



NOAA
FISHERIES

2019 Gulf of Alaska Pacific cod

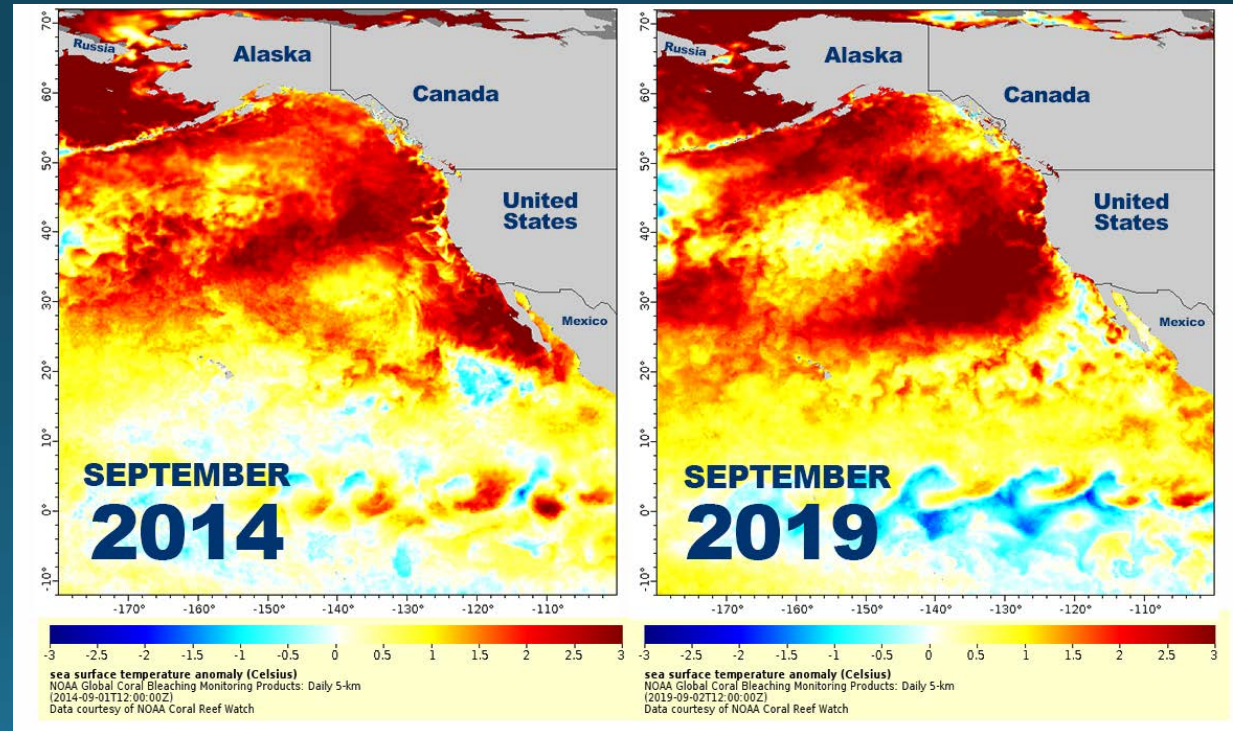
Steve Barbeaux, Kerim Aydin, Ben Fissel,
Kirstin Holsman, Ben Laurel, Wayne Palsson,
Lauren Rogers, Kalei Shotwell,
Qiong Yang, and Stephani Zador

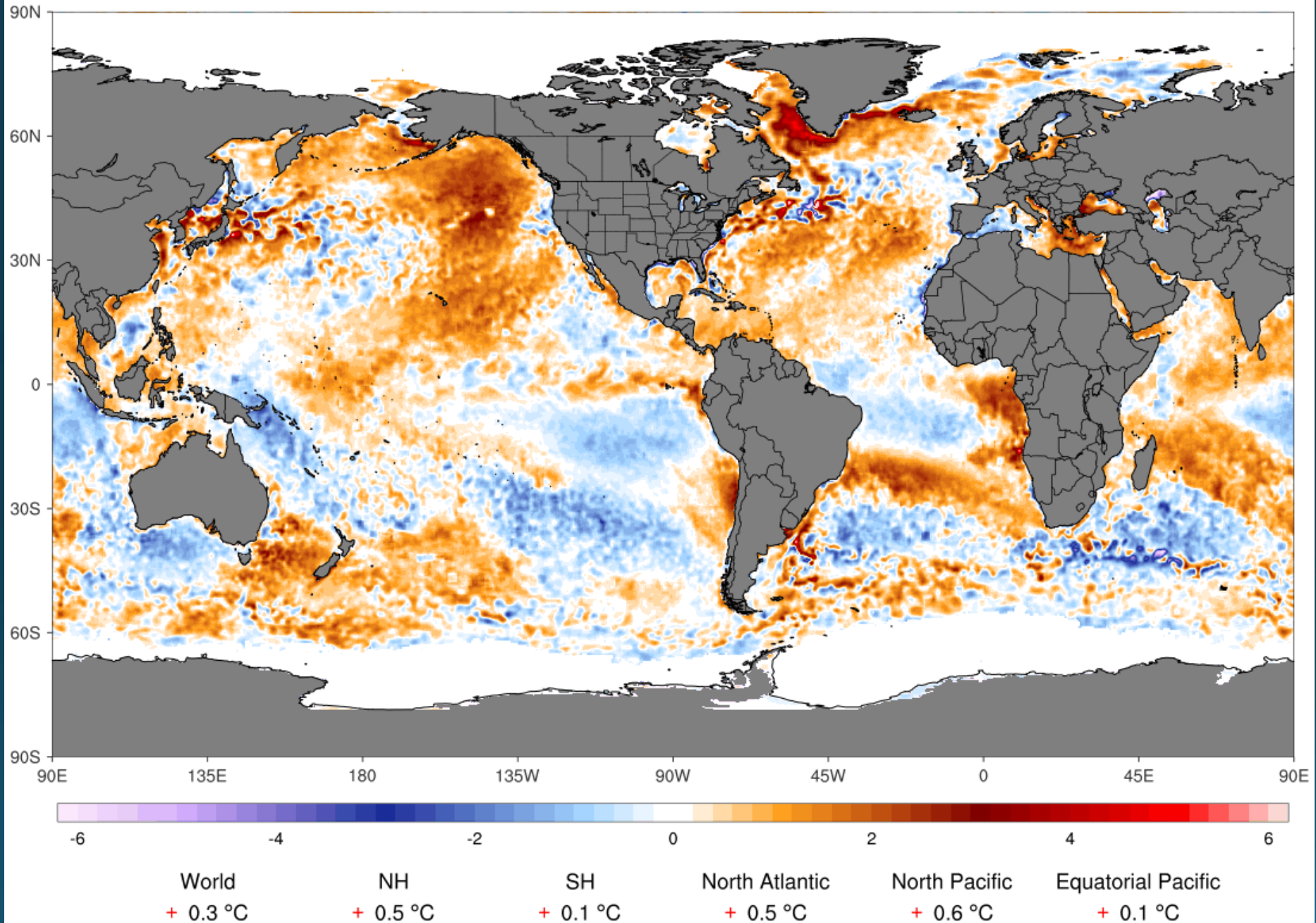


Anomalously warm waters 2018-2019



- New heatwave began September 10, 2018
- Summer of 2019 surface temps were warmer than “blob” years.

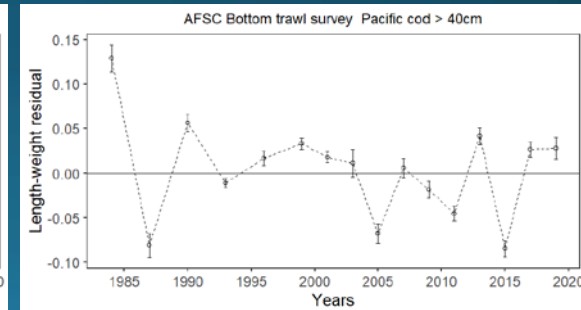
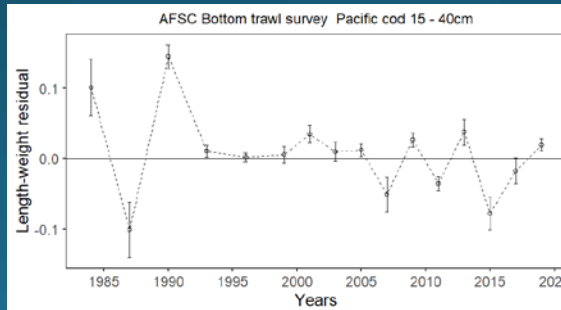
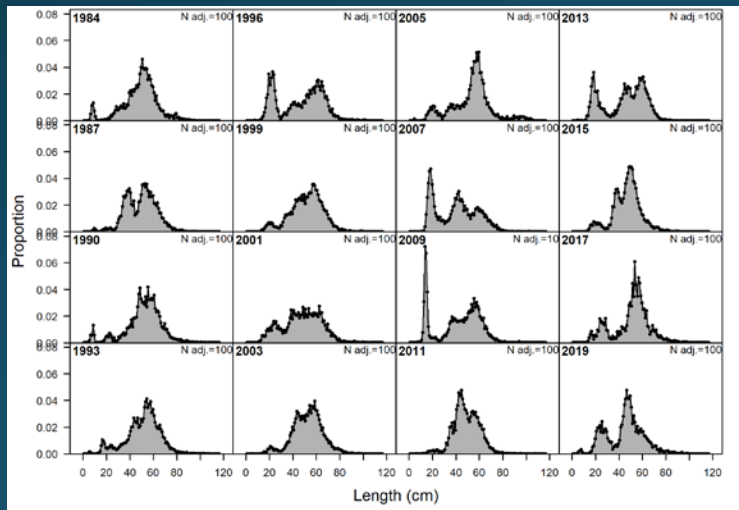
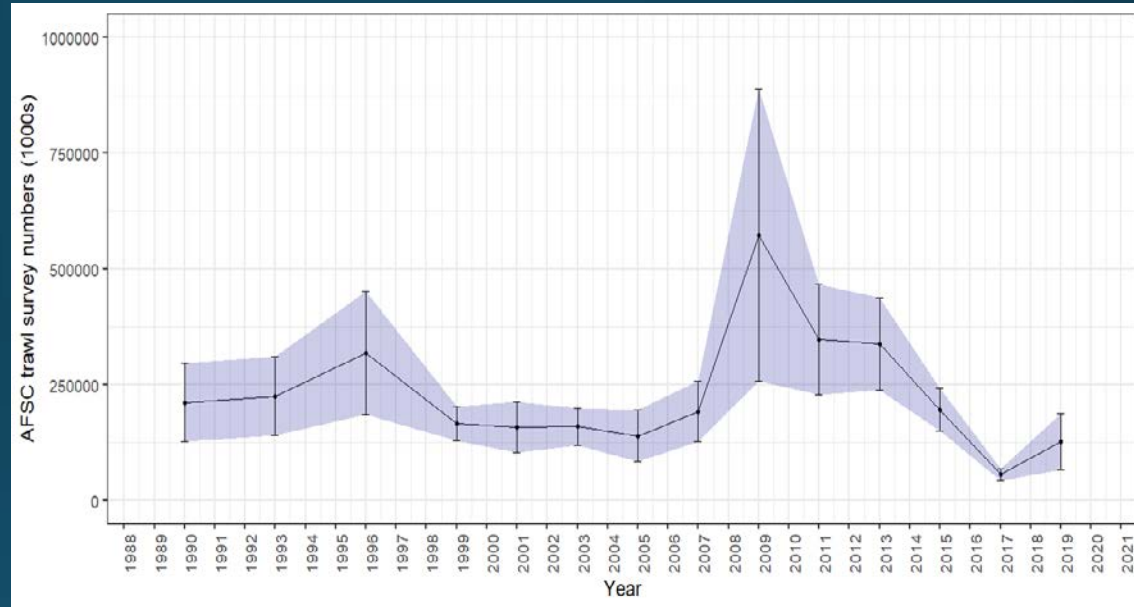




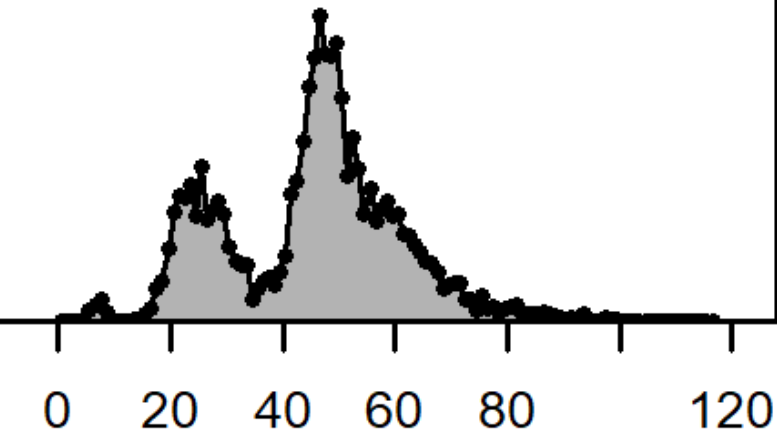
GOA Pacific cod 2019 AFSC Bottom trawl survey



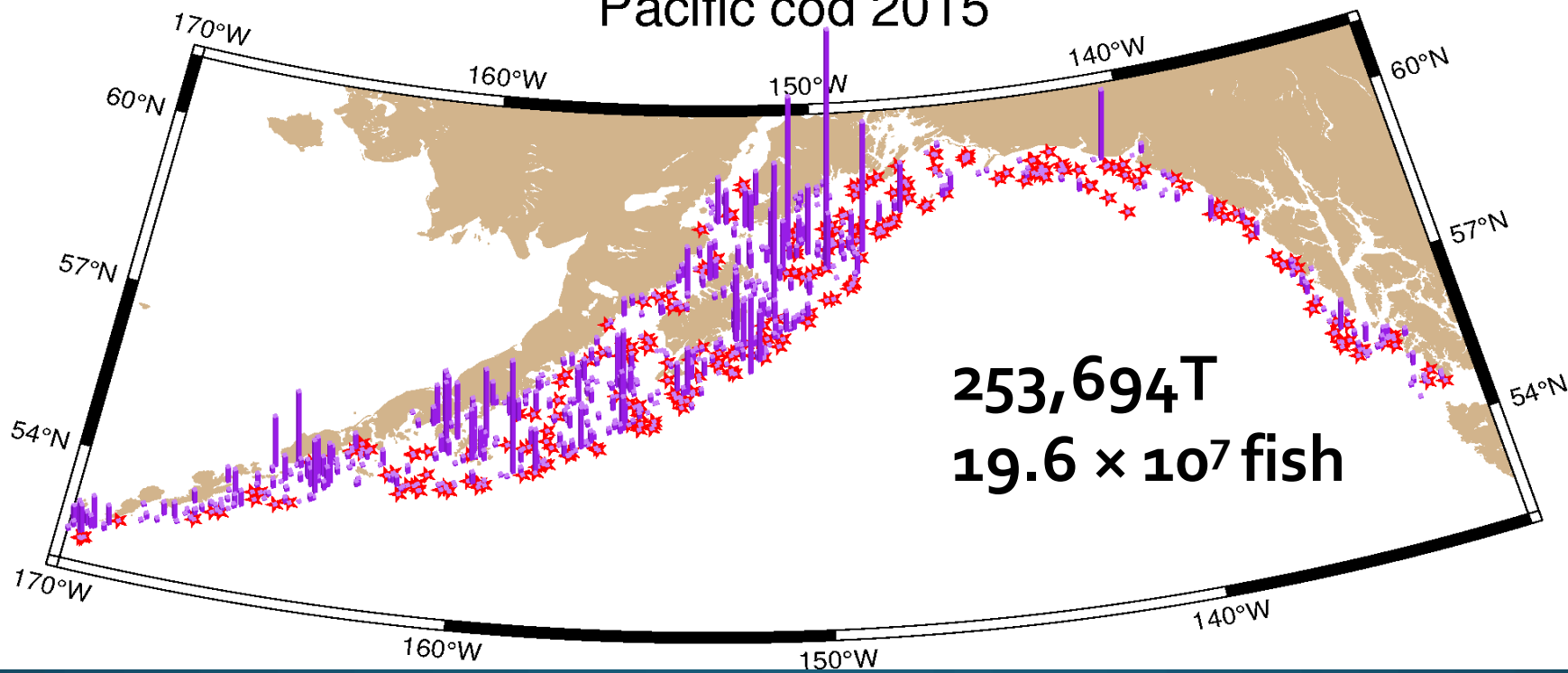
- 126% increase in abundance from 2017
 - 5.6×10^7 to 12.7×10^7 fish
- Second lowest biomass estimate in time series
 - 69% increase to 181,581 t
 - Highest CV in time series (0.243)



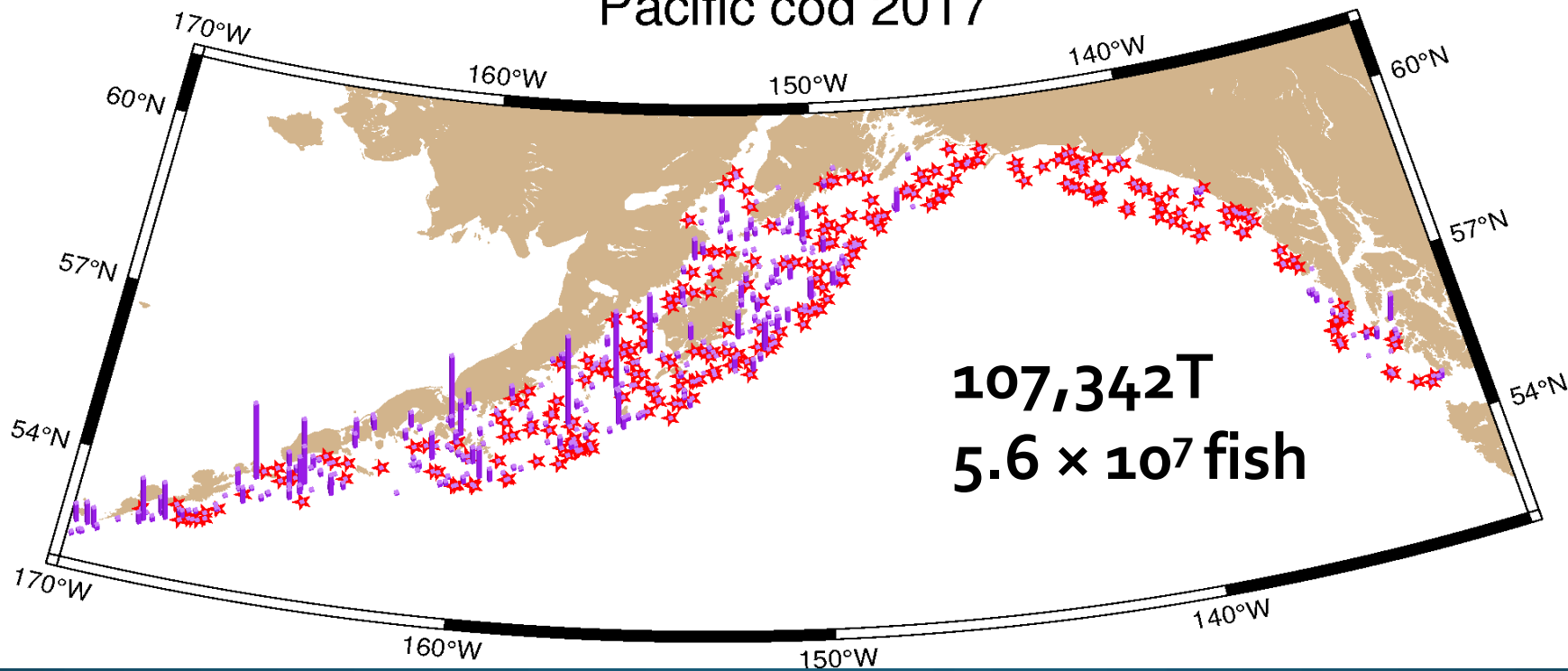
2019



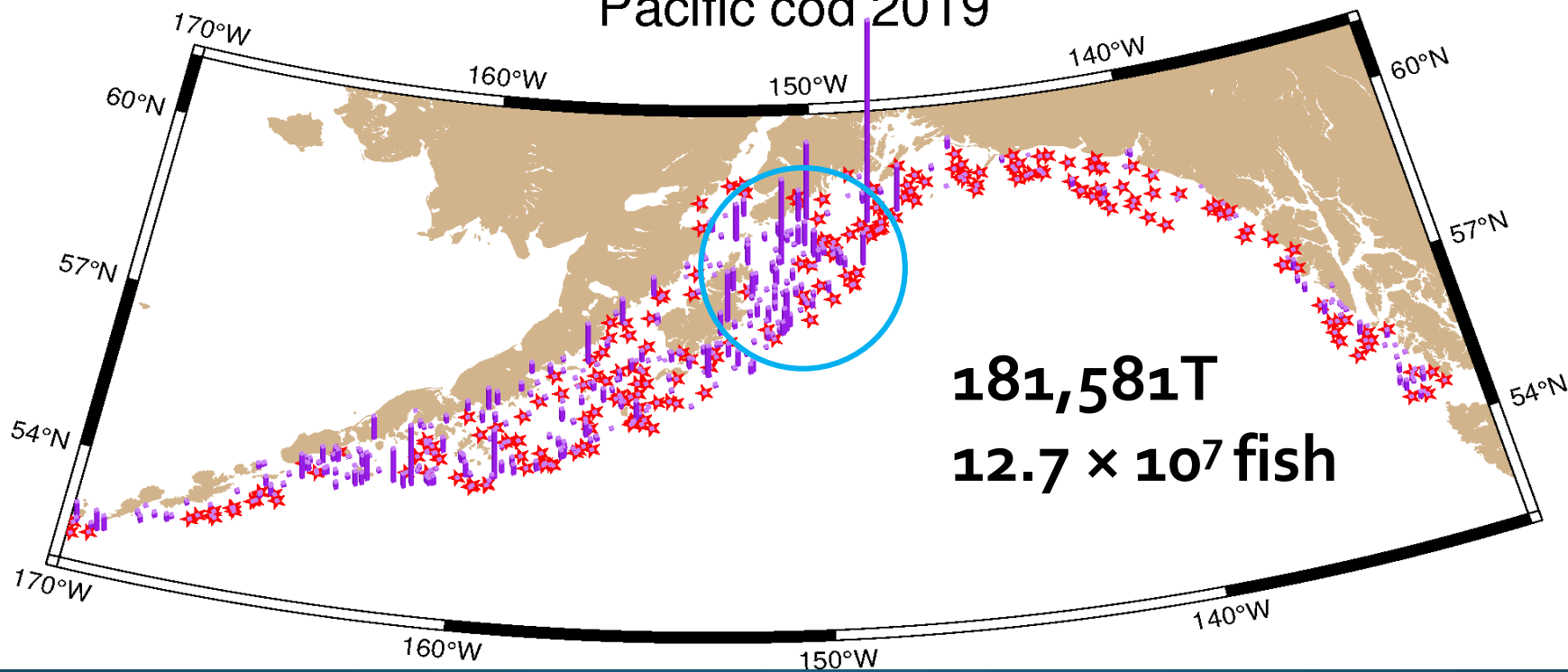
Pacific cod 2015



Pacific cod 2017



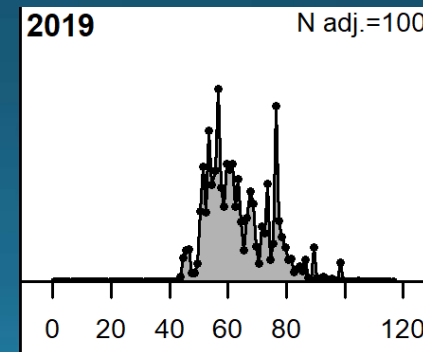
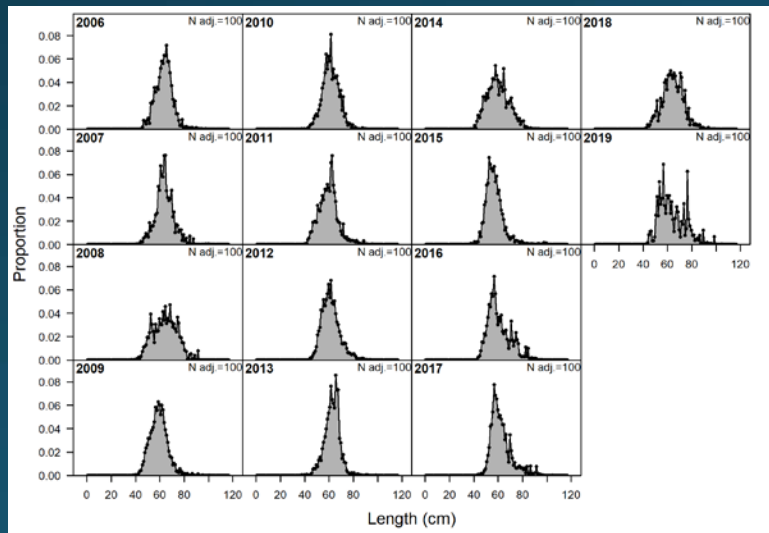
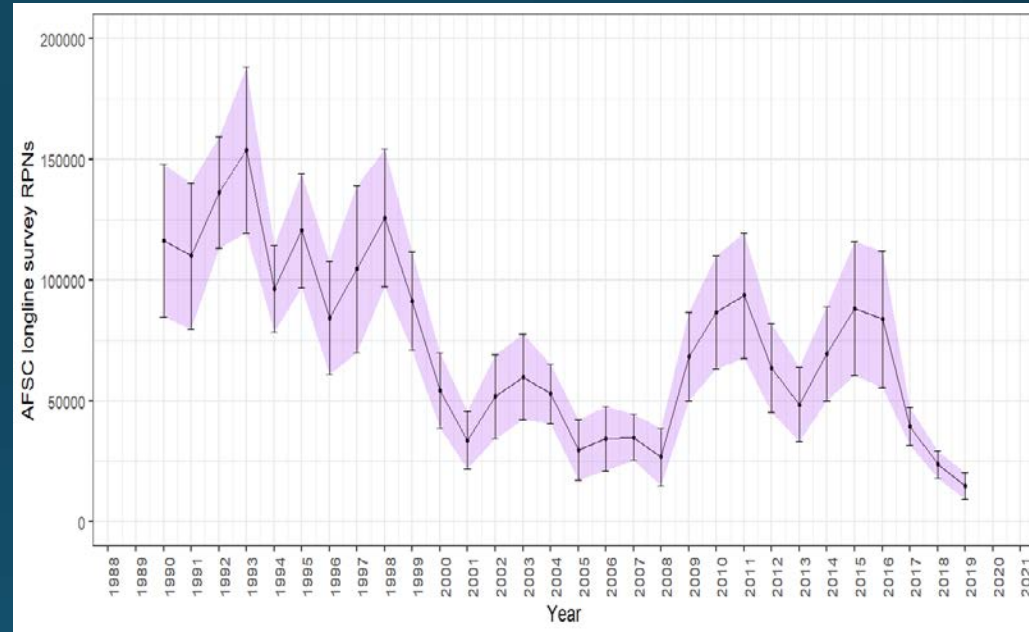
Pacific cod 2019



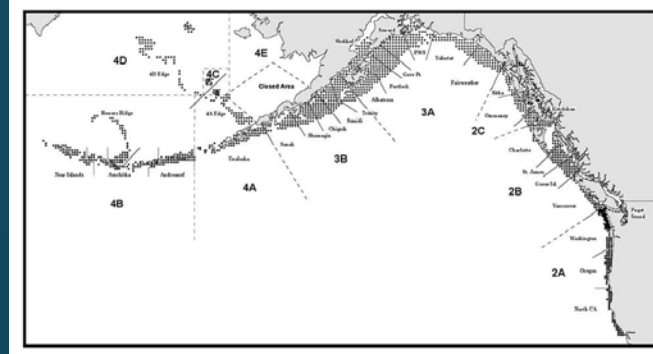
AFSC longline survey



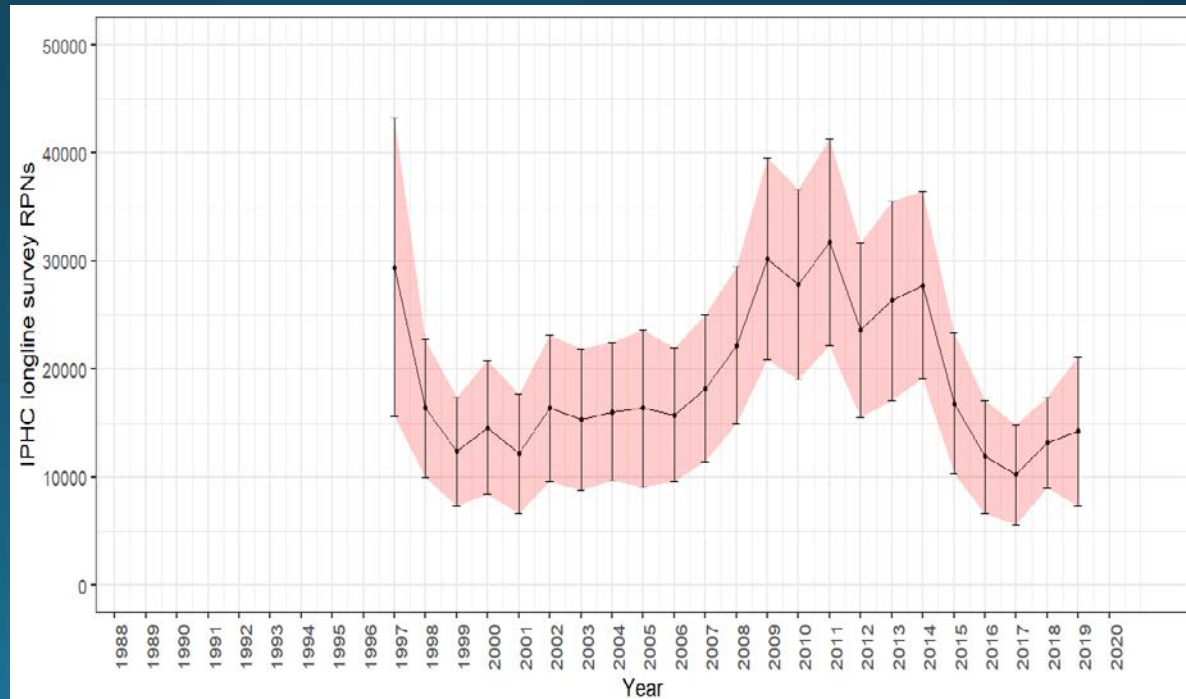
- 2019 Lowest index value in series
 - 19,933 RPN
 - 37% decline from 2018
 - 83% decline since 2015
- Survey of large cod
 - Deep > 150 m depth
 - > ~40 cm

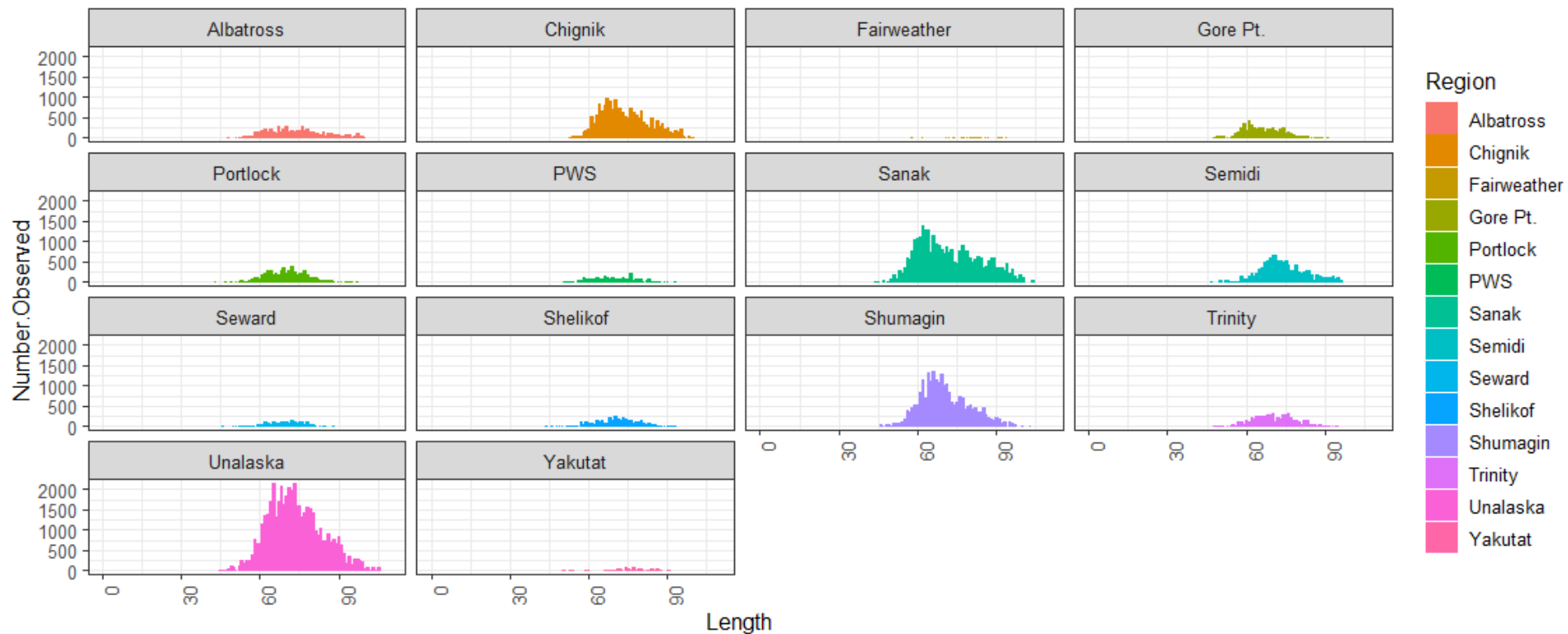
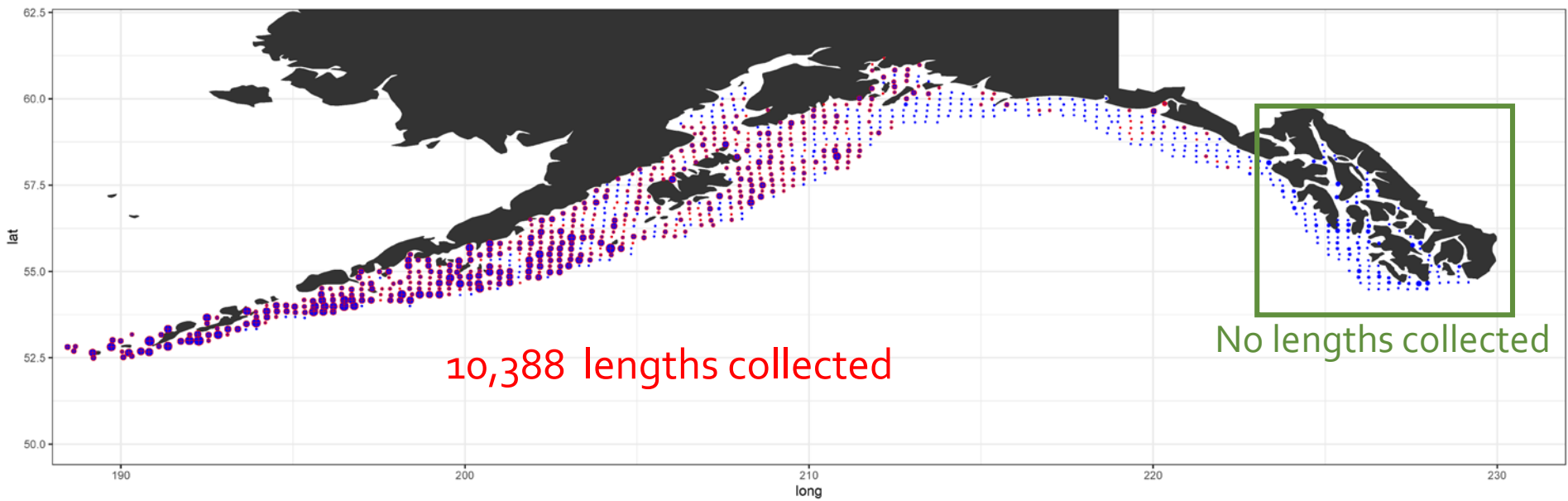


IPHC longline survey 1997-2019



- Surveys GOA shelf area
 - Comparable to AFSC bottom trawl survey
 - 2017 lowest in time series
 - 7.9% increase from 2018 to 2019
 - Highest cv of time series (0.25)

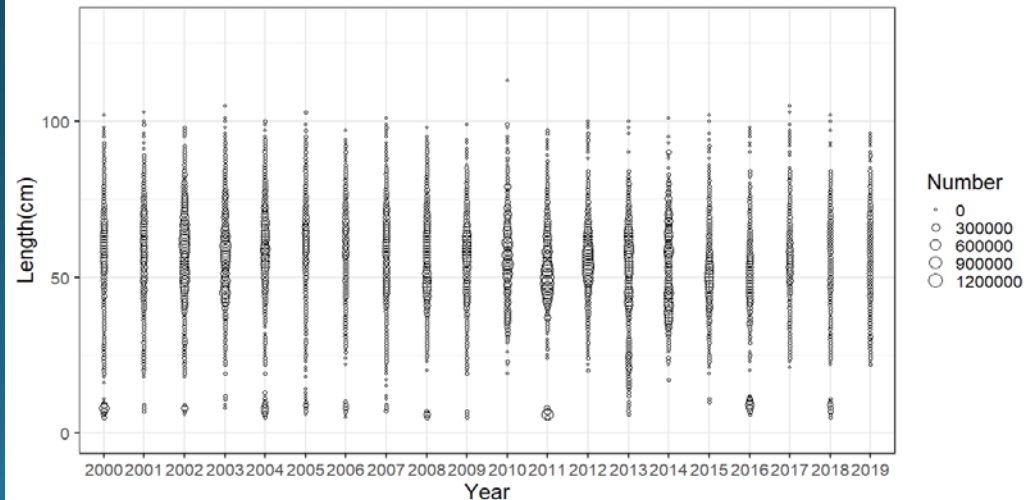
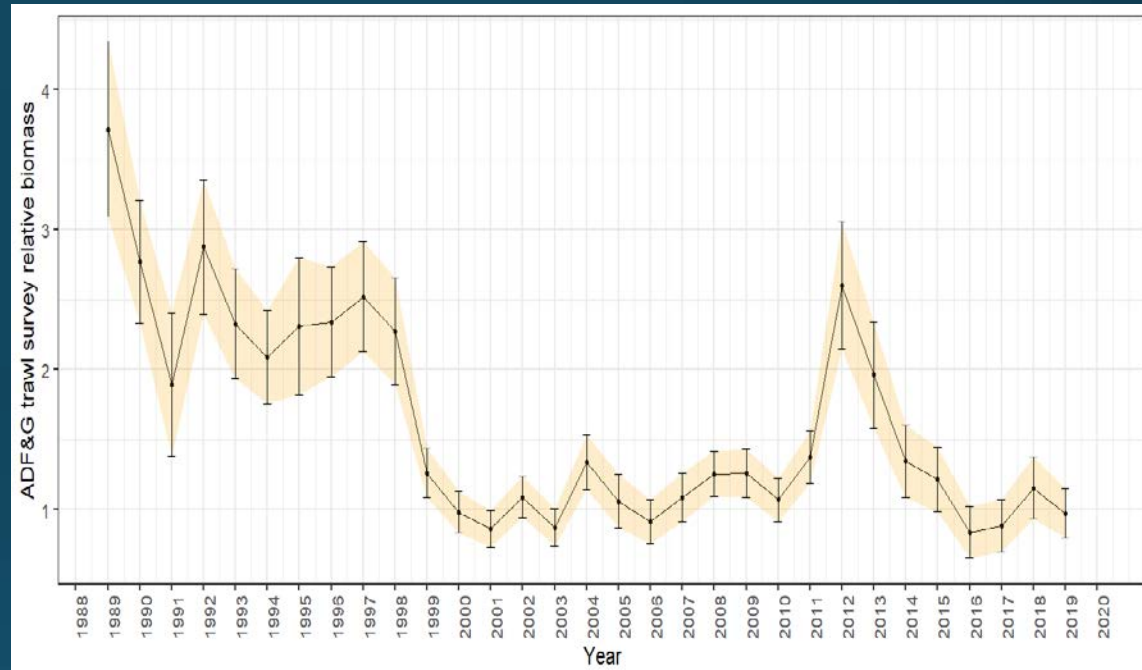






ADF&G large-mesh trawl survey 1990-2018

- Generally near-shore
- Random-effects model used for index
- 2016 lowest relative biomass estimate in series
- 16.4% decrease from 2018 to 2019

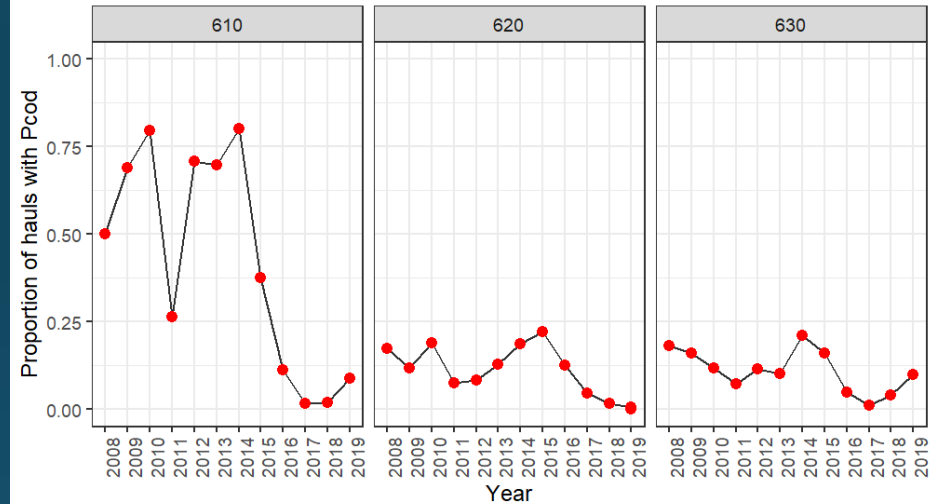




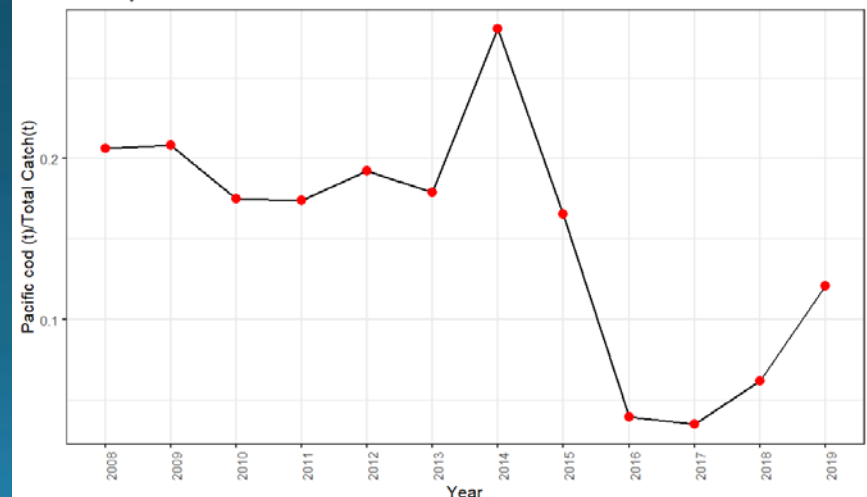
Bycatch rates in pollock and shallow-water flat fisheries

- Encounter rate in pelagic pollock fishery is a mixed signal depending on area
- Up in 610 and 630, down in 620
- Bycatch rate in shallow water flatfish fishery appears higher in 2019 compared to 2016 through 2018
- Remains low compared to prior years

Pcod bycatch in GOA pelagic fisheries 2008-2019 Jan-Feb



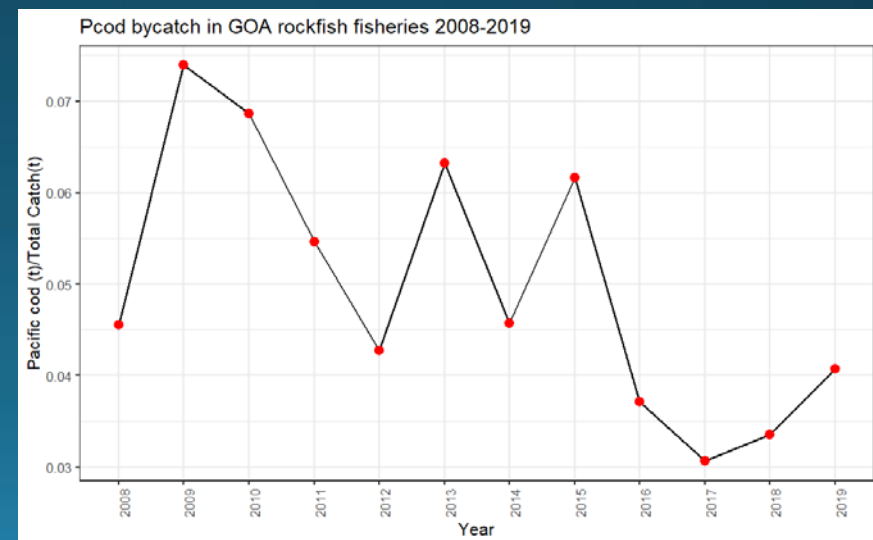
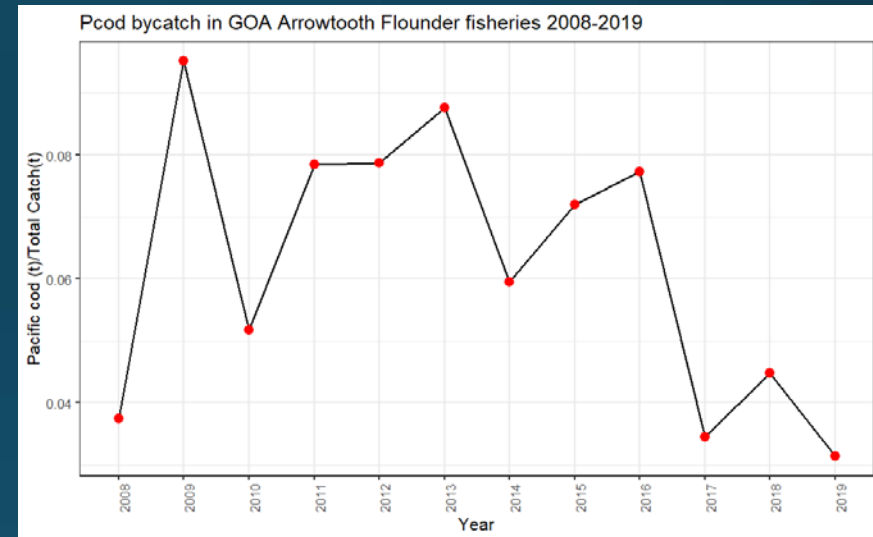
Pcod bycatch in GOA Shallow water flatfish fisheries 2008-2019





Bycatch rates in Arrowtooth and rockfish fisheries

- Bycatch rate in GOA arrowtooth target fishery was up in 2018, but dropped in 2019.
- Bycatch rate in rockfish target fisheries rising since 2017.



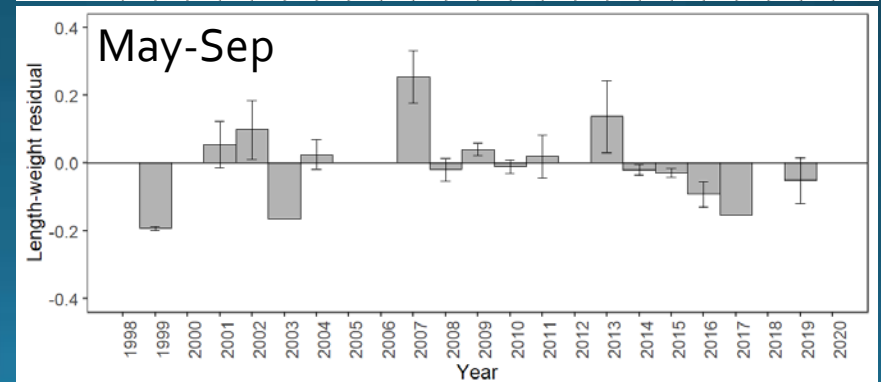
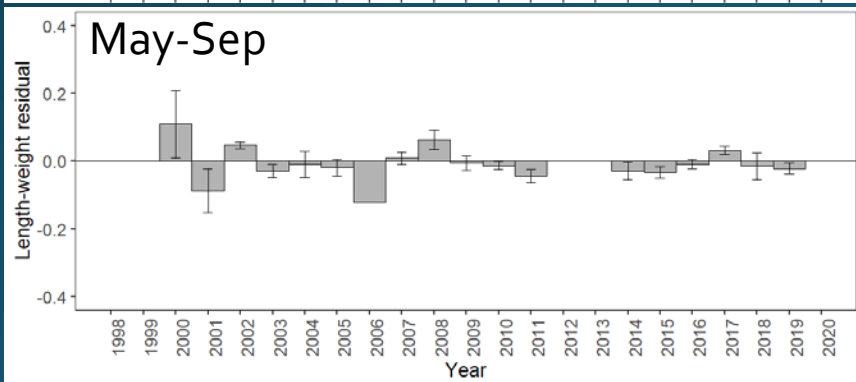
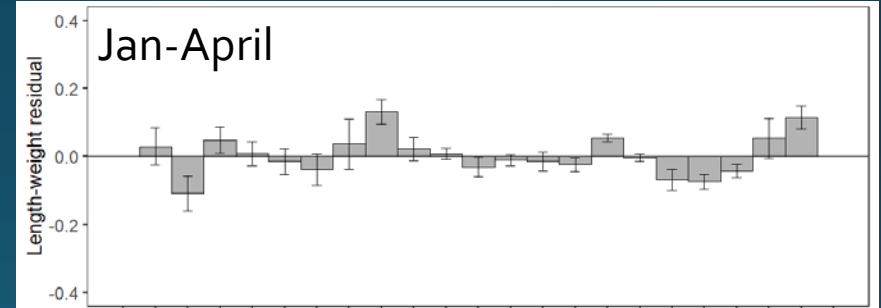
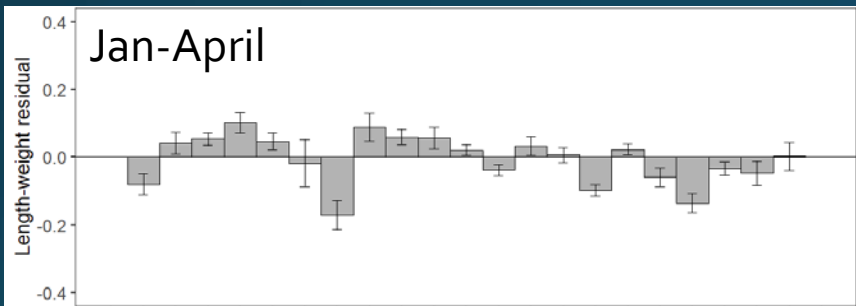


Pacific cod weight at length in fisheries

- Mixed seasonal signals
 - Good to average condition in the Winter/ early Spring
 - Poorer condition in the late Spring/Summer

Western GOA Longline

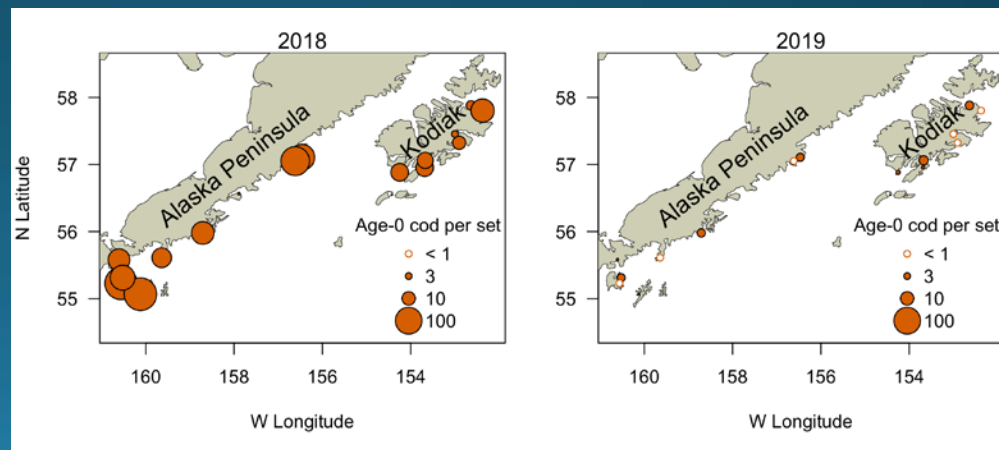
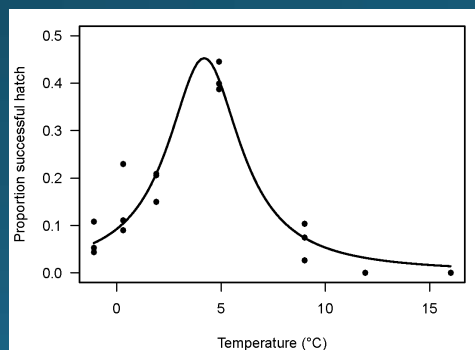
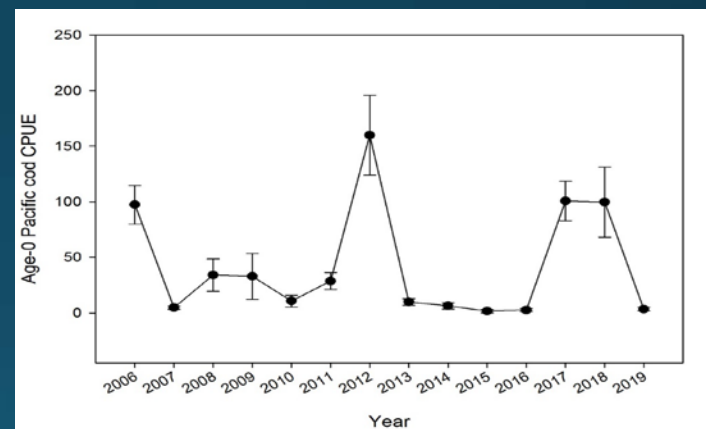
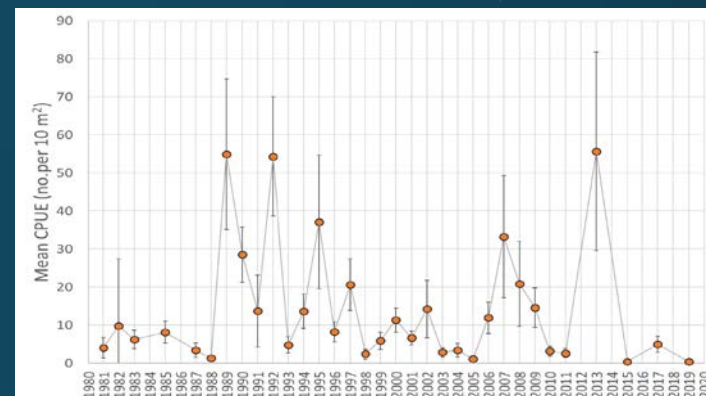
Central GOA Longline





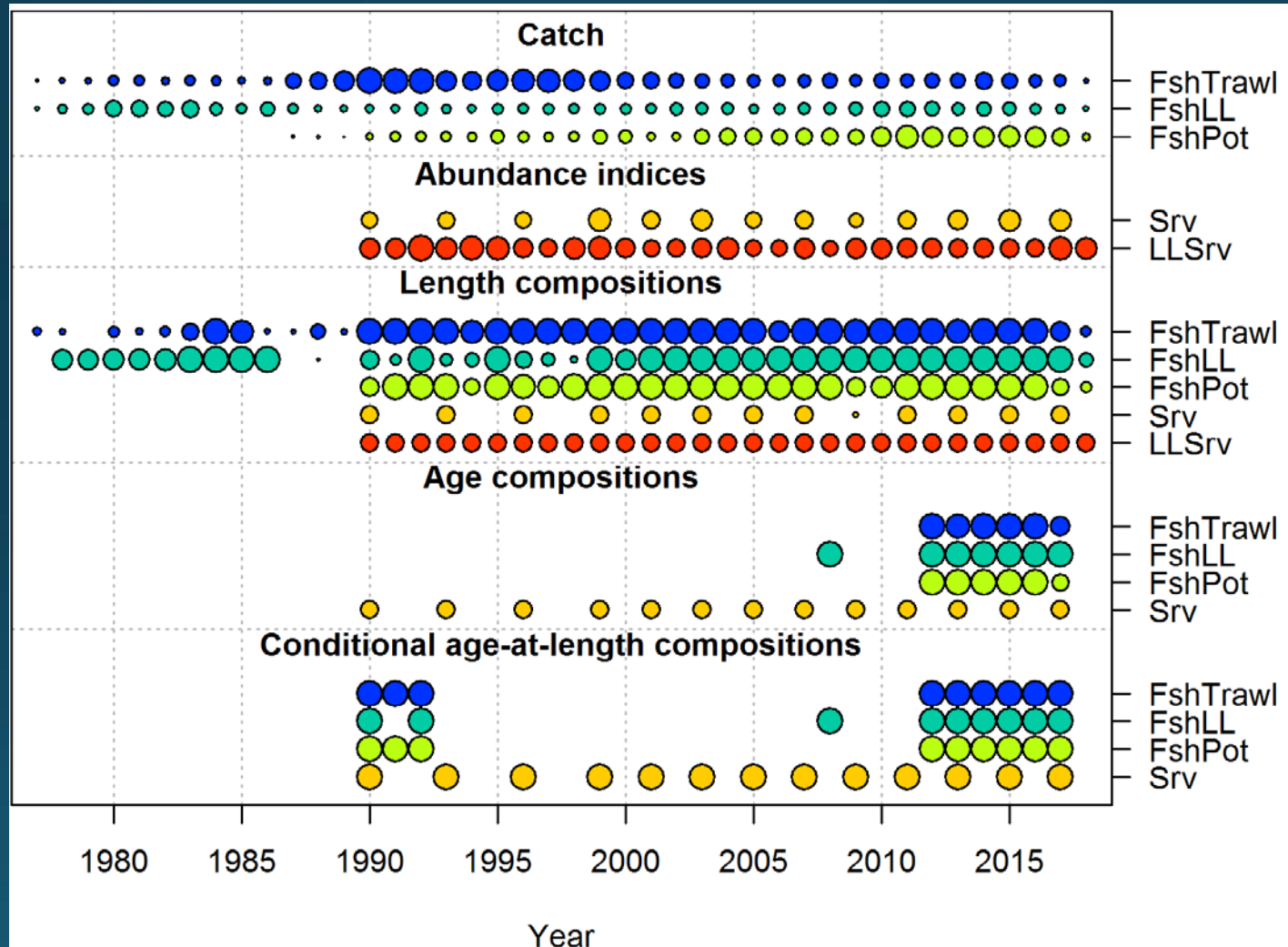
Larval surveys

- Ichthyoplankton survey (1981-2019)
 - 2019 very low
- Age-0 Kodiak beach seine survey (2006-2019)
 - 2019 very low
- Age-0 western GOA beach seine survey (2018-2019)
 - 2019 order of magnitude lower than 2018





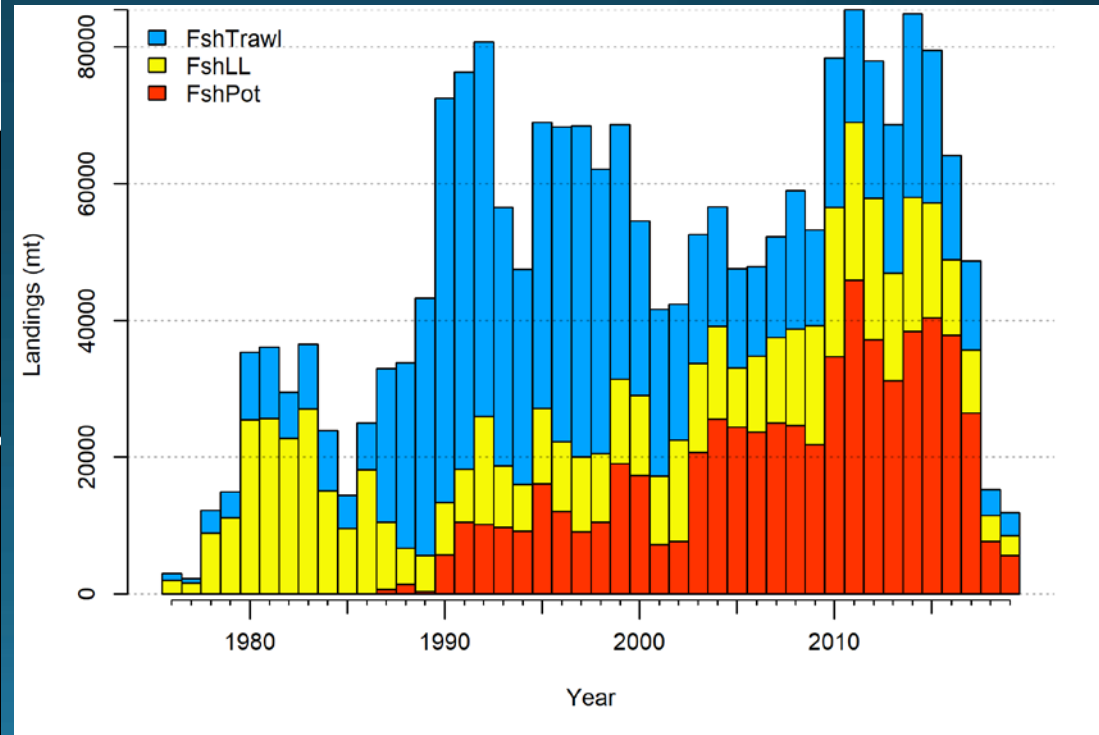
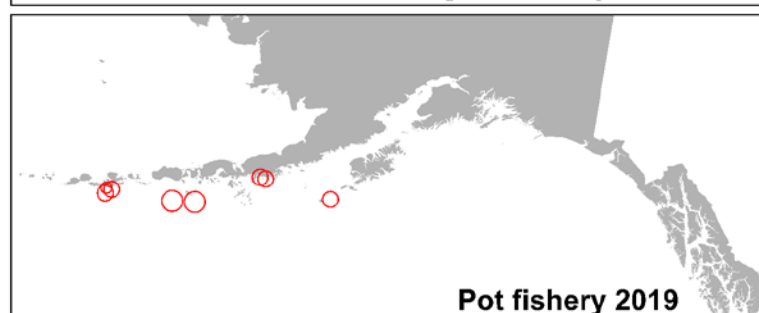
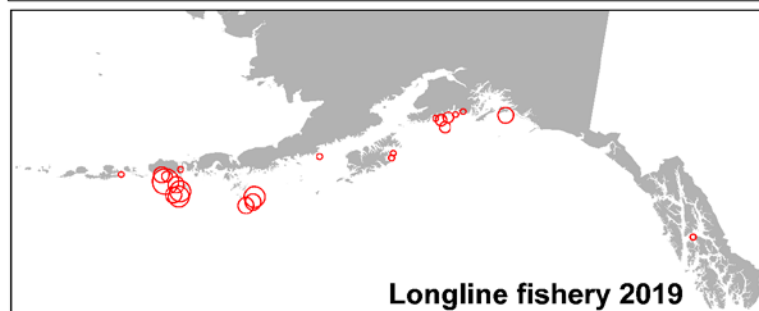
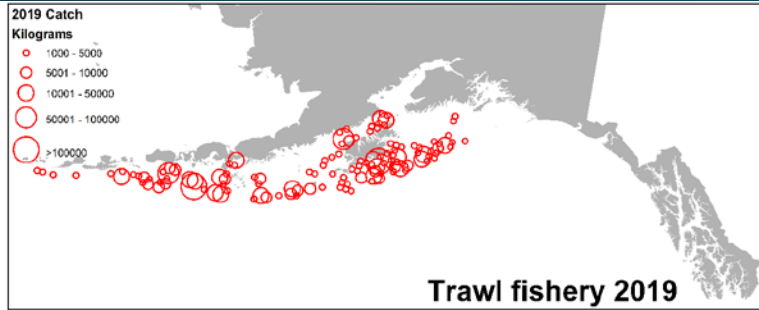
Data used in assessments





Catch

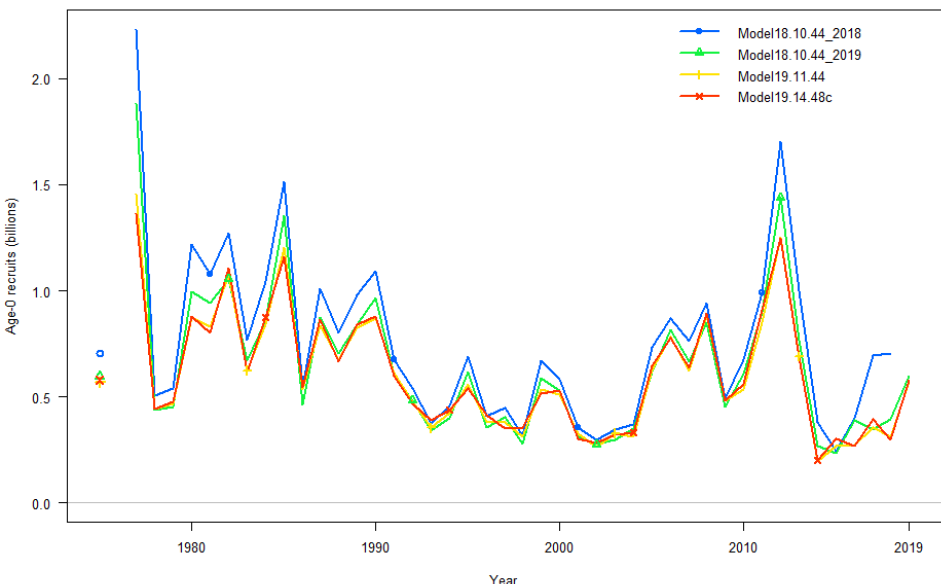
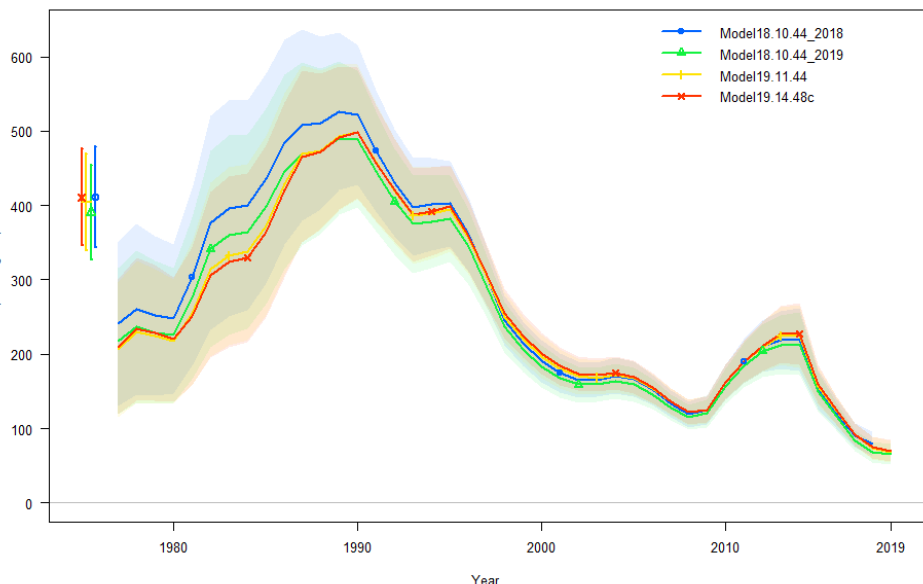
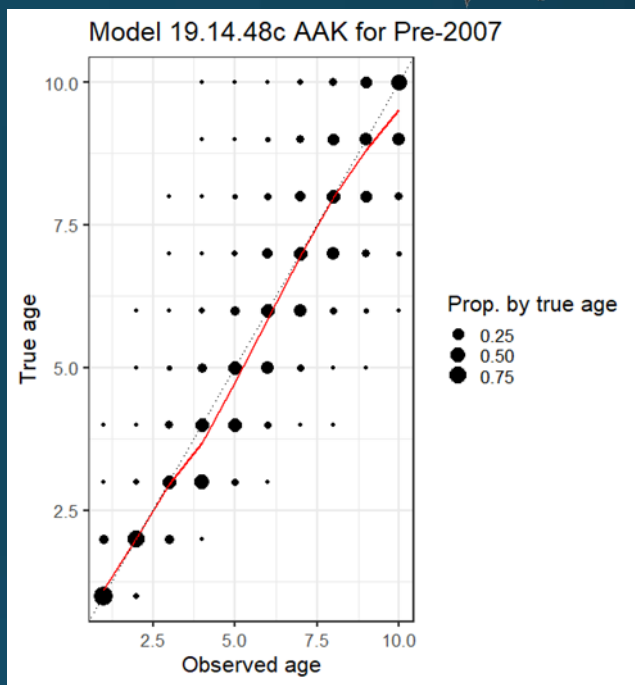
- ABC for 2019 remained low at 17,000 t reduced from 18,000t in 2018
- Total catch in 2019 at $< ABC_{2019} \sim 15,000t$



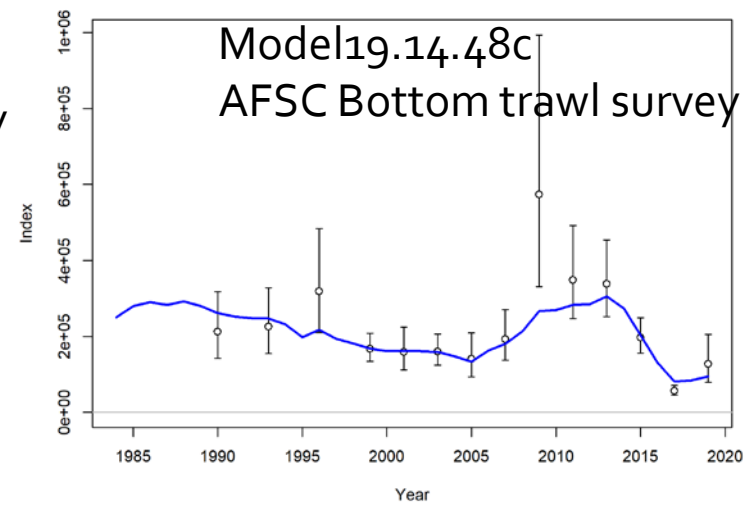
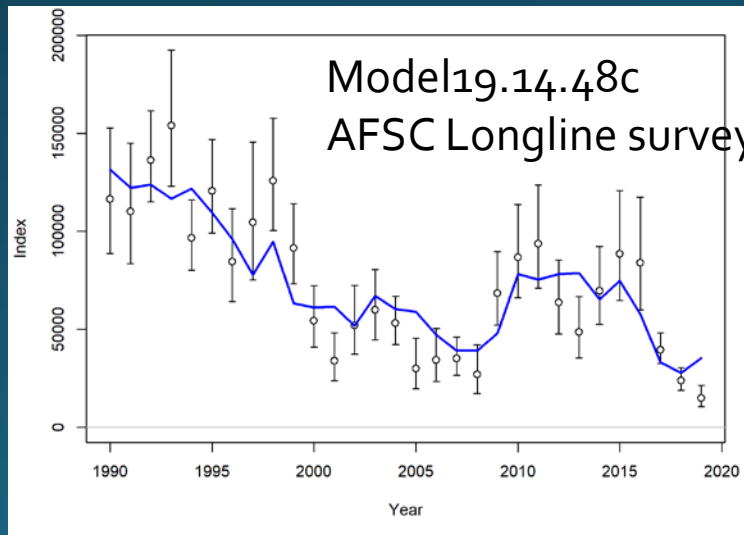
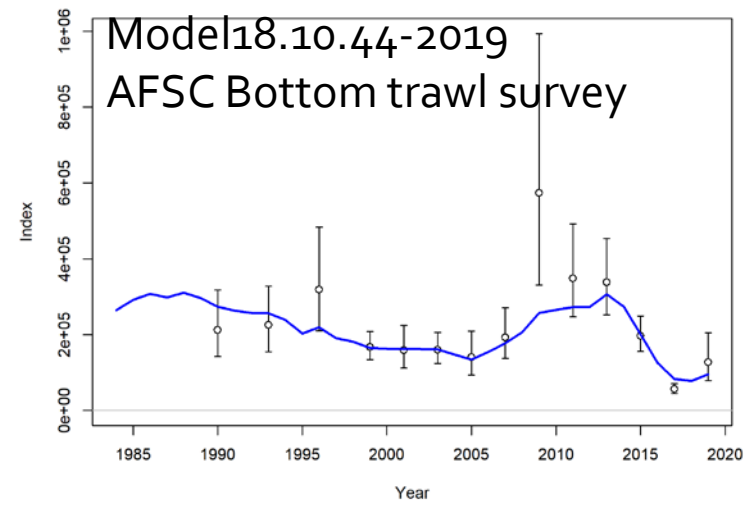
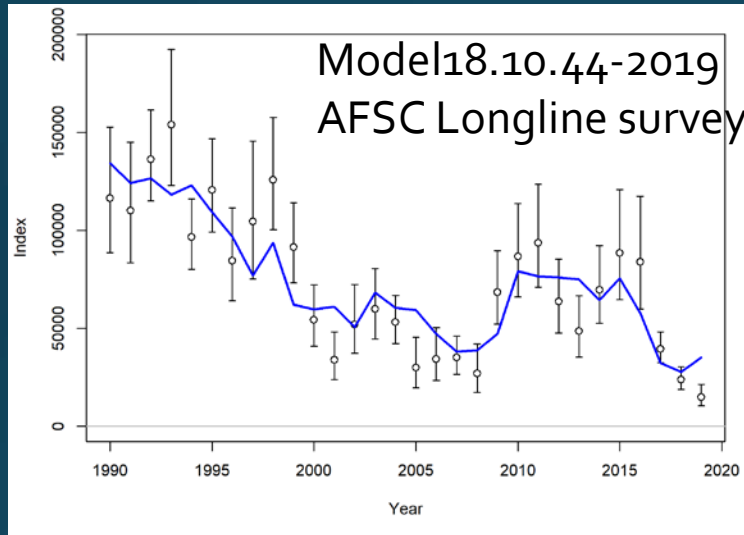


Models reviewed in 2019

Model	Data	Plus group	Aging error	Aging bias
18.10.44	No age data pre-2007	20+	No	No
19.11.44	No age data pre-2007	10+	Yes	No
19.14.48c	All Cond. length at age	10+	Yes	Pre-2007 fit, 2007+ fixed at 0



Index fits



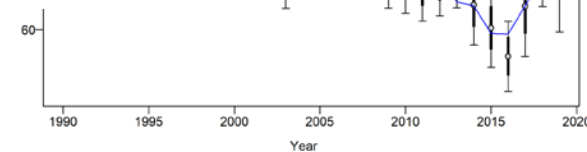
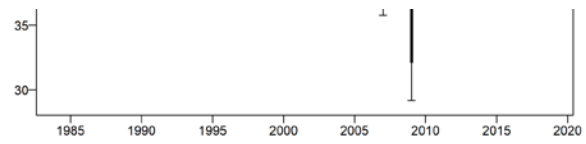
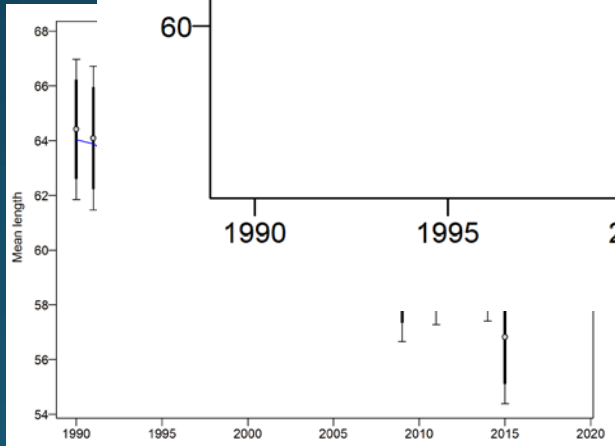
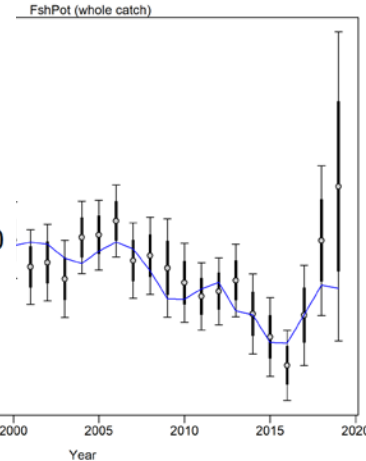
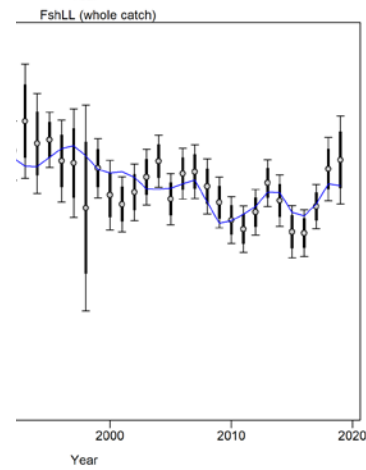
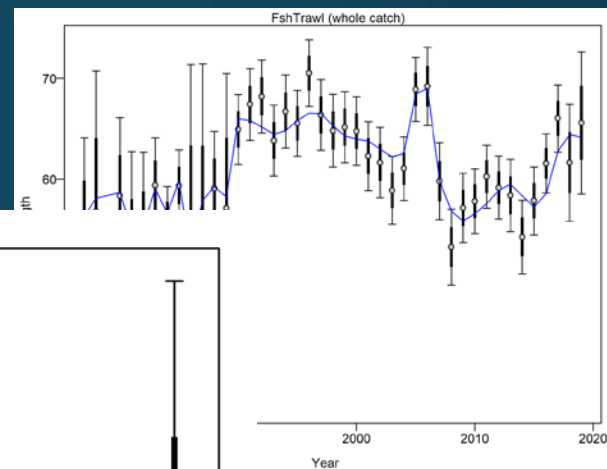
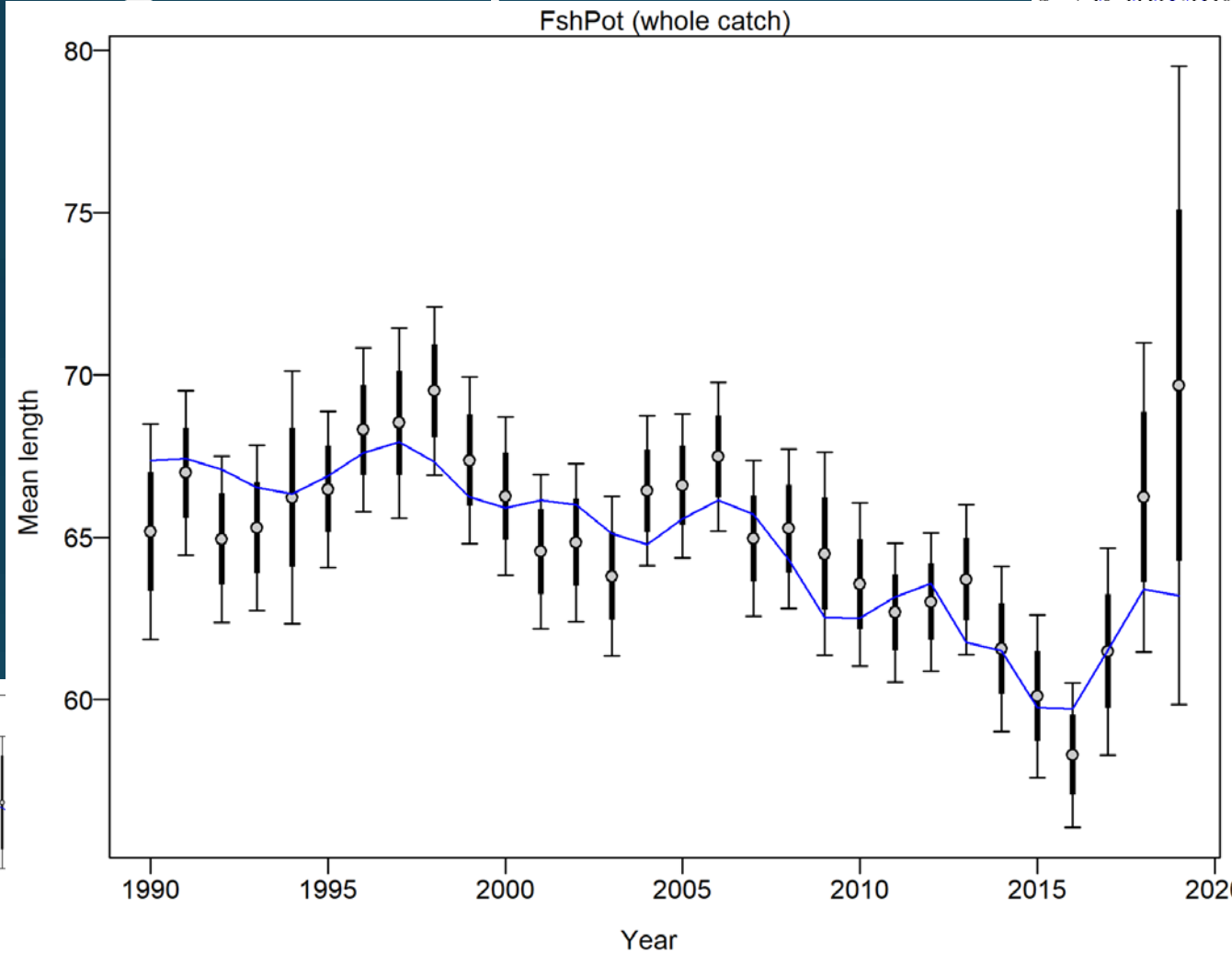
Minor changes in results with major management implications



	M18.10.44	M19.11.44	M19.14.48c
Parameters			
R_0 billions	0.598	0.571	0.579
Steepness	1.0	1.0	1.0
Natural Mortality	0.49	0.49	0.49
M_{14-16}	0.85	0.81	0.81
q_{Shelf}	1.16	1.10	1.08
$q_{longline}$	1.23	1.16	1.15
L_{min}	5.29	3.49	2.30
L_{max}	99.46	99.46	99.46
Von Bert K	0.17	0.18	0.19
Results			
SSB_{1978} (t)	118,283	115,078	117,113
$SSB_{100\%}$ (t)	173,544	185,651	187,780
SSB_{2019} (t)	29,386	32,387	33,274
$SSB_{2010\%}$	16.9	17.4	17.7
SSB_{2020} (t)	29,782	31,840	32,958
$SSB_{2020\%}$	17.2	17.2	17.6
SSB_{2021} (t)	38,841	40,403	42,026
$SSB_{2021\%}$	22.4	21.8	22.4
$F_{35\%}$	0.750	0.676	0.668
$F_{40\%}$	0.603	0.546	0.540

Model 19.14.48c

Length composition fits

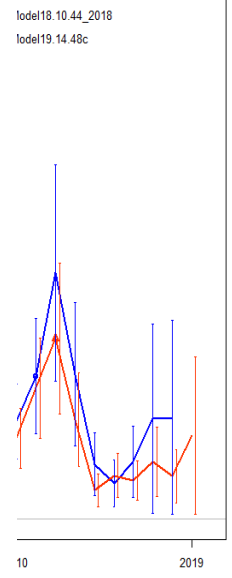
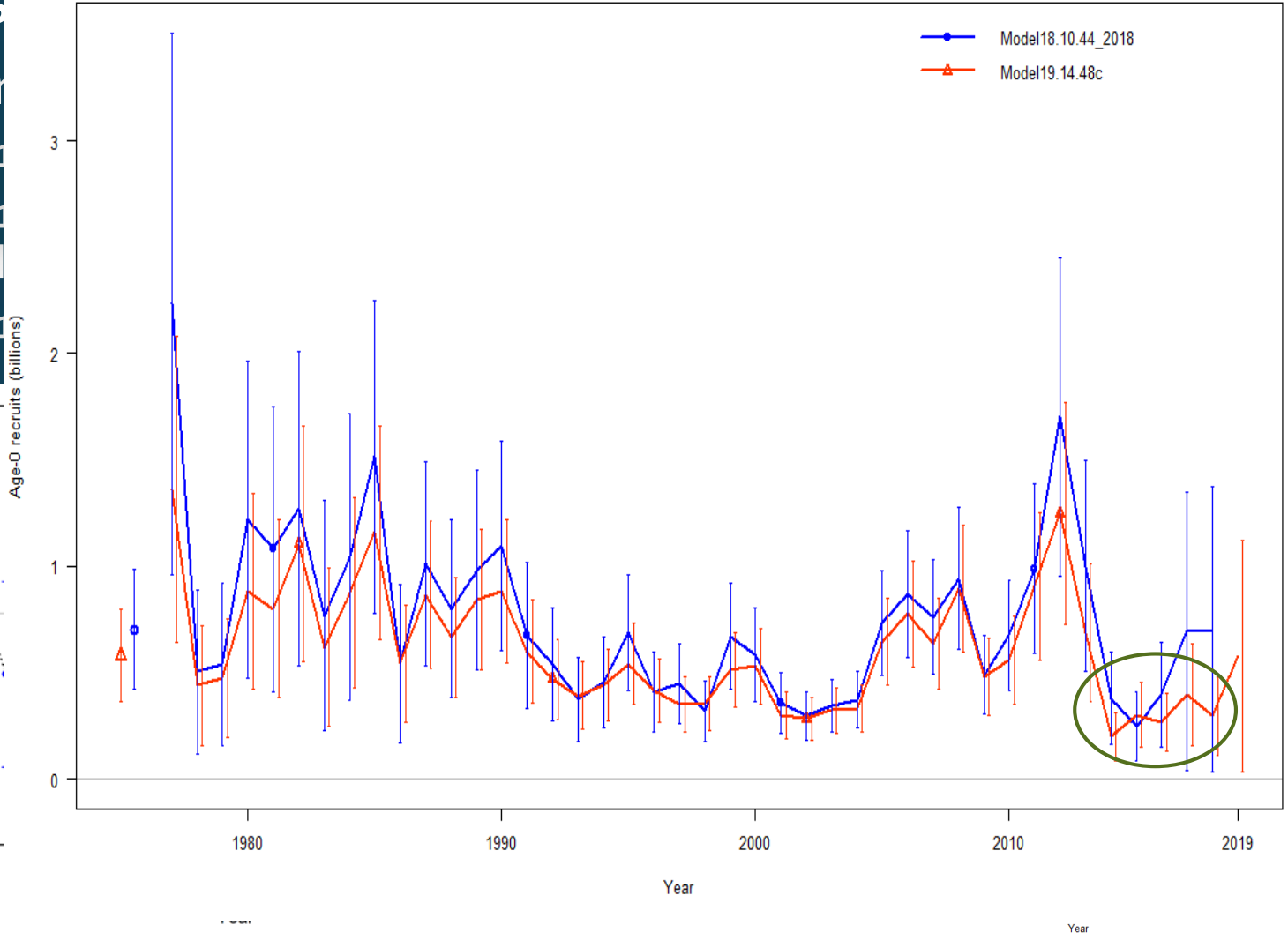
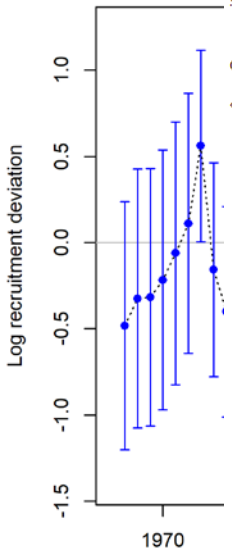




GOA Pacific cod

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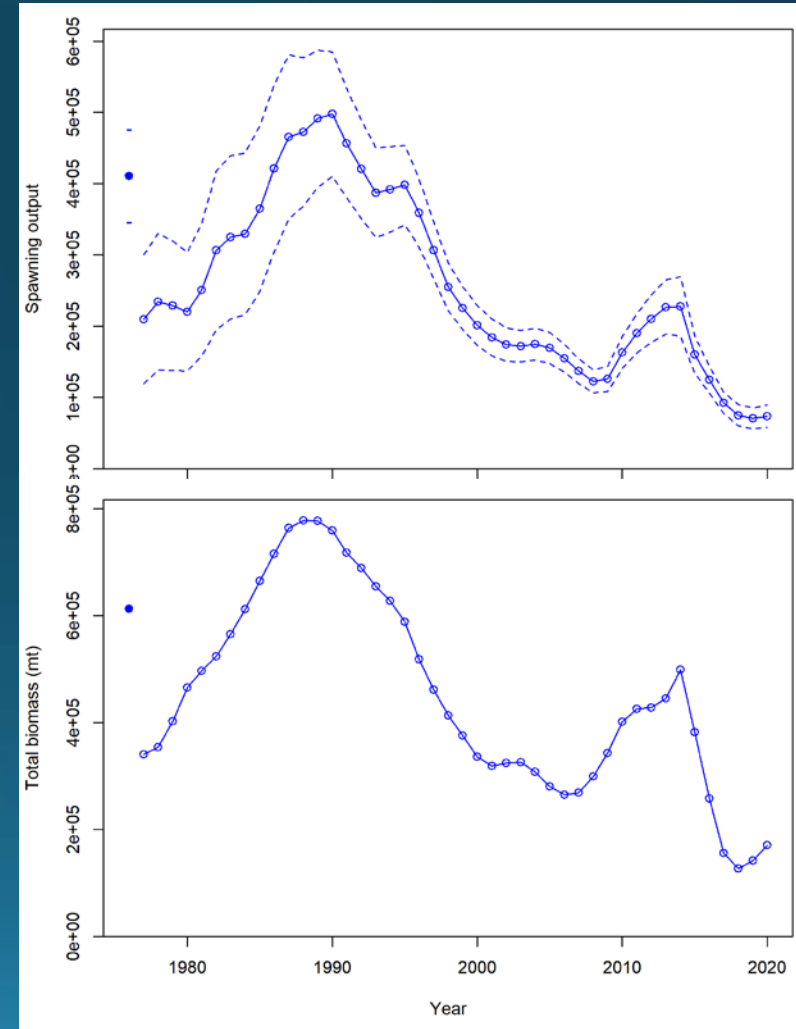
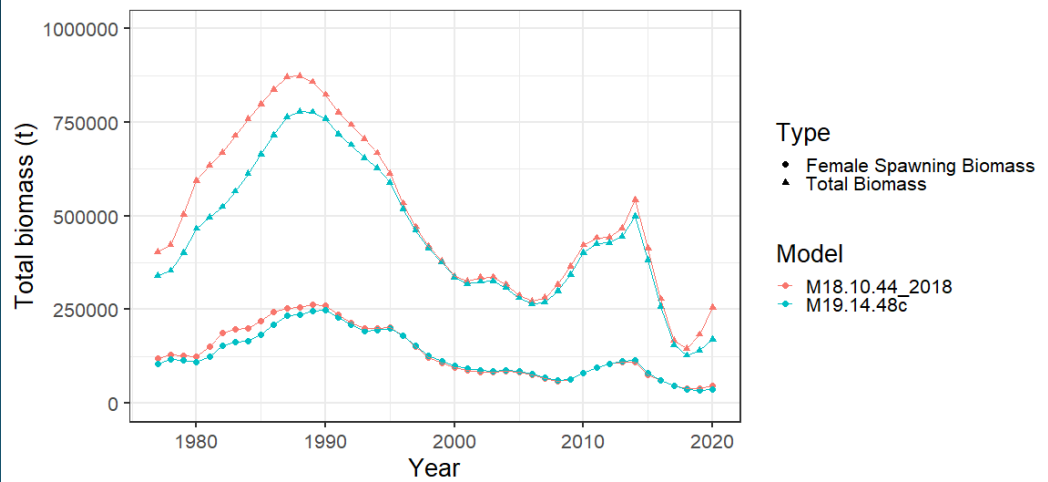




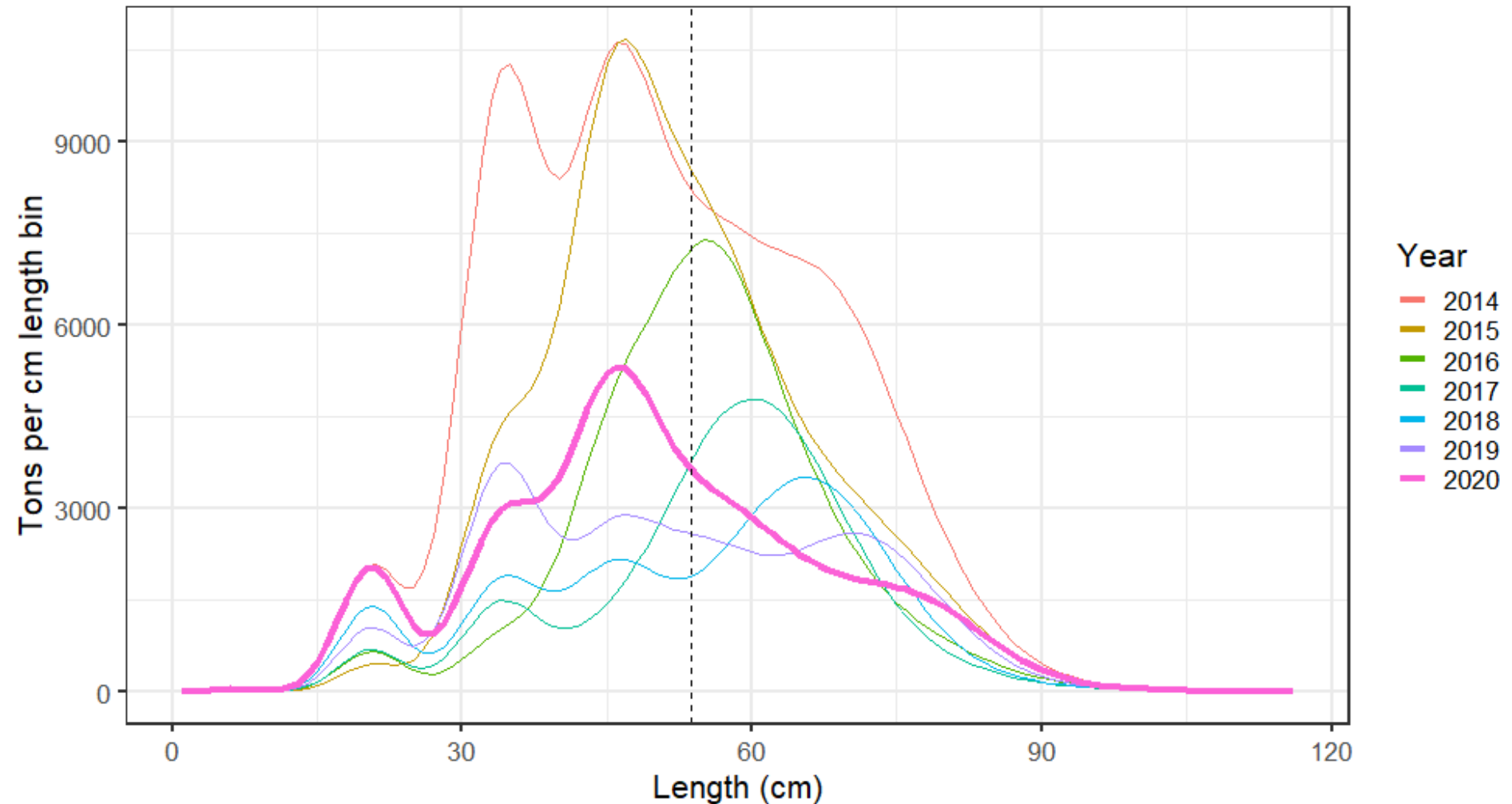
GOA Pacific cod

Assessment Model Spawning Biomass

- Lowest female spawning biomass in 2019 (32,231 t)
- Peak female spawning biomass in 1990 (248,915 t)
- 2018 previous low at 37,369 t
- Dipped to a low of 61,215 in previous low period in 2008
- Build up in 2009-2013 based on large 2005-2008 year classes
- Peak in 2014 total biomass due to large 2011-2012 year classes



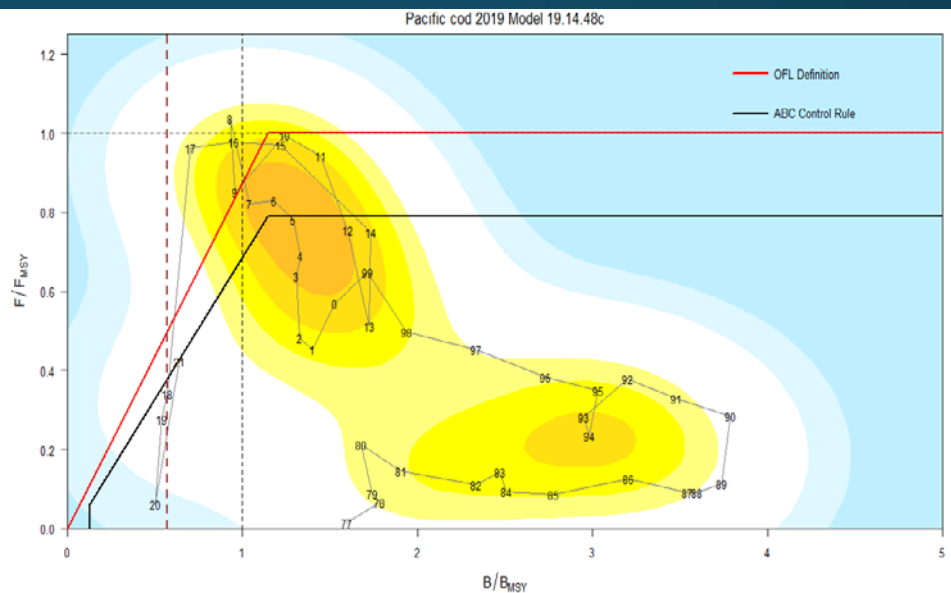
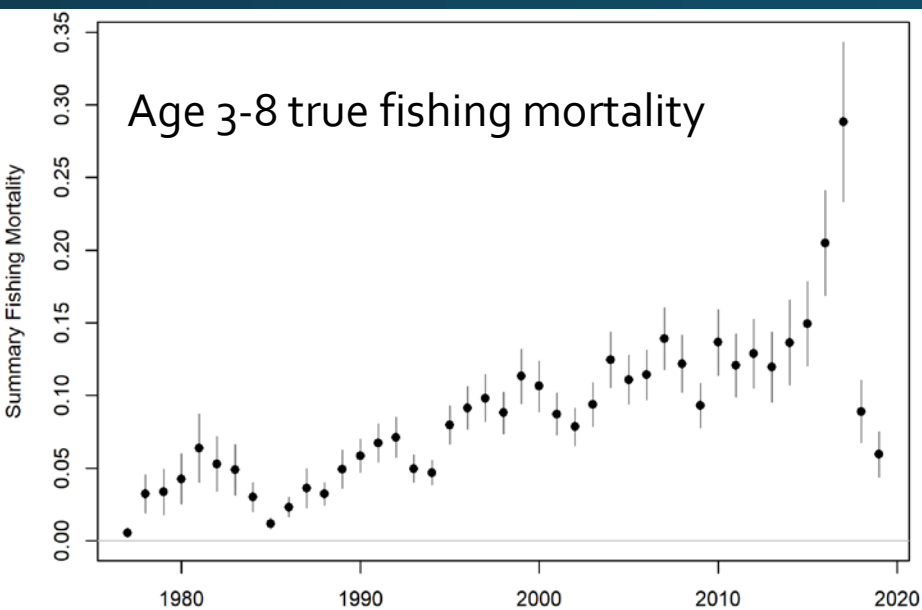
Total biomass by length





GOA Pacific cod Model 19.14.48c Fishing mortality

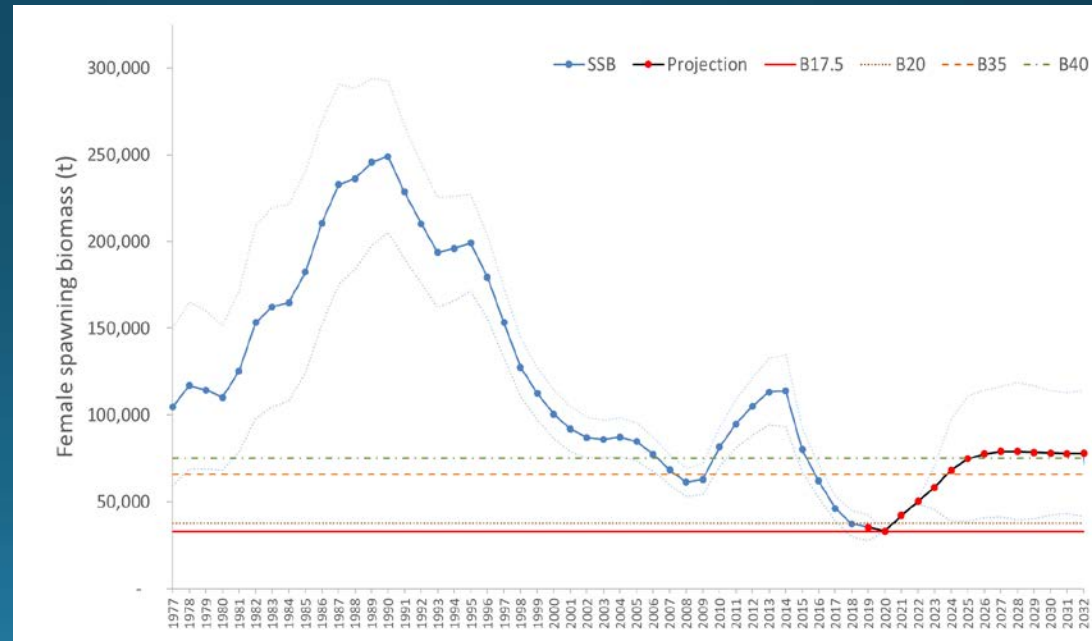
- Increasing trend in F over time until 2018
- Relatively high F 2016-2017
- Below $B_{20\%}$ for 2018-2020
- Projected to be above $B_{20\%}$ in 2021 under average conditions





GOA Pacific cod Assessment Model Projections

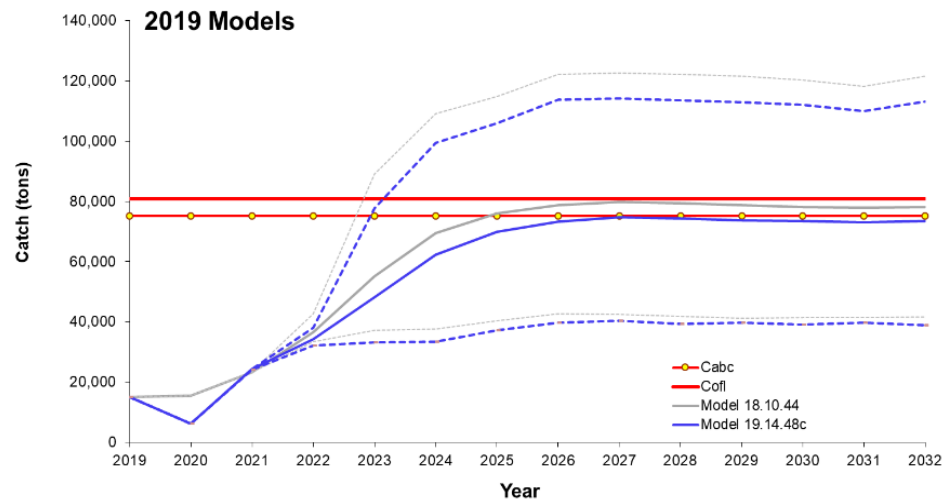
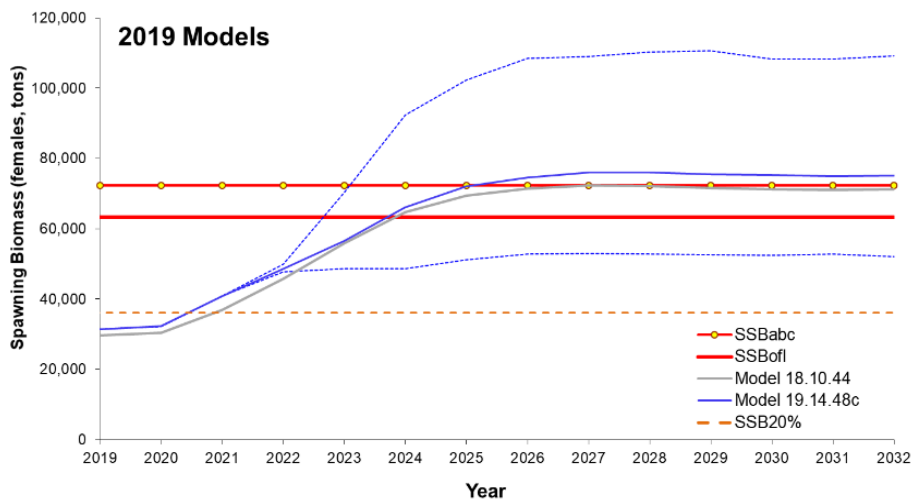
- Spawning biomass projected to reach all-time low in 2020
- Due to high mortality of the 2011 and 2012 age classes and expected poor recruitment 2014-2018
- First increase expected in 2021 given low fishing pressure
- Projection based on average recruitment after 2018





GOA Pacific cod Model 19.14.48c Projections

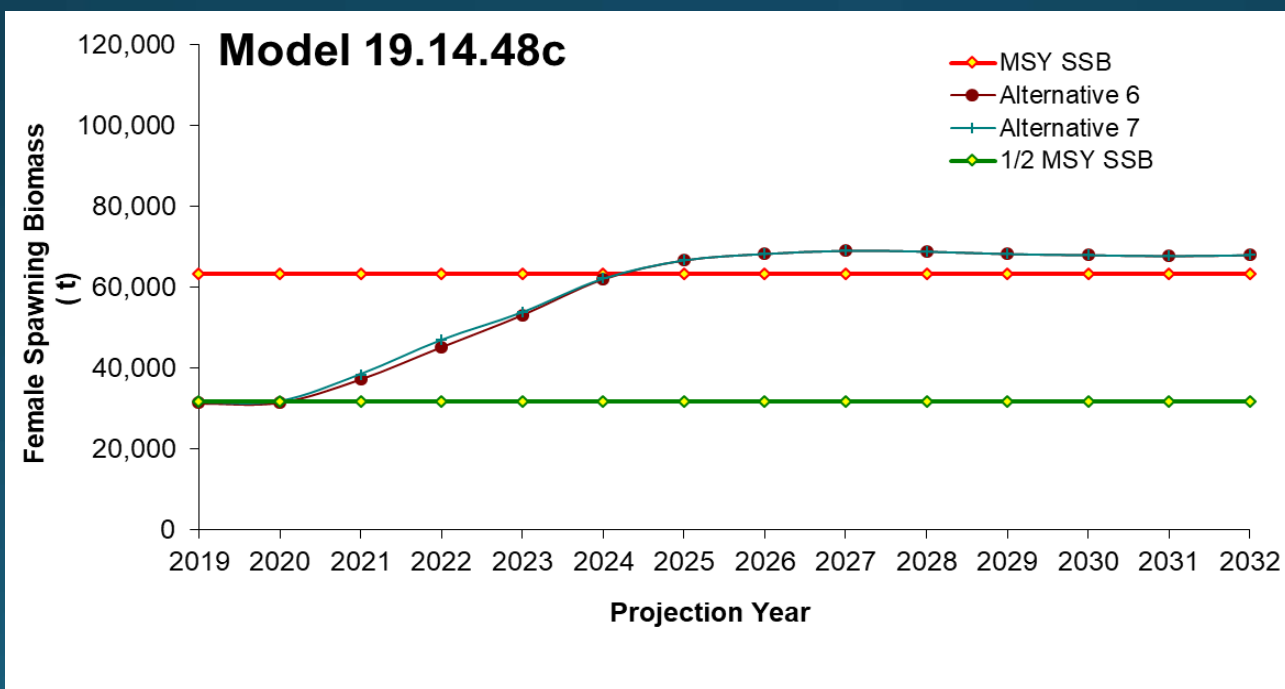
- Below $B_{20\%}$ in 2020
- Adjusted catch to 6,300 t in 2020
 - 3,300t state fishery and
 - 3,000 t as bycatch in other fisheries





GOA Pacific cod Model 19.14.48c Projections

- Above $B_{17.5\%}$ in 2019 and 2020
- Above $B_{35\%}$ by 2029 and 2031
- Not overfished, not overfishing...



GOA Pacific cod Dorn risk matrix

Assessment-related considerations	Population dynamics considerations	Environmental/ecosystem considerations	Fishery Performance	Overall score (highest of the individual scores)
Level 2: Substantially increased	Level 2: Substantially increased	Level 2: Substantially increased	Level 1: Normal	Level 2: Substantially increased

Assessment - Level 2:

- Modeling uncertainty in the early recruitment estimates and model sensitivity relative to other North Pacific assessments where this is not an issue.

Population dynamics - Level 2:

- With average recruitment it is expected that the stock status will improve, however there are indications that 2019 recruitment is well below average.

Environment - Level 2:

- Conditions in 2017 and early 2018 appeared to have improved
- Currently experiencing heatwave (10 Sept 2018 – present)
- Fishery Performance - Level 1:
 - Mixed signals

GOA Pacific cod

Status



Authors' recommended Model 19.14.48c

- $B_{2020} = B_{17.6\%}$
- $B_{2021} = B_{22.4\%}$

- Below $B_{20\%}$ requires shutting down of directed fisheries for SSL concerns in 2020

- MaxABC recommendation at 14,621 t for 2020
- MaxABC recommendation at 24,820 for 2021

- All projections here assume 6,300t of catch in 2020
 - (3,300 t state fishery and 3,000 t bycatch in other fisheries)
- Area apportionment based on random effects model

Quantity	As estimated or <i>specified last</i> year for:		As estimated or <i>specified this</i> year for:	
	2019	2020	2020	2021
<i>M</i> (natural mortality rate)	0.50	0.50	0.49	0.49
Tier	3b	3b	3b	3b
Projected total (age 0+) biomass (t)	207,198	266,066	203,373	261,484
Female spawning biomass (t)				
Projected	34,701	34,774	32,958	42,026
<i>B</i> _{100%}	172,240	172,240	187,780	187,780
<i>B</i> _{40%}	68,896	68,896	75,112	75,112
<i>B</i> _{35%}	60,284	60,284	65,723	65,723
<i>F</i> _{OFL}	0.36	0.36	0.27	0.36
<u><i>maxF</i>_{ABC}</u>	0.29	0.29	0.22	0.29
<i>F</i> _{ABC}	0.25	0.29	0.22	0.29
OFL (t)	23,669	26,078	17,794	30,099
<u><i>maxABC</i> (t)</u>	19,665	21,592	14,621	24,820
ABC (t)	*17,000	21,592	**14,621	**24,820

	Western	Central	Eastern	Total
Random effects area apportionment (last year)	22.7% (44.9%)	70.6% (45.1%)	6.7% (10.0%)	100%
2020 ABC	3,319	10,322	980	14,621
2021 ABC	5,634	17,523	1,663	24,820

M19.14.48c- MCMC

- Well behaved posteriors
 - 1,000,000 iterations (150,000 burn in and thinned by 1,000)
- Results
 - 85.3% probability of being $\leq B_{20\%}$ in 2019
 - 39.8% probability of being $\leq B_{17.5\%}$ in 2019
 - 73.3% probability of being $\leq B_{20\%}$ in 2020
 - 27.7% probability of being $\leq B_{17.5\%}$ in 2020

