



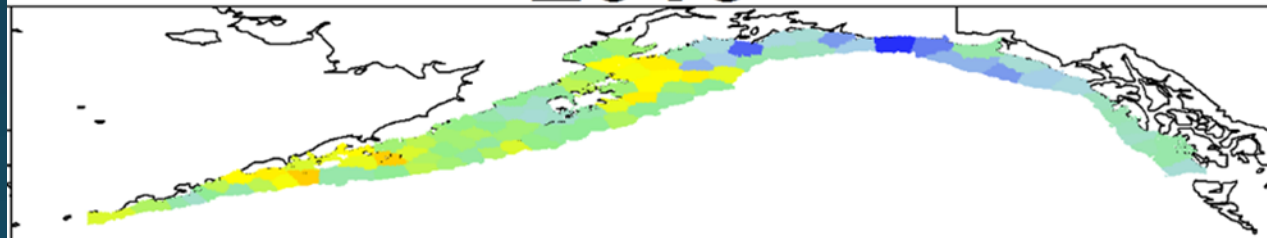
"Would you please elaborate on 'then something bad happened'?"

Gulf of Alaska Pacific cod

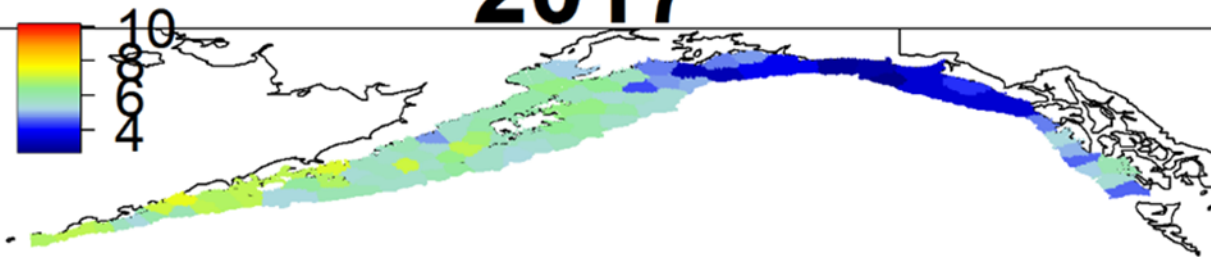
Steven J. Barbeaux, Kerim Aydin,
Ben Fissel, Kirstin Holsman,
Kalei Shotwell, Wayne Palsson,
Qiong Yang, and Stephani Zador
NPFMC SSC

December 5, 2017

2015

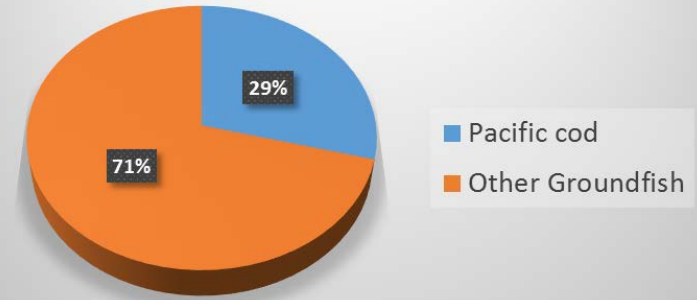


2017



GOA Groundfish Economics

Gulf of Alaska groundfish first-wholesale revenue



- 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.

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 o+) 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
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F_{OFL}	0.652	0.652	0.42	0.40
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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

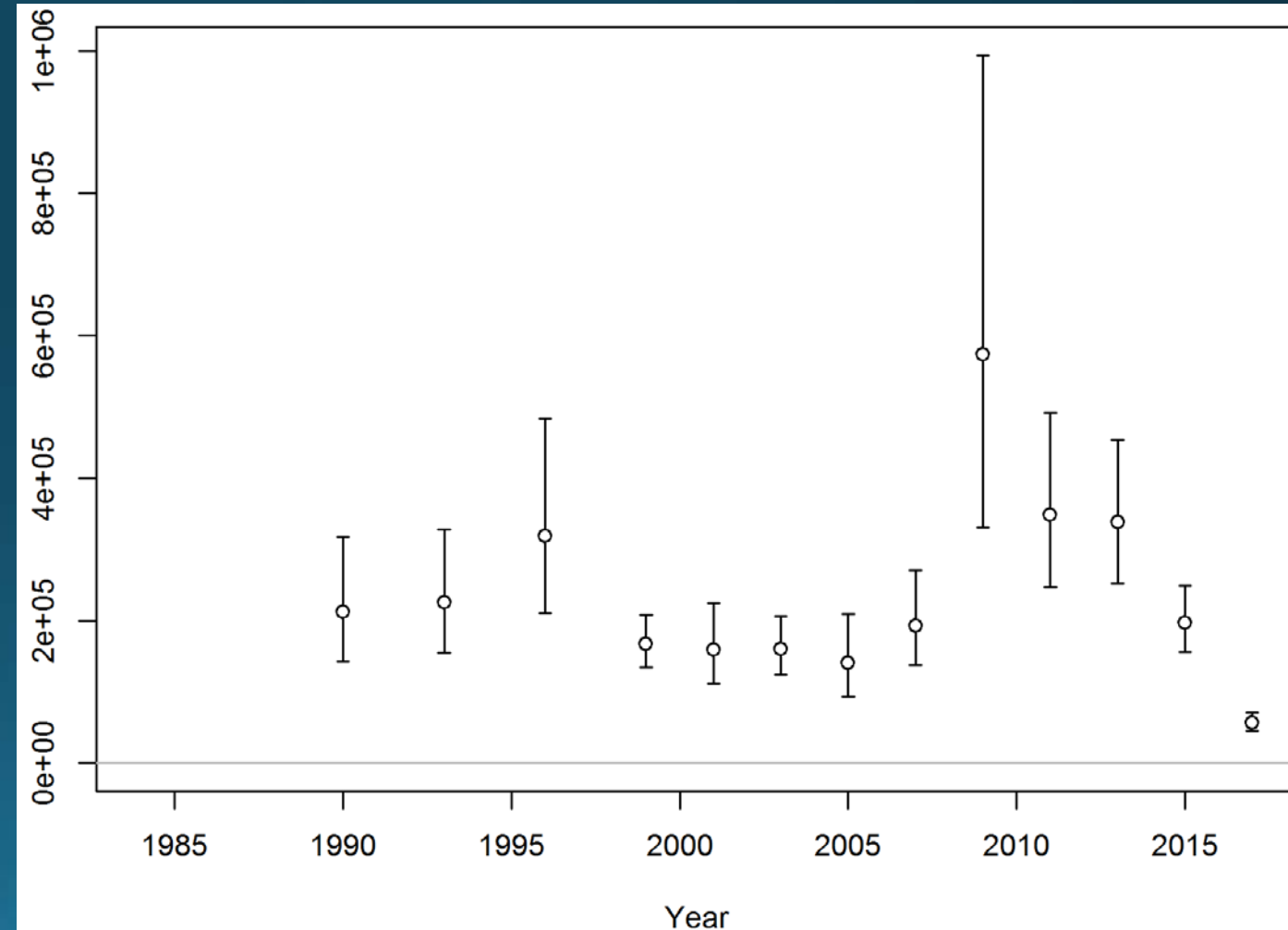
	Western	Central	Eastern	Total
Random effects area apportionment (percent)	44.9	45.1	10.0	100.00
2018 ABC	8,082	8,118	1,800	18,000
2019 ABC	7,633	7,667	1,700	17,000

GOA Pacific cod

2017 Bottom trawl survey



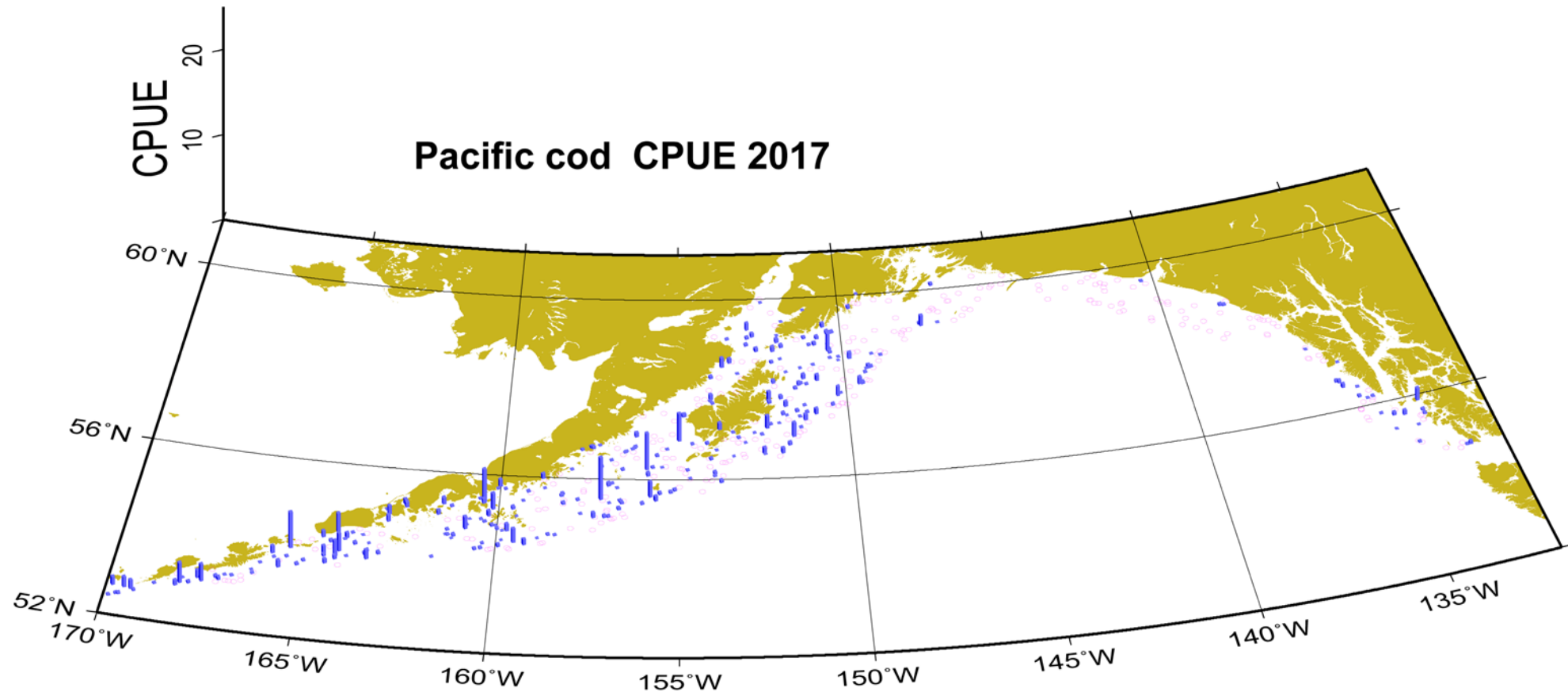
- Lowest estimate ever
 1.96×10^8 fish and 107,324 t
- Precise estimate (0.117 CV)
- 71% decline in abundance
since 2015 (83% since 2013)
- 58% decline in biomass
since 2015 (78% since 2013)

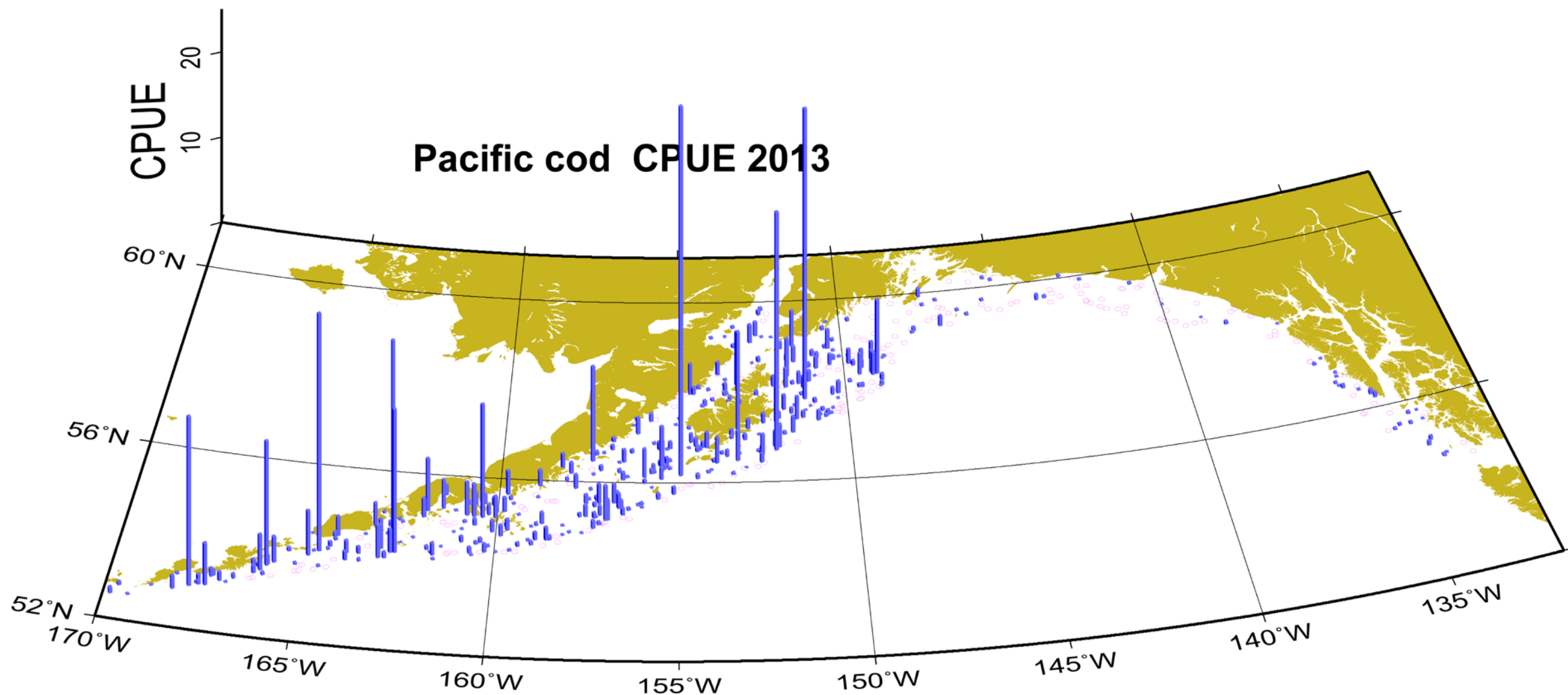


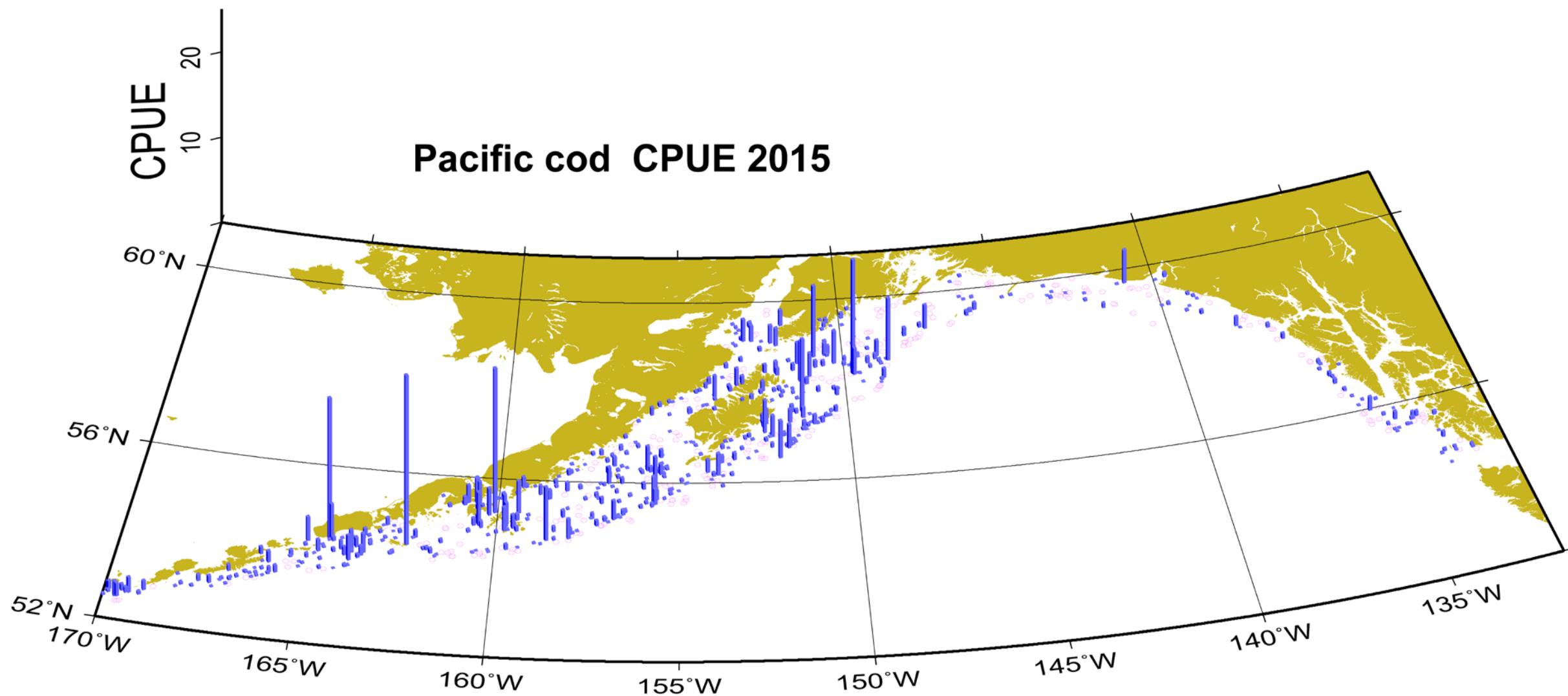
GOA Pacific cod Bottom trawl survey

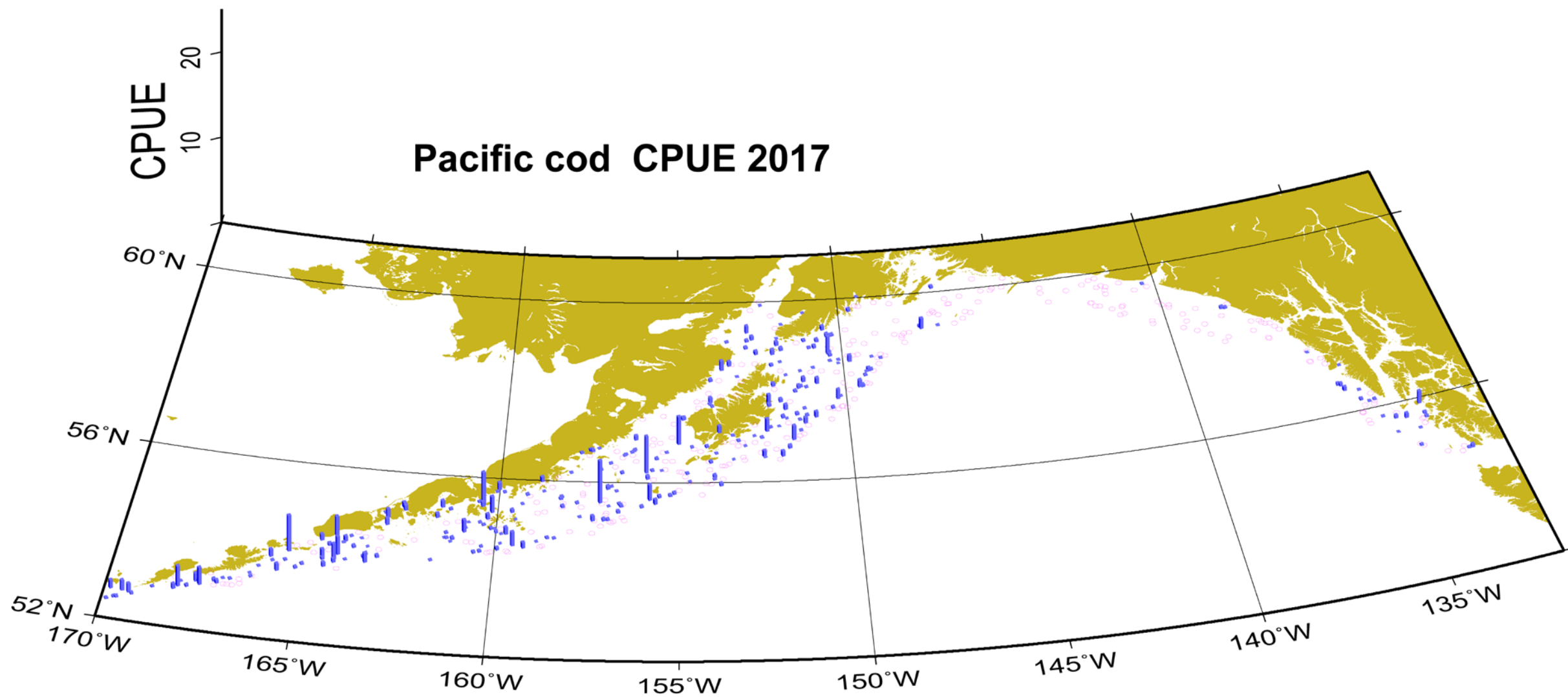


- Low density through surveyed area
- Some medium-low density along Alaska Peninsula and south of Unimak Island





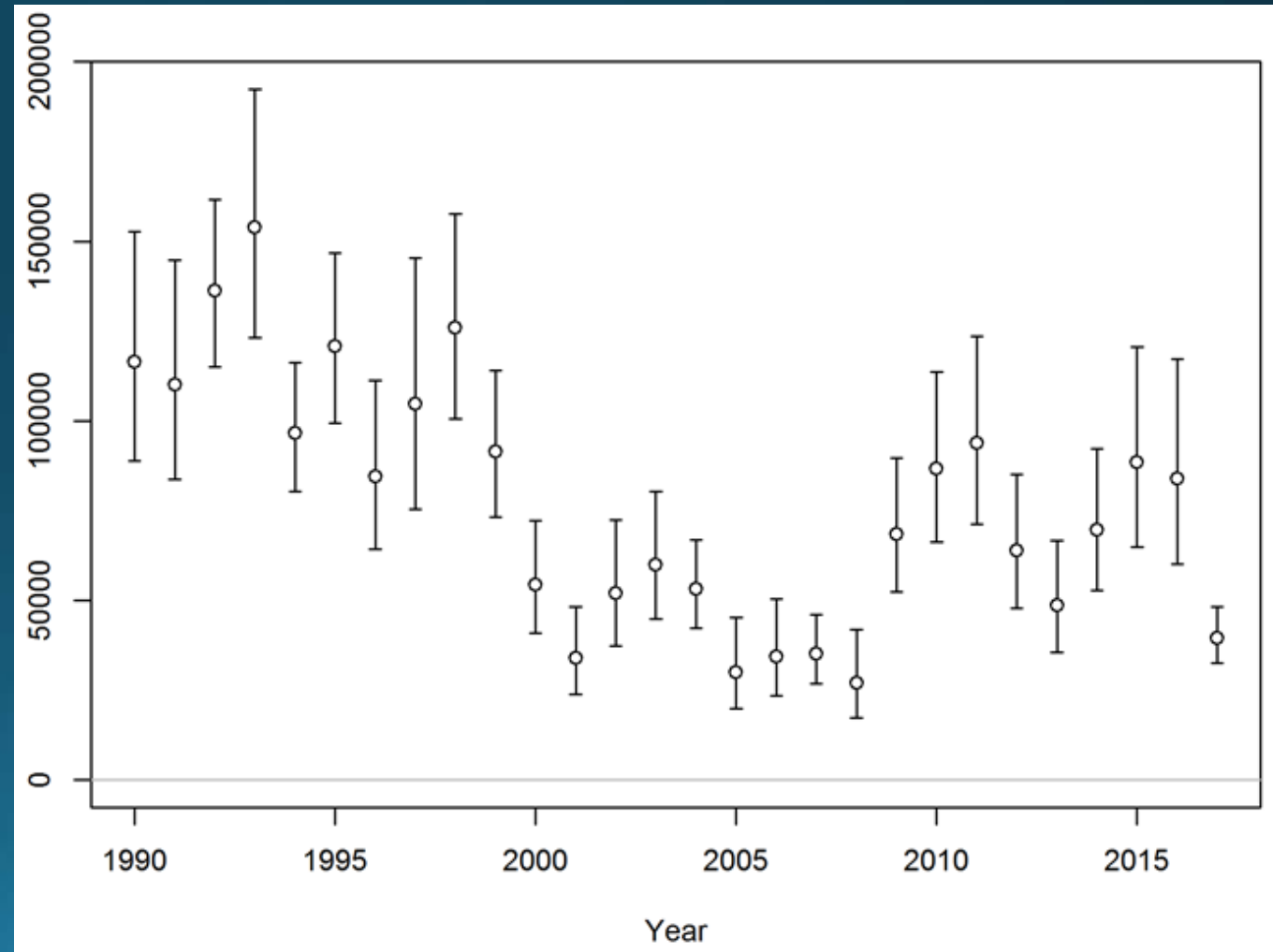
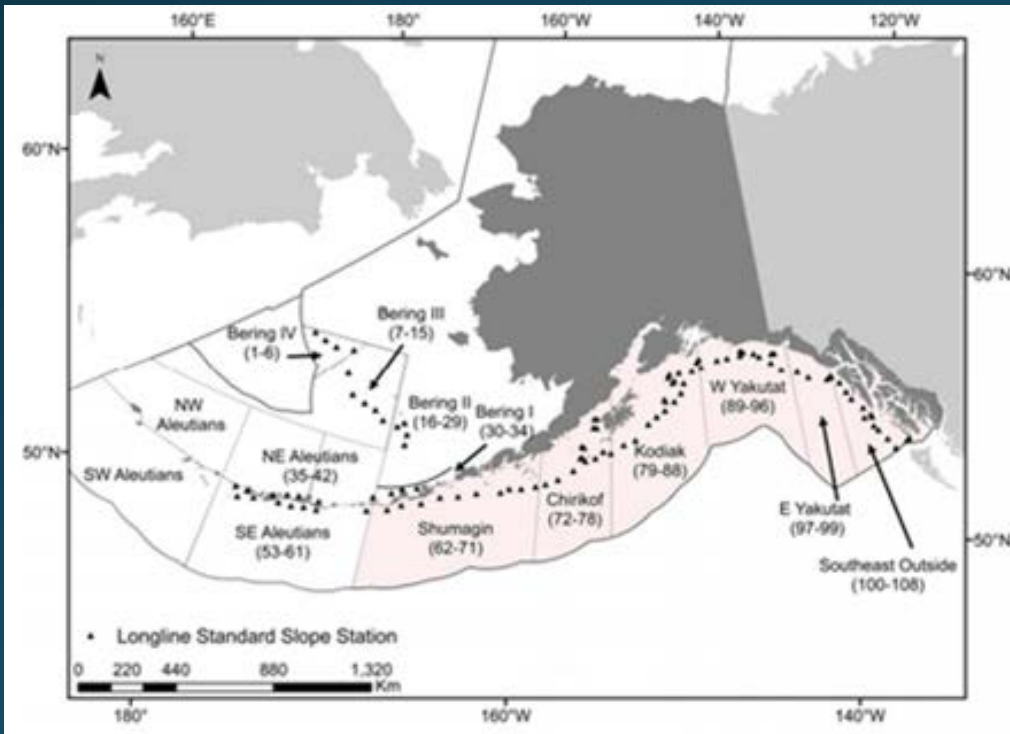




GOA Pacific cod AFSC longline survey



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



GOA Pacific cod

Other surveys

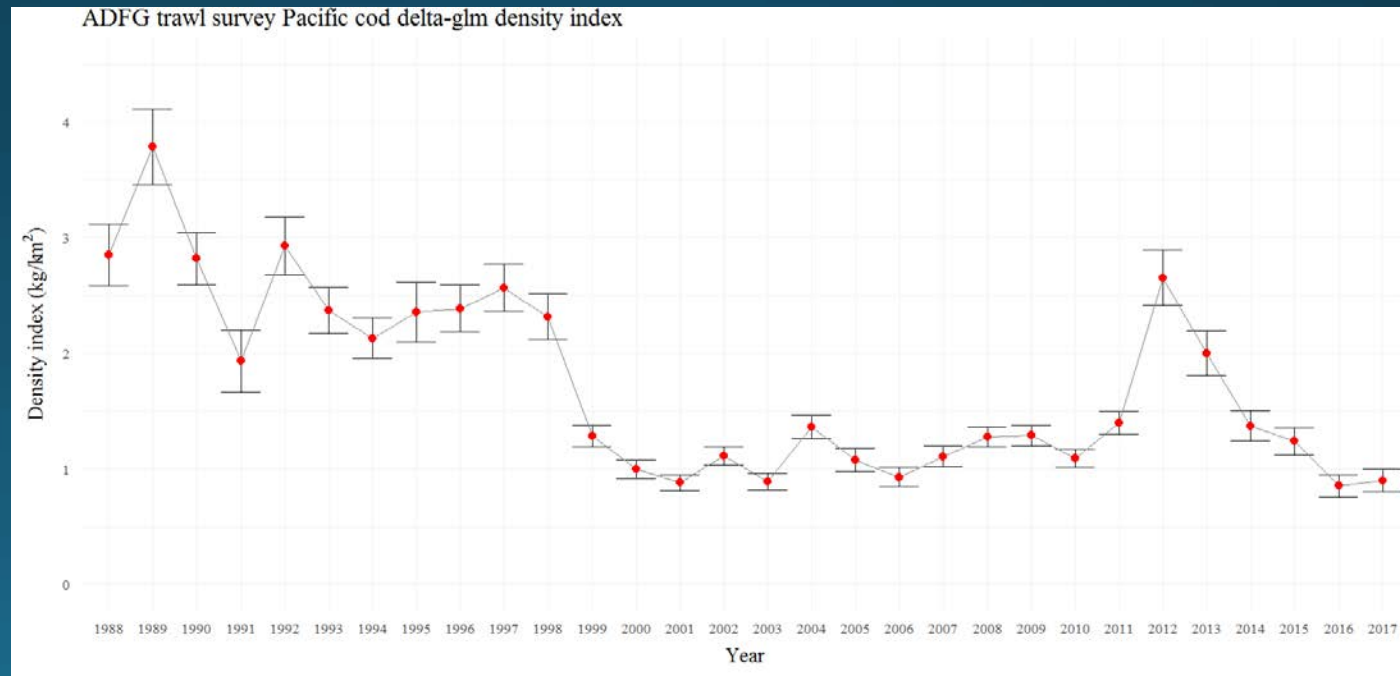
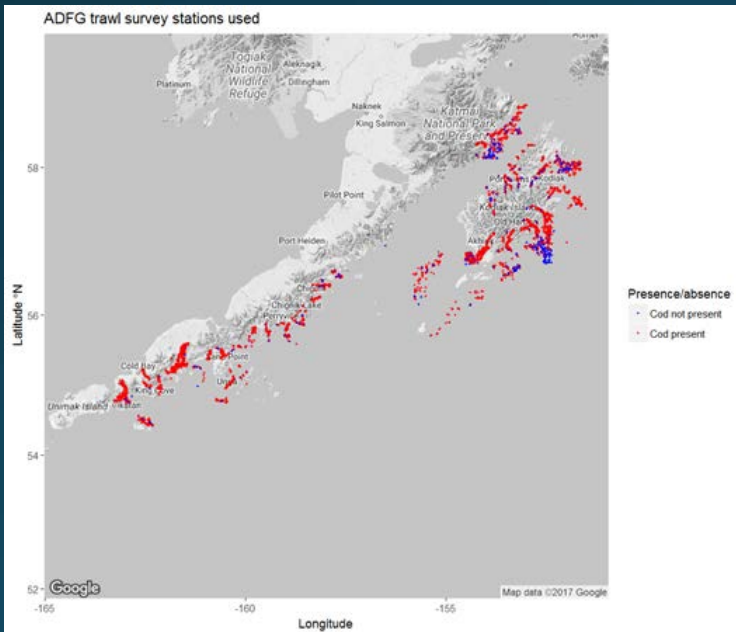
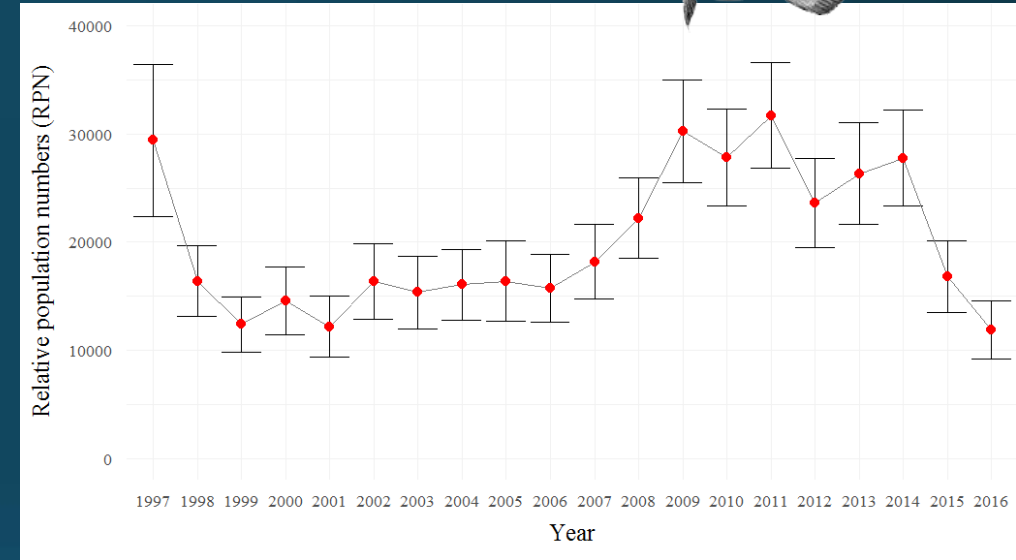


IPHC longline survey 1997-2016

- 2016 Lowest

ADFG trawl survey 1988-2017

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

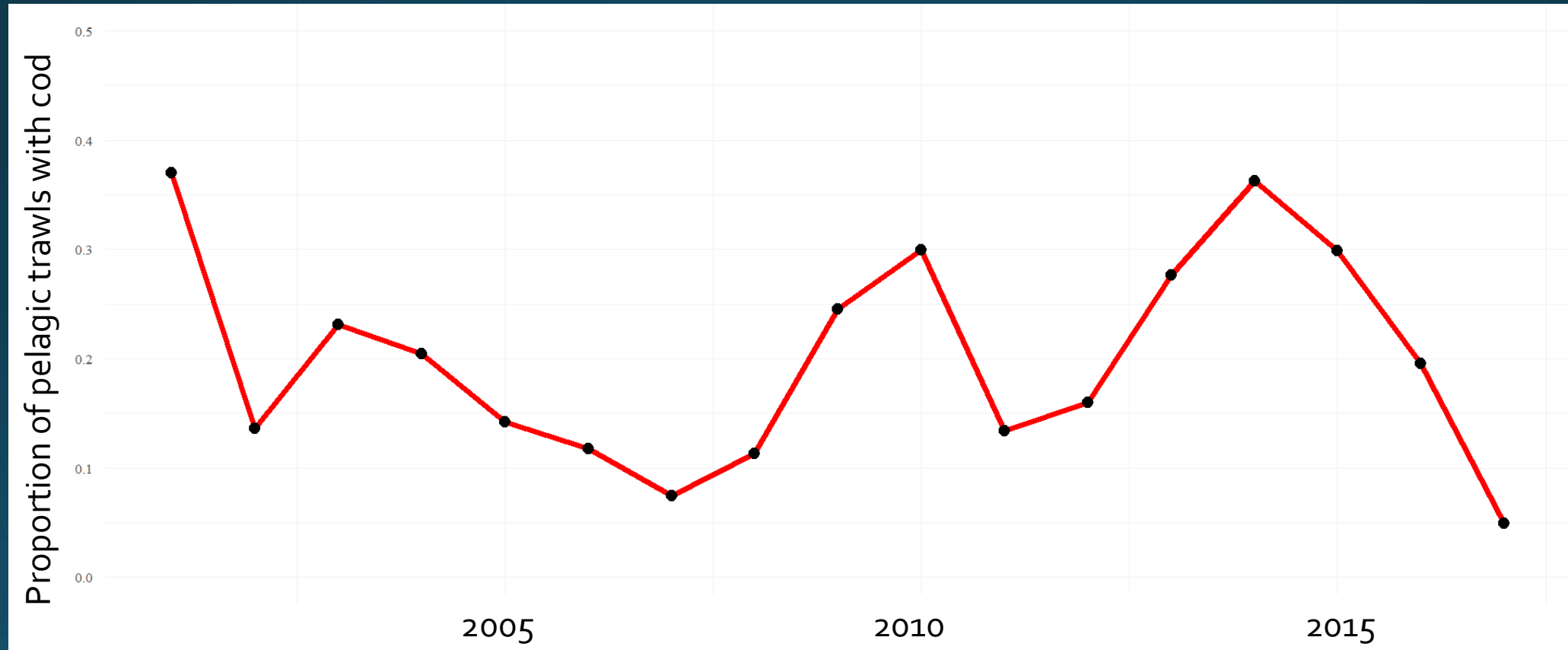


GOA Pacific cod

Bycatch in pollock fishery



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

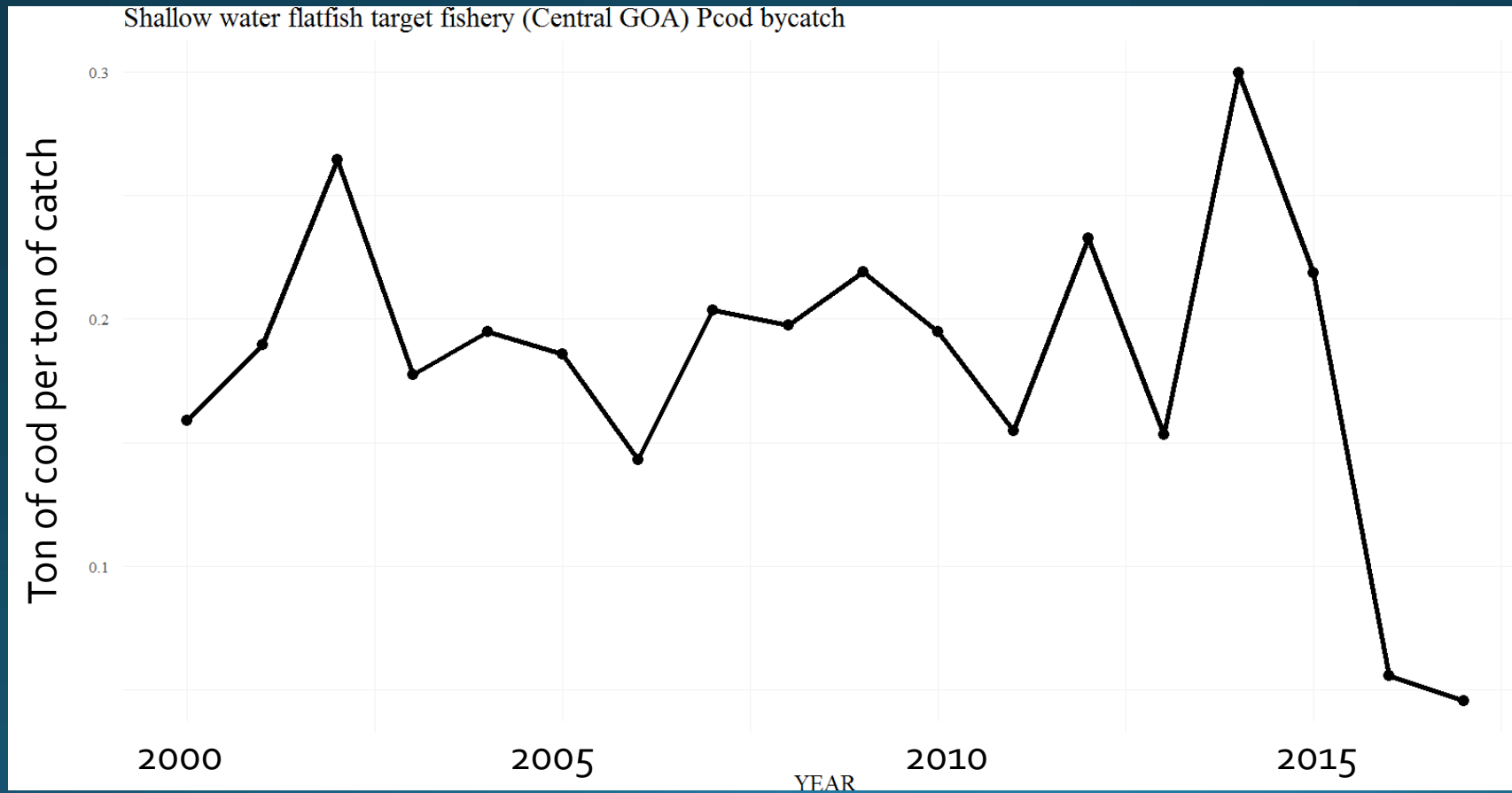


GOA Pacific cod

Bycatch in shallow water flatfish fishery



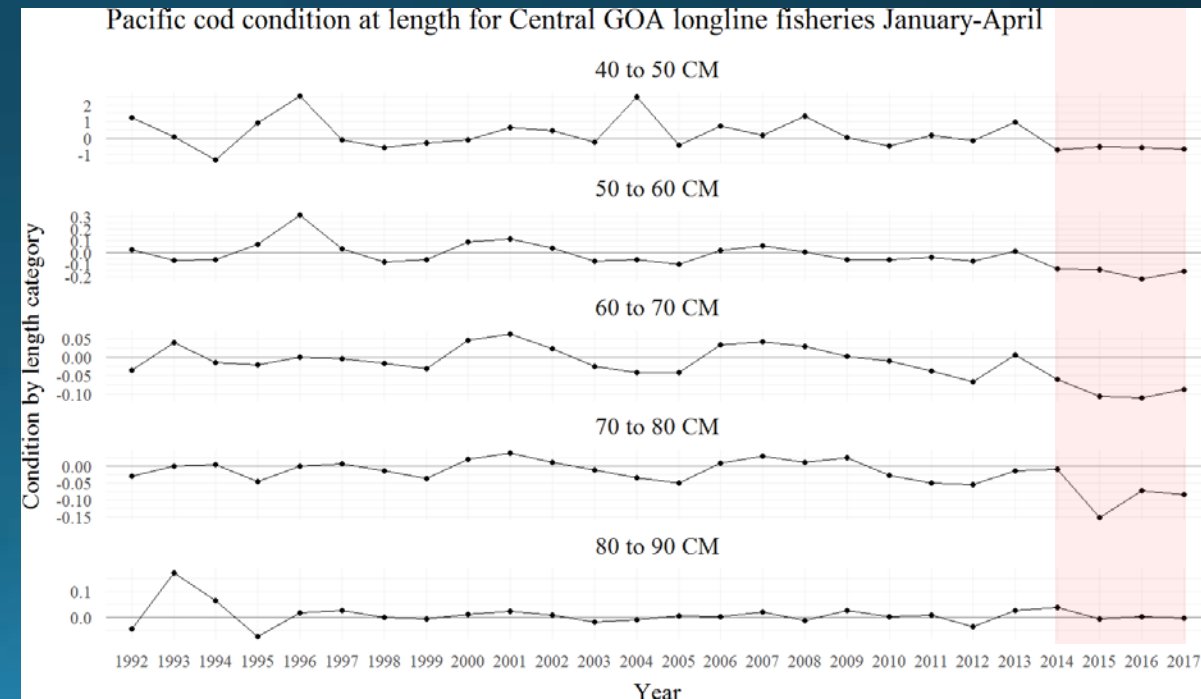
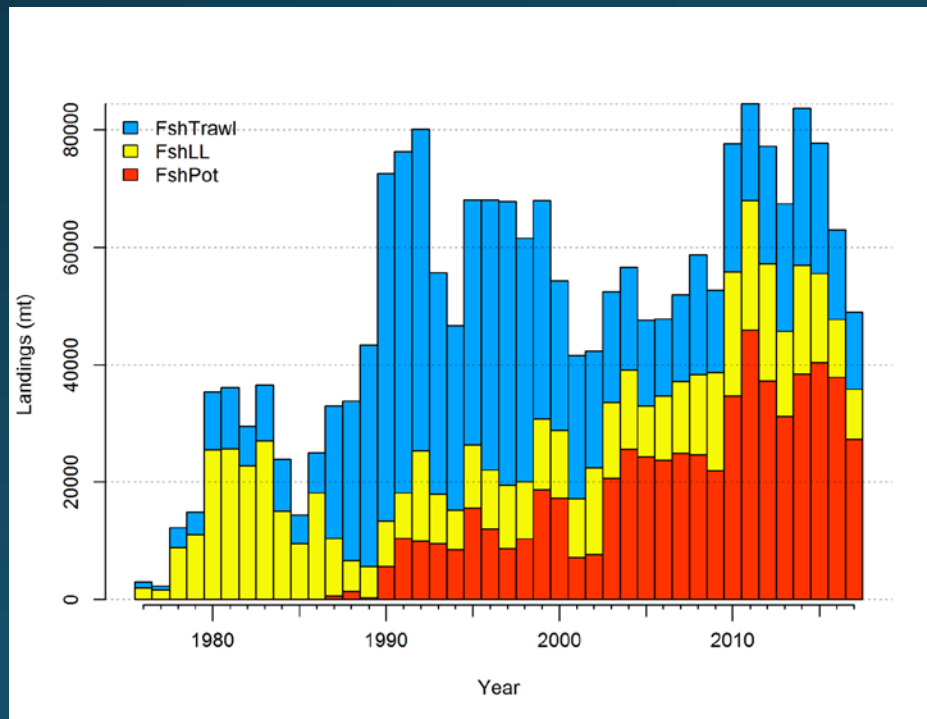
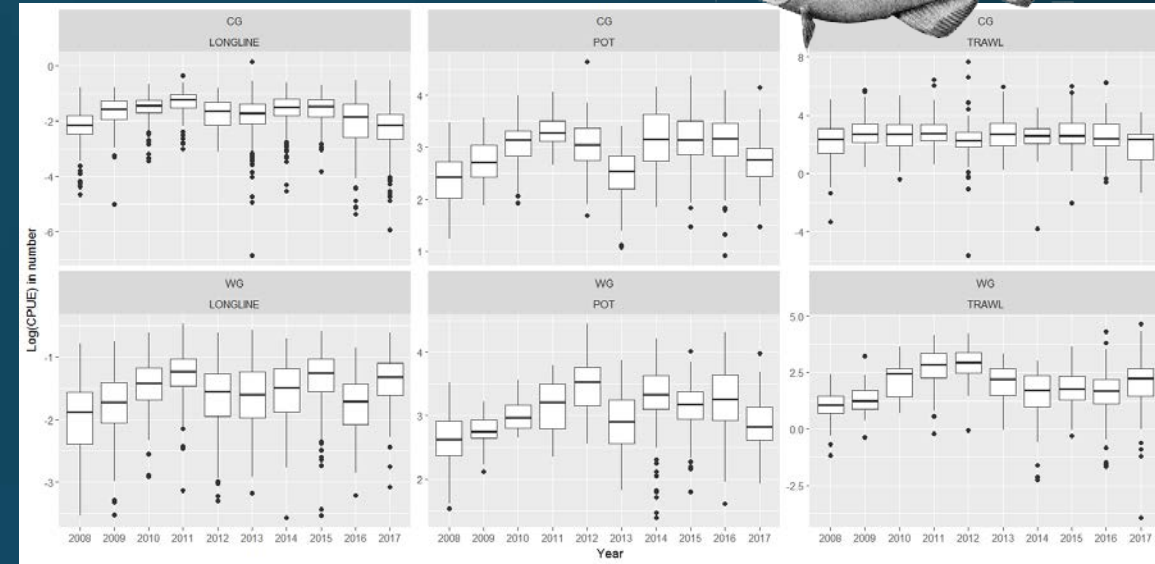
- January-August for all years – only Central GOA



GOA Pacific cod Fishery data



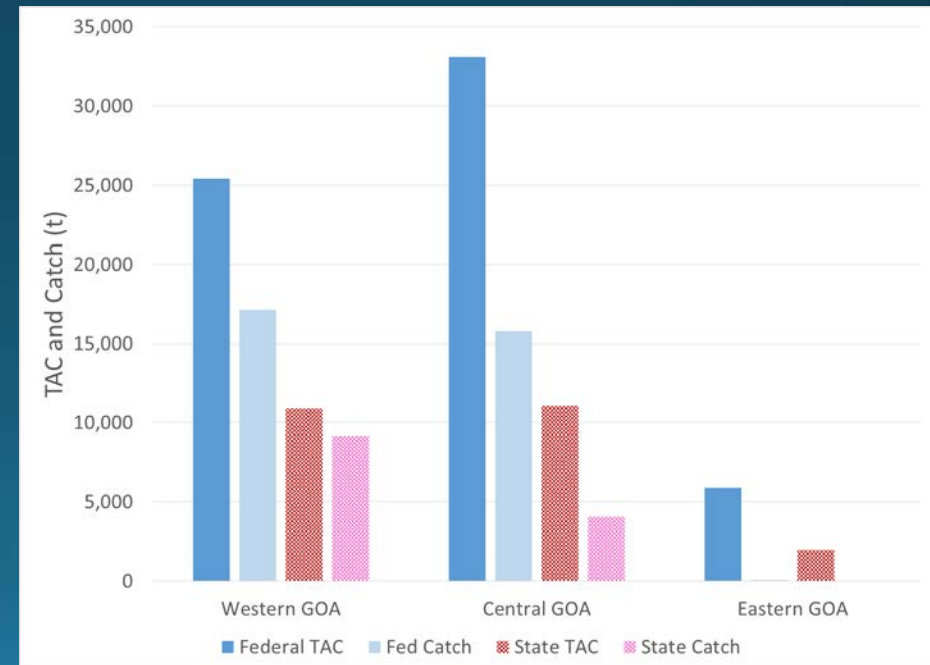
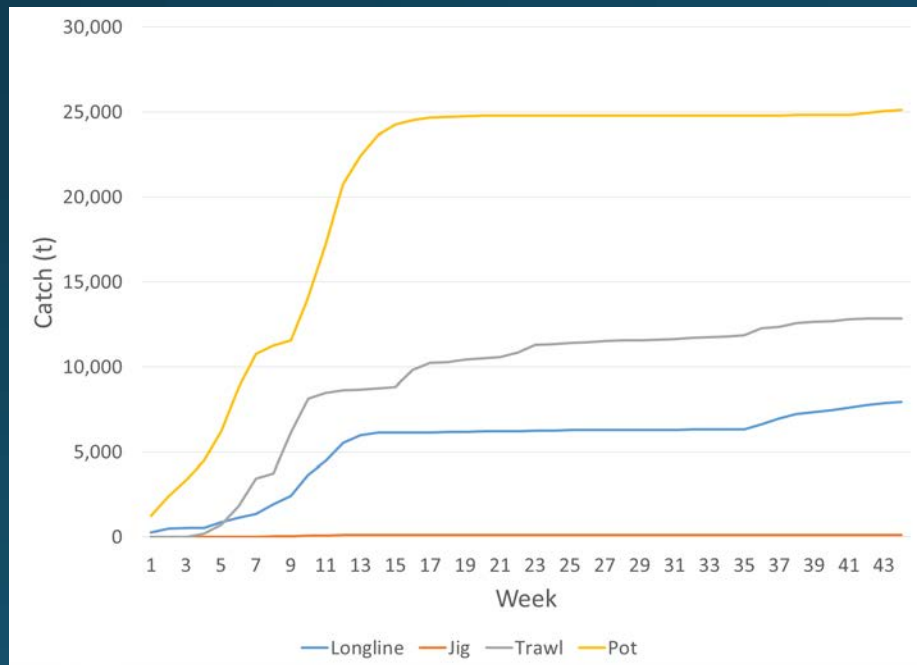
- Catch at < 60% of ABC
- Low CPUE in Central GOA all fisheries
- Low CPUE in pot fishery in Western GOA, high CPUE for other sectors
- Poor condition for 2014-2017 in longline and pot fisheries for fish < 80cm



GOA Pacific cod 2017 Fishery data



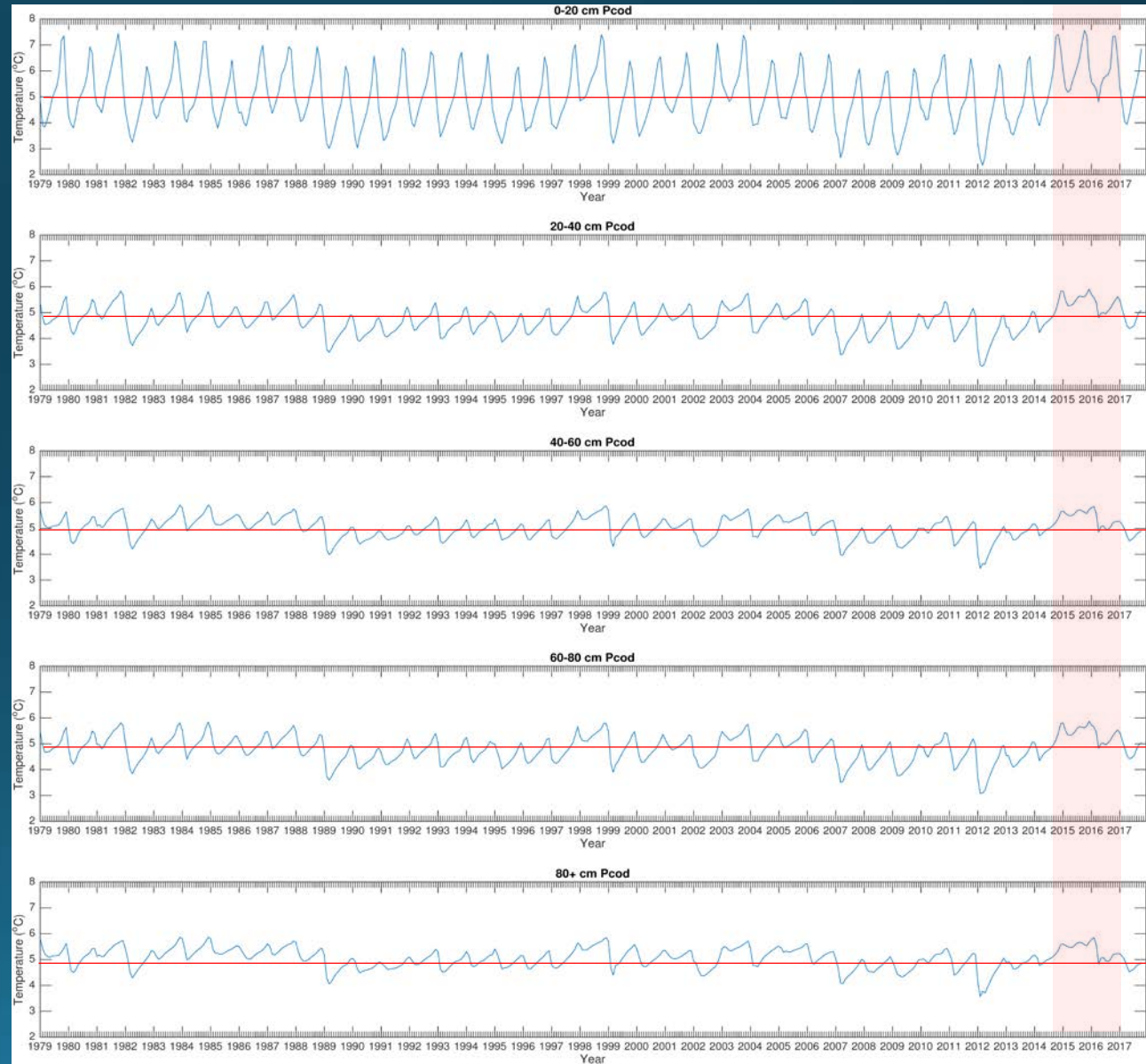
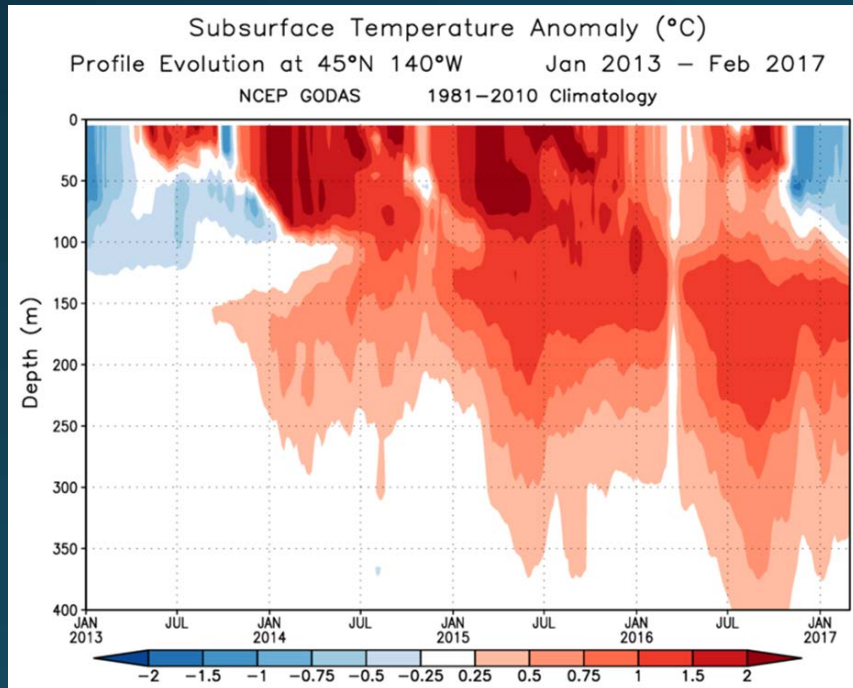
- 2017 combined state and federal fishery currently at 52% of ABC
 - Western GOA 72% of ABC (67.6% Federal and 84.1% State)
 - Central GOA 45% of ABC (47.6% Federal and 36.8% State)
 - Eastern GOA at < 1% of ABC (< 1% Federal and State)

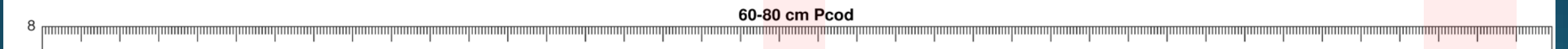
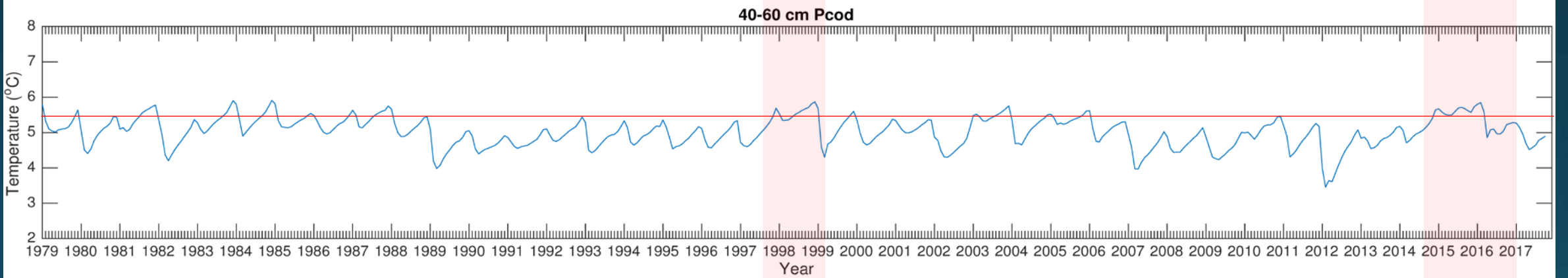
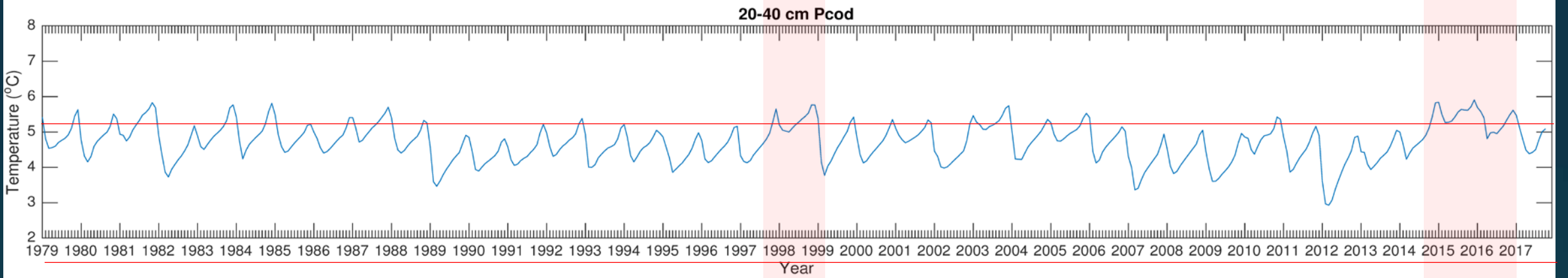
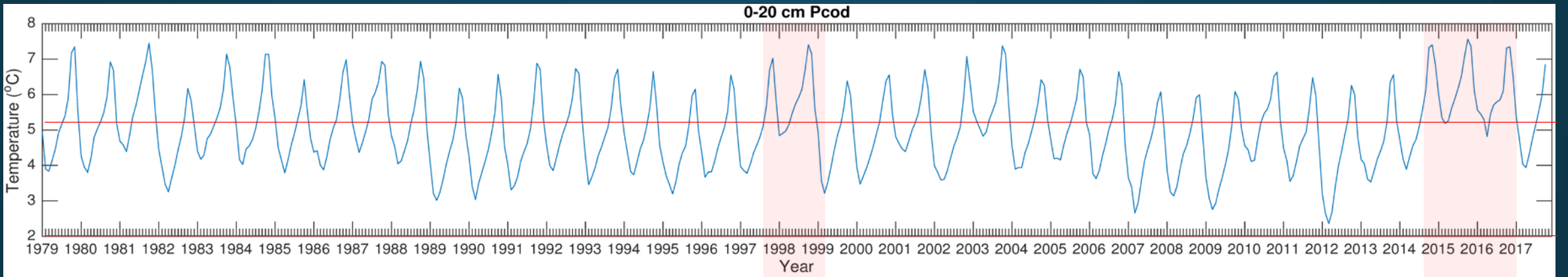


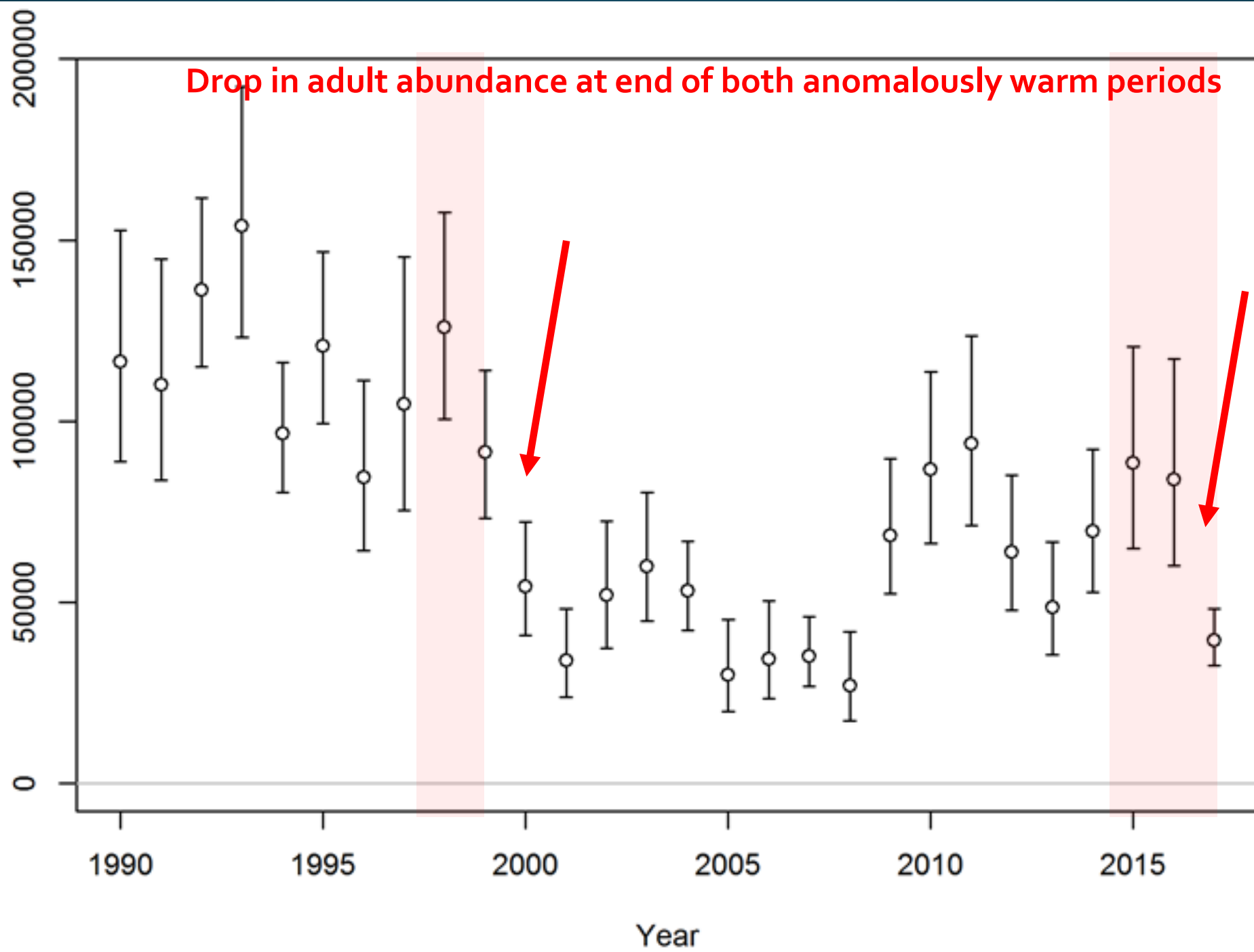
*As of 11/4/2017

Anomalous warm waters 2014-2016

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







Anomalously warm waters 2014-2016



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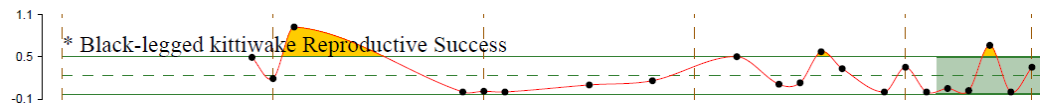
Science

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

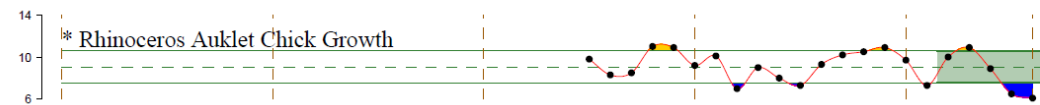
Author: **Yereth Rosen** | Updated: September 30, 2016 | Published January 29, 2016



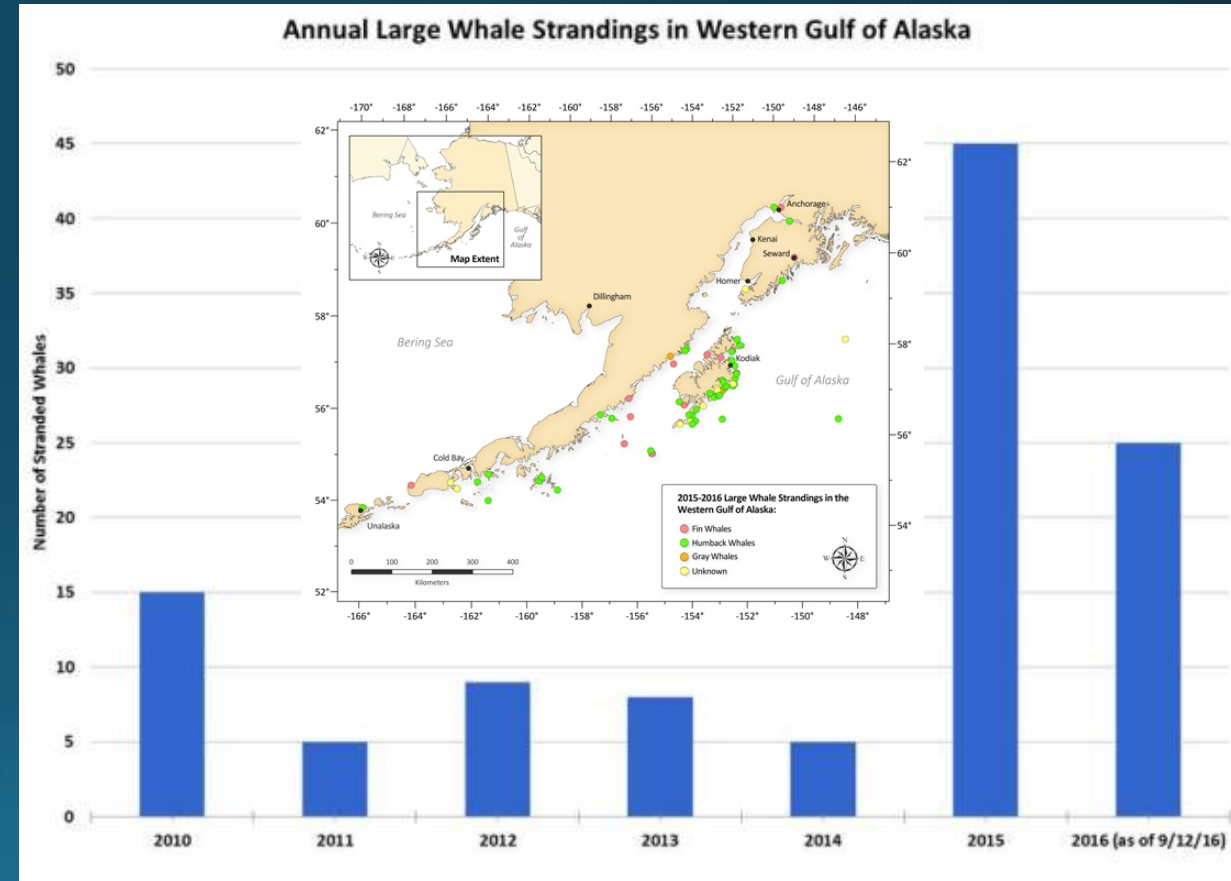
West



East



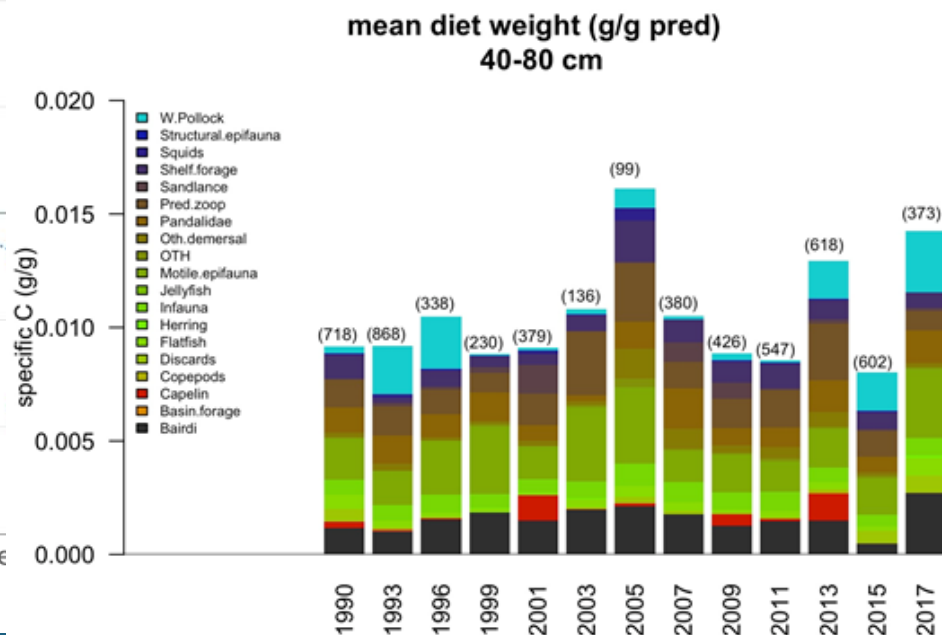
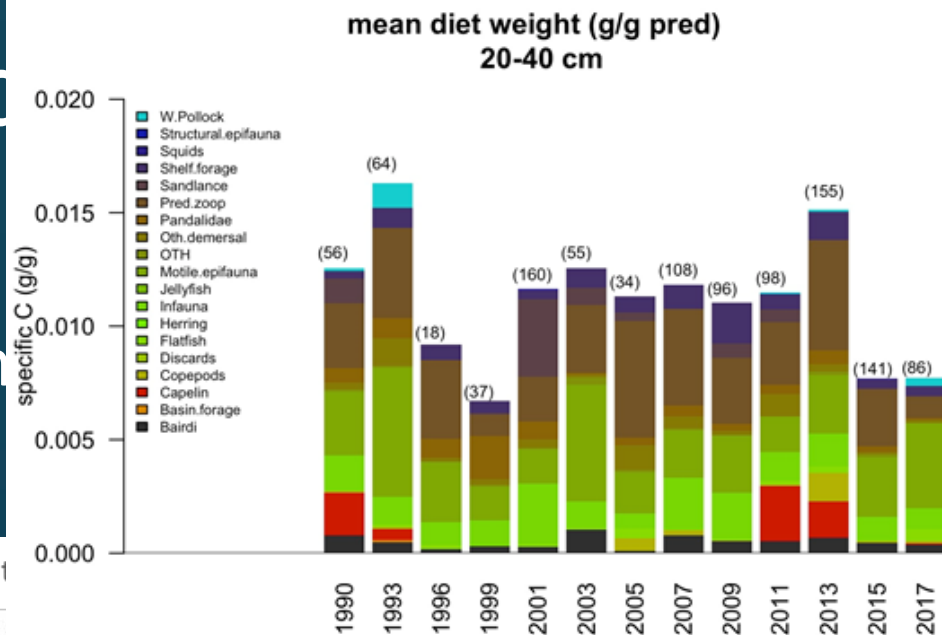
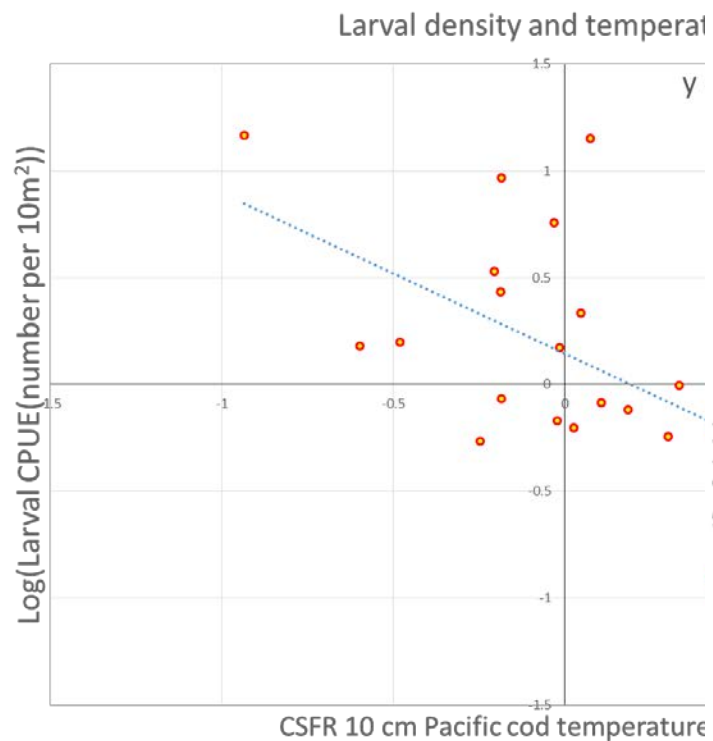
Analysis by Stephani Zador



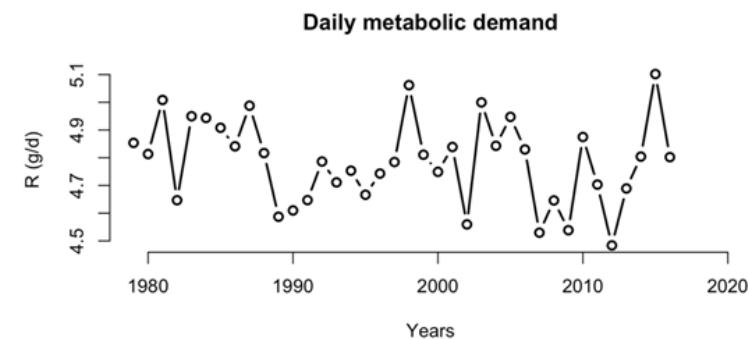
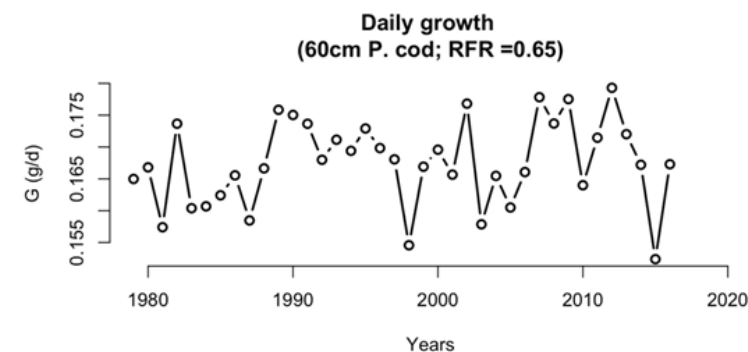
GOA Pacific cod

The Blob

- Likely substantial impact



and natural mortality



energetics analysis by Kirsten Holsman



GOA Pacific cod

Bio-energetics summary



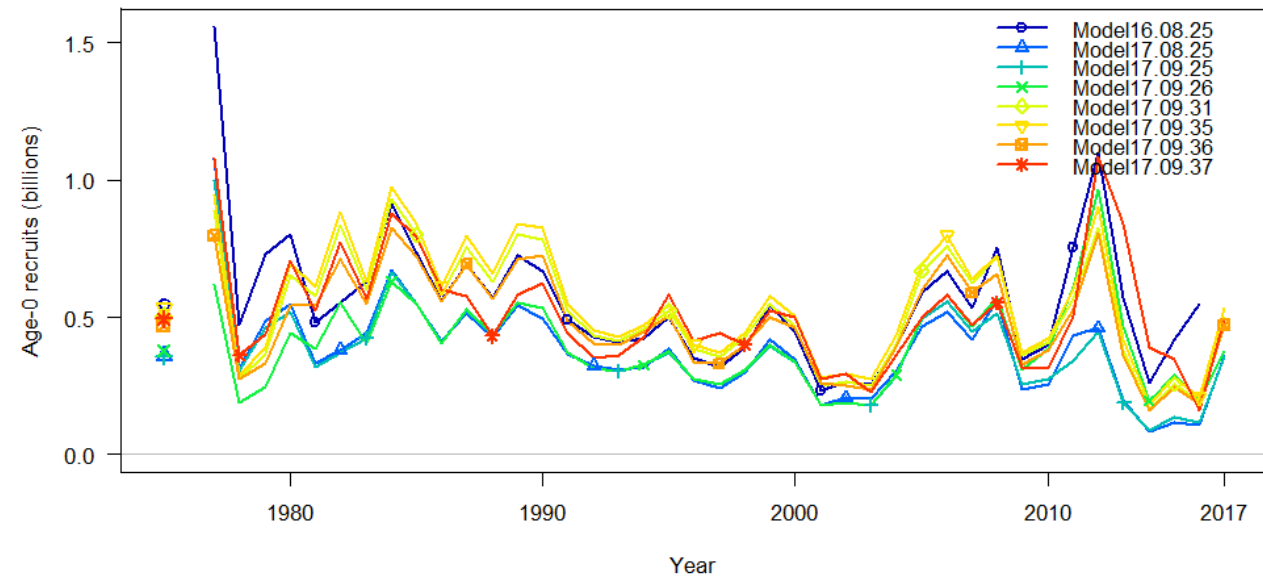
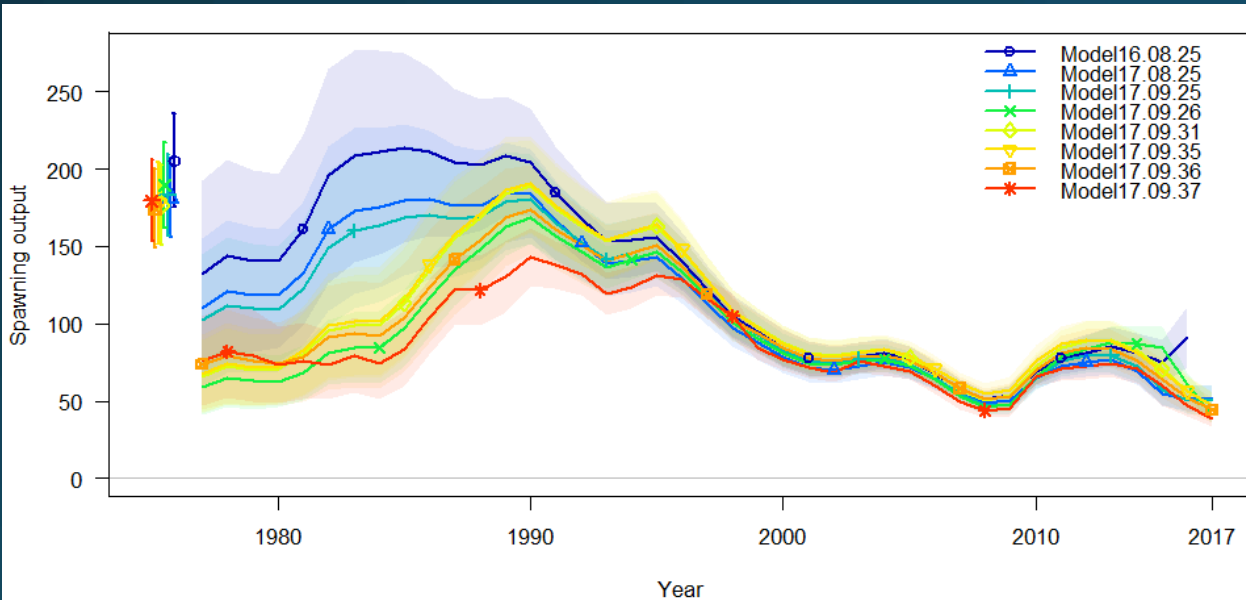
- Warmer temperatures were throughout the year and water column
- Higher metabolism in warmer temps lead to higher forage requirements
- Indications of lower forage amounts in 2015-2016
- Combination likely lead to higher Pacific cod natural mortality for these years.

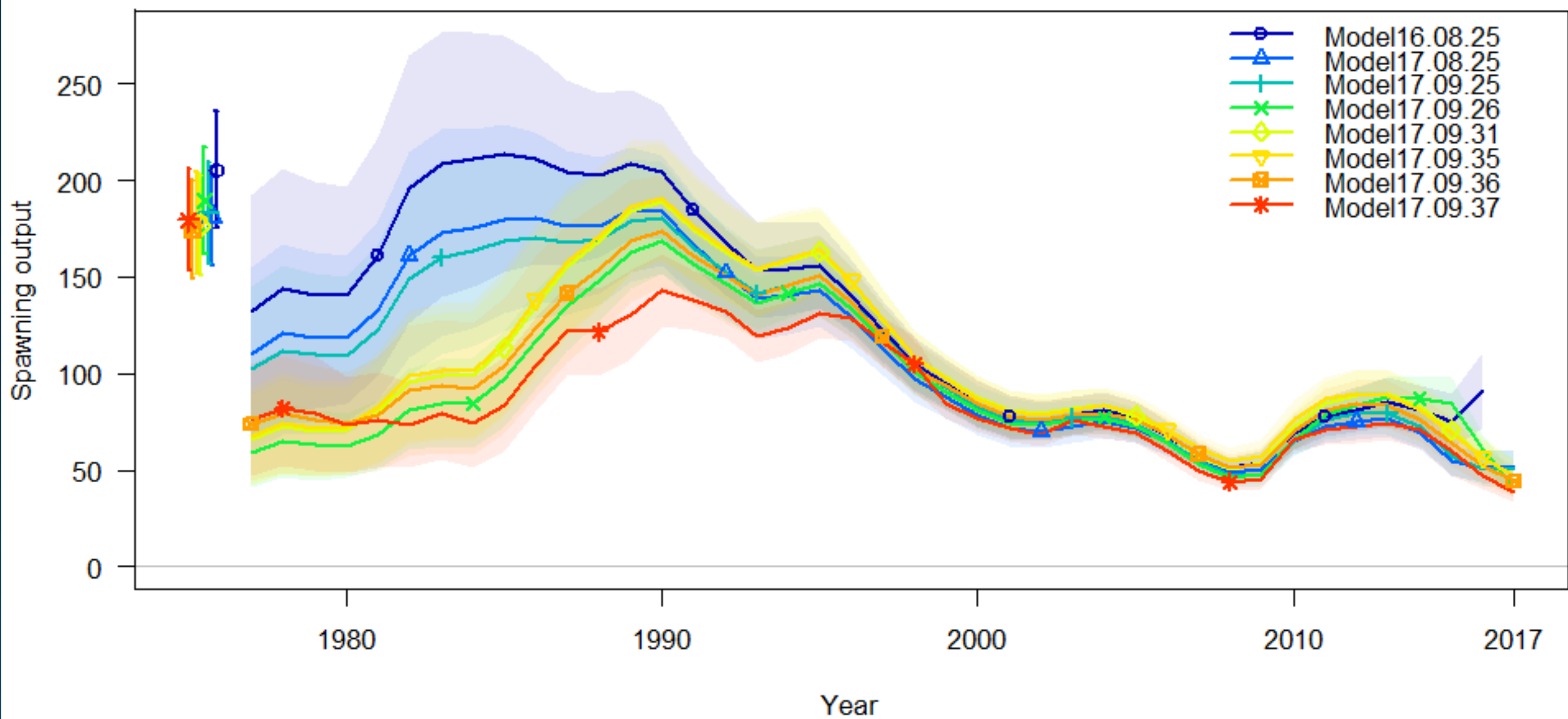
GOA Pacific cod

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





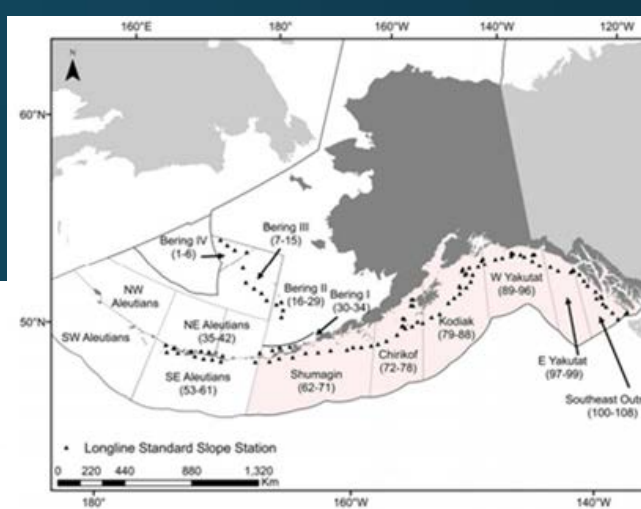
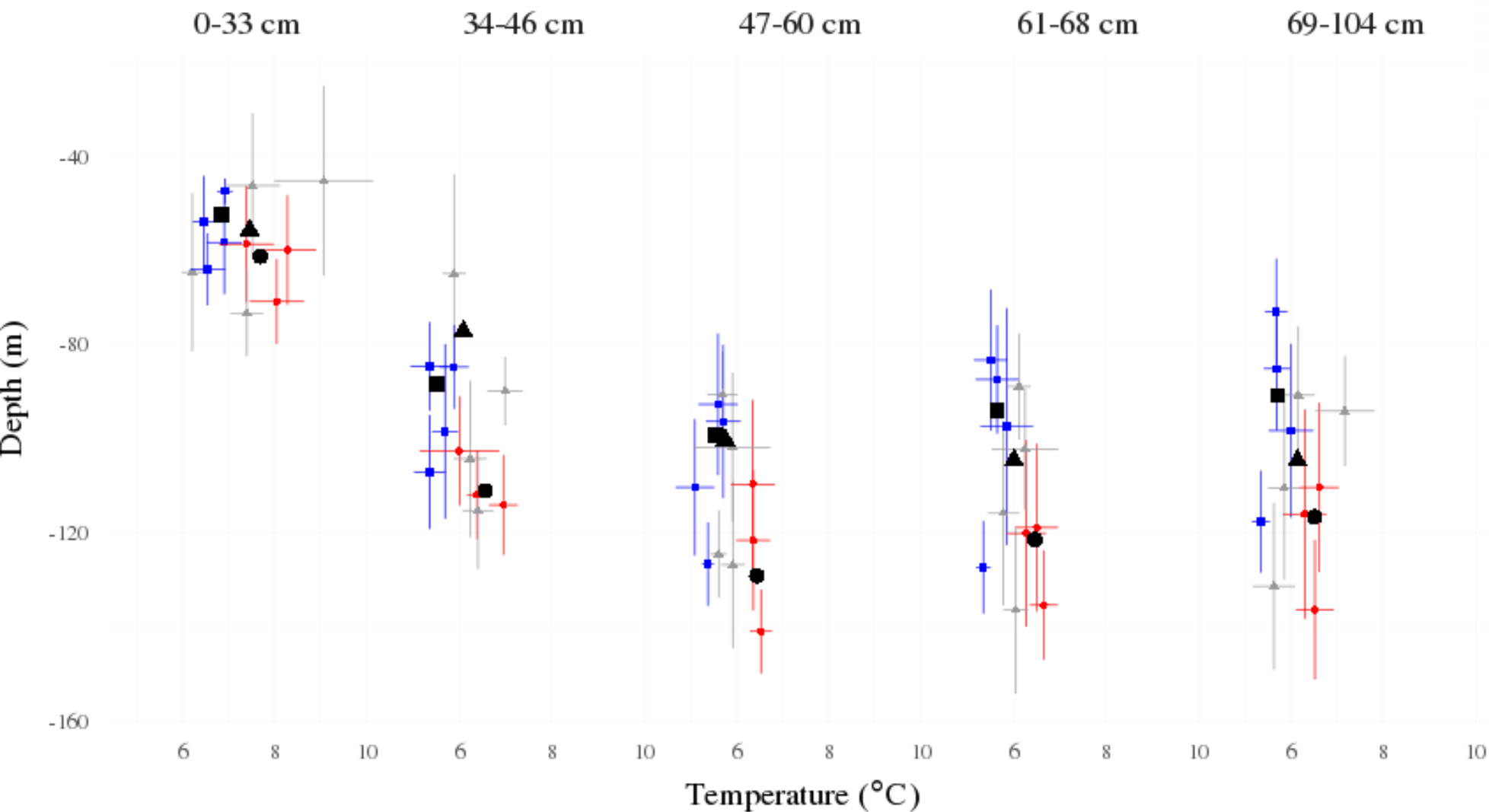
GOA Pacific cod

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

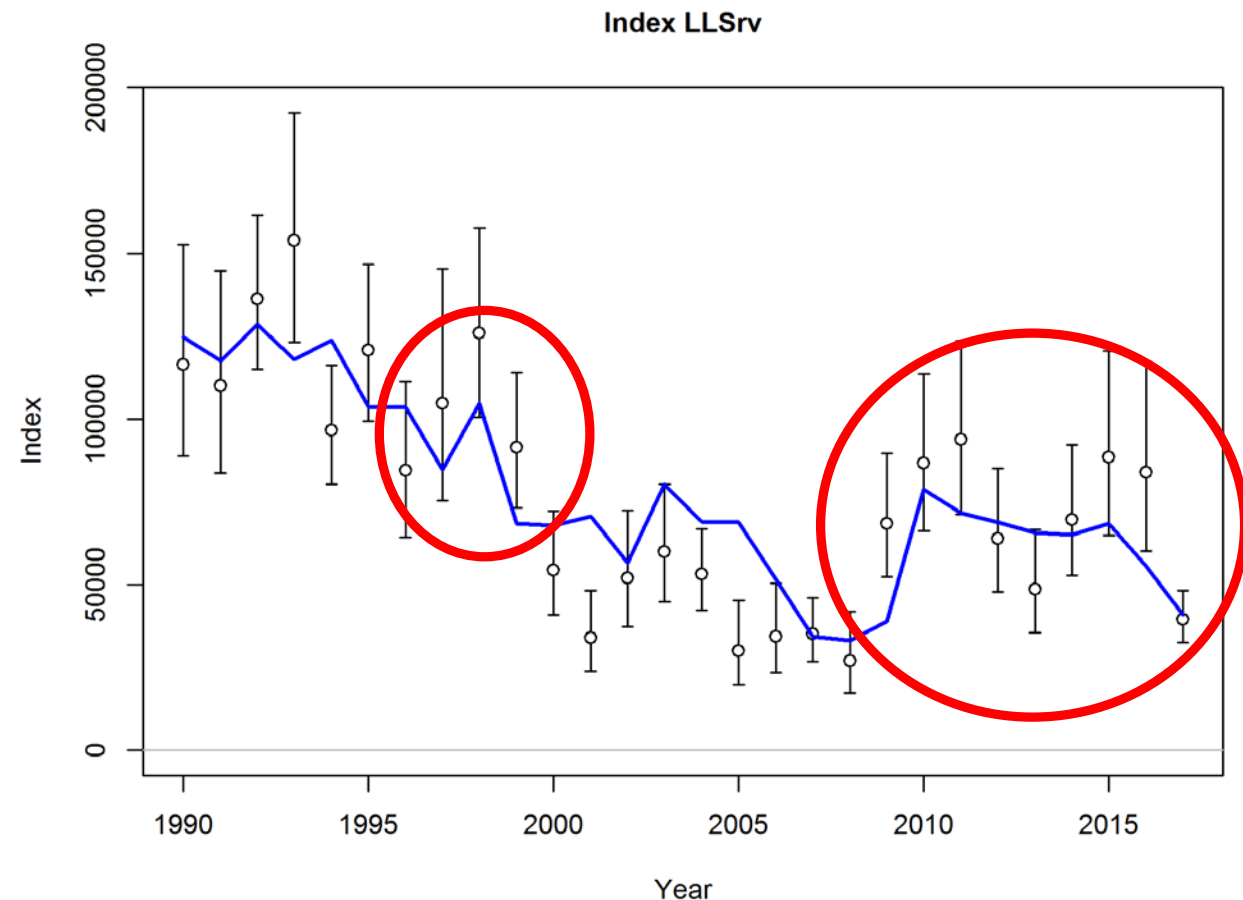
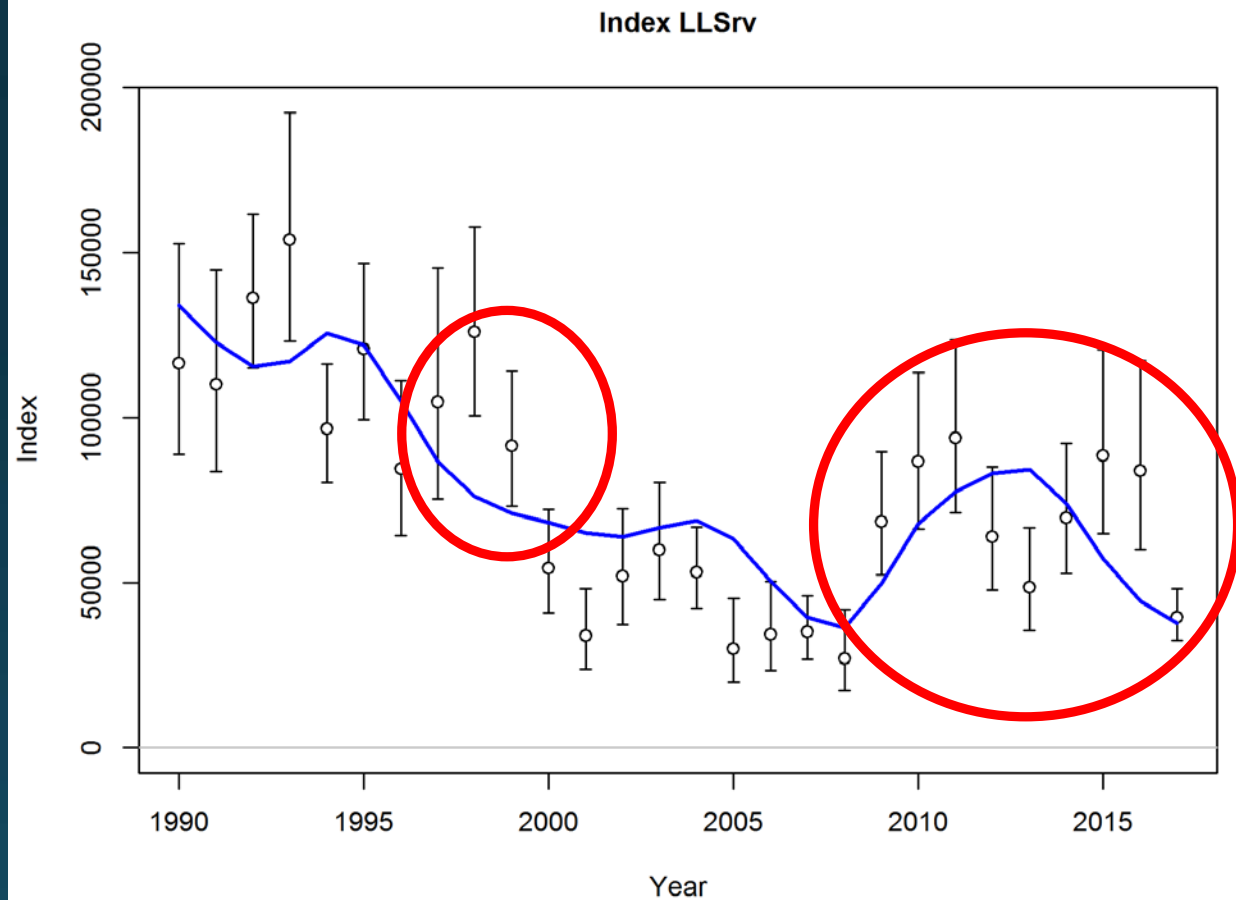
Pacific cod (*Gadus macrocephalus*)



Shelf temp.

- COLD
- ▲ MED
- WARM

Including temperature on catchability improved fit to the AFSC longline survey

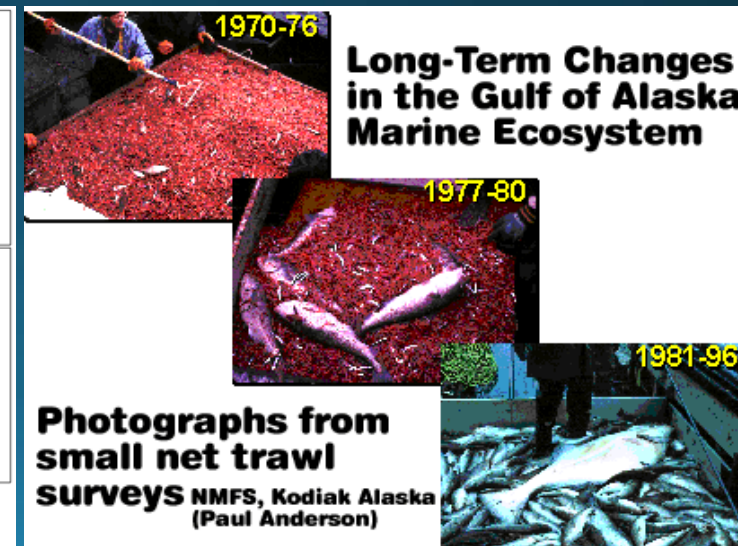
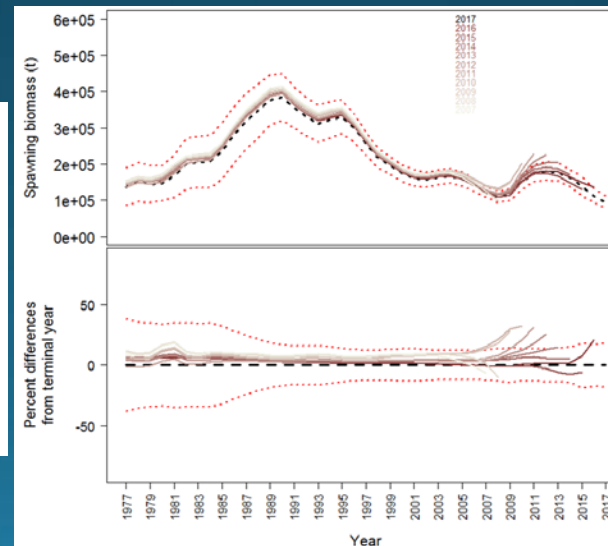
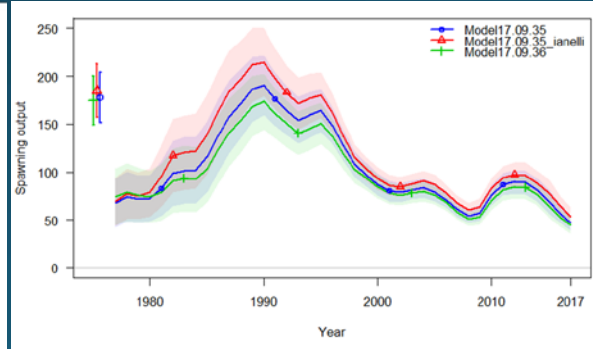
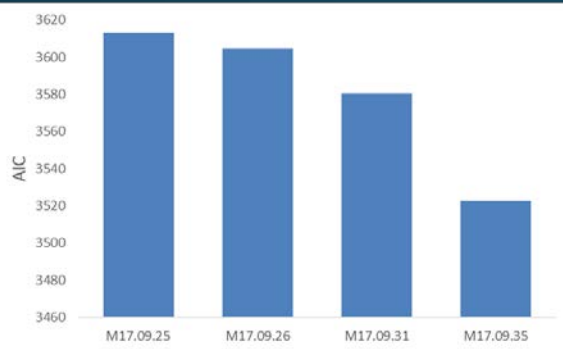


GOA Pacific cod

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)

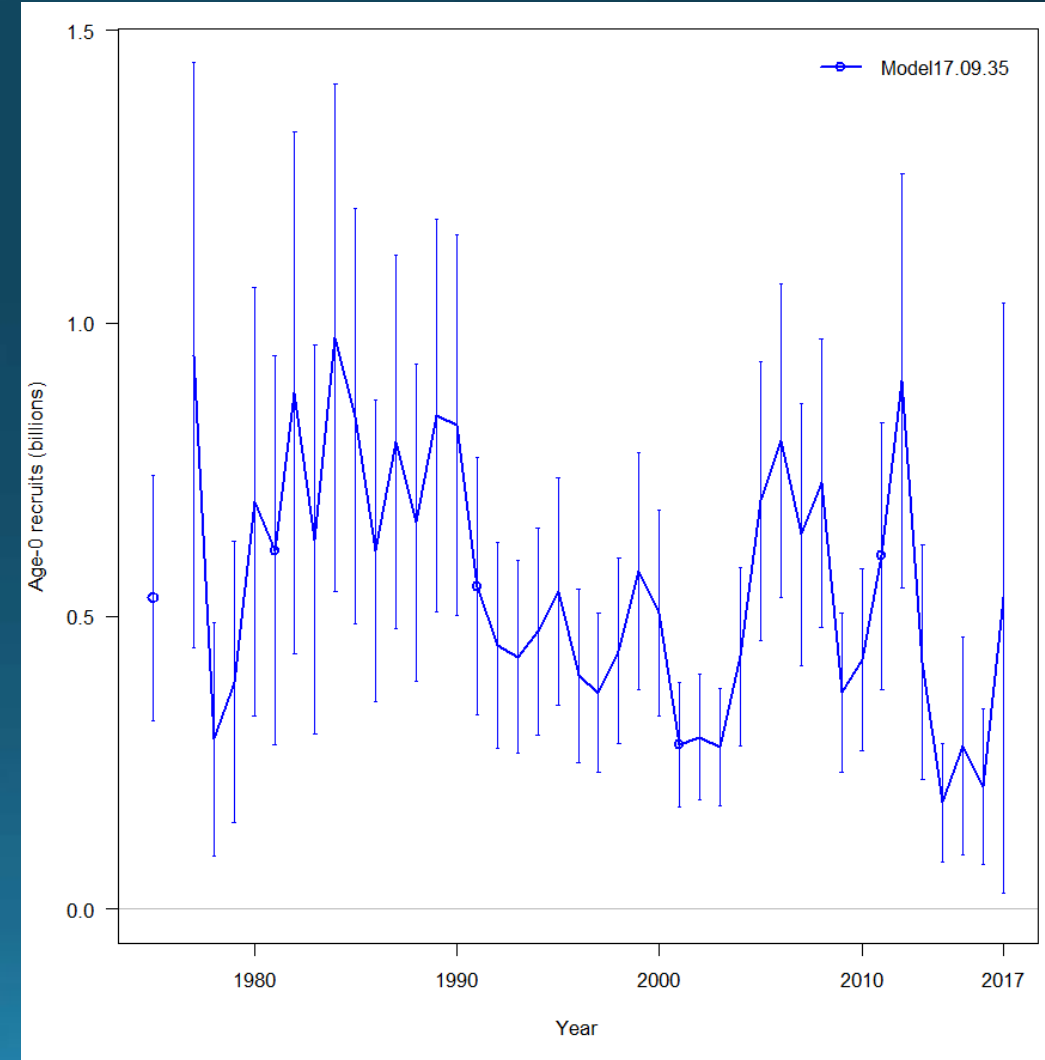


GOA Pacific cod

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

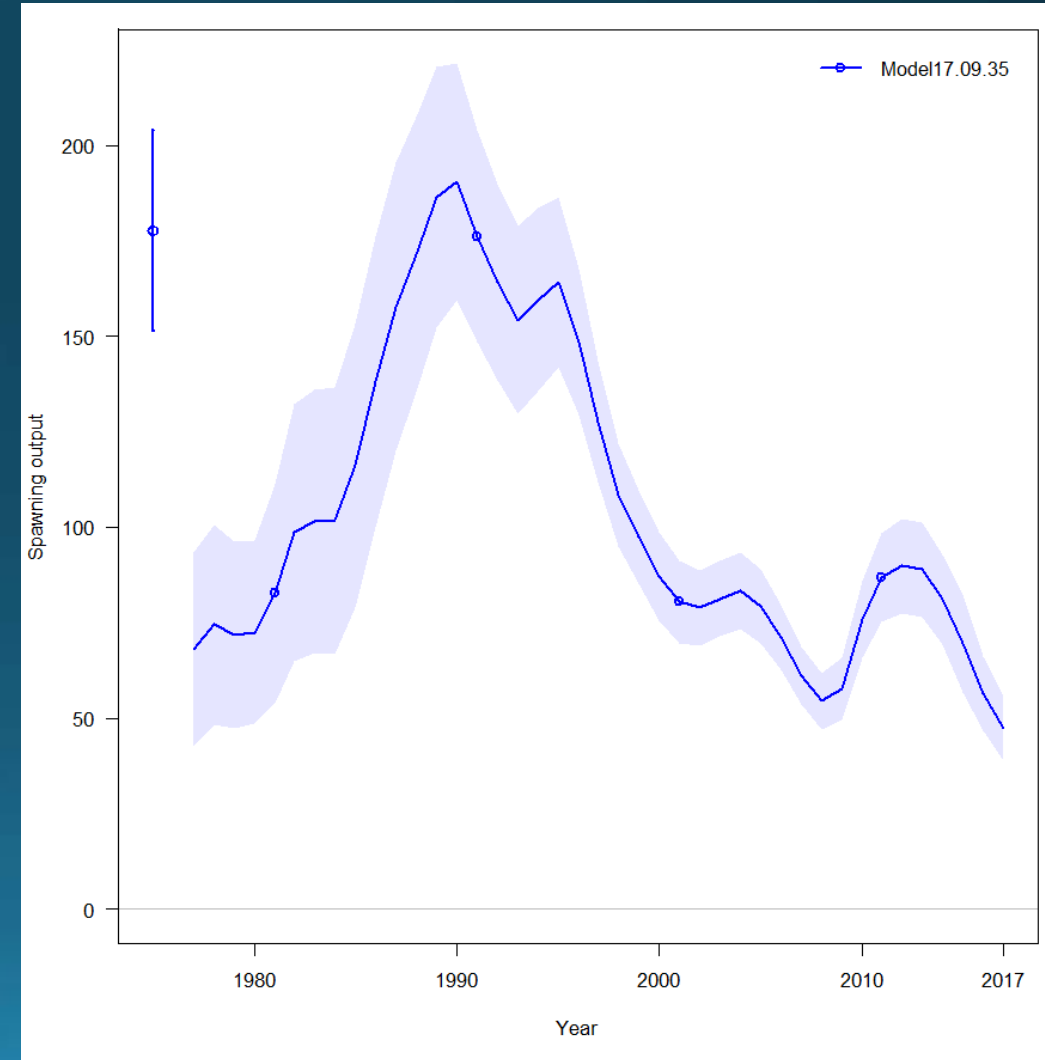


GOA Pacific cod

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

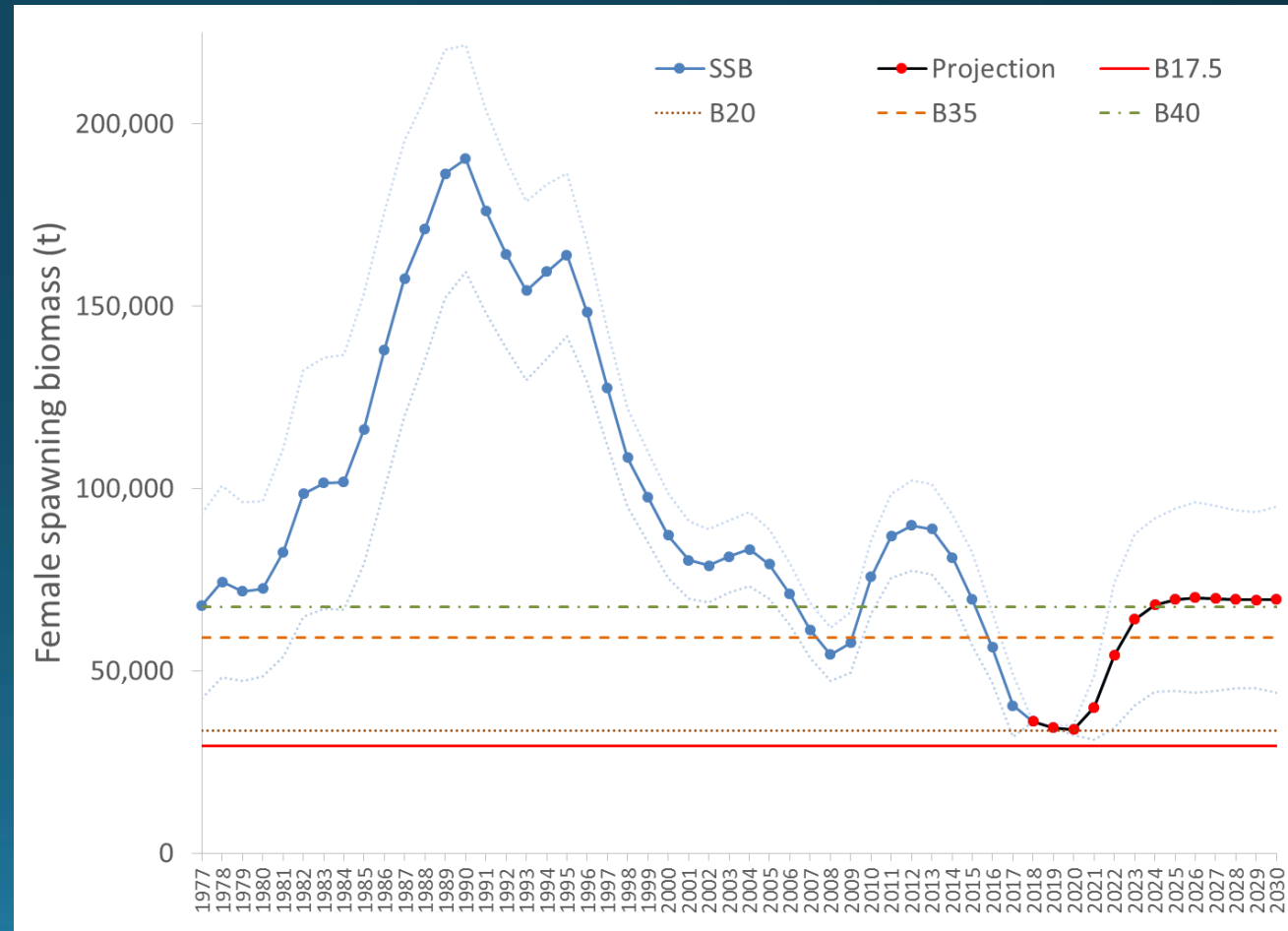


GOA Pacific cod

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

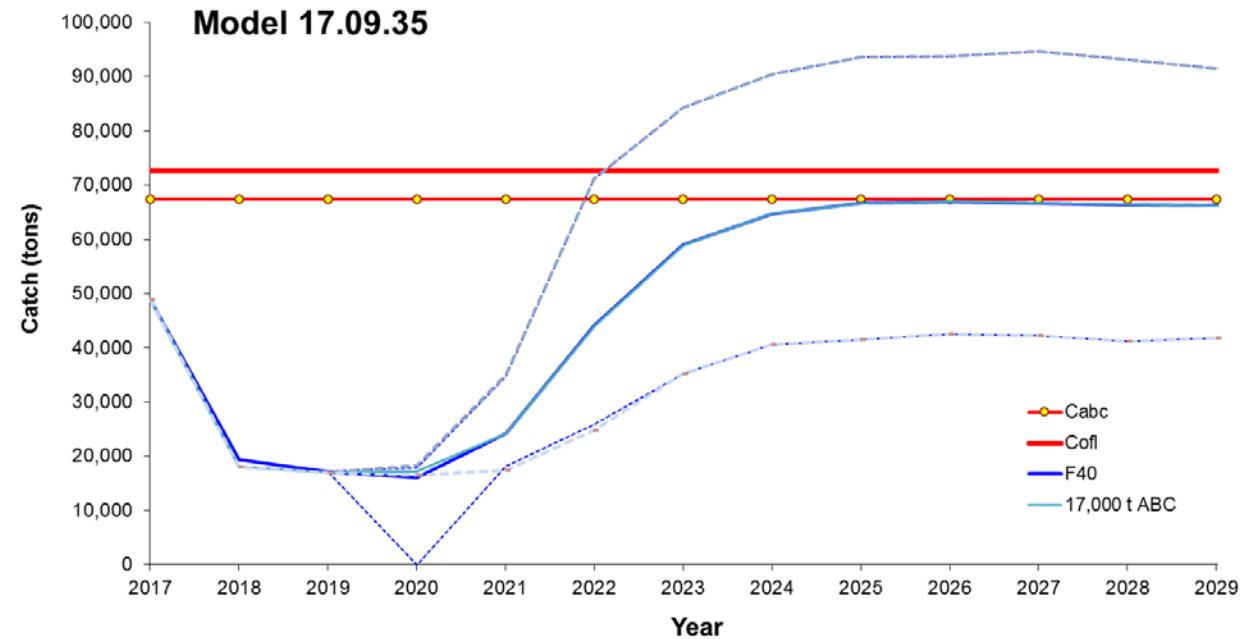
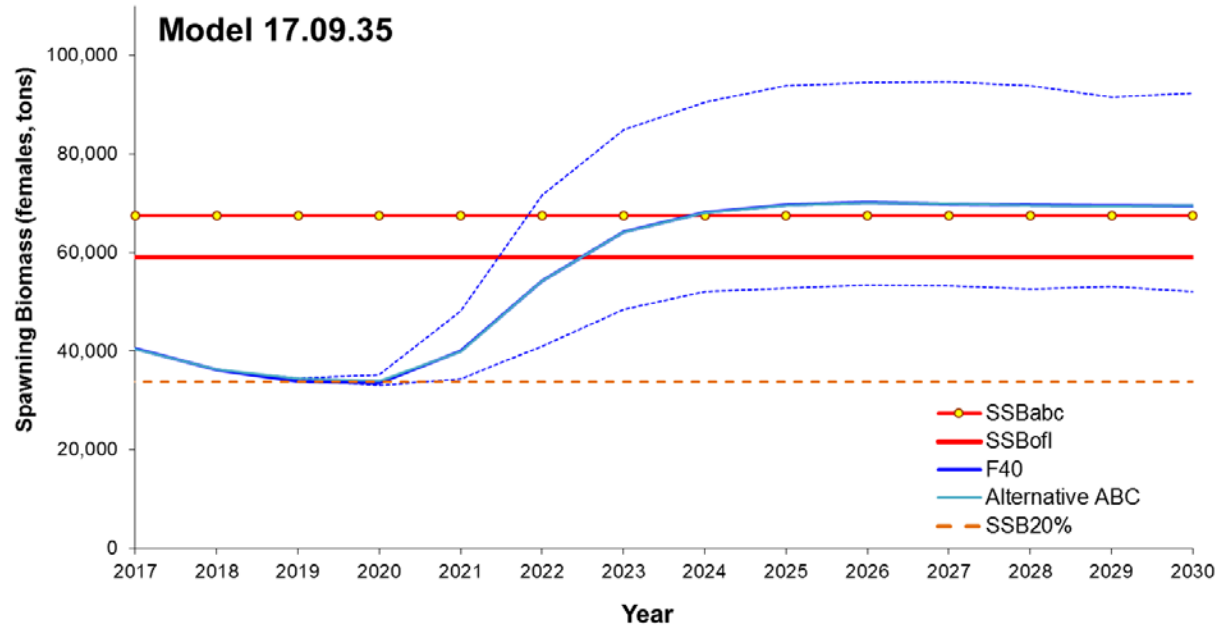




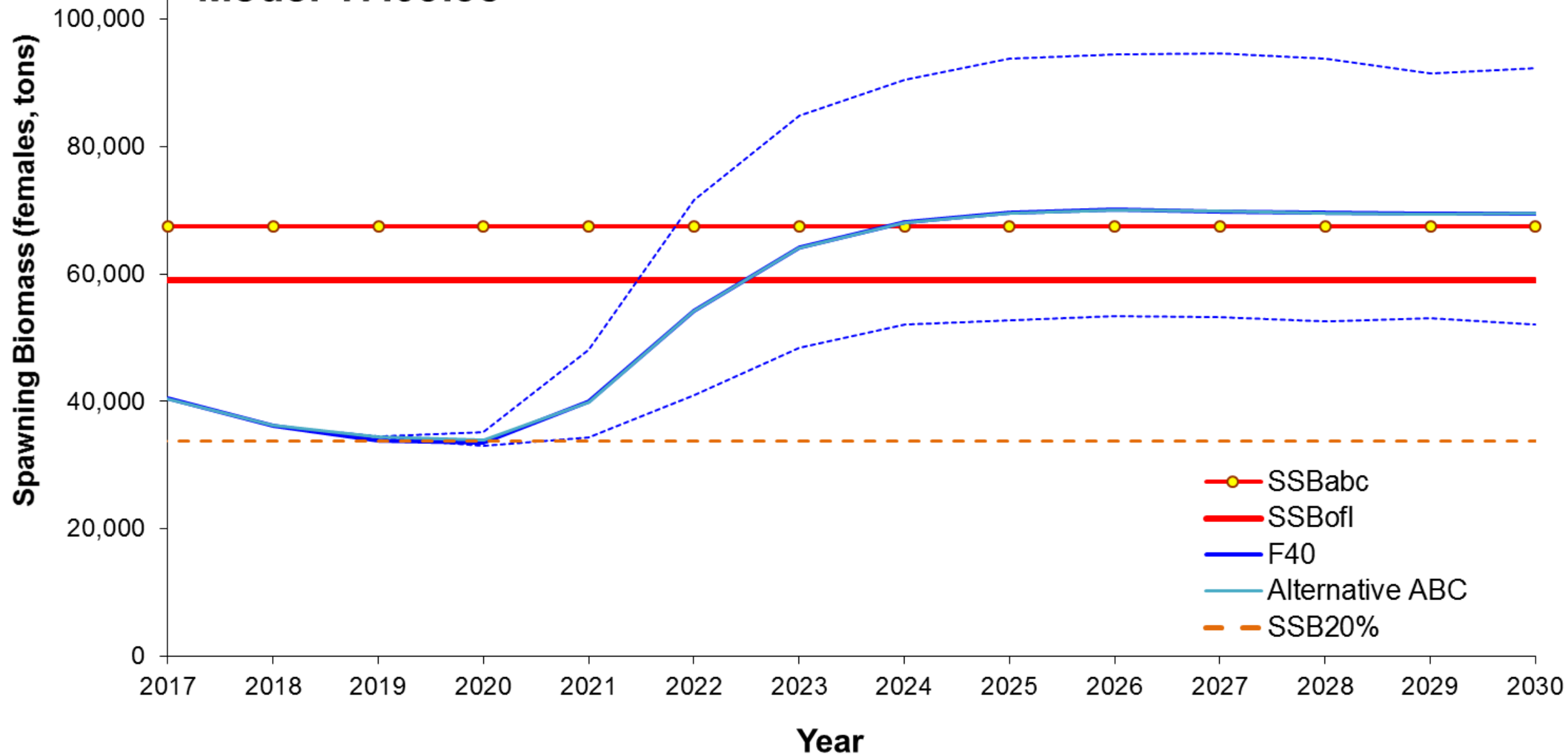
GOA Pacific cod

Model 17.09.35 Projections

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



Model 17.09.35



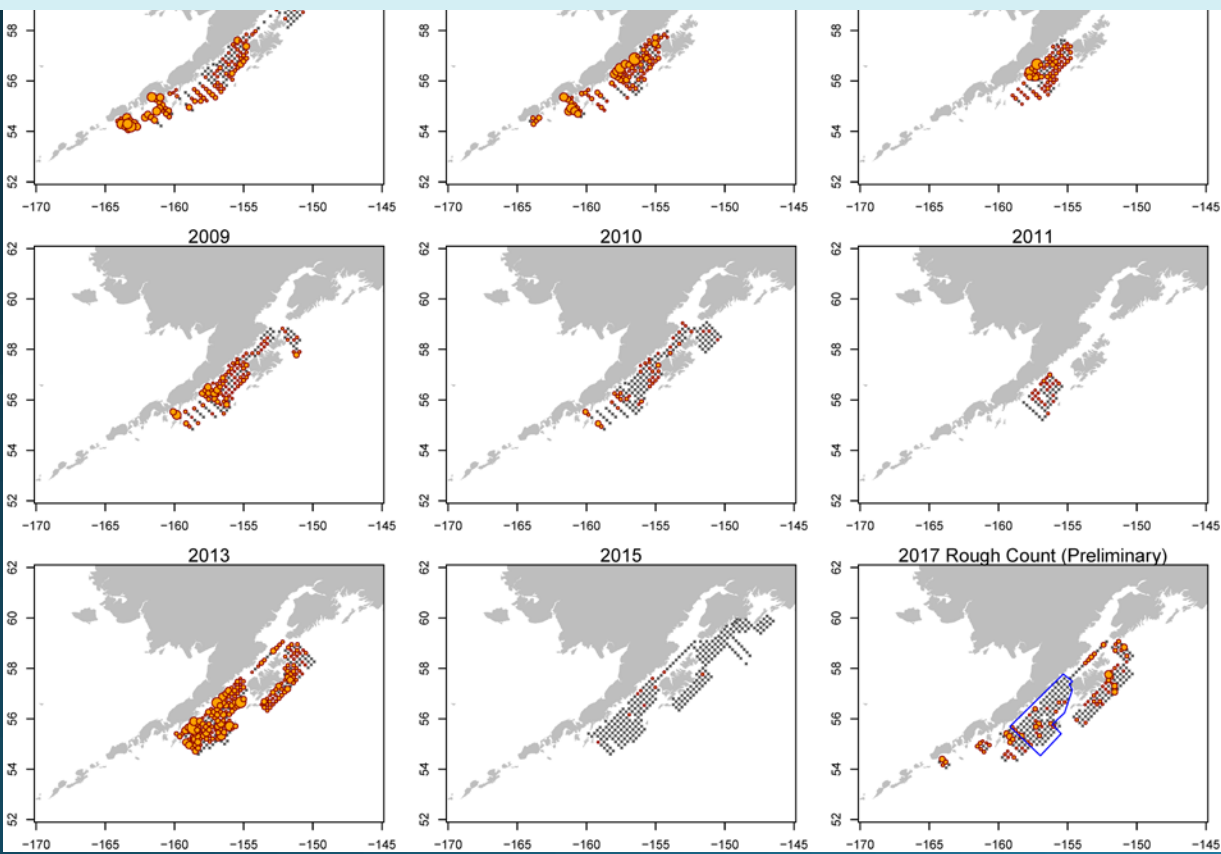
GOA Pacific cod

Future outlook

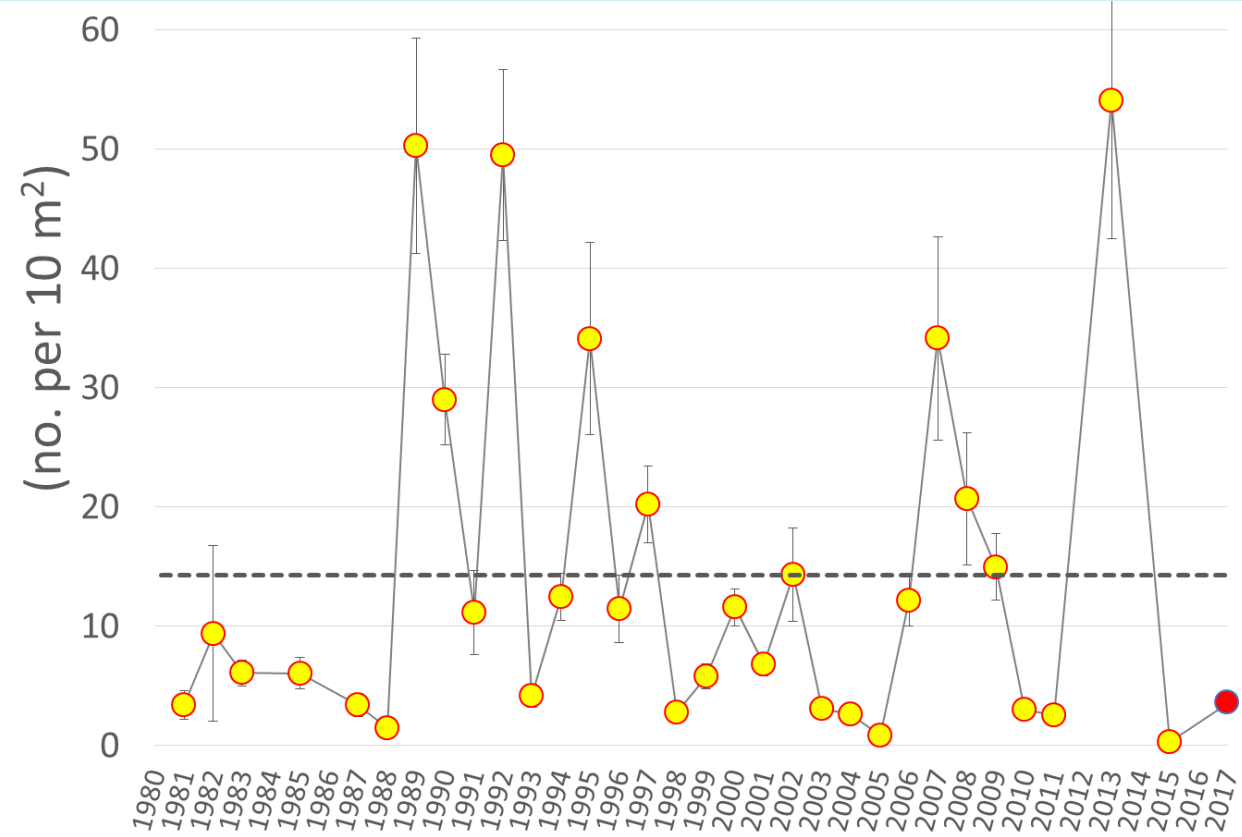


- Preliminary 2017 larval survey densities below average

Larval abundance is not correlated with recruitment



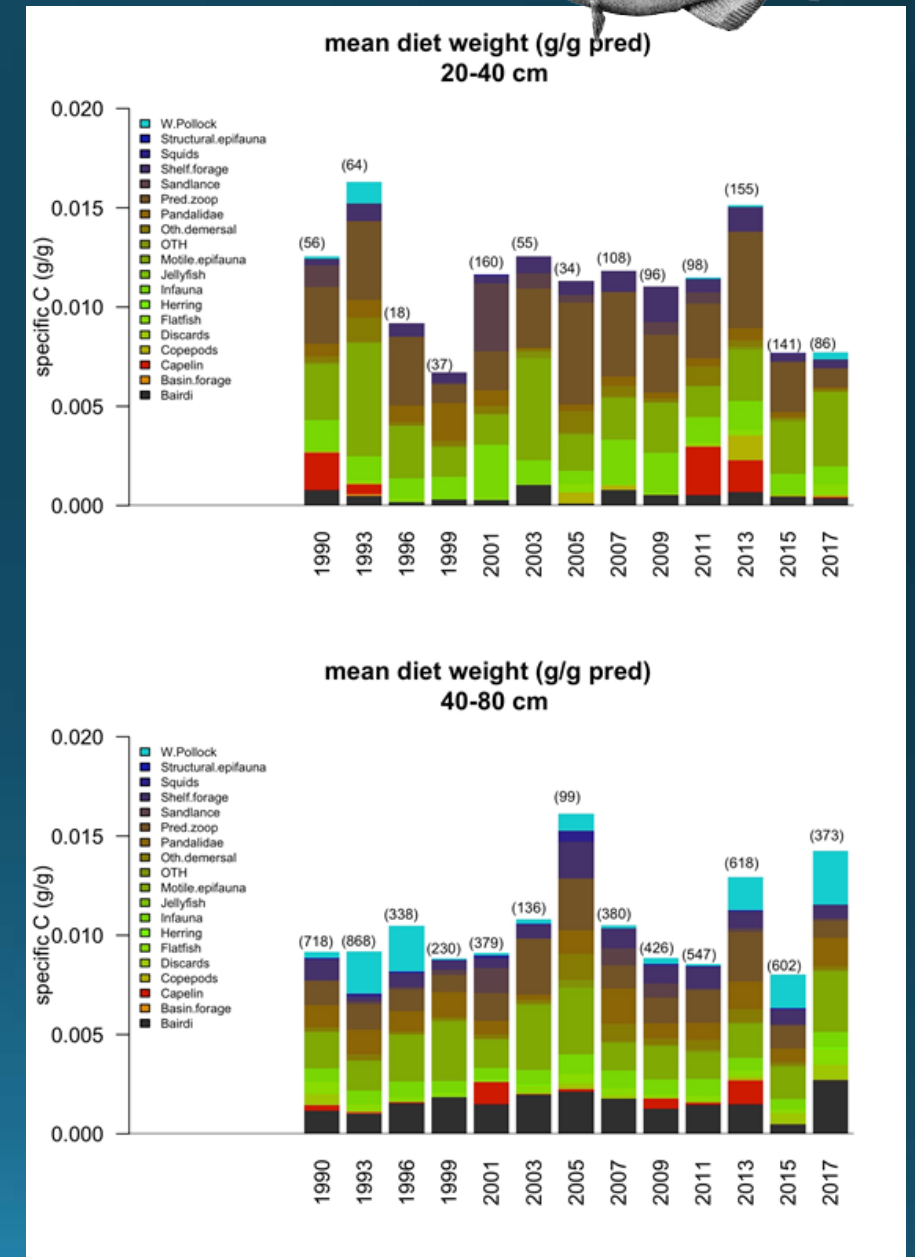
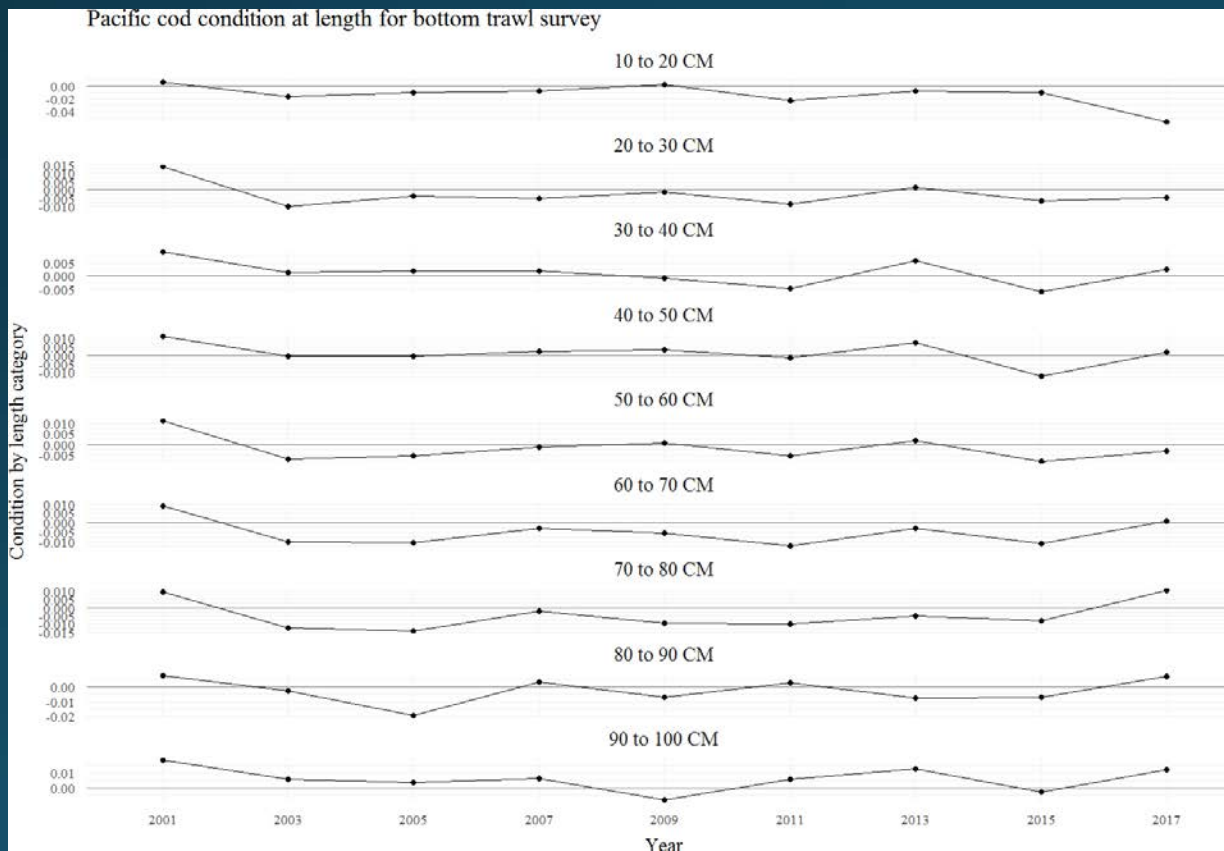
Pacific cod larvae mean CPUE



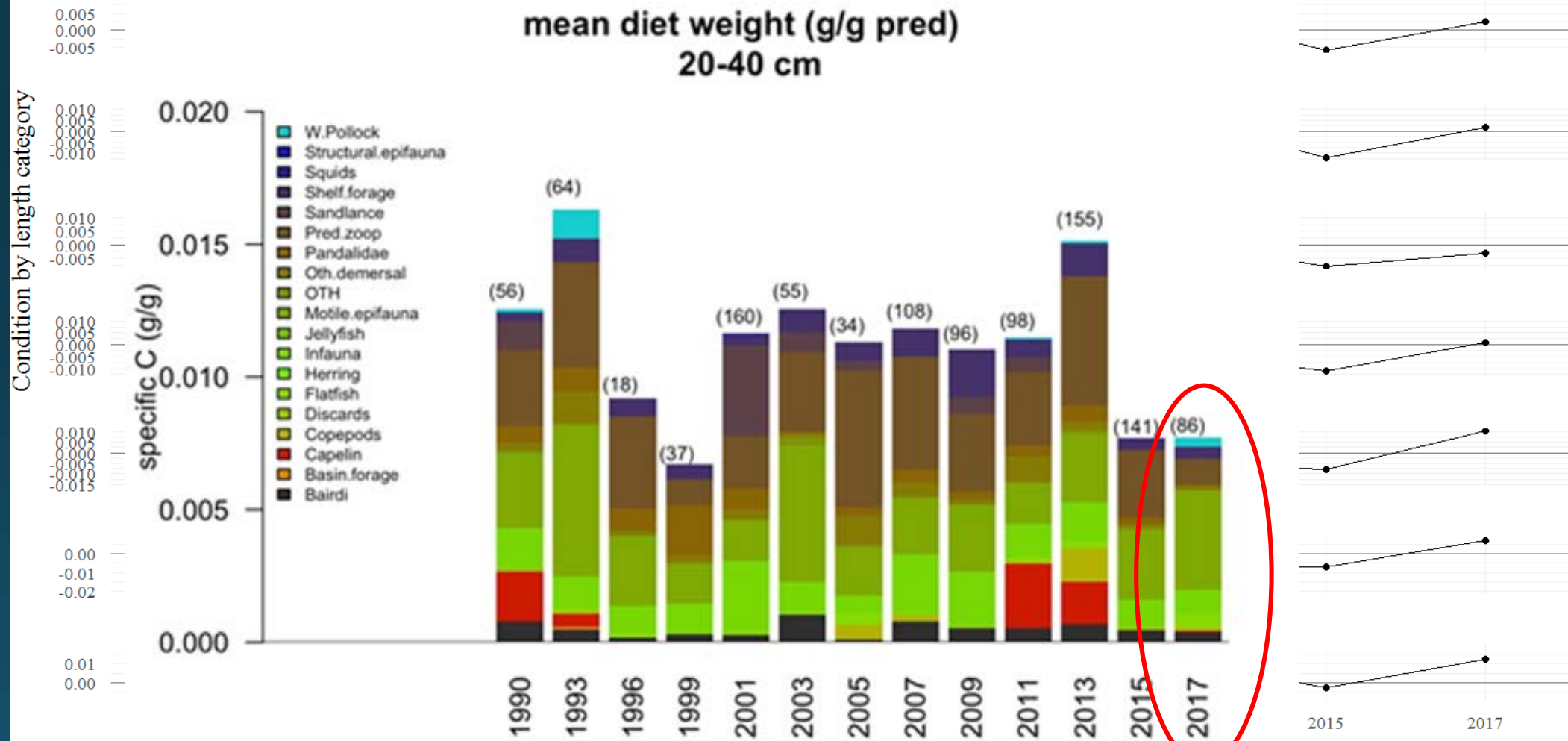
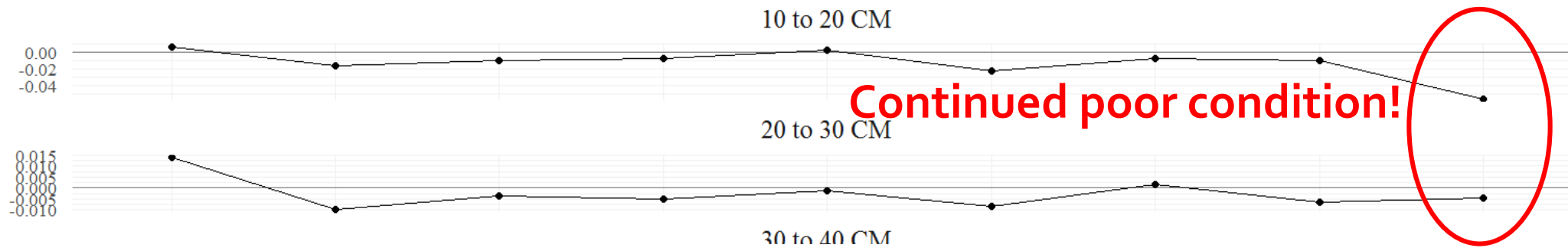
GOA Pacific cod

Future outlook

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

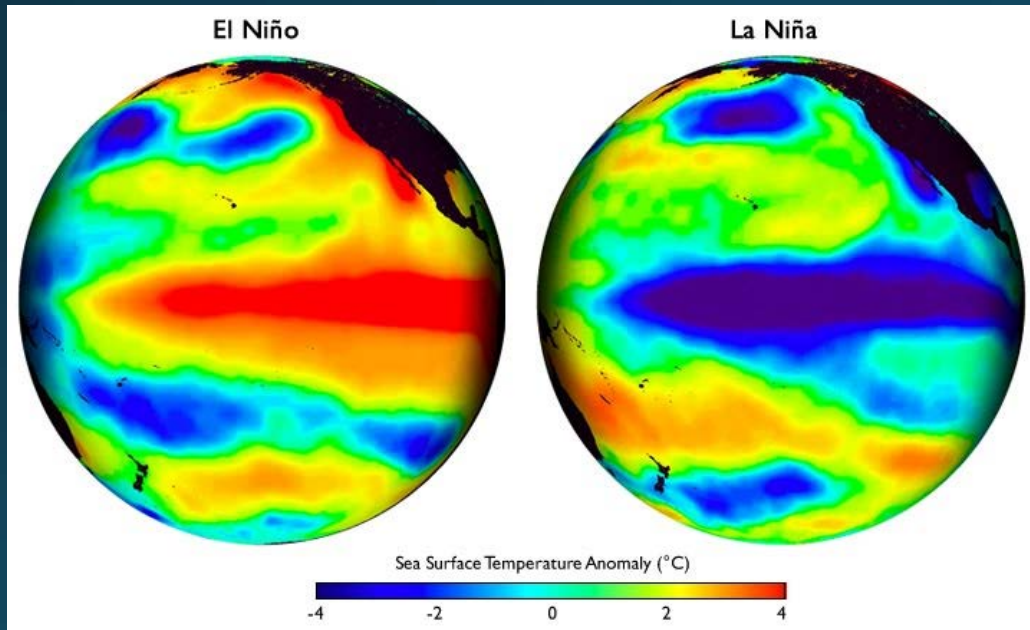


Pacific cod condition at length for bottom trawl survey



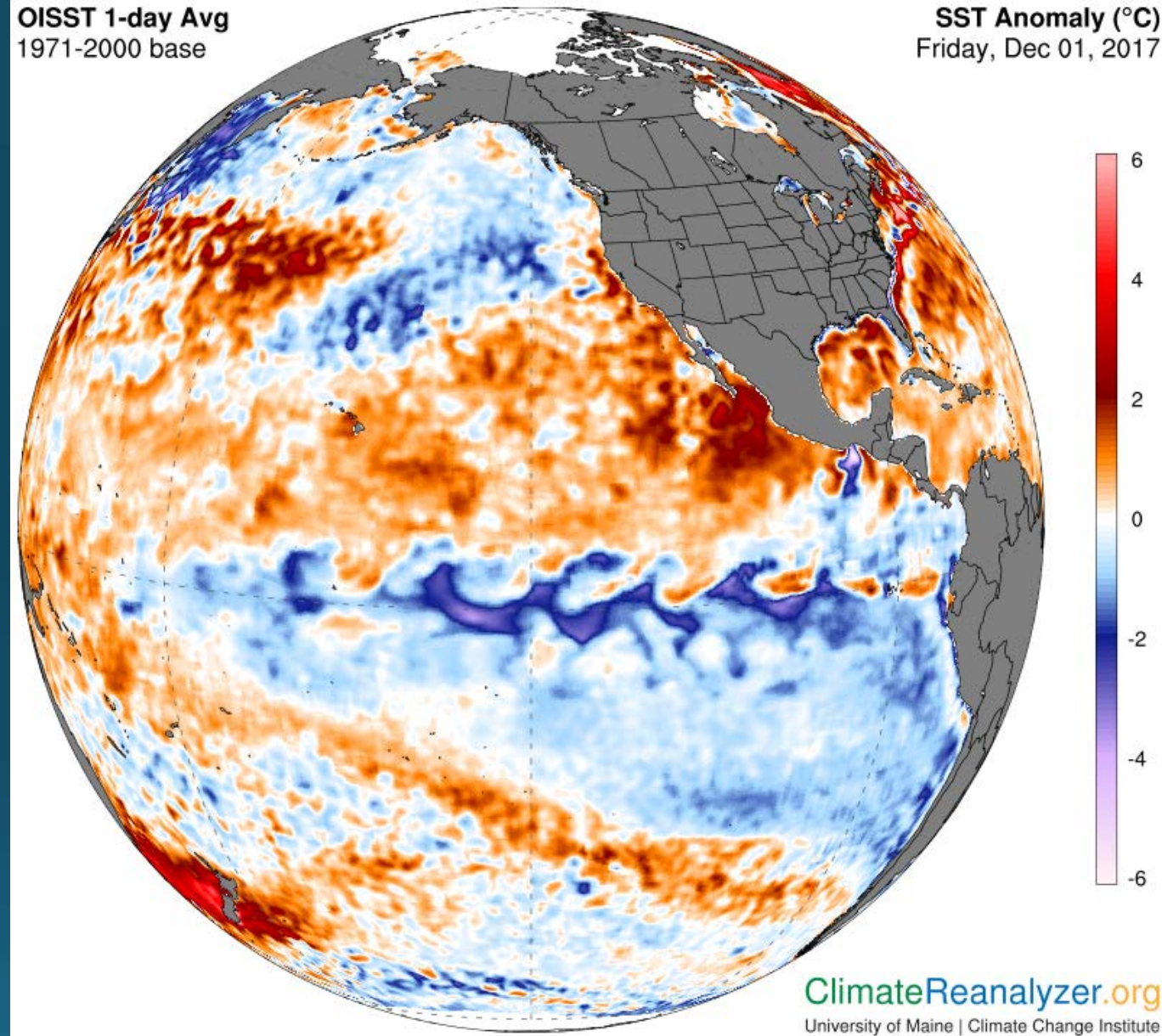
GOA Pacific cod Future outlook

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



OISST 1-day Avg
1971-2000 base

SST Anomaly (°C)
Friday, Dec 01, 2017



World
+ 0.2 °C

Northern Hemisphere
+ 0.4 °C

North Atlantic
+ 0.7 °C

Equatorial Pacific
- 0.1 °C

Southern Hemisphere
+ 0.1 °C

North Pacific
+ 0.2 °C

GOA Pacific cod

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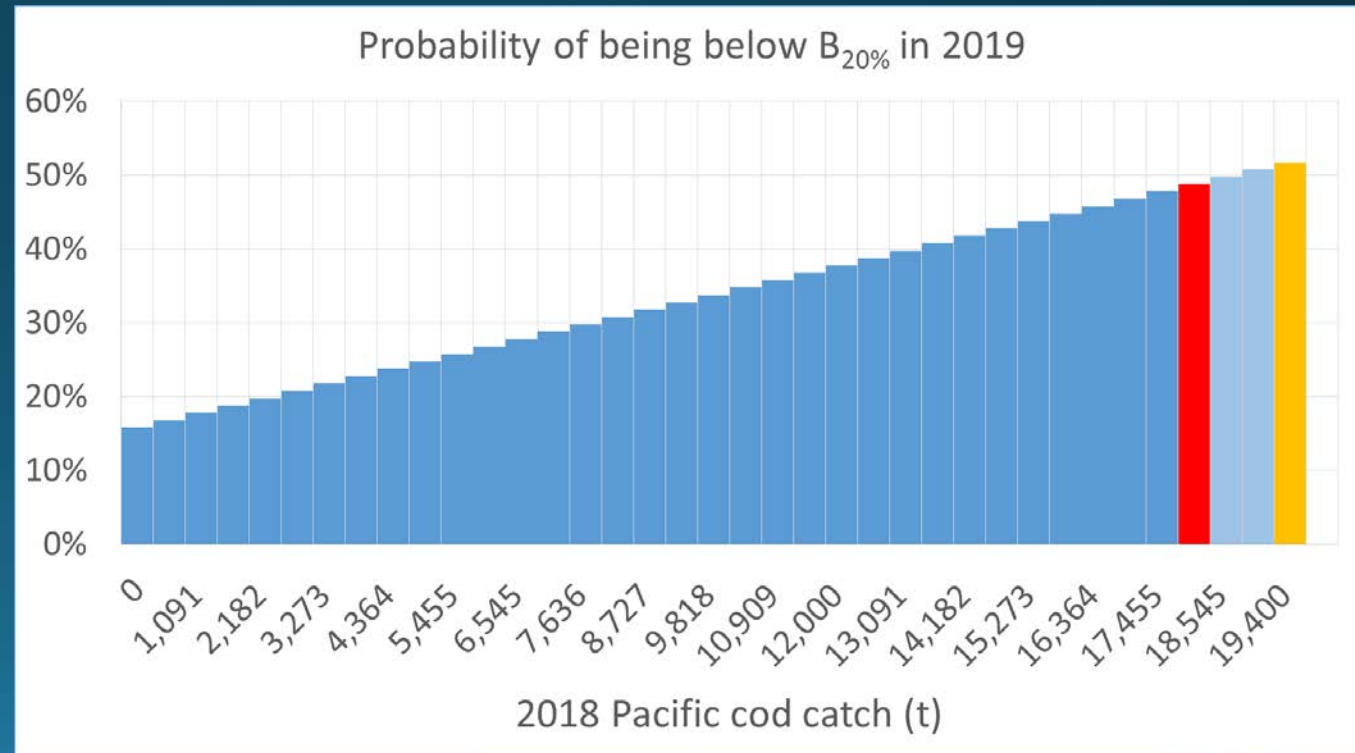
GOA Pacific cod

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

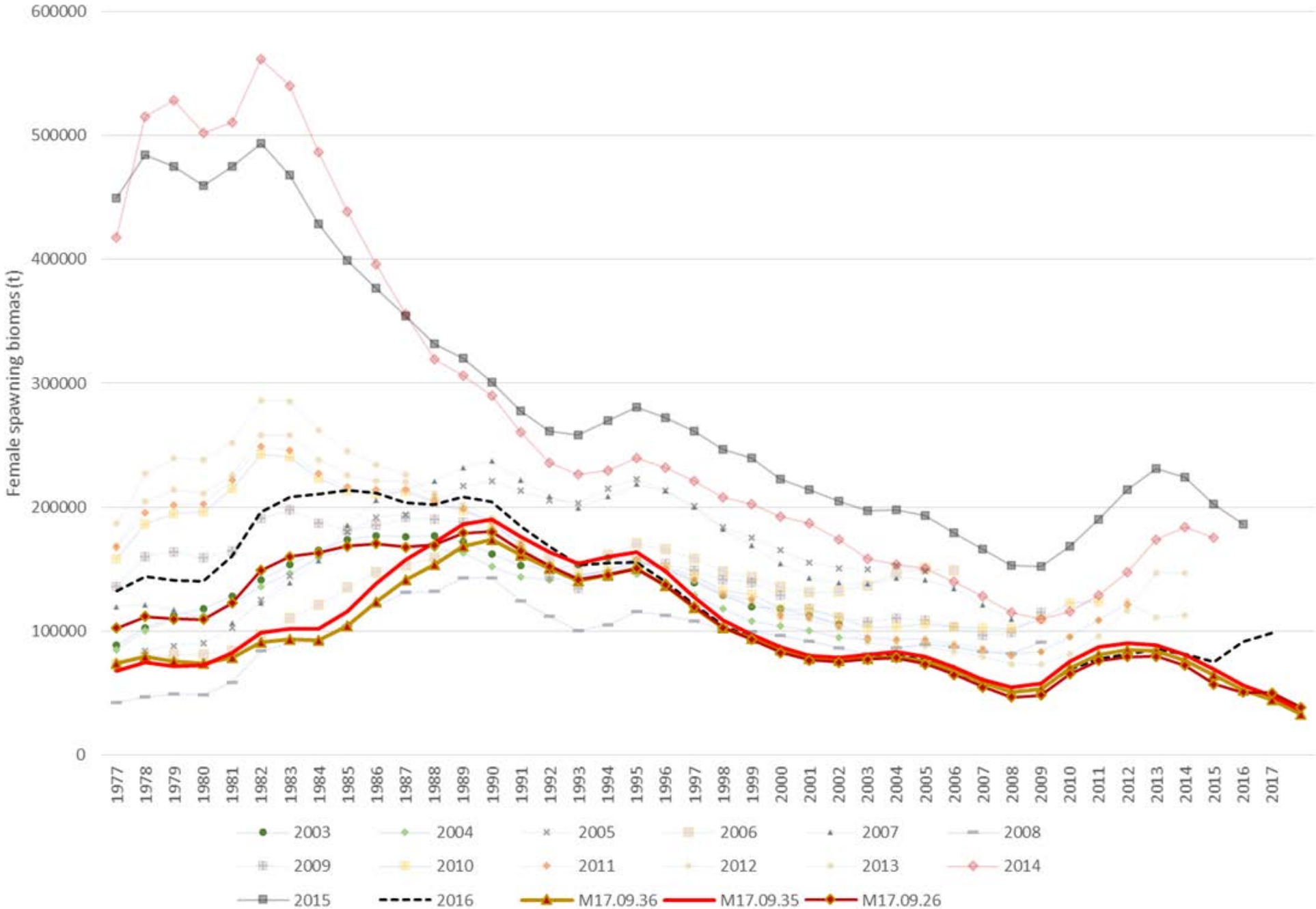


- 16% probability with no catch in 2018
- ~49% probability at 18,000 t catch in 2018
- $\pm 10\%$ by $\pm 5,455$ t

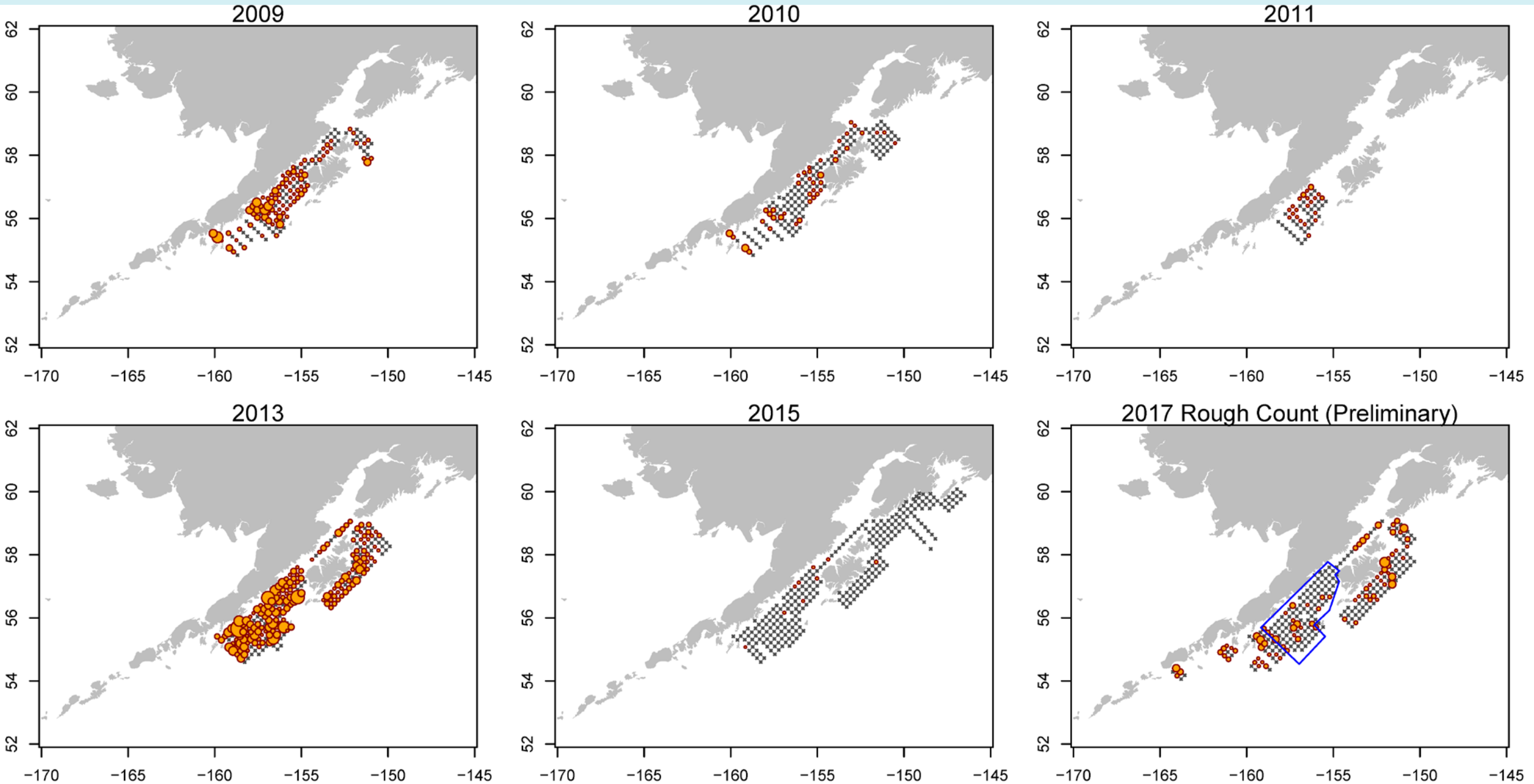
Assumes final 2017 catch at 48,941 t
(currently at 46,948 t)



GOA Pacific cod models female spawning biomass by year



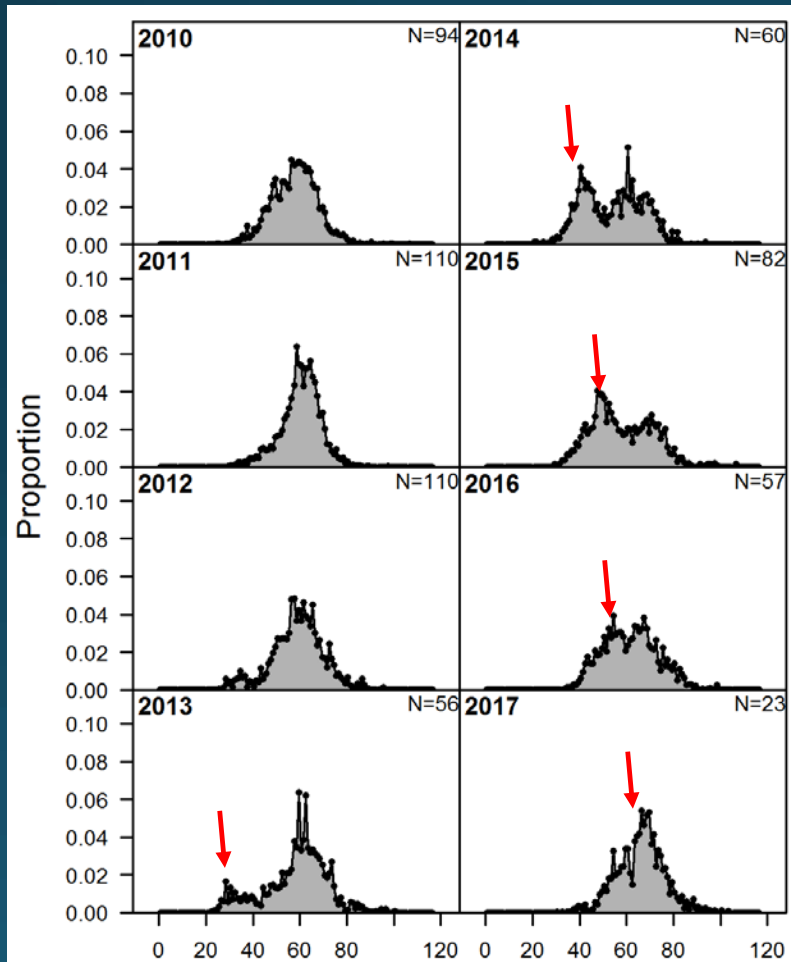
Larval abundance is not correlated with recruitment



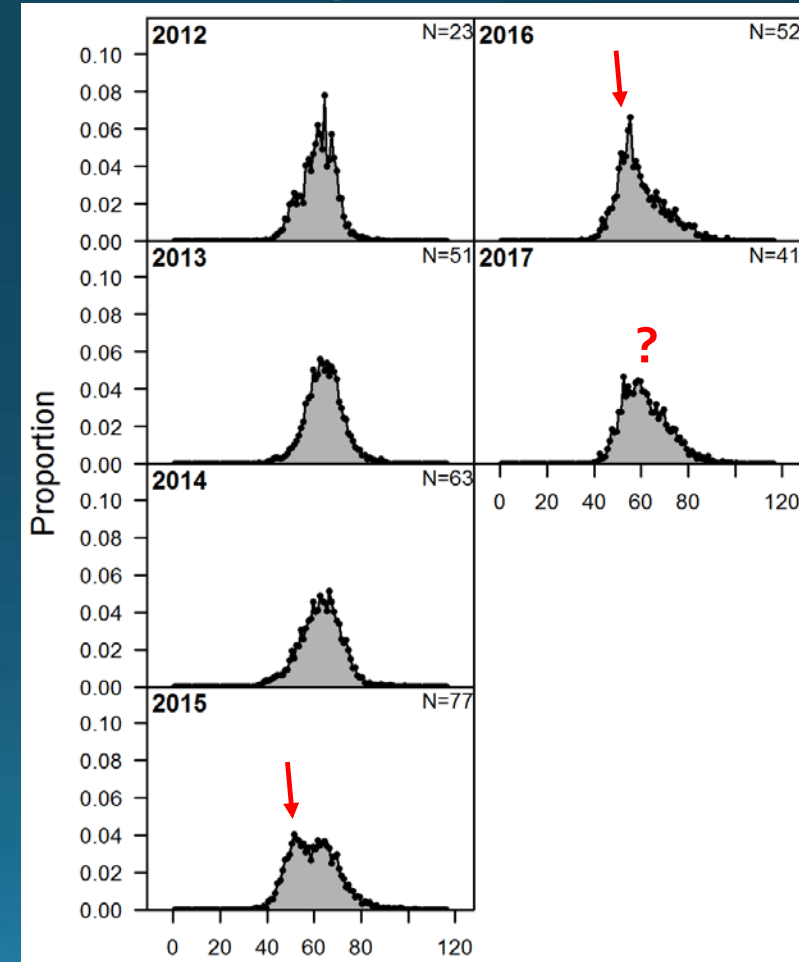
GOA Pacific cod Fishery length composition



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)

