

California Halibut - Southern Stock

Operating Model Report

Kat Meyer, CDFW Julia Coates, CDFW, Julia.Coates@wildlife.ca.gov
Sarah Valencia, SeaChange Analytics Adrian Hordyk, Blue Matter Science Ltd.

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Introduction

This OM was built as part of a project with the California Department of Fish and Wildlife to conduct a Management Strategy Evaluation for the southern California Halibut stock. All parameters in the operating model were based on the 2019 stock assessment (Meyer 2020).

Operating Model

The OM rdata file can be downloaded from [here](#)

Download and import into R using `myOM <- readRDS('OM.rdata')`

Species Information

Species: *Paralichthys californicus*

Common Name: *California Halibut*

Management Agency: CDFW

Region: California, USA

Sponsor: Resource Legacy Fund

Latitude: 34.42083

Longitude: -119.69819

OM Parameters

OM Name: Name of the operating model: HAL_CA

nsim: The number of simulations: 500

proyears: The number of projected years: 50

interval: The assessment interval - how often would you like to update the management system? 4

pstar: The percentile of the sample of the management recommendation for each method: 0.5

maxF: Maximum instantaneous fishing mortality rate that may be simulated for any given age class: 0.8

reps: Number of samples of the management recommendation for each method. Note that when this is set to 1, the mean value of the data inputs is used. 1

Source: A reference to a website or article from which parameters were taken to define the operating model
See full report for details

Stock Parameters

Mortality and age: maxage, R0, M, Msd

maxage: The maximum age of individuals that is simulated. There are maxage+1 (recruitment to age-0) age classes in the storage matrices. maxage is the plus group where all age-classes > maxage are grouped, unless option switched off with OM@cpars\$plusgroup=0 . Single value. Positive integer.

Specified Value(s): 40

Maximum age is believed to be about 30 years old, although individuals of this age are rarely seen today and the maximum age in the available data, and the maximum age observed in the available data was 26. The maximum age in the model was set to 40 to account for the scenarios with lower M.

R0: Initial number of unfished recruits to age-0. This number is used to scale the size of the population to match catch or data, but does not affect any of the population dynamics unless the OM has been conditioned with data. As a result, for a data-limited fishery any number can be used for R0 . In data-rich stocks R0 may be estimated as part of a stock assessment, but for data limited stocks users can choose either an arbitrary number (say, 1000) or choose a number that produces simulated catches in recent historical years that are similar to real world catch data. Single value. Positive real number.

Specified Value(s): 1e+05

R0 was estimated in the 2019 Halibut stock assessment.

M: The instantaneous rate of natural mortality. For each simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. Uniform distribution lower and upper bounds. Non-negative real numbers.

Specified Value(s): 0.1, 0.2

Natural mortality for the California halibut is not well understood, and it was estimated to be within the range of 0.1 – 0.3. Reed and MacCall (1988) estimated M as 0.3 using the method of Pauly (1980) and 0.15 is based on Hoenig’s (1983) method using age of oldest individual.

Use of an approach recommended in the ‘Accepted Practices and Guidelines for Groundfish Stock Assessments’ (PFMC 2017), produces an estimate of 0.22 for females and 0.27 for males based on the maximum ages of 30 and 23, respectively (Then et al 2015). These results are close to the parameters used in the 2010 assessment of California Halibut and for several other related flatfish species (0.3 for male and 0.2 for female). In the OM female mortality was parameterized as ranging from 0.17 to 0.27.

Msd: Inter-annual variation in M expressed as a coefficient of variation of a log-normal distribution. For each simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. If this parameter is positive, yearly M is drawn from a log-normal distribution with a mean specified by $\log(M)$ drawn for that simulation and a standard deviation in log space specified by the value of Msd drawn for that simulation. Uniform distribution lower and upper bounds. Non-negative real numbers

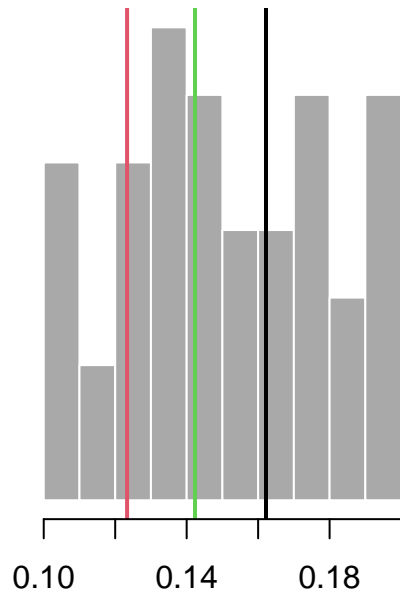
Specified Value(s): 0, 0.05

There is no information on the yearly variability in M. .

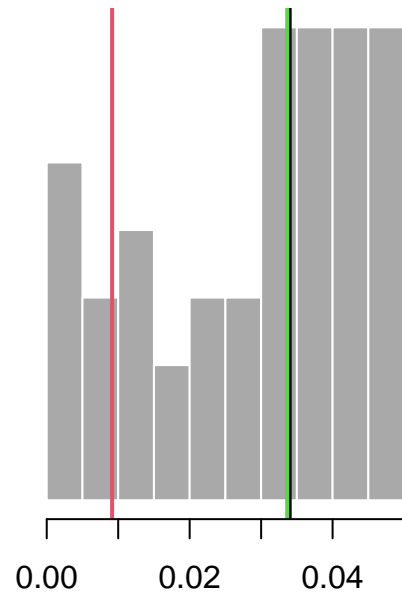
Natural Mortality Parameters

Sampled Parameters Histograms of simulations of M, and Msd parameters, with vertical colored lines indicating 3 randomly drawn values used in other plots:

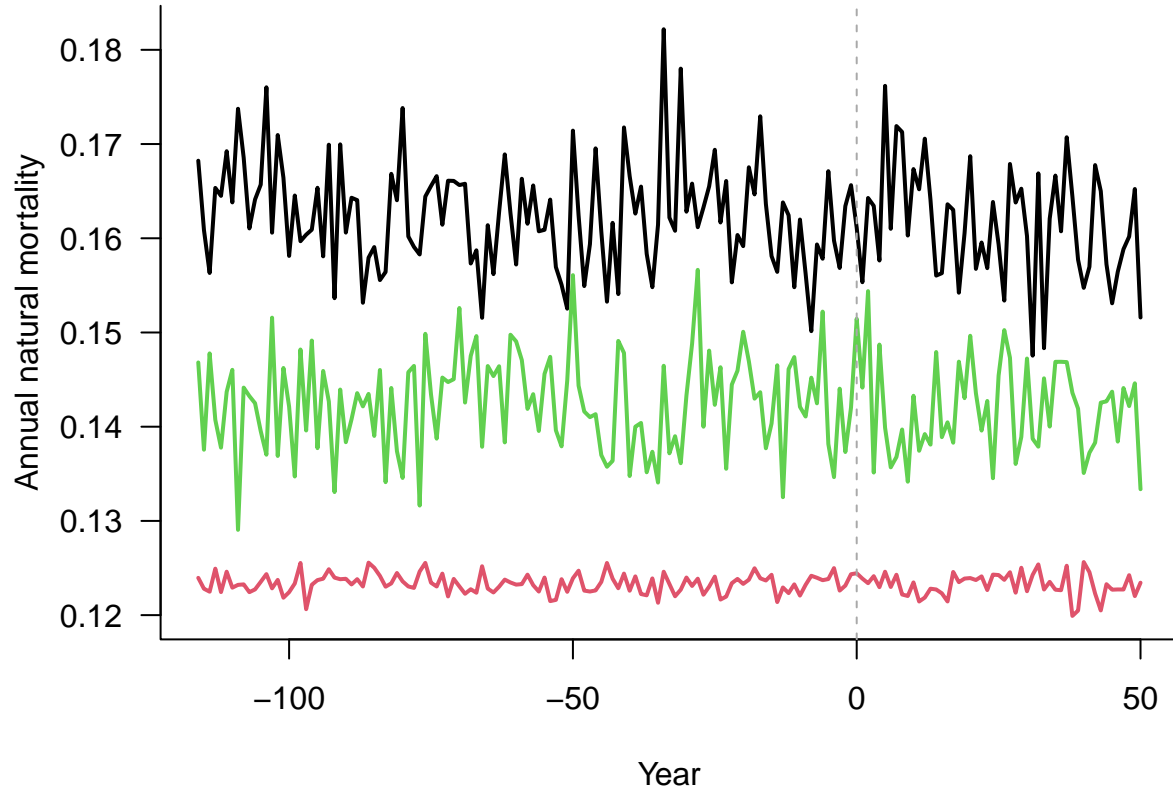
Natural mortality (M)



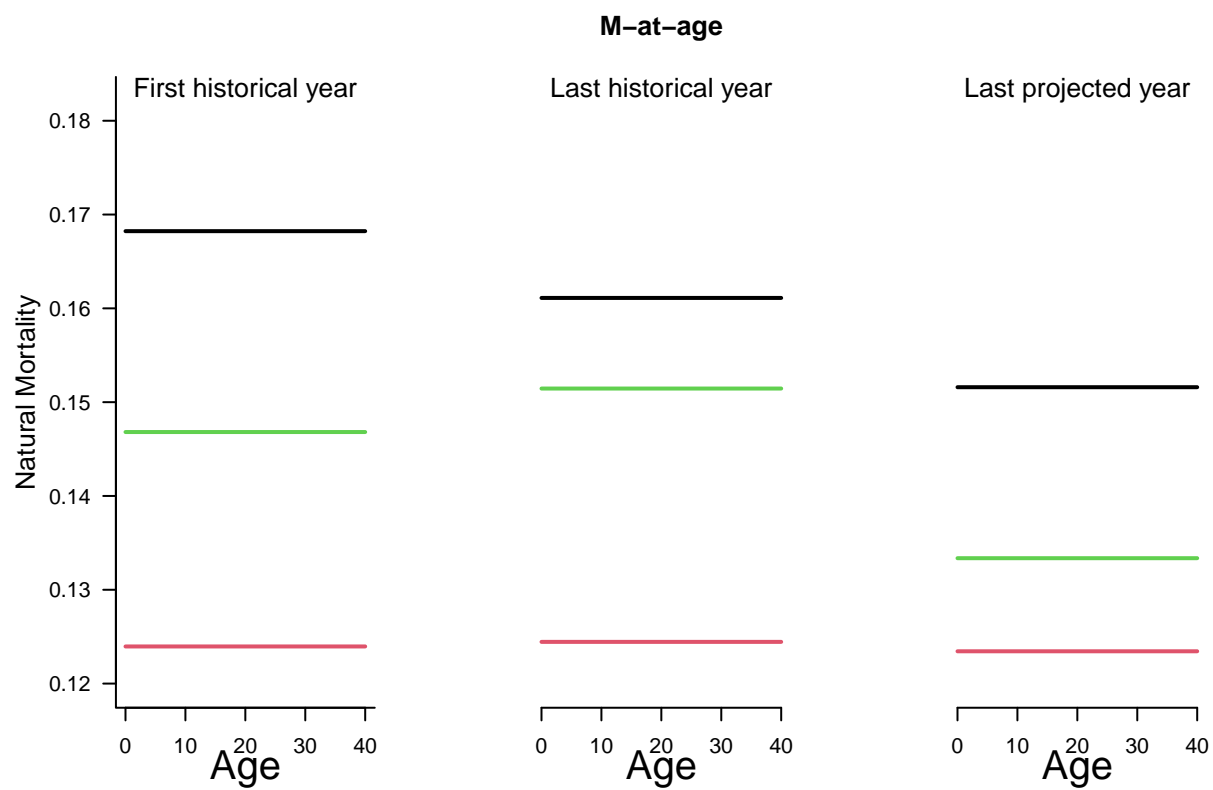
M interannual variability (Msd)



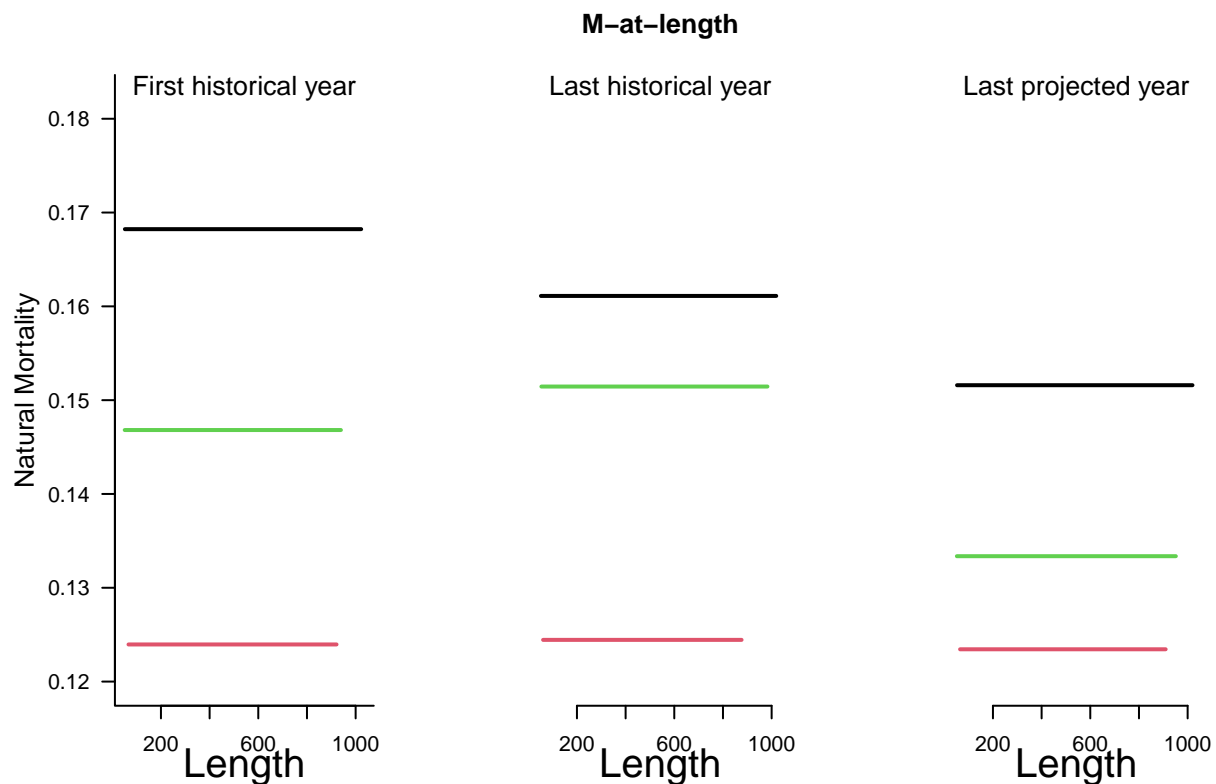
Time-Series The average natural mortality rate by year for adult fish for 3 simulations. The vertical dashed line indicates the end of the historical period:



M-at-Age Natural mortality-at-age for 3 simulations in the first historical year, the last historical year (i.e., current year), and the last projected year:



M-at-Length Natural mortality-at-length for 3 simulations in the first historical year, the last historical year (i.e., current year), and the last projected year:



Recruitment: **h**, **SRrel**, **Perr**, **AC**

h: Steepness of the stock recruit relationship. Steepness governs the proportion of unfished recruits produced when the stock is at 20% of the unfished population size. For each simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. This value is the same in all years of a given simulation. Uniform distribution lower and upper bounds. Values from 1/5 to 1.

Specified Value(s): 0.6, 0.9

There does not appear to be a relationship between spawning stock abundance and the magnitude of recruitment for the range of stock sizes that have been observed (Maunder et al., 2011). The 2011 stock assessment assumed a steepness (h) of 1, which means that recruitment is independent of spawning stock and results in a very low BMSY. The spawning stock appears to have been at low levels for the last three decades, and there may be insufficient contrast in the data to estimate steepness reliably. Therefore there is little confidence in a steepness estimate of 1. However, there is evidence that steepness is high for productive flatfish (van der Veer et al. 2015), and Halibut are likely to be highly productive.

In the updated 2019 stock assessment, the base model assumes a steepness of 0.9. At values below this the model was still able to converge, but estimated stock sizes were very low. In this model we tested a range between 0.7 to 0.95 to account for possible periods of lower productivity.

SRrel: Type of stock-recruit relationship. Use 1 to select a Beverton Holt relationship, 2 to select a Ricker relationship. Single value. Integer

Specified Value(s): 1

A Beverton-Holt stock-recruitment was used.

Perr: Recruitment process error, which is defined as the standard deviation of the recruitment deviations in log space. For each simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. Uniform distribution lower and upper bounds. Non-negative real numbers.

Specified Value(s): 0.3, 0.6

Recruitment is known to be relatively variable, with clear large recruitment years and high autocorrelation. The 2019 stock assessment estimated recruitment variability (σ_R) as 0.6. We assumed this was a mid point and modeled a range of $\pm 20\%$ on each side.

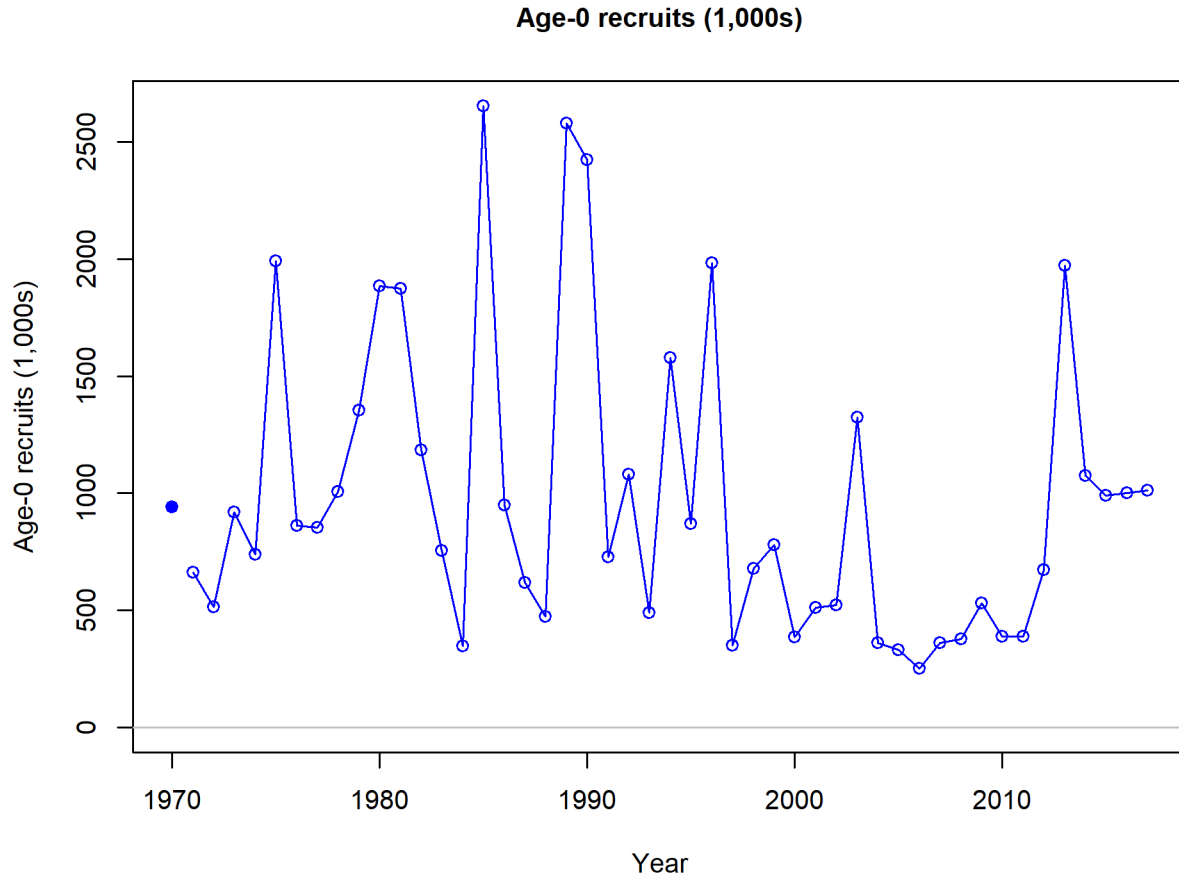


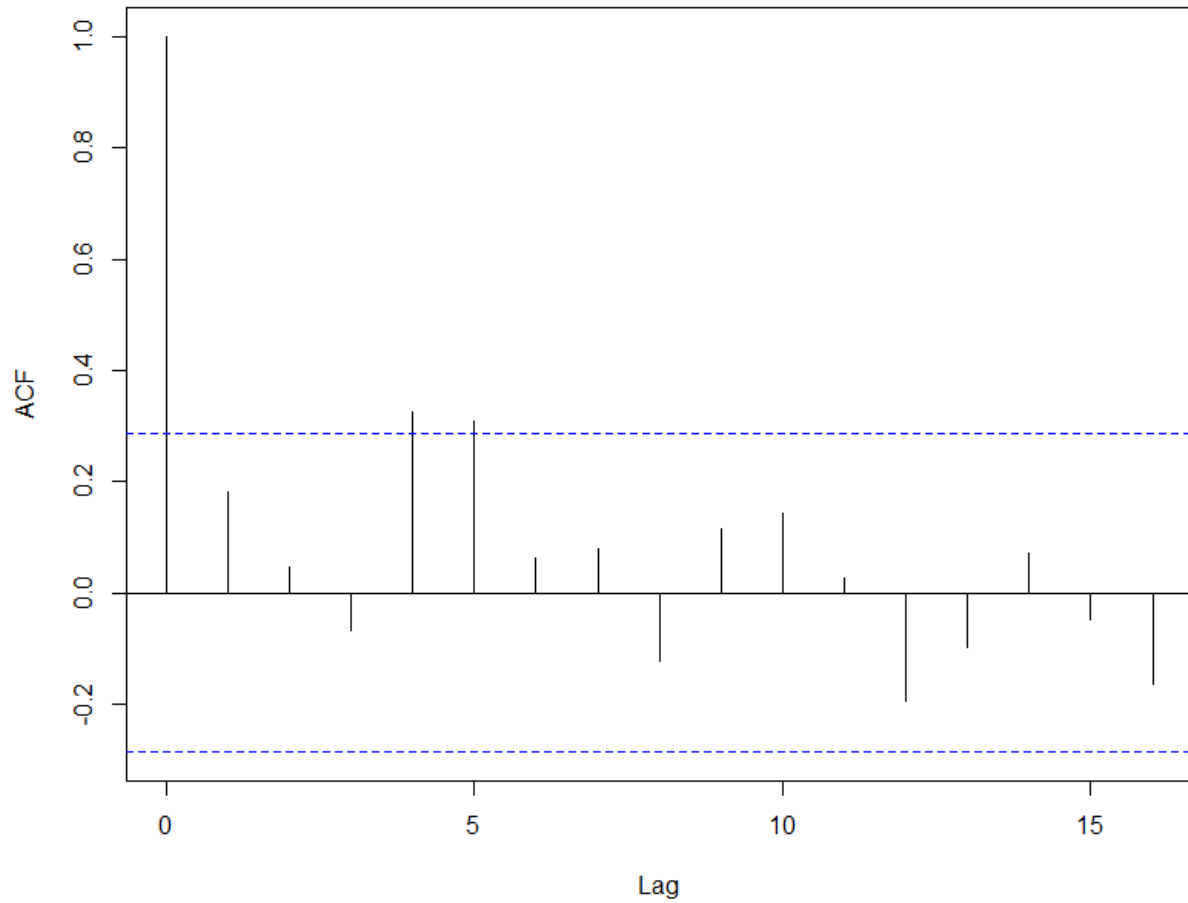
Figure 1: Recruitment deviations from 2019 stock assessment

AC: Autocorrelation in the recruitment deviations in log space. For each simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided, and used to add lag-1 autocorrelation to the log recruitment deviations. Uniform distribution lower and upper bounds. Non-negative real numbers.

Specified Value(s): 0.5, 0.9

It is believed that strong autocorrelation in recruitment due to favorable environmental conditions may affect recruitment. An analysis of autocorrelation of the recruitment deviations showed that there was significant autocorrelation at lags of 4 and 5 years, which corresponds with the approximate age at maturity for Halibut.

SS output Recruitment Estimates

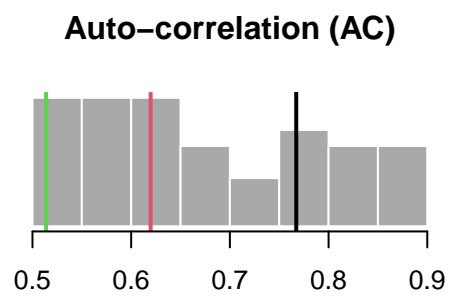
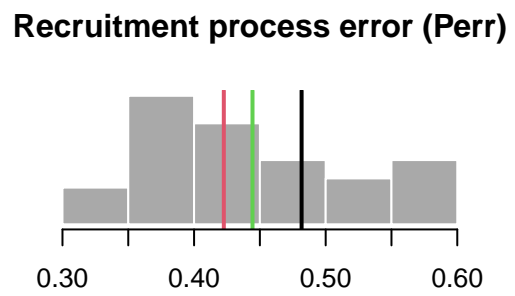
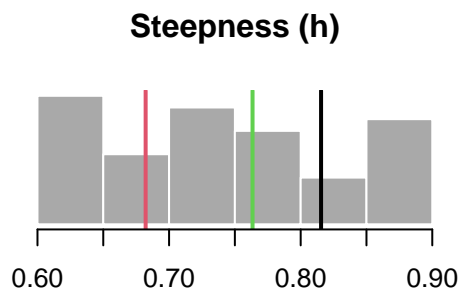


This suggests that a large year class has a ripple effect upn reaching maturity, but does not provide stong evidence for the effect of multiple years of good recruitment based on favorable oceanic conditions, as is believed to occur in the Central California stock. It is possible that, due to the low stock biomass over the last few decades, there have been very few good recruitment years.

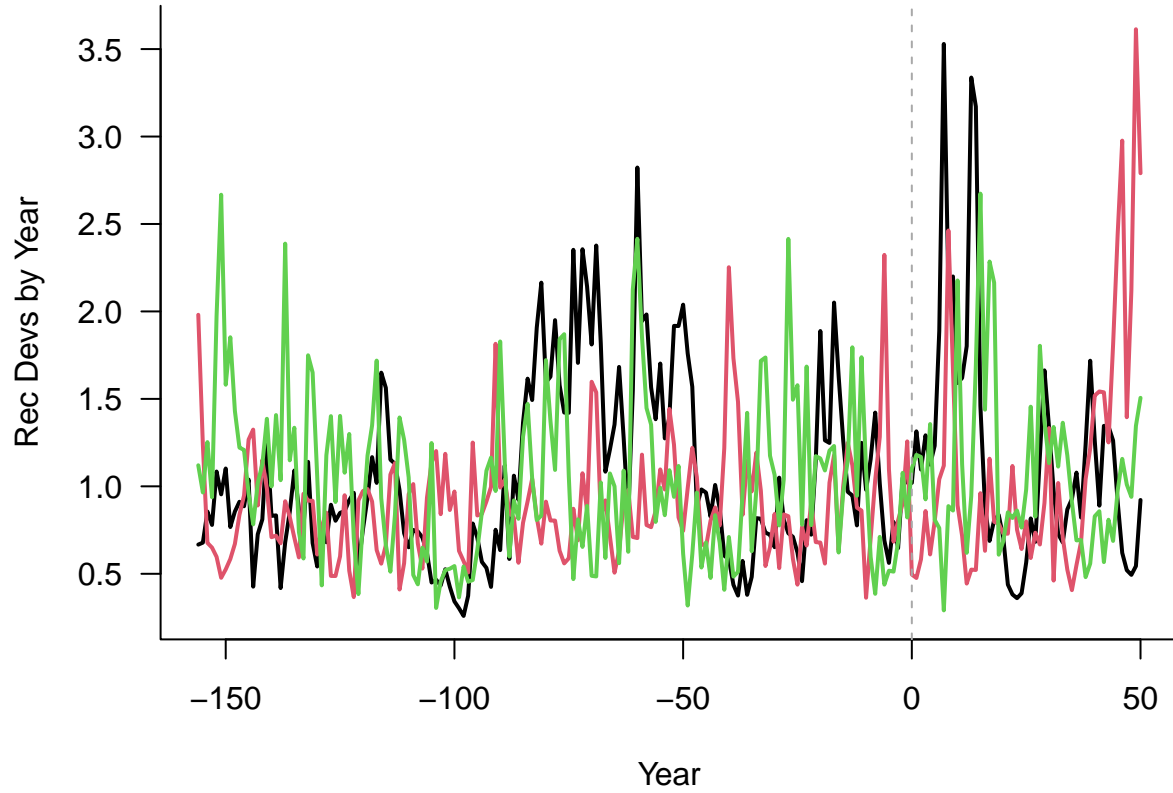
Autocorrelation was estimated from the stock assessment recruitment deviations at 0.684. In the base model we assumed that AC ranged between 0.5 and 0.9.

Recruitment Parameters

Sampled Parameters Histograms of 48 simulations of steepness (**h**), recruitment process error (**Perr**) and auto-correlation (**AC**) for the Beverton-Holt stock-recruitment relationship, with vertical colored lines indicating 3 randomly drawn values used in other plots:



Time-Series Time-series plot showing 3 samples of recruitment deviations for historical and projection years:



Growth: Linf, K, t0, LenCV, Ksd, Linfsd

Linf: The von Bertalanffy growth parameter Linf, which specifies the average maximum size that would be reached by adult fish if they lived indefinitely. For each simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. This value is the same in all years unless Linfsd is a positive number. Uniform distribution lower and upper bounds. Positive real numbers.

Specified Value(s): 821, 1914

Growth has been well studied, but appears to vary between regions (Southern and Central) and perhaps also over time (MacNair et al. 2001, Barnes et al. 2015). Females grow considerably larger than males, and sexual dimorphism in growth is accounted in this model via a two sex model

The von Bertalanffy growth parameters for southern California halibut have been estimated at Linf = 92.53 cm (standard error (SE) 12.14), $K = 0.08$ (0.02) and $t_0 = -2.2$ (0.41) for males, and Linf = 1367.7 mm (273.4), $K = 0.08$ (0.02) and $t_0 = -1.2$ (0.48) for females (MacNair et al. 2001). The ranges for the growth parameters were set at the reported mean \pm the reported standard deviation.

A more recent paper (Barnes et al. 2015) fit growth parameters to more recently collected data, and estimated a smaller Linf for both males and females. It is unknown whether this reduction in the estimated average maximum size is due to a lack of older/larger individuals due to heavy fishing pressure or an environmentally or genetically driven decrease in the maximum size, as has been documented in some other fish (including Pacific Halibut). We are assuming for the base model that the older parameters from MacNair are more representative of the sizes Halibut can attain, which is a more precautionary assumption, as incorrectly assuming a smaller Linf could lead to lower estimates of total mortality and a perceived increase in productivity via higher growth rates. However, this is a source of uncertainty in the model.

K: The von Bertalanffy growth parameter k , which specifies the average rate of growth. For each simulation

a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. This value is the same in all years unless Ksd is a positive number. Uniform distribution lower and upper bounds. Positive real numbers.

Specified Value(s): 0.04, 0.12

t0: The von Bertalanffy growth parameter t_0 , which specifies the theoretical age at a size 0. For each simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. Uniform distribution lower and upper bounds. Non-positive real numbers.

Specified Value(s): -2.16, -0.24

LenCV: The coefficient of variation (defined as the standard deviation divided by mean) of the length-at-age. For each simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided to specify the distribution of observed length-at-age, and the CV of this distribution is constant for all age classes (i.e, standard deviation increases proportionally with the mean). Uniform distribution lower and upper bounds. Positive real numbers.

Specified Value(s): 0.1, 0.15

The 2019 stock assessment assumed a constant CV in length at age of 0.1 throughout the lifespan of Halibut.

Ksd: Inter-annual variation in K. For each simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. If this parameter has a positive value, yearly K is drawn from a log-normal distribution with a mean specified by the value of K drawn for that simulation and a standard deviation (in log space) specified by the value of Ksd drawn for that simulation. Uniform distribution lower and upper bounds. Non-negative real numbers.

Specified Value(s): 0, 0.03

There is no information on how variable growth is from year to year. We assumed a CV of 0-10%.

Linf sd: Inter-annual variation in Linf. For each simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. If this parameter has a positive value, yearly Linf is drawn from a log-normal distribution with a mean specified by the value of Linf drawn for that simulation and a standard deviation (in log space) specified by the value of Linf sd drawn for that simulation. Uniform distribution lower and upper bounds. Non-negative real numbers.

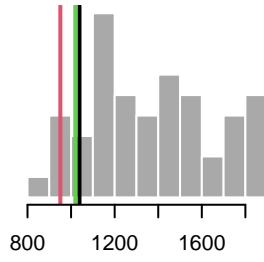
Specified Value(s): 0, 0.03

There is no information on how variable growth is from year to year. We assumed a CV of 0-10%.

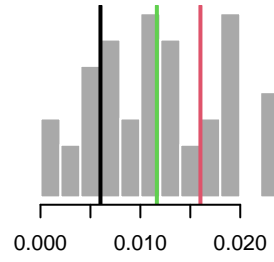
Growth Parameters

Sampled Parameters Histograms of simulations of von Bertalanffy growth parameters Linf, K, and t_0 , and inter-annual variability in Linf and K (Linf sd and Ksd), with vertical colored lines indicating 3 randomly drawn values used in other plots:

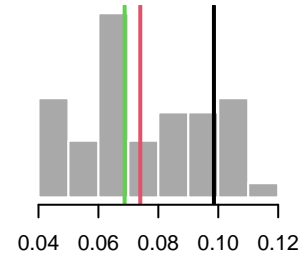
Asymptotic length (Linf)



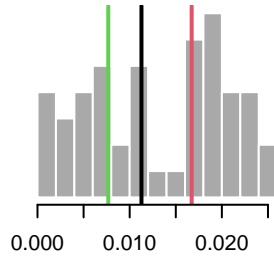
Linf interannual variability (Linf:



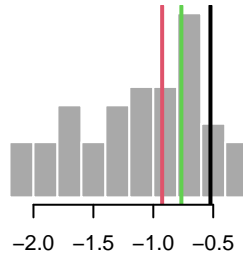
vB growth coefficient (K)



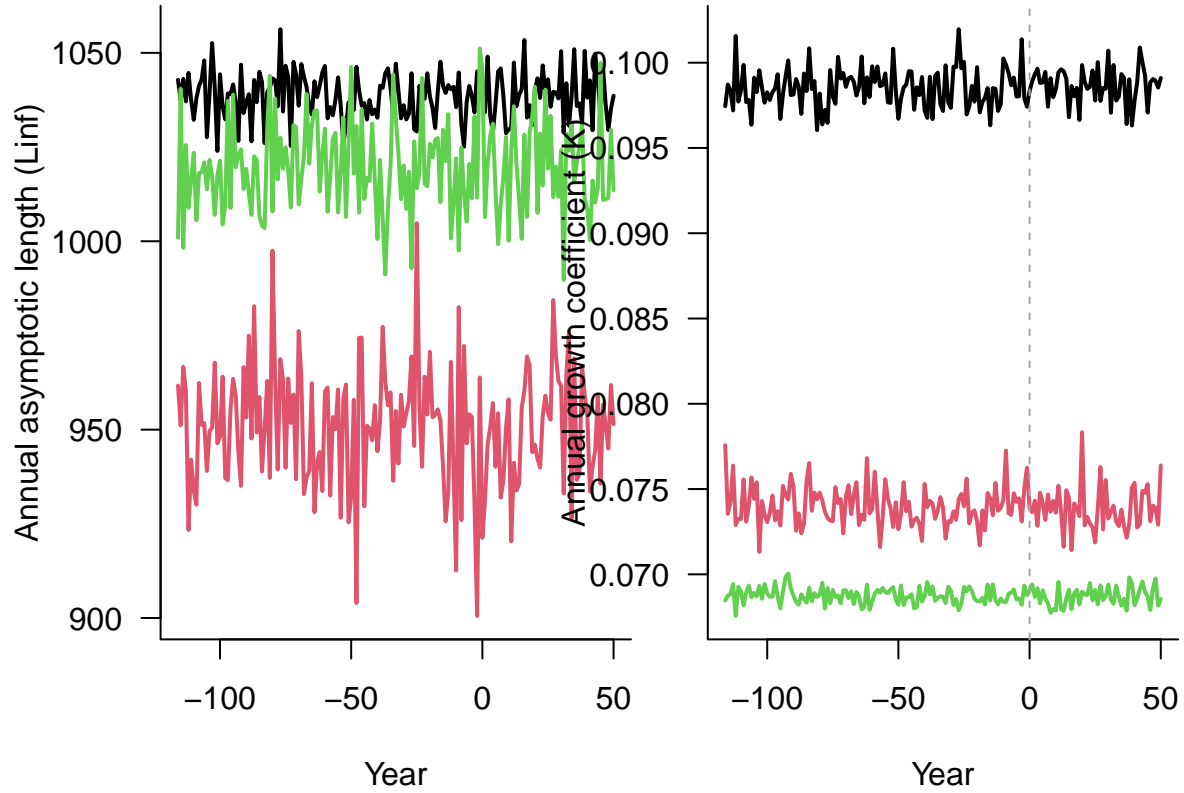
K interannual variability (Ksd)



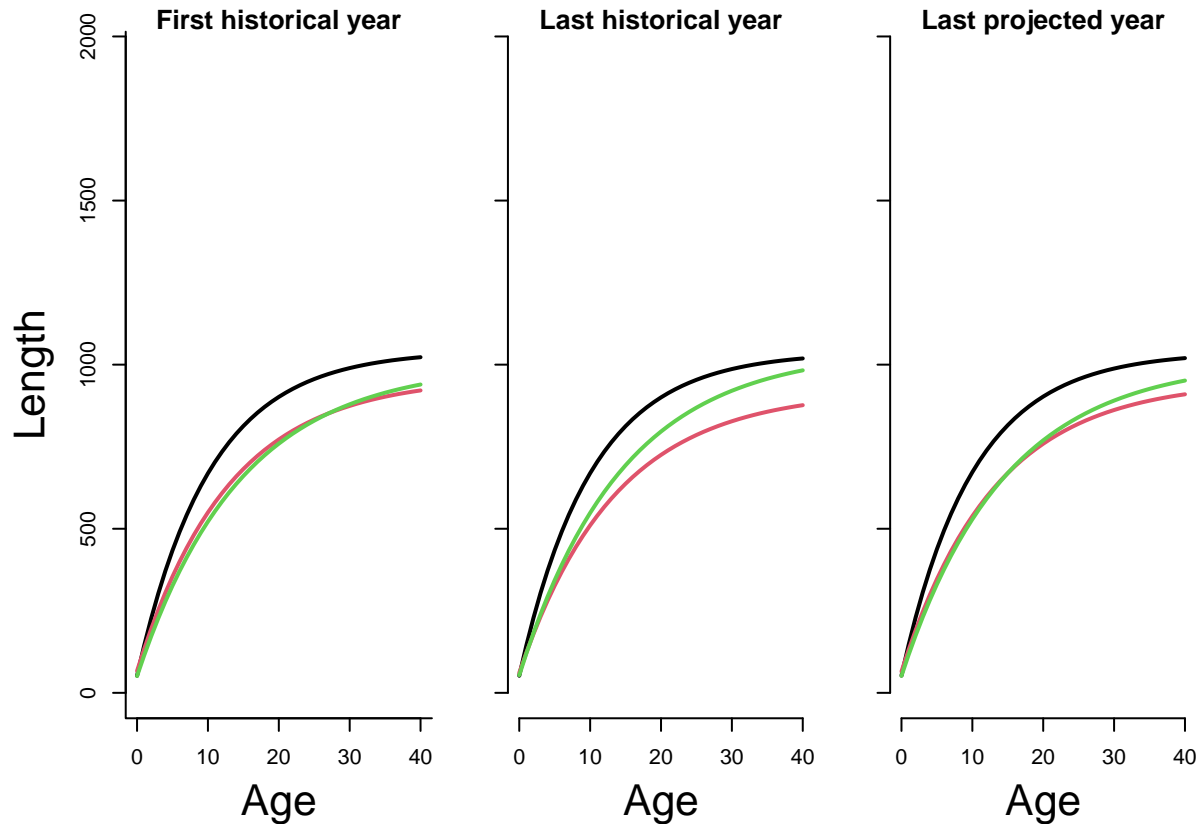
Age at length 0 (t0)



Time-Series The Linf and K parameters in each year for 3 simulations. The vertical dashed line indicates the end of the historical period:



Growth Curves Sampled length-at-age curves for 3 simulations in the first historical year, the last historical year, and the last projection year.



Maturity: L50, L50_95

L50: Length at 50% maturity. For each simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. The L50 and L50_95 parameters are converted to ages using the growth parameters provided and used to construct a logistic curve to determine the proportion of the population that is mature in each age class. Uniform distribution lower and upper bounds. Positive real numbers.

Specified Value(s): 424, 515

Love and Brooks (1990) estimated the size at maturity for the California halibut. They estimated L50 of 471 mm and L95 of about 600 mm for female fish. An L50 of 47.1 cm was used in the 2019 stock assessment.

Lesyna and Barnes 2016 used data provided by Love and Brooks for Southern California Halibut and estimated a slightly smaller L50 (45.5 cm, with a range of 44.8 to 47.2). *Note to us - Kat is checking to see if she fit a different model and why this is different.

We modeled a female range for L50 at the reported value for females (47.1) +/- a CV of 10% (42.4 – 51.5 cm) and L50_95 at 8.0 – 10.0 cm. For males, we modeled a midpoint L50 of 22.7 +/- a CV of 10% (20.43 – 24.97) based on Love and Brooks (1990). The L50_95 was modeled at 8.1 – 14.4 cm.

L50_95: Difference in lengths between 50% and 95% maturity. For each simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. The value drawn is then added to the length at 50% maturity to determine the length at 95% maturity. This parameterization is used instead of specifying the size at 95 percent maturity to avoid situations where the value drawn for the size at 95% maturity is smaller than that at 50% maturity. The L50 and L50_95 parameters are converted to ages using the growth parameters provided and used to construct a logistic curve to determine the proportion of the population that is mature in each age class. Uniform distribution lower and upper bounds. Positive real

numbers.

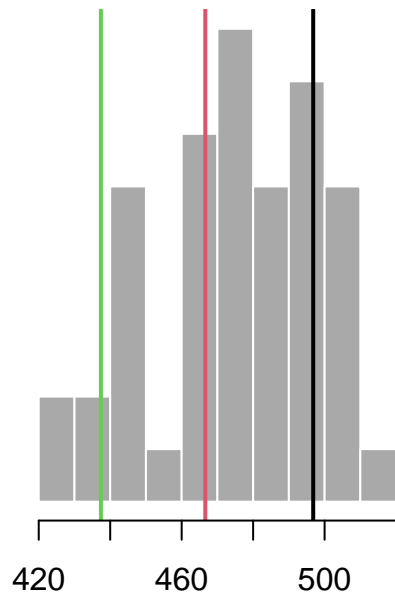
Specified Value(s): 80, 100

See above.

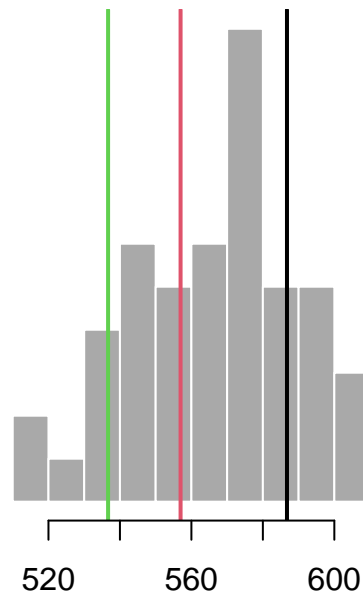
Maturity Parameters

Sampled Parameters Histograms of simulations of L50 (length at 50% maturity), and L95 (length at 95% maturity), with vertical colored lines indicating 3 randomly drawn values used in other plots:

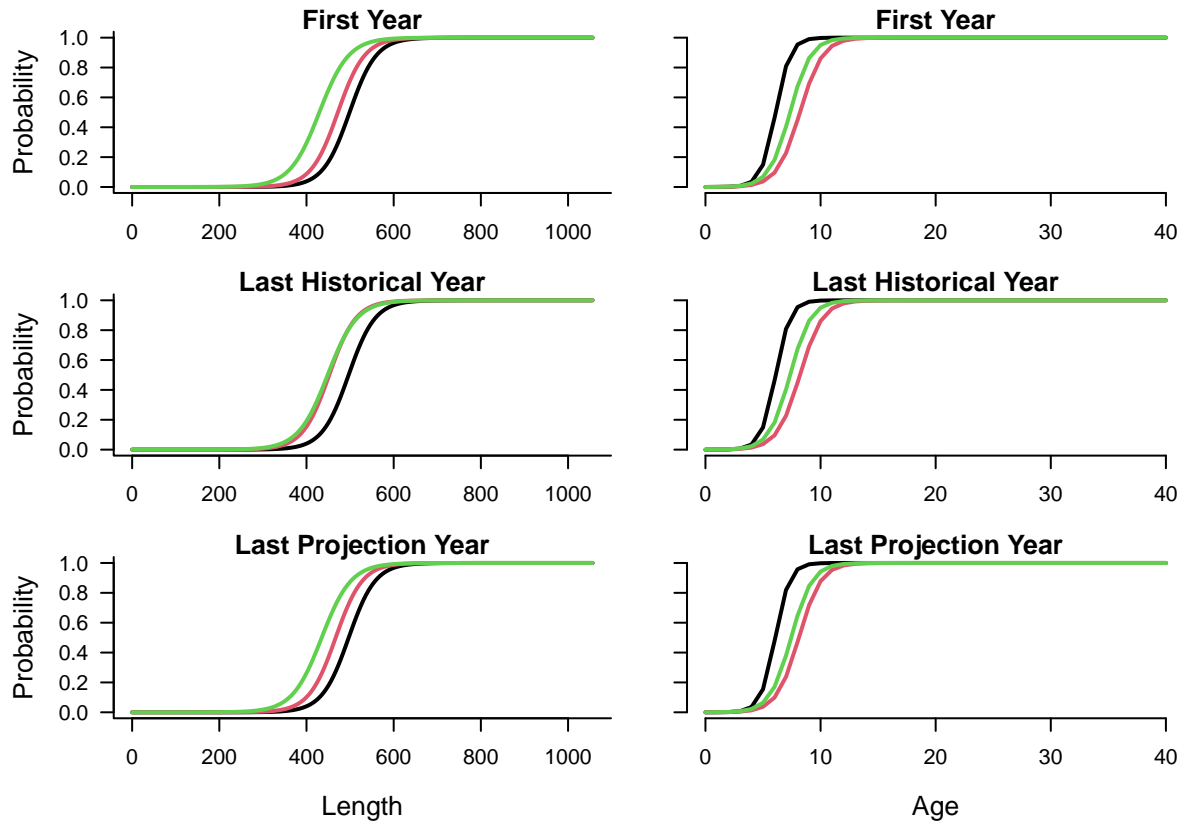
Length at 50% maturity (L50)



Length at 95% maturity (L95)



Maturity at Age and Length Maturity-at-age and -length for 3 simulations in the first historical year, the last historical year (i.e., current year), and the last projected year:



Stock depletion and Discard Mortality: D , F_{disc}

D: Estimated current level of stock depletion, which is defined as the current spawning stock biomass divided by the unfished spawning stock biomass. For each simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. This parameter is used during model initialization to select a series of yearly historical recruitment values and fishing mortality rates that, based on the information provided, could have resulted in the specified depletion level in the simulated last historical year. Uniform distribution lower and upper bounds. Positive real numbers (typically < 1)

Specified Value(s): 0.1, 0.25

The 2019 stock assessment estimated that southern stock of California halibut is at 18% of virgin stock size in the base model. The depletion estimate was highly sensitive to assumptions about a number of parameters, including natural mortality. and the depletions estimates ranged from 9% to $>30\%$. In reflection of this uncertainty about the s set to 0. – 0.25 to reflect the low but uncertain estimate of current stock size.

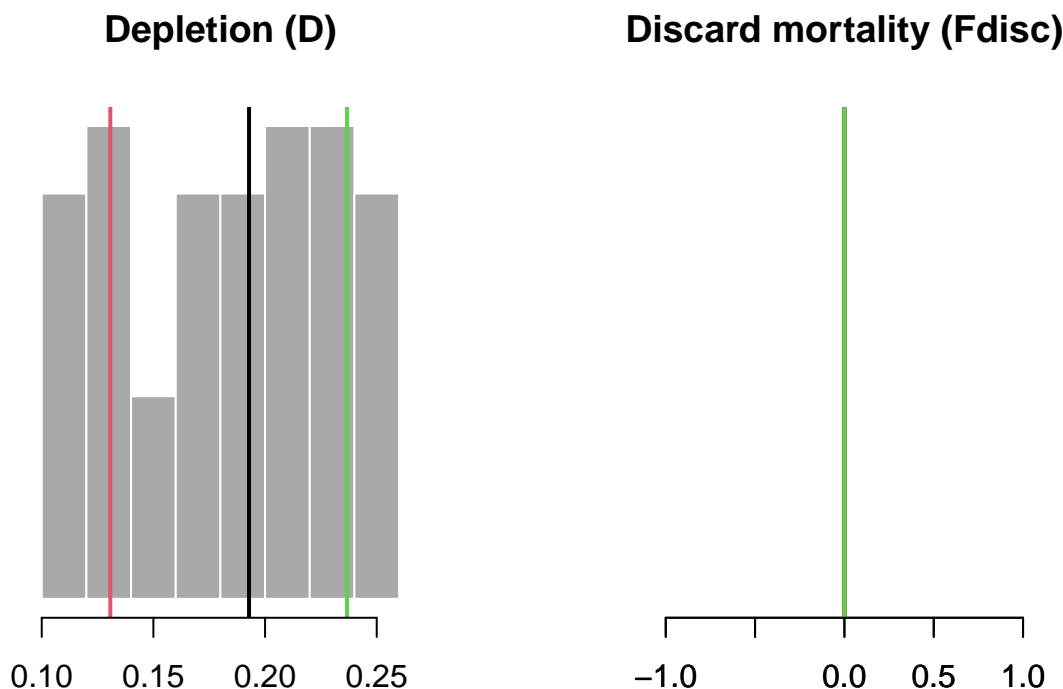
F_{disc} : The instantaneous discard mortality rate the stock experiences when fished using the gear type specified in the corresponding fleet object and discarded. For each simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. Uniform distribution lower and upper bounds. Non-negative real numbers.

Specified Value(s): 0, 0

The discard mortality depends on the gear type used and the handling procedures. In this fishery there are a number of different gear types, and discard mortality rates have been estimated at between 10 and 60%. They are likely to be very low for hook and line gear, but very high for gill net or long tow trawl gear.

Depletion and Discard Mortality

Sampled Parameters Histograms of simulations of depletion (spawning biomass in the last historical year over average unfished spawning biomass; D) and the fraction of discarded fish that are killed by fishing mortality (F_{disc}), with vertical colored lines indicating 3 randomly drawn values.



Length-weight conversion parameters: a, b

a: The alpha parameter in allometric length-weight relationship. Single value. Weight parameters are used to determine catch-at-age and population-at-age from the number of individuals in each age class and the length of each individual, which is drawn from a normal distribution determined by the L_{inf} , K , t_0 , and $LenCV$ parameters. As a result, they function as a way to scale between numbers at age and biomass, and are not stochastic parameters. Single value. Positive real number.

Specified Value(s): 0

These parameters were estimated from unpublished CDFW length-weight data.

*Note it would be helpful to include supporting image.

b: The beta parameter in allometric length-weight relationship. Single value. Weight parameters are used to determine catch-at-age and population-at-age from the number of individuals in each age class and the length of each individual, which is drawn from a normal distribution determined by the L_{inf} , K , t_0 , and $LenCV$ parameters. As a result, they function as a way to scale between numbers at age and biomass, and are not stochastic parameters. Single value. Positive real number.

Specified Value(s): 3.05

See above

Spatial distribution and movement: Size_area_1, Frac_area_1, Prob_staying

Size_area_1: The size of area 1 relative to area 2. The fraction of the unfished biomass in area 1. Please specify numbers between 0 and 1. For each simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. For example, if Size_area_1 is 0.2, then 20% of the total area is allocated to area 1. Fishing can occur in both areas, or can be turned off in one area to simulate the effects of a no take marine reserve. Uniform distribution lower and upper bounds. Positive real numbers.

Specified Value(s): 0.15, 0.25

For this OM this Size_area_1 has been set equal to Frac_area_1 which assumes equal density in Area 1 and Area 2.

Frac_area_1: The fraction of the unfished biomass in area 1. Please specify numbers between 0 and 1. For each simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. For example, if Frac_area_1 is 0.5, then 50% of the unfished biomass is allocated to area 1, regardless of the size of area 1 (i.e, size and fraction in each area determine the density of fish, which may impact fishing spatial targeting). In each time step recruits are allocated to each area based on the proportion specified in Frac_area_1. Uniform distribution lower and upper bounds. Positive real numbers.

Specified Value(s): 0.15, 0.25

We assume no spatial structure in these stocks, so we modeled 2 equally sized areas.

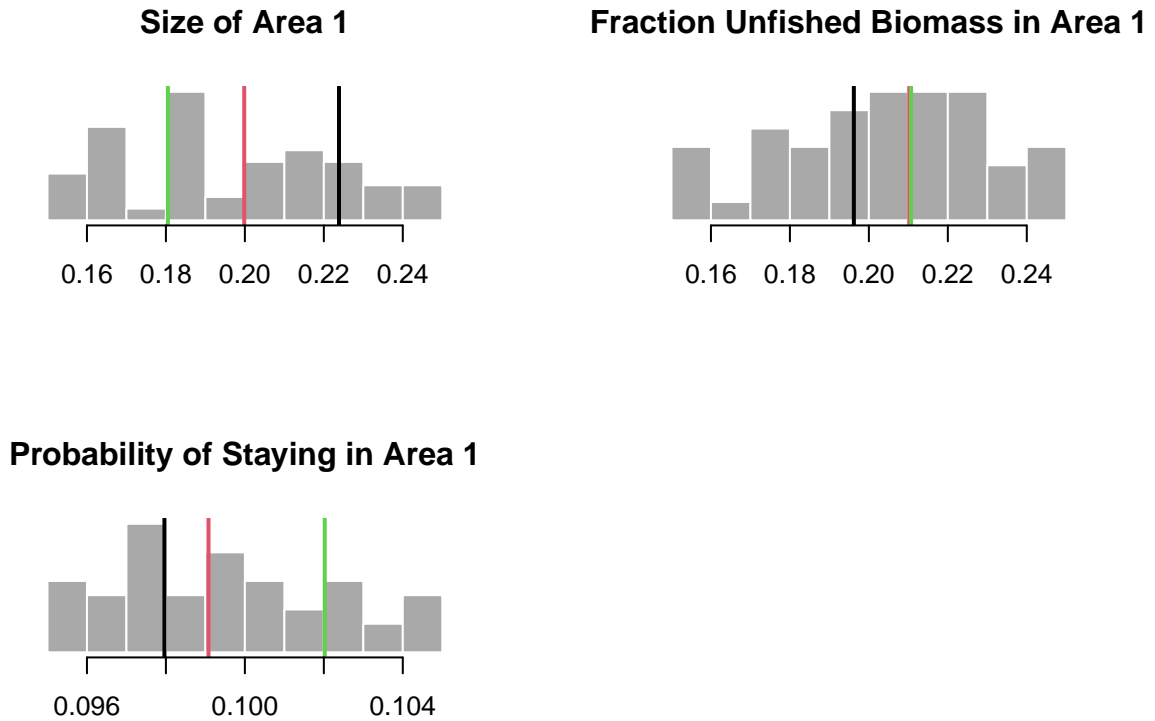
Prob_staying: The probability of individuals in area 1 remaining in area 1 over the course of one year. Please specify numbers between 0 and 1. For each simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. For example, in an area with a Prob_staying value of 0.95 each fish has a 95% probability of staying in that area in each time step, and a 5% probability of moving to the other area. Uniform distribution lower and upper bounds. Positive fraction.

Specified Value(s): 0.1, 0.1

California halibut are highly mobile. We assume they mix freely between areas.

Spatial & Movement

Sampled Parameters Histograms of 48 simulations of size of area 1 (**Size_area_1**), fraction of unfished biomass in area 1 (**Frac_area_1**), and the probability of staying in area 1 in a year (**Prob_staying**), with vertical colored lines indicating 3 randomly drawn values used in other plots:



Fleet Parameters

The Southern California Halibut fleet is composed of a number of different commercial and recreational fleets, including commercial bottom trawl, commercial gillnet, commercial hook and line, the recreational CPFV fleet, and recreational other, which include all other (non-CPFV) modes of fishing such as hook and line from private vessels and piers.

Historical years of fishing, spatial targeting: `nyears`, `Spat_targ`

`nyears`: The number of years for the historical simulation. Single value. For example, if the simulated population is assumed to be unfished in 1975 and this is the year you want to start your historical simulations, and the most recent year for which there is data available is 2019, then `nyears` equals 45.

Specified Value(s): 117

The fishery for California halibut began in the late 1800s. However there is limited data on the fishery other than historical catch prior to 1971. Because of this the stock assessment models the stock from 1971 to 2017, and in the base case model we decided to mirror the assessment, so the number of historical years is 47.

`Spat_targ`: Distribution of fishing in relation to vulnerable biomass (VB) across areas. The distribution of fishing effort is proportional to VB^{Spat_targ} . Upper and lower bounds of a uniform distribution. For each simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. This parameter allows the user to model either avoidance or spatial targeting behavior by the fleet. If the parameter value is 1, fishing effort is allocated across areas in proportion to the population density of that area. Values below 1 simulate an avoidance behavior and values above 1 simulate a targeting behavior.

Specified Value(s): 1, 1

Targeting was assumed proportional to biomass.

Trend in historical fishing effort (exploitation rate), interannual variability in fishing effort: EffYears, EffLower, EffUpper, Esd

EffYears: Vector indicating the historical years where there is information available to infer the relative fishing effort expended. This vector is specified in terms of the position of the year in the vector rather than the calendar year. For example, say our simulation starts with an unfished stock in 1975, and the current year (the last year for which there is data available) is 2019. Then there are 45 historical years simulated, and EffYears should include numbers between 1 and 45. Note that there may not be information available for every historical year, especially for data poor fisheries. In these situations, the EffYears vector should include only the positions of the years for which there is information, and the vector may be shorter than the total number of simulated historical years (nyears).

See nyears (above).

EffLower: Lower bound on relative fishing effort corresponding to EffYears. EffLower must be a vector that is the same length as EffYears describing how fishing effort has changed over time. Information on relative fishing effort can be entered in any units provided they are consistent across the entire vector because the data provided will be scaled to 1 (divided by the maximum number provided).

The 2019 stock assessment produces an estimate of the yearly fishing mortality rate for each fleet. This was used to parameterize historical trends in relative fishing effort. EffLower and EffUpper were calculated by using the point estimate for each year $\pm 20\%$.

Effort in the bottom trawl fleet has been very low since the early 1970s. This is a reflection of the depleted state of this fishery since this time period. Catch rates have been higher in central California, and so bottom trawl effort has been much higher in that region.

Recreational Other has had the highest historical rates of fishing mortality. However, it is also the fleet where there is the least information on fishing effort. This effort trajectory is likely to be a source of uncertainty.

EffUpper: Upper bound on relative fishing effort corresponding to EffYears. EffUpper must be a vector that is the same length as EffYears describing how fishing effort has changed over time. Information on relative fishing effort can be entered in any units provided they are consistent across the entire vector because the data provided will be scaled to 1 (divided by the maximum number provided).

See EffYears

EffYears	EffLower	EffUpper
1900	0.00	0.00
1910	0.10	0.20
1934	0.10	0.20
1939	0.00	0.00
1946	0.00	0.00
1949	0.35	0.65
1964	0.65	0.95
1965	0.65	0.95
1986	0.65	0.75
1989	0.85	1.00
2000	0.85	1.00
2016	0.85	1.00

Esd: Additional inter-annual variability in fishing mortality rate. For each historical simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. If this parameter has a positive (non-zero) value, the yearly fishing mortality rate is drawn from a log-normal distribution with

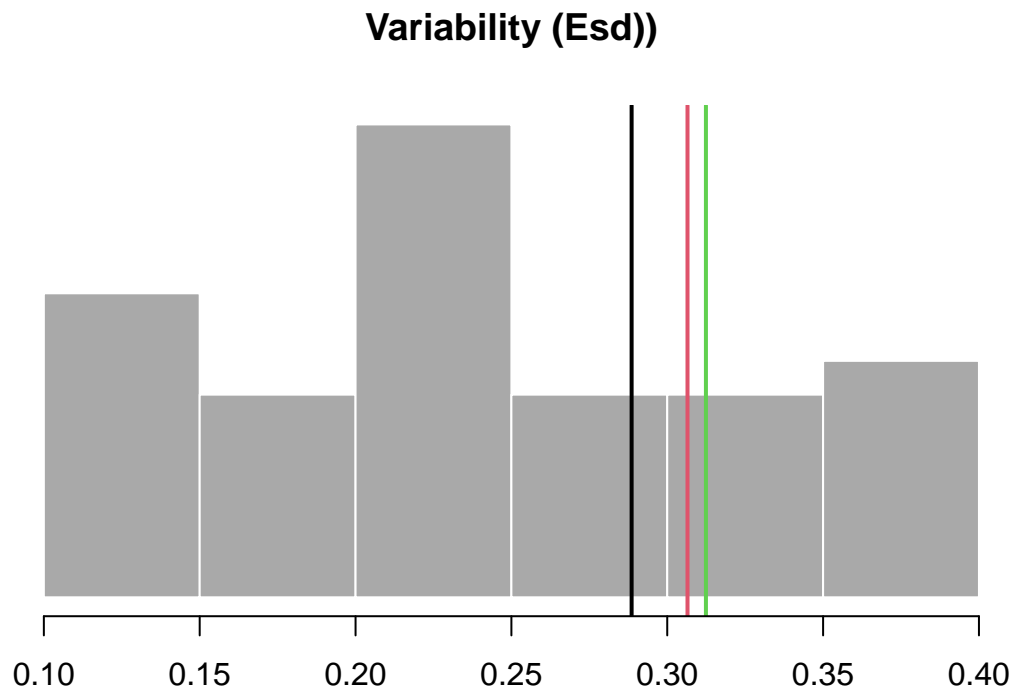
a standard deviation (in log space) specified by the value of `Esd` drawn for that simulation. This parameter applies only to historical projections.

Specified Value(s): 0.1, 0.4

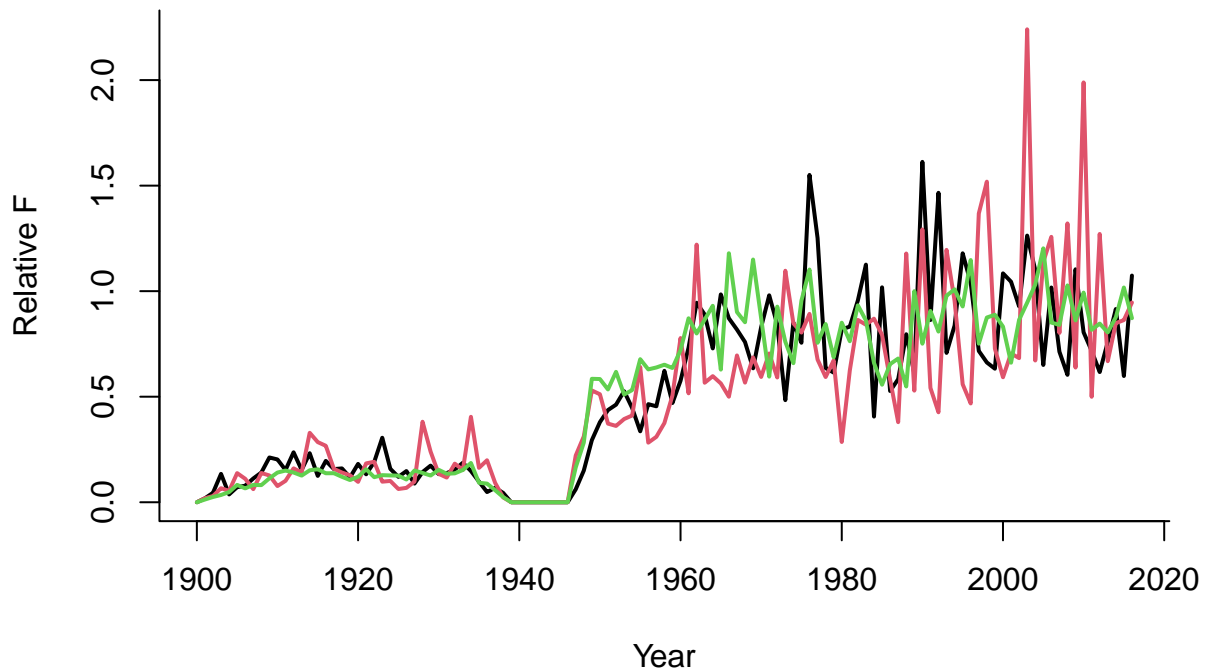
To assess historical interannual variability in fishing effort we calculated the CV of the estimated `F` time series for each fleet. This produced a point estimate of the standard deviation relative to the mean fishing mortality, and then we modeled a range of $\pm 25\%$.

Historical Effort

Sampled Parameters Histograms of 48 simulations of inter-annual variability in historical fishing mortality (`Esd`), with vertical colored lines indicating 3 randomly drawn values used in the time-series plot:



Time-Series Time-series plot showing 3 trends in historical fishing mortality (`OM@EffUpper` and `OM@EffLower` or `OM@cpars$Find`):



Annual increase in catchability, interannual variability in catchability: **qinc**, **qcv**

qinc: Mean temporal trend in catchability (also thought of as the efficiency of fishing gear) parameter, expressed as a percentage change in catchability (q) per year. For each simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. Positive numbers indicate an increase and negative numbers indicate a decrease. q then changes by this amount for in each year of the simulation This parameter applies only to forward projections.

Specified Value(s): 0, 2

There is no evidence of increases or decreases in catchability in the fishery in the last 20+ years. Participation in the commercial bottom trawl and gill net fleets is limited via California limited entry permits system. However, those with a federal bottom trawl permits could switch to targeting halibut in the future, and so future effort in these sectors could potentially increase to some degree. There are no limits to participation in the commercial hook and line, CPFV, and recreational other fleets, and so these could experience effort increases in the future. For the base model we assumed that **qinc** ranged from -0.5 to 0.5% each year across all fleets, but will explore alternative future scenarios in robustness testing.

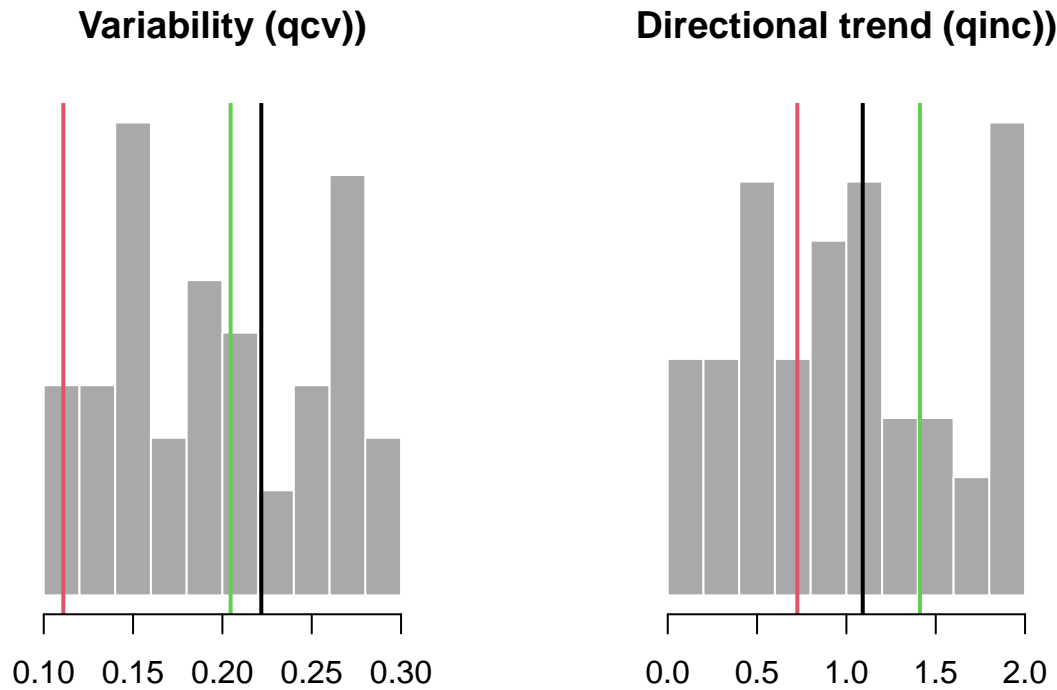
qcv: Inter-annual variability in catchability expressed as a coefficient of variation. For each simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. This parameter applies only to forward projections.

Specified Value(s): 0.1, 0.3

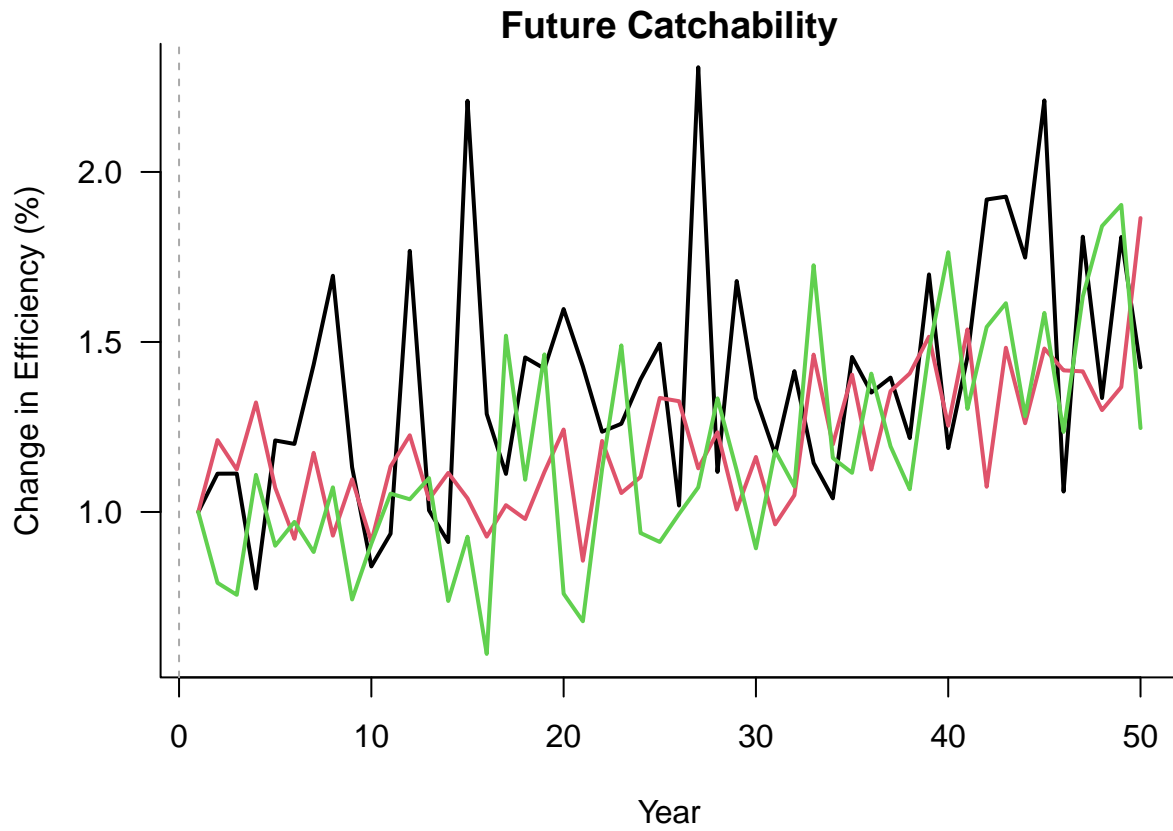
We modeled a range that allows for minimal to moderate variability in catchability from year to year. While the true value is unknown, there are a number of environmental and behavioral factors that can influence the catchability of flatfish from year to year.

Future Catchability

Sampled Parameters Histograms of 48 simulations of inter-annual variability in fishing efficiency (q_{cv}) and average annual change in fishing efficiency (q_{inc}), with vertical colored lines indicating 3 randomly drawn values used in the time-series plot:



Time-Series Time-series plot showing 3 trends in future fishing efficiency (catchability):



Fishery gear length selectivity: L5, LFS, Vmaxlen, isRel

L5: Shortest length at which 5% of the population is vulnerable to selection by the gear used in this fleet. Values can either be specified as lengths (in the same units used for the maturity and growth parameters in the stock object) or as a percentage of the size of maturity (see the parameter isRel for more information). For each simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. This value is the same in all years unless cpars is used to provide time-varying selection.

Specified Value(s): 0, 0

Selectivity is different for males and females in the assessment model due to behavioral differences between the sexes. In general, the selectivity for males is highly dome shaped, and the peak selectivity does not reach 1. This suggests that males are less vulnerable to the fishing gear overall, which may be because males do not aggregate in nearshore waters in the way that females do, and are thus caught less often. In addition, the data suggests larger males are less vulnerable to the fishing gear than mid-sized males. However, the selectivity curves used were estimated outside the model due to minimal size and fleet specific data, and so there is a lot of uncertainty in the selectivity of each gear type, as well as how it interacts with each sex. There is no fishery-independent data available for selectivity benchmarking. Currently, the selectivity of the gill net fleet is assumed to be asymptotic, while that of the other fleets is assumed to be dome shaped for at least one sex, but this is a source of uncertainty that will be explored in robustness testing.

LFS: Shortest length at which 100% of the population is vulnerable to selection by the gear used by this fleet. Values can either be specified as lengths (in the same units used for the maturity and growth parameters in the stock object) or as a percentage of the size of maturity (see the parameter isRel for more information). For each simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. This value is the same in all years unless cpars is used to provide time-varying selection.

Specified Value(s): 0, 0

See SelYears

Vmaxlen: Proportion of fish selected by the gear at the asymptotic length ('Stock@Linf'). Upper and Lower bounds between 0 and 1. A value of 1 indicates that 100% of fish are selected at the asymptotic length, and the selection curve is logistic. If Vmaxlen is less than 1 the selection curve is dome shaped. For example, if Vmaxlen is 0.4, then only 40% of fish are vulnerable to the fishing gear at the asymptotic length.

Specified Value(s): 0, 0

See SelYears

isRel: Specify whether selection and retention parameters use absolute lengths or relative to the size of maturity. Single logical value (TRUE or FALSE).

Specified Value(s): FALSE

Selectivity parameters are in absolute units.

Fishery length retention: LR5, LFR, Rmaxlen, DR

LR5: Shortest length at which 5% of the population is vulnerable to retention by the fleet. Values can either be specified as lengths (in the same units used for the maturity and growth parameters in the stock object) or as a percentage of the size of maturity (see the parameter isRel for more information). For each simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. This value is the same in all years unless cpars is used to provide time-varying selection.

Specified Value(s): 0, 0

This slot was not included in DLMtool at the time the OM was built. The retention curve is assumed to be equivalent to the selectivity curve, which may not be a correct assumption for this fishery. See SelYears for more details.

LFR: Shortest length where 100% of the population is vulnerable to retention by the fleet. Values can either be specified as lengths (in the same units used for the maturity and growth parameters in the stock object) or as a percentage of the size of maturity (see the parameter isRel for more information). For each simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. This value is the same in all years unless cpars is used to provide time-varying selection.

Specified Value(s): 0, 0

See LR5

Rmaxlen: Proportion of fish retained at the asymptotic length ('Stock@Linf'). Upper and Lower bounds between 0 and 1. A value of 1 indicates that 100% of fish are retained at the asymptotic length, and the selection curve is logistic. If Rmaxlen is less than 1 the retention curve is dome shaped. For example, if Rmaxlen is 0.4, then only 40% of fish at the asymptotic length are retained.

Specified Value(s): 1, 1

See LR5

DR: Discard rate, defined as the proportion of fully selected fish that are discarded by the fleet. Upper and Lower bounds between 0 and 1, with a value of 1 indicates that 100% of selected fish are discarded. For each simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided.

Specified Value(s): 0, 0

This slot was not included in DLMtool at the time the OM was built. No general discarding was modelled.

Current Year: CurrentYr

CurrentYr: The last historical year simulated before projections begin. Single value. Note that this should match the last historical year specified in the Data object, which is usually the last historical year for which data is available.

Specified Value(s): 2016

The OM was populated on data from 2016

Existing Spatial Closures: MPA

MPA: Logical argument (TRUE or FALSE). Creates an MPA in Area 1 for all years if true is selected. Defaults to FALSE.

Specified Value(s): FALSE

This slot was not included in DLMtool at the time the OM was built. Historical MPAs have now been included in recent versions of DLMtool.

Obs Parameters

Except where information was found to suggest alternative values, the parameters used for the observation model were based on the values presented in Carruthers et al. (2014) and are found in the ‘Generic_Obs’ observation object in the DLMtool.

Catch statistics: Cobs, Cbiascv, CAA_nsamp, CAA_ESS, CAL_nsamp, CAL_ESS

Cobs: Observation error around the total catch. Observation error in the total catch is expressed as a coefficient of variation (CV). Cobs requires upper and lower bounds of a uniform distribution, and for each simulation a CV is sampled from this distribution. Each CV is used to specify a log-normal error distribution with a mean of 1 and a standard deviation equal to the sampled CV. The yearly observation error values for the catch data are then drawn from this distribution. For each time step the simulation model records the true catch, but the observed catch is generated by applying this yearly error term (plus any bias, if specified) to the true catch.

Specified Value(s): 0.1, 0.3

Borrowed from Generic_Obs

Cbiascv: Log-normally distributed coefficient of variation controlling the sampling bias in observed catch for each simulation. Bias occurs when catches are systematically skewed away from the true catch level (for example, due to underreporting of catch or undetected illegal catches). Cbiascv is a single value specifying the standard deviation of a log-normal distribution with a mean of 1 and a standard deviation equal to the sampled CV. For each simulation a bias value is drawn from this distribution, and that bias is applied across all years.

Specified Value(s): 0.1

Borrowed from Generic_Obs

CAA_nsamp: Number of catch-at-age observations collected per time step. For each time step a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. Positive integers.

Specified Value(s): 100, 200

Borrowed from Generic_Obs

CAA_ESS: Effective sample size of catch-at-age observations collected per time step. For each time step a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. CAA_ESS should not exceed CAA_nsamp. Positive integers.

Specified Value(s): 25, 50

Borrowed from Generic_Obs

CAL_nsamp: Number of catch-at-length observations collected per time step. For each time step a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. Positive integers.

Specified Value(s): 100, 200

Borrowed from Generic_Obs

CAL_ESS: Effective sample size. For each time step a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. CAL_ESS should not exceed CAL_nsamp. Positive integers.

Specified Value(s): 25, 50

Borrowed from Generic_Obs

Index imprecision, bias and hyperstability: Iobs, Btobs, Btbiascv, beta

Iobs: Observation error in the relative abundance index expressed as a coefficient of variation (CV). Iobs requires upper and lower bounds of a uniform distribution, and for each simulation a CV is sampled from this distribution. Each CV is used to specify a log-normal error distribution with a mean of 1 and a standard deviation equal to the sampled CV. The yearly observation error values for the index of abundance data are then drawn from this distribution. For each time step the simulation model records the true change in abundance, but the observed index is generated by applying this yearly error term (plus any bias, if specified) to the true relative change in abundance. Positive real numbers.

Specified Value(s): 0.1, 0.4

Borrowed from Generic_Obs

Btobs: Observation error in the absolute abundance expressed as a coefficient of variation (CV). Btobs requires upper and lower bounds of a uniform distribution, and for each simulation a CV is sampled from this distribution. Each CV is used to specify a log-normal error distribution with a mean of 1 and a standard deviation equal to the sampled CV. The yearly observation error values for the absolute abundance data are then drawn from this distribution. For each time step the simulation model records the true abundance, but the observed abundance is generated by applying this yearly error term (plus any bias, if specified) to the true abundance. Positive real numbers.

Specified Value(s): 0.33, 3

Borrowed from Generic_Obs

Btbiascv: Log-normally distributed coefficient (CV) controlling error in observations of the current stock biomass. Bias occurs when the observed index of abundance is systematically higher or lower than the true relative abundance. Btbiascv is a single value specifying the standard deviation of a log-normal distribution with a mean of 1 and a standard deviation equal to the sampled CV. For each simulation a bias value is drawn from this distribution, and that bias is applied across all years. Positive real numbers.

Specified Value(s): 0.2

Borrowed from Generic_Obs

beta: A parameter controlling hyperstability/hyperdepletion in the measurement of abundance. For each simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. Values below 1 lead to hyperstability (the observed index decreases more slowly than the true

abundance) and values above 1 lead to hyperdepletion (the observed index decreases more rapidly than true abundance). Positive real numbers.

Specified Value(s): 0.8, 1.2

The range for the beta parameter was set to 0.8 – 1.2 to reflect the perceived increased reliability of CPUE data for this stock compared to the “Generic_obs” default values.

Bias in maturity, natural mortality rate and growth parameters: LenMbiascv, Mbiascv, Kbiascv, t0biascv, Linfbiascv

LenMbiascv: Log-normal coefficient of variation for sampling bias in observed length at 50 percent maturity. LenMbiascv is a single value specifying the standard deviation of a log-normal distribution with a mean of 1 and a standard deviation equal to the sampled CV. For each simulation a bias value is drawn from this distribution, and that bias is applied across all years. Positive real numbers.

Specified Value(s): 0.1

Borrowed from Generic_Obs

Mbiascv: Log-normal coefficient of variation for sampling bias in observed natural mortality rate. Uniform distribution lower and upper bounds. Mbiascv is a single value specifying the standard deviation of a log-normal distribution with a mean of 1 and a standard deviation equal to the sampled CV. For each simulation a bias value is drawn from this distribution, and that bias is applied across all years. Positive real numbers.

Specified Value(s): 0.3

The CV for natural mortality was increased to 30% to reflect high uncertainty in this parameter.

Kbiascv: Log-normal coefficient of variation for sampling bias in observed growth parameter K. Kbiascv is a single value specifying the standard deviation of a log-normal distribution with a mean of 1 and a standard deviation equal to the sampled CV. For each simulation a bias value is drawn from this distribution, and that bias is applied across all years. Positive real numbers.

Specified Value(s): 0.1

Borrowed from Generic_Obs

t0biascv: Log-normal coefficient of variation for sampling bias in observed t0. t0biascv is a single value specifying the standard deviation of a log-normal distribution with a mean of 1 and a standard deviation equal to the sampled CV. For each simulation a bias value is drawn from this distribution, and that bias is applied across all years. Positive real numbers.

Specified Value(s): 0.1

Borrowed from Generic_Obs

Linfbiascv: Log-normal coefficient of variation for sampling bias in observed maximum length. Linfbiascv is a single value specifying the standard deviation of a log-normal distribution with a mean of 1 and a standard deviation equal to the sampled CV. For each simulation a bias value is drawn from this distribution, and that bias is applied across all years. Positive real numbers.

Specified Value(s): 0.05

See Kbiascv

Bias in length at first capture, length at full selection: LFCbiascv, LFSbiascv

LFCbiascv: Log-normal coefficient of variation for sampling bias in observed length at first capture. LFCbiascv is a single value specifying the standard deviation of a log-normal distribution with a mean of 1 and a standard deviation equal to the sampled CV. For each simulation a bias value is drawn from this distribution, and that bias is applied across all years. Positive real numbers.

Specified Value(s): 0.05

Borrowed from Generic_Obs

LFSbiascv: Log-normal coefficient of variation for sampling bias in length-at-full selection. LFSbiascv is a single value specifying the standard deviation of a log-normal distribution with a mean of 1 and a standard deviation equal to the sampled CV. For each simulation a bias value is drawn from this distribution, and that bias is applied across all years. Positive real numbers.

Specified Value(s): 0.05

Borrowed from Generic_Obs

Bias in fishery reference points, unfished biomass, FMSY, FMSY/M ratio, biomass at MSY relative to unfished: FMSY_Mbiascv, BMSY_B0biascv

FMSY_Mbiascv: Log-normal coefficient of variation for sampling bias in estimates of the ratio of the fishing mortality rate that gives the maximum sustainable yield relative to the assumed instantaneous natural mortality rate. FMSY/M. FMSY_Mbiascv is a single value specifying the standard deviation of a log-normal distribution with a mean of 1 and a standard deviation equal to the sampled CV. For each simulation a bias value is drawn from this distribution, and that bias is applied across all years. Positive real numbers.

Specified Value(s): 0.2

Borrowed from Generic_Obs

BMSY_B0biascv: Log-normal coefficient of variation for sampling bias in estimates of the BMSY relative to unfished biomass (BMSY/B0). BMSY_B0biascv is a single value specifying the standard deviation of a log-normal distribution with a mean of 1 and a standard deviation equal to the sampled CV. For each simulation a bias value is drawn from this distribution, and that bias is applied across all years. Positive real numbers.

Specified Value(s): 0.2

Borrowed from Generic_Obs

Management targets in terms of the index (i.e., model free), the total annual catches and absolute biomass levels: Irefbiascv, Crefbiascv, Brefbiascv

Irefbiascv: Log-normal coefficient of variation for sampling bias in the observed relative index of abundance (Iref). Irefbiascv is a single value specifying the standard deviation of a log-normal distribution with a mean of 1 and a standard deviation equal to the sampled CV. For each simulation a bias value is drawn from this distribution, and that bias is applied across all years. Positive real numbers.

Specified Value(s): 0.2

Borrowed from Generic_Obs

Crefbiascv: Log-normal coefficient of variation for sampling bias in the observed reference catch (Cref). Crefbiascv is a single value specifying the standard deviation of a log-normal distribution with a mean of 1 and a standard deviation equal to the sampled CV. For each simulation a bias value is drawn from this distribution, and that bias is applied across all years. Positive real numbers.

Specified Value(s): 0.2

Borrowed from Generic_Obs

Brefbiascv: Log-normal coefficient of variation for sampling bias in the observed reference biomass (Bref). Brefbiascv is a single value specifying the standard deviation of a log-normal distribution with a mean of 1 and a standard deviation equal to the sampled CV. For each simulation a bias value is drawn from this distribution, and that bias is applied across all years. Positive real numbers.

Specified Value(s): 0.5

Borrowed from Generic_Obs

Depletion bias and imprecision: **Dbiascv**, **Dobs**

Dbiascv: Log-normal coefficient of variation for sampling bias in the observed depletion level. **Dbiascv** is a single value specifying the standard deviation of a log-normal distribution with a mean of 1 and a standard deviation equal to the sampled CV. For each simulation a bias value is drawn from this distribution, and that bias is applied across all years. Positive real numbers.

Specified Value(s): 0.5

Borrowed from Generic_Obs

Dobs: Log-normal coefficient of variation controlling error in observations of stock depletion among years. Observation error in the depletion expressed as a coefficient of variation (CV). **Dobs** requires the upper and lower bounds of a uniform distribution, and for each simulation a CV is sampled from this distribution. Each CV is used to specify a log-normal error distribution with a mean of 1 and a standard deviation equal to the sampled CV. The yearly observation error values for the depletion data are then drawn from this distribution. For each time step the simulation model records the true depletion, but the observed depletion is generated by applying this yearly error term (plus any bias, if specified) to the true depletion.

Specified Value(s): 0.05, 0.1

Borrowed from Generic_Obs

Recruitment compensation and trend: **hbiascv**, **Recbiascv**, **sigmaRbiascv**

hbiascv: Log-normal coefficient of variation for sampling persistent bias in steepness. **hbiascv** is a single value specifying the standard deviation of a log-normal distribution with a mean of 1 and a standard deviation equal to the sampled CV. For each simulation a bias value is drawn from this distribution, and that bias is applied across all years. Positive real numbers.

Specified Value(s): 0.2

Borrowed from Generic_Obs

Recbiascv: Log-normal coefficient of variation for sampling persistent bias in recent recruitment strength. **Recbiascv** requires the upper and lower bounds of a uniform distribution, and for each simulation a CV is sampled from this distribution. Each CV is used to specify a log-normal error distribution with a mean of 1 and a standard deviation equal to the sampled CV. The yearly bias values for the depletion data are then drawn from this distribution. Positive real numbers.

Specified Value(s): 0.1, 0.3

Borrowed from Generic_Obs

sigmaRbiascv: Log-normal coefficient of variation for sampling persistent bias in recruitment variability. **sigmaRbiascv** is a single value specifying the standard deviation of a log-normal distribution with a mean of 1 and a standard deviation equal to the sampled CV. For each simulation a bias value is drawn from this distribution, and that bias is applied across all years. Positive real numbers.

Specified Value(s): 0.1

No justification provided.

Effort: **Eobs**, **Ebiascv**

Eobs: Observation error around the total effort. Observation error in the total effort is expressed as a coefficient of variation (CV). **Eobs** requires upper and lower bounds of a uniform distribution, and for each simulation a CV is sampled from this distribution. Each CV is used to specify a log-normal error distribution with a mean of 1 and a standard deviation equal to the sampled CV. The yearly observation error values for

the effort data are then drawn from this distribution. For each time step the simulation model records the true effort, but the observed effort is generated by applying this yearly error term (plus any bias, if specified) to the true effort.

Specified Value(s): 0, 0

No justification provided.

Ebiascv: Log-normally distributed coefficient of variation controlling the sampling bias in observed effort for each simulation. Bias occurs when effort is systematically skewed away from the true effort level. Ebiascv is a single value specifying the standard deviation of a log-normal distribution with a mean of 1 and a standard deviation equal to the sampled CV. For each simulation a bias value is drawn from this distribution, and that bias is applied across all years.

Specified Value(s): 0

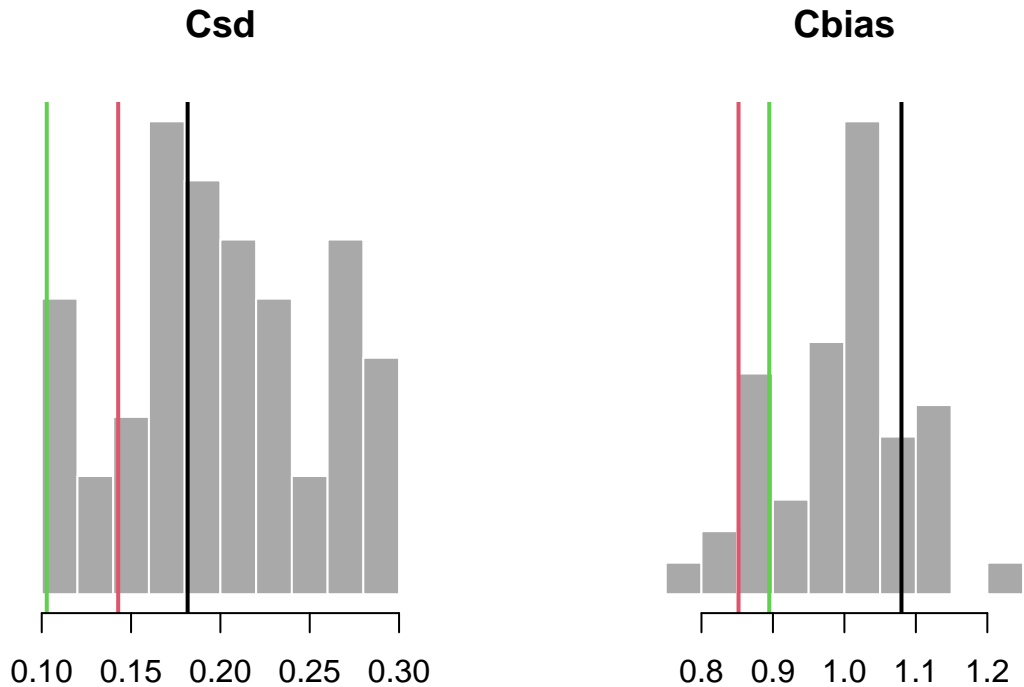
No justification provided.

Obs Plots

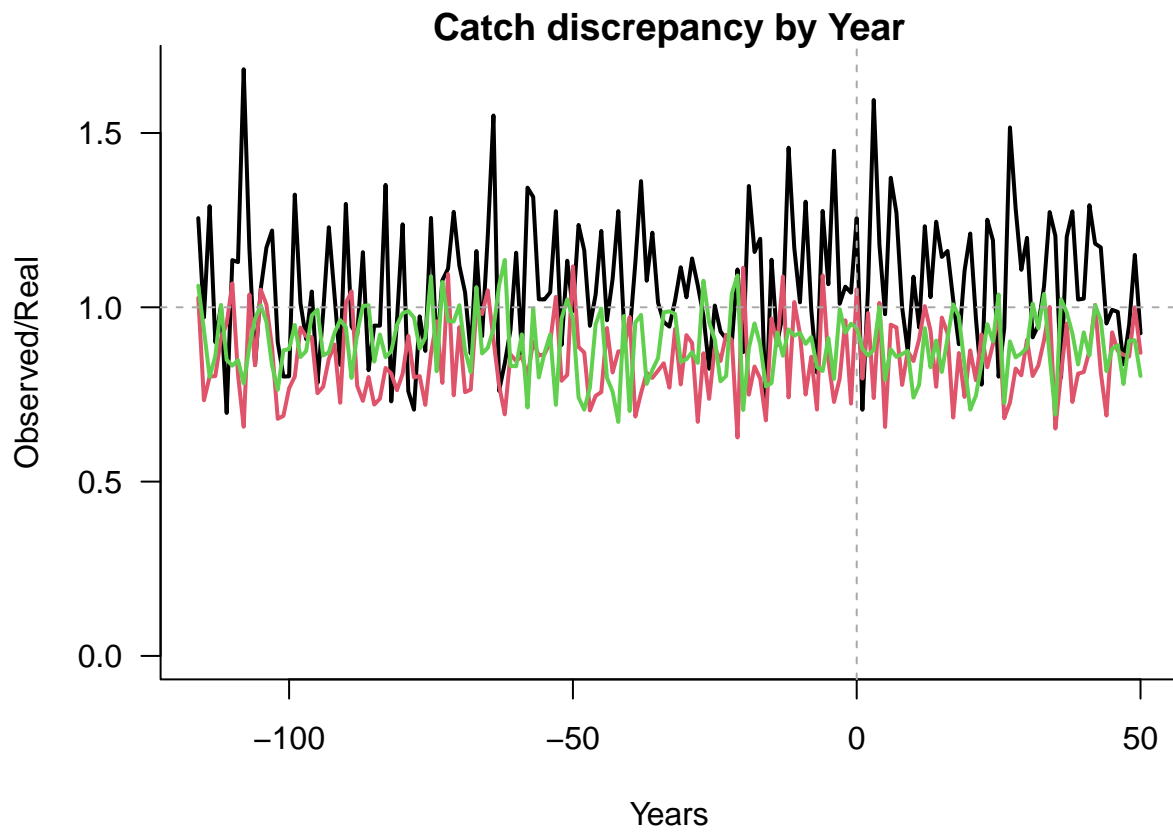
Observation Parameters

Catch Observations

Sampled Parameters Histograms of 48 simulations of inter-annual variability in catch observations (**Csd**) and persistent bias in observed catch (**Cbias**), with vertical colored lines indicating 3 randomly drawn values used in other plots:

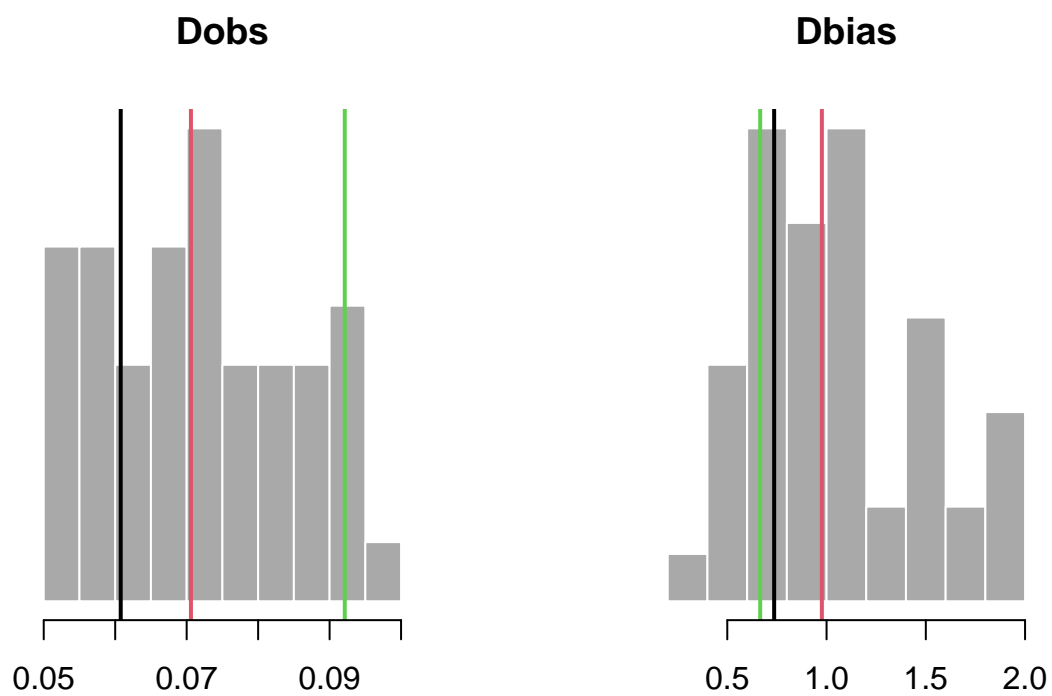


Time-Series Time-series plots of catch observation error for historical and projection years:

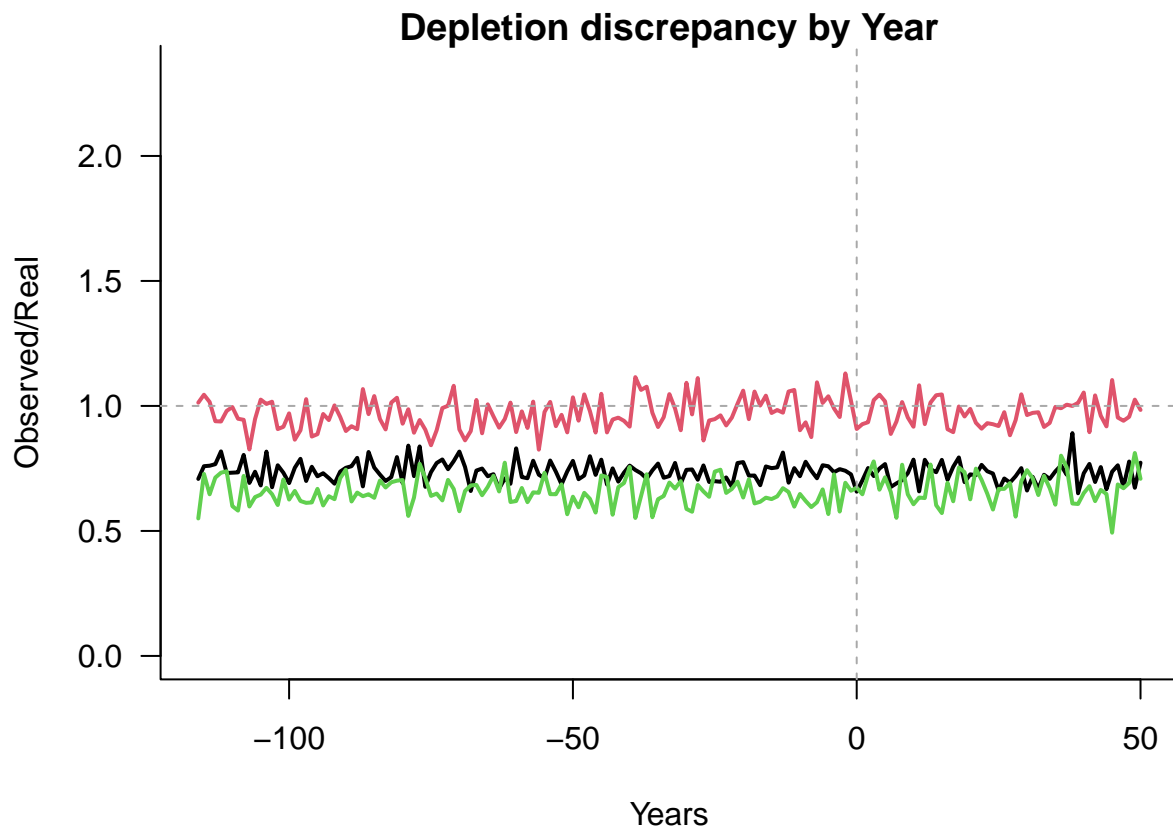


Depletion Observations

Sampled Parameters Histograms of 48 simulations of inter-annual variability in depletion observations (*Dobs*) and persistent bias in observed depletion (*Dbias*), with vertical colored lines indicating 3 randomly drawn values used in other plots:

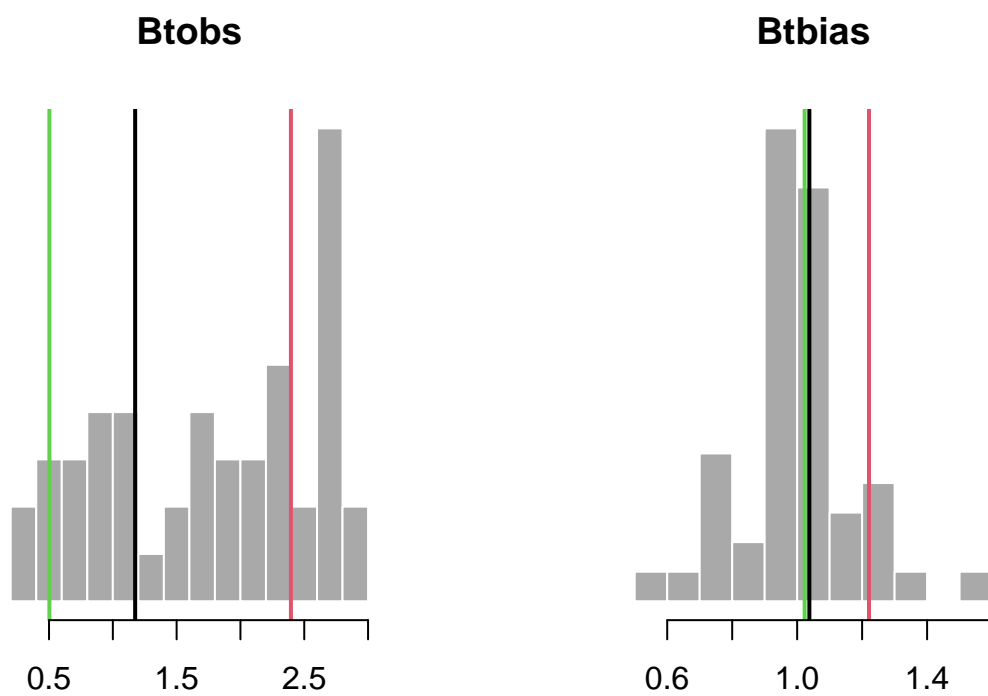


Time-Series Time-series plots of depletion observation error for historical and projection years:

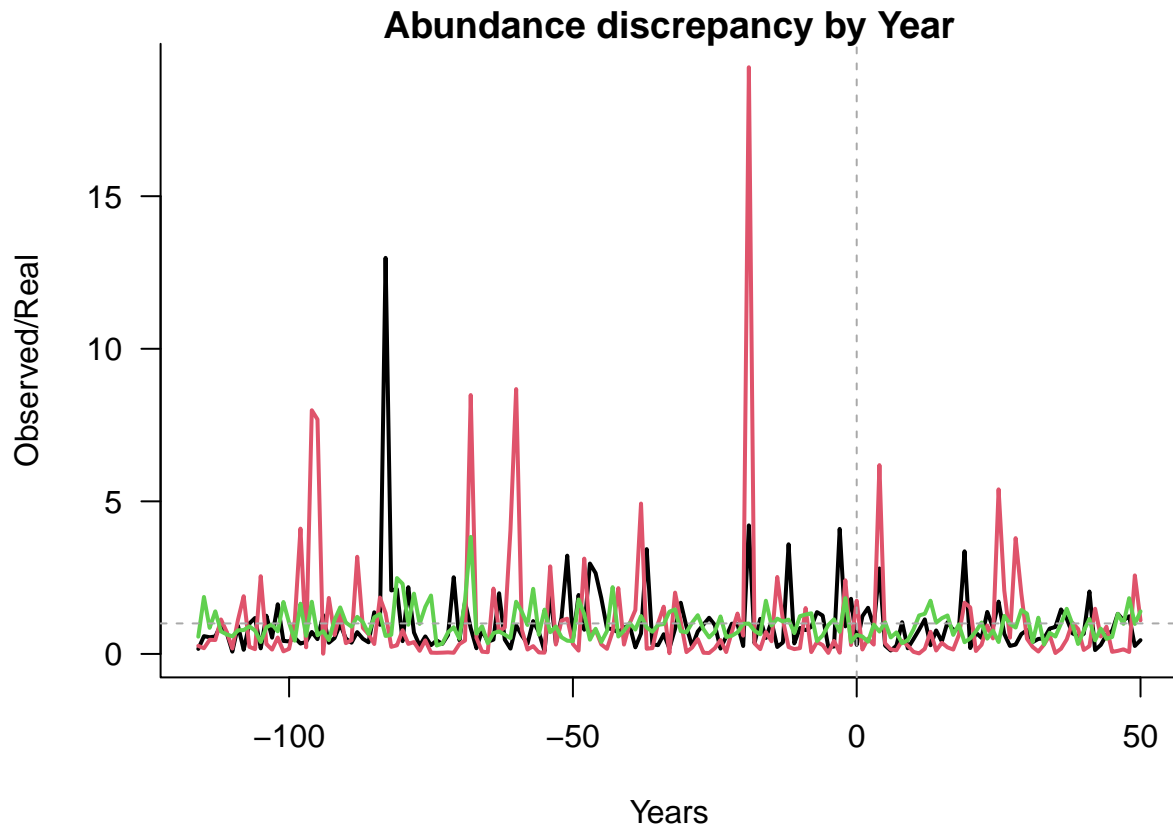


Abundance Observations

Sampled Parameters Histograms of 48 simulations of inter-annual variability in abundance observations (**Btobs**) and persistent bias in observed abundance (**Btbias**), with vertical colored lines indicating 3 randomly drawn values used in other plots:

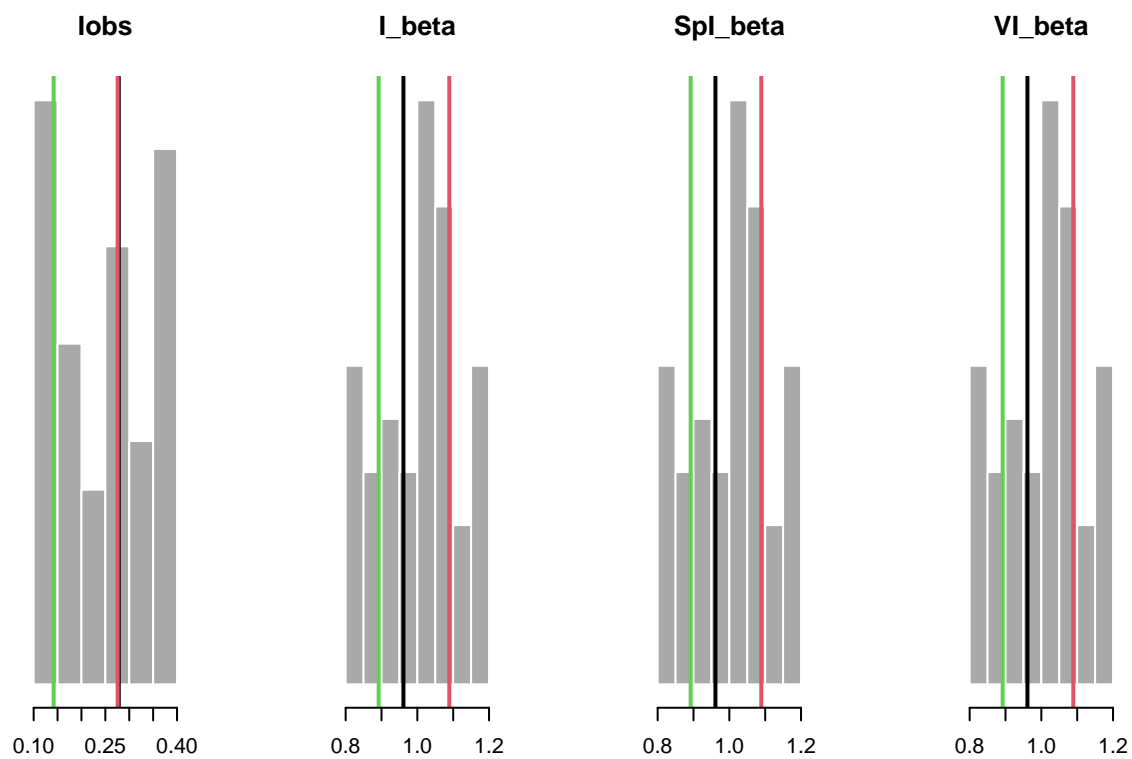


Time-Series Time-series plots of abundance observation error for historical and projection years:

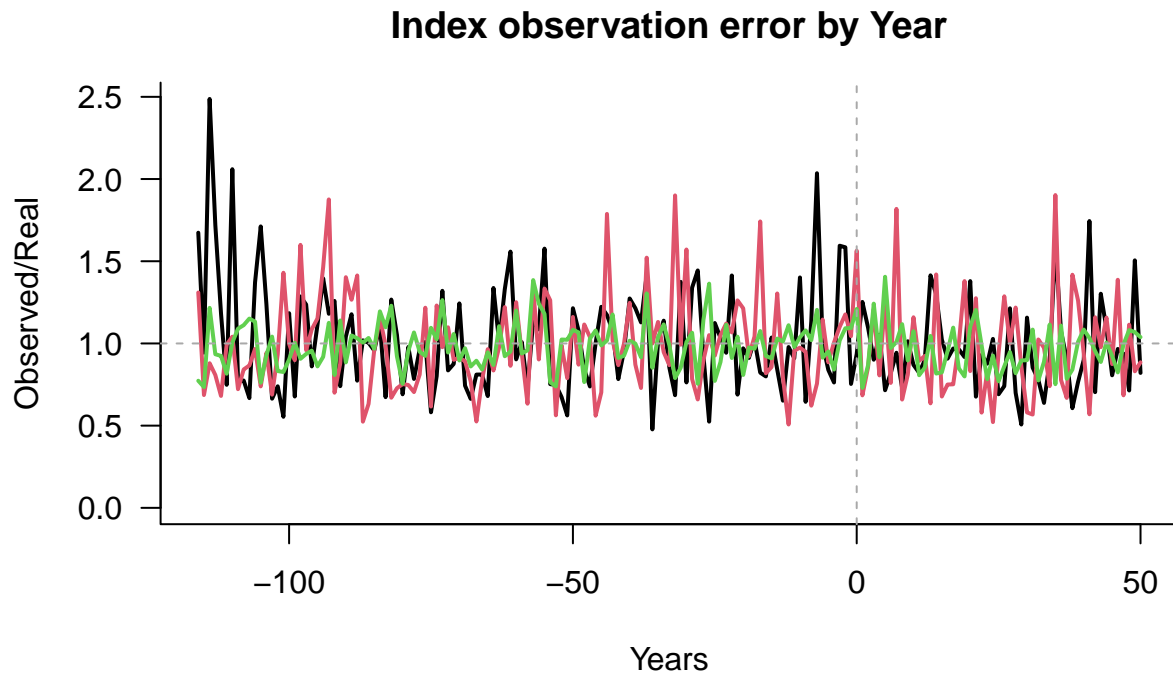


Index Observations

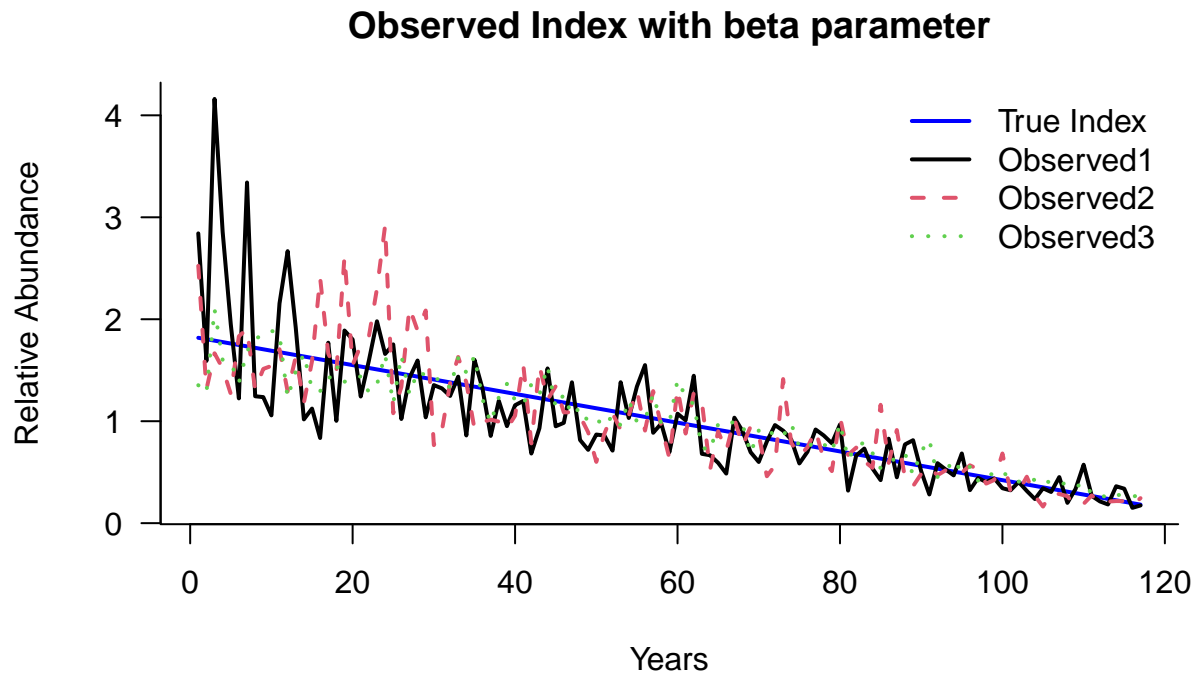
Sampled Parameters Histograms of 48 simulations of inter-annual variability in index observations (*Iobs*) and hyper-stability/depletion in observed index (*beta*), with vertical colored lines indicating 3 randomly drawn values used in other plots:



Time-Series Time-series plot of 3 samples of index observation error:

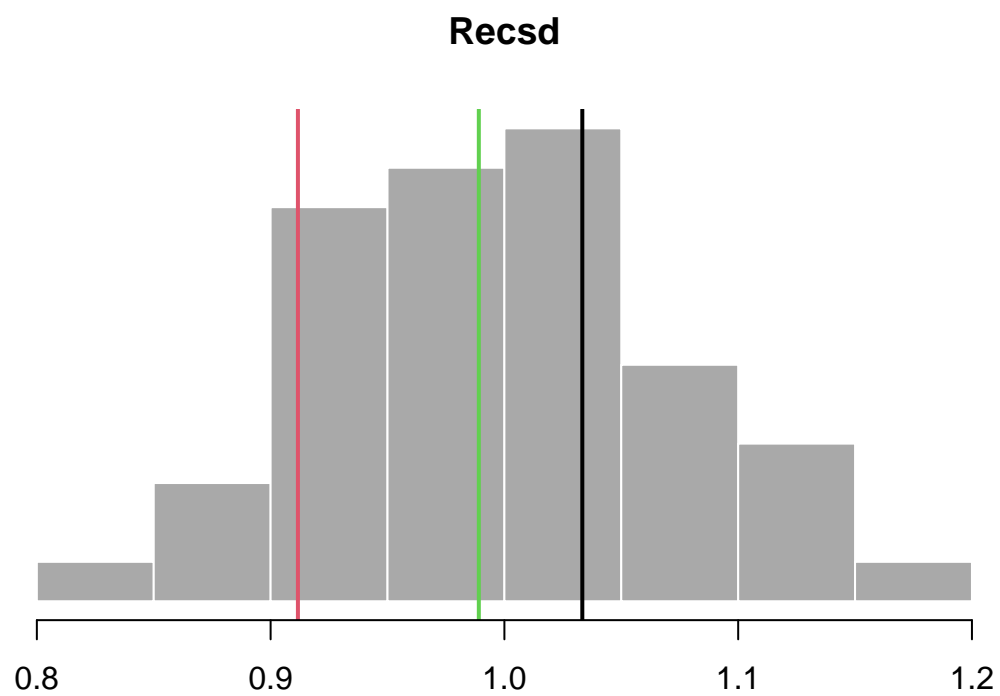


Plot showing an example true abundance index (blue) with 3 samples of index observation error and the hyper-stability/depletion parameter (**beta**):

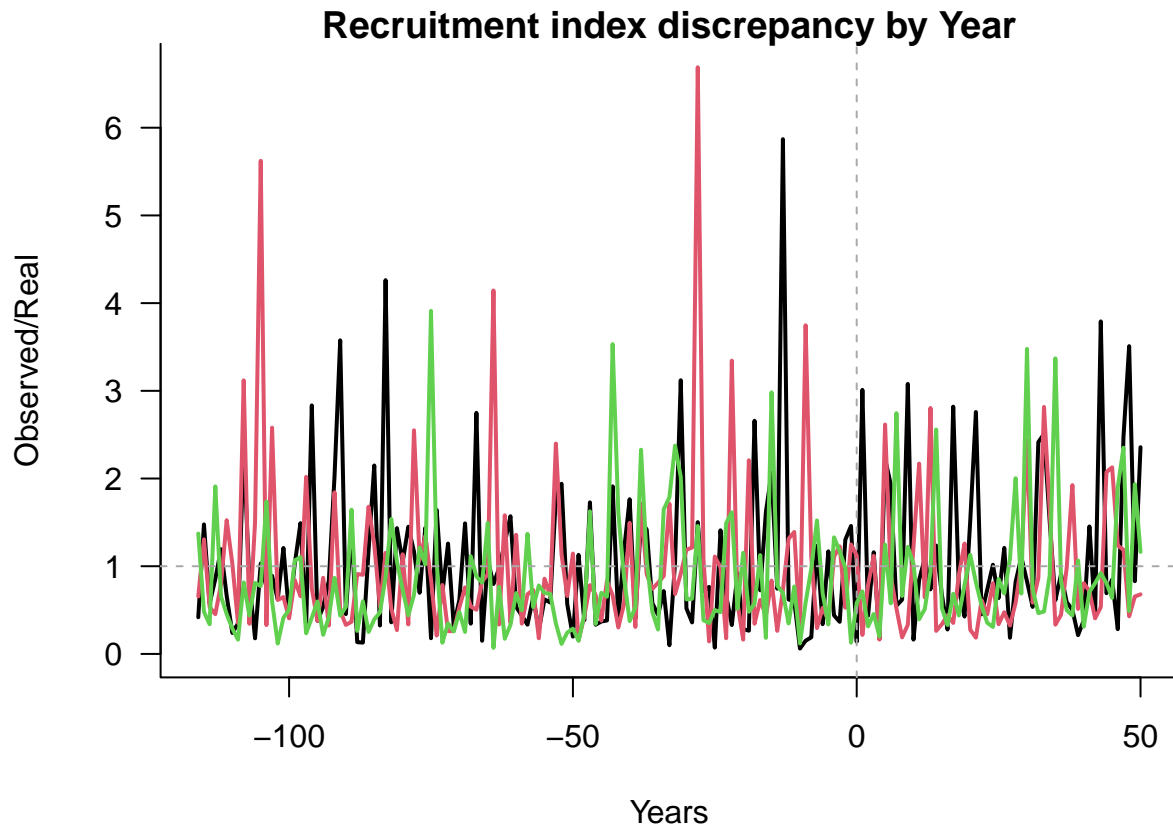


Recruitment Observations

Sampled Parameters Histograms of 48 simulations of inter-annual variability in index observations (*Recsd*) , with vertical colored lines indicating 3 randomly drawn values used in other plots:

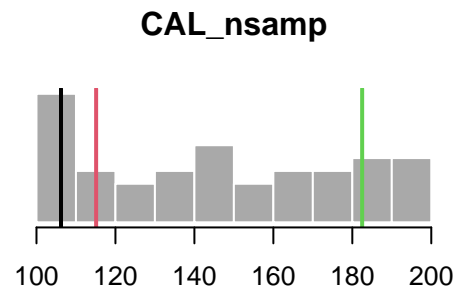
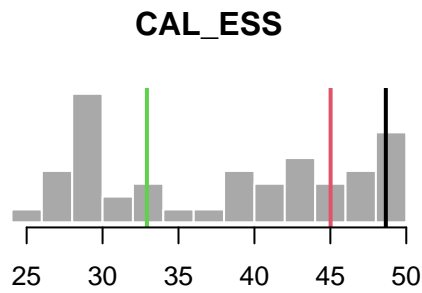
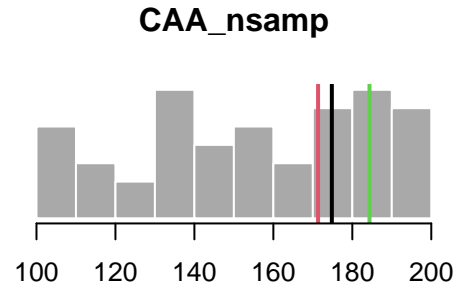
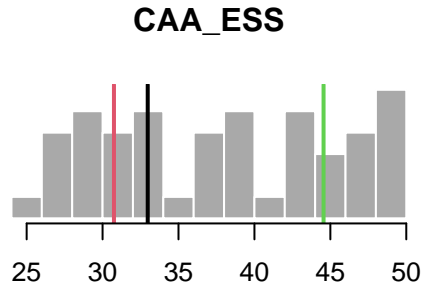


Time-Series Timeseries plots of observation error for recruitment:



Composition Observations

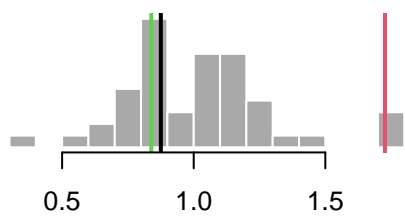
Sampled Parameters Histograms of 48 simulations of catch-at-age effective sample size (`CAA_ESS`) and sample size (`CAA_nsamp`) and catch-at-length effective (`CAL_ESS`) and actual sample size (`CAL_nsamp`) with vertical colored lines indicating 3 randomly drawn values:



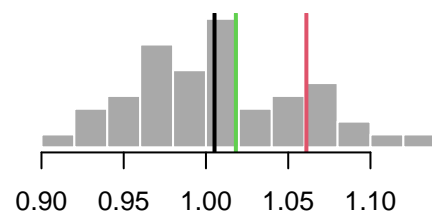
Parameter Observations

Sampled Parameters Histograms of 48 simulations of bias in observed natural mortality (**Mbias**), von Bertalanffy growth function parameters (**Linfbias**, **Kbias**, and **t0bias**), length-at-maturity (**lenMbias**), and bias in observed length at first capture (**LFCbias**) and first length at full capture (**LFSbias**) with vertical colored lines indicating 3 randomly drawn values:

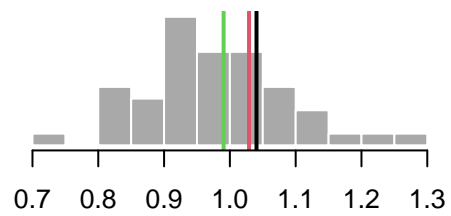
Mbias



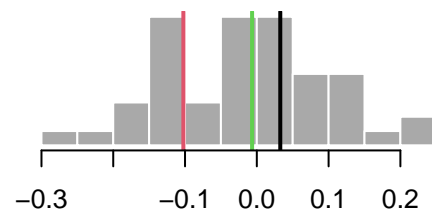
Linfbias

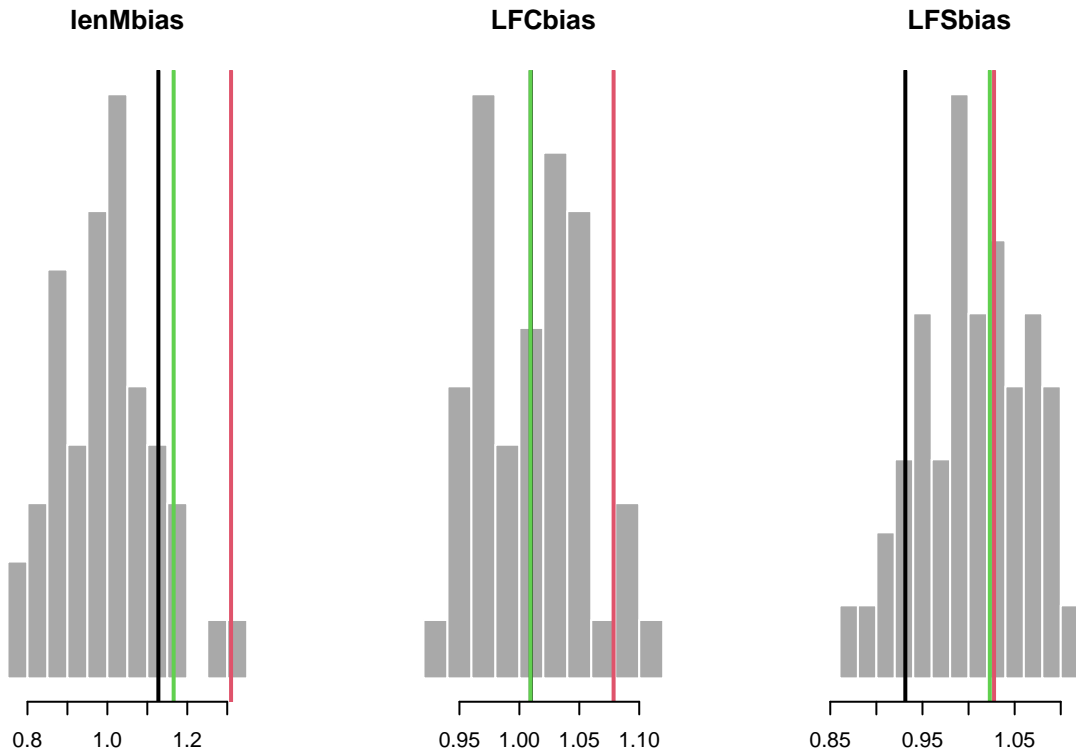


Kbias



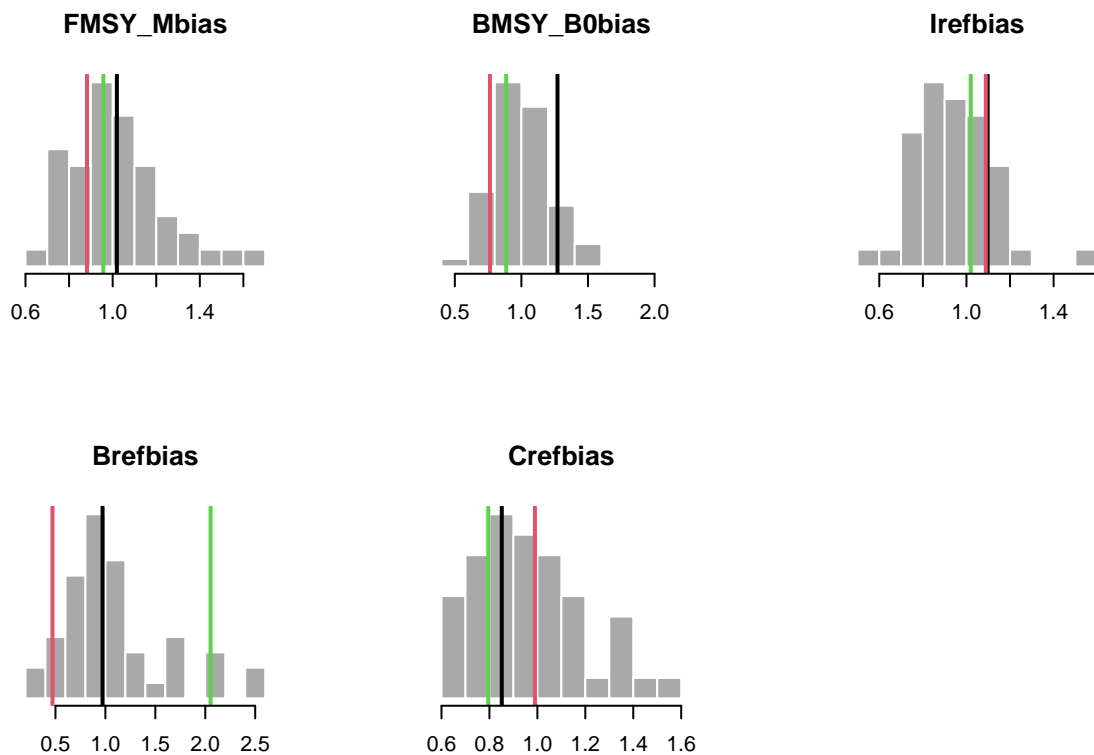
t0bias





Reference Point Observations

Sampled Parameters Histograms of 48 simulations of bias in observed FMSY/M (FMSY_Mbias), BMSY/B0 (BMSY_B0bias), reference index (Irefbias), reference abundance (Brefbias) and reference catch (Crefbias), with vertical colored lines indicating 3 randomly drawn values:



Imp Parameters

Implementation error was not included in DLMtool at the time this OM was built. Here it is assumed that management is implemented perfectly. These values may be updated when the OM is revised in 2018.

Output Control Implementation Error: TACFrac, TACSD

TACFrac: Mean fraction of recommended TAC that is actually taken. For each historical simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. This value is the mean TAC fraction obtained across all years of that simulation, and a yearly TAC frac is drawn from a log-normal distribution with the simulation mean and a coefficient of variation specified by the value of TACSD drawn for that simulation. If the value drawn is greater than 1 the amount of catch taken is greater than that recommended by the TAC, and if it is less than 1 the amount of catch taken is less than that recommended by the TAC. Positive real numbers.

Specified Value(s): 1, 1

Borrowed from Perfect_Imp

TACSD: Log-normal coefficient of variation in the fraction of recommended TAC that is actually taken. For each historical simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. This value is used, along with the TACFrac drawn for that simulation, to create a log-normal distribution that yearly values specifying the actual amount of catch taken are drawn from. Positive real numbers.

Specified Value(s): 0, 0

Borrowed from Perfect_Imp

Effort Control Implementation Error: TAEFrac, TAESD

TAEFrac: Mean fraction of recommended TAE that is actually taken. For each historical simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. This value is the mean TAE fraction obtained across all years of that simulation, and a yearly TAE frac is drawn from a log-normal distribution with the simulation mean and a coefficient of variation specified by the value of TAESD drawn for that simulation. If the value drawn is greater than 1 the amount of effort employed is greater than that recommended by the TAE, and if it is less than 1 the amount of effort employed is less than that recommended by the TAE. Positive real numbers.

Specified Value(s): 1, 1

Borrowed from Perfect_Imp

TAESD: Log-normal coefficient of variation in the fraction of recommended TAE that is actually taken. For each historical simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. This value is used, along with the TAEFrac drawn for that simulation, to create a log-normal distribution that yearly values specifying the actual amount of effort employed are drawn from. Positive real numbers.

Specified Value(s): 0, 0

Borrowed from Perfect_Imp

Size Limit Control Implementation Error: SizeLimFrac, SizeLimSD

SizeLimFrac: Mean fraction of recommended size limit that is actually retained. For each historical simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. This value is the mean size limit fraction obtained across all years of that simulation, and a yearly size limit fraction is drawn from a log-normal distribution with the simulation mean and a coefficient of variation specified by the value of SizeLimSD drawn for that simulation. If the value drawn is greater than 1 the size of fish retained is greater than that recommended by the size limit, and if it is less than 1 the amount of size of fish retained is less than that recommended by the size limit. Positive real numbers.

Specified Value(s): 1, 1

Borrowed from Perfect_Imp

SizeLimSD: Log-normal coefficient of variation in the fraction of recommended size limit that is actually retained. For each historical simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. This value is used, along with the SizeLimFrac drawn for that simulation, to create a log-normal distribution that yearly values specifying the actual fraction of the size limit retained are drawn from. Positive real numbers.

Specified Value(s): 0, 0

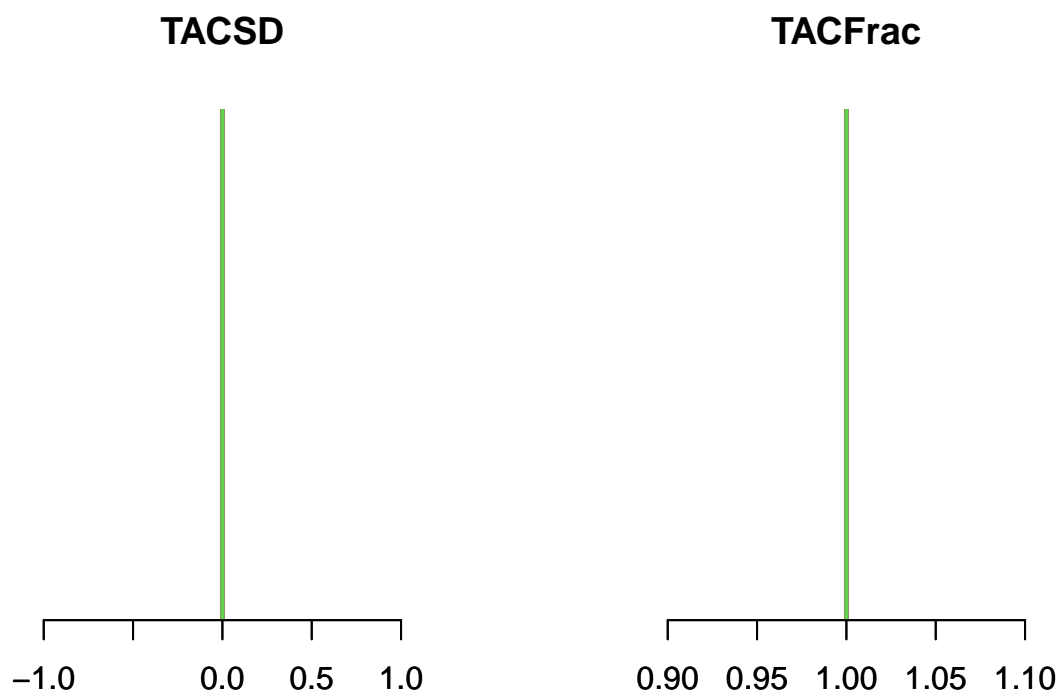
Borrowed from Perfect_Imp

Imp Plots

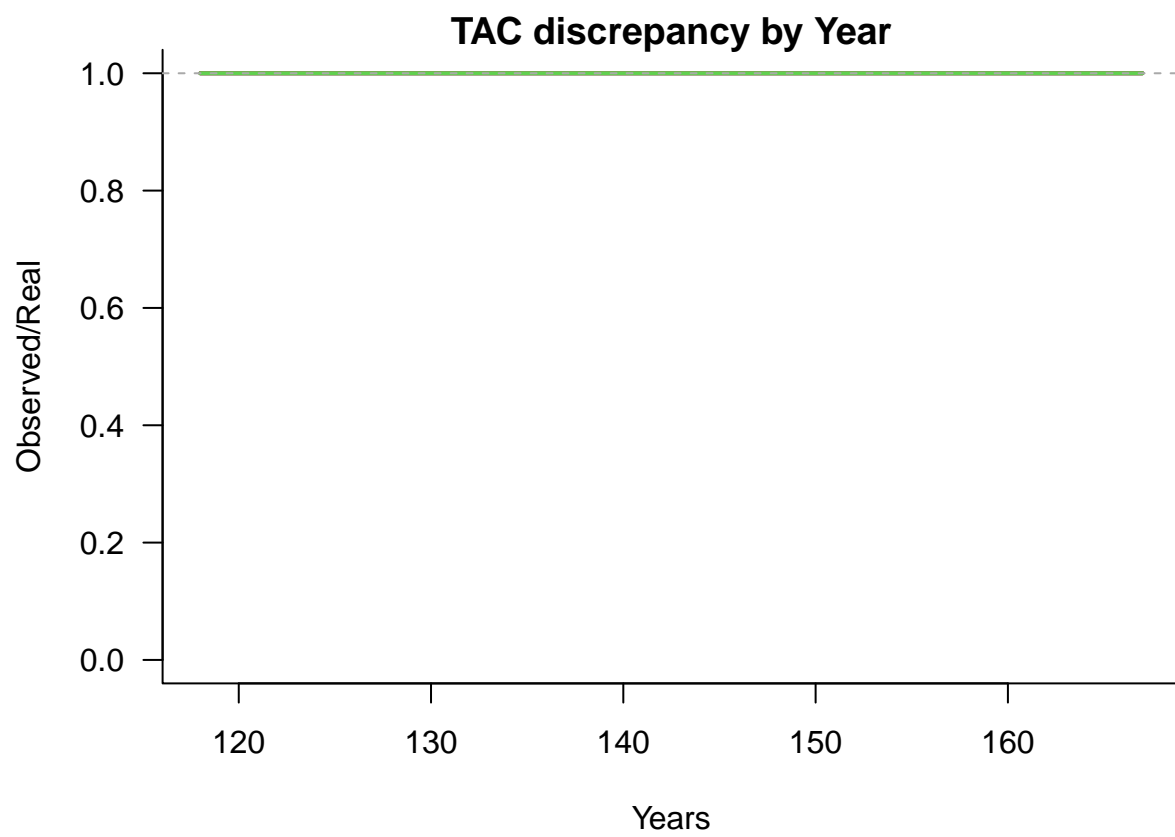
Implementation Parameters

TAC Implementation

Sampled Parameters Histograms of 0 simulations of inter-annual variability in TAC implementation error (TACSD) and persistent bias in TAC implementation (TACFrac), with vertical colored lines indicating 3 randomly drawn values used in other plots:

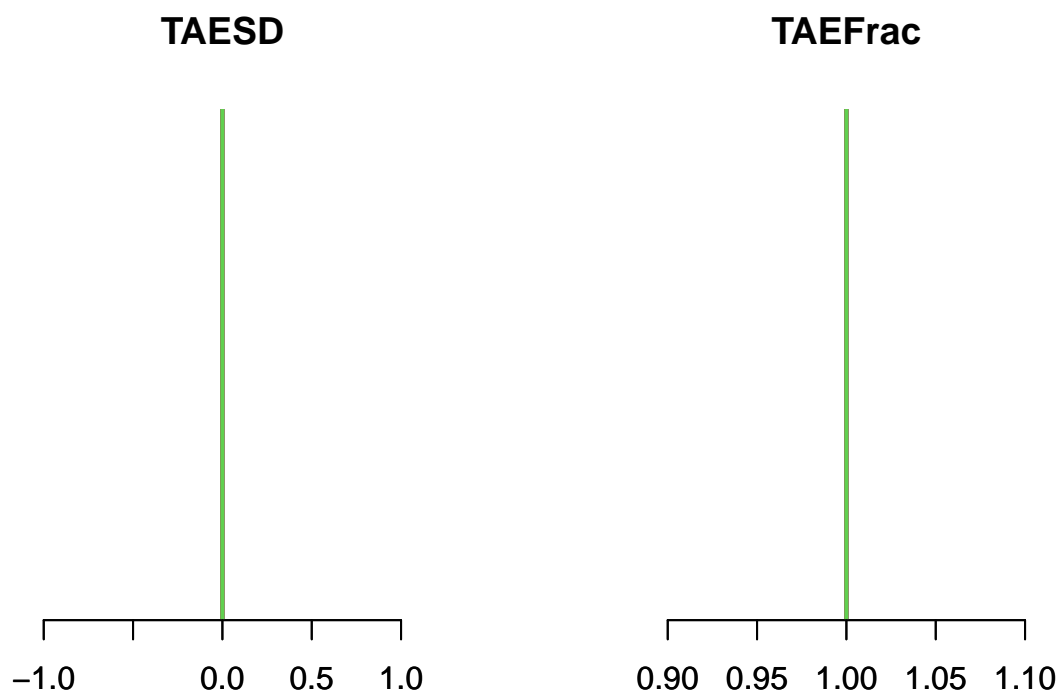


Time-Series Time-series plots of 0 samples of TAC implementation error by year:

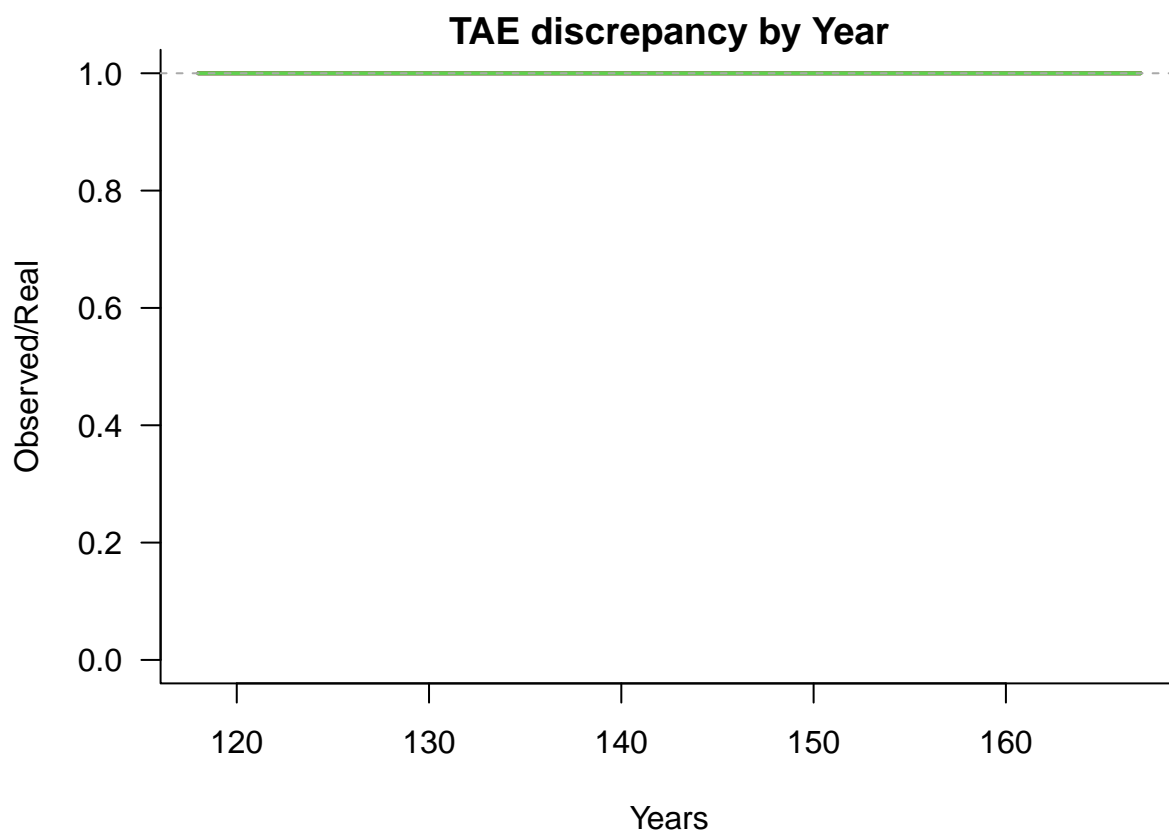


TAE Implementation

Sampled Parameters Histograms of 0 simulations of inter-annual variability in TAE implementation error (**TAESD**) and persistent bias in TAC implementation (**TAEFrac**), with vertical colored lines indicating 3 randomly drawn values used in other plots:

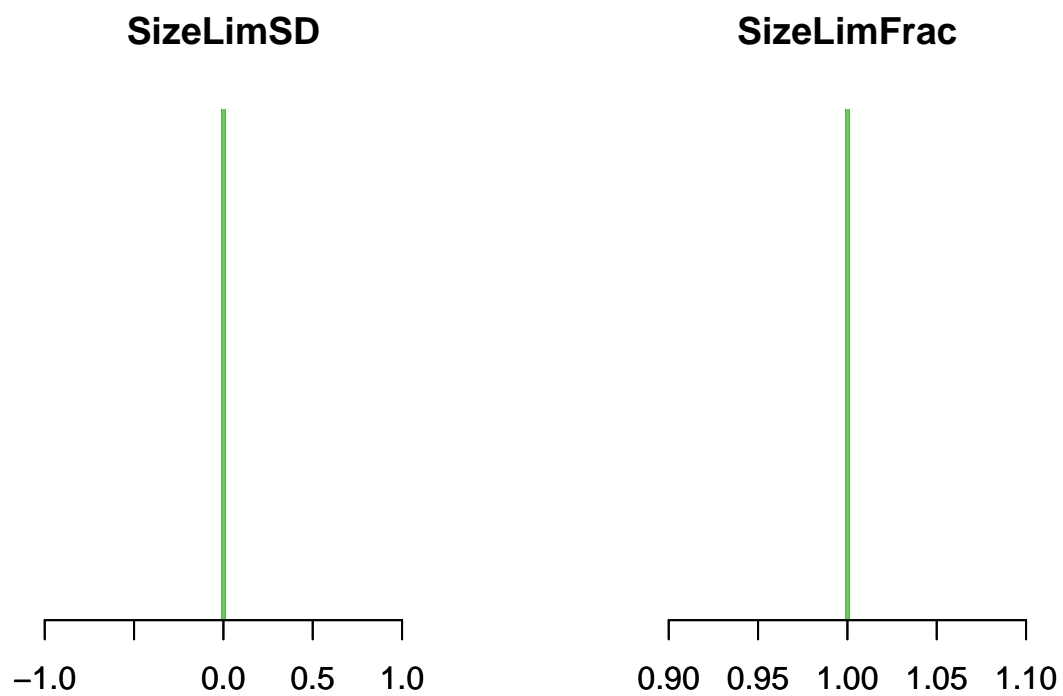


Time-Series Time-series plots of 0 samples of TAE implementation error by year:

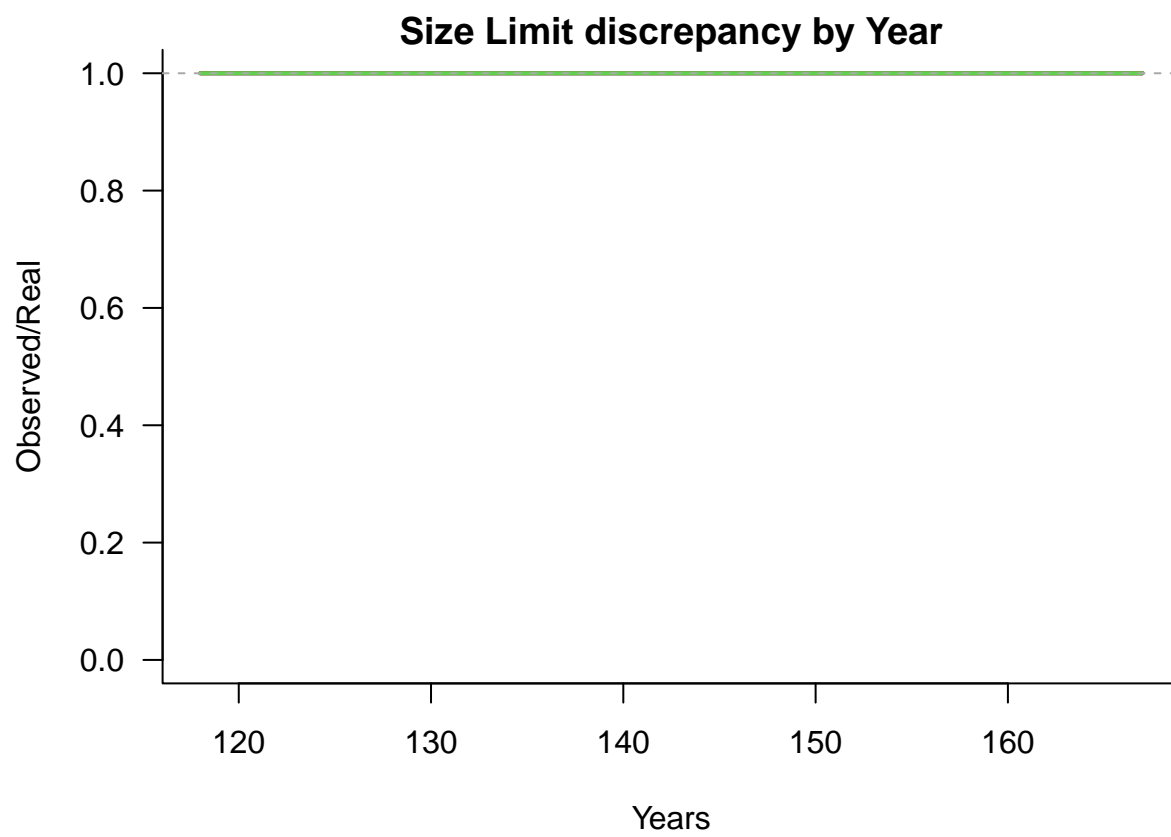


Size Limit Implementation

Sampled Parameters Histograms of 0 simulations of inter-annual variability in size limit implementation error (**SizeLimSD**) and persistent bias in size limit implementation (**SizeLimFrac**), with vertical colored lines indicating 3 randomly drawn values used in other plots:



Time-Series Time-series plots of 0 samples of Size Limit implementation error by year:

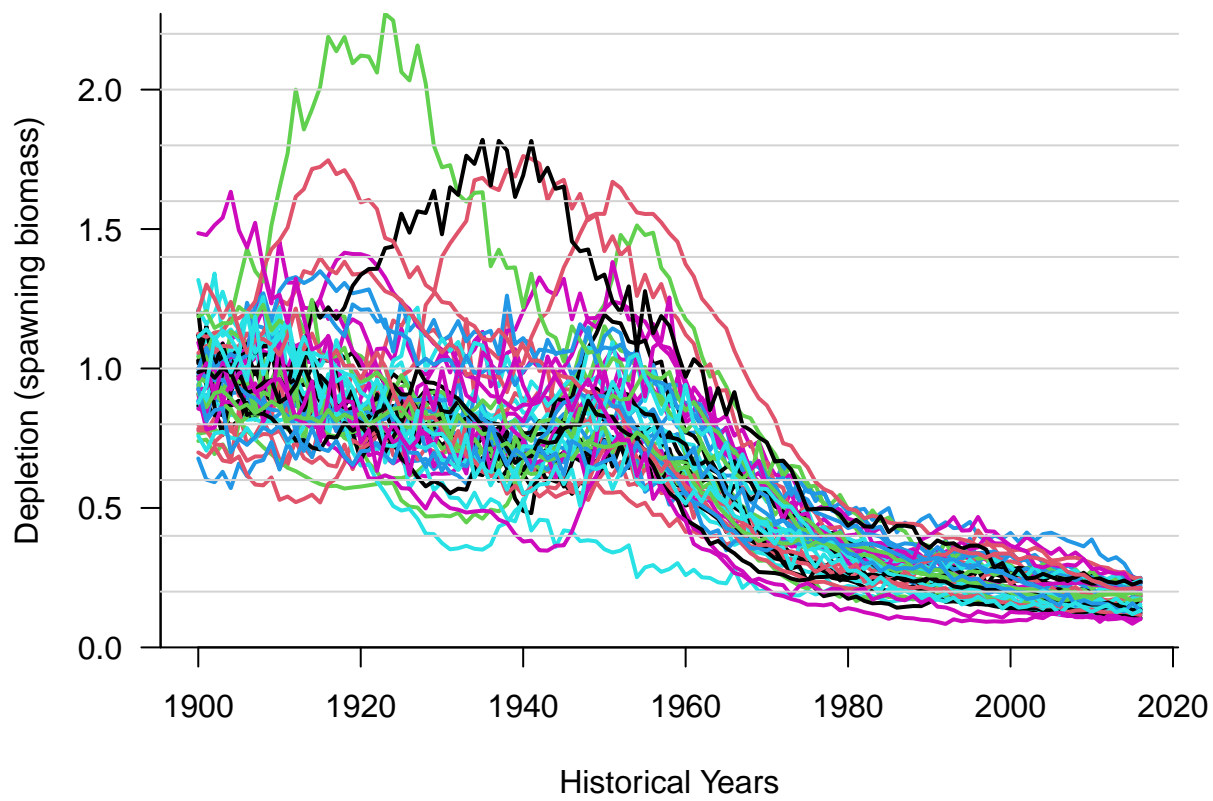


Historical Simulation Plots

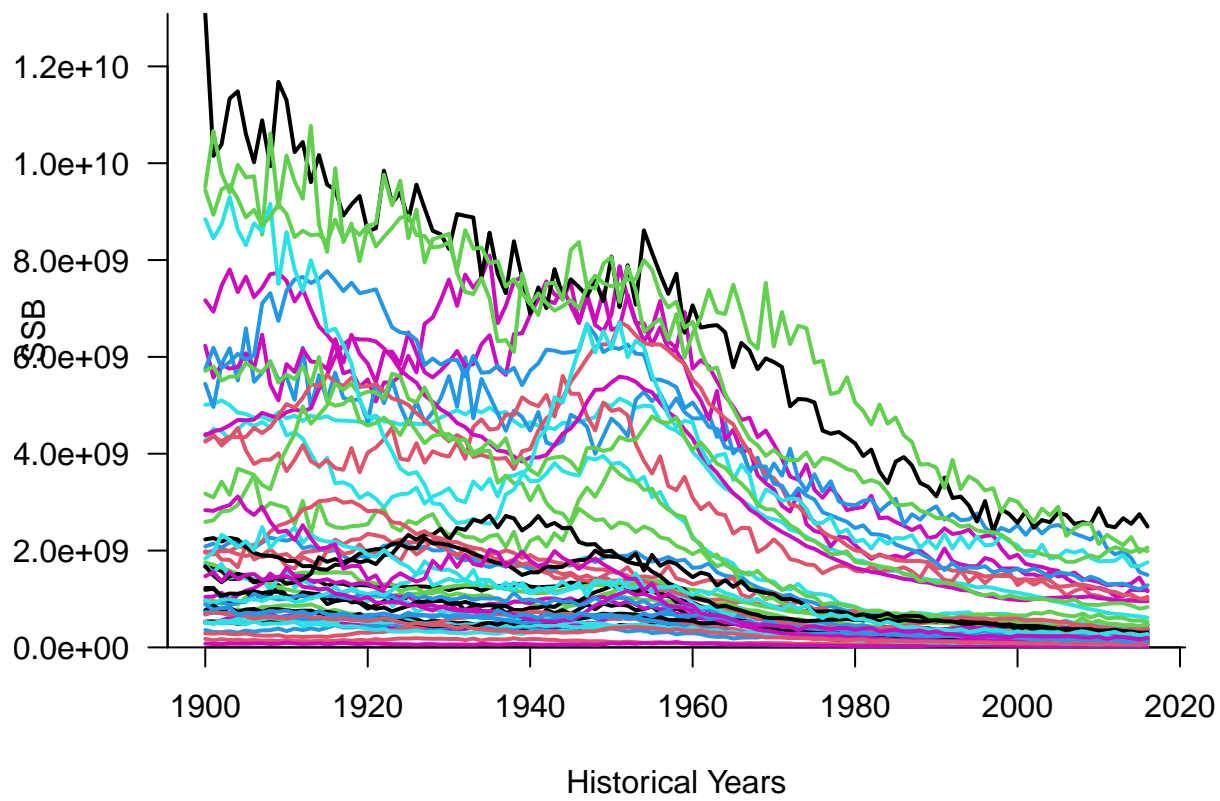
Historical Time-Series

Spawning Biomass

Depletion Time-series plots of SB/SB0:

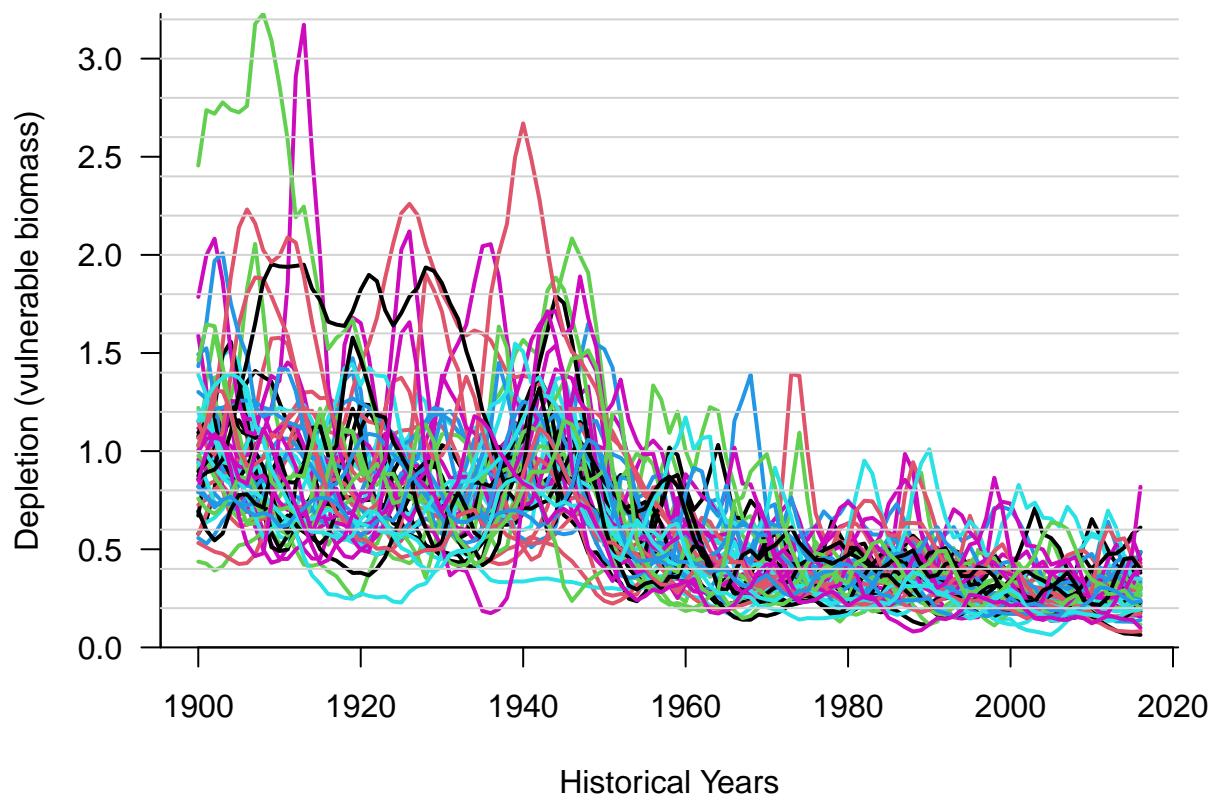


Absolute Time-series plots of absolute SB:

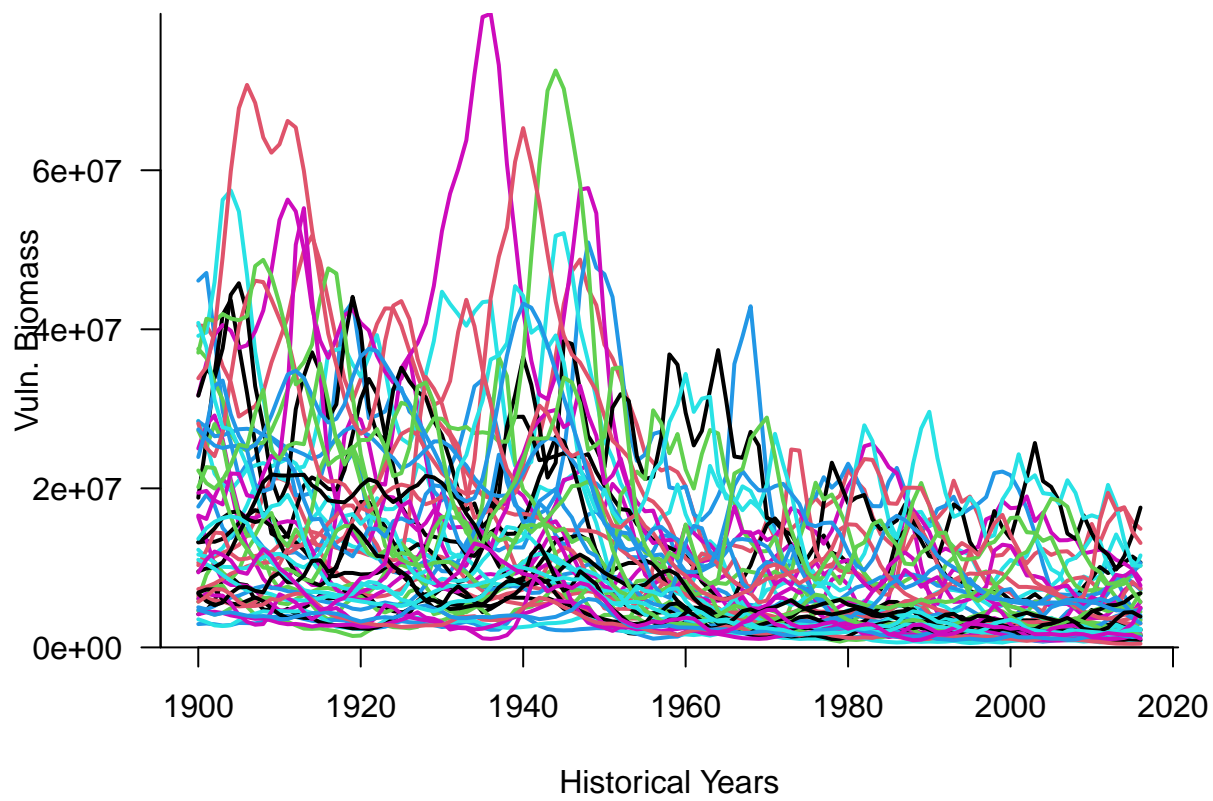


Vulnerable Biomass

Depletion Time-series plots of VB/VB0:

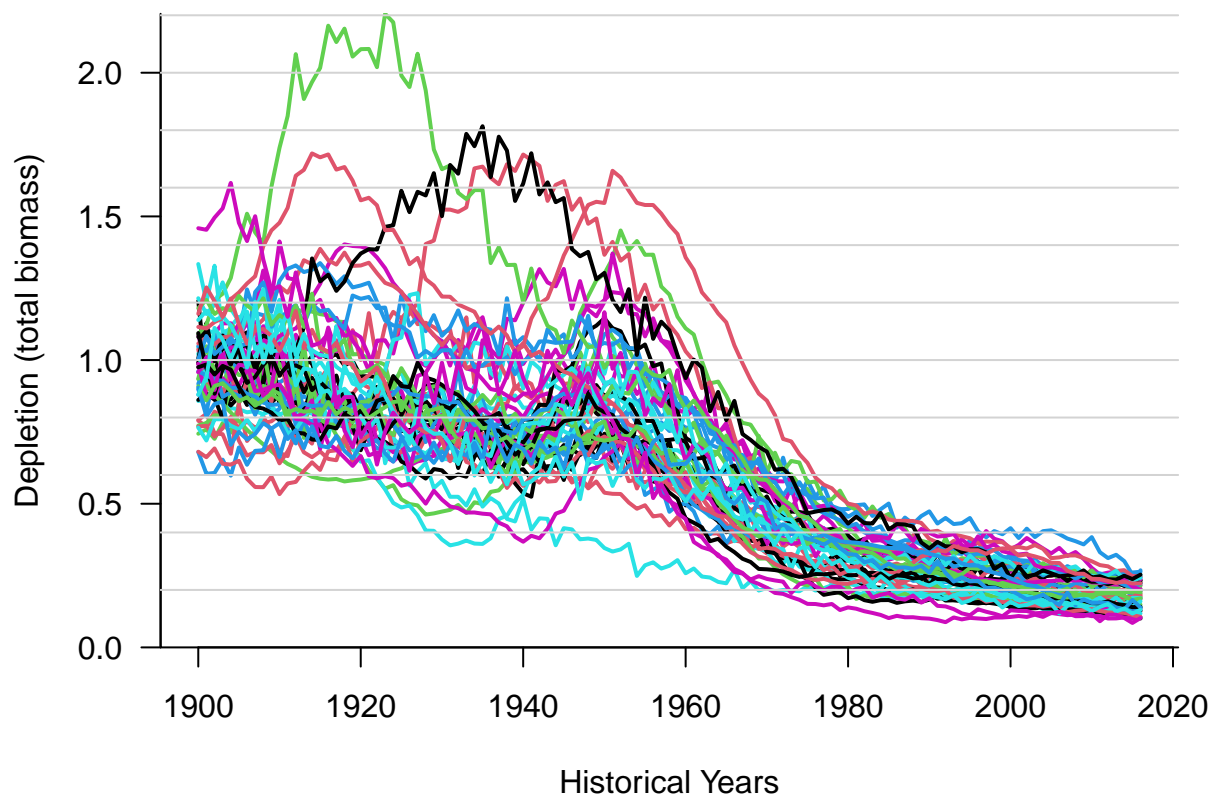


Absolute Time-series plots of absolute VB:

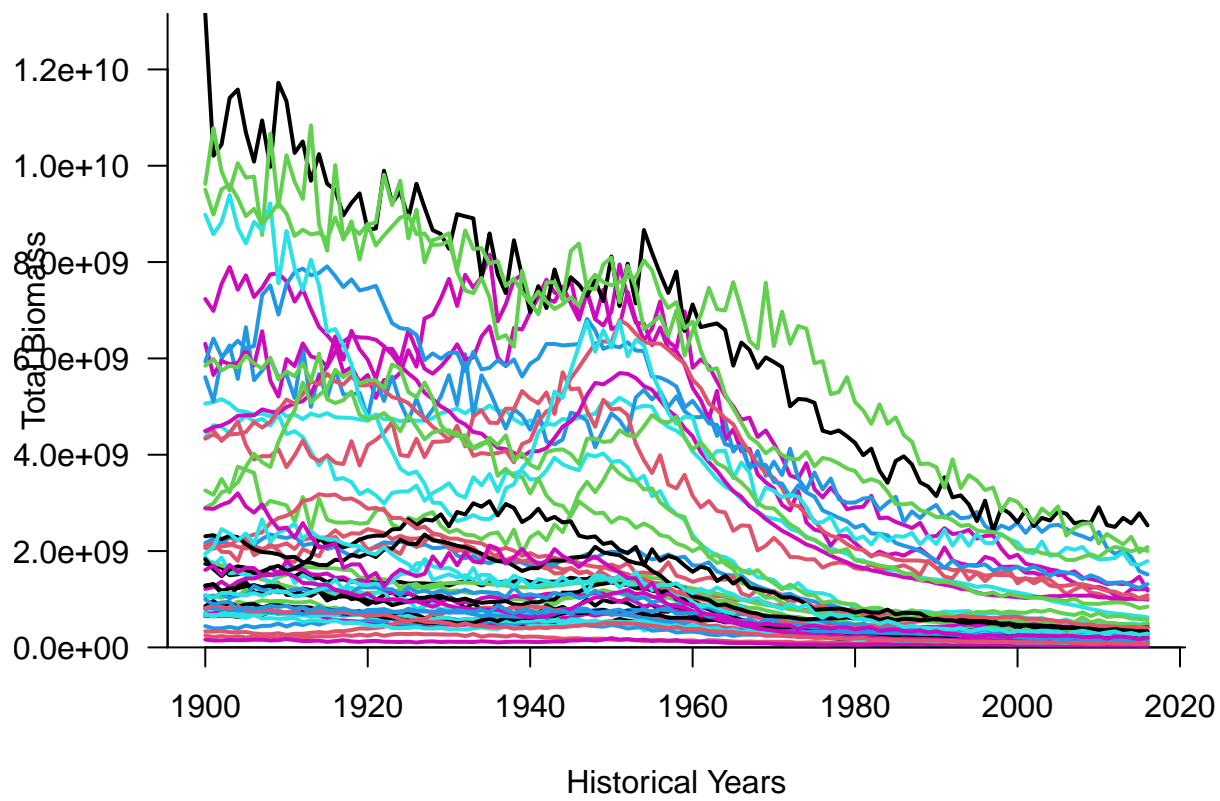


Total Biomass

Depletion Time-series plots of B/B_0 :

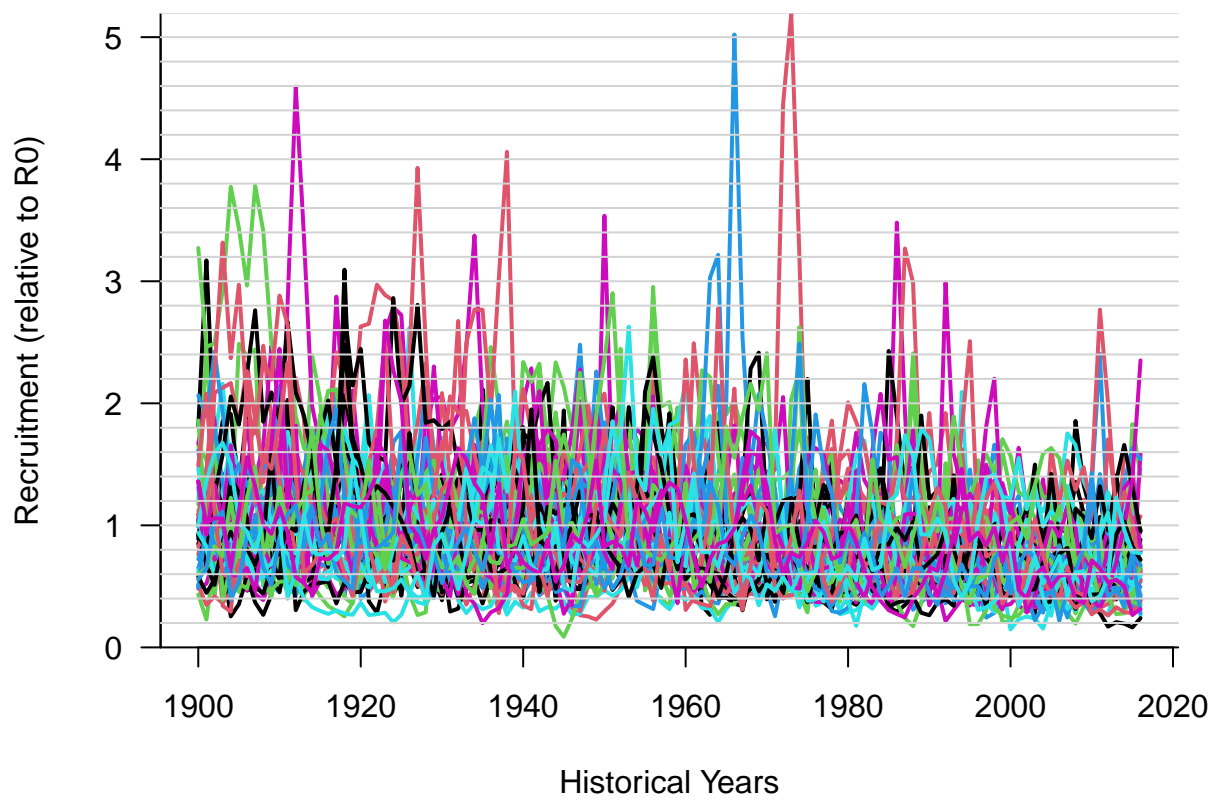


Absolute Time-series plots of absolute B:

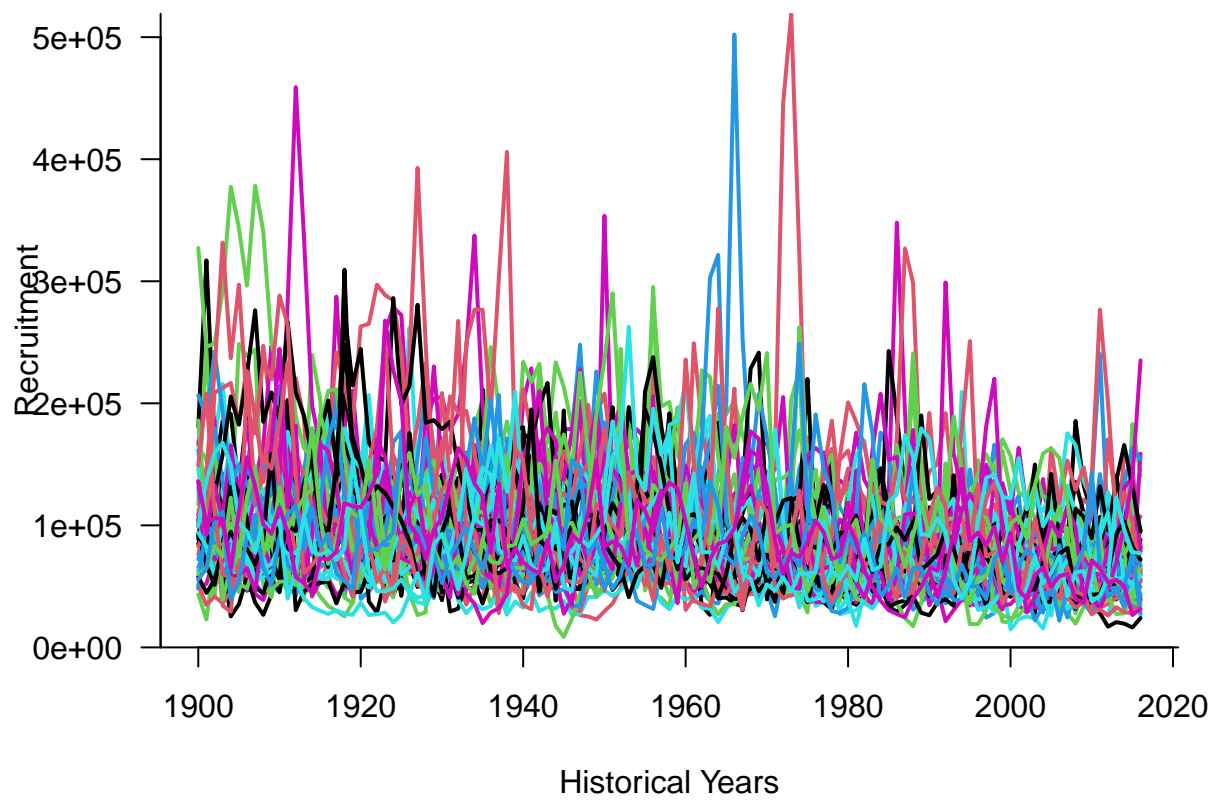


Recruitment

Relative Time-series plot of recruitment relative to R_0 :

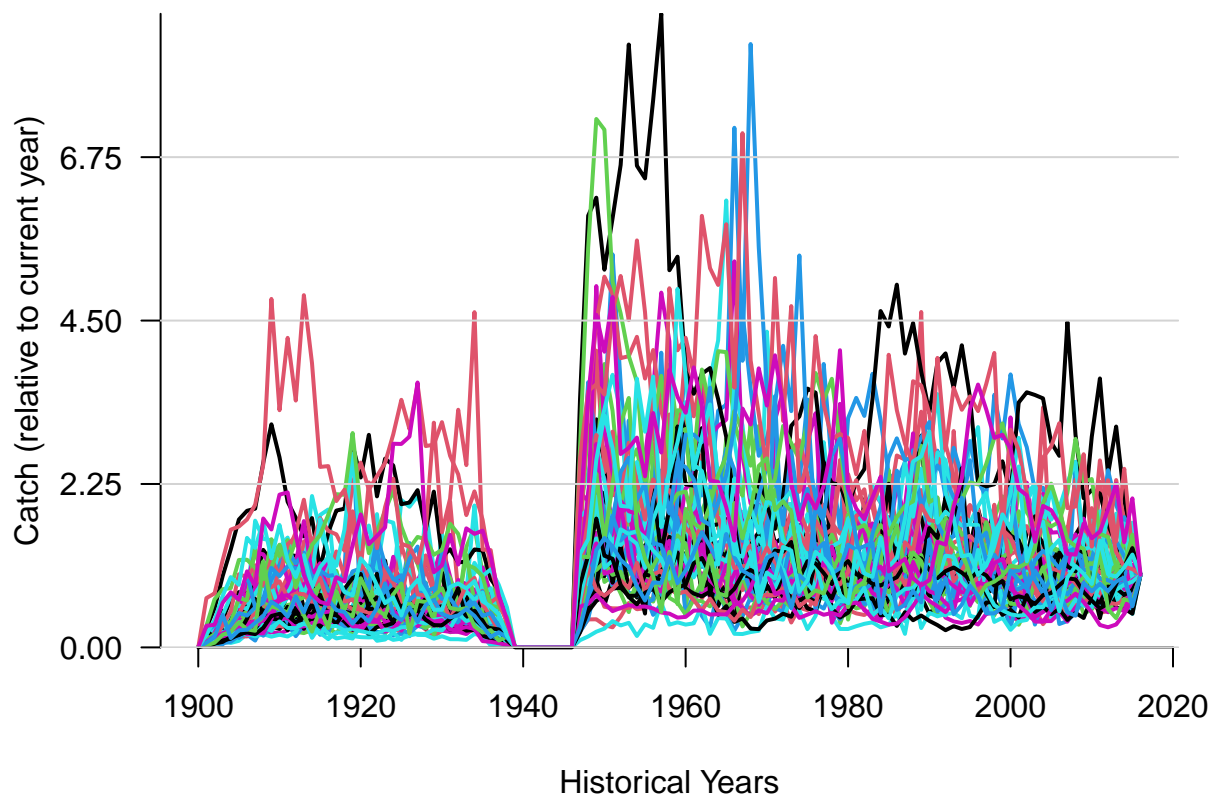


Absolute Time-series plot of absolute recruitment:

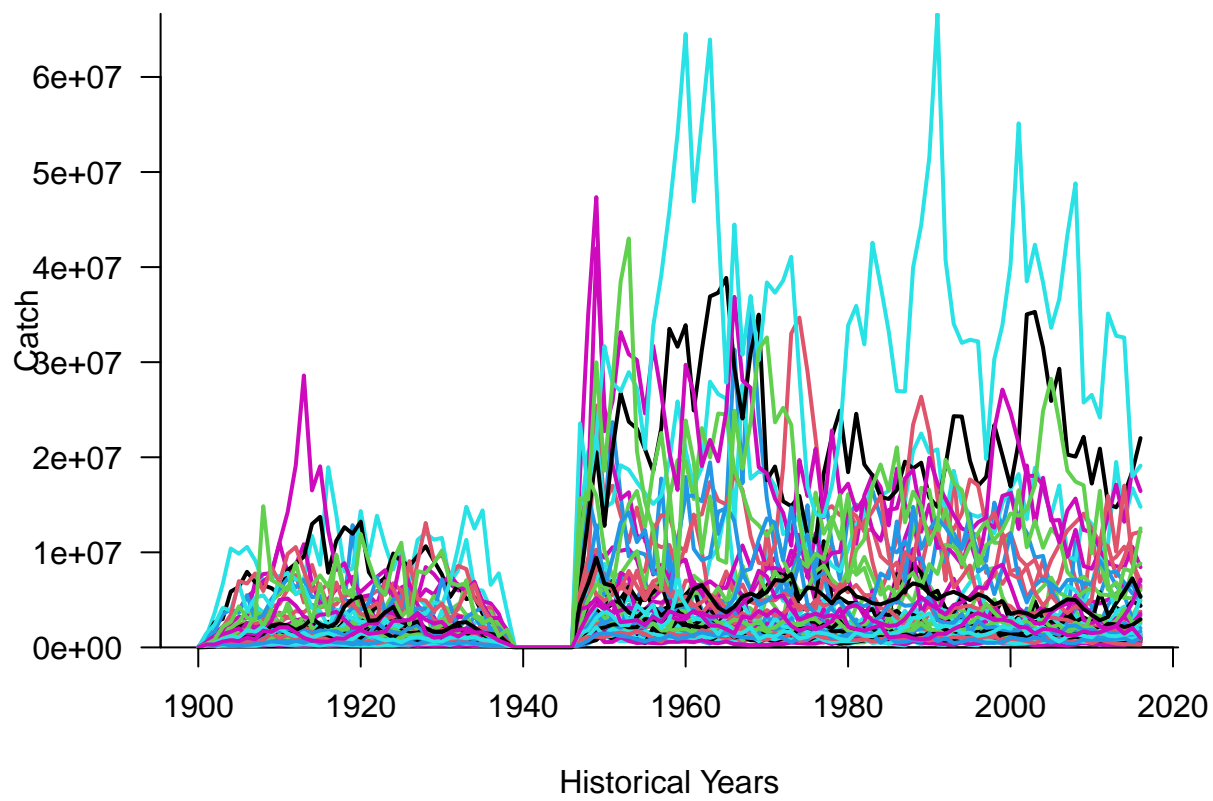


Catch

Relative Time-series of catch relative to the current year:

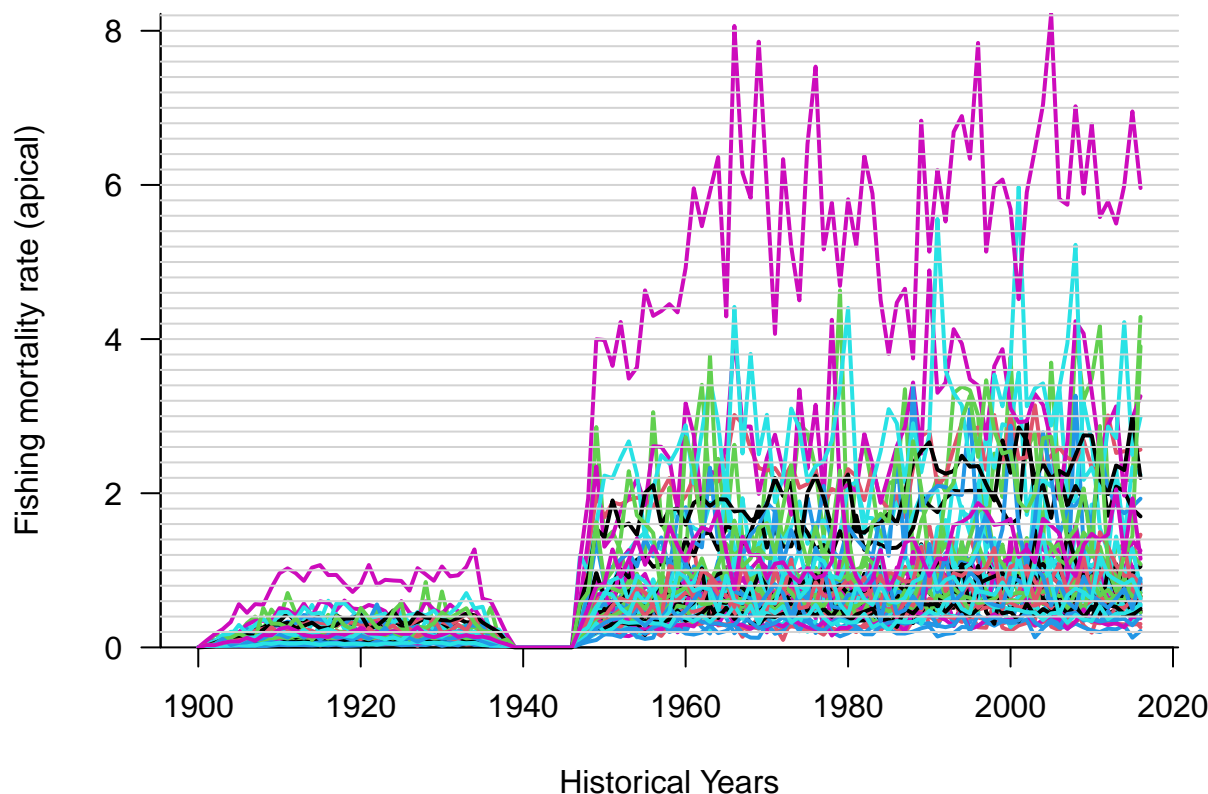


Absolute Time-series of absolute catch:



Historical Fishing Mortality

Historical Time-Series Time-series of historical fishing mortality:



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