Join by teleconference:

Call in #: 1-800-315-6338
Access code: 4861842

Bering Sea Snow Crab

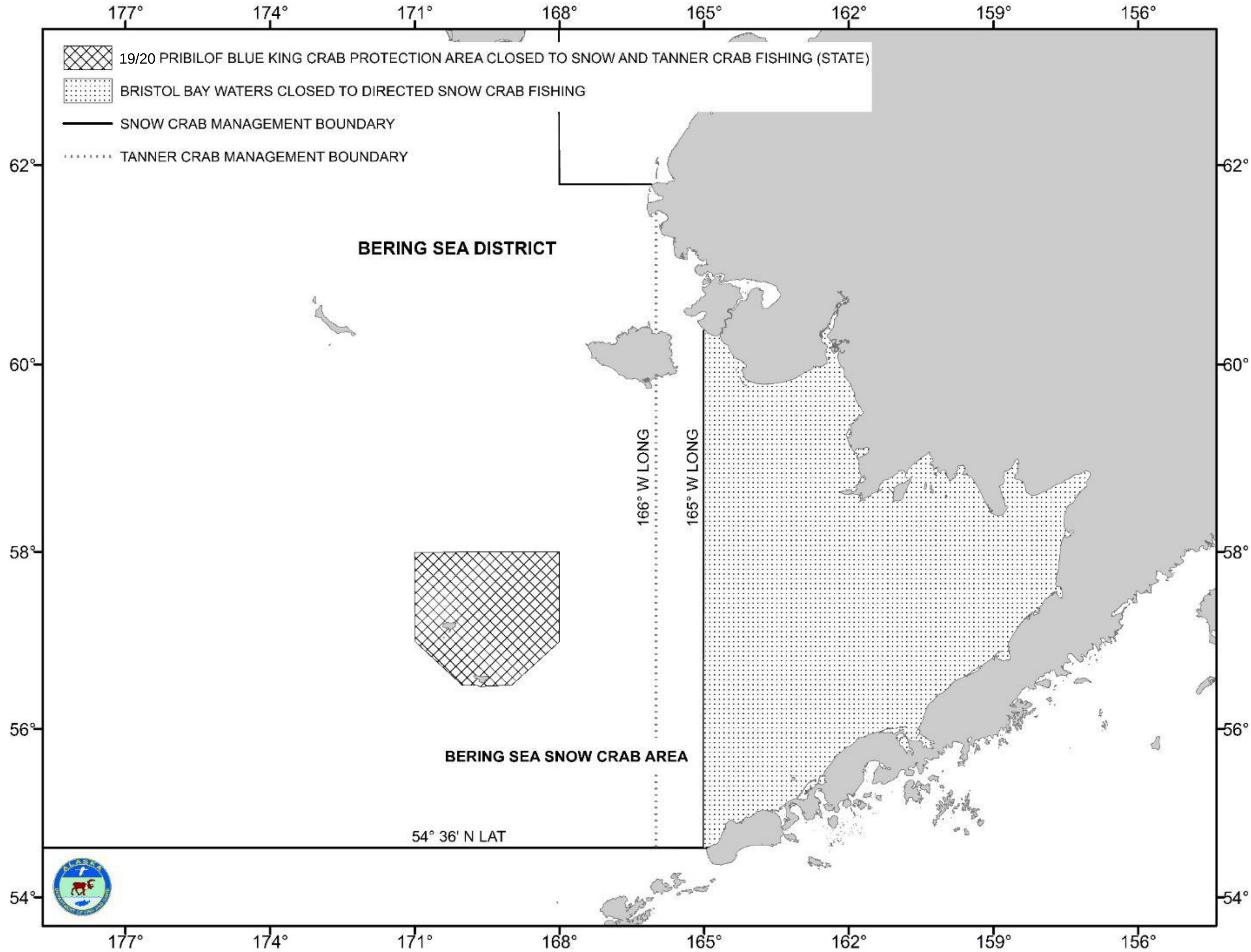
Federal 2019/20 ABC, OFL Determination

- ABC = 96.8-mill lb total catch
  - including bycatch mortality of males and females in all fisheries
  - **based on a 20% buffer on OFL**

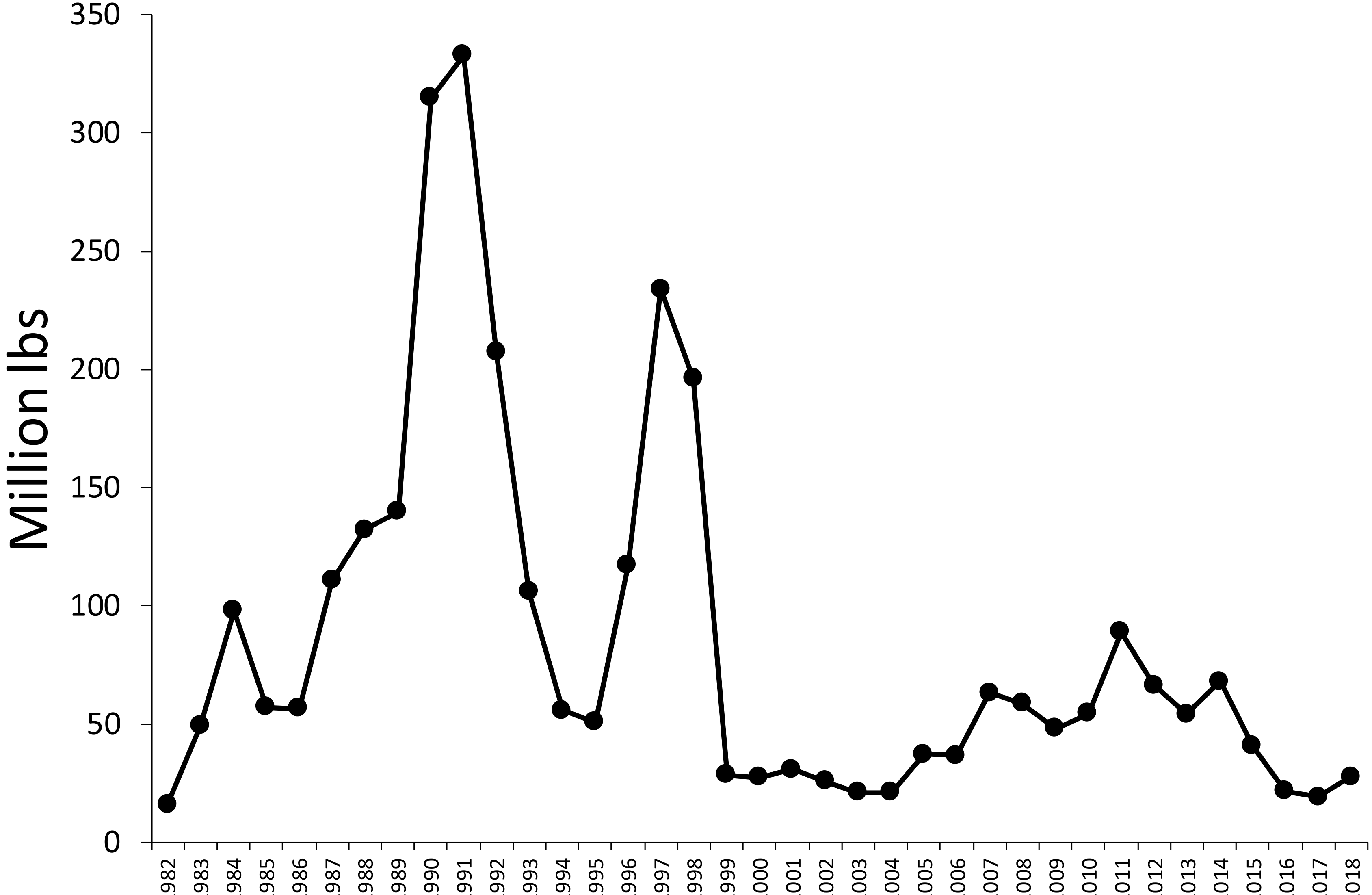
- OFL = 121.0 mill lb total catch

Historical status and catch specifications for snow crab (million lb). Shaded values are new estimates or projections based on the current assessment. Other table entries are based on historical assessments and are not updated except for total and retained catch.

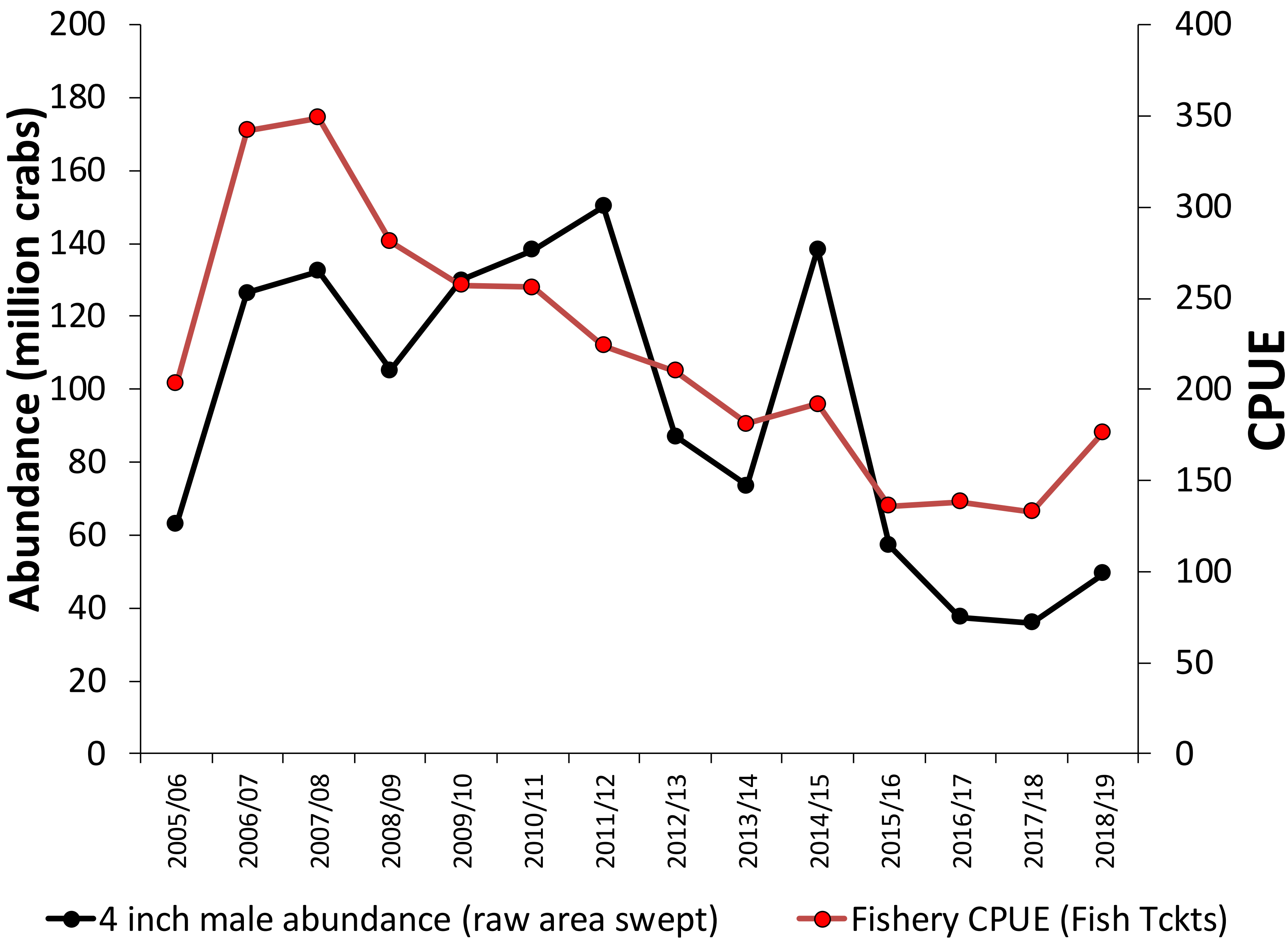
Year	MSST	Biomass (MMB)	TAC	Retained Catch	Total Catch	OFL	ABC
2015/16	167.1	201.9	40.6	40.6	47.2	183.2	137.4
2016/17	167.1	211.9	21.4	21.4	24.3	52.3	47.0
2017/18	157.4	219.6	19.0	19.0	23.2	62.6	50.0
2018/19	138.9	271.4	27.6	27.6	34.0	65.5	52.5
2019/20		368.8				121.0	96.8

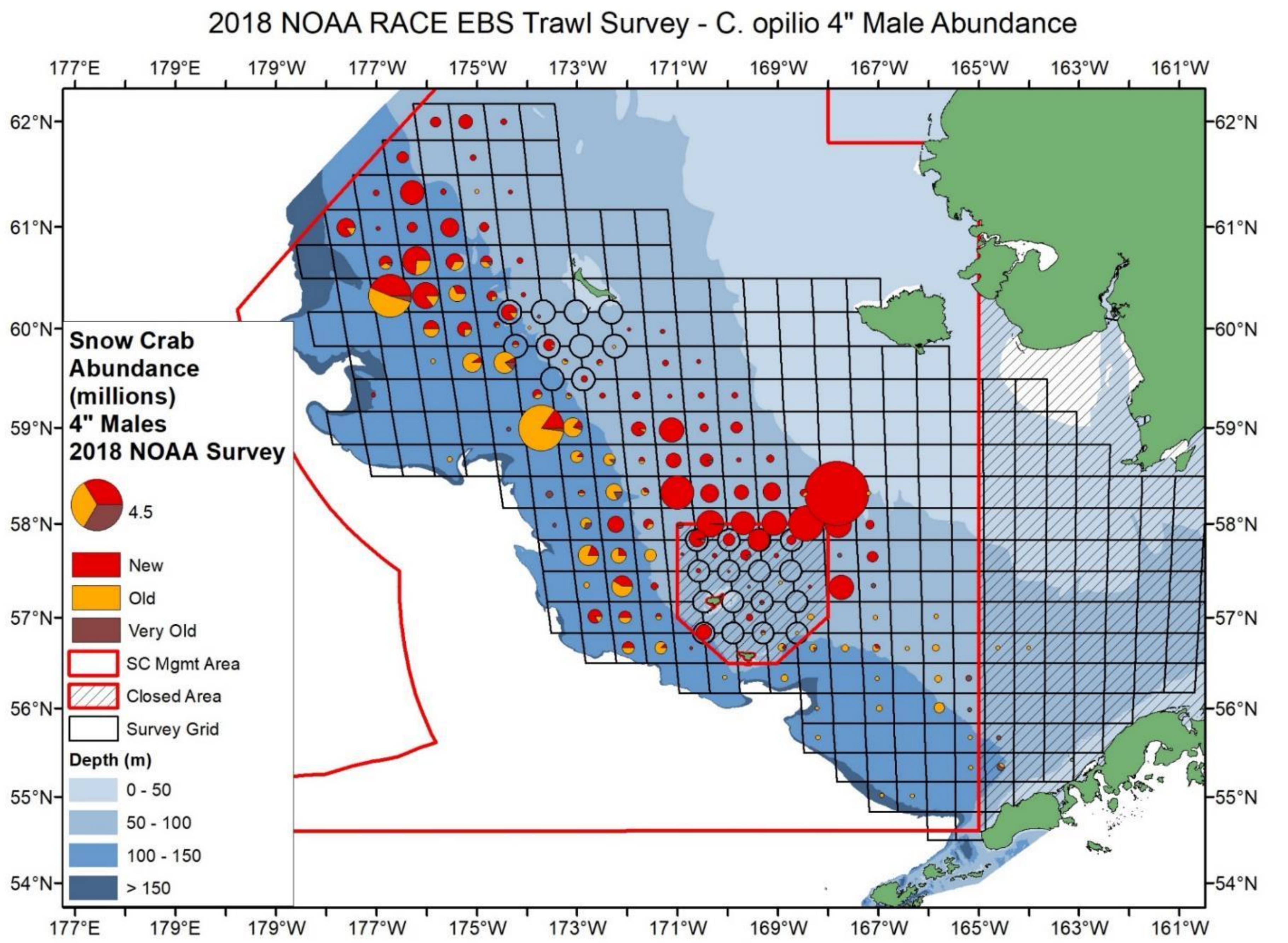

19/20 PRIBILOF BLUE KING CRAB PROTECTION AREA CLOSED TO SNOW AND TANNER CRAB FISHING (STATE)
BRISTOL BAY WATERS CLOSED TO DIRECTED SNOW CRAB FISHING
SNOW CRAB MANAGEMENT BOUNDARY
TANNER CRAB MANAGEMENT BOUNDARY
BERING SEA DISTRICT
166° W LONG
165° W LONG
BERING SEA SNOW CRAB AREA
54° 36' N LAT
177°
174°
171°
168°
165°
162°
159°
156°
62°
60°
58°
56°
54°

Historical TACs

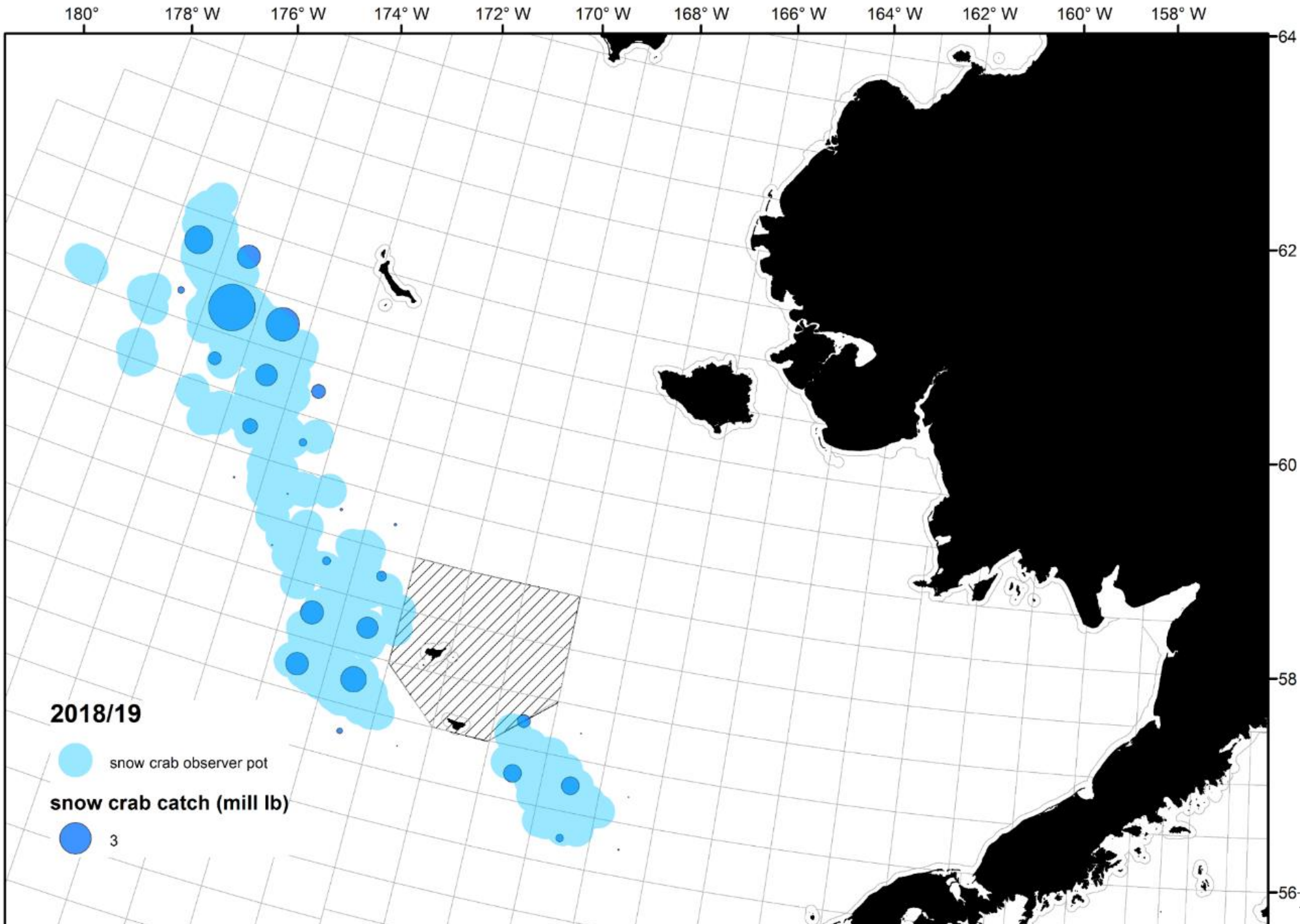


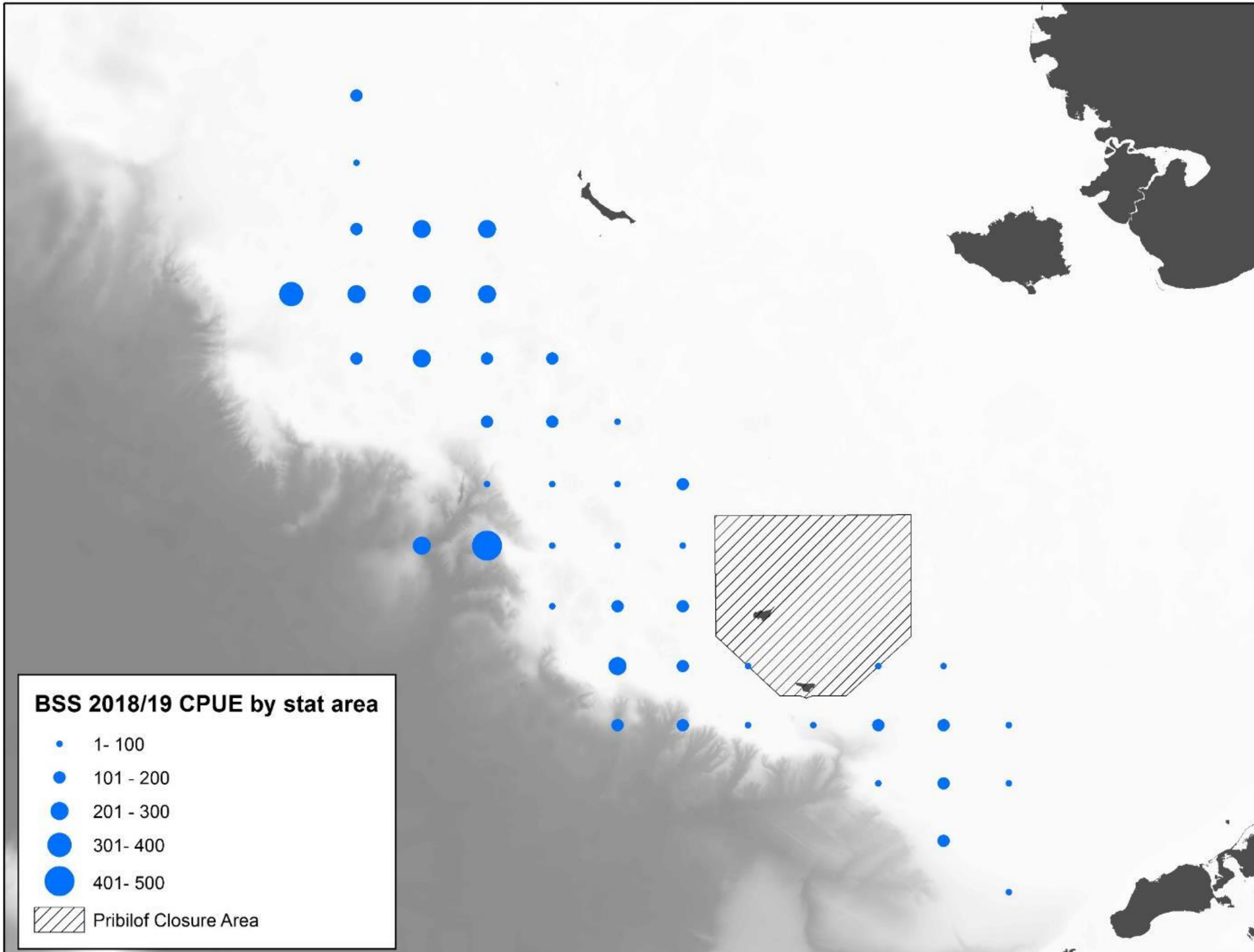
Preferred Male Abundance and CPUE Since Rationalization



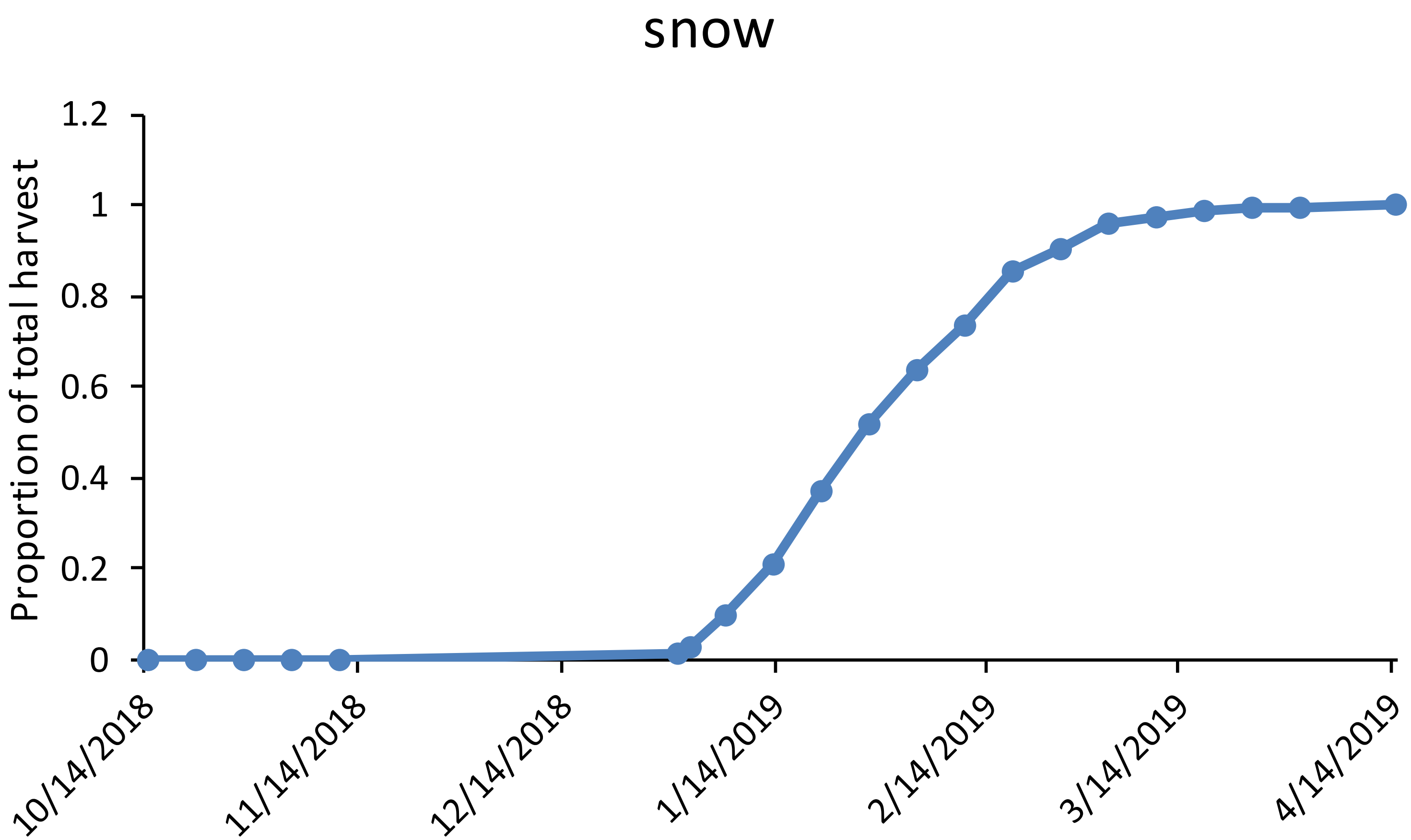

2018 NOAA RACE EBS Trawl Survey - C. opilio 4" Male Abundance
177°E
179°E
179°W
177°W
175°W
173°W
171°W
169°W
167°W
165°W
163°W
161°W
62°N
61°N
60°N
59°N
58°N
57°N
56°N
55°N
54°N
Snow Crab Abundance (millions) 4" Males 2018 NOAA Survey
4.5
New
Old
Very Old
SC Mgmt Area
Closed Area
Survey Grid
Depth (m)
0 - 50
50 - 100
100 - 150
> 150

2018/19 BSS Harvest




BSS 2018/19 CPUE by stat area
1- 100
101 - 200
201 - 300
301- 400
401- 500
Pribilof Closure Area

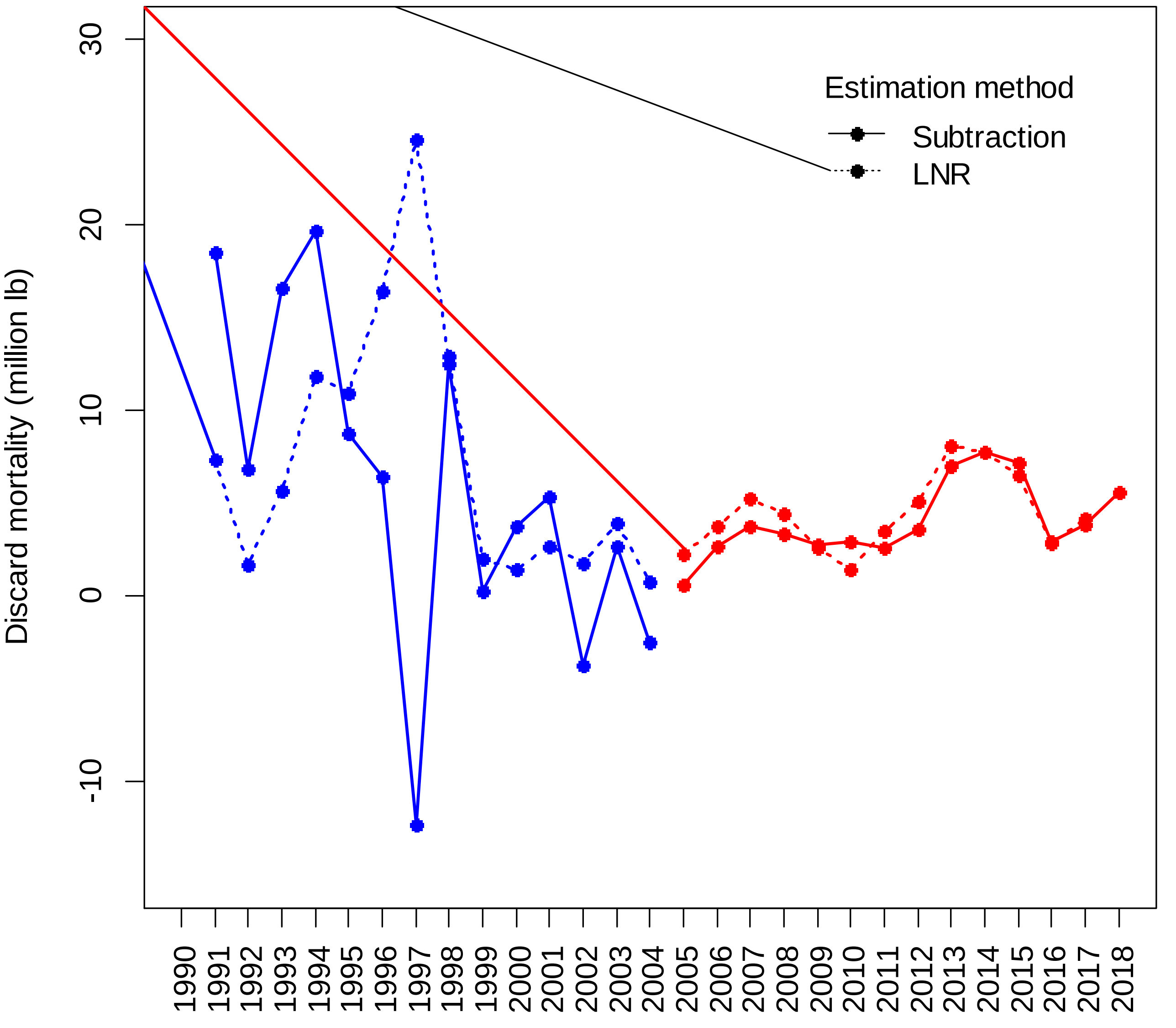
2018/19 snow crab



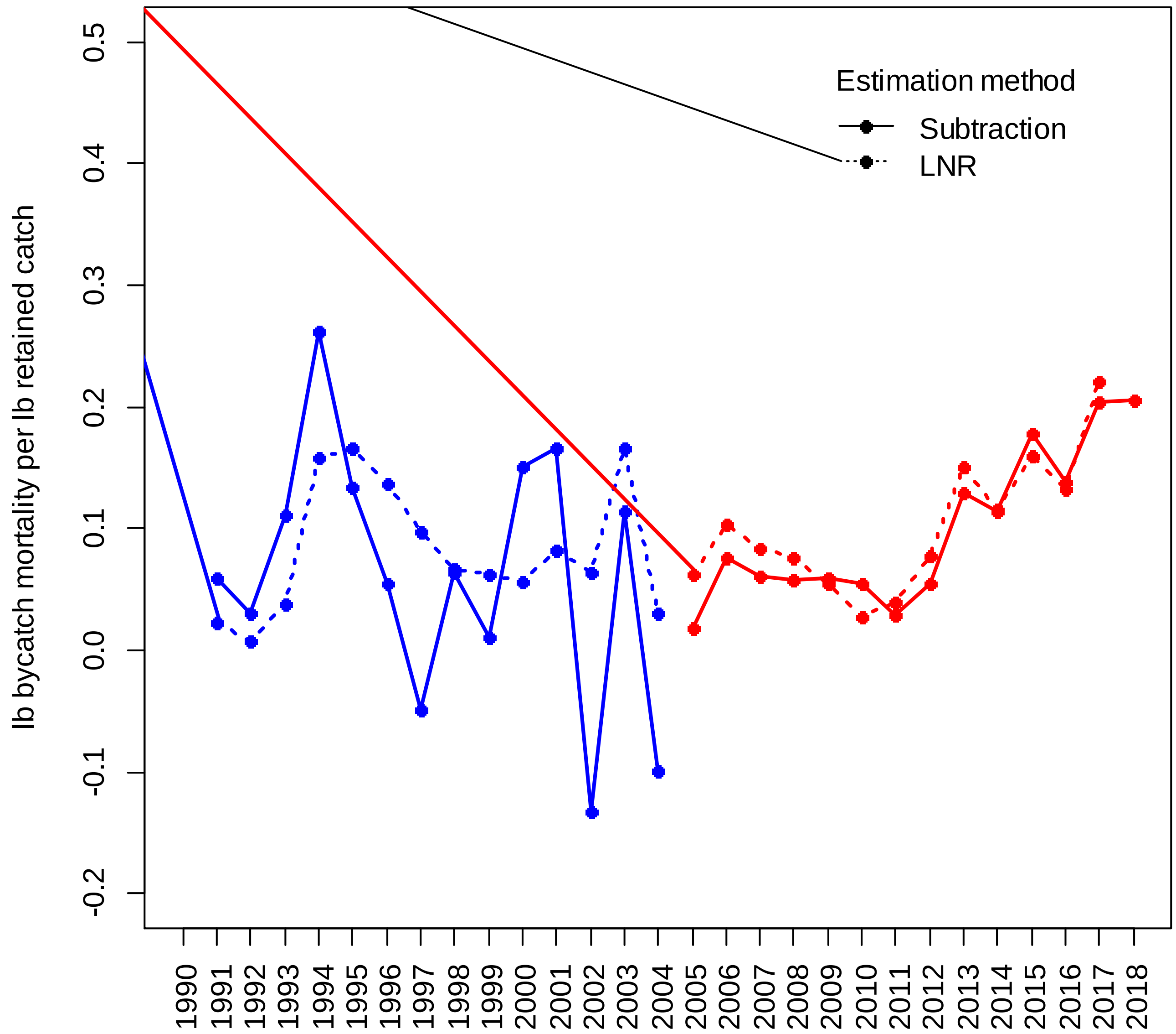
2018/19 BSS observations from the fleet

- Many vessels ended up fishing SW of Saint Matthew Island where CPUE was high and there was clean (new shell) crab.
  - Many vessels initially tried to fish in more traditional areas (W/NW of Pribilofs) before eventually moving north in search of better fishing.
- Several captains reported having to move gear around more than usual to find clean crab in fish-able numbers.
- Fishing W/NW of Pribilofs saw LOTS of juveniles (many reports from captains over the season). Captains reported that legal crab in these areas were “dirty” and described it as a “junkpile”, meaning that lots of sorting was required to end up with new shell 4-inch plus crab.
- Sea ice did not impact the fishery. The ice edge stopped at Saint Matthew at maximum extend and then retreated North.
- Majority of the fleet saw better fishing than in 2017/18 season.

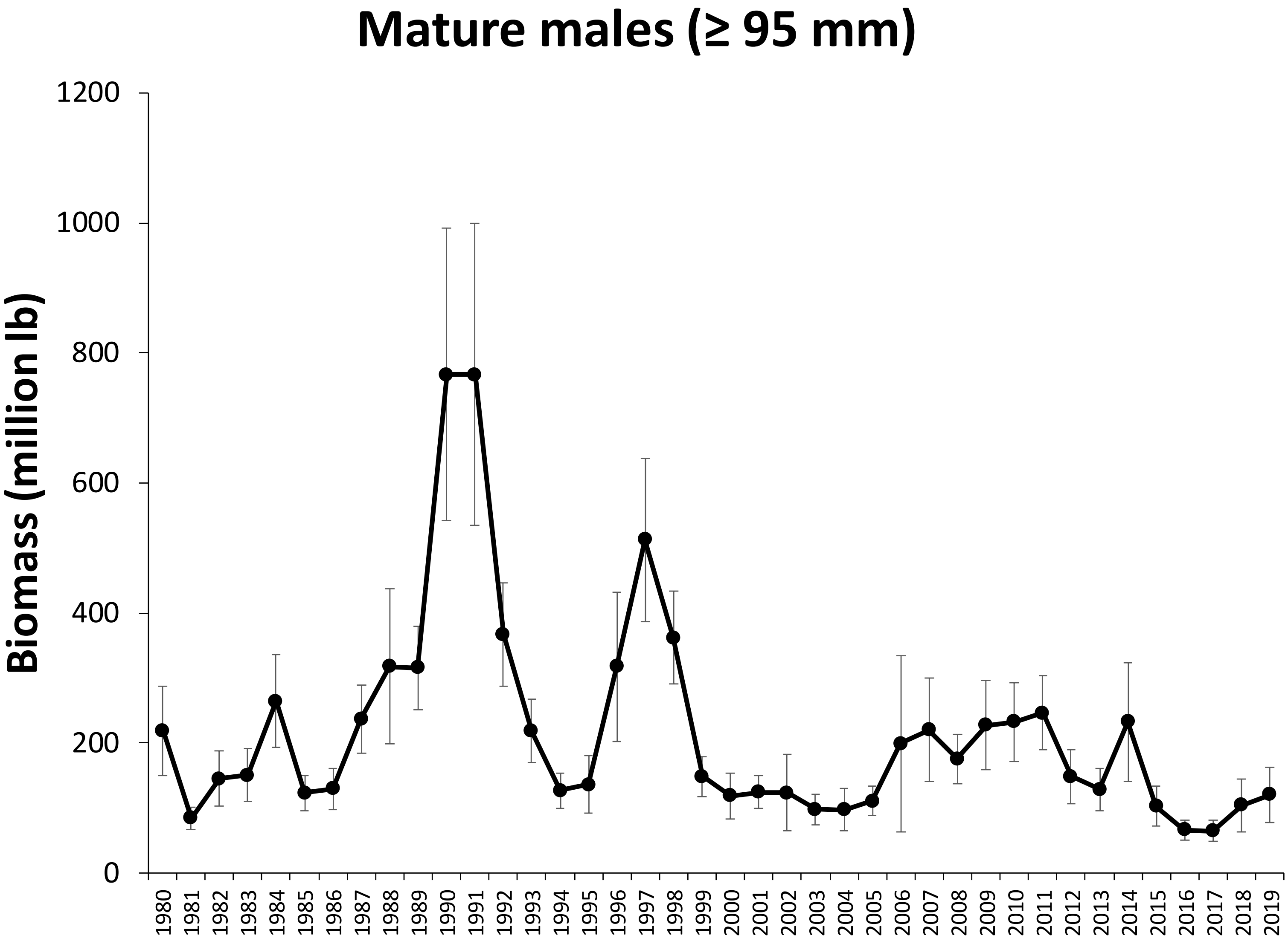
snow crab discard mortality



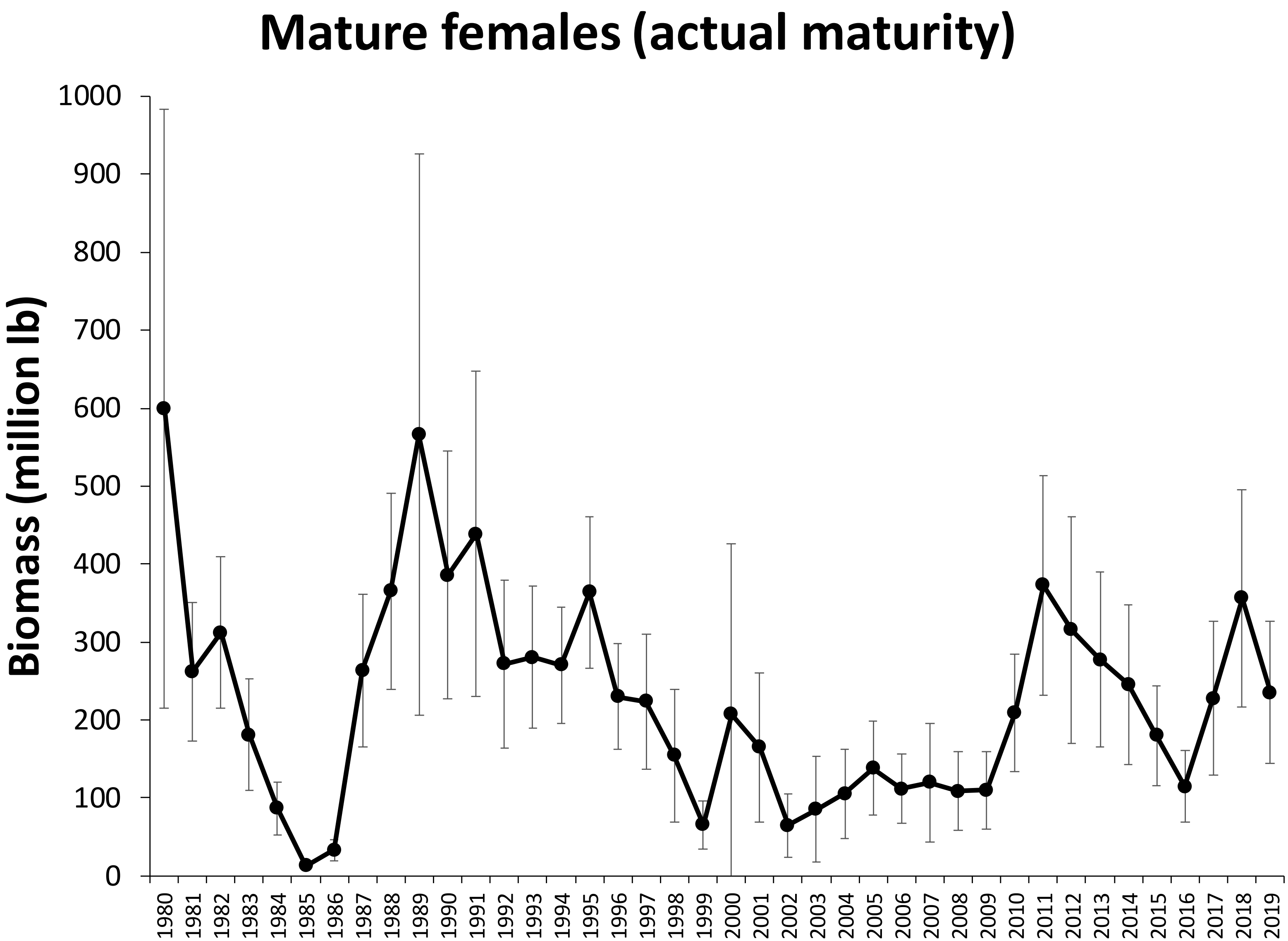
snow crab discard mortality rate



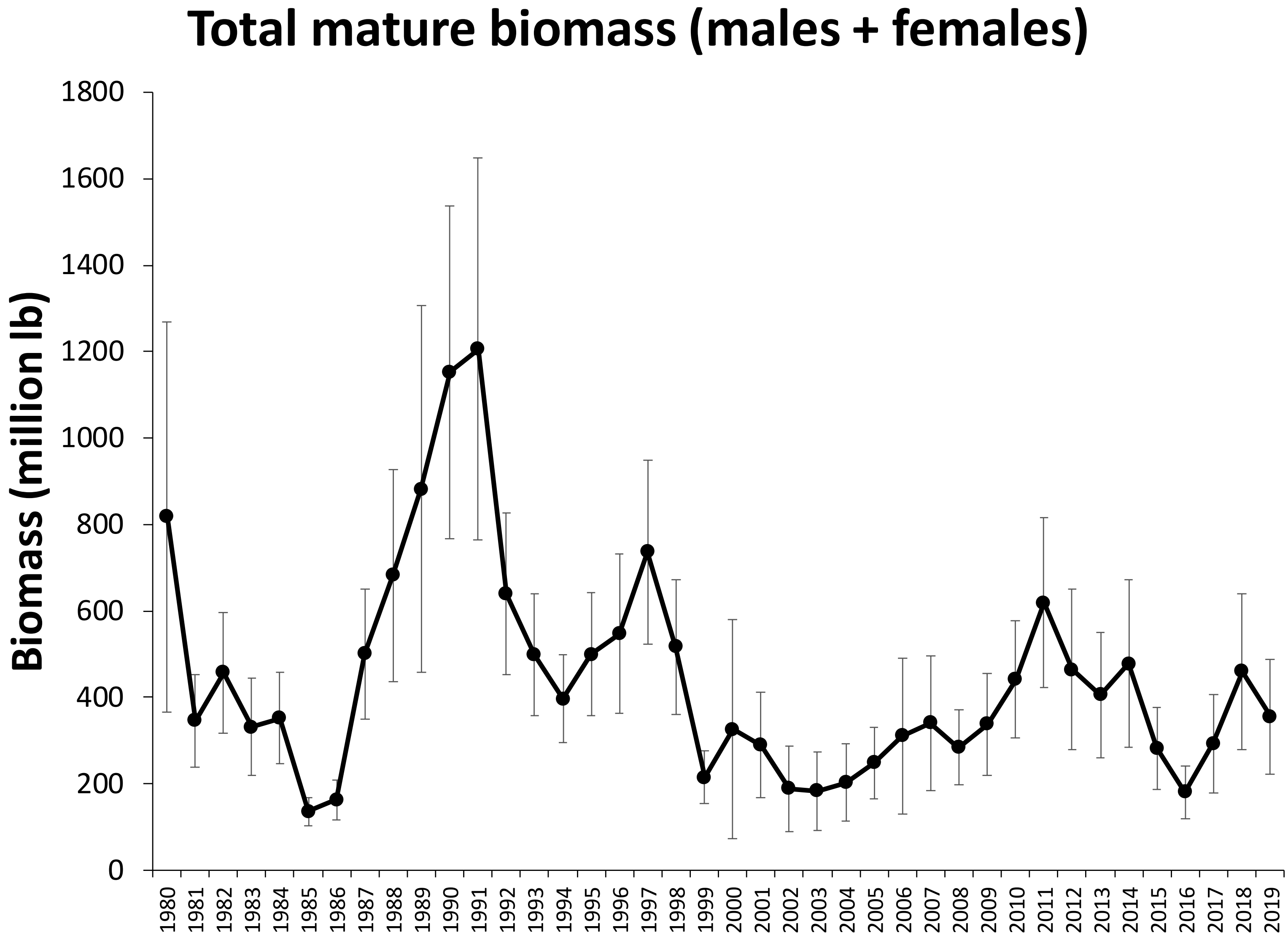
NOAA survey area-swept



NOAA survey area-swept

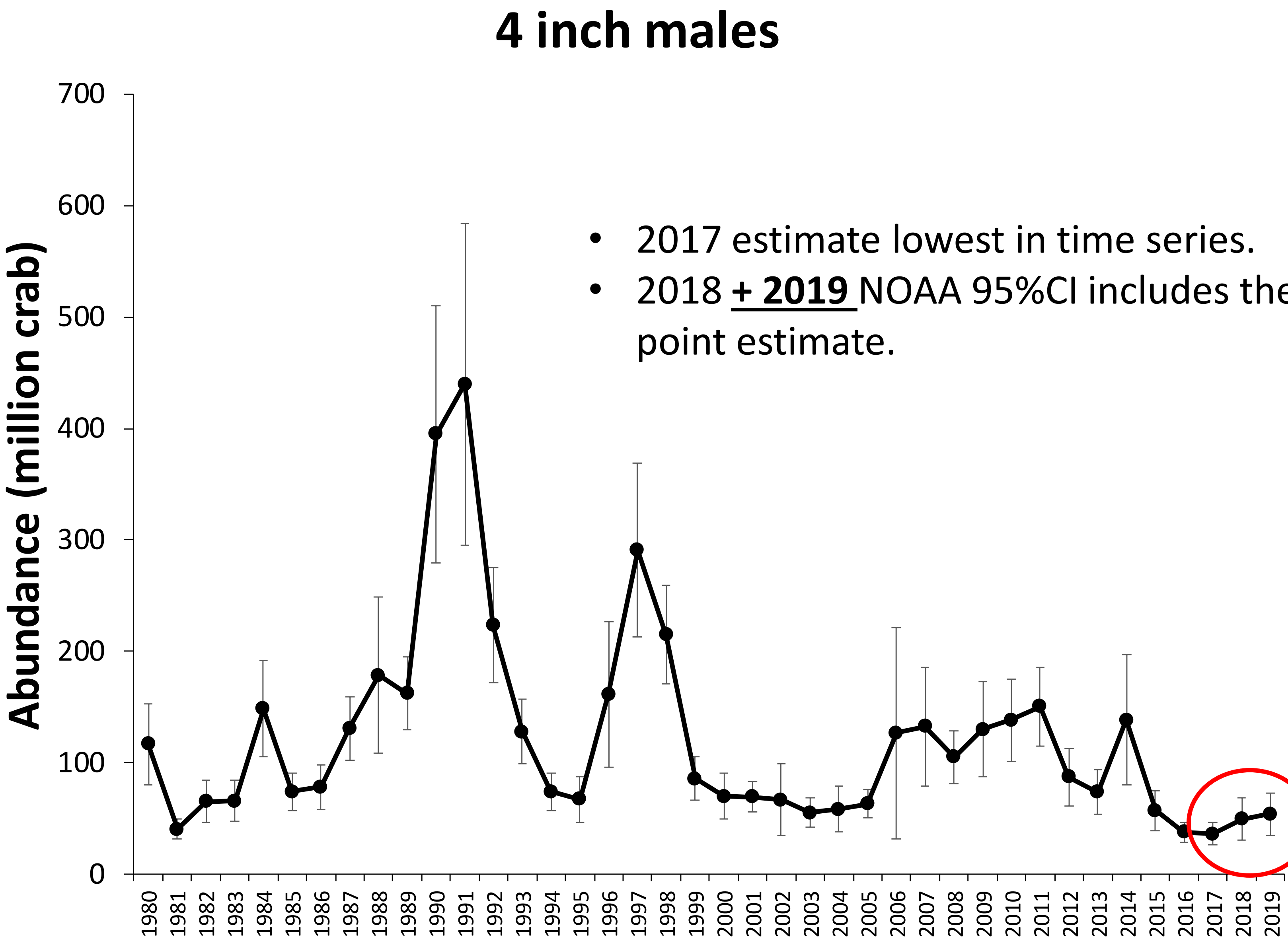


NOAA survey area-swept

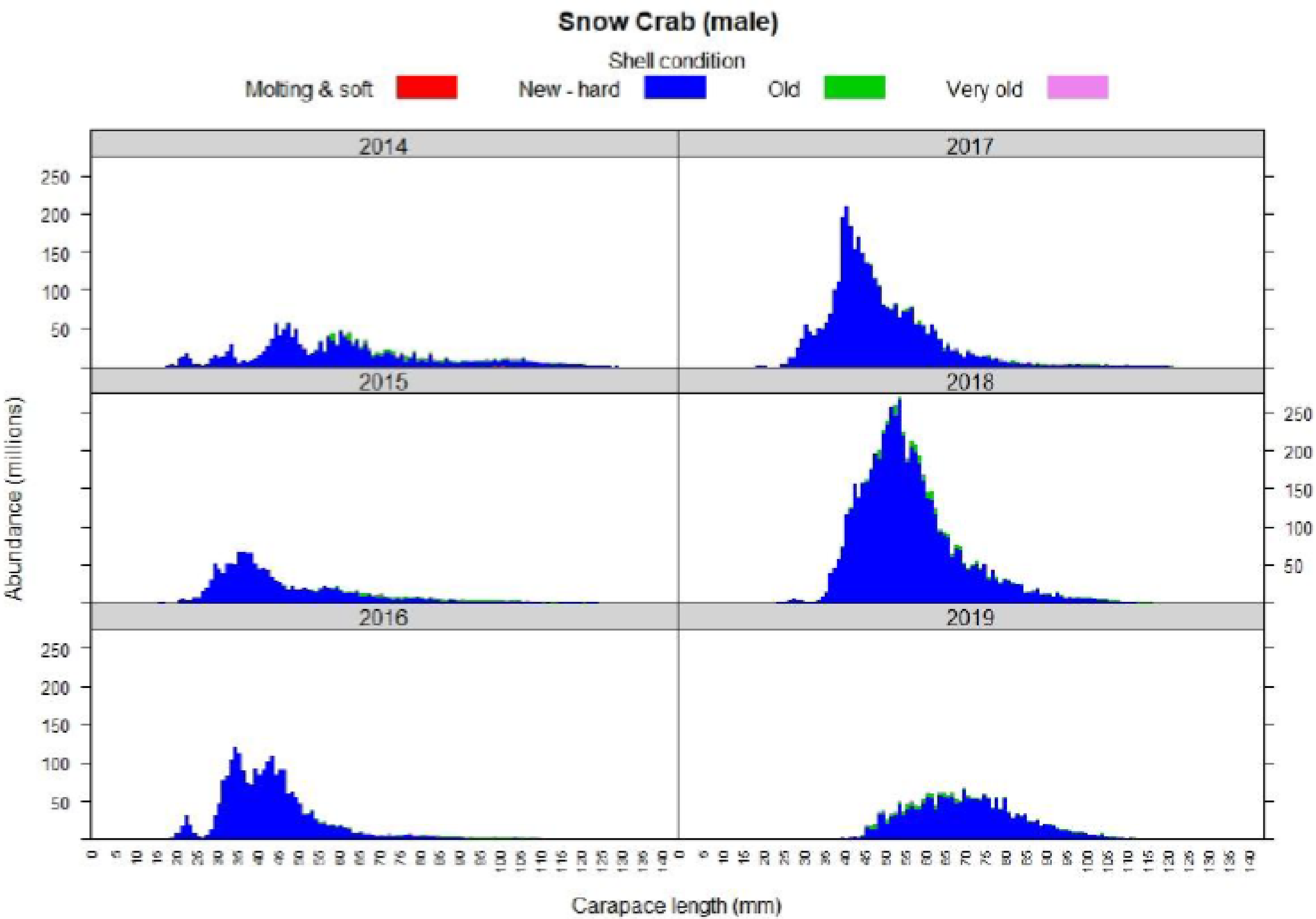


Male maturity defined as ≥ 95 mm

NOAA survey area-swept

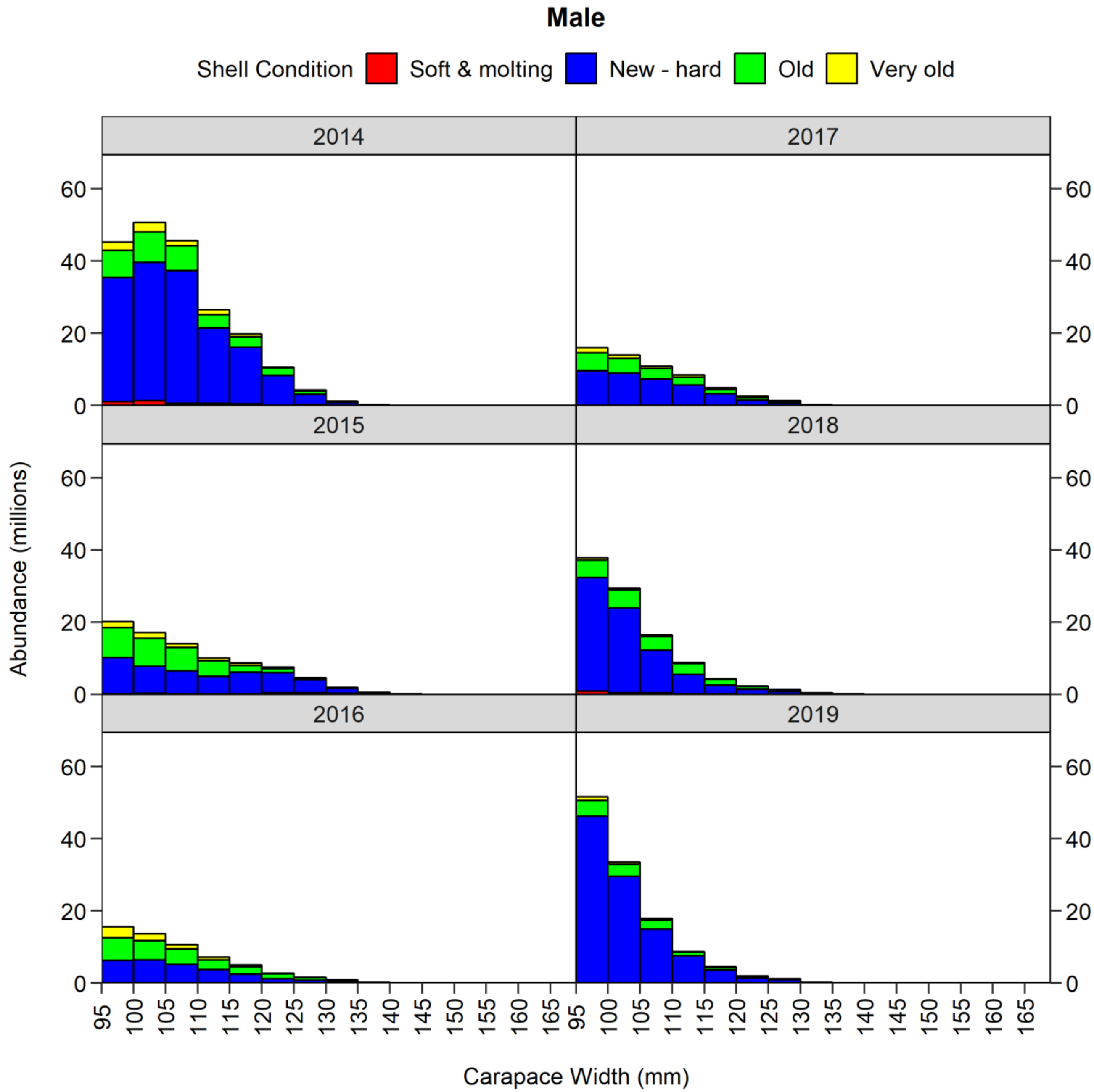


- 2017 estimate lowest in time series.
- 2018 <u>**+ 2019**</u> NOAA 95%CI includes the 2017 point estimate.

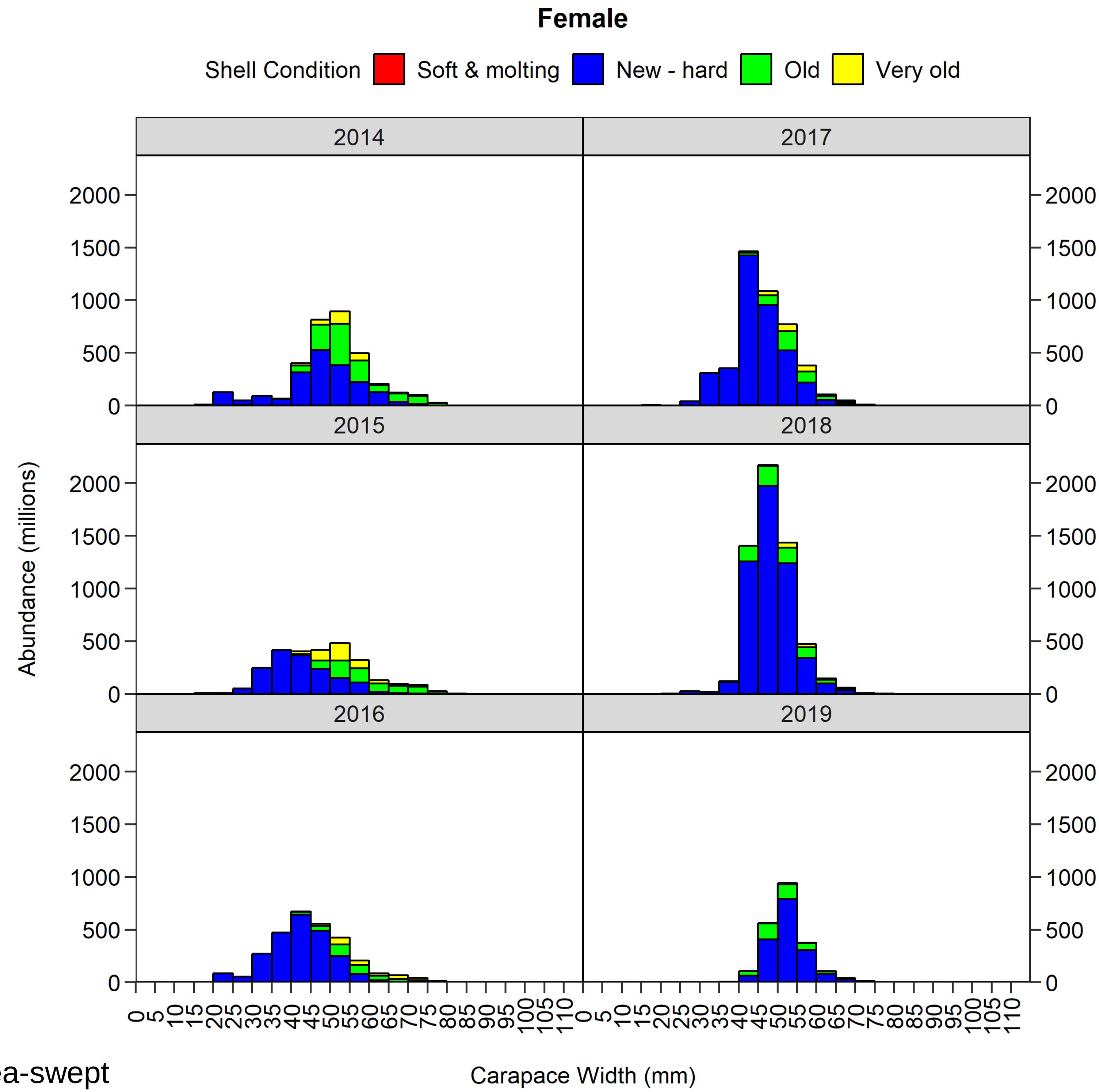


NOAA survey area-swept

Males ≥ 95

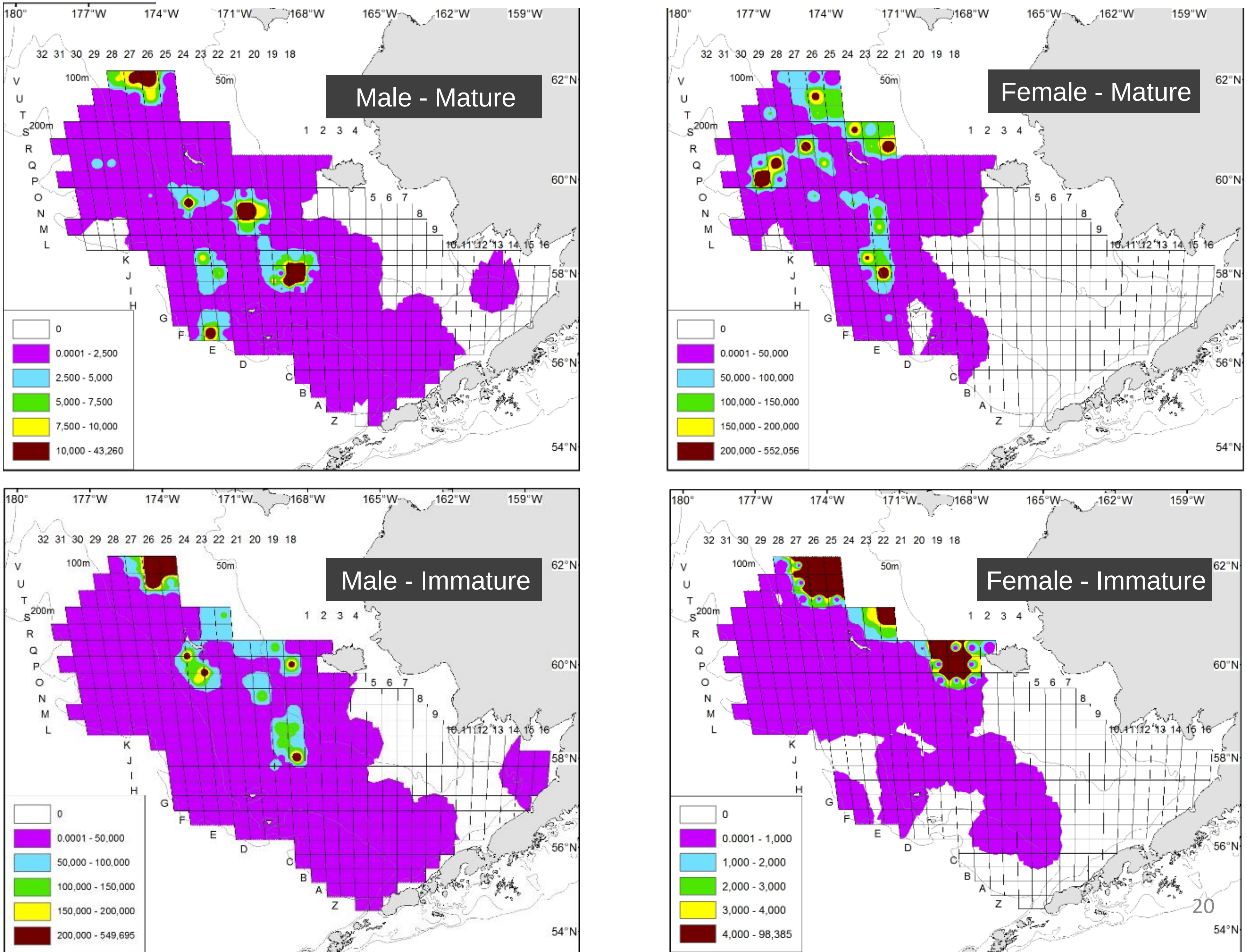


NOAA survey area-swept

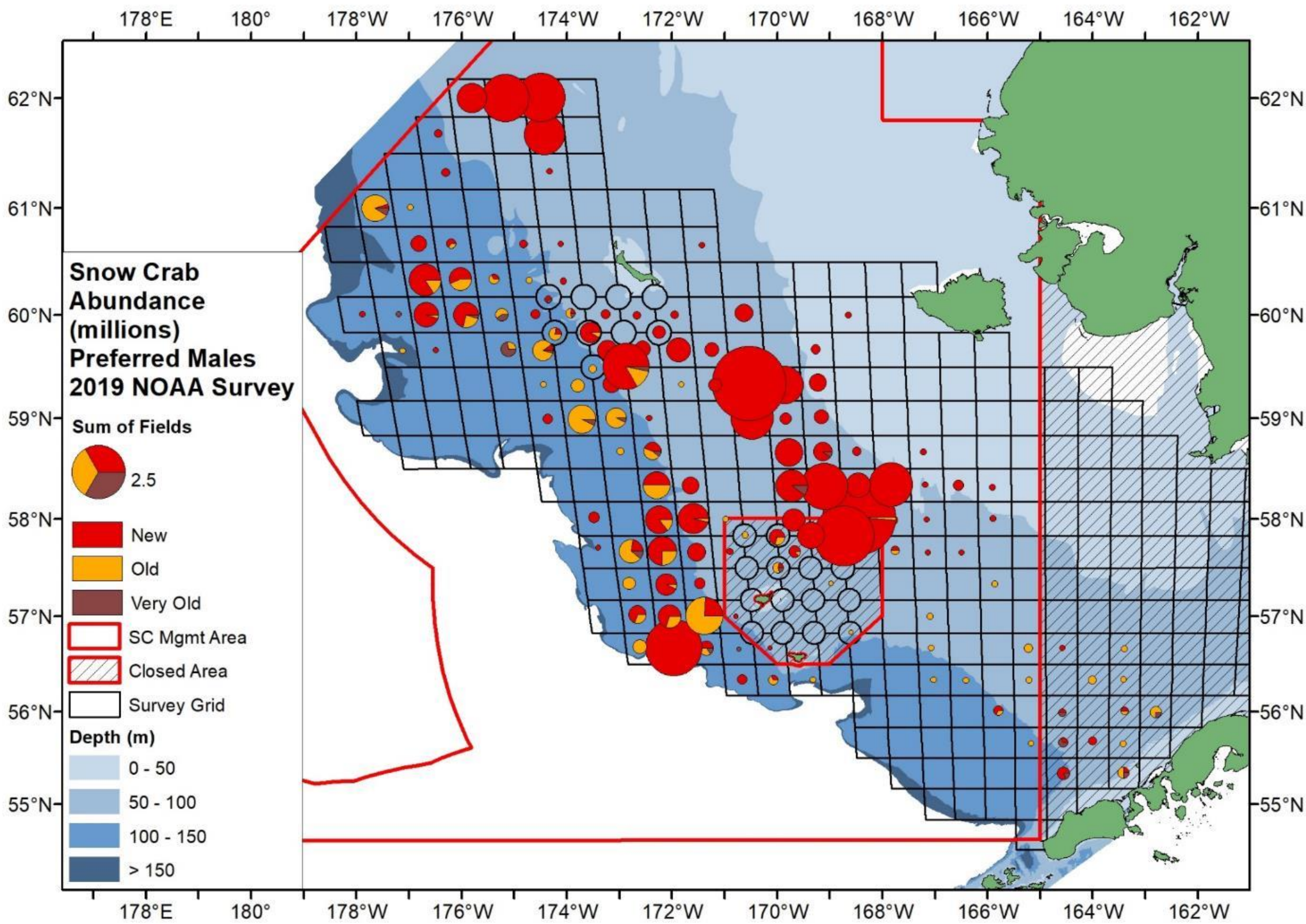


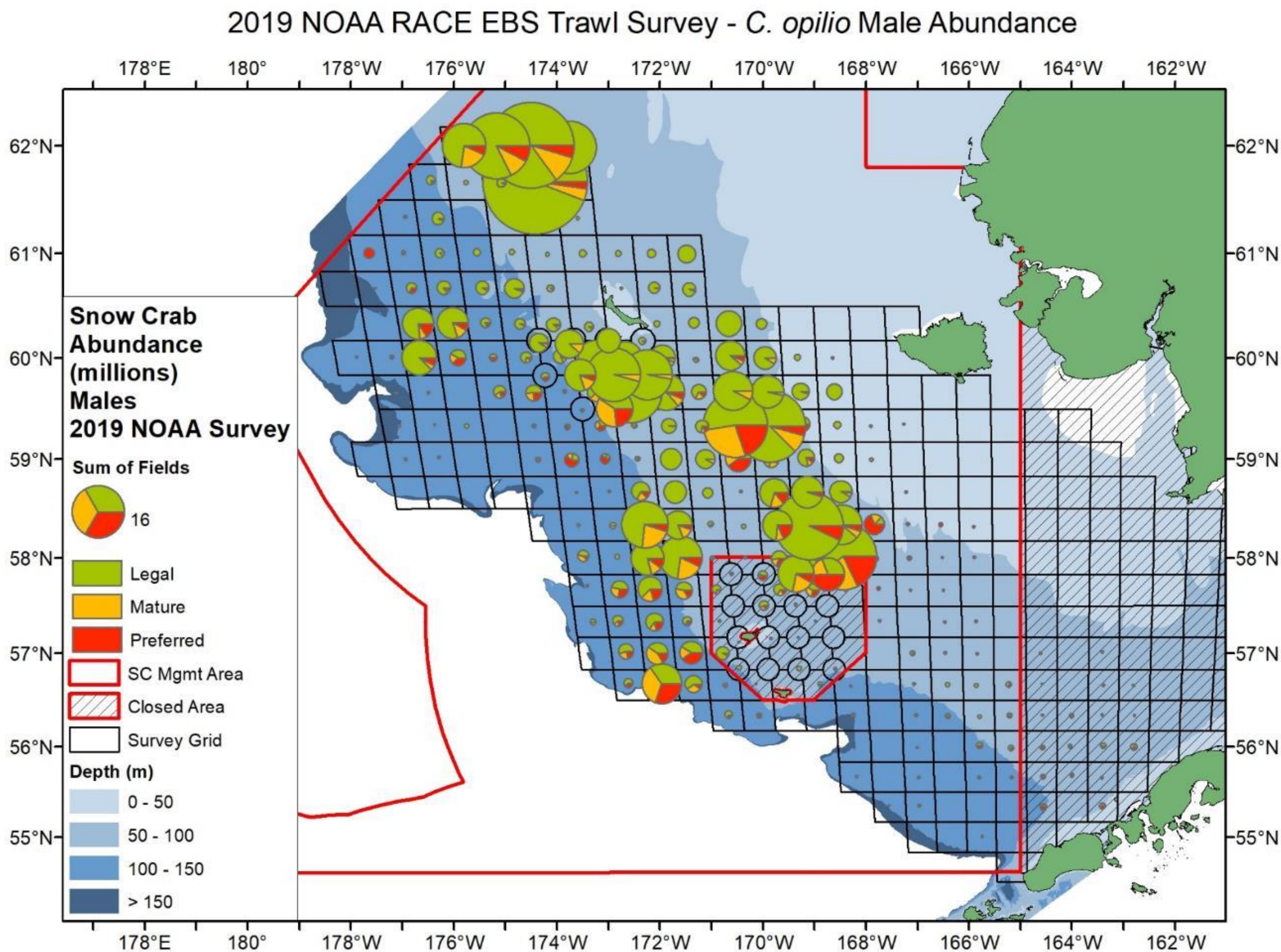
NOAA survey area-swept

From 2019 NOAA Survey Presentation to CPT by Jon Richar



2019 NOAA RACE EBS Trawl Survey - *C. opilio* Preferred Male Abundance




2019 NOAA RACE EBS Trawl Survey - *C. opilio* Male Abundance
178°E
180°
178°W
176°W
174°W
172°W
170°W
168°W
166°W
164°W
162°W
62°N
61°N
60°N
59°N
58°N
57°N
56°N
55°N
Snow Crab Abundance (millions) Males 2019 NOAA Survey
Sum of Fields
16
Legal
Mature
Preferred
SC Mgmt Area
Closed Area
Survey Grid
Depth (m)
0 - 50
50 - 100
100 - 150
> 150

Bering Sea Snow Crab

Review of Stock Assessment Model

Selected model scenario “19.7” –

CPT minutes: “…..exhibited the best retrospective pattern among the models, it estimated male survey catchability closer to what was implied by the BSFRF side-by-side data, it incorporated one of the priors for increased *M*, and it used the linear growth model for males.”

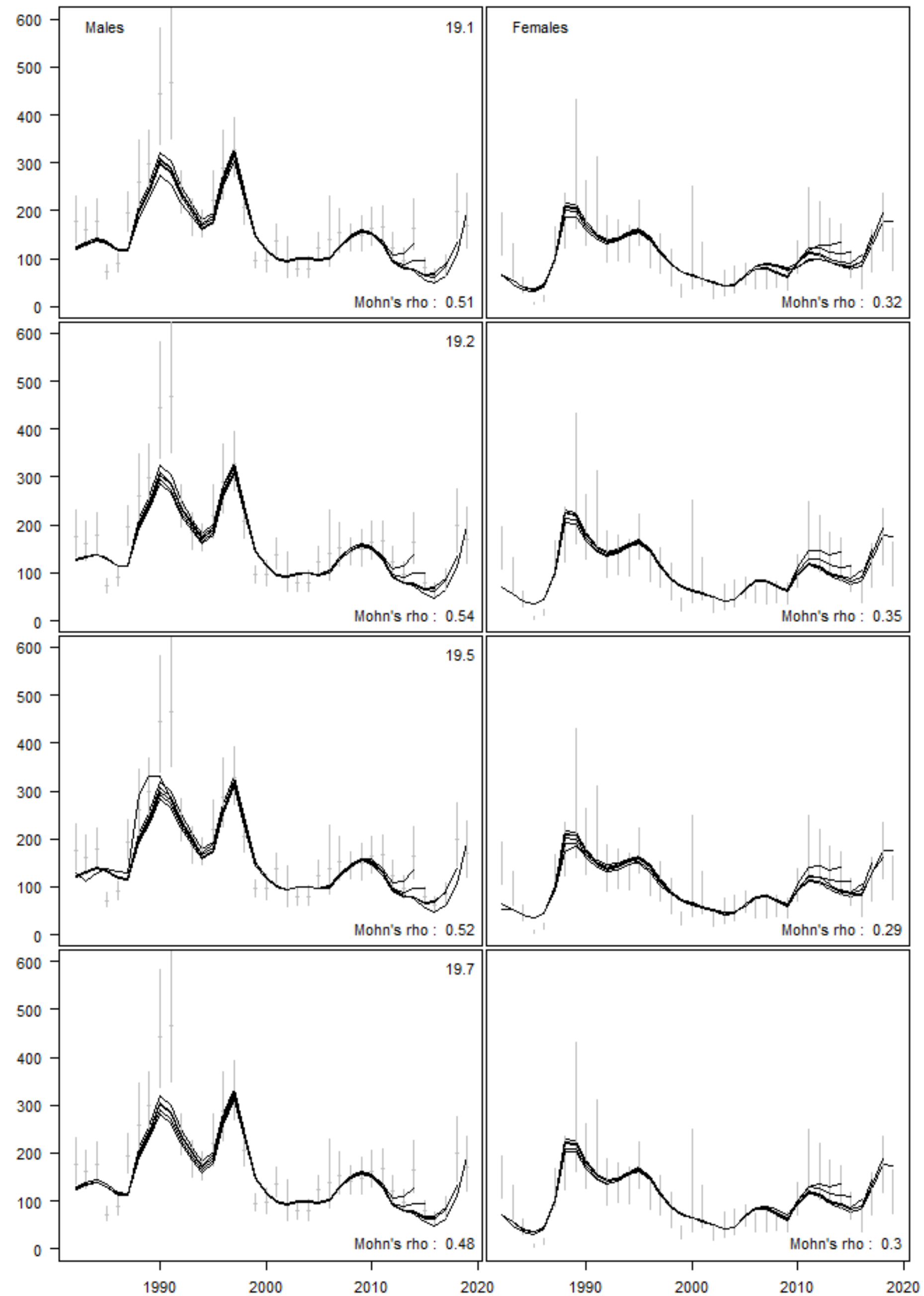
Retrospective patterns

A retrospective pattern is a consistent directional change in assessment estimates of management quantities (e.g. MMB) in a given year when additional years of data are added to an assessment.

CPT minutes: "*Models tended to overestimate MMB in the terminal year because an initially-strong recruitment event in 2010 disappeared in subsequent surveys.*"

Mohn's rho: the average relative bias of retrospective estimates

> 0.20 worthy of raising an eye-brow?



Bering Sea Snow Crab

2019 Snow Crab SAFE chapter:

Scientific uncertainty (p. 22)

Previous analyses suggest that retrospective patterns may be a problem for the snow crab assessment (Szuwalski and Turnock, 2016; Szuwalski, 2017), which was supported by this analysis. Retrospective patterns can result from unaccounted for time-varying processes in the population dynamics of the model (Hurtado et al., 2015). The retrospective patterns in MMB for snow crab appears to be at least partially a result of large estimates of survey MMB in 2014 and 2018. The large estimated survey MMB may have caused by a change in catchability during those years and **focused research on time-variation in important population processes for snow crab should be pursued to confront retrospective biases.** Efforts to address catchability and the spatial dynamics of the snow crab fishery are currently underway.

Bering Sea Snow Crab

2019 Snow Crab SAFE chapter:

Author recommendations (p. 21)

When considering overall fit, retrospective patterns and stability of the model under jittering, there is no clear winner among the presented scenarios. Model 19.3 (highest M) fit the data best, model 19.7 (high M + linear male growth) had the smallest retrospective patterns for males, and model 19.5 was the most stable under jittering. Among the models presented, the key choices are between natural mortality priors and functional forms of growth.

Natural mortality should be higher than assumed in the past, given empirical meta-analyses and survey data for mature individuals not selected by the fishery. However, given confounding with other parameters and the large impact on management advice, it may be wise to chose a more precautionary prior for M the assessment until other confounded processes are explored more fully.

The question of using a linear growth curve or kinked growth curve does not have a clear answer. It makes sense that maturing individuals would grow less. It has been noted in previous assessments that growth data from maturing individuals were thrown out because the increments were smaller than others. However, the current growth function does not capture this process because it is kinked at a specific size and the molt to maturity occurs over a range of sizes. The kinked growth curve has also been a sources of model instability to this point. A potentially more realistic growth model would be one that fits two growth curves: one for immature crab and one for maturing crab. However, this would require the growth increment data to be split between 'immature' and 'maturing' growth increments, which are not currently available.

Given these observations, the author preferred model is 19.7. Natural mortality should be higher than previously assumed and the instability of the kinked growth curve overshadows any perceived (though potentially misguided) realism introduced.

Summary of Model uncertainty

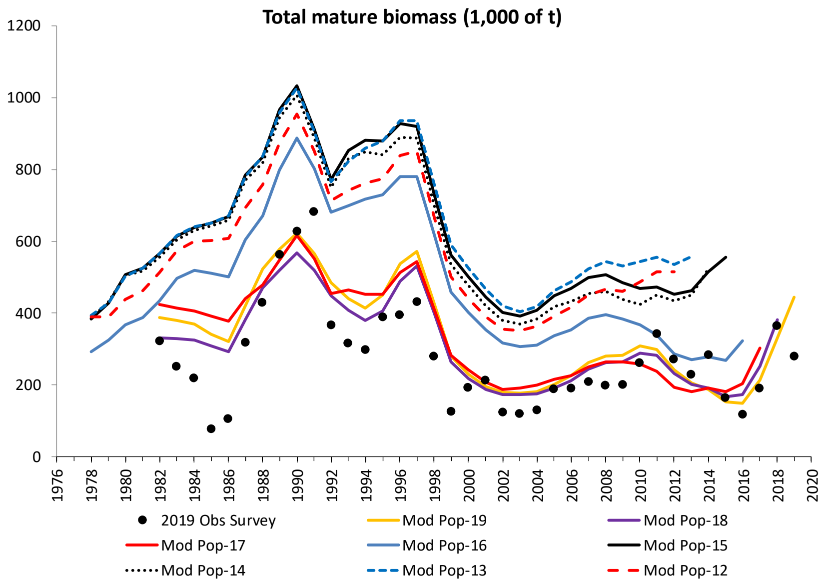
- Continuation of issues identified in prior years, including:
  - Retrospective patterns
  - Issues with population processes (e.g., natural mortality, growth)
  - large range of management quantities between model scenarios (see table below)

Changes in management quantities for each considered model (kt).

Model	MMB	B35	F35	FOFL	OFL
18.1	85.84	142.8	1.22	1.04	29.74
19.1	100.5	133.7	1.24	1.24	45.47
19.2	110.8	125.2	1.71	1.71	54.07
19.3	125.7	121.3	2.48	2.48	66.07
19.4	104.5	135.2	1.3	1.3	47.77
19.5	97.41	132.9	1.31	1.31	44.18
19.6	91.75	129.7	1.37	1.37	39.57
19.7	111.4	126.1	1.93	1.93	54.92

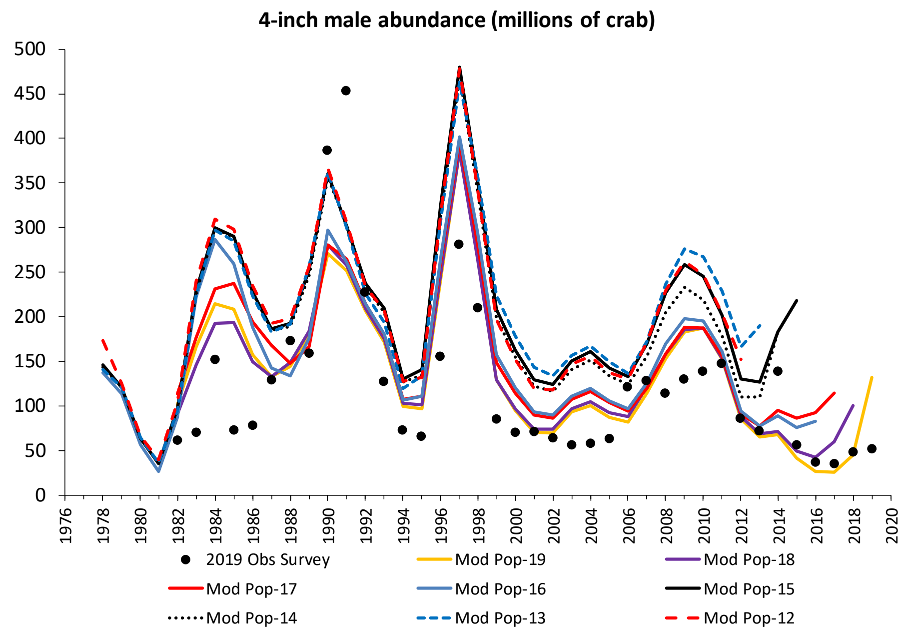
= 121 mill lb

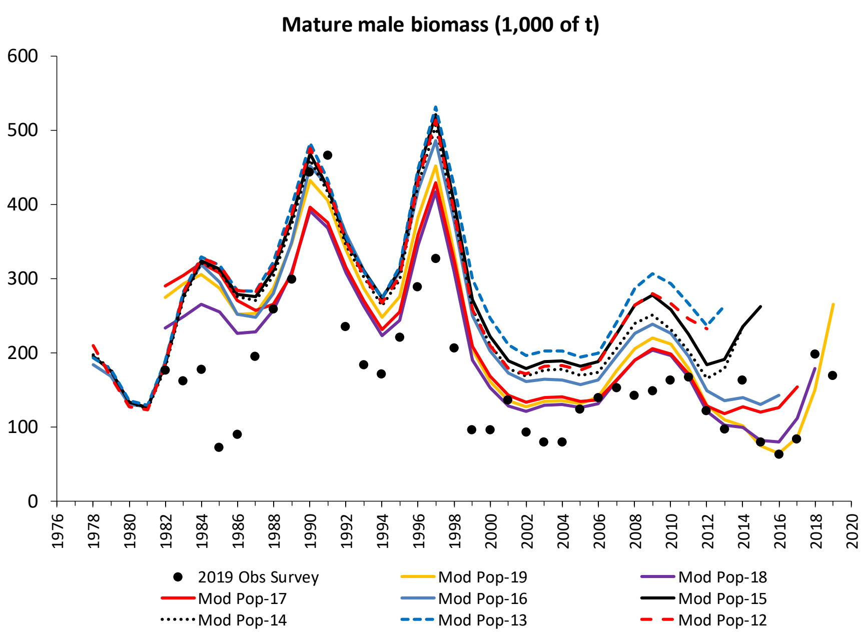
“Observed” (area-swept) vs model “population” estimates



TMB: 2012 − 2019 Models

(2019 model = “19.7”)

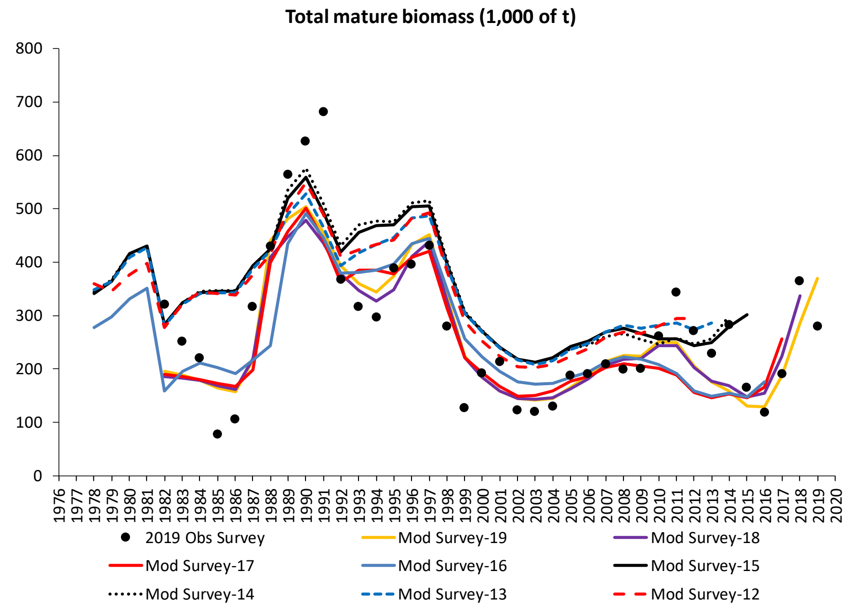


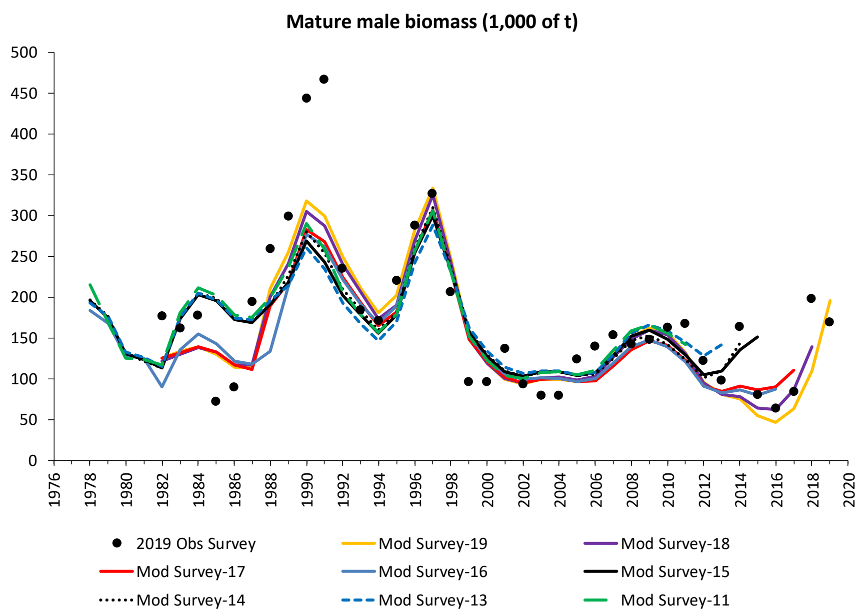


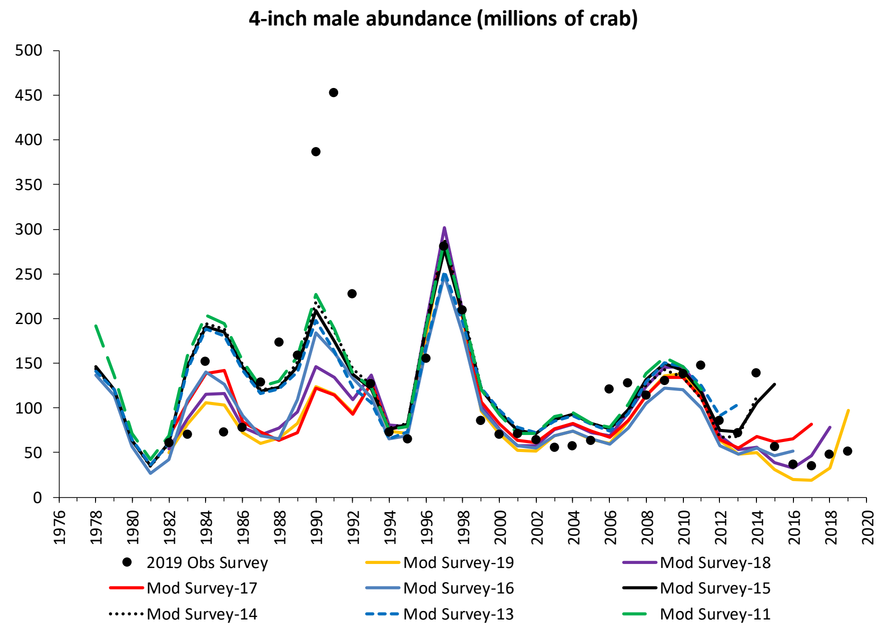
- Shape has changed over time, magnitude of estimates have changed over time
- Lots of uncertainty

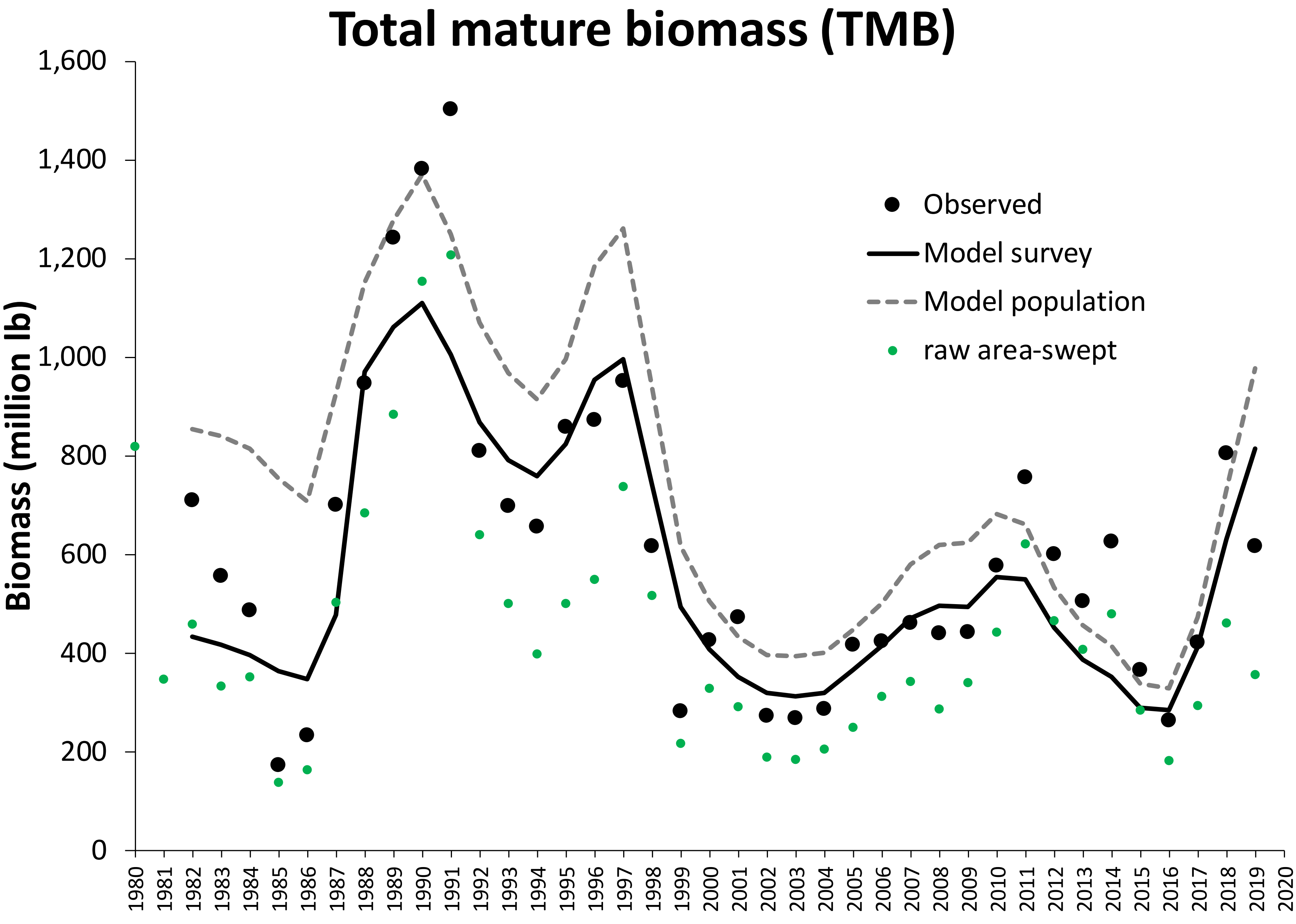
“Observed” (area-swept) vs model “survey” estimates

TMB: 2012 − 2019 Models
(2019 model = “19.7”)



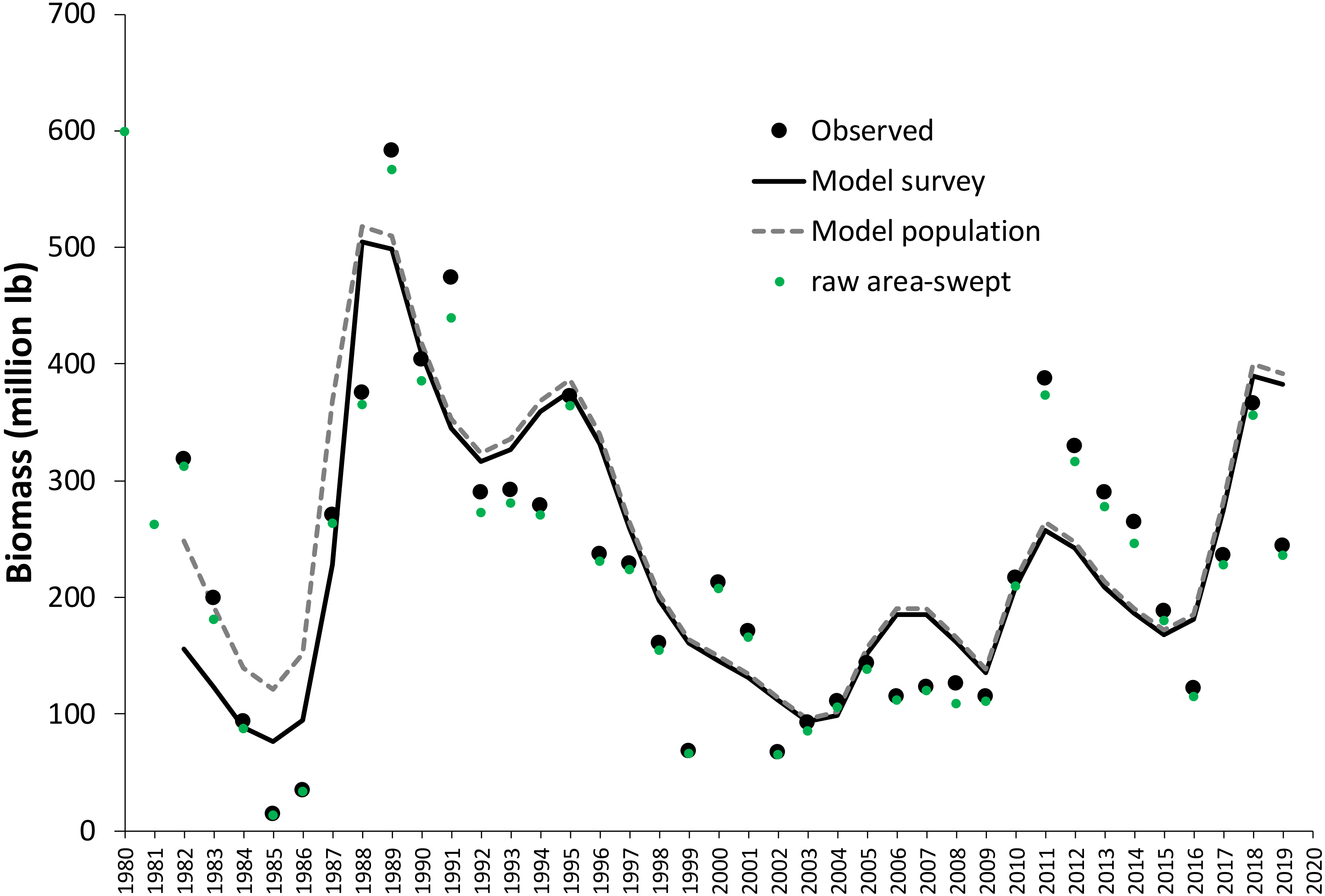




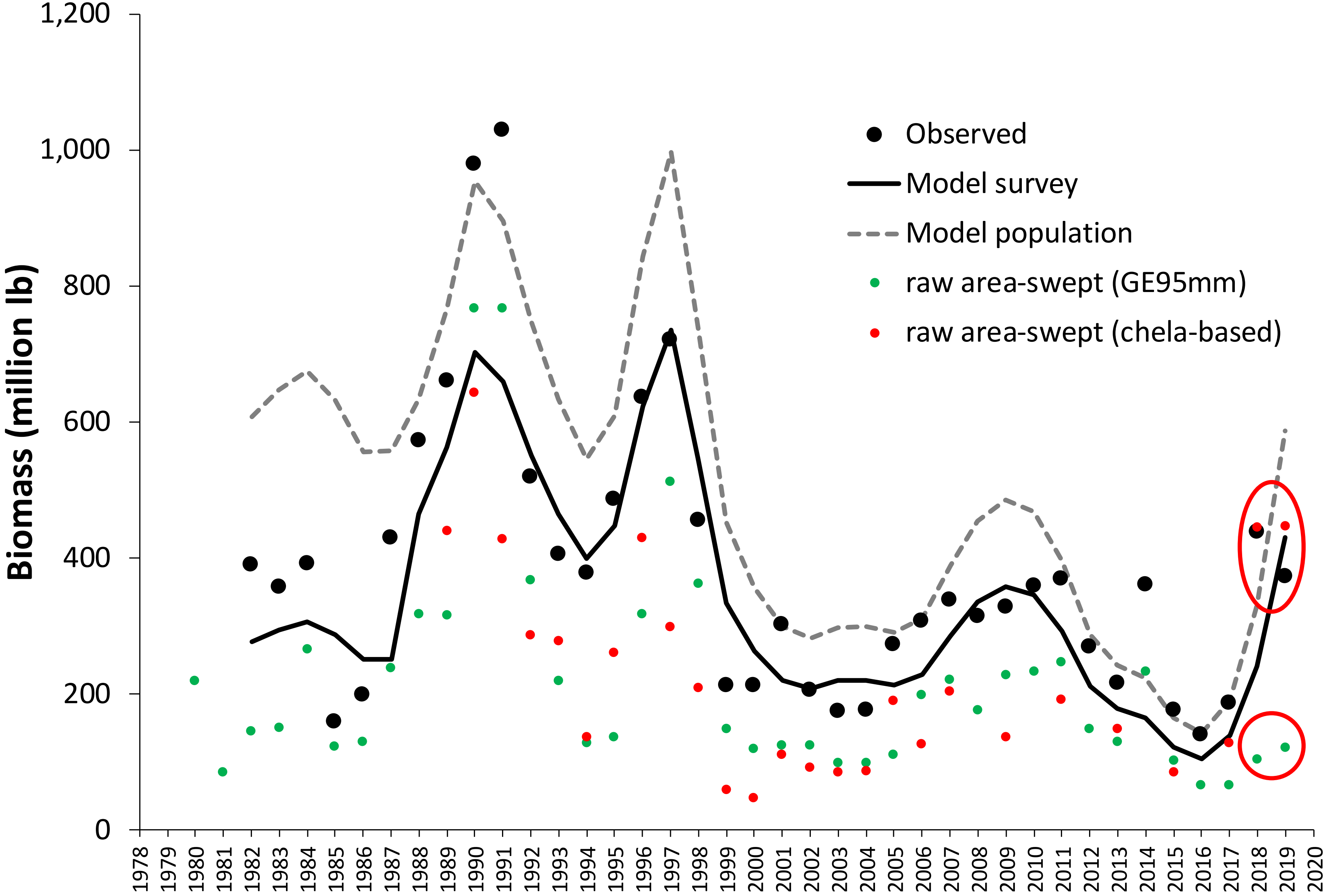


Total mature biomass (TMB)
Biomass (million lb)
1,600
1,400
1,200
1,000
800
600
400
200
0
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
Observed
Model survey
Model population
raw area-swept

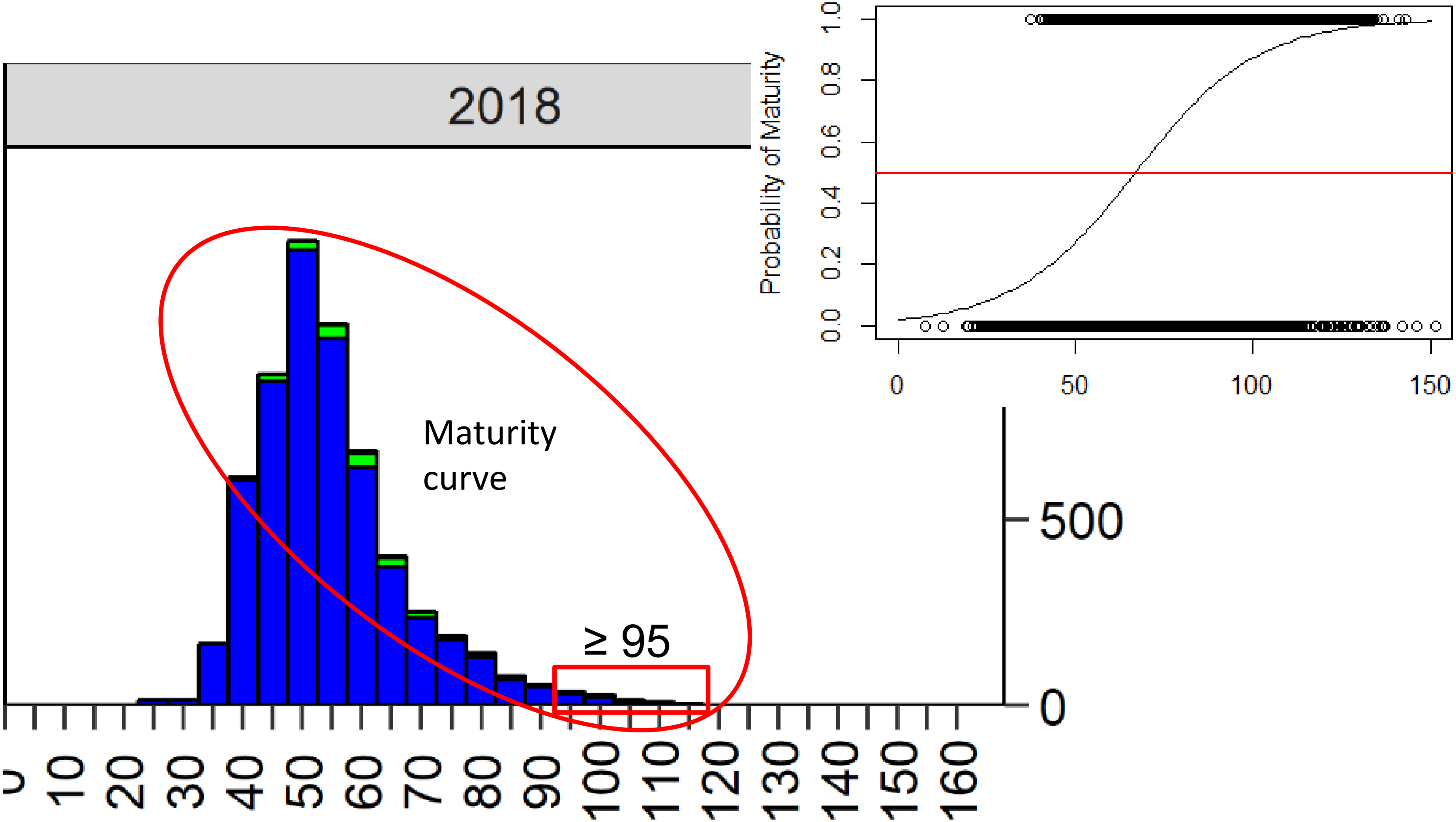
Mature female biomass



Mature male biomass

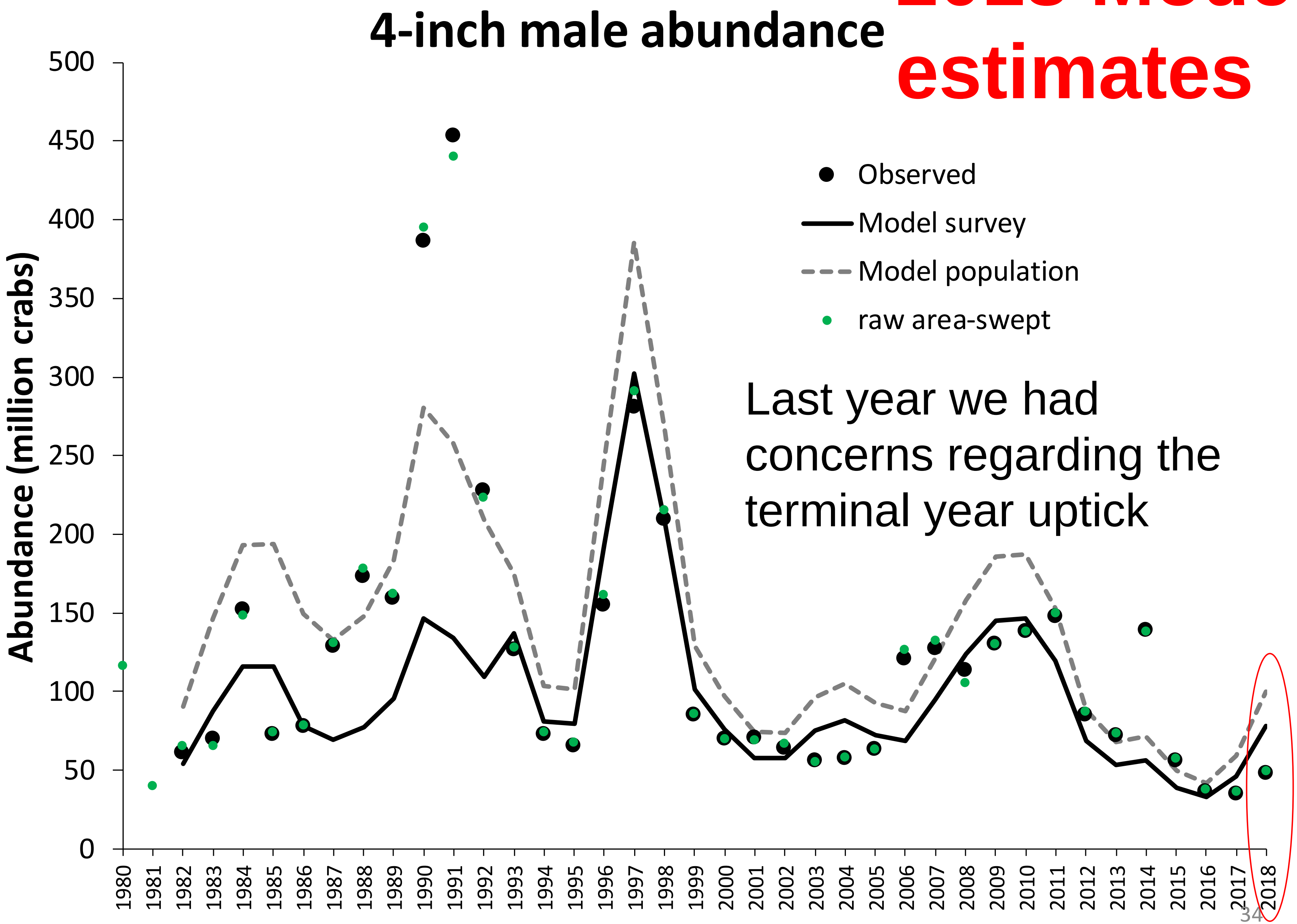


MMB is super sensitive to how male maturity is defined!



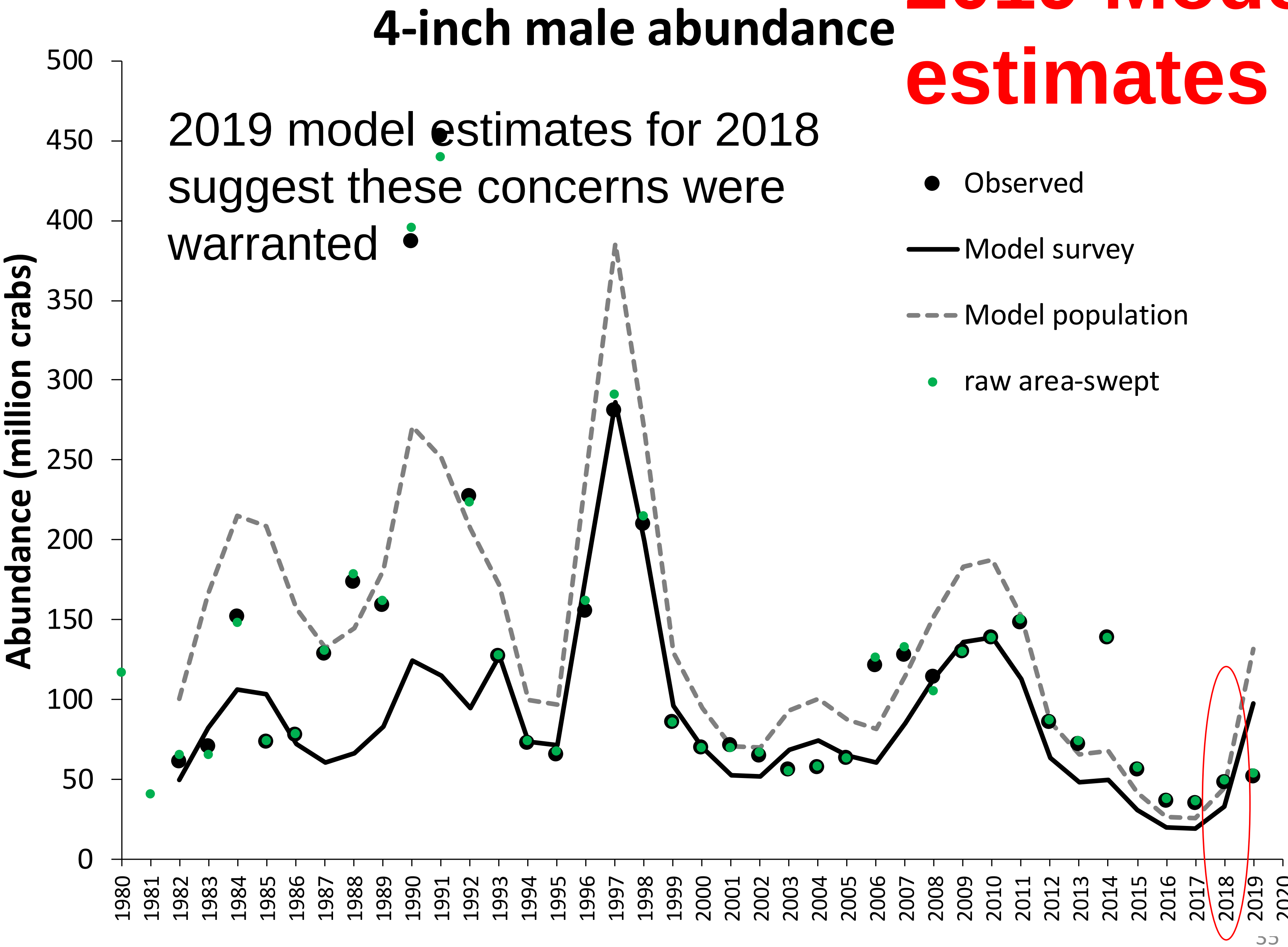
- **95 mm size cut-off likely underestimates mature male biomass**
- This is why a maturity curve (developed from chela morphology) is applied to area-swept estimates to estimate “model observed”
- MMB estimate sensitive to shape of curve

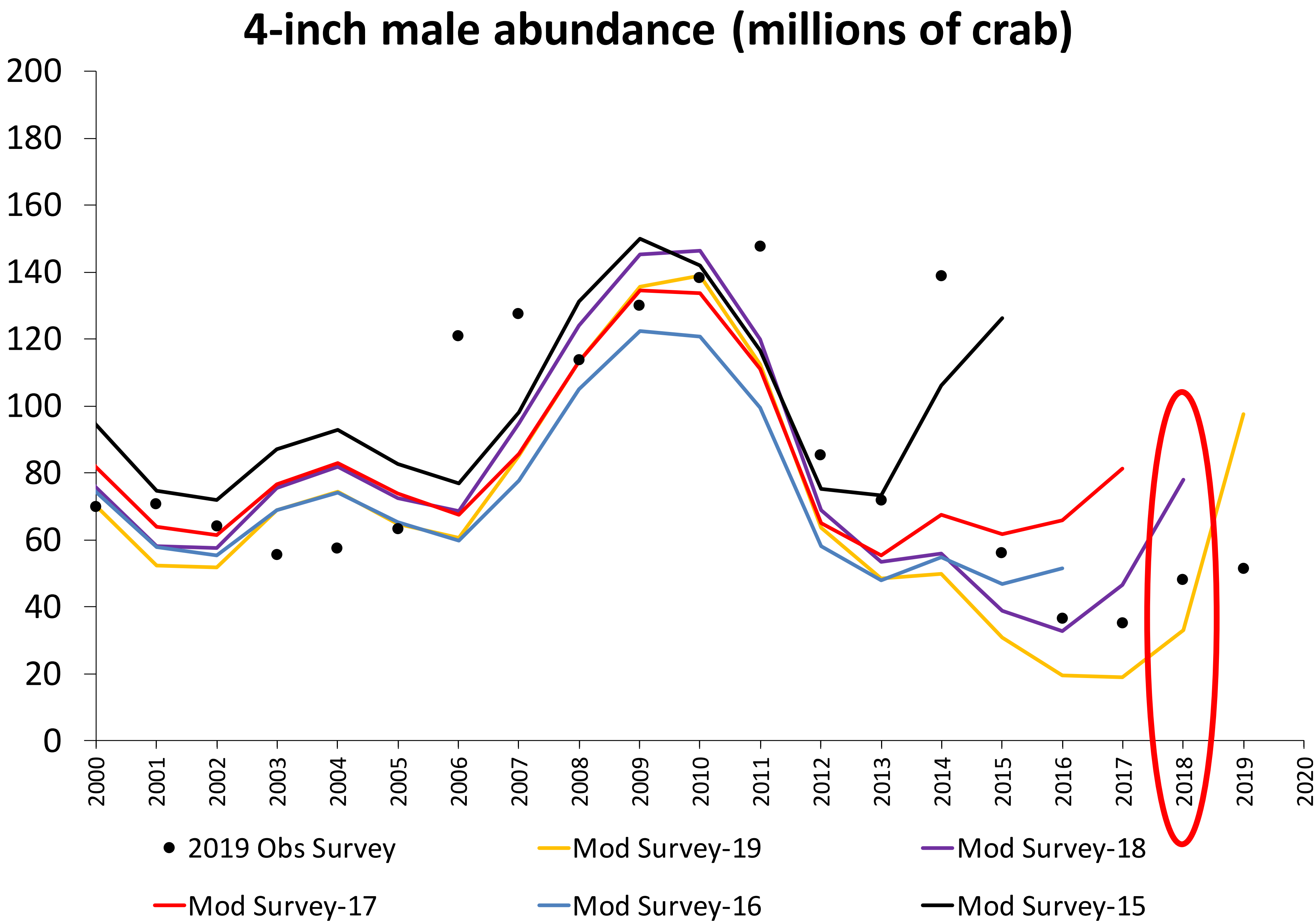
2018 Model estimates



Last year we had concerns regarding the terminal year uptick

2019 Model estimates





4-inch male abundance (millions of crab)
200
180
160
140
120
100
80
60
40
20
0
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2019 Obs Survey
Mod Survey-19
Mod Survey-18
Mod Survey-17
Mod Survey-16
Mod Survey-15

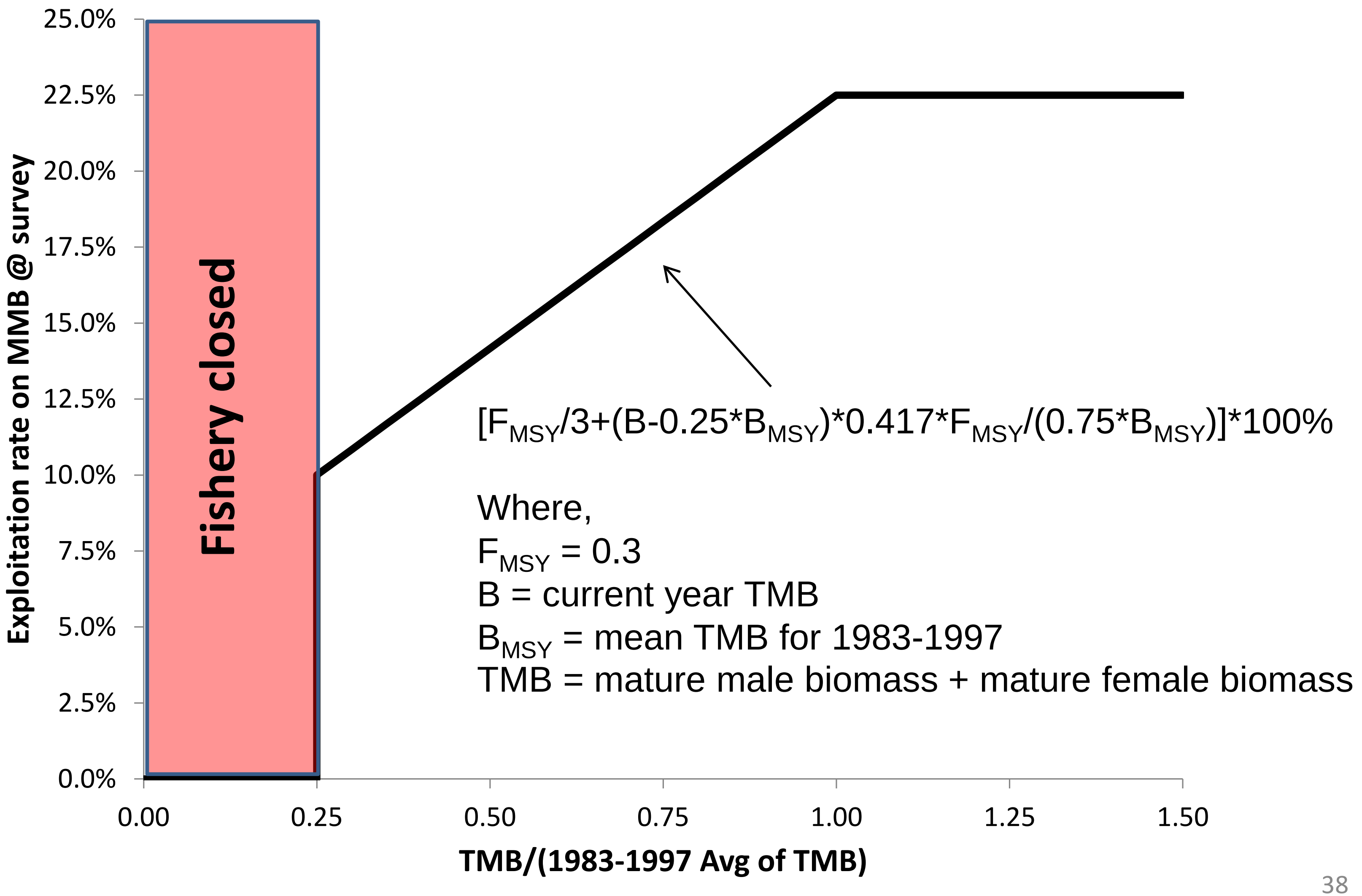
Harvest Strategy: developed in 2002

1. Threshold for opening fishery: 25% B_{MSY}
2. Exploitation on MMB:
   - $B<25\%\ B_{MSY,}$ = 0%
   - $0.25*B_{MSY} \le B < B_{MSY}$, exploitation increases linearly from 1/3 F_{MSY} to $0.75*F_{MSY}$, by equation: $[F_{MSY}/3+(B-0.25*B_{MSY})*0.417*F_{MSY}/(0.75*B_{MSY})]*100\%$.
   - $B>B_{MSY,}$ = 75% of F_{MSY} = 0.75*0.3 = 22.5%
3. Max Cap: 58% harvest rate on exploitable legal males (4-inch males: 100% new shell + 25% (or other) old shell)

Jheng, J., Siddeek, S., Pengilly, D., Woodby, D. 2002. Overview of recommended harvest strategy for snow crabs in the eastern Bering Sea. RIRNo.5J02-03

Bering Sea Snow Crab: State harvest strategy (5 AAC 35.517):

Exploitation rate on mature male biomass (MMB) as function of total mature biomass (TMB) (B_{MSY} and F_{MSY} as defined in FMP Amendment 7)

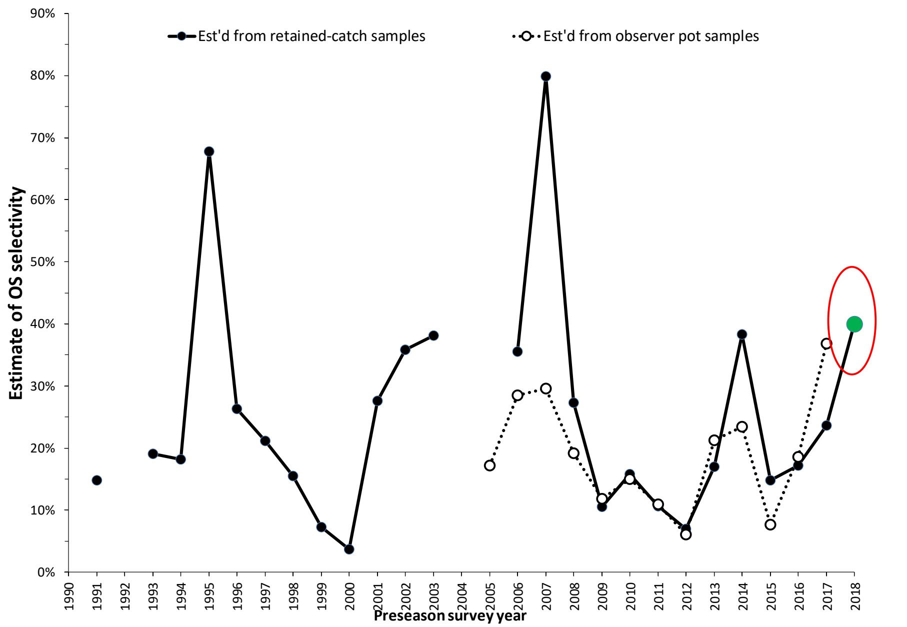


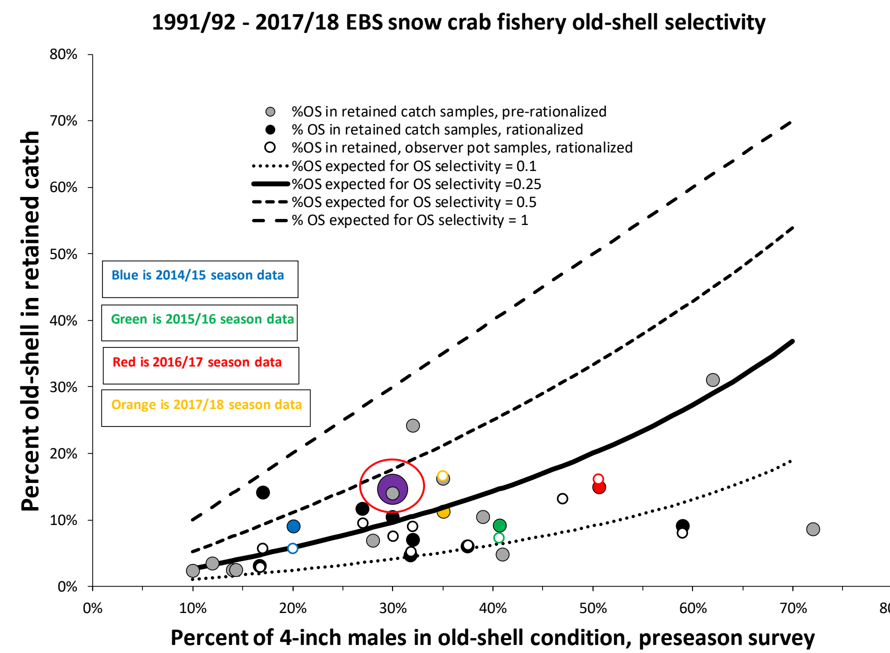
State harvest strategy (5 AAC 35.517)

(5) “exploited legal males” means 100 percent of the new-shell male *C. opilio* Tanner crab that are at least 102 millimeters (four inches) in width of shell, plus a percentage of old-shell male *C. opilio* Tanner crab that are at least 102 millimeters in width of shell estimated at the time of survey; the percentage of old-shell male *C. opilio* Tanner crab will be based on the **expected fishery selectivity** for old-shell versus new-shell male *C. opilio* Tanner crab

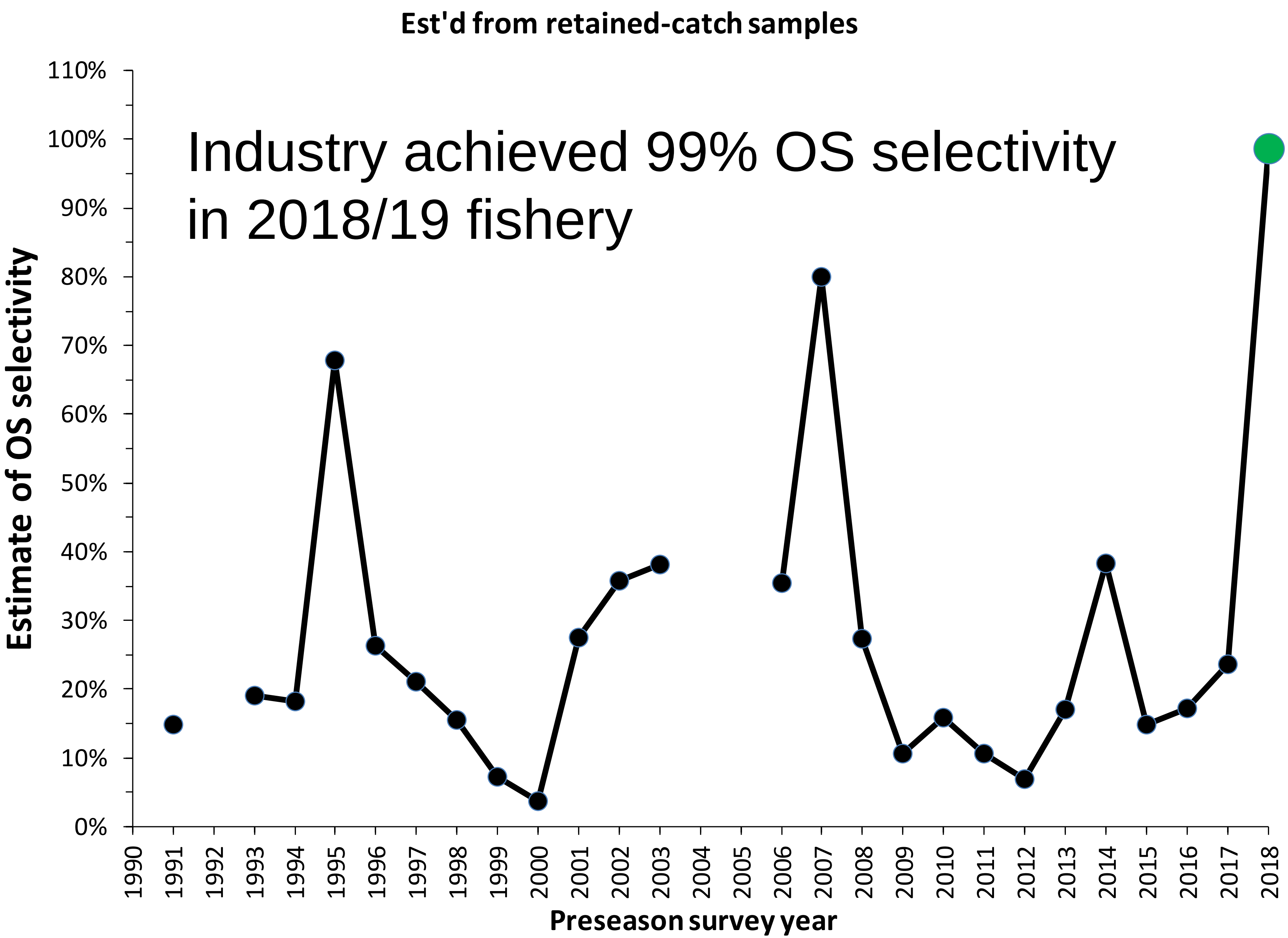
In the past, have used 0.25 as estimate of fishery selectivity for old shell males relative to new shell males

- Prior to 2018 we used 25% oldshell selectivity as it approximated the long-term average
- At the time (2018), we felt 40% selectivity was not unreasonable

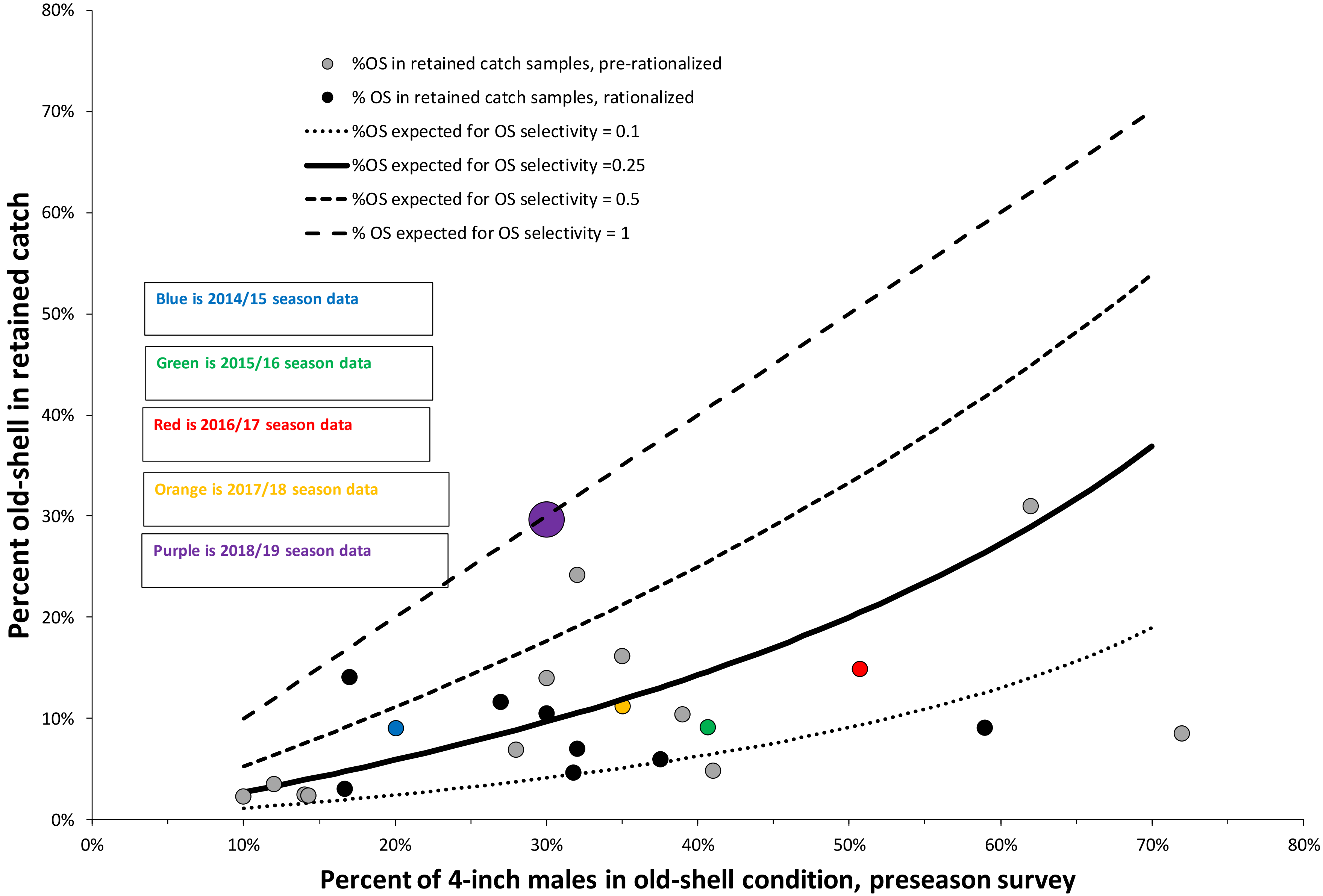


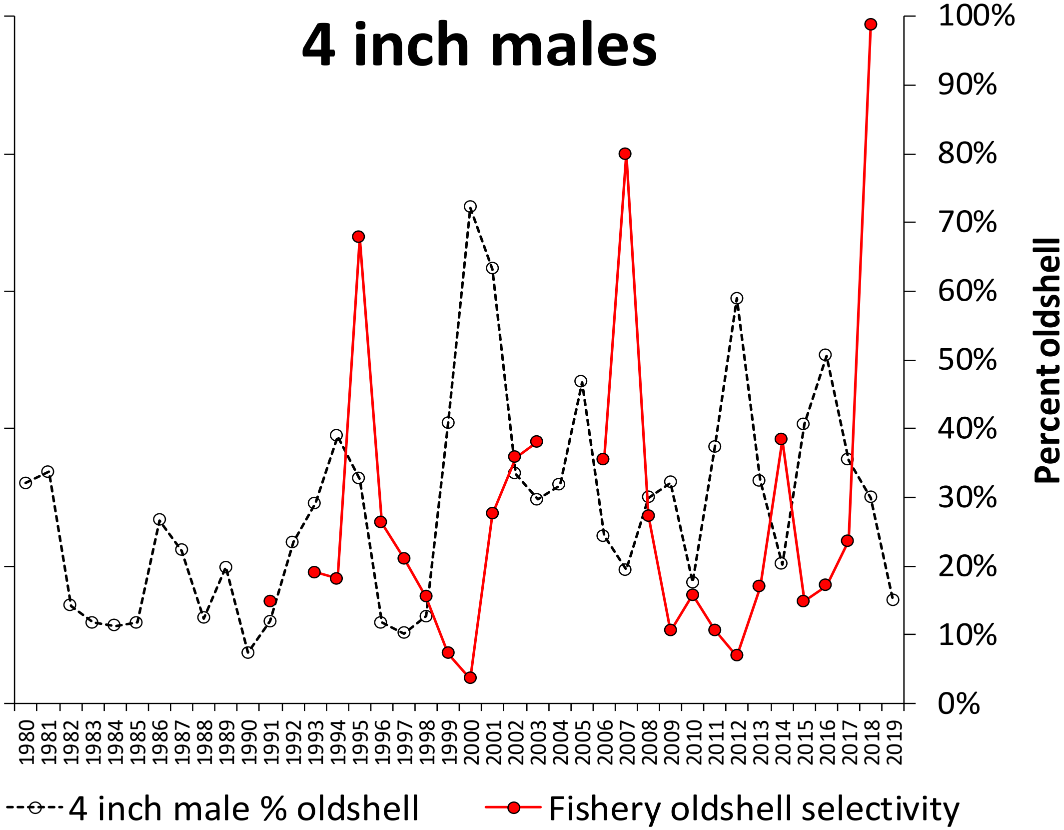


Industry achieved 99% OS selectivity in 2018/19 fishery



1991/92 - 2018/19 EBS snow crab fishery old-shell selectivity





Peaks offset: High oldshell selectivity when %OS in population is low

May suggest more sorting occurs when more OS in population

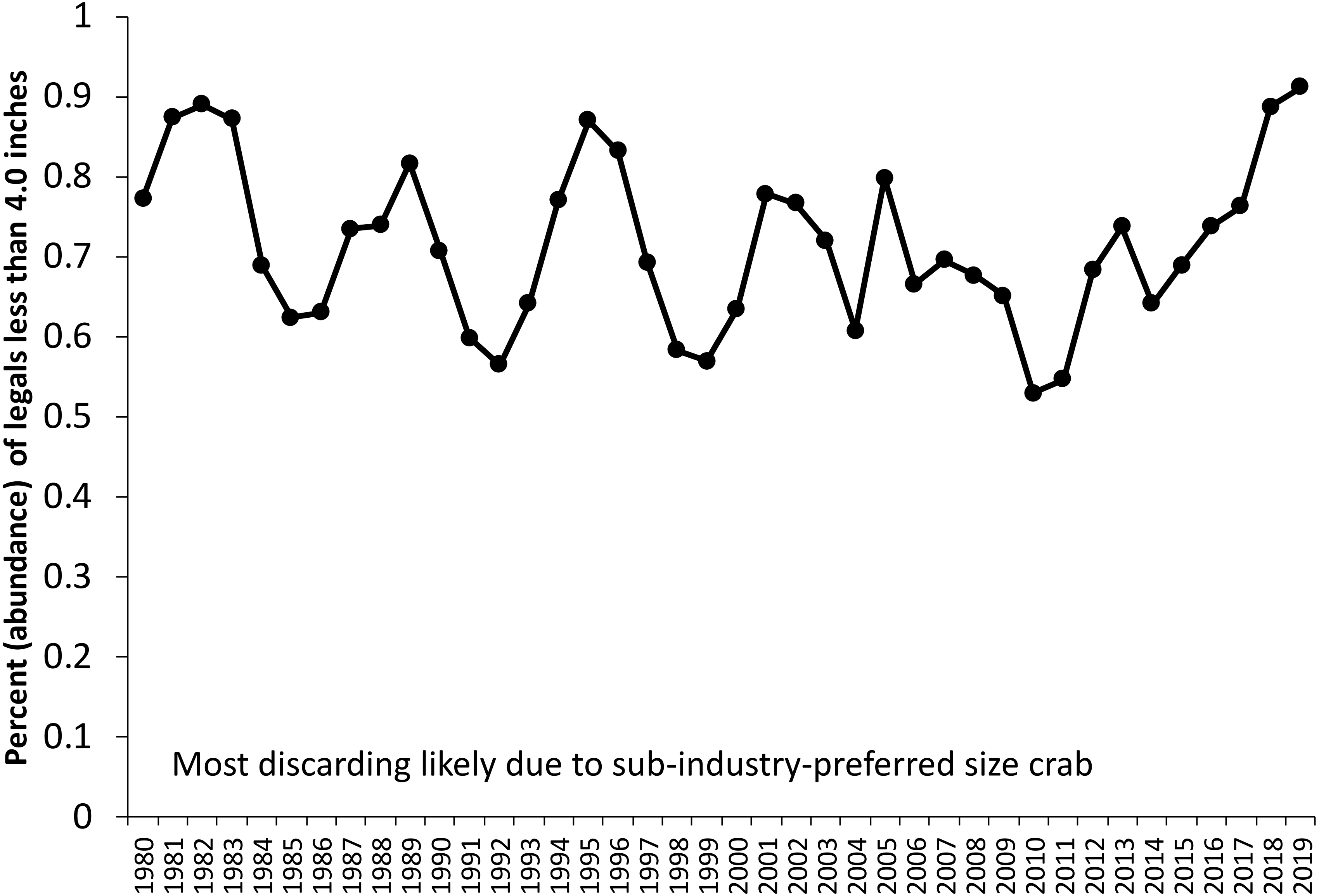
Less sorting when %OS is lower

- 2019: drop in % oldshell in the population from 30% to 15%
- Expect continued high oldshell selectivity: assumed 75% OS selectivity for 2019/20 TAC computations

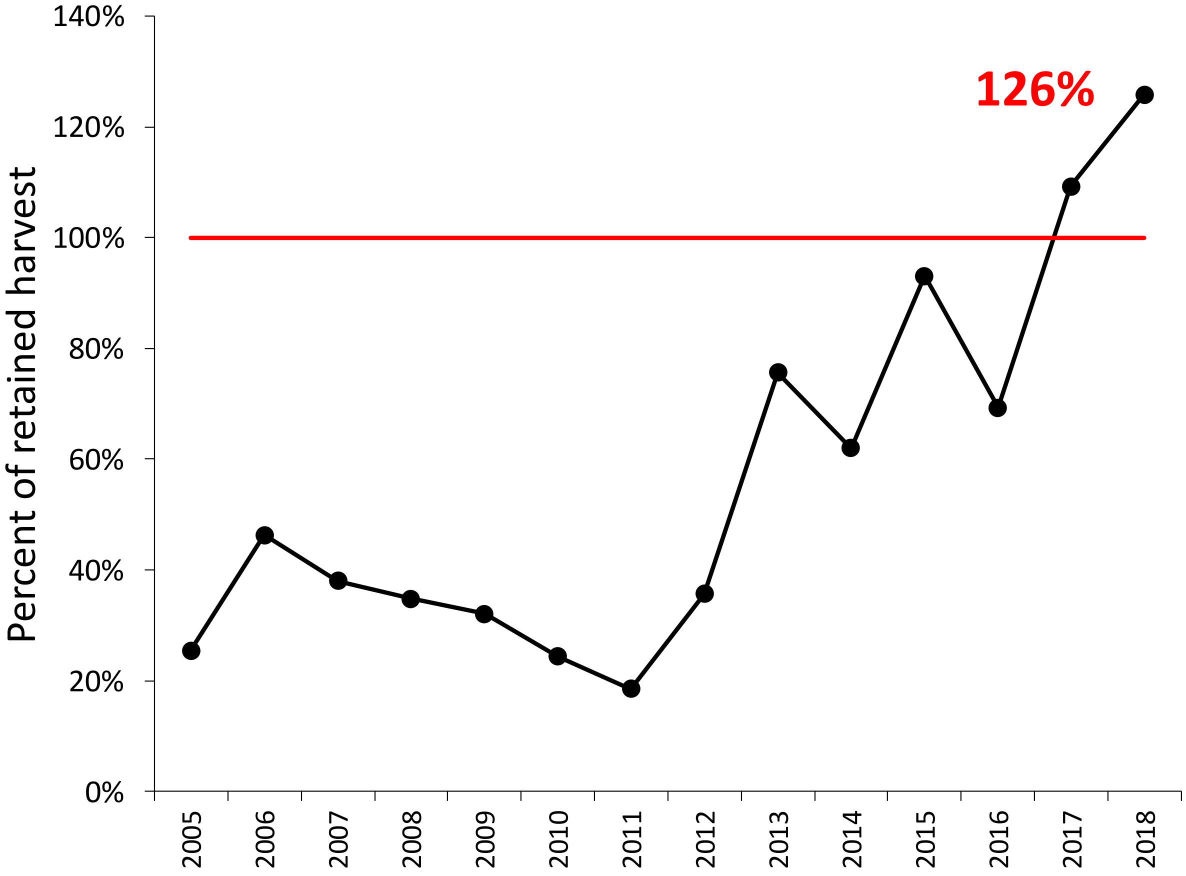
Looking ahead:

- Use quantiles to capture coarse-level predictions for OS selectivity based on previous fishery and current year survey data (%OS in population)

Sub-industry-preferred legal males (3.1 to 4.0 inches)



Male discard rates



Implies that for every crab retained, 1.26 crab are tossed overboard

Based on numbers of crabs

Handling mortality rate not applied

Finally:

5 AAC 35.517 (c) "In implementing this harvest strategy, the board directs the department to use the best scientific information available and to consider the ***reliability of estimates*** of *C. opilio* Tanner crab, the manageability of the fishery, and any other factors the department determines necessary to be consistent with the **sustained yield principles**"

In 2019, we computed TAC using **four** sets of estimates of TMB, MMB, and number of 4-in CW males

1. **"Area Swept" estimates**………..raw area-swept, defining male maturity at ≥ 95 CW and female maturity as morphometric (abdomen shape)

2. **"Model observed" estimates**………..model estimates of area-swept, defining male and female maturity within the model using maturity ogives informed by morphometric data using historic chela height data and female abdomen shape

3. **"Model survey" estimates**………….the fitted line that interprets what the model observed estimates "should have been", attempting to correct for survey sampling error

4. **"Model population" estimates**………the fitted line that applies a survey selectivity curve by sex and size, attempting to correct for trawl efficiency (Q) …….estimates of the underlying population….. "the population estimate if all crabs in the line of the survey trawl net were caught"
    - Q = proportion of animals in trawl path captured
    - Q <1 in 2010−2019 stock assessment models

Assumes 75% OS selectivity

Computed 2019/20 TACs: area-swept and Model "sep devs" estimates. Assumed old-shell fishery selectivity = 0.75 relative to new-shell.

	Raw area-swept (MM GE95)		Survey Observed (Model Maturity Status)		Survey (Model Predicted)		Population (Model Estimated)	
	TMB	MMB	TMB	MMB	TMB	MMB	TMB	MMB
1983-1997 Average (millions lb)	**581.5**	316.6	**803.8**	527.8	**755.7**	466.3	**1,032.2**	712.6
2019 Estimate (millions lb)	**355.7**	**120.3**	**616.2**	**372.8**	**813.3**	**430.6**	**978.2**	**586.4**
(2019 Est)/(1983-1997 Avg)	**61%**	38%	**77%**	71%	**108%**	92%	**95%**	82%
F_{MSY} =		**0.3**		**0.3**		**0.3**		**0.3**
Exploitation Rate on MMB		**0.160**		**0.186**		**0.225**		**0.216**
Computed TAC = Exp Rate X MMB (millions lb)		19.28		69.40		96.88		126.89
Max TAC (58% cap on exploited legal males (million lb)		35.63		34.02		64.73		87.32
TAC		**19.283**		**34.019**		**64.727**		**87.32**
TAC: Millions of 4-inch legals at 1.19 lb avg wt		16.22		28.62		54.46		73.46
TAC: % of RAW area-swept estimate of 4-inch legals at time of survey		30%		53%		101%		137%
TAC: % of model area-swept estimate of 4-inch legals at time of survey		32%		56%		106%		143%
TAC: % of model survey estimate of 4-inch legals at time of survey		17%		29%		56%		75%
TAC: % of model population estimate of 4-inch legals at time of survey		12%		22%		41%		56%
TAC: % of RAW area-swept estimate of "ELM" at time of survey		31%		55%		105%		142%
TAC: % of model area-swept estimate of "ELM" at time of survey		33%		58%		110%		149%
TAC: % of model survey estimate of "ELM" at time of survey		17%		30%		58%		78%
TAC: % of model population estimate of "ELM" at time of survey		13%		23%		43%		58%

	Area-swept (Raw NOAA values)	Survey Observed (Area-swept Est.)	Survey (Model Predicted)	Population (Model Estimated)
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% old shell (from area-swept)	15%	15%	15%	15%
Expected old shell selectivity	0.75	0.75	0.75	0.75
Exploited legal males ("ELM"; millions)	51.7	49.3	93.9	126.7
Max TAC (= 0.58xELMxW; millions lb)	**35.63**	**34.02**	**64.73**	**87.32**

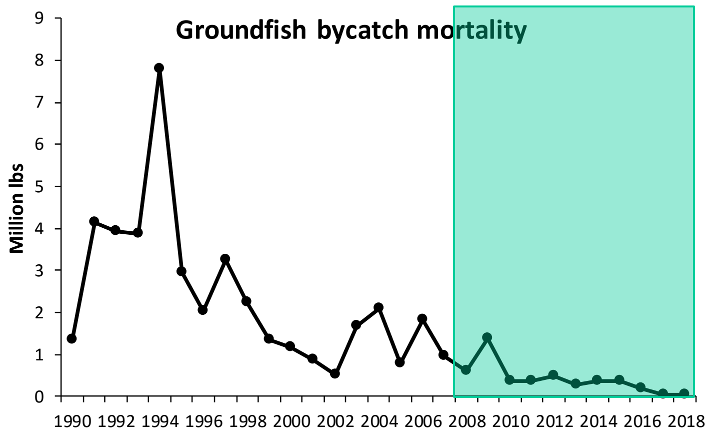
Bering Sea Snow Crab

Computed TACs relative to ABC = 96.8 mill lb

From 2019 snow crab SAFE chapter:

Table 8: Observed retained catches, discarded catch, and bycatch. Discards and bycatch have assumed mortalities applied.

Survey year	Retained catch (kt)	Discarded females (kt)	Discarded males (kt)	Trawl bycatch (kt)
1982	11.85	0.02	1.27	0.37
1983	12.16	0.01	1.24	0.48
1984	29.94	0.01	2.76	0.51
1985	44.45	0.01	4.01	0.44
1986	46.22	0.02	4.25	1.88
1987	61.4	0.03	5.52	0.01
1988	67.79	0.04	5.82	0.67
1989	73.4	0.05	6.68	0.78
1990	149.1	0.05	15.21	0.6
1991	143	0.06	12	1.88
1992	104.7	0.12	17.06	1.78
1993	67.94	0.08	5.32	1.76
1994	34.13	0.06	4.03	3.54
1995	29.81	0.02	5.75	1.34
1996	54.22	0.07	7.44	0.92
1997	114.4	0.01	5.73	1.47
1998	88.09	0.01	4.67	1.01
1999	15.1	0	0.52	0.61
2000	11.46	0	0.62	0.53
2001	14.8	0	1.89	0.39
2002	12.84	0	1.47	0.23
2003	10.86	0	0.57	0.76
2004	11.29	0	0.51	0.95
2005	16.77	0	1.36	0.36
2006	16.49	0	1.78	0.83
2007	28.59	0.01	2.53	0.43
2008	26.56	0.01	2.06	0.27
2009	21.78	0.01	1.23	0.63
2010	24.61	0.01	0.62	0.17
2011	40.29	0.18	1.69	0.16
2012	30.05	0.03	2.32	0.22
2013	24.49	0.07	3.27	0.12
2014	30.82	0.17	3.52	0.16
2015	18.42	0.07	2.96	0.16
2016	9.67	0.02	1.31	0.08
2017	8.6	0.02	1.93	0.02
2018	12.51	0.02	2.86	0.02



2019/20 maximum TAC relative to avoiding ABC = 96.8 million lb total fishery mortality

Assumptions		Mortality (million lb)
Assume max mortality in groundfish fisheries, 08/09-18/19 =		1.39
Remaining for directed (incl. bycatch mort), mill lb (ABC-Subtotal) =	95.41	
Assume maximum (lb discard mort)/(lb retained) in directed fishery, **90/91-18/19** =	0.230	
Maximum TAC = (remaining for directed)/(1+0.230) =		**77.56**

To safely stay below ABC, 2019/20 TAC should not exceed 77.56 mill lb

Assumes 75% OS selectivity

Computed 2019/20 TACs: area-swept and Model "sep devs" estimates. Assumed old-shell fishery selectivity = 0.75 relative to new-shell.

	Raw area-swept (MM GE95)		Survey Observed (Model Maturity Status)		Survey (Model Predicted)		Population (Model Estimated)	
	TMB	MMB	TMB	MMB	TMB	MMB	TMB	MMB
1983-1997 Average (millions lb)	**581.5**	316.6	**803.8**	527.8	**755.7**	466.3	**1,032.2**	712.6
2019 Estimate (millions lb)	**355.7**	**120.3**	**616.2**	**372.8**	**813.3**	**430.6**	**978.2**	**586.4**
(2019 Est)/(1983-1997 Avg)	**61%**	38%	**77%**	71%	**108%**	92%	**95%**	82%
F_{MSY} =		**0.3**		**0.3**		**0.3**		**0.3**
Exploitation Rate on MMB		**0.160**		**0.186**		**0.225**		**0.216**
Computed TAC = Exp Rate X MMB (millions lb)		19.28		69.40		96.88		126.89
Max TAC (58% cap on exploited legal males (million lb)		35.63		34.02		64.73		87.32
TAC		**19.283**		**34.019**		**64.727**		**87.32**
TAC: Millions of 4-inch legals at 1.19 lb avg wt		16.22		28.62		54.46		73.46
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	Area-swept (Raw NOAA values)	Survey Observed (Area-swept Est.)	Survey (Model Predicted)	Population (Model Estimated)
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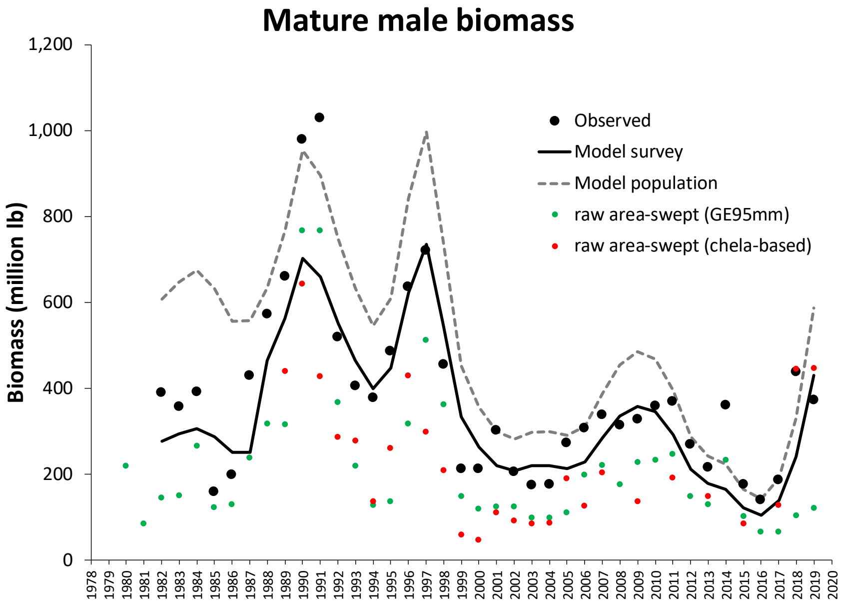
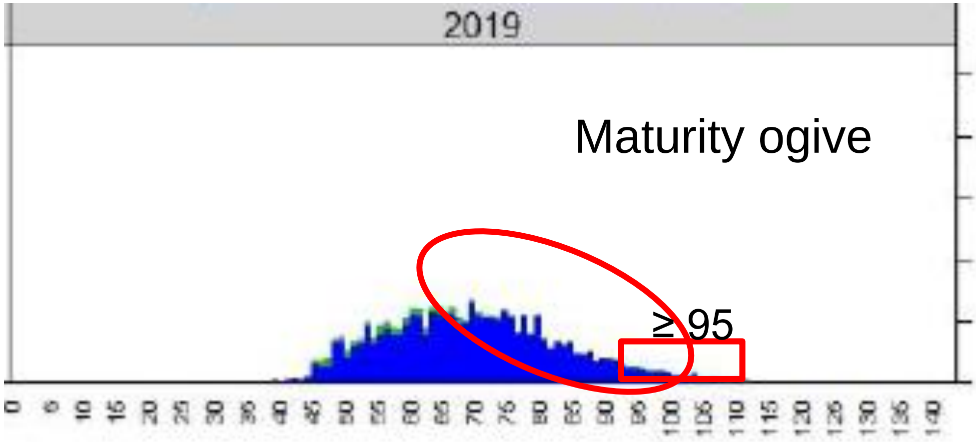
Max TAC (= 0.58xELMxW; millions lb)	**35.63**	**34.02**	**64.73**	**87.32**

Raw area-swept estimates using 95 mm size cut-off likely underestimates MMB





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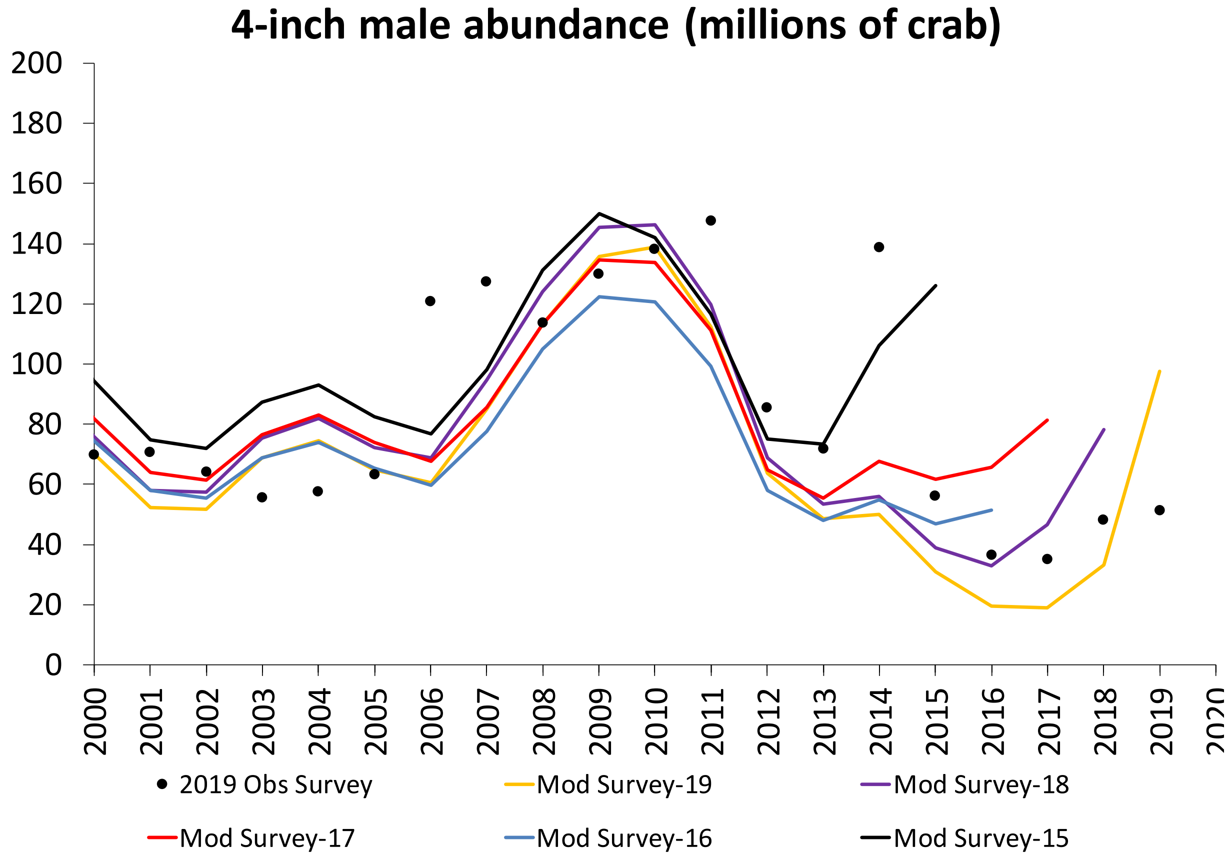
- In 2019, TAC computations are limited by abundance of exploitable legal males (i.e., 4-inch males)

- Model tends to overestimate 4-inch male abundance in terminal year



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Max TAC (= 0.58xELMxW; millions lb)	**35.63**	**34.02**	**64.73**	**87.32**

Yields an additional 2.65 mill lb (compared to 25% OS selectivity)

Bering Sea Snow Crab

Historical Summary of Estimates Used for Setting TAC

Through 2005/06: raw area-swept

- all that was available

2006/10 − 2009/10: model survey

- Approval of snow crab assessment model by CPT/SSC in fall 2006
- Survey-predicted estimates = population estimates; Q = 1

2010/11 − 2012/13 (TAC 54, 89, 66 mil lb): model population (with Q < 1)

2013/14 (TAC 54 mil lb): model survey

- Trend in model estimates versus area-swept & very low Q

2014/15 (TAC 68 mil lb): model observed

- Trend in estimates of year from subsequent models (retrospective pattern)

2015/16 (TAC 41 mil lb): mid-point between model survey and model observed

- High uncertainty with model estimates

2016/17 (TAC 22 mil lb): 10% buffer on model survey

- High uncertainty with model estimates

2017/18 (TAC 19 mil lb): model observed

- High uncertainty with model estimates
- Fishery performance (declining trend in CPUE, reports from fishery = low performance in historic areas)

2018/19 (TAC 27 mill lb): model observed

- Uncertainty with model estimates
- Confidence with estimates of MMB and 4 inch males

2018 TAC with 2019 model population estimates

2018 model population estimates:

- 2018 TMB = 840.4 million lb
- 1983-1997 average for TMB = 936.8 million lb
- 2018 MMB = 394.8 million lb
- 2018 number of males ≥ 4-in CW males = 99.9 million crab
- Computed 2018/19 TAC = 57.29 million lb
    - equivalent to 99% of the area-swept estimate of 4-in males at survey

2019 model population estimates:

- 2018 TMB = 730.6 million lb
- 1983-1997 average for TMB = 1032.2 million lb
- 2018 MMB = 330.5 million lb
- 2018 number of males ≥ 4-in CW males = 44.7 million crab
- Computed 2018/19 TAC = 25.62 million lb
    - equivalent to 41% of the area-swept estimate of 4-in males at survey

2018 TAC with 2019 model survey estimates

2018 model survey estimates:
- 2018 TMB = 744.5 million lb
- 1983-1997 average for TMB = 725.1.6million lb
- 2018 MMB = 307.3 million lb
- 2018 number of males $\geq$ 4-in CW males = 78.1 million crab
- Computed 2018/19 TAC = 44.802 million lb
  - equivalent to 99% of the area-swept estimate of 4-in males at survey

2019 model survey estimates:
- 2018 TMB = 629.9 million lb
- 1983-1997 average for TMB = 755.7million lb
- 2018 MMB = 240.5 million lb
- 2018 number of males $\geq$ 4-in CW males = 33.1 million crab
- Computed 2018/19 TAC = 18.99 million lb
  - equivalent to 31% of the area-swept estimate of 4-in males at survey

This year it boiled down to:

1. Our confidence in estimates of male maturity
   - consideration of area-swept vs model estimates
   - High MMB driving the use of the max cap harvest control rule when using model estimates

2. Overestimation in terminal year
   - 4 inch males

…same concerns as last year

TAC recommendation

Use model observed estimates:

TAC = 34.019 million lb

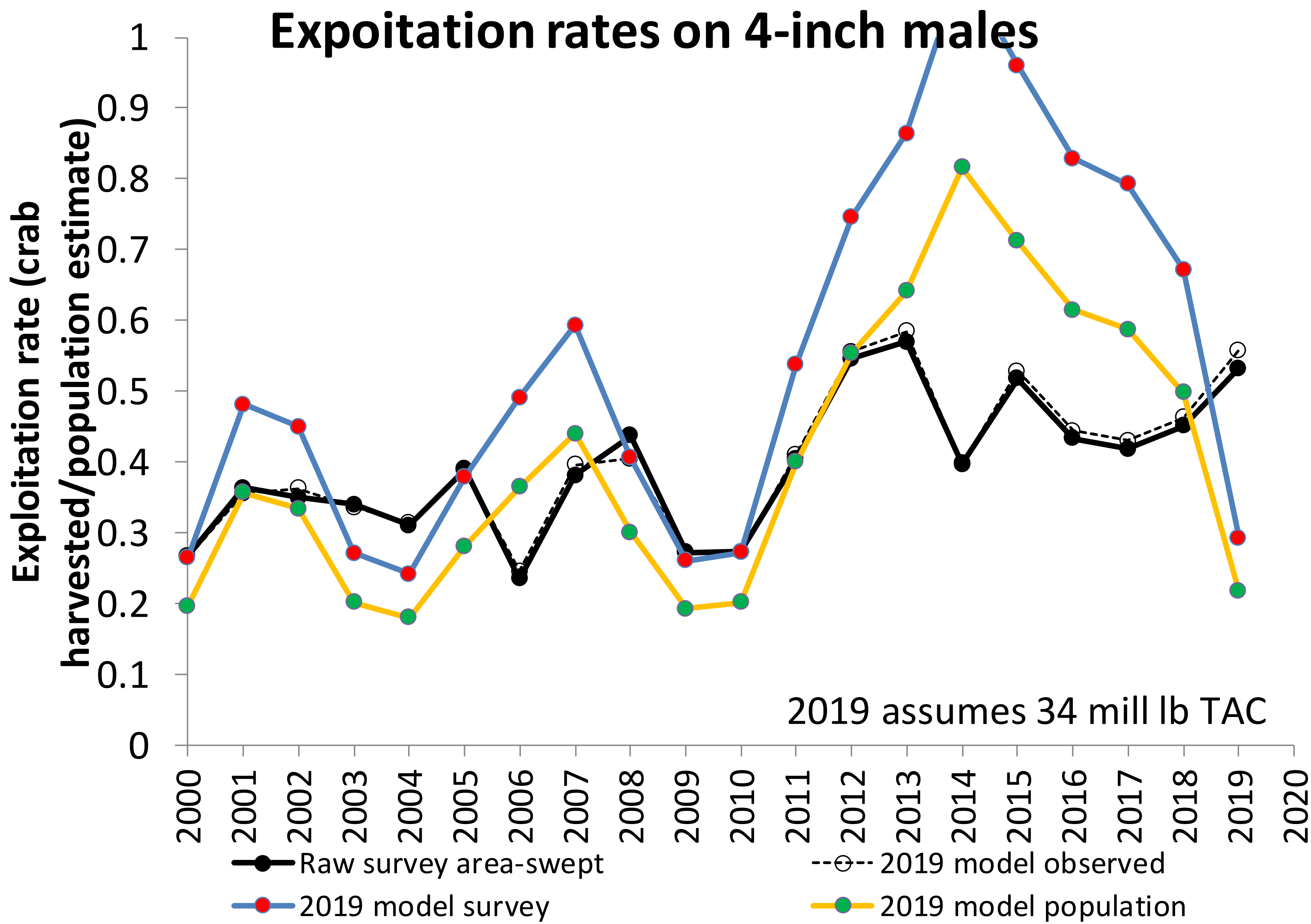
- Use of model observed estimate consistent with CPT feeling of model uncertainty.

  2019 CPT minutes:

  – *"The models continued to exhibit some degree of instability in model results, as evidenced by convergence to different local minima in the objective function when jittering was done."*

  – *"In addition, all the models exhibited generally similar retrospective patterns in MMB (with some better than others) as data from the most recent model year was "peeled away". Models tended to overestimate MMB in the terminal year because an initially-strong recruitment event in 2010 disappeared in subsequent surveys."*

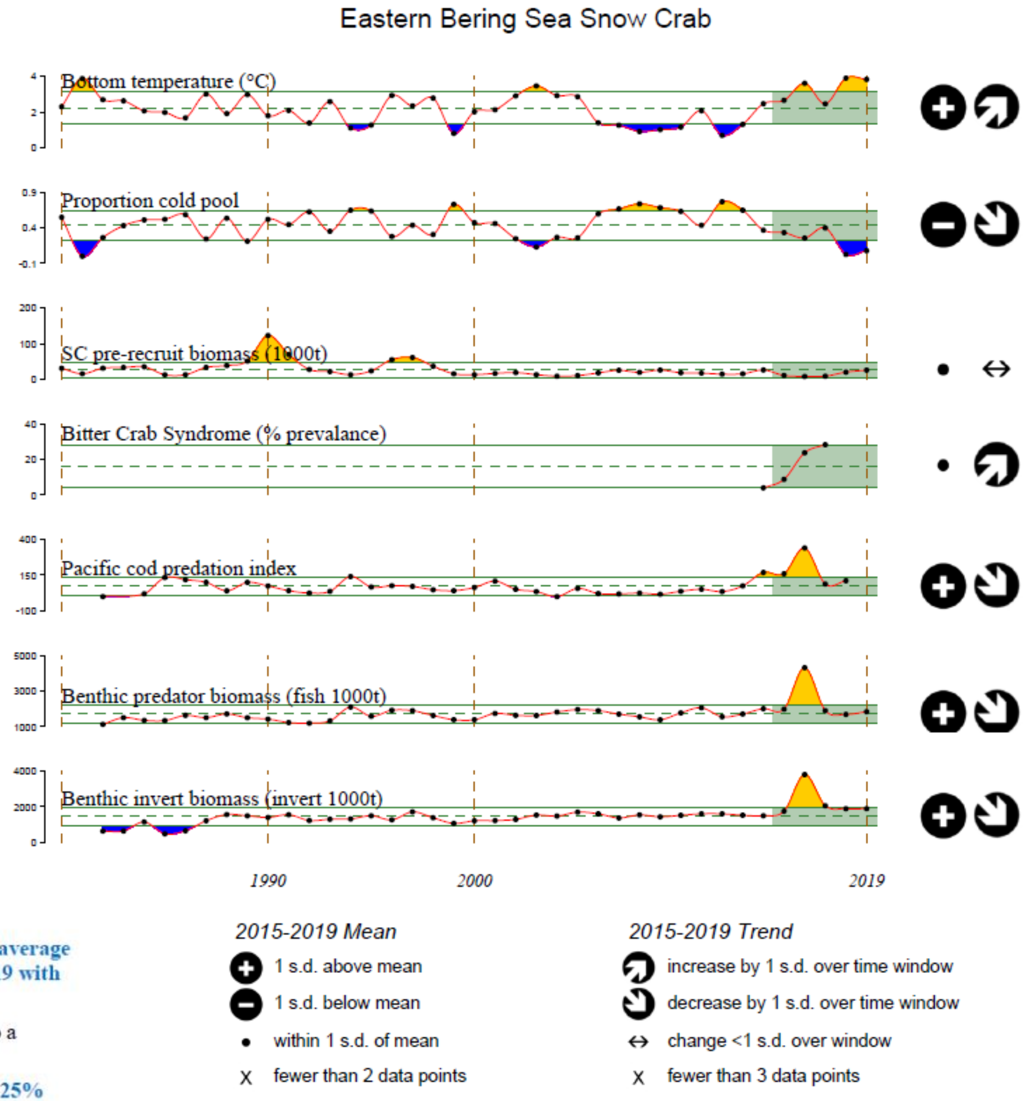
- Assumes 75% OS selectivity
  - results in an additional 2.65 mill lb relative to 25% OS selectivity



Expoitation rates on 4-inch males
Exploitation rate (crab harvested/population estimate)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2019 assumes 34 mill lb TAC
Raw survey area-swept
2019 model observed
2019 model survey
2019 model population

Ecosystem status report card

Erin Fedewa, May 2019 CPT

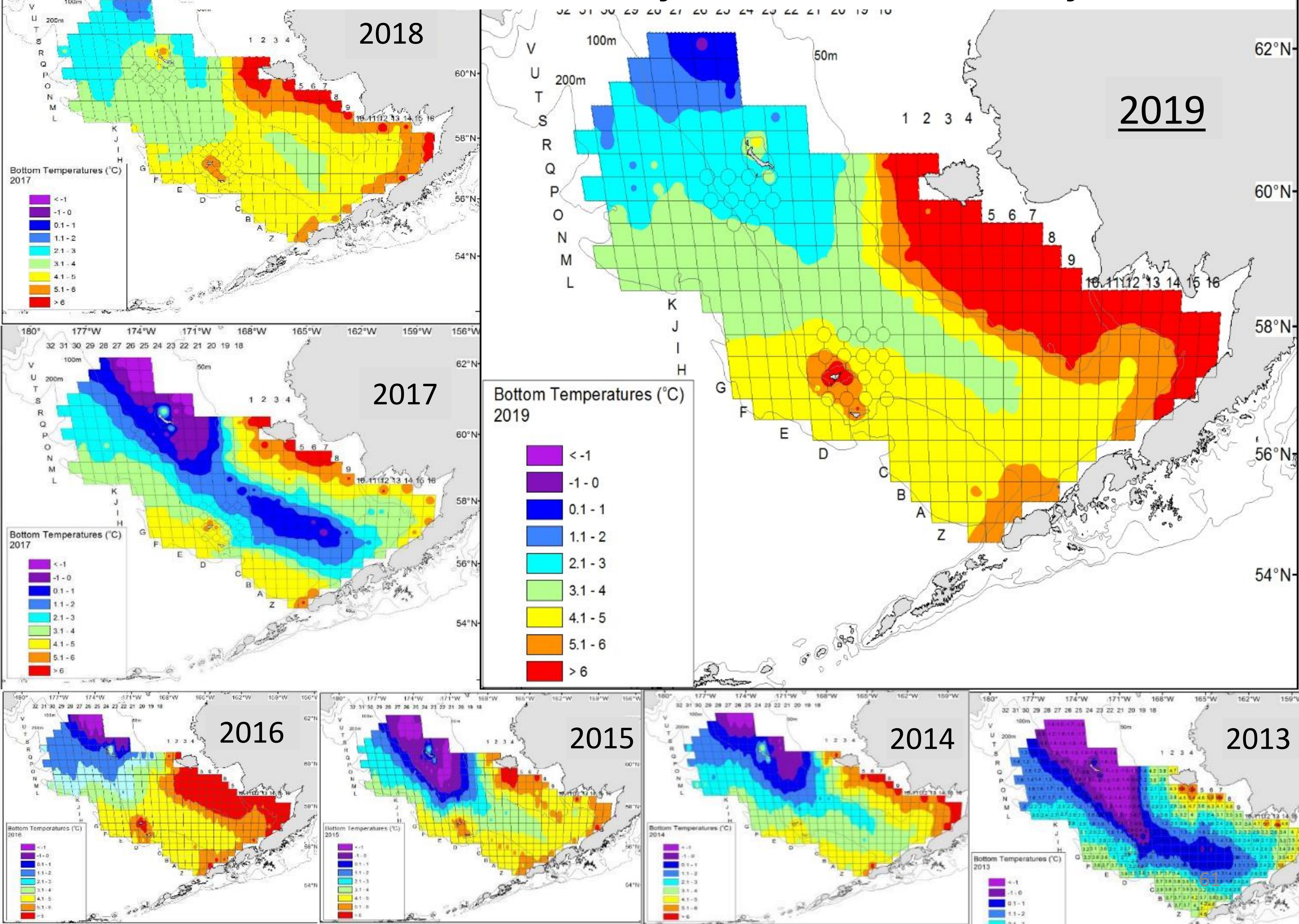


EBS Snow Crab Ecosystem Considerations

- Summer bottom temperatures in the snow crab management area were well above average in 2019, and the cold pool extent was the lowest on record in 2018, followed by 2019 with the second lowest value in the time series.
- Snow crab pre-recruit (males 95-101 mm CW) biomass has continued to increase to a near-average level in 2019, following a decline in 2015.
- Prevalence of bitter crab syndrome in juvenile snow crab has increased by nearly 25% since monitoring efforts began in 2014, with infection rates as high as 49% northeast of St Matthew Island.
- Pacific cod predation on snow crab has remained above the long-term average since 2012. Relatively high predation rates in the past five years reflect high catches of Pacific cod in the snow crab management area.
- Benthic invert biomass has remained above average in recent years, attributed to high catches of sea stars in the snow crab management area.

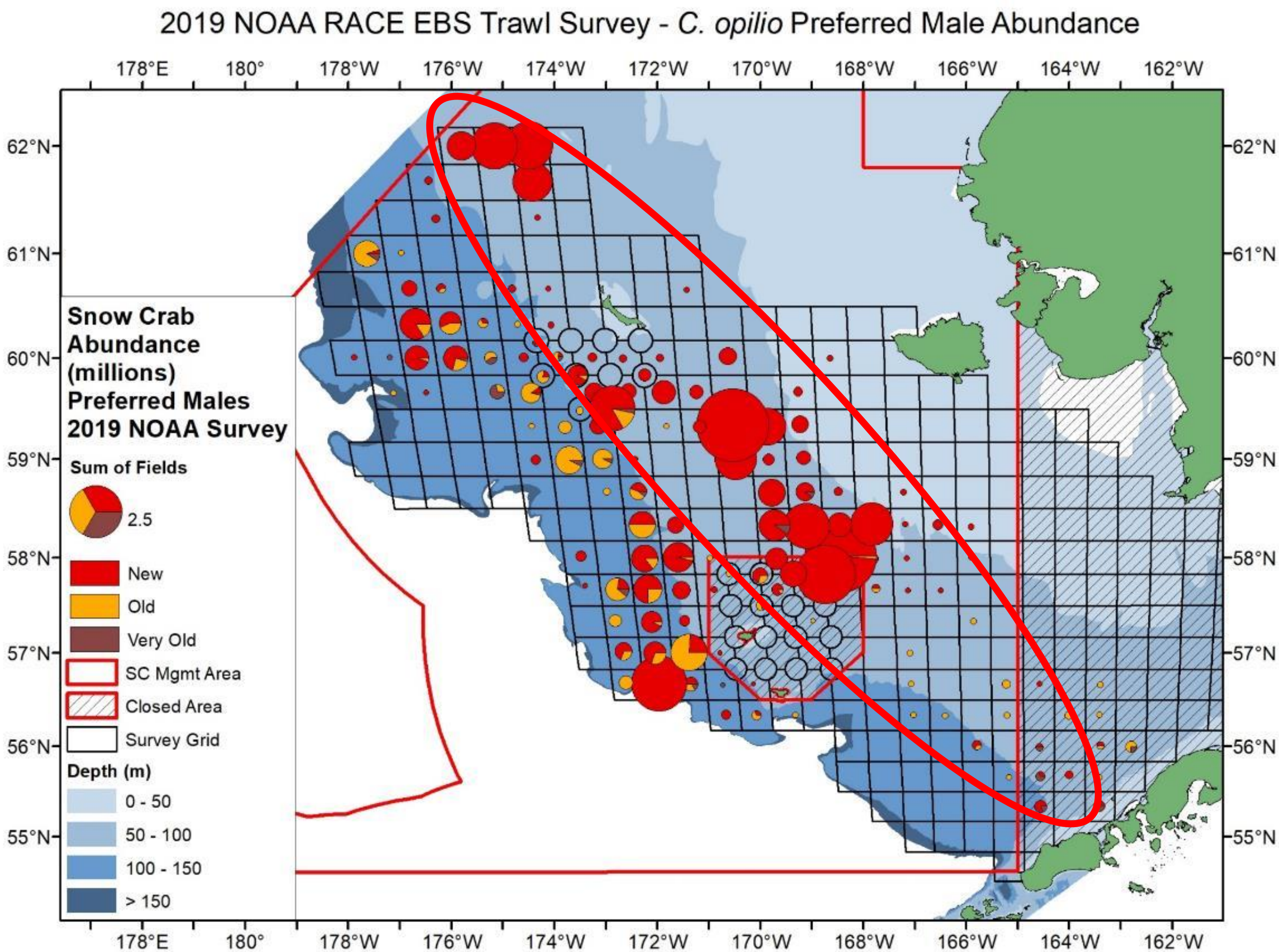
Environmental change and associated potential stressors

From 2019 NOAA Survey Presentation to CPT by Jon Richar

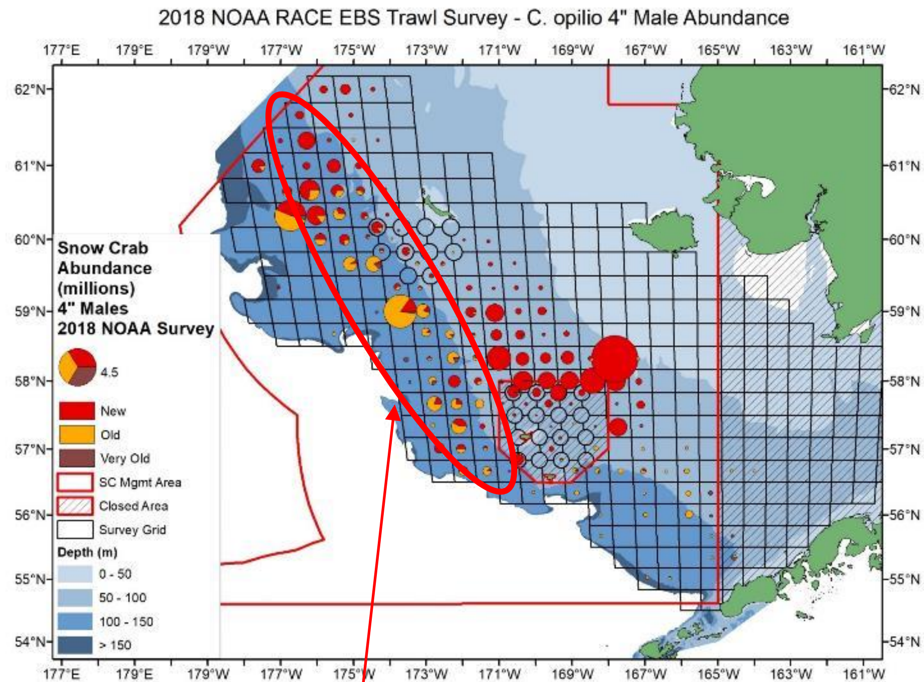


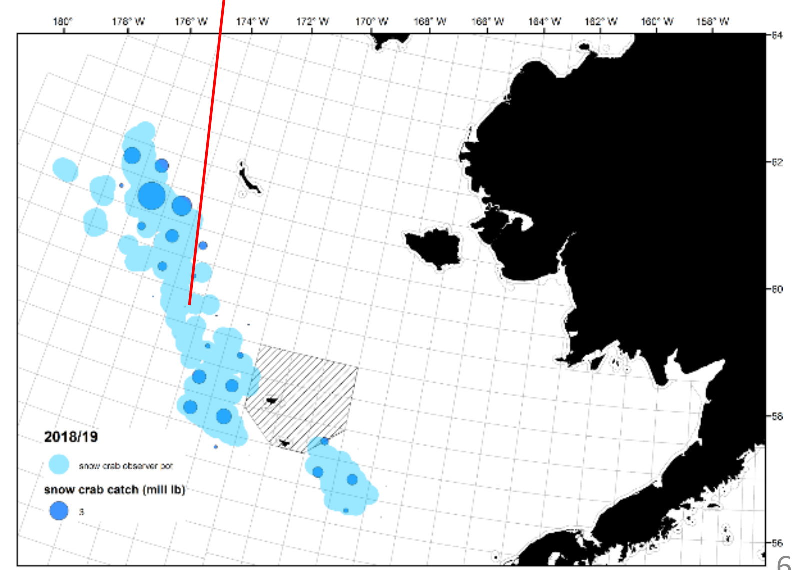
Spatial distribution

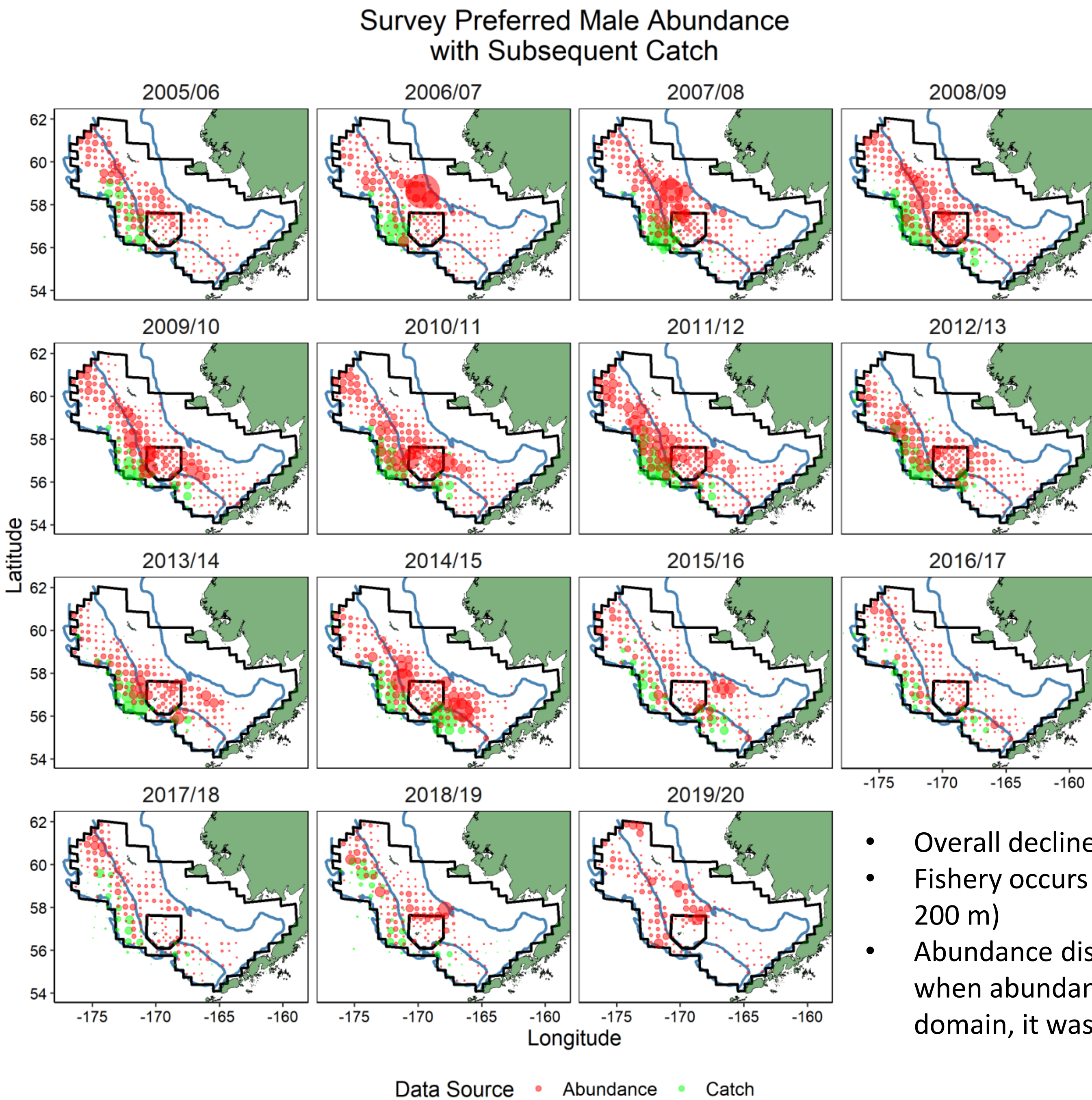
Lots of crabs in the "middle domain"



- In 2018/19, most of the fishing occurred in the “outer domain”
- No fishing north of the PI closure box despite lots of crab there







- Overall decline in 4” male abundance
- Fishery occurs in the outer domain (100-200 m)
- Abundance distribution is variable: when abundance was high in middle domain, it was also high in outer domain

Snow Crab Outlook

- Increased abundance estimates, with many small crab in the population
  - High estimates of MMB
  - Disappointing decrease in strong 2018 juvenile cohort
    - BUT, may still see continued increases in MMB and 4 inch males
- Unusually warm conditions in EBS and potential stressors on crab populations: recent trend of warm years and related unknown effects on spatial distribution, survey catchability, natural mortality, future recruitment, etc
- Weather forecast for 2019/20 season: projected continuation of warmth but reduced in magnitude relative to 2018/19

Final Thoughts

- Increase in last years TAC corresponded with an increase in CPUE
  - Had to move gear from traditional fishing grounds
- High proportion of legals in 3.1-4.0 inch size range
  - Highest ever discard rate in 2018/19 fishery
- High mature biomass → 58% exploitation rate on 4 inch males capped the TAC
  - MMB estimates are sensitive to maturity curve

Final Thoughts

- 4 inch males: 2019 up from last year but 2017 was lowest point in area-swept time series and falls within the 2018 and 2019 point estimate 95% CI
  - Uncertainty in 2019 increase in 4 inch males
  - Exploitation rate on 4” males similar to last year

- Unfavorable survey distribution of preferred size males
  - Aggregations in middle domain at survey → move south-west into more traditional fishing grounds by the time the fishery starts?

DONE!