



NOAA
FISHERIES

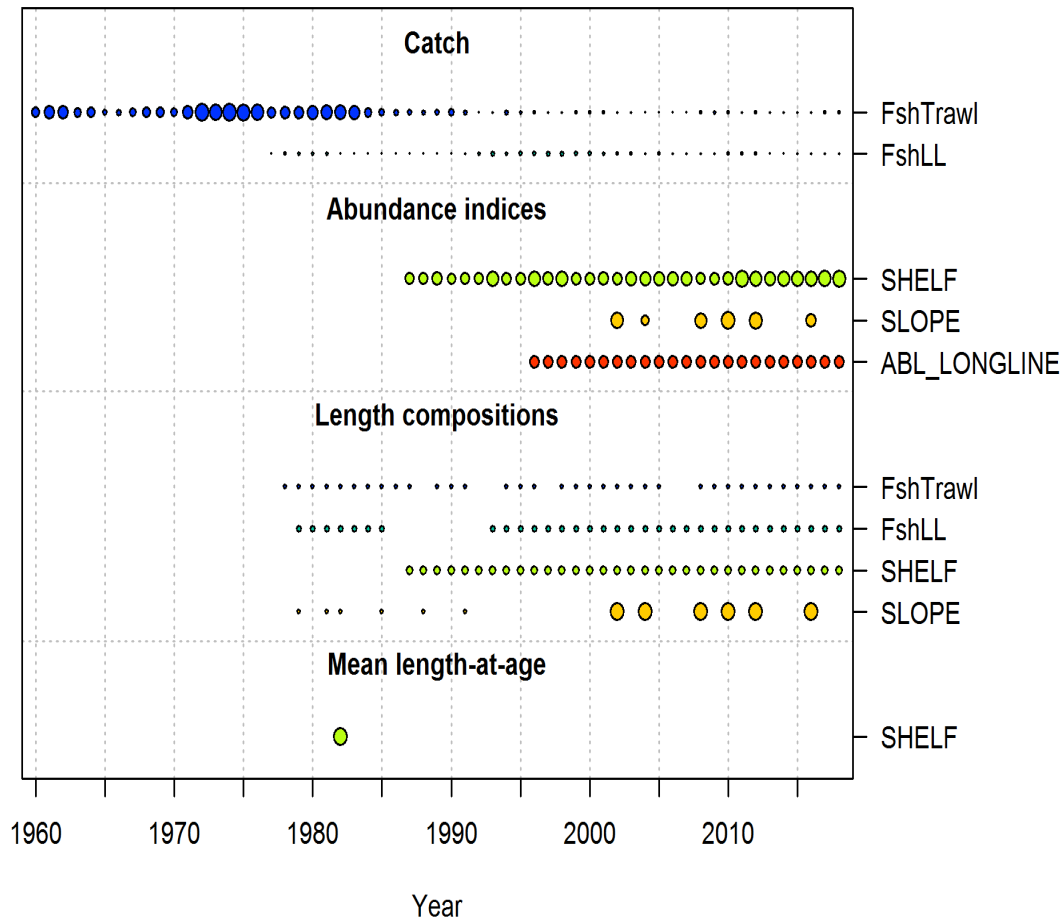
Assessment of BSAI Greenland turbot

November 13, 2018

September Plan Team Meeting

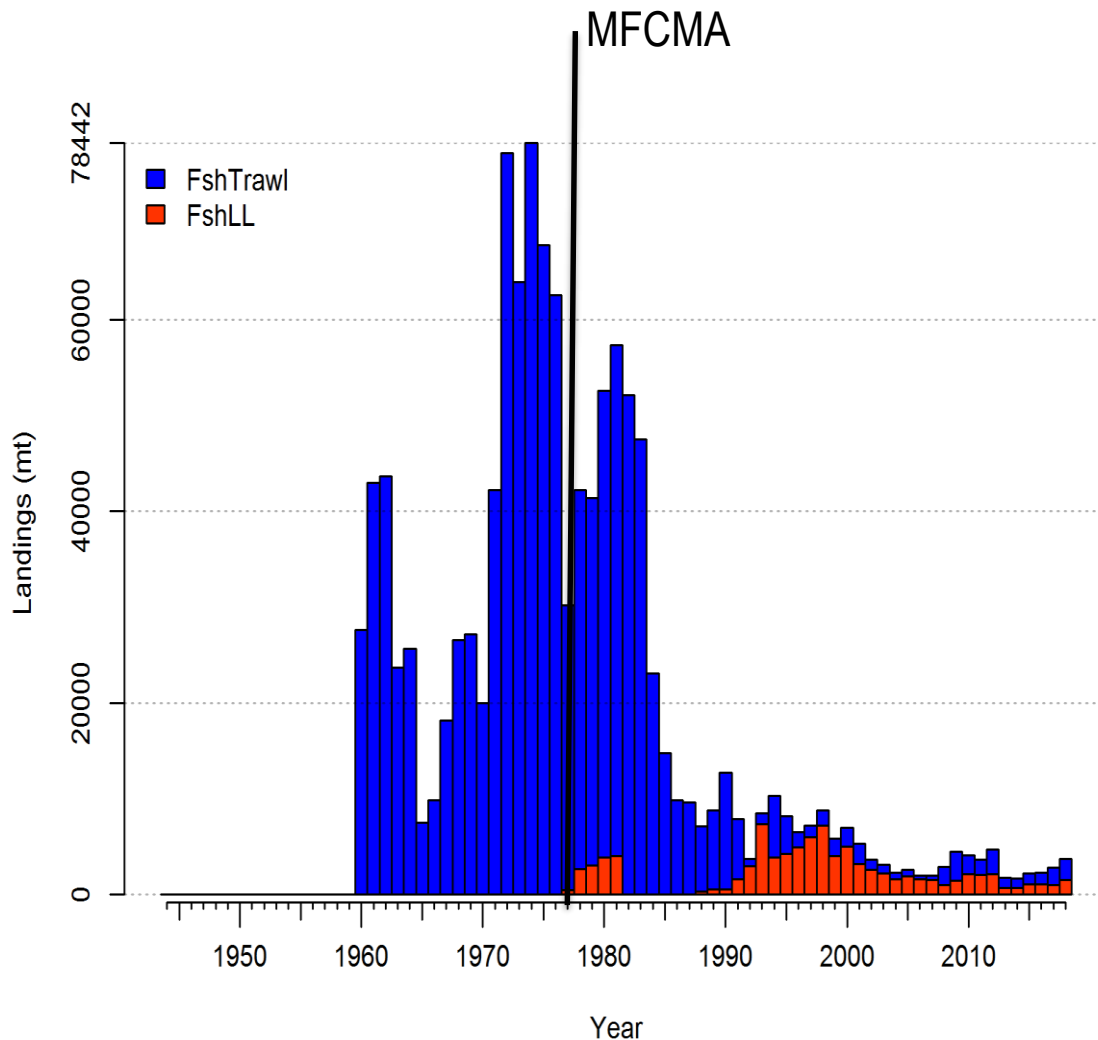
- Evaluated the behavior of the 2016 accepted assessment
 - Showed there was some model instability
 - Seemed linked to the ABL longline catchability and poorly estimated selectivity parameters
 - Model estimating the ABL longline survey catchability helped the model to be more stable (16.1b)
- Worthwhile to explore the model that linked recruitment and mean temperature
 - Concern that recruitment will remain low given the warming trends of the EBS
- Plan Team recommendations for November
 - Bring forward previous assessment model (16.1), model 16.1b, and the model linking recruitment and temperature

Data and model structure



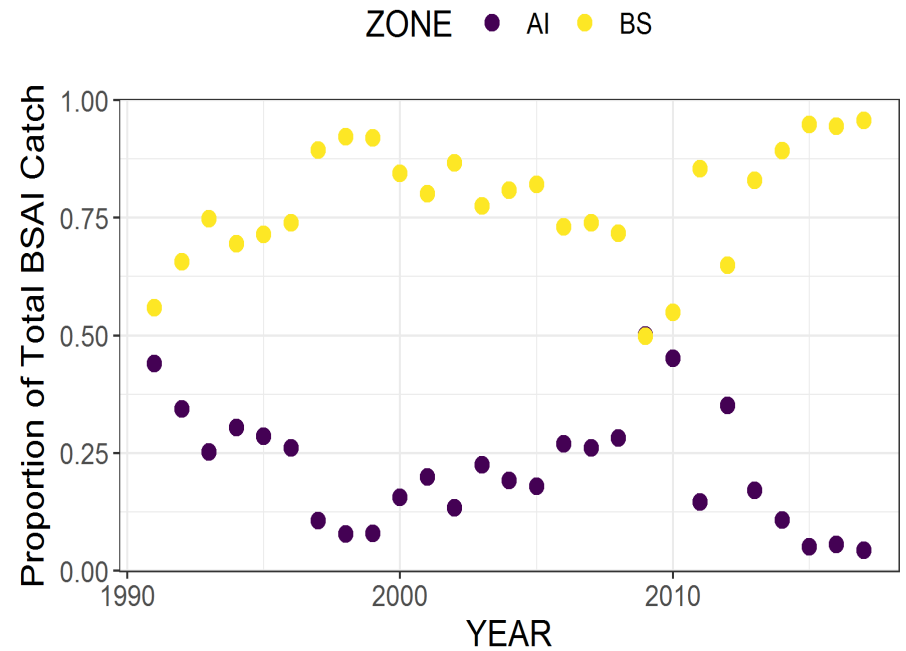
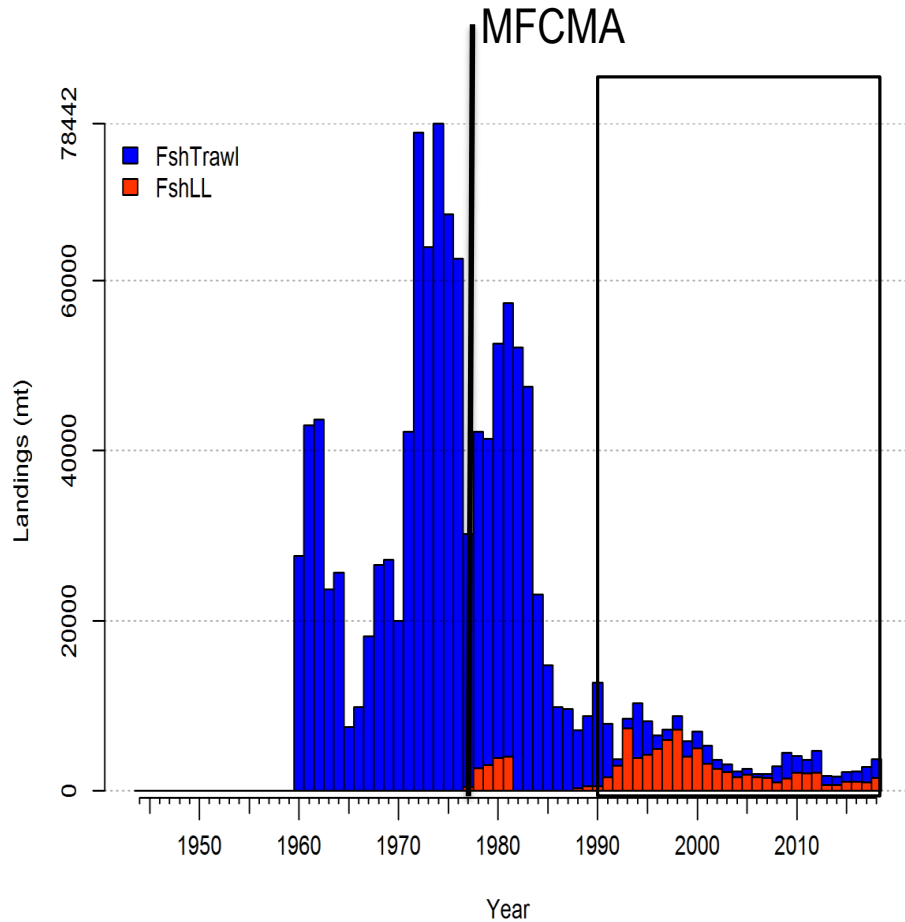
- Models developed in Stock Synthesis
- 2 fleets, 3 surveys
 - Trawl fishery
 - Longline fishery
 - EBS shelf survey
 - EBS slope survey
 - ABL longline survey

Fishery catch



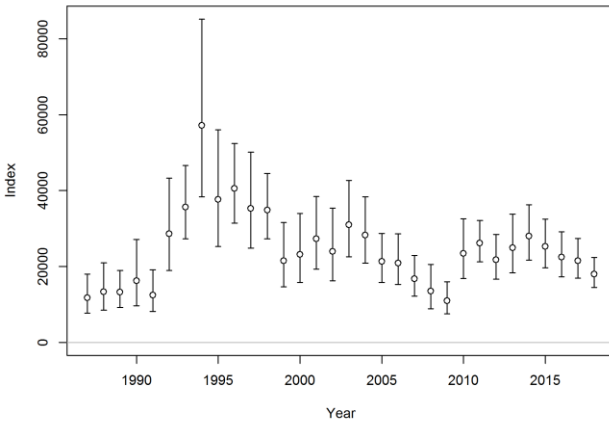
- 1960 – 2018
- Early catch mainly trawl fishery
- Peaked in early 1970s
- Secondary peak in 1982
- Large decline mid-80s
- Starting in the 1990s predominantly longline

Fishery catch

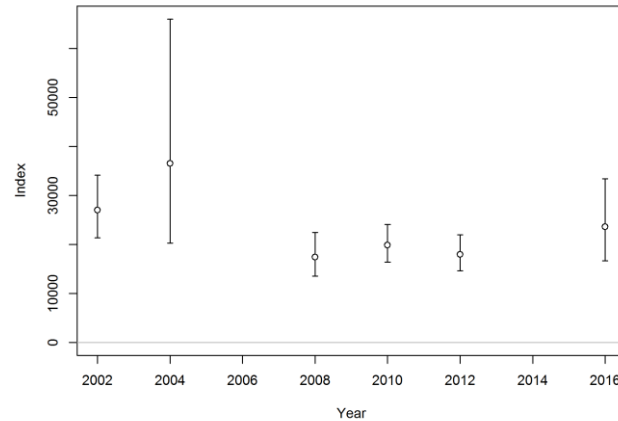


Survey biomass estimates

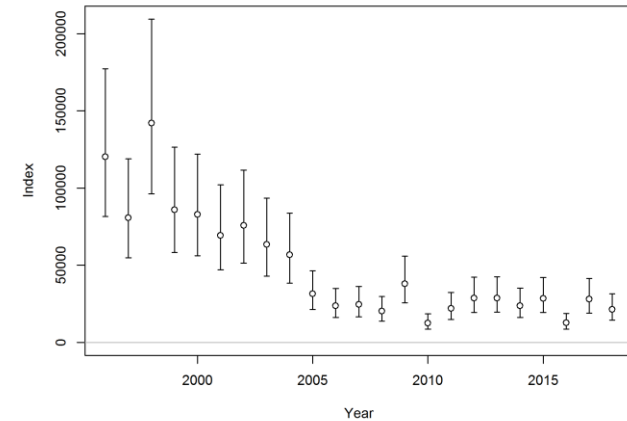
Shelf



Slope

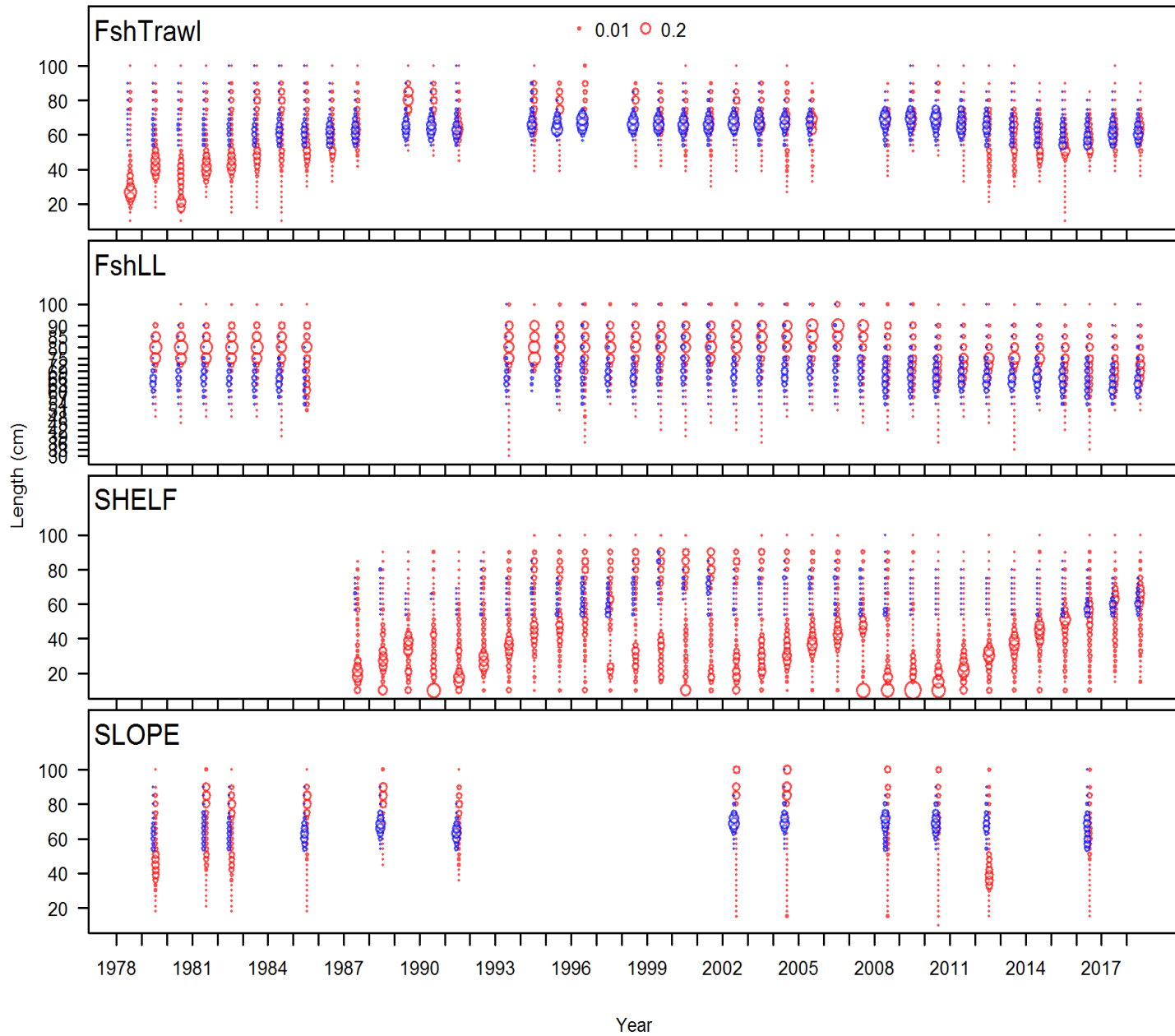


ABL Longline

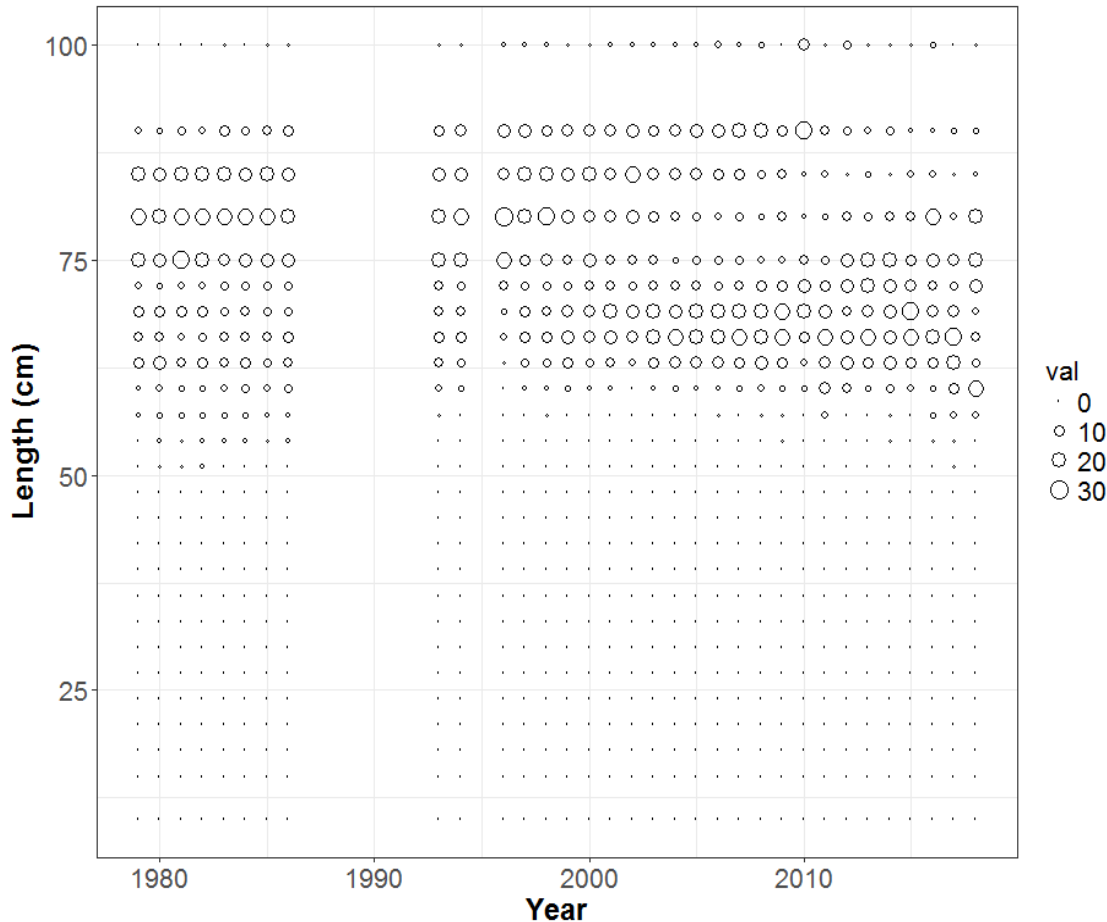


- Shelf declined by 16% in 2018
- Slope survey not updated
- ABL longline declined by 23% in 2018
 - Sampled Aleutian Islands

Length composition

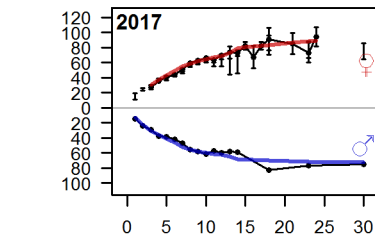
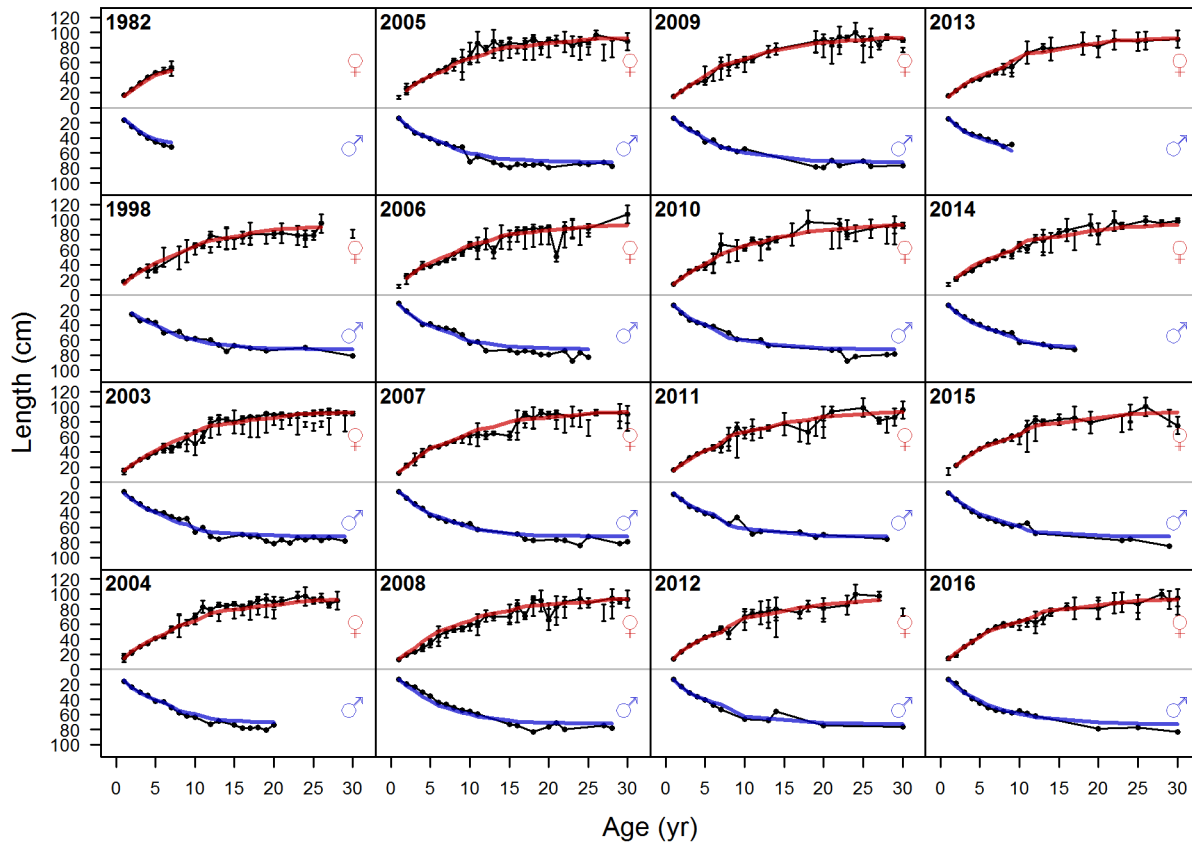


Length composition



- ABL longline
 - 1979 – 2018
 - Combined sexes
 - Not included in the likelihood

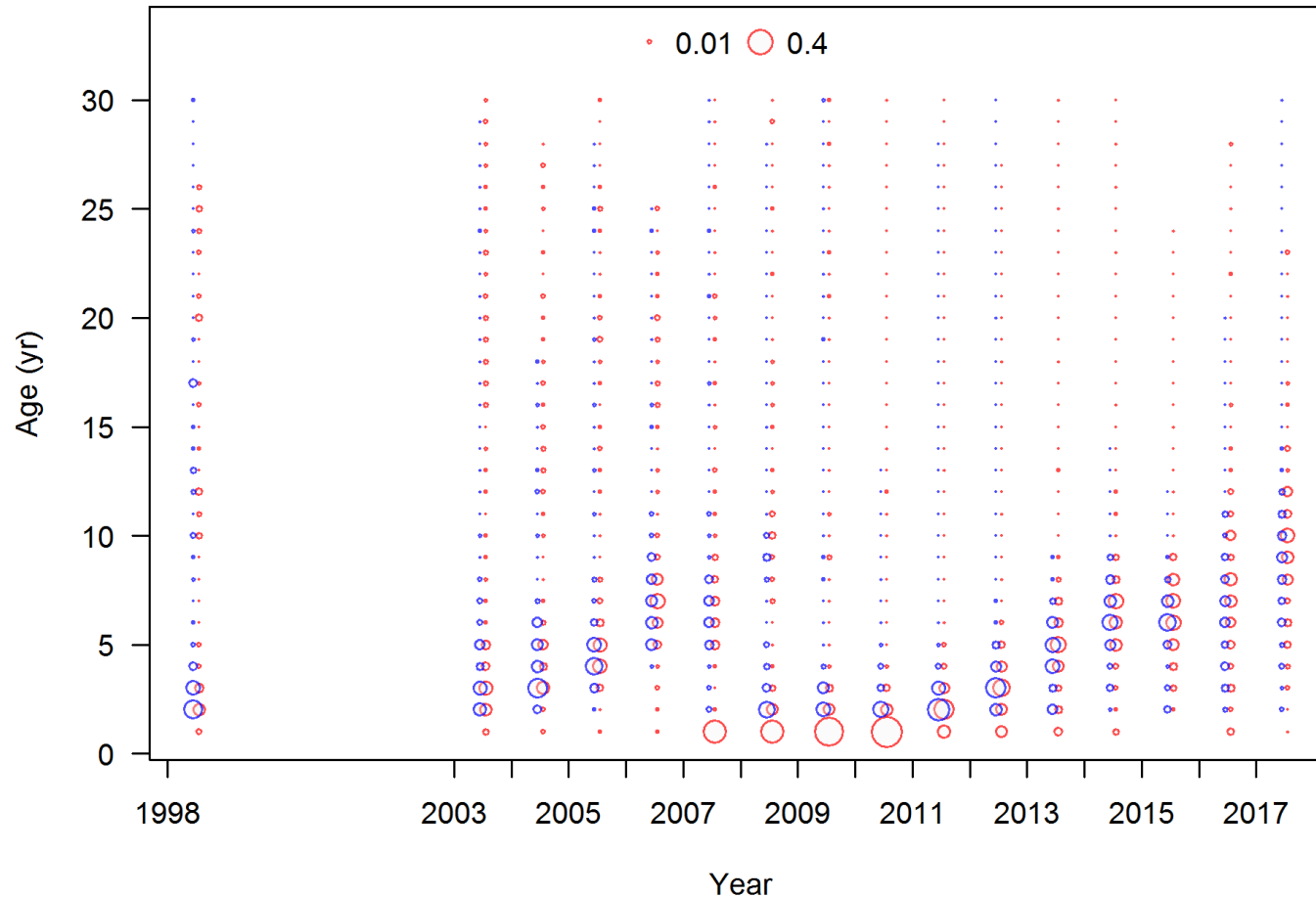
Mean weight-at-age



Age

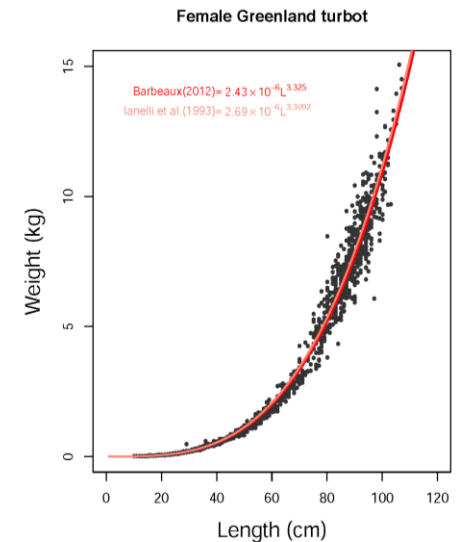
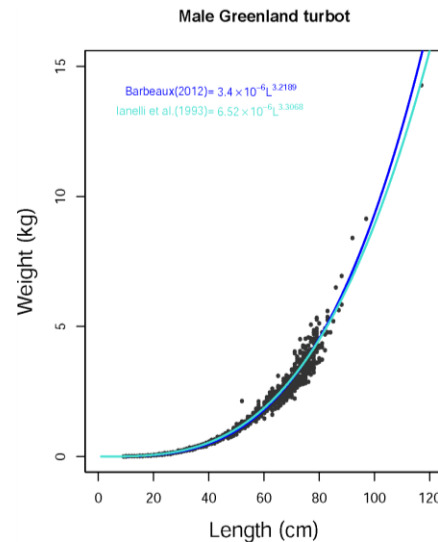
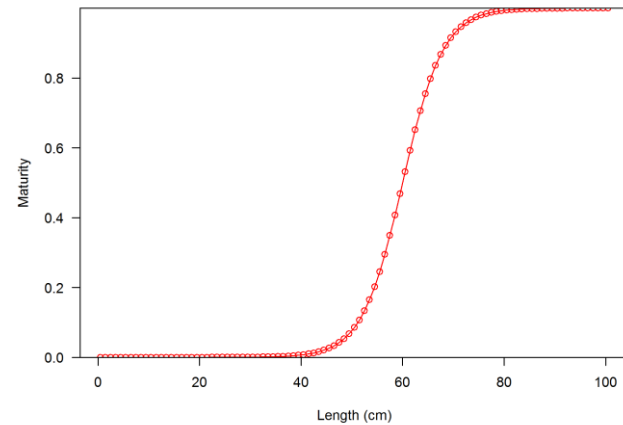
Age composition: Shelf survey

- Data were not included in the likelihood



Model structure

- Natural mortality – Fixed
 - $M = 0.112$ (Cooper et al. 2007)
 - Same for females and males
- Maturity at length – fixed parameters
 - L50: 60 cm (D'yakov 1982)
 - Slope: -0.25 (D'yakov 1982)
- Weight-length relationship – fixed parameters
 - Males: $W = 3.4 \times 10^{-6} L^{3.2189}$
 - Females: $W = 2.43 \times 10^{-6} L^{3.325}$
 - Barbeaux et al. (2012)
- von Bertalanffy growth
 - Length at minimum age (estimated)
 - Length at maximum age (estimated)
 - Growth coefficient (estimated)
 - CVs at young and old age (fixed)
 - 15% young and 9% old



Model structure

- Stock-recruitment (Beverton-Holt)
 - R_0 – Estimated
 - Steepness - Fixed = 0.79 (Myers et al. 1999)
 - Sigma R - Fixed = 0.6
 - Autocorrelation – Estimated
 - Normal prior
 - Mean = 0.473 and Stdev = 0.265 (Thorson et al. 2014)
 - Recruitment deviations - Estimated
 - Early: 1945 - 1970
 - Main: 1970 - 2013
 - Forecast: 2014 - 2019

Model structure

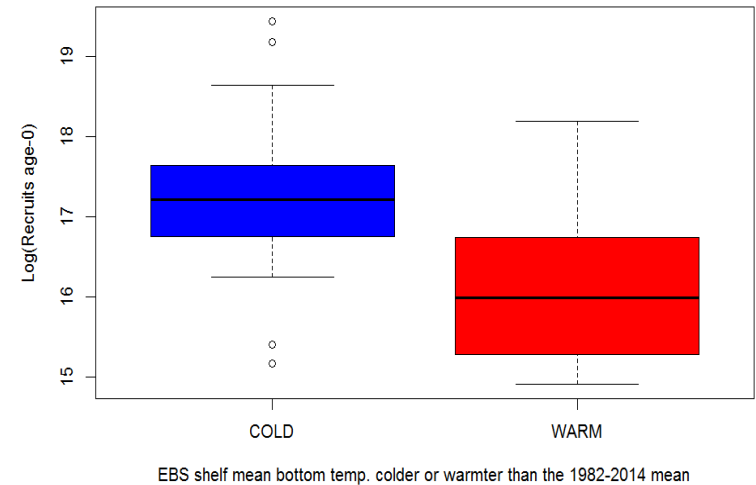
- Selectivity
 - Sex-specific, size-based
 - ABL longline survey: Fixed logistic
 - Double normal pattern
 - Trawl fishery, longline fishery, EBS shelf and slope surveys
 - Slope selectivity is constrained to be logistic
 - Female selectivity offset from males for longline fishery and slope survey
 - Male selectivity were offset from female for trawl fishery and shelf survey
 - Time-varying selectivity using time blocks
 - Trawl fishery: pre-1989 (10), 1989-2005 (14), 2006 -2018 (11)
 - Longline fishery: pre-1991 (7), 1991-2007 (15), 2008-2018 (11)
 - EBS shelf survey: pre-1992(5), 1992-1995 (4), 1996-2000 (5), 2001-2018 (18)
 - EBS slope survey: pre-2002 (6), 2002-2010 (4), 2011-2018 (2)

Alternative models

Model	16.1 (2016 model)	16.1b	16.1c
Model dimensions			
Start and end year	1945, 2018	1945, 2018	1945, 2018
Catchability			
EBS shelf	0.616	0.616	0.616
EBS slope	0.574	0.574	0.574
ABL longline	Analytically derived	Estimated	Estimated
Recruitment			
R0	Estimated	Estimated	Estimated
Environmental link	-	-	Estimated
Recruitment deviations	Estimated	Estimated	Estimated
Autocorrelation	Estimated	Estimated	Estimated
Steepness	0.79	0.79	0.79
Steepness	0.6	0.6	0.6

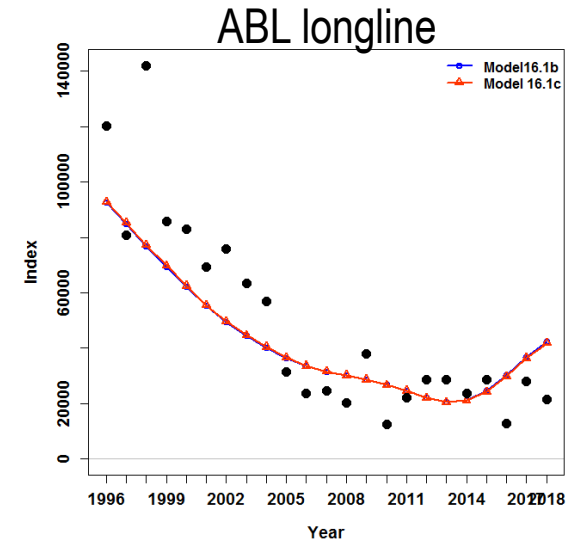
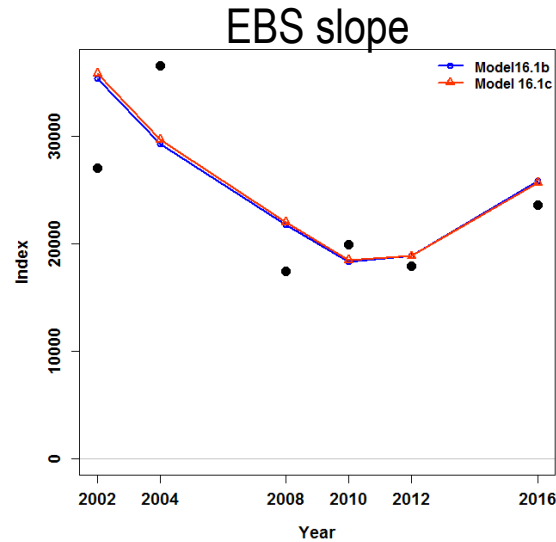
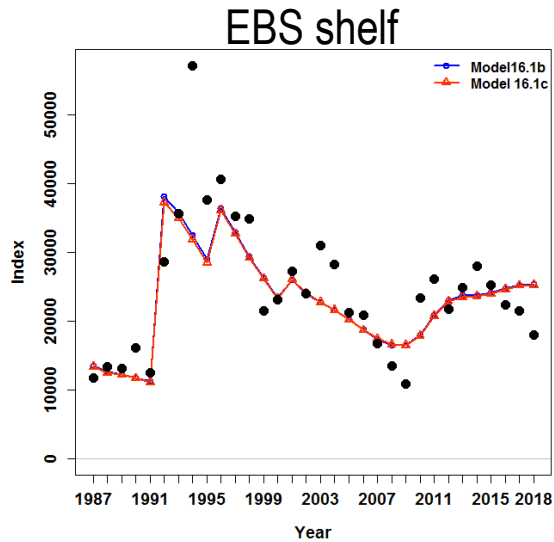
Model 16.1c

- Environmental index
 - 0 for warm years and -1 for cold years
 - 1945 - 1982: -1 for years with negative average PDO values
 - 1982 - 2018:
 - Calculated the mean bottom temperature from the bottom trawl survey from 1982-2018
 - -1 for years where bottom temperature was below one standard deviation from the mean bottom temperature
- Linked to R0
 - Additive effect: $P' = P + L \cdot \text{env}$
 - Separate R0 for cold years



Barbeaux et al. 2016

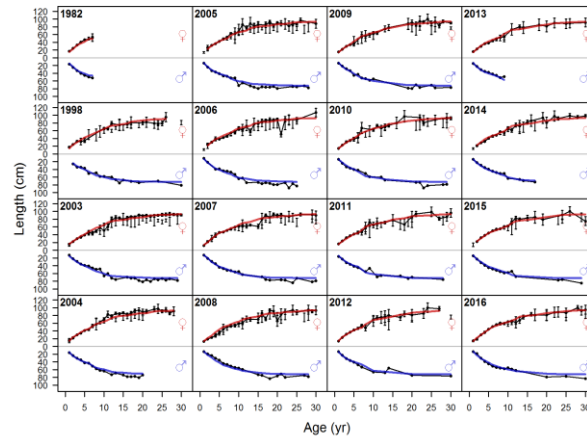
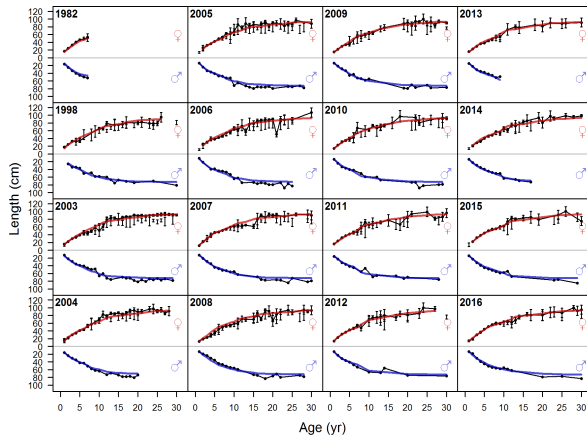
Model fit to indices



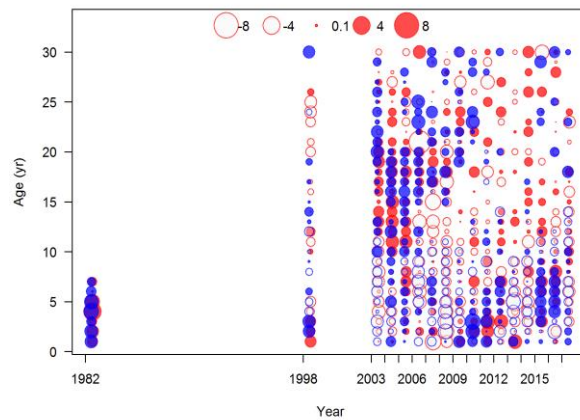
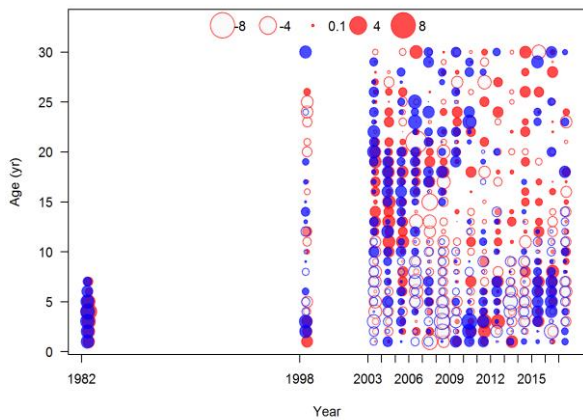
Survey	Model 16.1b	Model 16.1c
Shelf	0.209	0.211
Slope	0.176	0.179
ABL longline	0.394	0.392

- Similar survey likelihood components:
 - Model 16.1b: -30.7
 - Model 16.1c: -30.4

Model fit to mean size-at-age



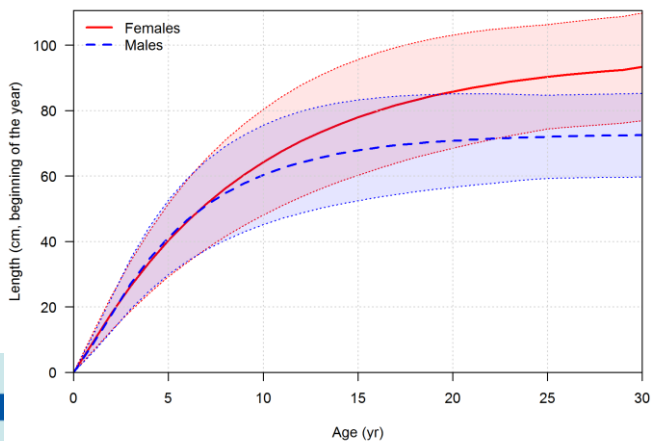
- Likelihoods:
- Model 16.1b: 1276.9
- Model 16.1c: 1277.2



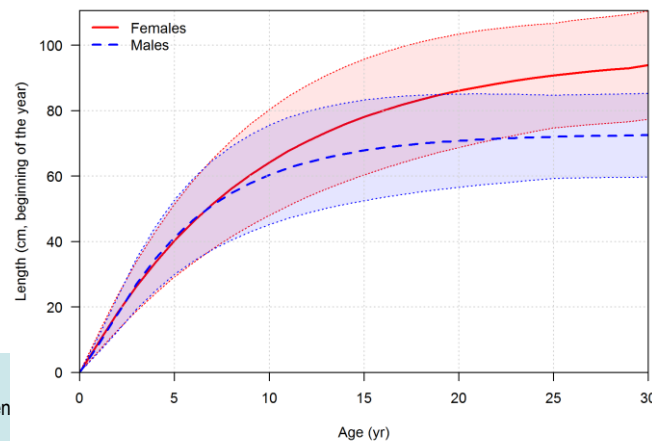
Growth estimates

	16.1b		16.1.c	
Label	Value	StDev	Value	Stdev
Biology				
L Amin female	15.06	0.24	15.19	0.23
L Amax female	90.29	0.43	90.70	0.41
von Bert k female	0.11	0.00	0.11	0.00
L Amin male	14.13	0.22	14.17	0.22
L Amax male	71.99	0.35	71.97	0.35
von Bert k male	0.19	0.00	0.19	0.00

Ending year expected growth (with 95% intervals)

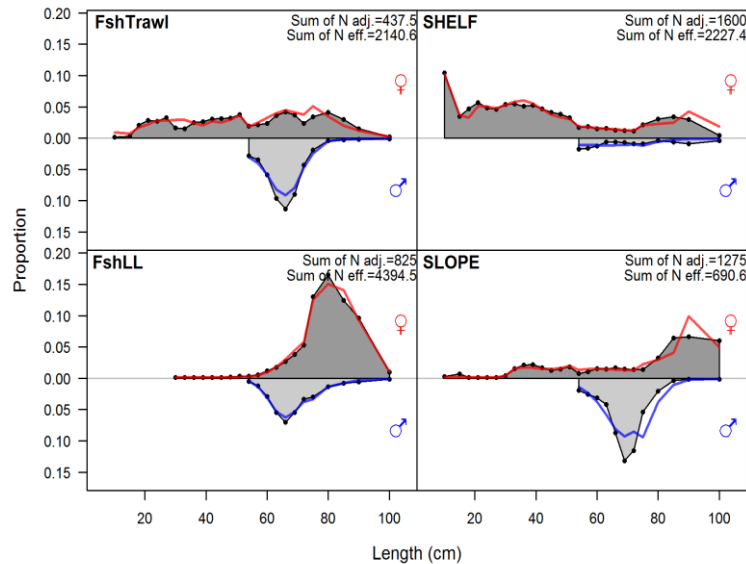


Ending year expected growth (with 95% intervals)

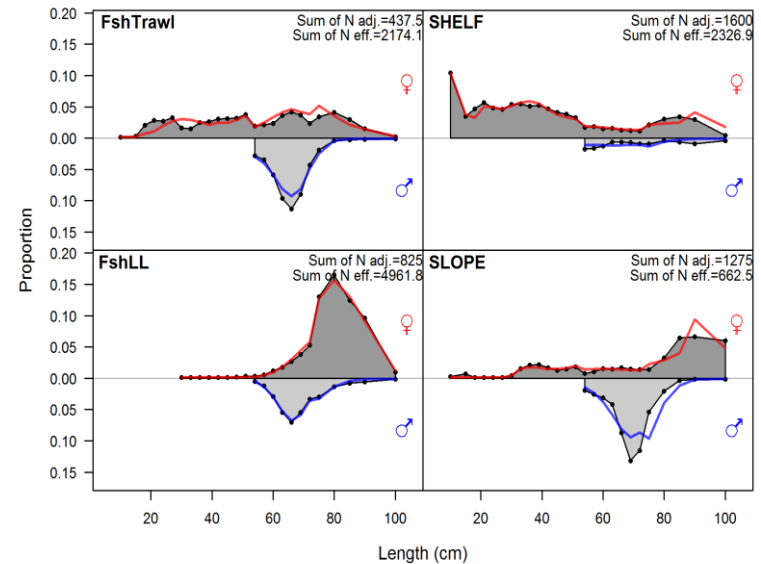


Fit to length composition estimates

Model 16.1b



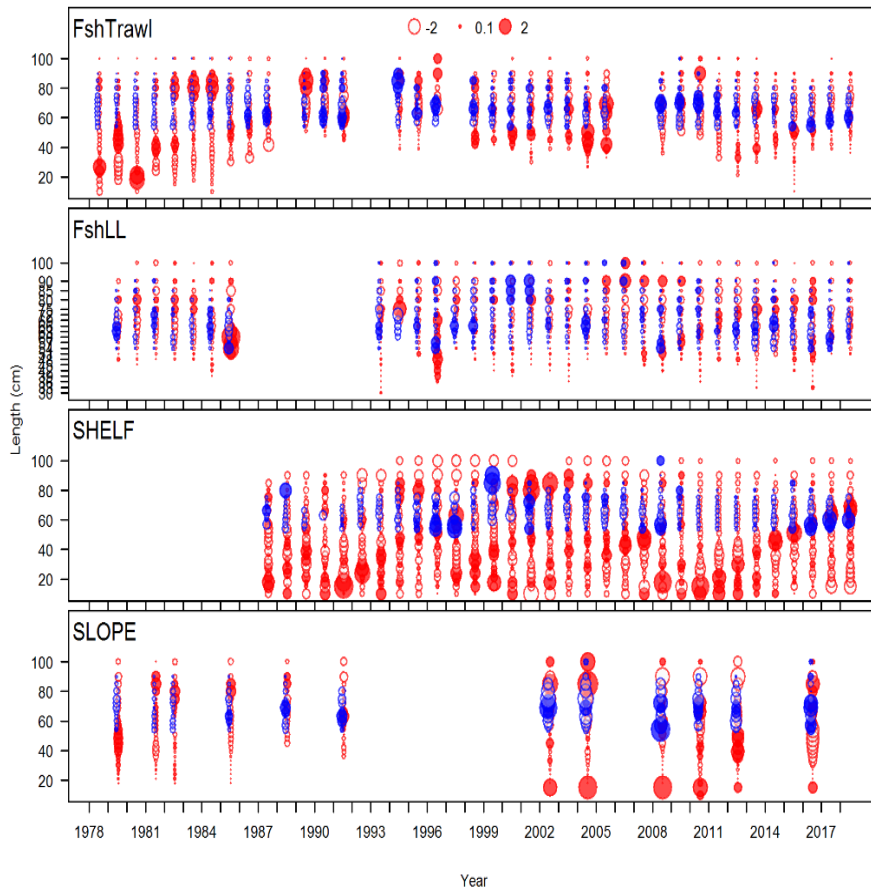
Model 16.1c



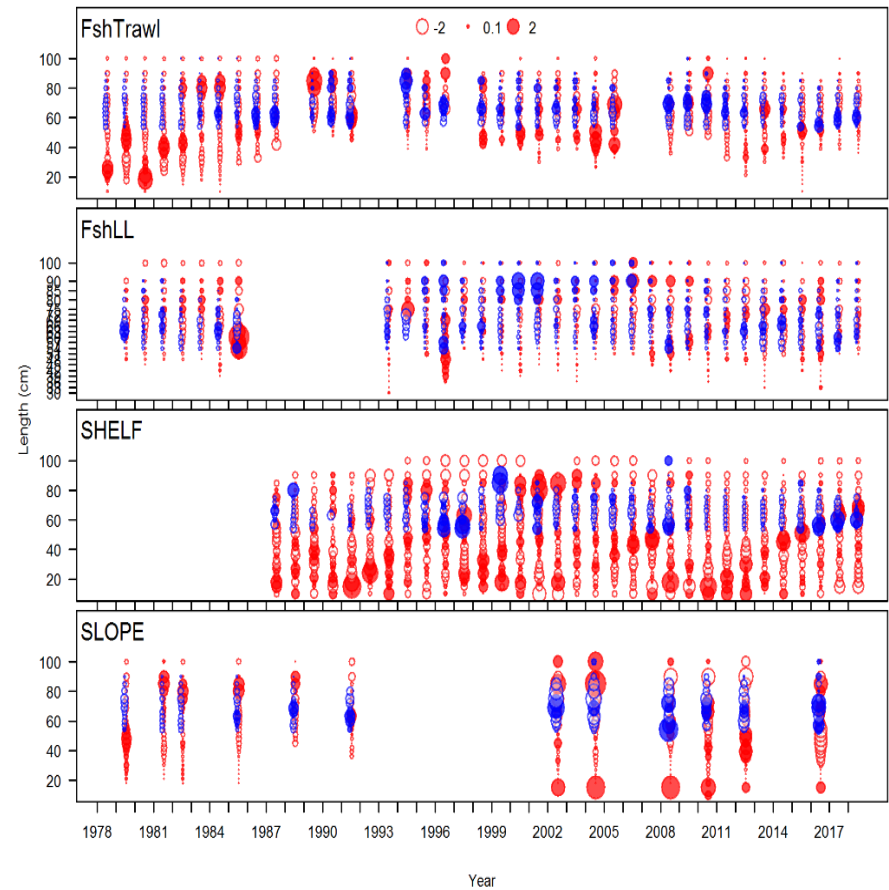
Model	16.1b					16.1c				
Fleet/Survey	Trawl	Longline	Shelf	Slope	ABL LL	Trawl	Longline	Shelf	Slope	ABL LL
Likelihood	105.7	62.9	291.3	196.8	0	102.3	64.9	286.5	200.3	0

Residuals

Model 16.1b

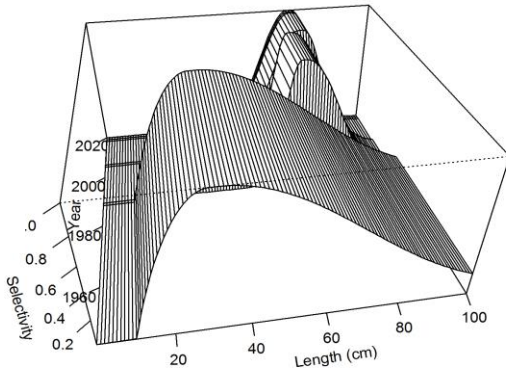


Model 16.1c



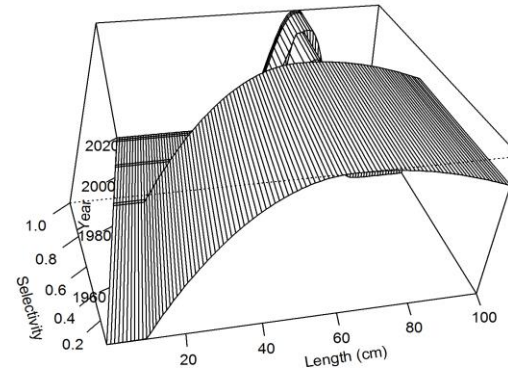
Selectivity: Trawl fishery

Female

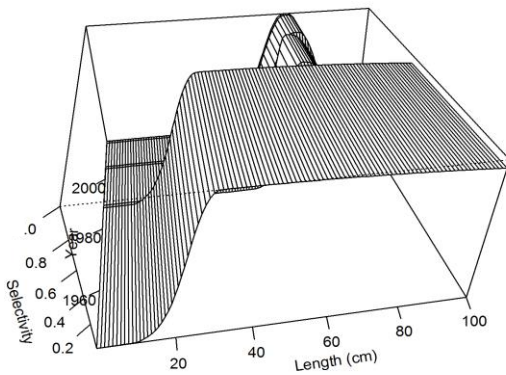


Model
16.1b

Male

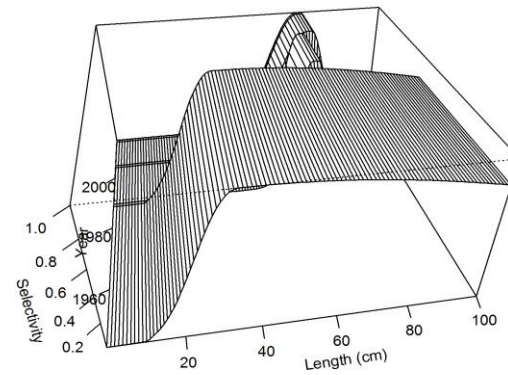


Female time-varying selectivity for FshTrawl



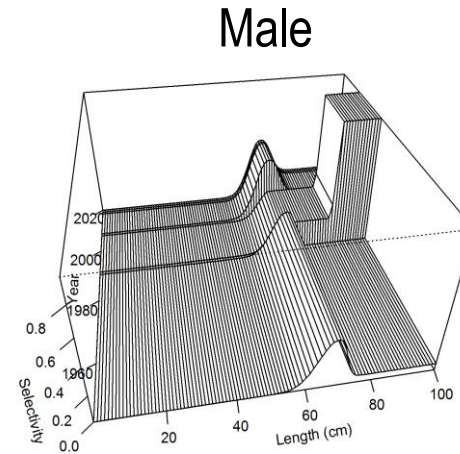
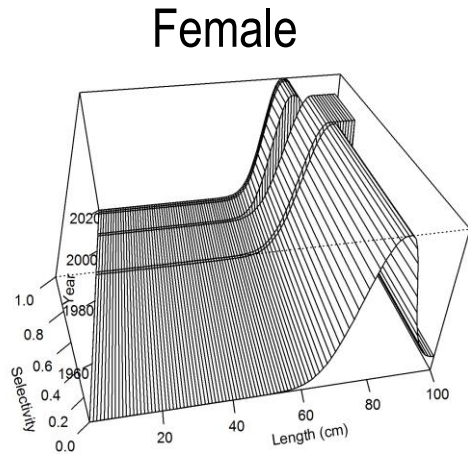
Model
16.1c

Male time-varying selectivity for FshTrawl

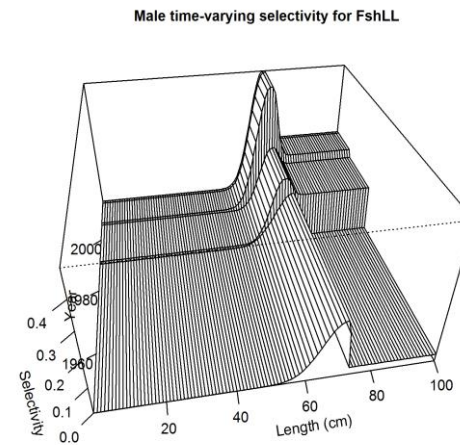
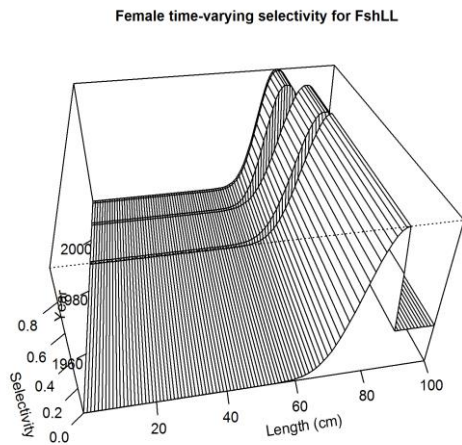


Selectivity: Longline fishery

Model
16.1b



Model
16.1c



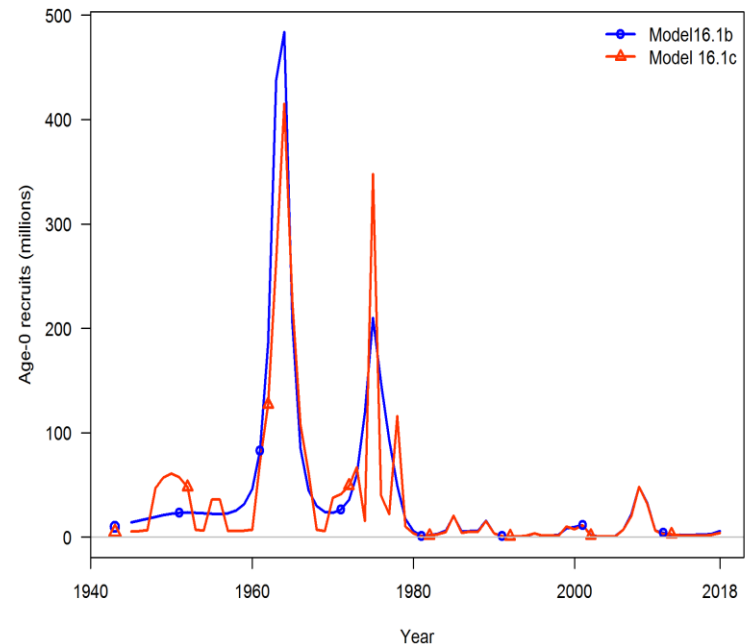
Likelihoods

	16.1b		16.1c	
Component	Likelihood	Gradient	Likelihood	Gradient
Total	2019.9	3.65e-06	1998.0	0.00151
Catch	5.6E-12		2.0E-13	
Survey	-30.7		-30.4	
Length comp	656.8		653.9	
Size at age	1276.9		1277.2	
Recruitment	101.05		79.03	

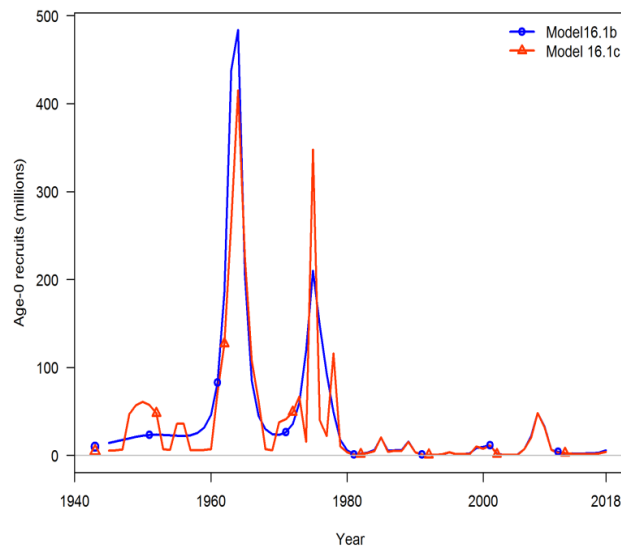
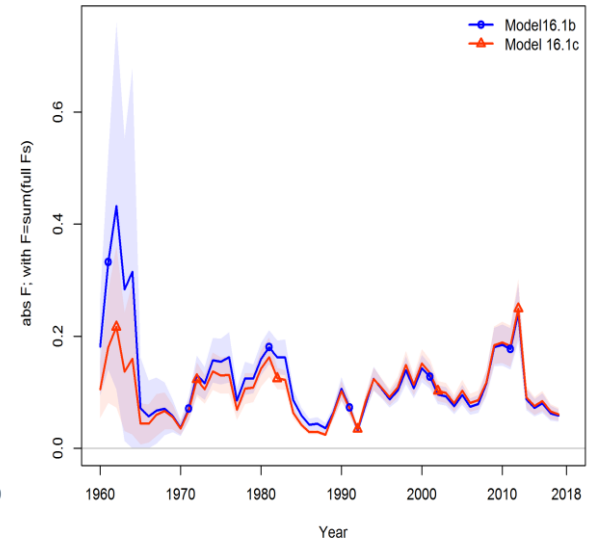
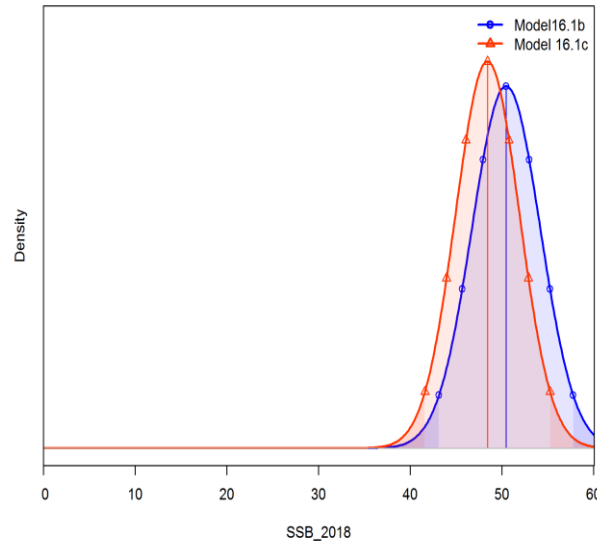
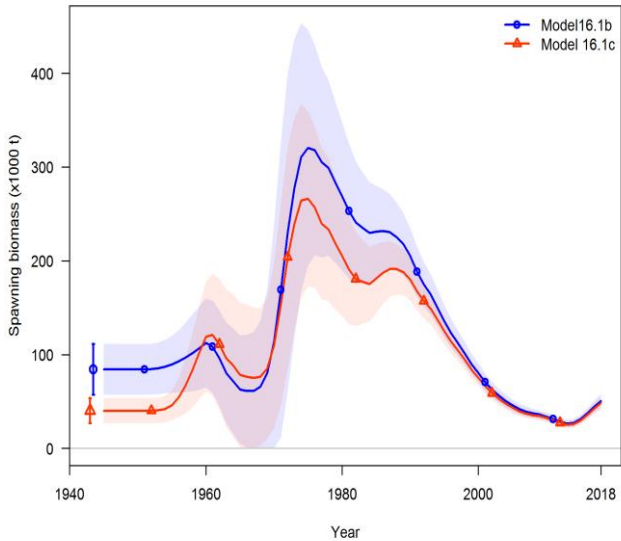
- Similar fits to the data components
- Overall likelihood is lower for model 16.1c with one additional parameters
- Biggest difference in the recruitment likelihood component

Recruitment

- Differences
 - R0
 - Model 16.1b - 9.8 million
 - Model 16.1c – 4.6 million
 - Autocorrelation parameter
 - Model 16.1b – 0.61
 - Model 16.1c – 0.44 (prior estimate)
 - Recruitment estimates are in the early recruitment period
 - Projections use recruitment from 1978 – 2016
 - Similar average recruitment between models

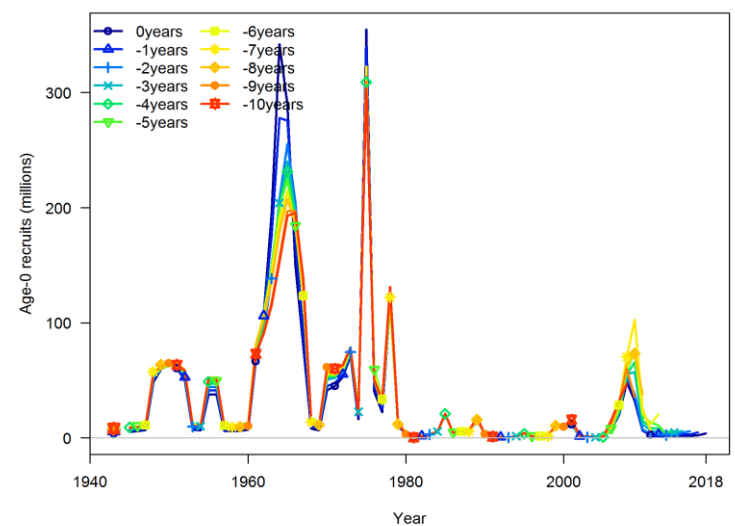
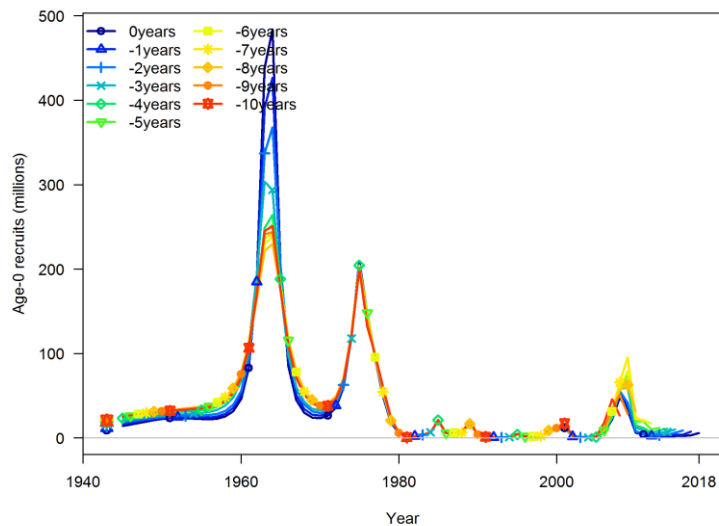
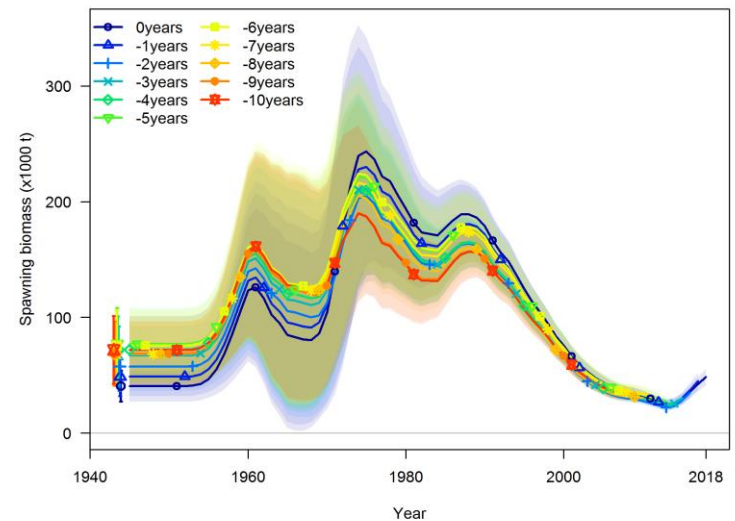
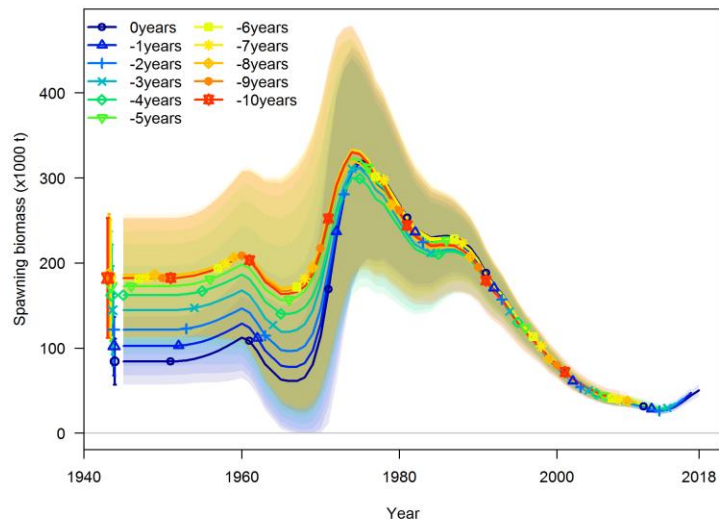


Spawning biomass and fishing mortality



- Early years differences are due to the estimated initial conditions
 - Fishing in the model starts in 1960
- Large increase in spawning biomass is driven by the large recruitment events in early 1960s and 1970s
- Estimated selectivity in early period is dome-shaped for model 16.1b
- 2018 spawning biomass estimate similar

Retrospective analysis



- Mohn's rho: 0.097 (16.1b) and 0.045 (16.1c)

Recommendation

- Model 16.1b is preferred
 - Similar retrospective pattern and Mohn's rho statistics
 - Fits to the data were similar between models with some trade-offs
 - Model 16.1c had better fit to the shelf survey and trawl fishery length composition data
 - Model 16.1b had better fit to the slope survey and longline fishery length composition data
- Likelihood improvement was mainly in the recruitment component with bias adjustment

Recommendation

- Model 16.1b is preferred
 - Likelihood improvement for model 16.1c was mainly in the recruitment component
 - Could indicate that the environmental data were informative about annual recruitment
 - Environmental index was a series of 0s and -1
 - Allows R_0 to differ between cold and warm years, but the additive effect is the same for years prior to 1977 and after
 - Future assessments/research should evaluate other methods to:
 - Account for acknowledged regime shift after 1977
 - Account for inter-annual variability due to warm and cold years

Projections

- Recruitment time-series
 - Age -1 recruits
 - 1978 – 2016
- Catch
 - 2018 – Product of the 2018 TAC and the average proportion of the TAC caught (2013-2017)
 - All other years catch was equal to max ABC unless the scenario stated otherwise

Harvest recommendations

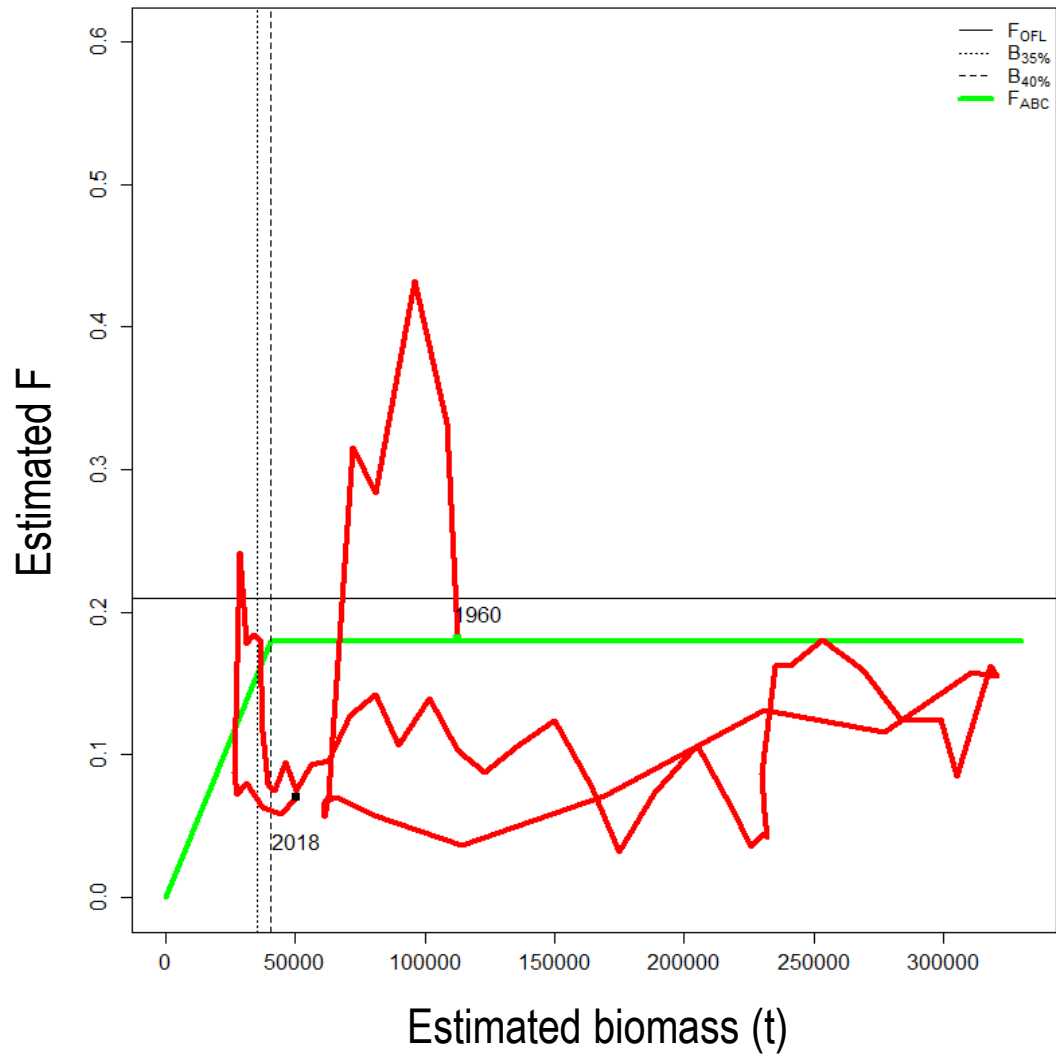
Quantity	As estimated or specified last year for:		As estimated or recommended this year for:	
	2018	2019	2019	2020
M (natural mortality rate)	0.112	0.112	0.112	0.112
Tier	3a	3a	3a	3a
Projected total (age 1+) biomass (t)	126,417	127,021	105,930	98,876
Female spawning biomass (t)	58,035	61,878	54,244	52,743
B_{100%}	103,097	103,097	90,534	90,534
B_{40%}	41,239	41,239	36,213	36,213
B_{35%}	36,084	36,084	31,687	31,687
F_{OFL}	0.22	0.22	0.21	0.21
maxF_{ABC}	0.18	0.18	0.18	0.18
F_{ABC}	0.18	0.18	0.18	0.18
OFL (t)	13,148	13,540	11,362	10,476
maxABC (t)	11,132	11,473	9,658	8,908
ABC (t)	11,132	11,473	9,658	8,908
Status	As determined last year for:		As determined this year for:	
	2016	2017	2017	2018
Overfishing	No	n/a	No	n/a
Overfished	n/a	No	n/a	No
Approaching overfished	n/a	No	n/a	No

Apportionment

Area	2019 ABC	2020 ABC
Aleutian Islands	1,227	1,131
Eastern Bering Sea	8,431	7,777
Total	9,658	8,908

- Determined from the proportion of adult biomass observed in the EBS slope survey estimates and the Aleutian Islands for the past four years (when they overlapped)
 - 12.7% (unchanged from 2016 estimate)

Phase plot



Future directions

- An evaluation of non-binary environmental indices and methods for linking environmental covariates to recruitment
- Spatial considerations
 - Stock extends into Russian waters, but not considered in assessment
 - Given the ontogeny of the species, spatial models accounting for this should be explored
- Model's ability to estimate selectivity parameters
 - Investigate simplified time blocks

Divider Title

Additional Divider Information



Data Source	Years
Fishery catch (Trawl & Longline)	1960 - 2018
Fishery length composition: Trawl Longline	1978 - 2018 1979 - 2018
Survey biomass	
EBS shelf	1987 - 2018
EBS slope	2002, 2004, 2008, 2010, 2012, 2016
ABL Longline	1996 - 2018
Survey length composition	
EBS shelf	1987 - 2018
EBS slope	1979, 1981 1982, 1985, 1988, 1991, 2002, 2004, 2008, 2010, 2012, 2016
ABL Longline (not included in likelihood)	1979 – 2018, except 1987-1992
Survey age composition	
EBS shelf (not included in likelihood)	1998, 2003 - 2017
EBS shelf mean weight-at-age	1982, 1998, 2003 - 2017