C1 BSAI CRAB STOCKS
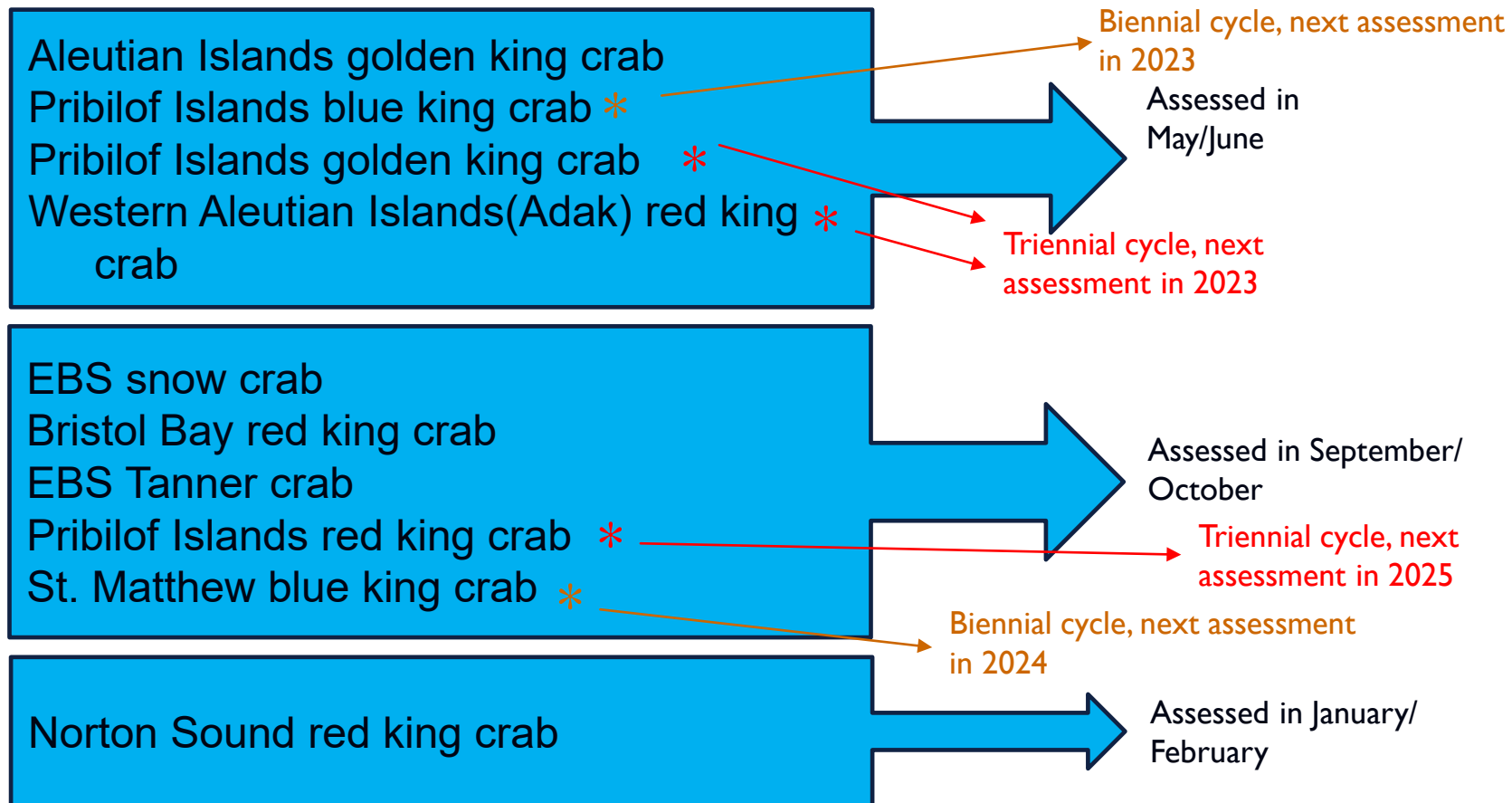
KATIE PALOF & MIKE LITZOW (CPT CO-CHAIRS)
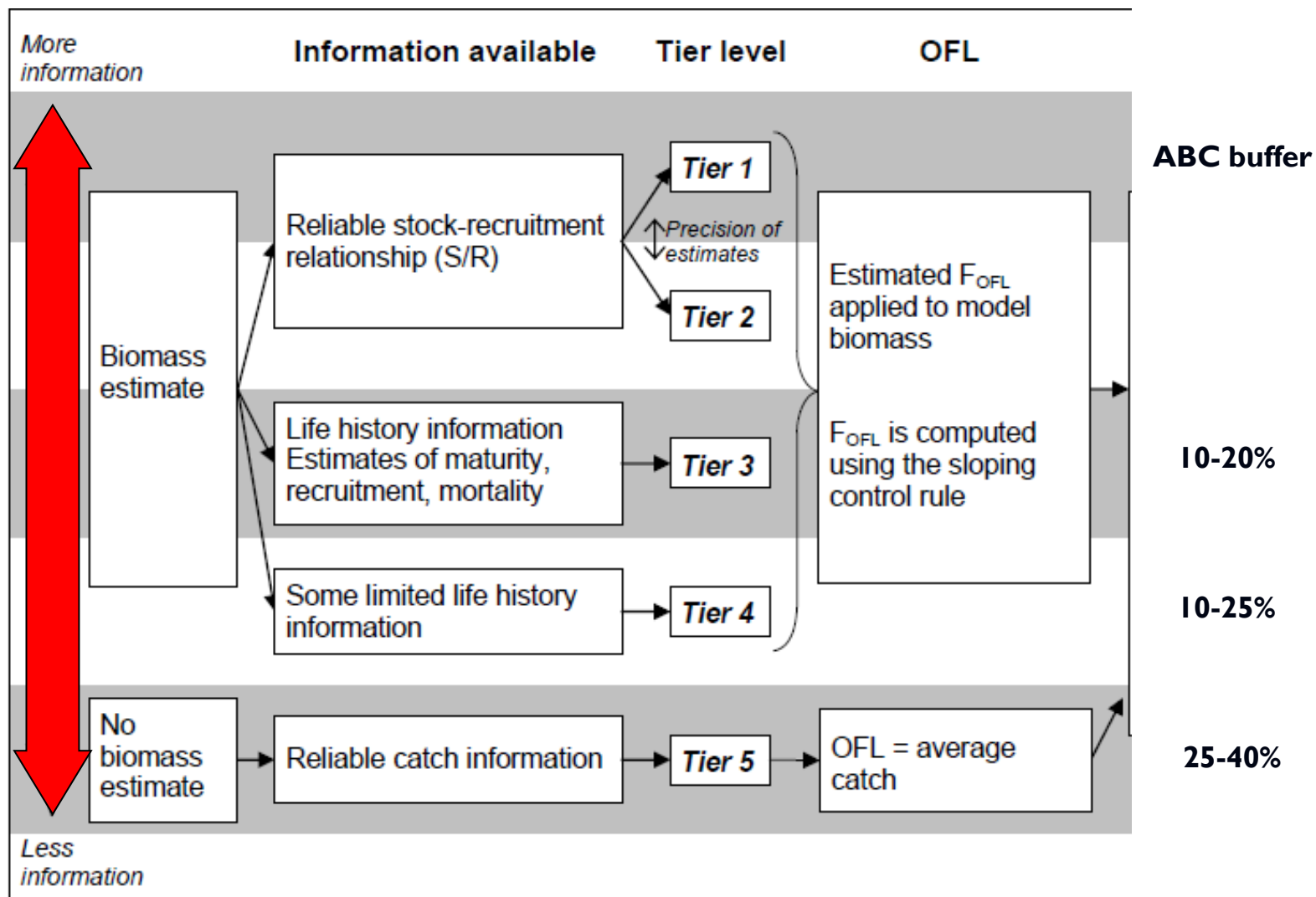
FEB 2023 NPFMC MEETING – FEB 6TH – 13TH SEATTLE, WA

CPT MEETING MINUTES – JAN 17TH- 20TH, 2023 ANCHORAGE, AK

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 2025

Biennial cycle, next assessment in 2024

Norton Sound red king crab

Assessed in January/February

2

	Information available	Tier level	OFL	
More information				ABC buffer

Diagram content:

More information ↑

Biomass estimate →
- Reliable stock-recruitment relationship (S/R) → Tier 1 / Tier 2 (↑Precision of ↓estimates)
- Life history information. Estimates of maturity, recruitment, mortality → Tier 3
- Some limited life history information → Tier 4

Tier 1–4 OFL: Estimated F_{OFL} applied to model biomass. F_{OFL} is computed using the sloping control rule.

No biomass estimate → Reliable catch information → Tier 5 → OFL = average catch

Less information ↓

ABC buffer values:
- Tier 1–2: ABC buffer
- Tier 3: 10-20%
- Tier 4: 10-25%
- Tier 5: 25-40%

3

JANUARY 2023 AGENDA

✓ **NSRKC final assessment, OFL and ABC**

✓ AIGKC proposed model runs for May/June

✓ PIGKC Tier 4/5 work for May/June

✓ Modeling workshop/GMACS updates and progress

✓ Simpler models workshop scoping

✓ Discussion on guidelines for start date of data

✓ Research updates: BSFRF updates, BBRKC distribution models, tagging updates, OA research updates

✓ Crab Economic SAFE

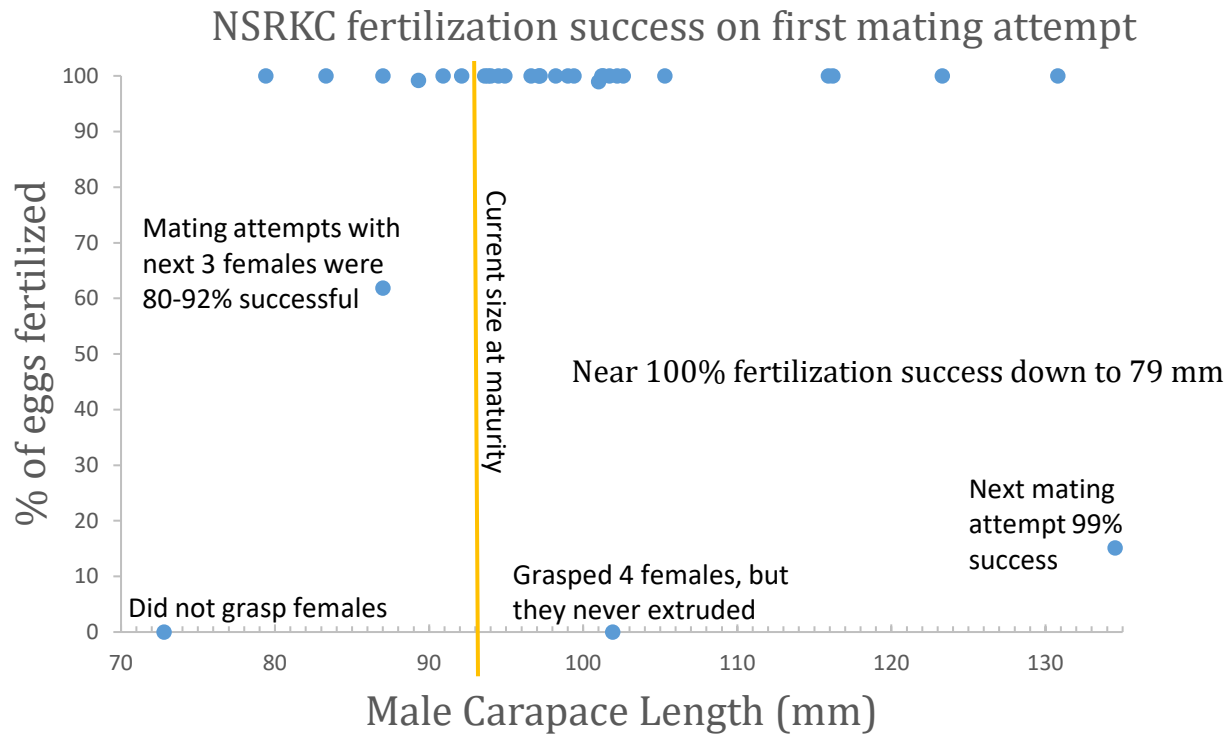✓ Council topic updates: Snow crab rebuilding final action, council crab prioritization

NORTON SOUND RED KING CRAB (NSRKC)

FINAL ASSESSMENT 2023

NSRKC male size a maturity – Zacher et al. Kodiak

- Initial results, low sample size, but interesting results
- CPT encouraged future work on NSRKC and other crab stocks using a similar experimental process


NSRKC fertilization success on first mating attempt

% of eggs fertilized

Male Carapace Length (mm)

Current size at maturity

Mating attempts with next 3 females were 80-92% successful

Near 100% fertilization success down to 79 mm

Next mating attempt 99% success

Did not grasp females

Grasped 4 females, but they never extruded

NSRKC OVERVIEW

- **Fishery overview**

  - A summer fishery was held in 2022 after two years without a fishery. CPUE in 2022 was the highest value since 2011.

- **Changes to the input data**

  - Winter subsistence, winter and summer commercial crab fishery harvest updated through winter 2021/22 and summer 2022.

  - NMFS 2022 trawl survey (abundance, length-shell compositions)

  - No ADF&G survey in summer 2022 (logistic issues)

- **Model presented:** 21.0 – previous model with updated data

  - Fishery CPUE high, NMFS abundance down from 2021

- **Other issues pertaining to this stock:**

  - Length-independent (status quo) vs length-dependent OFL calculation

  - Total vs retained catch OFL and associated discard estimate
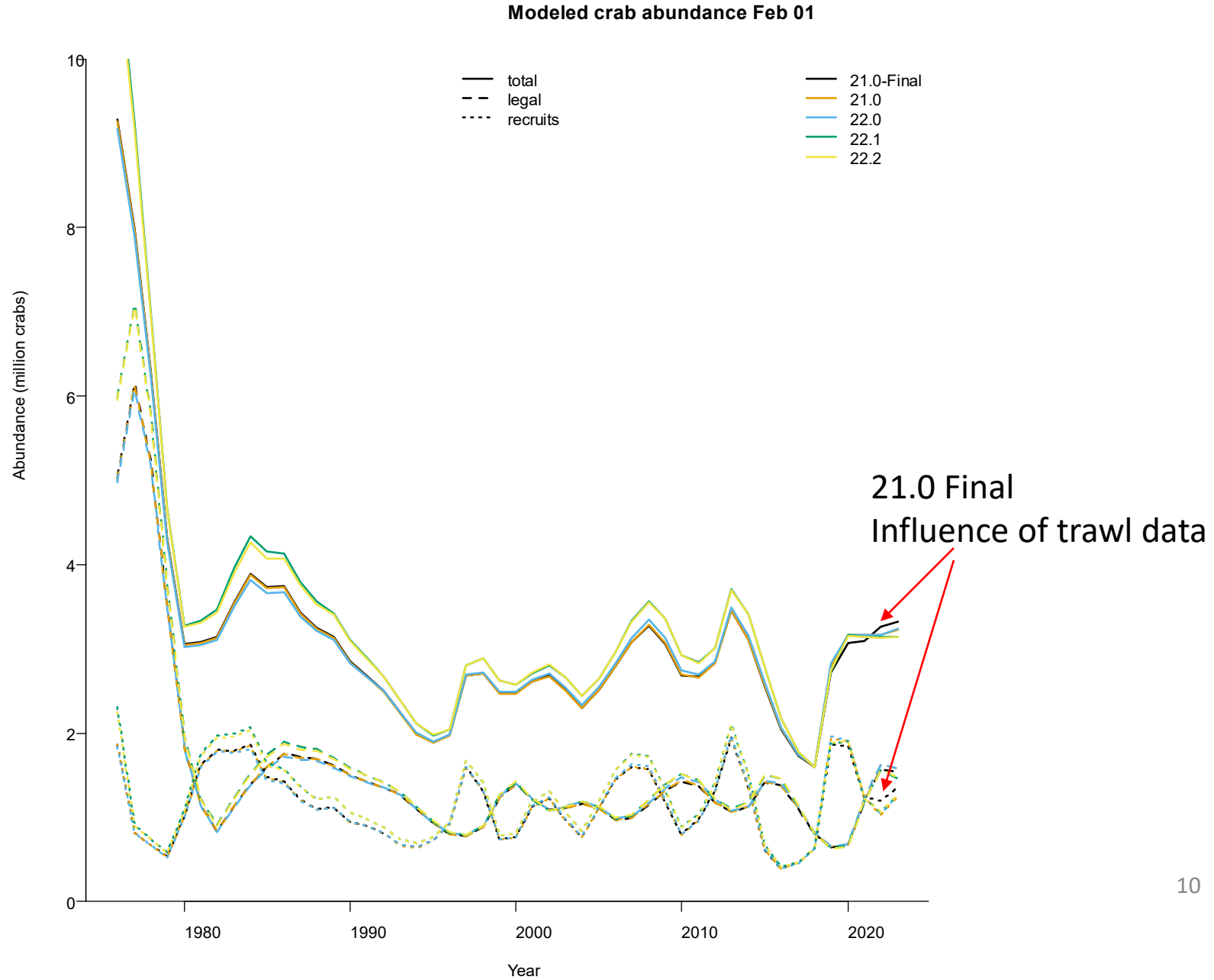
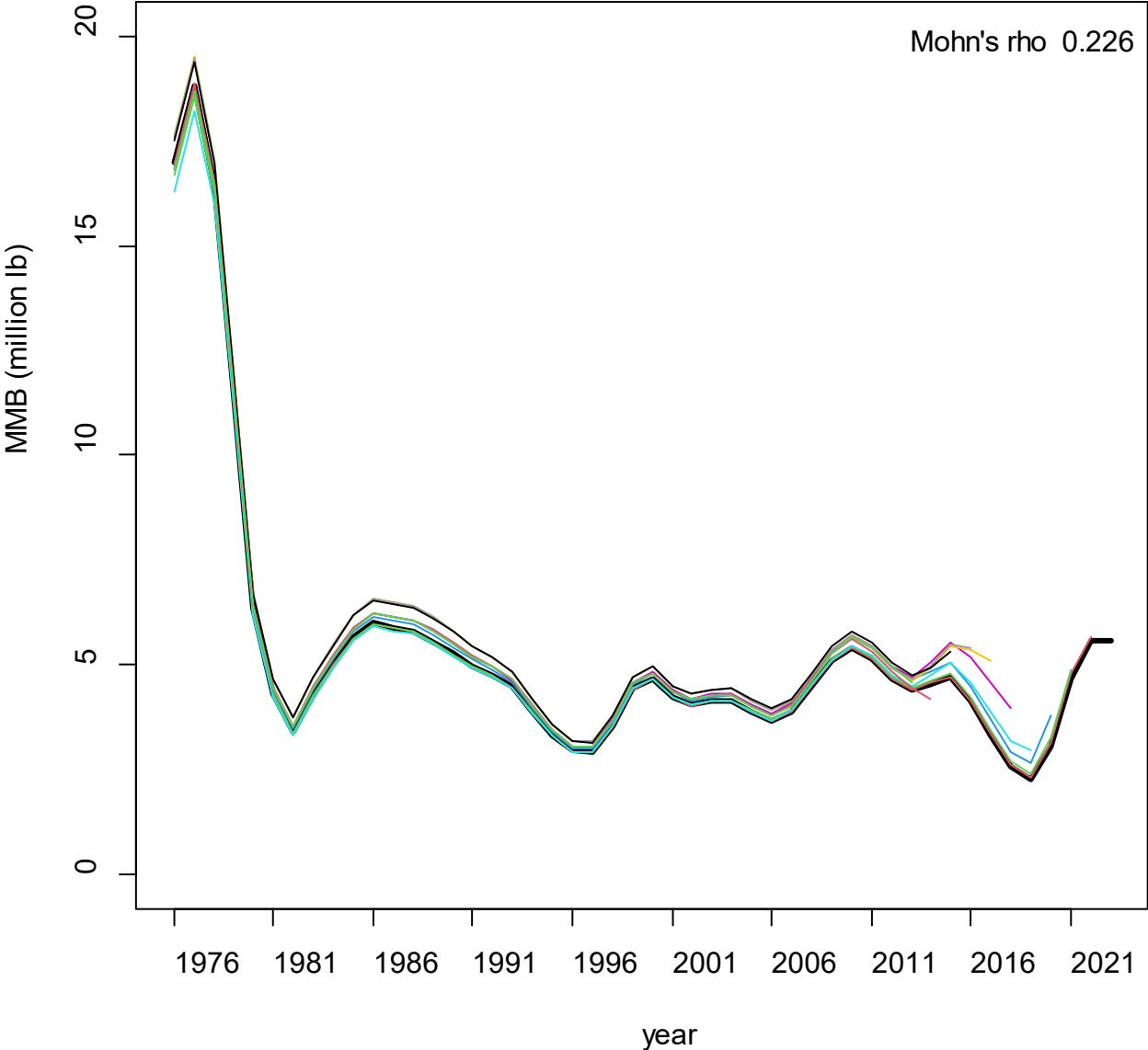# Summer Com Catch and CPUE , and Trawl abundance
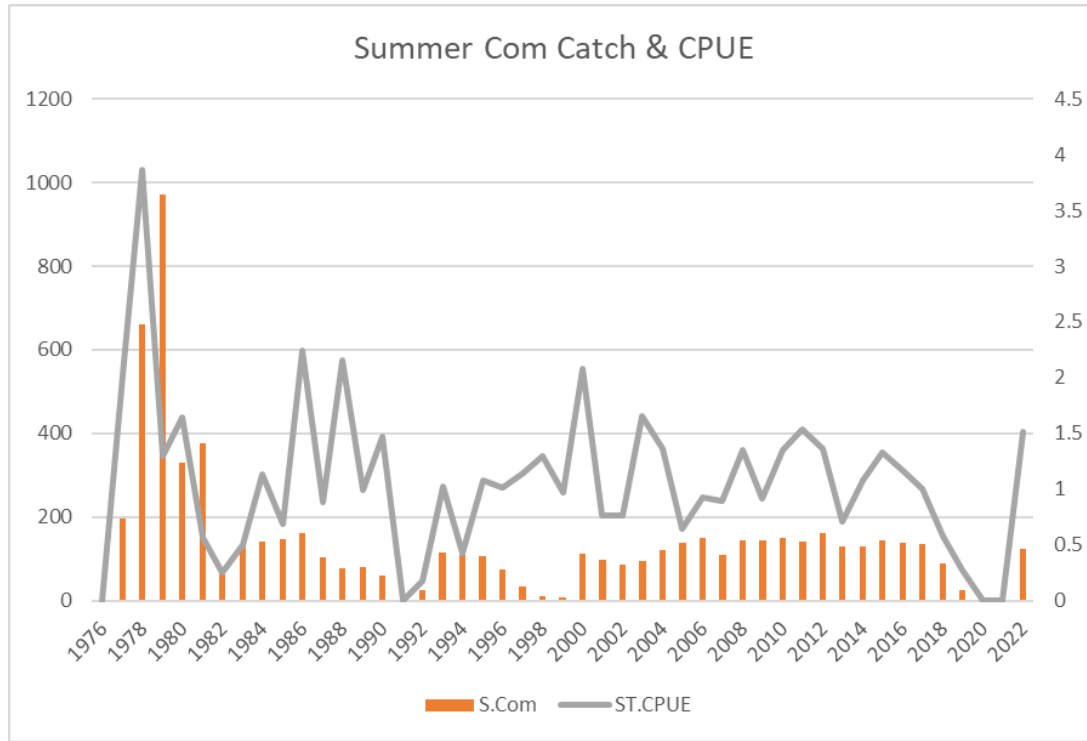
NSRKC Trawl Survey

Not aligning well

Abundance

Modeled crab abundance Feb 01
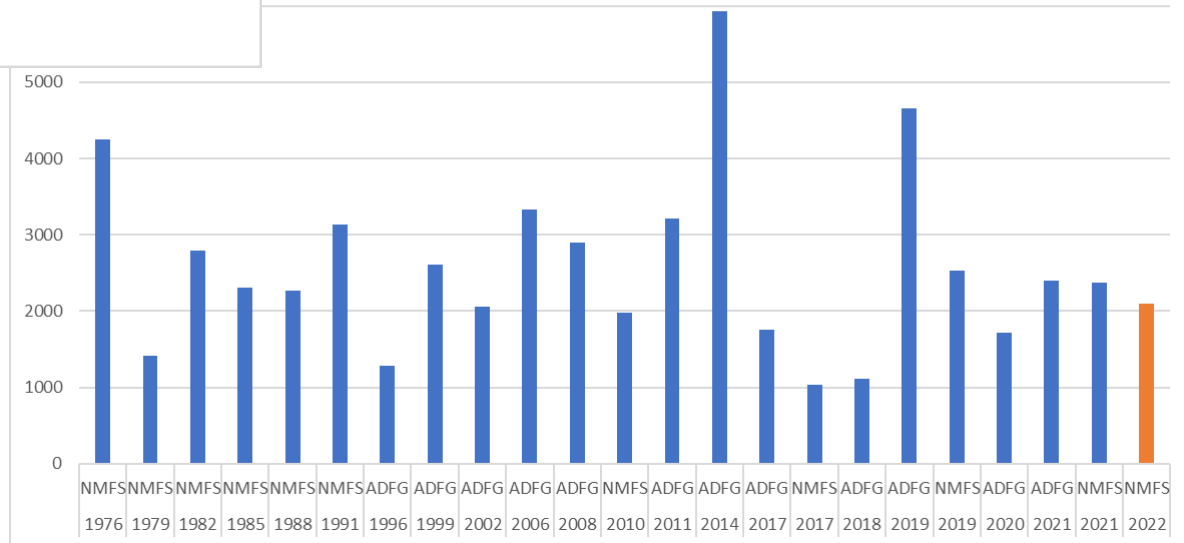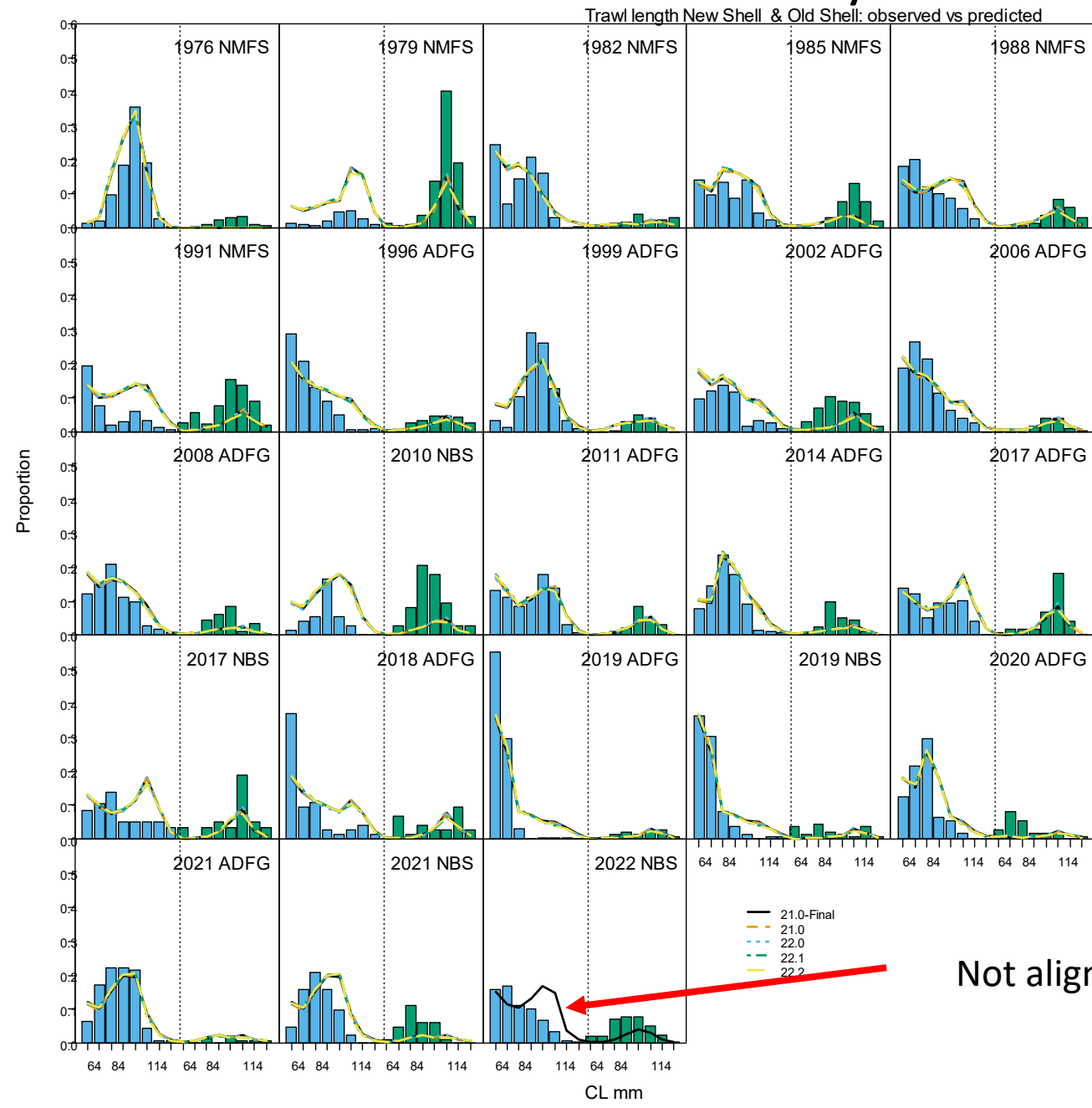
Retrospective

Retrospective Analysis Model 21.0

CPT RECOMMENDATIONS

- **Endorsed base model 21.0, 30% buffer**
- **Length-independent F_{OFL}**
  - Status quo
  - Tier 4 calculations were not established to consider length based natural mortality or multiple M values
  - Uncertain that large crab have higher natural mortality vs other possibilities
- **Discard mortality estimates**
  - Model uses small sample of observer data (~6 years) to estimate a retention curve, estimates a retained OFL and discard OFL
  - At end of year – how to account for "total" catch without observer data
    - **CPT recommend** model estimated discard rate to be used for 2022 total catch
- **Total vs retained catch OFLs**
  - Model estimated discard rate used both to set OFL and to establish total catch, this is circular
  - Without observer data "retained" catch OFL does a better job of accounting for removals.
    - Observer data is NOT prioritized for this fishery due to high cost of data collection and inability for observer data to be representative of the fleet
  - **CPT recommends** going back to retained catch OFL for 2023

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CPT RECOMMENDATIONS

- **Buffer – 30%**

  - Reduced from 40% in 2022

  - Reduced concern for stock – high CPUE, less issues with female portion of the stock, reduction in some model fit issues

  - Buffer was at 30% under retained catch OFL previously

Year	MSST	Biomass (MMB)	GHL	Retained Catch Mortality[1]	Total Catch Mortality[2]	OFL[3]	ABC[3]
2018	1.09	1.85	0.13	0.14	0.15	0.20	0.16
2019	1.03	1.41	0.07	0.04	0.04	0.11	0.09
2020	1.04	1.66	0.08	Conf.	Conf.	0.13	0.09
2021	1.03	2.27	0.14	0.003	0.003	0.29	0.16
2022	0.95	2.42	0.15	0.15	0.16	0.30	0.18
2023	1.20	2.40				0.292	0.204

- Jittering analysis to evaluate model convergence was completed and corrected during the meeting – great effort by the author.

AIGKC PROPOSED MODELS 2023

- Addressing CPT/SSC comments

  - Models to address retrospective patterns – size composition changes, CPUE weighting, time-varying catchability, inclusion of co-operative survey data for EAG (21.1g)

  - Cooperative survey incorporation into EAG (Appendix C)

  - GMACS transition (Appendix D)

  - Models to address maturity differences between EAG and WAG

  - Combined AI model

AIGKC proposed models for May 2023

| Model	Area	CPUE Data Type and Maturity Option	Period for Mean Number of Recruit Calculation for (a) Initial Equilibrium Abundance and (b) Reference Points Estimations; and Remarks
21.1e2 (accepted model in May/June 2022, implemented with up to 2021/22 data)- core/base model	AI, EAG, WAG	Observer data from 1995/96–2021/22; Fish ticket data from 1985/86–1998/99; Observer and fish ticket CPUE standardization by the negative binomial model; the knife-edge maturity size of 116 mm CL; $M = 0.22$; and three catchability and additional CVs during 1985–1998; 1995–2004; and 2005–2021.	1987–2017; CPT/SSC suggested base model.
21.1f (core model)	AI, EAG, WAG	21.1e2 + observer CPUE data standardized including Year: Block interaction.	1987–2017
21.1e2 LF14	AI, EAG, WAG	21.1e2 + size composition limited to 2014/15	1987–2017
21.1f LF14	AI, EAG, WAG	21.1f + size composition limited to 2014/15	1987–2017
21.1e2CPUE5Wt	EAG, WAG	21.1e2 + CPUE likelihood weighted by 5	1987–2017
21.1fCPUE5Wt	EAG, WAG	21.1f + CPUE likelihood weighted by 5	1987–2017
21.1e2Q	EAG	21.1e2 + variable catchability	1987–2017
21.1g	EAG	21.1e2 + EAG cooperative pot survey standardized CPUE	1987–2017
21.1e2 a, b, c	AI, EAG, WAG	21.1e2 +variable period for mean recruitment estimation	a: 1987–2019; b: 1987–2020; c: 1987–2021
	GMACS version of core models, 21.1e2 and 21.1f, for EAG and WAG		

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AIGKC PROPOSED MODELS 2023

- Change in authorship – Tyler Jackson (ADF&G)

- CPT recommends for May 2023:

  - Models 21.2e2, 21.1f, and EAG only - 21.1g and 21.1g-like (with 21.1f as base)

  - ONLY GMACS models in May 2023

    - Bridging analysis successful and recommends the transition to GMACS

    - Differences between bespoke and GMACS

      - Early (pre-data) period has different MMB due to how these models "spin-up" the population.

      - Small differences in unfished recruitment leads to small differences in reference point estimates

      - OFL calculation difference – bespoke assessment calculates $F_{35\%}$ based on a grid search and GMACS uses a Newton-Raphson algorithm (more accurate)
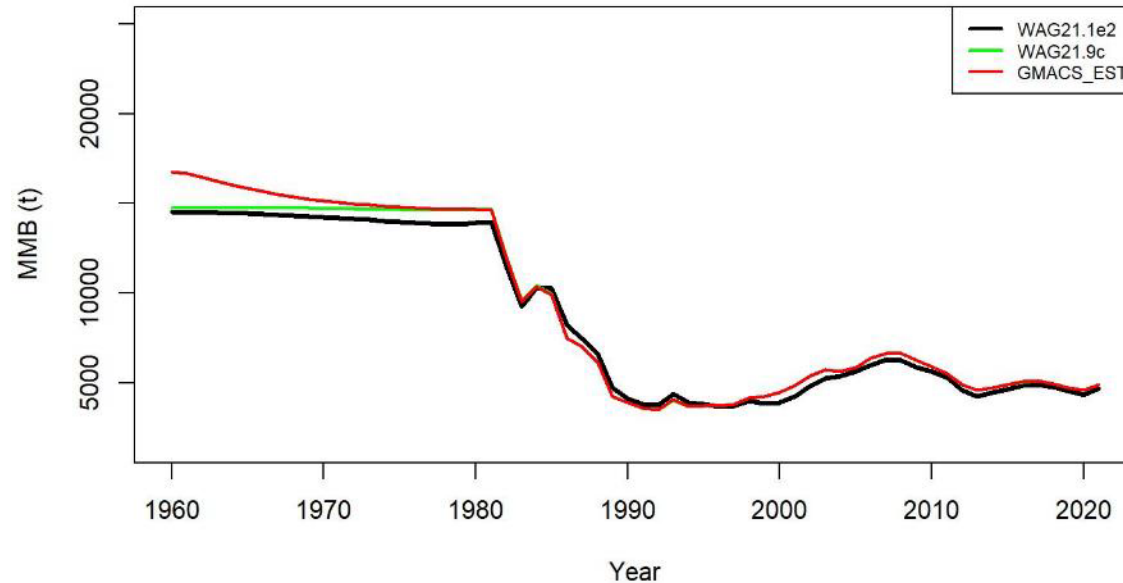
GMACS IMPLEMENTATION - EAG
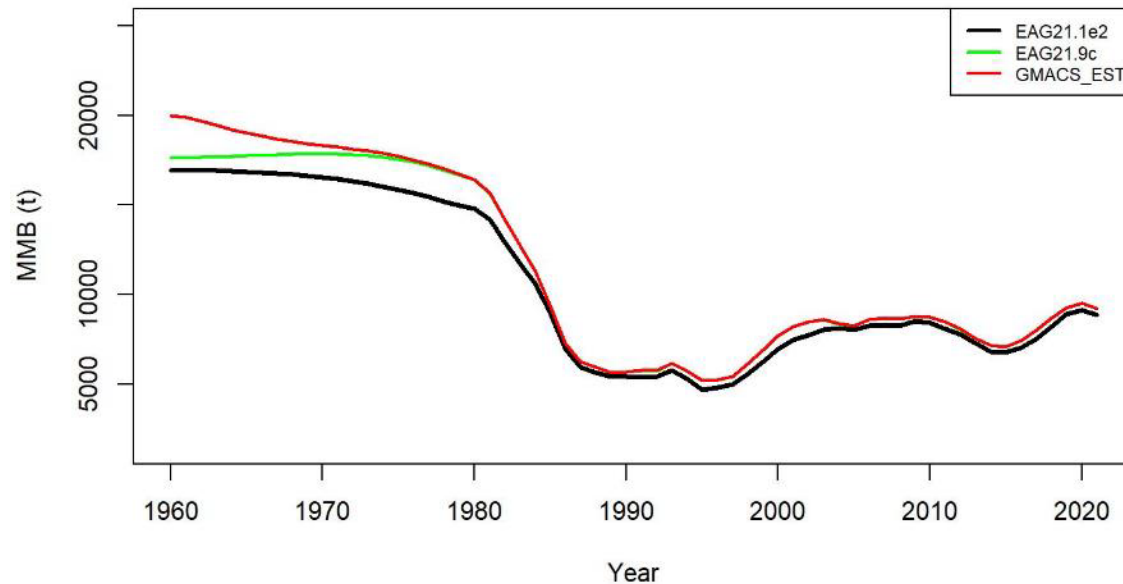
- 21.1e2 (status quo, black)
- 21.9c (modified 21.1e2 to match GMACS, green)
- GMACS_est (red)

Figure D.1. Comparison of MMB trends for EAG golden king crab, 1960–2021 (black: status quo model EAG21.1e2; green: EAG21.9c (modified EAG21.1e2); and red: GMACS_EST).

GMACS IMPLEMENTATION - WAG

- 21.1e2 (status quo, black)
- 21.9c (modified 21.1e2 to match GMACS, green)
- GMACS_est (red)

Figure D.2. Comparison of MMB trends for WAG golden king crab, 1960–2021 (black: status quo model WAG21.1e2; green: WAG21.9c (modified WAG21.1e2); and red: GMACS_EST).
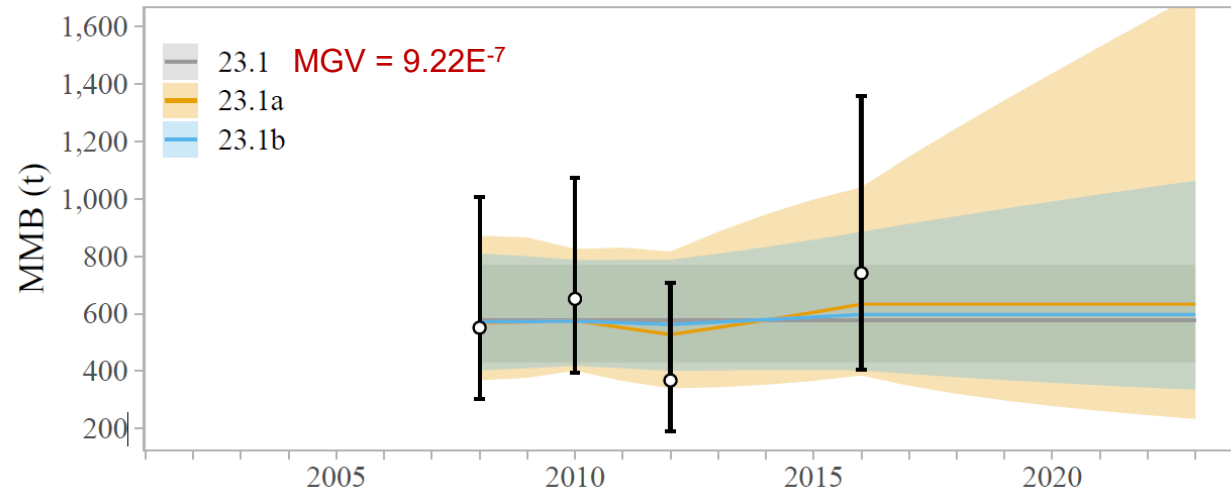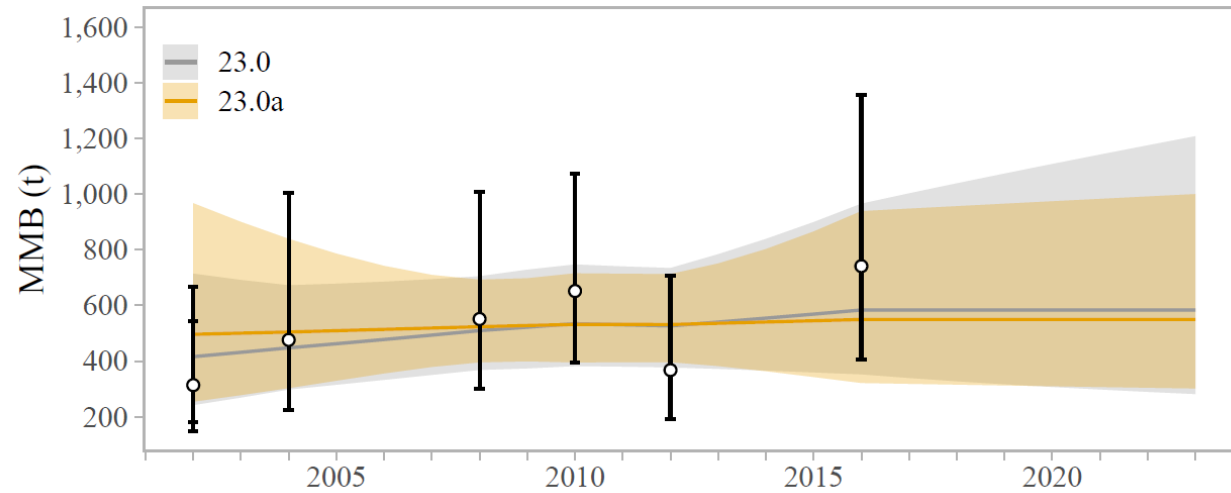
PIGKC PROPOSED MODELS - 2023

- Tier 5 stock (OFL determined using average catch), triennial assessment

- Many SSC/CPT comments were addressed

- Models presented:

  - Previously accepted Tier 5 with updated catch estimates

  - Tier 4 models using *rema* (Sullivan et al. 2022) to fit EBS slope survey data

  - Tier 4/5 approach (from spiny dogfish/groundfish) – uses "raw" estimates of survey biomass to determine the current year biomass using an average MMB

Fig 4.

Tier 4 approaches
- Small amount of survey data doesn't capture dynamics of the stock well
- Uncertain when new data might be available
- Overall estimates of reference points are similar to Tier 5

PIGKC PROPOSED MODELS - 2023

- Tier 5 stock (OFL determined using average catch), triennial assessment

- Many SSC/CPT comments were addressed

- Models presented:

    - Previously accepted Tier 5 with updated catch estimates

    - Tier 4 models using *rema* (Sullivan et al. 2022) to fit EBS slope survey data

    - Tier 4/5 approach (from spiny dogfish/groundfish) – uses "raw" estimates of survey biomass to determine the current year biomass using an average MMB

- CPT recommends Tier 5 approach

    - Slope survey infrequency and unsure of new data point, does not capture the dynamics of the stock well

    - All modeling outcomes have similar resulting OFLs

BALANCE OF CPT REPORT

MODELING WORKSHOP

- GMACS progress:
  - Matthieu Veron (post-doc) has made A LOT of progress
    - Merging king and snow crab coding branches
    - Updating GitHub site and documentation
    - Updating 'gmr' R package
      - Includes routines to compare model output for version control
  - https://github.com/GMACS-project
  - Future work:
    - Complete the documentation and R package vignettes
    - Including more crab stocks – NSRKC, tanner
    - Discussion on future of GMACS – including location and "gatekeepers"

Simpler Modeling Workshop

- SSC suggested a Simpler Modeling Working Group in October 2022: *"Crab models have become increasingly complex over time, and model parsimony is a key goal for assessments. It is difficult to balance this with the need to account for the complex dynamics of crab populations. For multiple crab stocks, the SSC suggests that fitting a range of simpler models and data-limited approaches, such as the Tier 4 calculation, can also provide insight into the differences between raw survey observations and integrated assessment model output."*

- Working Group comprised of CPT & SSC members

- Objectives:
  - Better align and simplify crab models- establish a simpler "base" model for stocks and add features from there (stock-specific)
  - Bridge the difference between State and Federal processes – in terms of models utilized and currency of management

- 1st Working Group meeting: **03/27-03/28**

Guidelines for changing model start date

- October 2022 Report: "*The SSC supports the CPT plans to discuss appropriate model start dates…The SSC recommends that the CPT explore a consistent approach across all EBS stocks to use trawl survey data after 1982 when gear and sampling designs were more standardized.*"

- Survey gear standardized in 1982, spatial grid standardized in 1988

- Tanner crab example:
  - Model begins in 1948, estimates different selectivity to account for pre-1982 survey gear and spatial footprint
  - Starting model in 1982 produced no meaningful change to reference points or time series of R, MMB

- BBRKC example:
  - Survey spatial coverage more uniform through time
  - Current start date (1975) requires large values of M and R early in the time series, creating modeling difficulties
  - Reference point estimates use data from 1984 onwards, so changing model start date does not change reference point estimates

Guidelines for changing model start date – CPT recommendations

- Default should be to use all the data available – long history of CPT recommendations

- Moving the start date if:

  - Early data are suspect *and* this leads to convergence issues or divergent trajectories for the stock

  - Changes in population dynamics present difficulties in modeling periods of very different *M, R*, etc.

- If a changing start date is proposed, CPT requests diagnostics for effect on reference points and stock status

Bering Sea Fisheries Research Foundation (BSFRF) update

preliminary core area sampling coverage
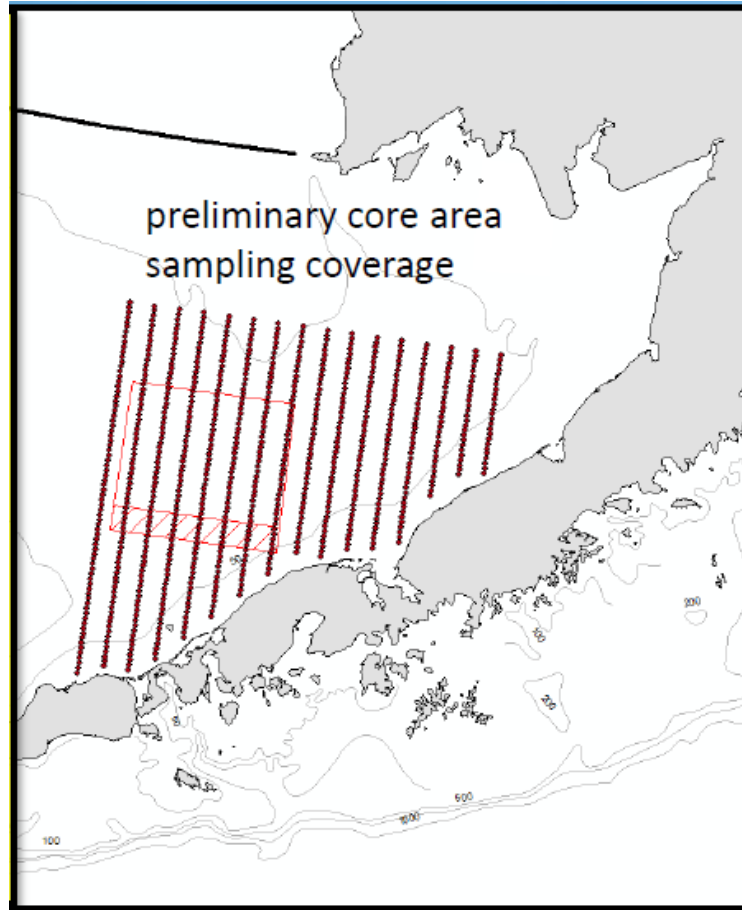
- Cooperative BSFRF / ADF&G / NOAA winter BBRKC pot survey

- Start date ~March 12

- 2 vessels, 20-25 days each

- Three goals:

  - Winter distribution

  - Winter movement (~175 satellite tag releases tied to centers of abundance)

  - Research to reduce female & sublegal catches in directed fishery

- Additional $2.75M Congressionally Directed Spending to fund BSFRF research

Research update – Crab tagging

- Leah Zacher (AFSC Kodiak): Summary of five years of tagging effort for BBRKC / planning for 2023 tagging

  - Data available on male summer -> fall and fall -> winter movement, female fall -> spring movement

  - Next steps: scaling up to population inferences, increased focus on females and habitat / temperature information

- Jared Weems (ADF&G Kodiak): Update on pilot acoustic tagging detection with Slocum glider

  - Study using Kodiak Tanner crabs

  - Successful test, possible applications for Bering Sea

# Research update – Ocean acidification
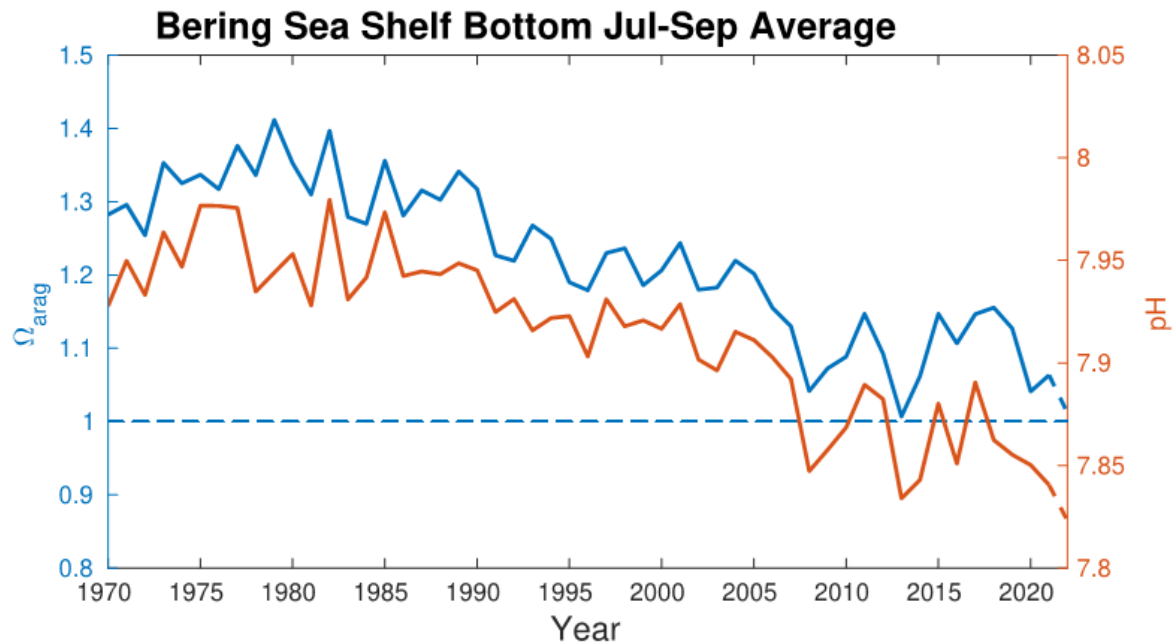
Model hindcast: aragonite saturation and pH.

- Darren Pilcher (CICOES/PMEL): Update on carbonate chemistry modeling
  - Model hindcast shows decadal declines
  - Validation underway
- Chris Long (AFSC Kodiak): Update on lab studies on BBRKC effects
  - Strongest effects on juveniles
  - Threshold / range studies needed to understand effects between ambient and pH 7.8

Research update – BBRKC bycatch distribution models

Period: Sep/Oct, Target: Yellowfin Sole
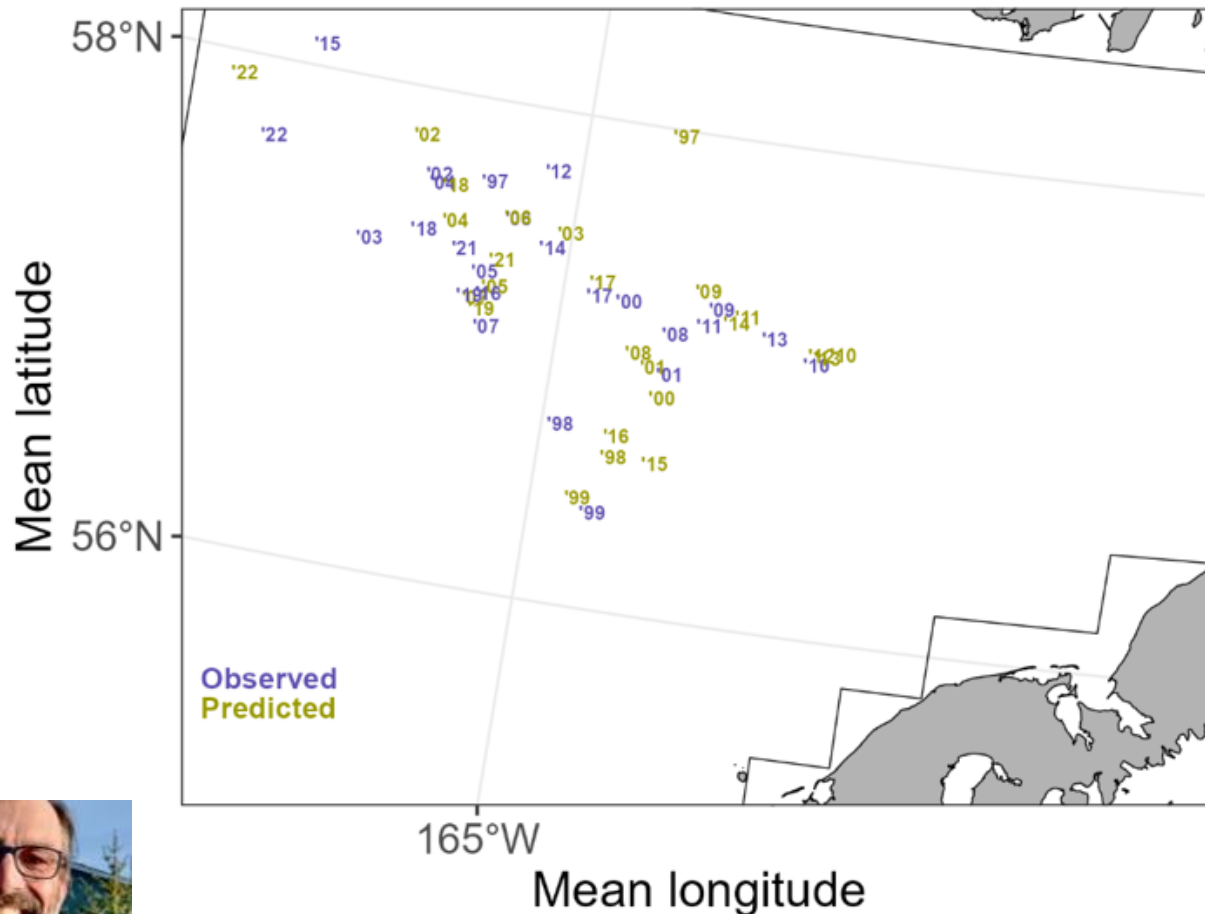
- Emily Ryznar (AFSC Kodiak)
- Boosted regression tree models to predict bycatch in bottom trawl fisheries
- Example (left): legal male BBRKC bycatch centers of distribution in Sept/Oct yellowfin sole fishery, observed and predicted

QUESTIONS?

- Thanks to all CPT members and crab authors.

- Thanks to Siddeek for his time served on crab plan team and as AIGKC assessment author