fixed at 60 cm in PCL (Semba *et al.* 2011) and L_{inf} generated stochastically. The growth rate (*K*) was generated stochastically and natural mortality (*M*) generated based on the life history invariant, $M = 1.5K$ (Charnov 1993) with the addition of stochastic error in this relationship (Figure 3). The process error in growth (i.e. individual variation in length-at-age) was fixed at 0.1 for size at age 0 and was modeled as normally distributed with the standard deviation proportional to the mean asymptotic length-at-age (Methot and Wetzle 2013).

Mating was assumed to occur at the fourth calendar quarter, which corresponds to the beginning of the parturition season (Mollet *et al.* 2000; Joung and Hsu 2005). Litter size was generated stochastically based on published values (Joung and Hsu 2005; Semba *et al.* 2011). The maturity ogive was modeled as an age-based maturity ogive, where the age-at-50 percent-maturity and slope of the logistic function were generated stochastically. Recruitment timing (pupping) was assumed to occur in the fourth quarter which is based on the 9-13 months gestation period (Semba *et al.* 2011) and 23-25 months gestation period (Joung and Hsu 2005).

The fleet component of the simulation model included: 61 years of simulated population dynamics with fishing that started from an unfished population, 2 fleets in each area removing catches with the same age-based selectivity of gear in the area; one fleet represents precise CPUE (CV at 0.2) and size data (effective sample size of 100) and the other fleet represents imprecise CPUE (CV at 0.4) and size data (effective sample size of 10). A variety of mean fishing mortality trajectories were simulated that increased at the start of the time series then remained constant, then increased or decreased after being harvested for 40 years (Figure 4; Carruthers *et al.* 2012). Catchability coefficients were assumed to be constant over time for each fishery.

3. Characterization/calculation of population status and data indicators

For each simulation, two general categories of indicators were evaluated. CPUEs were taken from each of the three areas with both low and high precision. Average annual change in CPUE was calculated (Λ_{CPUE}), which was the difference between the CPUE at the end and the beginning of the time series divided by the number of years. Length composition data were also taken from each of the three areas with low and high precision. Average annual change in mean length was calculated (Λ_{size}), which was the difference between the mean length at the end and the beginning of the time series divided by the number of years.

Stock status was determined based on comparing the current spawning stock biomass (B_{cur}) and fishing intensity ($FSPR_{cur}$: residual spawning output given current fishing intensity and the biological characteristics of the stock as a fraction of unfished spawning output) level to their maximum sustainable yield (MSY)-based reference points. The B_{cur} was defined as the spawning biomass estimated in the terminal year and the $FSPR_{cur}$ was defined as average of estimates for the latest three years to account for uncertainty and fluctuation in the estimates for recent years.

We classified stock status in terms of B_{cur}/B_{MSY} where crashed stocks were $B_{cur}/B_{MSY} < 0.2$, overexploited stocks were $0.2 < B_{cur}/B_{MSY} < 1$, and not overexploited stocks were $B_{cur}/B_{MSY} > 1$ (Figure 5). We also classified stock status based on $FSPR_{cur}/FSPR_{MSY}$ where overfishing stocks were $FSPR_{cur}/FSPR_{MSY} > 1$ and not overfishing stocks were $FSPR_{cur}/FSPR_{MSY} < 1$.

4. Comparison of methods

We evaluated the effects of 4 levels of data time spans for Λ_{CPUE} and Λ_{size} (recent 33 years of the time series, recent 20 years, recent 10 years, and recent 5 years) on estimates of B_{cur}/B_{MSY} and $FSPR_{cur}/FSPR_{MSY}$. We summarized the frequencies between these two categorical variables (Λ and stock status) across 4 levels of data time span. The conditional probability of different category of stock status given the Λ value was calculated. We determined if Λ_{CPUE} and Λ_{size} were predictive of B_{cur}/B_{MSY} or $FSPR_{cur}/FSPR_{MSY}$ given different data time spans.

RESULTS AND DISCUSSION

Eight examples of 10,000 simulations are illustrated in Figure 6.

Each question is reviewed in light of the results, using conditional probabilities tables as a summary statistic. This is followed by a general summary about implications.

1. What data source is the best indicator of stock condition?

Indices of CPUE seem to be the best indicators for representing the stock status of the shortfin mako shark in the North Pacific Ocean. This conclusion is based mainly on the higher number of conditional probabilities ≥ 0.75 for lambda observed in the CPUE indicators compared to average length (e.g. Table 2; Details in Appendix A).

2. Is it the reliability of the indicator dependent on the duration of its time series?

The number of years of the time series matters (e.g. Table 2; Details in Appendix A). The value of lambda for the different time series lengths (33 yr vs 20 yr vs 5 yr) measures the absolute depletion from the time between the beginning and the end of the time series. The same lambda can have different interpretations depending upon its value relative to the initial biomass when the data series begins. Thus, results tend to be more robust as the data gets closer to the unfished levels (i.e. for the 33 yr CPUE time series) (Figure 7).

3. What is the impact of data precision on the reliability of the indicator?

Data precision does matter for determine stock status. The number of conditional probabilities on lambda ≥ 0.75 is slightly higher for the 33 year CPUE time series with low CV (CPUE 1, CPUE 3, and CPUE 5) compared to the 33 year CPUE time series with high CV (CPUE 2, CPUE 4, and CPUE 6). Additionally, the difference in the number of conditional probabilities on lambda ≥ 0.75 between high and low CV gets larger as the duration of CPUE time series gets shorter (e.g. Table 3; Details in Appendix A).

4. Does geographic area or age class measured affect the reliability of the indicator?

All areas provide indicators with some ability to inform stock status. Although as the duration of the CPUE time series gets shorter, indicators from adult areas (CPUEs 3-6) seem to provide better information than indicators from the recruit area (CPUEs 1 and 2) for assessing overexploited or not overexploited populations (e.g. Table 3; Details in Appendix A).

5. **What is the effect of assuming different mixing rates of fish among areas in the indicators?**

In our simulations we found minor differences between the indicators from low and median mixing rates (e.g. Table 4; Details in Appendix A).

In conclusion: CPUE lambda provides better quality information on stock than average length; the longer or beginning closer to virgin biomass data time series are more informative; precise data (low CV) are better than imprecise data (high CV); and data from the adult areas (2 and 3) are better than data from the recruit area (1). We also have to consider interactions, for example the short time series affects the recruit CPUE index more than it does the adult CPUE index.

We also noted that in our simulations, sample sizes were low (<100) for some lambdas. Caution should be taken when one intends to use the conditional probability as absolute risk, due to the low sample sizes.

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Table 1. The sampling distributions of the parameters and variables that were used to develop each simulated population and derive all catch, CPUE and length observations. All parameter values (except for recruitment deviations and fishing mortality, *F*) were drawn once from the distribution to produce a single simulated population. Annual recruitment deviations and *F*'s were drawn from the appropriate distribution for each year of the simulation. Uniform random variables are represented by Uniform(minimum bound, maximum bound), Gaussian random variables are represented by Normal(mean, standard deviation), and parameters determined as a function of other random variables are denoted f().

Parameter/variables	Sampling distribution
<u>Recruitment</u>	
Log unfished recruitment ln(R_0) ('000's fish)	Fixed at 8.7
Standard deviation for recruitment in log space (σ_R)	Normal (0.6, 0.15)
Shape of the mortality-depletion relationship (*Beta*)	Fixed at 2
Compensation parameter (*Sfrac*) that controls potential decrease in pre-recruit mortality as spawning output is reduced	Uniform (0.1, 0.5)
<u>Mortality</u>	
Natural mortality (*M*, yr^{-1})	Uniform (0.07, 0.2)
Fishing mortality (*F*, yr^{-1}) for each area	See Figure 3
<u>Growth</u>	
Length at age 0 fixed (L_0, cm)	Fixed at 60
CV of length at age 0	Fixed at 0.1
Asymptotic length (L_{inf}, cm)	Uniform (260, 370)
CV of asymptotic length at age	Normal (0.1, 0.025)
Growth coefficient (*K*) determined from *M*/1.5 with 10% variation	$f(M)$ (see Figure 2)
<u>Reproduction</u>	
Age at 50% maturity	Uniform (17, 20)
Maturity slope	Uniform (-0.9, -0.3)
Litter size	Normal (11, 1.5)
<u>Movement</u>	
Fraction of fish that move from Area 1 to Area 2	Uniform (0.6, 0.9)
Maximum juvenile age with 1% of fish staying in Area 1 ($A_{\max\_juvenile}$)	Uniform (4, 8)
Standard deviation for $A_{\max\_juvenile}$ that move out of area 1 to area 2 or 3 in log space	Normal (0, 0.05)

Mixing rate from area 2 to area 3	Scenario 1: Normal (0.05, 0.02); Scenario 2: Normal (0.3, 0.02)
Age-based selectivity P1: Age at which selectivity=1 begins P2: Width of full selectivity P3: Slope of ascending limb P4: Slope of descending limb	
Area 1: Asymptotic	P1: fixed at $A_{\text{max\_juvenile}}$; P2: fixed at 4.14; P3: as function of P1 and age-0 selectivity from Uniform (0.2, 0.9) ; P4: fixed at 8.
Area 2: Dome-shaped or asymptotic	P1: Uniform (7, 9); P2: Uniform (-5, -1); P3: as function of P1 and age-0 selectivity at 0.001; P4: Uniform (4, 6).
Area 3: Dome-shaped or asymptotic	P1: Uniform (11, 14); P2: Uniform (-5, -1); P3: as function of P1 and age-0 selectivity at 0.001; P4: Uniform (6, 8).

Table 2: Contingency table between precise Λ and B_{cur}/B_{MSY} for the low mixing rate scenario. NA indicates sample size < 30 and * indicates sample size < 100 given each Λ.

Low mixing rate		Recent 33 yrs data			Recent 20 yrs data			Recent 10 yrs data			Recent 5 yrs data		
		B/Bmsy < 0.2	0.2 < B/Bmsy < 1	B/Bmsy > 1	B/Bmsy < 0.2	0.2 < B/Bmsy < 1	B/Bmsy > 1	B/Bmsy < 0.2	0.2 < B/Bmsy < 1	B/Bmsy > 1	B/Bmsy < 0.2	0.2 < B/Bmsy < 1	B/Bmsy > 1
CPUE1 (area1)	-0.2	0.78*	0.17*	0.05*	0.31	0.35	0.34	0.11	0.48	0.42	0.18	0.37	0.45
	-0.15	0.77	0.20	0.04	0.59	0.23	0.18	0.44	0.31	0.26	0.44	0.30	0.25
	-0.1	0.63	0.29	0.08	0.35	0.39	0.26	0.47	0.30	0.23	0.28	0.39	0.33
	-0.05	0.30	0.40	0.30	0.45	0.32	0.23	0.40	0.34	0.26	0.47	0.29	0.24
	0	0.03	0.27	0.70	0.09	0.35	0.56	0.31	0.33	0.36	0.41	0.34	0.26
	0.05	NA	NA	NA	0.00	0.21	0.79	0.04	0.36	0.60	0.29	0.36	0.35
	0.1	NA	NA	NA	NA	NA	NA	0.00	0.29	0.71	0.30	0.32	0.38
	0.15	NA	NA	NA	NA	NA	NA	0.00*	0.20*	0.80*	0.05	0.32	0.63
CPUE3 (area2)	-0.2	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00	0.34	0.66
	-0.15	NA	NA	NA	NA	NA	NA	0.00	0.40	0.60	0.38	0.29	0.33
	-0.1	0.84	0.15	0.01	0.75	0.18	0.07	0.43	0.32	0.25	0.28	0.39	0.33
	-0.05	0.13	0.49	0.38	0.29	0.40	0.30	0.43	0.32	0.25	0.48	0.30	0.22
	0	0.00	0.17	0.83	0.00	0.30	0.70	0.14	0.38	0.48	0.31	0.36	0.33
	0.05	NA	NA	NA	0.00	0.13	0.87	0.00	0.31	0.69	0.12	0.37	0.51
	0.1	NA	NA	NA	NA	NA	NA	0.00*	0.25*	0.75*	0.00	0.33	0.67
	0.15	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00	0.22	0.78
CPUE5 (area3)	-0.2	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.20	0.27	0.54
	-0.15	NA	NA	NA	NA	NA	NA	0.00	0.44	0.56	0.20	0.37	0.43
	-0.1	0.85	0.14	0.00	0.75	0.20	0.05	0.41	0.33	0.26	0.41	0.32	0.27
	-0.05	0.11	0.50	0.40	0.29	0.40	0.31	0.41	0.33	0.26	0.38	0.35	0.27
	0	0.00	0.14	0.86	0.00	0.26	0.74	0.16	0.35	0.48	0.39	0.30	0.30
	0.05	NA	NA	NA	0.00*	0.11*	0.89*	0.00	0.29	0.71	0.08	0.39	0.53
	0.1	NA	NA	NA	NA	NA	NA	0.00*	0.16*	0.84*	0.00	0.33	0.67
	0.15	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00	0.28	0.72

Low mixing rate		Recent 33 yrs data			Recent 20 yrs data			Recent 10 yrs data			Recent 5 yrs data		
		B/Bmsy < 0.2	0.2 < B/Bmsy < 1	B/Bmsy > 1	B/Bmsy < 0.2	0.2 < B/Bmsy < 1	B/Bmsy > 1	B/Bmsy < 0.2	0.2 < B/Bmsy < 1	B/Bmsy > 1	B/Bmsy < 0.2	0.2 < B/Bmsy < 1	B/Bmsy > 1
Len1 (area1)	-0.2	0.26	0.36	0.38	0.33	0.34	0.33	0.34	0.32	0.33	0.35	0.32	0.33
	-0.15	0.42	0.30	0.28	0.13	0.47	0.40	0.36	0.29	0.35	0.39*	0.37*	0.24*
	-0.1	0.49	0.27	0.24	0.38	0.33	0.29	0.00	0.48	0.52	0.38*	0.33*	0.29*
	-0.05	0.44	0.29	0.27	0.58	0.22	0.21	0.00	0.48	0.52	0.56*	0.22*	0.23*
	0	0.42	0.30	0.28	0.29	0.37	0.34	0.48	0.21	0.31	0.53*	0.25*	0.22*
	0.05	0.29	0.36	0.35	0.39	0.31	0.30	0.36	0.33	0.30	0.00*	0.43*	0.57*
	0.1	0.35	0.33	0.31	0.30	0.37	0.33	0.56	0.21	0.23	0.35	0.37	0.28
	0.15	0.32	0.34	0.34	0.31	0.33	0.36	0.32	0.35	0.33	0.30	0.35	0.35
Len3 (area2)	-0.2	0.39	0.31	0.30	0.39	0.32	0.29	0.33	0.33	0.34	0.30	0.34	0.35
	-0.15	0.24	0.37	0.39	0.21	0.42	0.37	0.15	0.38	0.46	0.00	0.43	0.57
	-0.1	0.36	0.33	0.31	0.20	0.40	0.40	0.17	0.39	0.45	0.25	0.34	0.41
	-0.05	0.36	0.31	0.33	0.29	0.36	0.35	0.15	0.44	0.41	0.39	0.30	0.31
	0	0.25	0.39	0.35	0.46	0.27	0.27	0.36	0.34	0.30	0.38	0.31	0.31
	0.05	0.16	0.40	0.44	0.19	0.41	0.40	0.28	0.38	0.34	0.24	0.37	0.39
	0.1	0.36	0.33	0.31	0.41	0.31	0.27	0.55	0.24	0.21	0.54	0.22	0.24
	0.15	0.34	0.32	0.34	0.29	0.33	0.39	0.35	0.33	0.32	0.36	0.33	0.31
Len5 (area3)	-0.2	0.30	0.32	0.37	0.31	0.35	0.34	0.31	0.36	0.33	0.32	0.33	0.34
	-0.15	0.30	0.37	0.33	0.39	0.34	0.27	0.14	0.43	0.43	0.00	0.48	0.52
	-0.1	0.22	0.39	0.39	0.42	0.32	0.26	0.26	0.39	0.35	0.43	0.27	0.30
	-0.05	0.39	0.32	0.29	0.22	0.42	0.36	0.47	0.28	0.25	0.48	0.25	0.26
	0	0.45	0.29	0.27	0.44	0.30	0.26	0.38	0.30	0.31	0.21	0.38	0.42
	0.05	0.49	0.27	0.24	0.34	0.36	0.30	0.39	0.28	0.32	0.20	0.36	0.44
	0.1	0.33	0.36	0.31	0.35	0.35	0.30	0.33	0.34	0.33	0.35	0.37	0.28
	0.15	0.19	0.39	0.42	0.31	0.29	0.41	0.35	0.31	0.34	0.35	0.33	0.32

Table 3: Contingency table between ʎ$_{\mathrm{CPUE}}$ and B_{cur}/B_{MSY} for the low mixing rate scenario. NA indicates sample size < 30 and * indicates sample size < 100 given each ʎ.

Low mixing rate		Recent 33 yrs data			Recent 20 yrs data			Recent 10 yrs data			Recent 5 yrs data		
		B/Bmsy < 0.2	0.2 < B/Bmsy < 1	B/Bmsy > 1	B/Bmsy < 0.2	0.2 < B/Bmsy < 1	B/Bmsy > 1	B/Bmsy < 0.2	0.2 < B/Bmsy < 1	B/Bmsy > 1	B/Bmsy < 0.2	0.2 < B/Bmsy < 1	B/Bmsy > 1
	-0.2	0.78*	0.17*	0.05*	0.31	0.35	0.34	0.11	0.48	0.42	0.18	0.37	0.45
	-0.15	0.77	0.20	0.04	0.59	0.23	0.18	0.44	0.31	0.26	0.44	0.30	0.25
	-0.1	0.63	0.29	0.08	0.35	0.39	0.26	0.47	0.30	0.23	0.28	0.39	0.33
CPUE1	-0.05	0.30	0.40	0.30	0.45	0.32	0.23	0.40	0.34	0.26	0.47	0.29	0.24
(area1)	0	0.03	0.27	0.70	0.09	0.35	0.56	0.31	0.33	0.36	0.41	0.34	0.26
	0.05	NA	NA	NA	0.00	0.21	0.79	0.04	0.36	0.60	0.29	0.36	0.35
	0.1	NA	NA	NA	NA	NA	NA	0.00	0.29	0.71	0.30	0.32	0.38
	0.15	NA	NA	NA	NA	NA	NA	0.00*	0.20*	0.80*	0.05	0.32	0.63
	-0.2	0.74	0.20	0.06	0.47	0.27	0.26	0.21	0.40	0.39	0.26	0.34	0.39
	-0.15	0.55	0.34	0.10	0.42	0.33	0.25	0.43	0.30	0.27	0.30	0.35	0.35
	-0.1	0.63	0.25	0.12	0.49	0.30	0.21	0.47	0.29	0.24	0.28	0.38	0.35
CPUE2	-0.05	0.27	0.41	0.32	0.40	0.34	0.27	0.41	0.33	0.26	0.43	0.31	0.25
(area1)	0	0.07	0.32	0.61	0.18	0.37	0.46	0.34	0.34	0.32	0.52	0.27	0.21
	0.05	0.00	0.22	0.78	0.00	0.31	0.69	0.18	0.37	0.46	0.33	0.36	0.30
	0.1	NA	NA	NA	0.00*	0.24*	0.76*	0.00	0.37	0.63	0.29	0.36	0.35
	0.15	NA	NA	NA	NA	NA	NA	0.10	0.26	0.63	0.17	0.34	0.49
	-0.2	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00	0.34	0.66
	-0.15	NA	NA	NA	NA	NA	NA	0.00	0.40	0.60	0.38	0.29	0.33
	-0.1	0.84	0.15	0.01	0.75	0.18	0.07	0.43	0.32	0.25	0.28	0.39	0.33
CPUE3	-0.05	0.13	0.49	0.38	0.29	0.40	0.30	0.43	0.32	0.25	0.48	0.30	0.22
(area2)	0	0.00	0.17	0.83	0.00	0.30	0.70	0.14	0.38	0.48	0.31	0.36	0.33
	0.05	NA	NA	NA	0.00	0.13	0.87	0.00	0.31	0.69	0.12	0.37	0.51
	0.1	NA	NA	NA	NA	NA	NA	0.00*	0.25*	0.75*	0.00	0.33	0.67
	0.15	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00	0.22	0.78
	-0.2	0.89*	0.11*	0.01*	0.77*	0.13*	0.10*	0.38	0.29	0.33	0.25	0.34	0.41
	-0.15	0.82	0.16	0.02	0.64	0.22	0.14	0.19	0.42	0.40	0.28	0.38	0.34
	-0.1	0.67	0.26	0.07	0.49	0.32	0.19	0.33	0.36	0.31	0.38	0.34	0.28
CPUE4	-0.05	0.22	0.43	0.35	0.36	0.35	0.29	0.46	0.30	0.24	0.47	0.31	0.22
(area2)	0	0.02	0.27	0.71	0.05	0.38	0.57	0.26	0.37	0.36	0.42	0.30	0.28
	0.05	0.00	0.16	0.84	0.16	0.23	0.61	0.30	0.28	0.42	0.15	0.42	0.42
	0.1	NA	NA	NA	0.00*	0.21*	0.79*	0.00	0.35	0.65	0.26	0.33	0.41
	0.15	NA	NA	NA	NA	NA	NA	0.00	0.34	0.66	0.22	0.30	0.48
	-0.2	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.20	0.27	0.54
	-0.15	NA	NA	NA	NA	NA	NA	0.00	0.44	0.56	0.20	0.37	0.43
	-0.1	0.85	0.14	0.00	0.75	0.20	0.05	0.41	0.33	0.26	0.41	0.32	0.27
CPUE5	-0.05	0.11	0.50	0.40	0.29	0.40	0.31	0.41	0.33	0.26	0.38	0.35	0.27
(area3)	0	0.00	0.14	0.86	0.00	0.26	0.74	0.16	0.35	0.48	0.39	0.30	0.30
	0.05	NA	NA	NA	0.00*	0.11*	0.89*	0.00	0.29	0.71	0.08	0.39	0.53
	0.1	NA	NA	NA	NA	NA	NA	0.00*	0.16*	0.84*	0.00	0.33	0.67
	0.15	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00	0.28	0.72
	-0.2	0.92*	0.07*	0.01*	0.48*	0.33*	0.19*	0.12	0.38	0.49	0.31	0.30	0.39
	-0.15	0.85	0.13	0.01	0.67	0.22	0.11	0.19	0.42	0.39	0.28	0.36	0.36
	-0.1	0.66	0.26	0.07	0.54	0.31	0.16	0.48	0.29	0.23	0.45	0.31	0.24
CPUE6	-0.05	0.19	0.43	0.38	0.34	0.35	0.31	0.42	0.31	0.26	0.43	0.31	0.26
(area3)	0	0.02	0.27	0.70	0.07	0.36	0.57	0.25	0.38	0.37	0.34	0.37	0.29
	0.05	0.00*	0.12*	0.88*	0.00	0.27	0.73	0.09	0.37	0.54	0.31	0.35	0.34
	0.1	NA	NA	NA	0.00*	0.15*	0.85*	0.11	0.28	0.61	0.22	0.35	0.43
	0.15	NA	NA	NA	NA	NA	NA	0.00	0.29	0.71	0.09	0.35	0.56

Table 4: Contingency table between precise $ʎ_{CPUE}$ and B_{cur}/B_{MSY} for low mixing rate and median mixing rate scenarios. NA indicates sample size < 30 and * indicates sample size < 100 given each ʎ.

Low mixing rate		**Recent 33 yrs data**			**Recent 20 yrs data**			**Recent 10 yrs data**			**Recent 5 yrs data**		
		B/Bmsy < 0.2	**0.2 < B/Bmsy < 1**	**B/Bmsy > 1**	**B/Bmsy < 0.2**	**0.2 < B/Bmsy < 1**	**B/Bmsy > 1**	**B/Bmsy < 0.2**	**0.2 < B/Bmsy < 1**	**B/Bmsy > 1**	**B/Bmsy < 0.2**	**0.2 < B/Bmsy < 1**	**B/Bmsy > 1**
	-0.2	0.78*	0.17*	0.05*	0.31	0.35	0.34	0.11	0.48	0.42	0.18	0.37	0.45
	-0.15	0.77	0.20	0.04	0.59	0.23	0.18	0.44	0.31	0.26	0.44	0.30	0.25
	-0.1	0.63	0.29	0.08	0.35	0.39	0.26	0.47	0.30	0.23	0.28	0.39	0.33
CPUE1 (area1)	**-0.05**	0.30	0.40	0.30	0.45	0.32	0.23	0.40	0.34	0.26	0.47	0.29	0.24
	0	0.03	0.27	0.70	0.09	0.35	0.56	0.31	0.33	0.36	0.41	0.34	0.26
	0.05	NA	NA	NA	0.00	0.21	0.79	0.04	0.36	0.60	0.29	0.36	0.35
	0.1	NA	NA	NA	NA	NA	NA	0.00	0.29	0.71	0.30	0.32	0.38
	0.15	NA	NA	NA	NA	NA	NA	0.00*	0.20*	0.80*	0.05	0.32	0.63
	-0.2	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00	0.34	0.66
	-0.15	NA	NA	NA	NA	NA	NA	0.00	0.40	0.60	0.38	0.29	0.33
	-0.1	0.84	0.15	0.01	0.75	0.18	0.07	0.43	0.32	0.25	0.28	0.39	0.33
CPUE3 (area2)	**-0.05**	0.13	0.49	0.38	0.29	0.40	0.30	0.43	0.32	0.25	0.48	0.30	0.22
	0	0.00	0.17	0.83	0.00	0.30	0.70	0.14	0.38	0.48	0.31	0.36	0.33
	0.05	NA	NA	NA	0.00	0.13	0.87	0.00	0.31	0.69	0.12	0.37	0.51
	0.1	NA	NA	NA	NA	NA	NA	0.00*	0.25*	0.75*	0.00	0.33	0.67
	0.15	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00	0.22	0.78
	-0.2	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.20	0.27	0.54
	-0.15	NA	NA	NA	NA	NA	NA	0.00	0.44	0.56	0.20	0.37	0.43
	-0.1	0.85	0.14	0.00	0.75	0.20	0.05	0.41	0.33	0.26	0.41	0.32	0.27
CPUE5 (area3)	**-0.05**	0.11	0.50	0.40	0.29	0.40	0.31	0.41	0.33	0.26	0.38	0.35	0.27
	0	0.00	0.14	0.86	0.00	0.26	0.74	0.16	0.35	0.48	0.39	0.30	0.30
	0.05	NA	NA	NA	0.00*	0.11*	0.89*	0.00	0.29	0.71	0.08	0.39	0.53
	0.1	NA	NA	NA	NA	NA	NA	0.00*	0.16*	0.84*	0.00	0.33	0.67
	0.15	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00	0.28	0.72

Median mixing rate		**Recent 33 yrs data**			**Recent 20 yrs data**			**Recent 10 yrs data**			**Recent 5 yrs data**		
		B/Bmsy < 0.2	**0.2 < B/Bmsy < 1**	**B/Bmsy > 1**	**B/Bmsy < 0.2**	**0.2 < B/Bmsy < 1**	**B/Bmsy > 1**	**B/Bmsy < 0.2**	**0.2 < B/Bmsy < 1**	**B/Bmsy > 1**	**B/Bmsy < 0.2**	**0.2 < B/Bmsy < 1**	**B/Bmsy > 1**
	-0.2	0.90*	0.08*	0.02*	0.39	0.26	0.35	0.31	0.35	0.34	0.20	0.36	0.44
	-0.15	0.83	0.14	0.03	0.24	0.44	0.31	0.35	0.37	0.28	0.50	0.27	0.24
	-0.1	0.67	0.25	0.07	0.42	0.36	0.22	0.40	0.34	0.25	0.42	0.31	0.27
CPUE1 (area1)	**-0.05**	0.23	0.45	0.32	0.40	0.34	0.25	0.38	0.35	0.26	0.43	0.32	0.25
	0	0.00	0.27	0.73	0.21	0.31	0.48	0.31	0.34	0.35	0.35	0.35	0.30
	0.05	NA	NA	NA	0.00	0.20	0.80	0.27	0.27	0.45	0.30	0.37	0.33
	0.1	NA	NA	NA	NA	NA	NA	0.00	0.25	0.75	0.26	0.32	0.41
	0.15	NA	NA	NA	NA	NA	NA	0.00*	0.22*	0.78*	0.00	0.34	0.66
	-0.2	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00	0.36	0.64
	-0.15	NA	NA	NA	NA	NA	NA	0.33	0.33	0.34	0.12	0.41	0.47
	-0.1	0.83	0.16	0.01	0.69	0.23	0.08	0.42	0.31	0.27	0.51	0.28	0.22
CPUE3 (area2)	**-0.05**	0.16	0.47	0.36	0.32	0.38	0.29	0.40	0.33	0.27	0.43	0.33	0.24
	0	0.00	0.17	0.83	0.00	0.29	0.71	0.21	0.35	0.44	0.27	0.37	0.37
	0.05	NA	NA	NA	0.00*	0.17*	0.83*	0.00	0.34	0.66	0.07	0.39	0.54
	0.1	NA	NA	NA	NA	NA	NA	0.00*	0.25*	0.75*	0.00	0.34	0.66
	0.15	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00	0.25	0.75
	-0.2	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00	0.37	0.63
	-0.15	NA	NA	NA	NA	NA	NA	0.00	0.52	0.48	0.14	0.41	0.45
	-0.1	0.83	0.17	0.01	0.72	0.22	0.06	0.34	0.35	0.31	0.39	0.32	0.29
CPUE5 (area3)	**-0.05**	0.18	0.46	0.37	0.31	0.40	0.29	0.44	0.31	0.25	0.43	0.32	0.25
	0	0.00	0.14	0.86	0.00	0.24	0.76	0.15	0.37	0.48	0.26	0.38	0.36
	0.05	NA	NA	NA	0.00*	0.12*	0.88*	0.00	0.29	0.71	0.30	0.29	0.41
	0.1	NA	NA	NA	NA	NA	NA	0.00*	0.27*	0.73*	0.18	0.26	0.56
	0.15	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00	0.30	0.70

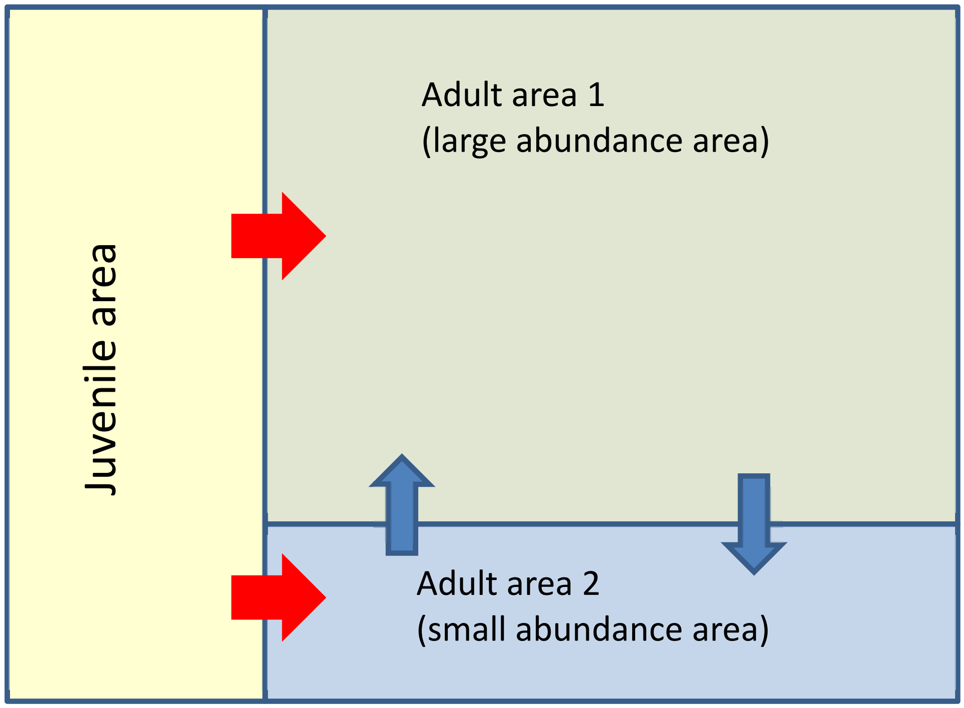

Figure 1. Spatial description of simulation model, where juvenile nursery area has limited adults, high abundance adult area approximates large spatial area, and low abundance adult area represents small spatial area.

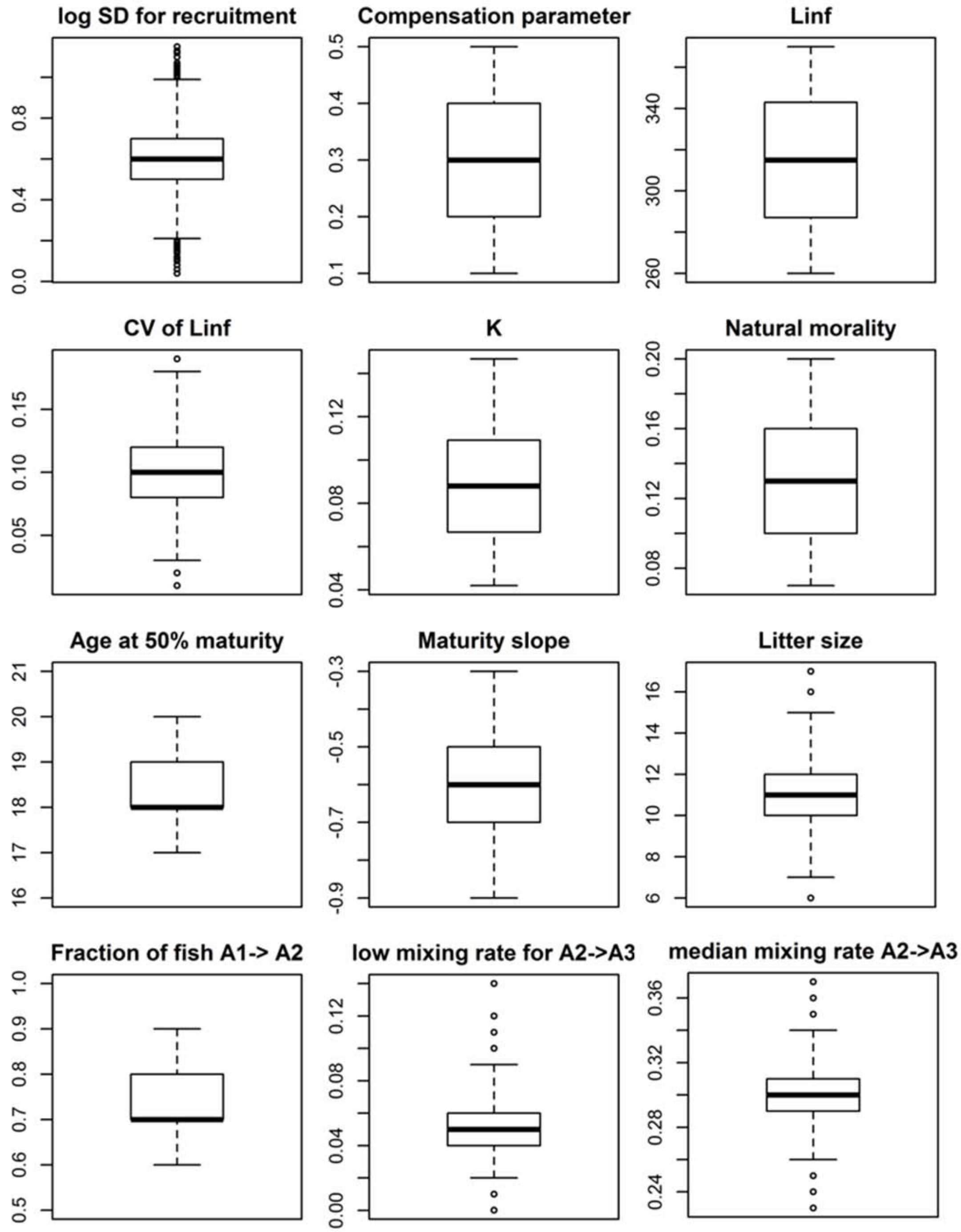

Figure 2. Box plot illustrating the distribution of key model system parameters used to generate the synthetic populations. The box represents 25th and 75th percentiles and the error bars the 5th and 95th percentiles.

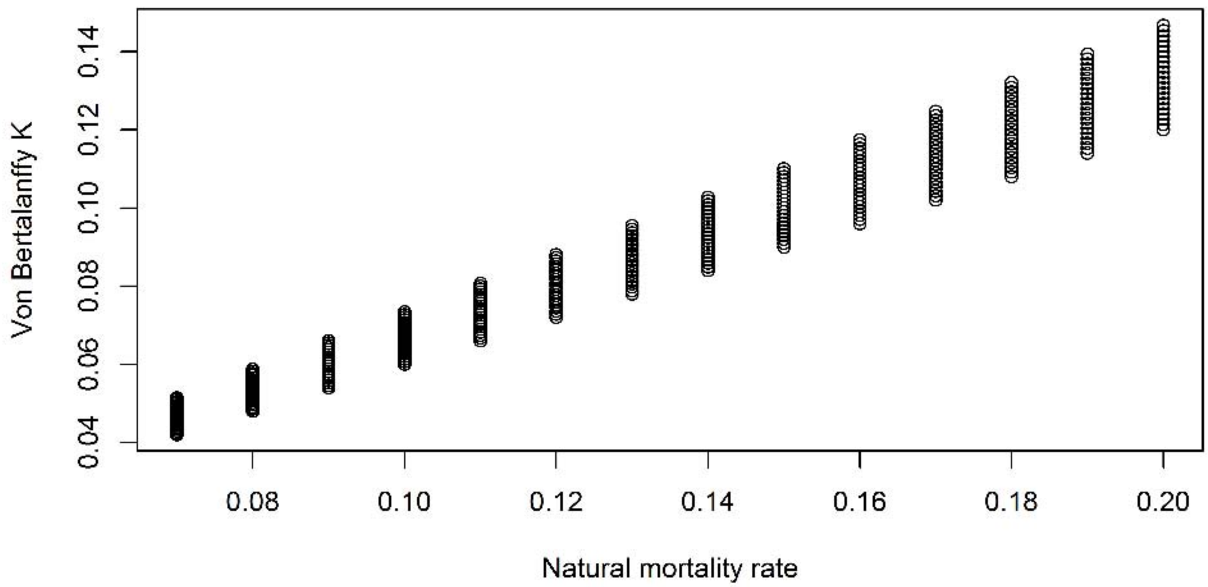

Figure 3. The fitted relationship (natural mortality is the independent variable) from which the von Bertalanffy growth parameter K was randomly sampled. Natural mortality rate is sampled uniformly in the range 0.07-0.2 (Table 1).

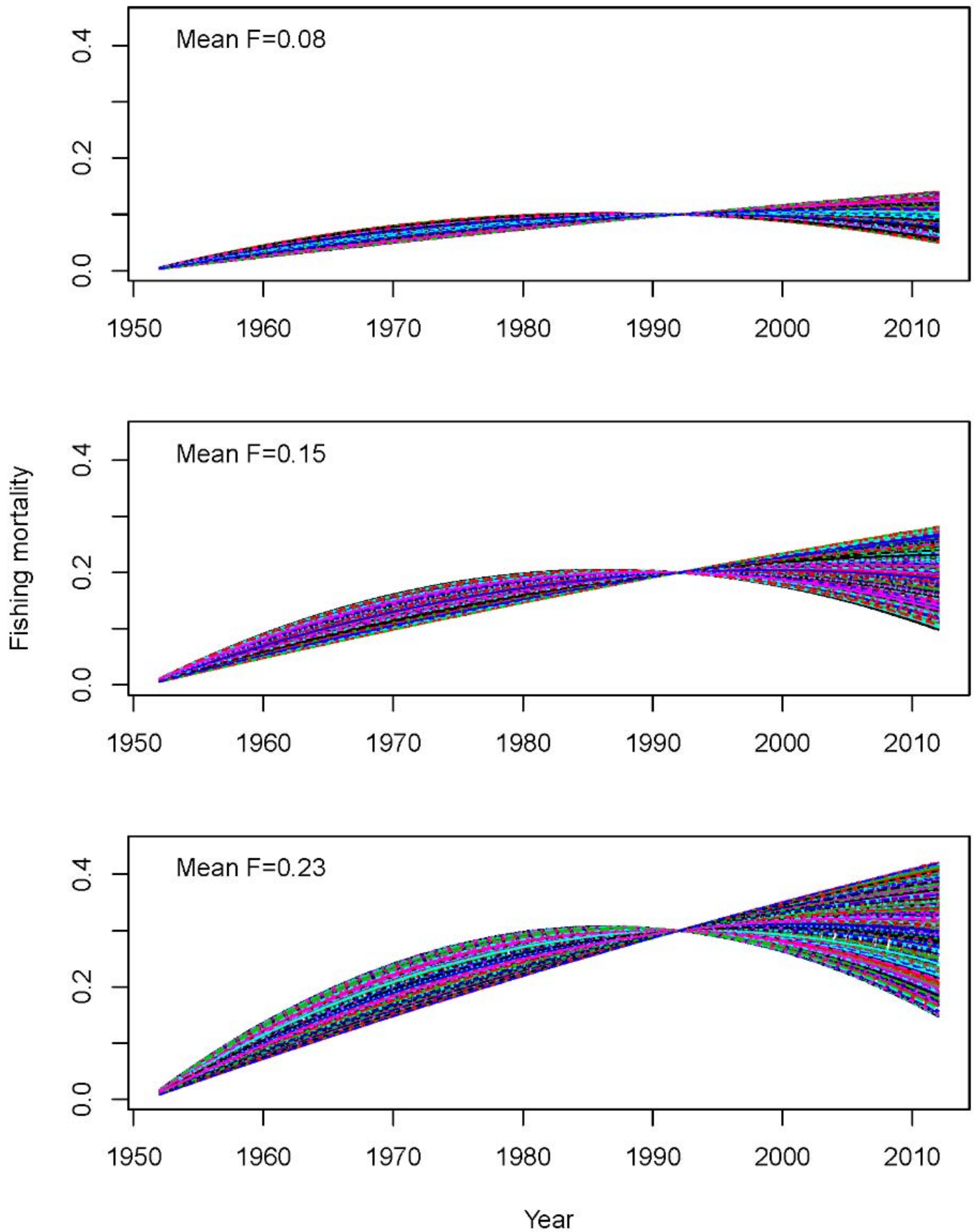

Figure 4. The range of simulated fishing mortality trends.

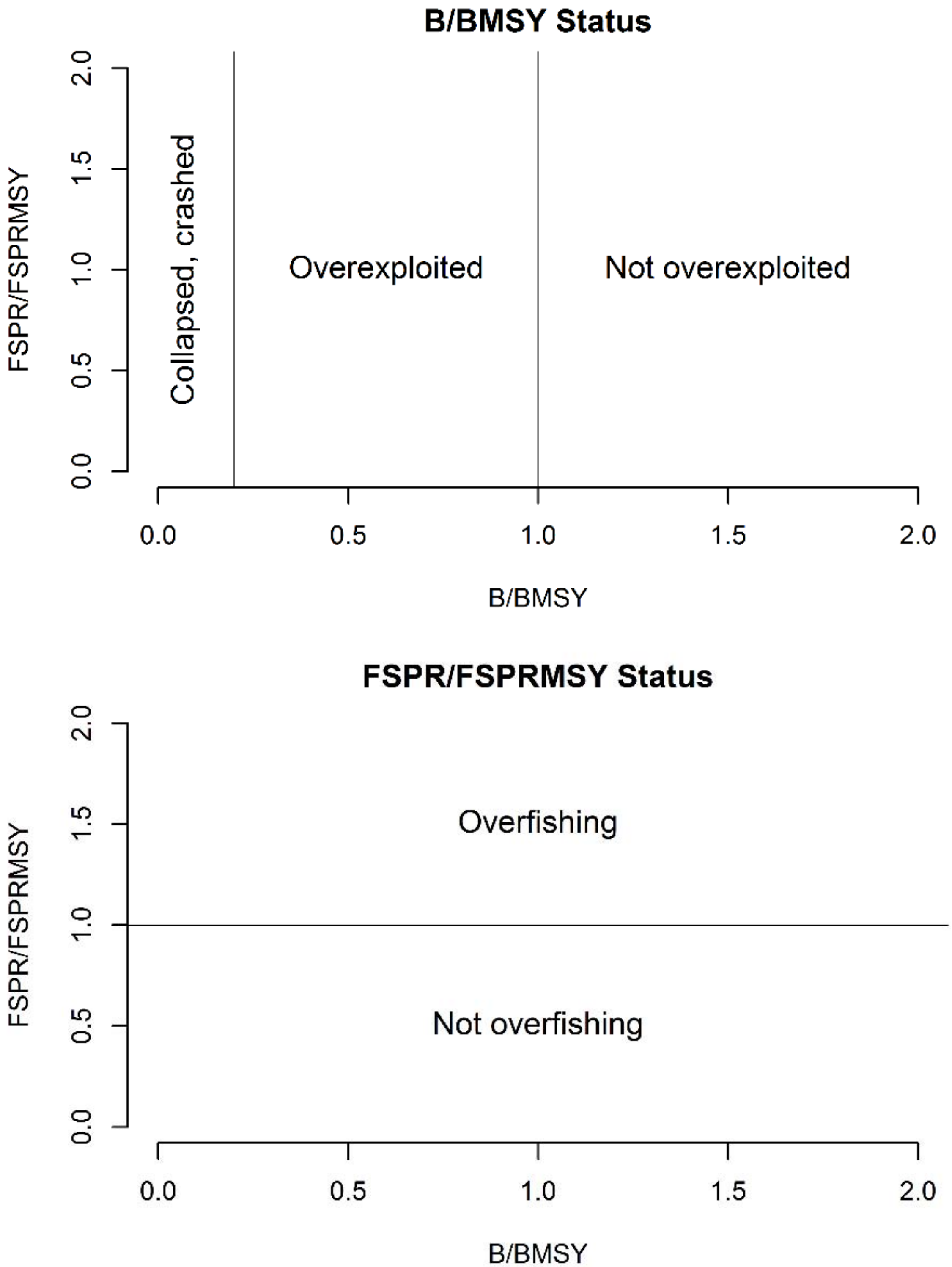

Figure 5. The stock status definitions used.

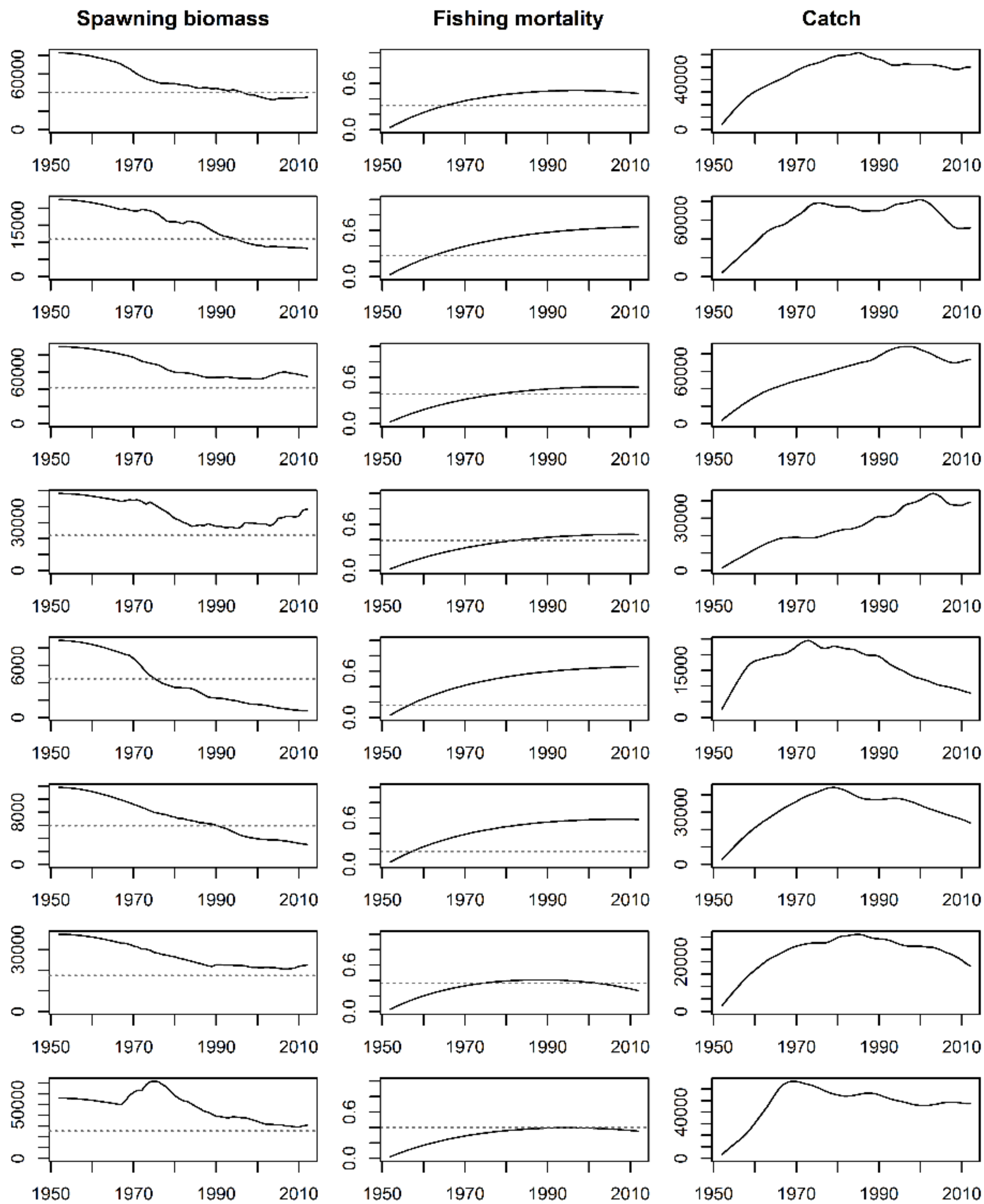

Figure 6. Eight example simulations where in each row represents a single population. The dotted lines represent MSY-based reference points.

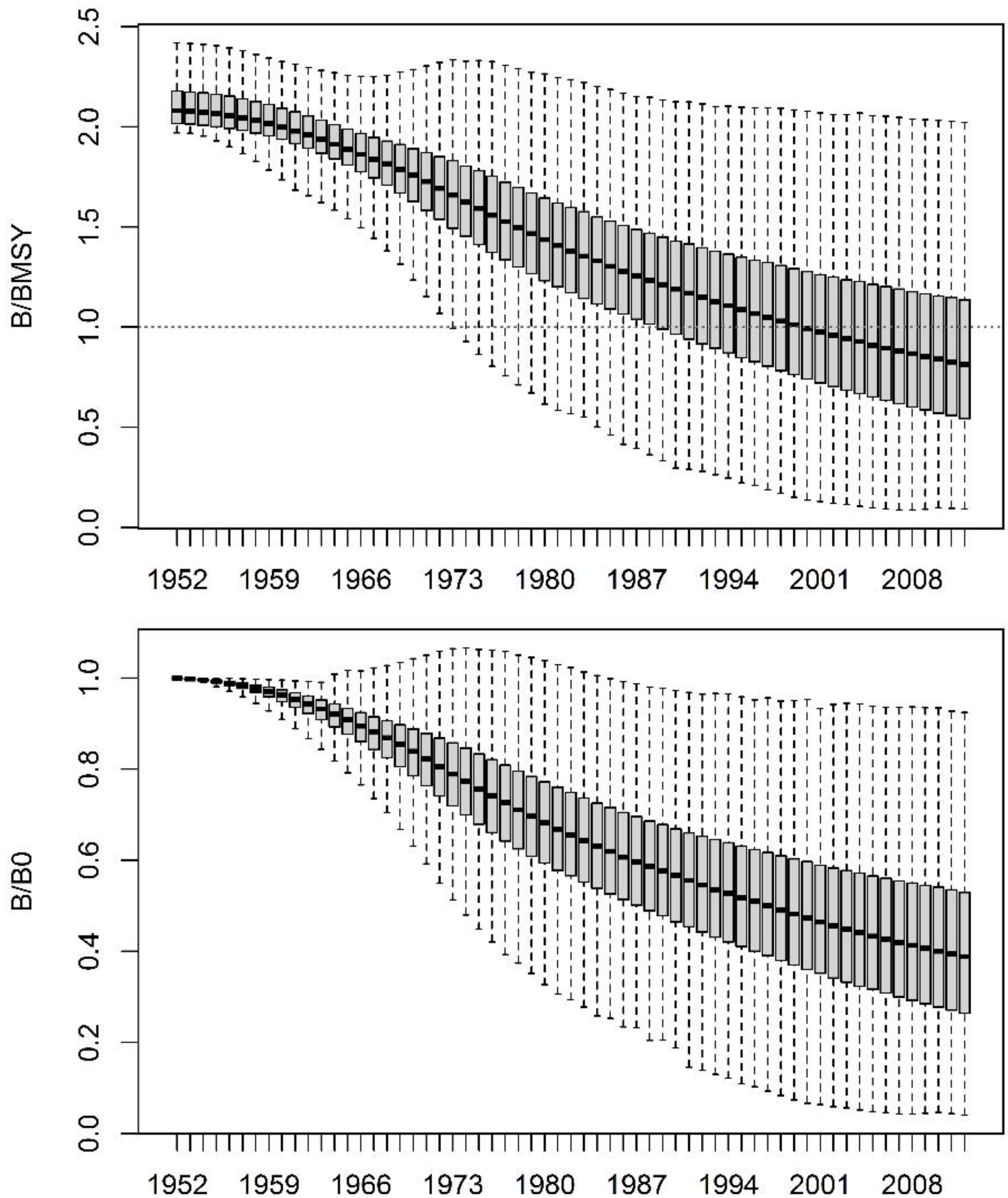

Figure 7. Box plots illustrating the distributions of spawning stock biomass relative to its maximum sustainable yield (MSY)-based reference points (upper panel) and spawning stock biomass relative to its unfished level from 10,000 synthetic populations. The box represents 25th and 75th percentiles and the error bars the 5th and 95th percentiles.

Appendix A: CPUE lambda over B/Bmsy status

Scenerio1: Low mixing rate

		Recent 33 yrs data			Recent 20 yrs data			Recent 10 yrs data			Recent 5 yrs data		
		B/Bmsy < 0.2	0.2 < B/Bmsy < 1	B/Bmsy > 1	B/Bmsy < 0.2	0.2 < B/Bmsy < 1	B/Bmsy > 1	B/Bmsy < 0.2	0.2 < B/Bmsy < 1	B/Bmsy > 1	B/Bmsy < 0.2	0.2 < B/Bmsy < 1	B/Bmsy > 1
	-0.2	0.78*	0.17*	0.05*	0.31	0.35	0.34	0.11	0.48	0.42	0.18	0.37	0.45
	-0.15	0.77	0.20	0.04	0.59	0.23	0.18	0.44	0.31	0.26	0.44	0.30	0.25
	-0.1	0.63	0.29	0.08	0.35	0.39	0.26	0.47	0.30	0.23	0.28	0.39	0.33
CPUE1 (area1)	**-0.05**	0.30	0.40	0.30	0.45	0.32	0.23	0.40	0.34	0.26	0.47	0.29	0.24
	0	0.03	0.27	0.70	0.09	0.35	0.56	0.31	0.33	0.36	0.41	0.34	0.26
	0.05	NA	NA	NA	0.00	0.21	0.79	0.04	0.36	0.60	0.29	0.36	0.35
	0.1	NA	NA	NA	NA	NA	NA	0.00	0.29	0.71	0.30	0.32	0.38
	0.15	NA	NA	NA	NA	NA	NA	0.00*	0.20*	0.80*	0.05	0.32	0.63
	-0.2	0.74	0.20	0.06	0.47	0.27	0.26	0.21	0.40	0.39	0.26	0.34	0.39
	-0.15	0.55	0.34	0.10	0.42	0.33	0.25	0.43	0.30	0.27	0.30	0.35	0.35
	-0.1	0.63	0.25	0.12	0.49	0.30	0.21	0.47	0.29	0.24	0.28	0.38	0.35
CPUE2 (area1)	**-0.05**	0.27	0.41	0.32	0.40	0.34	0.27	0.41	0.33	0.26	0.43	0.31	0.25
	0	0.07	0.32	0.61	0.18	0.37	0.46	0.34	0.34	0.32	0.52	0.27	0.21
	0.05	0.00	0.22	0.78	0.00	0.31	0.69	0.18	0.37	0.46	0.33	0.36	0.30
	0.1	NA	NA	NA	0.00*	0.24*	0.76*	0.00	0.37	0.63	0.29	0.36	0.35
	0.15	NA	NA	NA	NA	NA	NA	0.10	0.26	0.63	0.17	0.34	0.49
	-0.2	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00	0.34	0.66
	-0.15	NA	NA	NA	NA	NA	NA	0.00	0.40	0.60	0.38	0.29	0.33
	-0.1	0.84	0.15	0.01	0.75	0.18	0.07	0.43	0.32	0.25	0.28	0.39	0.33
CPUE3 (area2)	**-0.05**	0.13	0.49	0.38	0.29	0.40	0.30	0.43	0.32	0.25	0.48	0.30	0.22
	0	0.00	0.17	0.83	0.00	0.30	0.70	0.14	0.38	0.48	0.31	0.36	0.33
	0.05	NA	NA	NA	0.00	0.13	0.87	0.00	0.31	0.69	0.12	0.37	0.51
	0.1	NA	NA	NA	NA	NA	NA	0.00*	0.25*	0.75*	0.00	0.33	0.67
	0.15	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00	0.22	0.78
	-0.2	0.89*	0.11*	0.01*	0.77*	0.13*	0.10*	0.38	0.29	0.33	0.25	0.34	0.41
	-0.15	0.82	0.16	0.02	0.64	0.22	0.14	0.19	0.42	0.40	0.28	0.38	0.34
	-0.1	0.67	0.26	0.07	0.49	0.32	0.19	0.33	0.36	0.31	0.38	0.34	0.28
CPUE4 (area2)	**-0.05**	0.22	0.43	0.35	0.36	0.35	0.29	0.46	0.30	0.24	0.47	0.31	0.22
	0	0.02	0.27	0.71	0.05	0.38	0.57	0.26	0.37	0.36	0.42	0.30	0.28
	0.05	0.00	0.16	0.84	0.16	0.23	0.61	0.30	0.28	0.42	0.15	0.42	0.42
	0.1	NA	NA	NA	0.00*	0.21*	0.79*	0.00	0.35	0.65	0.26	0.33	0.41
	0.15	NA	NA	NA	NA	NA	NA	0.00	0.34	0.66	0.22	0.30	0.48
	-0.2	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.20	0.27	0.54
	-0.15	NA	NA	NA	NA	NA	NA	0.00	0.44	0.56	0.20	0.37	0.43
	-0.1	0.85	0.14	0.00	0.75	0.20	0.05	0.41	0.33	0.26	0.41	0.32	0.27
CPUE5 (area3)	**-0.05**	0.11	0.50	0.40	0.29	0.40	0.31	0.41	0.33	0.26	0.38	0.35	0.27
	0	0.00	0.14	0.86	0.00	0.26	0.74	0.16	0.35	0.48	0.39	0.30	0.30
	0.05	NA	NA	NA	0.00*	0.11*	0.89*	0.00	0.29	0.71	0.08	0.39	0.53
	0.1	NA	NA	NA	NA	NA	NA	0.00*	0.16*	0.84*	0.00	0.33	0.67
	0.15	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00	0.28	0.72
	-0.2	0.92*	0.07*	0.01*	0.48*	0.33*	0.19*	0.12	0.38	0.49	0.31	0.30	0.39
	-0.15	0.85	0.13	0.01	0.67	0.22	0.11	0.19	0.42	0.39	0.28	0.36	0.36
	-0.1	0.66	0.26	0.07	0.54	0.31	0.16	0.48	0.29	0.23	0.45	0.31	0.24
CPUE6 (area3)	**-0.05**	0.19	0.43	0.38	0.34	0.35	0.31	0.42	0.31	0.26	0.43	0.31	0.26
	0	0.02	0.27	0.70	0.07	0.36	0.57	0.25	0.38	0.37	0.34	0.37	0.29
	0.05	0.00*	0.12*	0.88*	0.00	0.27	0.73	0.09	0.37	0.54	0.31	0.35	0.34
	0.1	NA	NA	NA	0.00*	0.15*	0.85*	0.11	0.28	0.61	0.22	0.35	0.43
	0.15	NA	NA	NA	NA	NA	NA	0.00	0.29	0.71	0.09	0.35	0.56

CPUE lambda over B/Bmsy status

Scenerio2: Median mixing rate

		Recent 33 yrs data			Recent 20 yrs data			Recent 10 yrs data			Recent 5 yrs data		
		B/Bmsy < 0.2	0.2 < B/Bmsy < 1	B/Bmsy > 1	B/Bmsy < 0.2	0.2 < B/Bmsy < 1	B/Bmsy > 1	B/Bmsy < 0.2	0.2 < B/Bmsy < 1	B/Bmsy > 1	B/Bmsy < 0.2	0.2 < B/Bmsy < 1	B/Bmsy > 1
CPUE1 (area1)	**-0.2**	0.90*	0.08*	0.02*	0.39	0.26	0.35	0.31	0.35	0.34	0.20	0.36	0.44
	-0.15	0.83	0.14	0.03	0.24	0.44	0.31	0.35	0.37	0.28	0.50	0.27	0.24
	-0.1	0.67	0.25	0.07	0.42	0.36	0.22	0.40	0.34	0.25	0.42	0.31	0.27
	-0.05	0.23	0.45	0.32	0.40	0.34	0.25	0.38	0.35	0.26	0.43	0.32	0.25
	0	0.00	0.27	0.73	0.21	0.31	0.48	0.31	0.34	0.35	0.35	0.35	0.30
	0.05	NA	NA	NA	0.00	0.20	0.80	0.27	0.27	0.45	0.30	0.37	0.33
	0.1	NA	NA	NA	NA	NA	NA	0.00	0.25	0.75	0.26	0.32	0.41
	0.15	NA	NA	NA	NA	NA	NA	0.00*	0.22*	0.78*	0.00	0.34	0.66
CPUE2 (area1)	**-0.2**	0.74	0.21	0.06	0.39	0.29	0.32	0.26	0.38	0.36	0.33	0.32	0.35
	-0.15	0.74	0.19	0.06	0.51	0.28	0.22	0.47	0.30	0.24	0.21	0.43	0.36
	-0.1	0.53	0.34	0.13	0.41	0.36	0.24	0.35	0.38	0.27	0.42	0.33	0.26
	-0.05	0.32	0.38	0.30	0.40	0.34	0.26	0.41	0.32	0.27	0.42	0.32	0.26
	0	0.03	0.33	0.64	0.20	0.36	0.45	0.35	0.34	0.31	0.34	0.37	0.30
	0.05	0.00	0.19	0.81	0.19	0.23	0.58	0.29	0.31	0.41	0.41	0.32	0.28
	0.1	NA	NA	NA	0.00	0.24	0.76	0.12	0.32	0.56	0.30	0.36	0.34
	0.15	NA	NA	NA	NA	NA	NA	0.00	0.28	0.72	0.21	0.30	0.50
CPUE3 (area2)	**-0.2**	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00	0.36	0.64
	-0.15	NA	NA	NA	NA	NA	NA	0.33	0.33	0.34	0.12	0.41	0.47
	-0.1	0.83	0.16	0.01	0.69	0.23	0.08	0.42	0.31	0.27	0.51	0.28	0.22
	-0.05	0.16	0.47	0.36	0.32	0.38	0.29	0.40	0.33	0.27	0.43	0.33	0.24
	0	0.00	0.17	0.83	0.00	0.29	0.71	0.21	0.35	0.44	0.27	0.37	0.37
	0.05	NA	NA	NA	0.00*	0.17*	0.83*	0.00	0.34	0.66	0.07	0.39	0.54
	0.1	NA	NA	NA	NA	NA	NA	0.00*	0.25*	0.75*	0.00	0.34	0.66
	0.15	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00	0.25	0.75
CPUE4 (area2)	**-0.2**	0.97*	0.03*	0.00*	0.00*	0.53*	0.47*	0.40	0.26	0.34	0.22	0.36	0.42
	-0.15	0.85	0.14	0.02	0.62	0.23	0.16	0.21	0.40	0.39	0.34	0.34	0.32
	-0.1	0.64	0.27	0.09	0.51	0.31	0.18	0.44	0.30	0.26	0.40	0.32	0.28
	-0.05	0.20	0.45	0.35	0.35	0.35	0.30	0.43	0.31	0.25	0.45	0.31	0.24
	0	0.00	0.28	0.72	0.15	0.35	0.51	0.29	0.35	0.36	0.46	0.29	0.25
	0.05	0.00	0.17	0.83	0.00	0.28	0.72	0.00	0.43	0.57	0.21	0.41	0.39
	0.1	NA	NA	NA	0.00*	0.23*	0.77*	0.00	0.37	0.63	0.20	0.36	0.45
	0.15	NA	NA	NA	NA	NA	NA	0.00	0.27	0.73	0.08	0.35	0.57
CPUE5 (area3)	**-0.2**	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00	0.37	0.63
	-0.15	NA	NA	NA	NA	NA	NA	0.00	0.52	0.48	0.14	0.41	0.45
	-0.1	0.83	0.17	0.01	0.72	0.22	0.06	0.34	0.35	0.31	0.39	0.32	0.29
	-0.05	0.18	0.46	0.37	0.31	0.40	0.29	0.44	0.31	0.25	0.43	0.32	0.25
	0	0.00	0.14	0.86	0.00	0.24	0.76	0.15	0.37	0.48	0.26	0.38	0.36
	0.05	NA	NA	NA	0.00*	0.12*	0.88*	0.00	0.29	0.71	0.30	0.29	0.41
	0.1	NA	NA	NA	NA	NA	NA	0.00*	0.27*	0.73*	0.18	0.26	0.56
	0.15	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.00	0.30	0.70
CPUE6 (area3)	**-0.2**	0.94*	0.06*	0.00*	0.82*	0.12*	0.06*	0.46	0.27	0.27	0.26	0.33	0.40
	-0.15	0.85	0.13	0.02	0.65	0.23	0.12	0.28	0.35	0.38	0.47	0.27	0.26
	-0.1	0.66	0.27	0.06	0.54	0.29	0.17	0.43	0.30	0.26	0.12	0.46	0.42
	-0.05	0.18	0.44	0.38	0.33	0.36	0.31	0.37	0.34	0.29	0.46	0.30	0.24
	0	0.00	0.27	0.73	0.03	0.38	0.59	0.32	0.34	0.34	0.41	0.32	0.26
	0.05	0.00*	0.11*	0.89*	0.00	0.25	0.75	0.09	0.41	0.51	0.25	0.38	0.37
	0.1	NA	NA	NA	0.00*	0.24*	0.76*	0.00	0.32	0.68	0.33	0.31	0.36
	0.15	NA	NA	NA	NA	NA	NA	0.00	0.33	0.67	0.09	0.34	0.57

CPUE lambda over F/Fmsy_status

Scenerio1: Low mixing rate

		Recent 33 yrs data		Recent 20 yrs data		Recent 10 yrs data		Recent 5 yrs data	
		F/Fmsy > 1	**F/Fmsy < 1**	**F/Fmsy > 1**	**F/Fmsy < 1**	**F/Fmsy > 1**	**F/Fmsy < 1**	**F/Fmsy > 1**	**F/Fmsy < 1**
CPUE1 (area1)	**-0.2**	0.69*	0.31*	0.75	0.25	0.50	0.50	0.48	0.52
	-0.15	0.80	0.20	0.57	0.43	0.50	0.50	0.55	0.45
	-0.1	0.70	0.30	0.59	0.41	0.54	0.46	0.54	0.46
	-0.05	0.58	0.42	0.59	0.41	0.59	0.41	0.53	0.47
	0	0.34	0.66	0.41	0.59	0.49	0.51	0.54	0.46
	0.05	NA	NA	0.23	0.77	0.41	0.59	0.54	0.46
	0.1	NA	NA	NA	NA	0.37	0.63	0.47	0.53
	0.15	NA	NA	NA	NA	0.22*	0.78*	0.34	0.66
CPUE2 (area1)	**-0.2**	0.78	0.22	0.51	0.49	0.46	0.54	0.45	0.55
	-0.15	0.76	0.24	0.63	0.37	0.52	0.48	0.53	0.47
	-0.1	0.61	0.39	0.61	0.39	0.54	0.46	0.54	0.46
	-0.05	0.57	0.43	0.56	0.44	0.52	0.48	0.55	0.45
	0	0.39	0.61	0.45	0.55	0.53	0.47	0.57	0.43
	0.05	0.27	0.73	0.34	0.66	0.51	0.49	0.55	0.45
	0.1	NA	NA	0.24*	0.76*	0.42	0.58	0.49	0.51
	0.15	NA	NA	NA	NA	0.33	0.67	0.42	0.58
CPUE3 (area2)	**-0.2**	NA	NA	NA	NA	NA	NA	0.36	0.64
	-0.15	NA	NA	NA	NA	0.47	0.53	0.47	0.53
	-0.1	0.95	0.05	0.74	0.26	0.58	0.42	0.54	0.46
	-0.05	0.62	0.38	0.59	0.41	0.58	0.42	0.61	0.39
	0	0.23	0.77	0.32	0.68	0.44	0.56	0.50	0.50
	0.05	NA	NA	0.18	0.82	0.29	0.71	0.43	0.57
	0.1	NA	NA	NA	NA	0.24*	0.76*	0.36	0.64
	0.15	NA	NA	NA	NA	NA	NA	0.25	0.75
CPUE4 (area2)	**-0.2**	0.75*	0.25*	0.47*	0.53*	0.47	0.53	0.49	0.51
	-0.15	1.00	0.00	0.59	0.41	0.49	0.51	0.53	0.47
	-0.1	0.81	0.19	0.64	0.36	0.55	0.45	0.52	0.48
	-0.05	0.58	0.42	0.56	0.44	0.57	0.43	0.60	0.40
	0	0.32	0.68	0.41	0.59	0.52	0.48	0.49	0.51
	0.05	0.19	0.81	0.30	0.70	0.40	0.60	0.53	0.47
	0.1	NA	NA	0.20*	0.80*	0.36	0.64	0.44	0.56
	0.15	NA	NA	NA	NA	0.29	0.71	0.39	0.61
CPUE5 (area3)	**-0.2**	NA	NA	NA	NA	NA	NA	0.37	0.63
	-0.15	NA	NA	NA	NA	0.73	0.27	0.47	0.53
	-0.1	0.97	0.03	0.85	0.15	0.54	0.46	0.55	0.45
	-0.05	0.61	0.39	0.60	0.40	0.57	0.43	0.58	0.42
	0	0.21	0.79	0.28	0.72	0.44	0.56	0.50	0.50
	0.05	NA	NA	0.15*	0.85*	0.28	0.72	0.40	0.60
	0.1	NA	NA	NA	NA	0.19*	0.81*	0.42	0.58
	0.15	NA	NA	NA	NA	NA	NA	0.22	0.78
CPUE6 (area3)	**-0.2**	1.00*	0.00*	0.62*	0.38*	0.49	0.51	0.44	0.56
	-0.15	0.95	0.05	0.70	0.30	0.57	0.43	0.48	0.52
	-0.1	0.82	0.18	0.66	0.34	0.58	0.42	0.59	0.41
	-0.05	0.56	0.44	0.57	0.43	0.56	0.44	0.56	0.44
	0	0.31	0.69	0.38	0.62	0.48	0.52	0.56	0.44
	0.05	0.16*	0.84*	0.31	0.69	0.40	0.60	0.51	0.49
	0.1	NA	NA	0.19*	0.81*	0.31	0.69	0.45	0.55
	0.15	NA	NA	NA	NA	0.33	0.67	0.38	0.62

CPUE lambda over F/Fmsy_status

Scenerio2: Median mixing rate

		Recent 33 yrs data		Recent 20 yrs data		Recent 10 yrs data		Recent 5 yrs data	
		F/Fmsy > 1	F/Fmsy < 1	F/Fmsy > 1	F/Fmsy < 1	F/Fmsy > 1	F/Fmsy < 1	F/Fmsy > 1	F/Fmsy < 1
CPUE1 (area1)	-0.2	0.48*	0.52*	0.37	0.63	0.51	0.49	0.46	0.54
	-0.15	0.80	0.20	0.57	0.43	0.69	0.31	0.57	0.43
	-0.1	0.80	0.20	0.62	0.38	0.62	0.38	0.45	0.55
	-0.05	0.60	0.40	0.58	0.42	0.55	0.45	0.61	0.39
	0	0.32	0.68	0.42	0.58	0.48	0.52	0.52	0.48
	0.05	NA	NA	0.23	0.77	0.40	0.60	0.55	0.45
	0.1	NA	NA	NA	NA	0.27	0.73	0.42	0.58
	0.15	NA	NA	NA	NA	0.34*	0.66*	0.41	0.59
CPUE2 (area1)	-0.2	1.00	0.00	0.47	0.53	0.51	0.49	0.53	0.47
	-0.15	0.93	0.07	0.56	0.44	0.55	0.45	0.44	0.56
	-0.1	0.71	0.29	0.58	0.42	0.61	0.39	0.55	0.45
	-0.05	0.58	0.42	0.54	0.46	0.52	0.48	0.52	0.48
	0	0.35	0.65	0.50	0.50	0.53	0.47	0.66	0.34
	0.05	0.24	0.76	0.31	0.69	0.43	0.57	0.58	0.42
	0.1	NA	NA	0.26	0.74	0.45	0.55	0.46	0.54
	0.15	NA	NA	NA	NA	0.28	0.72	0.37	0.63
CPUE3 (area2)	-0.2	NA	NA	NA	NA	NA	NA	0.47	0.53
	-0.15	NA	NA	NA	NA	0.57	0.43	0.42	0.58
	-0.1	0.97	0.03	0.74	0.26	0.55	0.45	0.54	0.46
	-0.05	0.61	0.39	0.57	0.43	0.55	0.45	0.59	0.41
	0	0.23	0.77	0.35	0.65	0.46	0.54	0.49	0.51
	0.05	NA	NA	0.09*	0.91*	0.33	0.67	0.48	0.52
	0.1	NA	NA	NA	NA	0.23*	0.77*	0.35	0.65
	0.15	NA	NA	NA	NA	NA	NA	0.24	0.76
CPUE4 (area2)	-0.2	1.00*	0.00*	1.00*	0.00*	0.49	0.51	0.44	0.56
	-0.15	1.00	0.00	0.52	0.48	0.51	0.49	0.52	0.48
	-0.1	0.85	0.15	0.64	0.36	0.57	0.43	0.55	0.45
	-0.05	0.59	0.41	0.55	0.45	0.54	0.46	0.63	0.37
	0	0.31	0.69	0.41	0.59	0.51	0.49	0.55	0.45
	0.05	0.22	0.78	0.30	0.70	0.40	0.60	0.49	0.51
	0.1	NA	NA	0.25*	0.75*	0.43	0.57	0.43	0.57
	0.15	NA	NA	NA	NA	0.30	0.70	0.38	0.62
CPUE5 (area3)	-0.2	NA	NA	NA	NA	NA	NA	0.32	0.68
	-0.15	NA	NA	NA	NA	0.44	0.56	0.44	0.56
	-0.1	0.97	0.03	0.83	0.17	0.61	0.39	0.53	0.47
	-0.05	0.60	0.40	0.61	0.39	0.55	0.45	0.55	0.45
	0	0.21	0.79	0.28	0.72	0.45	0.55	0.58	0.42
	0.05	NA	NA	0.19*	0.81*	0.28	0.72	0.41	0.59
	0.1	NA	NA	NA	NA	0.35*	0.65*	0.30	0.70
	0.15	NA	NA	NA	NA	NA	NA	0.29	0.71
CPUE6 (area3)	-0.2	1.00*	0.00*	0.56*	0.44*	0.56	0.44	0.42	0.58
	-0.15	1.00	0.00	0.84	0.16	0.47	0.53	0.55	0.45
	-0.1	0.83	0.17	0.60	0.40	0.49	0.51	0.55	0.45
	-0.05	0.56	0.44	0.57	0.43	0.56	0.44	0.58	0.42
	0	0.31	0.69	0.40	0.60	0.52	0.48	0.55	0.45
	0.05	0.16*	0.84*	0.27	0.73	0.46	0.54	0.51	0.49
	0.1	NA	NA	0.22*	0.78*	0.34	0.66	0.40	0.60
	0.15	NA	NA	NA	NA	0.25	0.75	0.41	0.59

Mean length lambda over B/Bmsy status

Scenerio1: Low mixing rate

		Recent 33 yrs data			Recent 20 yrs data			Recent 10 yrs data			Recent 5 yrs data		
		B/Bmsy < 0.2	0.2 < B/Bmsy < 1	B/Bmsy > 1	B/Bmsy < 0.2	0.2 < B/Bmsy < 1	B/Bmsy > 1	B/Bmsy < 0.2	0.2 < B/Bmsy < 1	B/Bmsy > 1	B/Bmsy < 0.2	0.2 < B/Bmsy < 1	B/Bmsy > 1
Len1 (area1)	**-0.2**	0.26	0.36	0.38	0.33	0.34	0.33	0.34	0.32	0.33	0.35	0.32	0.33
	-0.15	0.42	0.30	0.28	0.13	0.47	0.40	0.36	0.29	0.35	0.39*	0.37*	0.24*
	-0.1	0.49	0.27	0.24	0.38	0.33	0.29	0.00	0.48	0.52	0.38*	0.33*	0.29*
	-0.05	0.44	0.29	0.27	0.58	0.22	0.21	0.00	0.48	0.52	0.56*	0.22*	0.23*
	0	0.42	0.30	0.28	0.29	0.37	0.34	0.48	0.21	0.31	0.53*	0.25*	0.22*
	0.05	0.29	0.36	0.35	0.39	0.31	0.30	0.36	0.33	0.30	0.00*	0.43*	0.57*
	0.1	0.35	0.33	0.31	0.30	0.37	0.33	0.56	0.21	0.23	0.35	0.37	0.28
	0.15	0.32	0.34	0.34	0.31	0.33	0.36	0.32	0.35	0.33	0.30	0.35	0.35
Len2 (area1)	**-0.2**	0.29	0.35	0.36	0.35	0.33	0.32	0.31	0.34	0.35	0.36	0.32	0.32
	-0.15	0.23	0.38	0.40	0.53	0.25	0.22	0.34	0.36	0.30	0.00*	0.55*	0.45*
	-0.1	0.37	0.34	0.29	0.46	0.28	0.26	0.43	0.26	0.30	0.70*	0.14*	0.16*
	-0.05	0.49	0.25	0.26	0.40	0.32	0.28	0.29	0.34	0.36	0.45*	0.23*	0.32*
	0	0.43	0.28	0.28	0.44	0.28	0.28	0.59	0.18	0.23	0.00*	0.56*	0.44*
	0.05	0.52	0.24	0.24	0.40	0.32	0.28	0.00	0.45	0.55	0.45*	0.31*	0.24*
	0.1	0.30	0.33	0.37	0.30	0.35	0.35	0.46	0.26	0.28	0.00*	0.36*	0.64*
	0.15	0.31	0.35	0.34	0.26	0.36	0.38	0.34	0.34	0.32	0.29	0.35	0.35
Len3 (area2)	**-0.2**	0.39	0.31	0.30	0.39	0.32	0.29	0.33	0.33	0.34	0.30	0.34	0.35
	-0.15	0.24	0.37	0.39	0.21	0.42	0.37	0.15	0.38	0.46	0.00	0.43	0.57
	-0.1	0.36	0.33	0.31	0.20	0.40	0.40	0.17	0.39	0.45	0.25	0.34	0.41
	-0.05	0.36	0.31	0.33	0.29	0.36	0.35	0.15	0.44	0.41	0.39	0.30	0.31
	0	0.25	0.39	0.35	0.46	0.27	0.27	0.36	0.34	0.30	0.38	0.31	0.31
	0.05	0.16	0.40	0.44	0.19	0.41	0.40	0.28	0.38	0.34	0.24	0.37	0.39
	0.1	0.36	0.33	0.31	0.41	0.31	0.27	0.55	0.24	0.21	0.54	0.22	0.24
	0.15	0.34	0.32	0.34	0.29	0.33	0.39	0.35	0.33	0.32	0.36	0.33	0.31
Len4 (area2)	**-0.2**	0.33	0.34	0.33	0.34	0.34	0.32	0.30	0.35	0.35	0.32	0.34	0.35
	-0.15	0.43	0.30	0.27	0.48	0.26	0.26	0.33	0.34	0.33	0.38*	0.29*	0.32*
	-0.1	0.43	0.28	0.29	0.39	0.29	0.32	0.46	0.25	0.28	0.31	0.36	0.33
	-0.05	0.26	0.37	0.38	0.35	0.32	0.33	0.26	0.36	0.38	0.00*	0.44*	0.56*
	0	0.21	0.42	0.37	0.27	0.34	0.39	0.42	0.27	0.31	0.32	0.36	0.32
	0.05	0.37	0.30	0.34	0.29	0.35	0.36	0.22	0.39	0.40	0.00*	0.38*	0.62*
	0.1	0.36	0.31	0.33	0.37	0.32	0.31	0.21	0.37	0.42	0.32	0.35	0.33
	0.15	0.31	0.34	0.35	0.31	0.34	0.35	0.37	0.32	0.31	0.36	0.33	0.32
Len5 (area3)	**-0.2**	0.30	0.32	0.37	0.31	0.35	0.34	0.31	0.36	0.33	0.32	0.33	0.34
	-0.15	0.30	0.37	0.33	0.39	0.34	0.27	0.14	0.43	0.43	0.00	0.48	0.52
	-0.1	0.22	0.39	0.39	0.42	0.32	0.26	0.26	0.39	0.35	0.43	0.27	0.30
	-0.05	0.39	0.32	0.29	0.22	0.42	0.36	0.47	0.28	0.25	0.48	0.25	0.26
	0	0.45	0.29	0.27	0.44	0.30	0.26	0.38	0.30	0.31	0.21	0.38	0.42
	0.05	0.49	0.27	0.24	0.34	0.36	0.30	0.39	0.28	0.32	0.20	0.36	0.44
	0.1	0.33	0.36	0.31	0.35	0.35	0.30	0.33	0.34	0.33	0.35	0.37	0.28
	0.15	0.19	0.39	0.42	0.31	0.29	0.41	0.35	0.31	0.34	0.35	0.33	0.32
Len6 (area3)	**-0.2**	0.34	0.33	0.33	0.37	0.33	0.30	0.36	0.33	0.31	0.35	0.32	0.32
	-0.15	0.31	0.37	0.32	0.49	0.27	0.24	0.38	0.33	0.29	0.56*	0.23*	0.21*
	-0.1	0.40	0.29	0.31	0.29	0.35	0.36	0.60	0.20	0.20	0.28	0.34	0.38
	-0.05	0.32	0.36	0.32	0.36	0.32	0.32	0.00	0.54	0.46	0.00*	0.51*	0.49*
	0	0.22	0.41	0.37	0.29	0.35	0.36	0.20	0.36	0.44	0.32	0.37	0.32
	0.05	0.52	0.23	0.25	0.31	0.36	0.33	0.24	0.43	0.33	0.00	0.48	0.52
	0.1	0.18	0.44	0.38	0.42	0.30	0.28	0.50	0.27	0.23	0.52	0.28	0.20
	0.15	0.30	0.34	0.36	0.26	0.35	0.39	0.29	0.34	0.37	0.31	0.34	0.35

Mean length lambda over B/Bmsy status

Scenerio2: Median mixing rate

		Recent 33 yrs data			Recent 20 yrs data			Recent 10 yrs data			Recent 5 yrs data		
		B/Bmsy < 0.2	0.2 < B/Bmsy < 1	B/Bmsy > 1	B/Bmsy < 0.2	0.2 < B/Bmsy < 1	B/Bmsy > 1	B/Bmsy < 0.2	0.2 < B/Bmsy < 1	B/Bmsy > 1	B/Bmsy < 0.2	0.2 < B/Bmsy < 1	B/Bmsy > 1
	-0.2	0.31	0.34	0.35	0.37	0.32	0.31	0.31	0.34	0.35	0.32	0.35	0.33
	-0.15	0.26	0.40	0.34	0.21	0.37	0.42	0.50	0.23	0.27	0.00	0.46	0.54
	-0.1	0.32	0.33	0.34	0.00	0.54	0.46	0.39	0.36	0.26	0.54*	0.28*	0.17*
Len1	**-0.05**	0.34	0.37	0.30	0.00	0.49	0.51	0.33	0.33	0.34	0.00*	0.51*	0.49*
(area1)	**0**	0.35	0.35	0.30	0.19	0.37	0.43	0.38	0.29	0.33	0.00*	0.48*	0.52*
	0.05	0.15	0.43	0.42	0.50	0.25	0.25	0.62	0.21	0.17	0.00*	0.55*	0.45*
	0.1	0.35	0.30	0.36	0.37	0.33	0.30	0.00	0.46	0.54	0.48*	0.21*	0.32*
	0.15	0.39	0.30	0.31	0.33	0.33	0.34	0.34	0.34	0.33	0.36	0.31	0.33
	-0.2	0.32	0.33	0.35	0.35	0.34	0.32	0.28	0.35	0.37	0.33	0.34	0.33
	-0.15	0.55	0.22	0.23	0.44	0.30	0.26	0.58	0.20	0.22	0.00*	0.58*	0.42*
	-0.1	0.31	0.36	0.34	0.27	0.41	0.32	0.00	0.44	0.56	0.00*	0.52*	0.48*
Len2	**-0.05**	0.18	0.42	0.40	0.26	0.36	0.37	0.59	0.18	0.23	0.00*	0.48*	0.52*
(area1)	**0**	0.41	0.27	0.32	0.00	0.53	0.47	0.00	0.50	0.50	0.00*	0.67*	0.33*
	0.05	0.19	0.40	0.41	0.00	0.47	0.53	0.00	0.54	0.46	0.00*	0.43*	0.57*
	0.1	0.34	0.35	0.31	0.53	0.22	0.25	0.00	0.55	0.45	0.00*	0.55*	0.45*
	0.15	0.34	0.34	0.32	0.33	0.32	0.35	0.39	0.31	0.30	0.35	0.32	0.33
	-0.2	0.34	0.34	0.32	0.38	0.32	0.30	0.27	0.35	0.37	0.34	0.32	0.35
	-0.15	0.37	0.32	0.31	0.44	0.29	0.27	0.50	0.23	0.28	0.51	0.24	0.25
	-0.1	0.35	0.34	0.31	0.43	0.29	0.28	0.27	0.39	0.35	0.36	0.28	0.36
Len3	**-0.05**	0.40	0.29	0.31	0.23	0.40	0.36	0.42	0.32	0.26	0.35	0.35	0.30
(area2)	**0**	0.41	0.30	0.28	0.23	0.39	0.37	0.25	0.36	0.39	0.37	0.30	0.33
	0.05	0.36	0.31	0.33	0.31	0.34	0.34	0.40	0.31	0.28	0.00	0.52	0.48
	0.1	0.21	0.39	0.40	0.25	0.39	0.36	0.25	0.35	0.40	0.00	0.51	0.49
	0.15	0.23	0.37	0.40	0.28	0.33	0.39	0.37	0.32	0.30	0.33	0.35	0.32
	-0.2	0.33	0.35	0.33	0.38	0.33	0.30	0.31	0.34	0.36	0.29	0.35	0.37
	-0.15	0.26	0.37	0.37	0.21	0.40	0.39	0.34	0.31	0.35	0.49*	0.21*	0.30*
	-0.1	0.24	0.39	0.37	0.22	0.40	0.38	0.37	0.38	0.25	0.47	0.27	0.26
Len4	**-0.05**	0.25	0.39	0.36	0.00	0.48	0.52	0.52	0.25	0.22	0.00*	0.63*	0.37*
(area2)	**0**	0.33	0.33	0.35	0.21	0.41	0.39	0.52	0.25	0.23	0.51*	0.26*	0.24*
	0.05	0.25	0.37	0.38	0.00	0.46	0.54	0.00	0.51	0.49	0.00*	0.39*	0.61*
	0.1	0.48	0.26	0.26	0.20	0.38	0.42	0.34	0.36	0.30	0.00	0.52	0.48
	0.15	0.36	0.31	0.33	0.37	0.30	0.33	0.34	0.33	0.32	0.37	0.32	0.30
	-0.2	0.24	0.36	0.40	0.36	0.33	0.31	0.36	0.33	0.31	0.30	0.34	0.36
	-0.15	0.37	0.33	0.30	0.40	0.31	0.29	0.35	0.31	0.34	0.00	0.55	0.45
	-0.1	0.41	0.30	0.29	0.35	0.35	0.30	0.23	0.39	0.38	0.47	0.26	0.27
Len5	**-0.05**	0.46	0.27	0.27	0.48	0.28	0.25	0.36	0.35	0.29	0.00	0.53	0.47
(area3)	**0**	0.22	0.42	0.36	0.36	0.37	0.27	0.46	0.30	0.25	0.56	0.25	0.19
	0.05	0.30	0.39	0.31	0.41	0.31	0.29	0.00	0.51	0.49	0.54	0.23	0.23
	0.1	0.42	0.31	0.28	0.33	0.35	0.33	0.37	0.38	0.25	0.00	0.49	0.51
	0.15	0.32	0.30	0.38	0.16	0.35	0.49	0.31	0.32	0.37	0.35	0.32	0.32
	-0.2	0.24	0.37	0.38	0.35	0.33	0.31	0.33	0.34	0.33	0.31	0.34	0.35
	-0.15	0.52	0.24	0.24	0.19	0.42	0.39	0.00	0.50	0.50	0.00*	0.44*	0.56*
	-0.1	0.30	0.36	0.34	0.21	0.46	0.33	0.53	0.26	0.21	0.42	0.30	0.28
Len6	**-0.05**	0.24	0.40	0.37	0.34	0.34	0.32	0.35	0.34	0.32	0.67*	0.17*	0.16*
(area3)	**0**	0.48	0.27	0.25	0.45	0.29	0.26	0.34	0.34	0.32	0.00	0.54	0.46
	0.05	0.35	0.38	0.27	0.33	0.34	0.34	0.36	0.36	0.28	0.53*	0.21*	0.26*
	0.1	0.43	0.28	0.29	0.20	0.36	0.44	0.53	0.26	0.21	0.00	0.50	0.50
	0.15	0.34	0.31	0.35	0.33	0.32	0.35	0.32	0.33	0.35	0.35	0.33	0.32

Mean length lambda over F/Fmsy status

Scenerio1: Low mixing rate

		Recent 33 yrs data		Recent 20 yrs data		Recent 10 yrs data		Recent 5 yrs data	
		F/Fmsy > 1	F/Fmsy < 1	F/Fmsy > 1	F/Fmsy < 1	F/Fmsy > 1	F/Fmsy < 1	F/Fmsy > 1	F/Fmsy < 1
Len1 (area1)	**-0.2**	0.52	0.48	0.52	0.48	0.52	0.48	0.50	0.50
	-0.15	0.55	0.45	0.52	0.48	0.46	0.54	0.63*	0.37*
	-0.1	0.53	0.47	0.63	0.37	0.45	0.55	0.63*	0.37*
	-0.05	0.56	0.44	0.55	0.45	0.48	0.52	0.41*	0.59*
	0	0.50	0.50	0.50	0.50	0.43	0.57	0.60*	0.40*
	0.05	0.59	0.41	0.52	0.48	0.57	0.43	0.54*	0.46*
	0.1	0.47	0.53	0.56	0.44	0.43	0.57	0.46*	0.54*
	0.15	0.45	0.55	0.46	0.54	0.49	0.51	0.50	0.50
Len2 (area1)	**-0.2**	0.51	0.49	0.50	0.50	0.51	0.49	0.51	0.49
	-0.15	0.61	0.39	0.58	0.42	0.53	0.47	0.46*	0.54*
	-0.1	0.54	0.46	0.58	0.42	0.64	0.36	0.73*	0.27*
	-0.05	0.48	0.52	0.63	0.37	0.46	0.54	0.48*	0.52*
	0	0.53	0.47	0.53	0.47	0.50	0.50	0.49*	0.51*
	0.05	0.44	0.56	0.57	0.43	0.64	0.36	0.64*	0.36*
	0.1	0.55	0.45	0.48	0.52	0.66	0.34	0.37*	0.63*
	0.15	0.48	0.52	0.48	0.52	0.49	0.51	0.49	0.51
Len3 (area2)	**-0.2**	0.55	0.45	0.57	0.43	0.51	0.49	0.51	0.49
	-0.15	0.54	0.46	0.52	0.48	0.44	0.56	0.53	0.47
	-0.1	0.60	0.40	0.47	0.53	0.46	0.54	0.57	0.43
	-0.05	0.50	0.50	0.51	0.49	0.58	0.42	0.49	0.51
	0	0.49	0.51	0.47	0.53	0.54	0.46	0.55	0.45
	0.05	0.45	0.55	0.53	0.47	0.47	0.53	0.58	0.42
	0.1	0.44	0.56	0.50	0.50	0.44	0.56	0.58	0.42
	0.15	0.44	0.56	0.44	0.56	0.49	0.51	0.48	0.52
Len4 (area2)	**-0.2**	0.52	0.48	0.53	0.47	0.52	0.48	0.51	0.49
	-0.15	0.54	0.46	0.49	0.51	0.60	0.40	0.62*	0.38*
	-0.1	0.53	0.47	0.52	0.48	0.50	0.50	0.50	0.50
	-0.05	0.49	0.51	0.56	0.44	0.46	0.54	0.38*	0.62*
	0	0.57	0.43	0.44	0.56	0.55	0.45	0.52	0.48
	0.05	0.47	0.53	0.53	0.47	0.47	0.53	0.34*	0.66*
	0.1	0.45	0.55	0.45	0.55	0.51	0.49	0.60	0.40
	0.15	0.47	0.53	0.48	0.52	0.48	0.52	0.49	0.51
Len5 (area3)	**-0.2**	0.48	0.52	0.51	0.49	0.53	0.47	0.51	0.49
	-0.15	0.52	0.48	0.54	0.46	0.55	0.45	0.48	0.52
	-0.1	0.55	0.45	0.54	0.46	0.44	0.56	0.57	0.43
	-0.05	0.52	0.48	0.50	0.50	0.47	0.53	0.56	0.44
	0	0.55	0.45	0.58	0.42	0.51	0.49	0.40	0.60
	0.05	0.53	0.47	0.60	0.40	0.44	0.56	0.53	0.47
	0.1	0.50	0.50	0.54	0.46	0.50	0.50	0.64	0.36
	0.15	0.42	0.58	0.43	0.57	0.48	0.52	0.49	0.51
Len6 (area3)	**-0.2**	0.50	0.50	0.52	0.48	0.53	0.47	0.50	0.50
	-0.15	0.52	0.48	0.48	0.52	0.40	0.60	0.62*	0.38*
	-0.1	0.52	0.48	0.48	0.52	0.47	0.53	0.47	0.53
	-0.05	0.55	0.45	0.52	0.48	0.67	0.33	0.27*	0.73*
	0	0.59	0.41	0.49	0.51	0.50	0.50	0.60	0.40
	0.05	0.46	0.54	0.62	0.38	0.55	0.45	0.46	0.54
	0.1	0.54	0.46	0.59	0.41	0.51	0.49	0.73	0.27
	0.15	0.46	0.54	0.46	0.54	0.47	0.53	0.50	0.50

Mean length lambda over F/Fmsy status

Scenerio2: Median mixing rate

		Recent 33 yrs data		Recent 20 yrs data		Recent 10 yrs data		Recent 5 yrs data	
		F/Fmsy > 1	F/Fmsy < 1	F/Fmsy > 1	F/Fmsy < 1	F/Fmsy > 1	F/Fmsy < 1	F/Fmsy > 1	F/Fmsy < 1
Len1 (area1)	-0.2	0.52	0.48	0.52	0.48	0.50	0.50	0.50	0.50
	-0.15	0.54	0.46	0.67	0.33	0.38	0.62	0.53	0.47
	-0.1	0.47	0.53	0.59	0.41	0.74	0.26	0.76*	0.24*
	-0.05	0.61	0.39	0.51	0.49	0.52	0.48	0.42*	0.58*
	0	0.53	0.47	0.44	0.56	0.38	0.62	0.77*	0.23*
	0.05	0.58	0.42	0.52	0.48	0.51	0.49	0.48*	0.52*
	0.1	0.45	0.55	0.46	0.54	0.48	0.52	0.62*	0.38*
	0.15	0.45	0.55	0.47	0.53	0.51	0.49	0.49	0.51
Len2 (area1)	-0.2	0.49	0.51	0.52	0.48	0.49	0.51	0.50	0.50
	-0.15	0.54	0.46	0.58	0.42	0.54	0.46	0.70*	0.30*
	-0.1	0.49	0.51	0.61	0.39	0.59	0.41	0.49*	0.51*
	-0.05	0.54	0.46	0.47	0.53	0.52	0.48	1.00*	0.00*
	0	0.53	0.47	0.63	0.37	0.43	0.57	0.67*	0.33*
	0.05	0.54	0.46	0.46	0.54	0.67	0.33	0.42*	0.58*
	0.1	0.65	0.35	0.48	0.52	0.47	0.53	0.52*	0.48*
	0.15	0.48	0.52	0.47	0.53	0.50	0.50	0.49	0.51
Len3 (area2)	-0.2	0.60	0.40	0.57	0.43	0.53	0.47	0.50	0.50
	-0.15	0.57	0.43	0.62	0.38	0.44	0.56	0.61	0.39
	-0.1	0.56	0.44	0.43	0.57	0.35	0.65	0.40	0.60
	-0.05	0.51	0.49	0.52	0.48	0.61	0.39	0.46	0.54
	0	0.49	0.51	0.52	0.48	0.37	0.63	0.43	0.57
	0.05	0.47	0.53	0.56	0.44	0.58	0.42	0.45	0.55
	0.1	0.44	0.56	0.49	0.51	0.48	0.52	0.44	0.56
	0.15	0.40	0.60	0.43	0.57	0.49	0.51	0.51	0.49
Len4 (area2)	-0.2	0.54	0.46	0.54	0.46	0.51	0.49	0.51	0.49
	-0.15	0.51	0.49	0.48	0.52	0.42	0.58	0.38*	0.62*
	-0.1	0.51	0.49	0.51	0.49	0.60	0.40	0.31	0.69
	-0.05	0.56	0.44	0.61	0.39	0.67	0.33	0.71*	0.29*
	0	0.51	0.49	0.55	0.45	0.55	0.45	0.52*	0.48*
	0.05	0.48	0.52	0.51	0.49	0.37	0.63	0.31*	0.69*
	0.1	0.58	0.42	0.37	0.63	0.48	0.52	0.65	0.35
	0.15	0.44	0.56	0.47	0.53	0.49	0.51	0.50	0.50
Len5 (area3)	-0.2	0.52	0.48	0.56	0.44	0.55	0.45	0.52	0.48
	-0.15	0.58	0.42	0.59	0.41	0.63	0.37	0.51	0.49
	-0.1	0.59	0.41	0.61	0.39	0.43	0.57	0.37	0.63
	-0.05	0.46	0.54	0.59	0.41	0.60	0.40	0.60	0.40
	0	0.58	0.42	0.60	0.40	0.54	0.46	0.68	0.32
	0.05	0.55	0.45	0.60	0.40	0.52	0.48	0.51	0.49
	0.1	0.40	0.60	0.43	0.57	0.46	0.54	0.44	0.56
	0.15	0.37	0.63	0.37	0.63	0.45	0.55	0.48	0.52
Len6 (area3)	-0.2	0.50	0.50	0.57	0.43	0.52	0.48	0.53	0.47
	-0.15	0.54	0.46	0.48	0.52	0.58	0.42	0.38*	0.62*
	-0.1	0.59	0.41	0.46	0.54	0.76	0.24	0.47	0.53
	-0.05	0.47	0.53	0.49	0.51	0.47	0.53	0.44*	0.56*
	0	0.57	0.43	0.63	0.37	0.44	0.56	0.66	0.34
	0.05	0.49	0.51	0.53	0.47	0.46	0.54	0.48*	0.52*
	0.1	0.55	0.45	0.41	0.59	0.67	0.33	0.64	0.36
	0.15	0.46	0.54	0.45	0.55	0.48	0.52	0.47	0.53