Review of TACs

Bering Sea Crab:
2018/19 Season

ADF&G presentation to BSAI crab industry, 8 Oct 2018: Seattle

Join by teleconference:
Call in #: 1-800-315-6338
Access code: 4861842
Outline

• Introduction
• PIBKC
• PIRKC
• SMBKC
• BBRKC
• Tanner
• Intermission
• snow
2018/19 TAC Summary

Federal Overfishing Level (OFL), Acceptable Biological Catch (ABC), and total allowable catch (TAC) established by state for Bering Sea king and Tanner crab fisheries, 2018/19.

<table>
<thead>
<tr>
<th>Fishery</th>
<th>OFL (mill lb)</th>
<th>ABC (mill lb)</th>
<th>TAC (mill lb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bering Sea snow crab</td>
<td>65.48</td>
<td>52.47</td>
<td>27.581</td>
</tr>
<tr>
<td>(total catch)</td>
<td></td>
<td>(total catch)</td>
<td>(retained catch)</td>
</tr>
<tr>
<td>Bristol Bay red king crab</td>
<td>11.76</td>
<td>9.41</td>
<td>4.308</td>
</tr>
<tr>
<td>(total catch)</td>
<td></td>
<td>(total catch)</td>
<td>(retained catch)</td>
</tr>
<tr>
<td>St. Matthew blue king crab</td>
<td>0.08</td>
<td>0.07</td>
<td>0</td>
</tr>
<tr>
<td>(total male catch)</td>
<td></td>
<td>(total male catch)</td>
<td>(directed fishery closed)</td>
</tr>
<tr>
<td>Bering Sea Tanner crab</td>
<td>46.01</td>
<td>36.82</td>
<td>0 (EBT), 2.439 (WBT)</td>
</tr>
<tr>
<td>(total catch)</td>
<td></td>
<td>(total catch)</td>
<td>(retained catch)</td>
</tr>
<tr>
<td>Pribilof red king crab</td>
<td>1.06</td>
<td>0.80</td>
<td>0</td>
</tr>
<tr>
<td>(total catch)</td>
<td></td>
<td>(total catch)</td>
<td>(directed fishery closed)</td>
</tr>
<tr>
<td>Pribilof blue king crab</td>
<td>0.0026</td>
<td>0.002</td>
<td>0</td>
</tr>
<tr>
<td>(total catch)</td>
<td></td>
<td>(total catch)</td>
<td>(directed fishery closed)</td>
</tr>
</tbody>
</table>

Details follow…
**OFL**: Level of fishing mortality that jeopardizes the capacity of a stock to produce the maximum sustained yield on a continuing basis.

**ABC**: Level of annual catch that accounts for scientific uncertainty and is set to prevent the OFL from being exceeded.

In practice ABC limits mortality of **ALL** male and female crabs regardless of size, from all sources of fishery mortality (i.e. retained catch, bycatch in directed and nondirected crab fisheries, and groundfish fisheries).

**TAC**: Annual catch target for the directed fishery, set to prevent exceeding the ABC for that stock. **Limits legal sized males**, but must consider all sources of mortality to ensure the ABC is not exceeded.
• How can we account for all this change over time??
• Potential different realities create challenges in estimating population abundance
Population Abundance

**Surveys:** bottom trawl yields area-swept estimates
- Net mensuration: net width x tow length = area-swept
- Crab catch / area-swept → density → expand to total area
- Survey-based abundance *indices* (i.e., area-swept estimates)
  - Sampling error, survey selectivity, summer snap-shot

**Stock Assessment Models:** quantitative predictions about crab populations
- Length-based analysis: reduces uncertainty in annual abundance estimates
- Can account for gear selectivity, natural mortality, growth, etc
- Lots assumptions that goes into them:
  - Growth
  - Male maturity
  - Natural mortality
  - Etc
Example of Sampling Error

A size class that gets larger from one year to the next suggest sampling error, not that more crab were born and immediately were in that size class.
Example of Sampling Error

From 2018 NOAA Tech Memo

- The survey fails to detect portions of the population.
- Survey estimates of newshell female snow crab were 125 million in 1999, yet estimates of oldshell mature females was nearly 1,000 million in 2000.
- Estimates of oldshell females should be at or below levels of newshell females the year prior.
Federal Crab Stock Assessment Process

- NMFS Crab Survey Industry survey
- Fishery Data
- Research
- Population Models (CPT)
- Initial OFLs and ABCs
- Technical Review
- Public Input
- NPFMC (SSC)
- Final OFLs and ABCs
- ADF&G TACs
FMP 8.2.2. Total Allowable Catch and Guideline Harvest Level

The FMP authorizes the State to set preseason TACs and GHLs under State regulations.

The State will take into account the following factors, to the extent information is available, in developing harvest strategies or setting TACs and GHLs:

1. whether the ACL for that stock was exceeded in the previous year;
2. stock status relative to the OFL and ACL;
3. estimates of exploitable biomass;
4. estimates of recruitment;
5. estimates of thresholds;
6. market and other economic considerations;
7. additional uncertainty; and
8. any additional factors pertaining to the health and status of the stock or the marine ecosystem.

Additional uncertainty includes:

1. management uncertainty (i.e., uncertainty in the ability of managers to constrain catch so the ACL is not exceeded, and uncertainty in quantifying the true catch amount) and
2. scientific uncertainty identified and not already accounted for in the ABC (i.e., uncertainty in bycatch mortality, estimates of trends and absolute estimates of size composition, shell condition, molt status, reproductive condition, spatial distribution, bycatch of non-target crab stocks, environmental conditions, fishery performance, fleet behavior, and the quality and amount of data available for these variables).
Life Cycle
Crabs

Kingdom: Animalia

Phylum: Arthropoda ("Arthro"=jointed, "pod" =foot or leg)

Subphylum: Crustacea

Class: Malacostraca

Order: Decapoda ("Deca"=10, "pod"=foot or leg)

Infraorder: Brachyura, Anomura

Infraorder

Anomura

Brachyura
Biology: Anomurans vs. Brachyurans

**Anomurans** (king crabs)
- No terminal molt
  - Females molt yearly
  - Males may molt
- No sperm retention
  - Males must be present at fertilization
- Podding behavior
  - Patchy distribution
  - Could impact survey precision

**Brachyurans** (snow, Tanner)
- Terminal molt (oldshell)
  - Females
  - Males
- Sperm retention
  - Males not present at fertilization
  - Complicates our understanding of mating dynamics and reproductive potential
Groups considered in TAC setting

**Mature males**: generally thought of as “currency” of the population. Exploitation rates scaled to MMB or TMB

**Mature females**: represent an important component of the reproductive potential of the population

**Legal males**: a size intended to allow at least one opportunity for mating before potential removal by fishery

**Industry preferred males**: often larger than the legal size. Group of individuals targeted by the fishery.
Abundance estimates in TAC setting

1. “Area Swept” estimates………..raw area-swept; male maturity defined by size cut-off, female maturity defined by abdomen shape

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

3. “Model survey” estimates………… interprets what the area-swept 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

• These estimates can differ greatly
• In any given year we don’t know what estimate is closer to the true population size
• Resulting TAC can vary depending on what set of estimates is used
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Federal 2018/19 Status

Stock estimated at 6% of $B_{MSY}$ in 2017/18
Stock projected at 6% of $B_{MSY}$ in 2018/19
  • biomass must be above 25% of $B_{MSY}$ for directed fishery opening

ABC = 2,000 lb total catch
OFL = 2,600 lb total catch

State harvest strategy (5 AAC 34.918)

• Stock threshold for opening fishery:
  • 13.2-million pounds total (male and female) mature biomass @ survey for 2 consecutive years
  • 10% exploitation then applied to mature male abundance

2017 estimate for total mature biomass @ survey:
  • 0.89-million pounds (NMFS area-swept estimate)
2018 estimate for total mature biomass @ survey:
  • 0.50-million pounds (NMFS area-swept estimate)

→ Stock is below state threshold for a fishery opening
Pribilof Blue King Crab

Mature males (≥ 120 mm CL)

Mature females (≥ 100 mm CL)

NOAA area-swept
Pribilof Blue King Crab

Closed areas to protect stock from overfishing in 2018/19

• A portion of the Pribilof District closed to commercial crab fisheries
• Area closure for all crab fisheries (i.e., snow crab and Tanner crab):
Closed areas to protect stock from overfishing in 2018/19

Criteria for re-opening sections?
Developing metrics for opening portions of the closure area
• BKC spatial distribution in past 2-years
• Bycatch rates in recent fisheries
  • High risk of exceeding OFL (2,600 lbs): Observer numbers are expanded to entire fishery
  • Reassess expansion criteria: what is the most appropriate spatial extent in which to expand?

• Snow crab fishing grounds are vast
• Bycatch expansions should be restricted to those which are biologically relevant
Pribilof Red King Crab

Federal 2018/19 Status

ABC = 0.80 mill lb, including bycatch mortality of males and females in all fisheries
OFL = 1.06 mill lb

State harvest strategy: no harvest strategy in regulation, some harvest in the 1990s with BKC
Pribilof Red King Crab

**TAC = 0**

- Poor precision of abundance estimates
- Little sign of recruitment to stock
- Concerns for bycatch of blue king crabs remains very high
  - Pribilof blue king crab OFL= 2,600 lb (bycatch mortality only)

The same concerns since 1999
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St. Matthew Blue King Crab

Federal 2018/19 Status
Stock estimated at 35% of $B_{MSY}$ in 2017/18
- Below MSST (50% $B_{MSY}$), hence SMBKC is “overfished”
- Federal control rule: biomass must be 25% of $B_{MSY}$ for directed fishery opening
Stock projected to be at 35% of $B_{MSY}$ in 2018/19
- Federal rebuilding plan will be developed in coming year(s)

\[ \text{OFL} = 0.08 \text{ million lb} \]
St. Matthew Blue King Crab

St Matthew BKC Harvest

Million lb

St. Matthew Blue King Crab: State harvest strategy (5 AAC 34.917)

Stock threshold for opening fishery:
- Survey abundance of mature-sized males \((M) = 50\% \text{ of } 1978-2012 \text{ average}\)

Exploitation rate on mature-sized males \((M)\):
- 5\%, when \(M = 50\% \text{ of } 1978-2012 \text{ average}\)
- Increases linearly up to 10\% with increasing \(M\), up to the 1978-2012 average
- 10\%, when \(M \geq 1978-2012 \text{ average}\)
- Harvest capped at 25\% of legal male abundance \((L)\) at time of survey

Harvest strategy: exploitation rate on \(M\)

\(M = \text{mature-sized male (males } \geq 105 \text{ mm CL)}\)
\(M_{AVG:1978-2012} = \text{average of annual } M \text{ estimates for } 1978-2012\)
\(L = \text{legal-sized male (males } \geq 120 \text{ mm CL)} \text{ abundance}\)
Two surveys: NOAA bottom trawl survey and ADF&G pot survey

For population abundance estimates, models use:
- NMFS area swept bottom trawl abundance data
- ADF&G pot survey CPUE
Special Thanks to:

**P/V Stimson**
- Alaska Wildlife Trooper patrol vessel
- **Vessel crew**: Troy Magnusen (captain), Doug Campbell (mate), Ray Streitmatter, Dan Pulice, Josh Nelson, Eric Lorring (AWT)
- **ADF&G crew**: Vicki Vanek, Andy Nault, Aidan Coyle, Luke Henslee

...For doing an outstanding job during this year’s St. Matthew ADF&G pot survey.

The survey was a success, and the data was used in the 2018 stock assessment.
Mature males (≥105 mm CL)

Abundance (mill crabs) or CPUE

NOAA trawl survey (abundance)  ADF&G pot survey (CPUE)
Legal males (≥120 mm CL)

Abundance (mill crabs) or CPUE

NOAA trawl survey (abundance) ADF&G pot survey (CPUE)
NOAA trawl survey

St. Matthew Island Blue King Crab (male)

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

Abundance (millions)

Carapace length (mm)

2013
- 2016

2014
- 2017

2015
- 2018

Abundance (millions)

Carapace length (mm)

NOAA survey
Males
(ADF&G pot survey)

a. 1995 (N=5,064)

b. 1998 (N=5,253)

c. 2001 (N=3,411)

d. 2004 (N=699)

e. 2007 (N=3,551)

f. 2010 (N=4,173)

g. 2013 (N=2,471)

h. 2015 (N=1,115)

i. 2016 (N=858)

j. 2017 (N=731)

k. 2018 (N=368)
1995–2017 pooled ♂ CPUE

2018 ♂ CPUE

pot-only survey area
Both below state threshold for opening fishery
2018/19 St Matthew BKC fishery closed, TAC = 0

– Declared “overfished” in 2018 assessment
  • Need to closely monitor bycatch in snow + Tanner fisheries
– Below model AND area-swept threshold for opening fishery.
– Trawl and pot survey data are bleak
  • But, weak sign of recruits in 60-80 mm CL size class
St Matts BKC Bycatch

- OFL = 80,000 lb
- Possible bycatch in snow or Tanner fishery
  - Observer data expanded to entire fishery

2018: total BKC abundance (summer snapshot)

Expanded total SMBKC catch
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Bristol Bay Red King Crab

Federal 2017/18 Status
• ABC/ACL = 9.41-million lb total catch
  • including bycatch mortality of males and females in all fisheries
  • based on a 20% buffer on OFL
• OFL = 11.76-million lb total catch

Historical status and catch specifications for Bristol Bay red king 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.

<table>
<thead>
<tr>
<th>Year</th>
<th>MSST</th>
<th>Biomass (MMB)</th>
<th>TAC</th>
<th>Retained Catch</th>
<th>Total Catch</th>
<th>OFL</th>
<th>ABC</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014/15</td>
<td>28.7</td>
<td>60.1</td>
<td>9.99</td>
<td>10.01</td>
<td>11.99</td>
<td>15.04</td>
<td>13.53</td>
</tr>
<tr>
<td>2015/16</td>
<td>28.4</td>
<td>61.0</td>
<td>9.97</td>
<td>10.17</td>
<td>11.77</td>
<td>14.84</td>
<td>13.36</td>
</tr>
<tr>
<td>2016/17</td>
<td>27.6</td>
<td>56.9</td>
<td>8.47</td>
<td>8.65</td>
<td>9.45</td>
<td>14.63</td>
<td>13.17</td>
</tr>
<tr>
<td>2017/18</td>
<td>28.1</td>
<td>54.8</td>
<td>6.60</td>
<td>6.82</td>
<td>7.67</td>
<td>12.35</td>
<td>11.11</td>
</tr>
<tr>
<td>2018/19</td>
<td>45.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>11.76</td>
<td>9.41</td>
</tr>
</tbody>
</table>
Figure 4 from 2018 SAFE. Comparison of survey legal male abundances and catches per unit effort for Bristol Bay red king crab from 1968 to 2017.

- CPUE variable since rationalization (17-38), with 2016/17 fishery CPUE highest in ~30 years
  - Not unexpected given declining population trends
  - >50 % decline relative to prior year
2017/18 BBRKC Observations

• Captains reported one “school” of fast-moving crab on the grounds.
• Vessels would stay on top of the “school” to mark it and call in other vessels to area (radio fishing).
• Majority of vessels did not locate crab in their first sets (spots that were good fishing the year before) and had to immediately move gear and prospect other areas.
Bristol Bay Red King Crab

State harvest strategy (5 AAC 34.816)

• Stock threshold for opening fishery:
  • 8.4-million mature-sized females (females ≥ 90 mm CL), and
  • 14.5-mill lb of effective spawning biomass (ESB)

• Exploitation rate on mature-sized (≥120-mm CL) male abundance:
  • 10%, when ESB <34.75-mill lb
  • 12.5%, when ESB is between 34.75-mill lb and 55.0-mill lb
  • 15%, when ESB ≥55.0-mill lb

• Harvest capped at 50% of legal male abundance

2018 length-based analysis (LBA) estimates for determining fishery opening, computing TAC (area-swept estimates for comparison):

<table>
<thead>
<tr>
<th>Parameter</th>
<th>LBA</th>
<th>Area-swept Estimate (NMFS-AFSC)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Estimate</td>
<td>95% CI</td>
</tr>
<tr>
<td>ESB (millions of lb)</td>
<td>33.275</td>
<td>(-)</td>
</tr>
<tr>
<td>F (millions of crab)</td>
<td>13.053</td>
<td>(10.890 - 15.275)</td>
</tr>
<tr>
<td>M (millions of crab)</td>
<td>6.299</td>
<td>(5.234 - 7.383)</td>
</tr>
<tr>
<td>L (millions of crab)</td>
<td>5.376</td>
<td>(4.391 - 6.404)</td>
</tr>
<tr>
<td>W (lb)</td>
<td>(-)</td>
<td>(-)</td>
</tr>
</tbody>
</table>

• ESB = effective spawning biomass
• F = mature-sized female (females ≥ 90 mm CL) abundance
• M = mature-sized male (males ≥ 120 mm CL) abundance
• L = legal male (males ≥ 135 mm CL) abundance
• W = expected average weight of landed legal males

Avg wt 2017/18 Fishery = 6.840 lb
1. **Stock above threshold for opening fishery**
   - \( F = 13.053\)-million > threshold = 8.4-million (ADF&G LBA estimate)
   - \( ESB = 33.275\)-mill lb > threshold = 14.5-mill lb (ADF&G LBA estimate)

2. **Exploitation rate on mature-sized male abundance (M)**
   - \( ESB \) is between 14.50 mill lb and 34.75-mill lb
   → 10% exploitation rate on estimated mature male abundance

3. **TAC computation according to state harvest strategy:**
   - 10% exploitation rate applied to estimated mature-sized male abundance
     - 6.299-million mature-sized males (ADF&G LBA estimate)
     - \((0.10) \times (6.299\)-million\) = 0.630-million crabs
   
   • Check: 50% cap on harvest of legal males
     - 5.376-million legal males (ADF&G LBA estimate)
     - \((0.5) \times (5.376\)-million\) = 2.688-million crabs > 0.630-million crabs

→ Compute TAC on harvest of 0.630-million legal males, assuming 2017/18 fishery avg wt (6.840 lb) = 0.630 x 6.83949

\[ \text{TAC} = 4.308 \text{ million lb} \]
How does the 2018/19 TAC compare to historical TACs?

Historical TACs

Million lb


4.308
Bristol Bay Red King Crab: Total mortality @ TAC and ABC

Table 1a. Bristol Bay red king crab annual catch and bycatch mortality biomass (t) from July 1 to June 30. A handling mortality rate of 20% for the directed pot, 25% for the Tanner fishery, 80% for trawl and 50% or fixed gear was assumed to estimate bycatch mortality biomass.

<table>
<thead>
<tr>
<th>Year</th>
<th>U.S. Total</th>
<th>Cost-Recovery</th>
<th>Foreign</th>
<th>Total</th>
<th>Retained Catch</th>
<th>Pot Bycatch</th>
</tr>
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<tbody>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>1977</td>
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<tr>
<td>1978</td>
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<td>1979</td>
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<td>4891.0</td>
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<td>1980</td>
<td>5894.3</td>
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<td>5894.3</td>
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<tr>
<td>1981</td>
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<td>0.0</td>
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<td>1897.1</td>
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<td>5168.2</td>
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<td></td>
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<tr>
<td>1987</td>
<td>5574.2</td>
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<td>5574.2</td>
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<td>1988</td>
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<td>1989</td>
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<td>0.0</td>
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<tr>
<td>1990</td>
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<td>7868.1</td>
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<td>1992</td>
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<td>6666.6</td>
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<td>3093.7</td>
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</tr>
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</table>

Bycatch mortality (t)

Tanner crab fishery

(1993 change in regs: reduced tunnel eye height, closure of Tanner fishing east 163 after BB RKC fishery closes)

Directed BB RKC

Groundfish

Use 1993-2017

Use 1994-2017

2018 SAFE
Directed BBRKC fishery retained catch and bycatch mortality (from Table 1 of 2018 BBRKC SAFE chapter).

<table>
<thead>
<tr>
<th>Season</th>
<th>Retained (t)</th>
<th>Bycatch mortality (t)</th>
<th>Bycatch mortality per retained</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990/91</td>
<td>9272.8</td>
<td>1178.4</td>
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<td>1991/92</td>
<td>7885.2</td>
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<td>1992/93</td>
<td>3681.8</td>
<td>970.5</td>
<td>0.264</td>
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<td>1993/94</td>
<td>6659.5</td>
<td>1400.3</td>
<td>0.210</td>
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<td>1994/95</td>
<td>42.3</td>
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</tr>
<tr>
<td>1995/96</td>
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<td>4.9</td>
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<td>1996/97</td>
<td>3861.7</td>
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<td>1997/98</td>
<td>4042.1</td>
<td>264.3</td>
<td>0.065</td>
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<tr>
<td>1998/99</td>
<td>6779.2</td>
<td>1824.6</td>
<td>0.269</td>
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<tr>
<td>1999/00</td>
<td>5377.8</td>
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<td>0.060</td>
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<td>2001/02</td>
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<td>2003/04</td>
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<td>2005/06</td>
<td>8399.7</td>
<td>1857.8</td>
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<tr>
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<td>600.8</td>
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<tr>
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<td>1187.4</td>
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<td>9216.1</td>
<td>1313.9</td>
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<td>2013/14</td>
<td>3991.0</td>
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<td>0.103</td>
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<td>2014/15</td>
<td>4538.6</td>
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<td>0.148</td>
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<td>2015/16</td>
<td>4613.7</td>
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<td>2016/17</td>
<td>3923.9</td>
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<td>2017/18</td>
<td>3093.7</td>
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</table>
**Bristol Bay Red King Crab: Total mortality @ TAC and ABC**

### 2018/19 maximum total fishery mortality relative to avoiding ABC = 9.41 million lb

<table>
<thead>
<tr>
<th>Assumptions</th>
<th>Mortality (million lb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assume max mortality in groundfish fisheries, 94/95-17/18 =</td>
<td>0.44</td>
</tr>
<tr>
<td>Assume max mortality in Tanner crab fishery, 93/94-17/18 =</td>
<td>0.19</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td><strong>0.63</strong></td>
</tr>
<tr>
<td>Remaining for directed (incl. bycatch mort), mill lb (ABC-Subtotal) =</td>
<td>8.78</td>
</tr>
<tr>
<td>Assume maximum (lb discard mort)/(lb retained) in directed fishery, 90/91-17/18 =</td>
<td>0.269</td>
</tr>
<tr>
<td><strong>Maximum total mortality = (remaining for directed)/(1+0.269) =</strong></td>
<td><strong>6.92</strong></td>
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</tbody>
</table>

### Expectations from rationalized BBRKC seasons

<table>
<thead>
<tr>
<th>Assumptions</th>
<th>Mortality (million lb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assume max mortality in groundfish fisheries, 94/95-17/18 =</td>
<td>0.44</td>
</tr>
<tr>
<td>Assume max mortality in Tanner crab fishery, 93/94-17/18 =</td>
<td>0.19</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td><strong>0.63</strong></td>
</tr>
<tr>
<td>Remaining for directed (incl. bycatch mort), mill lb (ABC-Subtotal) =</td>
<td>8.78</td>
</tr>
<tr>
<td>Assume maximum (lb discard mort)/(lb retained) in directed fishery, 05/06-17/18 =</td>
<td>0.221</td>
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<tr>
<td><strong>Maximum total mortality = (remaining for directed)/(1+0.221) =</strong></td>
<td><strong>7.19</strong></td>
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<tr>
<td>Assume maximum (lb discard mort)/(lb retained) in directed fishery, 06/07-17/18 =</td>
<td>0.148</td>
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<tr>
<td><strong>Maximum total mortality = (remaining for directed)/(1+0.148) =</strong></td>
<td><strong>7.65</strong></td>
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## Bristol Bay Red King Crab: 2005/06 – 2017/18 seasons

**This Year: Consider a reduction from computed TAC for discards of legals in 2017/18?**

<table>
<thead>
<tr>
<th>Season</th>
<th>Harvest (mill lb)</th>
<th>CPUE</th>
<th>Female</th>
<th>Sublegal</th>
<th>Legal</th>
<th>Legal-Ret</th>
<th>Legal-NR</th>
<th>% Leg-NR</th>
</tr>
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<tr>
<td>2005/06</td>
<td>18.309</td>
<td>24</td>
<td>17.4</td>
<td>26.6</td>
<td>29.6</td>
<td>23.8</td>
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<td>20%</td>
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<tr>
<td>2006/07</td>
<td>15.444</td>
<td>34</td>
<td>3.1</td>
<td>25.8</td>
<td>34.7</td>
<td>33.4</td>
<td>1.3</td>
<td>4%</td>
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<tr>
<td>2007/08</td>
<td>20.366</td>
<td>28</td>
<td>7.3</td>
<td>31.4</td>
<td>29.6</td>
<td>29.2</td>
<td>0.4</td>
<td>1%</td>
</tr>
<tr>
<td>2008/09</td>
<td>20.329</td>
<td>22</td>
<td>5.8</td>
<td>29.3</td>
<td>23.7</td>
<td>23.3</td>
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<tr>
<td>2009/10</td>
<td>15.933</td>
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<td>2.6</td>
<td>24.5</td>
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<td>21.8</td>
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<tr>
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<td>18</td>
<td>3.4</td>
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<tr>
<td>2011/12</td>
<td>7.834</td>
<td>28</td>
<td>2.2</td>
<td>28.8</td>
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<td>2012/13</td>
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<td>30</td>
<td>1.6</td>
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<td>32.6</td>
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<td>9.1</td>
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<td>10.4</td>
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<td>6.820</td>
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<td>4.8</td>
<td>14.2</td>
<td>19.7</td>
<td>18.2</td>
<td>1.5</td>
<td>7%</td>
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</tbody>
</table>

2015/16: **Reduction** from computed TAC for discards of legals in 2014/15

2016/17: **No reduction** from computed TAC for discards of legals in 2015/16

2017/18: **No reduction** from computed TAC for discards of legals in 2016/17
Deduct last years discard mortality?

**THE DEDUCTION FOR DISCARD MORTALITY LAST YEAR (2017/18)**

- 964,593 = 2017/18 landed legal males (live and deadloss number from "Copy of 2017-18_BBRKC_IFQwithCDQ")
- 7.5% = estimated number of legals discarded for each legal retained in 2016/17 season (observer pot sample data)
  
  \[ \text{LegalNR/LegalRet} = \frac{1,178}{15,802} = 0.074548; \text{from potSummary-TR17} \]
- 14,382 = number discard and die at rate of 0.075 discards/retained and HM rate = 0.20
  
  \[ (964,593 \times 0.074548 \times 0.20 = 14,382) \]
- 98,363 = lb discarded **and died of handling mortality** at landed avg wt (6.843 lb)
  
  \[ (14,382 \times 6.840 = 98,363; \text{avg wt from } "\text{Copy of 2017-18_BBRKC_IFQwithCDQ}"
  \]
- 0.098 = rounded to millions of lb
- 4.210 = computed TAC - 0.098 = 4.308 - 0.098
  
  = final TAC for 2018/19

Assuming $8.40/lb, that’s $826,247!!
Bristol Bay Red King Crab

2018 results relative to area-swept:

Right: ADF&G length-based analysis (LBA model; with 2 levels of natural mortality for males and 3 levels for females) fit (line) to area-swept estimates (dots) of mature male (top panel) and mature female (bottom panel) Bristol Bay red king crab abundance (millions of crabs) from 1972 through 2018. (J. Zheng, ADF&G).

Below: LBA fit to area-swept estimates of legal male abundance.
Bristol Bay red king crab (male)

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

<table>
<thead>
<tr>
<th>Year</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
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</thead>
<tbody>
<tr>
<td>Abundance (millions)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Carapace length (mm)</td>
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</tbody>
</table>

NOAA survey data
Bristol Bay Red King Crab

2018 survey results:
Survey distribution, crab nm\(^{-2}\) station

Legal males

Mature females
Trends – Outlook: 2018 stock assessment recruitment trend

(from Figure 12(18.0a) in Zheng and Siddeek 2018, 2018 SAFE).
Overall Outlook

• Continued downward trajectory for ESB, M, F, L
  • Drop in 2018 more severe than expected
• Low estimated recruitment
• Length frequencies discouraging, no strong pulses of small crabs in system
Outline

• Introduction
• PIBKC
• PIRKC
• SMBKC
• BBRKC
• Tanner
• Intermission
• snow
Bering Sea Tanner Crab

Federal 2018/19 Status

ABC/ACL = 36.82-mill lb total catch
  • Including bycatch mortality of males and females in all fisheries
  • 2018/19 ABC set with 20% “buffer” on OFL (i.e., ABC = 0.8*OFL)
OFL = 46.01-mill lb total catch

Historical status and catch specifications for Eastern Bering Sea Tanner 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.

<table>
<thead>
<tr>
<th>Year</th>
<th>MSST</th>
<th>Biomass (MMB)</th>
<th>TAC (East + West)</th>
<th>Retained Catch</th>
<th>Total Catch Mortality</th>
<th>OFL</th>
<th>ABC</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014/15</td>
<td>29.53</td>
<td>157.78</td>
<td>15.10</td>
<td>13.58</td>
<td>20.19</td>
<td>69.40</td>
<td>55.51</td>
</tr>
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<td>2015/16</td>
<td>28.27</td>
<td>162.99</td>
<td>19.67</td>
<td>19.64</td>
<td>25.09</td>
<td>59.94</td>
<td>47.95</td>
</tr>
<tr>
<td>2016/17</td>
<td>32.15</td>
<td>171.87</td>
<td>0.00</td>
<td>0.00</td>
<td>2.52</td>
<td>56.46</td>
<td>45.17</td>
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<td>33.40</td>
<td>95.49</td>
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<td>2.50</td>
<td>5.22</td>
<td>56.03</td>
<td>44.83</td>
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<tr>
<td>2018/19</td>
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<td>79.26</td>
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<td>46.01</td>
<td>36.82</td>
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</table>

From 2018 SAFE Intro chapter, Model 18AM17
Historical TACs
East and west combined

Fishery CPUE (directed catch only)
Harvest Strategy Data Inputs

Population Biomass + Abundance

- NMFS survey raw area-swept
- Stock assessment model survey
- Stock assessment model population

Other model outputs relevant to the HS

- $F_{MSY} = F_{OFL} = 0.74$
- $M$ (natural mortality) = 0.23
- Retained selectivity curve

Concerns regarding estimates of 5 inch males
Figure 8: Pearson’s residuals for proportions-at-size from the NMFS (males by X) for scenario 18C2a.
Mature female error band

Below threshold
- Fishery Closed

Encompasses threshold
- TAC = \( \frac{B}{B_{AVG}} - 1 \) x (0.9) x \( C_{MSY} \)

Above threshold
- TAC = (0.9) x \( C_{MSY} \)

Males
- Males below 100% ave
  - Fishery Closed
- Males above 100% ave
  - TAC = \( \frac{B}{B_{AVG}} \) x (0.9) x \( C_{MSY} \)

Males below 25% ave
- Fishery Closed
Males 25%-100% ave
- Fishery Closed
Males above 100% ave
- TAC = (0.9) x \( C_{MSY} \)
Female "error band" control rule

- Error band above threshold
- Threshold within error band
- Error band below threshold

TAC multiplier vs. Male $B/B_{\text{AVE}}$
3 elements in TAC calculation

\[
TAC = (0.9) \times (B/B_{AVG}) \times C_{MSY}
\]

- **10% buffer**: Corresponded with OFL/ABC determination in federal stock assessment process. NPFMC adopted 10% buffer on OFL for determining ABC (i.e., ABC=0.9*OFL). **20% buffer currently used.**

- **Scalar**: Conservation measure that scales TAC depending on magnitude of mature male biomass relative to the long-term average. Influenced by mature female biomass when “error band” control rule applies \((B/B_{AVE} - 1)\).

- **“Exploited legal males”**: Biomass of legal males predicted to be targeted by the commercial fishery. Incorporates model estimates of fishery selectivity, instantaneous fishing mortality, natural mortality, survey biomass.
Female error band: NOAA 95% CI

Mature female biomass

Threshold: 12.12 mill lb
2018 error band: 5.94 – 15.62 mill lb
Estimated 95% CI interval via bootstrap

- Estimate pop. biomass by stratum (sum station estimate of biomass) with replication, then sum strata
- 5,000 replicates
- 0.025, 0.975 quantile of bootstrap distribution

![Bootstrap Distribution (B = 5000) with 95% Confidence Interval](image)
Mature males EAST of 166 W

NOT above 100% long-term average, cannot open fishery

1982-2016 ave: 47.54 mill lb
2018 estimate: 24.38 mill lb

51% of long-term average
Mature male biomass WEST of 166 W

Above 100% long-term average, CAN open fishery

1982-2016 ave: 42.39 mill lb
2018 estimate: 52.80 mill lb

125% of long-term average
Mature female error band

Below threshold

Encompasses threshold

Above threshold

Males below 100% ave

TAC = \( \frac{B}{B_{\text{AVG}}} - 1 \) x (0.9) x \( C_{\text{MSY}} \)

Fishery Closed

Fishery Closed

Males above 100% ave

TAC = (0.9) x \( C_{\text{MSY}} \)

West of 166

Fishery Closed

Males below 25% ave

TAC = (B/B_{\text{AVG}}) x (0.9) x \( C_{\text{MSY}} \)

Fishery Closed

Males 25%-100% ave

Males above 100% ave

TAC = (0.9) x \( C_{\text{MSY}} \)

East of 166
Mature males WEST of 166 W

\[
\frac{B}{B_{AVE}} = \frac{52.8}{42.4} = 1.2454
\]

\[
1.2454 - 1 = 0.2454
\]
$C_{MSY}$

“$C_{W,MSY}$ means the catch biomass of male *C. bairdi* Tanner crab in the portion of the Bering Sea District west of 166° W long. that are 127 millimeters (five inches) or greater in carapace width, including the lateral spines, resulting from fishing on the estimated mature male biomass of *C. bairdi* Tanner crab at the estimated mean time of mating at the full-selection $F_{MSY}$ rate or a proxy for the $F_{MSY}$ rate”

$F_{MSY}$ = the instantaneous fishing mortality rate that will produce MSY at the MSY-producing biomass
**C\textsubscript{MSY}: area-swept estimates**

Computing \( C\textsubscript{W,MSY} \) (millions of lb)

<table>
<thead>
<tr>
<th>Size Group</th>
<th>Male total Biomass</th>
<th>Fishery Selectivity</th>
<th>((1-\exp(-F\textsubscript{MSY})))</th>
<th>MSY catch = ( B\times C\times D )</th>
</tr>
</thead>
<tbody>
<tr>
<td>125-129</td>
<td>6.873</td>
<td>0.585469893</td>
<td>0.52288608</td>
<td>1.822</td>
</tr>
<tr>
<td>130-134</td>
<td>6.963</td>
<td>0.866567231</td>
<td>0.52288608</td>
<td>2.733</td>
</tr>
<tr>
<td>135-139</td>
<td>5.667</td>
<td>0.932940206</td>
<td>0.52288608</td>
<td>2.394</td>
</tr>
<tr>
<td>140-144</td>
<td>4.200</td>
<td>0.959293685</td>
<td>0.52288608</td>
<td>1.825</td>
</tr>
<tr>
<td>145-149</td>
<td>2.400</td>
<td>0.971696107</td>
<td>0.52288608</td>
<td>1.056</td>
</tr>
<tr>
<td>150-154</td>
<td>1.185</td>
<td>0.977544171</td>
<td>0.52288608</td>
<td>0.525</td>
</tr>
<tr>
<td>155-159</td>
<td>0.610</td>
<td>0.980270036</td>
<td>0.52288608</td>
<td>0.271</td>
</tr>
<tr>
<td>160-164</td>
<td>0.227</td>
<td>0.981531714</td>
<td>0.52288608</td>
<td>0.101</td>
</tr>
<tr>
<td>165-169</td>
<td>0.250</td>
<td>0.982113664</td>
<td>0.52288608</td>
<td>0.111</td>
</tr>
<tr>
<td>170-174</td>
<td>0.000</td>
<td>0.982381651</td>
<td>0.52288608</td>
<td>0.000</td>
</tr>
<tr>
<td>175-179</td>
<td>0.000</td>
<td>0.982504966</td>
<td>0.52288608</td>
<td>0.000</td>
</tr>
<tr>
<td>180+</td>
<td>0.000</td>
<td>0.98256169</td>
<td>0.52288608</td>
<td>0.000</td>
</tr>
<tr>
<td>Total</td>
<td>28.375</td>
<td>24.576</td>
<td>-</td>
<td>10.838</td>
</tr>
</tbody>
</table>

\[ C\text{\textsubscript{MSY}} = 10.838 \text{ million lb} \]

From Stockhausen, 12 Sept 2018 email.
Final TAC = (0.9) x (B/B_{\text{AVE}} - 1) x C_{\text{MSY}}

= 0.9 x 0.25 x 10.838 =

2.439 million lb
*Without the female error band control rule, (revision adopted at May 2017 BOF meeting), Tanner crab would be closed in both the east and west for 2018/19 due to being below the female threshold, even with the updated threshold calculations (updated year range, spatial extent, and maturity definition).
2.44 mill lb TAC relative to past

Historical TACs (E+W combined)
Exploitation rate on 5-inch males

- **East**
- **West**
- **East + West combined**

Based on area-swept estimates
**EAST**

5-inch males EAST of 166

- **Abundance (million crab)**
- **Percent old shell**

2018: 98% oldshell

**WEST**

5-inch males WEST of 166

- **Abundance (million crab)**
- **Percent old shell**

2018: 92% oldshell
5-inch males WEST of 166 W long

Percent 5-inch male available to fishing
(outside closure area)
Outside PI Closure Area (available to fishery)

- 2.44 million lb represents 22% of 5 inch males outside closure area
- Of the crab outside closure area, 88% of 5 inch males are oldshell
Newshell retention rates WEST of 166 W long

Generally, higher proportion of newshell crab in retained catch relative to survey-based population estimate.
2005/06 - 2017/18 EBS Tanner crab fishery old-shell selectivity

- % OS in retained catch samples, rationalized
- %OS in retained, observer pot 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 2013/14 season data
Green is 2014/15 season data
Red is 2015/16 season data
Orange is 2017/18 season data

Expected %OS_{retained\_catch} (lines)=
\[
\frac{selectivity \times %OS_{survey}}{(selectivity \times %OS_{survey} + %NS_{survey})}
\]
Dockside samples
- Mean: 39% OS selectivity
- 2017: 6% OS selectivity

\[
\%OS_{\text{retained\_catch}} = \frac{\text{selectivity} \times \%OS_{\text{survey}}}{(\text{selectivity} \times \%OS_{\text{survey}} + \%NS_{\text{survey}})}
\]
“Exploited legal males” = 100% NS 5-inch males + %OS 5-inch males

If we assume a similar OS selectivity rate as 2017 (6%), “exploited legal males” =
• Total area in WEST: 3.77 mill lb
• Area outside closure box: 1.96 mill lb

If we assume a mean OS selectivity rate from recent fisheries (39%), “exploited legal males” =
• Total area in WEST: 12.41 mill lb
• Area outside closure box: 5.26 mill lb
What does this mean?

- Fleet will likely need to retain oldshell males, if we assume area-swept estimates (abundance, %shell conditions, spatial distribution) are “real” (i.e., reflect reality of the population at the time of fishery)
  - This means: 55% of retained catch must be in oldshell condition to capture 2.44 million lb of “exploited legal males” (assuming area-swept data)
Estimates of annual biomass of “preferred-size” legal male Tanner crabs (≥5.0 inches, east of 166° W longitude; ≥5.0 inches, west of 166° W longitude) in the Bering Sea District 1975–2018.
Tanner crab east 166W (male)

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

Carapace length (mm)

Abundance (millions)

2013

2014

2015

2016

2017

2018

2018 NOAA area-swept
Tanner crab outlook

• Mature females are still in a declining trend, but there is a strong cohort of 25-60 mm crabs in population, which has carried foreword from the 2017 cohort ....hope for the future

• Mature males in the east show signs of population decline, while mature males in the west have been stable

• % old shell for 5-inch males in the east and west is high (+90%)

• Strong cohort of juvenile males (25-55 mm), especially in the west, provides hope for fishery in ~5 years-isch........
Intermission:
Snow crab next