

## Status of the U.S. sablefish resource in 2015

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# Outline

## 1 Overview

- Distribution along the U.S. West Coast
- Growth and maturity

## 2 Data

- Data sources included in the model
- Fishery-dependent data
- Fishery-independent data
- Externally derived relationships

## 3 Model

- General model structure and assumptions
- Changes from 2011
- Results
- 5 year retrospective analysis
- Model convergence

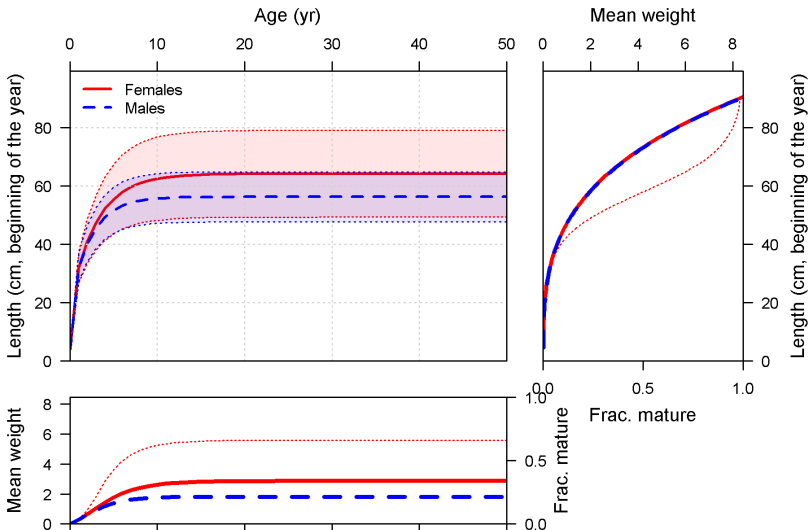
## 1 Overview

- ## 2 Data

### 3 Model



90% Max size at ages 5 (females) & 8 (males)



# Sablefish update from 2011

# Outline

## 1 Overview

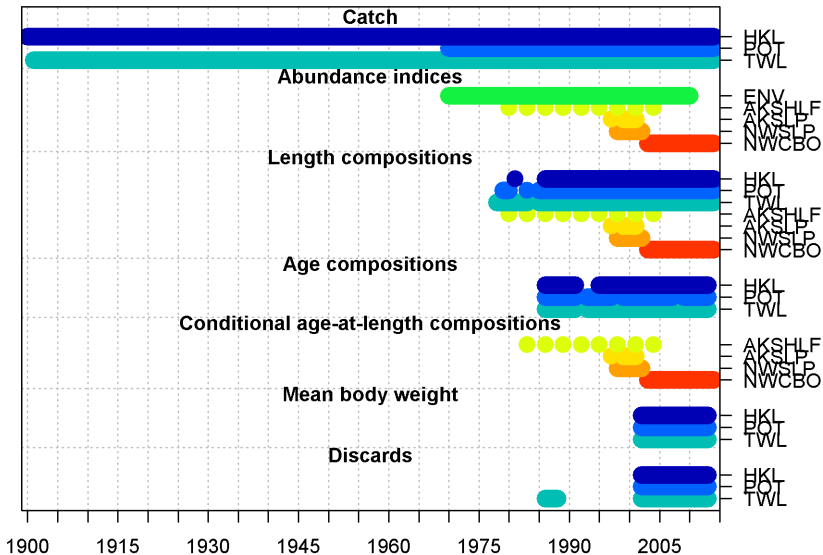
## 2 Data

- Data sources included in the model
- Fishery-dependent data
- Fishery-independent data
- Externally derived relationships

## 3 Model

### Data sources included in the model

## Included data

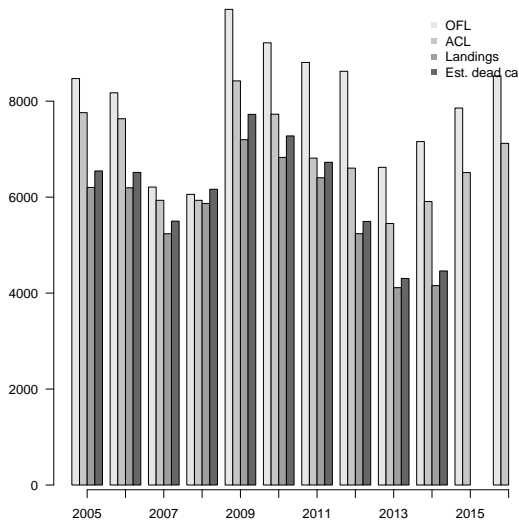






## Fishery-dependent data

Landings are  $<ACL$

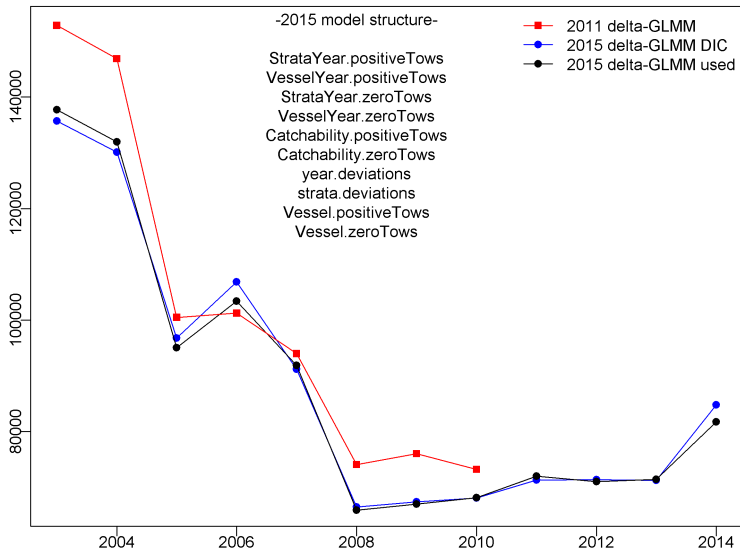


## Percent catch by gear in last decade

**Table:** Recent yearly sablefish landings (mt) by fleet, with their associated relative yearly proportion.

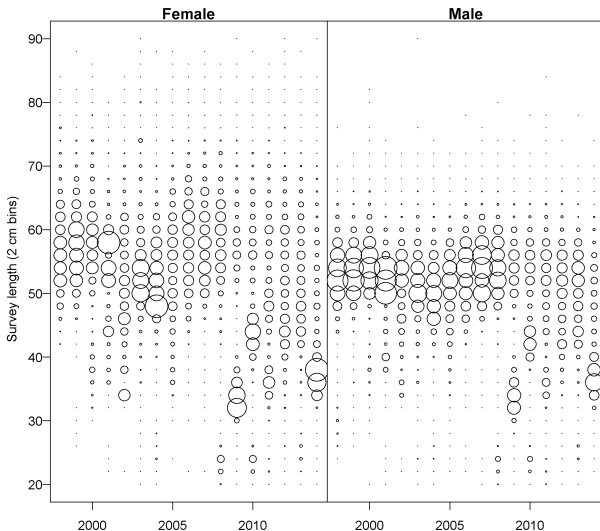
	Hook-and-Line		Pot		Trawl	
Year	mt	%	mt	%	mt	%
2005	2,807	45.25	997	16.08	2,399	38.67
2006	2,604	42.04	1,053	17.00	2,538	40.96
2007	2,060	39.34	688	13.13	2,489	47.53
2008	2,301	39.21	675	11.51	2,892	49.28
2009	3,274	45.48	863	11.99	3,061	42.53
2010	3,379	49.48	910	13.33	2,539	37.19
2011	3,231	50.46	1,449	22.62	1,724	26.92
2012	2,561	48.90	1,179	22.50	1,498	28.60
2013	1,865	45.33	846	20.57	1,402	34.09
2014	1,868	44.95	1,032	24.83	1,256	30.22

## Index of abundance

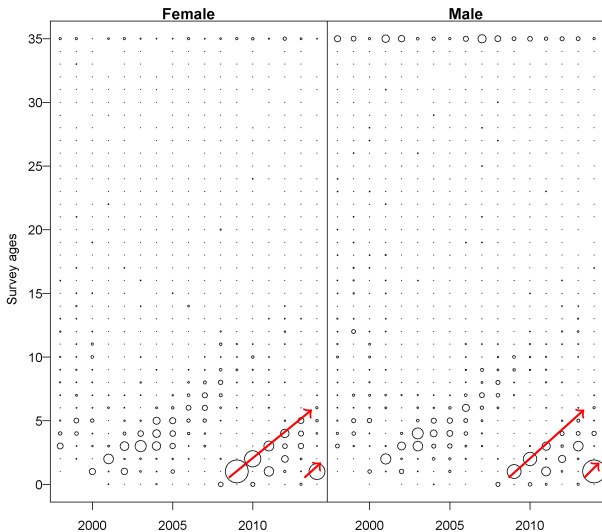


## Fishery-independent data

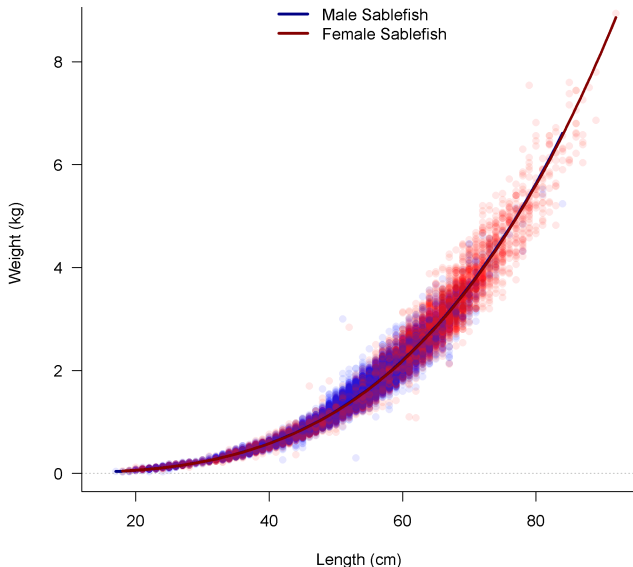
## NWFSC length compositions



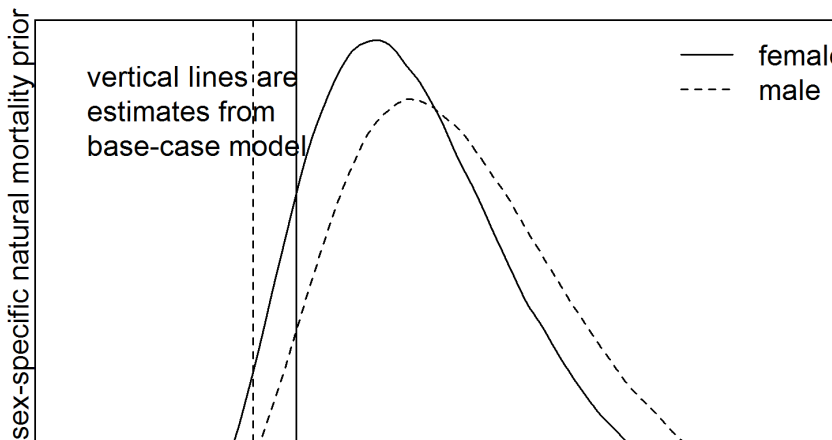
# NWFSC age compositions



# Sex-specific weight-length relationship (survey data)



# Prior on natural mortality ( $M$ )





# Outline

## 1 Overview

## 2 Data

## 3 Model

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- Changes from 2011
- Results
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# Stock Synthesis version 3.24u

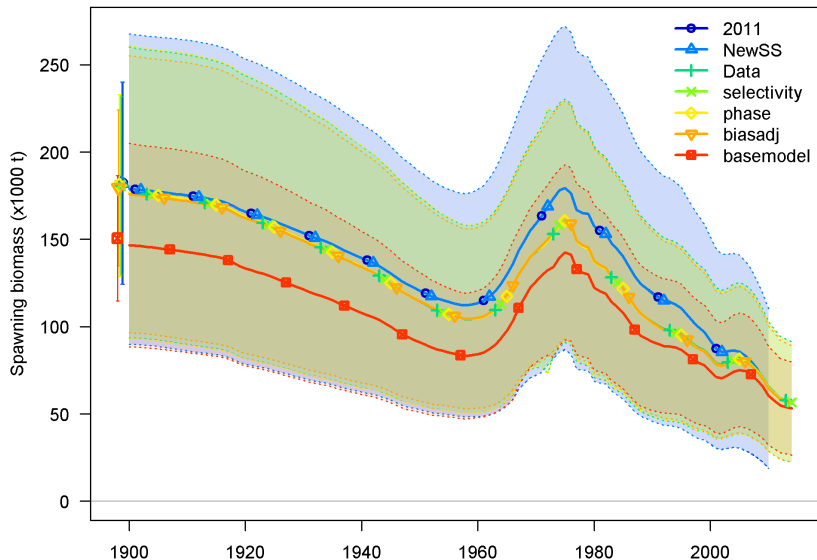
# General model structure and assumptions

- 1900 - 2014 Landings
- Max age == 35
- Lengths 20 - 90 (2 cm bins)
- Survey conditional age-at-length data
- Fixed steepness
- Sex-specific natural mortality ( $M$ )
- Bias-correction of recruitment deviations
- Vague priors except on  $M$

## Changes from 2011

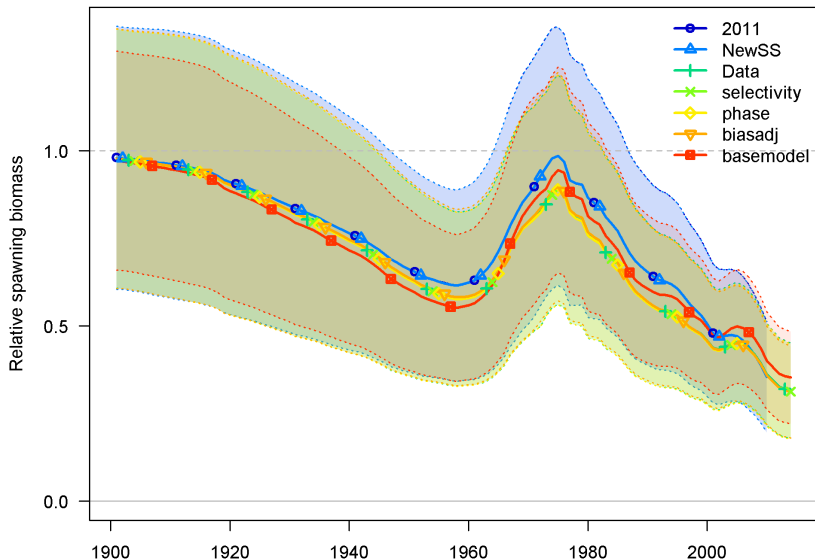
- Stock Synthesis version 3.24u.
- Turn off initial  $F$  calculation.
- Delta-generalized linear mixed effect model (delta-GLMM) with strata & vessel effects.
- Survey composition data (unsexed assigned 50:50 sex ratio).
- Fishery composition data (standardized code; PacFIN\_Uutilities.R):
  - update discard ratios and mean weight;
  - assign unsexed assigned 50:50 sex ratio;
  - sex and data specific expansion factors.
- Update weight-length relationship (survey data only).
- Add full retention for trawl during catch-share program.
- Estimate  $M$  in phase 3 (instead of 8).
- Tune  $\sigma_r$  based on RMSE & update bias adjustment.

## SSB comparisons on path to basemodel

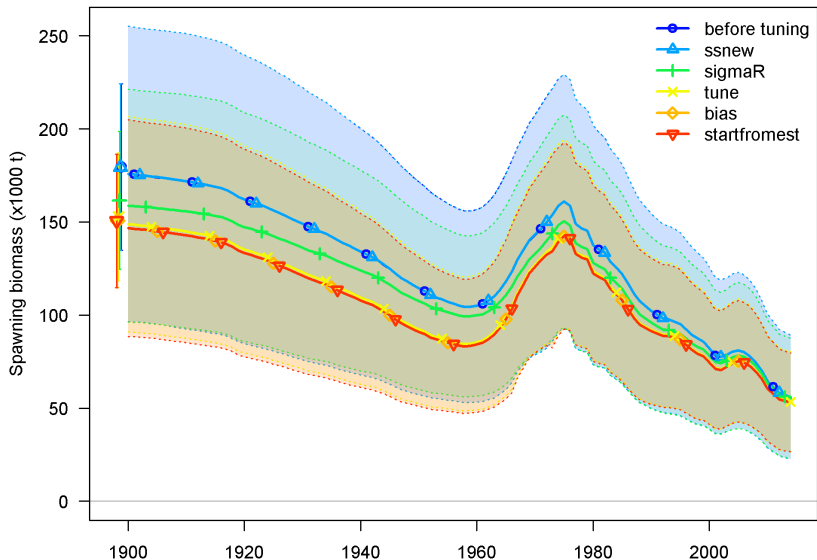


Changes from 2011

# Depletion comparisons on path to basemodel

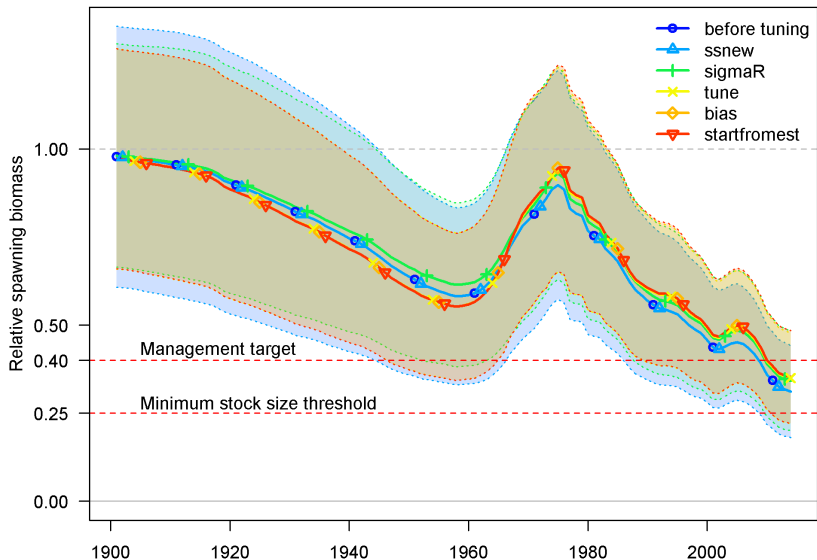


## SSB comparison during tune procedure



Changes from 2011

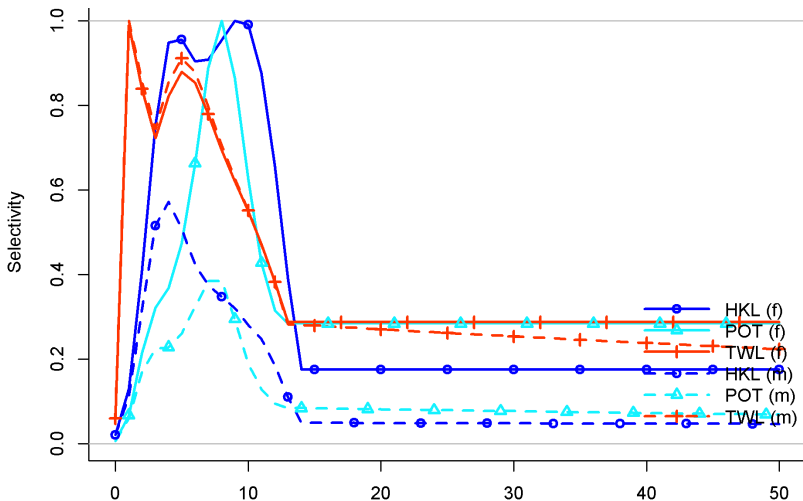
# Depletion comparison during tune procedure



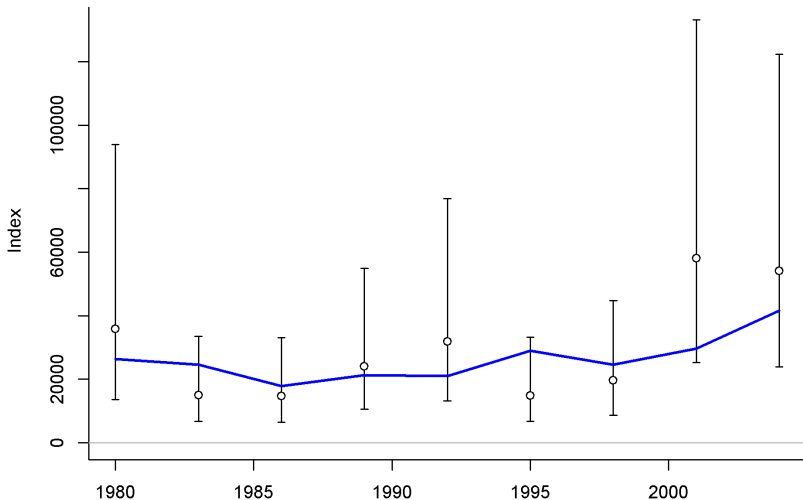


- Selectivity
- Fit to the index
- Fit to mean body weight from discard data
- Composition data
- Recruitment
- Derived quantities

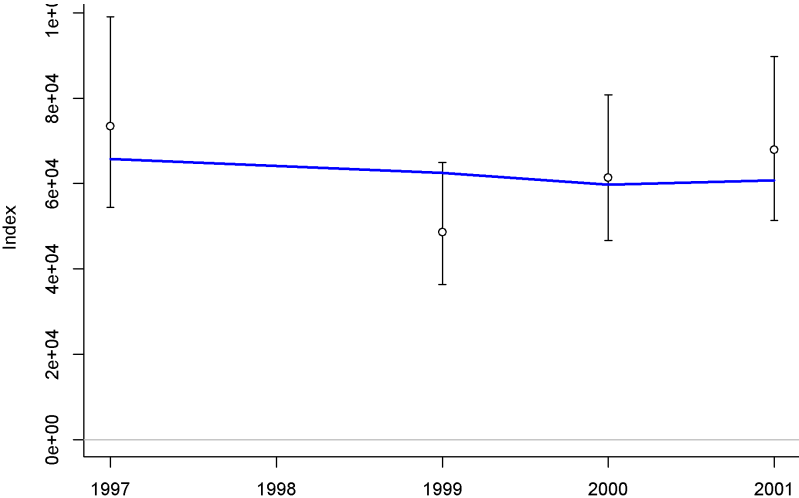
## Selectivity



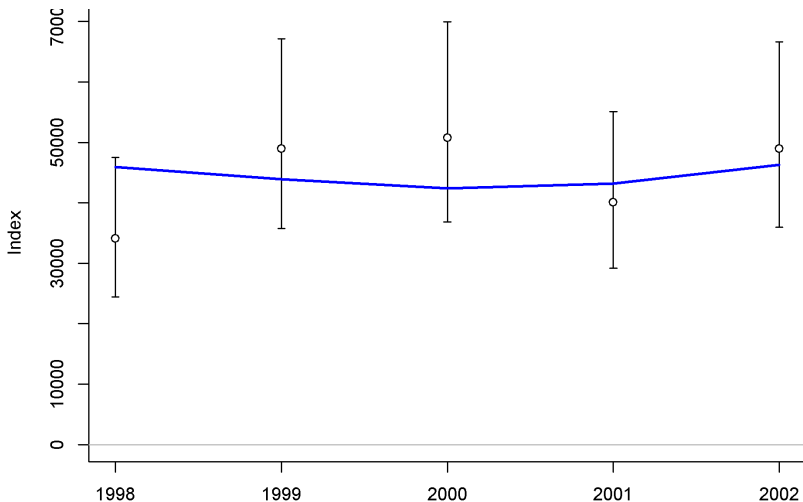
# Fit to AK Shelf survey (AKSHLF)



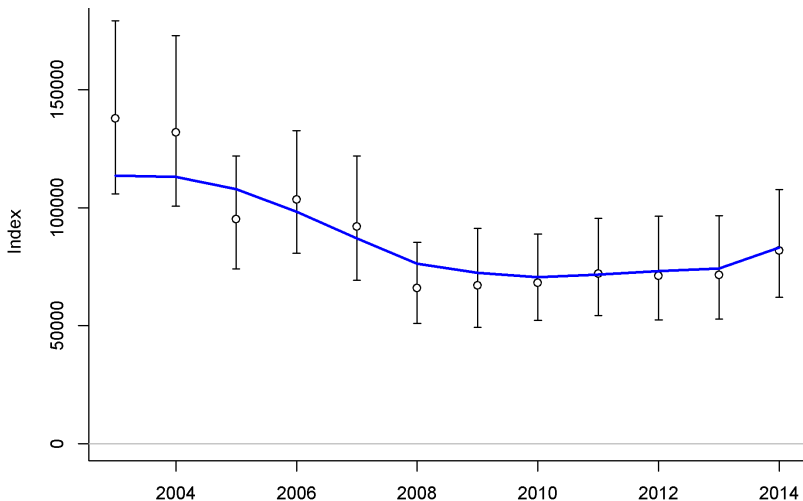
# Fit to AK Slope survey (AKSLP)



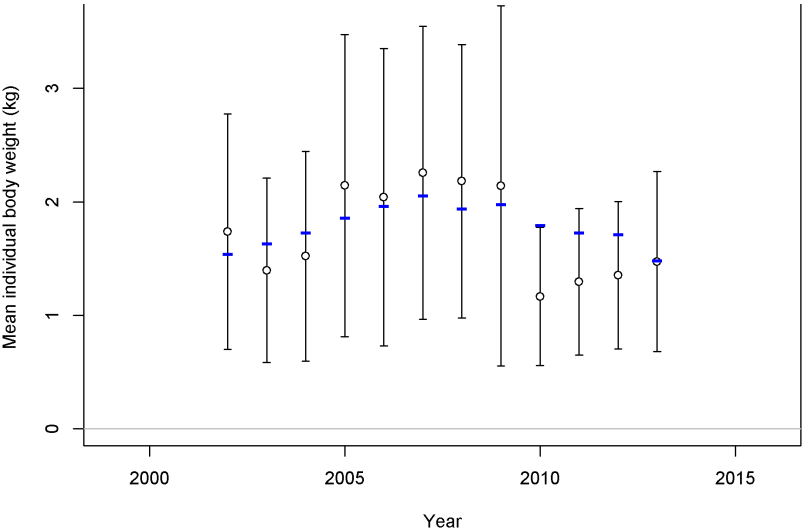
## Fit to NW Slope survey (NWSLP)



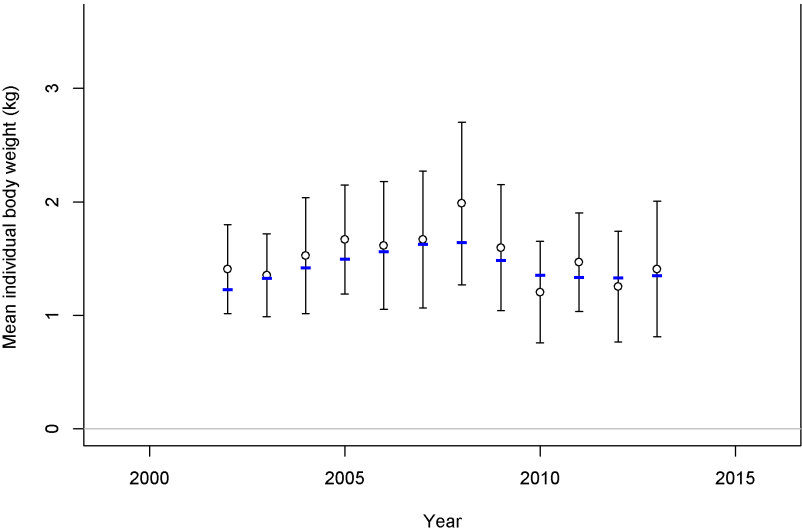
### Fit to NW Bottom trawl survey (NWFSCBO)



# Fit to mean body weight from HKL discard

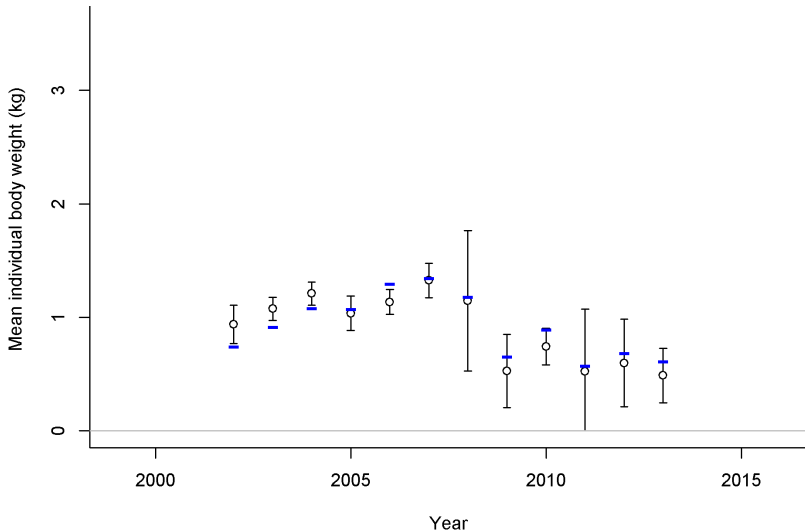


# Fit to mean body weight from POT discard

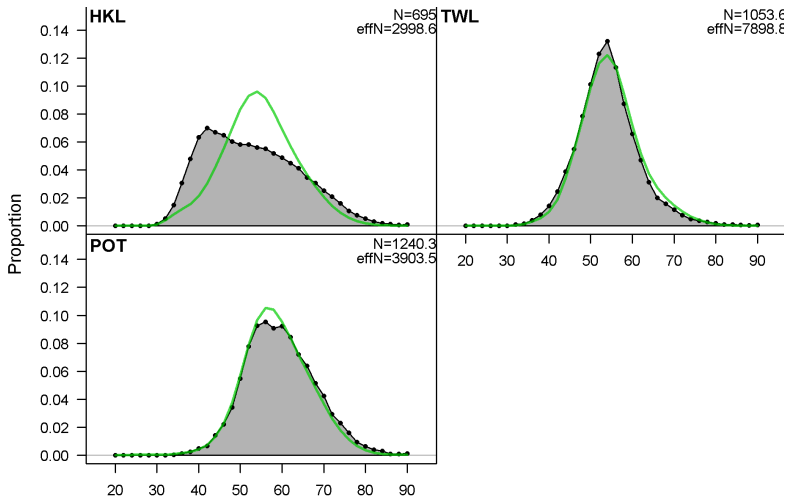




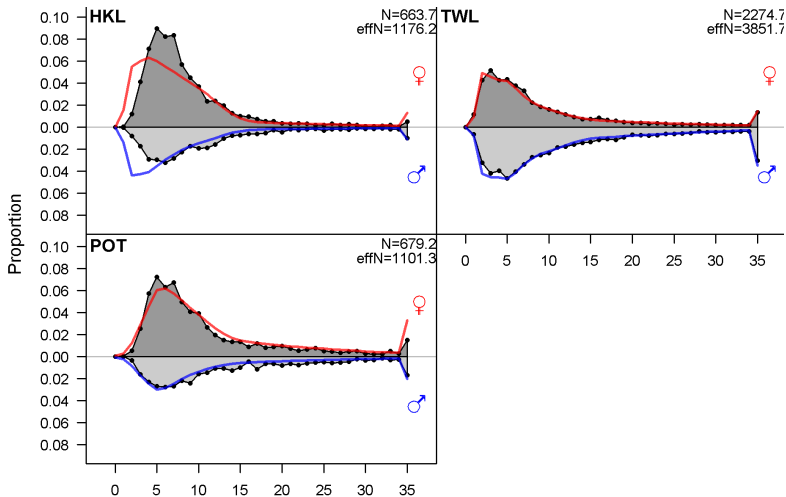
# Fit to mean body weight from TWL discard



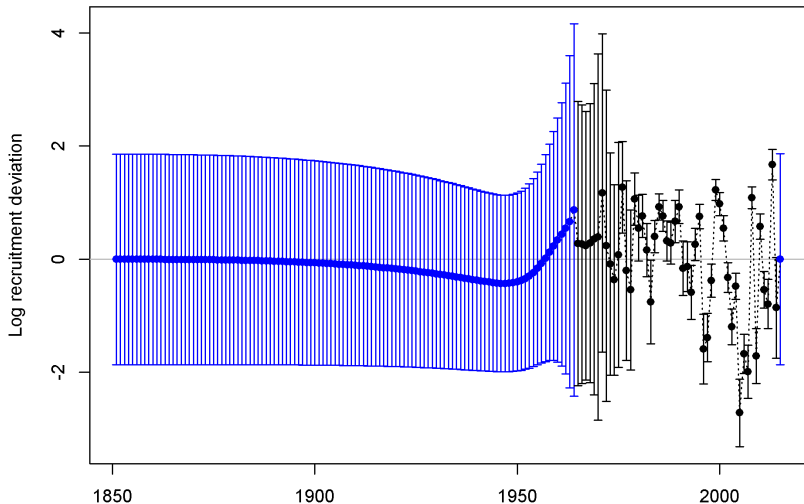
# Fishery length compositions



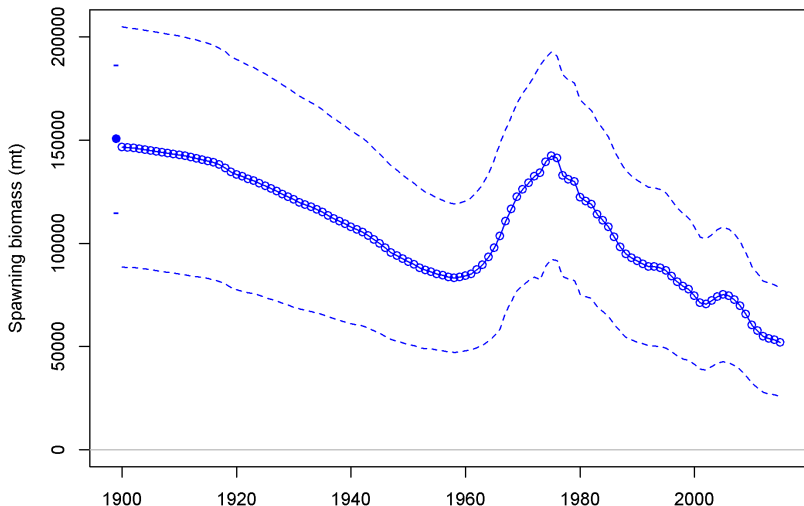
## Fishery age compositions



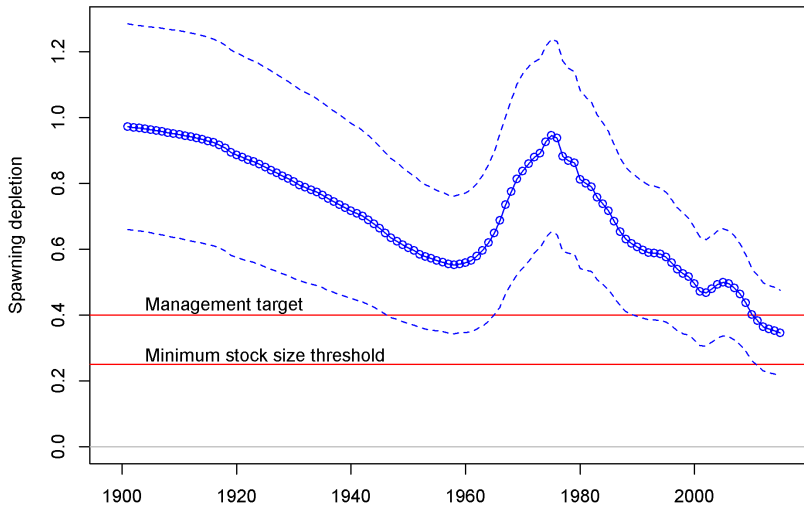
# Recruitment deviations



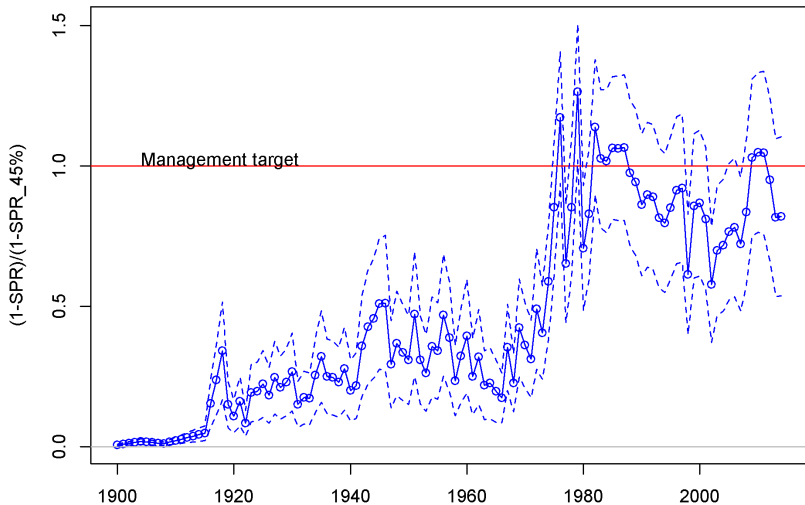
## Spawning stock biomass



# Depletion



# 1 - SPR



**Table:** Projection of potential sablefish OFL, ACL, and estimated spawning biomass and depletion for the base-case model based on the 40:10 correction to the  $F_{45\%}$  overfishing limit/target (OFL) and an 8.7% reduction to approximate the P\* approach. Catch allocation used for the forecast reflects the average distribution of fishing intensity among fleets (hook-and-line, pot, and trawl) during 2012-2013.

Year	OFL <sup>1</sup> (mt)	ABC <sup>1</sup> (mt)	ACL <sup>1</sup> (mt)	Spawning biomass (mt)	Relative depletion
2015	7,857	7,173	6,512	52,001	34.52 %
2016	8,526	7,784	7,121	54,044	35.88 %
2017	8,050	7,349	7,116	55,001	36.52 %
2018	8,329	7,604	7,419	56,153	37.28 %
2019	8,489	7,751	7,596	56,844	37.74 %
2020	8,648	7,896	7,755	57,185	37.97 %
2021	8,719	7,961	7,823	57,278	38.03 %
2022	8,659	7,905	7,767	57,236	38.00 %
2023	8,592	7,844	7,703	57,173	37.96 %
2024	8,529	7,787	7,645	57,121	37.92 %
2025	8,453	7,717	7,575	57,100	37.91 %
2026	8,369	7,641	7,501	57,114	37.92 %



## Management reference points

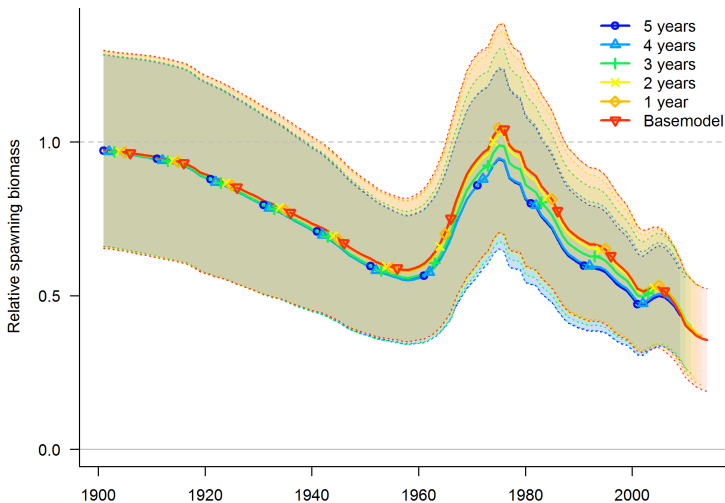
**Table:** Summary of sablefish reference points as estimated using the base-case model. Yields include discard mortality. Given steepness is a fixed parameter, the uncertainty in these reference points remains grossly underestimated.

Quantity	Estimated value	~95% interval
Unfished total biomass (mt)	440,648	323,201-558,095
Unfished 4+ biomass (mt)	413,038	303,832-522,244
Unfished spawning biomass ( $SB_0$ , mt)	150,622	114,728-186,516
Unfished recruitment ( $R_0$ , thousands)	17,198	11,304-23,092
<b>Reference points based on <math>SB_{40\%}</math></b>		
MSY Proxy spawning biomass ( $SB_{40\%}$ , mt)	60,249	45,891-74,606
Relative spawning depletion at $SB_{40\%}$	40%	
SPR resulting in $SB_{40\%}$	50%	
Exploitation rate resulting in $SB_{40\%}$	3.85%	3.37-4.32%
Yield with $SPR_{SB_{40\%}}$ at $SB_{40\%}$ (mt)	7,476	5,171-9,781
<b>Reference points based on SPR proxy for MSY</b>		
Spawning biomass at $SPR_{MSY-proxy}$ ( $SPR_{proxy}$ , mt)	51,212	39,008-63,415
Relative spawning depletion at $SPR_{proxy}$	34%	
$SPR_{proxy}$	45%	
Exploitation rate corresponding to $SPR_{proxy}$	4.58%	4.01-5.15%
Yield with $SPR_{proxy}$ at $SB_{SPR}$ (mt)	7,759	5,368-10,150
<b>Reference points based on estimated MSY values</b>		
Spawning biomass at MSY ( $SB_{MSY}$ , mt)	44,090	33,526-54,654
Relative spawning depletion at $SB_{MSY}$	29%	
$SPR_{MSY}$	41%	41-41%
Exploitation rate corresponding to $SPR_{proxy}$	5.26%	4.60-5.92%
Yield with $SPR_{proxy}$ at $SB_{SPR}$ (mt)	7,837	5,424-10,251



## 5 year retrospective analysis

# Retrospective



# Jitter

- 100 jitter iterations with jitter = 0.1
- 100 of 100 likelihoods == 4979.98

**Table:** Maximum percent difference in derived quantities from 100 iterations, using a jitter value of 0.1.

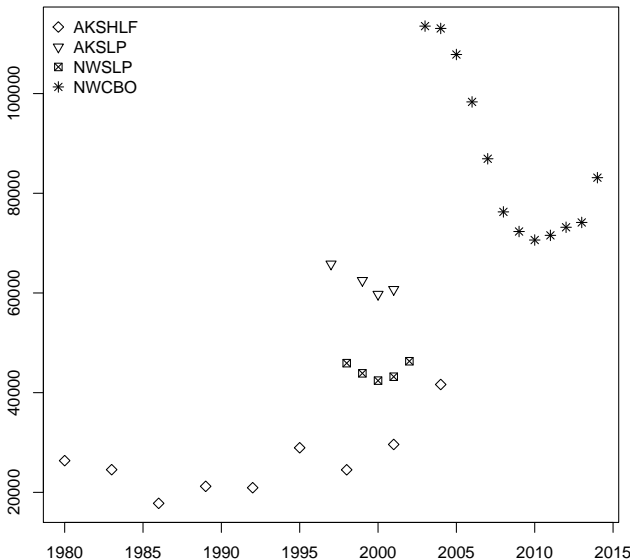
	Max perc diff
$SSB_0$	0.0013
$SSB_{initial}$	0.0014
$F_{msy}$	0.0019

Thank you

# Additional slides

# Data

# Index of abundance





# Results

# Table of estimated biomass, recruitment, and depletion

**Table:** Recent trend in estimated sablefish spawning biomass (mt), recruitment (1000s), and relative depletion, with their associated ~95% intervals.

Year	Spawning biomass (mt)	~95% interval	Recruitment (1000s)	~95% interval	Depletion	~95% interval
2005	75,200	42,559-107,841	642	196-1,088	50%	34-66%
2006	74,485	42,022-106,948	1,822	946-2,698	49%	33-66%
2007	72,609	40,664-104,554	1,317	546-2,088	48%	32-64%
2008	69,741	38,767-100,714	28,068	17,153-38,982	46%	31-62%
2009	65,698	35,976-95,419	1,681	661-2,701	44%	29-58%
2010	60,360	32,091-88,629	16,124	9,224-23,025	40%	26-54%
2011	57,637	29,961-85,314	5,183	2,603-7,764	38%	25-52%
2012	54,800	27,815-81,784	3,974	1,652-6,297	36%	23-50%
2013	53,841	27,015-80,668	46,247	24,209-68,285	36%	22-49%
2014	53,125	26,509-79,742	3,671	7-7,335	35%	22-48%
2015	52,001	25,698-78,303	13,067	0-38,041	35%	22-48%

# Trend in relative spawning potential ratio and $F$

**Table:** Recent trend in relative spawning potential ratio ( $1\text{-SPR}/1\text{-SPR}_{\text{Target}=0.45}$ ) and relative exploitation rate (catch/biomass of age-4 and older fish).

Year	Relative SPR	~95% interval	Relative exploitation rate	~95% interval
2005	77%	52-101%	2.73%	1.56-3.90%
2006	78%	53-103%	2.79%	1.58-3.99%
2007	72%	48-96%	2.47%	1.39-3.56%
2008	84%	58-109%	2.89%	1.61-4.16%
2009	103%	75-131%	3.89%	2.13-5.64%
2010	105%	76-133%	3.97%	2.13-5.81%
2011	105%	76-134%	4.00%	2.10-5.89%
2012	95%	66-124%	3.08%	1.62-4.54%
2013	82%	54-110%	2.55%	1.32-3.78%
2014	82%	54-110%	2.58%	1.34-3.83%

# Trend in landings and estimated dead catch

**Table:** Recent trend in sablefish landings and estimated total dead catch (mt) relative to OFL (ABCs at the time) and ACLs (OYs at the time).

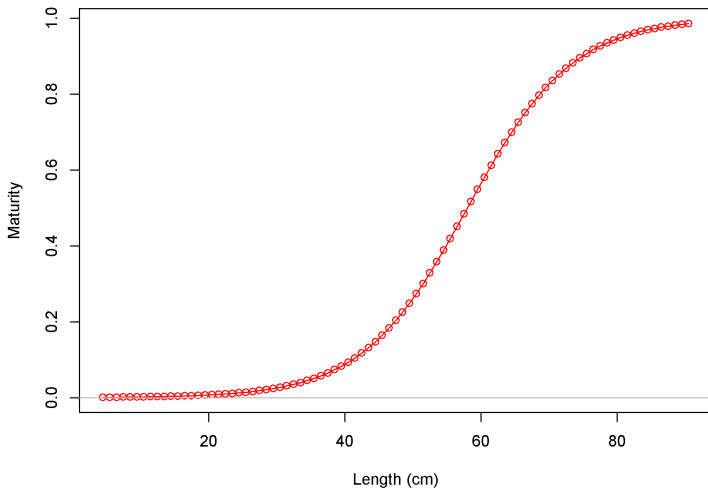
Year	OFL (mt) <sup>1</sup>	ACL (mt) <sup>1</sup>	Landings (mt)	Estimated dead catch (mt) <sup>2</sup>
2005	8471	7761	6203	6545.62
2006	8175	7634	6195	6515.59
2007	6210	5934	5237	5499.59
2008	6058	5934	5868	6163.55
2009	9914	8423	7198	7724.84
2010	9217	7729	6828	7276.24
2011	8808	6813	6404	6726.63
2012	8623	6605	5238	5493.75
2013	6621	5451	4113	4305.49
2014	7158	5909	4156	4460.99
2015	7857	6512		

# Sensitivity

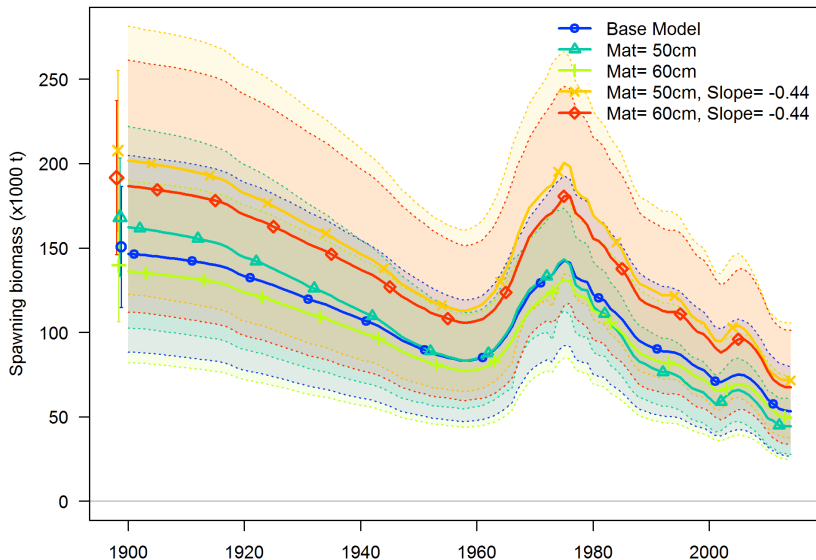
# Maturity at length derived from literature values

- Analysis of variation in Maturity at Length
  - Head et al. (2014) presented findings suggesting new values for female maturity length and slope ( $\beta$ ):
    - $L_{50}$  between 50 and 60 cm
    - $\beta$  (female maturity slope) = -0.44
  - The 2011 sablefish assessment used  $L_{50} = 58$  cm and  $\beta = -0.13$
  - The 2014 base model uses  $L_{50} = 58$  cm and  $\beta = -0.13$
  - This sensitivity analysis examines:
    - $L_{50}$  between 50 cm and 60 cm,  $\beta = 0.13$
    - $L_{50}$  between 50 cm and 60 cm,  $\beta = -0.44$

# Maturity-at-length (literature values, sensitivity analyses)

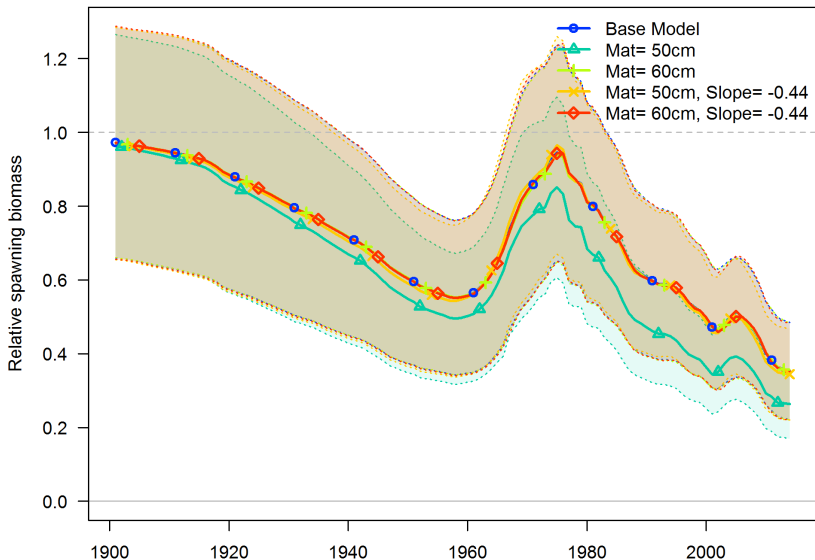


## SSB comparison





## Depletion comparison



Maturity at length

# Likelihood comparison

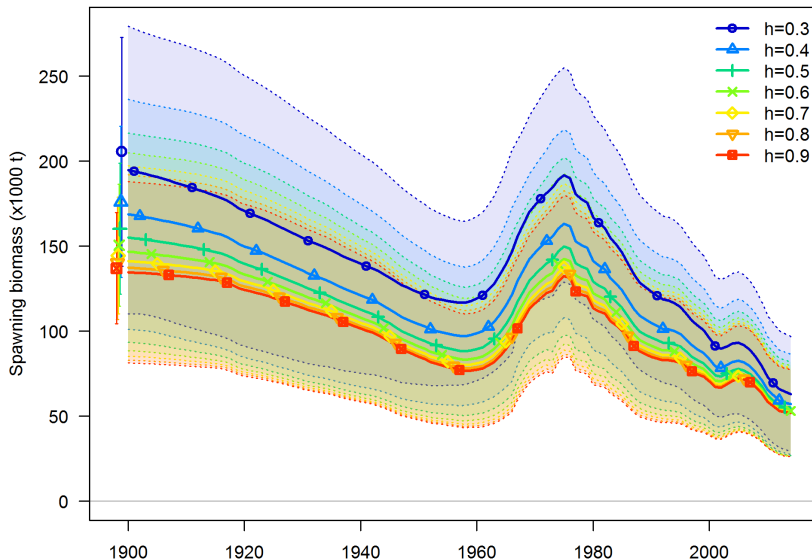
Range in steepness ( $h$ ) from 0.3 to 0.9

## Sensitivity for steepness ( $h$ ):

- base-case model  $h$  is fixed at 0.6;
- range from  $h = 0.3$  to  $h = 0.9$ ;
- a major source of unmodelled uncertainty;
- results in a change in  $B_0$  with fairly consistent current  $SSB$ .

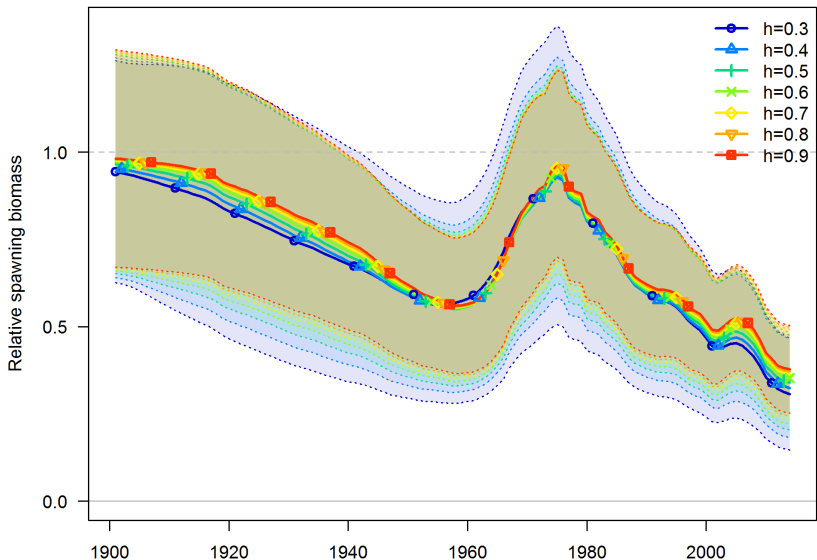
Range in steepness ( $h$ ) from 0.3 to 0.9

# SSB comparison



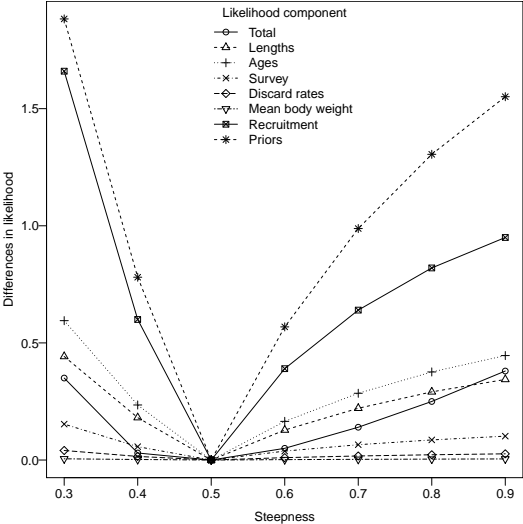
Range in steepness ( $h$ ) from 0.3 to 0.9

# Depletion comparison



Range in steepness ( $h$ ) from 0.3 to 0.9

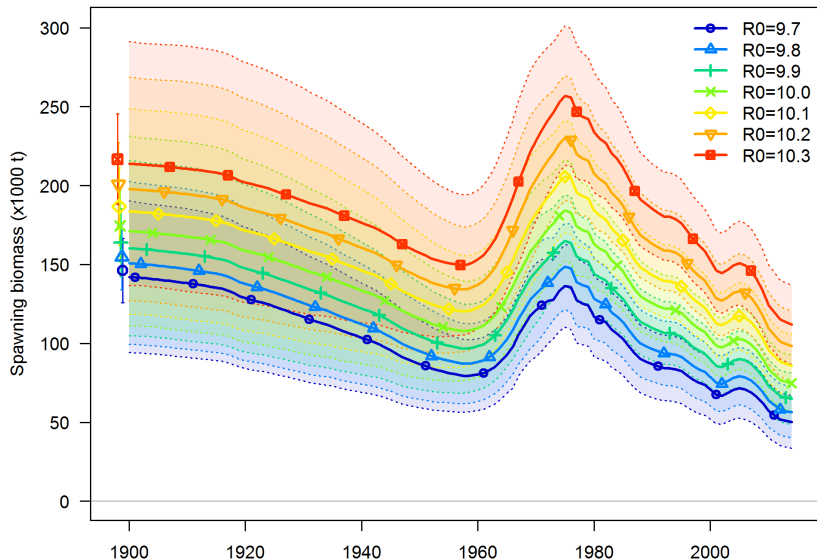
# Likelihood comparison



# Sensitivity to fixed values of $R_0$ :

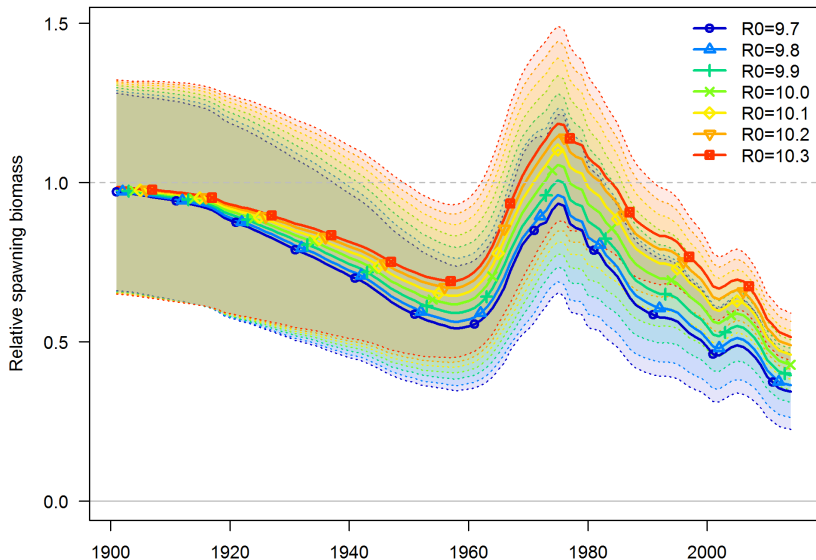
- values explored include 9.7 to 10.3
- results display a shift in scale, with slightly greater shifts in  $SSB_0$  than current  $SSB$ ;
- data is not extremely informative.

## SSB comparison



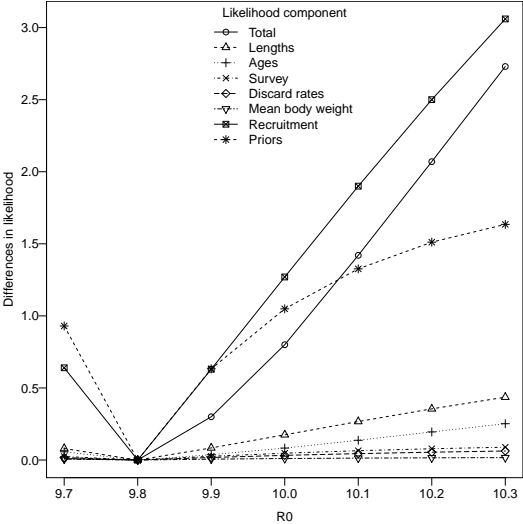


# Depletion comparison



Sensitivity to  $R_0$

# Likelihood comparison



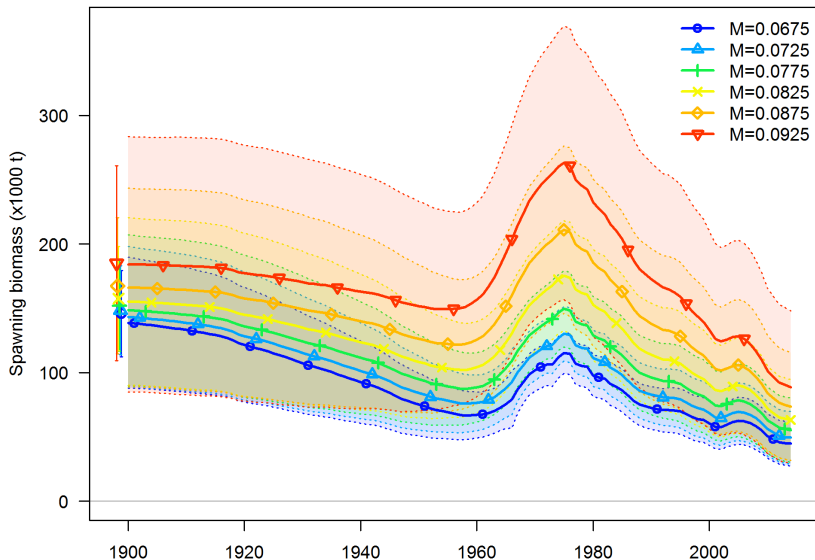
Sensitivity to fixed values of female natural mortality ( $M_{fem}$ )

# Sensitivity to fixed values of female natural mortality ( $M_{fem}$ ):

- values explored range from 0.0675 to 0.0925
- results in a shift in scale of the *SSB*
- leads to somewhat smaller confidence intervals about *SSB* and relative depletion than when estimating the parameter;
- largest ranges in results around late 1970s when the largest catches were taken.

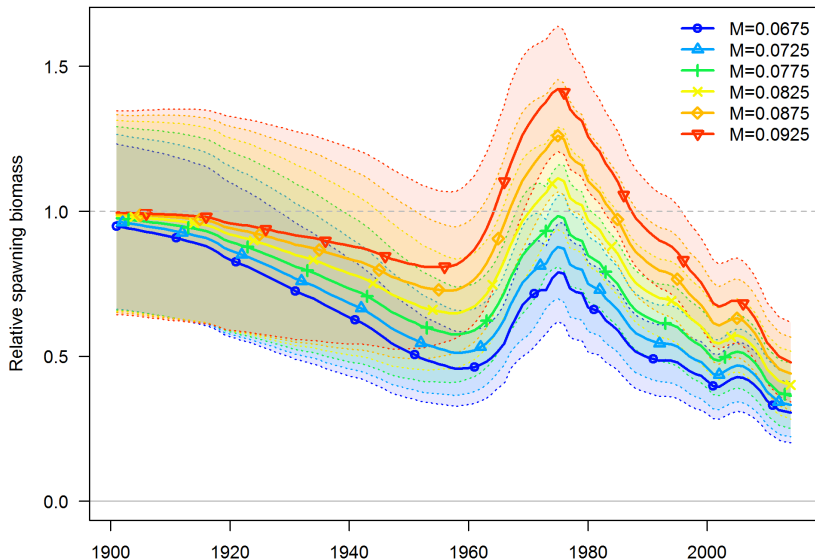
Sensitivity to fixed values of female natural mortality ( $M_{fem}$ )

# SSB comparison

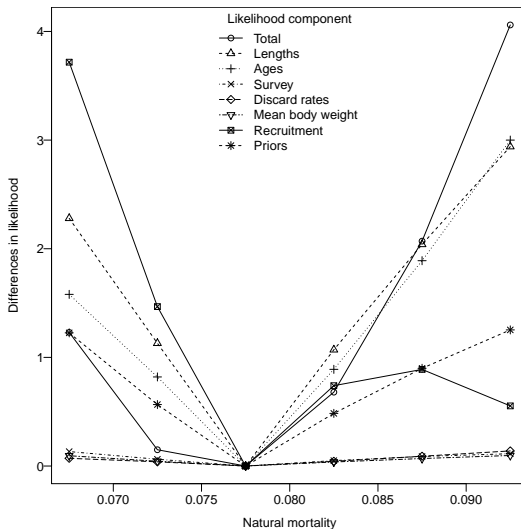


Sensitivity to fixed values of female natural mortality ( $M_{fem}$ )

# Depletion comparison



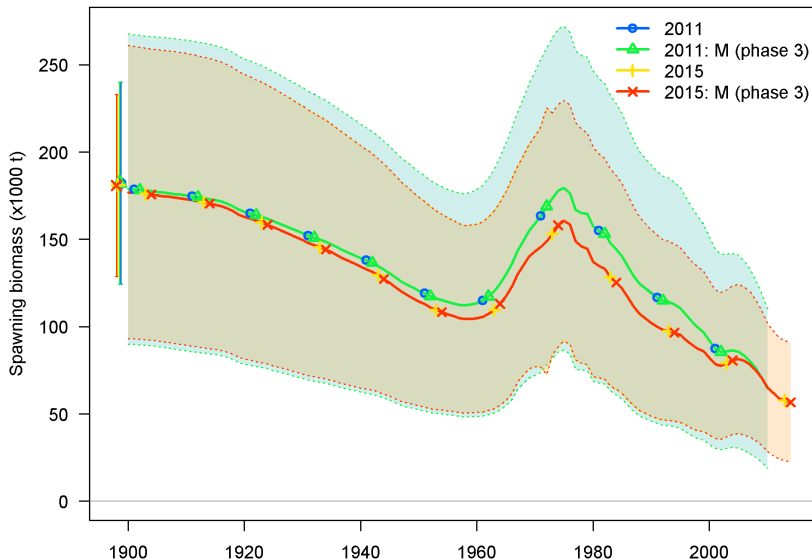
## Likelihood comparison



# Estimating $M$ in phase 8 (2011) or 3 (2015)

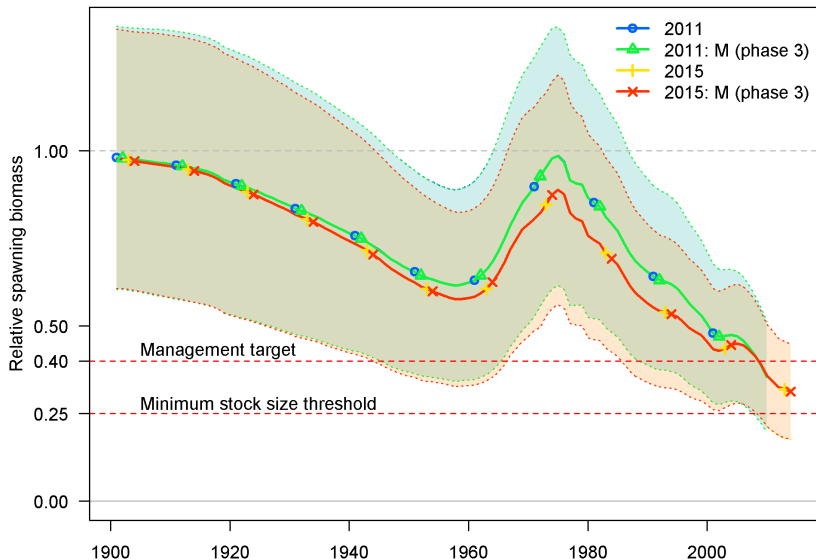
- 2011  $M$  (female & male) estimated in phase 8 (terminal phase);
- 2015 prior to tuneing,  $M$  phase changed to 3;
- No difference in model output, only stability.

# SSB comparison





# Depletion comparison



## Likelihood comparison

type	component	2011	2011: M (phase 3)	2015	2015: M (phase 3)
Derived	SBzero	182133.00	182133.00	180888.00	180888.00
	current_depletion	0.33	0.33	0.31	0.31
	last_years_SPRratio	0.94	0.94	0.95	0.95
	R0	22263.41	22263.41	21843.97	21843.97
Likelihood-		3800.32	3800.32	4466.18	4466.18
	Discard	-57.56	-57.56	-79.65	-79.65
	Forecast_Recruitment	0.00	0.00	2.39	2.39
	Parm_priors	2.55	2.55	2.65	2.65
	Recruitment	22.11	22.11	20.65	20.65
Parameter	M_fem	0.08	0.08	0.08	0.08
	M_male	0.06	0.06	0.06	0.06

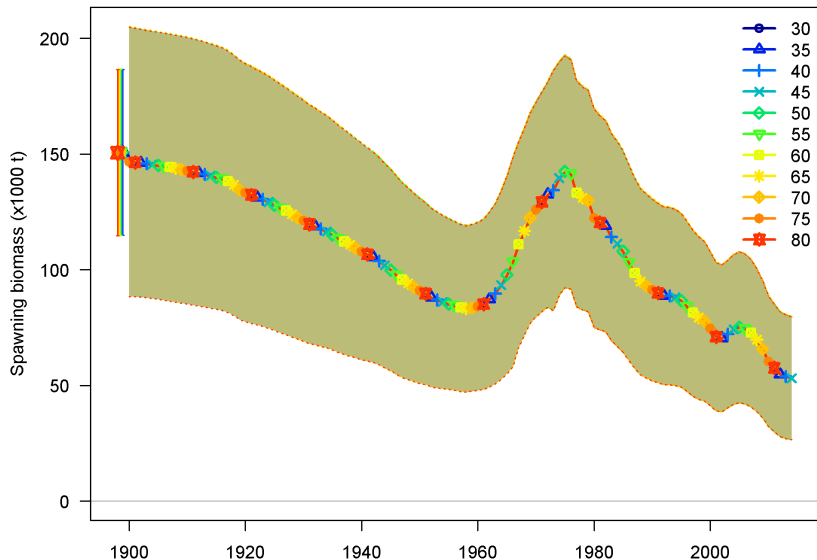
50:50 ratio for unsexed survey compositions

# Maximum length used in 50:50 assignment of unsexed fish to males and females

- length below which all unsexed fish are assigned to males and females using a 50:50 ratio;
  - 2011 == 30 cm
  - 2015 == 71 cm
- above this length the ratio is determined from the observed sex ratio, or the observed ratio of the closest bin;
- no difference in model output.

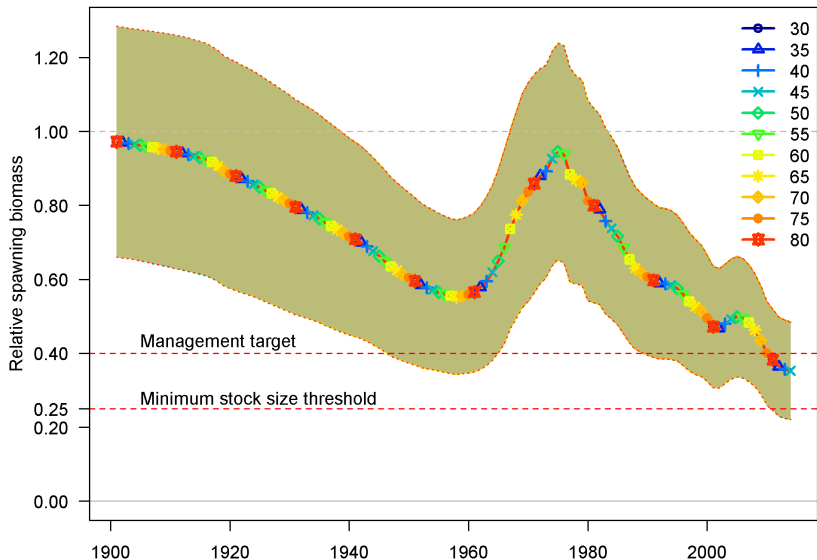
## 50:50 ratio for unsexed survey compositions

## SSB comparison



## 50:50 ratio for unsexed survey compositions

## Depletion comparison

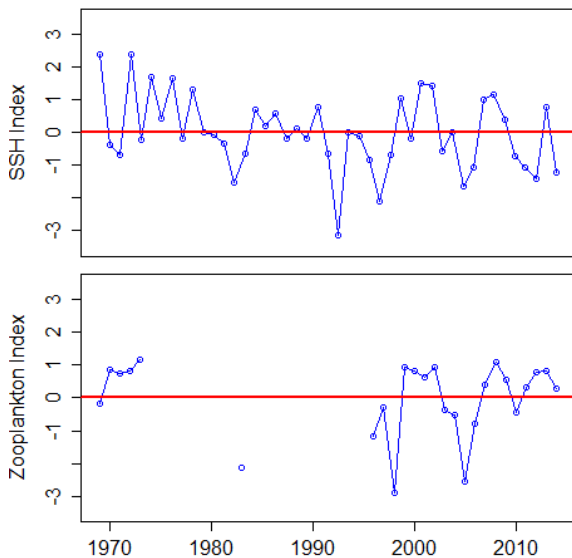


## Likelihood comparison

type	component	30	45	60	75
Derived	SBzero	150752.00	150785.00	150851.00	150606.00
	current_depletion	0.35	0.35	0.35	0.35
	last_years_SPRratio	0.93	0.93	0.93	0.93
	R0	17193.90	17201.64	17212.31	17197.00
Likelihood	-	4980.34	4979.35	4978.68	4980.28
	Discard	-78.82	-78.82	-78.81	-78.81
	Parm_priors	3.04	3.04	3.04	3.05
	Recruitment	25.20	25.19	25.19	25.20
	Survey	-35.83	-35.83	-35.83	-35.84

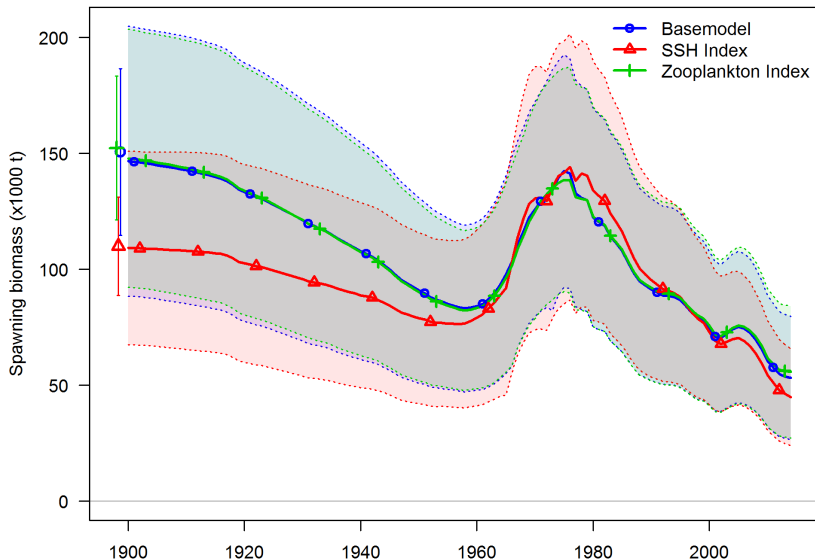
- Inclusion of an environmental index of recruitment using a 'survey'
  - Sea surface height (SSH) (W. Peterson 2015)
  - Zooplankton abundance (B. Black 2015)
- Recruitment success linked to productivity in California Current
  - Relationship is contentious
- Time series of indices extended to 2014
- SSH index resulted in slightly lower recruitment deviations
- Zooplankton index did not result in much change

## Time series of environmental index

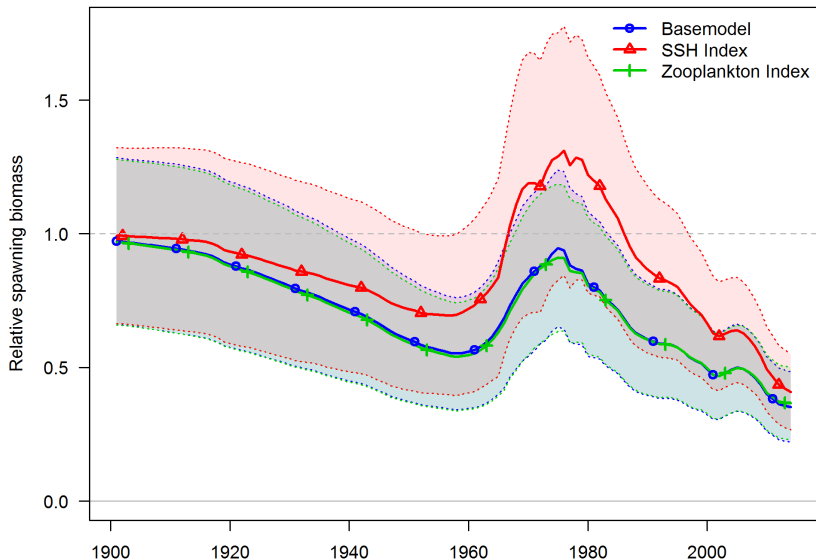




## SSB comparison



## Depletion comparison



# Likelihood comparisons