Kelp Bass, Southern California Recreational Fishery

Operating Model Report

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Introduction

Kelp bass (Paralabrax clathratus), often referred to as calico bass, are one of the most common sea basses inhabiting southern California coastal waters and are an important recreational species. Fishery-dependent and fishery-independent data indicated abundance had been declining, and in response, the minimum size limit was increased and the bag limit was decreased in 2013. We performed an MSE using the DLMtool to test whether current management is likely to meet long-term goals. Because this species is known to be influenced by shifts in water temperature, we also tested management procedure performance under exploratory climate change scenarios.

The number of simulations for a final model run (nsim) was set at 350 and fishing was projected 50 years to the future (proyears). The management interval tested was 4 years. The maximum instantaneous fishing mortality rate for an age class (maxF) was set at 0.8, which is the default value in the DLMtool. The number of samples for stochastic MPs (reps) was set at 1, and the percentile of the sample of the management recommendation (pstar) used for any stochastic MPs was set at 0.5, meaning the median recommendation was selected.

We used custom parameters (cpars) to parameterize time varying retention of kelp bass due to a variety of size limit changes over the fishery history. The minimum size has changed a number of times. A size limit of 276 mm was first established in 1953. It was increased to 279 mm in 1957, 299 mm in 1958, and to 305 mm in 1959, and it remained there until it was increased to the present size in 2013 to address concerns regarding the status of barred sand bass and kelp bass populations. RecFIN data on size compositions of the catch suggest that a small percentage of sublegal fish are retained each year. Because of this, rather than parameterizing a knife-edged retention curve at the size limit we fit a logistic retention curve to the size composition data from the Private Rental and CPFV fleets for each year of available data (1980 to 2018). We assumed that all fish were able to be retained prior to 1953, and that retention followed the size limits implemented between 1953 and 1959. For the period between 1960 and 1980 we assumed that retention for each year was equal to the estimated retention of 1980. Retention was estimated annually from the data from 1980 on. This generated an array of probability of retention values for each size bin of 10 mm width to be populated in the cpars$RetL slot. This array has dimensions simulations x length bins x years.

Operating Model

The OM rdata file can be downloaded from here

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

Species Information

Species: *Paralabrax clathratus*

Common Name: *Kelp Bass*

Management Agency: CDFW

Region:

OM Parameters

OM Name: Name of the operating model: OMKB

nsim: The number of simulations: 350

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

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): 44

The maximum observed age is 34 yr (CDFG 2004) and the maximum length is 72.1 cm (28 in) (Love and Passarelli 2020). A max age of 44 was used to allow full exploration of possible age structures and because age has been observed during a time when the resource had been heavily fished.

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): 1000

In the absence of a stock assessment, there is currently no estimate for R0. It is used as a scaling parameter in the DLMtool, so the starting number of recruits does not affect the results of the model, and it was set arbitrarily at 1000.

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): 0.18, 0.29

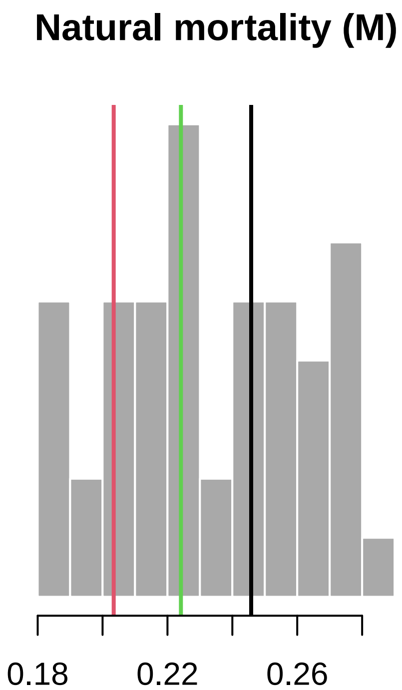
Jarvis et al. (2014) used growth parameters (Linf and K) and average water temperature (Pauly 1980) to estimate an instantaneous rate for M of 0.178. Young (1963) estimated 0.287 based on fish lengths from relatively unfished population. However, a study by Then et al. (2015) found that a method that used maximum age produced more reliable estimates of natural mortality. Using the maximum age of 34 yr suggests that the natural mortality is slightly higher at 0.194. The maximum observed age may have been biased by fishing pressure. We assumed that natural mortality estimators ranged between these two values in order to capture the uncertainty.

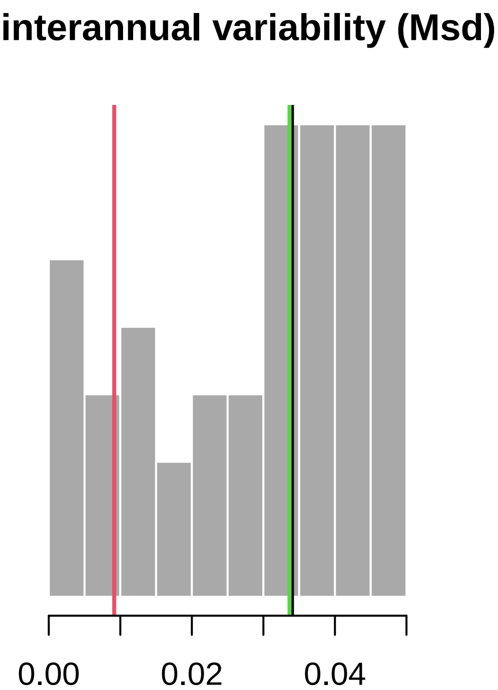
Msd: Inter-annual variation in M expressed as a coefficient of variation of a log-normal distribution. For each simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. If this parameter is positive, yearly M is drawn from a log-normal distribution 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

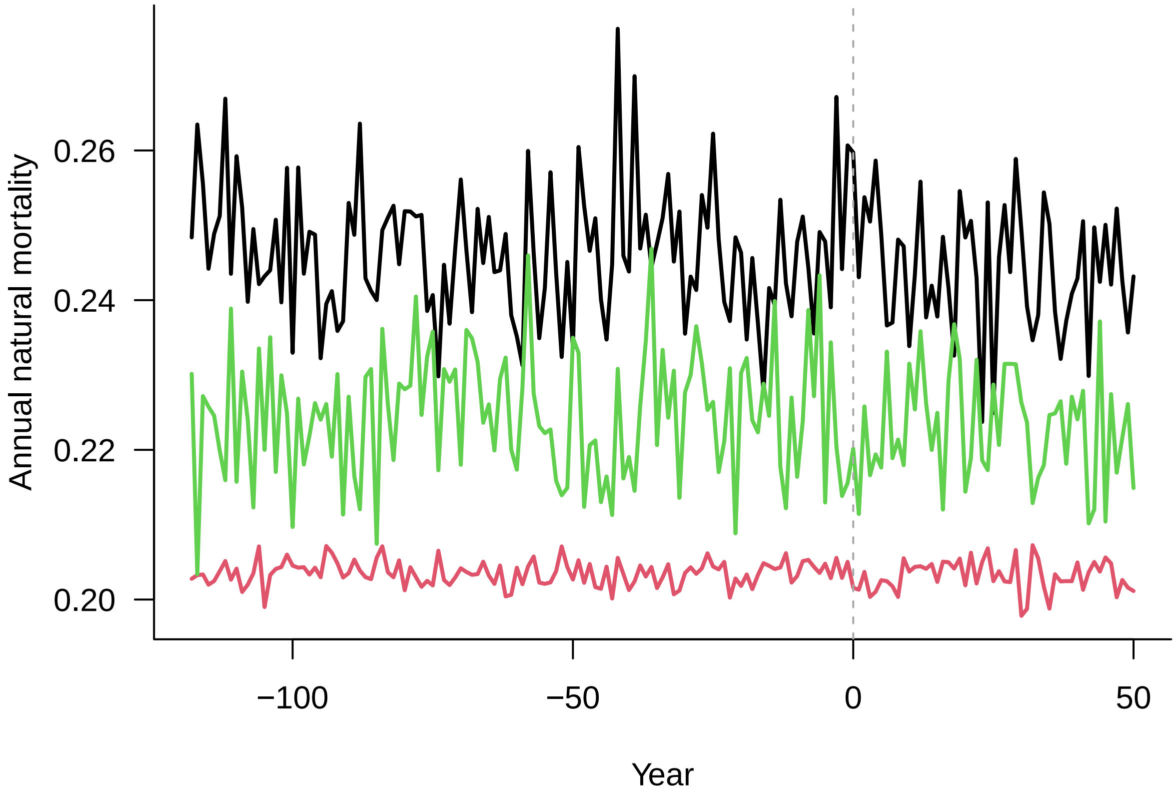
Natural Mortality Parameters

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

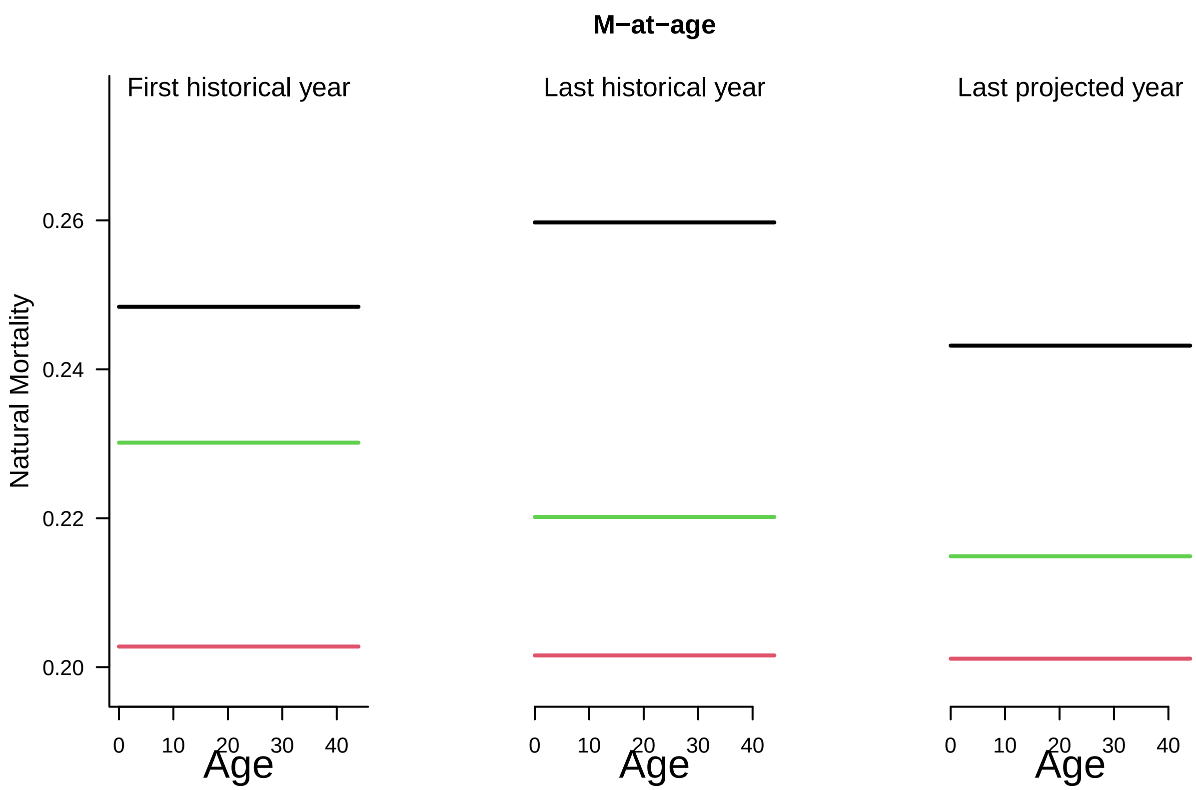




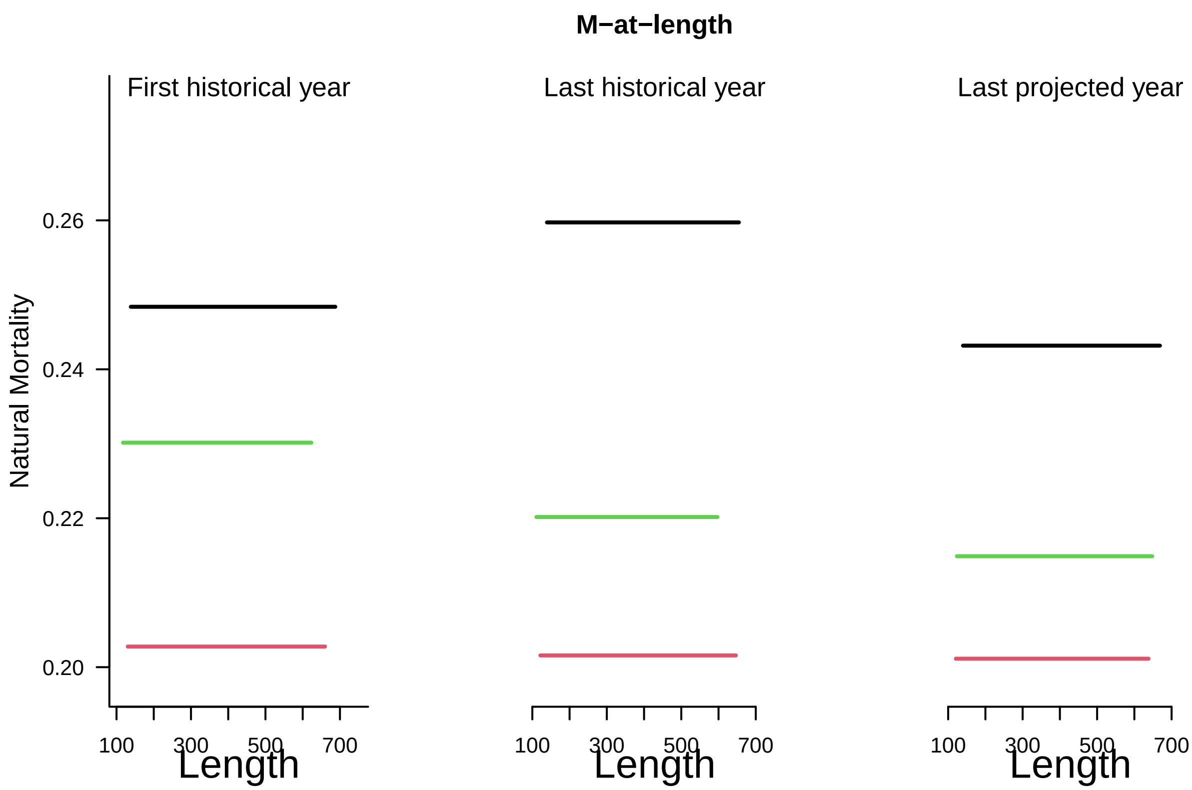
Time-Series The average natural mortality rate by year for adult fish for 3 simulations. The vertical dashed line indicates the end of the historical period:



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, 0.8

Due to little information regarding h for similar species, we explored a wide range.

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

We assumed a Beverton-Holt stock recruitment relationship.

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): 0.2, 0.5

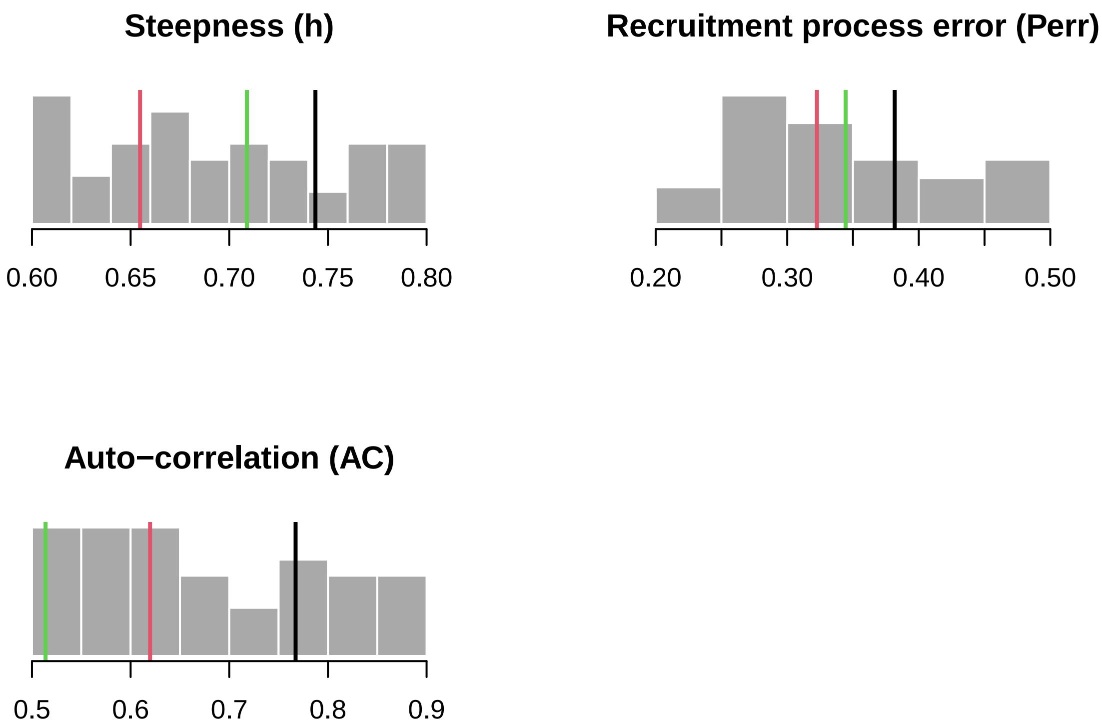
Low to moderate interannual variation was assumed.

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.

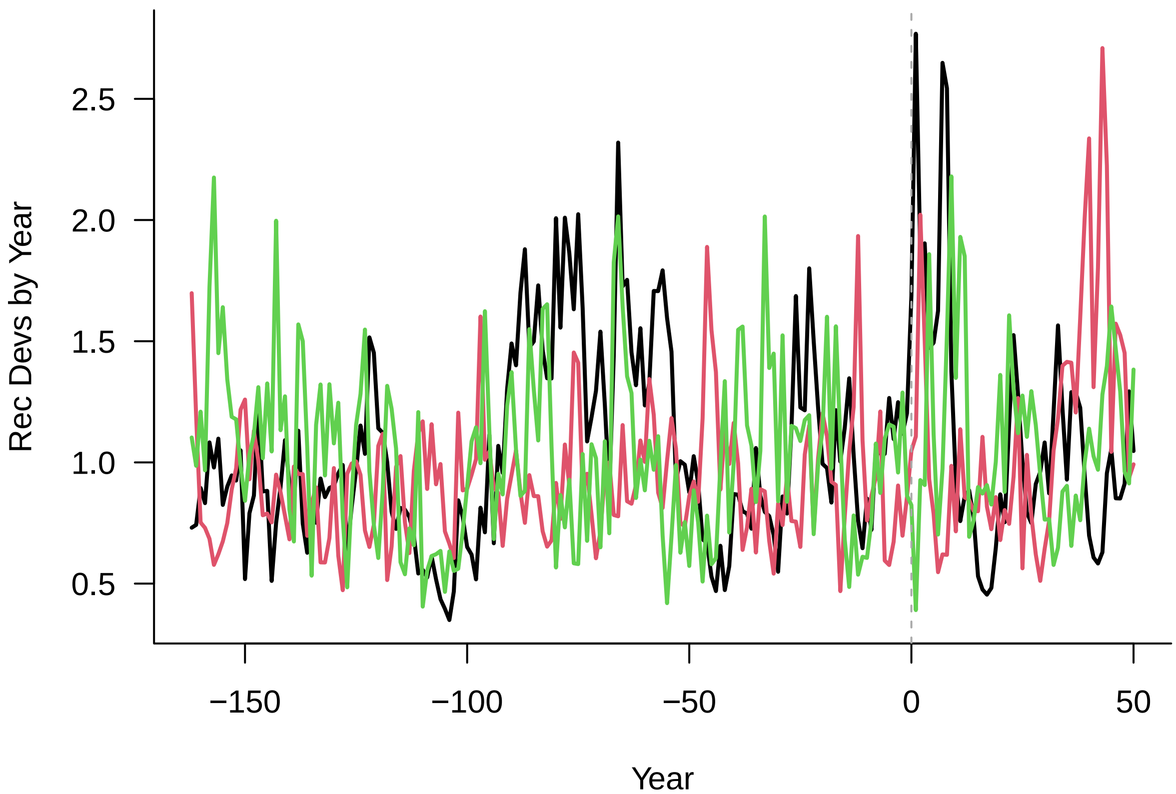
Specified Value(s): 0.5, 0.9

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 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): 660, 735

The ranges used for growth parameters are based on unpublished CDFW data as well as Love et al. 1996.

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): 0.05, 0.07

t0: The von Bertalanffy growth parameter t0, 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): -3.98, -3.02

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): 0.05, 0.15

Based on the observed variability in the length at age presented in Love et al. 1996, we modeled a CV between 5 and 15%.

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.

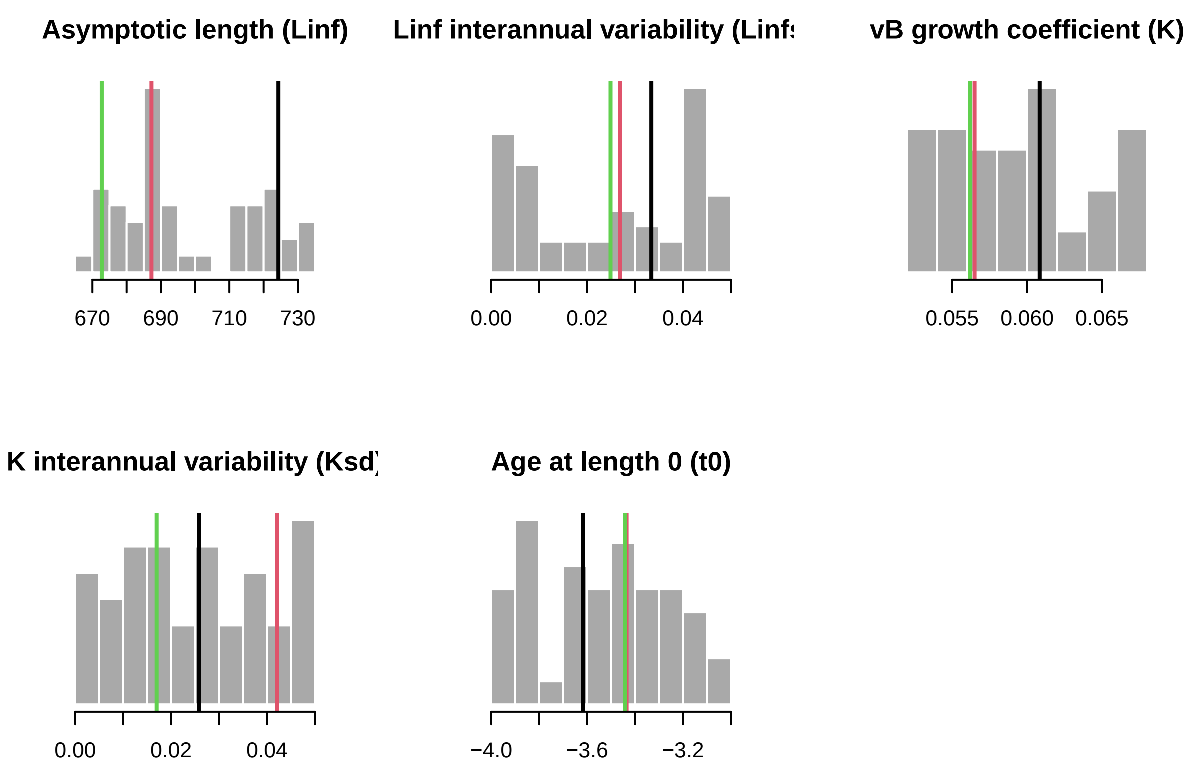
Specified Value(s): 0, 0.05

Linfsd: 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 Linfsd drawn for that simulation. Uniform distribution lower and upper bounds. Non-negative real numbers.

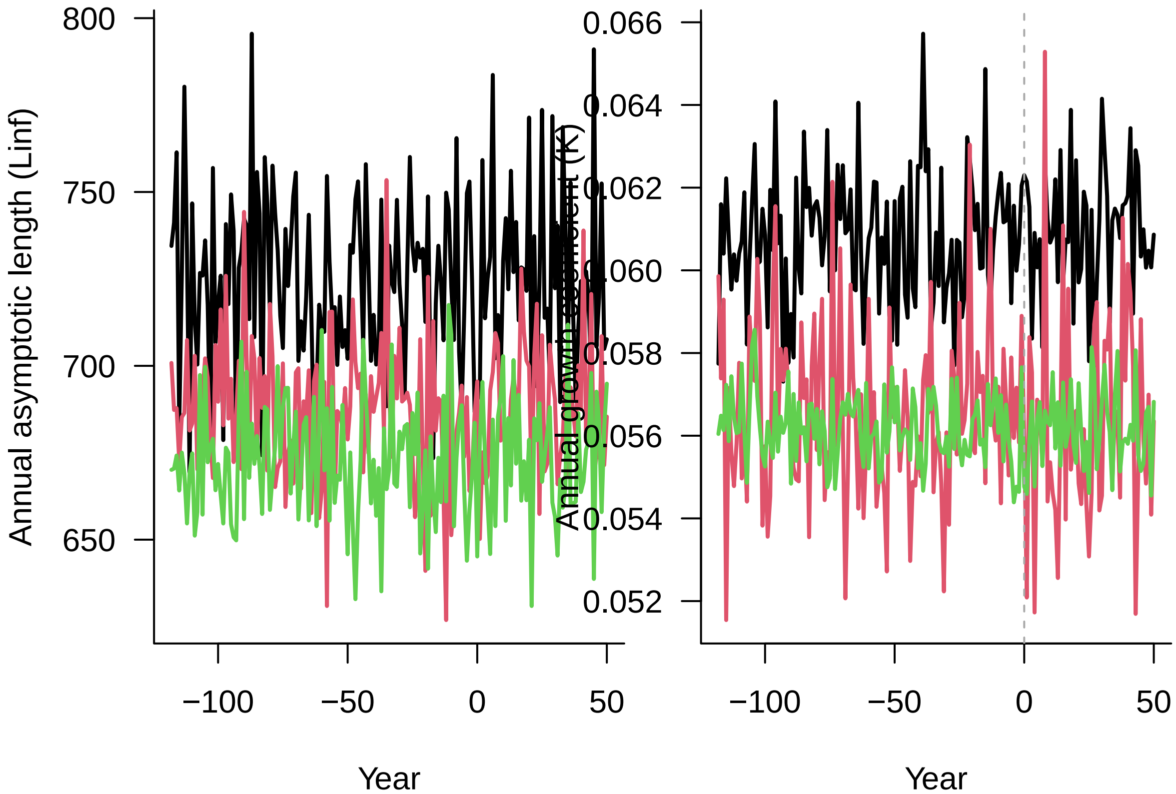
Specified Value(s): 0, 0.05

Growth Parameters

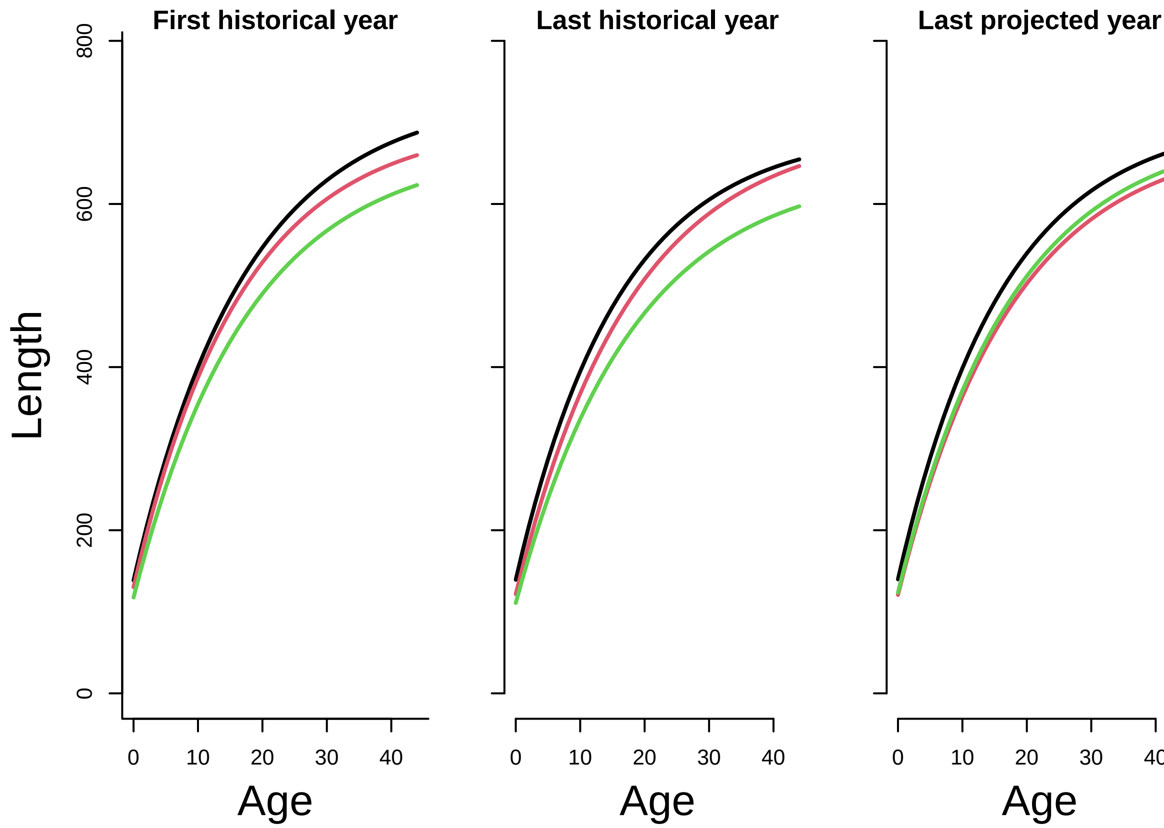
Sampled Parameters Histograms of simulations of von Bertalanffy growth parameters `Linf`, `K`, and `t0`, and inter-annual variability in Linf and K (`Linfsd` and `Ksd`), with vertical colored lines indicating 3 randomly drawn values used in other plots:



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): 220, 230

Values were based on information in Love et al. 1996. Fifty percent of males are mature at 22.0 cm (8.7 in) and females at 22.6 cm (9.0 in).

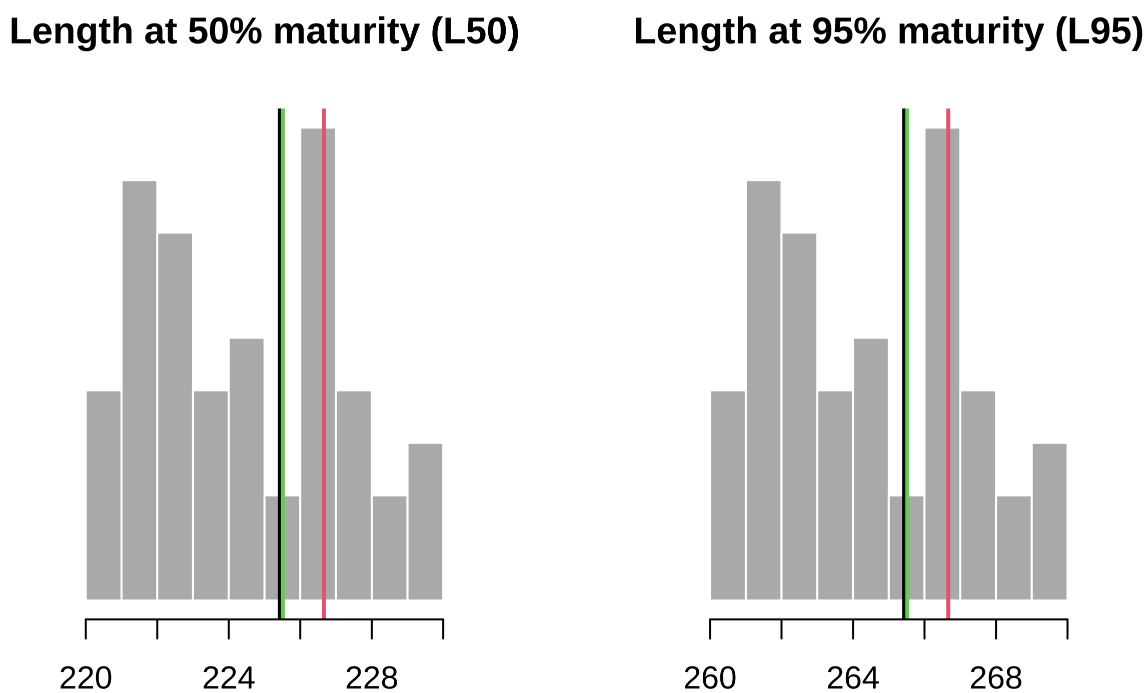
L50_95: Difference in lengths between 50% and 95% maturity. For each simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. The value drawn is then added to the length at 50% maturity to determine the length at 95% maturity. This parameterization 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): 40, 40

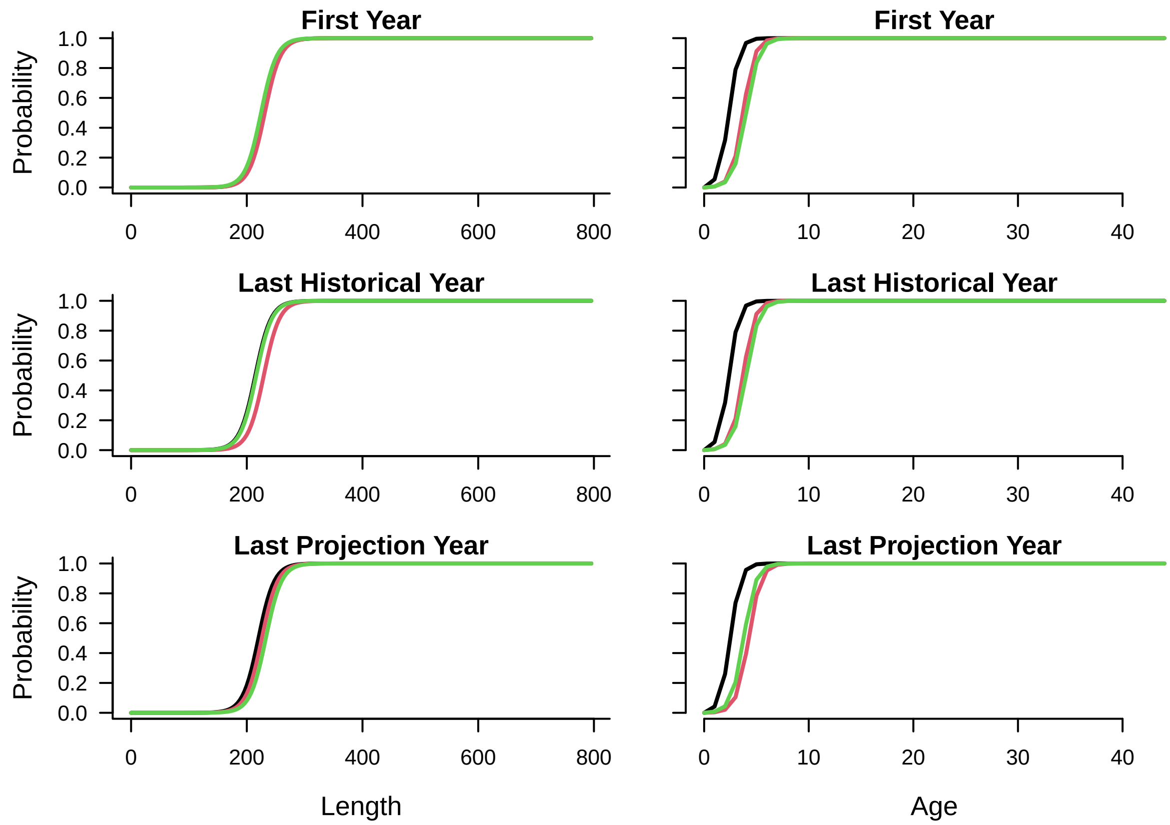
Values were based on information in Love et al. 1996. All males are mature by 26 cm (10 in) and 4 years and females by 27 cm (11 in) and 5 years.

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:



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, Fdisc

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): 0.25, 0.4

No formal stock assessment exists for kelp bass. Analysis of fishery-dependent and fishery-independent datasets along with environmental variables indicate abundance has declined concurrently with increases in exploitation. Since 2013, kelp bass landings and Catch Per Unit Effort have started to increase for Commercial Passenger Fishing Vessels and remained relatively stable for private/rental boats (CDFW 2019) Stock reduction analysis in MSEtool was also used to estimate depletion.

Fdisc: 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.

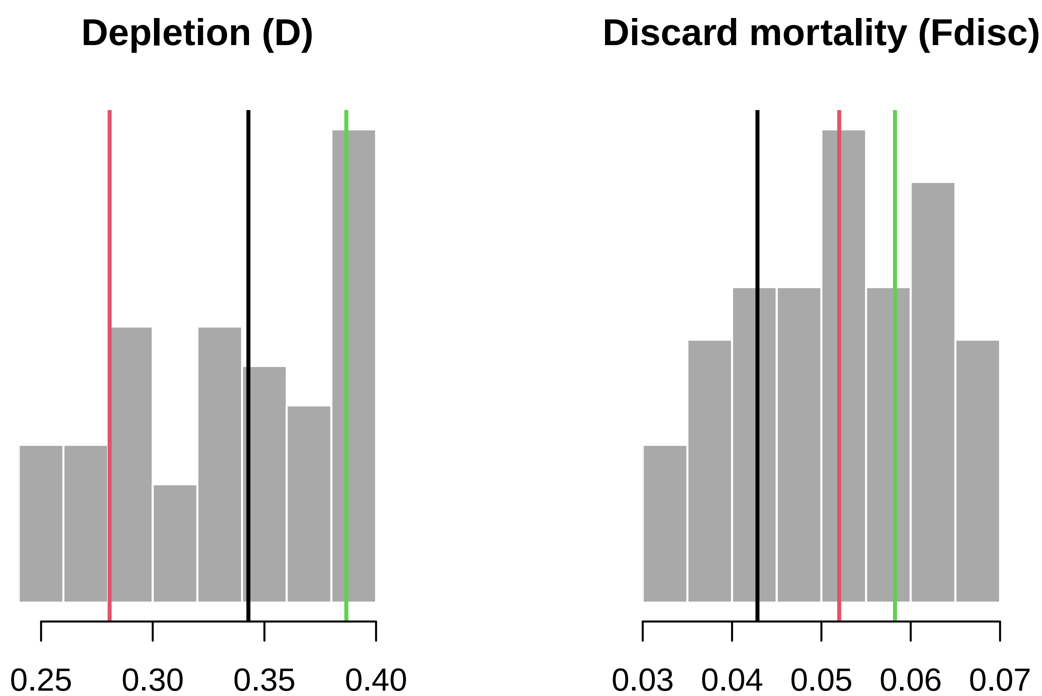
Specified Value(s): 0.03, 0.07

Discard mortality is primarily caused by fishing-related trauma as well as predation from California sea lions, sea birds, harbor seals, and other marine life. Initial post-release mortality for kelp bass has been estimated to be 1.87% (Semmens and Parnell 2014). Fish held in net pens over a ten day period exhibited a 3.1% mortality rate during this trial period prior to release (this number reported for all the basses combined).

However, recently collected data by CDFW staff suggest that up to 11.3% of sampled kelp bass exhibited signs of barotrauma upon release. It is not known whether these barotrauma symptoms contribute to post-release mortality, but higher levels of discard mortality were explored in robustness testing.

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 (`Fdisc`), 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 Linf , K , t0 , 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

Based on information in Williams et al. (2013). Some error may have been introduced by different fish measuring methods. Williams used standard length and we modeled total length. The alpha parameter was converted in order to model the weight of the population in metric tons.

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 determine by the Linf , K , t0 , 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): 3.01

Based on information in Williams et al. (2013). Some error may have been introduced by different fish measuring methods. Williams used standard length and we modeled total length.

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): 0.12, 0.12

An estimated 12% of southern California's hard substrate between 0-30m depth is within marine protected areas (MPAs). This was used as a proxy for appropriate kelp bass habitat. Actual habitat area varies with the coverage of kelp over available hard bottom.

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): 0.12, 0.12

The percent of kelp bass population in MPAs was assumed to be proportional to the area protected.

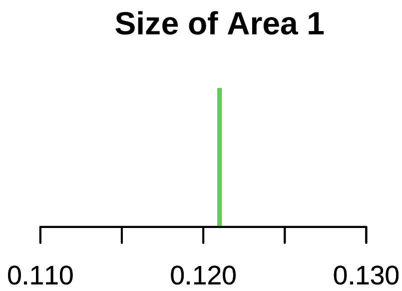
Prob_staying: The probability of individuals in area 1 remaining in area 1 over the course of one year. Please specify numbers between 0 and 1. For each simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. For example, in an area with a Prob_staying 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.

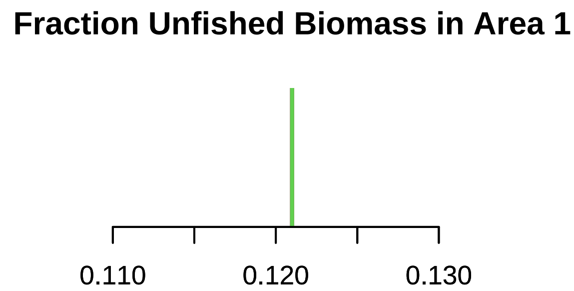
Specified Value(s): 0.95, 0.99

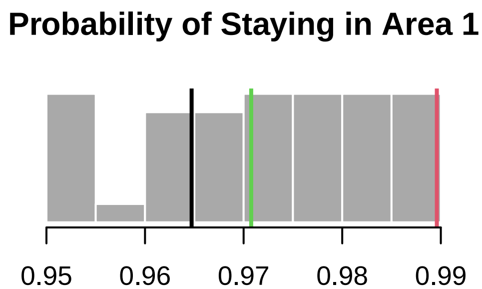
Home ranges of kelp bass have been estimated to range between 33-11,224 m2. This is smaller than southern California MPAs.

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 (`Frac_area_1`), with vertical colored lines indicating 3 randomly drawn values used in other plots:







Fleet Parameters

Kelp bass has been fished in California since the late 1800s. Commercial landings were first recorded in 1916. The commercial fishery was closed in 1953, and for this reason this model focuses only on the recreational fleet.

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): 119

Historical fishing period modeled is 1900 to 2018.

Spat_targ: Distribution of fishing in relation to vulnerable biomass (VB) across areas. The distribution of fishing effort is proportional to VBˆSpat_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

We assumed fishing activity is spread approximately evenly across the entire spatial distribution of 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).

There are three data sets available with which to estimate historical fishing effort: 1) historical catch and effort data from the CPFV fleet between 1936 and 1979, which includes catches specified as "rock bass", a category that can include barred sand bass, kelp bass, or spotted sand bass, as well as by individual species 2) historical commercial landings, which were outlawed in 1953, and 3) the modern Marine Log System (MLS) database, which records catch and effort for all CPFV trips since 1980. Kelp bass have been a popular nearshore recreational species since landings data were first collected, and likely prior to that. We model fishing beginning in 1900, but do not have precise effort estimates prior to 1980, when the modern MLS database began. Prior to this, we have little landings data on which to base an effort estimate. We assume no fishing effort in 1900, modest effort in the first half of the 20th century, dropping to zero during WWII, and increasing from there.

Beginning in 1980, there are more comprehensive data to assess fishing effort. The modern CPFV logbook database records every CPFV trip in California, and thus total fishing effort (whether trips or angler hours) in this database would vastly overestimate the amount of fishing effort applied to the kelp bass stock. In contrast, limiting the database to those trips that encountered a kelp bass may provide an underestimate of true level of fishing effort because it would not count those trips that were targeting kelp bass but did not catch one (something that is more likely to happen as the stock size declines, and which would decrease the assumed current fishing effort in forward projections). It has been suggested that the species composition of the catch can be used as a proxy to determine which CPFV trips are fishing in an area where kelp bass are also likely to occur (Stephens and MacCall 2004). Therefore, we determined which trips were likely to have been targeting kelp bass based on species usually caught along with kelp bass. This species composition was determined through the application of an associated species model, which is a logistic regression on presence/absence data to determine the probability of a species co-occurring in the catch with kelp bass (Stephens and MacCall 2004). This analysis produces a list of species that have a moderate to high probability of co-occurring with a kelp bass in CPFV catch records. It is then possible to filter the CPFV database to include only trips that caught at least one of these associated species, and to consider those trips as targeting kelp bass.

Due to the size of the CPFV database (over 4 million unique observations) and the number of species in the database, trips outside of the Southern California area (defined as CDFW blocks 630-900, as well as block 950) were removed. In addition, trips targeting a species that was highly unlikely to co-occur with kelp bass were removed based on expert judgement. These included trips that landed salmon, large highly migratory fish such as tuna, and those landing lobsters or other invertebrates that would have been targeted with a gear type other than hook and line. We also removed those species that made up less than 0.1% of the total catch. A logistic regression was fit to presence/absence data, and a backward stepwise model selection procedure was performed. We then examined the coefficients of the selected model, which provides the log odds of predicting co-occurrence in the reported catch with kelp bass. We included all species that were highly positively associated with kelp bass (had a coefficient > 0.5). We fit this model to different versions of the data to examine how species associations may have changed over time, including using data restricted by seasons, as well as before and after 1995 to determine whether species assemblages had changed due to fishing or environmental conditions over the almost 40 year period analyzed. Our preferred model restricted the trips to the summer months (July and August) for all years of data, and positively associated species.

The CPFV database was then filtered to include trips that caught at least one of the associated species (in addition to trips that caught at least one kelp bass). Different metrics of yearly fishing effort were then calculated from this data set, including the number of trips per year, the number of hours fished across all trips, the number of anglers fishing, and the number of angler-hours. Because the trends in these various effort metrics were similar over time, it was decided to use the number of trips scaled to 1 +/- 20% to parameterize EffUpper and EffLower between 1980 and 2018.

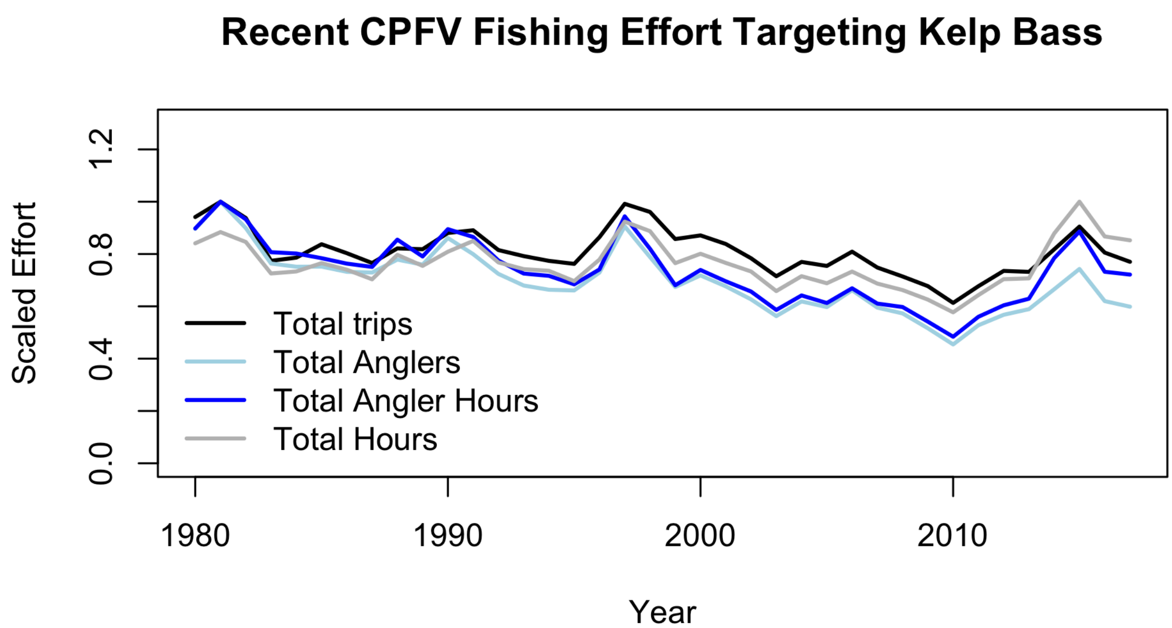


Figure 1: Kelp Bass Fishing Effort: CPFV fleet

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).

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).

EffYears	EffLower	EffUpper
1900	0.000	0.000
1910	0.100	0.200
1934	0.100	0.200
1939	0.000	0.000
1946	0.000	0.000
1949	0.350	0.650
1964	0.650	0.750
1974	0.549	0.851
1975	0.617	0.783
1976	0.646	0.754
1977	0.592	0.808

EffYears	EffLower	EffUpper
1979	0.607	0.793
1980	0.607	0.910
1981	0.670	1.000
1982	0.628	0.941
1983	0.569	0.854
1984	0.570	0.855
1985	0.600	0.900
1986	0.631	0.946
1987	0.623	0.934
1988	0.631	0.947
1989	0.612	0.918
1990	0.676	1.010
1991	0.685	1.030
1992	0.647	0.971
1993	0.644	0.966
1994	0.612	0.918
1995	0.612	0.918
1996	0.694	1.040
1997	0.800	1.200
1998	0.797	1.200
1999	0.654	0.982
2000	0.704	1.060
2001	0.689	1.030
2002	0.628	0.942
2003	0.595	0.893
2004	0.614	0.922
2005	0.581	0.872
2006	0.610	0.914
2007	0.571	0.856
2008	0.540	0.810
2009	0.513	0.769
2010	0.421	0.632
2011	0.464	0.697
2012	0.500	0.750
2013	0.457	0.686
2014	0.536	0.804
2015	0.548	0.821
2016	0.521	0.781
2017	0.513	0.769
2018	0.523	0.784

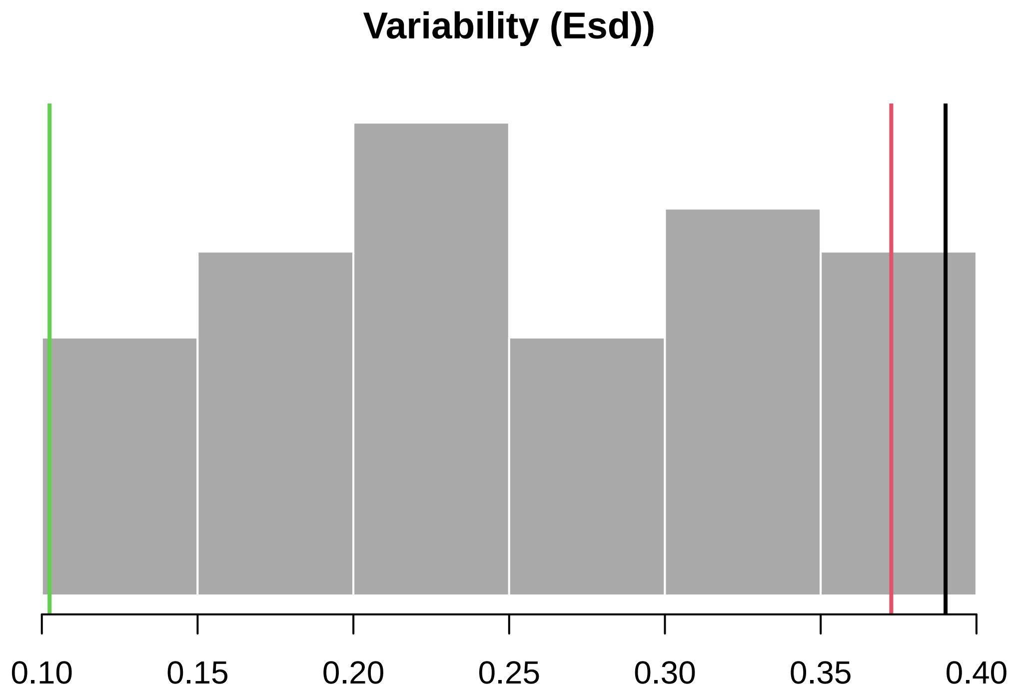
Esd: Additional inter-annual variability in fishing mortality rate. For each historical simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. If this parameter has a positive (non-zero) value, the yearly fishing mortality rate is drawn from a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

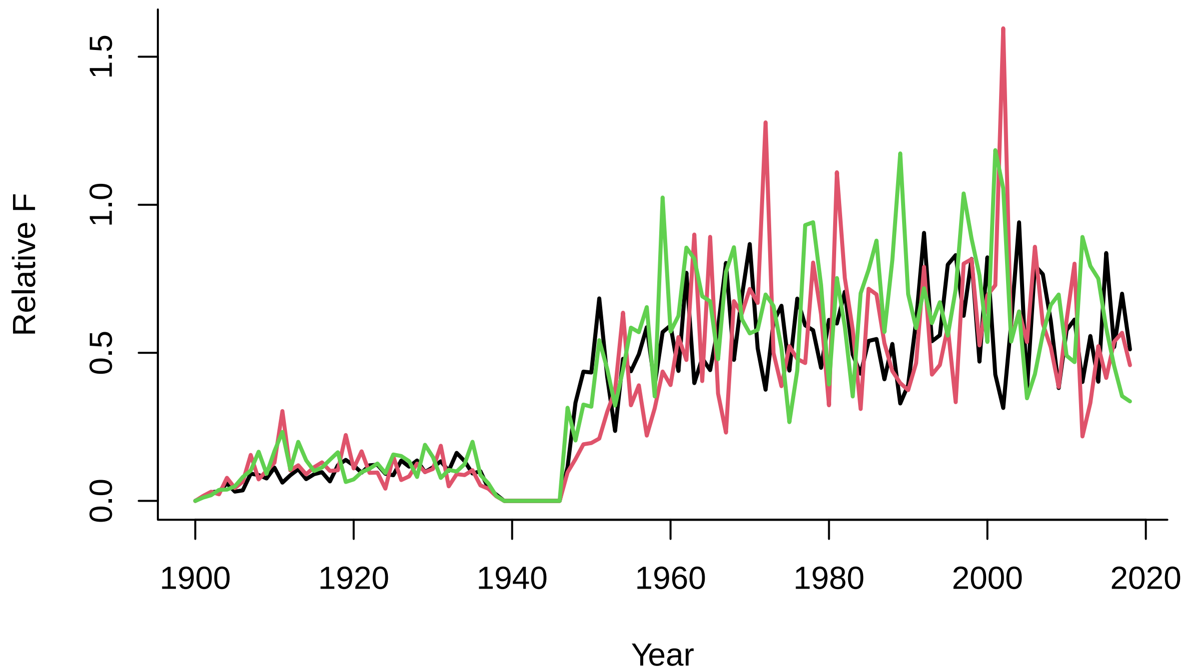
An interannual variability in effort of 10-40% was assumed. These are the default values from the DLMtool,and are used to assist in fitting historical fishing mortality trends to the effort time series provided in EffUpper and EffLower.

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 though 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): -0.1, 0.1

We assumed no increase in catchability over time in the base model but sensitivity tested increasing catchability to reflect the increasing population of recreational fishers in California.

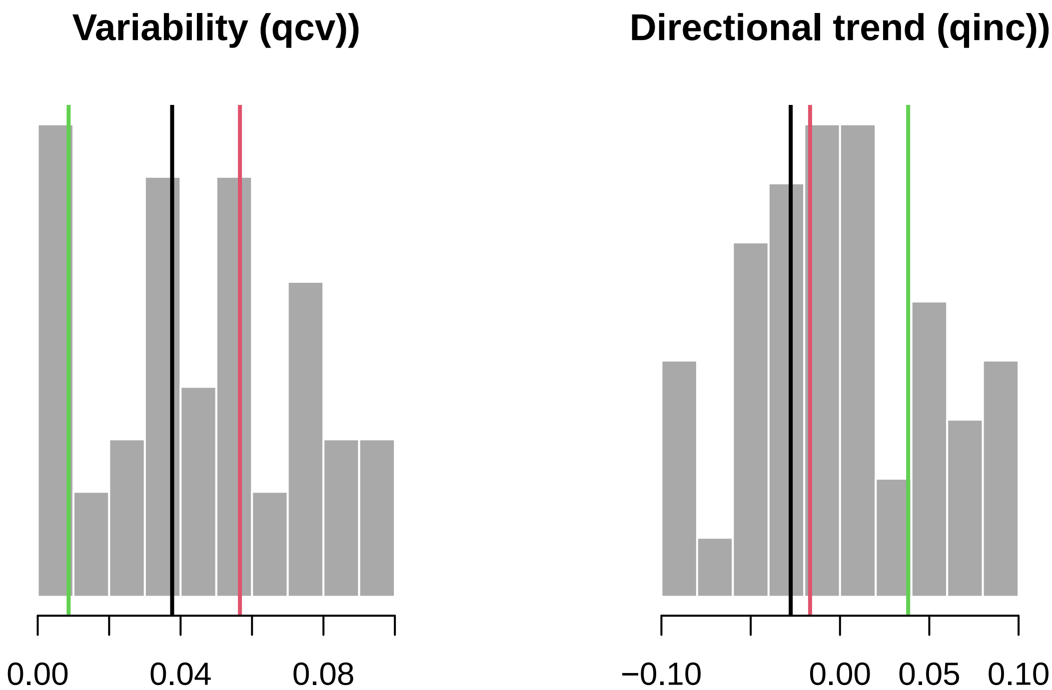
qcv: Inter-annual variability in catchability expressed as a coefficient of variation. For each simulation a single value is drawn from a uniform distribution specified by the upper and lower bounds provided. This parameter applies only to forward projections.

Specified Value(s): 0, 0.1

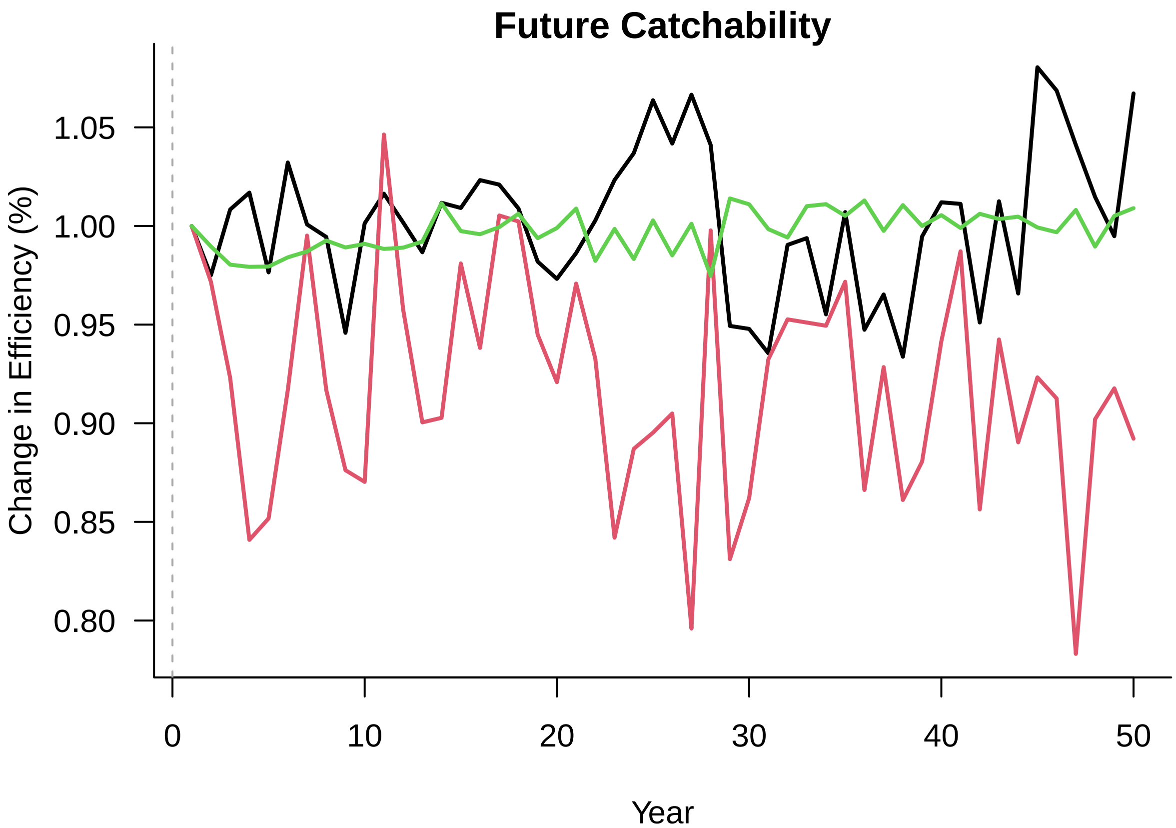
We assumed a small amount of inter-annual variability in fishing efficiency with a CV between 0 and 0.1.

Future Catchability

Sampled Parameters Histograms of 48 simulations of inter-annual variability in fishing efficiency (`qcv`) and average annual change in fishing efficiency (`qinc`), 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): 130, 160

One of the primary changes to the DLMtool after the demo phase of this project was the addition of parameters to specify a retention curve that is separate from the selectivity curve. This allows us to more accurately model any mortality associated with the discard of sublegal fish.

Depending on the type of hooks and baits used it is possible to catch kelp bass that are much smaller than the legal size limit. The majority of these fish are released, though the available data suggests that some sublegals are retained each year. An ongoing Department study monitoring bass discard rates aboard CPFVs has recorded kelp bass as small as 4 in (105 mm) being caught and released. We fit a logistic curve to RecFIN data (2004-2012, prior to a change in the legal size limit) that included both retained and discarded fish to determine the size at which fish can be caught by anglers. Based on this we estimated that fish first become vulnerable to hook and line gear between 130-160mm, and are fully vulnerable at 250-275mm. We assumed a logistic selectivity curve, and so the vulnerability at the maximum size was set to 1.

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): 250, 275

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): 1, 1

There is no evidence that larger fish are less vulnerable to hook and line gear.

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

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

Refer to the last section of the introduction in this report for a description of how cpars were used to calculate retention.

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

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

Assuming logistic selectivity curves.

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): 0.01, 0.04

Values were informed by the ratio of retained to discarded fish available in the RecFIN database.

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): 2018

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

The 2x3 matrix specifies the timing of MPA closures during the fishery history and the proportion of fishing grounds removed for two areas. Historical years are specified in column 1. Proportion of grounds closed in areas 1 and 2 are specified in columns 2 and 3. Area 1 represents MPAs and area 2 represents open fishing grounds. MPAs were first implemented at the Channel Islands closing approximately 65% of the total area (area 1) that would ultimately become southern California's full MPA network implemented in 2012.

Obs Parameters

The Observation Table contains the parameters that are used to generate the simulated fishery data within the MSE model. Except for exceptions noted below, 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 except where information was found to suggest alternative values (see below).

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

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

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): 0, 800

Values were based on the most recent CDFW study. CAA data is not currently collected annually. However, this was explored in a fishery improvement analysis.

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): 0, 800

Same as corresponding nsamp because samples would be able to come from a broad range of the population.

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): 1600, 2700

Based off annual number of CRFS lengths in RecFIN for most recent years (2013-2018).

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): 1600, 2700

It is assumed that the effective sample size is the same as the number of lengths sampled. This is because the sampled lengths come from a number of different sampling events targeting the different fishing modes at different locations and times of the year. As a result, each observed length is likely to be an independent observation.

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

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

Btbiascv: Log-normally distributed coefficient (CV) controlling error in observations of the current stock biomass. Bias occurs when the observed index of abundance is 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

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): 0.6, 1

Assumed moderate values for hyperstability in the abundance index.

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

No justification provided.

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): 0.05

No justification provided.

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): 0.05

No justification provided.

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): 0.05

No justification provided.

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

No justification provided.

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

No justification provided.

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

No justification provided.

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

No justification provided.

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

No justification provided.

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

No justification provided.

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

No justification provided.

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

No justification provided.

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

No justification provided.

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

No justification provided.

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

No justification provided.

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

No justification provided.

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

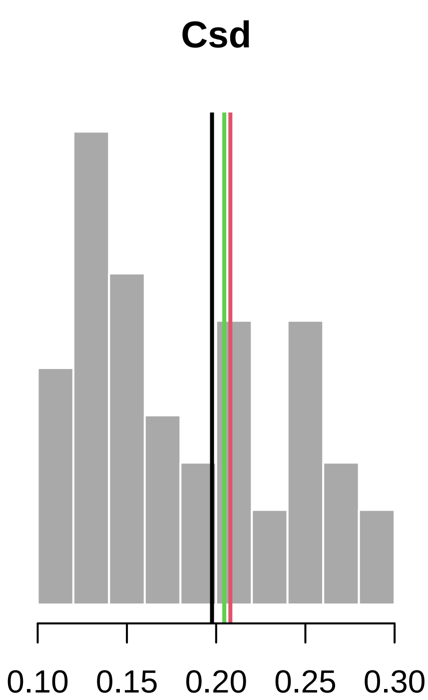
No justification provided.

Obs Plots

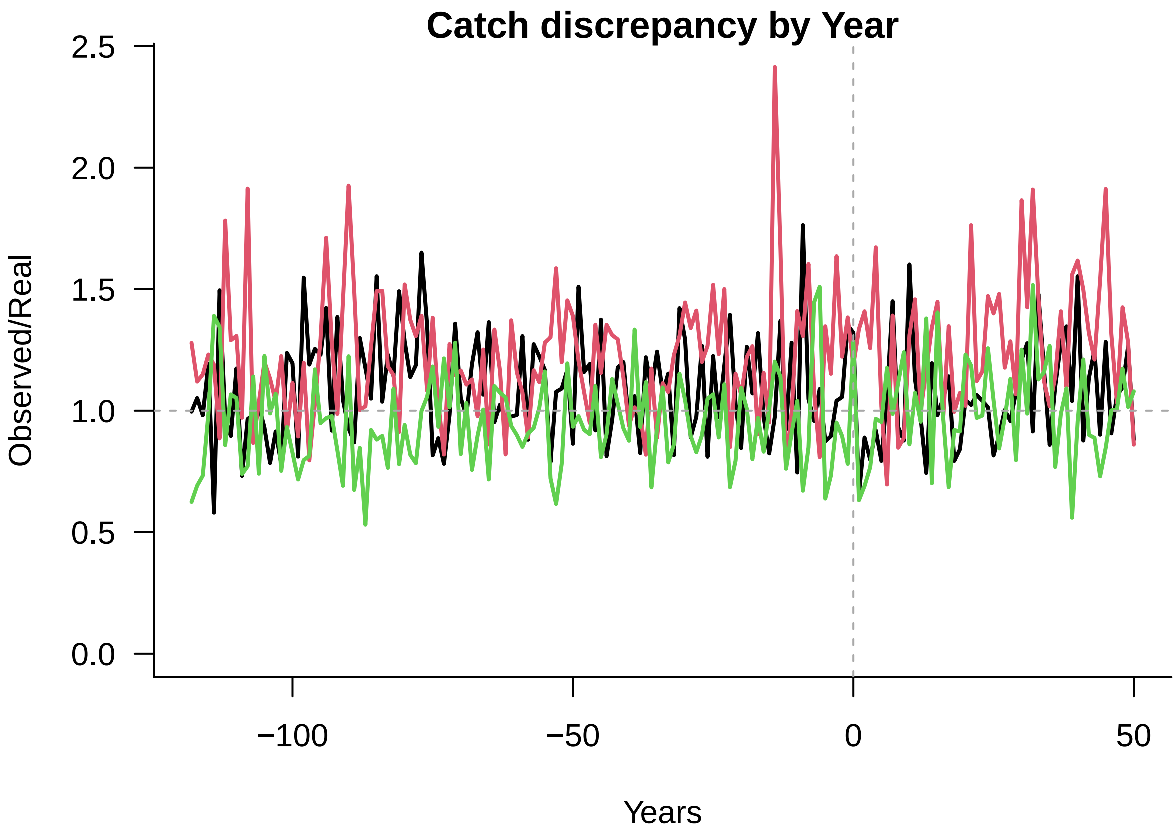
Observation Parameters

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:

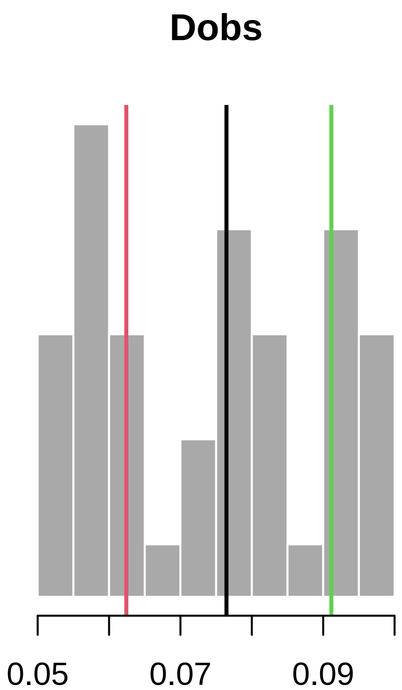


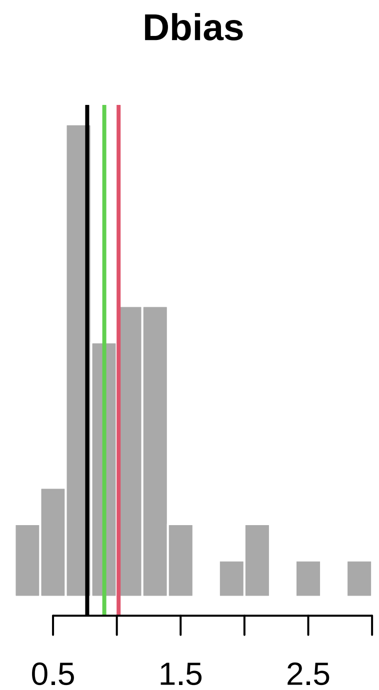
Time-Series Time-series plots of catch observation error for historical and projection years:



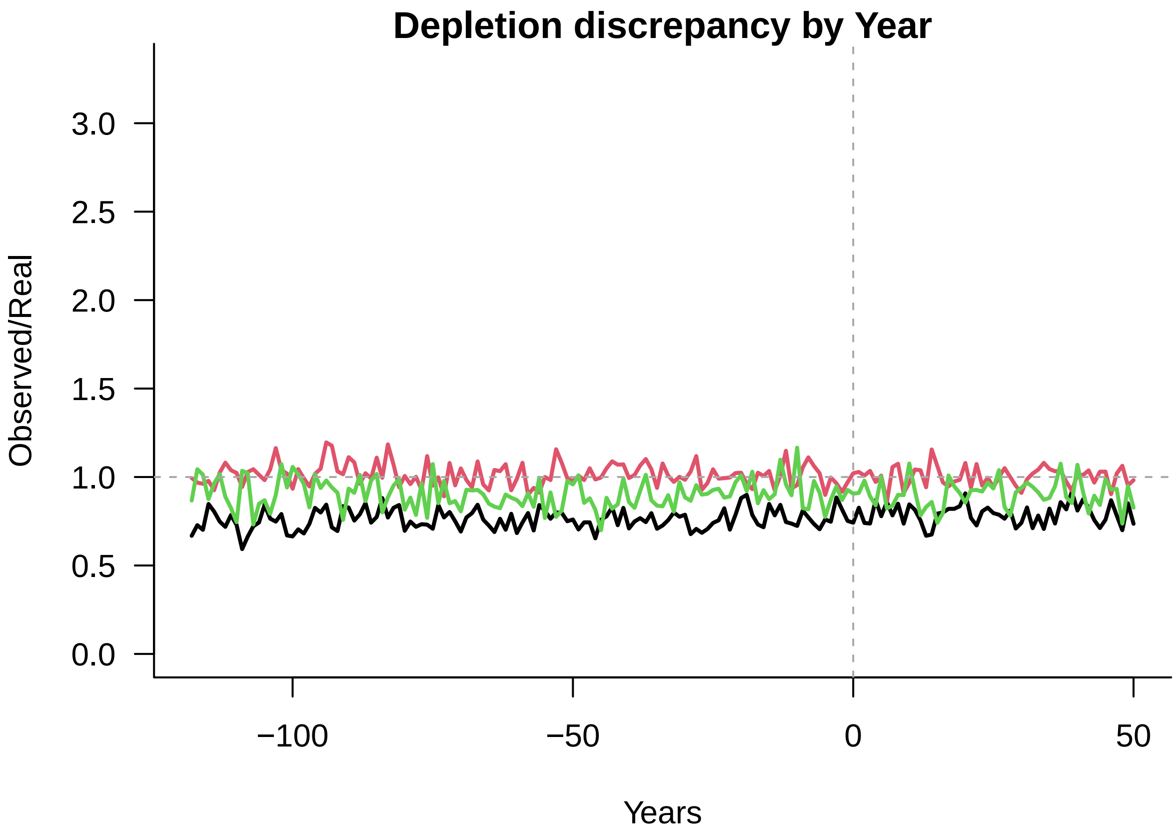
Depletion Observations

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:



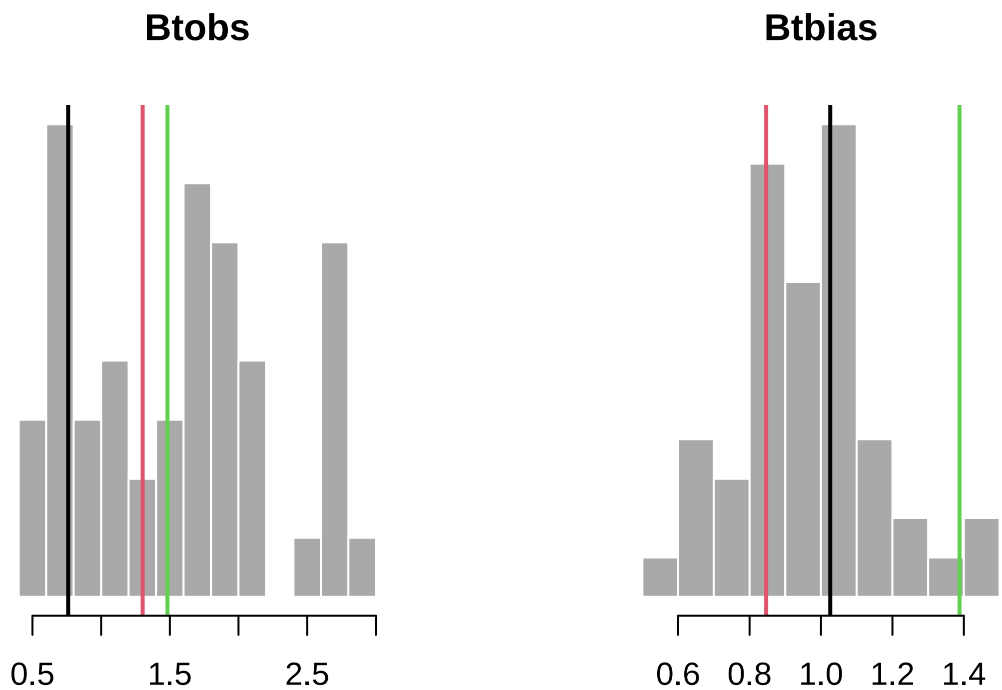


Time-Series Time-series plots of depletion observation error for historical and projection years:

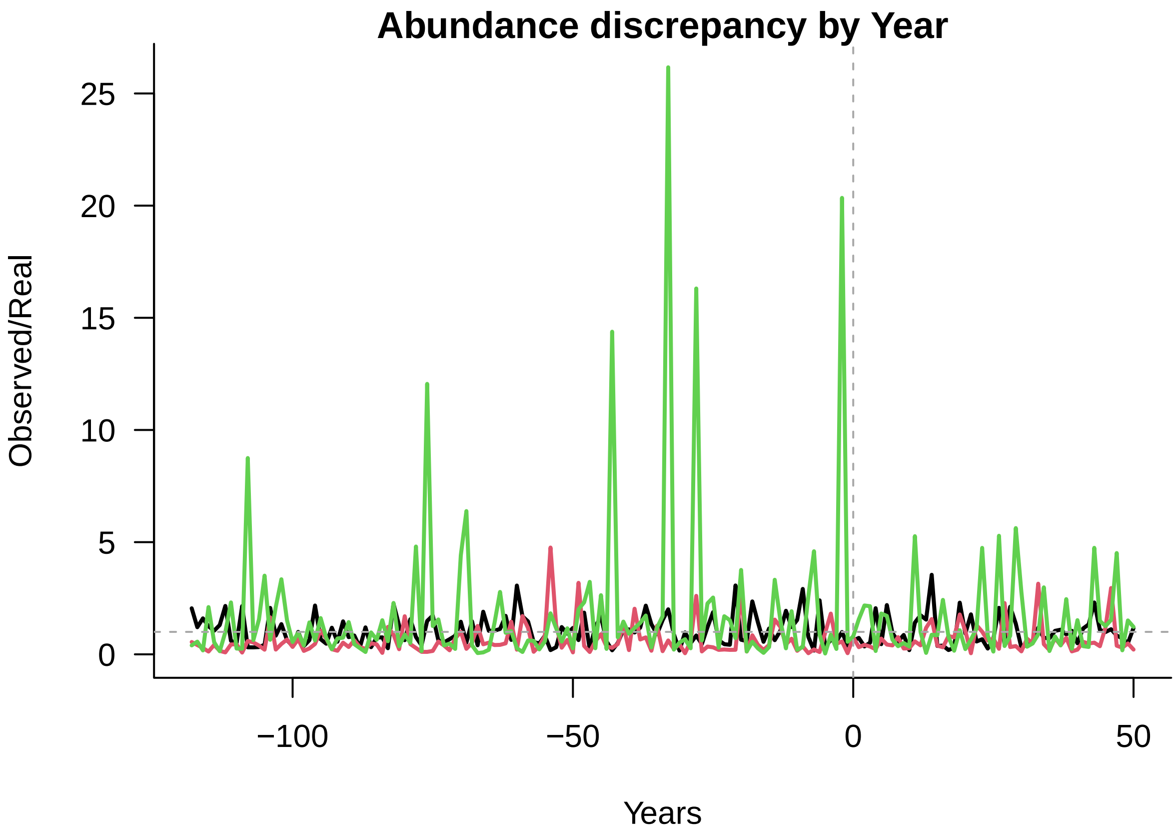


Abundance Observations

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:

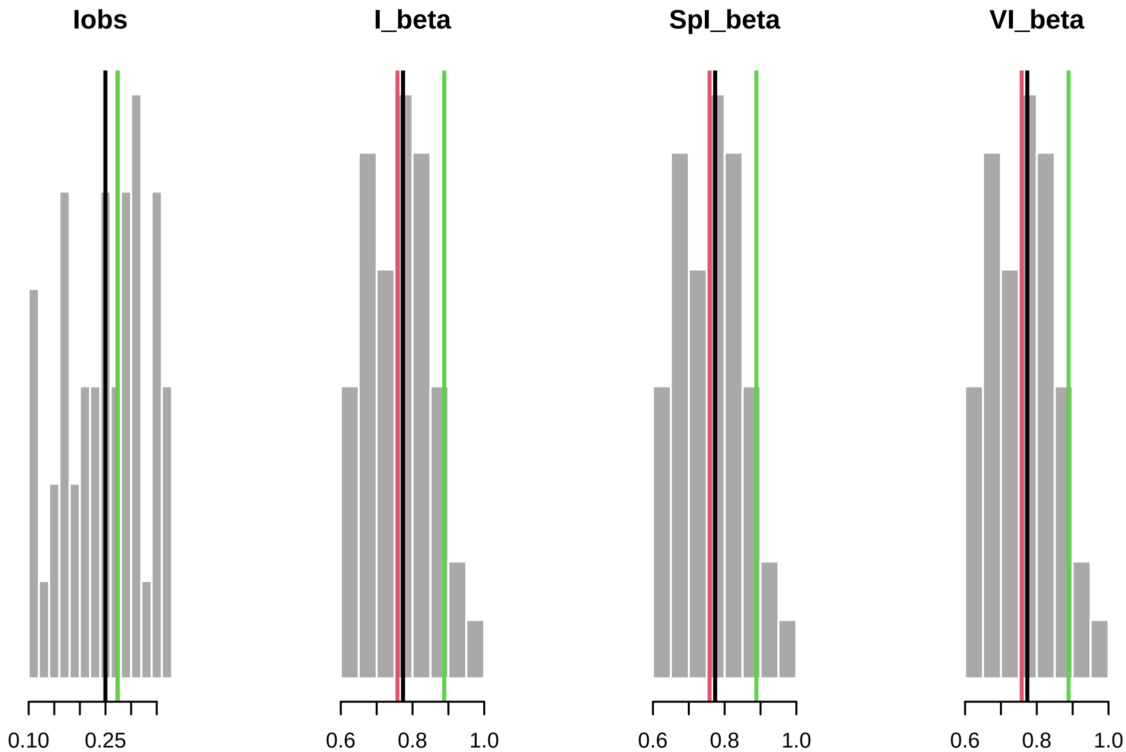


Time-Series Time-series plots of abundance observation error for historical and projection years:

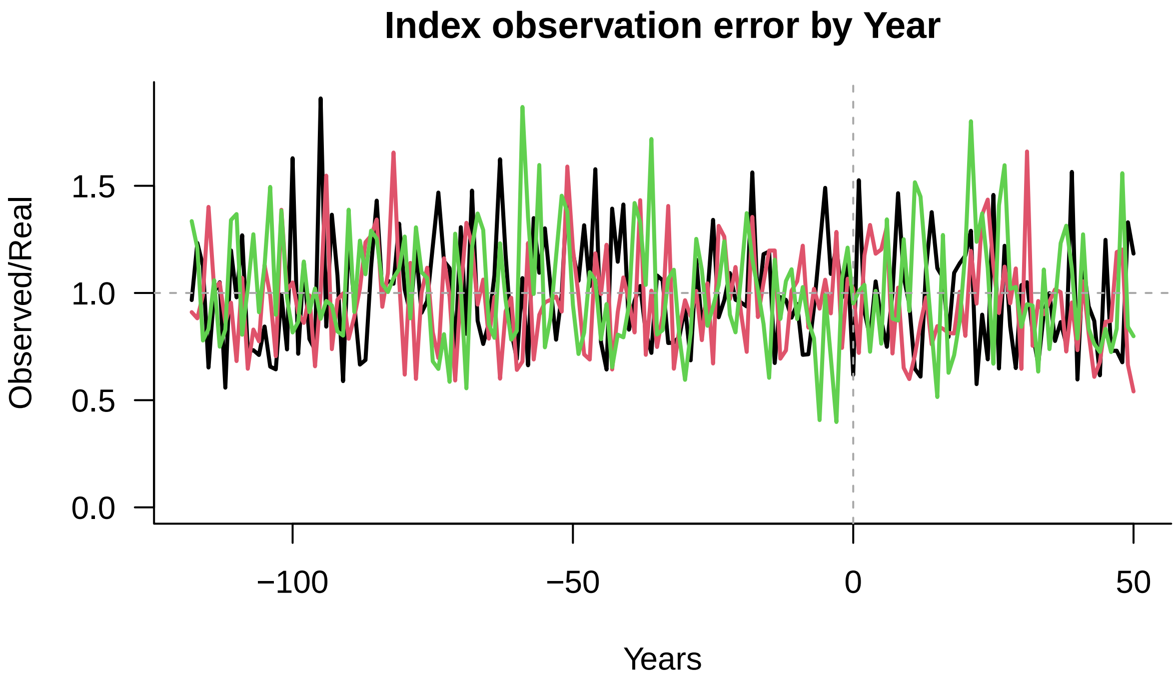


Index Observations

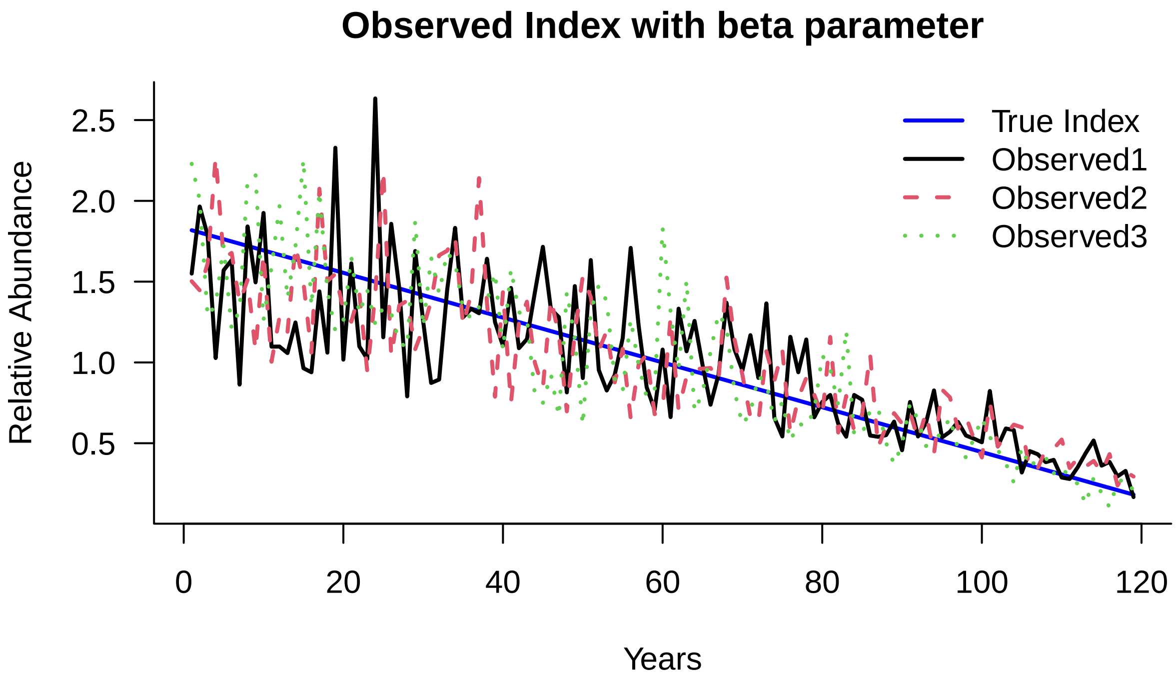
Sampled Parameters Histograms of 48 simulations of inter-annual variability in index observations (`Iobs`) and hyper-stability/depletion in observed index (`beta`), with vertical colored lines indicating 3 randomly drawn values used in other plots:



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

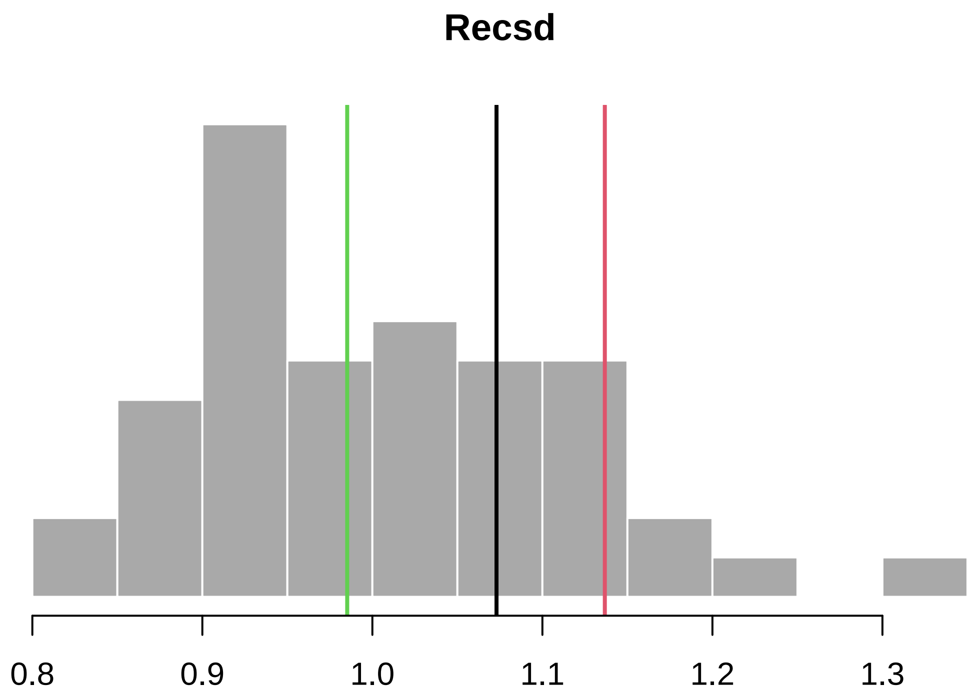


Plot showing an example true abundance index (blue) with 3 samples of index observation error and the hyper-stability/depletion parameter (`beta`):

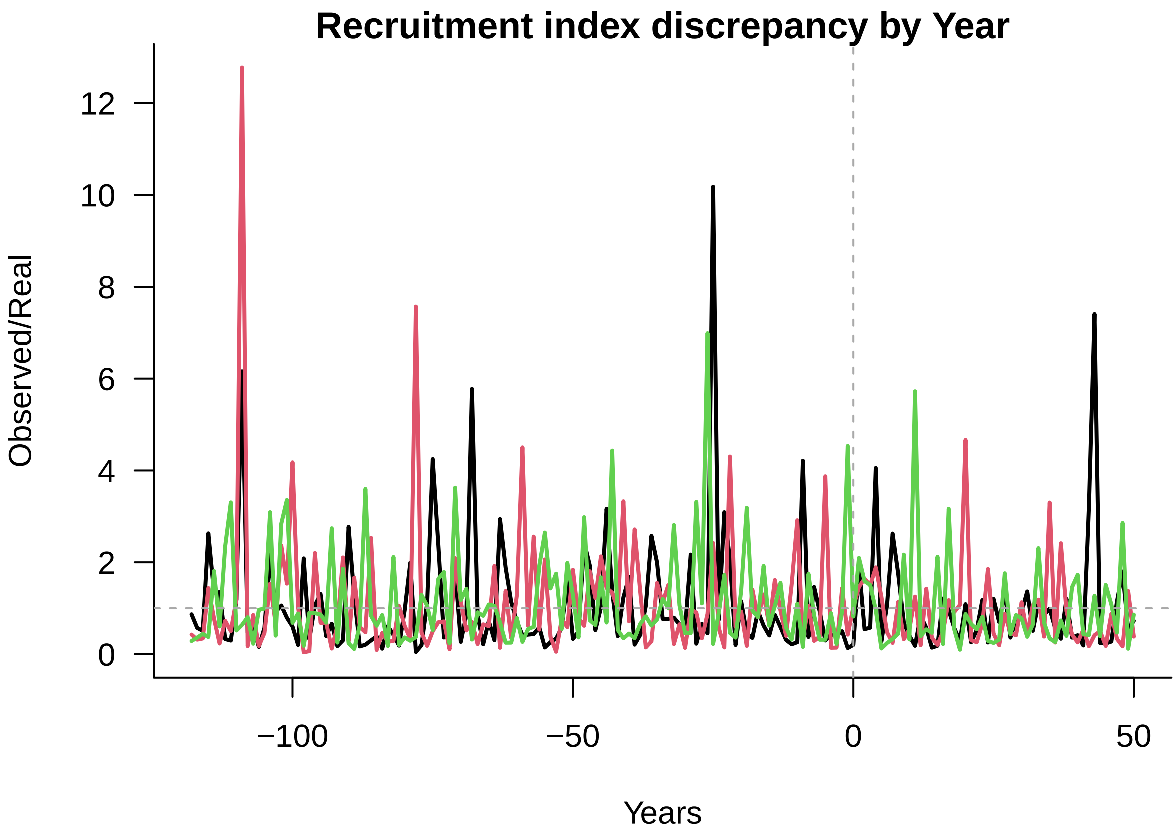


Recruitment Observations

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:

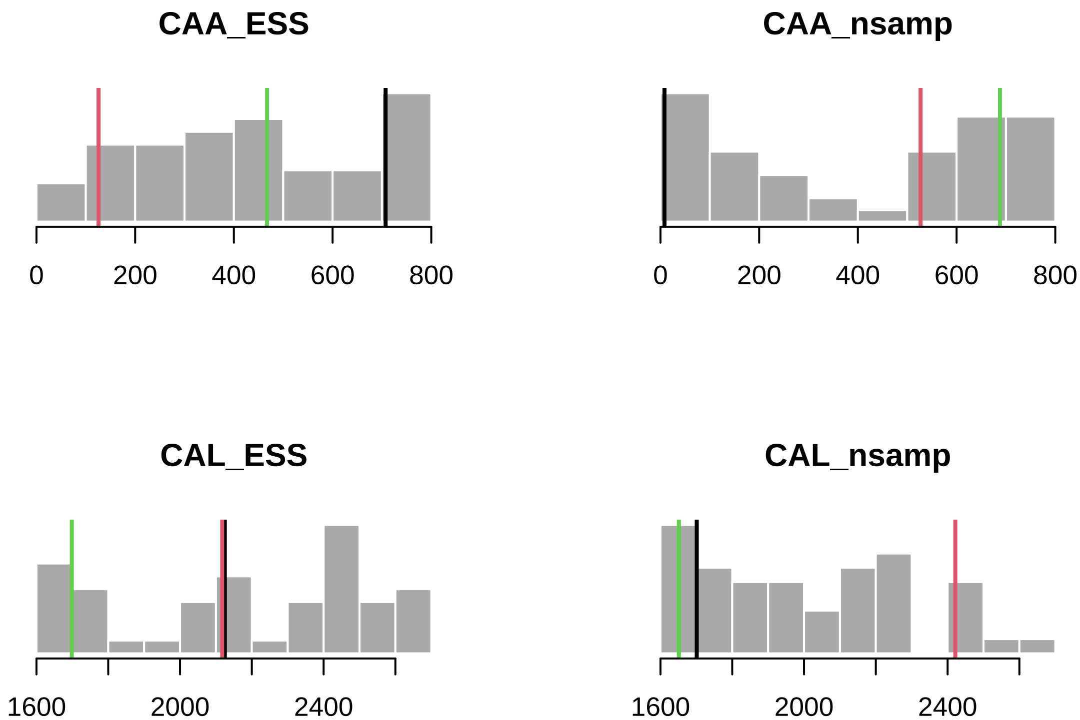


Time-Series Timeseries plots of observeration error for recruitment:



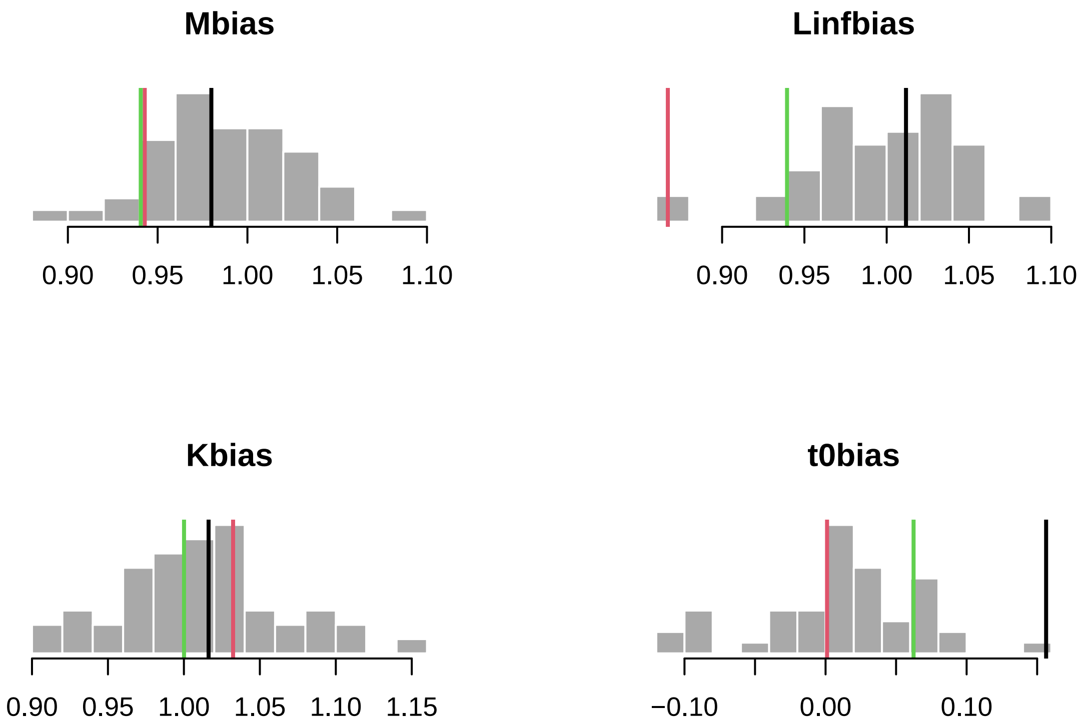
Composition Observations

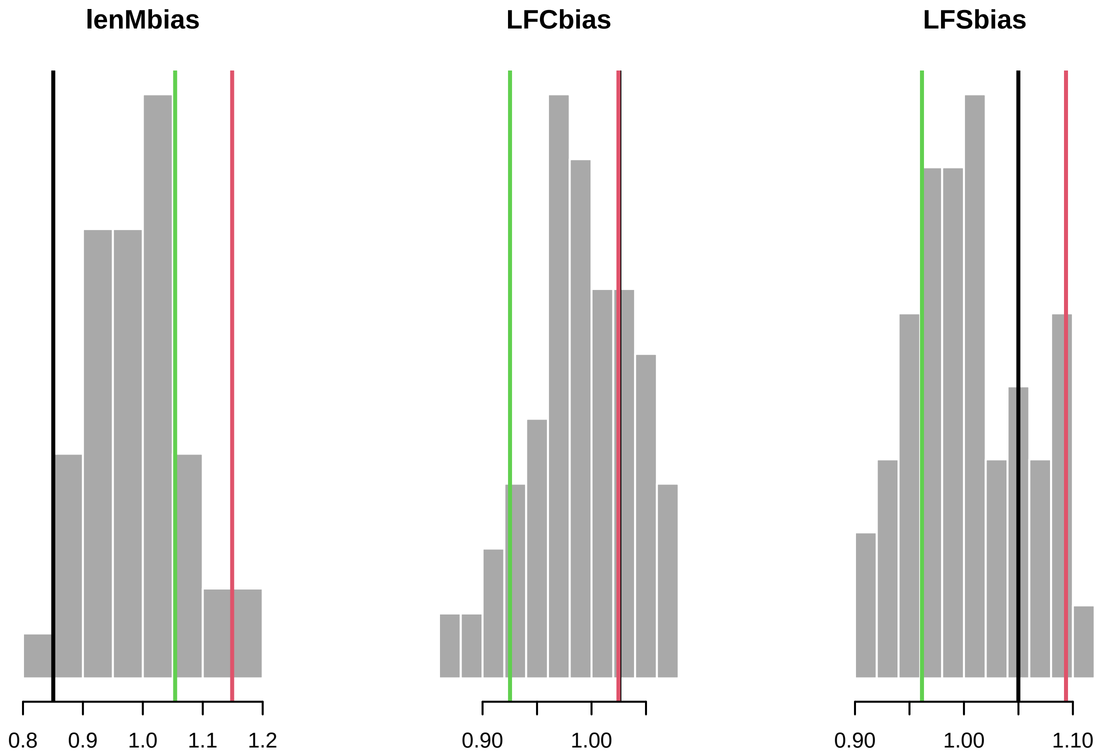
Sampled Parameters Histograms of 48 simulations of catch-at-age effective sample size (`CAA_ESS`) and sample size (`CAA_nsamp`) and catch-at-length effective (`CAL_ESS`) and actual sample size (`CAL_nsamp`) with vertical colored lines indicating 3 randomly drawn values:



Parameter Observations

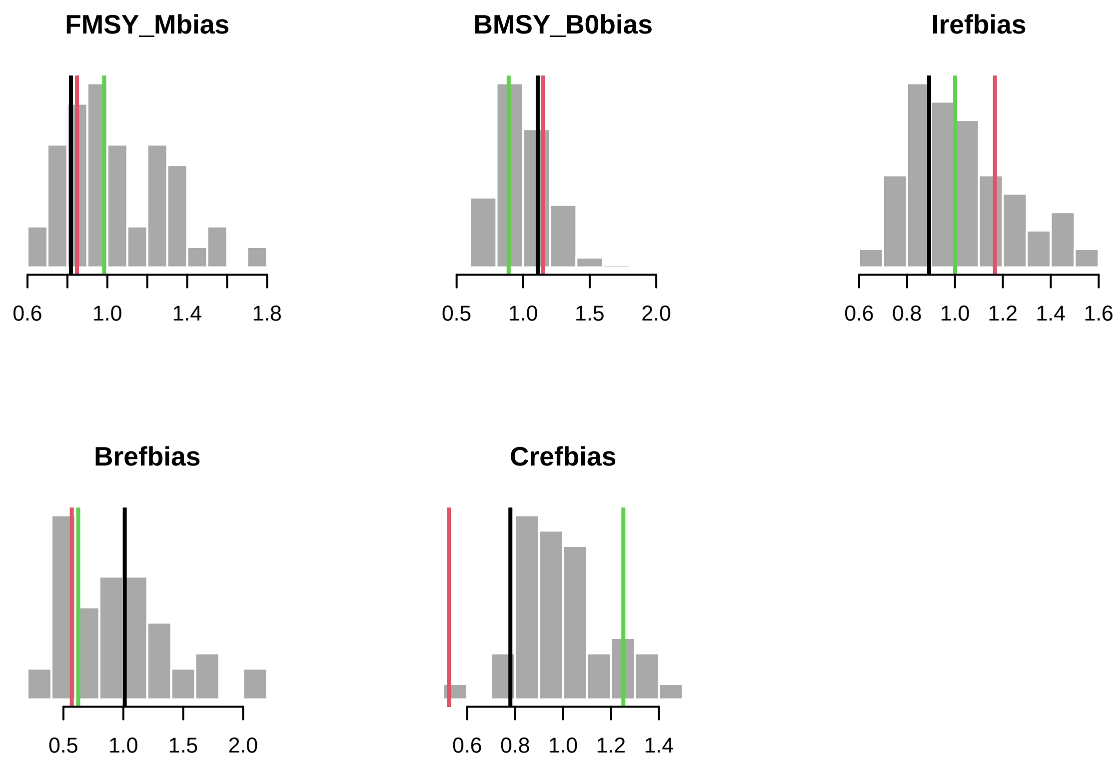
Sampled Parameters Histograms of 48 simulations of bias in observed natural mortality (`Mbias`), von Bertalanffy growth function parameters (`Linfbias`, `Kbias`, and `t0bias`), length-at-maturity (`lenMbias`), and bias in observed length at first capture (`LFCbias`) and first length at full capture (`LFSbias`)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


Mbias
0.90
0.95
1.00
1.05
1.10
Linfbias
0.90
0.95
1.00
1.05
1.10
Kbias
0.90
0.95
1.00
1.05
1.10
1.15
t0bias
−0.10
0.00
0.10



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

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

Perfect implementation.

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

Perfect implementation.

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

Perfect implementation.

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 speciying the actual amount of efort employed are drawn from. Positive real numbers.

Specified Value(s): 0, 0

Perfect implementation.

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): 0.95, 0.97

Anything within 90% of the minimum size limit is retained. Value based on evaluation of RecFIN length frequencies.

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 speciying the actual fraction of the size limit retained are drawn from. Positive real numbers.

Specified Value(s): 0, 0

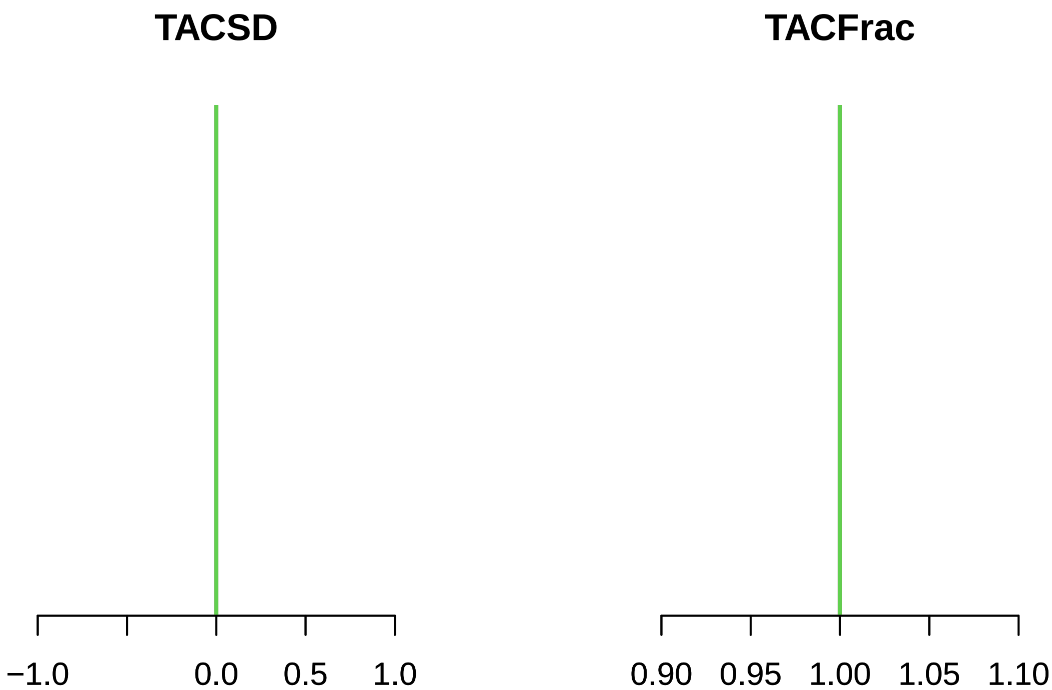
It was assumed that the implementation of the size limit would not change from year to year, and so this paramter was set to 0.

Imp Plots

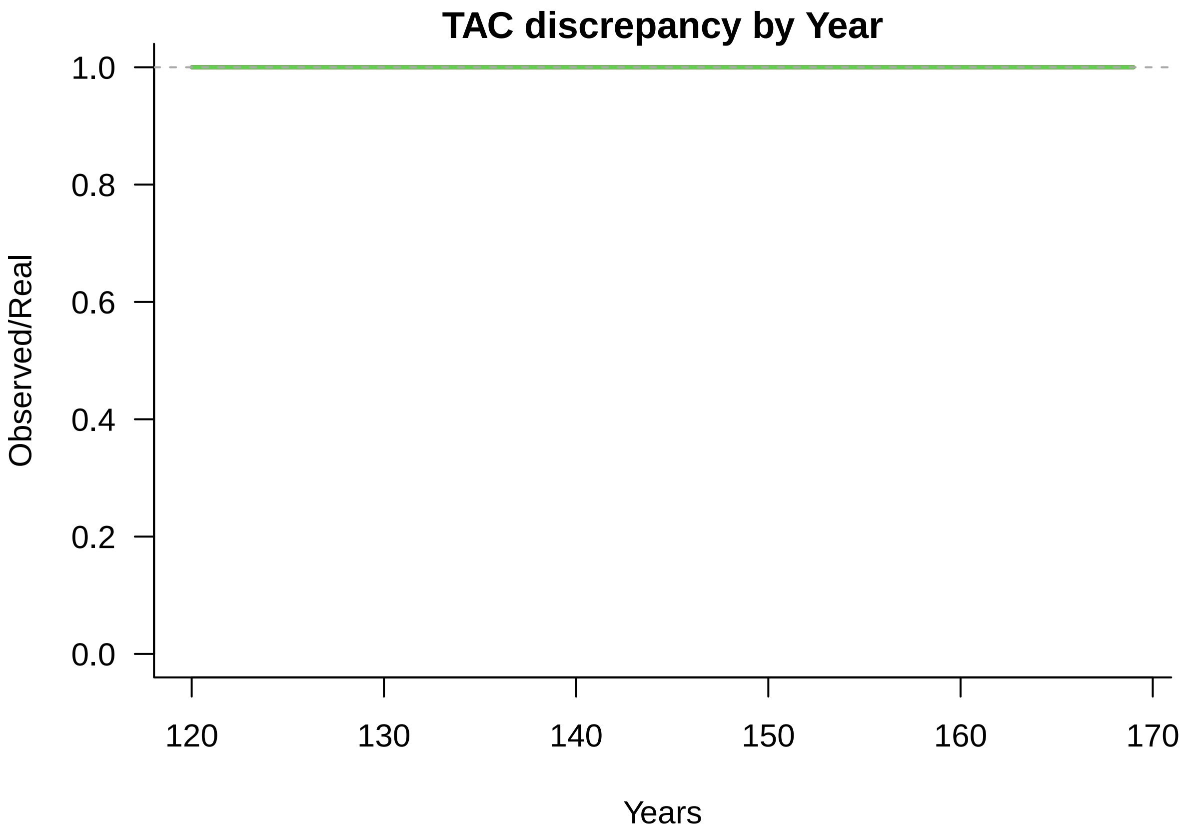
Implementation Parameters

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:

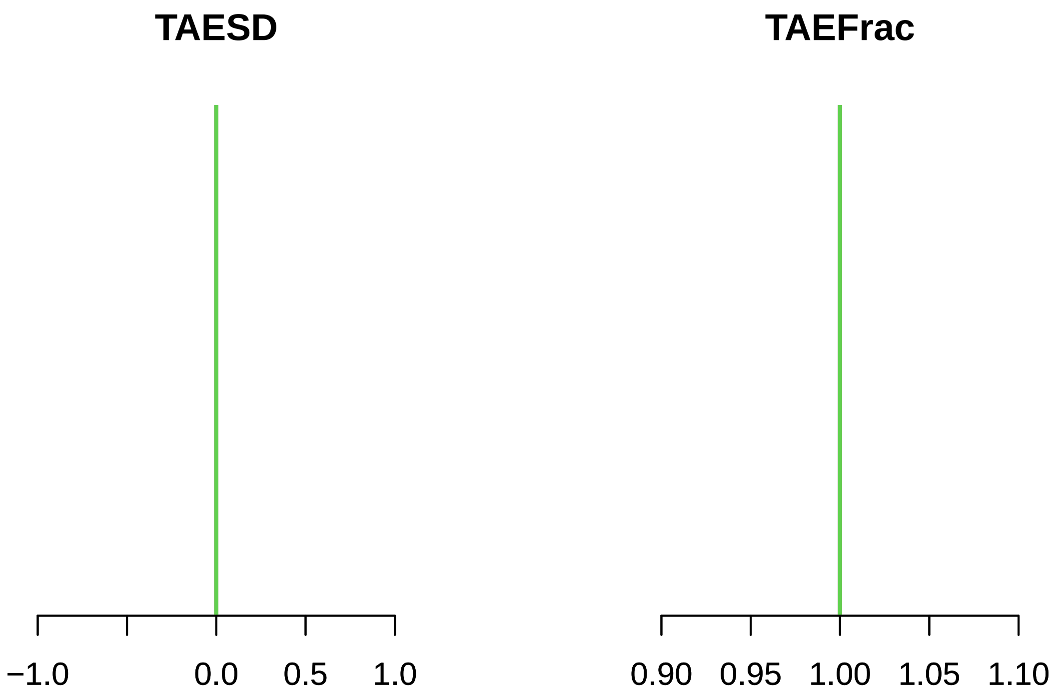


Time-Series Time-series plots of 0 samples of TAC implementation error by year:

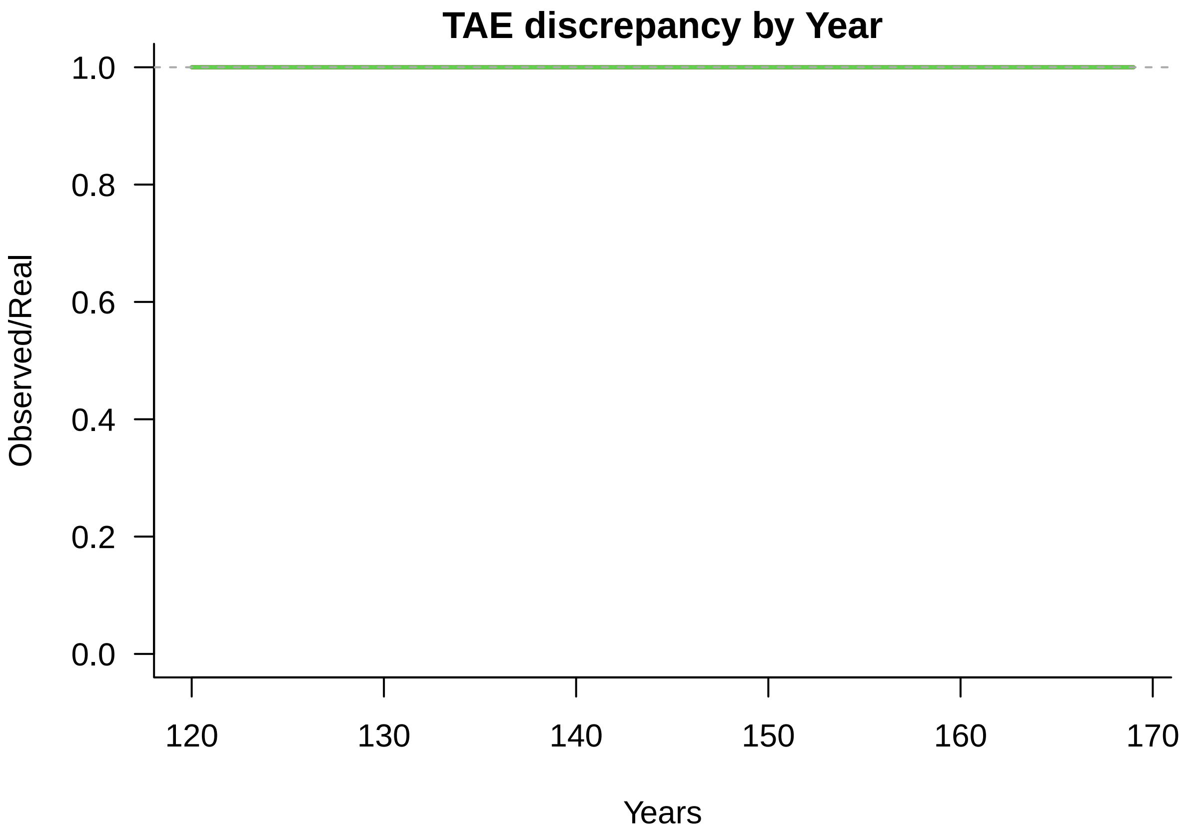


TAE Implementation

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:

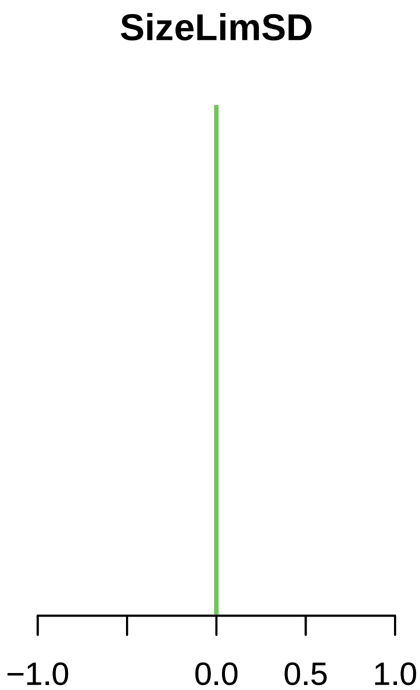


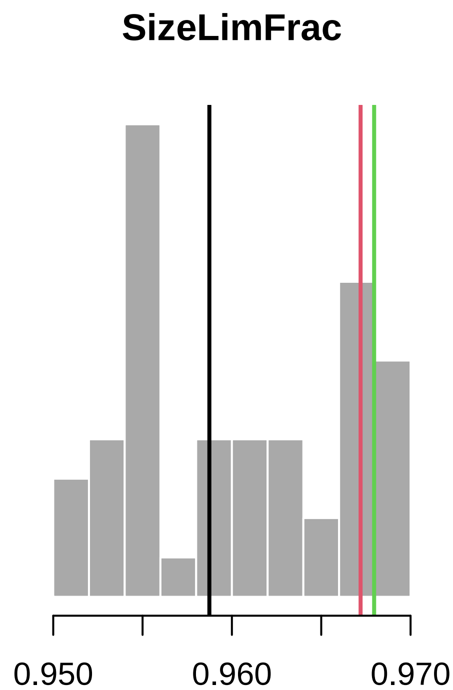
Time-Series Time-series plots of 0 samples of TAE implementation error by year:



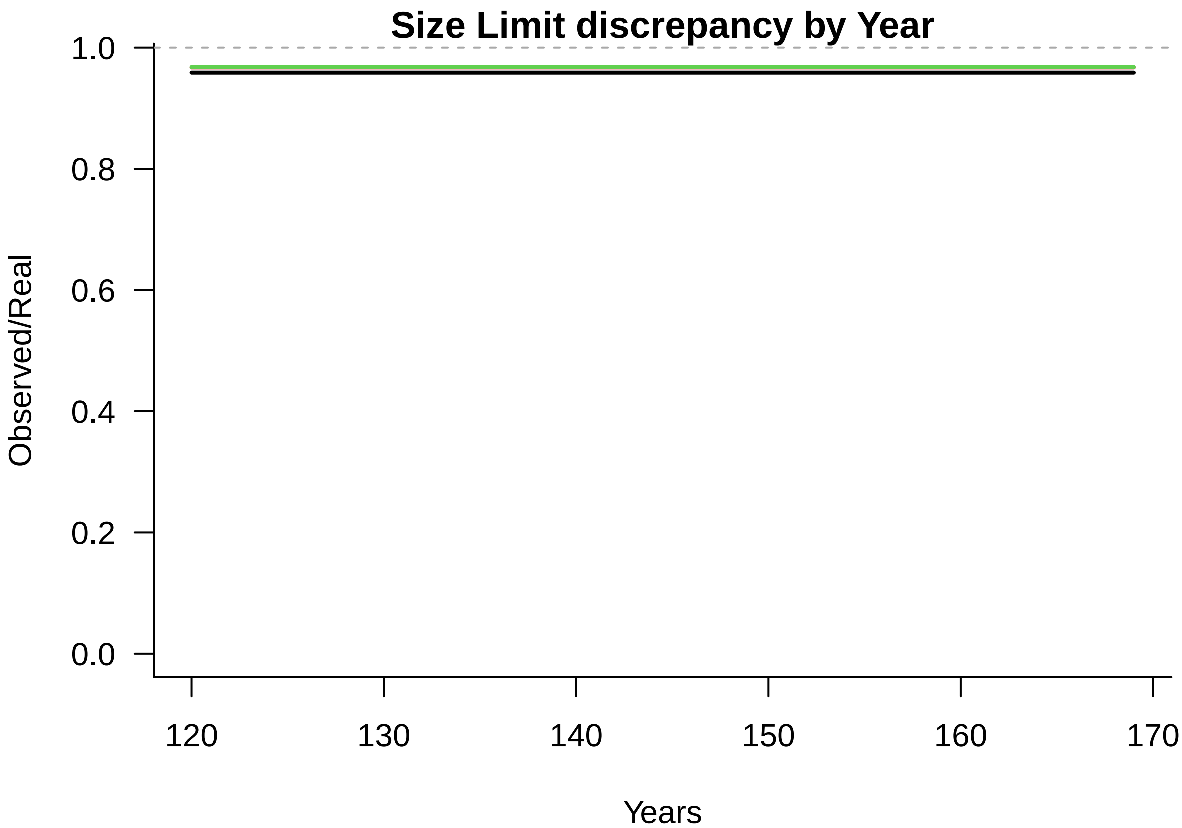
Size Limit Implementation

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:

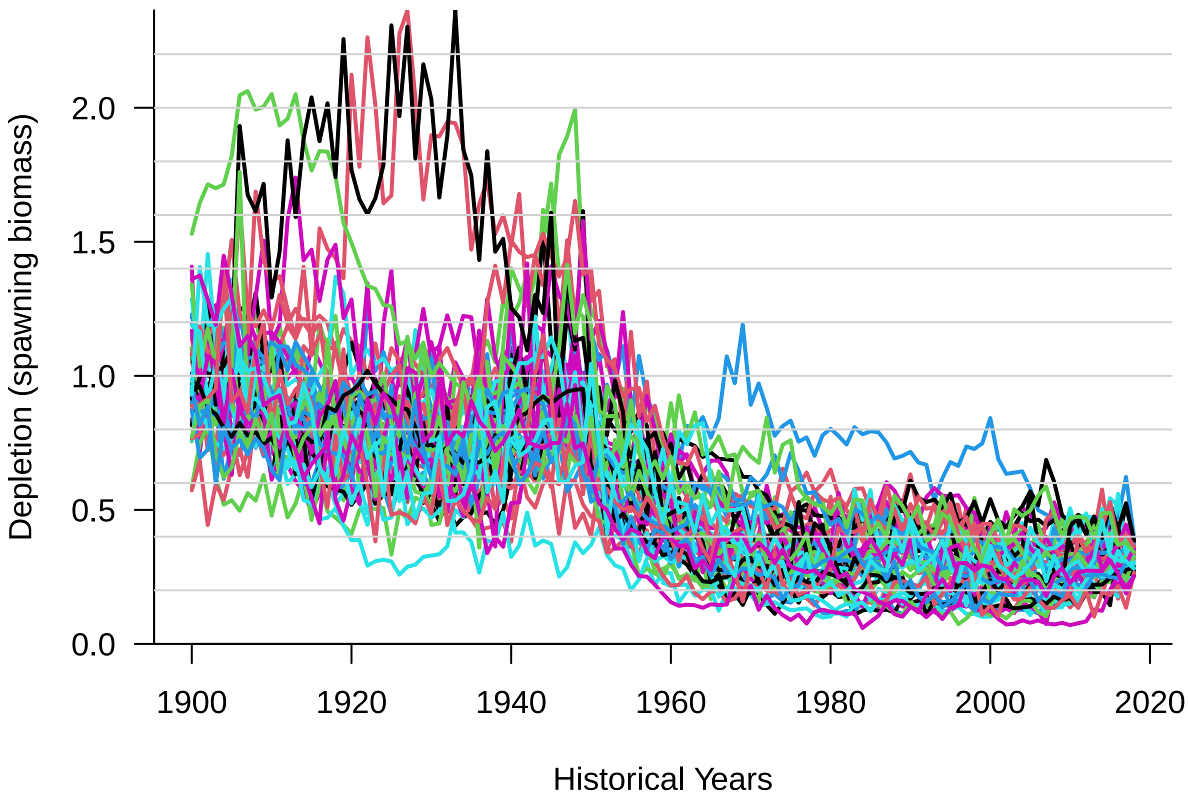


Historical Simulation Plots

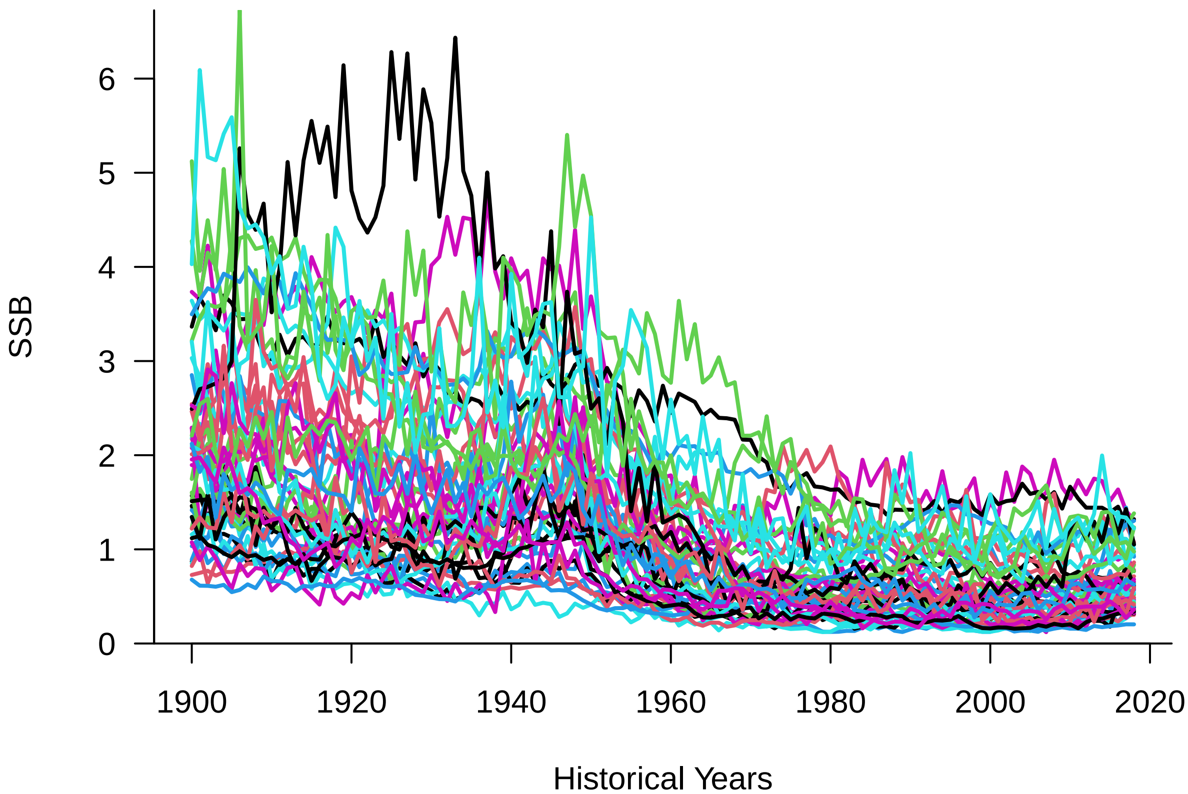
Historical Time-Series

Spawning Biomass

Depletion Time-series plots of SB/SB0:

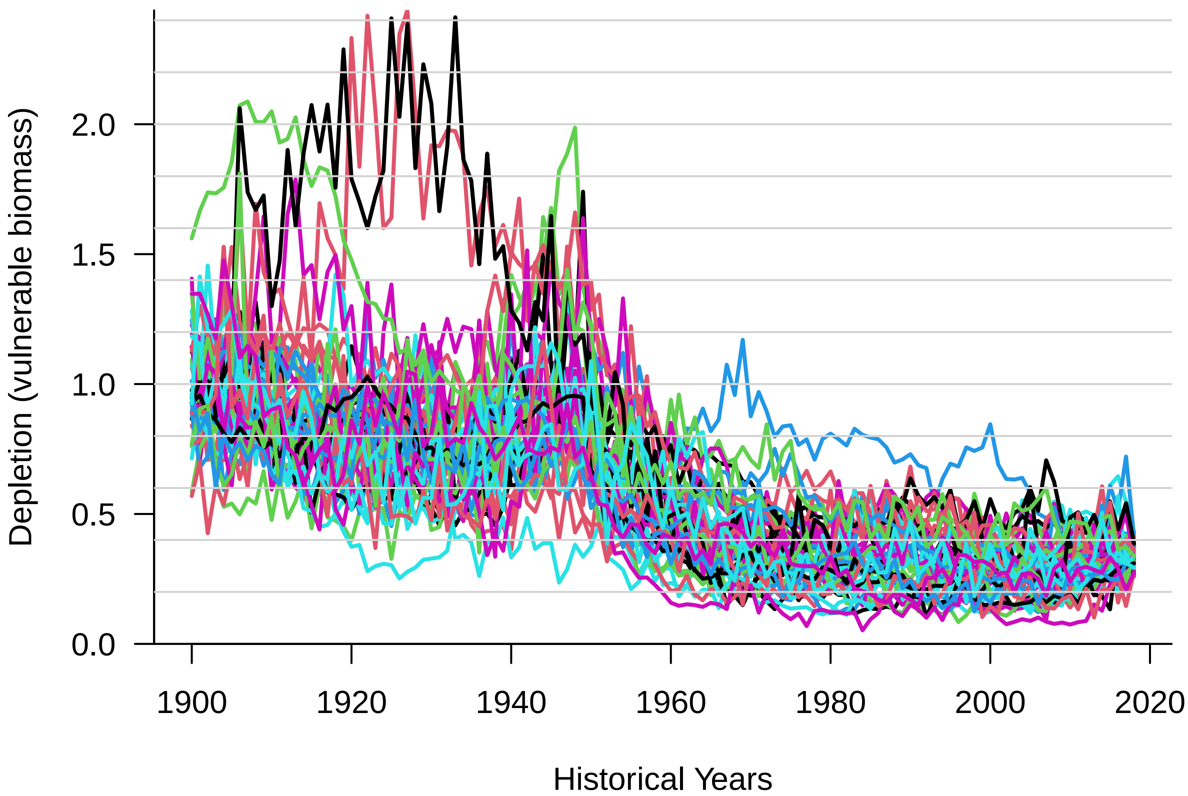


Absolute Time-series plots of absolute SB:

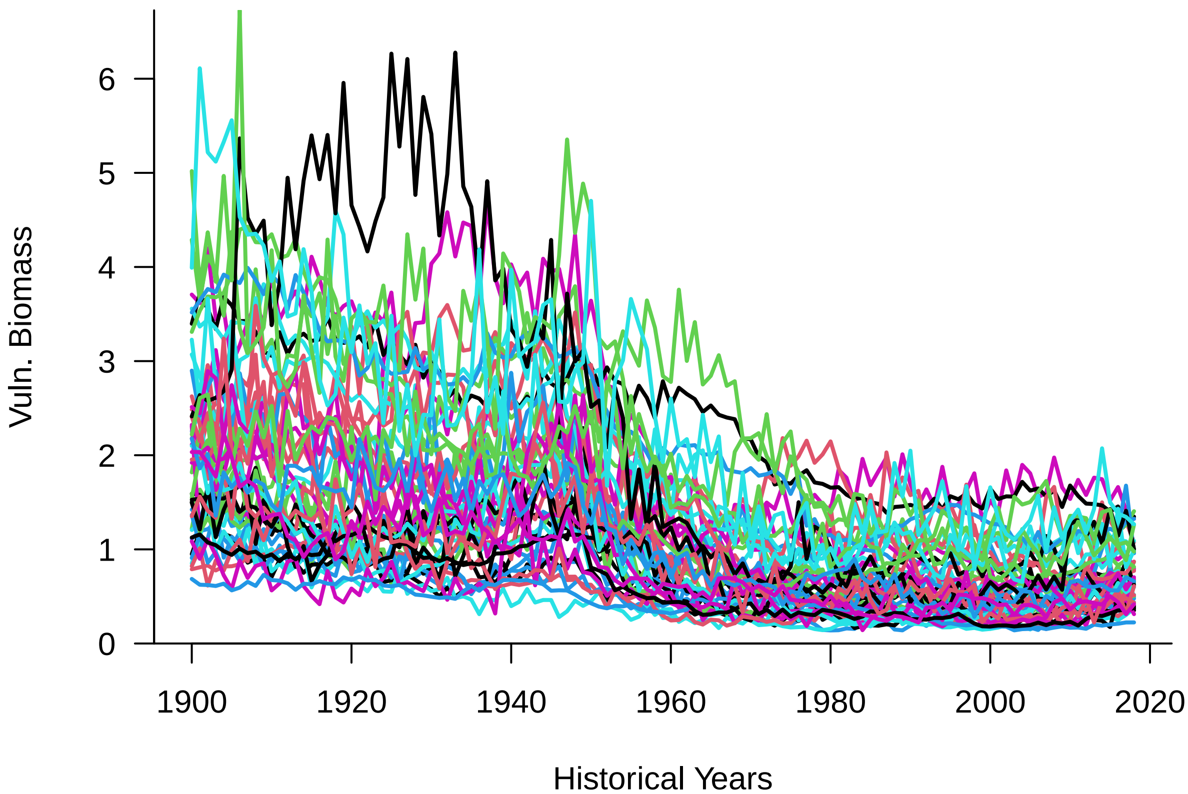


Vulnerable Biomass

Depletion Time-series plots of VB/VB0:

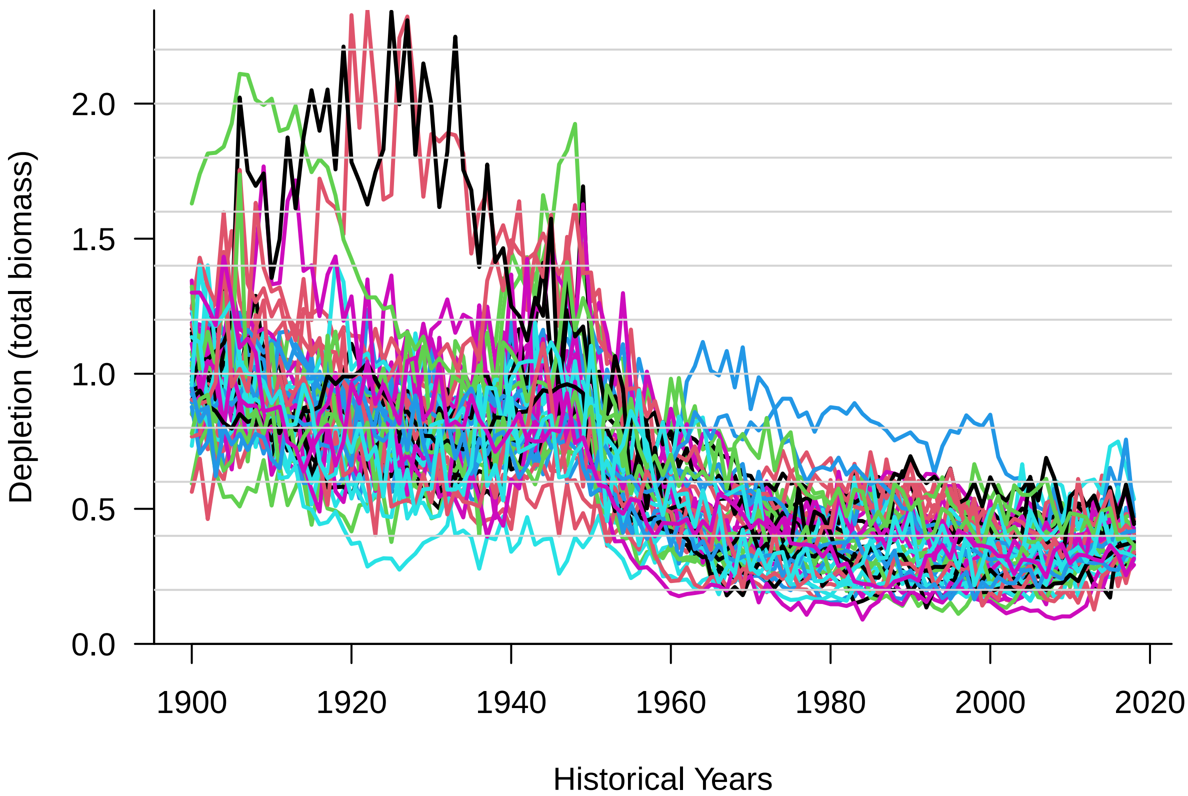


Absolute Time-series plots of absolute VB:

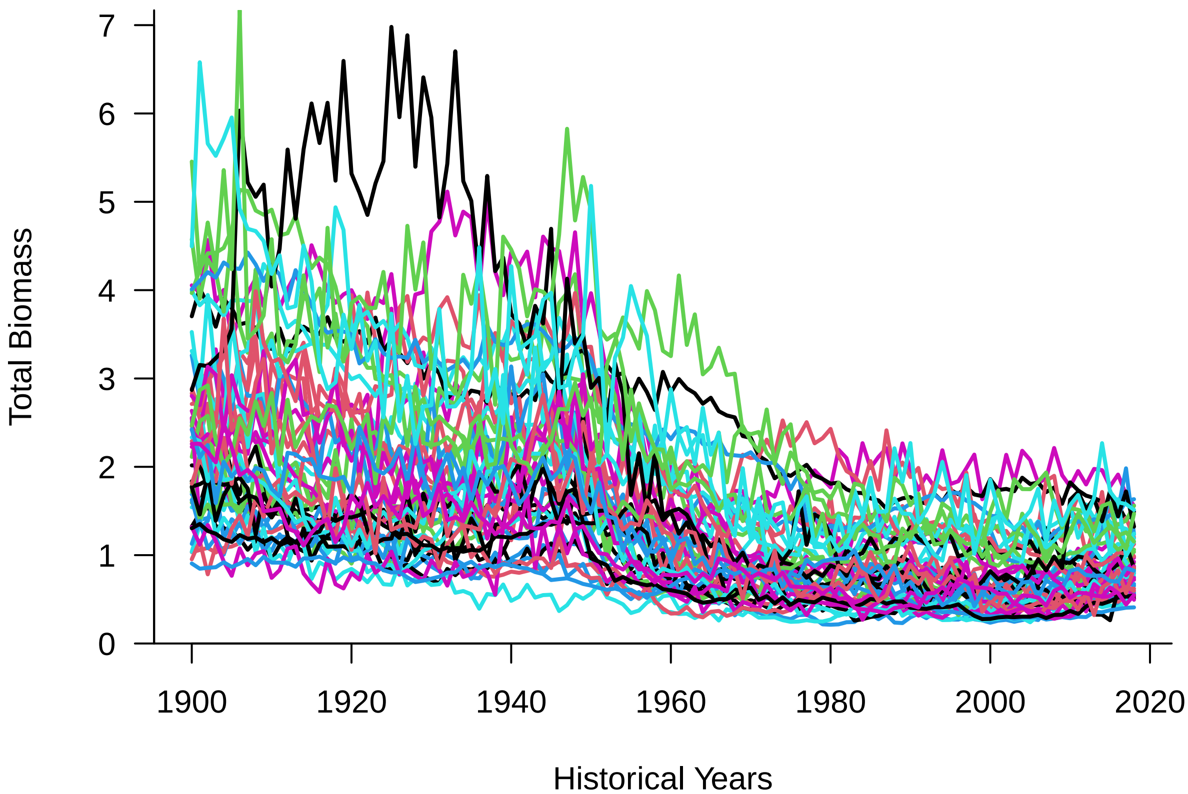


Total Biomass

Depletion Time-series plots of B/B0:

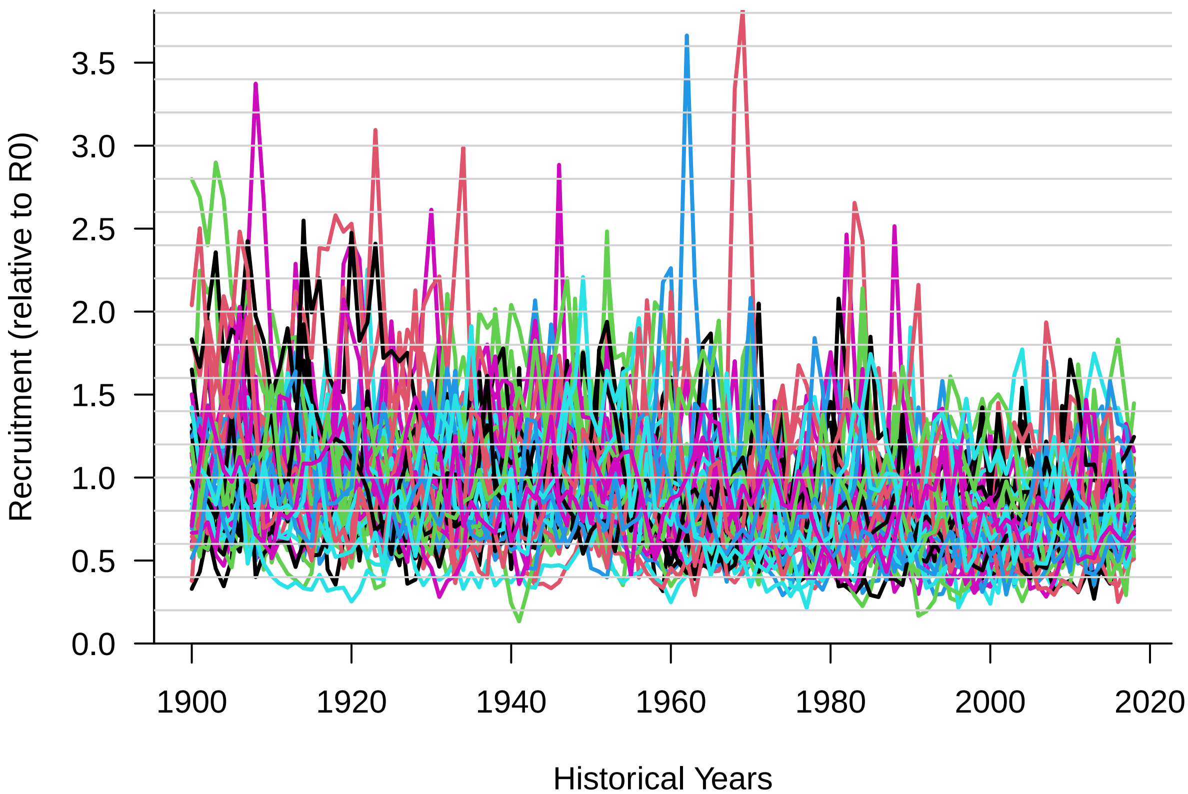


Absolute Time-series plots of absolute B:

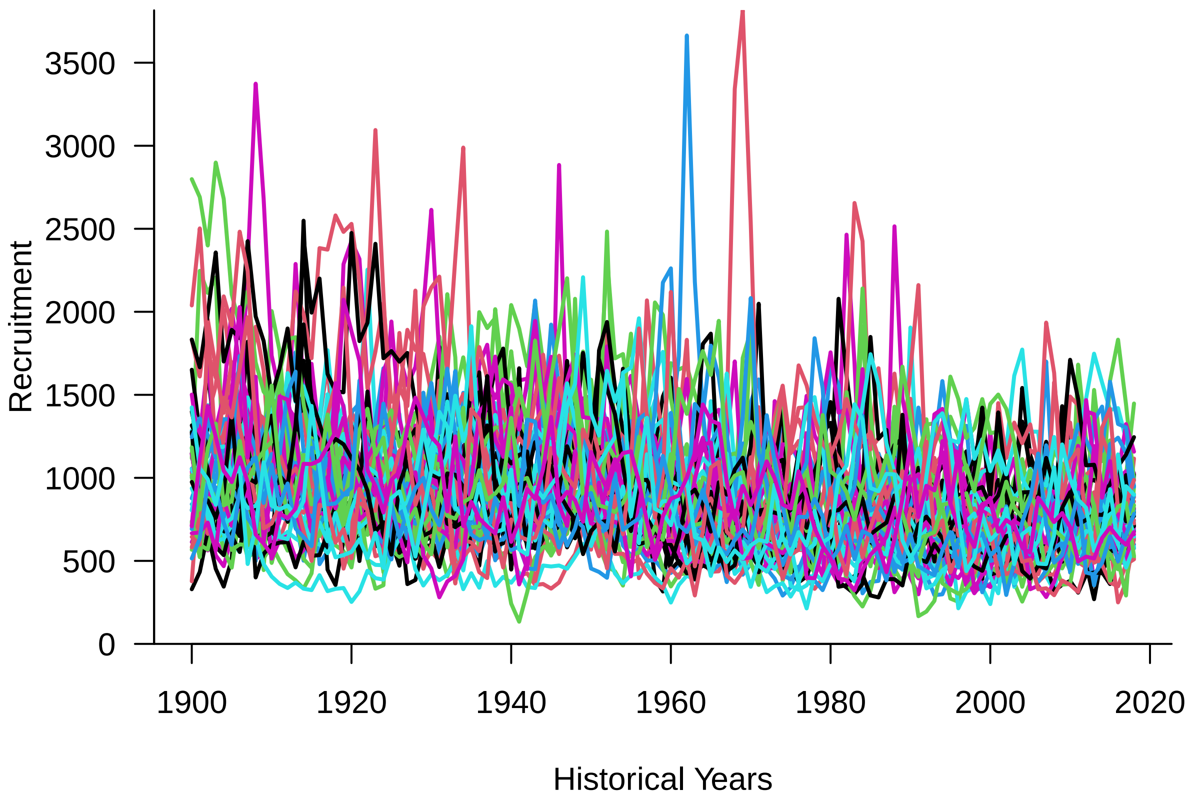


Recruitment

Relative Time-series plot of recruitment relative to R0:

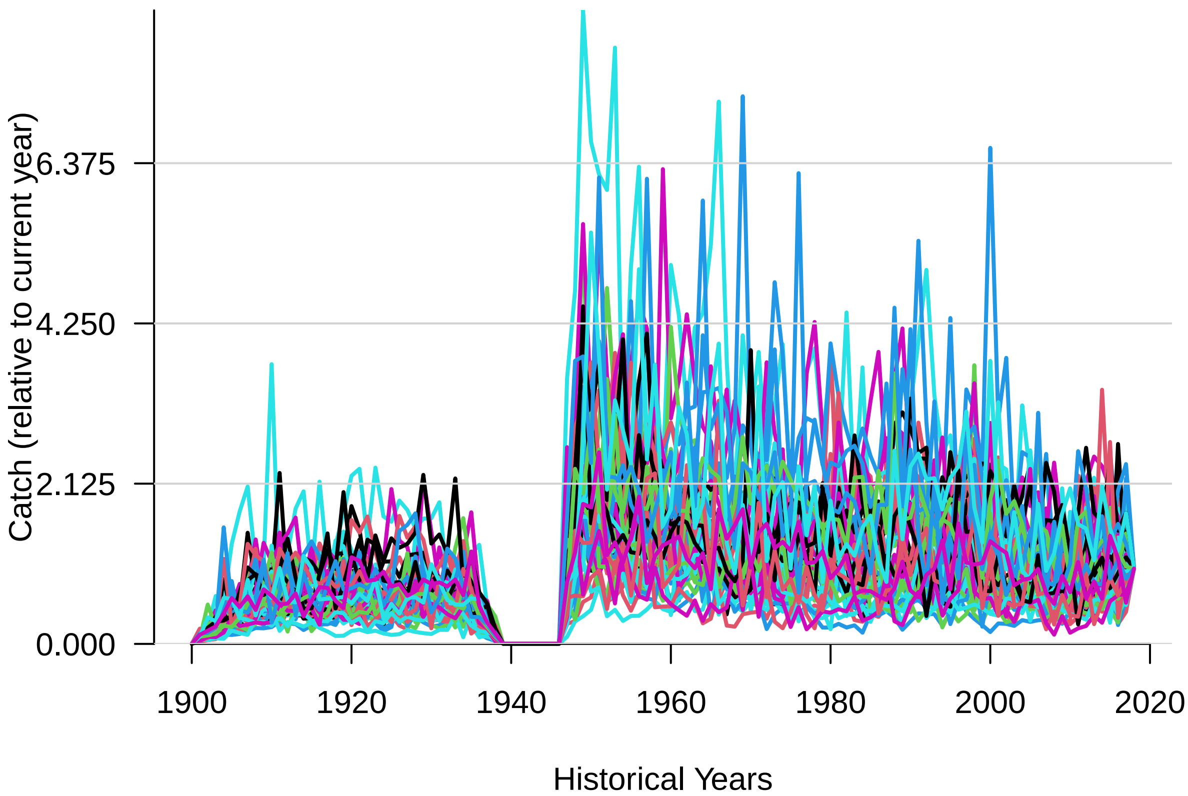


Absolute Time-series plot of absolute recruitment:

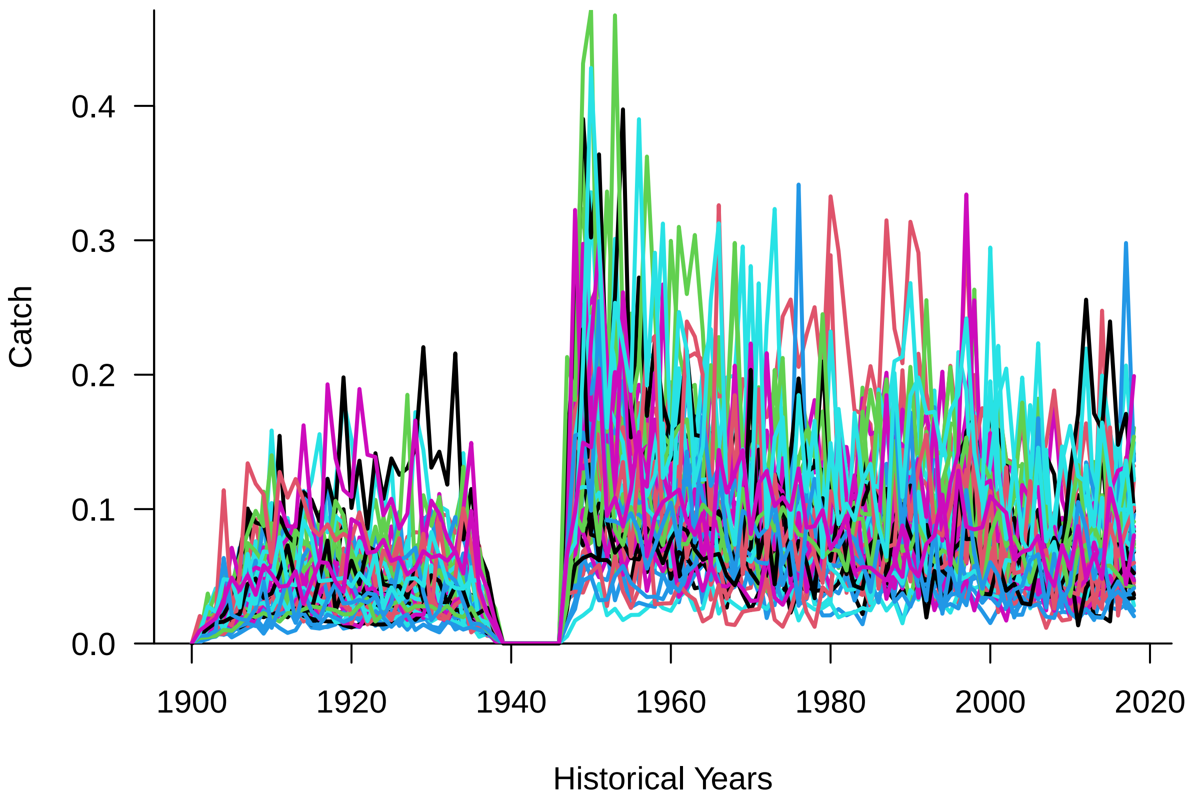


Catch

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

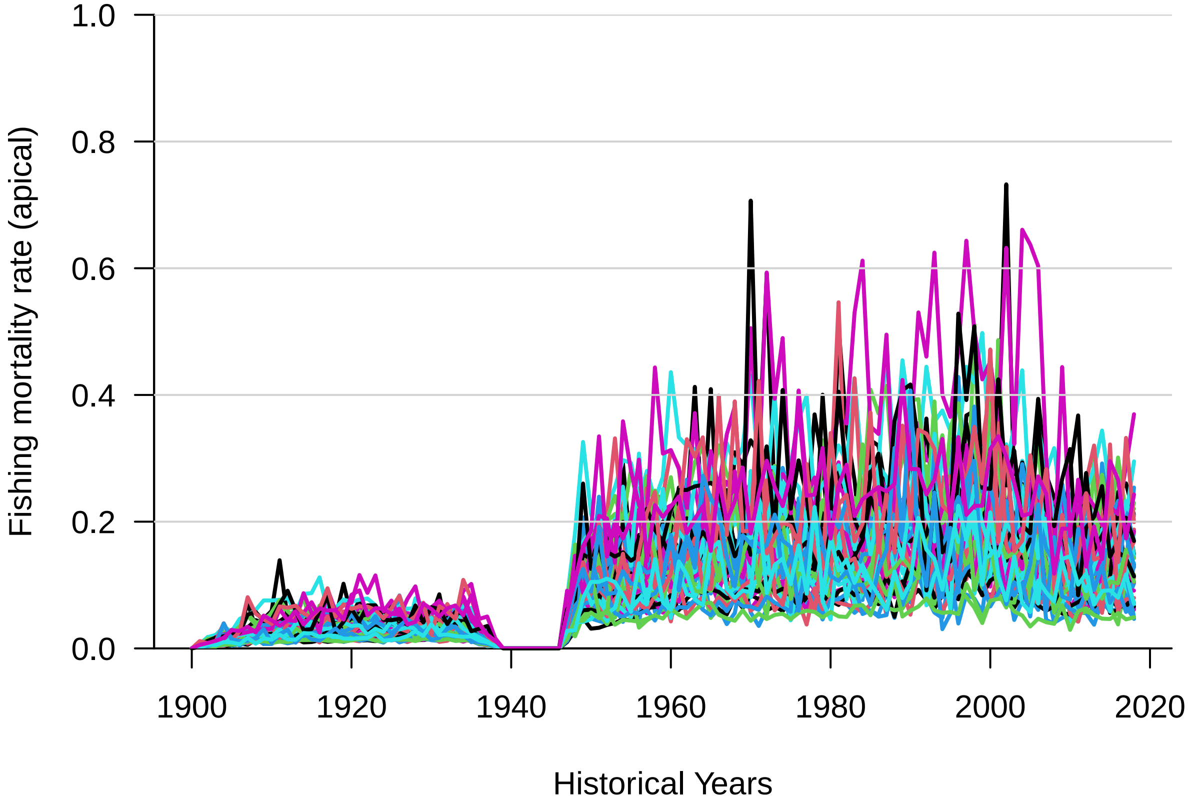


Absolute Time-series of absolute catch:



Historical Fishing Mortality

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



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