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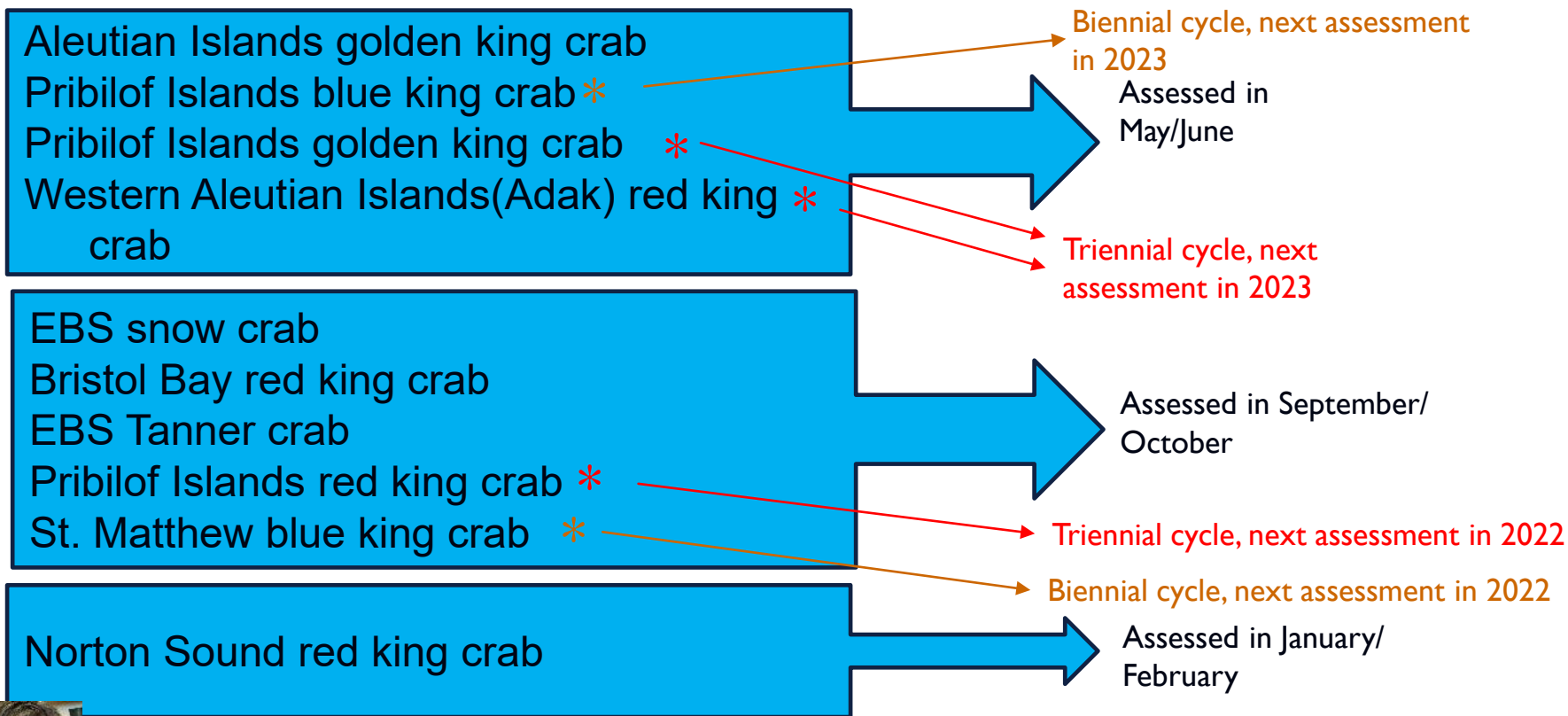
# C1 BSAI CRAB STOCKS

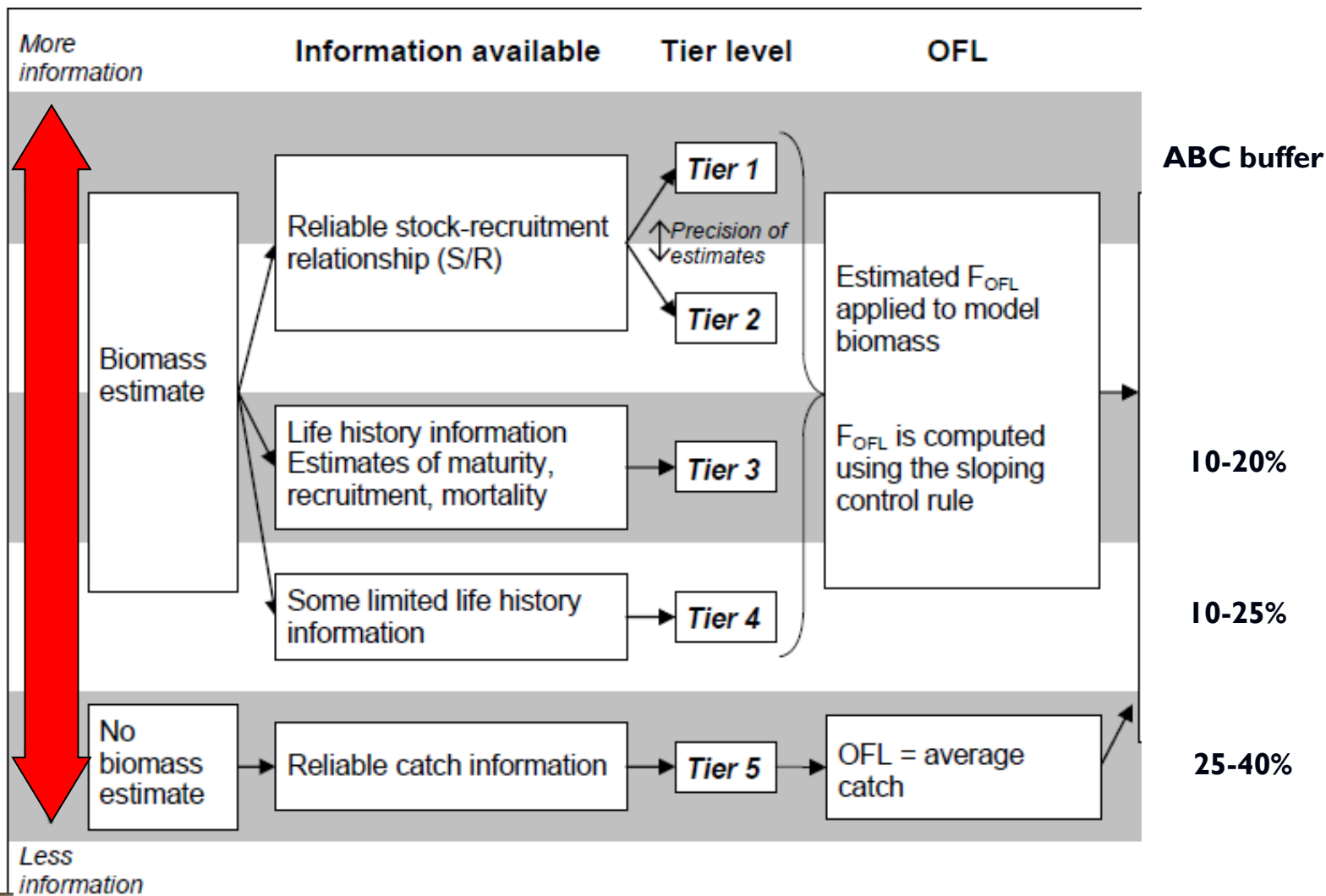
KATIE PALOF & MARTIN DORN,

CPT MEETING MINUTES – SEPT 13-16, 2021



# BSAI CRAB STOCKS MANAGEMENT TIMING





# SEPT 2021 AGENDA

- 2021 bottom trawl survey results
- **Snow crab final assessment, OFL and ABC**, fishery update, **ESP indicator draft**
- **Tanner crab final assessment, OFL and ABC**, fishery update
- **BBRKC final assessment, OFL and ABC**, fishery update, ESP report card update
- Overfishing update and rollover specifications: **PIRKC, SMBKC**
- Risk table: comment on SSC report
- Proposed model runs: **NSRKC**
- Overfishing updates: **WAIRKC, PIGKC, PIBKC, AIGKC**
- Ecosystem status report
- ABSC industry survey updates
- BSFRF research updates
- AFSC climate science regional action plan for EBS and Artic
- GMACS updates
- New business/ co-chair elections



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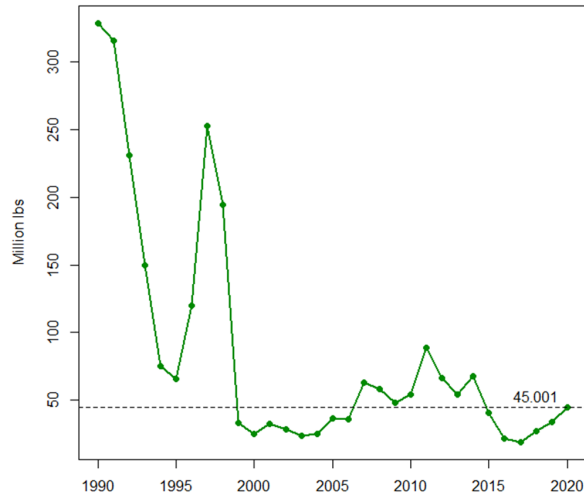
# SNOW CRAB

FINAL ASSESSMENT, OFL/ABC SPECS

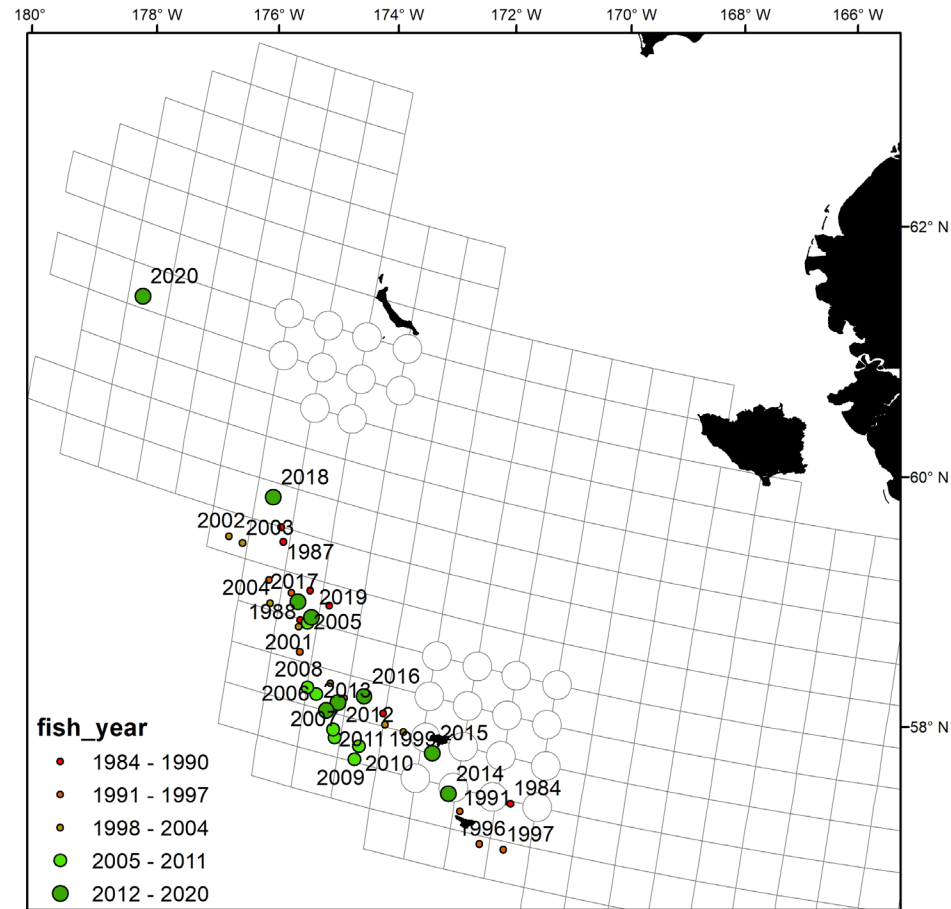
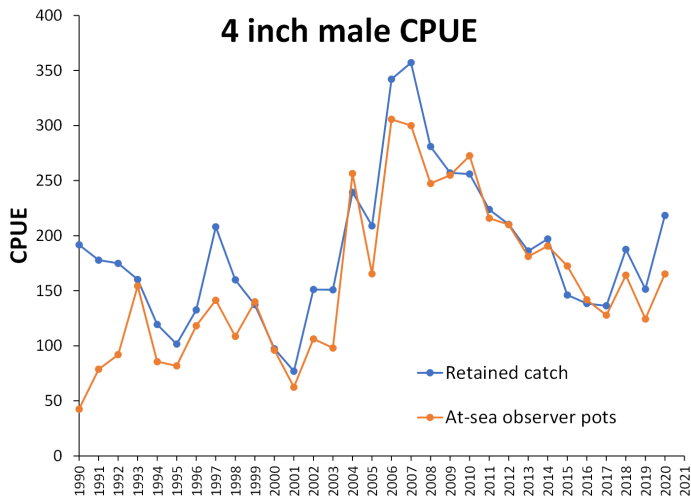


# SNOW CRAB FISHERY UPDATE

snow crab retained catch



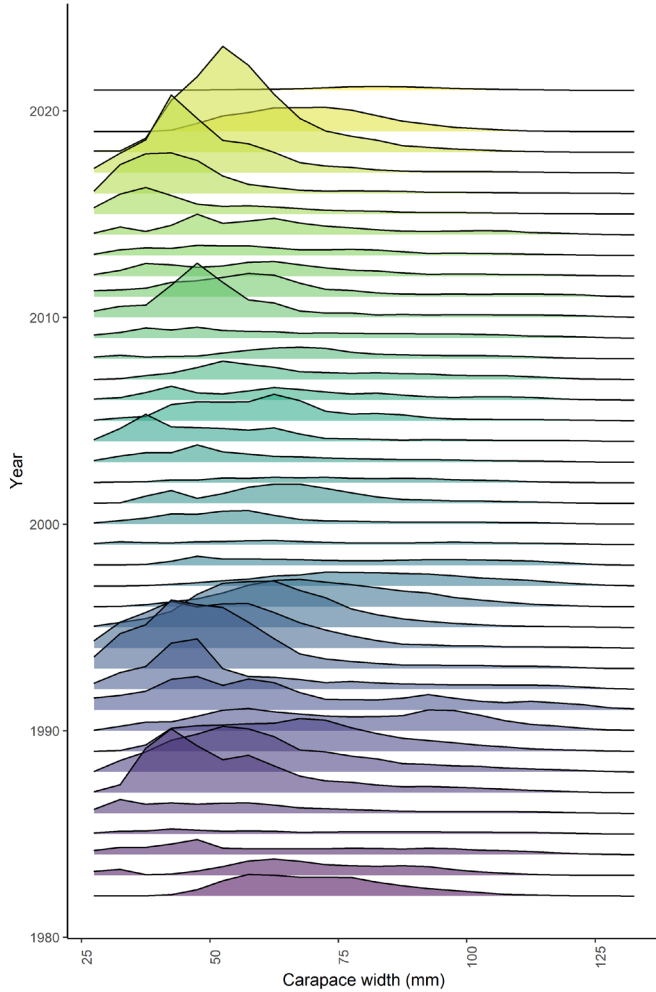
4 inch male CPUE



Record lows

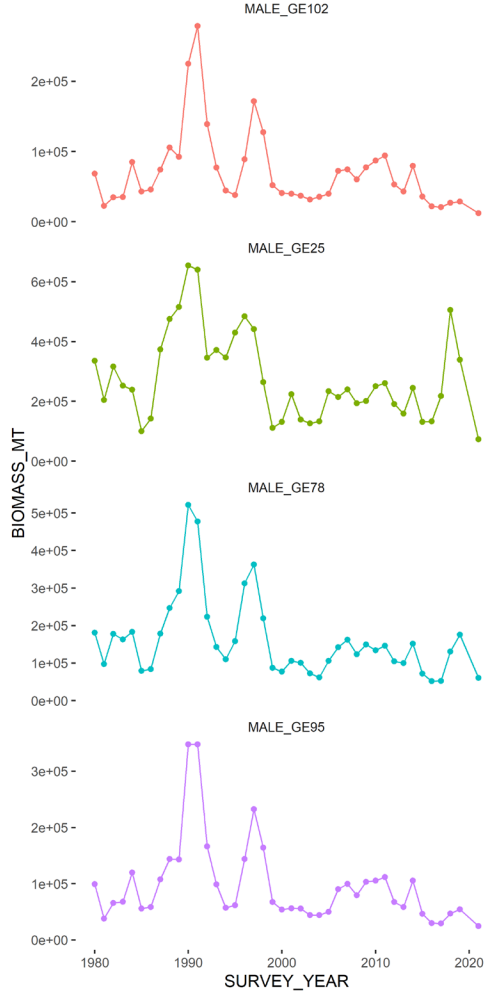
Maturity

What happened?



The drop in observed numbers of male crab at size from 2018 to 2019 was even more severe in 2021.

## Record lows



## Maturity

## What happened?

Nearly every size grouping is at all time lows.

Size group	Current biomass (kt)	Previous low (kt)	Overfished declaration (1999)
>101 mm	12.4	20.7 (2016)	52.0
>24 mm	73.5	99.8 (1985)	111.5
>77 mm	60.1	51.7 (2016)	87.1
>94 mm	24.4	29.4 (2016)	67.4



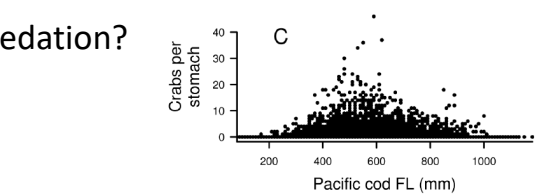
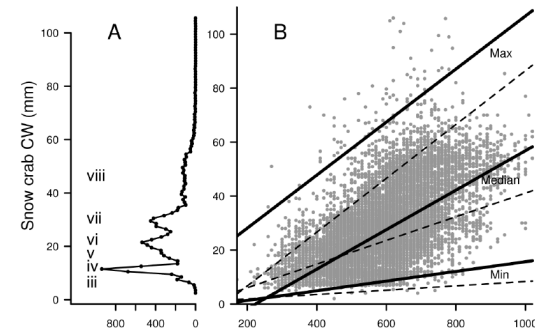
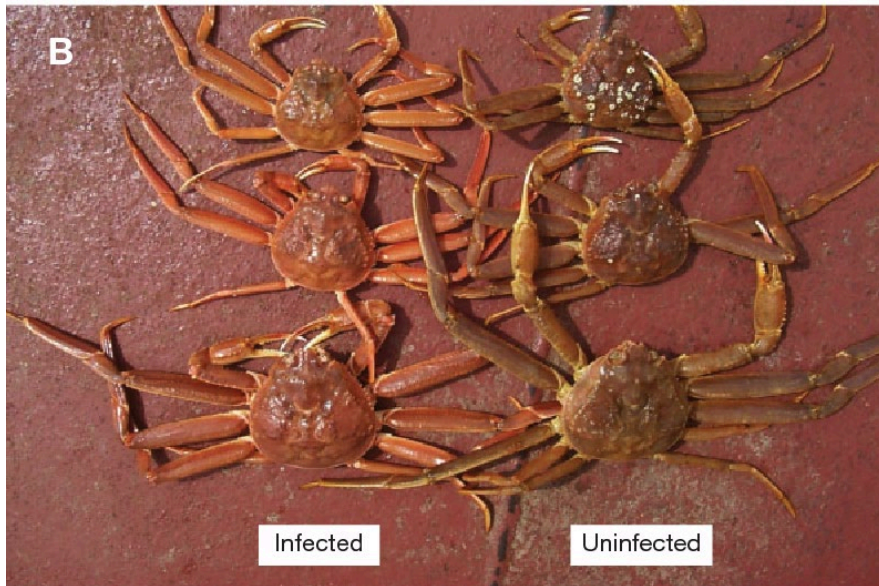
# Record lows

# Maturity

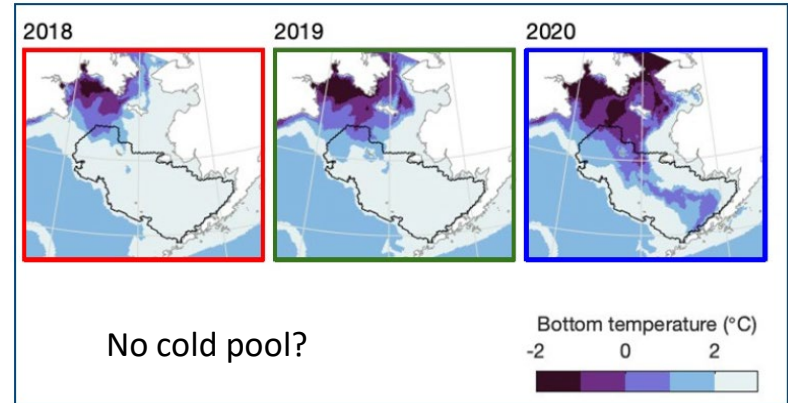
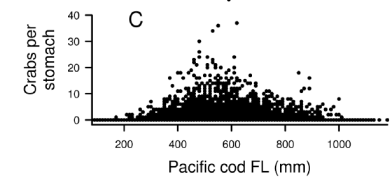
# What happened?

The best available information suggests a mortality event occurred.

Bitter crab syndrome?



Cod predation?



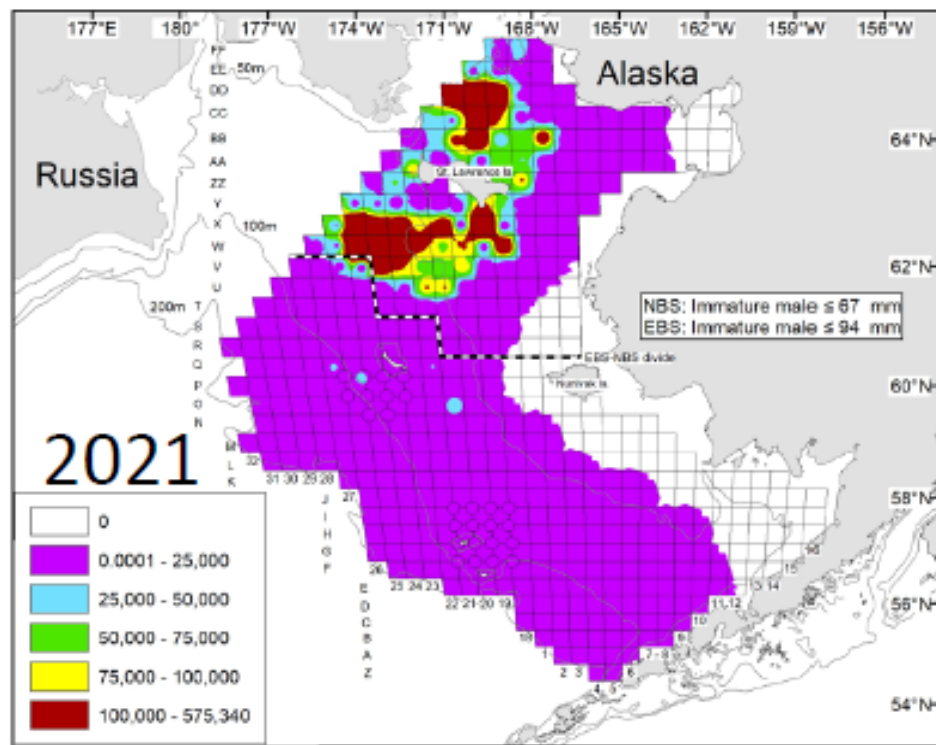
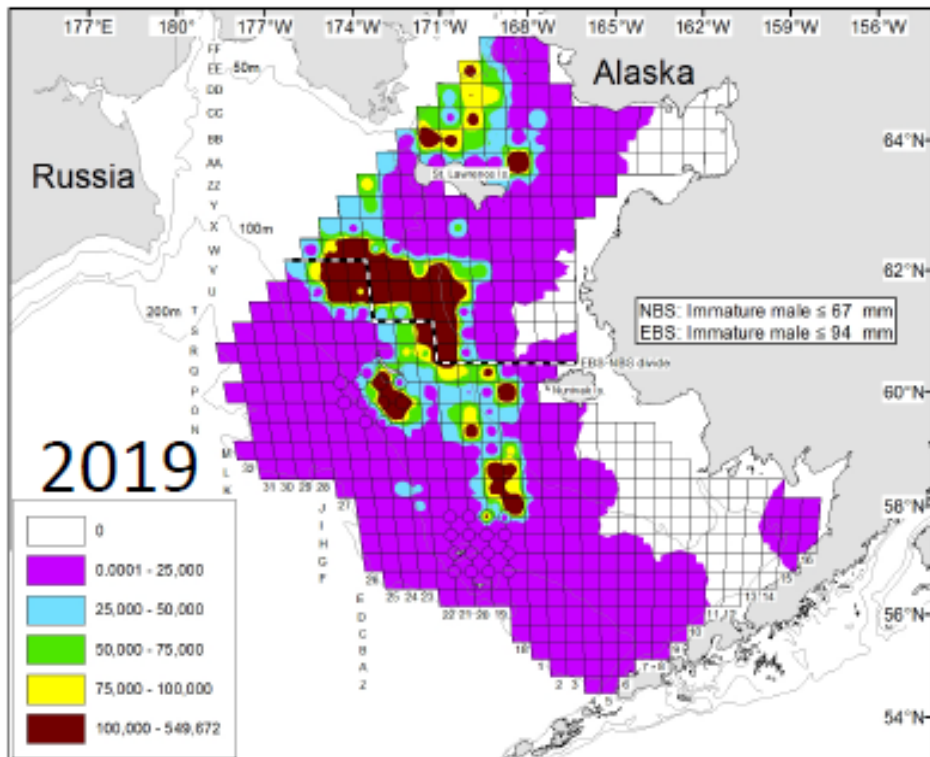
## Possibilities

- The crab are alive:
  - Crab moved into the northern Bering Sea
  - Crab are in the eastern Bering Sea, but the survey didn't see them
  - Crab moved off of the shelf
  - Crab moved into Russian waters
- The crab are dead:
  - Predation
  - Disease
  - Temperature effects
  - Fishery effects
  - Cannibalism

## Possibilities

- The crab are alive:
  - **Crab moved into the northern Bering Sea**
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# Immature males

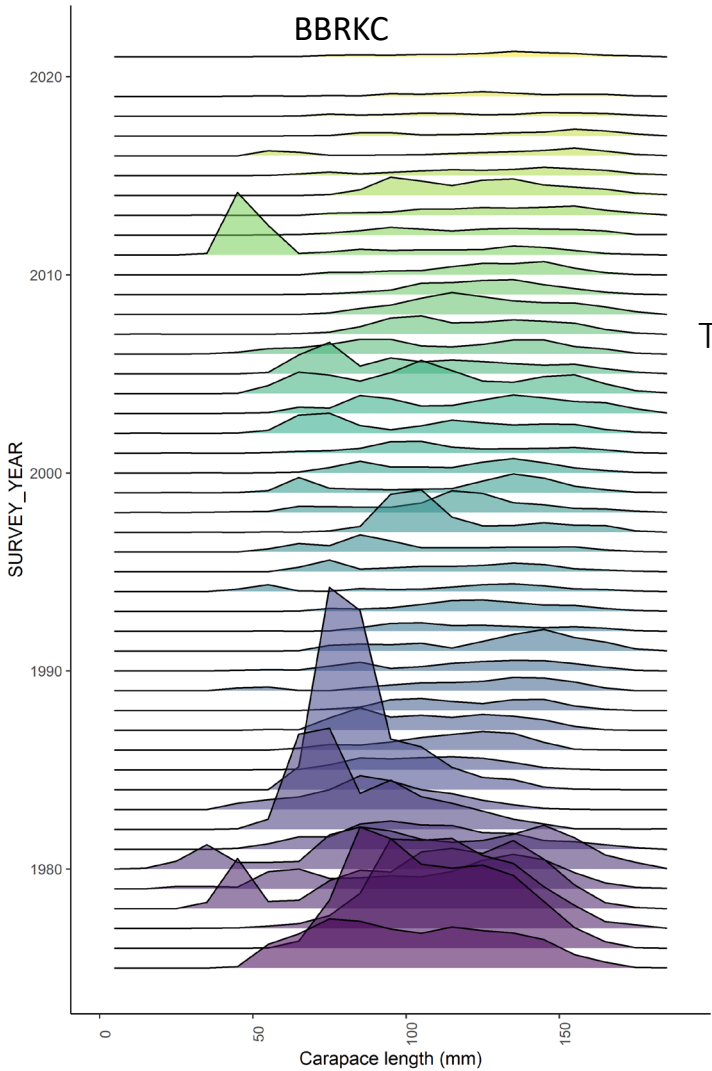


Crab are still present in the NBS, but the densities at size ranges that are missing from the EBS are not sufficiently high to suggest crab from the EBS moved into the NBS.

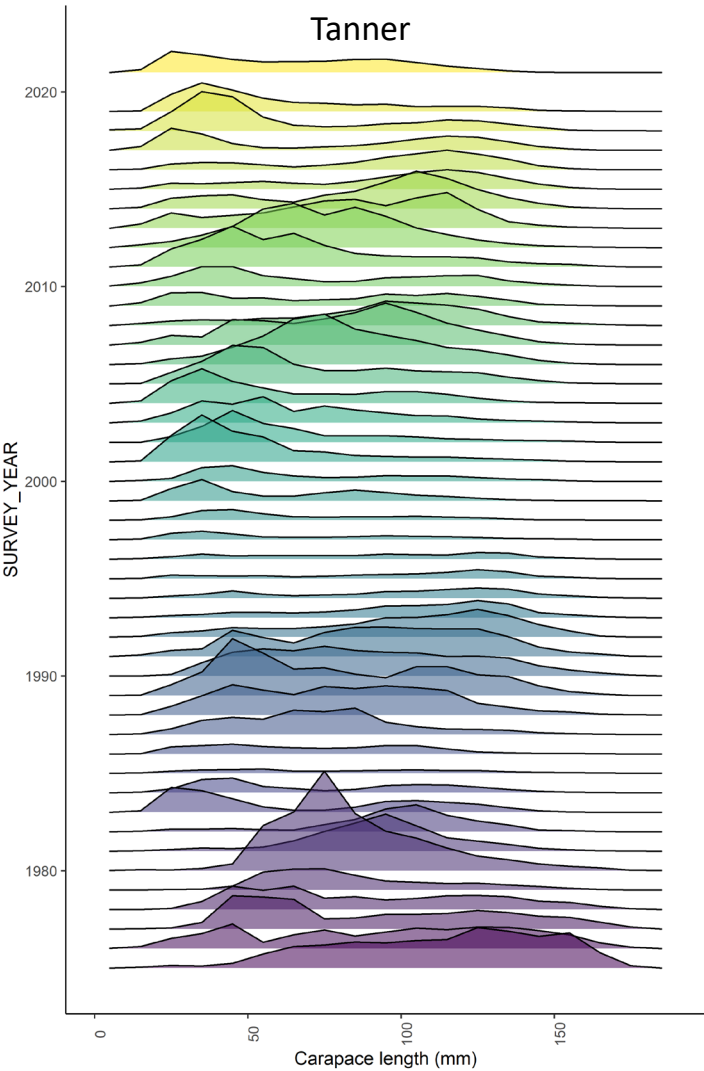
## Possibilities

- The crab are alive:
  - Crab moved into the northern Bering Sea
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  - Disease
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  - Fishery effects
  - Cannibalism

# Snow crab final assessment 2021



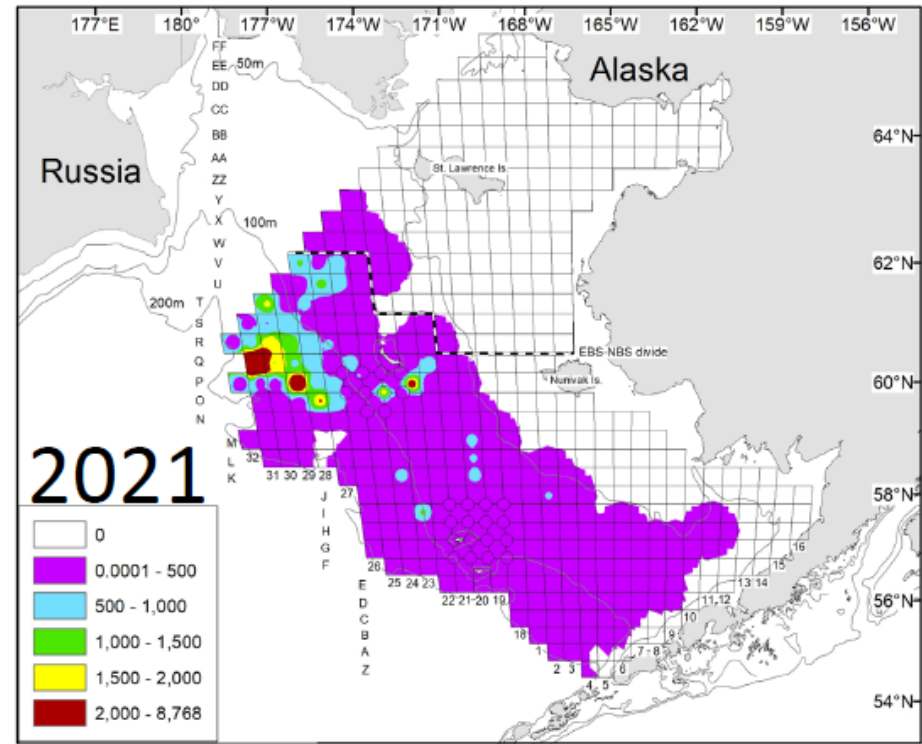
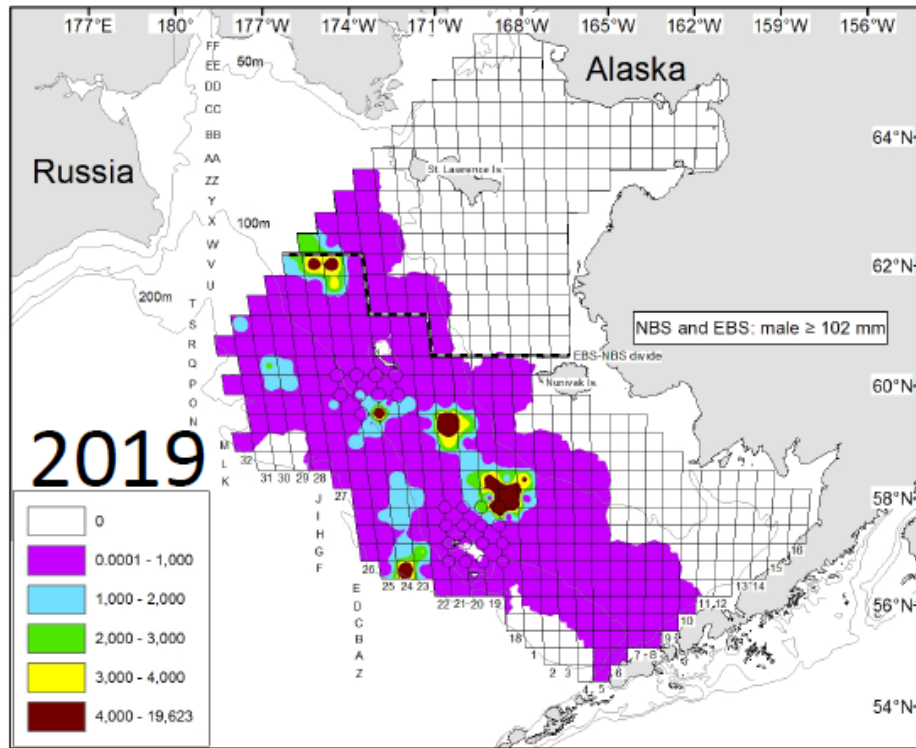
The survey worked as expected for Tanner and BBRKC.



## Possibilities

- The crab are alive:
  - Crab moved into the northern Bering Sea
  - Crab are in the eastern Bering Sea, but the survey didn't see them
  - Crab moved off of the shelf
  - **Crab moved into Russian waters**
- The crab are dead:
  - Predation – increased P.cod predation (2015 to 2019)?
  - Disease – increased bitter crab prevalence (2015 to 2019)
  - Temperature effects
  - Fishery effects
  - Cannibalism

# Industry preferred males



From Mike Litzow et al.

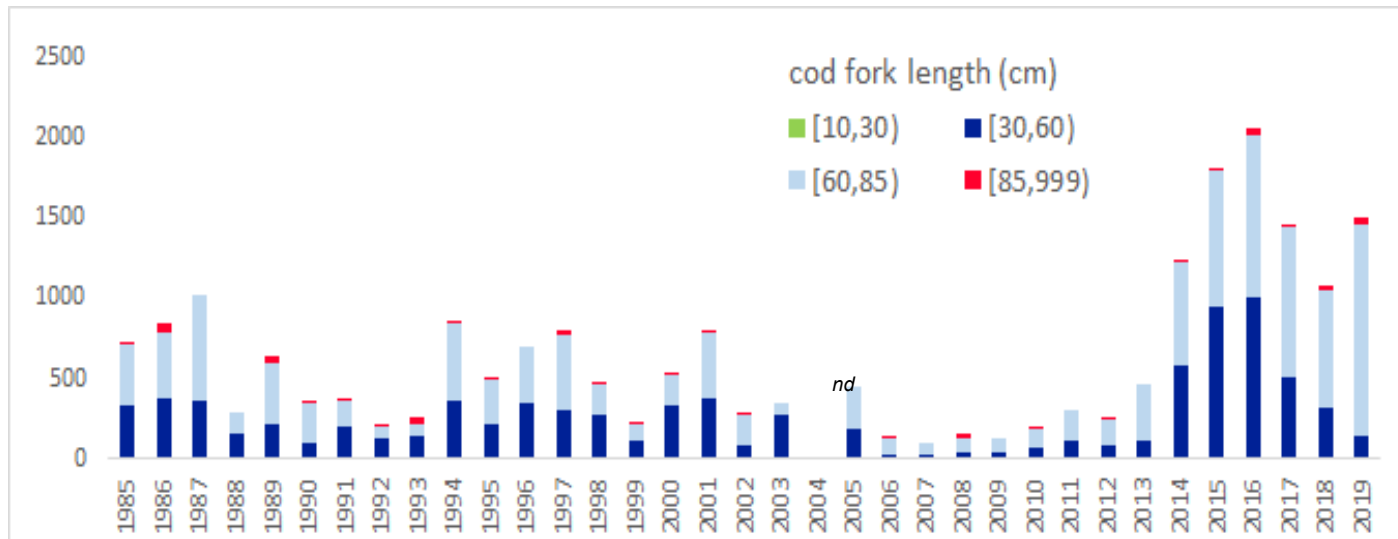
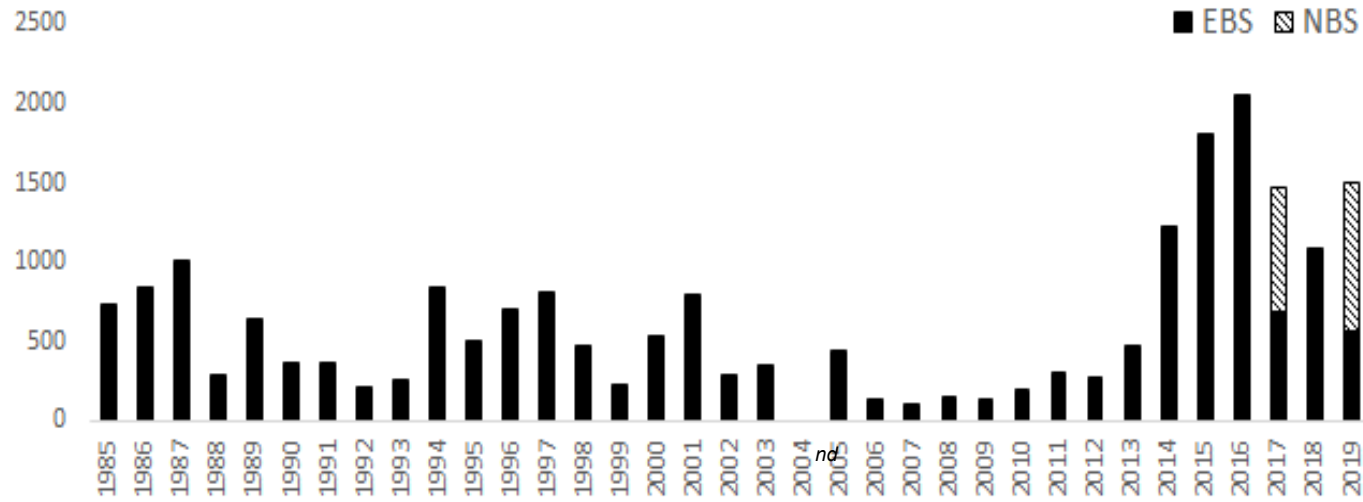


## Possibilities

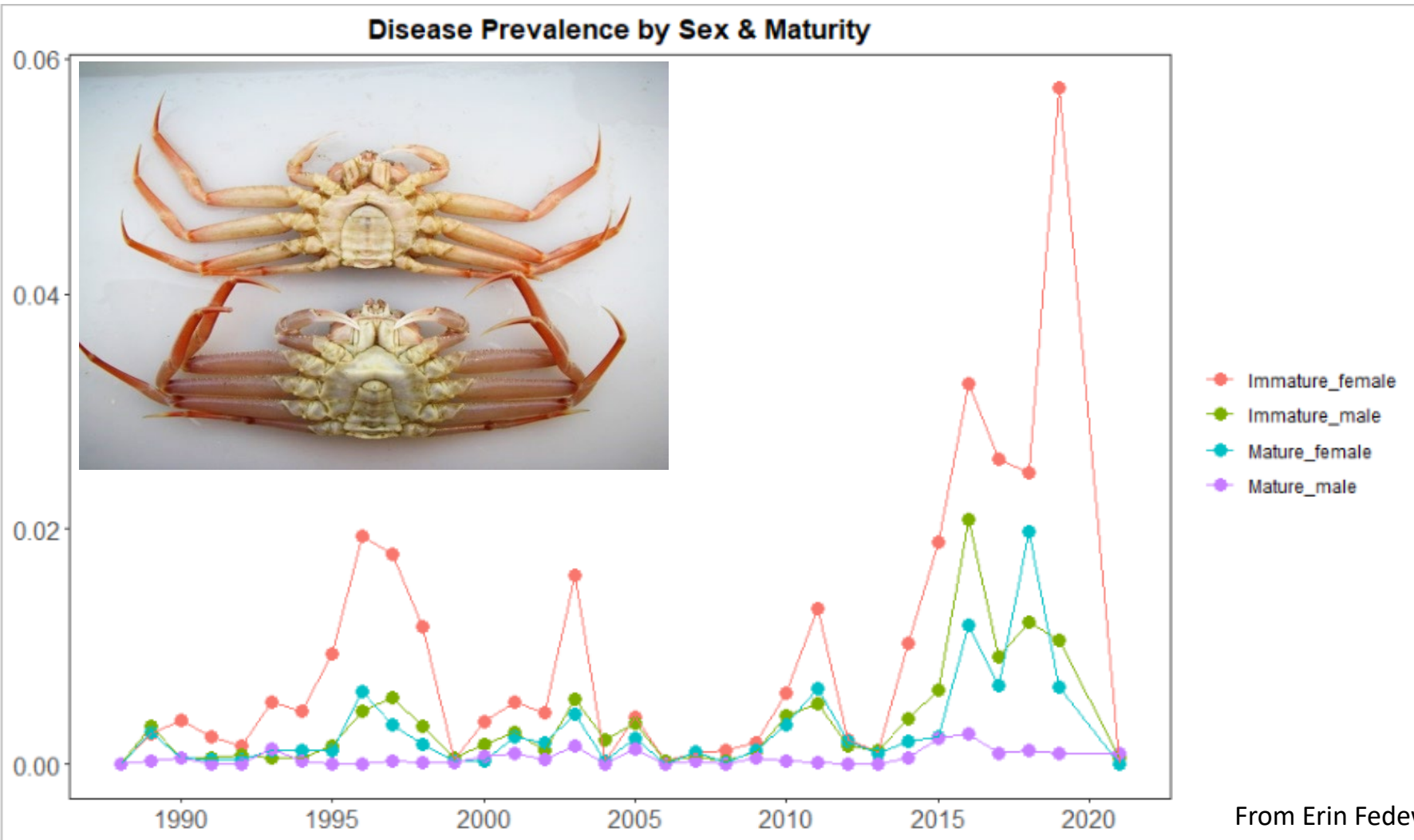
- The crab are alive:
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- The crab are dead:
  - Predation – increased P.cod predation (2015 to 2019)?
  - Disease – increased bitter crab prevalence (2015 to 2019)
  - Temperature effects
  - Fishery effects
  - Cannibalism

# Snow crab final assessment 2021

## Consumption of *C. opilio* by Pacific cod (mt/day)



# Snow crab final assessment 2021



From Erin Fedewa

# Possibilities

- The crab are alive:
  - Crab moved into the northern Bering Sea
  - Crab are in the eastern Bering Sea, but the survey didn't see them
  - Crab moved off of the shelf
  - Crab moved into Russian waters
- The crab are dead:
  - Predation – increased P.cod predation (2015 to 2019)?
  - Disease – increased bitter crab prevalence (2015 to 2019)
  - Temperature effects – 2018, 2019 cold pool smallest since 2003
  - Fishery effects – missing crab largely not vulnerable to directed fishery
  - Cannibalism ???

# Summary

- Missing crab were not in the NBS
- Survey worked as expected for Tanner crab
- Slope area is tiny compared to the area occupied by the animals on the shelf, particularly in the north
- Russian nominal CPUE dropped in 2020 while fishing the line
  
- Cod consumption was at all time highs in past several year
- Visually identified infections of bitter crab were at all time highs recently
- Bitter crab infections known to be more severe than visually identified based on focused PCR work during 2014-2017
- Bottom temperatures very high in 2018 and 2019—no cold pool
- Bycatch increased in 2018 and 2019, spatial foot print was expanded, but estimated fishing mortality very small
- Unobserved bycatch mortality add <15% additional mortality

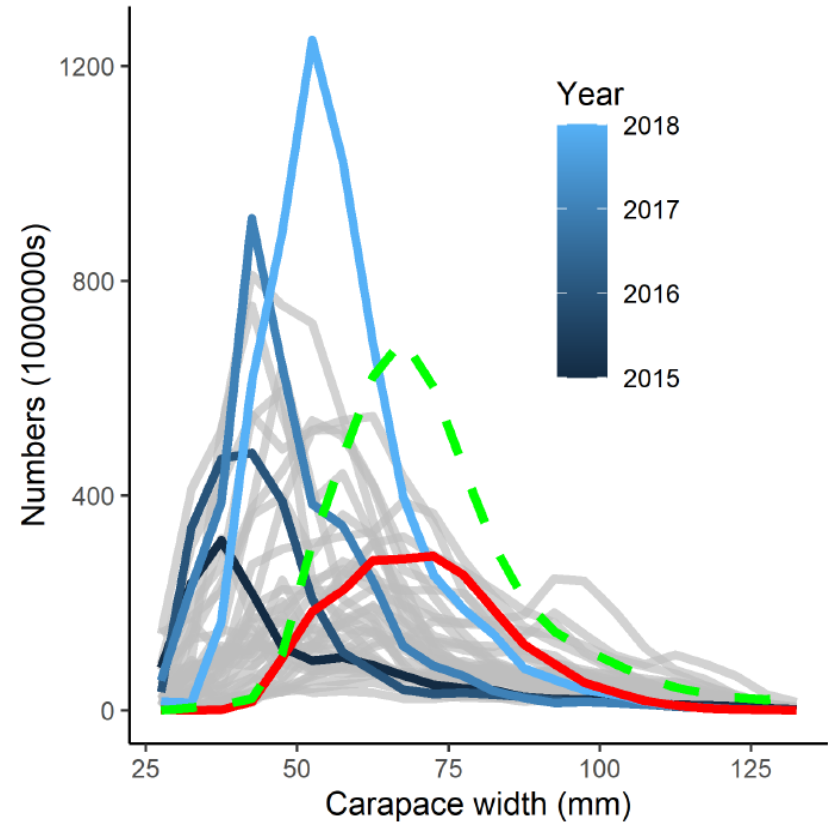
# ASSESSMENT MODELS

- Status quo model with updated data did not converge
- Availability and natural mortality parameters had large gradients
- 3 model options used availability/selectivity and/or mortality events in 2018 & 2019 to deal with unexpected survey results.
- CPT/SSC preferred model was 21.2 – which included a mortality event in 2018 and 2019

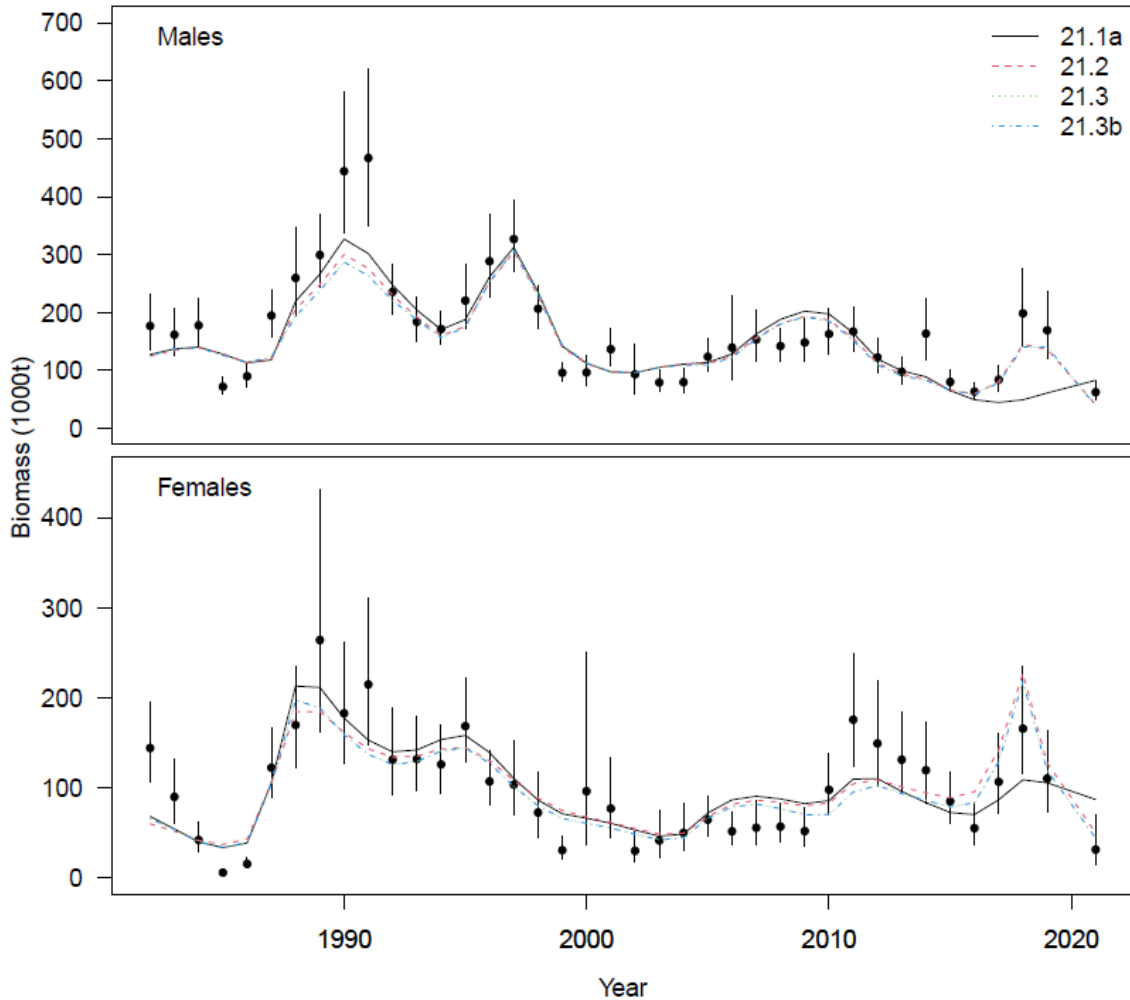


## Mortality Event: Why 2018 and 2019?

- Big decline from 2018 to 2019
- 2020 bycatch was very low, suggesting whatever mortality occurred happened before 2020



# Snow crab final assessment 2021



- If the model is not allowed to reach to the 2018-2019 data points and decline via mortality event, it will 'split the difference' between 2021 and 2018-2019 to some degree.
- This model mis-specification will pull up the estimate of the final year of MMB, which would result in an overly optimistic estimate of exploitable biomass (and giant retrospective patterns).



# Snow crab final assessment 2021

Status and catch specifications (1000 t) for snow crab. 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
2017/18	71.4	99.6	8.6	8.6	10.5	28.4	22.7
2018/19	63.0	123.1	12.5	12.5	15.4	29.7	23.8
2019/20	56.8	167.3	15.4	15.4	20.8	54.9	43.9
2020/21	76.7	26.74	20.4	20.4	26.2	95.4	71.6
2021/22		50.6				7.5	5.6

Status and catch specifications (million lb) for snow crab. 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
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	125.2	368.8	34.0	34.0	45.9	121.0	96.8
2020/21	169.1	58.95	45.0	45.0	57.8	210.3	157.7
2021/22		111.6				16.5	12.4

Year	Tier	B <sub>MSY</sub>	MMB	Status	F <sub>OFL</sub>	Years	M
2021/22	3B	153.4	50.6	0.33	0.37	1982-2020	0.27,0.28



## 25 % buffer on ABC:

- Retrospective patterns
- Model structure uncertainties (trade off between selectivity and mortality)
- Uncertainty around M and mortality event, assuming M returns to reference level
- Unexpected results from 2021 survey
- Additional model uncertainty in functional maturity, is F35% appropriate?
- Definition of reproductive outputs
- Last minute adjustments for model convergence, review ability is smaller



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# REBUILDING REQUIREMENTS REVIEW

DIANA STRAM NPFMC



# NOTIFICATION AND IMPLICATIONS

- Council will receive a notification in October [TBD] from the Agency that EBS Snow crab is overfished.
- MSA requires that a rebuilding plan be prepared and implemented within 2 years
  - Must specify a time frame to rebuild
  - Time frame not to exceed ten years (unless this cannot be accomplished in the absence of all fishing mortality)



# First steps for rebuilding plan = $T_{\min}$ and $T_{\max}$

- Need to specify  $T_{\min}$ 
  - $T_{\min}$  = time the stock or stock complex to rebuild to its MSY biomass level in the absence of any fishing mortality ( $\geq 50\%$  probability)
- Need to specify  $T_{\max}$  (maximum time for rebuilding)
- If  $T_{\min}$  for the stock or stock complex is 10 years or less, then  $T_{\max}$  is 10 years.
- If  $T_{\min}$  for the stock or stock complex exceeds 10 years, then other methods are under to determine  $T_{\max}$
- In situations where  $T_{\min}$  exceeds 10 years,  $T_{\max}$  establishes a maximum time for rebuilding that is linked to the biology of the stock.



# PLANNING FOR CPT MEETING (JANUARY)

- **Consideration 1:** projections of  $T_{\min}$  and  $T_{\max}$ 
  - If  $T_{\min}$  or the stock or stock complex is 10 years or less, then  $T_{\max}$  is 10 years.
- **Consideration 2:** Continued discussions of what factors appear to be causing observed decline
- Report back to SSC, AP, Council in February the results of both considerations
- Council to begin to draft alternatives in February for analysis in a rebuilding plan



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# BBRKC

FINAL ASSESSMENT 2021

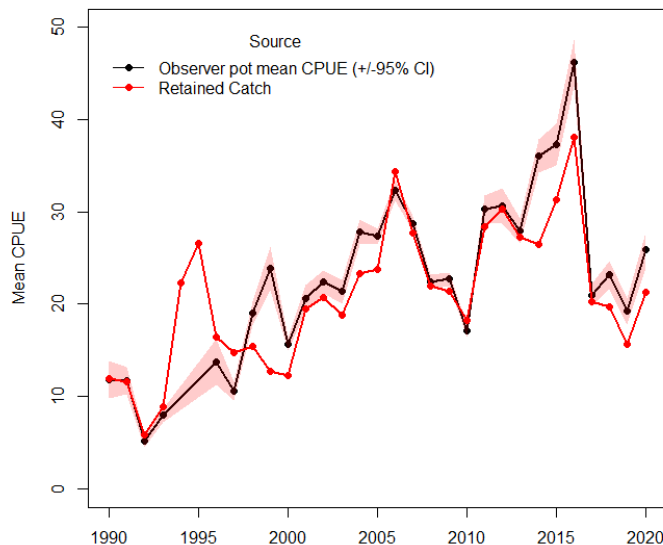


# BBRKC FISHERY UPDATE

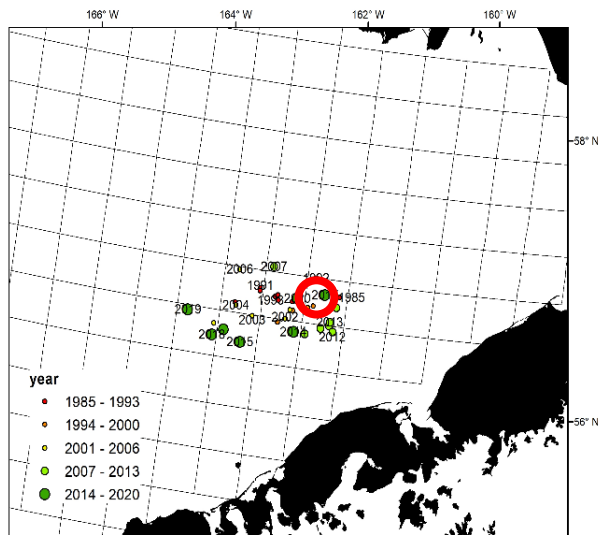
BBRKC retained catch



BBRKC legal male CPUE

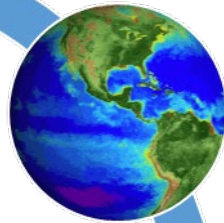


- Total catch for 2020/21 2771 mil lb, lowest catch in recent history
- Captains reported high CPUE fishing with nearly all new shell crab.
- Majority of captains reported that they saw more recruits in the pots than in the two previous seasons.
- Most captains reported seeing “some” females.
- Effort was well distributed across the fishing grounds, with vessels fishing more of the “traditional” areas to the east.
- Bycatch occurred primarily in yellowfin sole (stable) and pot cod fisheries (much reduced)



# BBRKC REPORT CARD: ECOSYSTEM INDICATORS

## Ecosystem Indicators



Physical



Lower Trophic



Upper Trophic

- + 1. Arctic Oscillation (climate model)
- + 2. Cold pool extent (BTS)
- + 3. Summer bottom temperature (BTS)
- + 4. pH index (ocean model)
- + 5. Production (chlorophyll *a*, satellite)
- 6. Wind stress (satellite)
- + 7. Benthic invertebrate biomass (BTS)
- 8. Juvenile sockeye salmon abundance (BAS)
- 9. Pacific cod biomass (BTS)
- + 10. Male recruit biomass (BTS)
- 11. Area Occupied (BTS)
- + 12. Catch distance from shore (BBRKC fishery)





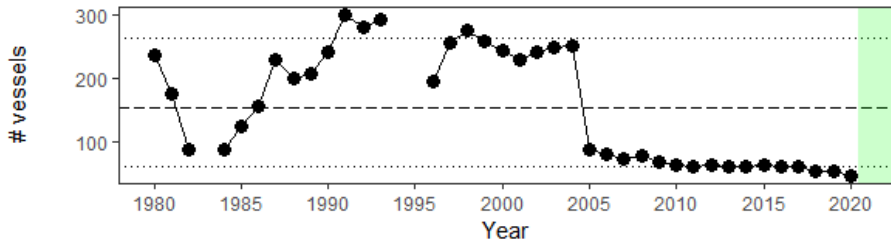
# ECOSYSTEM CONSIDERATIONS

- Above-average wind stress and persistently low levels of chlorophyll-*a* in Bristol Bay could indicate **poor larval feeding conditions** and **increased predation** on BBRKC early life stages
- Delayed spring BBRKC hatching relative to mid-May peak bloom timing may have resulted in a **spatiotemporal mismatch** between first-feeding larvae and preferred diatom prey.
- The cold pool did not extend into Bristol Bay in summer 2021, suggesting **optimal conditions for embryo development** and potentially **greater larval retention** within Bristol Bay
- Red king crab have experienced a **steady decline in bottom water pH** in the past 5 years.
- Spatial extent of mature female red king crab in Bristol Bay was above average in 2021 despite declines in abundance. **Northwest shifts in stock distribution** may limit the effectiveness of central Bristol Bay trawl closure areas designated to protect red king crab.

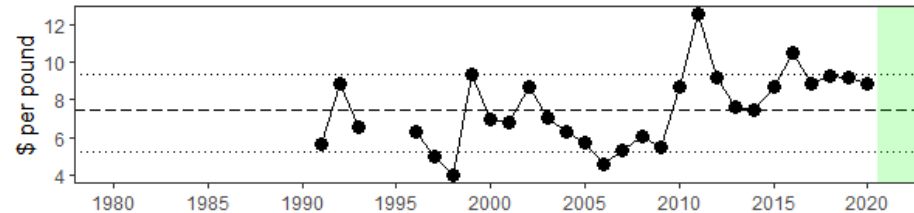


# SOCIOECONOMIC INDICATOR TIME SERIES

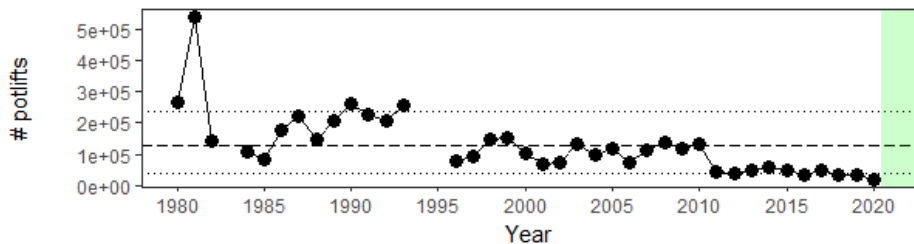
### Vessels Active in Fishery



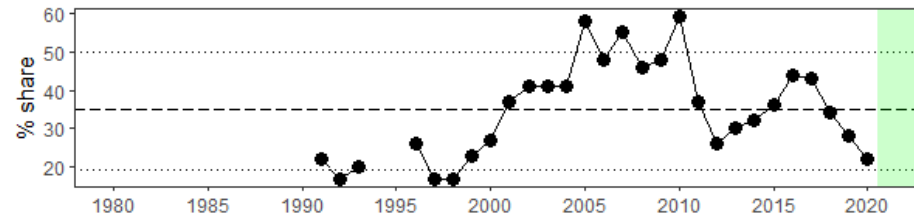
### Ex-vessel Price per Pound



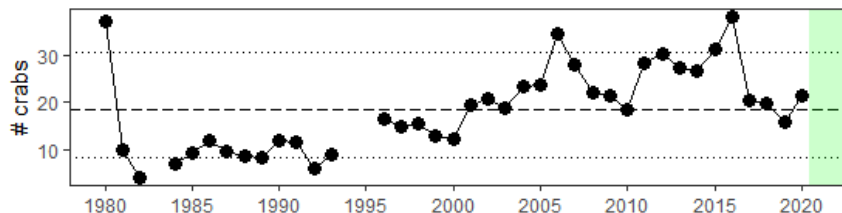
### Total Potlifts



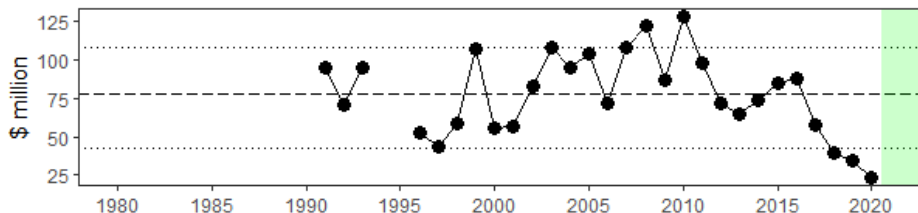
### BBRKC Ex-vessel Revenue Share



### CPUE



### Ex-vessel value of BBRKC landings

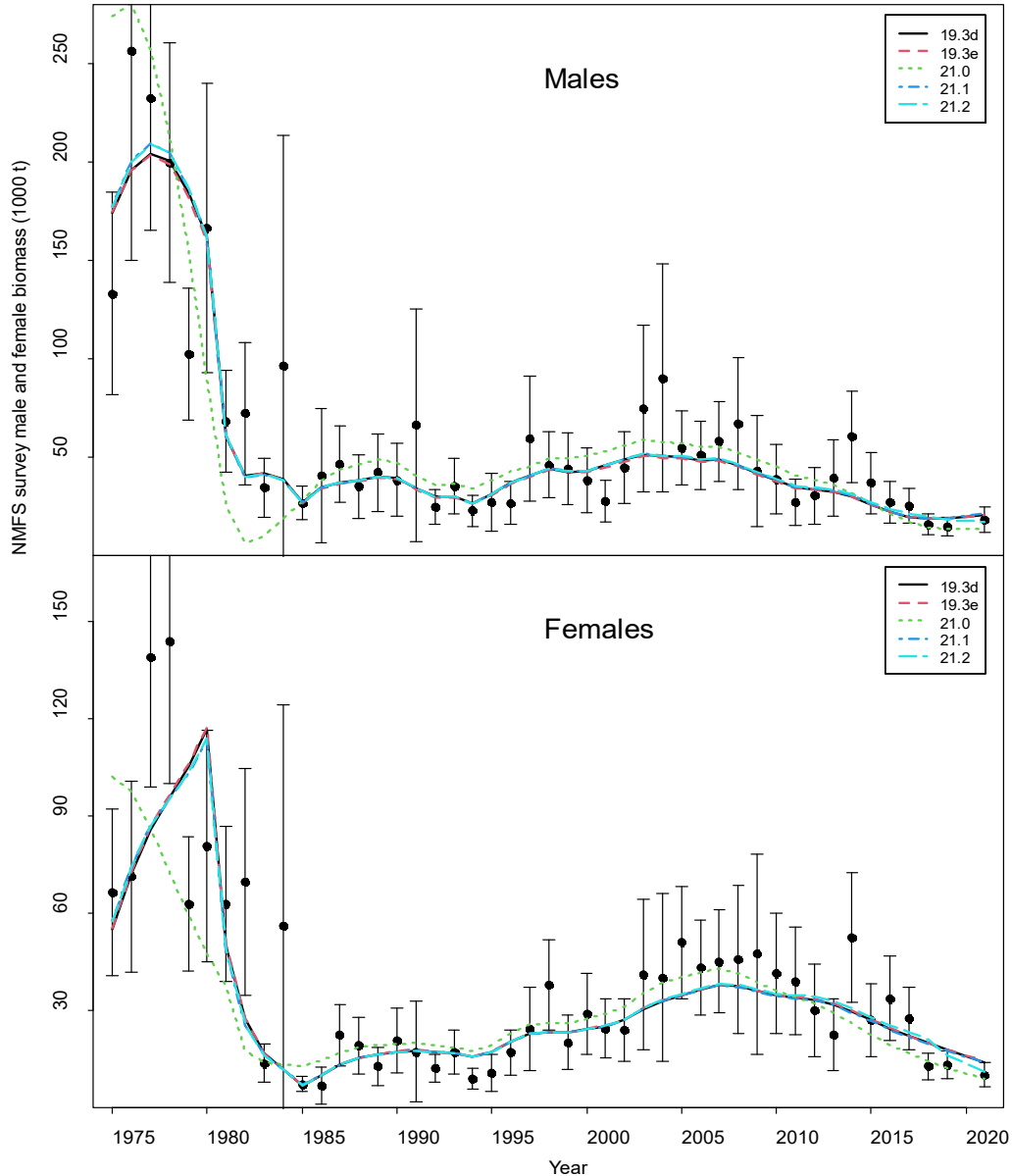


Indicator	2016 Status	2017 Status	2018 Status	2019 Status	2020 Status
Annual Red King Crab Active Vessels BBRKC Fishery	low	low	low	low	low
Annual Red King Crab Total Potlift BBRKC Fishery	neutral	neutral	neutral	neutral	low
Annual Red King Crab Potlift CPUE BBRKC Fishery	high	neutral	neutral	neutral	neutral
Annual Red King Crab Exvessel Price BBRKC Fishery	high	neutral	neutral	neutral	neutral
Annual Red King Crab Exvessel Revenue Share BBRKC Fishery	neutral	neutral	neutral	neutral	low
Annual Red King Crab Exvessel Value BBRKC Fishery	neutral	neutral	low	low	low

# BBRKC FINAL ASSESSMENT 2021

- Survey results: males slight increase, drop in females, overall abundance remains low
  - Female abundance below State of Alaska management threshold directed fishery is closed for 2021/22 season
- New data: 2021 survey data, directed fishery data, groundfish bycatch (abundance and size comps)
- Explored alternative configurations of for sex-specific catchability and selectivity (6 models examined)
- Model 21.1 preferred by the CPT
  - Simplification of selectivity parameters





Comparisons of area-swept estimates of male and female NMFS survey biomass and model prediction for model estimates in 2021 under five models. The error bars are plus and minus 2 standard deviations of model 19.3d.



## Status and catch specifications (1,000 t) (model 21.1):

Year	MSST	Biomass (MMB)	TAC	Retained Catch	Total Catch	OFL	ABC
2017/18	12.74 <sup>A</sup>	24.86 <sup>A</sup>	2.99	3.09	3.60	5.60	5.04
2018/19	10.62 <sup>B</sup>	16.92 <sup>B</sup>	1.95	2.03	2.65	5.34	4.27
2019/20	12.72 <sup>C</sup>	14.24 <sup>C</sup>	1.72	1.78	2.22	3.40	2.72
2020/21	12.12 <sup>D</sup>	13.96 <sup>D</sup>	1.20	1.26	1.57	2.14	1.61
2021/22		14.95 <sup>D</sup>				2.23	1.78

## Basis for the OFL: Values are in 1,000 t (model 21.1):

Year	Tier	B <sub>MSY</sub>	Current MMB	B/B <sub>MSY</sub> (MMB)	F <sub>OFL</sub>	Years to define B <sub>MSY</sub>	Natural Mortality
2017/18	3b	25.1	21.3	0.85	0.24	1984-2017	0.18
2018/19	3b	25.5	20.8	0.82	0.25	1984-2017	0.18
2019/20	3b	21.2	16.0	0.75	0.22	1984-2018	0.18
2020/21	3b	25.4	14.9	0.59	0.16	1984-2019	0.18
2021/22	3b	24.2	14.9	0.62	0.17	1984-2020	0.18

Model 21.1, base ABC buffer 20%



# CPT DISCUSSION ON ABC BUFFERS FOR BBKRC

- ABC base buffer 20%
- In 2020, the CPT recommended a larger buffer of 25% to account for the lack of a 2020 bottom trawl survey
- Uncertainty due to a cancelled survey is not relevant this year (no follow-on effects)
- Similar uncertainties exist as previously for this assessment:
  - Cold pool distributional shifts
  - Declining trends in mature biomass
  - Lack of recruitment,
  - Retrospective patterns
  - Poor recent environmental conditions
- CPT recommends reverting to a buffer of 20%



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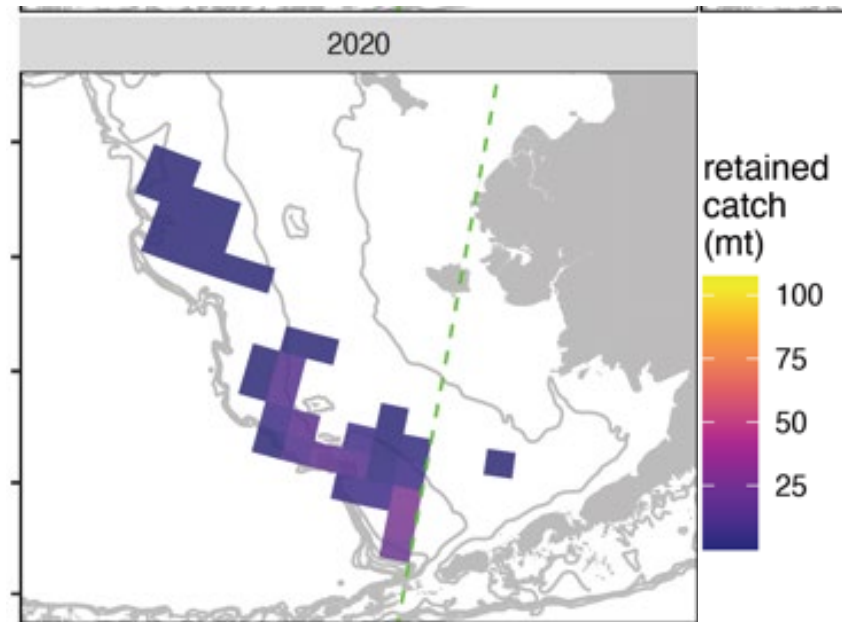
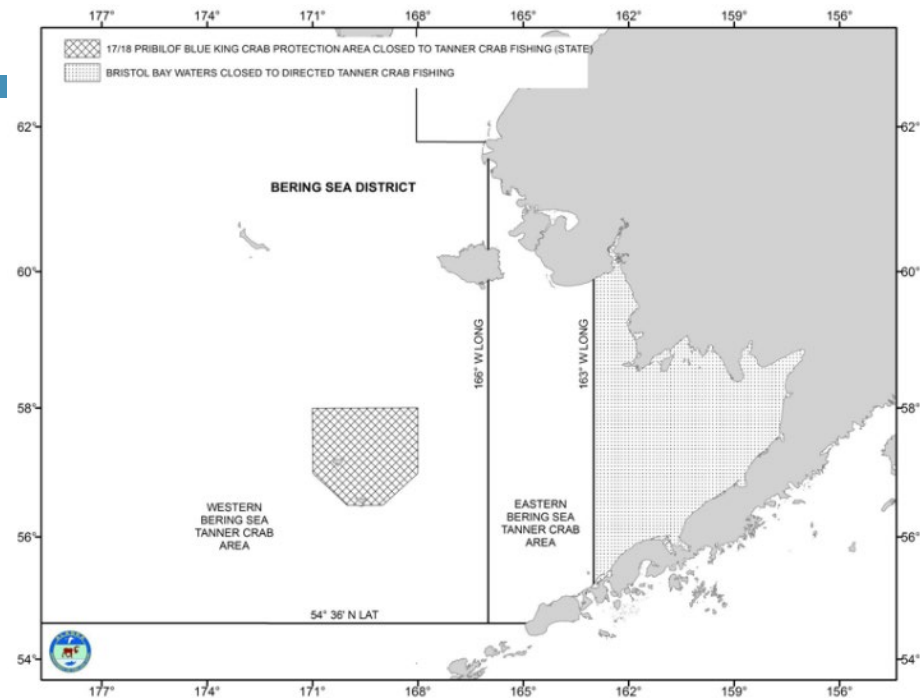
# TANNER CRAB

FINAL ASSESSMENT, OFL/ABC SPECS



## OVERVIEW

- 2020/21 Federal management
  - OFL: 21,130 t
  - ABC: 16,900 t
  - Total catch mortality: 960 t
    - mostly taken in directed fishery
- ADFG management
  - Eastern Area closed
    - MMB failed to meet threshold
  - Western Area
    - TAC: 1,070 t
    - Retained catch: 660 t
    - 41 vessels participated
    - CPUE: 21

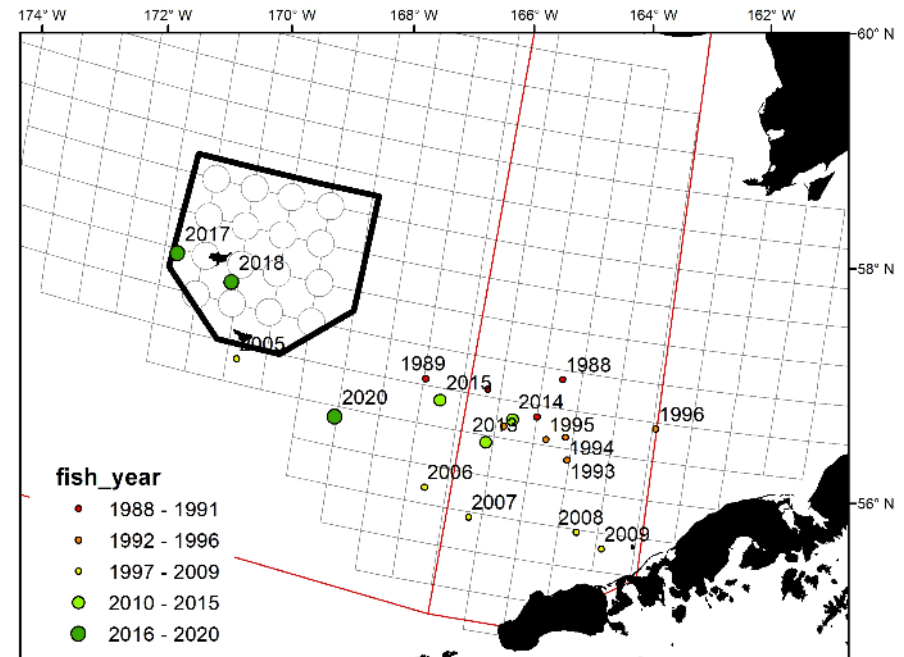
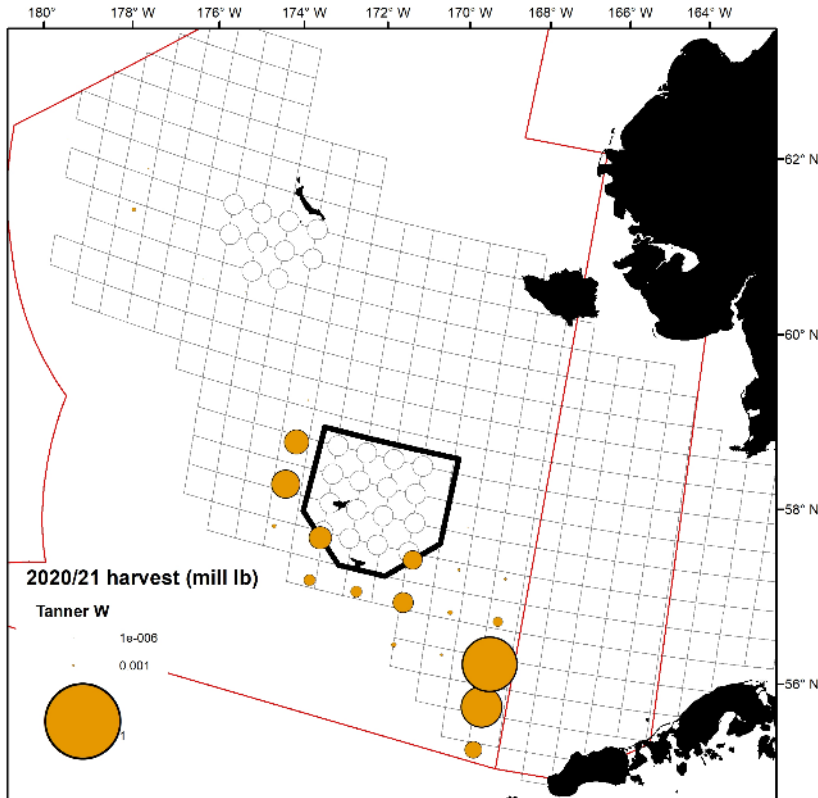




# 2020/21 TANNER CRAB RETAINED CATCH

## Fleet observations:

- Low cpue across WBT in fall after BBRKC
- Many vessels quit after one trip
- Good pots of legal crab here and there, but hard to find.



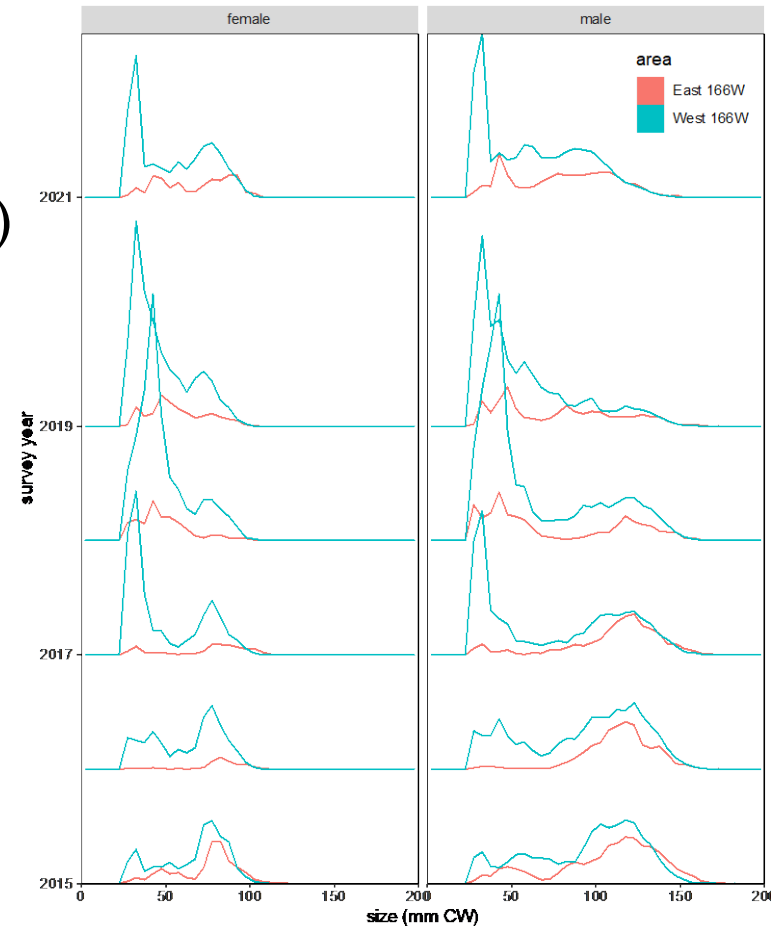
# OVERVIEW:

## Surveys

- 2021 NMFS EBS Shelf Survey Biomass
  - 31,138 t male biomass (+10%)
  - 4,409 t industry-preferred males (-55%)
  - 8,420 t mature female biomass (+77%)
- Concern:
  - lots of recent recruitment but it is not moving into larger size classes

## 2021/22 Management

- Based on preferred model (21.22a)
  - Tier 3a ( $B > B_{MSY}$ ; not overfished)
  - OFL: 27,170 t, ABC: 21,740 t

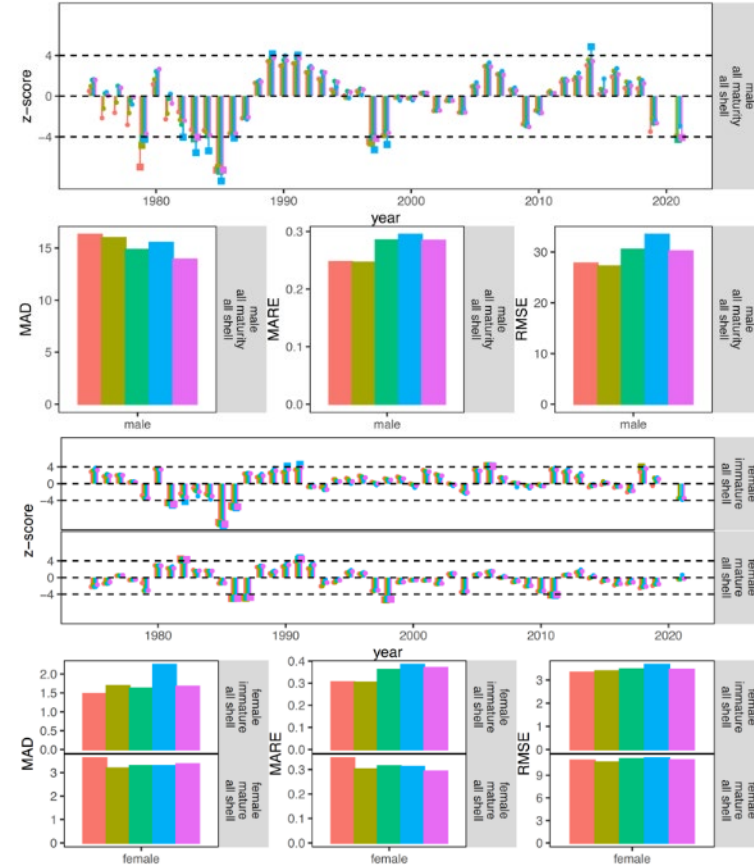
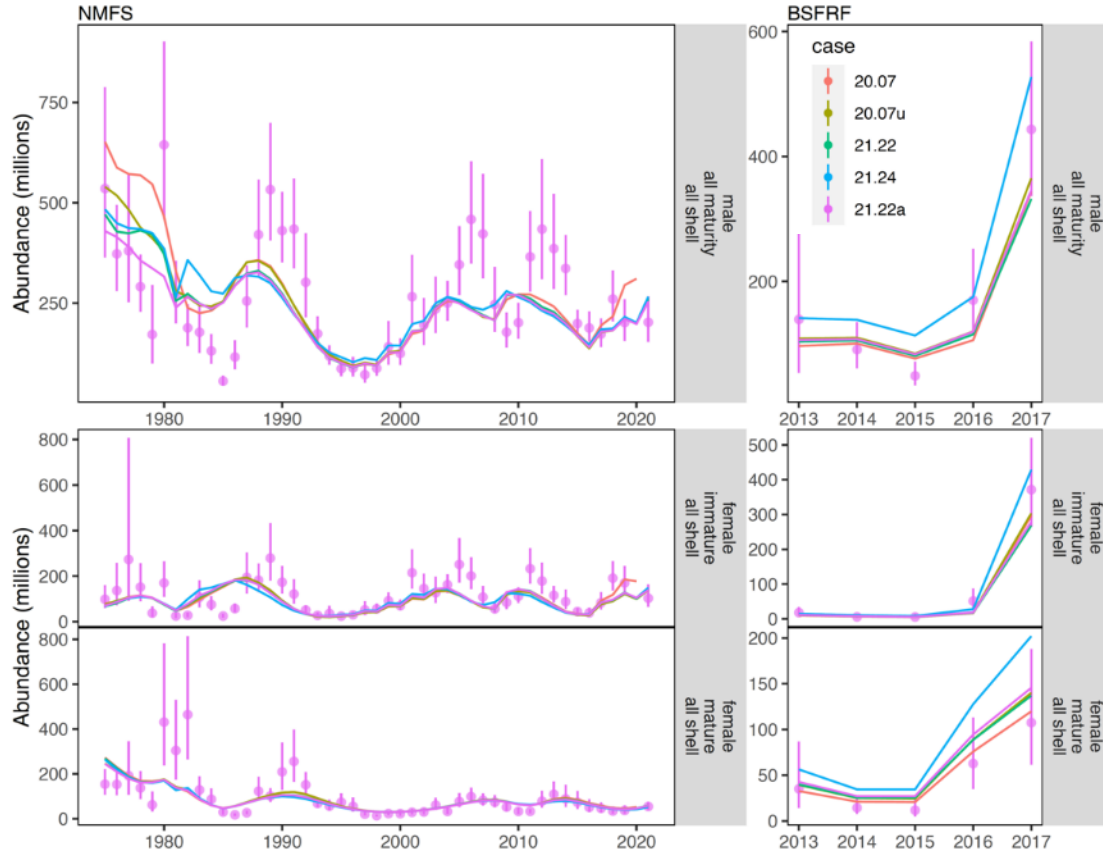


# TANNER CRAB FINAL ASSESSMENT 2021

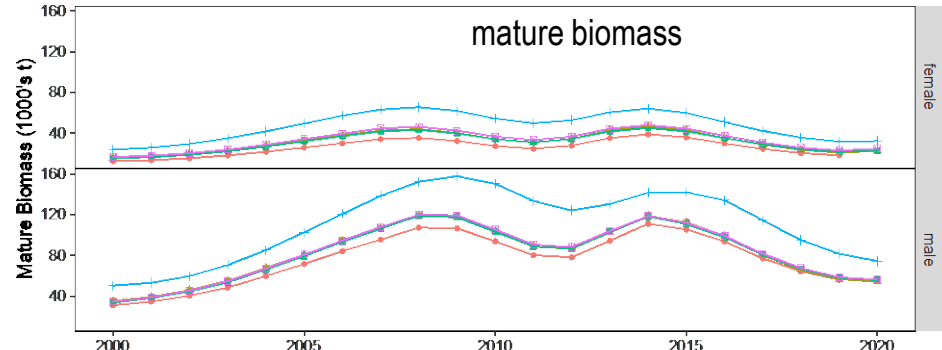
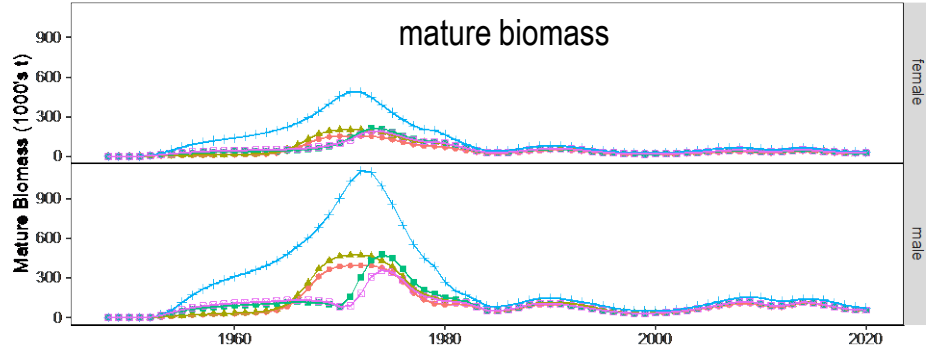
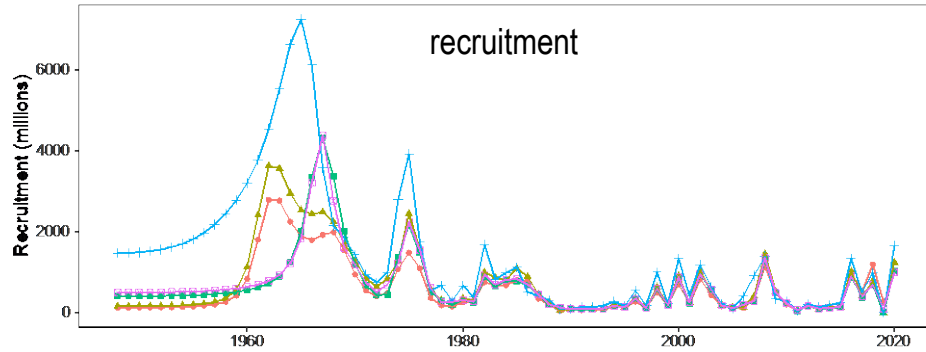
- Evaluated 4 models suggested by CPT/SSC from May 2021
  - Address model specifications; specifically, parameter distributions, bounds, and overall model complexities
- Model 21.22a endorsed by the CPT and author as preferred model
  - Model without parameter bound issues
  - Better convergence than 2020 model to the MLE estimate



# Diagnostic fits to NMFS Survey Abundance



# Population Results



# STOCK STATUS

- Tier 3a
- Not overfished
- No overfishing

Year	MSST	Biomass (MMB)	TAC (East + West)	Retained Catch	Total Catch Mortality	OFL	ABC
2017/18	15.15	64.09	1.13	1.13	2.37	25.42	20.33
2018/19	20.54	82.61	1.11	1.11	1.90	20.87	16.70
2019/20	18.31	56.15	0.00	0.00	0.54	28.86	23.09
2020/21	17.97	56.34	1.07	0.66	0.96	21.13	16.90
2021/22		42.57				27.17	21.74

Year	Tier	B <sub>M<sub>SY</sub></sub>	Current MMB	B/B <sub>M<sub>SY</sub></sub>	F <sub>OFL</sub> (yr <sup>-1</sup> )	Years to define B <sub>M<sub>SY</sub></sub>	Natural Mortality (yr <sup>-1</sup> )
2017/18	3a	29.17	47.04	1.49	0.75	1982-2017	0.23
2018/19	3a	21.87	23.53	1.08	0.93	1982-2018	0.23
2019/20	3b	41.07	39.55	0.96	1.08	1982-2019	0.23
2020/21	3b	36.62	35.31	0.96	0.93	1982-2019	0.23
2021/22	3a	35.94	42.57	1.18	1.17	1982-2020	0.23

\*immature: 0.23, females: 0.31, males: 0.30  
(Table 40, p. 108)



# CPT DISCUSSION ON ABC BUFFERS FOR TANNER CRAB

- ABC base buffer 20% (last two years)
- Improvements in parameter bound issues and convergence compared to 2020
- Similar uncertainties exist as previously for this assessment:
  - Overestimation of large crab
  - Overestimation of terminal survey biomass
- New uncertainties include:
  - Recruitment potential (smaller crab) not materializing in the larger crab portion of the stock
  - Low estimation of 2019 recruitment due to lack of a 2020 survey data point, lasting effect of 2020 missing survey
- CPT recommends a 20% buffer for 2021



# ROLL-OVER STOCKS: SMBKC

- Moved to a biennial assessment (next full assessment in 2022)
- Overfished, rebuilding plan put into place in 2020
- Total catch (all bycatch mortality) <<< ABC – no overfishing
- Recommendation is to rollover specs from 2020, similar bycatch mortality and no indication of increased risk or morality for this stock

Table 1: Status and catch specifications (1000 t) for the base model.

Year	MSST	Biomass ( $MMB_{\text{mating}}$ )	TAC	Retained catch	Total male catch	OFL	ABC
2017/18	1.85	2.05	0.00	0.00	0.003	0.12	0.10
2018/19	1.74	1.15	0.00	0.00	0.001	0.04	0.03
2019/20	1.67	1.06	0.00	0.00	0.001	0.04	0.03
2020/21		1.12	0.00	0.00	0.001	0.05	0.04
2021/22		1.12				0.05	0.04

Table 3: Basis for the OFL (1000 t) from the base model.

Year	Tier	$B_{MSY}$	Biomass ( $MMB_{\text{mating}}$ )	$B/B_{MSY}$	$F_{OFL}$	$\gamma$	Basis for $B_{MSY}$	Natural mortality
2017/18	4b	3.86	2.05	0.53	0.08	1	1978-2017	0.18
2018/19	4b	3.7	1.15	0.35	0.043	1	1978-2017	0.18
2019/20	4b	3.48	1.06	0.31	0.042	1	1978-2018	0.18
2020/21	4b	3.34	1.12	0.34	0.047	1	1978-2019	0.18
2021/22	4b	3.34	1.12	0.34	0.047	1	1978-2019	0.18





# ROLL-OVER STOCKS: PIRKC

- Moved to a triennial assessment (next full assessment in 2022)
- Total catch (all bycatch mortality) <<< ABC – no overfishing
- Recommendation is to rollover specs from 2019 assessment
  - Similar bycatch mortality
  - No directed fishing due to overfished PIBKC that would be likely bycatch
  - No increased risk for rolling over the specifications this year

Year	MSST (t)	Biomass (MMB)	TAC	Retained Catch	Total Catch	OFL	ABC
2015/16	2,756	9,062	0	0	4.32	2,119	1,467
2016/17	2,751	4,788	0	0	0.94	1,492	1,096
2017/18	2,751	3,439	0	0	1.41	404	303
2018/19	866	5,368	0	0	7.22	404	303
2019/20	866	6,431	0	0	3.84	864	648
2020/21		6,431			5.09	864	648



# RISK TABLE CPT COMMENTS ON SSC REPORT

- Current discussions about risks to the stock and the recommended buffer include many of the risk table components.
- Risk tables would better organize our current process, allow us to account for environmental or socioeconomic considerations, and provide better transparency and clarity for the public and SSC/Council
- Risk tables would assist the state management decisions by identifying concerns that should be taking into account in the TAC setting process.
- CPT would like to start exploring draft risk tables in the upcoming assessment cycle (May 2022). Looking for SSC recommendations.
- Eventually CPT supports developing a risk table – even if no environmental information is available about the stock – for all stocks to inform CPT and state management decisions.

