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.
Preferred Male Abundance and CPUE Since Rationalization

- **Abundance (million crabs)**
  - 4 inch male abundance (raw area swept)
  - Fishery CPUE (Fish Tckts)

- **CPUE**

Year-wise data points from 2005/06 to 2018/19.
2018/19 BSS Harvest

- 2018/19
- Snow crab observer pot
- Snow crab catch (mill lb)

Map showing the distribution of snow crab observer pots and catch in the BSS Harvest area for the 2018/19 season.
BSS 2018/19 CPUE by stat area

- 1-100
- 101-200
- 201-300
- 301-400
- 401-500

Pribilof Closure Area
2018/19 snow crab

Proportion of total harvest

snow
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

Discard mortality (million lb)

Estimation method
- Subtraction
- LNR
snow crab discard mortality rate

Estimation method

- Subtraction
- LNR

lb bycatch mortality per lb retained catch
NOAA survey area-swept

Mature males (≥ 95 mm)

Biomass (million lb)

NOAA survey area-swept

Mature females (actual maturity)
NOAA survey area-swept

Total mature biomass (males + females)

Male maturity defined as ≥ 95 mm
2017 estimate lowest in time series.

2018 + 2019 NOAA 95%CI includes the 2017 point estimate.
Snow Crab (male)

Shell condition
- Molting & soft
- New - hard
- Old
- Very old

Abundance (millions)

Carapace length (mm)


NOAA survey area-swept
Males ≥ 95

NOAA survey area-swept
Female

Shell Condition  
- Soft & molting  
- New - hard  
- Old  
- Very old

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Abundance (millions)

Carapace Width (mm)

NOAA survey area-swept
From 2019 NOAA Survey Presentation to CPT by Jon Richar
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?
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).

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<td>126.1</td>
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<td>1.93</td>
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= 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 (1,000 of t)

4-inch male abundance (millions of crab)
Total mature biomass (TMB)

- **Observed**
- **Model survey**
- **Model population**
- **raw area-swept**

Biomass (million lb)

Year: 1980 to 2020

Values:
- 0
- 200
- 400
- 600
- 800
- 1,000
- 1,200
- 1,400
- 1,600
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
4-inch male abundance

Last year we had concerns regarding the terminal year uptick

Abundance (million crabs)
2019 model estimates for 2018 suggest these concerns were warranted.
Harvest Strategy: developed in 2002

1. Threshold for opening fishery: 25% $B_{MSY}$

2. Exploitation on MMB:
   - $B<25% \ B_{MSY}$, $= 0\%$
   - $0.25* B_{MSY} \leq B < B_{MSY}$, 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)
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)

\[ \frac{F_{MSY}}{3} + (B - 0.25B_{MSY}) \times 0.417 \times F_{MSY} \times \frac{1}{0.75B_{MSY}} \times 100\% \]

Where,
- $F_{MSY} = 0.3$
- $B = \text{current year TMB}$
- $B_{MSY} = \text{mean TMB for 1983-1997}$
- TMB = mature male biomass + mature female biomass
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

- %OS in retained catch samples, pre-rationalized
- % OS in retained catch samples, rationalized
- %OS expected for OS selectivity = 0.1
- %OS expected for OS selectivity = 0.25
- %OS expected for OS selectivity = 0.5
- % OS expected for OS selectivity = 1

Blue is 2014/15 season data
Green is 2015/16 season data
Red is 2016/17 season data
Orange is 2017/18 season data
Purple is 2018/19 season data
4 inch males

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)

Most discarding likely due to sub-industry-preferred size crab
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
Computed 2019/20 TACs: area-swept and Model "sep devs" estimates. Assumed old-shell fishery selectivity = 0.75 relative to new-shell.

<table>
<thead>
<tr>
<th></th>
<th>Raw area-swept (MM GE95)</th>
<th>Survey Observed (Model Maturity Status)</th>
<th>Survey (Model Predicted)</th>
<th>Population (Model Estimated)</th>
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<tr>
<td></td>
<td>TMB</td>
<td>MMB</td>
<td>TMB</td>
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<td>1983-1997 Average (millions lb)</td>
<td>581.5</td>
<td>316.6</td>
<td>803.8</td>
<td>527.8</td>
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<td>755.7</td>
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<td>712.6</td>
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<td>2019 Estimate (millions lb)</td>
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<td>120.3</td>
<td>616.2</td>
<td>372.8</td>
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<td>813.3</td>
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<td>978.2</td>
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<td>586.4</td>
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<td>(2019 Est)/(1983-1997 Avg)</td>
<td>61%</td>
<td>38%</td>
<td>77%</td>
<td>71%</td>
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<td></td>
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<td>108%</td>
<td>92%</td>
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$F_{MSY} = 0.3$

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                      | 64.72                    | 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%                        |
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.

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<tr>
<th>Survey year</th>
<th>Retained catch (kt)</th>
<th>Discarded females (kt)</th>
<th>Discarded males (kt)</th>
<th>Trawl bycatch (kt)</th>
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<td>2.76</td>
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<td>1985</td>
<td>44.45</td>
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<td>6.01</td>
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<td>18.42</td>
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<td>2.96</td>
<td>0.16</td>
</tr>
<tr>
<td>2016</td>
<td>9.67</td>
<td>0.02</td>
<td>1.31</td>
<td>0.08</td>
</tr>
<tr>
<td>2017</td>
<td>8.6</td>
<td>0.02</td>
<td>1.03</td>
<td>0.02</td>
</tr>
<tr>
<td>2018</td>
<td>12.51</td>
<td>0.02</td>
<td>2.86</td>
<td>0.02</td>
</tr>
</tbody>
</table>

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

Assumptions

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

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<tr>
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<th>Raw area-swept (MM GE95)</th>
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<tr>
<td></td>
<td>TMB MMb</td>
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</tr>
<tr>
<td>1983-1997 Average (millions lb)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>581.5 316.6</td>
<td>803.8 527.8</td>
<td>755.7 466.3</td>
<td>1,032.2 712.6</td>
</tr>
<tr>
<td>2019 Estimate (millions lb)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>355.7 120.3</td>
<td>616.2 372.8</td>
<td>813.3 430.6</td>
<td>978.2 586.4</td>
</tr>
<tr>
<td>(2019 Est)/(1983-1997 Avg)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>61% 38%</td>
<td>77% 71%</td>
<td>108% 92%</td>
<td>95% 82%</td>
</tr>
</tbody>
</table>

\[ F_{\text{MSY}} = \frac{0.3}{0.3} = 1.0 \]

Exploitation Rate on MMB

\[ F_{\text{MSY}} = 0.160 \]

\[ F_{\text{MSY}} = 0.186 \]

\[ F_{\text{MSY}} = 0.225 \]

\[ F_{\text{MSY}} = 0.216 \]

Computed TAC = Exp Rate X MMB (millions lb)

\[ \text{TAC} = 19.28 \]

\[ \text{TAC} = 69.40 \]

\[ \text{TAC} = 96.88 \]

\[ \text{TAC} = 126.89 \]

Max TAC (58% cap on exploited legal males (million lb)

\[ \text{TAC} = 35.63 \]

\[ \text{TAC} = 34.02 \]

\[ \text{TAC} = 64.73 \]

\[ \text{TAC} = 87.32 \]

TAC: Millions of 4-inch legals at 1.19 lb avg wt

\[ \text{TAC} = 16.22 \]

\[ \text{TAC} = 28.62 \]

\[ \text{TAC} = 54.46 \]

\[ \text{TAC} = 73.46 \]

TAC: % of RAW area-swept estimate of 4-inch legals at time of survey

\[ \text{TAC} = 30\% \]

\[ \text{TAC} = 53\% \]

\[ \text{TAC} = 101\% \]

\[ \text{TAC} = 137\% \]

TAC: % of model area-swept estimate of 4-inch legals at time of survey

\[ \text{TAC} = 32\% \]

\[ \text{TAC} = 56\% \]

\[ \text{TAC} = 106\% \]

\[ \text{TAC} = 143\% \]

TAC: % of model survey estimate of 4-inch legals at time of survey

\[ \text{TAC} = 17\% \]

\[ \text{TAC} = 29\% \]

\[ \text{TAC} = 56\% \]

\[ \text{TAC} = 75\% \]

TAC: % of model population estimate of 4-inch legals at time of survey

\[ \text{TAC} = 12\% \]

\[ \text{TAC} = 22\% \]

\[ \text{TAC} = 41\% \]

\[ \text{TAC} = 56\% \]

TAC: % of RAW area-swept estimate of "ELM" at time of survey

\[ \text{TAC} = 31\% \]

\[ \text{TAC} = 55\% \]

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\[ \text{TAC} = 43\% \]

\[ \text{TAC} = 58\% \]

Abundance of ♂♂ ≥ 4-in CW (millions)

\[ 53.7 \]

\[ 51.3 \]

\[ 97.6 \]

\[ 131.6 \]

Average wt (W; from area-swept; lb)

\[ 1.189 \]

\[ 1.189 \]

\[ 1.189 \]

\[ 1.189 \]

% 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)

\[ 35.63 \]

\[ 34.02 \]

\[ 64.73 \]

\[ 87.32 \]
Raw area-swept estimates using 95 mm size cut-off likely underestimates MMB
Computed 2019/20 TACs: area-swept and Model "sep devs" estimates. Assumed old-shell fishery selectivity = 0.75 relative to new-shell.

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F_MSY = 0.3

Exploitation Rate on MMB

| Exploitation Rate on MMB | 0.160 | 0.186 | 0.225 | 0.216 |

Computed TAC = Exp Rate X MMB (millions lb)

| Computed TAC (millions lb) | 19.28 | 69.40 | 96.88 | 126.89 |

Max TAC (58% cap on exploited legal males (million lb)

| Max TAC (58% cap) | 35.63 | 34.02 | 64.73 | 87.32 |

TAC: Millions of 4-inch legals at 1.19 lb avg wt

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TAC: % of RAW area-swept estimate of 4-inch legals at time of survey

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TAC: % of model area-swept estimate of 4-inch legals at time of survey

| TAC: % of model area-swept estimate | 32%    | 56%    | 106%   | 143%   |

TAC: % of model survey estimate of 4-inch legals at time of survey

| TAC: % of model survey estimate | 17%    | 29%    | 56%    | 75%    |

TAC: % of model population estimate of 4-inch legals at time of survey

| TAC: % of model population estimate | 12%    | 22%    | 41%    | 56%    |

TAC: % of RAW area-swept estimate of "ELM" at time of survey

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TAC: % of model area-swept estimate of "ELM" at time of survey

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TAC: % of model population estimate of "ELM" at time of survey

| TAC: % of model population estimate of "ELM" | 13%    | 23%    | 43%    | 58%    |

Assumes 75% OS selectivity
• 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
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.

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</table>

<table>
<thead>
<tr>
<th>Area-swept (Raw NOAA values)</th>
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<td>Expected old shell selectivity</td>
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<td>0.75</td>
</tr>
<tr>
<td>Exploited legal males (&quot;ELM&quot;; millions)</td>
<td>51.7</td>
<td>49.3</td>
<td>93.9</td>
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<td>Max TAC (= 0.58xELMxW; millions lb)</td>
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<td>64.73</td>
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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 = 725.1.6 million lb
• 2018 MMB = 307.3 million lb
• 2018 number of males ≥ 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 = 755.7 million lb
• 2018 MMB = 240.5 million lb
• 2018 number of males ≥ 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:

\[ \text{TAC} = 34.019 \text{ million lb} \]

- 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
Exploitation rates on 4-inch males

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!