YELLOWFIN SOLE

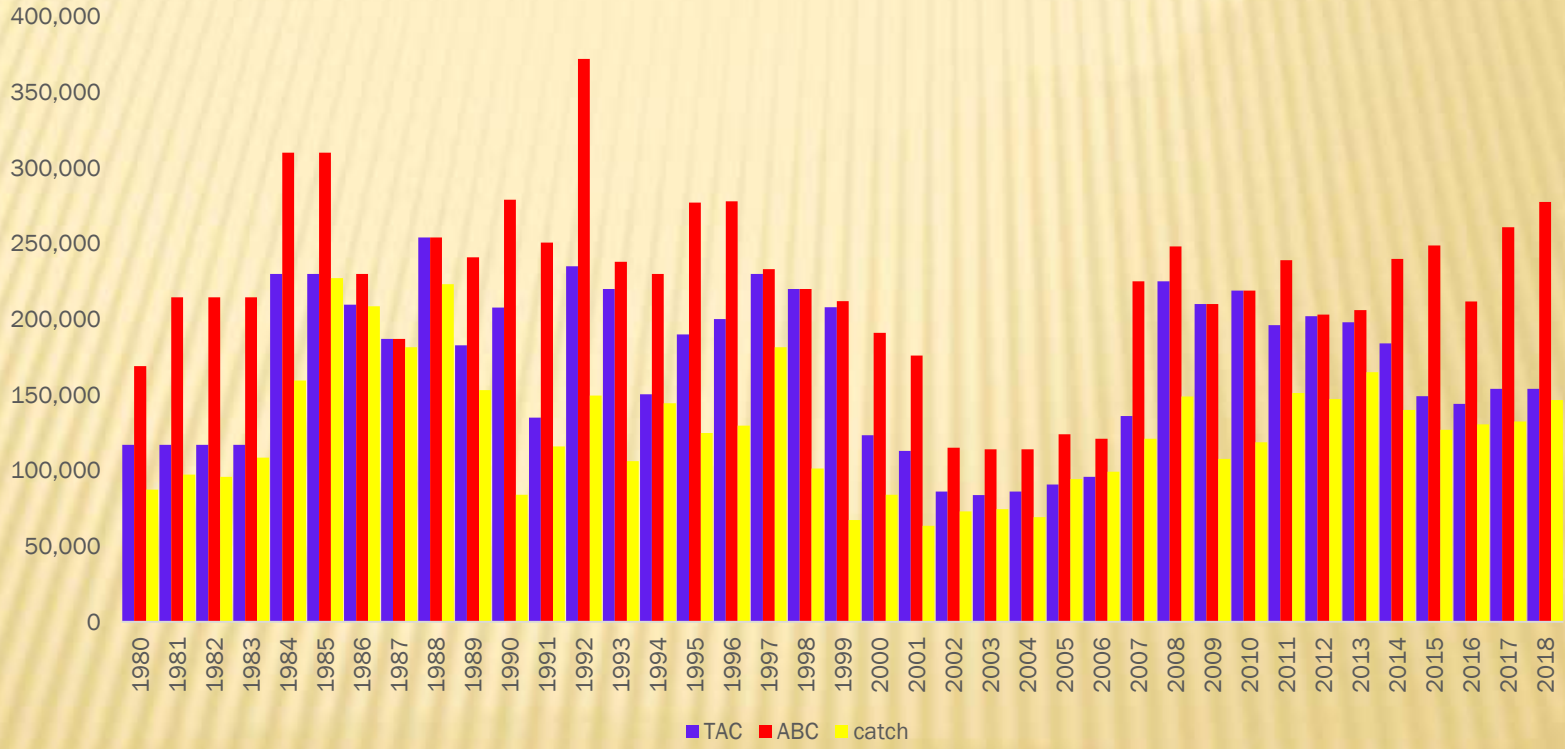
BY

WILDERBUER, NICHOL AND IANELLI

CHANGES TO THE INPUT DATA

- 2017 fishery age composition.
- 2017 survey age composition.
- 2018 trawl survey biomass point estimate and standard error.
- Estimate of catch (t) made through the end of 2018.
- Estimate of retained and discarded portions of the 2017 catch.
- Updated weight at age for survey

BSAI yellowfin sole ABC, TAC and catch (t)



BSAI YELLOWFIN SOLE

Current base model (Model 14_1)

Survey ⇩ 32%

ABC ⇩ 8%

FSB ⇩ 8%

Fabc ⇩ 8%

Quantity	As estimated or specified last year for:		As estimated or recommended this year for:	
	2018	2019	2019	2020
M (natural mortality rate)	0.12	0.12	0.12	0.12
Tier	1a	1a	1a	1a
Projected total (age 6+) biomass (t)	2,553,100	2,460,700	2,388,000	2,331,500
Female spawning biomass (t)				
Projected	895,600	890,000	827,900	796,600
B_0	1,204,000		1,236,000	
B_{MSY}	456,000		451,600	
F_{OFL}	0.12	0.12	0.118	0.118
maxF_{ABC}	0.109	0.109	0.107	0.107
F_{ABC}	0.109	0.109	0.107	0.107
OFL (t)	306,700	295,600	281,800	275,100
maxABC (t)	277,500	267,500	255,100	249,100
ABC (t)	277,500	267,500	255,100	249,100
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

BSAI YELLOWFIN SOLE

Proposed new base model (Model 18_1)

Survey ⇩ 32%

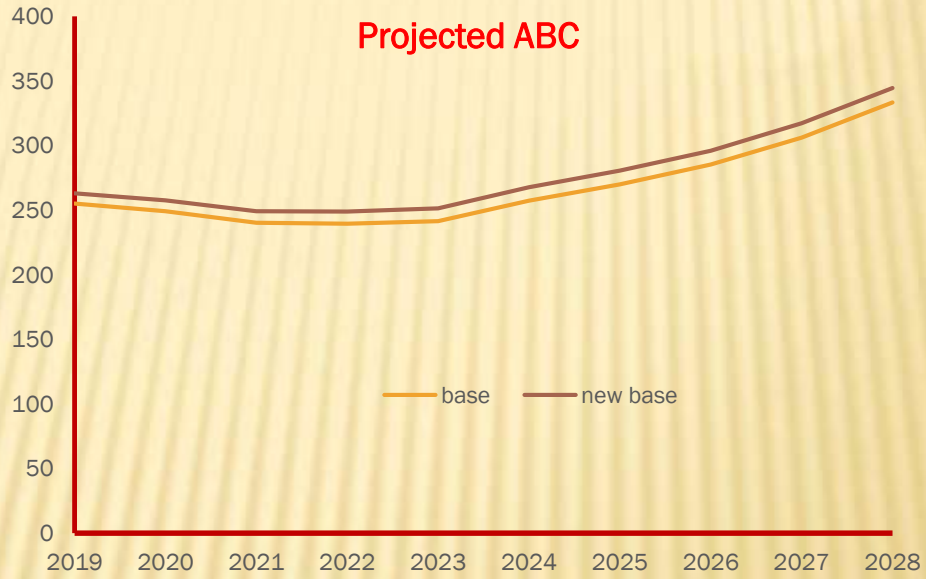
ABC ⇩ 5%

FSB ⇩ 5%

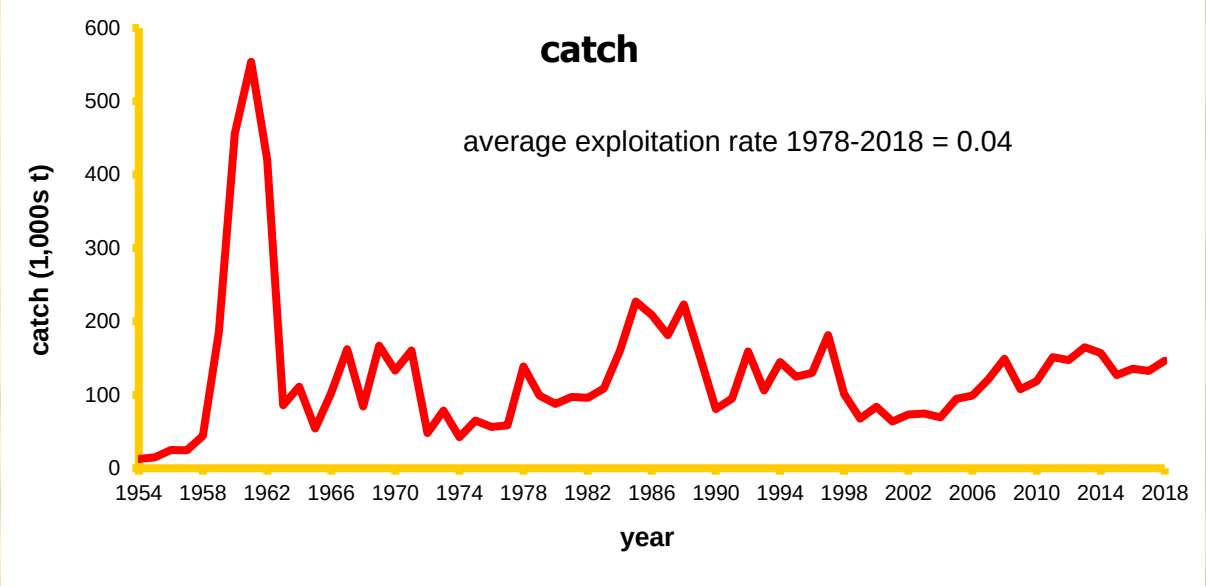
Fabc ⇩ 2%

Quantity	As estimated or specified last year for:		As estimated or recommended this year for:	
	2018	2019	2019	2020
M (natural mortality rate)	0.12	0.12	0.12	0.12
Tier	1a	1a	1a	1a
Projected total (age 6+) biomass (t)	2,553,100	2,460,700	2,462,400	2,411,700
Female spawning biomass (t)	587,300			
Projected	895,600	890,000	850,600	821,500
B_0	1,204,000		1,245,400	
B_{MSY}	456,000		460,800	
F_{OFL}	0.12	0.12	0.118	0.118
maxF_{ABC}	0.109	0.109	0.107	0.107
F_{ABC}	0.109	0.109	0.107	0.107
OFL (t)	306,700	295,600	290,000	284,000
maxABC (t)	277,500	267,500	263,200	257,800
ABC (t)	277,500	267,500	263,200	257,800
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

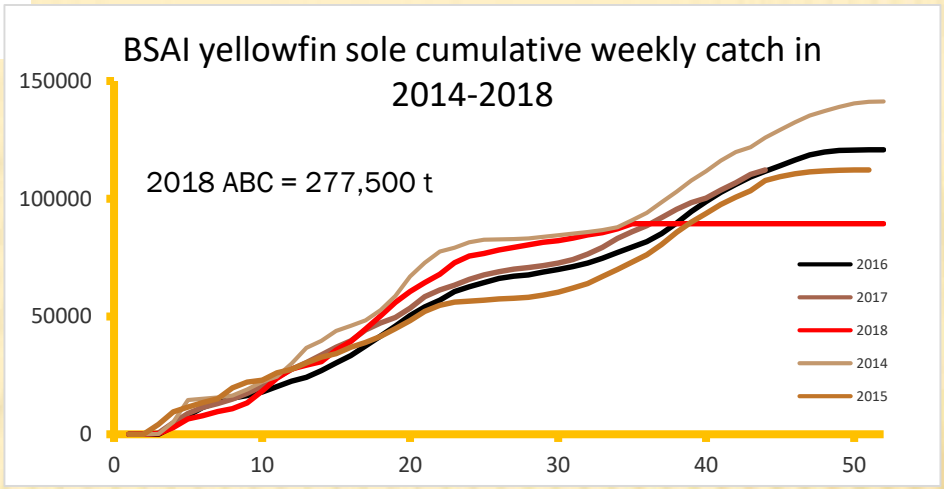
SIMILAR ABC ESTIMATES

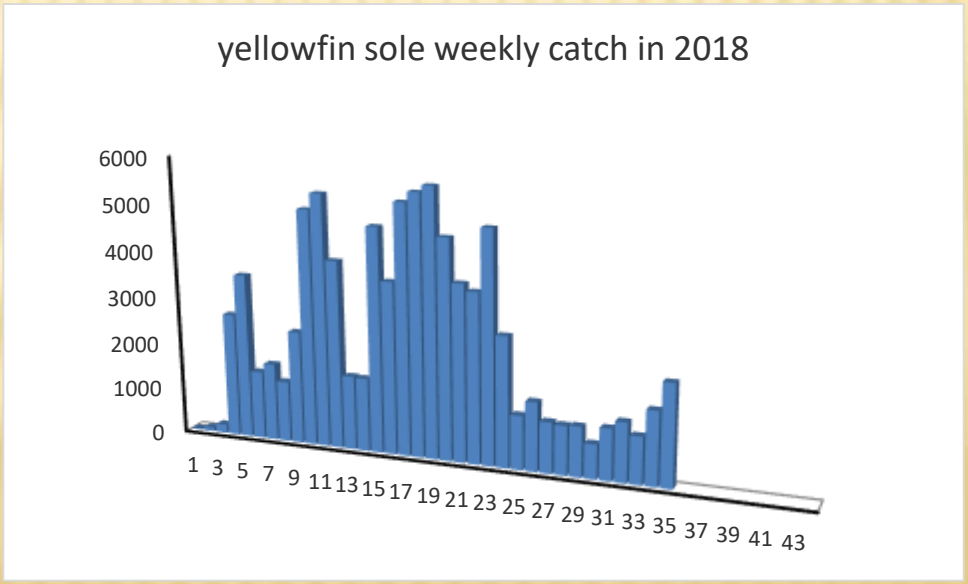


2018 CATCH ESTIMATE = 146,500 T
AVERAGE 1978-2018 EXPLOITATION RATE = 0.04



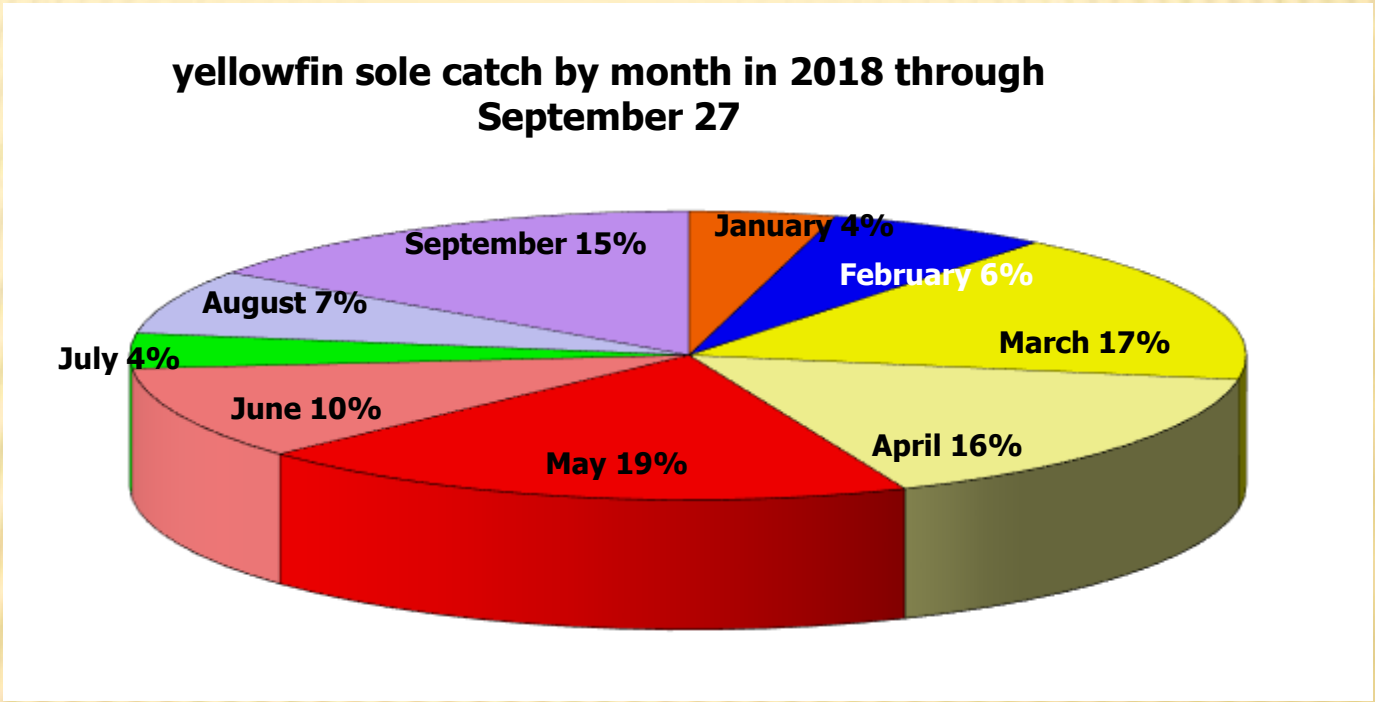
Cumulative and weekly catch



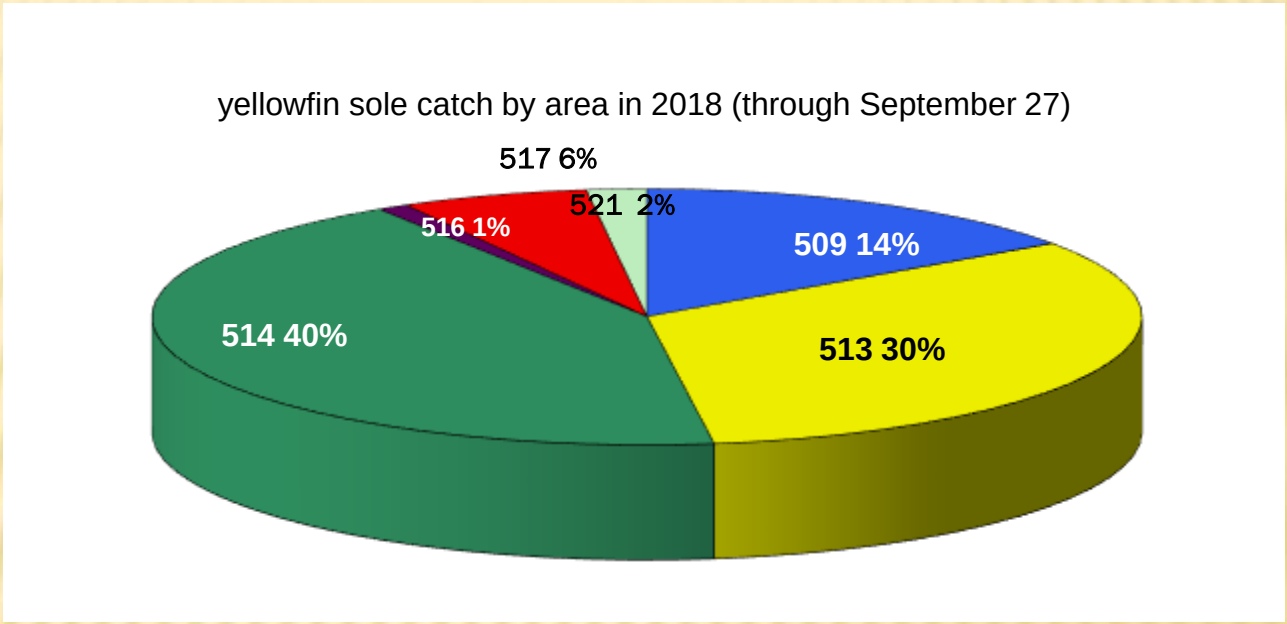


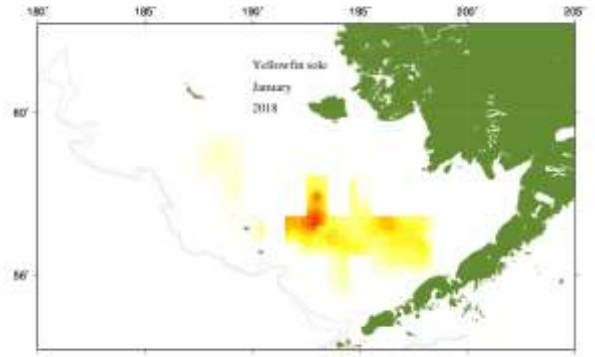
- Catch

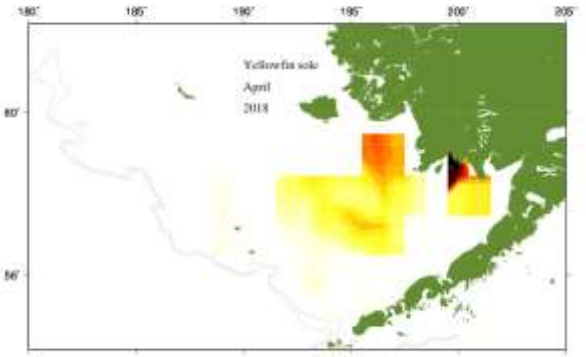
CATCH BY MONTH

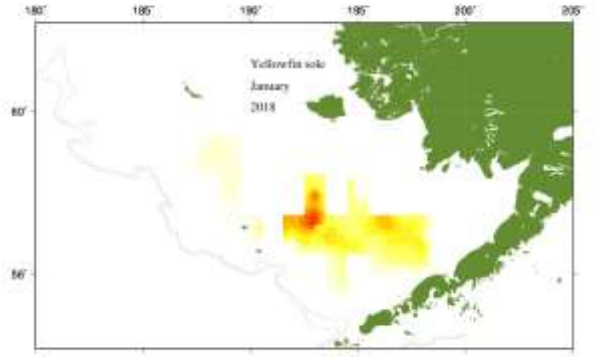


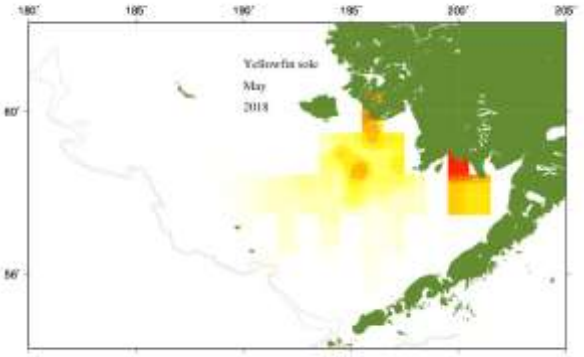
CATCH BY AREA

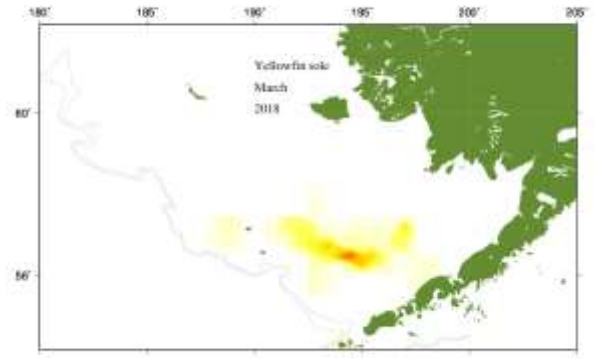


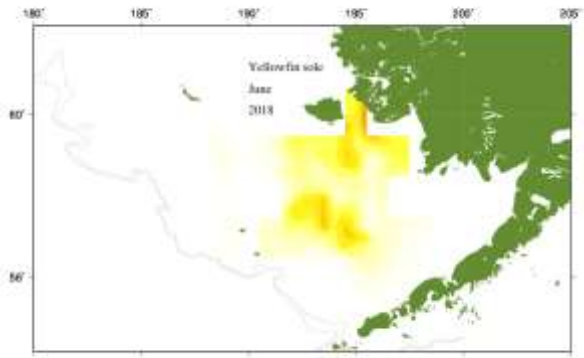

Yellowfin sole
January
2018

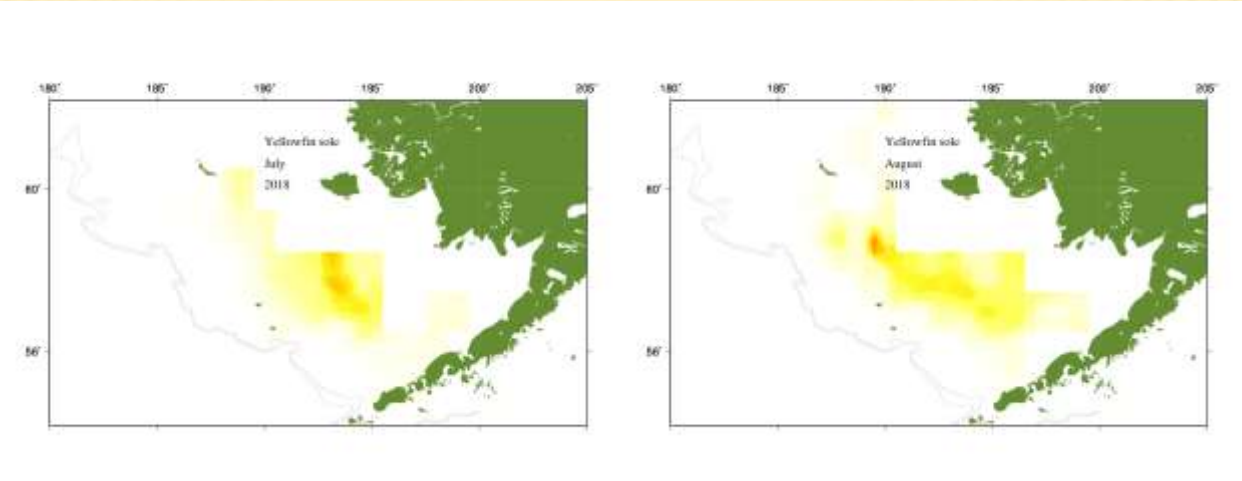

Yellowfin sole
April
2018

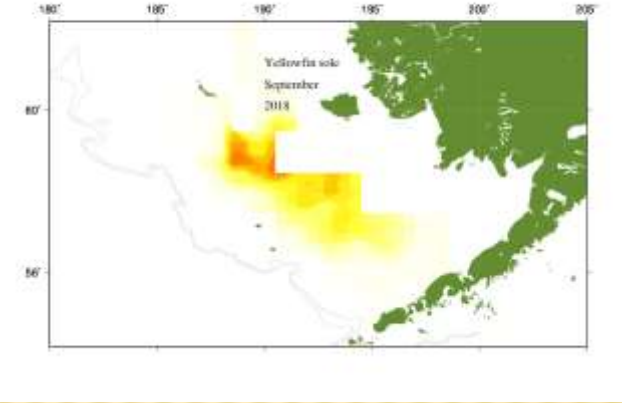

Yellowfin sole
January
2018


Yellowfin sole
May
2018

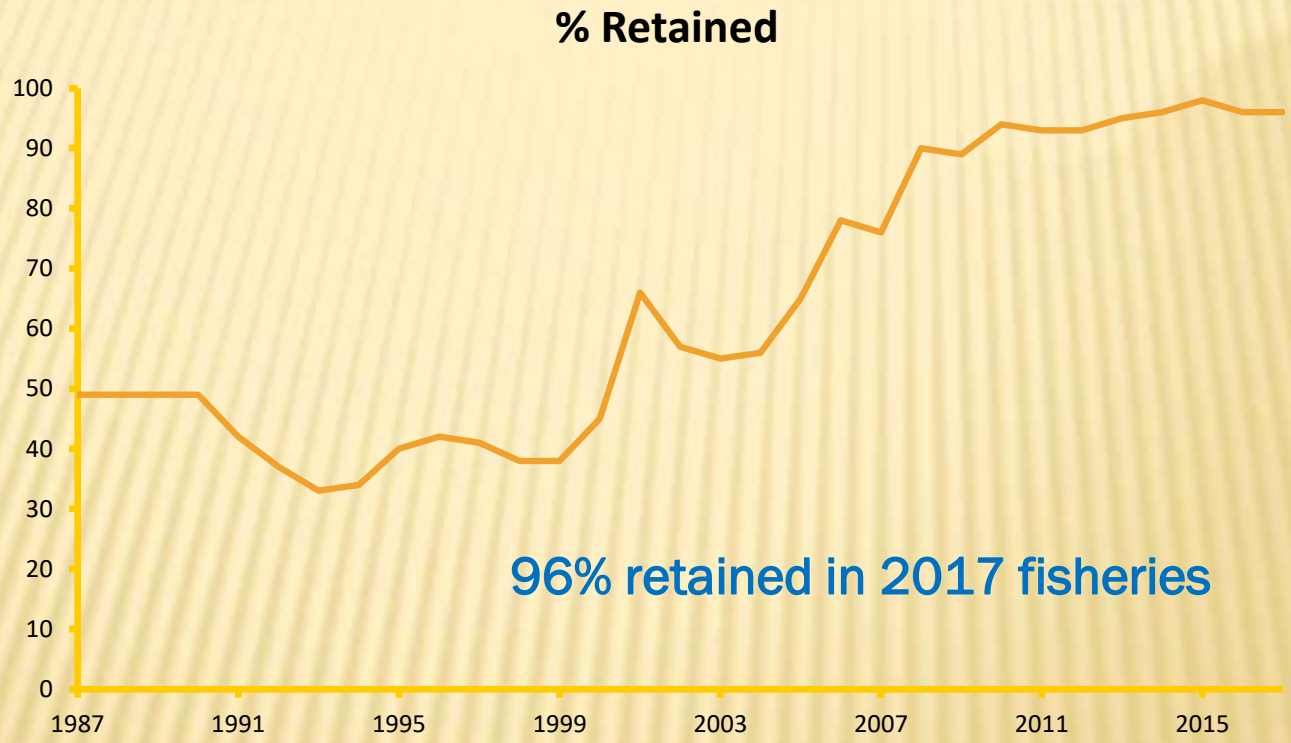

Yellowfin sole
March
2018


Yellowfin sole
June
2018


180°
185°
190°
195°
200°
205°
60°
56°
Yellowfin sole
July
2018
Yellowfin sole
August
2018

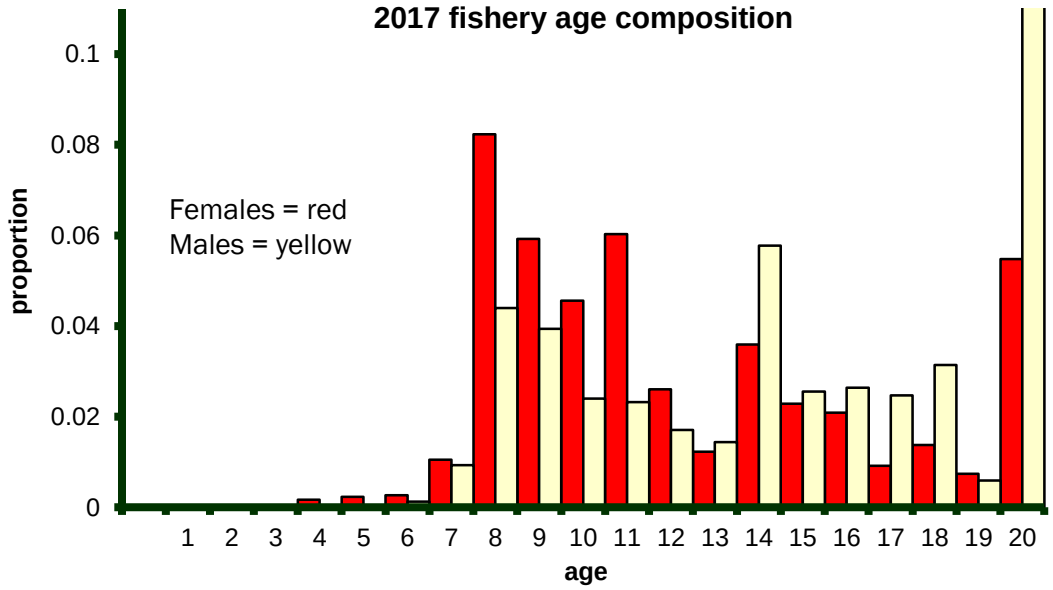

180°
185°
190°
195°
200°
205°
60°
56°
Yellowfin sole
September
2018

ANNUAL ESTIMATE OF RETAINED CATCH (%)

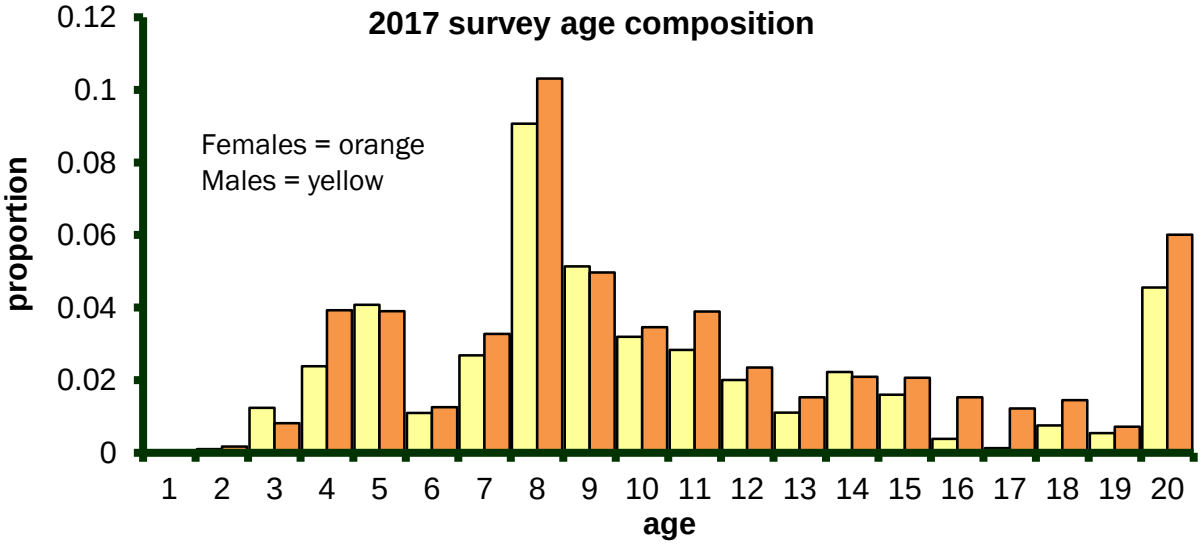


NEW DATA FOR 2018

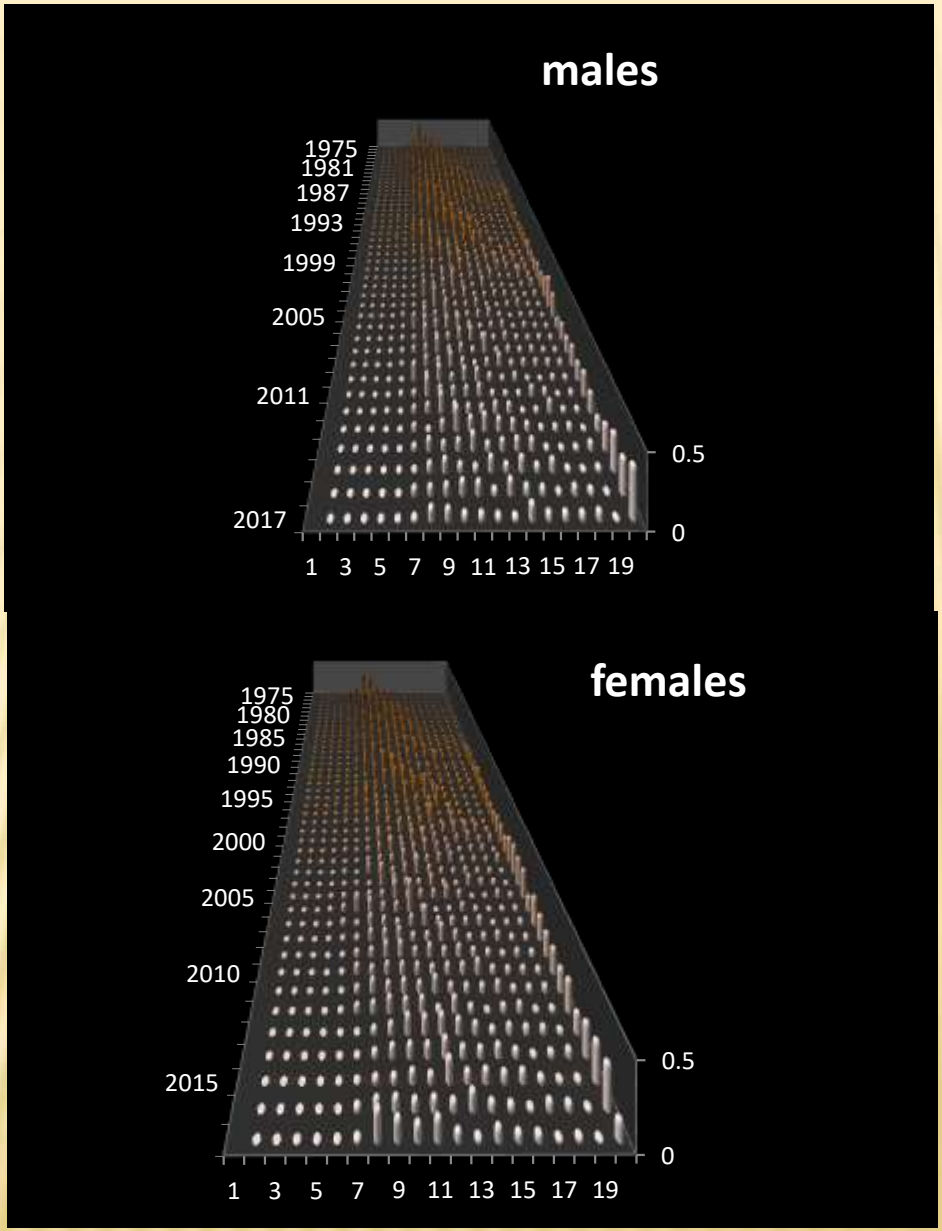
Avg. age = 13.2 years



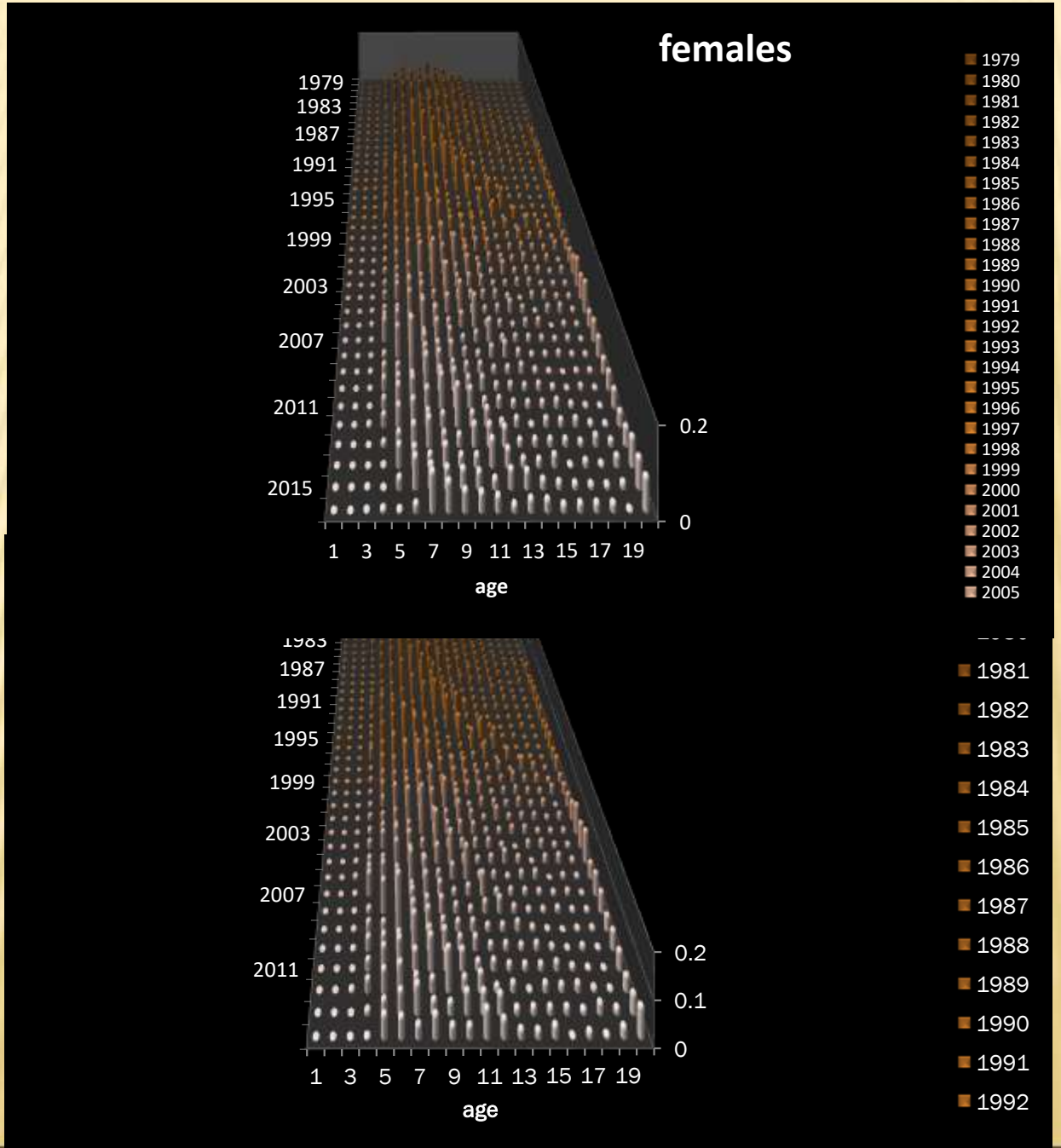
Model estimate of population Avg. age = 4.9 years



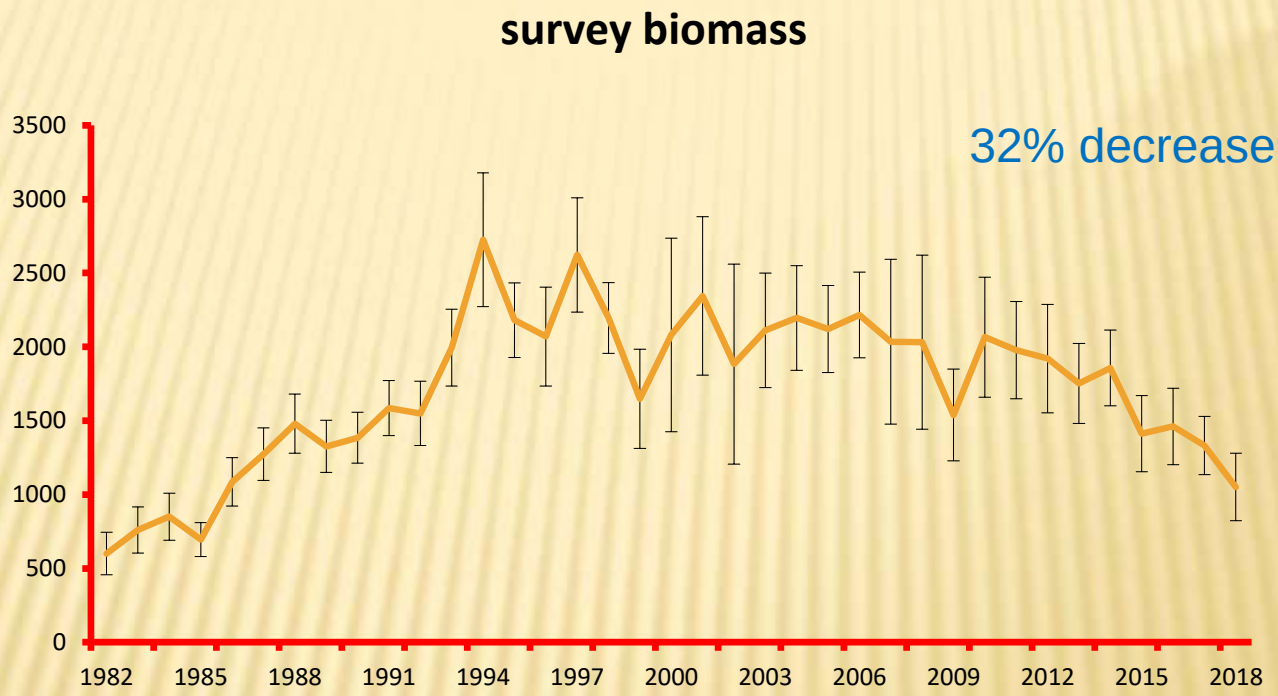
Fishery age composition



Survey age composition

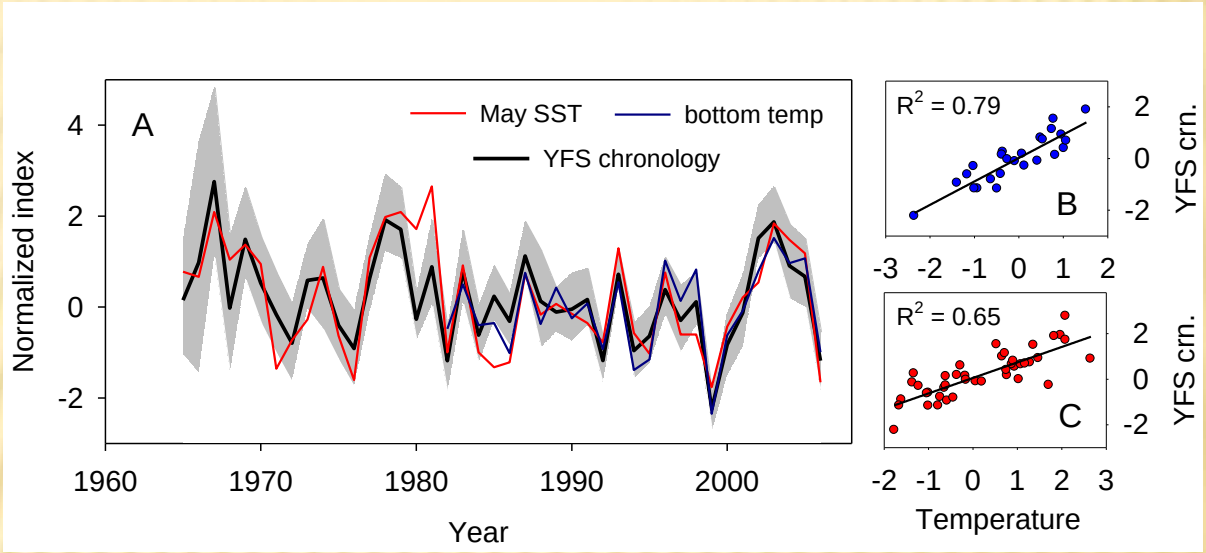


2018 SHELF SURVEY BIOMASS ESTIMATE = 1,051,500 T



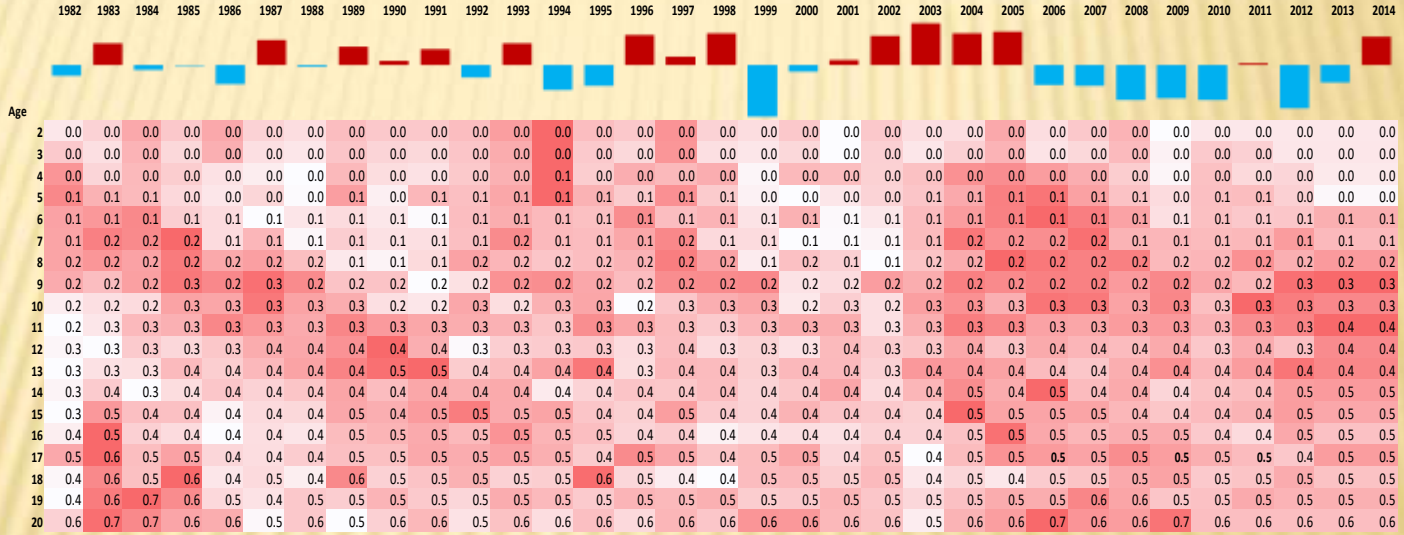
32% decrease from 2017

YEAR EFFECT ON GROWTH

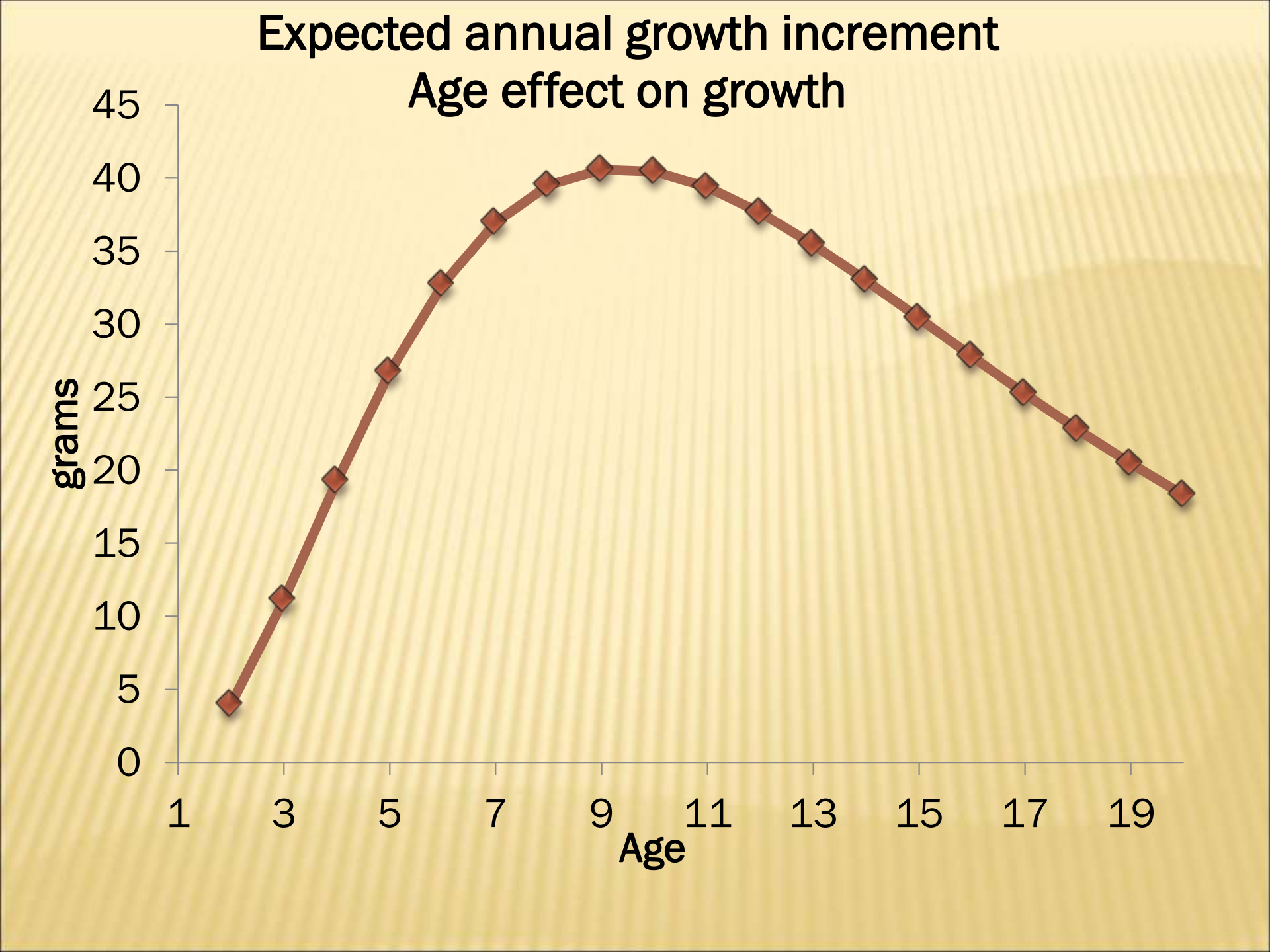


Annual growth corresponds to annual temperature

Assessment uses empirical data from annual survey length at age estimates



Age	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.1	0.1	0.0	0.0	0.0
6	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
7	0.1	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1
8	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.2	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
9	0.2	0.2	0.2	0.3	0.2	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3
10	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.3	0.2	0.3	0.3	0.2	0.3	0.3	0.3	0.2	0.3	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
11	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4
12	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3	0.3	0.3	0.4	0.3	0.3	0.3	0.4	0.3	0.3	0.4	0.3	0.4	0.4	0.4	0.4	0.3	0.4	0.3	0.4	0.4
13	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.4	0.4	0.4	0.4	0.3	0.4	0.4	0.3	0.4	0.4	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
14	0.3	0.4	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.4	0.5	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5
15	0.3	0.5	0.4	0.4	0.4	0.4	0.4	0.5	0.4	0.5	0.5	0.5	0.5	0.4	0.4	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.5	0.5	0.5
16	0.4	0.5	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.4	0.4	0.5	0.5	0.5
17	0.5	0.6	0.5	0.5	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.4	0.5	0.5	0.4	0.5	0.5	0.4	0.5	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.4	0.5	0.5	0.5
18	0.4	0.6	0.5	0.6	0.4	0.5	0.4	0.6	0.5	0.5	0.5	0.5	0.5	0.6	0.5	0.4	0.4	0.5	0.5	0.5	0.5	0.4	0.5	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
19	0.4	0.6	0.7	0.6	0.5	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.5
20	0.6	0.7	0.7	0.6	0.6	0.5	0.6	0.5	0.6	0.6	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.6	0.6	0.7	0.6	0.6	0.7	0.6	0.6	0.6	0.6	0.6


Expected annual growth increment
Age effect on growth
grams
45
40
35
30
25
20
15
10
5
0
1
3
5
7
9
11
13
15
17
19
Age

FLATFISH SPLIT-SEX MODEL

Input:

sex-specific estimates of fishery and survey age composition and weight at age, survey biomass, maturity

Output:

Sex-specific estimates of population number, fishing mortality, selectivity, fishery and survey age composition.

Allows for estimation of sex-specific natural mortality

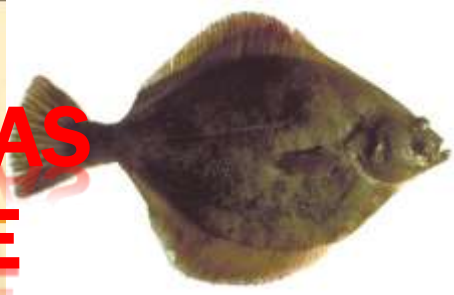
STOCK ASSESSMENT MODEL

- Data components include fishery and trawl survey age compositions and survey biomass and standard error
- Selectivity is fixed asymptotic for older fish
- Runs made with natural mortality fixed at 0.12 and estimated
- Ricker spawner-recruit curve estimated inside the model
- Fishery selectivity is estimated for each year and gender
- Catchability (q) is estimated for each year in the model by considering the relationship to annual bottom water temperature

For the base model

$$q = e^{\alpha + \beta T}$$

SURVEY START DATE ADDED AS ENVIRONMENTAL VARIABLE

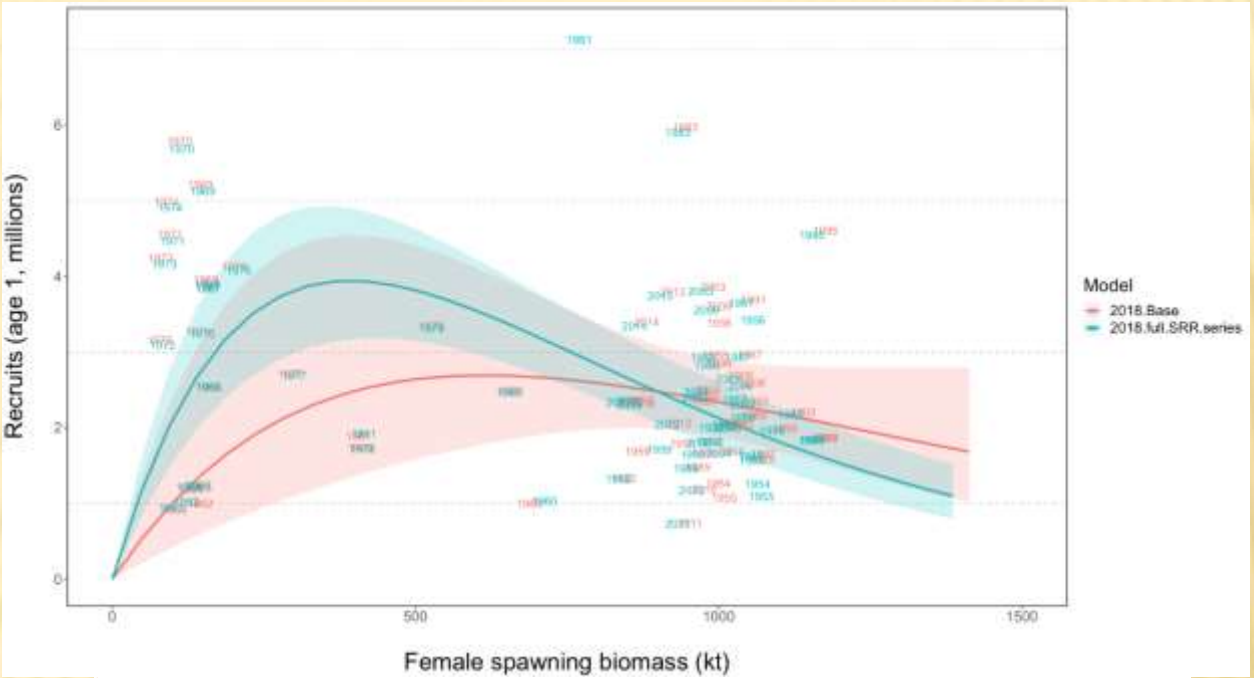


Proposed new Base Model

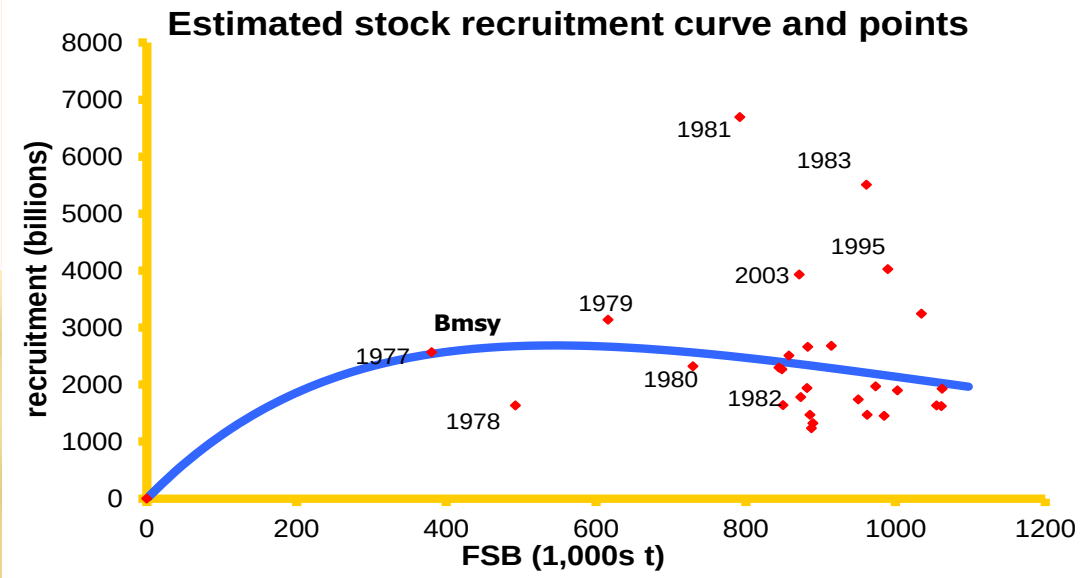
$$q = e^{-\alpha + \beta T + \gamma S + \mu T:S}$$

where T=survey bottom temperature (averaged per year for all stations <100 m), S=survey start date, and $T:S$=interaction of T and S.

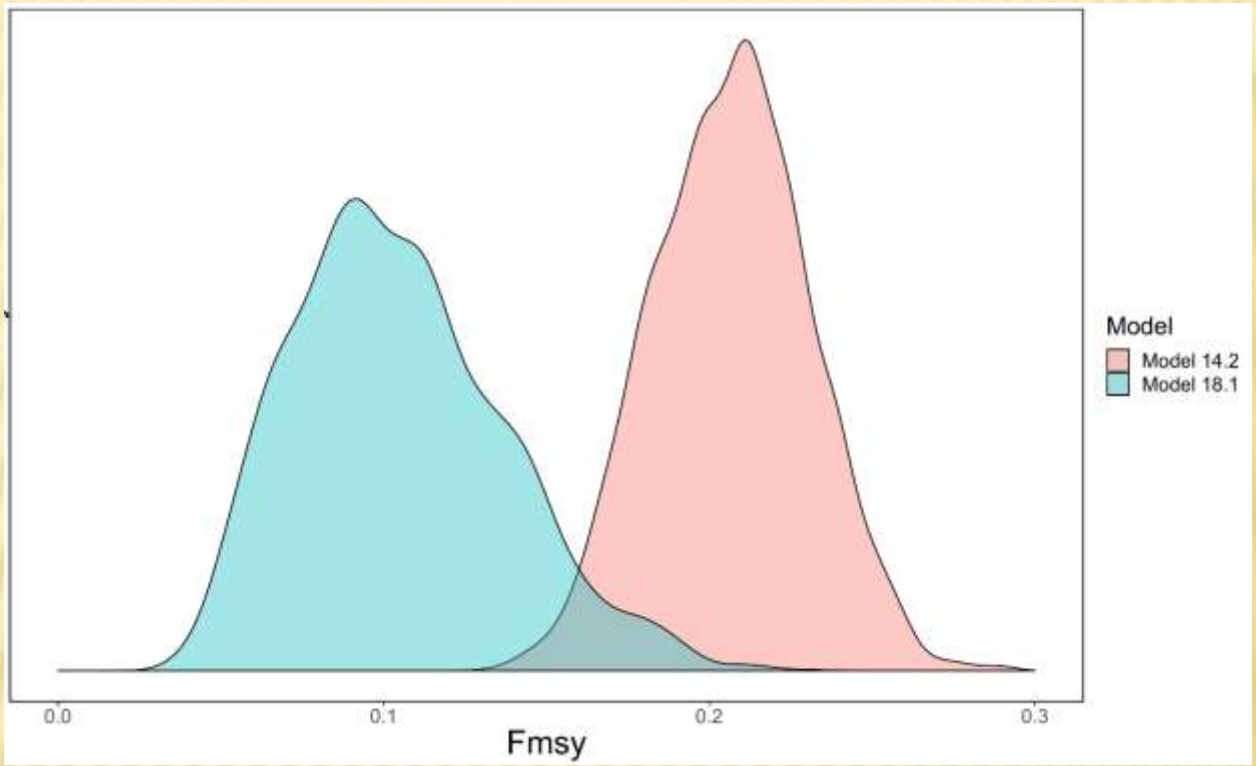
B_{msy} = 314,800 t



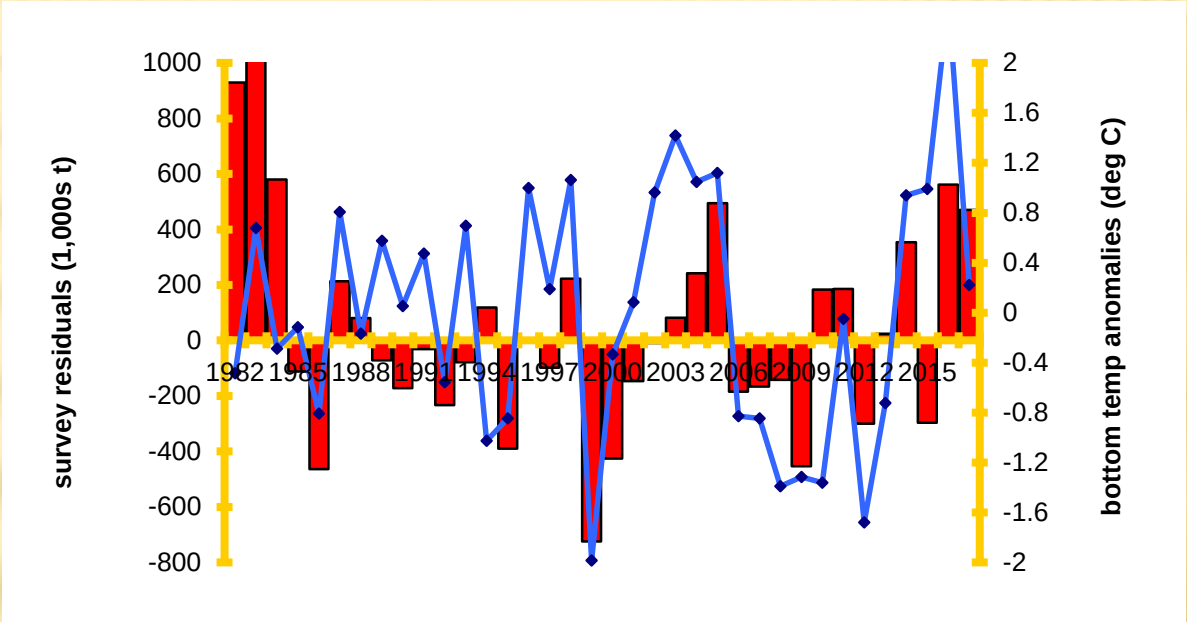
B_{msy} = 451,600 t



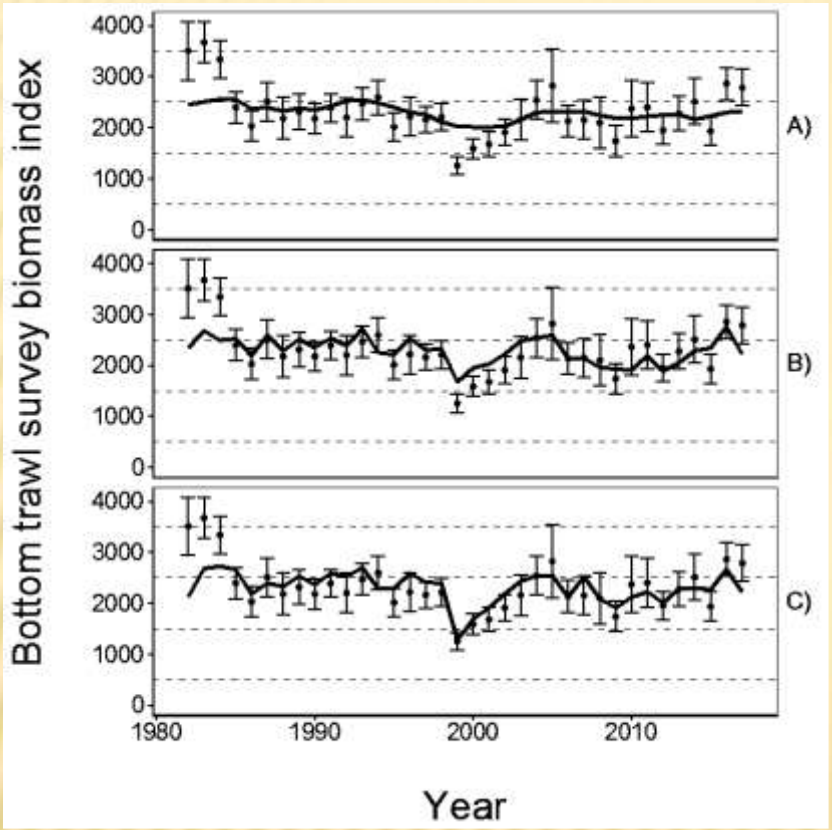
Distribution of pdf F_{msy} from mcmc runs



TRAWL SURVEY RESIDUALS (RED BARS) AND BOTTOM TEMPERATURE ANOMALIES (BLUE LINE)



CATCHABILITY MODELING



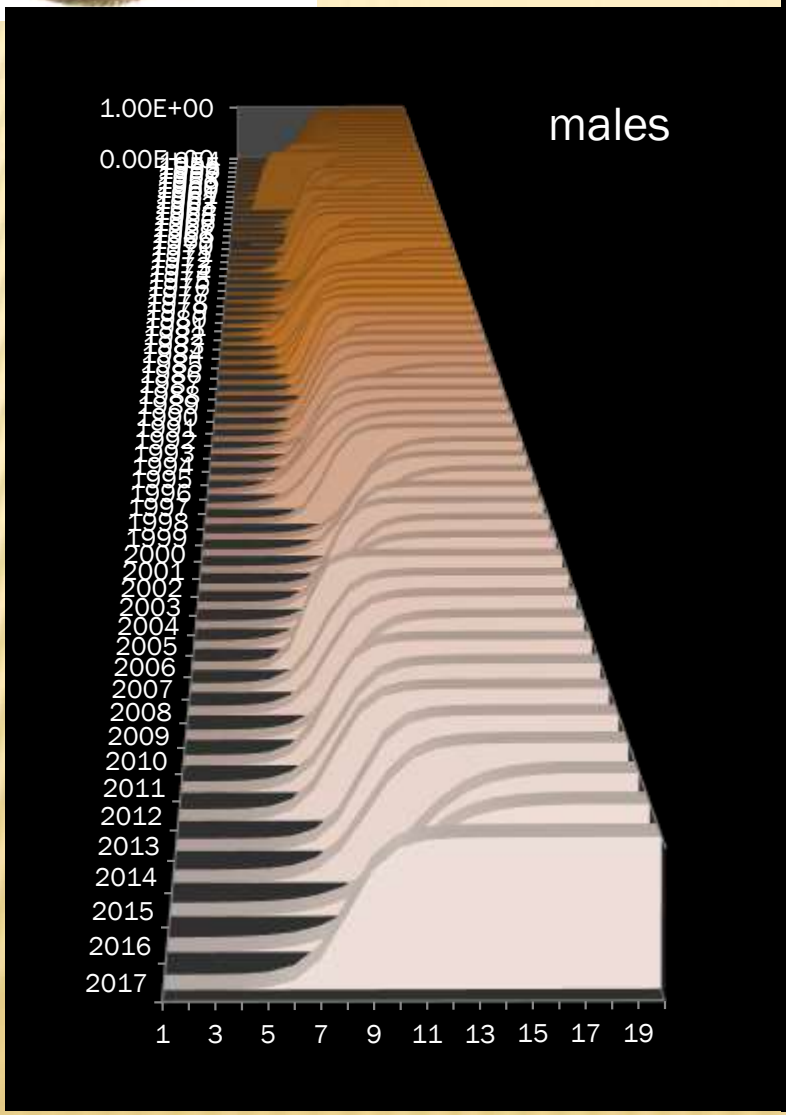
Constant q

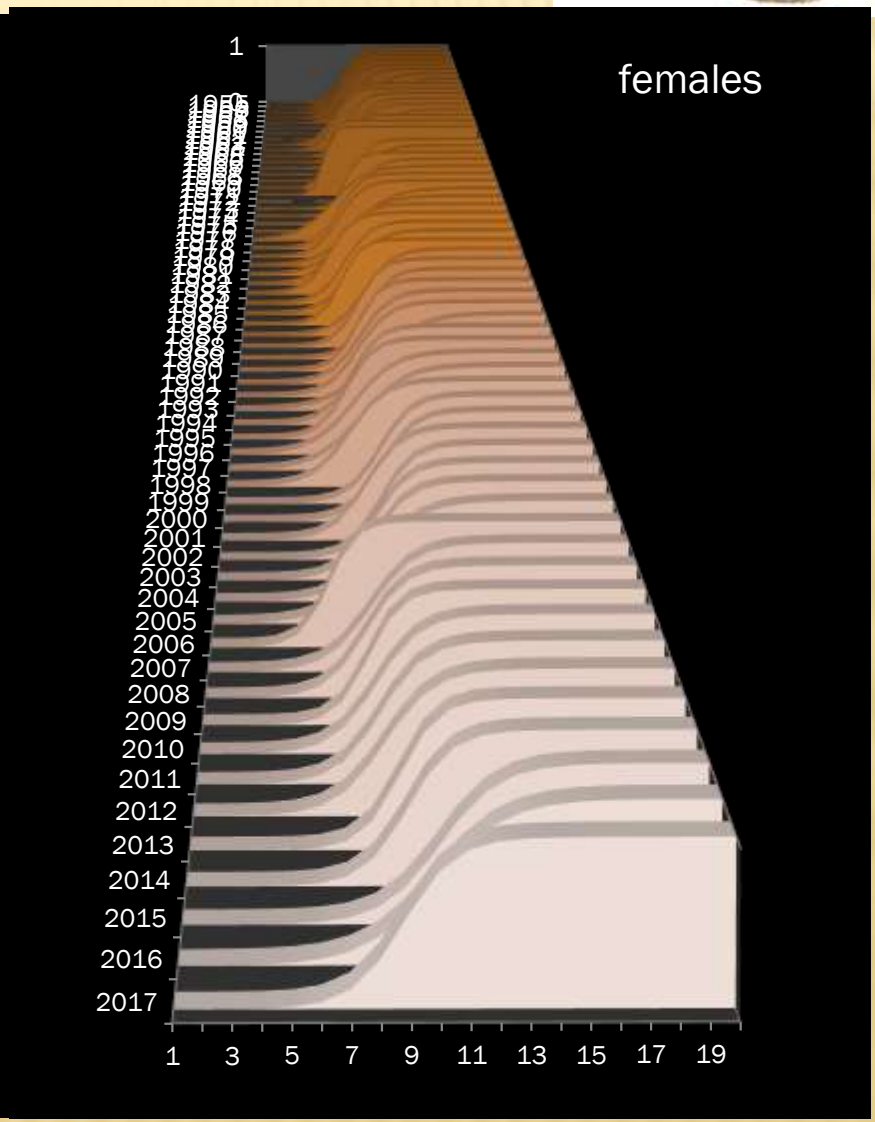
Temperature varying q

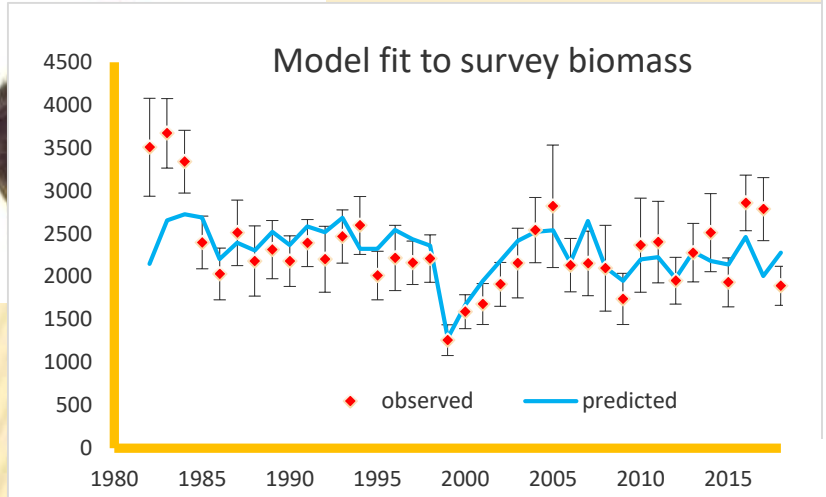
Temperature and survey start date

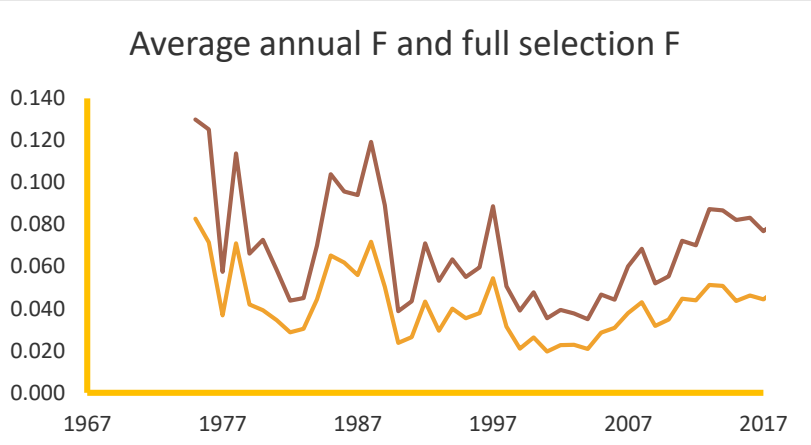
Nichol, Kotwicki, Wilderbuer and Lauth 2018, Fisheries Research

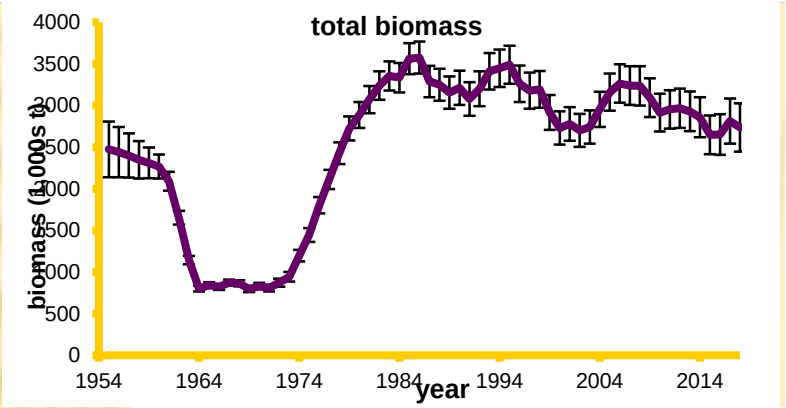
TIME-VARYING FISHERY SELECTIVITY

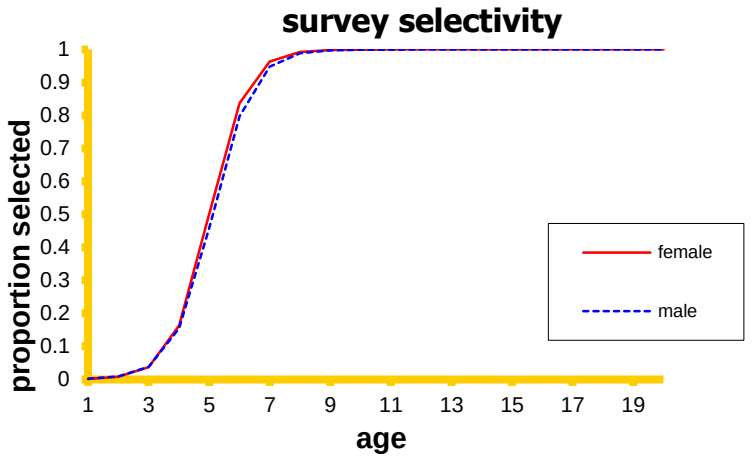


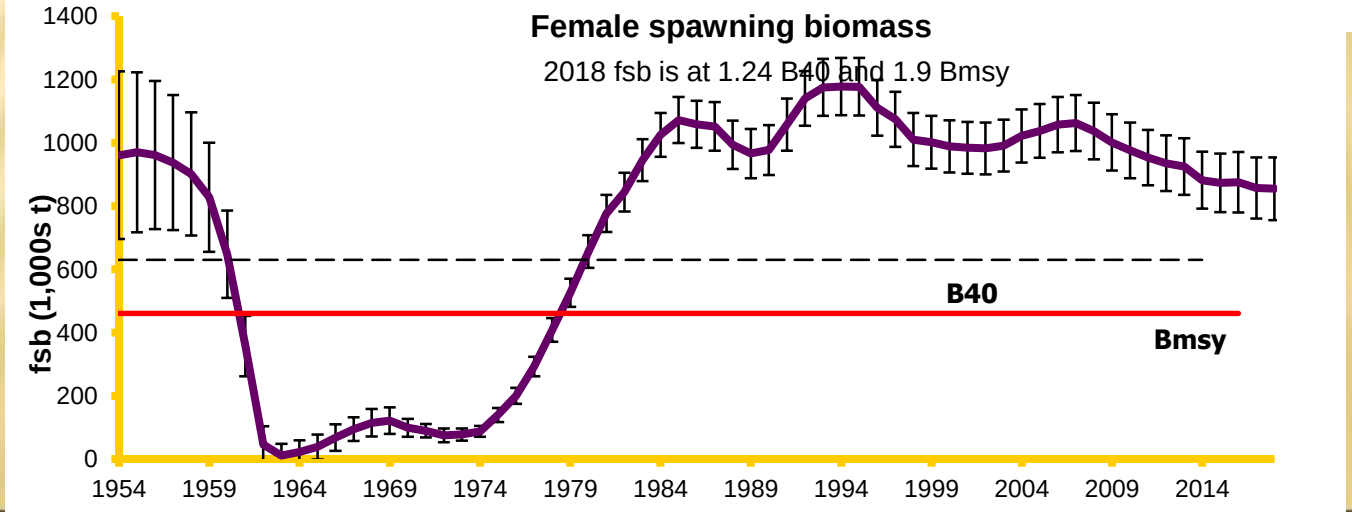



Model fit to survey biomass
4500
4000
3500
3000
2500
2000
1500
1000
500
0
observed
predicted
1980
1985
1990
1995
2000
2005
2010
2015

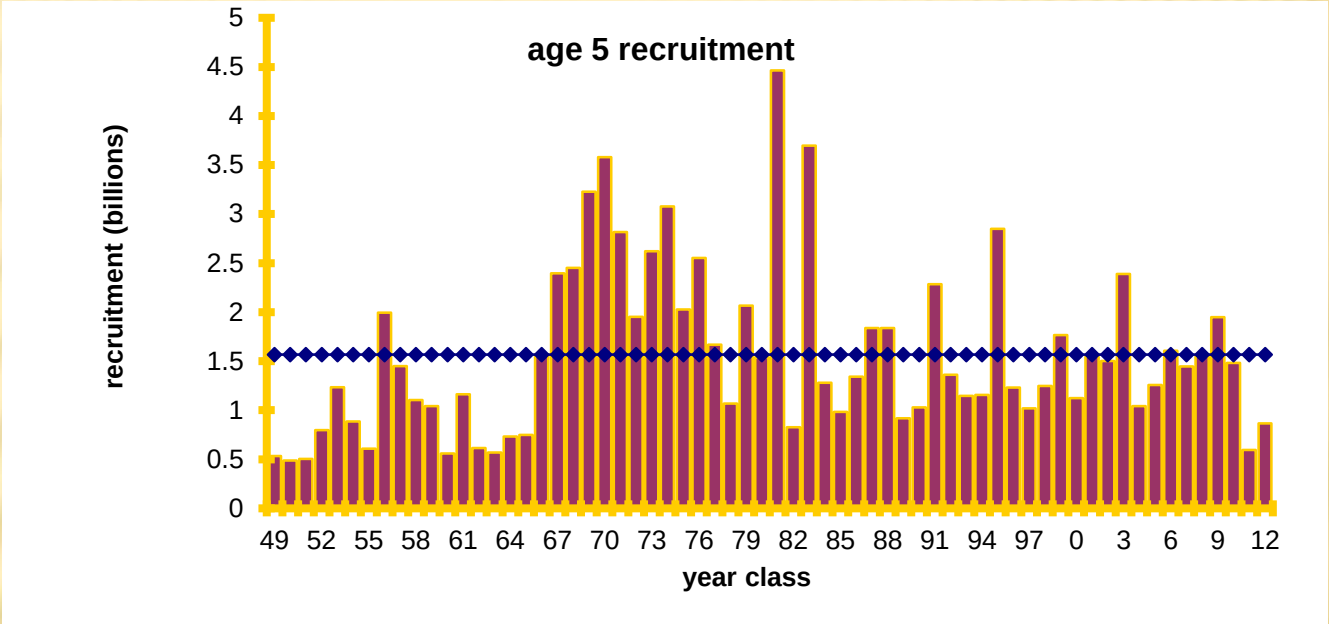

Average annual F and full selection F
0.140
0.120
0.100
0.080
0.060
0.040
0.020
0.000
1967
1977
1987
1997
2007
2017


total biomass
biomass (1,000s t)
4000
3500
3000
2500
2000
1500
1000
500
0
1954
1964
1974
1984
1994
2004
2014
year

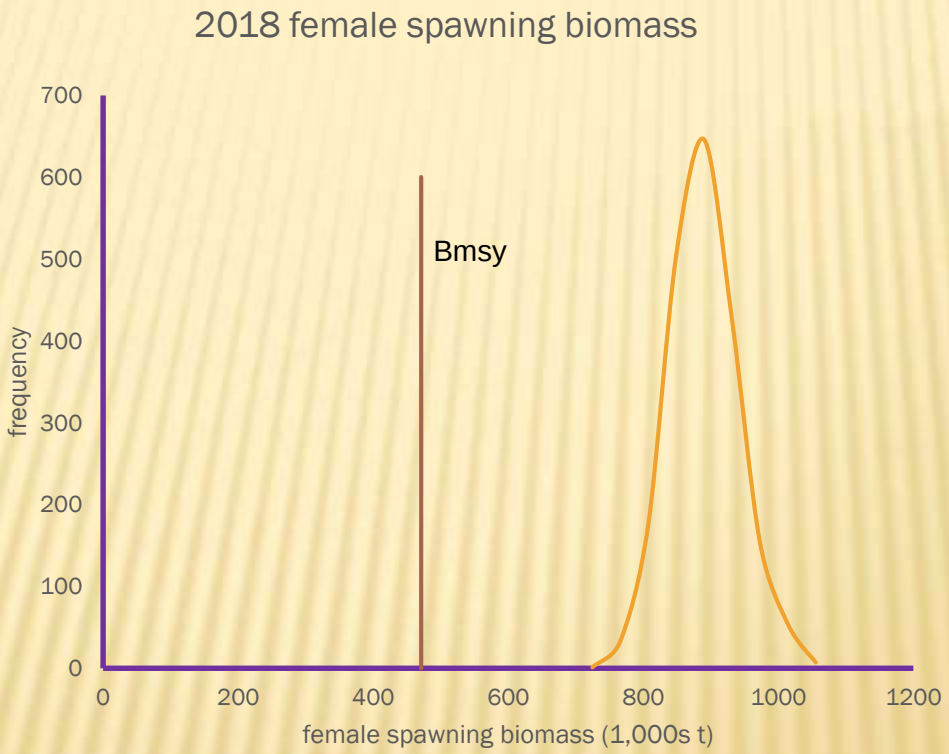

survey selectivity
proportion selected
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1
3
5
7
9
11
13
15
17
19
age
female
male


Female spawning biomass
2018 fsb is at 1.24 B40 and 1.9 Bmsy
fsb (1,000s t)
1400
1200
1000
800
600
400
200
0
B40
Bmsy
1954
1959
1964
1969
1974
1979
1984
1989
1994
1999
2004
2009
2014

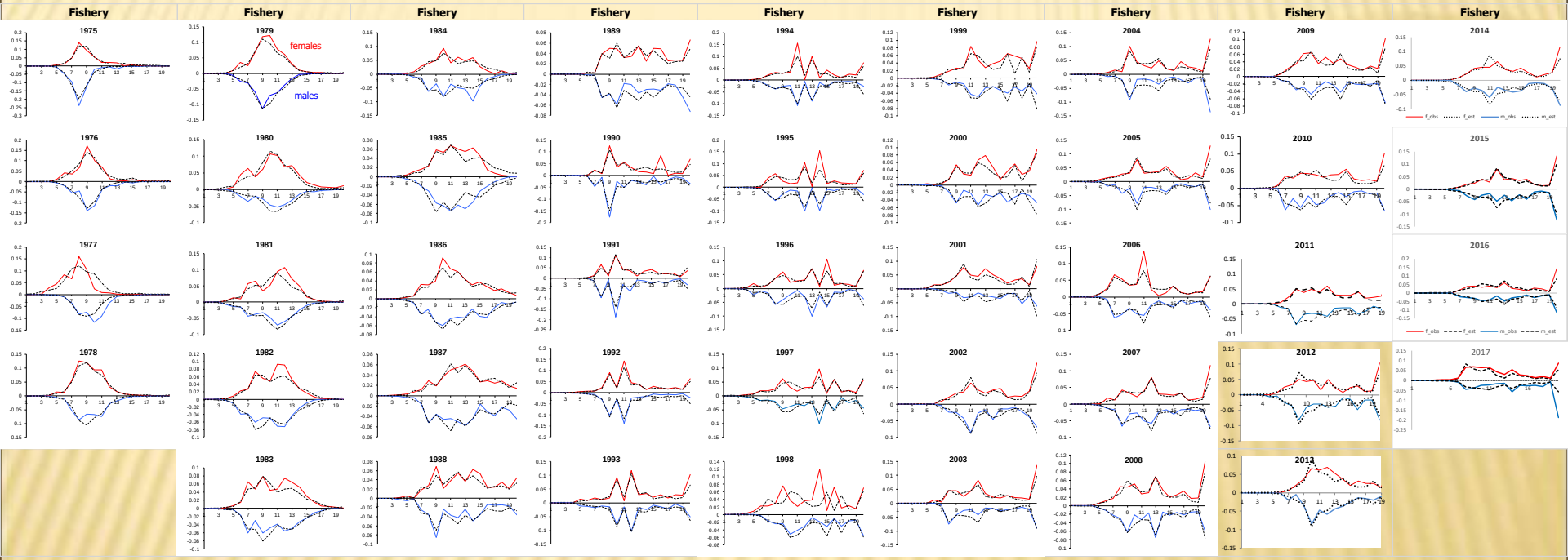
MODEL RESULTS



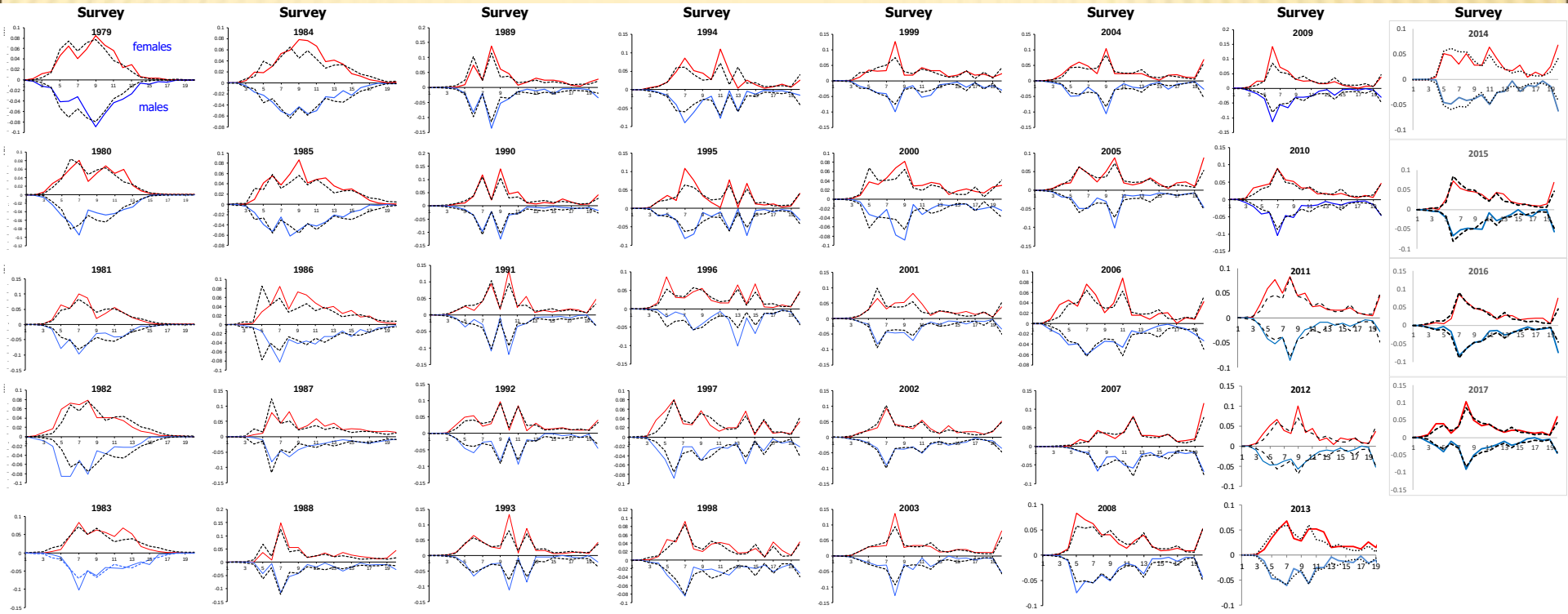
YELLOWFIN SOLE



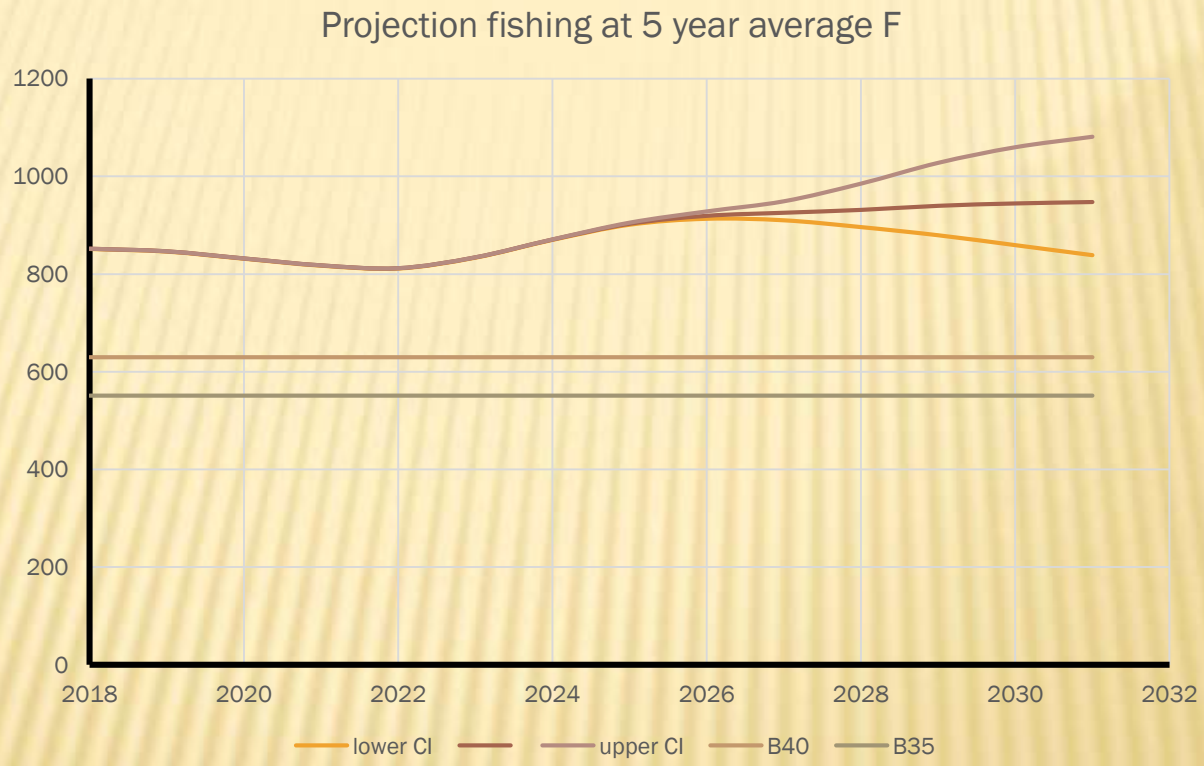
MODEL FIT TO FISHERY AGE COMPOSITION



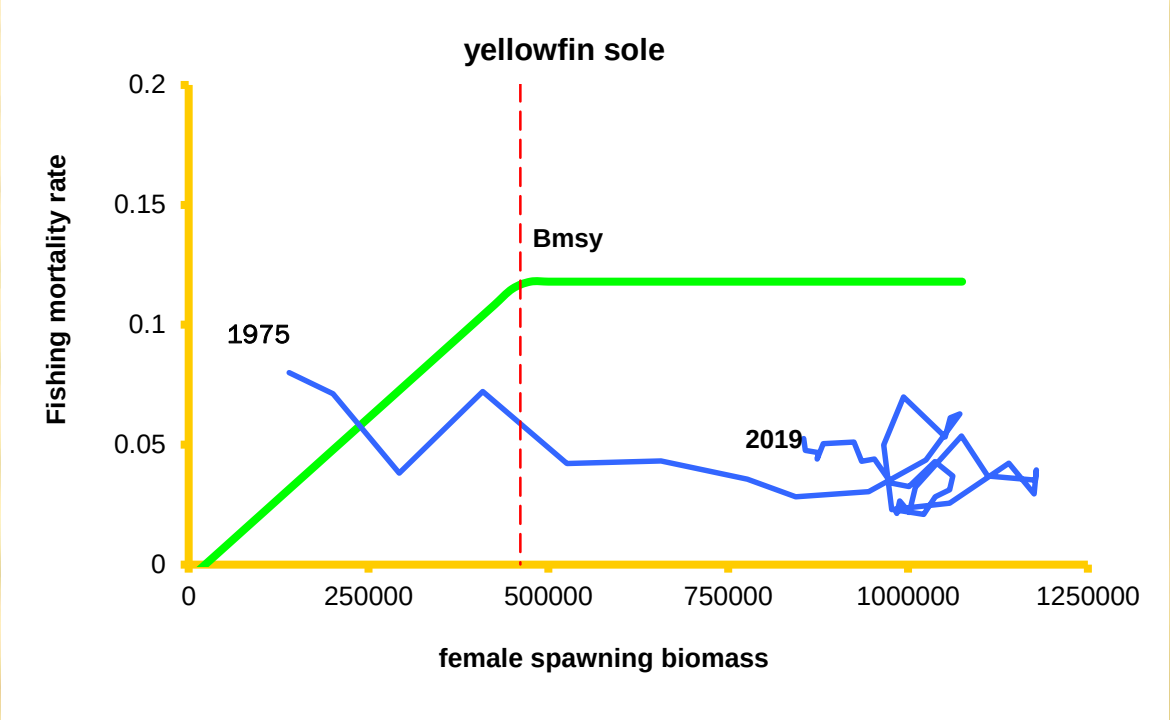
MODEL FIT TO SURVEY AGE COMPOSITION



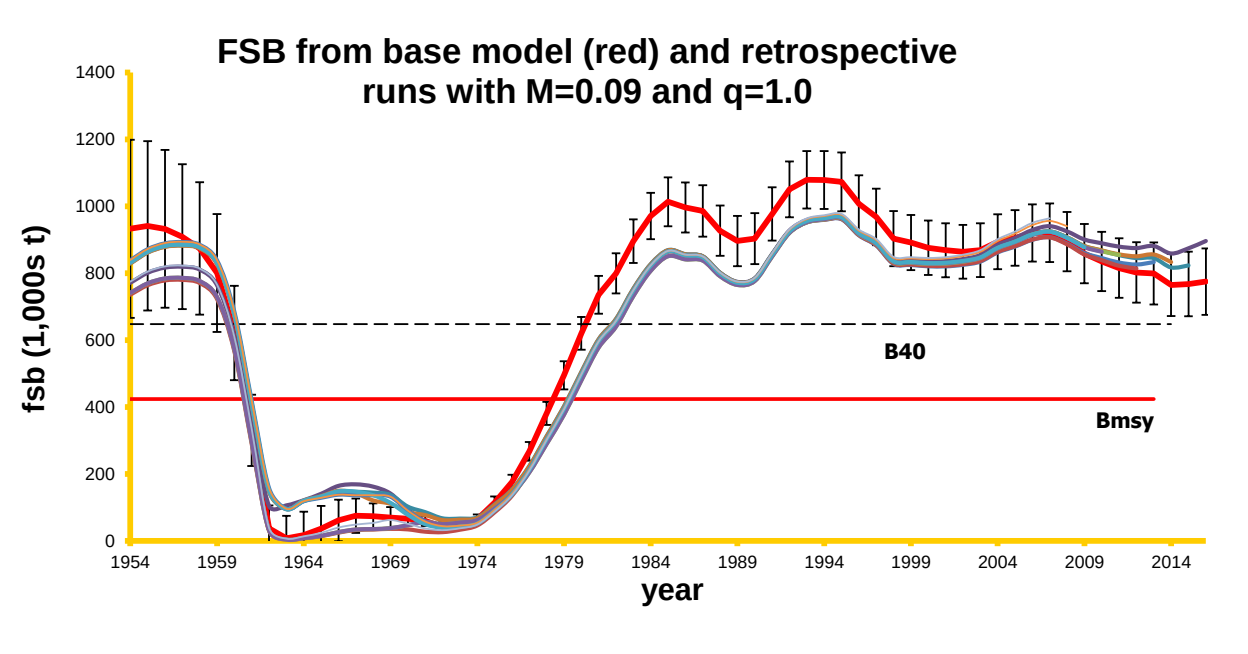
PROJECTED FEMALE SPAWNING BIOMASS



YELLOWFIN SOLE



RETROSPECTIVE ANALYSIS



17 year period from 1978-1995 retrospective trajectory was outside the confidence intervals of the stock assessment model run. Otherwise they are within the uncertainty of the model estimates of FSB.

RETROSPECTIVE ANALYSIS

Plan Team request to vary M and Q

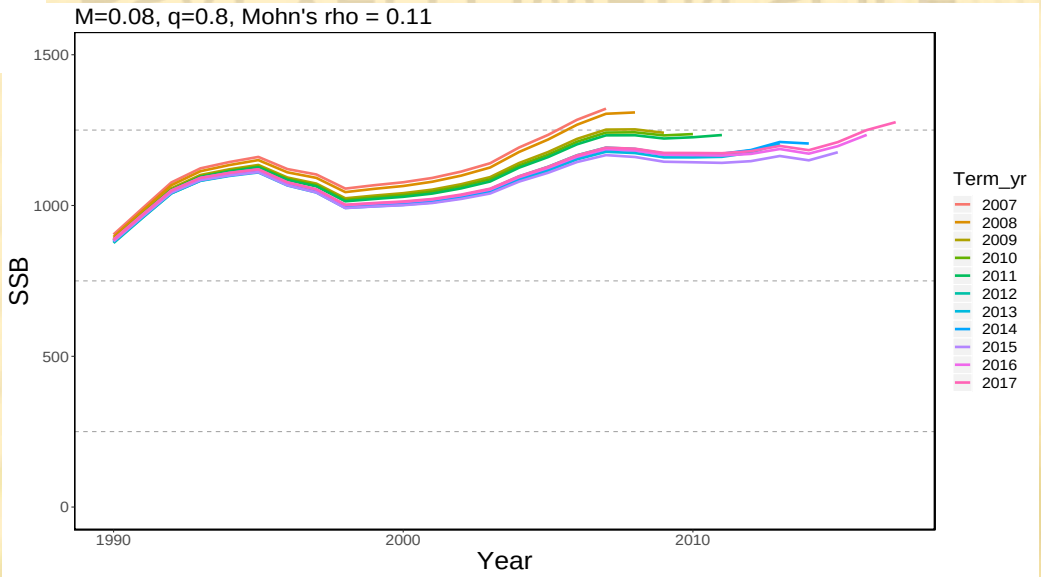
Mohn's rho

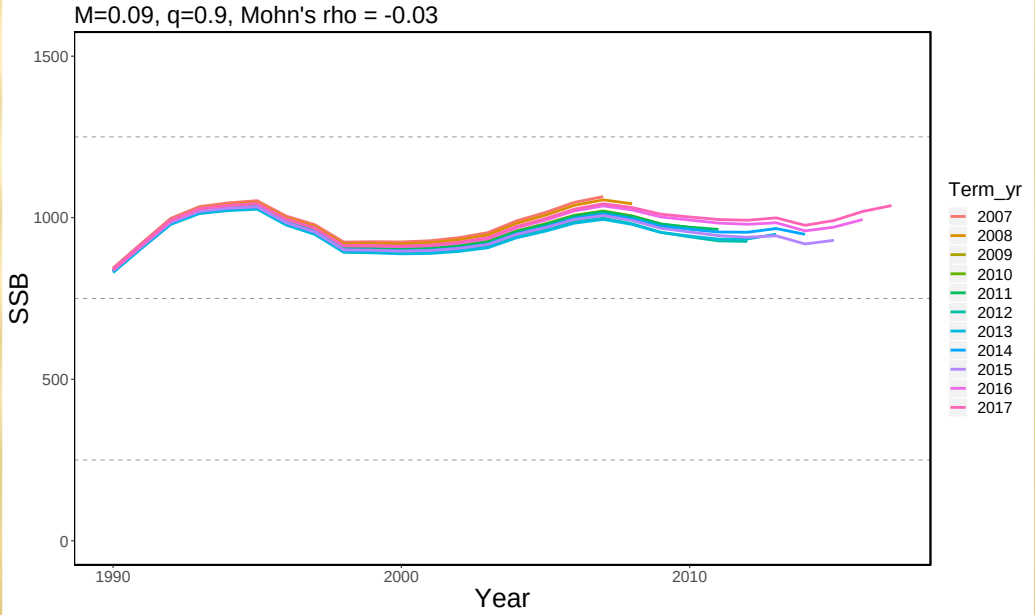
M \ q	0.8	0.9	1.0	1.1	1.2
0.08	0.11	0.01	0.02	0.05	0.08
0.09	0.04	0.03	0.06	0.08	0.11
0.10	0.02	0.06	0.09	0.12	0.14
0.11	0.07	0.09	0.12	0.14	0.16
0.12	0.12	0.12	0.14	0.16	0.19
0.13	0.12	0.14	0.16	0.19	0.21
0.14	0.14	0.16	0.18	0.20	0.22

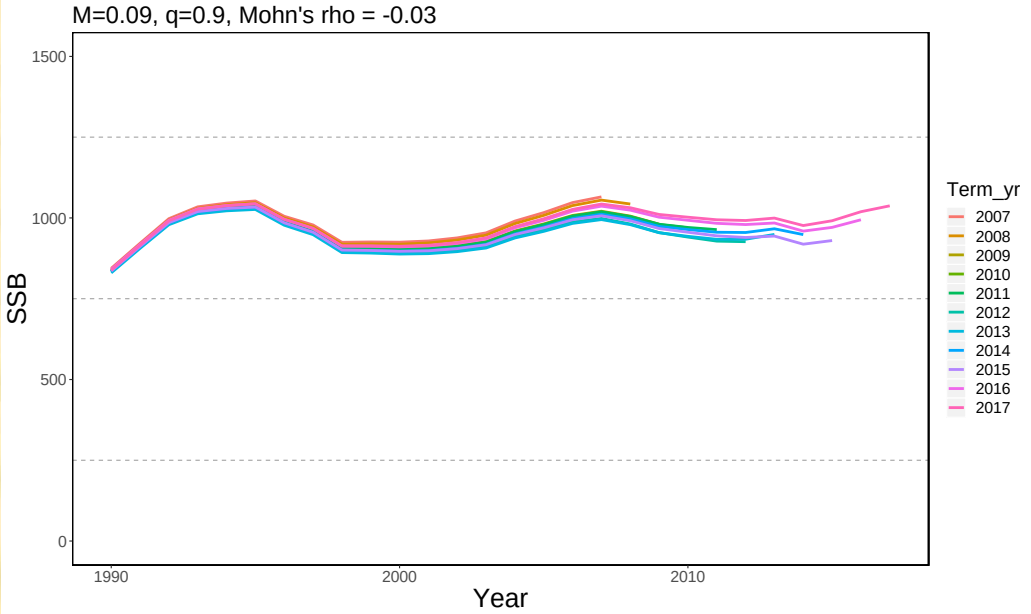
Log (likelihood)

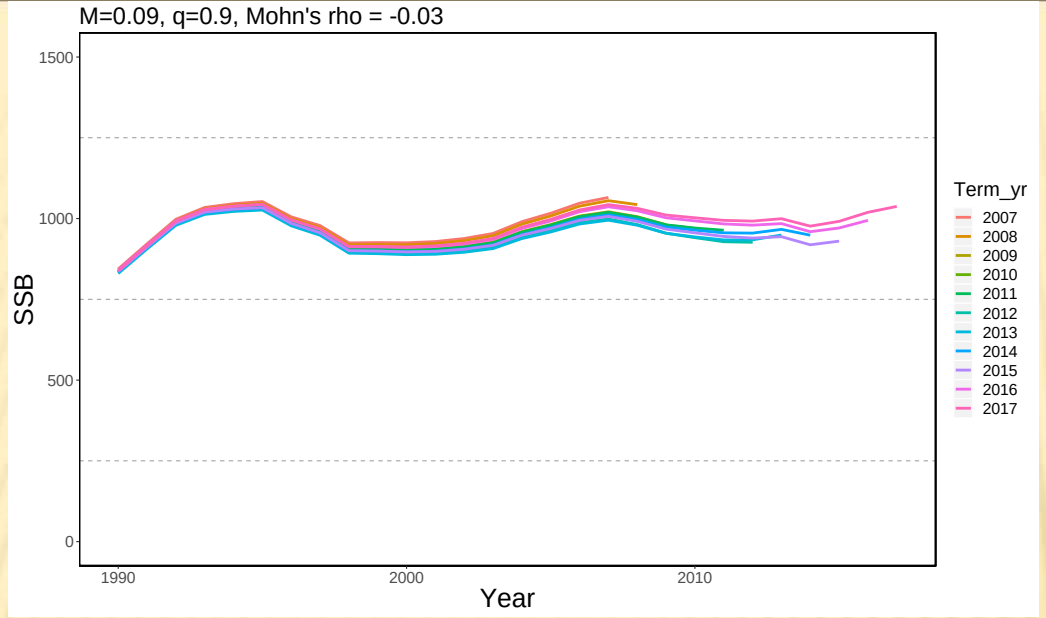
M \ q	0.8	0.9	1.0	1.1	1.2
0.08	303	73	48	28	14
0.09	230	44	26	13	4
0.10	177	24	13	4	0
0.11	142	13	5	2	1
0.12	121	7	3	3	6
0.13	8	6	6	9	14
0.14	8	8	11	16	23

BSAI YELLOWFIN SOLE






M=0.09, q=0.9, Mohn's rho = -0.03
1500
1000
500
0
SSB
1990
2000
2010
Year
Term_yr
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017



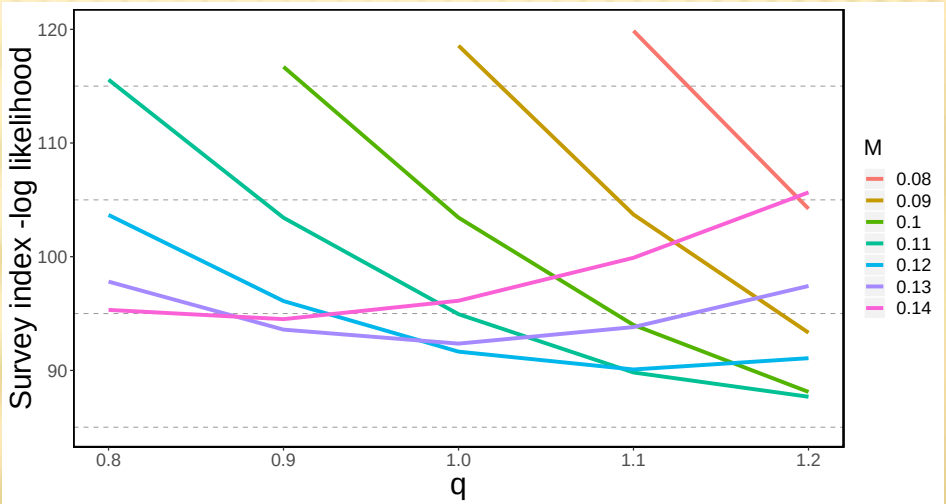
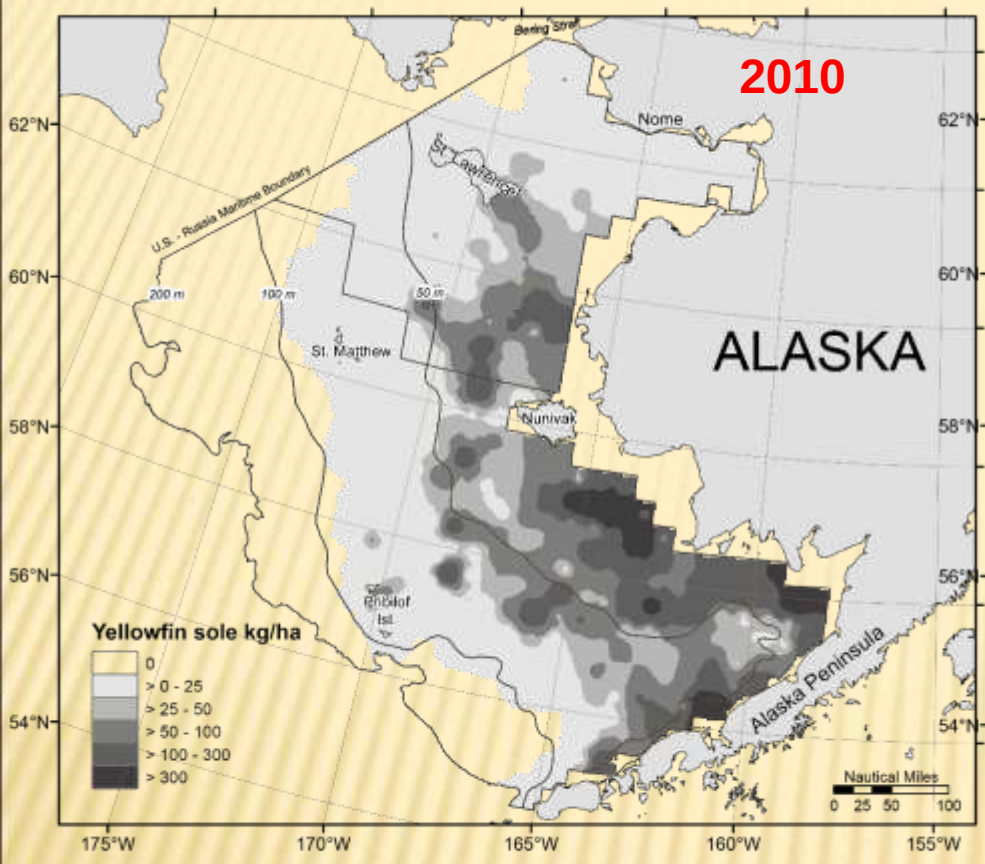
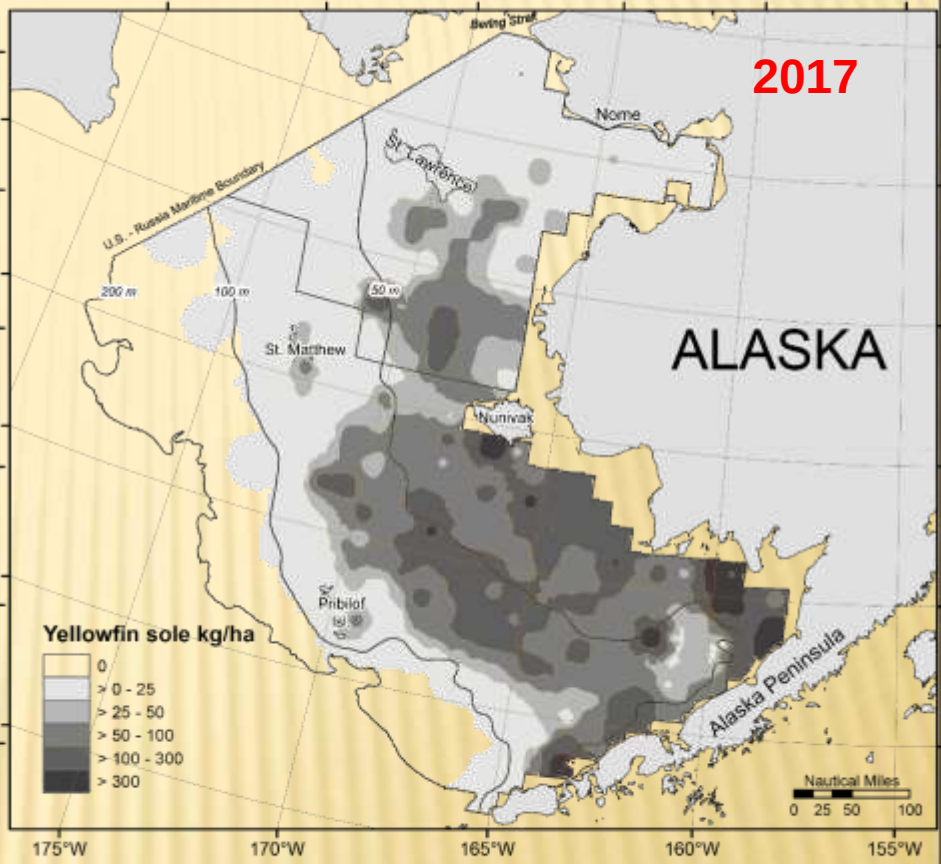


Figure on tradeoffs between M and q relative to negative log likelihood for the survey index

Northern Bering Sea





15.6% of EBS biomass in northern Bering Sea

13.6% of EBS biomass in northern Bering Sea

BSAI YELLOWFIN SOLE

Model 18_1, proposed new base model

Quantity	As estimated or specified last year for:		As estimated or recommended this year for:	
	2018	2019	2019	2020
M (natural mortality rate)	0.12	0.12	0.12	0.12
Tier	1a	1a	1a	1a
Projected total (age 6+) biomass (t)	2,553,100	2,460,700	2,462,400	2,411,700
Female spawning biomass (t)	587,300			
Projected	895,600	890,000	850,600	821,500
B_0	1,204,000		1,245,400	
B_{MSY}	456,000		460,800	
F_{OFL}	0.12	0.12	0.118	0.118
maxF_{ABC}	0.109	0.109	0.107	0.107
F_{ABC}	0.109	0.109	0.107	0.107
OFL (t)	306,700	295,600	290,000	284,000
maxABC (t)	277,500	267,500	263,200	257,800
ABC (t)	277,500	267,500	263,200	257,800
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

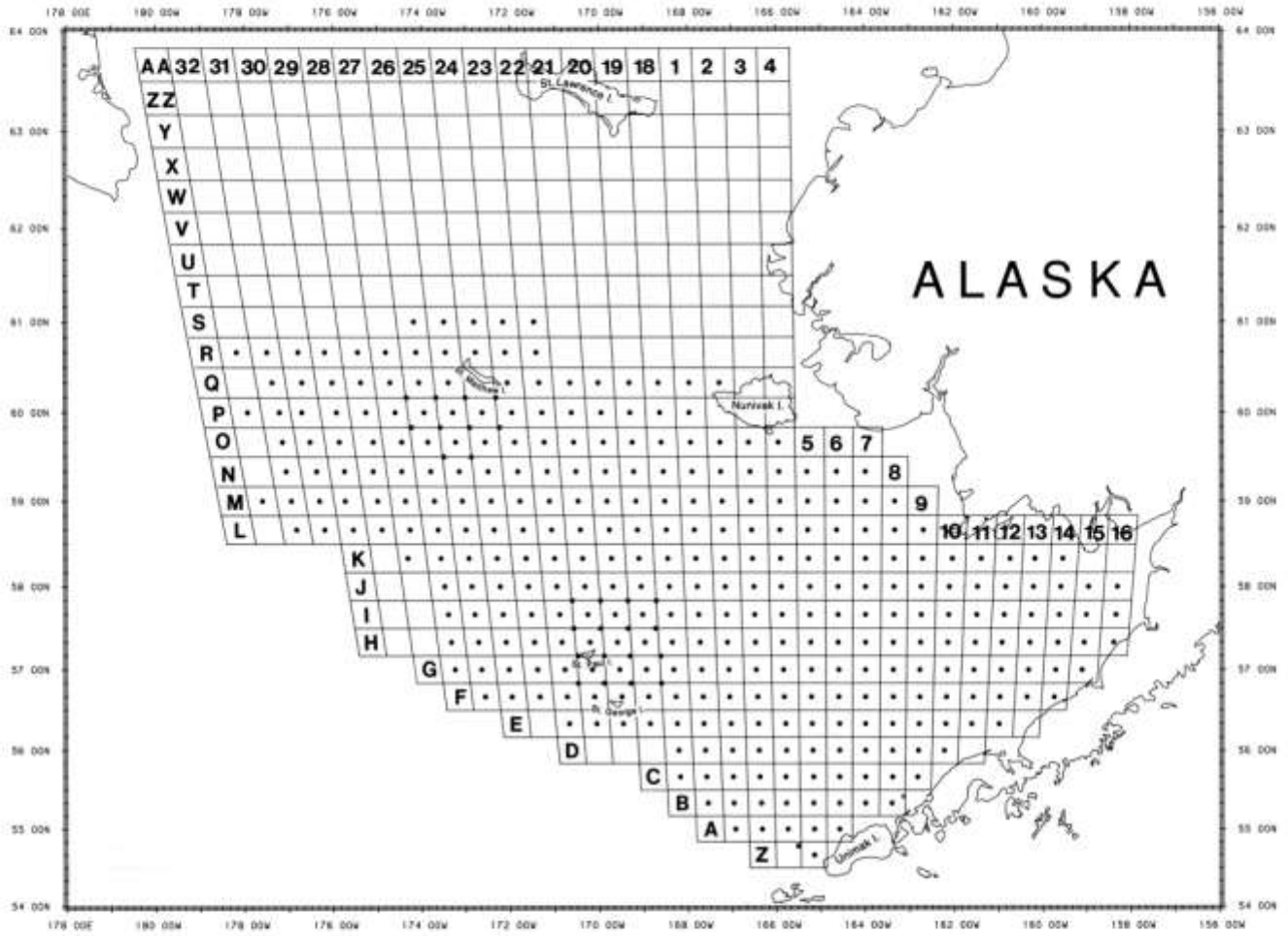


Figure 1. -- Eastern Bering Sea survey grid map of sampled stations.