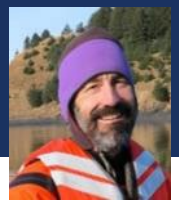
C3 BSAI CRAB STOCKS

KATIE PALOF & MIKE LITZOW,

CPT MEETING MINUTES – MAY 16 – 19TH, 2022



BSAI CRAB STOCKS MANAGEMENT TIMING

Aleutian Islands golden king crab
Pribilof Islands blue king crab *
Pribilof Islands golden king crab *
Western Aleutian Islands(Adak) red king crab *

Biennial cycle, next assessment in 2023

Assessed in May/June

Triennial cycle, next assessment in 2023

EBS snow crab
Bristol Bay red king crab
EBS Tanner crab
Pribilof Islands red king crab *
St. Matthew blue king crab *

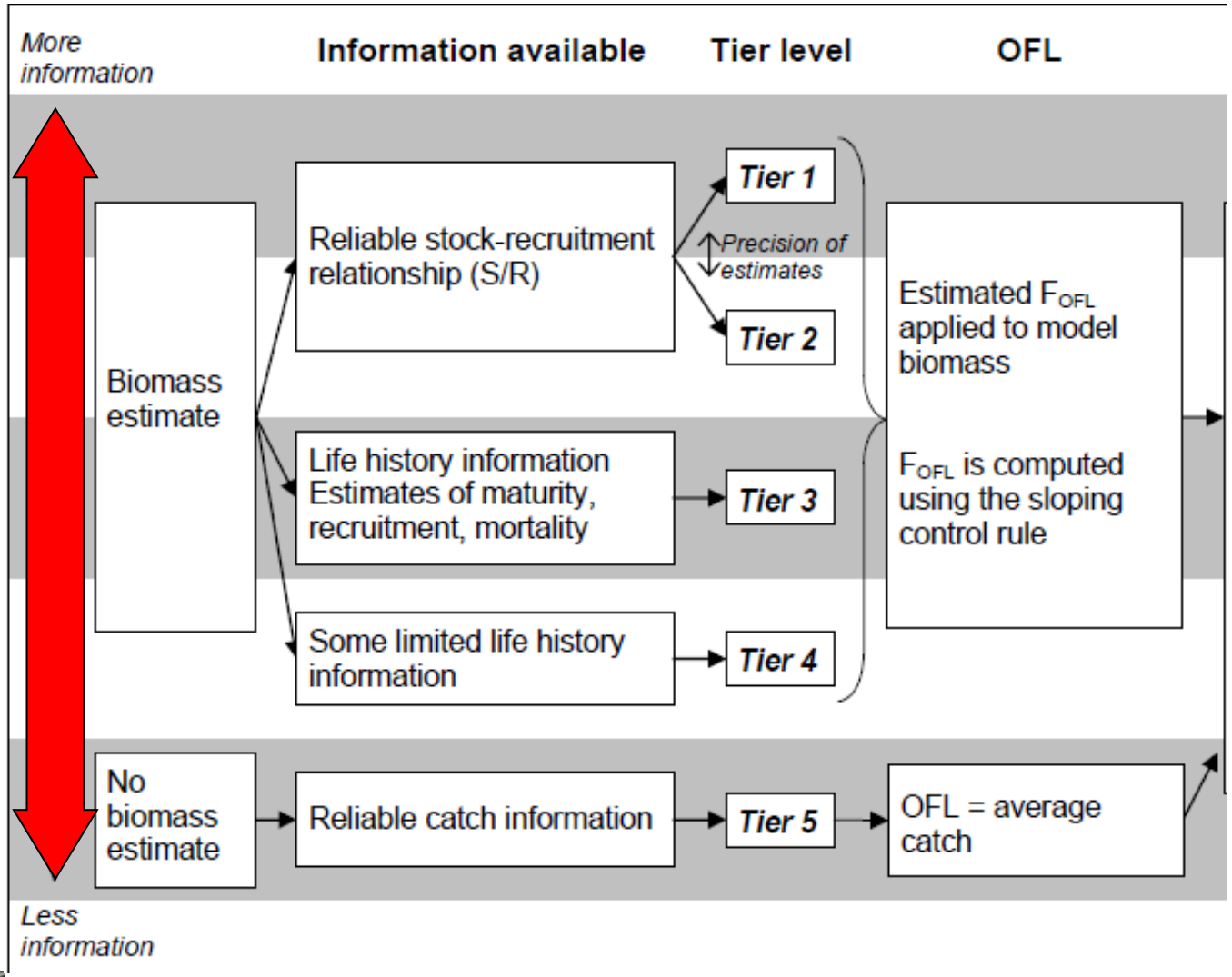
Assessed in September/ October

Triennial cycle, next assessment in 2022

Biennial cycle, next assessment in 2022

Norton Sound red king crab

Assessed in January/ February



ABC buffer

10-20%

10-25%

25-40%

MAY 2022 AGENDA

AIGKC final assessment, OFL and ABC

Proposed model runs for September:

- BBRKC, Tanner, SMBKC, PIRKC

Proposed model runs/GMACS adoption for snow crab (Cody)

Snow crab rebuilding plan (Cody)

Survey updates – corner station removal & BBRKC resampling protocols

Draft risk table updates - BBRKC

Research presentations – spatial assessment model for snow crab, snow crab IBM, BSFRF research projects

EFH next steps

Discussion on F35% and potential future alternatives

Timing of crab assessments discussion

BBRKC discussion paper planning (Oct)

Crab handling morality rate review

ALEUTIAN ISLAND GOLDEN KING CRAB (AIGKC)

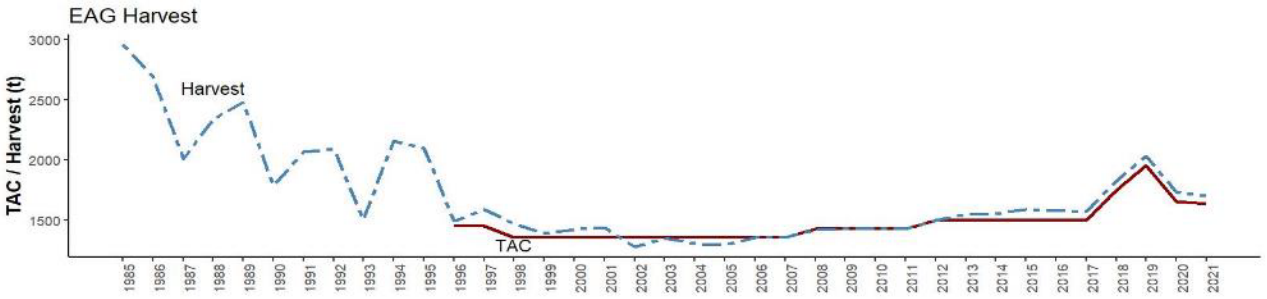
FINAL ASSESSMENT 2022

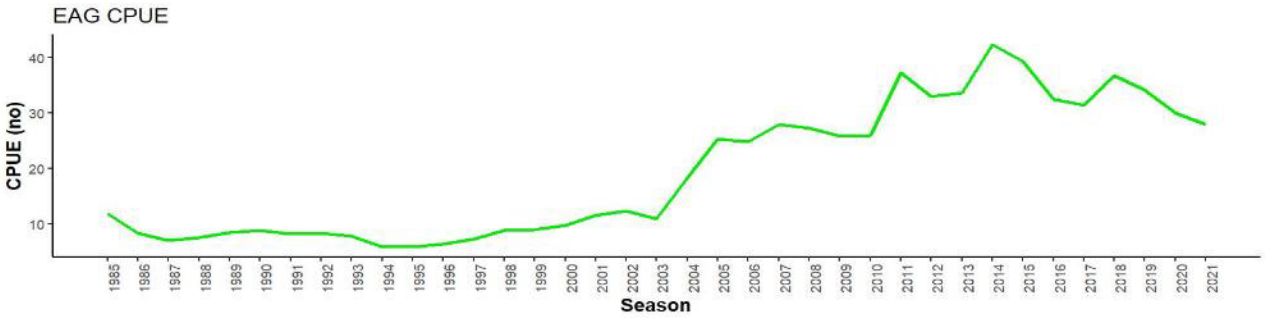
AIGKC MODELING APPROACH AND COMMENTS ADDRESSED

- Model approach:
  - Integrated male-only length-based models fitted to fishery dependent catch and CPUE data.
  - *Constant M* of 0.21yr^{-1}.
  - Projected the abundance from unfished equilibrium in 1960 to initialize the 1985 abundance.
- 5 models with **GMACS** (Appendix E) counterparts for EAG and WAG.
  - Good progress with GMACS, very close to adopting
- Models were presented with knife-edge maturity size of 111 mm CL (status quo) and updated 116 mm CL maturity size (new data) (Appendix C)
- Updated model structure with 3 catchability coefficients (base model assumes catchability is the same for fish ticket and early observer CPUE series)
- Investigation of the retrospective pattern in the EAG
- CPUE standardization with year*area effect
  - Provided plots asked for in Jan, but CPT did not see a retrospective run for this model

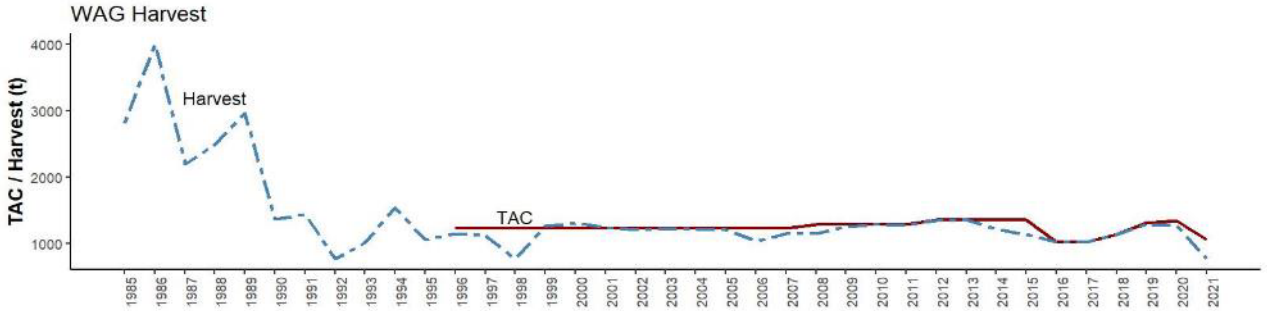
Catch (t) and CPUE (number of crab per pot lift), 1985/86–2021/22

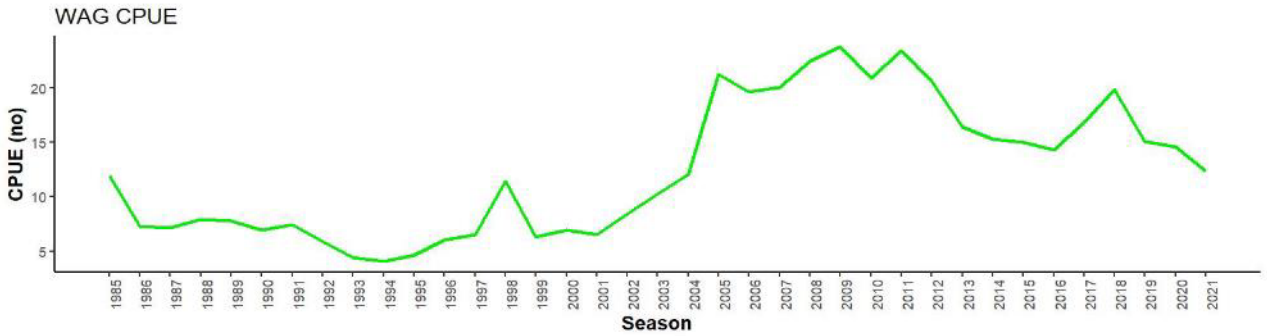
EAG





WAG





TACs :
2021/22:
(1) EAG: 3.61 million lbs
(2) WAG: 2.32 million lbs

*As of March 13, 2022, WAG fishery is ongoing (73%TAC harvested)

AIGKC MODELS PRESENTED

Model	CPUE Data Type and Maturity Option	Period for Mean Number of Recruit Calculation
21.1a (accepted in May 2021, implemented with up to 2021/22 data)-base model	Observer data 1995/96–2021/22; Fish ticket data 1985/86–1998/99; minimum maturity size 111 mm CL; two catchability and CVs for the 1985/86–2004/05 and 2005/06–2021/22 periods.	1987–2017.
21.1e	21.1a+ three catchability and CVs (1985/86–1998/99; 1995/96–2004/05; and 2005/06–2021/22).	ditto
21.1f	21.1e+ observer Year:Area interaction CPUE.	ditto
21.1e2	21.1e+ minimum maturity size 116 mm CL.	ditto
21.1f2	21.1f+ minimum maturity size 116 mm CL.	ditto

GMACS Ver. of the above five models: 21.1aG, 21.1eG, 21.1fG, 21.1e2G, 21.1f2G

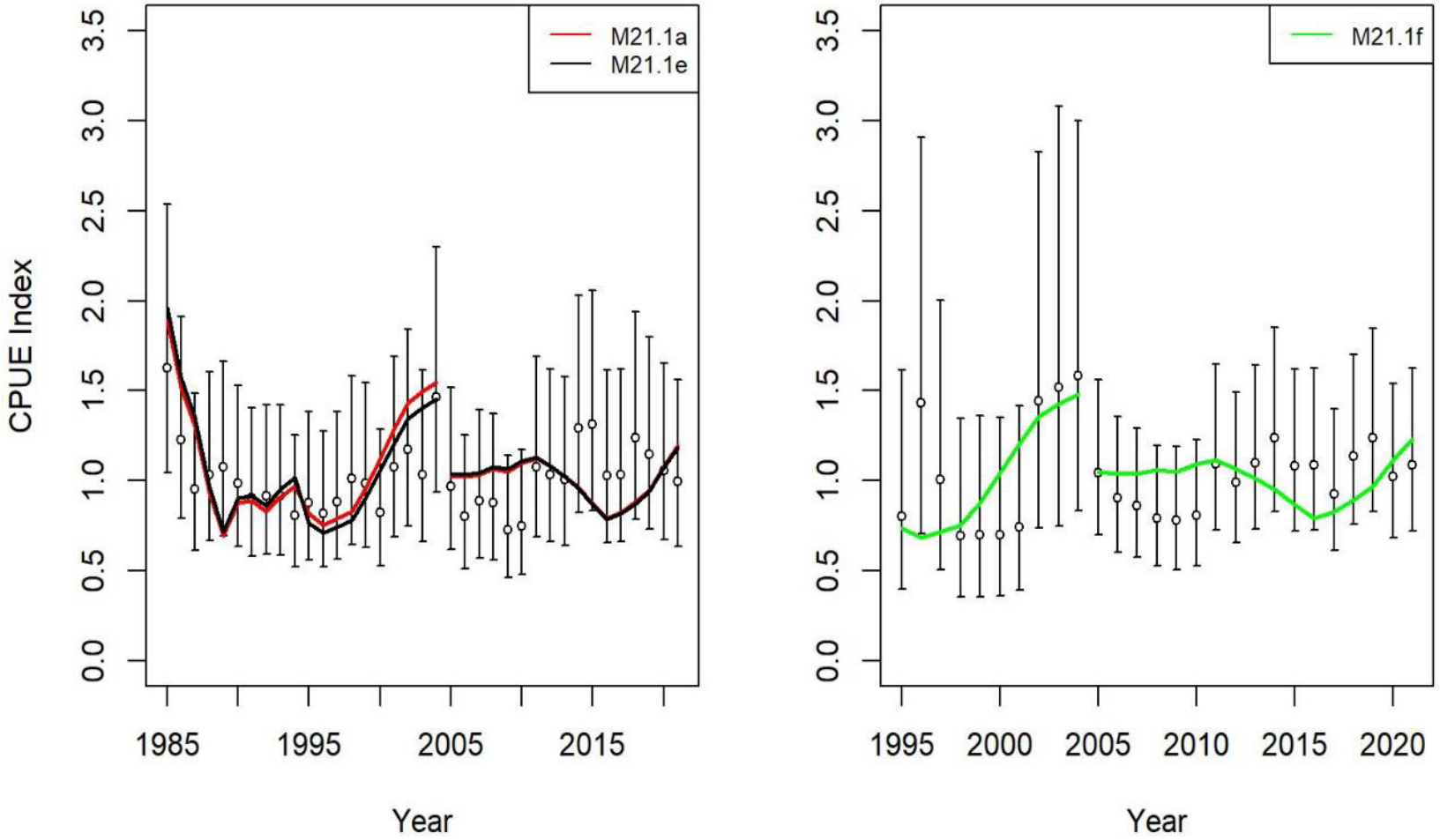


Figure 22. Comparison of input CPUE indices [open circles with +/- 2 SE for model 21.1a (left) and model 21.1f (right)] with predicted CPUE indices (colored solid lines) under 21.1a (red) and 21.1e (black)[left]; and 21.1f (green) [right] for EAG golden king crab data, 1985/86–2021/22. Model estimated additional standard error was added to each input standard error.

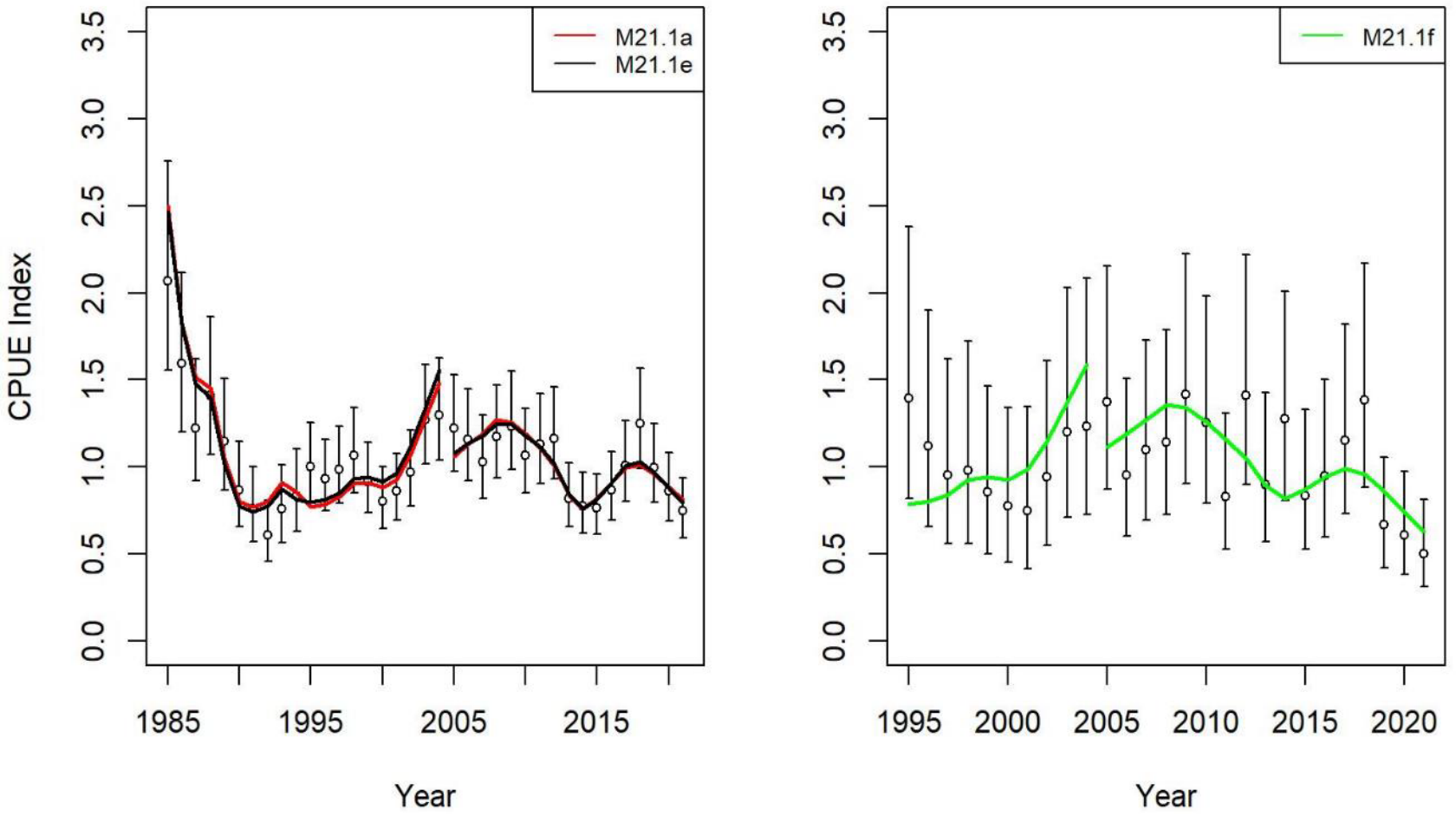
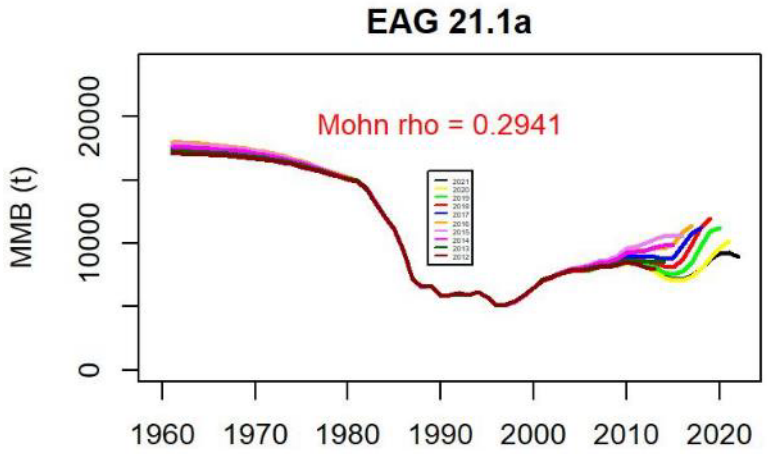
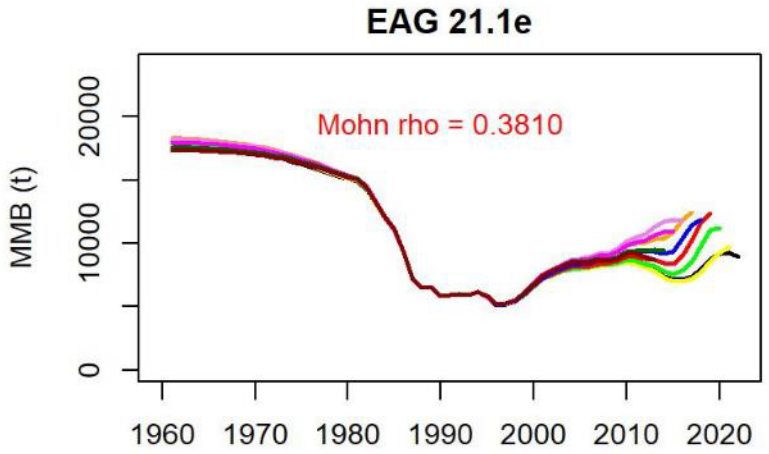


Figure 38. Comparison of input CPUE indices [open circles with +/- 2 SE for model 21.1a (left) and model 21.1f (right)] with predicted CPUE indices (colored solid lines) under 21.1a (red) and 21.1e (black)[left]; and 21.1f (green) [right] for WAG golden king crab data, 1985/86–2021/22. Model estimated additional standard error was added to each input standard error.

FIGURE 21. RETROSPECTIVE FITS OF MMB (WITH 9 PEELS) - 21.1A, 21.1E, AND 21.1EQ (VARIABLE CATCHABILITY DURING THE POST-RATIONALIZATION PERIOD) FOR GOLDEN KING CRAB IN THE EAG, 1961–2022.





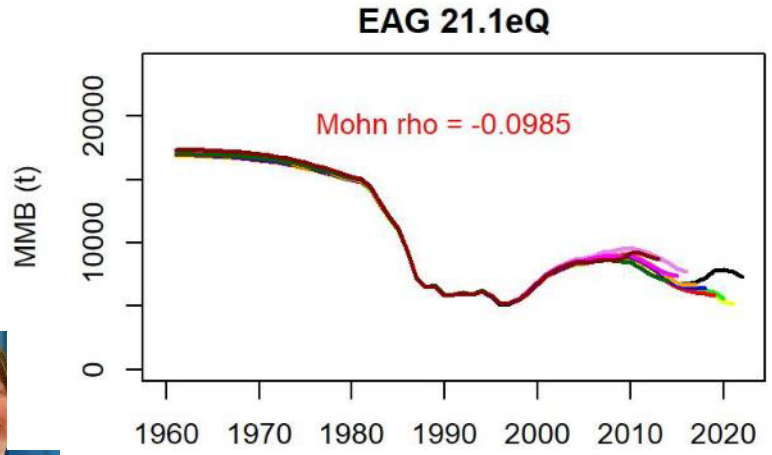
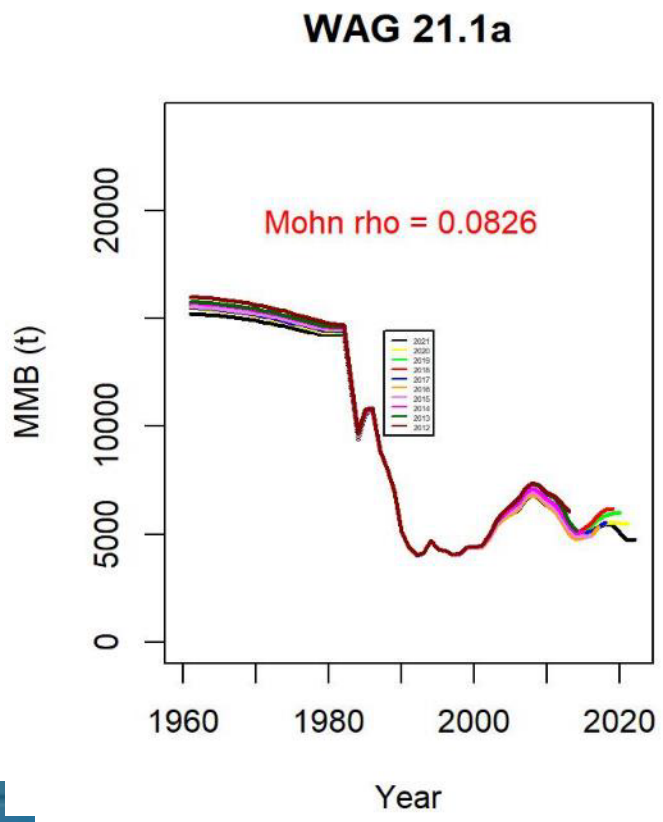
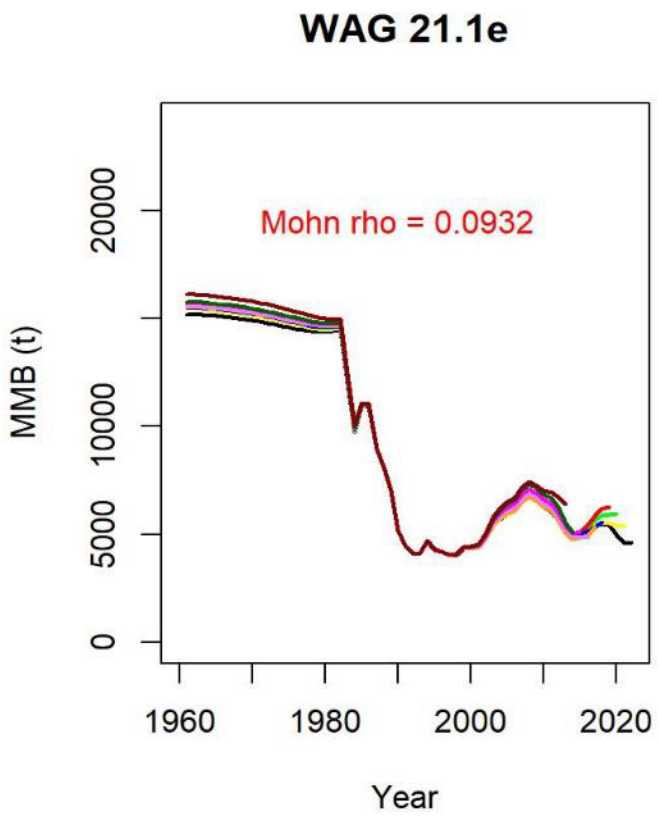
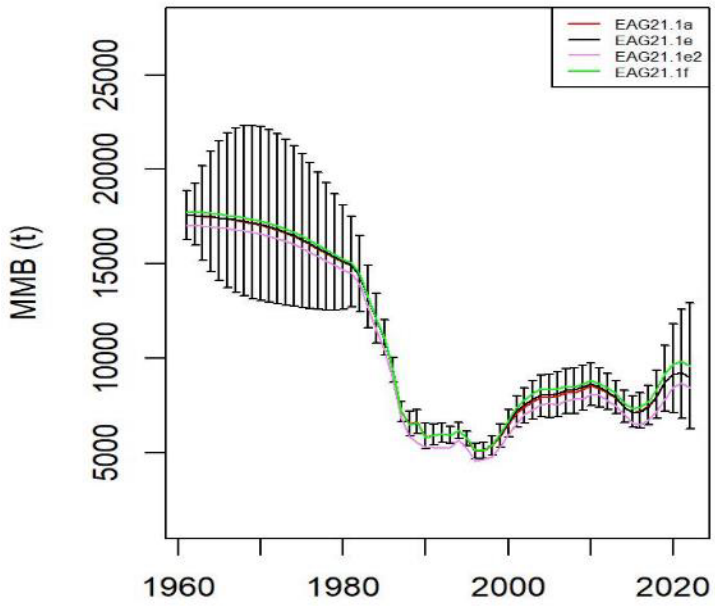


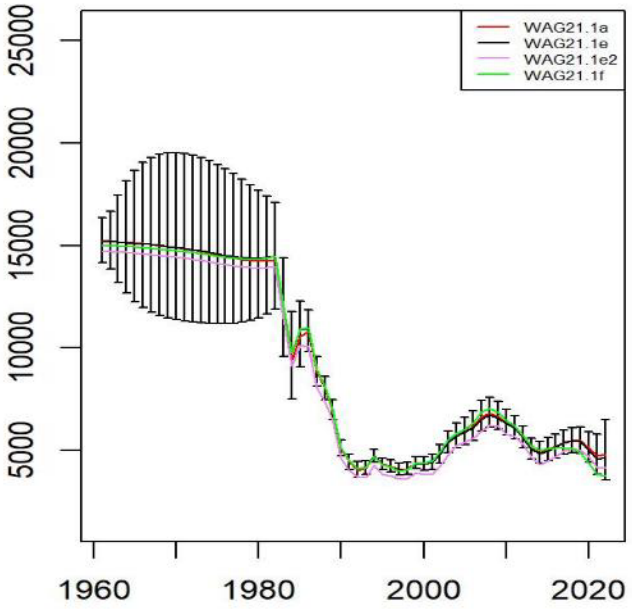
FIGURE 37. RETROSPECTIVE FITS OF MMB (WITH 9 PEELS) FOLLOWING REMOVAL OF TERMINAL YEAR DATA UNDER MODELS 21.1A AND 21.1E FOR GOLDEN KING CRAB IN THE WAG, 1961–2022.

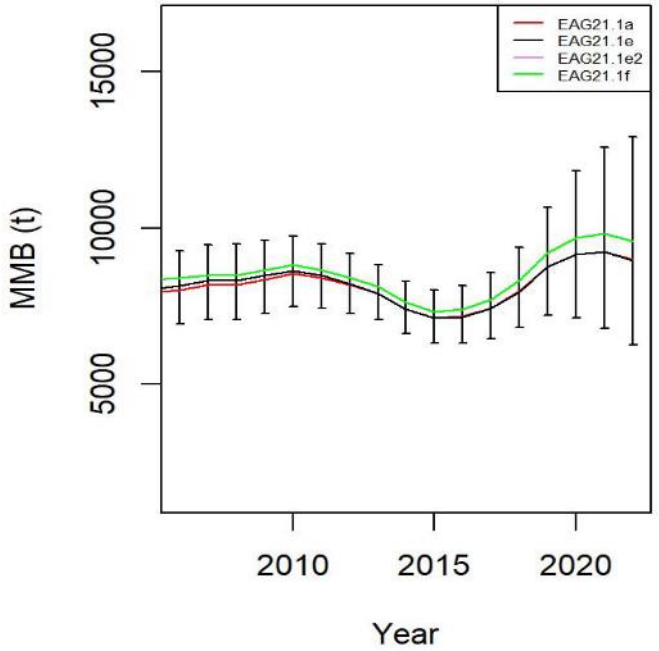


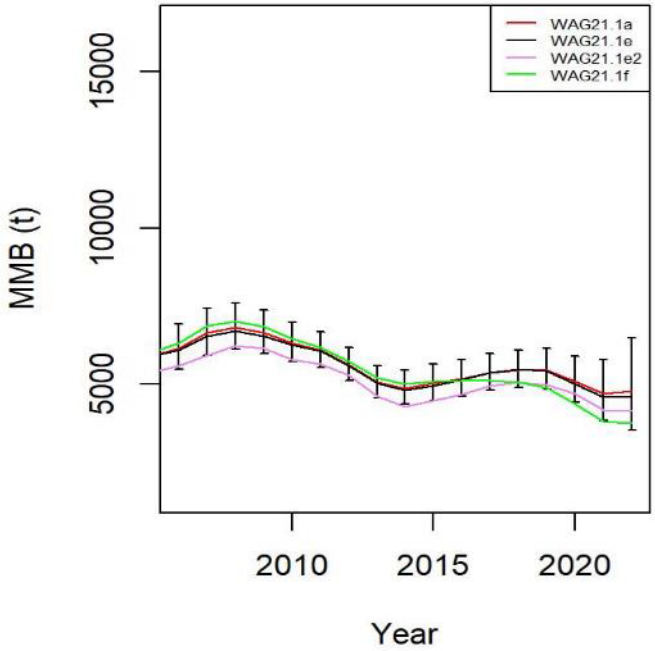


AIGKC final assessment 2022









Status and catch specifications for the entire Aleutian Islands fisheries (million lb)

Year	MSST	Biomass (MMB)	TAC	Retained Catch	Total Catch[a]	OFL	ABC[b]
2018/19	12.964	39.348	6.356	6.536	7.433	12.157	9.118
2019/20	13.041	36.124	7.180	7.317	8.222	11.572	8.679
2020/21	13.259	34.043	6.610	6.614	7.759	10.579	7.934
2021/22	12.917[c]	27.760[c]	5.930	5.460	6.007	10.620[d]	7.434[d,e]
2022/23		26.326[c]				8.291[c]	6.219[c,f]

a. Total retained catch plus estimated bycatch mortality of discarded bycatch during crab fisheries and groundfish fisheries.
b. 25% buffer was applied to total catch OFL to determine ABC.
c. Model 21.1e2 with hypothetical completed fisheries data from WAG was used to estimate MSST, MMB, and MMB projection for 2022/23.
d. OFL and ABC were estimated by the accepted model 21.1a in May 2021 assessment when the WAG fishery was not completed.
e. 30% buffer was applied to total catch OFL to determine ABC for the 2021/22 fishing season after SSC/Council's recommendation.
f. A proposed 25% buffer was applied to total catch OFL to determine ABC for the 2022/23 fishing season.

AIGKC RECOMMENDATIONS

- Model 21.1e2 chosen as recommended model by CPT
  - 3 catchability parameters (improvement to base model)
  - 116 mm CL size-at-maturity
    - Sample size increased (new data 10,815 vs. old data 3,755)
    - Combined data not valid due to change in sampling protocols
    - Future work on area specific size-at-maturity?
- Buffer 25%
  - “base” buffer from last year
  - Similar concerns from the past year with some improvements but none to lower buffer
- Future recommendations (more in minutes):
  - Transition to GMACS
  - Cooperative survey index included in EAG model
  - Investigate retrospective pattern in EAG

BBRKC PROPOSED MODEL RUNS

- Change in authorship
- Model scenarios explored:
  - Starting date for time series (status quo vs 1985)
  - M assumptions
    - Fixed or estimated in model
    - Additional mortality periods (late 70s/early 80s, 2015-2018)
  - Impacts of BSFRF data – specifically on selectivity
    - Q potentially higher than 1 due to herding
    - Removal decreases retrospective patterns
    - Not greatly influential data set in current model

CPT RECOMMENDATIONS - BBRKC

- Model runs for September:
  - Model 21.1b – updated status quo model
  - Model 22.0a – starts in 1985, estimates national mortality
  - Model 22.0 (not 22.0d) – base model that starts in 1985

TANNER PROPOSED MODEL RUNS

- Impacts on assessment
  - changes in bycatch estimation in groundfish fisheries
  - revised input sample sizes for survey size compositions
- Model simplifications
  - fit to ADFG management area-specific directed fishery catch data rather than aggregated data
    - may simplify selectivity for the directed fishery
  - start in 1982 to avoid
    - uncertain foreign fleet catch data
    - No elevated mortality period
    - major changes in survey gear, areal coverage
    - long initialization period
- Model additions
  - ability to estimate non-equilibrium initial numbers-at-XMSZ

CPT RECOMMENDATIONS – TANNER CRAB

Models for September:

- Model 22.01: Base model from last year updated with new data
- Model 22.03: Updated bycatch estimates for the groundfish fisheries, and fitting to fishery aggregate biomass. (improvement of model)
- Modified model 22.06a: Initial size composition in 1982 with a smoothing weight of 0.1, and initial composition parameters estimated on a logit scale, but also including the features of model 22.03. (model start date & initial condition change)
- Modified model 22.06a as described above plus bootstrap estimates of input sample sizes.

SMBKC PROPOSED MODEL RUNS

Last full assessment Sept. 2020 (moved to biennial cycle)

Overfished & under a rebuilding plan to be updated this fall (2022)

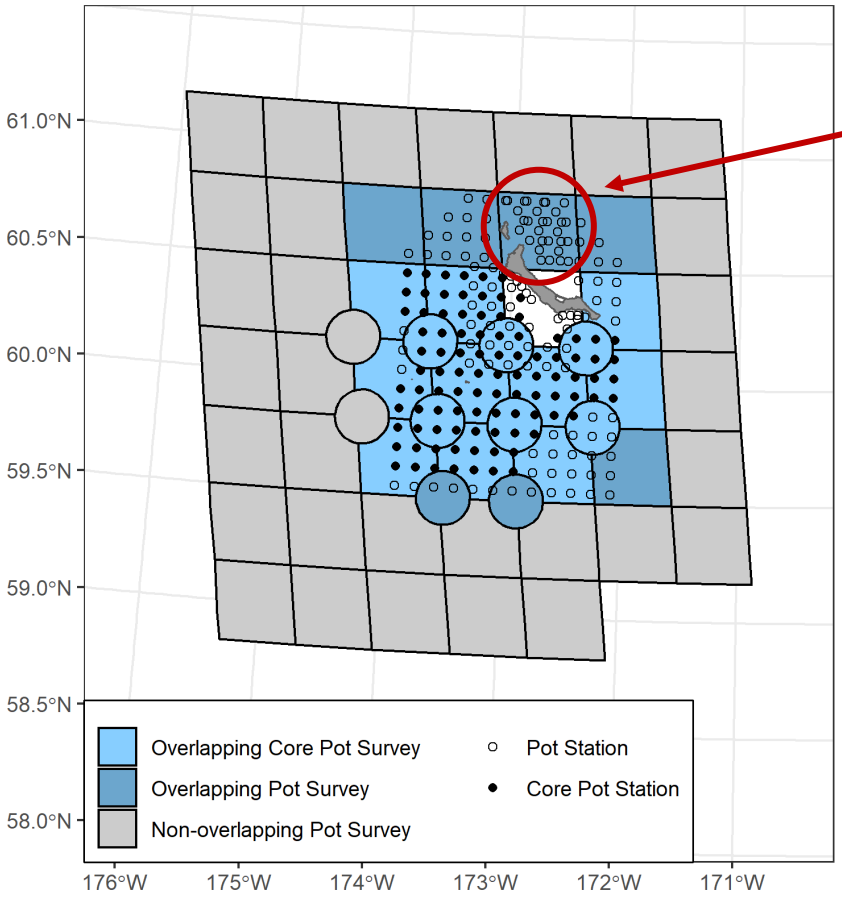
- No changes to fishing regulations
- No further bycatch restrictions
- Focused on recruitment expectations

Core model issues

- Discrepancies in trends between pot survey and trawl survey
- Spatial hot spots in surveys
- Poor fit of models to recent years survey data (2010+)

Proposed models

- Sensitivity on M estimates and assumptions of morality event in 1998



- Blue (survey overlap)
- Light blue core pot survey overlap
- Sampling density differences
- NMFS trawl survey samples in R-24 annually
- ADF&G pot survey R-24 sampling is opportunistically

CPT RECOMMENDATIONS – SMBKC

Summary of model runs:

- Model is not very sensitive to increases in natural mortality
- Removal of 1998 spike in M leads to changes in MMB and recruitment, and doesn't fit size comp data

Models for September:

- Model 16.0 – 2020 version
- Model 16.0 – updated with data for 2022
- Update on rebuilding in fall

PIRKC PROPOSED MODEL RUNS

- Triennial assessment cycle
- Current GMACS model (accepted in 2019)
- B_{MSY} redefined in 2019 as 35% of the average MMB observed from 2000 – present
- Input data:
  - Survey & bycatch data updated for 2019, 2020
  - Data for 2021/22 will be incorporated in Sept.
- CPT/SSC comments
  - Weighting of length comps (some here)
  - Explore ADF&G pot survey data (on-going)
  - Bering Sea wide exploration of RKC – stock structure (started in this document)

CPT RECOMMENDATIONS – PIRKC

Summary:

- Trends in SSB and overall model fit were similar, slight decline in biomass from 2019
- Healthy B_{MSY} proxy (3.25) – No overfishing
- Future work:
  - Sensitivity to life history characteristics (currently borrowed from BBRKC)
  - Exploration of potential Bering sea wide population connectivity

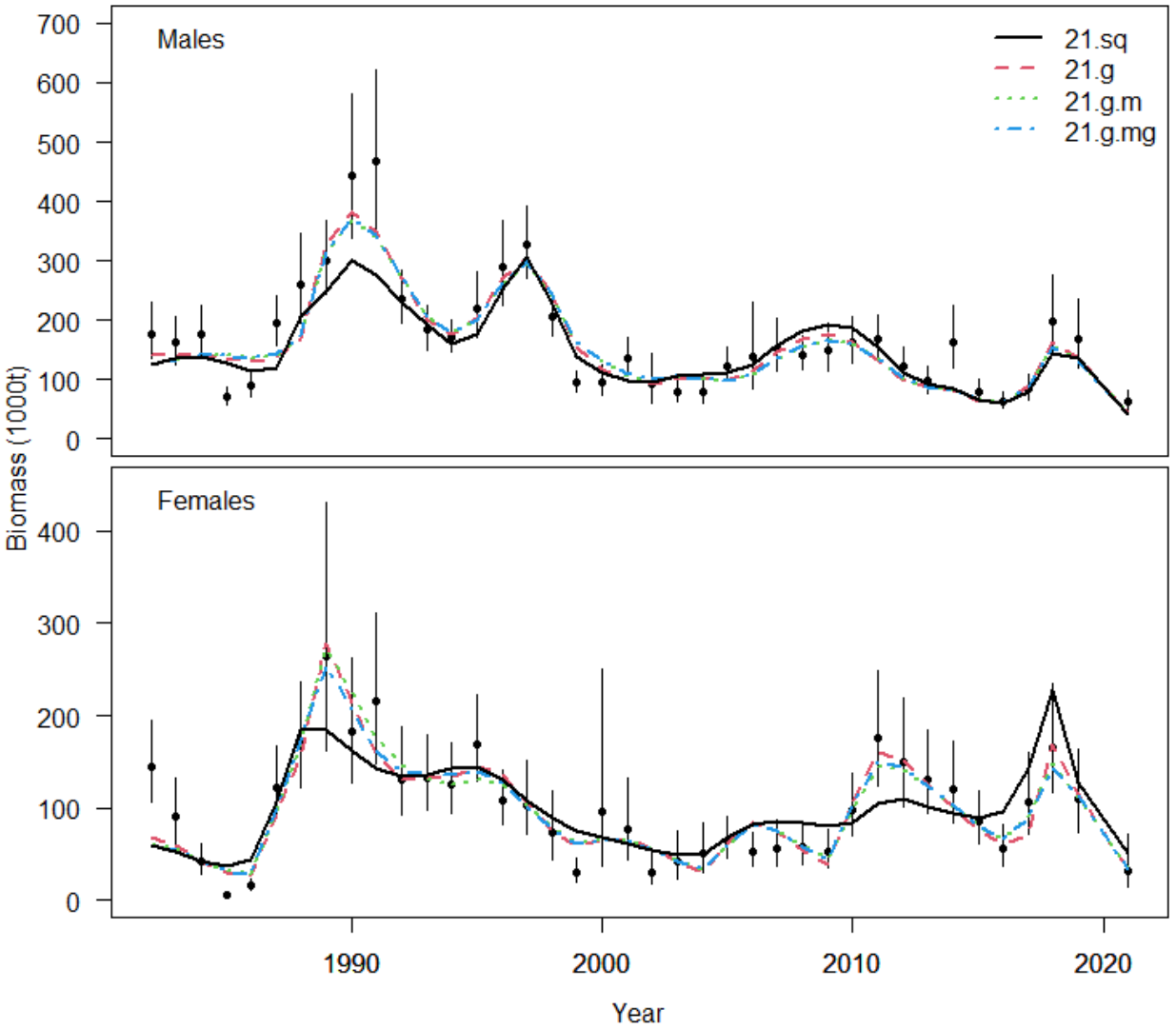
Recommended models for September:

- Model 19.1 (base model accepted in 2019)
- Model 19.1 (2022 updated data)
- (a) Model 19.1 (2022 updated data) + ADF&G pot survey data
- (b) Model 19.1 (2022 updated data) + trawl survey size composition (estimate bycatch selectivity)
- Model combining (a) and (b)

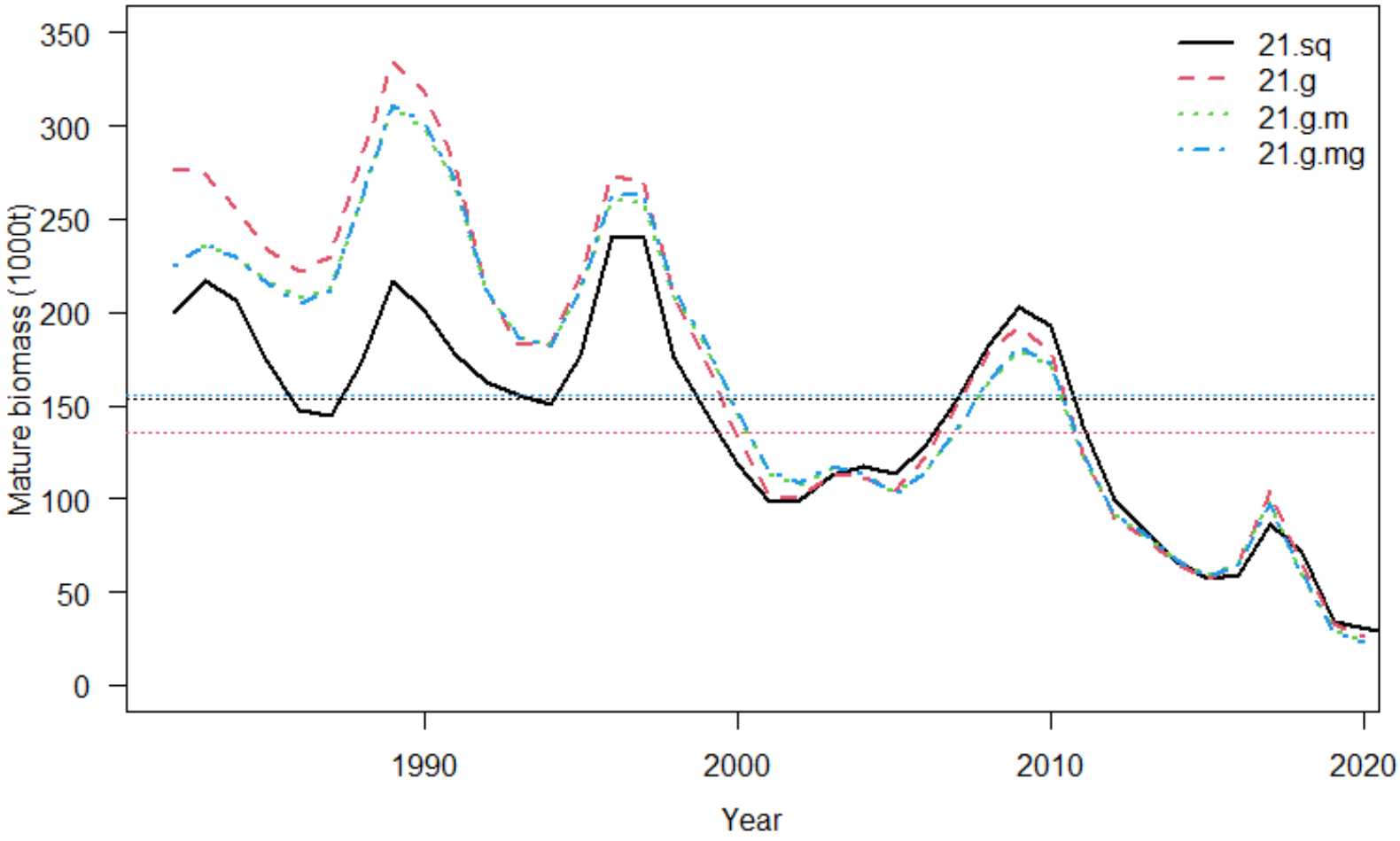
SNOW CRAB PROPOSED MODELS – TRANSITION TO GMACS

1. History of transition
    1. CPT adopted in fall 2019, SSC did not endorse
    2. Clarification of misspecifications and SSC concerns
2. Differences between GMACS and status quo
    1. General model parameterization and set up differences
3. Comparison of most recent GMACS and status quo model
    1. Generally similar with many improvements
4. Recommendations

GMACS VS. STATUS QUO



GMACS VS. STATUS QUO



AUTHOR RECOMMENDATIONS

Use GMACS as is based on:

- Superior convergence statistics
- Improved model assumptions
- Better fits to data sources
- Improvements in transparency and reproducibility

Do not pursue further matching exercises

Spend time working on actual problems instead of trying to match the dynamics of the status quo with GMACS

- Time-variation in population processes
- Currency of management and issues with F35%
- Treatment of maturity and BSFRF data
- Reference points in a changing environment
- Spatial issues

CPT RECOMMENDATIONS

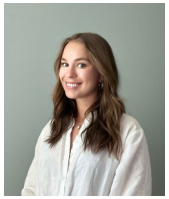
The **CPT supported the use of GMACS for the September 2022 assessment** of snow crab given that the fits are better, the model specification process is more transparent and hence easier to review, and GMACS is set up for projections unlike the status-quo model. The improvements of GMACS over the status-quo model substantially outweigh the minor concerns with the GMACS model. The CPT agreed that the models for the September meeting should:

- **Implement alternative specifications for the initial numbers-at-age** vector to eliminate the overestimation of catch and abundance of large animals in 1982-1984 – this change will improve the fits visually but will have little impact on final model outcomes.
- Use a **prior on *M*** that matches that used in the status-quo model.
- Both #1 and #2.
- The CPT also recommended that a jitter analysis be conducted on the GMACS models to further examine the convergence properties of GMACS for EBS snow crab.

SNOW CRAB REBUILDING

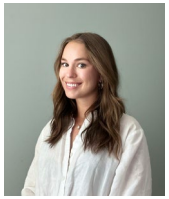
COUNCIL SNOW CRAB REBUILDING TIMELINE

- **October 19, 2019:** Snow Crab was declared overfished
  - Rebuilding of overfished stocks is required by the MSA section 304 within 2 years (October 2023)
    - MSA section 304 and the NS 1 guidelines for rebuilding overfished stocks
- **June 2022:** Select snow crab rebuilding alternatives for analysis
  - Summer 2022 – Staff will analyze the impacts of each of the alternatives
- **October 2022:** initial review of the snow crab rebuilding plan and potentially selected a preliminary preferred alternative
- **December 2022:** Council will take final action and select a preferred alternative to recommend to the Secretary of Commerce
  - Following selection of preferred alternative, NMFS prepares proposed FMP amendment text, draft notice of availability, draft Environmental Assessment, and, if required, a draft regulatory package




ADDITIONAL REFERENCE POINTS

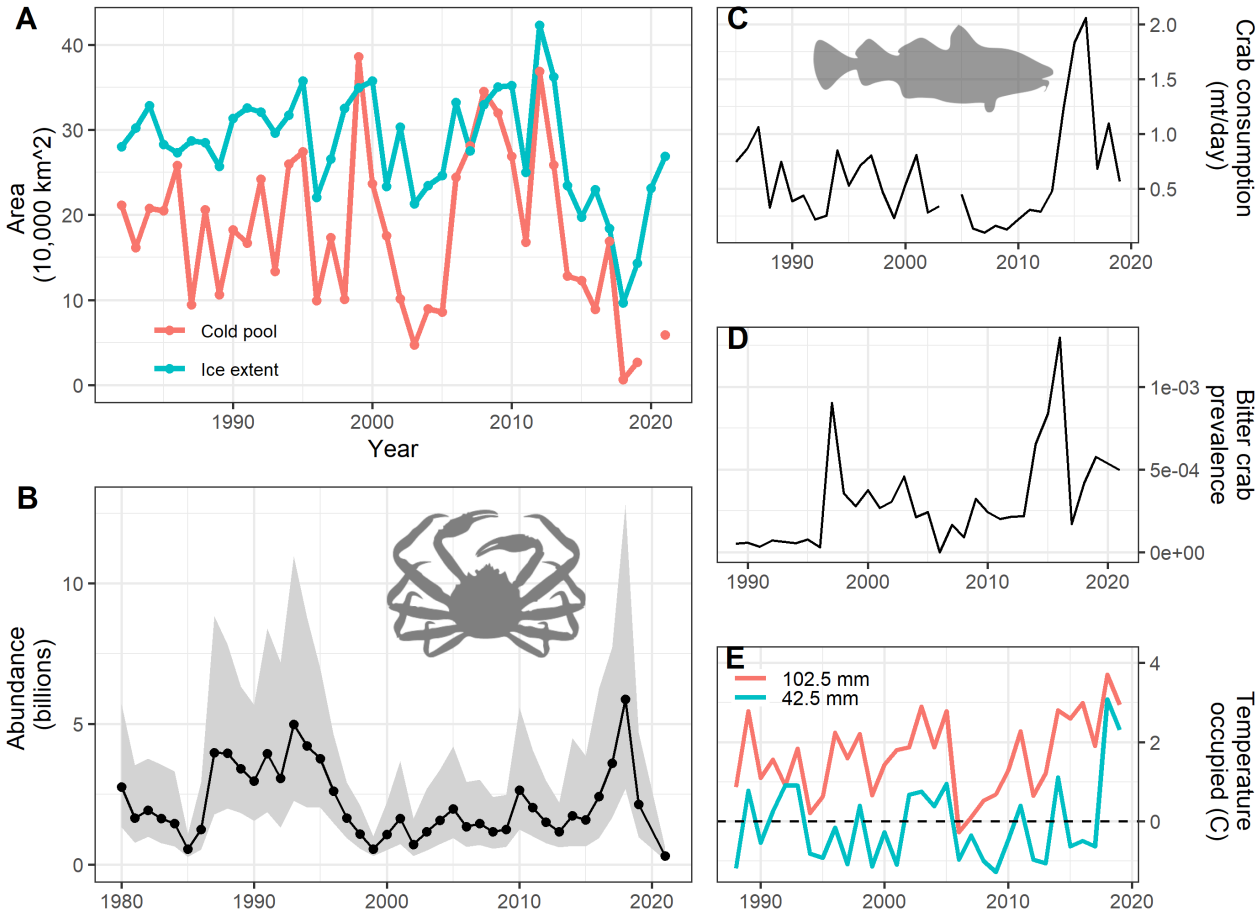
- **January 2023:** Council action should be submitted to NMFS within 15 mo. of notification of overfished to ensure sufficient time for Secretary of Commerce to implement the rebuilding measures
- **October 19, 2023:** Council has selected a preferred recommended rebuilding plan and Secretary of Commerce has implemented the rebuilding plan



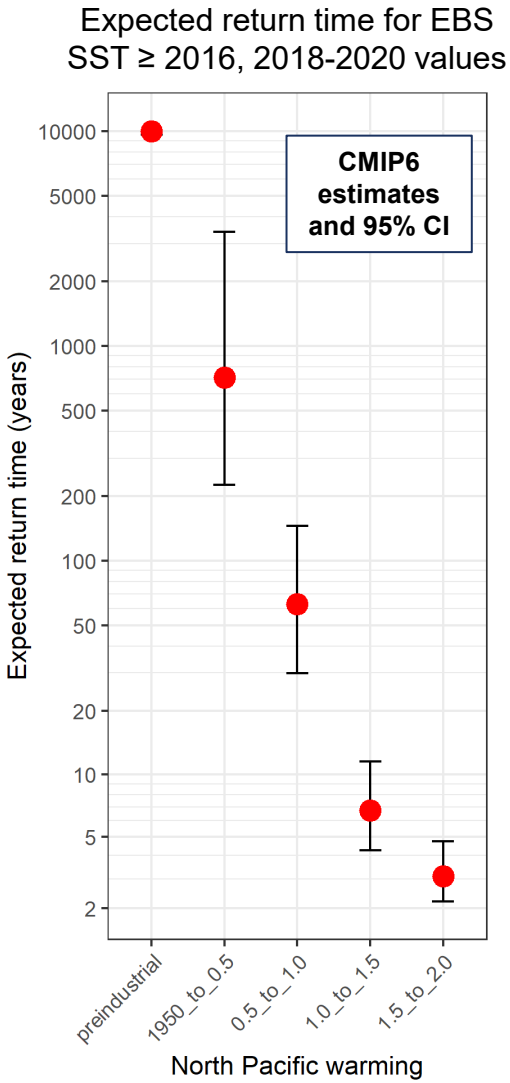

CONTEXT – WHAT HAPPENED?

High temperatures seem to be the best correlate with mortality in 2018 and 2019

This is somewhat unsatisfying because it does not provide a mechanism



CONTEXT – CLIMATE OUTLOOK



- Apparent snow crab collapse was associated with an index of EBS borealization
- ~100% of risk for EBS temperature as warm as 2014-2020 is human-induced
- Expected return time for extreme temperatures associated with high borealization / low snow crab abundance
  - every ~ 65 years in 2003-2019 climate
  - every ~ 7 years in current climate
  - every ~ 3 years by 2030s/2040s, depending on emissions scenarios

CONTEXT - UNOBSERVED MORTALITY

CPT Discussion

- The CPT discussed using a multiplier for observed bycatch numbers to estimate combined observed and unobserved mortality.
  - Results would be highly dependent on choice of multiplier
- The CPT recognizes that this is a difficult area of research and continues to encourage studies designed to improve mortality estimates
- The CPT also recommends that further efforts be made to protect post-molt (soft shell) crab.

REBUILDING PLAN: CPT DISCUSSION & RECOMMENDATION

- CPT discussion on “levers” in rebuilding projection scenarios:
  - Period for generating future recruitment (R)
  - Period for calculating proxy for B_{MSY} (here $B_{35\%}$)
    - All projections available use the same value
  - Values for future M (natural / non-fishing mortality)
  - Harvest strategies (ranges of fishing mortality (F) values) to consider in the analysis
- Uncertainty regarding appropriate choices for recruitment and M in projections
  - Do these reflect population and climate considerations


CPT DISCUSSION & RECOMMENDATION

Recruitment

- Three scenarios considered
  - 1982-2019 mean (currently used for calculating reference points)
  - 1994-2019 mean (starting after the decline in recruitment that precipitated last overfished declaration)
  - 1994-2015 mean (as above, but excluding large recruitment event beginning in 2015)

Non-fishing mortality (or natural mortality)

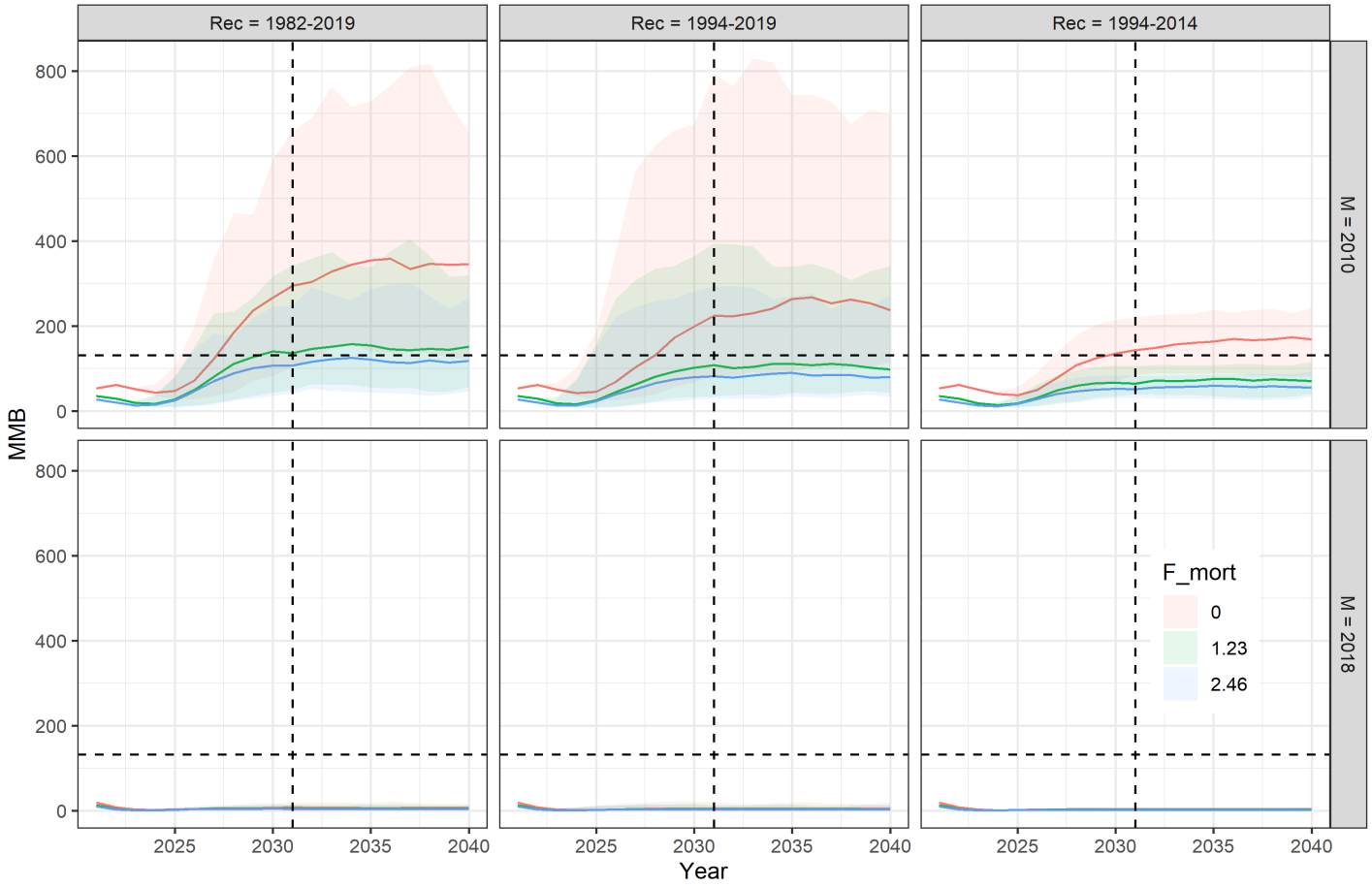
- Two scenarios considered
  - 1982-2017 mean
  - 2018 estimate (reflecting rate during recent mortality event)
- **Estimates T_{MIN} and T_{MAX} are largely dependent on *M***
- CPT noted that 1982-2017 mean is likely too optimistic, but 2018 estimate is likely much too pessimistic
- **CPT recommends 1982-2017 mean be used for projections**


CPT DISCUSSION & RECOMMENDATION

Fishing mortality

- Three harvest scenarios considered
  - No removals (F=0)
  - Bycatch only (F= average bycatch levels)
  - State harvest strategy (ABC control rule multiplied by average of TAC:ABC ratio)
- CPT discussed the likelihood that bycatch in groundfish fisheries has a greater effect during rebuilding than when stock above B_{MSY}
- CPT discussed the fact that unobserved mortality is absent from bycatch estimates and may be an important consideration in rebuilding
- Council could consider:
  - Expanding COBLZ boundary
  - Revising PSC limits (currently independent of abundance below 4.5 billion crabs)
  - Revise PSC formulas to focus on size-classes more vulnerable to bycatch


BIOMASS PROJECTIONS



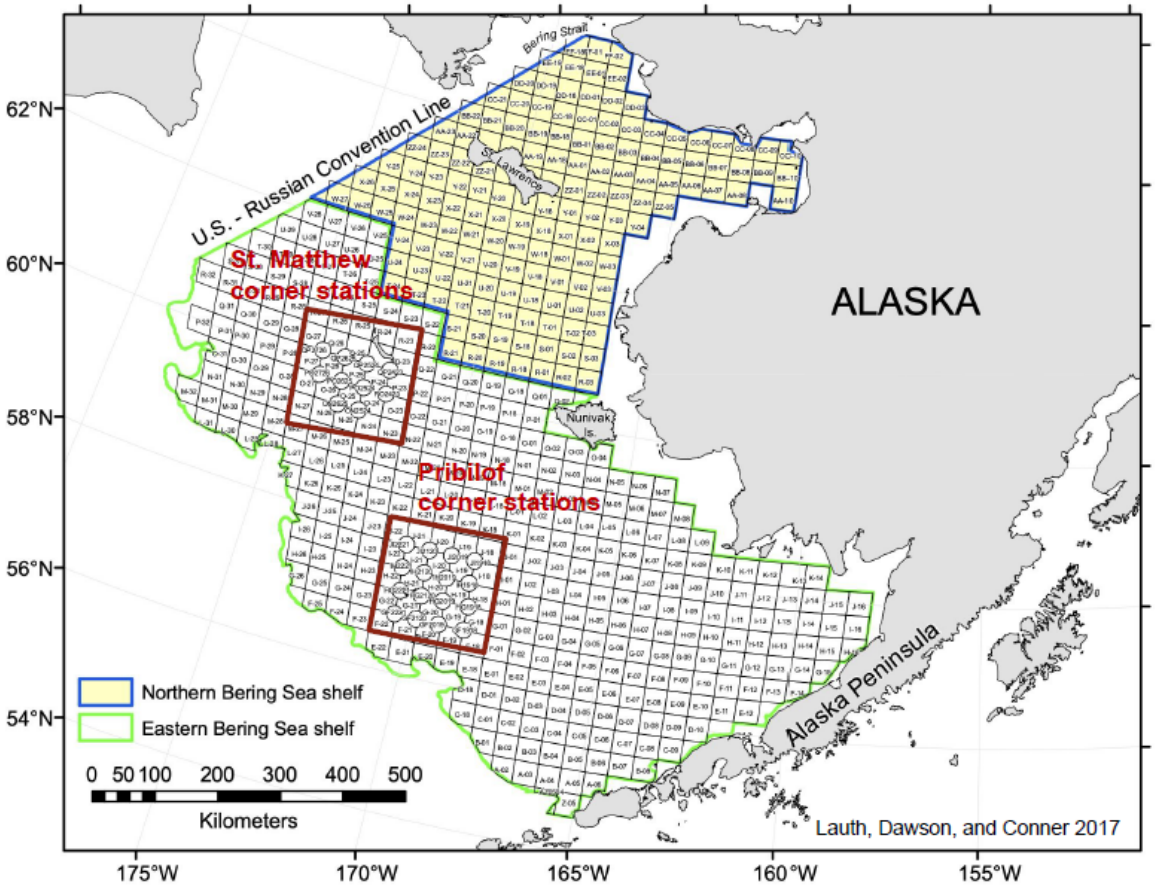
CPT-recommended *M*

Results in T_{MIN} < 10 years and T_{MAX} = 10 years for all combinations of *R*

BALANCE OF THE CPT REPORT

MAY 2022

SURVEY UPDATES – CORNER STATIONS



SURVEY UPDATES – CORNER STATIONS

CPT discussion

- Concern over value of stable long-term design e.g. for ecological information
- Discussed possibility of dropping a subset of corner stations (e.g. St. Matthew I. only)
- Discussed other options for dropping stations, e.g. dropping random NBS stations
- Supports adding deeper stations, but other options should be explored (e.g., industry survey)
- CPT does not recommend dropping corner stations at this time, and invites further explorations of this topic from the survey group

SURVEY UPDATES – BBRKC RESAMPLING

Proposed changes to survey protocol

- Threshold % of females having not completed molt-mate for triggering resample: change from 10% to 25%
- Standardize the number of stations resampled (20 stations)

CPT discussion

- Comfortable with the demonstrated effects on data collection
- Noted that the proposed change would only have affected 2021; in most resampling years > 40% have not completed molt-mate
- Noted that resampling is likely to become less common as the Bering continues to warm
- CPT supports the proposed change

BBRKC DRAFT RISK TABLE

- Using template from groundfish
- Reviewed SAFE doc and minutes to fill in each subject area
- ESP provided helpful information for areas 3 and 4
- Current buffer for BBRKC 20% - reflects increased concerns over a “baseline”
- Uncertainty about level of concern baseline
  - CPT discussion: level of concern should be based on an “ideal” crab model
  - Adjustments made to level to reflect this following CPT
- CPT discussion:
  - Who would put risk table together? Author but with modifications by CPT
  - Need to be able to flag ‘on-going’ concerns vs. ‘new’ concerns in risk table

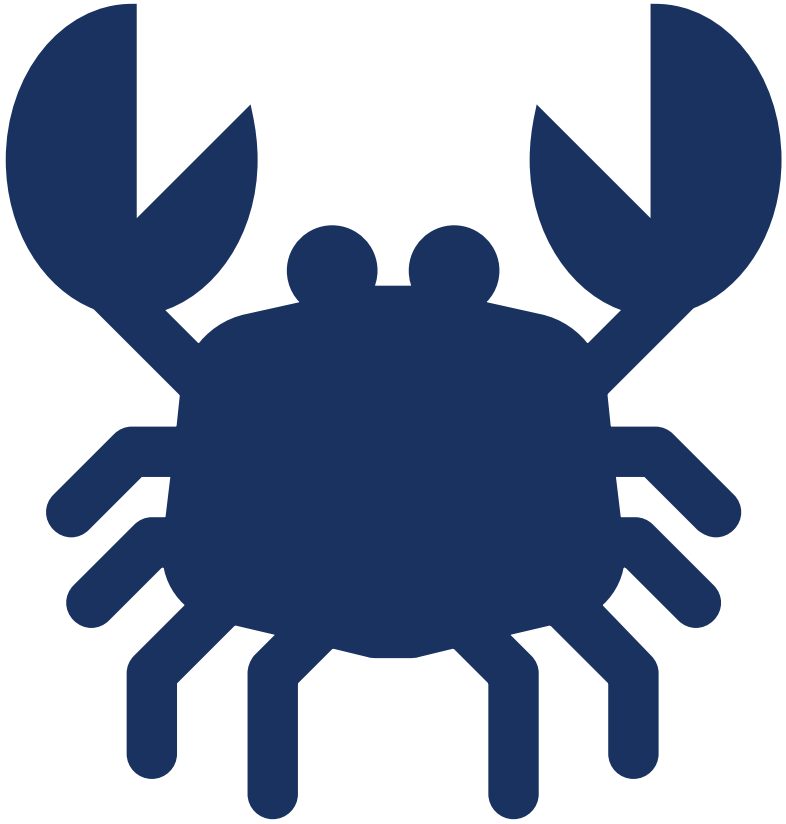
HANDLING MORTALITY RATES

- Most of the rates for crab fisheries were based on research conducted during the 1990s and 2000s

Targeted stock	Directed HM	Indirect HM	GF – trawl	GF – fixed
BBRKC	20%	Tanner 25%	80%	50%
Snow	30%		80%	50%
Tanner	32.1%	Snow 32.1% BBRKC 32.1%	80%	50%
AIGKC	20%	None	80%	50%

QUESTIONS?

- Thanks to all CPT members and crab authors.



BBRKC

Draft Risk Table Evaluation in 2022

Assessment-related considerations	**Population dynamics considerations**	**Environmental/ecosystem considerations**	**Fishery Performance**
-Strong retrospective pattern in MMB (high Mohn's rho) -Natural mortality time blocks -Have 2021 survey data point, no need for extra uncertainty for missing survey in 2020 -Stable GMACS reference model **Conclusion: ~~Level 1, No increased concerns~~** **Level 2, substantially increased concerns**	Poor recruitment in recent years led to a declining trends in mature biomass. No signs of recruitment improvements. Potential shifting spatial distributions? Decrease in female biomass below management threshold **Conclusion: Level 2, substantially increased concerns**	Increased potential predation of early life stages (BB salmon increases) Poor larval recruitment conditions last few years (ESP) Cold pool distributional shifts **Conclusion: ~~Level 1, No increased concerns~~** **Level 2, substantially increased concerns**	2020/21 fishery CPUE was up relative to previous yr Fishery in traditional grounds 75% of the catch in first week of fishery Bycatch typical levels in other fisheries. **Conclusion: Level 1, No increased concerns**

Sept/Oct 2021 recommended ABC = 80% of max ABC (20% buffer).