Assessment of the Yellowfin Sole Stock in the Bering Sea and Aleutian Islands

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11/13/2019

Responses to SSC and Plan Team Comments Specific to this Assessment

SSC December 2018

- The SSC encourages further exploration of the way mortality is handled in the model, for example through the use of sex-specific or time-varying mortality and the authors noted that they may be able to explore this more fully in 2019.

Authors' response

In the current assessment, a model was explored that used a fixed value for female natural mortality, and allowed male natural mortality to be estimated by within the model (Model 18.2).

Two models were considered in this assessment.

- Model 18.1a: Same model as in the 2018 assessment, updated with 2019 data. Model 18.1a used the same natural mortality for males and females, M=0.12.
- Model 18.2: Uses a fixed value for female natural mortality (M=0.12) and allowed male natural mortality to be estimated within the model. Model 18.2 is the preferred model.

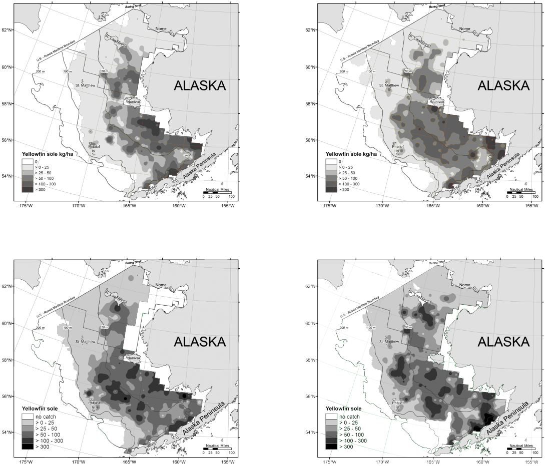
Responses to SSC and Plan Team Comments Specific to this Assessment

SSC December 2018

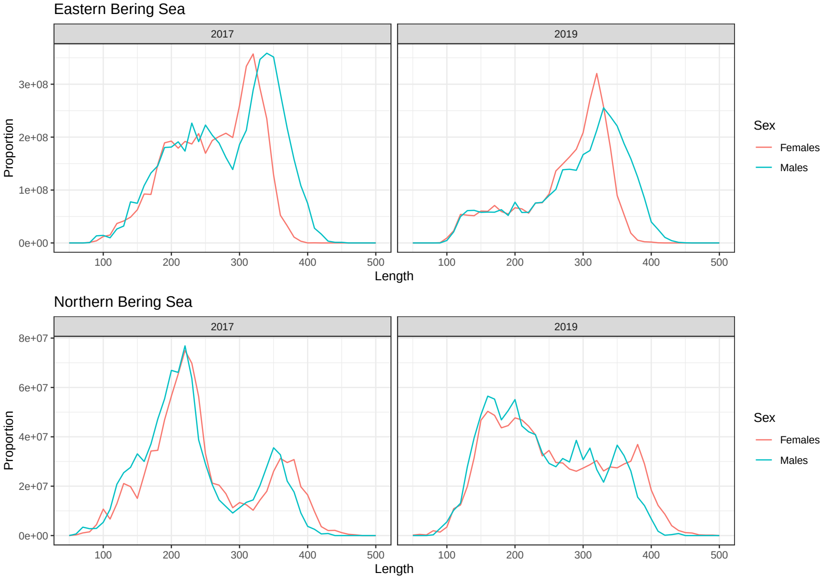
- Given recent changes in the distribution of other species, the SSC encourages authors to explore variability over time in the proportion of the stock in the NBS.
- Consider approaches for including the substantial biomass of NBS Yellowfin Sole in the model, with the expectations that NBS surveys will be conducted regularly in the future.

Annual EBS and NBS bottom trawl survey biomass and 95% CIs for Yellowfin Sole, 1982-2019.

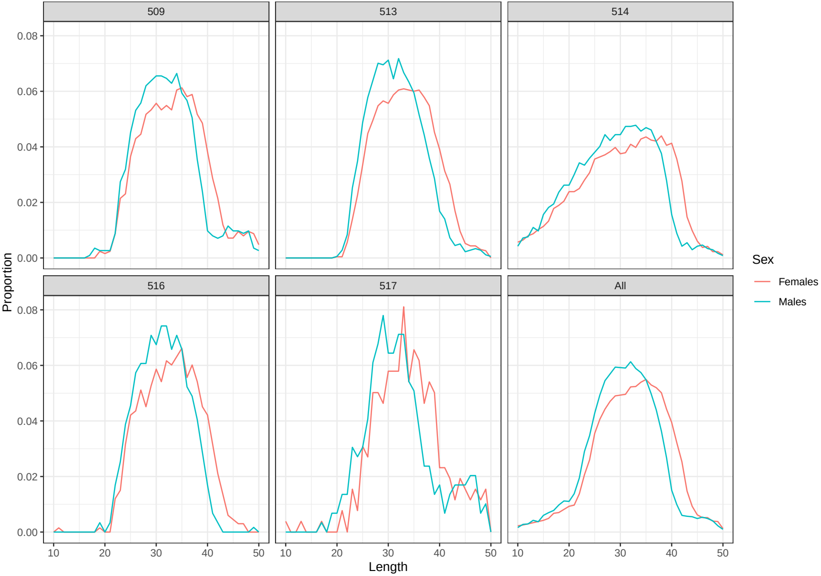
Distribution of Yellowfin Sole in the Bering sea, top row: 2010, 2017, bottom row: 2018, 2019.



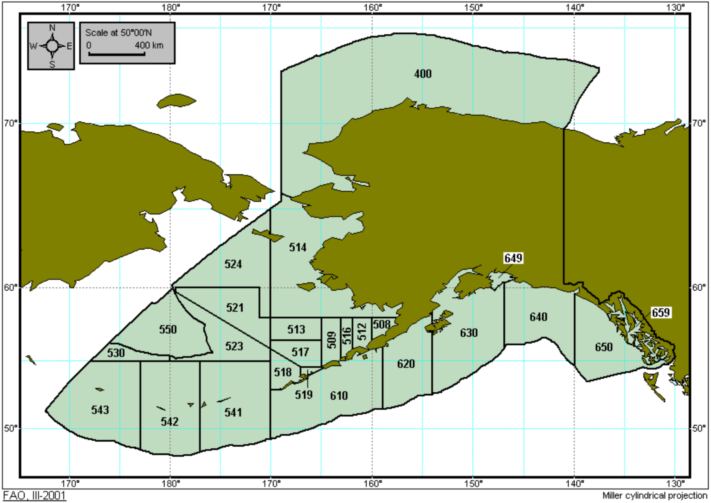
Estimated numbers at length (mm) of Yellowfin Sole from the EBS and NBS surveys, 2017 and 2019.



Size composition of the Yellowfin Sole catch in 2019 (through mid-September), by subarea and total.



NMFS areas



Scale at 50°00'N
0
400 km
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S
W
E
170°
180°
170°
160°
150°
140°
130°
70°
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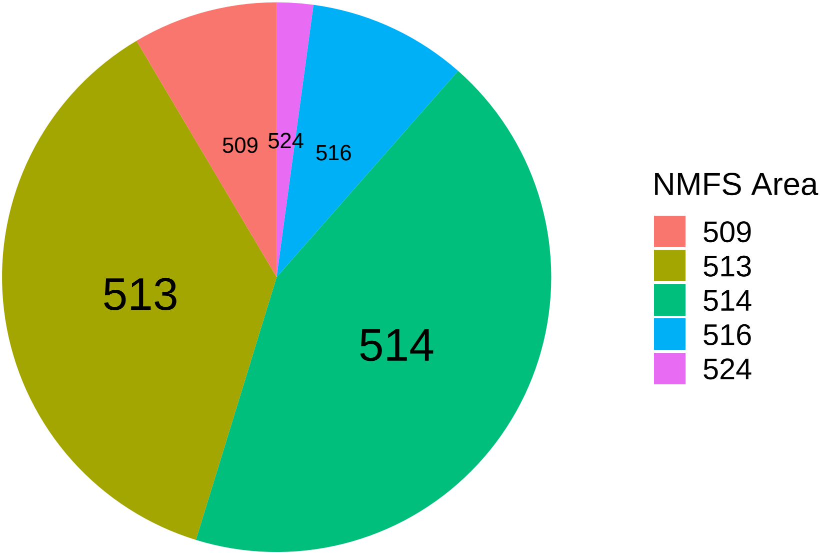
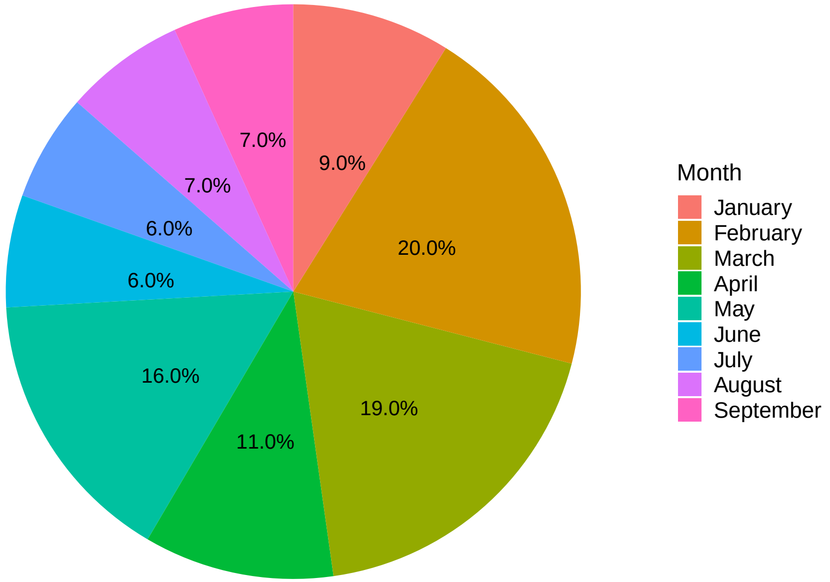
50°
400
514
524
521
550
523
513
517
509
516
512
508
530
518
519
543
542
541
610
620
630
649
640
650
659
FAO, III-2001
Miller cylindrical projection

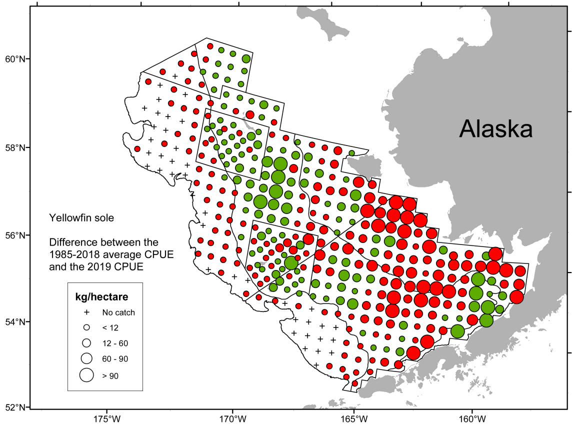
Areas of largest catch in 2019 were 513 and 514.



Largest fishery months in 2019 were February - May.

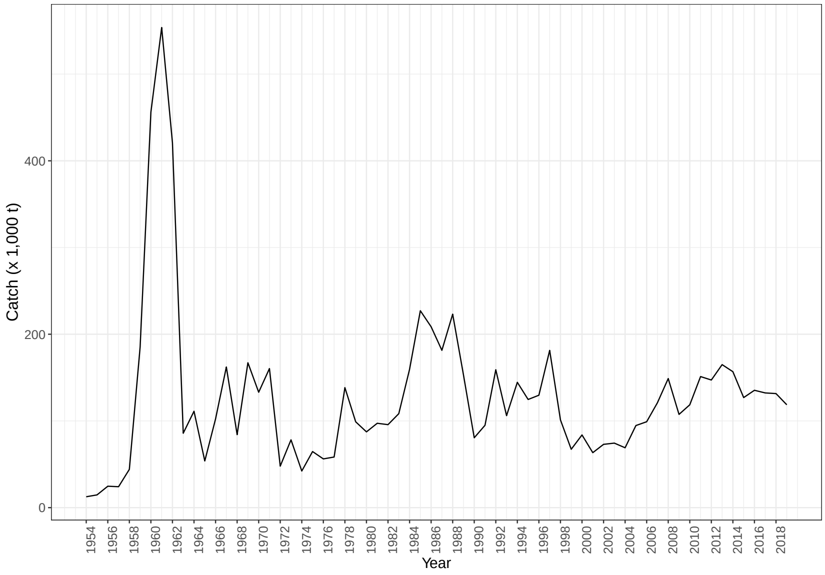


Difference between the 1985-2018 average trawl survey CPUE for yellowfin sole and the 2019 survey CPUE.



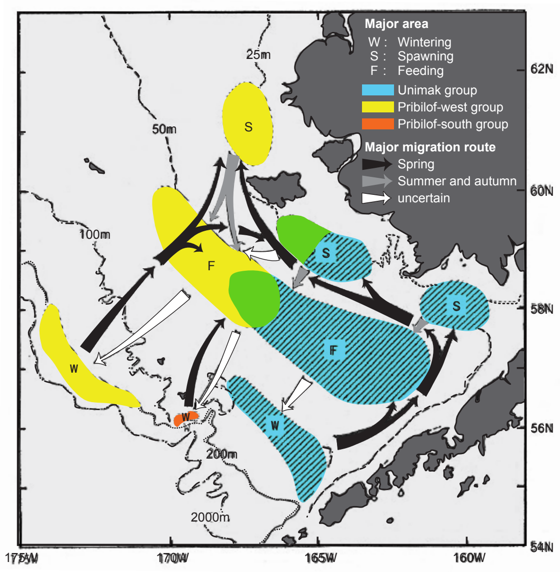
Green circles indicate that the magnitude of the catch was greater in 2019 than the long-term average, red circles indicate the catch was greater in the longterm average than in 2019.

Yellowfin Sole annual total catch (1,000s t) in the Eastern Bering Sea from 1954-2019.

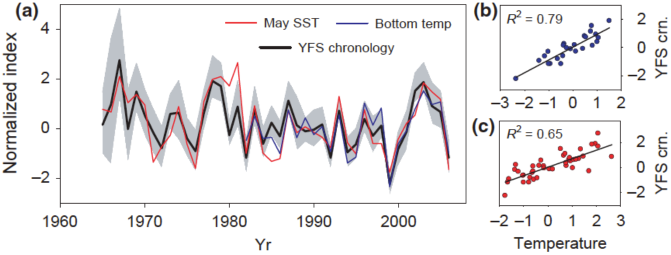


Catch per unit effort on NMFS eastern Bering Sea surveys, 1982-2019. Units are in kg/km2.

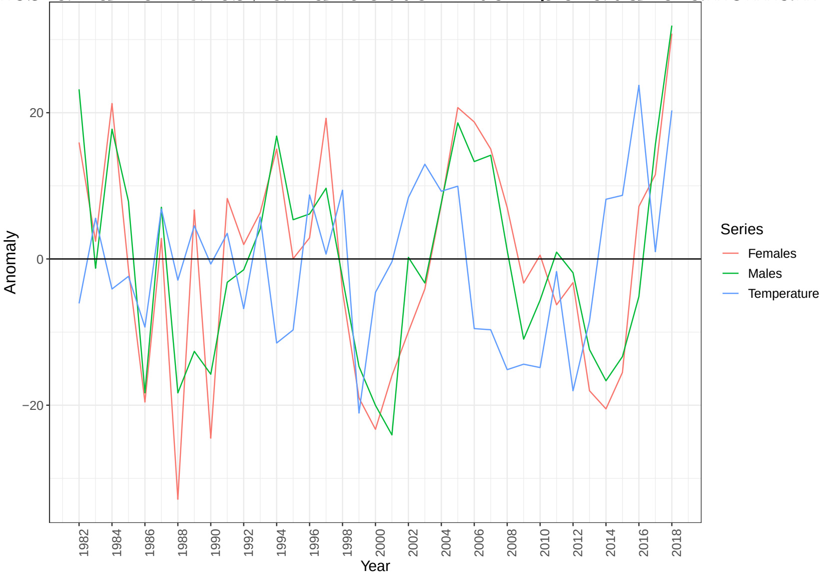
Distribution of wintering, spawning, and feeding areas for Yellowfin Sole in the Bering Sea.



Otolith growth rings show correlation between growth and temperature.



Yellowfin Sole length-at-age anomalies, for 5-year old males and females, and bottom temperature anomalies.



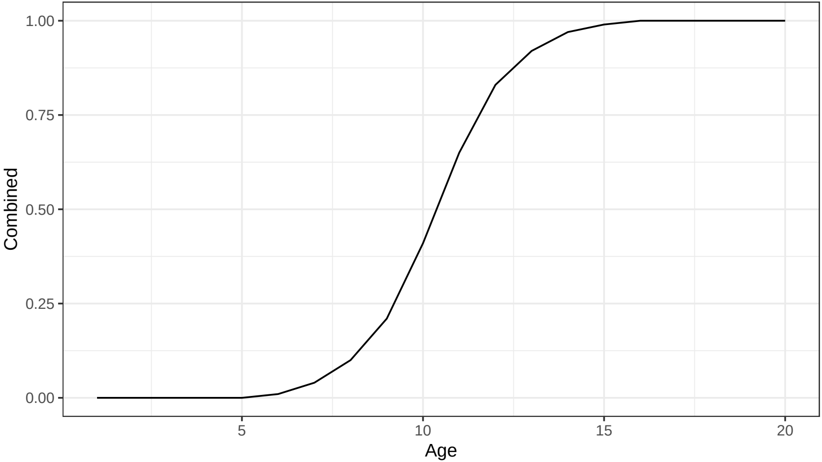
Note: Bottom temperature anomalies scaled up by a factor of 10 to demonstrate pattern.

Data included in the model

Data source	Year
Fishery catch	1954 - 2019
Fishery age composition	1964 - 2018
Fishery weight-at-age	1964 - 2018
Survey biomass and standard error	1982 - 2019
Bottom temperature	1982 - 2019
Survey age composition	1979 - 2018
Annual length, weight-at-age surveys	1979 - 2018
Age at maturity	Combined 1992 and 2012 samples

Maturity at age

- Yellowfin Sole maturity schedules estimated from two studies
- Nichol (1995) and TenBrink and Wilderbuer (2015)



Selectivity

- Two parameter formulation of the logistic function.
- Used for fishery and survey.
- Modeled separately for males and females.

Catchability

Survey catchability model was introduced in 2018, Model 18.1a.

- Included survey start date.
- This feature retained in current 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.

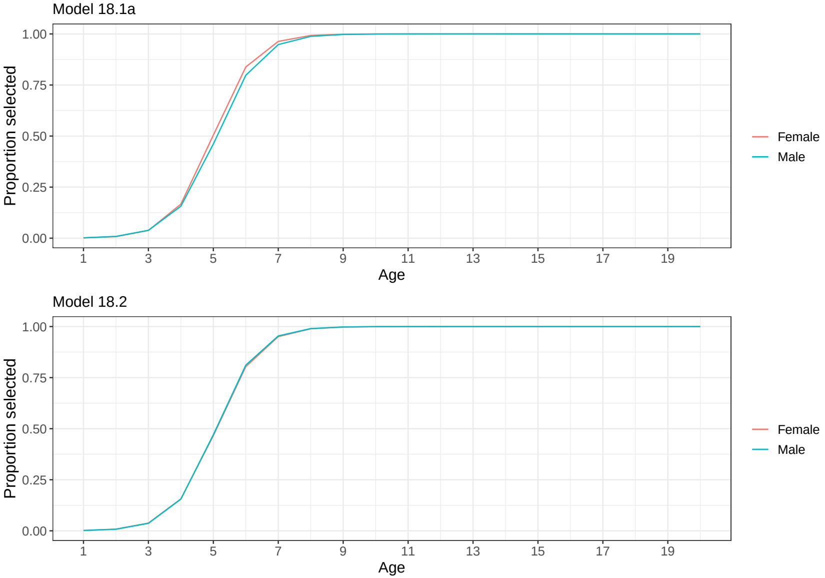
Spawner-Recruit Estimation

Annual recruitment estimates from 1978-2013 were constrained to fit a Ricker (1958) stock recruitment relationship:

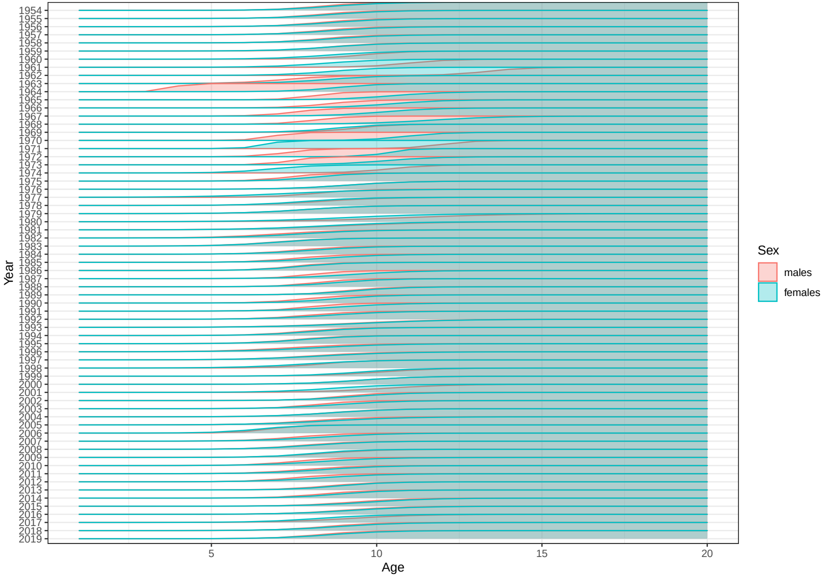
$R = \alpha S e^{-\beta S}$,

where R is age 1 recruitment, S is female spawning biomass in metric tons the previous year, and α and β are parameters estimated by the model.

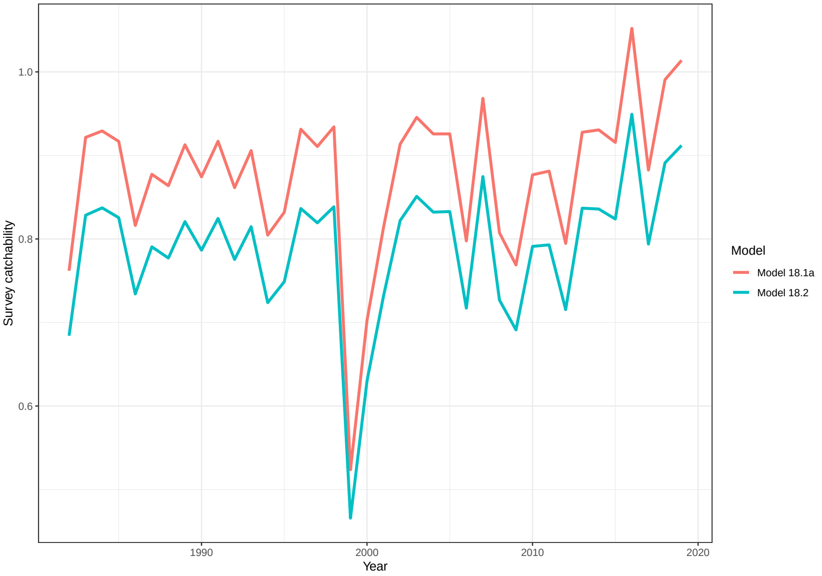
Estimate of survey selectivity for males and females, Model 18.1a upper panel, Model 18.2 lower panel.



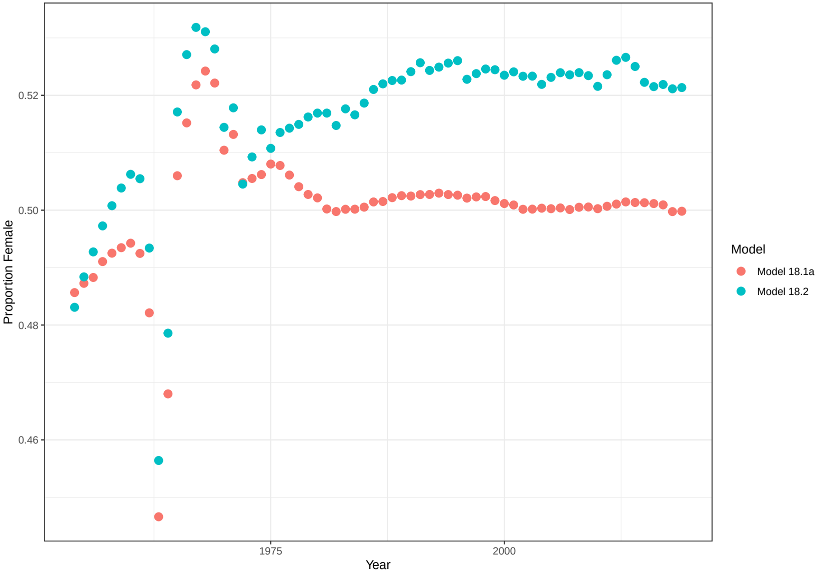
Estimate of fishery selectivity for males and females, 1954-2019.



Survey catchability for Model 18.1a and 18.2, 1982-2019.



Model estimates of the proportion of female Yellowfin Sole in the population, 1982-2018.



Likelihood table for Model 18.1a and 18.2

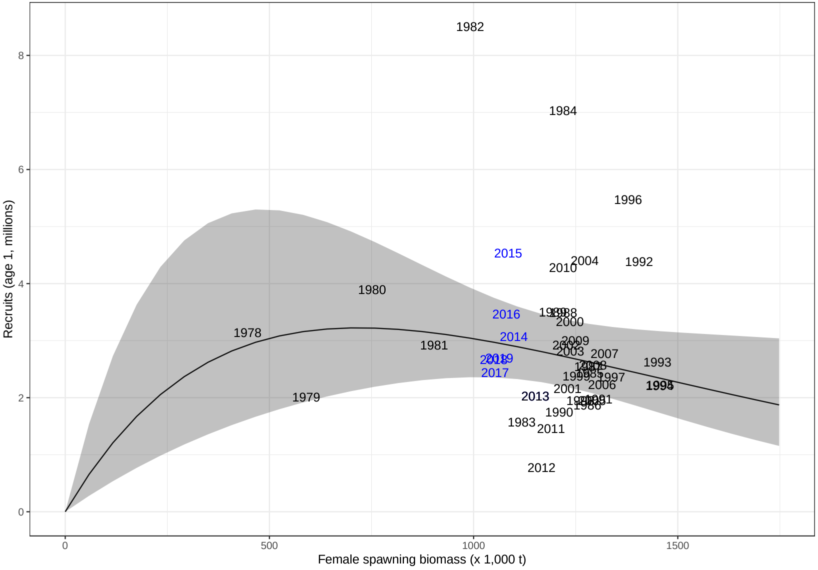
Likelihood component	Model 18.1a	Model 18.2
Survey age	589.29	560.25
Fishery age	654.46	609.64
Selectivity	61.75	62.81
Survey biomass	91.95	95.08
Recruitment	27.07	28.25
Catchability	0.0082	0.0069
Total	1424.54	1356.03

Comparison of results for Model 18.1a and Model 18.2

	Model 18.2		Model 18.1a	
Quantity	2020	2021	2020	2021
M (natural mortality rate)	0.12, 0.135	0.12, 0.135	0.12	0.12
Tier	1a	1a	1a	1a
Projected total (age 6+) biomass (t)	2,726,370	2,733,120	2,461,850	2,467,300
Projected female spawning biomass (t)	1,051,050	1,005,310	857,187	818,117
$B_{100\%}$	1,501,510	1,501,510	1,274,270	1,274,270
$B_{MSY\%}$	542,791	542,791	466,029 t	466,029 t
F_{OFL}	0.118	0.118	0.117	0.117
$maxF_{ABC}$	0.109	0.109	0.106	0.106
F_{ABC}	0.109	0.109	0.106	0.106
OFL	321,794	322,591	287,307	287,943
$maxABC$	296,060	296,793	260,918	261,497
ABC	296,060	296,793	260,918	261,497
Status	2018	2019	2018	2019

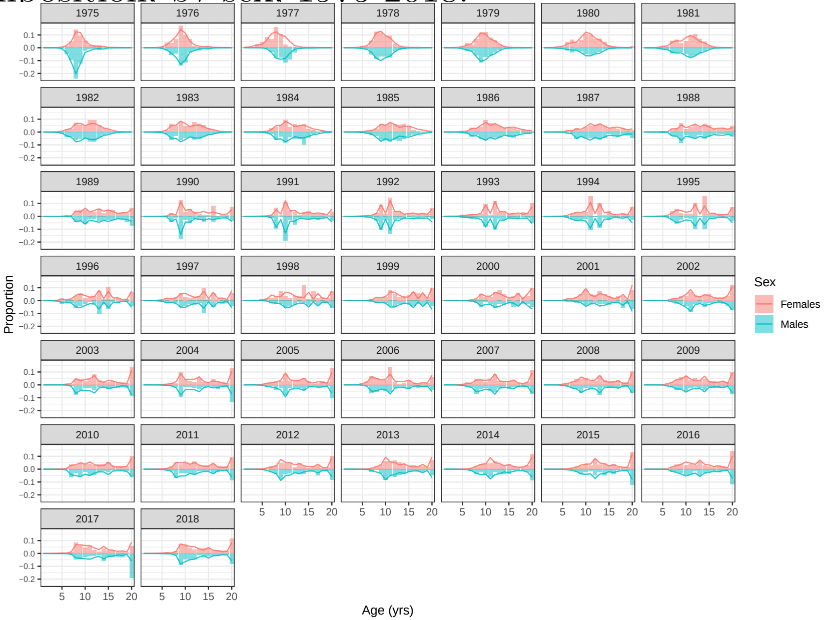
Projections for Model 18.1a and 18.2 were based on estimated catches of 118,642 t in 2019 and 137,230 used in place of maximum ABC for 2020.

Ricker stock recruitment curve, 95% CIs fit to FSB (years in black) and recruitment 1978-2013, Model 18.2.

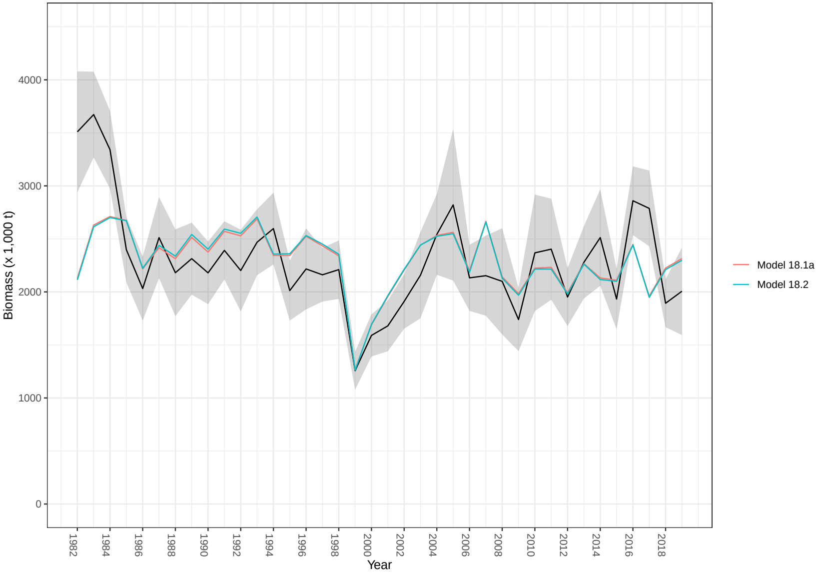


Model 18.2 fit to the time-series of survey age composition, by sex, 1979-2018.

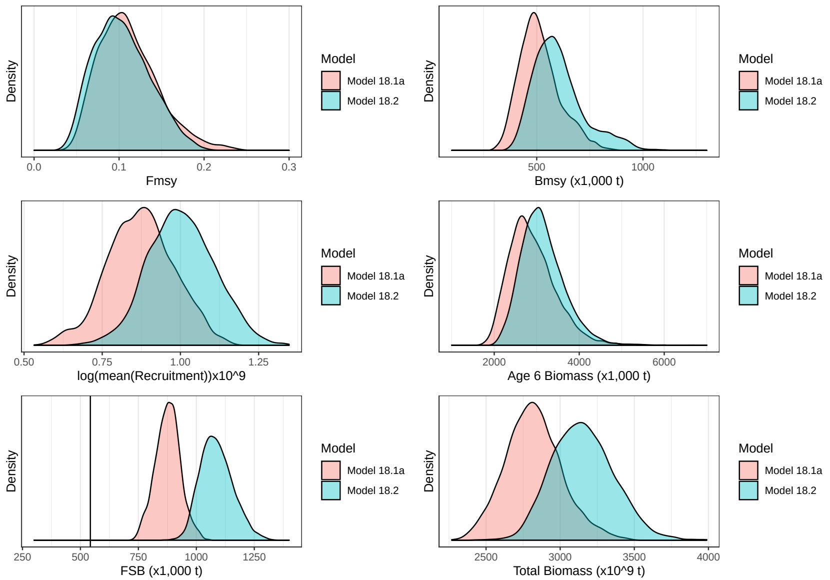
Model 18.2 fit to the time-series of fishery age composition, by sex, 1975-2018.



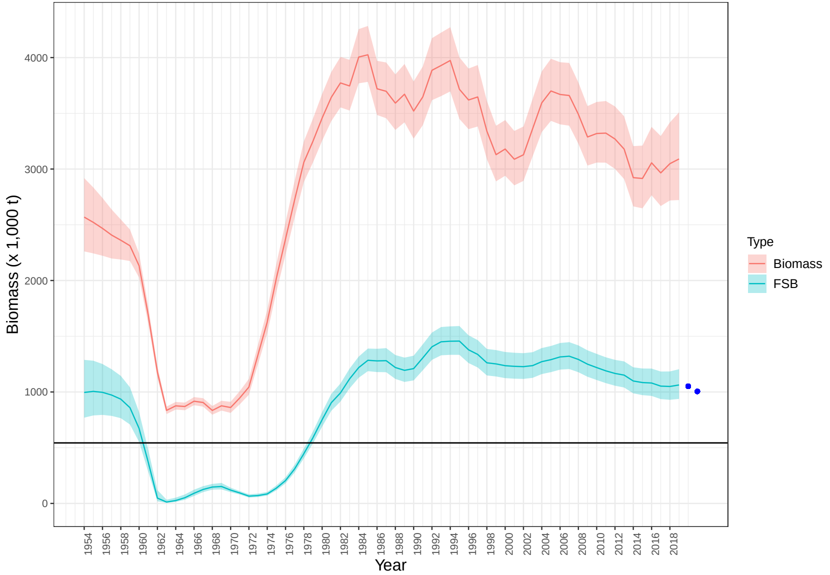
NMFS EBS survey biomass estimates, Model 18.1a and 18.2 fit to survey biomass estimates, 1982-2019.



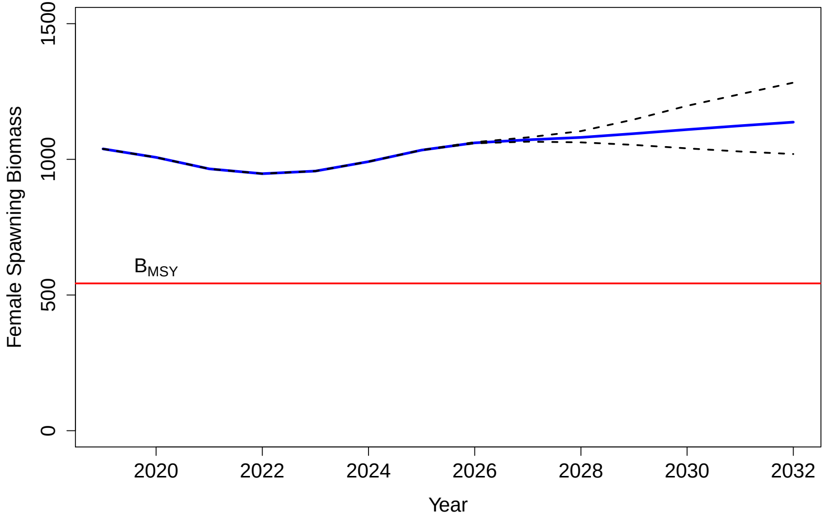
MCMC posterior distributions for Model 18.2.



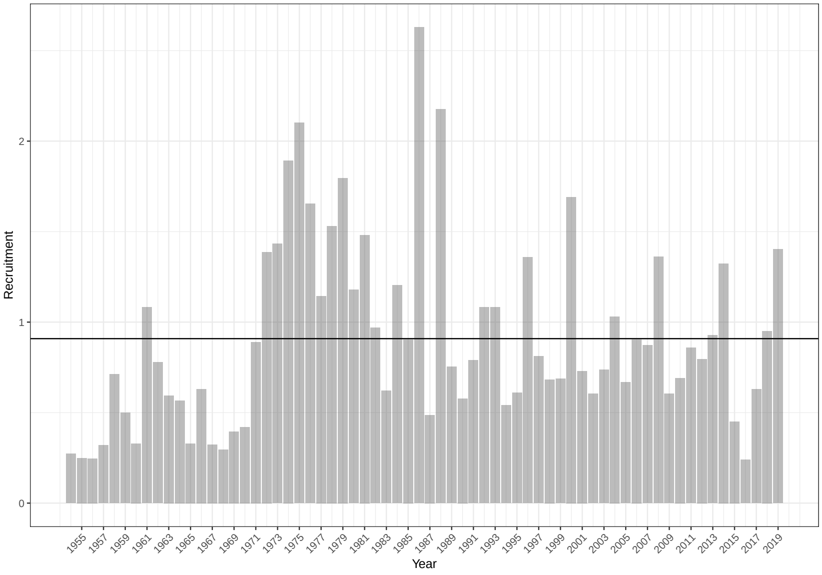
Model estimates of total (age 2+) and female spawning biomass with 95% confidence intervals, 1954-2019.



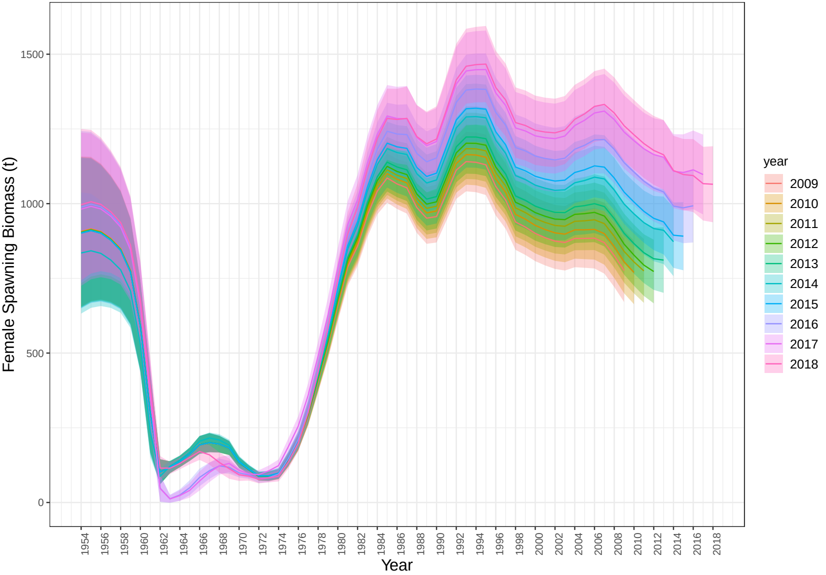
Projected female spawning biomass for 2019 to 2032 (blue line), and fishing at the 2014-2018 average.



Year class strength of age 5 Yellowfin Sole estimated by the stock assessment model, horizontal line = mean.



Retrospective plot of female spawning biomass. Data was sequentially removed through 2009.

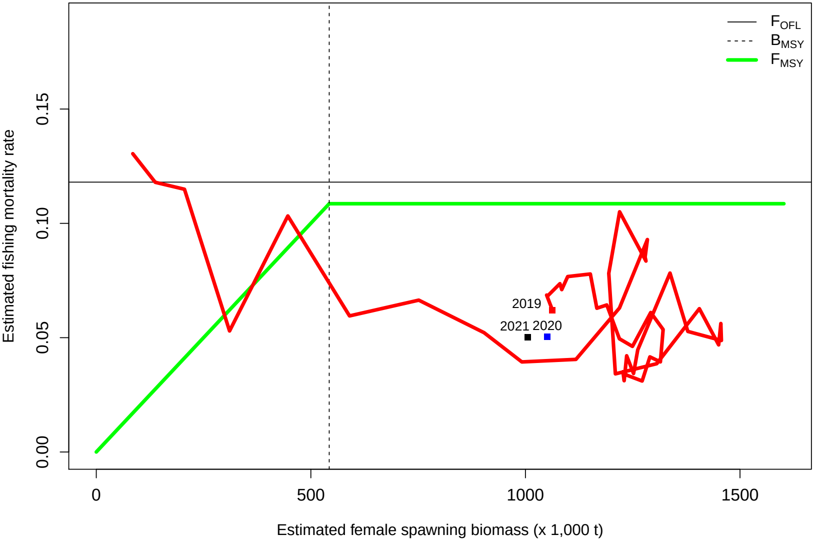


Relative differences in estimates of FSB between the 2019 preferred and retrospective runs.

Retrospective results

- Retrospective pattern for Model 18.2 similar to previous years.
- Earlier retrospective years indicated a lower level of spawning biomass than the current year's data
- Mohn's rho = -0.219.

Fishing mortality rate and female spawning biomass from 1975 to 2019 compared to harvest control rule.



Risk Assessment

Assessment related considerations

- Long time series - surveys 1982-2019 (no skipped years).
- Fish ages have been validated.
- Good fit to compositional and abundance data.
- Recruitment tracks strong year classes consistent with data.

Risk Assessment

Assessment related considerations (Level 1: Normal)

- Retrospective pattern has been subject of some concern.
- Large variability in survey biomass assessments for this stock due to temperature-influenced availability to the survey.
- Can contribute to undesirable patterns - earlier years not fitting the same highly variable information as the current year.
- Varying M and q to minimize retrospective bias may not be the best tool for model selection for BSAI Yellowfin Sole.
- Tension between model fit and good retrospective pattern.

Risk Assessment

Population dynamics considerations (Level 1: Normal)

- Population in slow decline since the strong 1981 and 1983 year-classes have passed through the population.
- The present biomass is well above B_{MSY}.
- Projections indicate that the FSB will remain well-above the B_{MSY} level through 2032.
- Population dynamics are not a concern for this assessment.

Risk Assessment

Environmental/ecosystem considerations (Level 1: Normal)

- YFS condition (length-weight residuals) was positive in all strata and continued an upward trend since 2017;
- The mean size of the groundfish community increased in 2019 buoyed by species including YFS, which had above average mean length;
- YFS abundance and biomass remained below the long-term mean over the southern shelf;
- YFS abundance and biomass increased between 2017 and 2019 over the northern shelf;
- Indirect measurements of prey availability suggest sufficient prey availability for YFS over the southern Bering Sea shelf;
- Increase of predators over the eastern Bering Sea shelf indicates increased risk of predation, although size, spatial, and/or temporal mismatches may exist and provide refuge for YFS;
- 2019 gray whale Unusual Mortality Event reflects poor feeding conditions in the northern Bering Sea during 2018.

Risk Assessment

Fishery performance considerations (Level 1: Normal)

- Recent surveys of the northern Bering sea have not indicated a large shift in the spatial distribution of the eastern Bering Sea stock of Yellowfin Sole.
- Landings of benthic foragers (including YFS) remained relatively stable through 2018.
- Landings of benthic forager flatfish may be larger than salmon, but salmon ex-vessel value is higher because it commands a higher price.
- Revenues from benthic forager flatfish (including YFS) decreased from 2012-2015 as a result of decreased prices; since 2015 price increases have increased value while landings have remained stable.

Risk Assessment Table

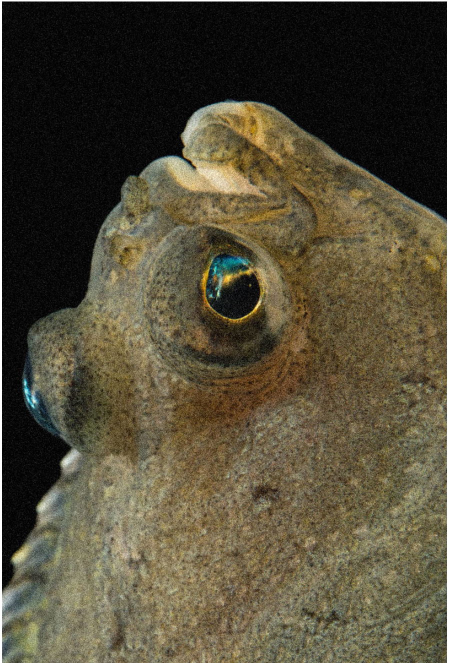
Assessment consideration	Population dynamics	Environmental ecosystem	Fishery performance	Overall
Level 1: Only minor, low level of concern	Level 1: Stock trends are typical for the stock and expected given stock dynamics; recent recruitment is within the normal range.	Level 1: Stock trends are typical for the stock and expected given stock dynamics; recent recruitment is within the normal range.	Level 1: No apparent environmental/ecosystem concerns	Level 1: Normal.

Summary Table

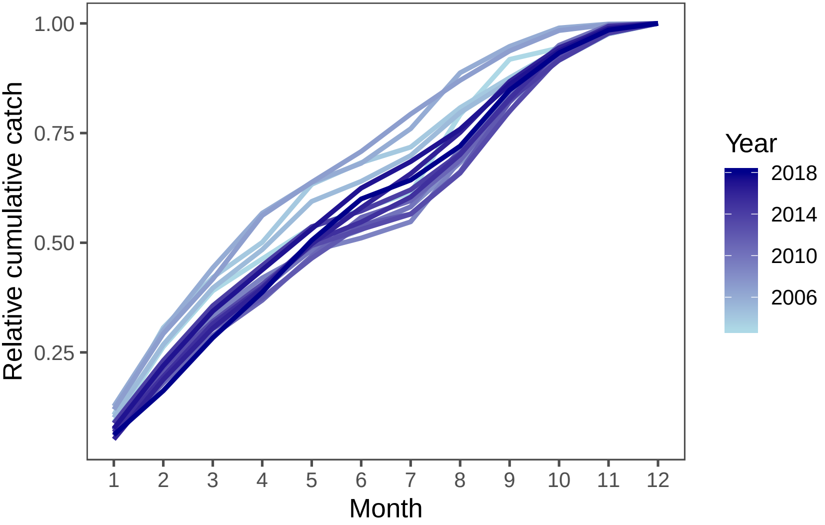
Quantity	As estimated or *specified last* year for: 2019	2020	As estimated or *recommended this* year for: 2020	2021
M (natural mortality rate)	0.12	0.12	0.12, 0.135	0.12, 0.135
Tier	1a	1a	1a	1a
Projected total (age 6+) biomass	2,388,000 t	2,331,500 t	2,726,370 t	2,733,120 t
Projected female spawning biomass	827,900 t	796,600 t	1,051,050 t	1,005,310 t
$B_{100\%}$	1,236,000 t	1,236,000 t	1,501,510 t	1,501,510 t
$B_{MSY\%}$	451,600 t	451,600 t	542,791 t	542,791 t
F_{OFL}	0.118	0.118	0.118	0.118
$maxF_{ABC}$	0.107	0.107	0.109	0.109
F_{ABC}	0.107	0.107	0.109	0.109
OFL	281,800 t	275,100 t	321,794 t	322,591 t
$maxABC$	255,100 t	249,100 t	296,060 t	296,793 t
ABC	255,100 t	249,100 t	296,060 t	296,793 t
Status	2017	2018	2018	2019
Overfishing	No	n/a	No	n/a
Overfished	n/a	No	n/a	No
Approaching overfished	n/a	No	n/a	No

Projections were based on estimated catches of 118,642 t in 2019 and 137,230 used in place of maximum ABC for 2020.

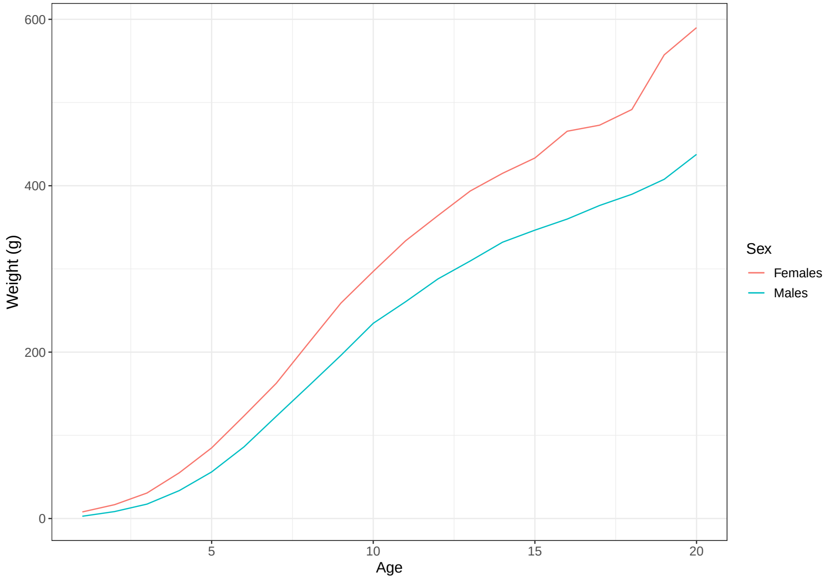
Questions?



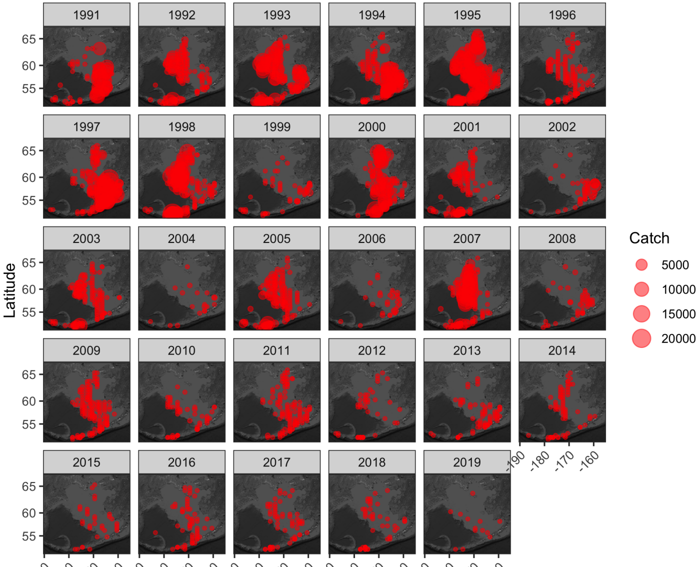
Yellowfin Sole annual cumulative catch by month and year (non CDQ) 2003-2019.



Average Yellowfin Sole weight-at-age (g) from trawl survey observations.

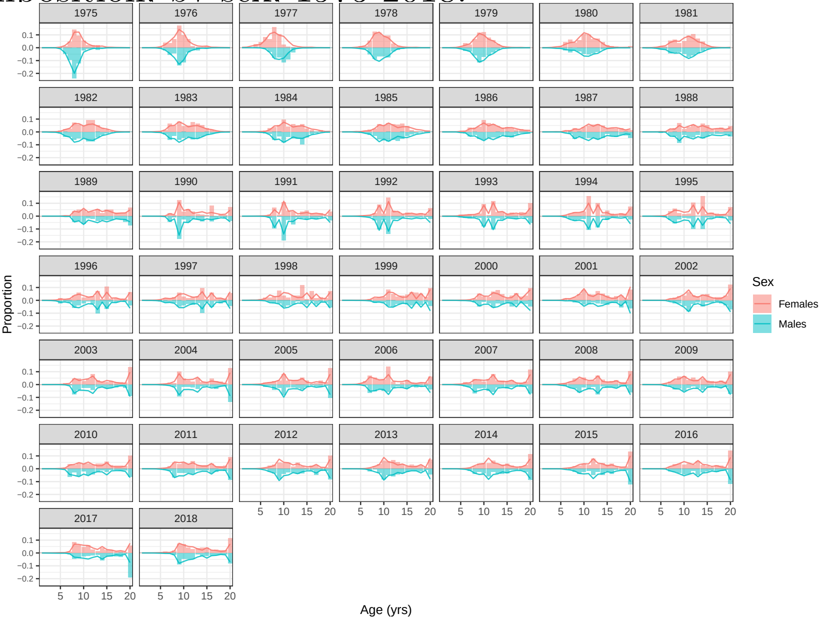


Catch of Yellowfin Sole in the BSAI, 1991-2019. Circles represent relative catch in ADFG Statistical Areas.



Model 18.1a fit to the time-series of survey age composition, by sex, 1979-2018.

Model 18.1a fit to the time-series of fishery age composition, by sex, 1975-2018.



Fishery locations by month, 2019.