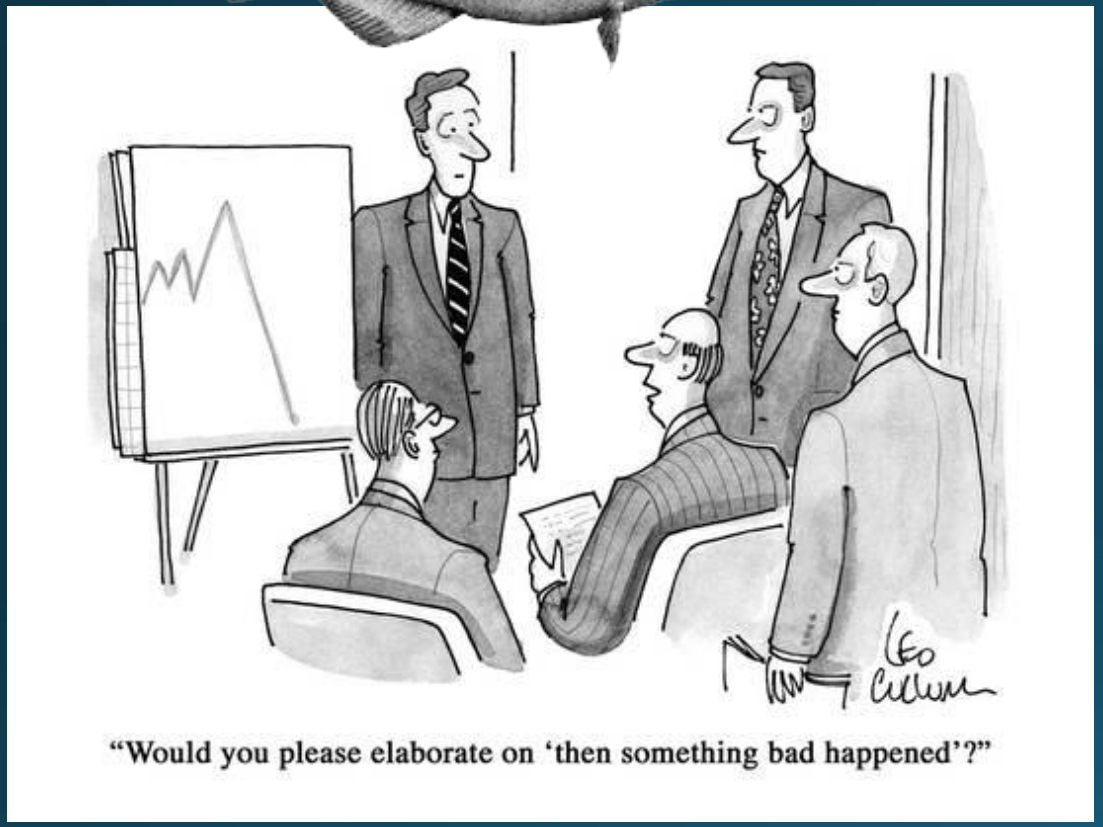
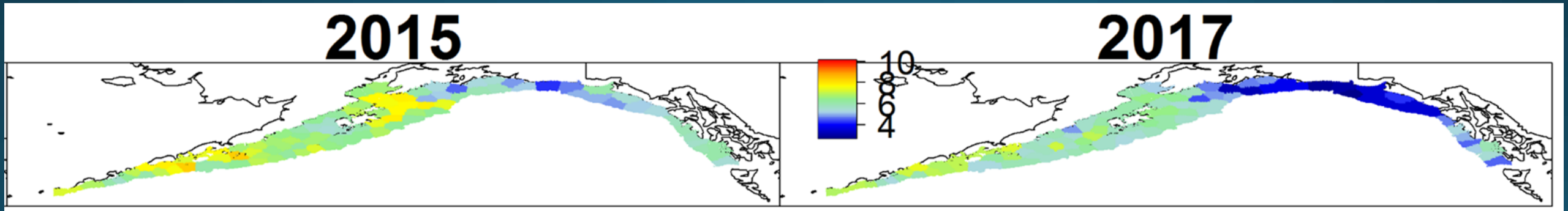


Gulf of Alaska Pacific cod

Steven J. Barbeaux, Kerim Aydin, Ben Fissel, Kirstin Holsman, Kalei Shotwell, Wayne Palsson, Qiong Yang, and Stephani Zador
NPFMC SSC

December 5, 2017



GOA Groundfish Economics

- The 2016 Gulf of Alaska groundfish fisheries generated $354 million in first-wholesale revenue which represents 15% of the Alaska groundfish value and 30% of the value of all commercial fisheries in the GOA
- The GOA groundfish fisheries support jobs on over 650 vessels with approximately 23,000 crew weeks.
- The average annual first-wholesale revenue of P. cod over the past 10 years (2007-2016) is $103 million.

Economic analysis by Ben Fissel

GOA Pacific cod Status

- Tier 3b ($B_{2018} = B_{21.5\%}$)
- 77% decrease in ABC from last year's projection
  - **Max ABC 2018 = 19,401 t**
  - **Recommended ABC 2018 = 18,000 t**
  - **Max ABC 2019 = 17,634 t**
  - **Recommended ABC = 17,000 t**
- Apportionment based on random effects model

Authors' recommended Model 17.09.35

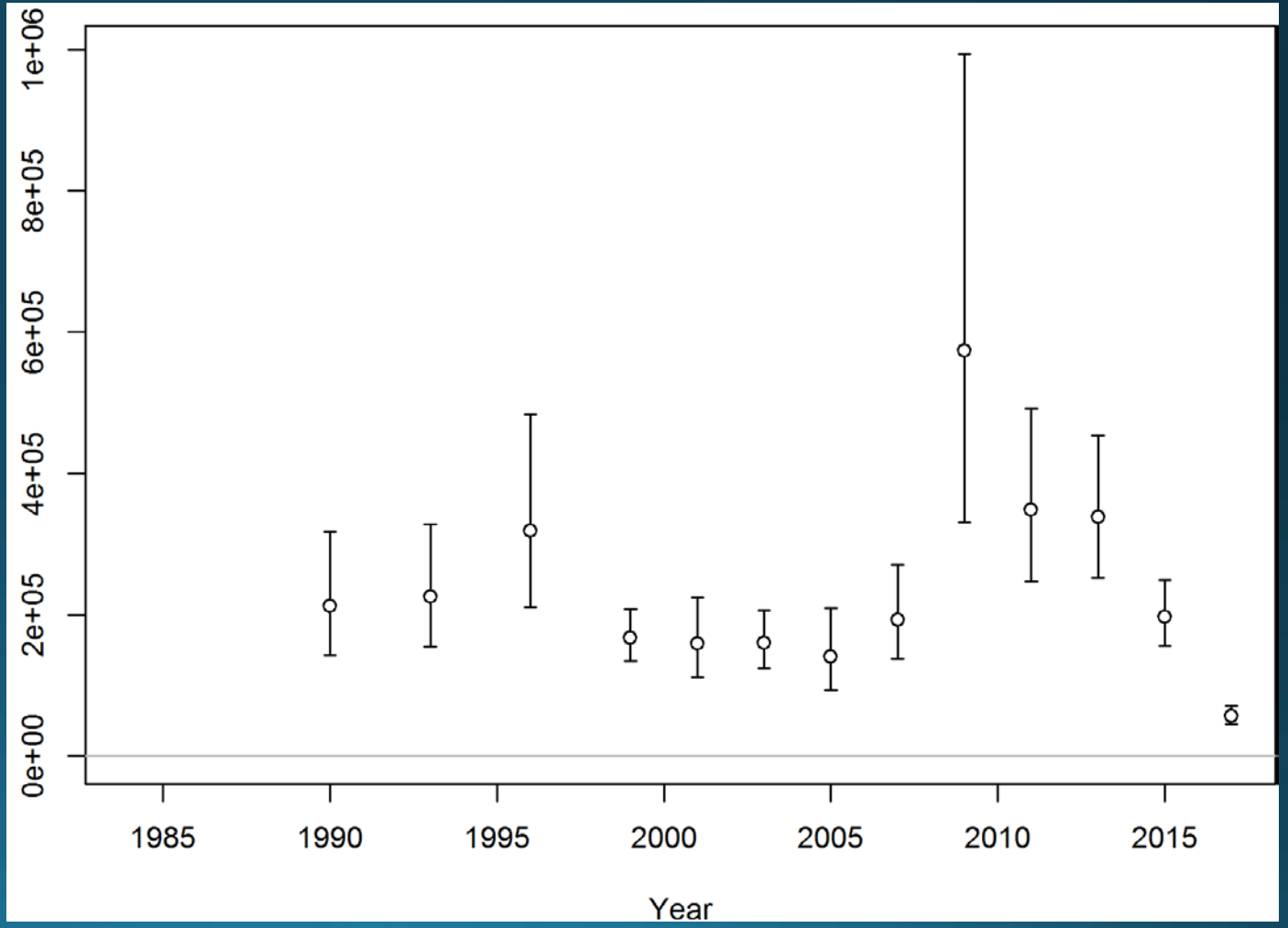
	As estimated or specified last year for:		As estimated or specified this year for:	
Quantity	2017	2018	2018	2019
M (natural mortality rate)	0.47	0.47	0.49	0.49
Tier	3a	3a	3b	3b
Projected total (age 0+) biomass (t)	426,384	428,885	170,565	198,942
Female spawning biomass (t)				
Projected	91,198	98,479	36,209	34,424
$B_{100\%}$	196,776	196,776	168,583	168,583
$B_{40\%}$	78,711	78,711	67,433	67,433
$B_{35\%}$	68,872	68,872	59,004	59,004
F_{OFL}	0.652	0.652	0.42	0.40
$maxF_{ABC}$	0.530	0.530	0.34	0.32
F_{ABC}	0.530	0.530	0.31	0.31
OFL (t)	105,378	94,188	23,565	21,412
maxABC (t)	88,342	79,272	19,401	17,634
ABC (t)	88,342	79,272	**18,000**	**17,000**
	As determined this year for:			
Status	2015	2016	2016	2017
Overfishing	no	n/a	No	n/a
Overfished	n/a	no	n/a	No
Approaching overfished	n/a	no	n/a	No

	Western	Central	Eastern	Total
Random effects area apportionment (percent)	44.9	45.1	10.0	100.00
2018 ABC	**8,082**	**8,118**	**1,800**	**18,000**
2019 ABC	**7,633**	**7,667**	**1,700**	**17,000**

GOA Pacific cod
2017 Bottom trawl survey

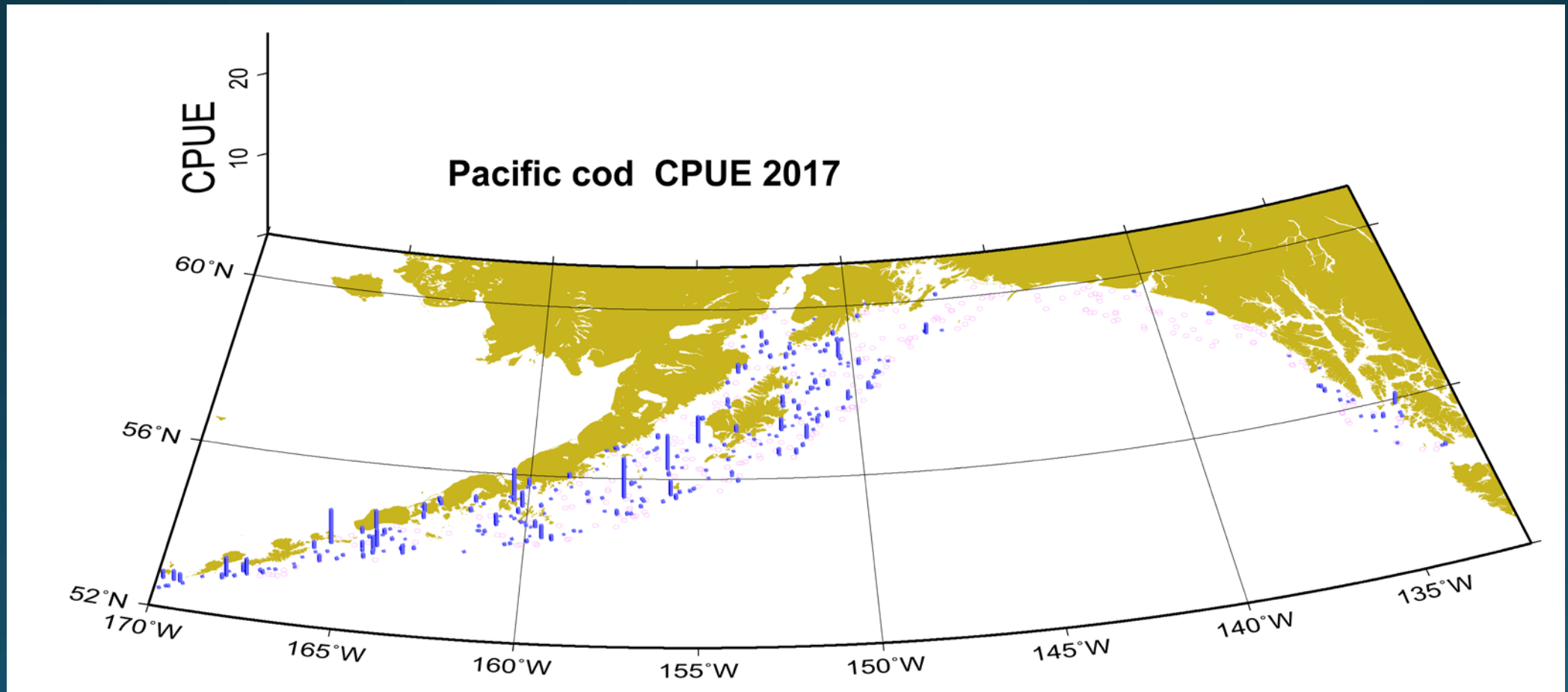
- Lowest estimate ever
  1.96×10^8 fish and 107,324 t
- Precise estimate (0.117 CV)

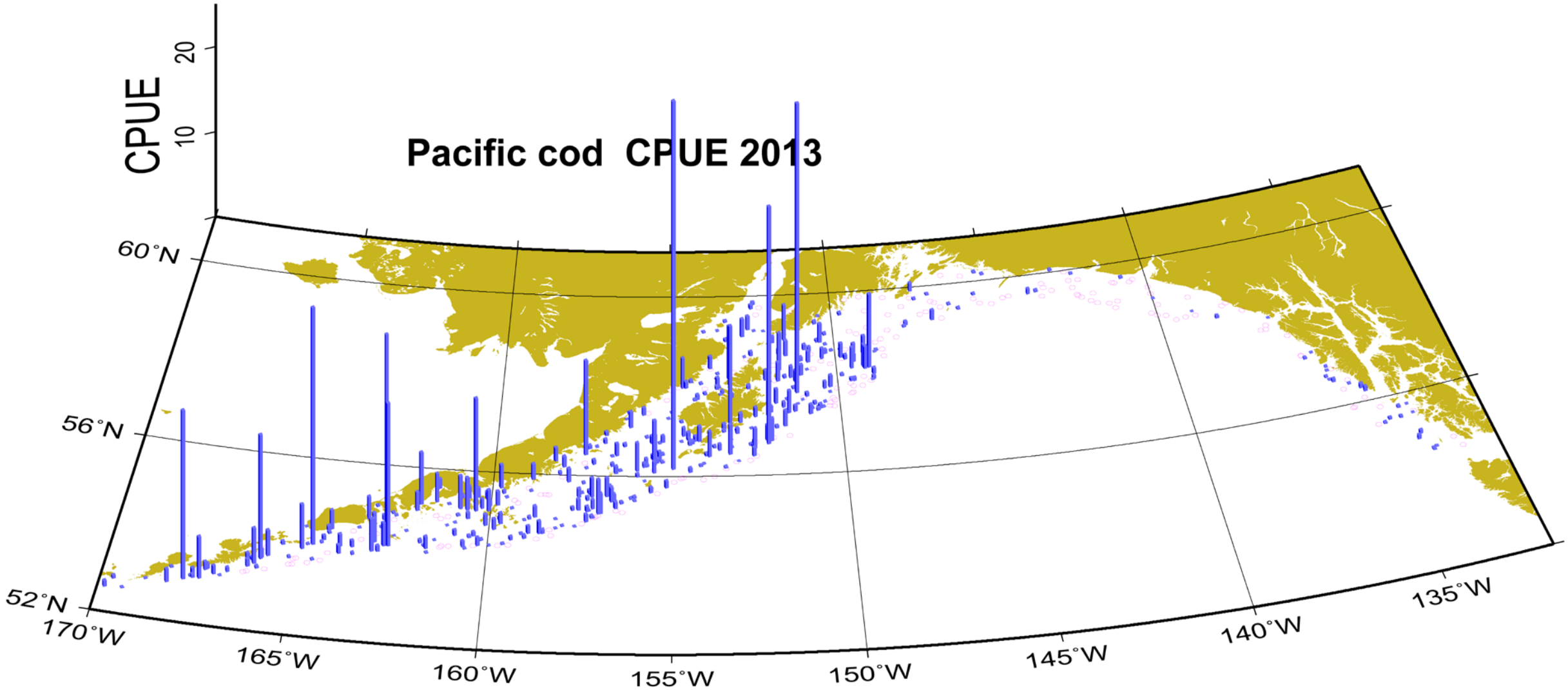
- 71% decline in abundance since 2015 (83% since 2013)
- 58% decline in biomass since 2015 (78% since 2013)

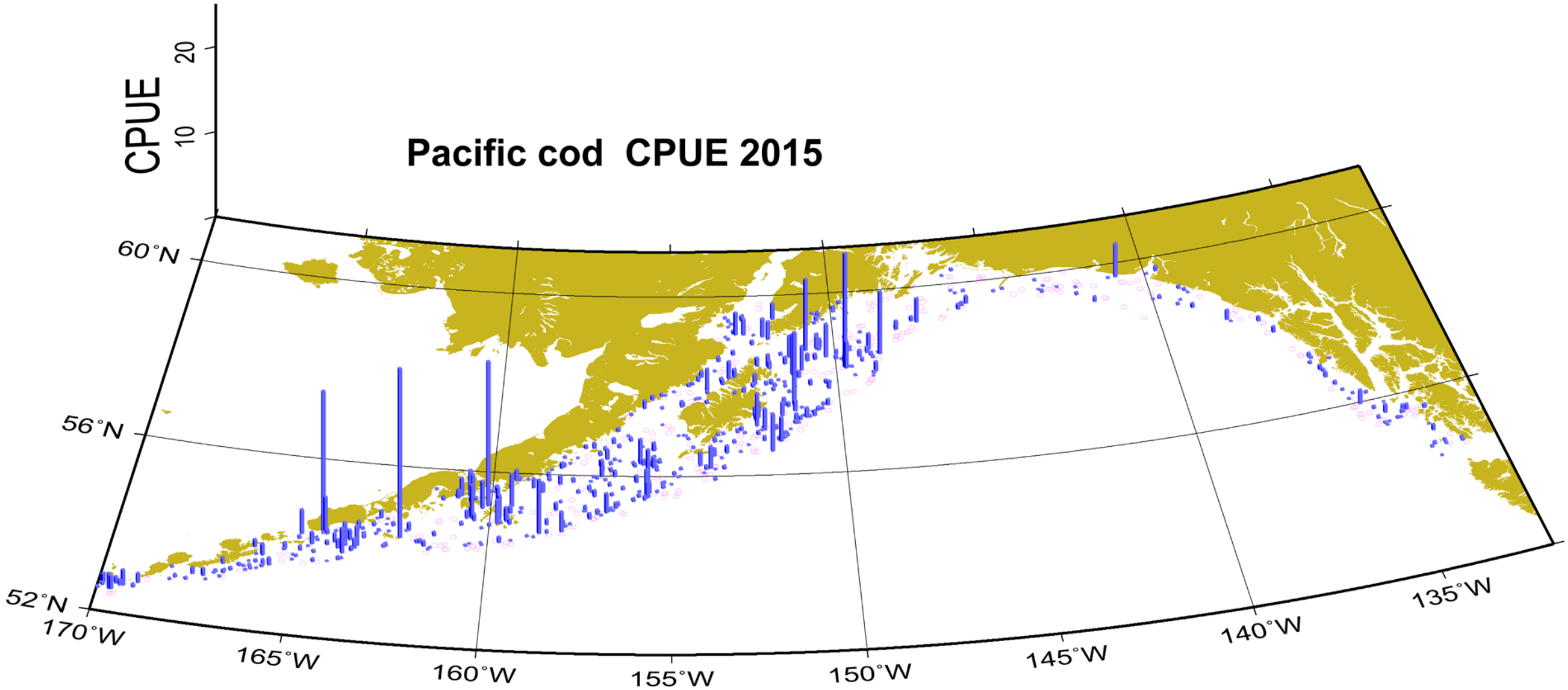


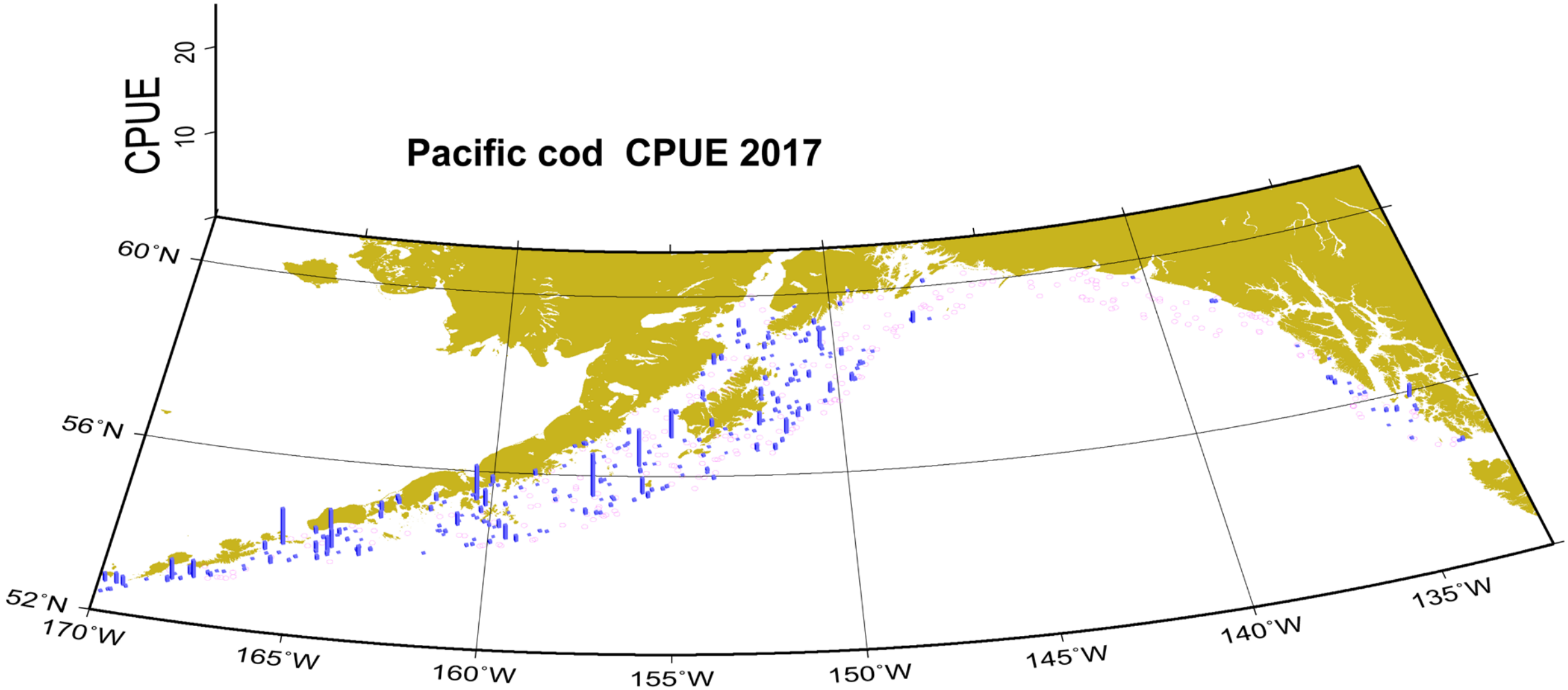
GOA Pacific cod
Bottom trawl survey

- Low density through surveyed area
- Some medium-low density along Alaska Peninsula and south of Unimak Island



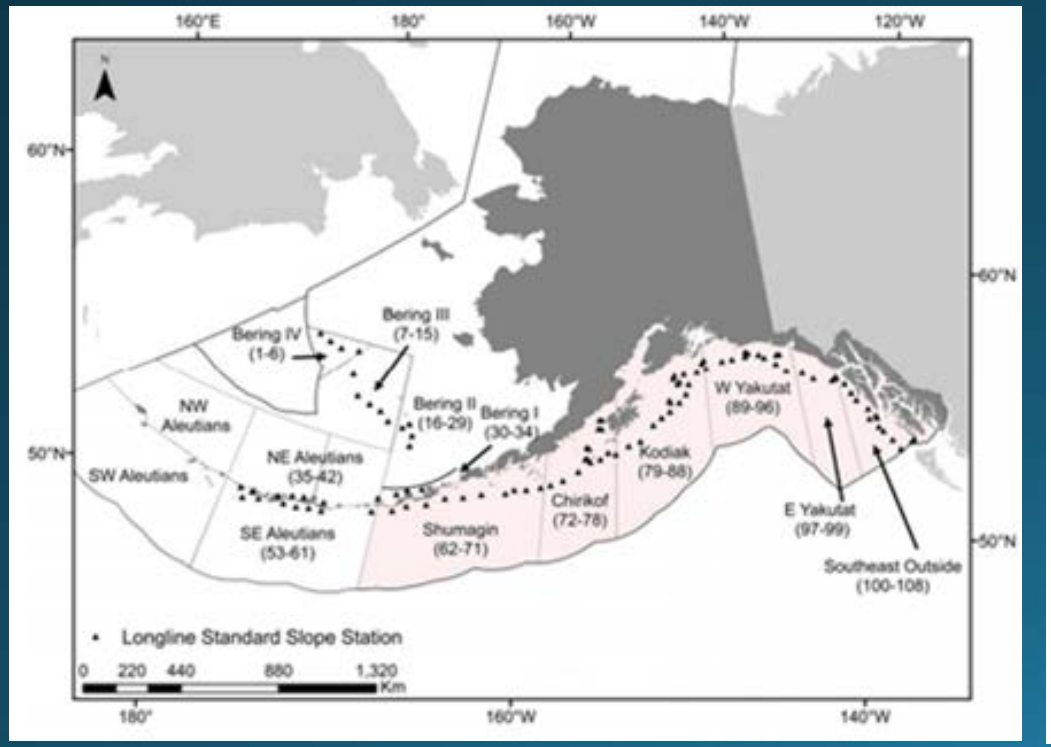

Pacific cod CPUE 2013
CPUE
10
20
60°N
56°N
52°N
170°W
165°W
160°W
155°W
150°W
145°W
140°W
135°W

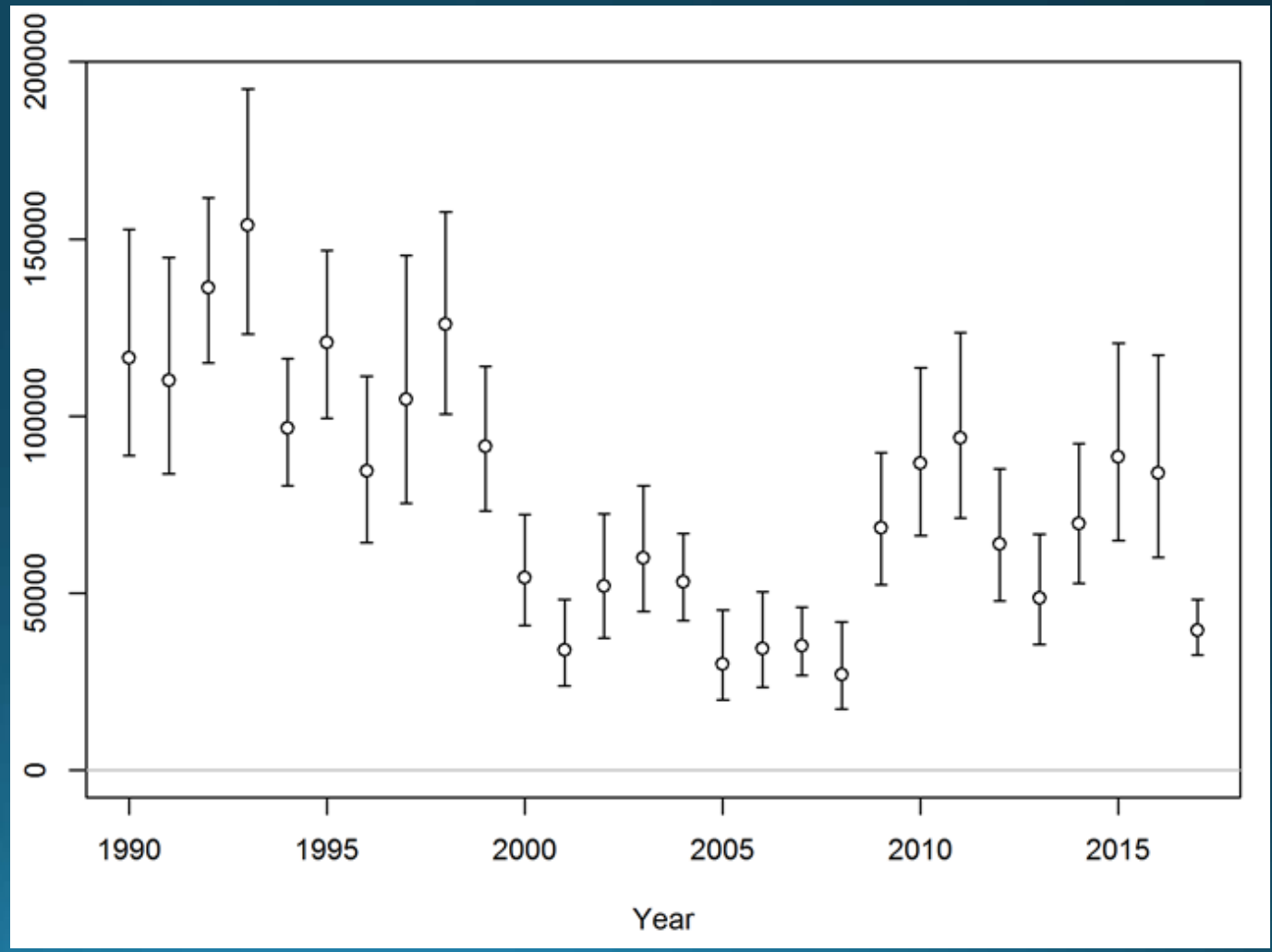

Pacific cod CPUE 2015
CPUE
10
20
60°N
56°N
52°N
170°W
165°W
160°W
155°W
150°W
145°W
140°W
135°W


Pacific cod CPUE 2017
CPUE
10
20
60°N
56°N
52°N
170°W
165°W
160°W
155°W
150°W
145°W
140°W
135°W

GOA Pacific cod
AFSC longline survey

- Low index value (39,523 RPN)
- 53% decline from 2016

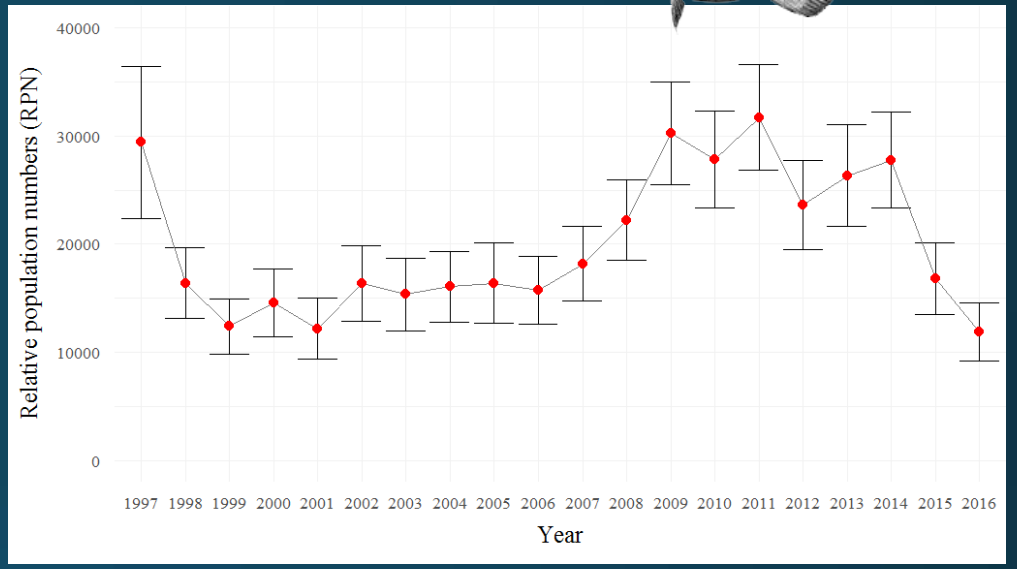




GOA Pacific cod
Other surveys

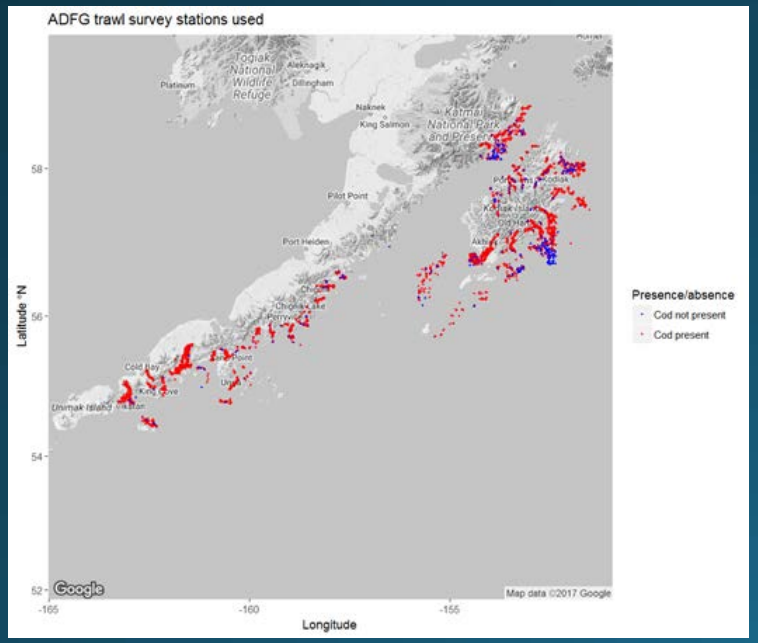
IPHC longline survey 1997-2016

- 2016 Lowest



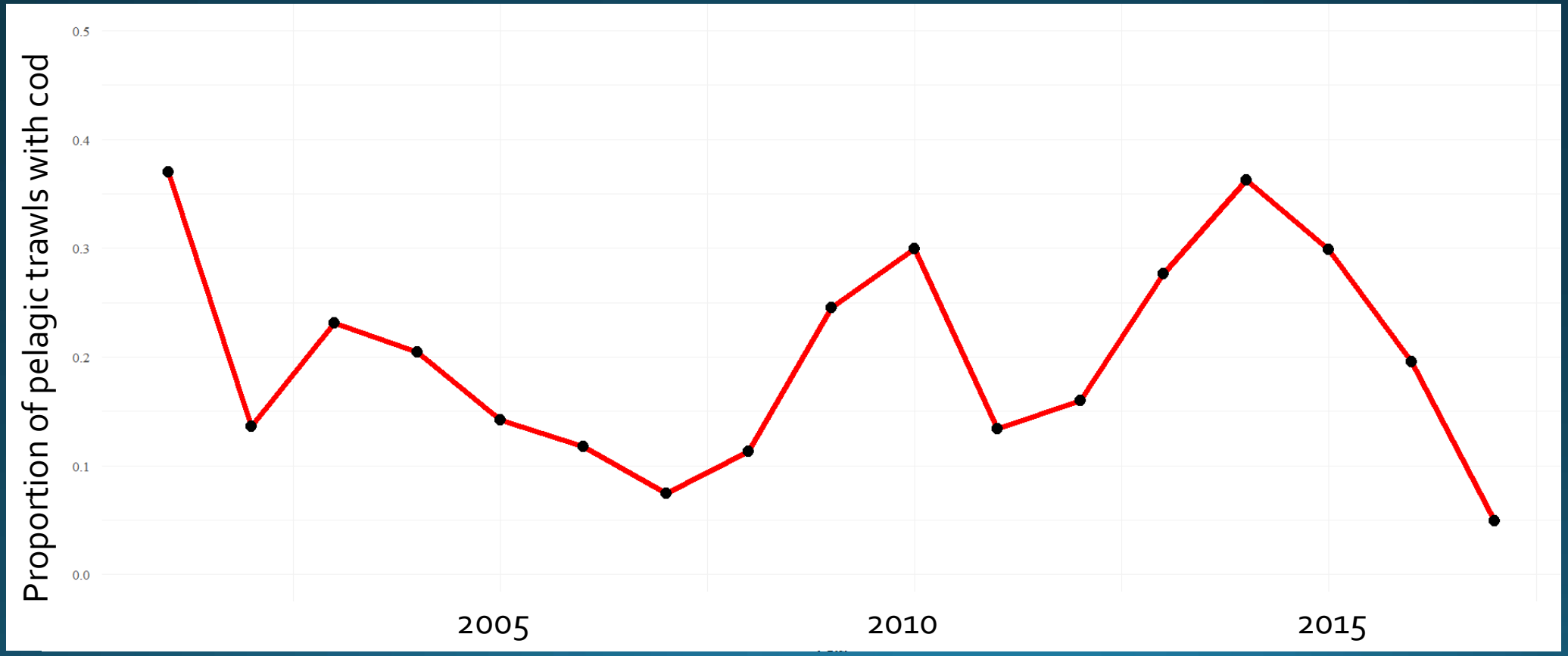
ADFG trawl survey 1988-2017

- Delta-GLM fit
- 2016 lowest
- 2017 slight increase from 2016 in Western GOA



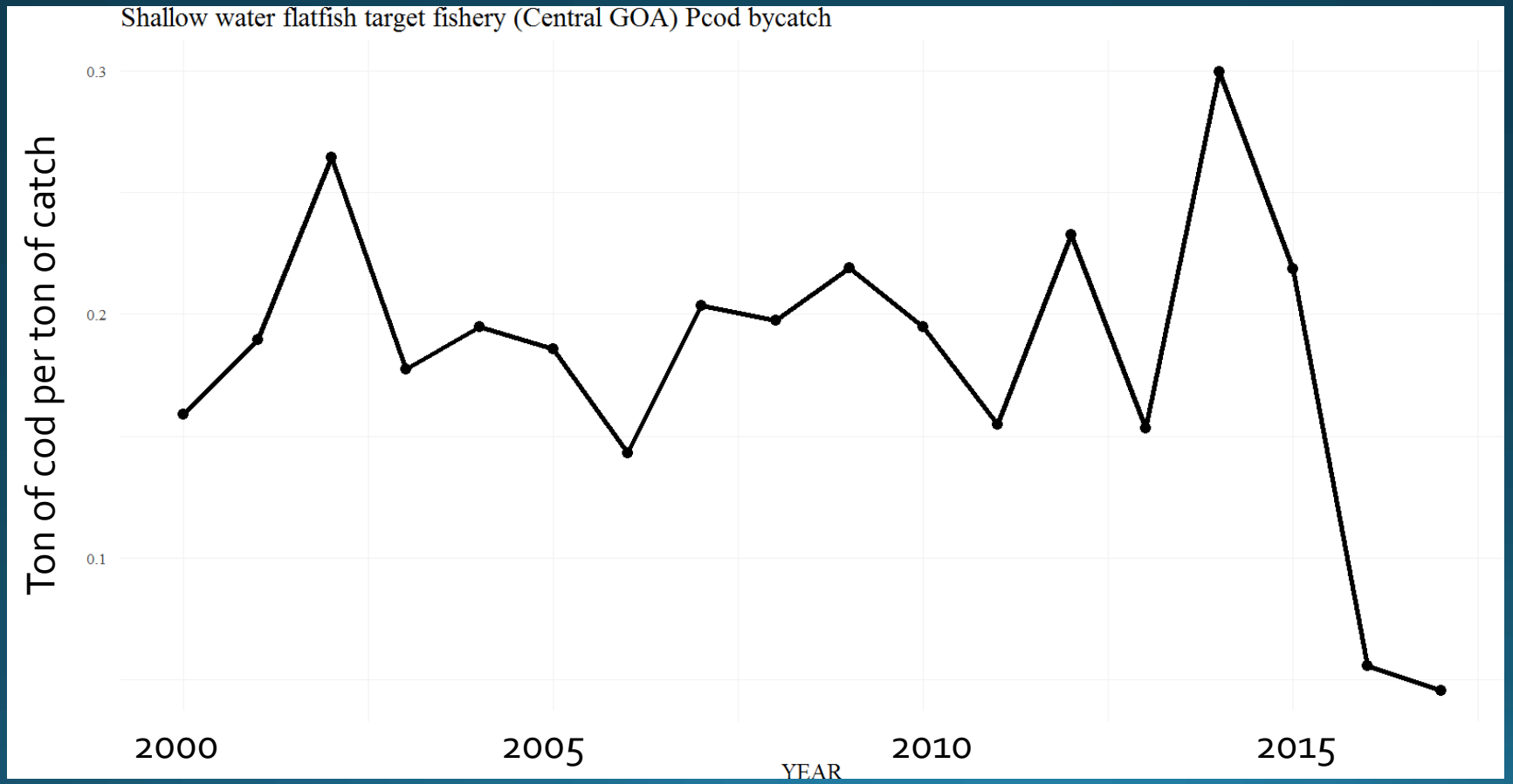
GOA Pacific cod
Bycatch in pollock fishery

- Proportion of pelagic pollock trawl hauls with pacific cod (Jan-Aug)



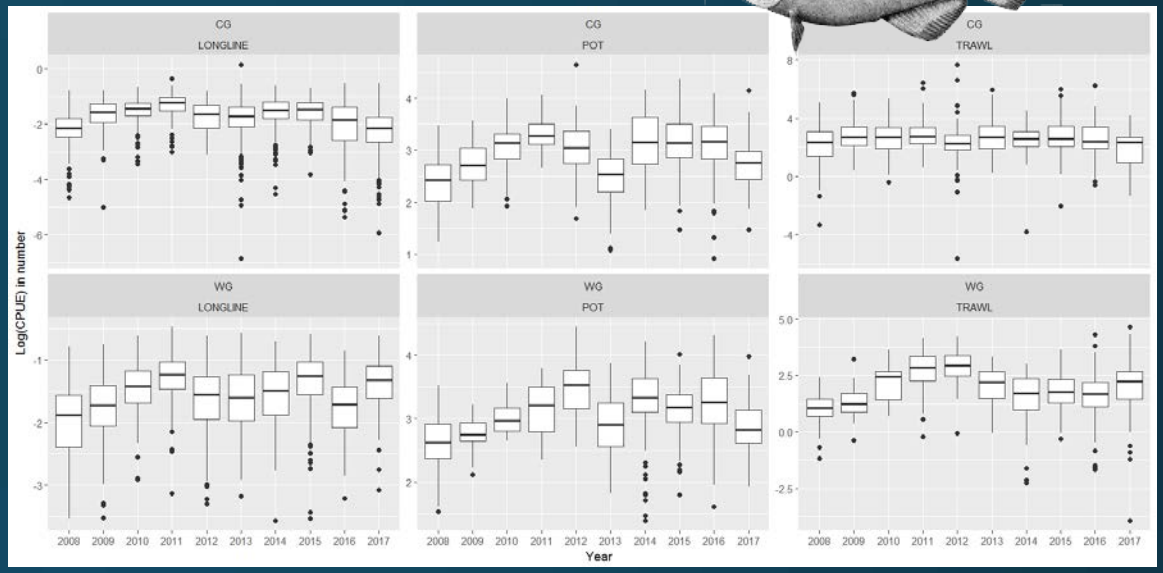
GOA Pacific cod
Bycatch in shallow water flatfish fishery

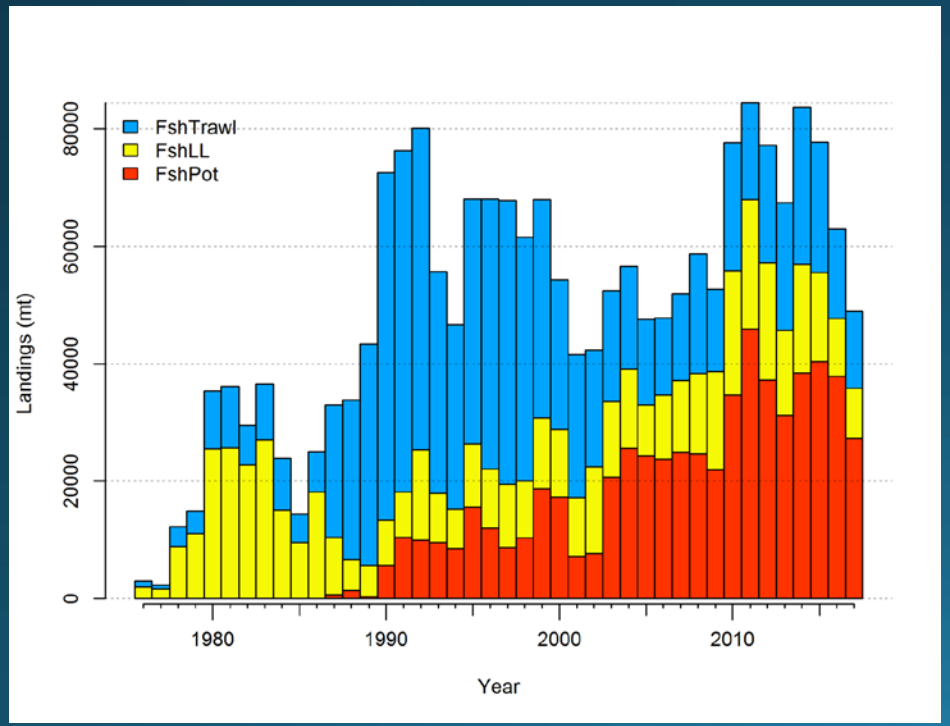
- January-August for all years – only Central GOA

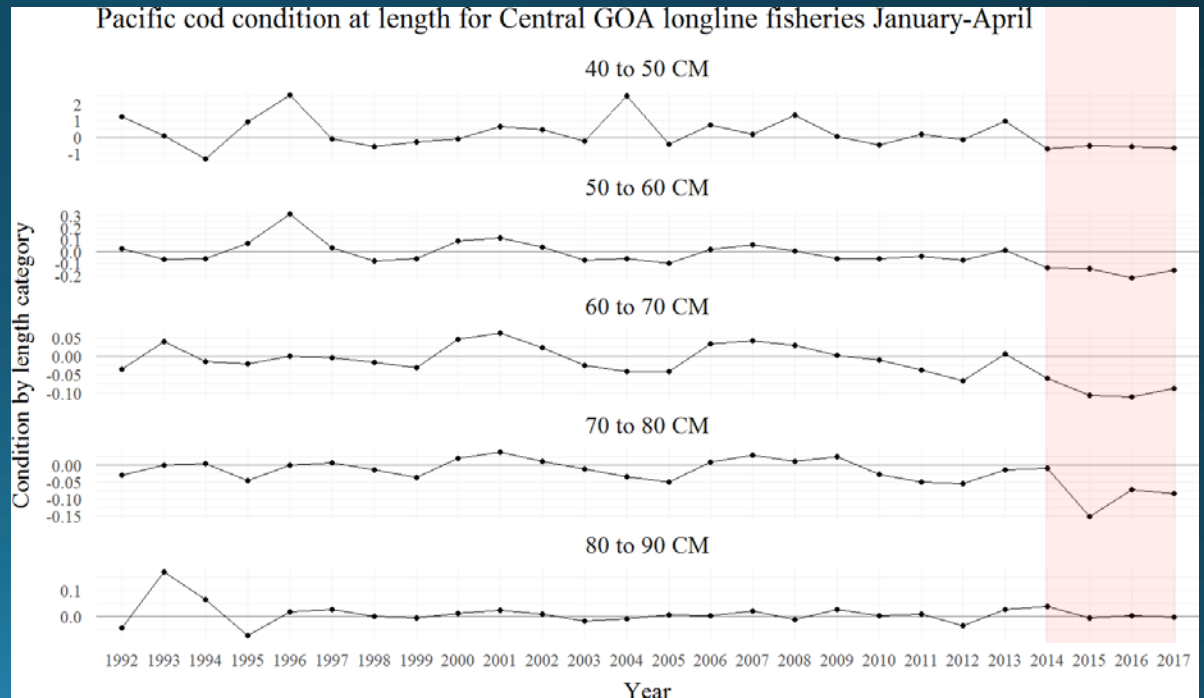


GOA Pacific cod Fishery data

- Catch at < 60% of ABC
- Low CPUE in Central GOA all fisheries
- Low CPUE in pot fishery in Western GOA, high CPUE for other sectors
- Poor condition for 2014-2017 in longline and pot fisheries for fish < 80cm

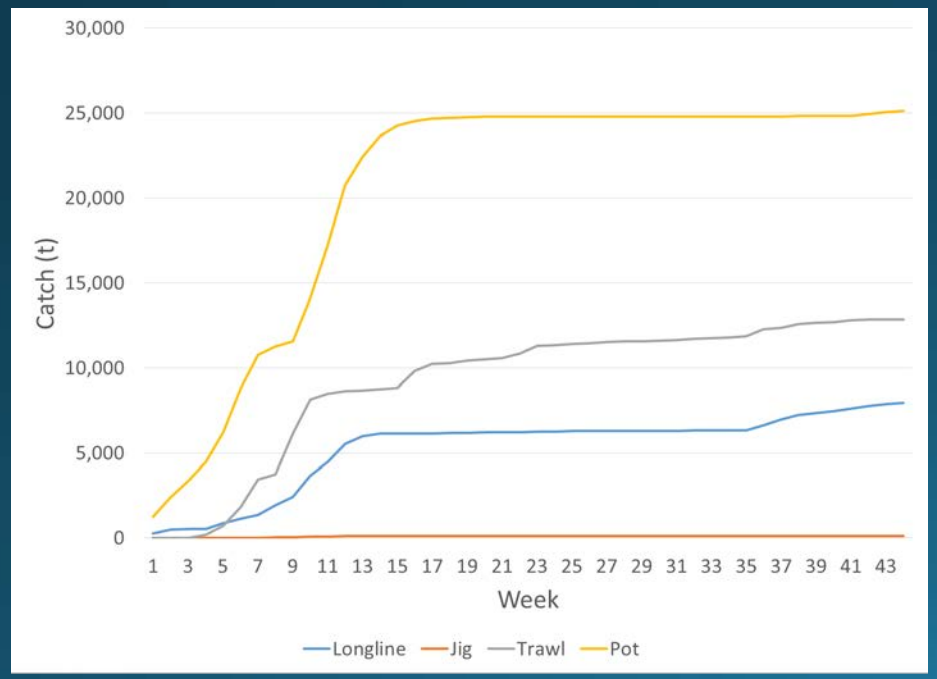


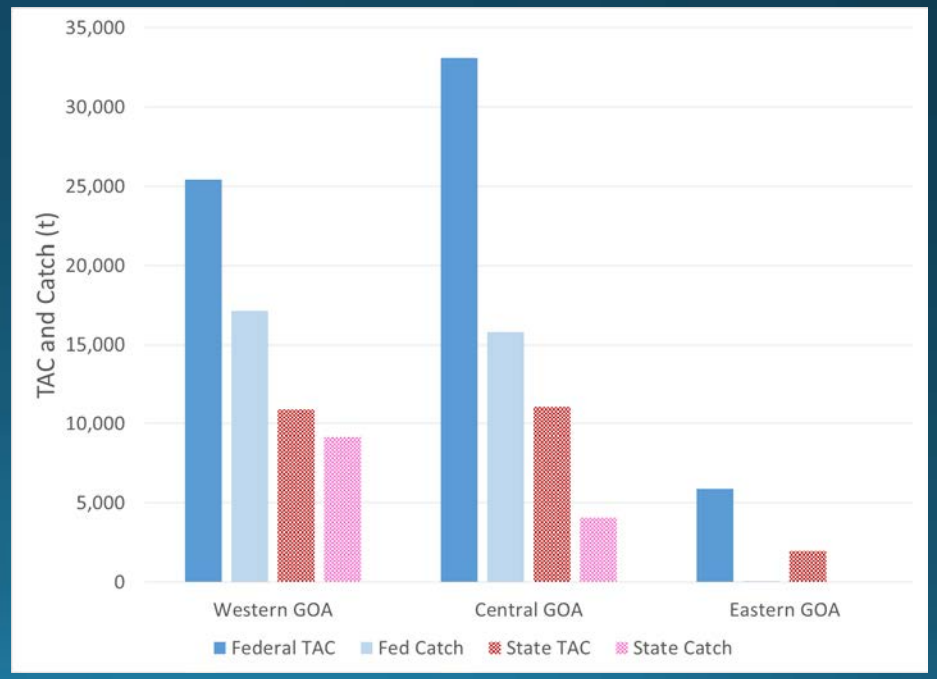




GOA Pacific cod
2017 Fishery data

- 2017 combined state and federal fishery currently at 52% of ABC
  - Western GOA 72% of ABC (67.6% Federal and 84.1% State)
  - Central GOA 45% of ABC (47.6% Federal and 36.8% State)
  - Eastern GOA at < 1% of ABC (< 1% Federal and State)

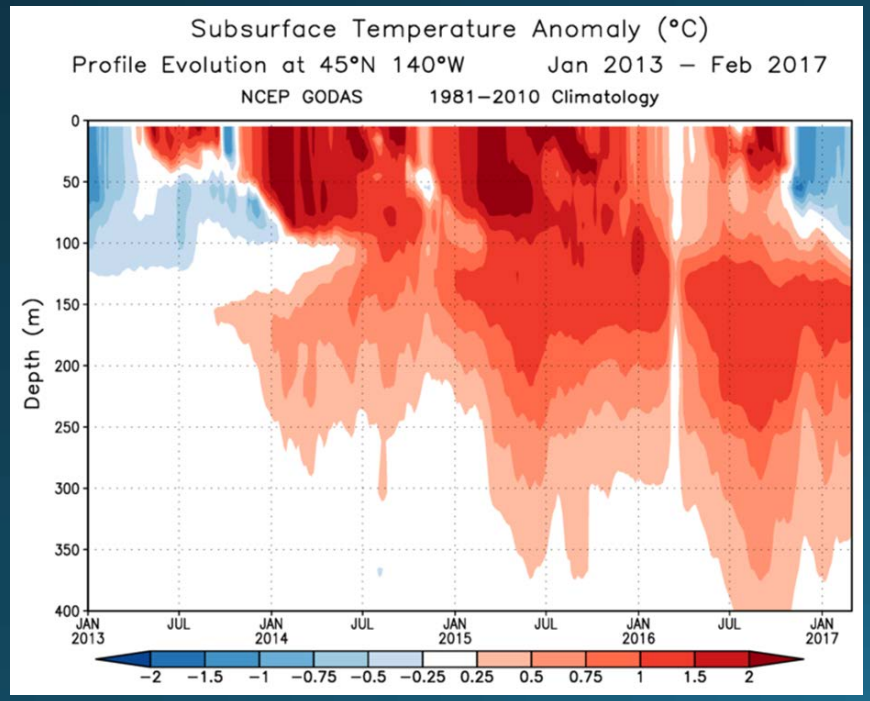


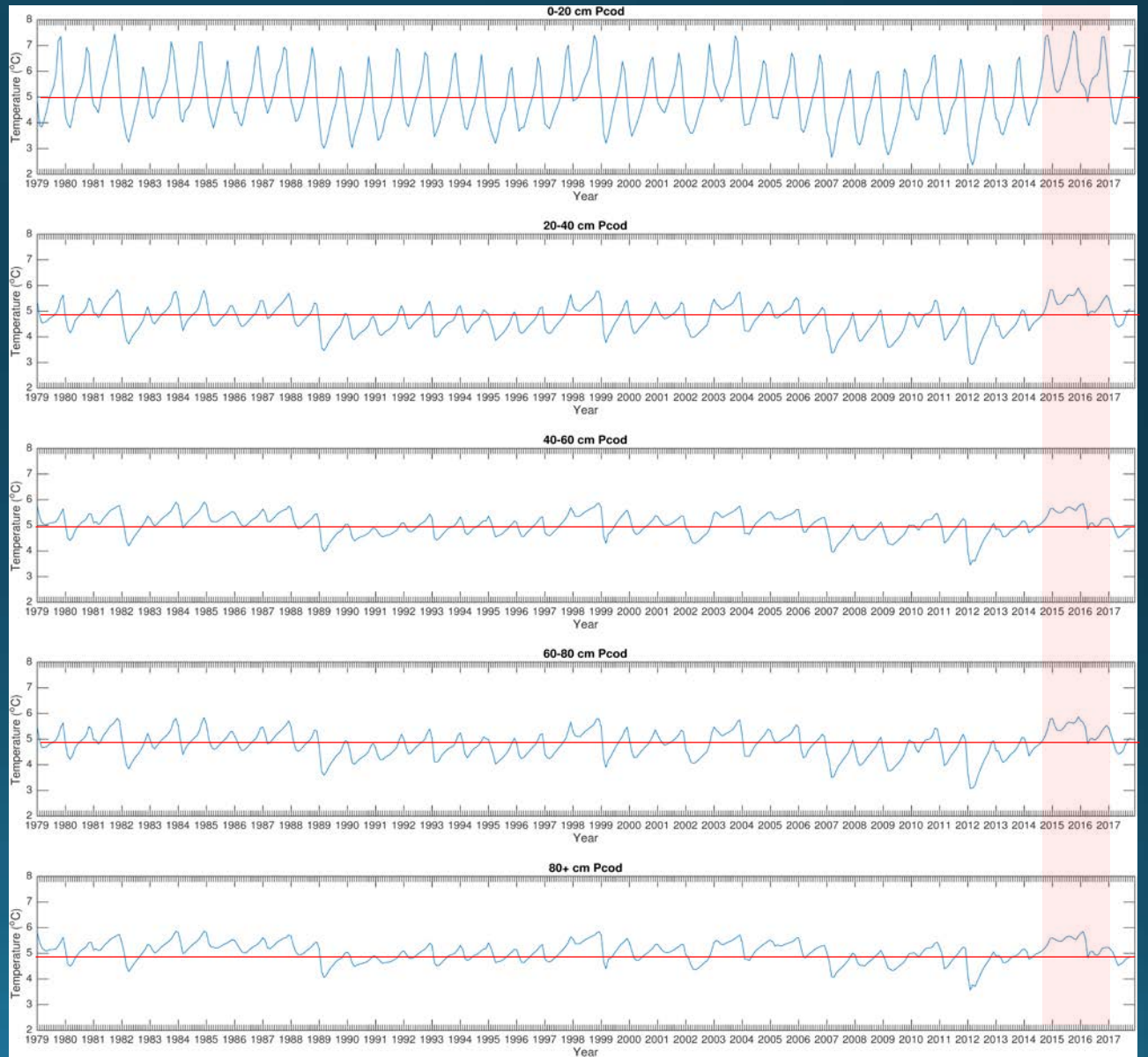


*As of 11/4/2017

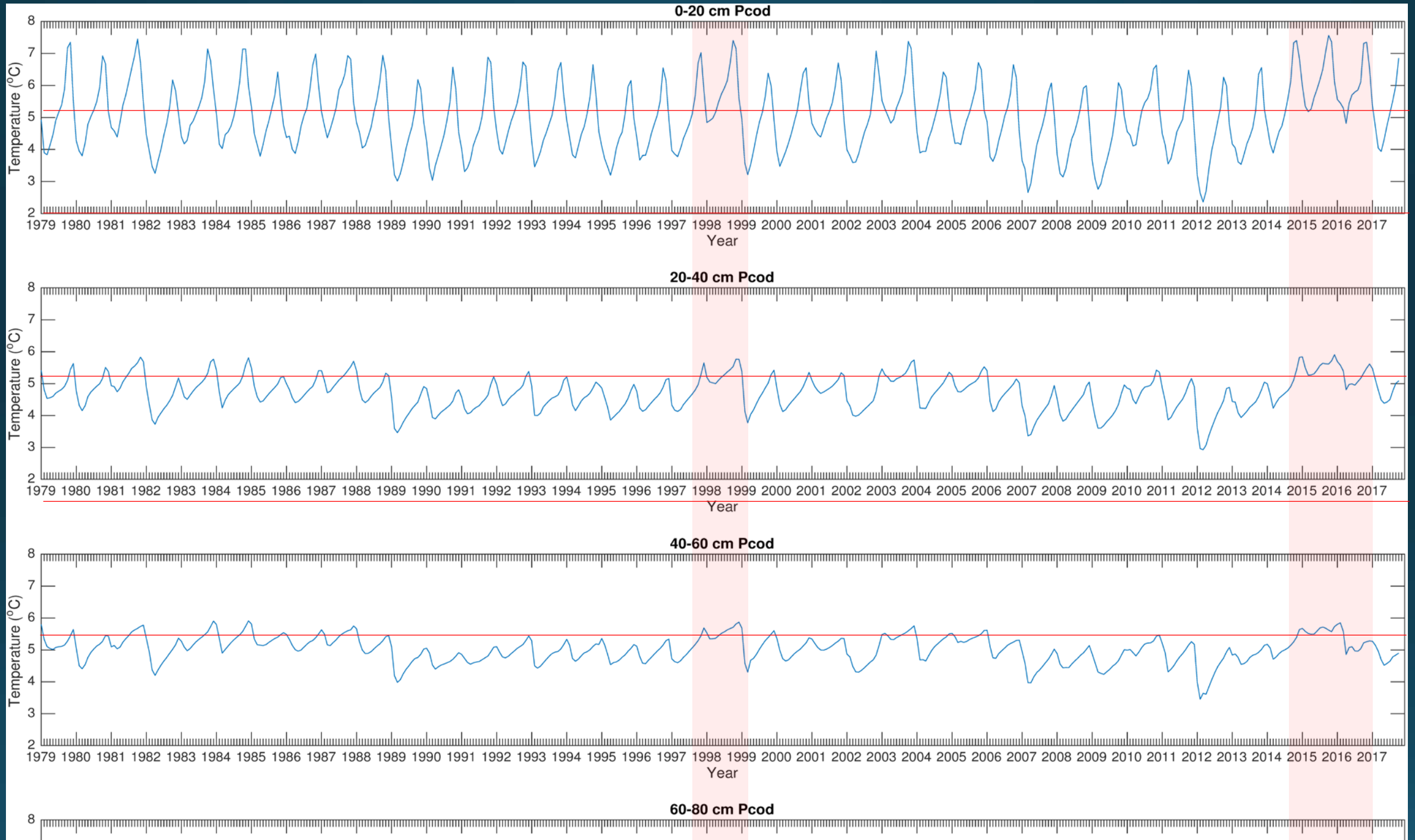
Anomalously warm waters 2014-2016

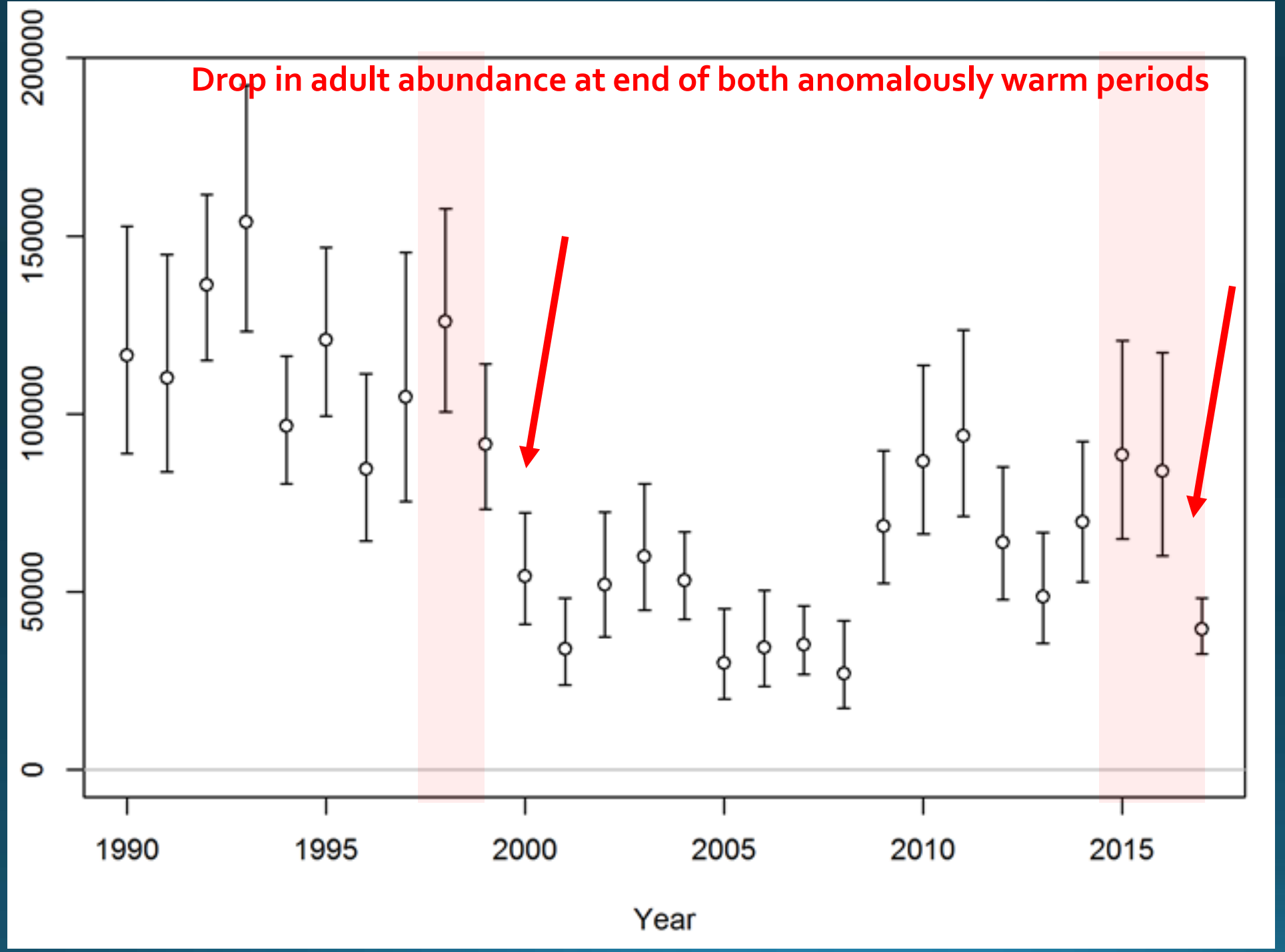
- Anomalously warm waters 2014-2016
- Deep and continued throughout the year





CFSR analysis by Qiong Yang, NPRB project 1509


0-20 cm Pcod
20-40 cm Pcod
40-60 cm Pcod
60-80 cm Pcod
Temperature (°C)
Year
8
7
6
5
4
3
2
1979 1980 1981 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 2015 2016 2017


Drop in adult abundance at end of both anomalously warm periods
200000
150000
100000
50000
0
1990
1995
2000
2005
2010
2015
Year

Anomalously warm waters 2014-2016

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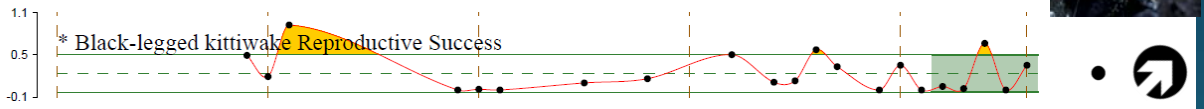
Science

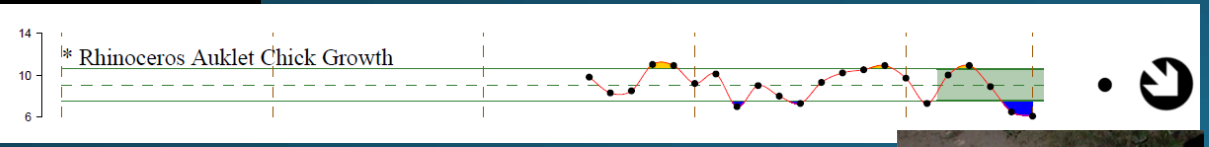
Scientists think Gulf of Alaska seabird die-off is biggest ever recorded

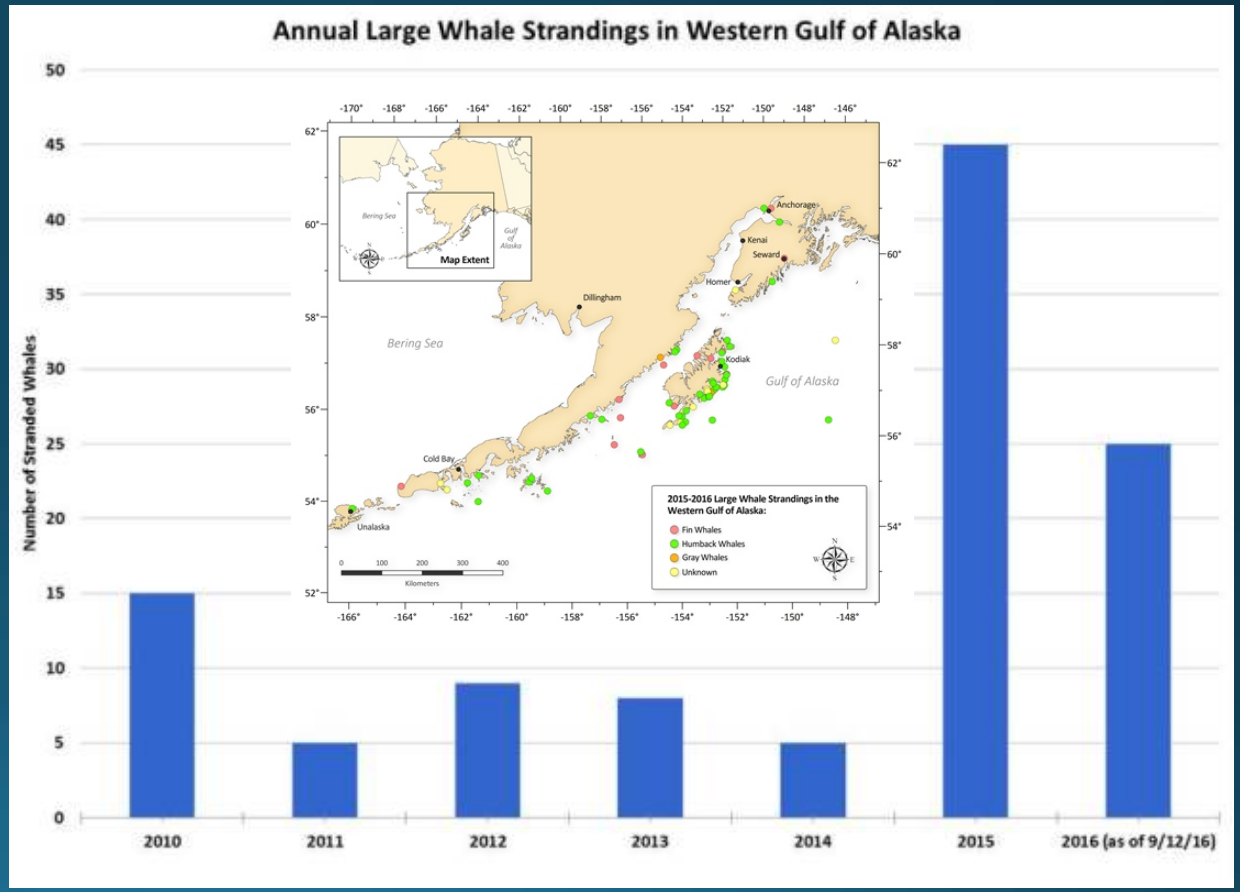
Author: Yereth Rosen | Updated: September 30, 2016 | Published January 29, 2016

West



East

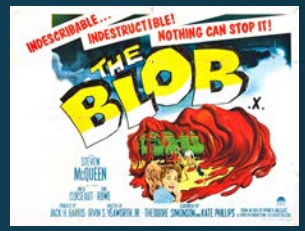


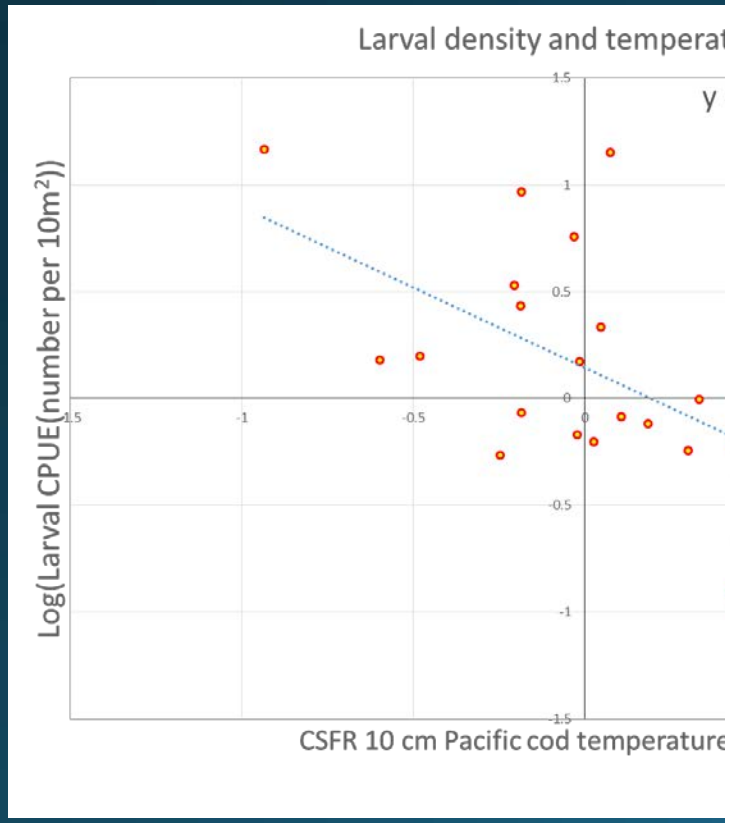


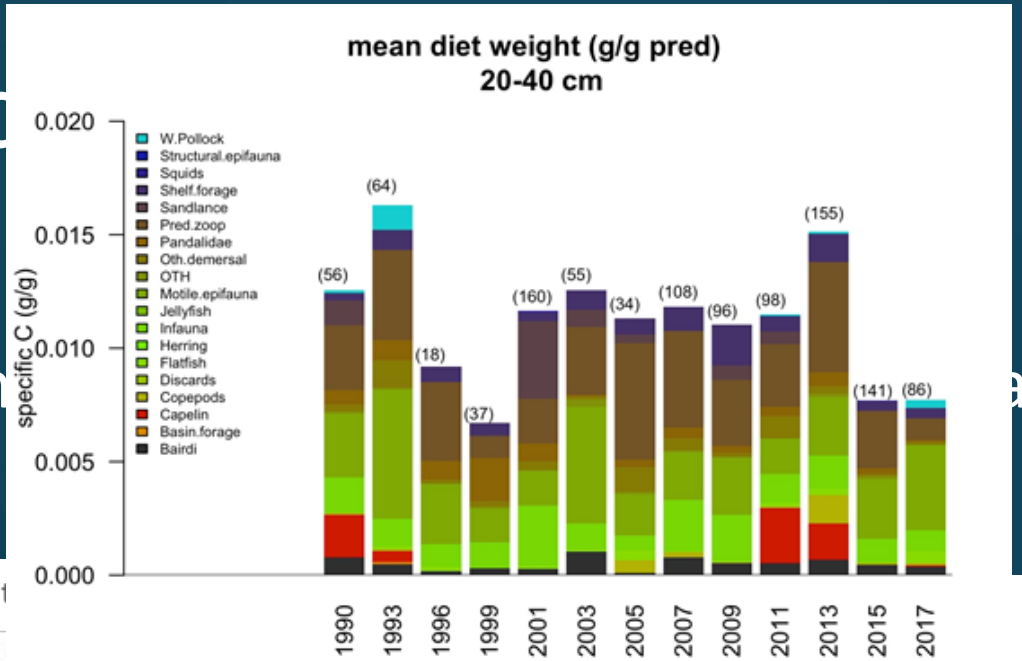
Analysis by Stephani Zador

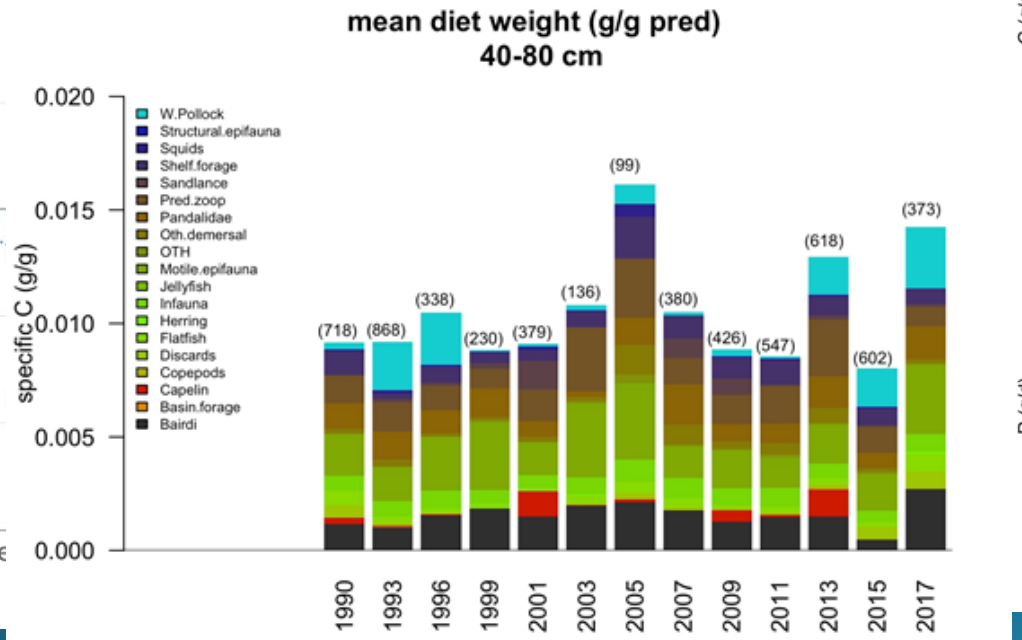
GOA Pacific cod
The Blob

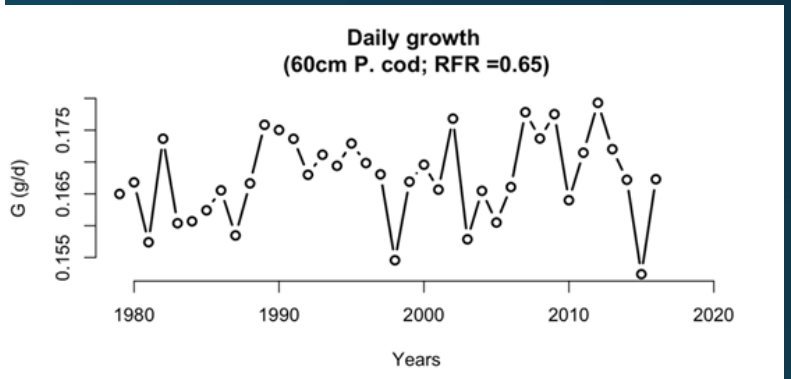
- Likely substantial in ... and natural mortality

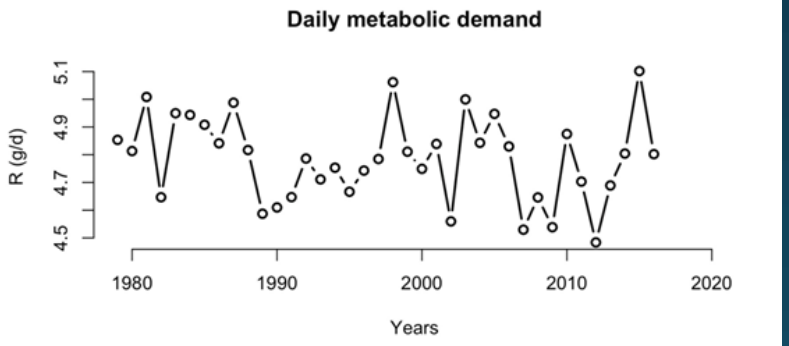












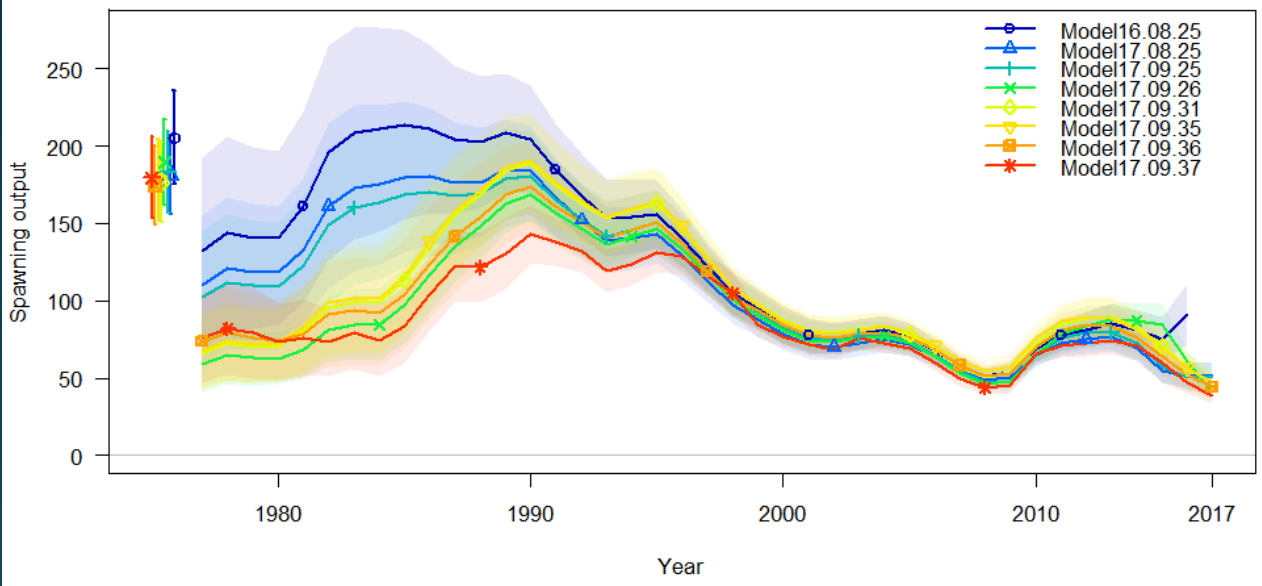
energetics analysis by Kirsten Holsman

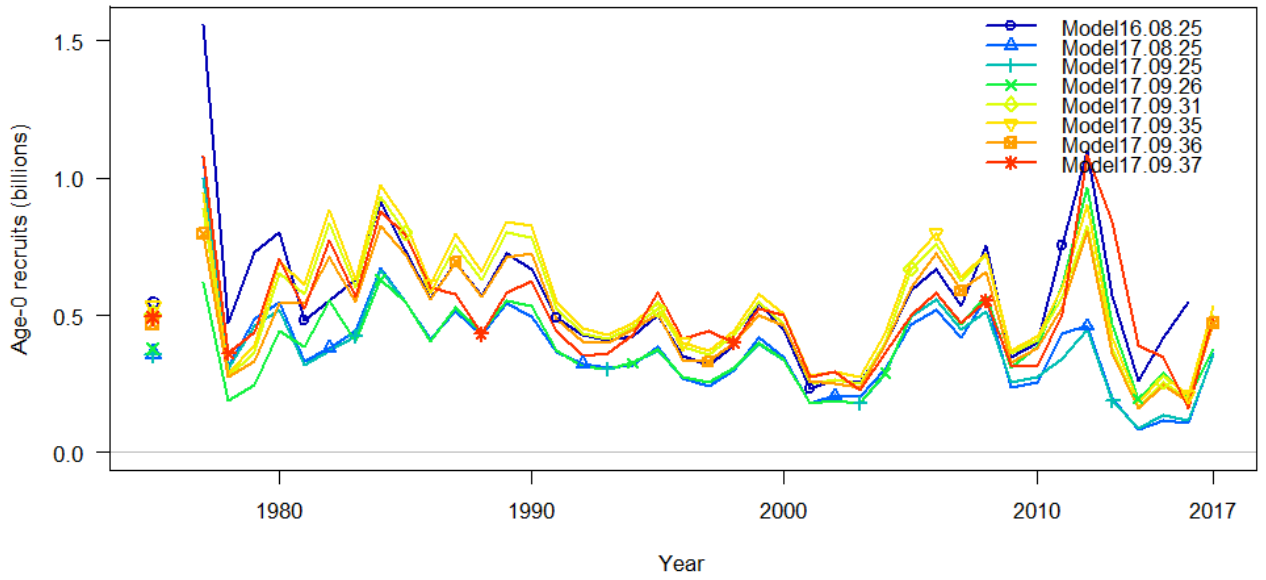
GOA Pacific cod
Bio-energetics summary

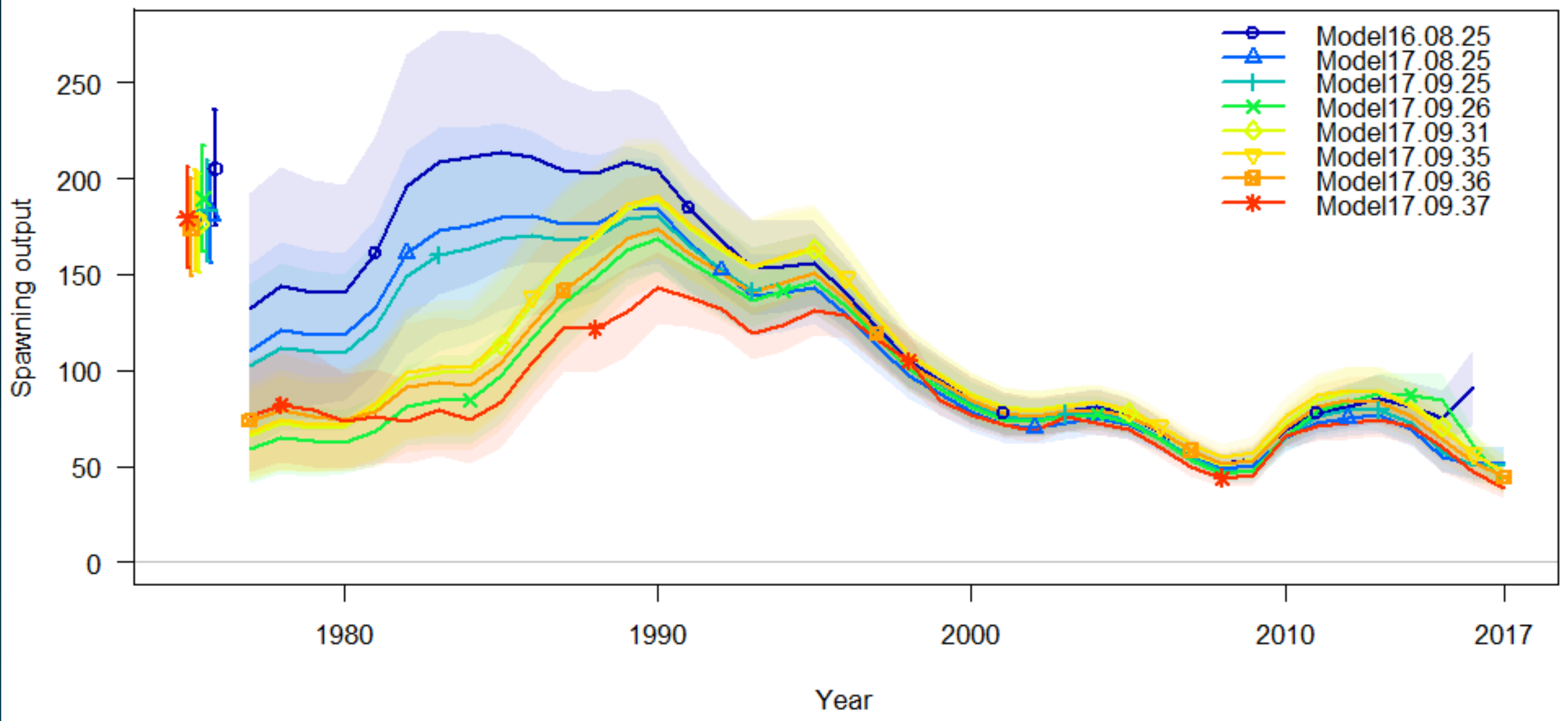
- Warmer temperatures were throughout the year and water column
- Higher metabolism in warmer temps lead to higher forage requirements
- Indications of lower forage amounts in 2015-2016
- Combination likely lead to higher Pacific cod natural mortality for these years.

GOA Pacific cod
Model exploration

- Eight models presented out of 38+ distinct models examined
  - Explored assumptions on natural mortality, growth, catchability, selectivity, and data weighting
  - Examined alternative models (hypothesis) to account for apparent decline



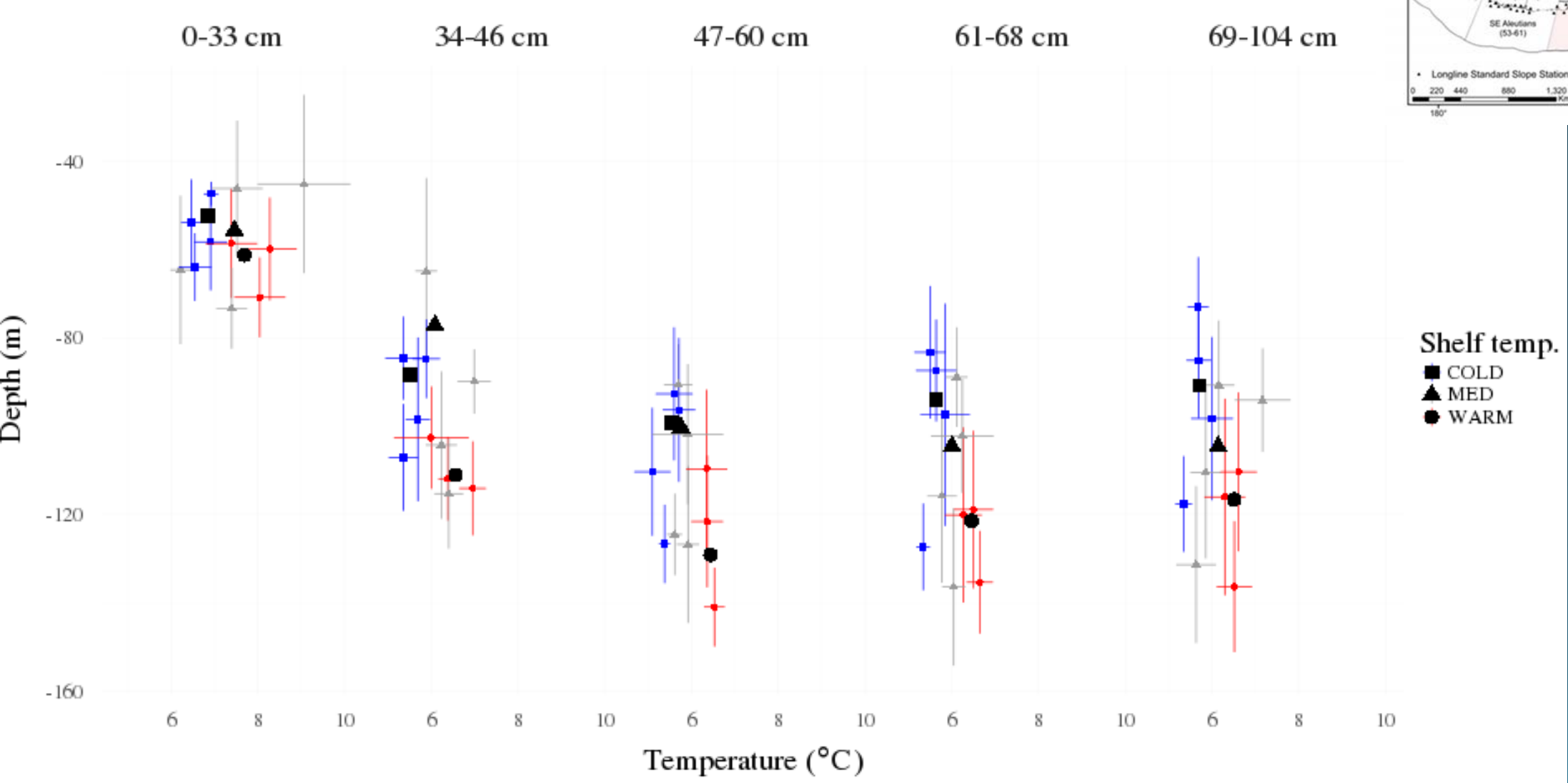


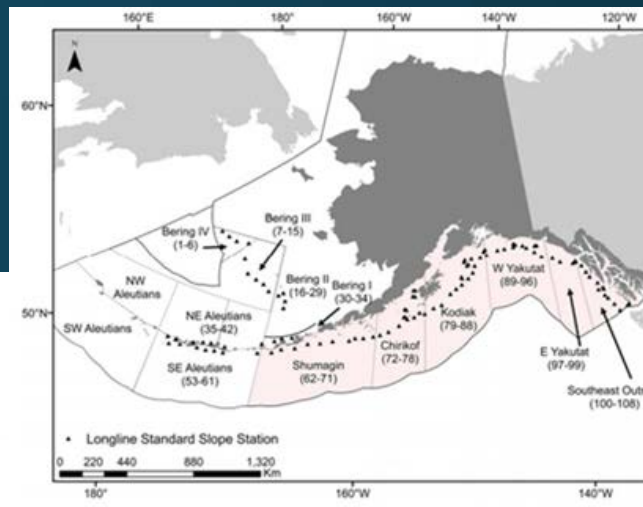

Model16.08.25
Model17.08.25
Model17.09.25
Model17.09.26
Model17.09.31
Model17.09.35
Model17.09.36
Model17.09.37
Spawning output
0
50
100
150
200
250
1980
1990
2000
2010
2017
Year

GOA Pacific cod
Model changes from 2016 preferred model

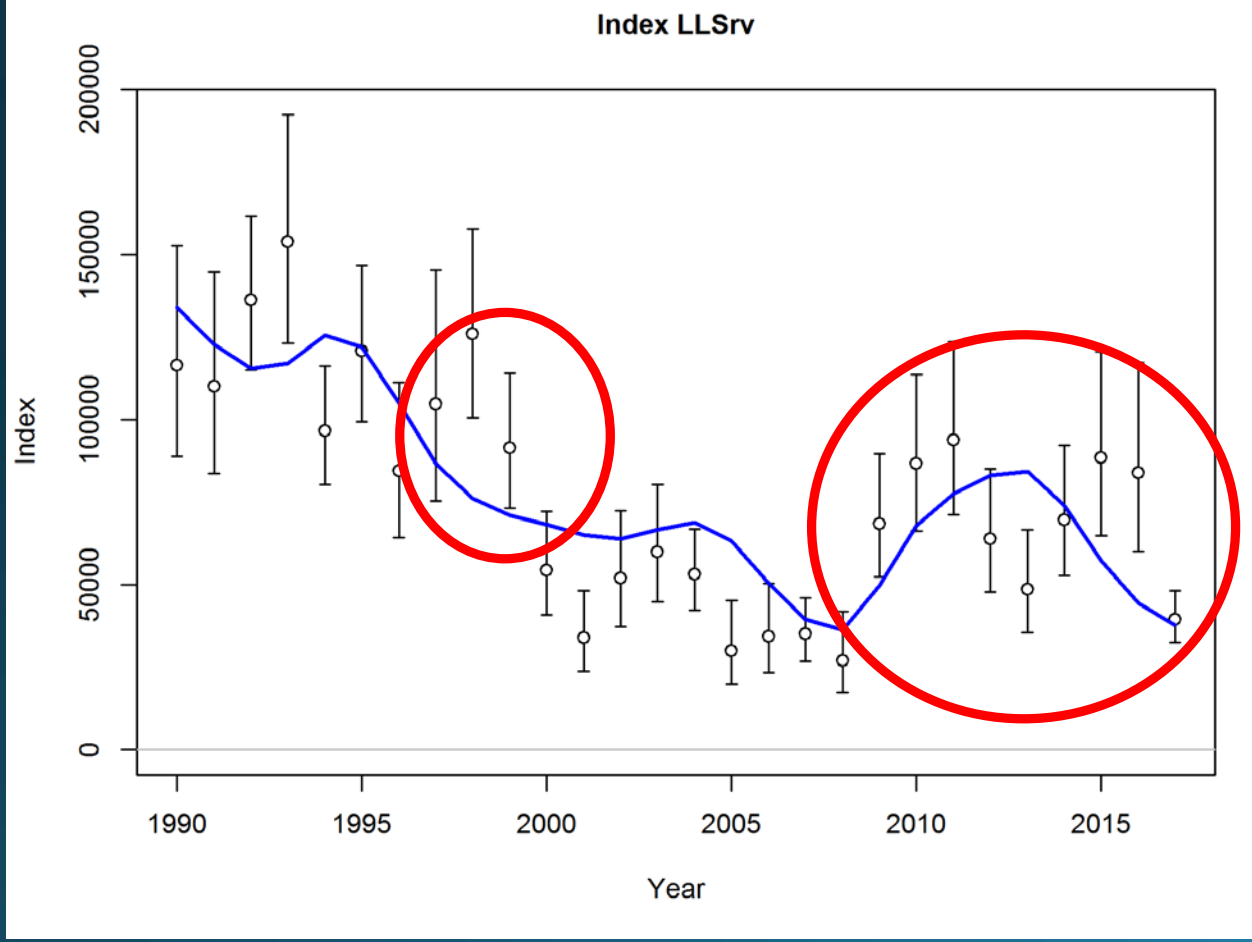
- Natural mortality estimated separately for 2015-2016
- 1977-1989 annually varying selectivity added for trawl and longline fisheries
- 2005-2006 block for trawl and longline fishery selectivity
- Catchability for AFSC longline survey conditioned on bottom temperatures

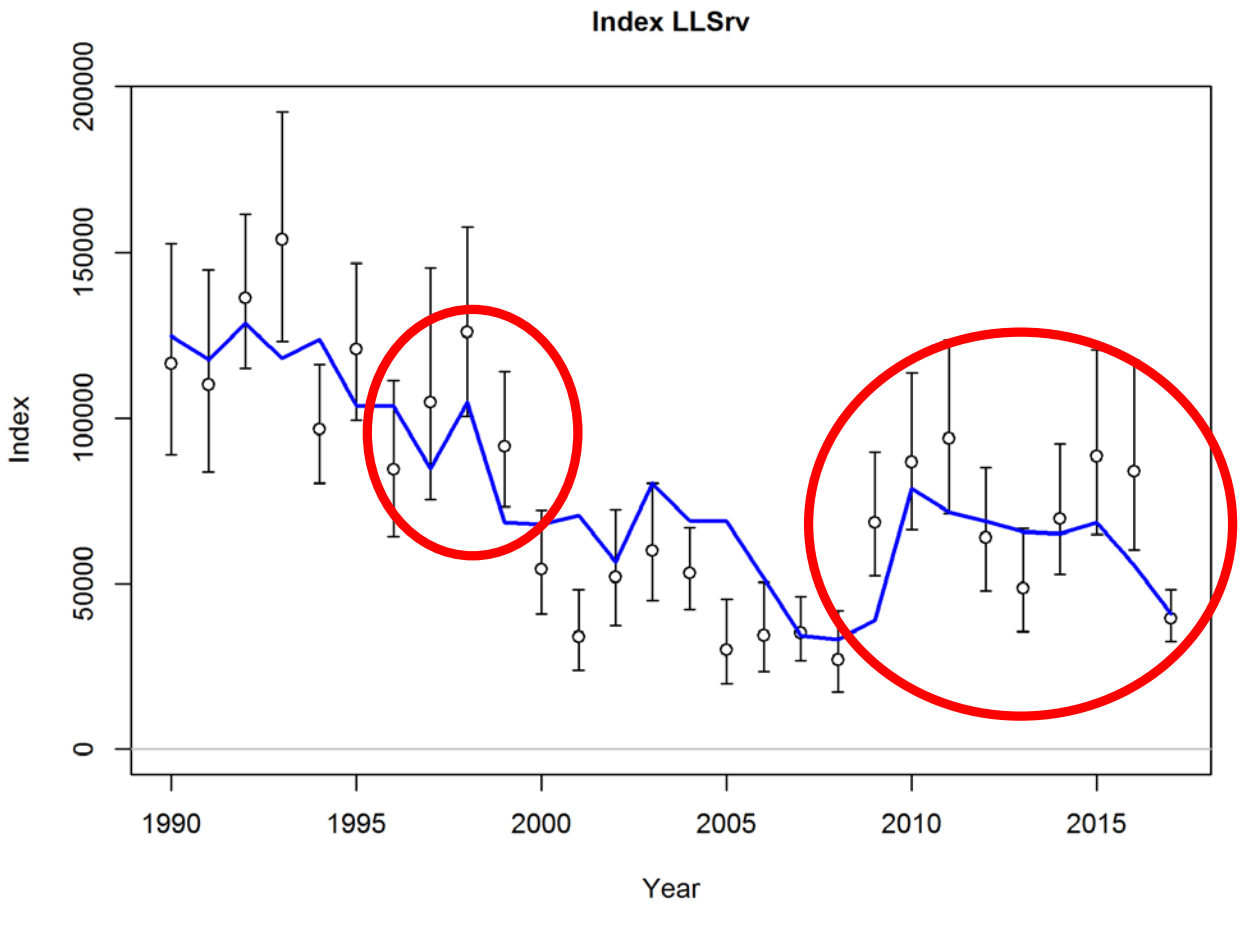
Pacific cod (*Gadus macrocephalus*)





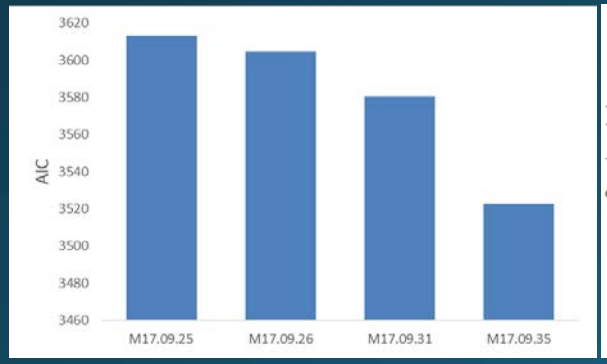
Including temperature on catchability improved fit to the AFSC longline survey

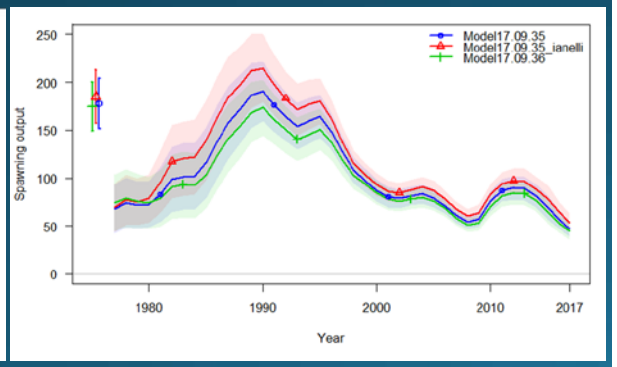


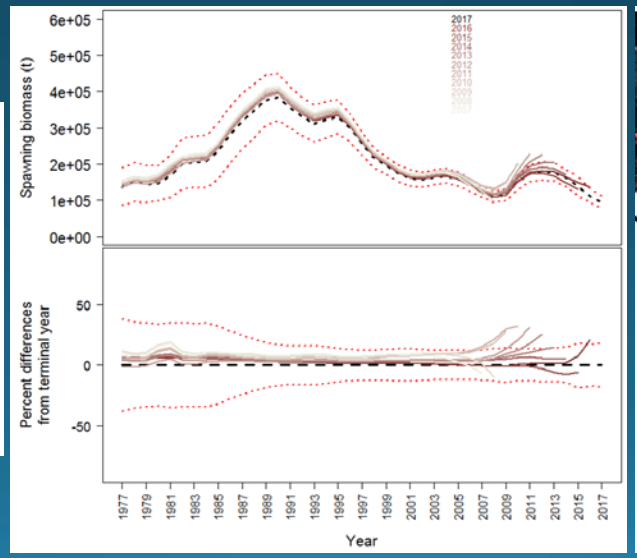


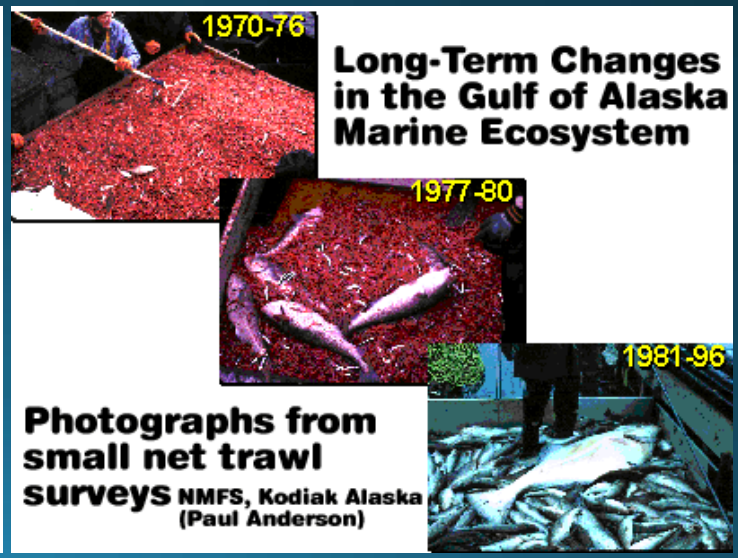
GOA Pacific cod
Model selection – Model17.09.35

- Of the comparable models Model17.09.35 has best overall fit
- Mid-way between Francis tuning and McAllister and Ianelli methods
- Acceptable retrospective pattern
- Biomass dynamics consistent with published history (Anderson and Piatt, 1999)



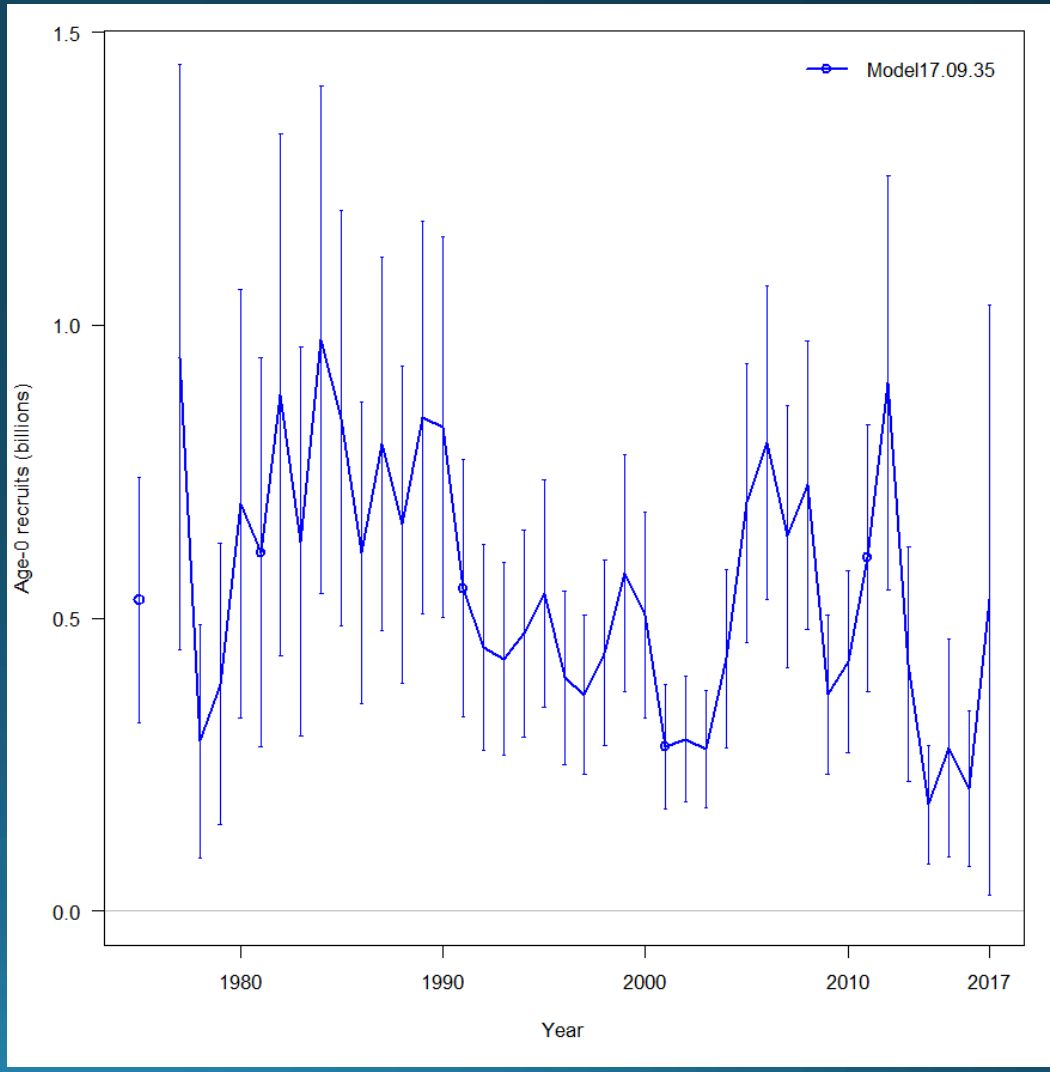






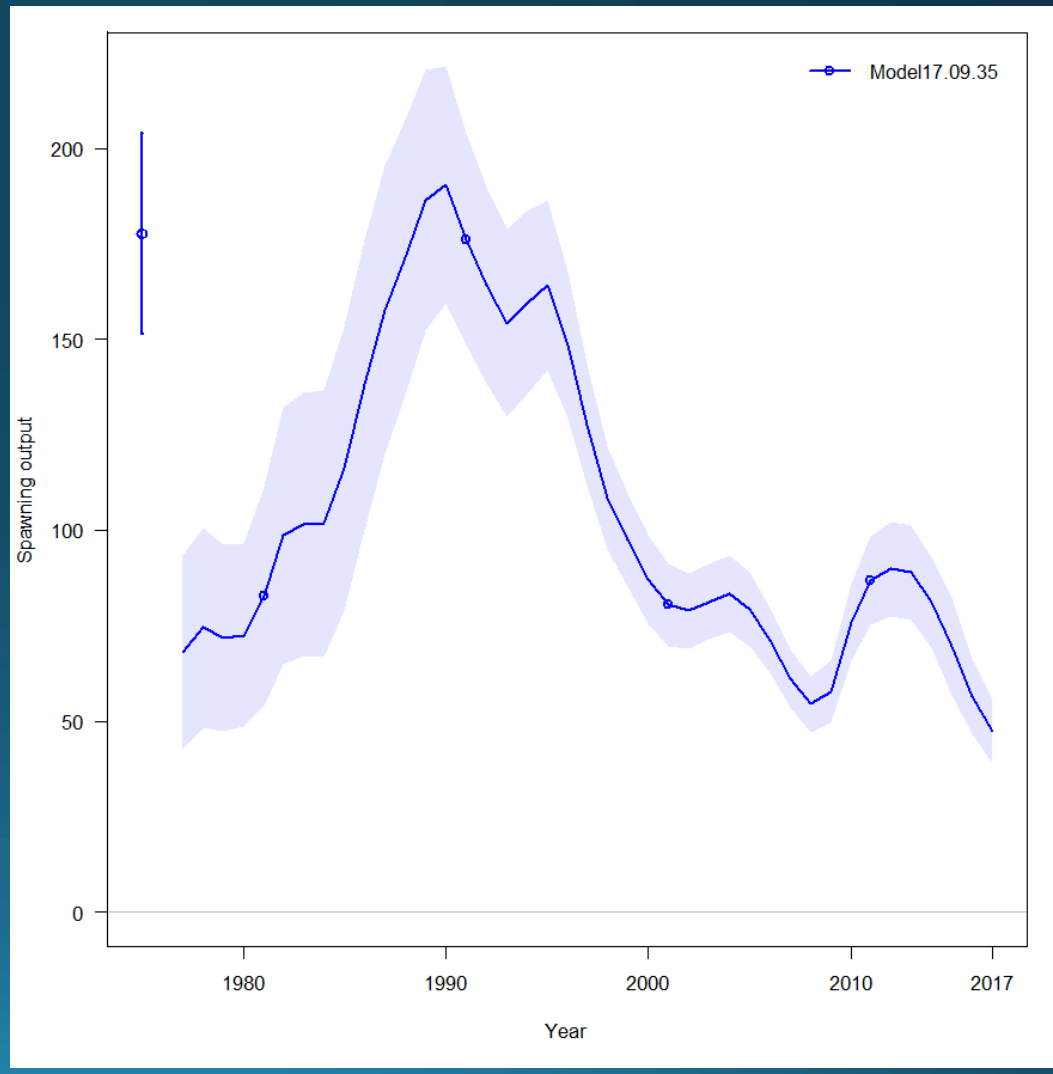
GOA Pacific cod
Model 17.09.35 Recruitment

- 2014 lowest recruitment estimate in time series at 0.14×10^9
- 2016 and 2015 second and third lowest recruitment estimates
- 1980-1990 series of large recruitment events ($\mu = 0.76 \times 10^9$)
- 1991-2004 series of poor recruitment $\mu = 0.43 \times 10^9$)
- 2012 recruits at 0.90×10^9



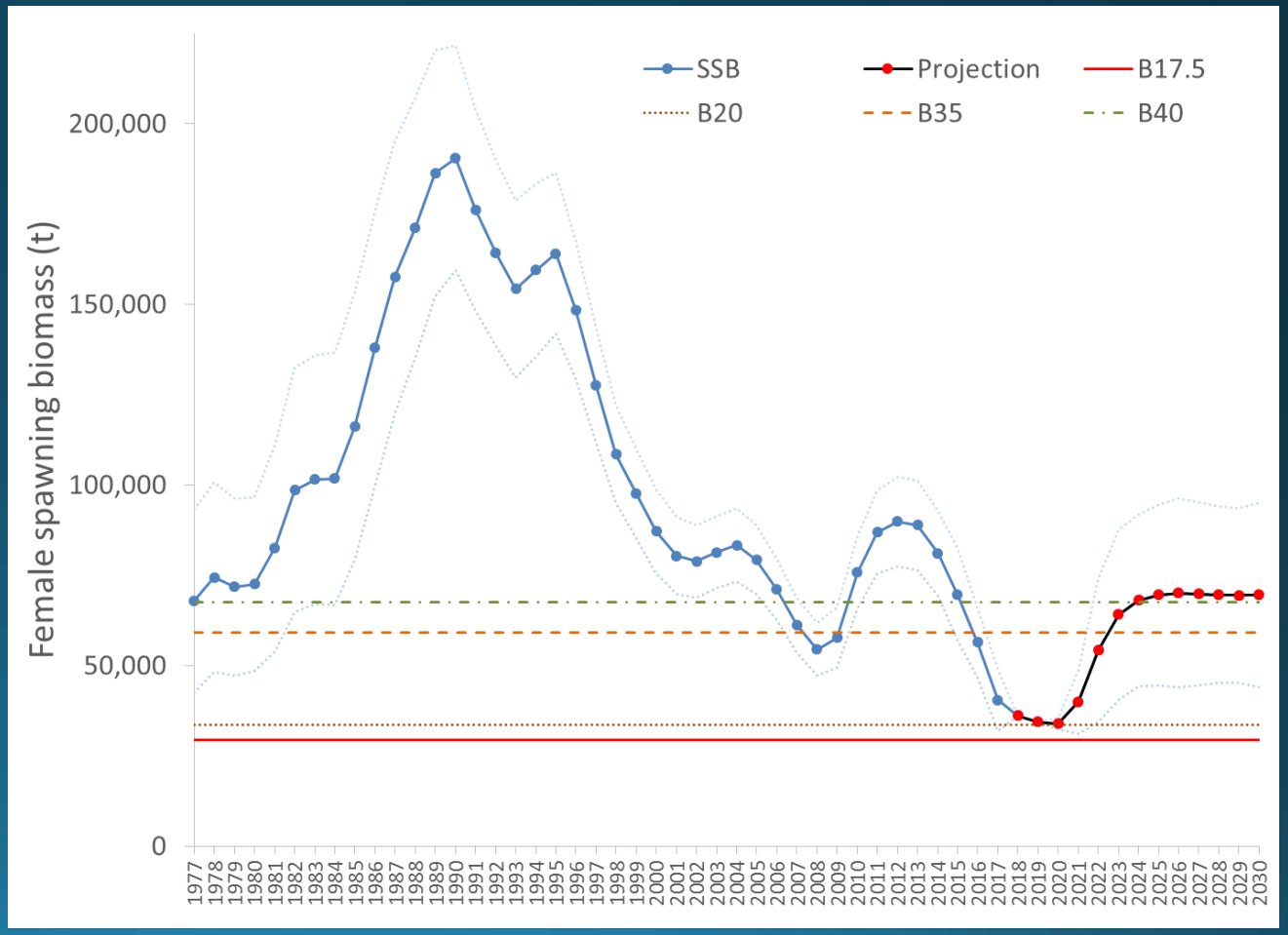
GOA Pacific cod
Model 17.09.35 Spawning biomass

- Peak female spawning biomass in 1990 (190,465 t)
- Lowest female spawning biomass in 2017 (47,326 t)
- 2008 previous low at 54,470 t
- Build up in 2009-2012 based on large 2006-2008 year classes



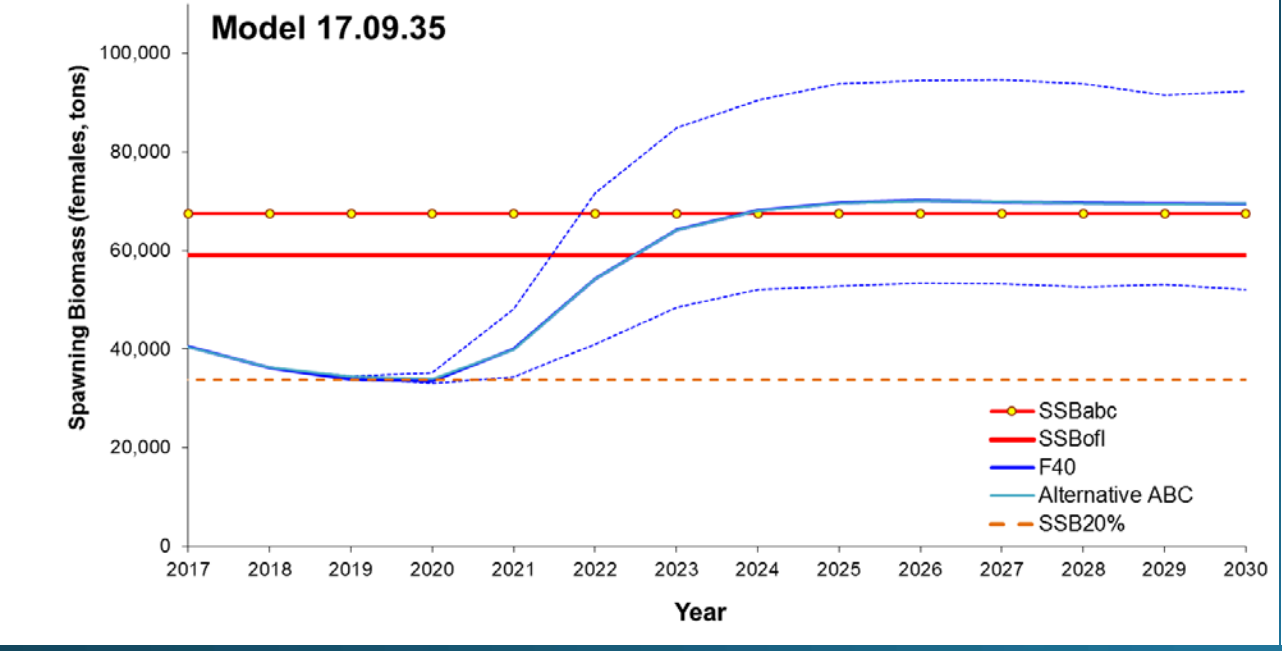
GOA Pacific cod Model 17.09.35 Projections

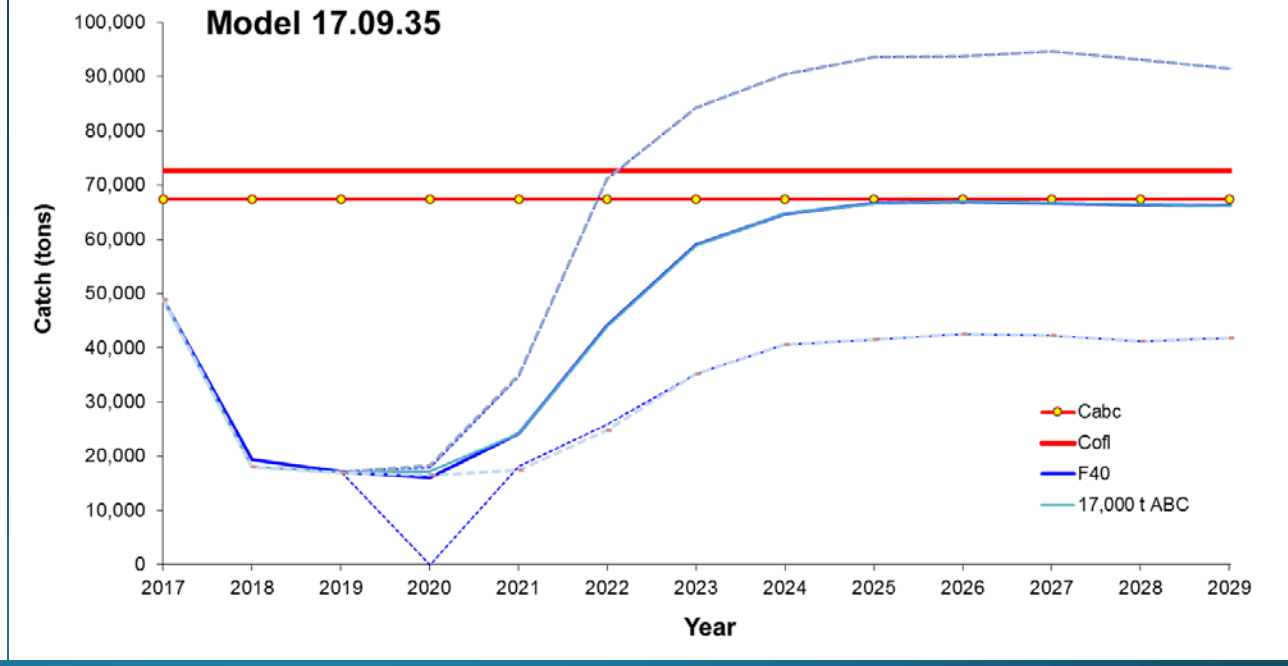
- Projected to reach all-time low in 2020
- Due to high mortality of the 2011 and 2012 age classes and expected poor recruitment 2013-2016
- First increase expected in 2021 given mean recruitment post-2016

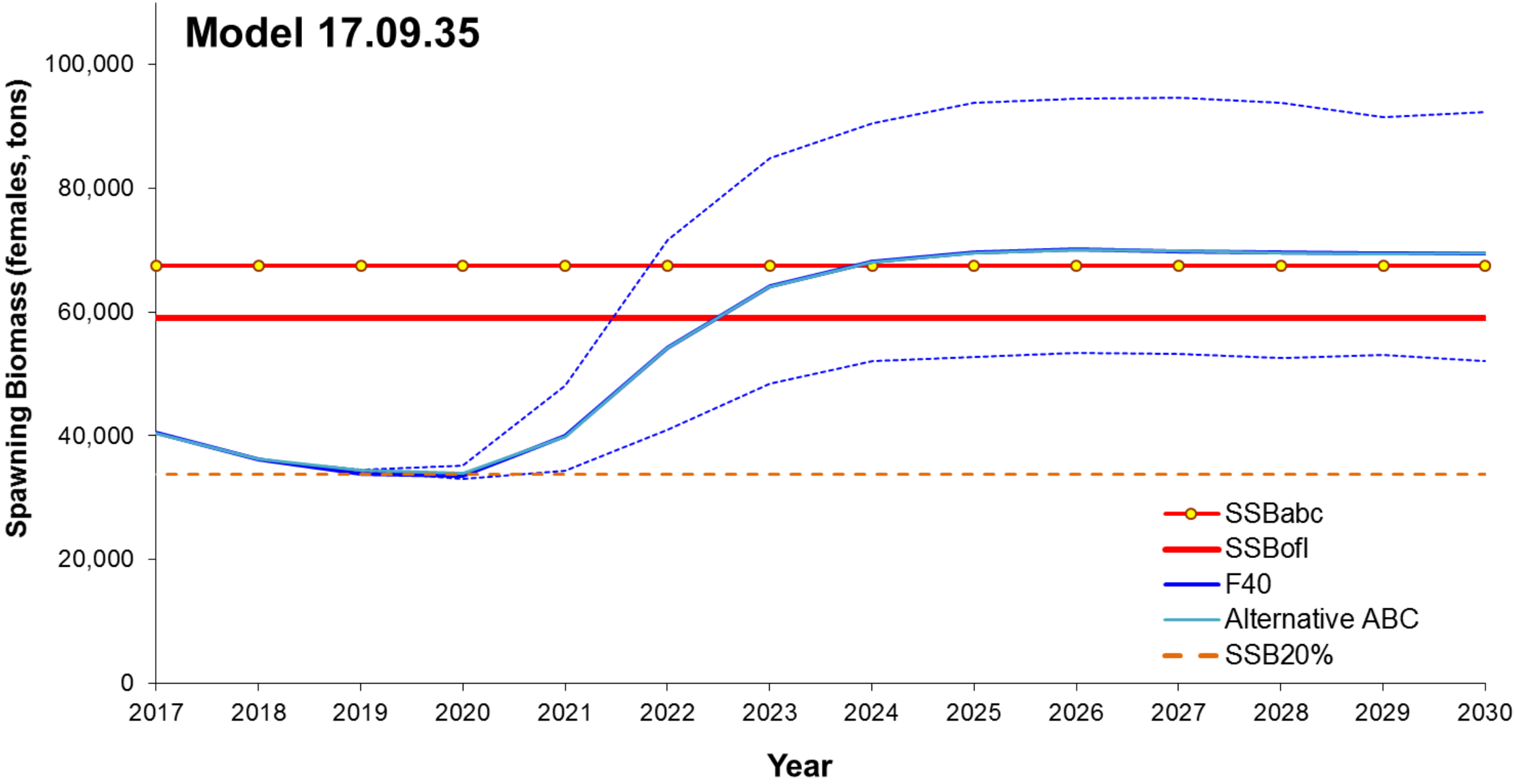


GOA Pacific cod
Model 17.09.35 Projections

- Approaches $B_{20\%}$
- ABC < Max ABC in 2018 and 2019 to remain above $B_{20\%}$
- Allowable catch below 18,000 t through 2020



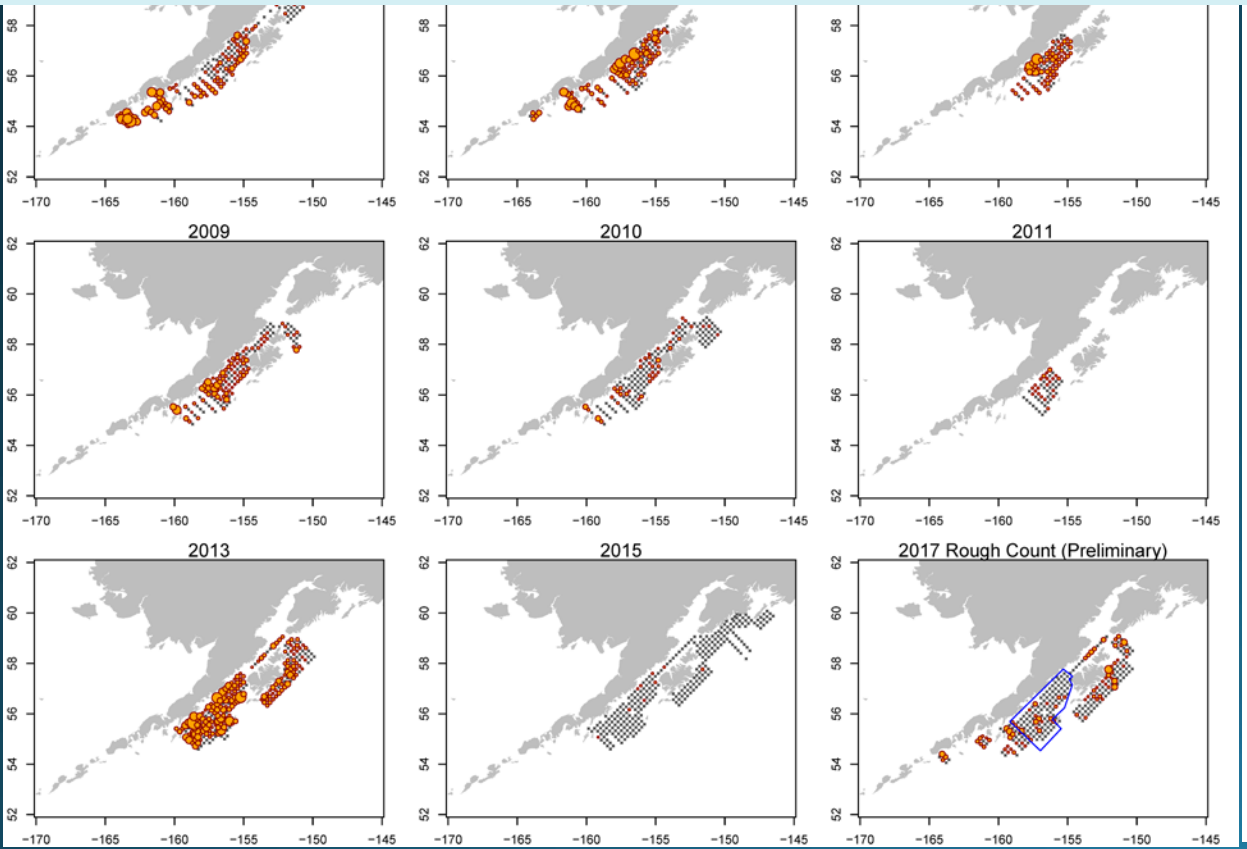


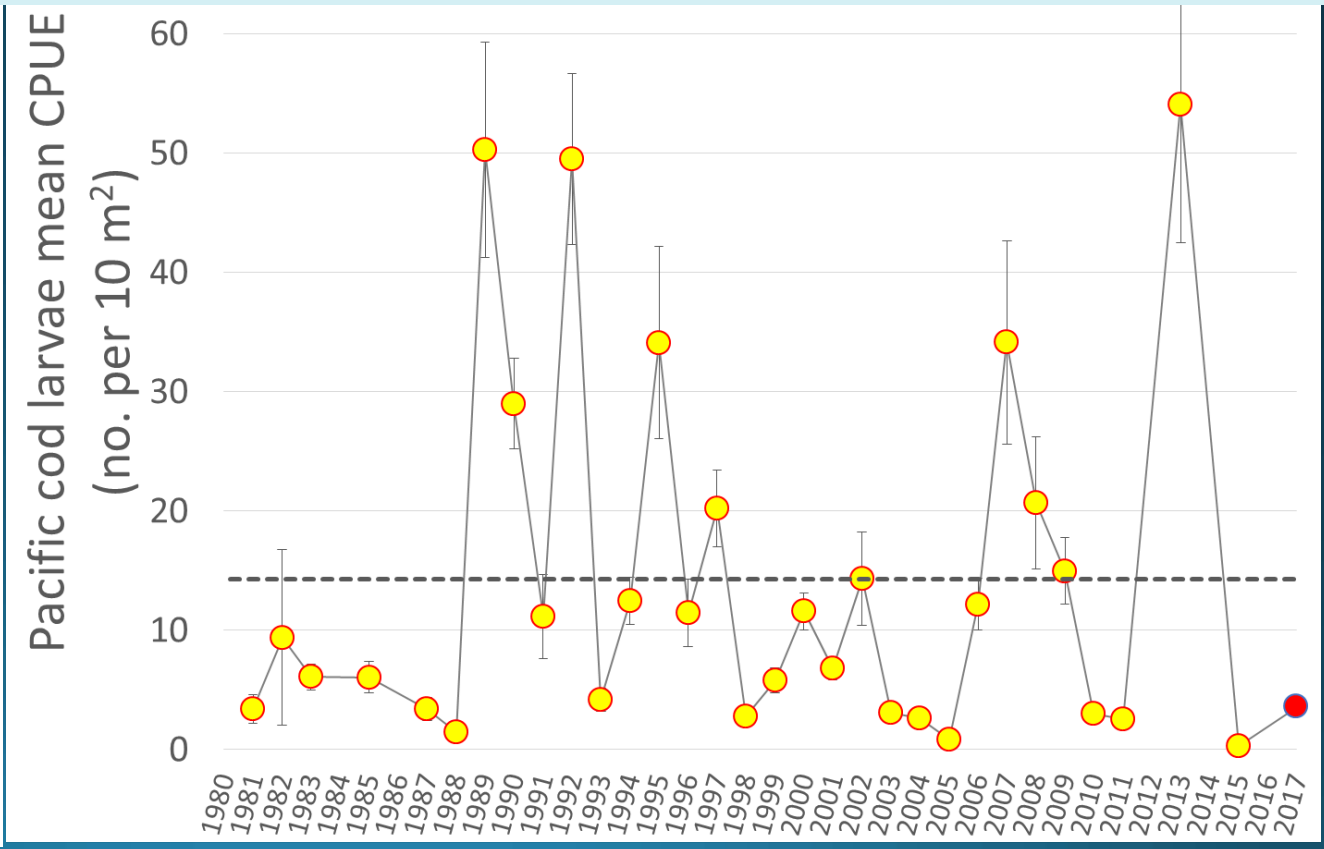

Model 17.09.35
Spawning Biomass (females, tons)
100,000
80,000
60,000
40,000
20,000
0
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
Year
SSBabc
SSBofl
F40
Alternative ABC
SSB20%

GOA Pacific cod
Future outlook

- Preliminary 2017 larval survey densities below average

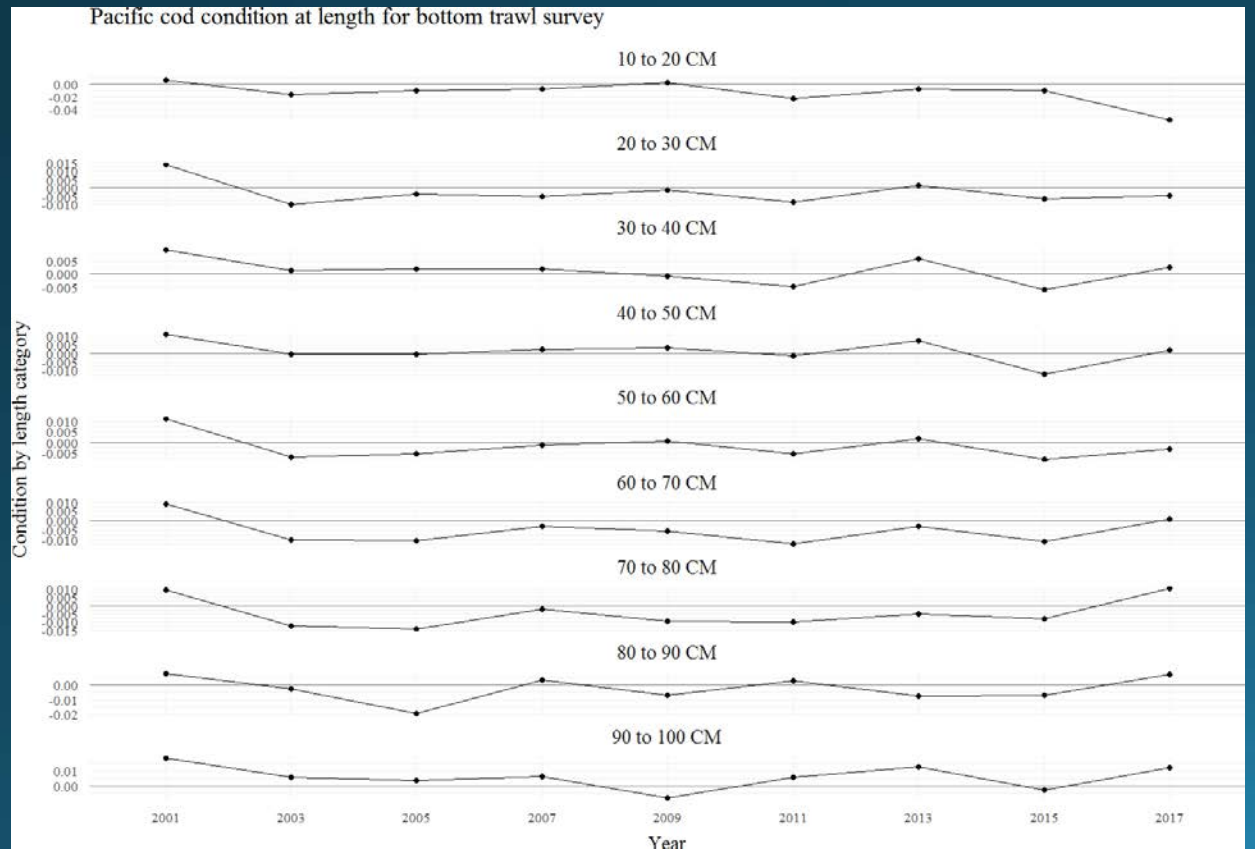
Larval abundance is not correlated with recruitment

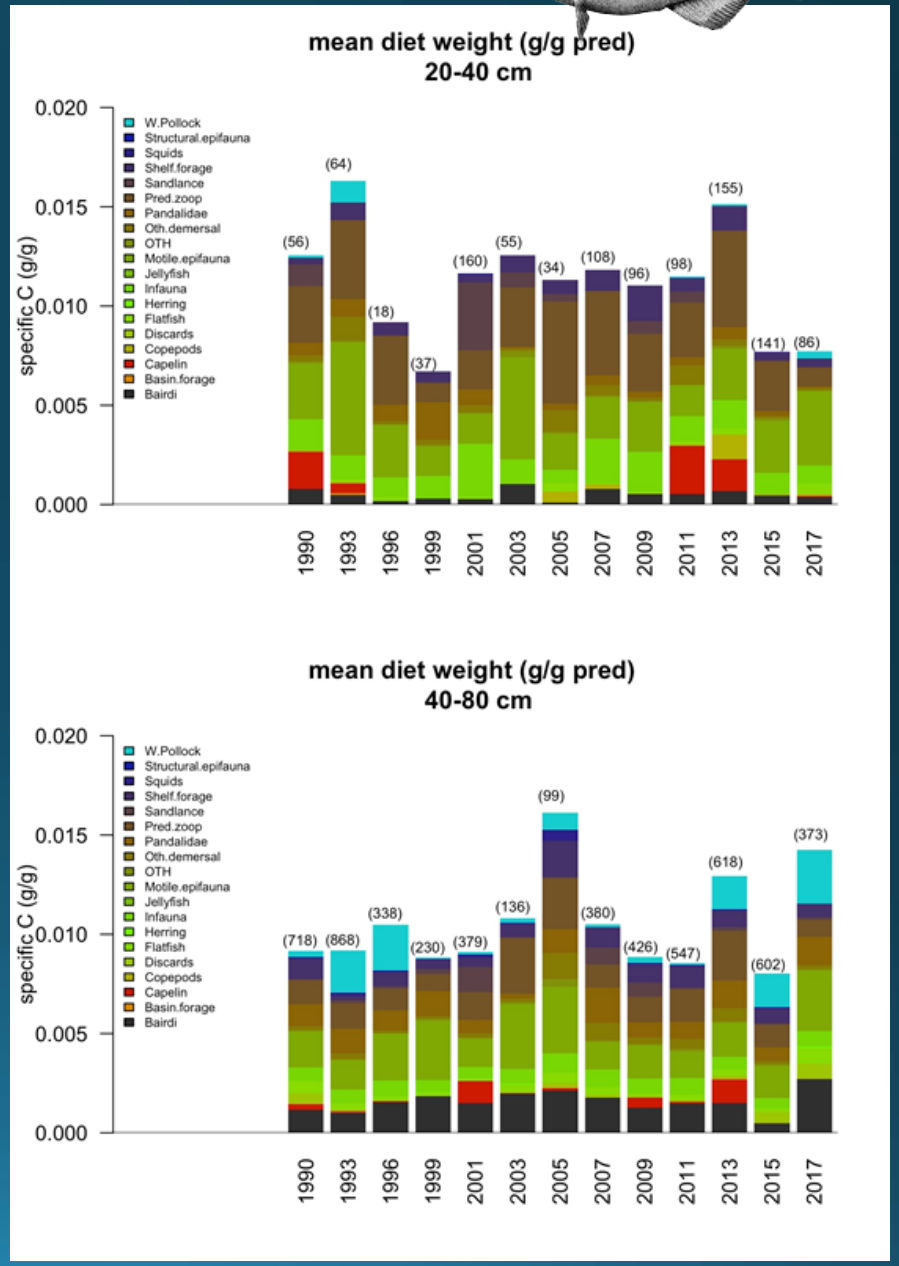




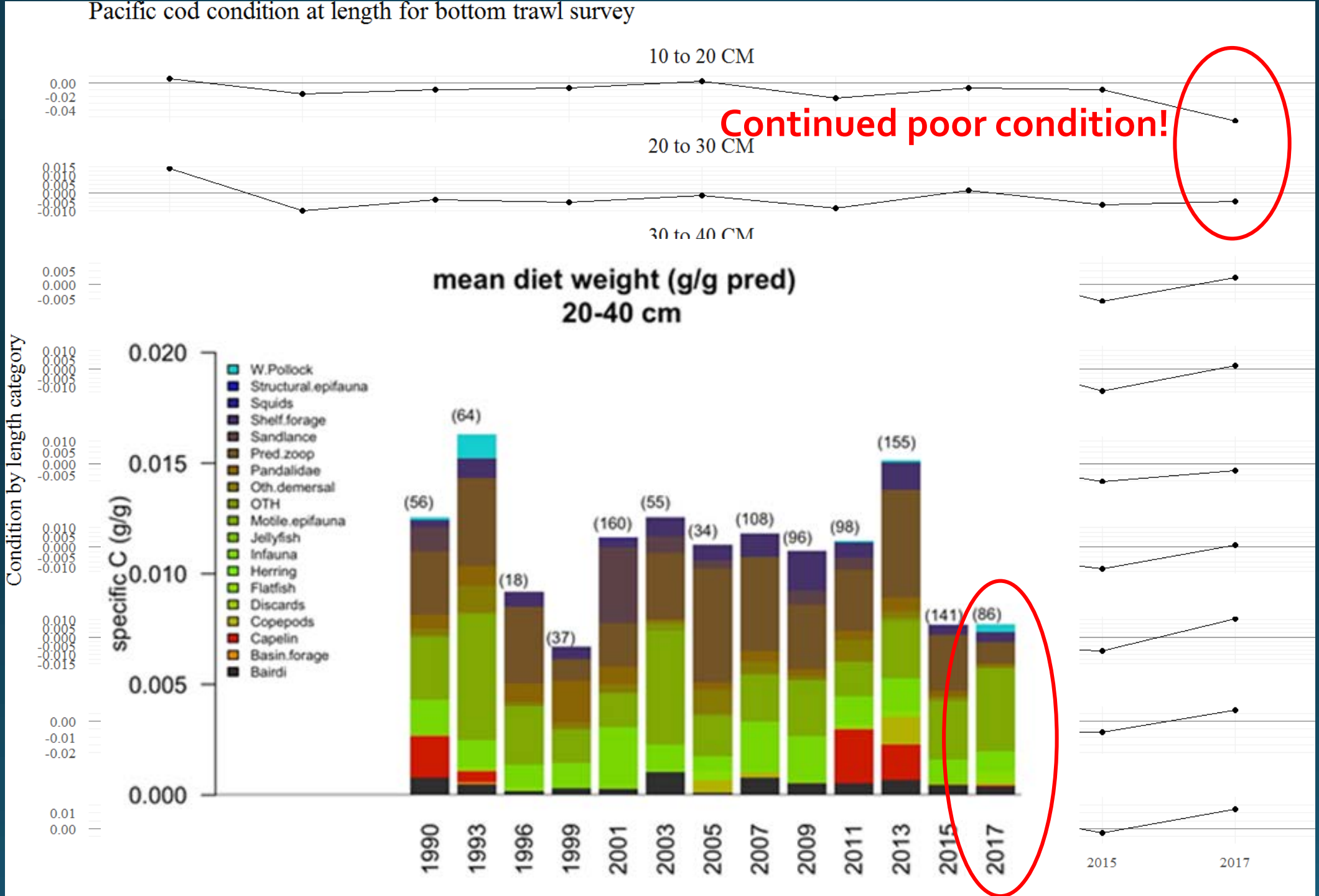
GOA Pacific cod
Future outlook

- 2017 stomach analysis
  - small fish remain below average
  - large fish (Pollock, Bairdi, Oth, shrimp ↑)



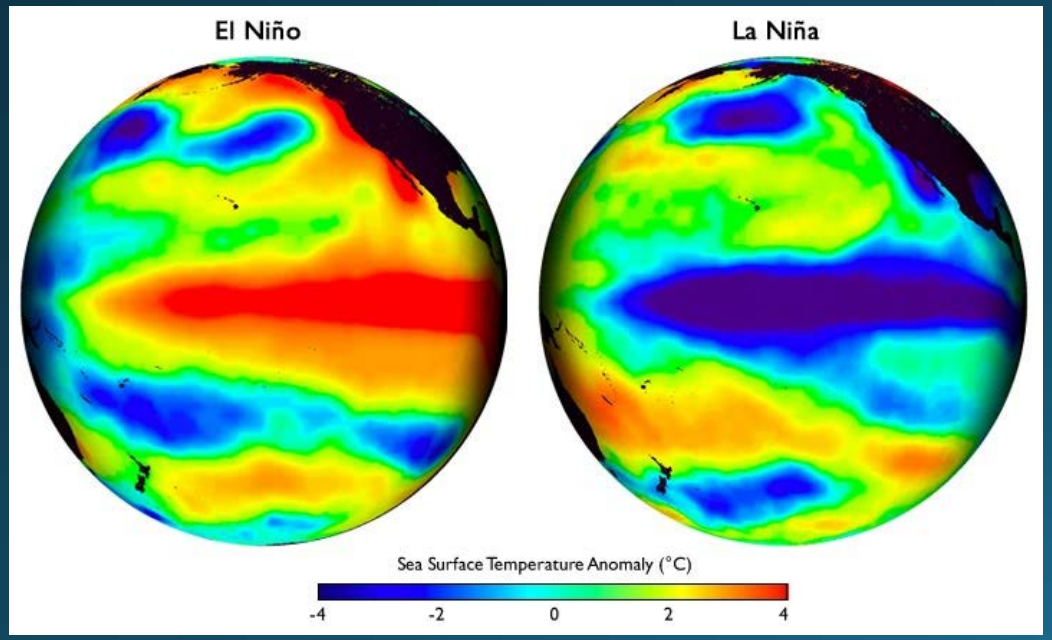


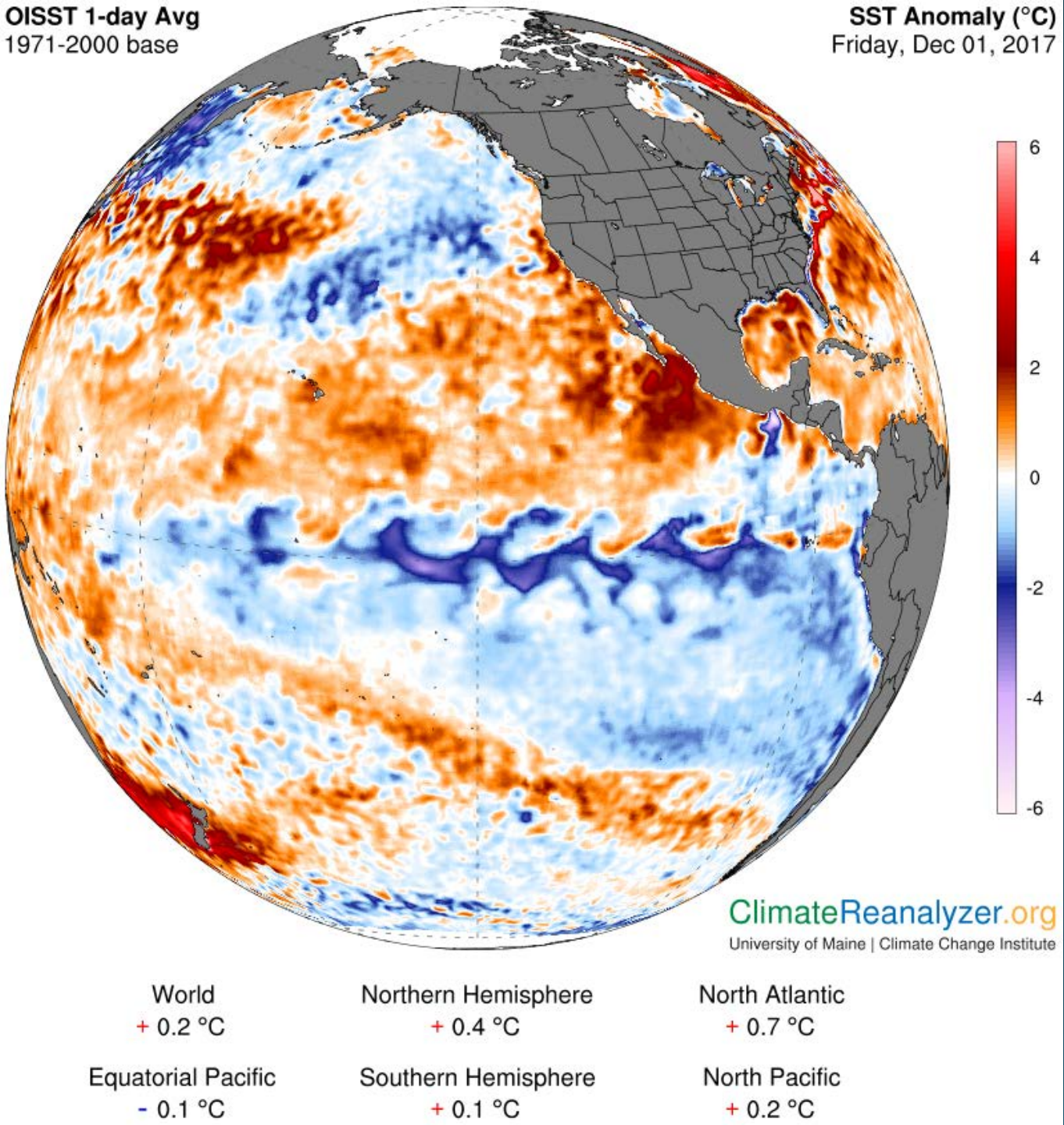
Pacific cod condition at length for bottom trawl survey



GOA Pacific cod Future outlook

- 65-75% probability of weak La Niña in 2018





GOA Pacific cod Status

- Tier 3b ($B_{2018} = B_{21.5\%}$)
- 77% decrease in ABC from last year's projection
  - **Max ABC 2018 = 19,401 t**
  - **Recommended ABC 2018 = 18,000 t**
  - **Max ABC 2019 = 17,634 t**
  - **Recommended ABC = 17,000 t**
- Apportionment based on random effects model

Authors' recommended Model 17.09.35

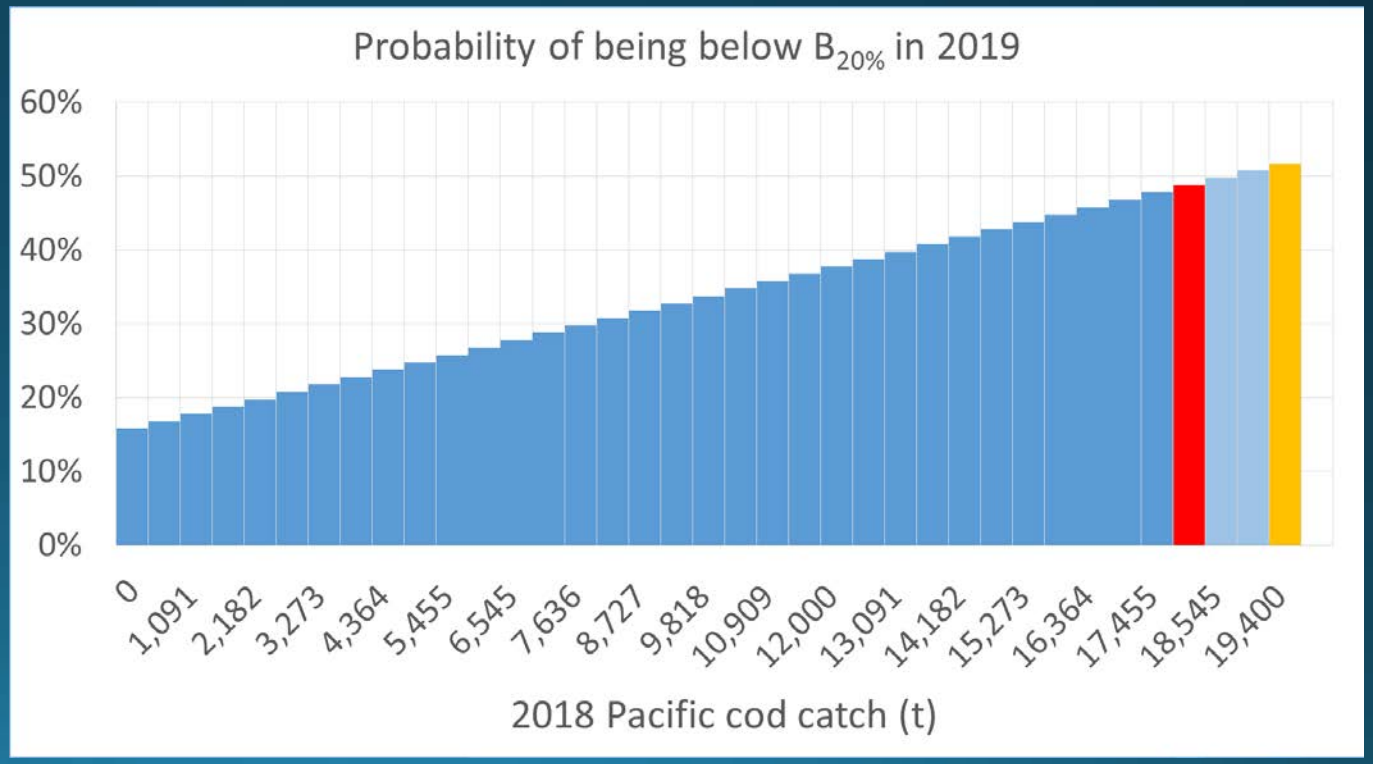
	As estimated or specified last year for:		As estimated or specified this year for:	
Quantity	2017	2018	2018	2019
M (natural mortality rate)	0.47	0.47	0.49	0.49
Tier	3a	3a	3b	3b
Projected total (age 0+) biomass (t)	426,384	428,885	170,565	198,942
Female spawning biomass (t)				
Projected	91,198	98,479	36,209	34,424
$B_{100\%}$	196,776	196,776	168,583	168,583
$B_{40\%}$	78,711	78,711	67,433	67,433
$B_{35\%}$	68,872	68,872	59,004	59,004
F_{OFL}	0.652	0.652	0.42	0.40
$maxF_{ABC}$	0.530	0.530	0.34	0.32
F_{ABC}	0.530	0.530	0.31	0.31
OFL (t)	105,378	94,188	23,565	21,412
maxABC (t)	88,342	79,272	19,401	17,634
ABC (t)	88,342	79,272	**18,000**	**17,000**
	As determined this year for:			
Status	2015	2016	2016	2017
Overfishing	no	n/a	No	n/a
Overfished	n/a	no	n/a	No
Approaching overfished	n/a	no	n/a	No

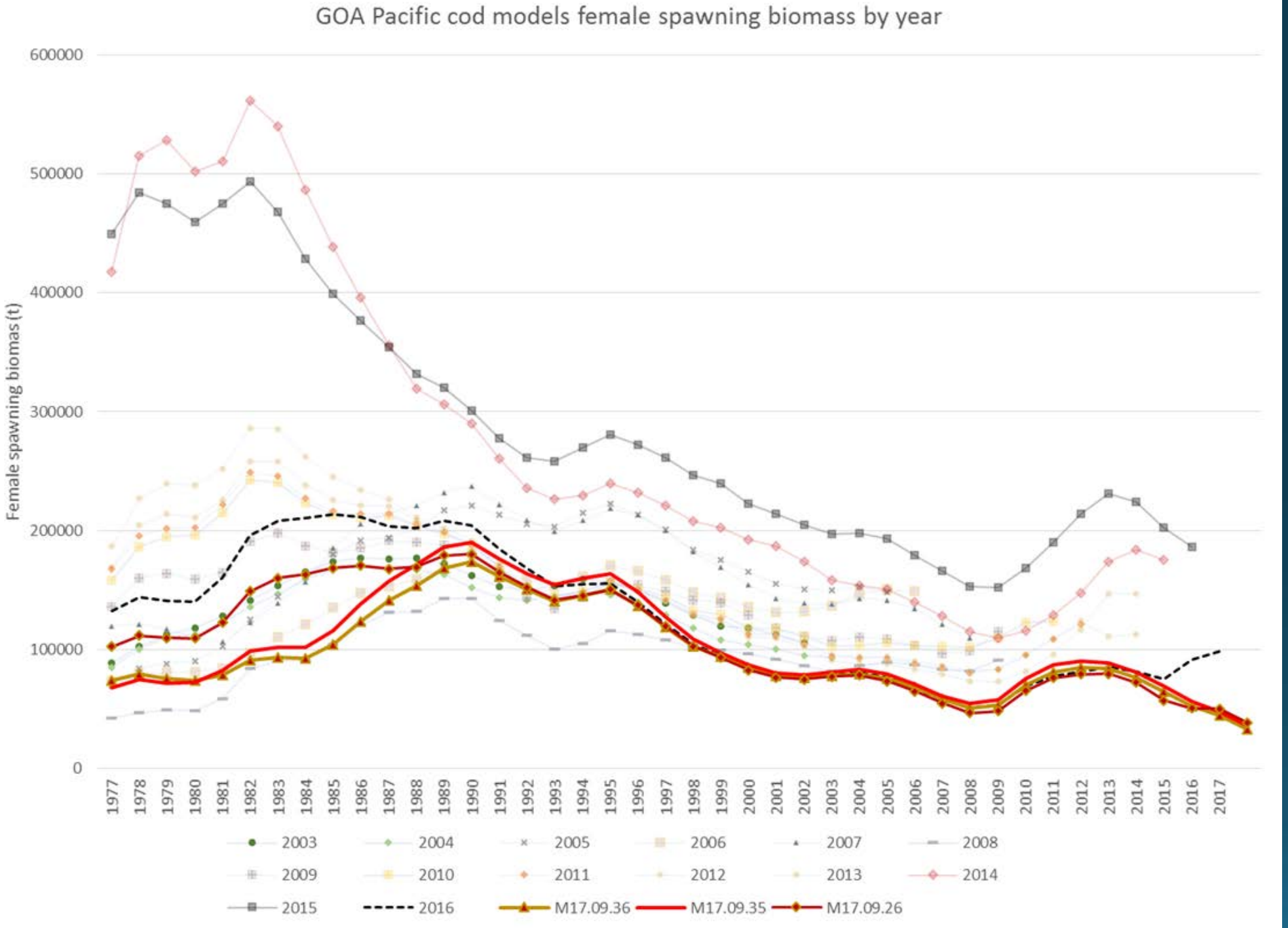
	Western	Central	Eastern	Total
Random effects area apportionment (percent)	44.9	45.1	10.0	100.00
2018 ABC	**8,082**	**8,118**	**1,800**	**18,000**
2019 ABC	**7,633**	**7,667**	**1,700**	**17,000**

GOA Pacific cod
Probability of being below $B_{20\%}$ in 2019

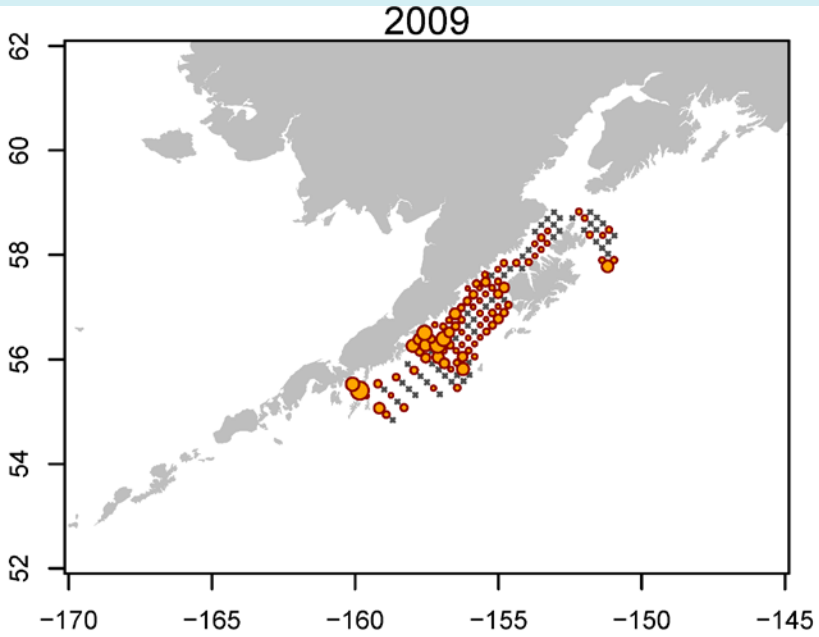
- 16% probability with no catch in 2018
- ~49% probability at 18,000 t catch in 2018
- ±10% by ±5,455 t

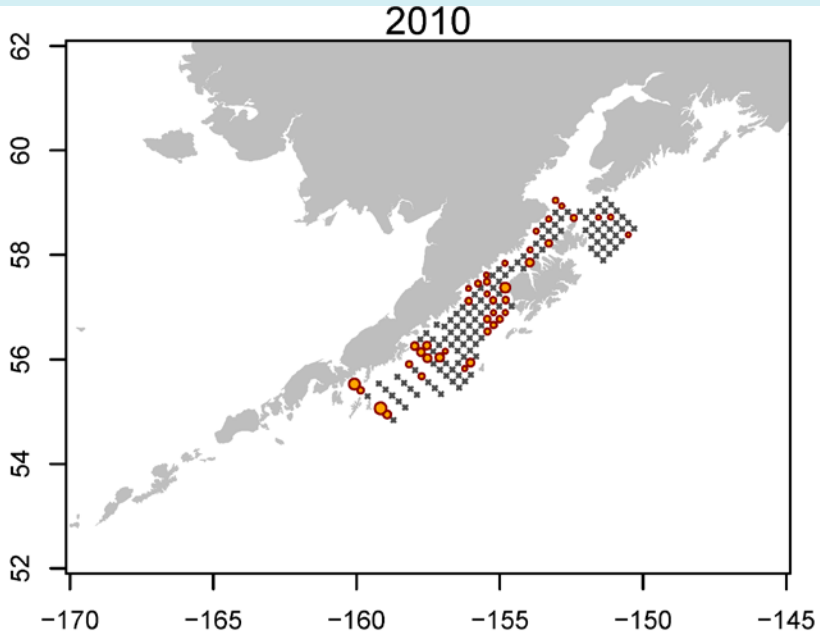
Assumes final 2017 catch at 48,941 t
(currently at 46,948 t)

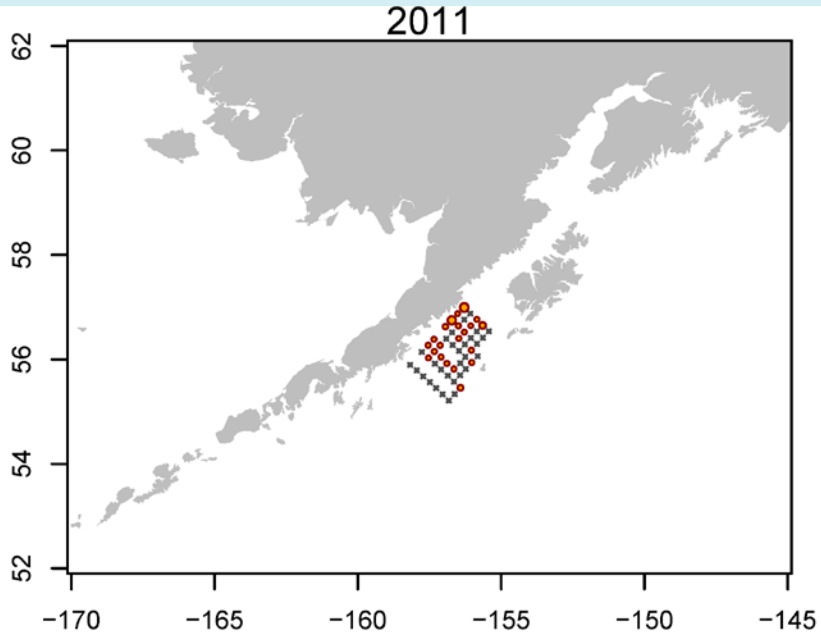


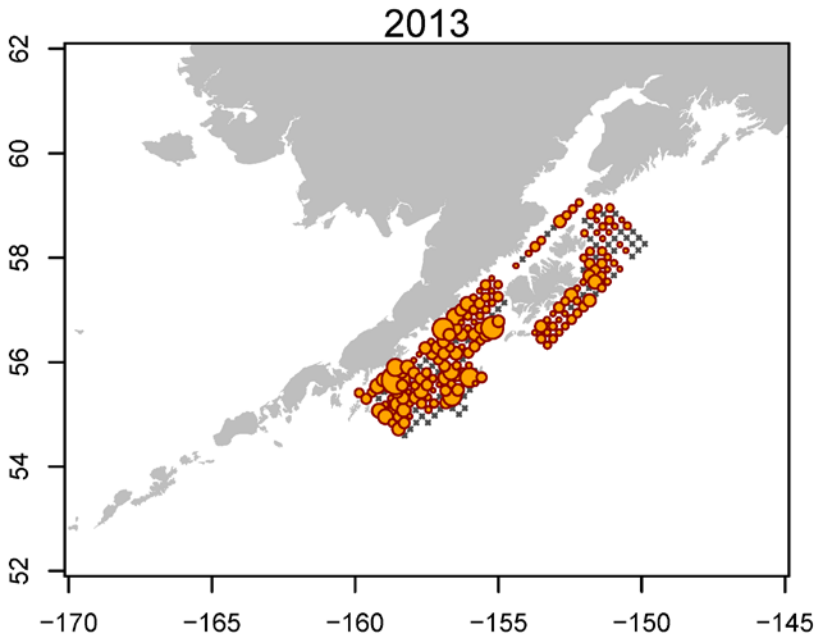

GOA Pacific cod models female spawning biomass by year
Female spawning biomas (t)
600000
500000
400000
300000
200000
100000
0
1977 1978 1979 1980 1981 1982 1983 1984 1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
M17.09.36
M17.09.35
M17.09.26

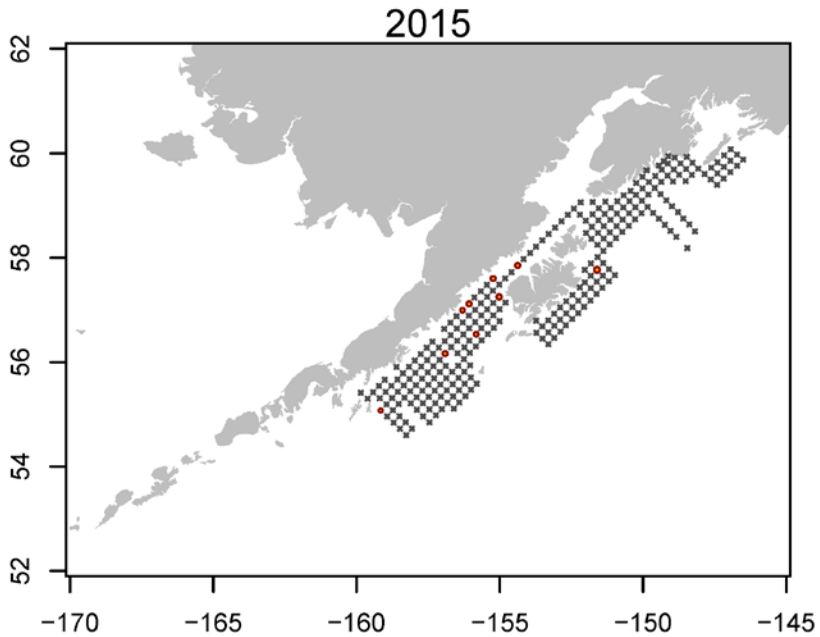
Larval abundance is not correlated with recruitment

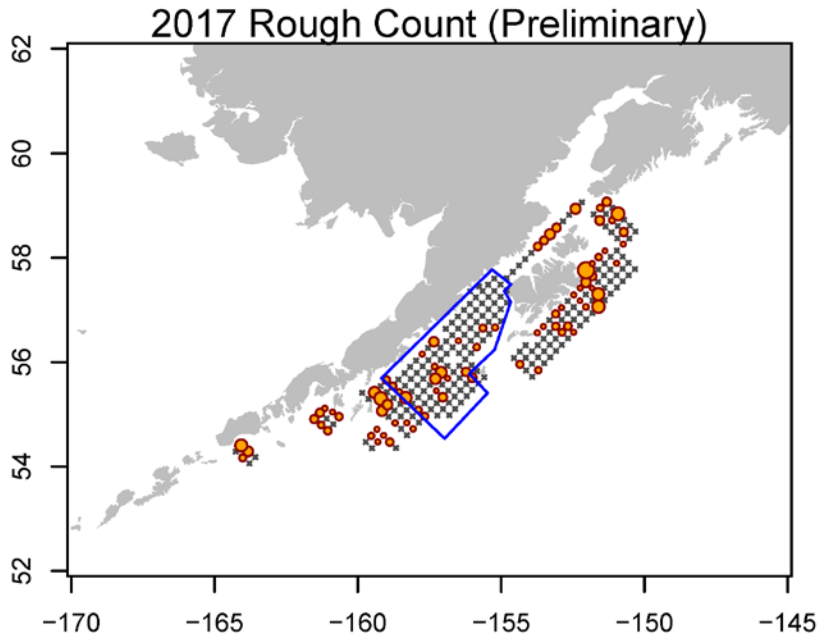






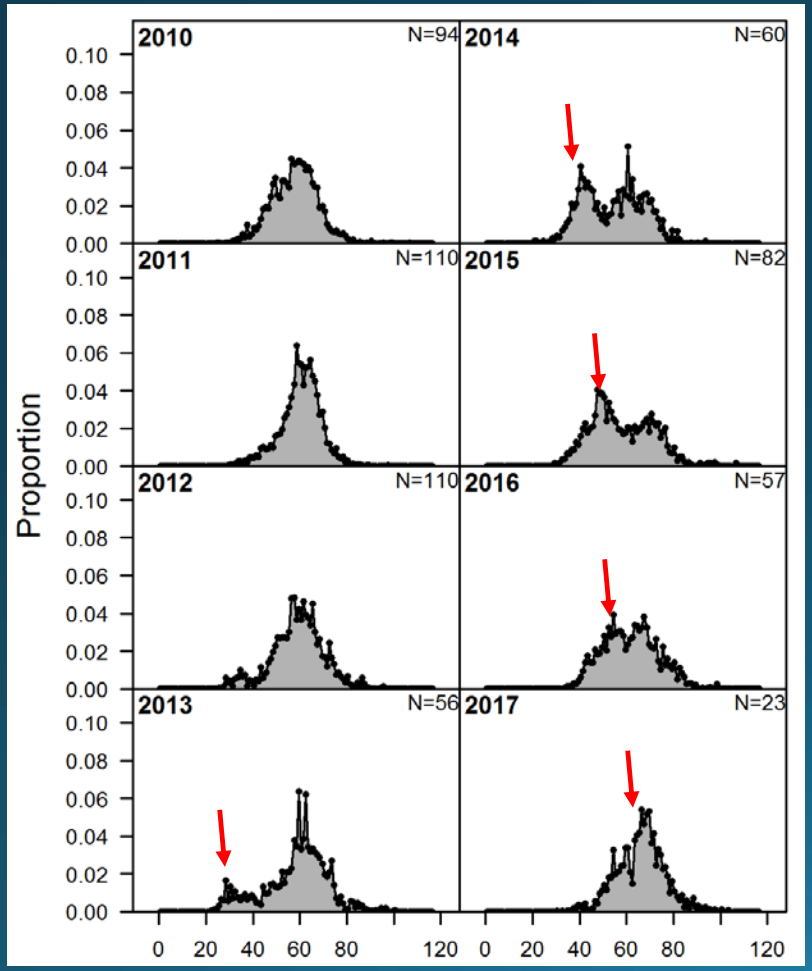




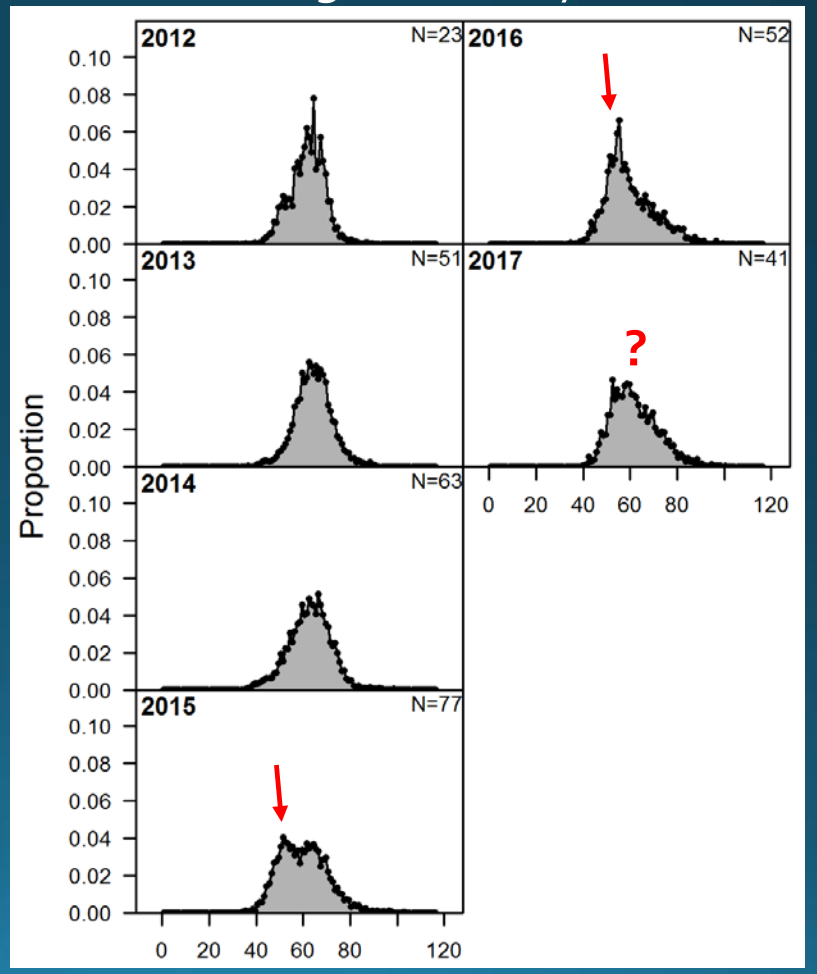


GOA Pacific cod
Fishery length composition

Trawl fishery

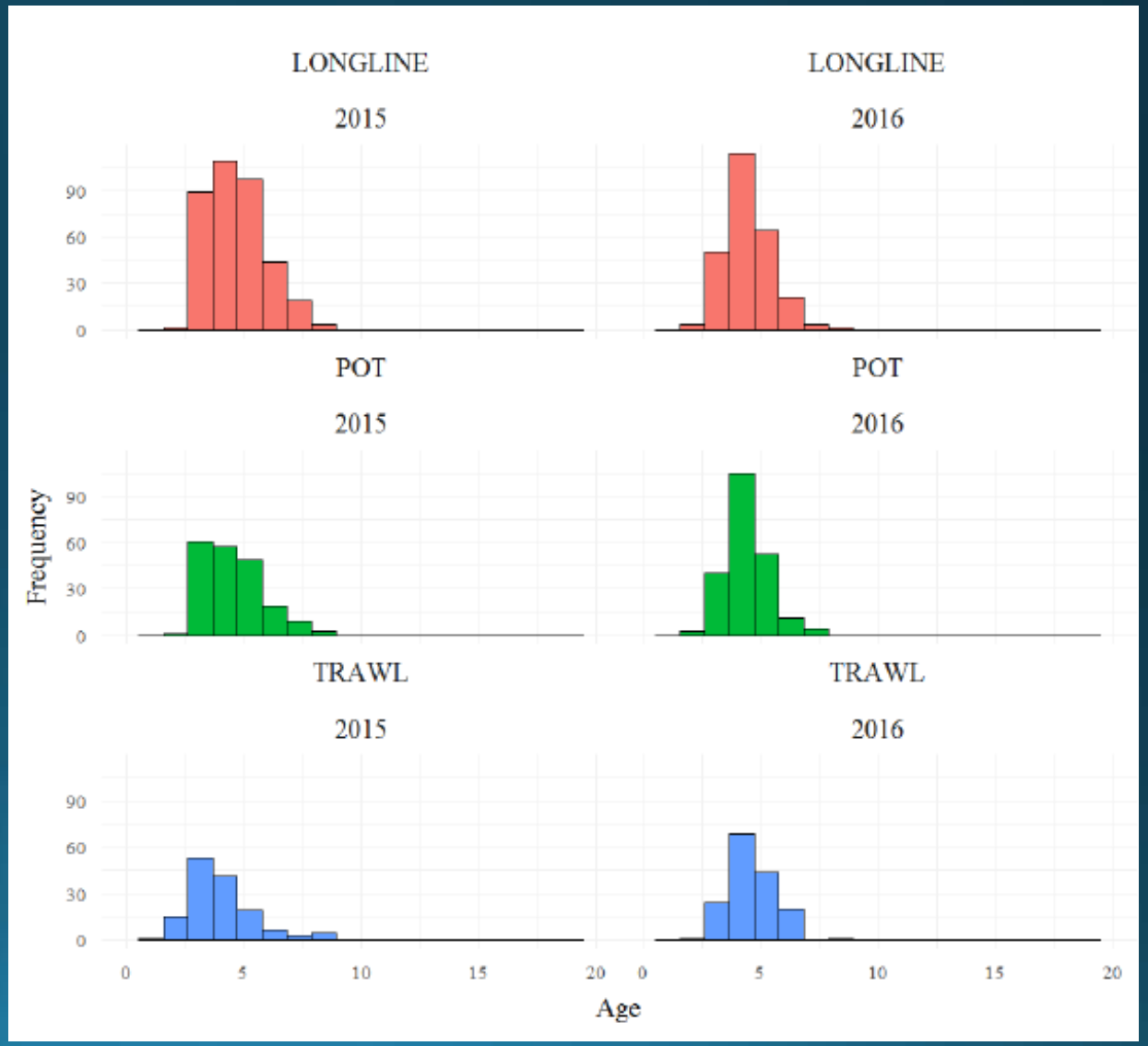


Longline fishery



GOA Pacific cod
Fishery age composition

- Two years aged 2015-2016
- Dominated by 2012 year class in 2016
- No fish > age 8
- Matches findings by Andrews (2016) which supports the "young fish" hypothesis through lead-radium dating (max Pcod age of 12-14)



Ages read by Delsa Anderl and Charles Hutchinson