

C2 BSAI CRAB STOCKS

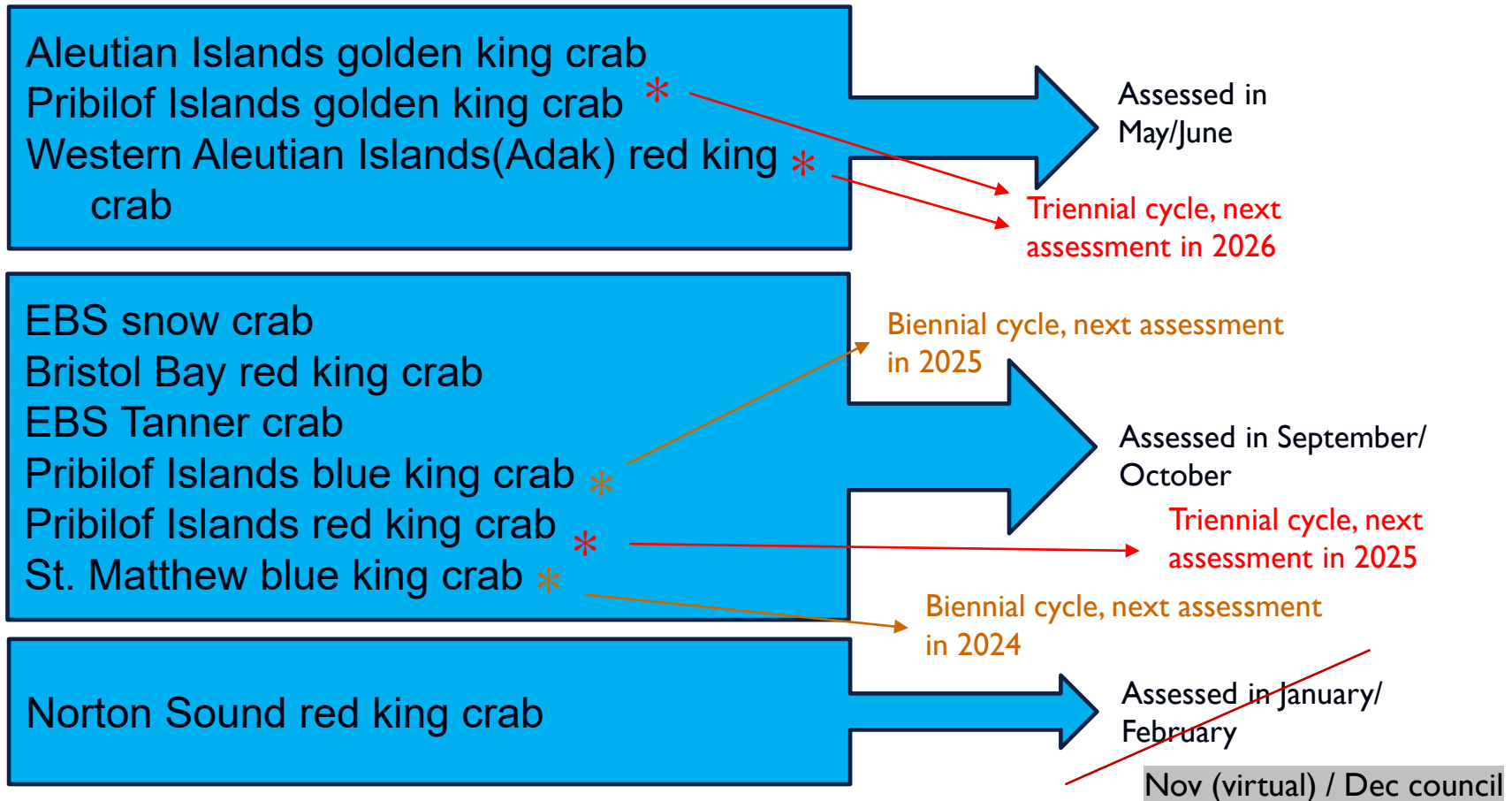
KATIE PALOF & MIKE LITZOW (CPT CO-CHAIRS)

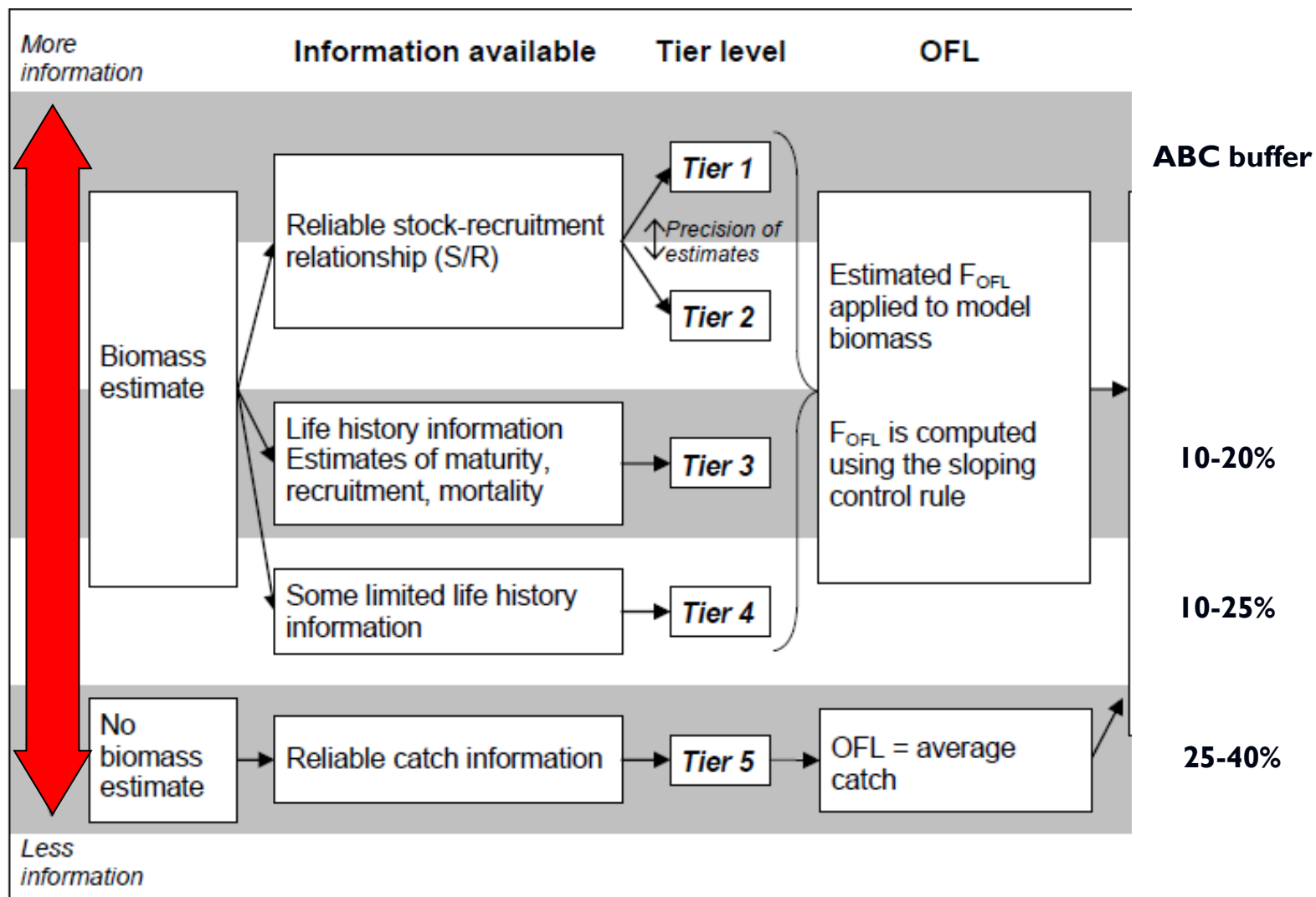
JUNE 2024 NPFMC MEETING | KODIAK, AK

CPT MEETING MINUTES – MAY 14TH – 16TH | ANCHORAGE, AK



BSAI CRAB STOCKS MANAGEMENT TIMING





MAY 2024 AGENDA

- ✓ **AIGKC final assessment, OFL and ABC**
- ✓ Proposed model runs:
 - ✓ Snow crab
 - ✓ Tanner crab
 - ✓ BBRKC
 - ✓ SMBKC
- ✓ BSFRF research updates
- ✓ Council topic updates
- ✓ ESP updates and planning
- ✓ Survey updates
- ✓ Crab observer program updates
- ✓ GMACS updates



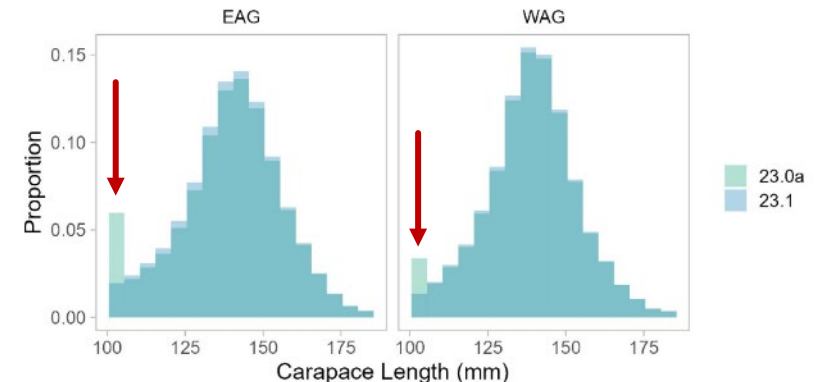


ALEUTIAN ISLAND GOLDEN KING CRAB (AIGKC)

FINAL SAFE, OFL / ABC 2024

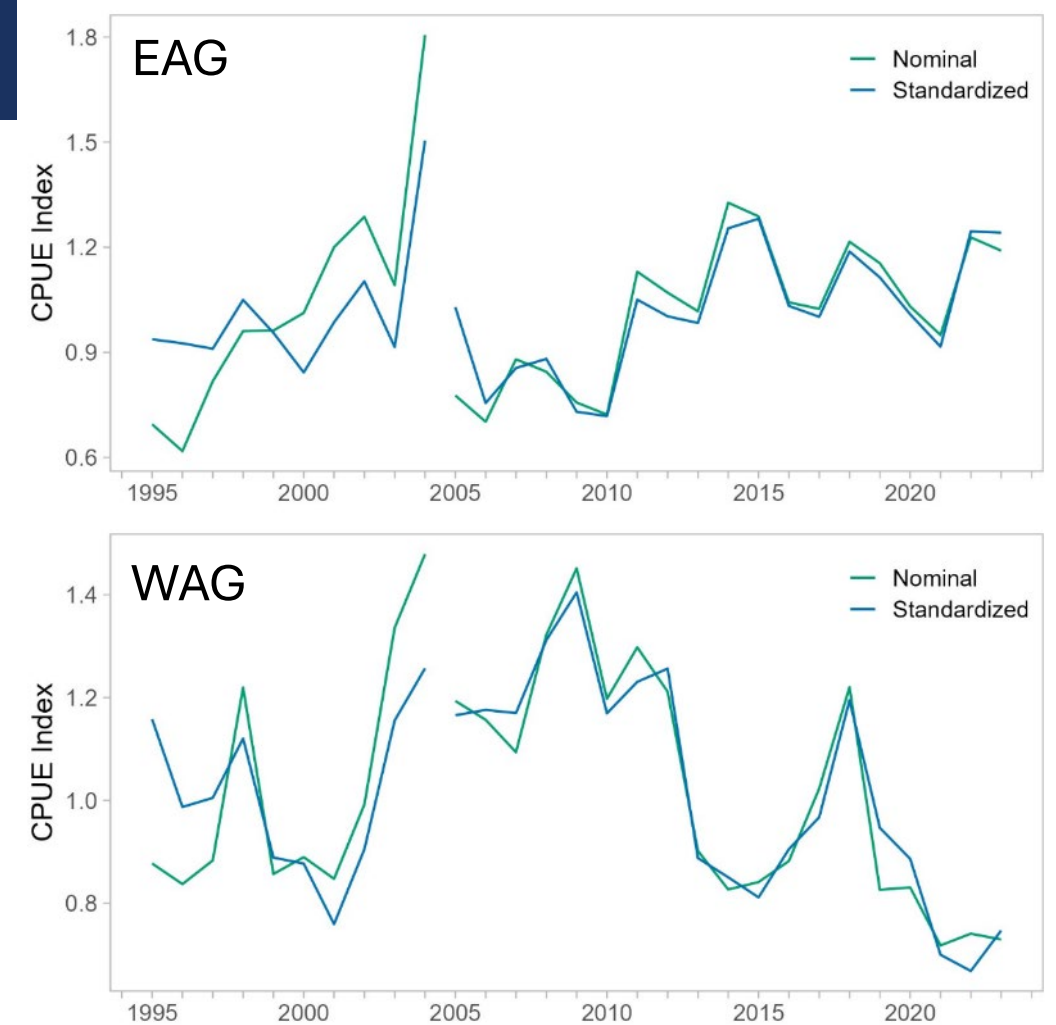
AIGKC EXPLORATIONS

- First final models under new authorship (Tyler Jackson)
- Data streamlining and recreating historic data from database performed in Jan 2024
- CPUE standardization
 - Detailed in appendix A; updated reviewed in Jan 2024
 - Changes from Jan to May:
 - Explore Tweedie distributions
 - Remove $s(\text{Lon}, \text{Lat})$ as covariate – overfitting concerns
 - Correct fish ticket data pull (included many 0 data entries that were errors)
- Model options:
 - 23.0a (base model 2023)
 - 23.1 (23.0a + truncated size composition to exclude crab less than the smallest size bin)
 - 23.1b (23.a + two selectivity periods in pre-rationalization CPUE)



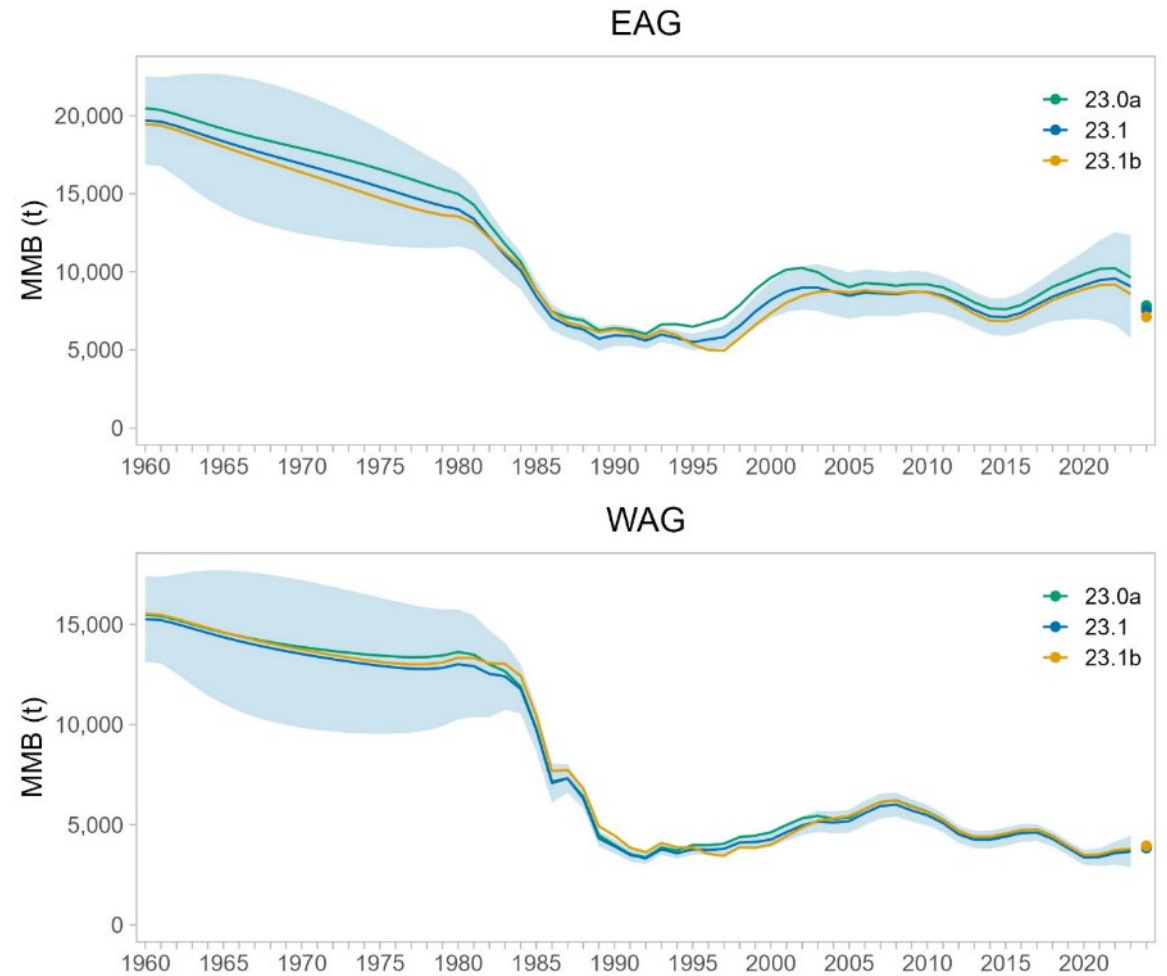
CPUE STANDARDIZATION

- Neg binomial distribution fit better for pre-rationalization CPUE standardization, Tweedie for post-rationalization (same in both areas)
- Author provided good diagnostics plots



MODEL FIT

- 23.1b fit EAG slightly better but issues with Francis weighting in WAG.
- 23.1 consistently fit well for both areas, but with minor jittering issue in WAG
- CPT discussed some issues with F estimates in bycatch time series in WAG (some similar problems arose in Tanner GMACS models) and appropriate GMACS fixes for this



FINAL SPECIFICATIONS

Table 14: Comparison of biological reference points for EAG models.

Model	MMB (t)	B _{35%} (t)	$\frac{MMB}{B_{35\%}}$	$\bar{R}_{1987-2017}$	F _{35%}	F _{OFL}	OFL (t)
23.0a	7,834	7,138	1.10	2,822	0.55	0.55	3,035
23.1	7,551	6,905	1.09	2,781	0.55	0.55	2,825
23.1b	7,112	6,906	1.03	2,795	0.59	0.59	2,699

Model	MMB (mil lb)	B _{35%} (mil lb)	$\frac{MMB}{B_{35\%}}$	$\bar{R}_{1987-2017}$	F _{35%}	F _{OFL}	OFL (mil lb)
23.0a	17.27	15.74	1.10	2,822	0.55	0.55	6.69
23.1	16.65	15.22	1.09	2,781	0.55	0.55	6.23
23.1b	15.68	15.23	1.03	2,795	0.59	0.59	5.95

Table 15: Comparison of biological reference points for WAG models.

Model	MMB (t)	B _{35%} (t)	$\frac{MMB}{B_{35\%}}$	$\bar{R}_{1987-2017}$	F _{35%}	F _{OFL}	OFL (t)
23.0a	3,904	4,698	0.83	1,869	0.54	0.44	945
23.1	3,837	4,638	0.83	1,866	0.54	0.44	900
23.1b	3,944	4,716	0.84	1,914	0.57	0.46	951

Model	MMB (mil lb)	B _{35%} (mil lb)	$\frac{MMB}{B_{35\%}}$	$\bar{R}_{1987-2017}$	F _{35%}	F _{OFL}	OFL (mil lb)
23.0a	8.61	10.36	0.83	1,869	0.54	0.44	2.08
23.1	8.46	10.23	0.83	1,866	0.54	0.44	1.98
23.1b	8.70	10.40	0.84	1,914	0.57	0.46	2.10



CPT RECOMMENDATIONS

- Model 23.1 for both areas
- 25% ABC buffer consistent with 2023 assessment
 - Level of uncertainty similar
 - Improvements in data processing and CPUE standardization
 - Poor model fit to index and poor retrospective patterns still prevalent
- Future work:
 - Explore retrospective pattern in EAG
 - Length comp weights are high, try Dirichlet multinomial
 - EAG cooperative survey incorporation
 - Explore EAG index fit – time varying catchability?
 - Re-visit size at maturity



SNOW CRAB: PROPOSED MODEL RUNS 2024

Outline

- Proposed models
 - Tier 3
 - Tier 4 fallback option
- Currency of management
 - MMB time series for different currencies
 - Yield curves
 - “Arbitrary” selection of vulnerable size as currency
 - Possible next steps building on Clark (1991) yield curve analysis
- Population projections under continued sea ice decline



PROPOSED TIER 3 MODEL

- Last year's accepted model (23.3a)
 - Probability of maturity defined outside model
 - BSFRF data as prior on NMFS survey selectivity
- Effort put into modeling narrative, currency of management decision
- CPT endorses continued use of this model

Process	Data	Historical assumptions	Updated assumptions
Recruitment	Survey abundance + size composition	Equal sex ratio	Unequal sex ratios
Natural mortality	Longevity + survey data	Constant with strong priors	Strong priors and time-block in 2018-2019
Growth	Growth increment	Piece-wise	Linear
Maturity	Chelae height	Single estimated ogive	Input yearly observations
Fishing mortality	Observer data	Freely estimated	GMACS changed form
Fishery selectivity	Observer data	Freely estimated	GMACS changed form
Survey selectivity	BSFRF	Logistic, BSFRF as survey	Non-parametric, BSFRF as priors

Table 1. Population processes modeled in the stock assessment for snow crab, the data that informs each process, historical assumptions about a given process, and updated assumptions included in the most recent assessment model.



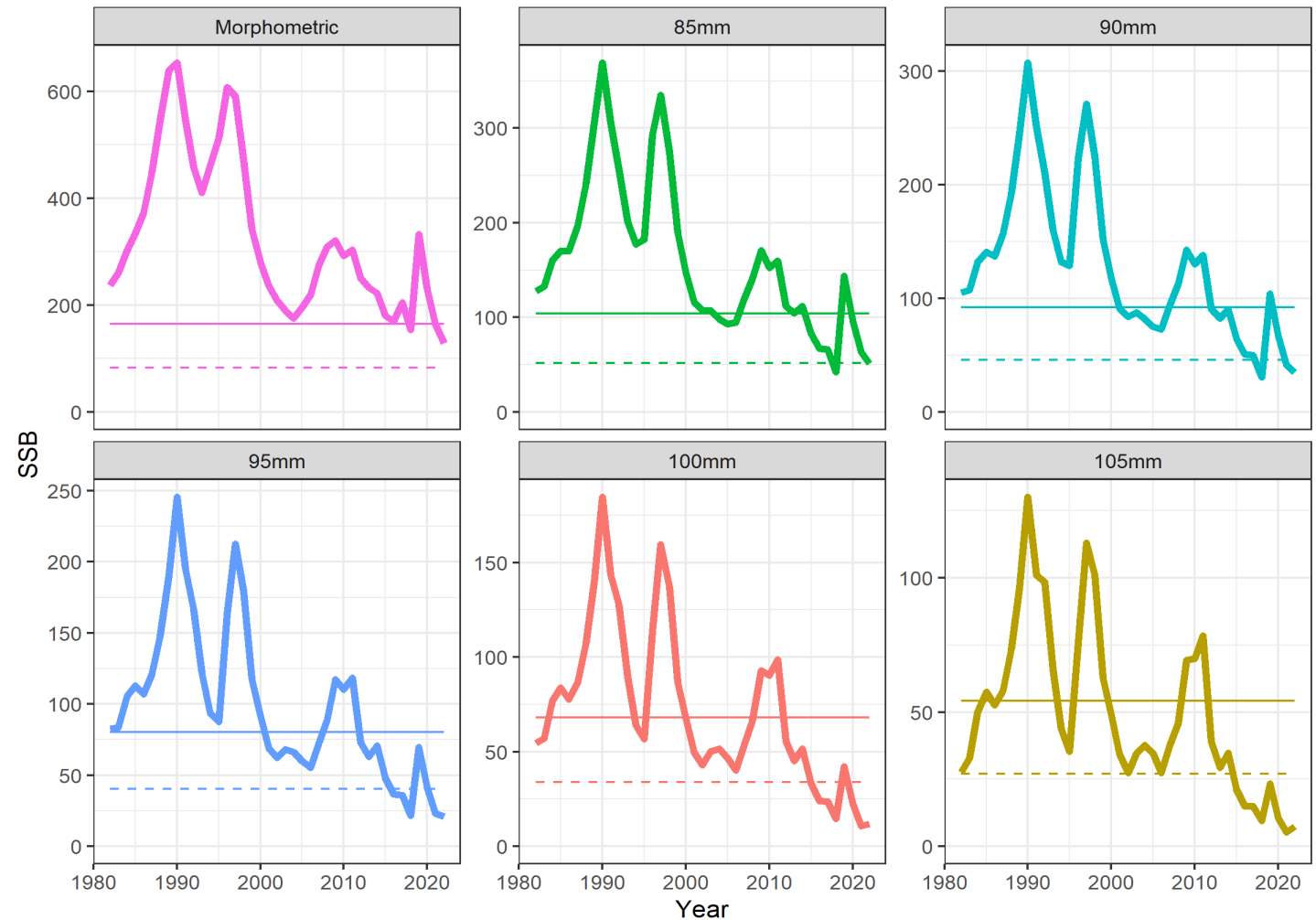
PROPOSED TIER 4 FALLBACK

- Author proposed two departures from SSC recommendations:
 - Instead of fitting REMA smooth to survey time series, use annual estimate of vulnerable biomass (≥ 95 mm CW males)
 - Motivations:
 - Snow crab are well sampled by the survey (238 positive stations in 2023), so less need for a smooth to address sampling error than for patchily-distributed species
 - High interannual variability in population makes a smoothed estimate inappropriate at times (e.g., 2019)
 - Decrement survey-estimated MMB by proportion of M occurring prior to fishery
 - Motivation: ignoring M may result in higher exploitation rate than assumed
 - CPT endorsed both ideas for Sept/Oct Tier 4 fallback option



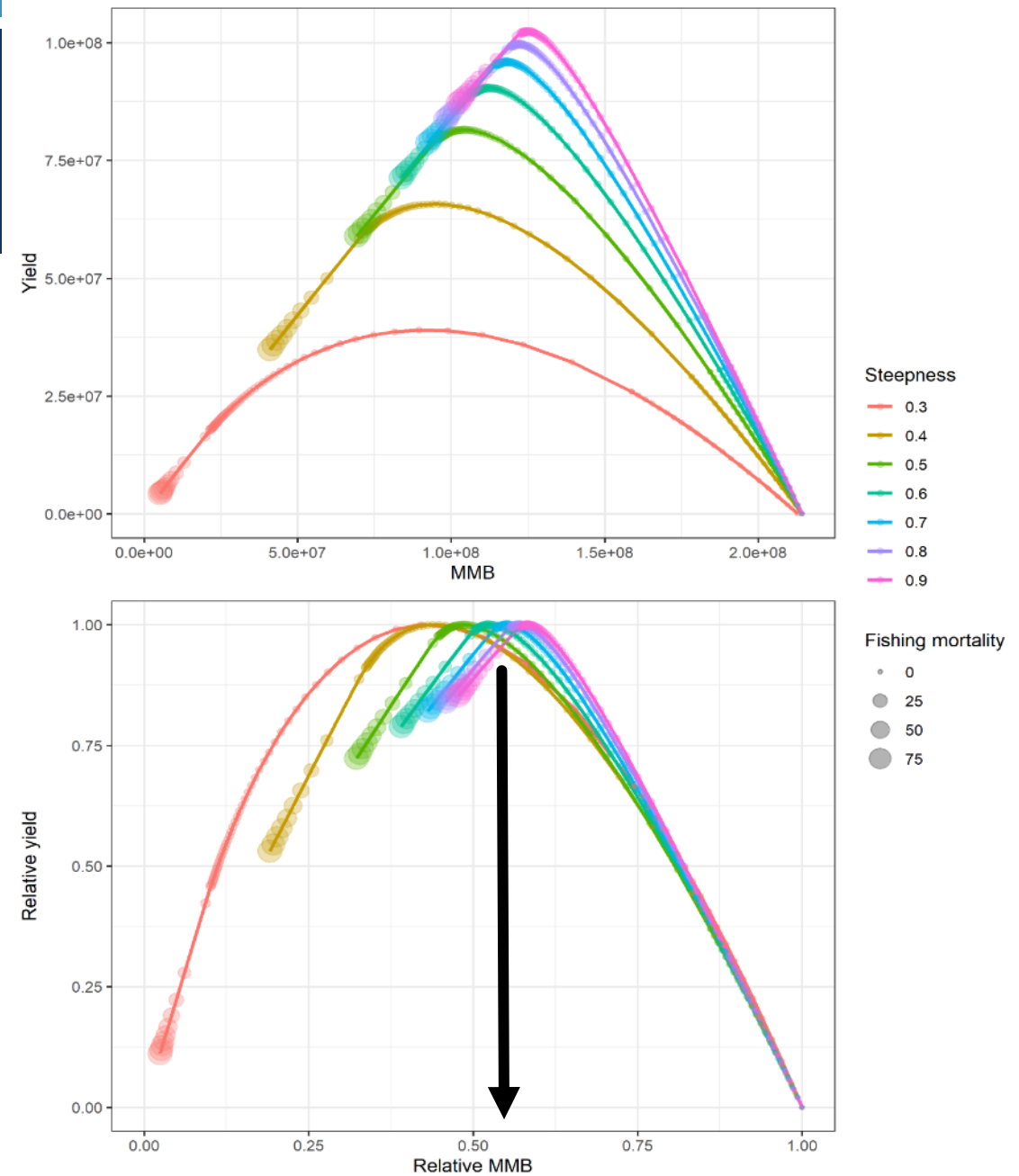
CURRENCY OF MANAGEMENT: IMPLICATIONS FOR STATUS & OFL

Estimated MMB from model 23.3a using different currencies of management



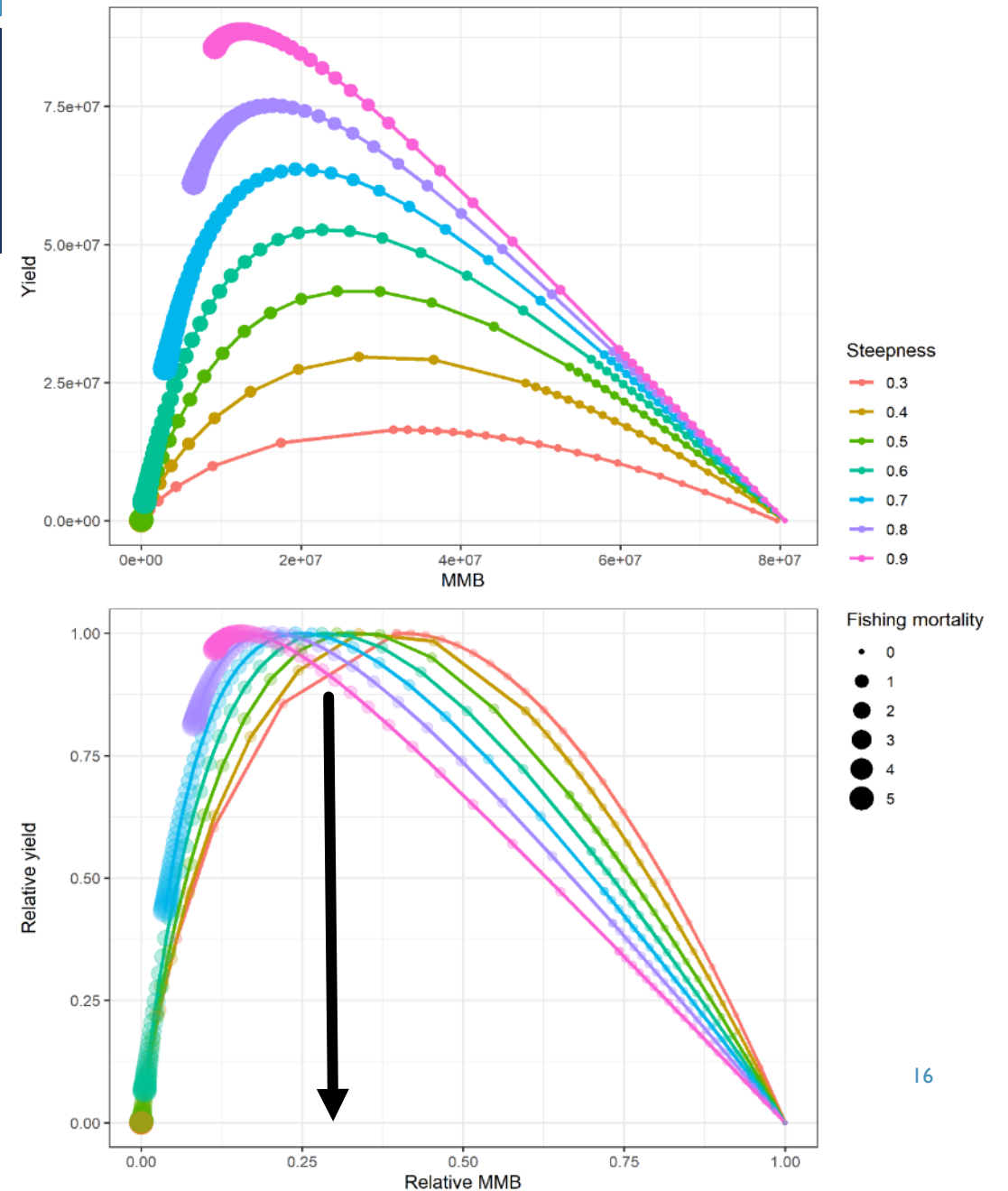
CURRENCY OF MANAGEMENT: YIELD CURVES

- Morphometric maturity as currency:
 - Maximin yield ~55% unfished SBPR
 - Large range of steepness values (S-R relationships) that cannot be depleted to B_{35}



CURRENCY OF MANAGEMENT: YIELD CURVES

- 95mm CW as currency:
 - Maximin yield $\sim 28\%$ unfished SBPR
 - Very similar value (29% SBPR) for currency of 100 mm CW



CURRENCY OF MANAGEMENT

Possible ways forward

- Set currency = vulnerable biomass (95mm CW)
 - Concerns: arbitrary definition, not based on MSY calculation
 - Vulnerable to changes in fishing practices (e.g., exploitation of legal-size crab < 101 mm CW)
 - CPT does not recommend
- Expand Clark (1991) approach
 - Calculate minimax solution over a range of steepness values (S-R relationships) and assumptions about the proportion of the stock driving density-dependence (morphometric males, 85 mm CW, 95 mm CW, etc.)
 - Evaluate robustness of F_{MSY} proxy to different assumptions concerning density-dependence to evaluate choice of currency for management
 - CPT endorses moving forward with this approach

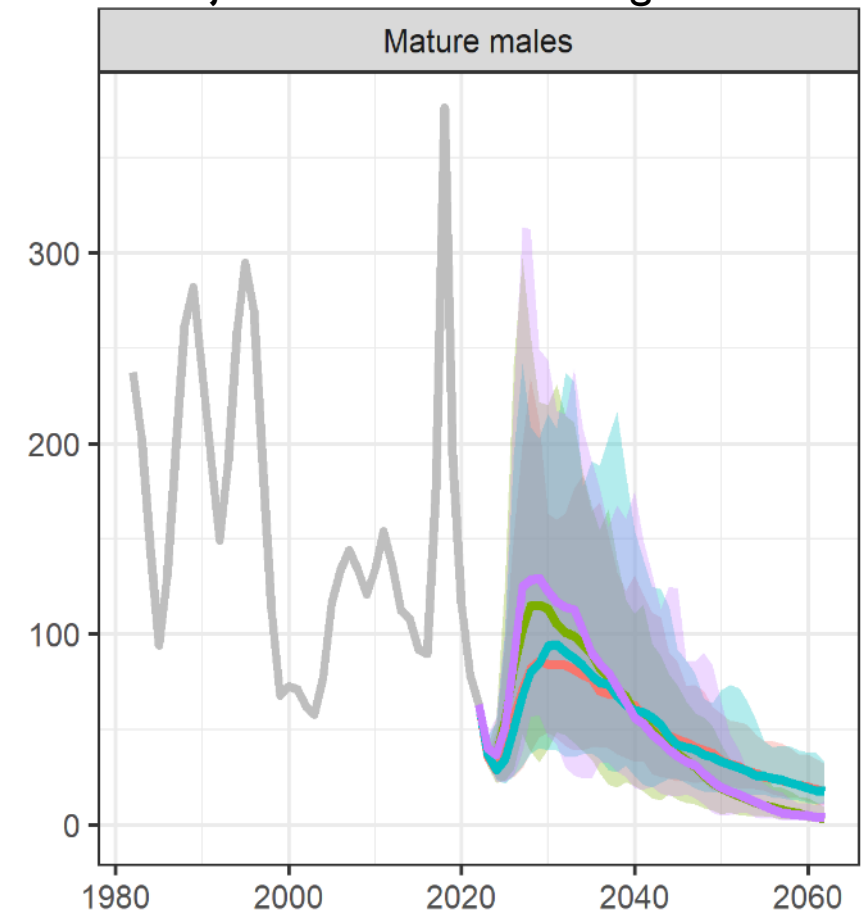


DECADAL-SCALE POPULATION PROJECTIONS

- Three recent papers have confirmed the importance of marginal ice habitat for snow crab (Szuwalski et al. 2023, Mallowney et al. 2024, Litzow et al. in press)
- **Density dependence** and **environmental covariates** explain variability in *mortality*, *recruitment* and *maturity* better than no covariates.
- Impacts of changes in **ice** are strong for *mortality* and *recruitment*
- **Density dependence** in *mortality* allows for a short window for rebound, after which the population declines



Projection under declining sea ice

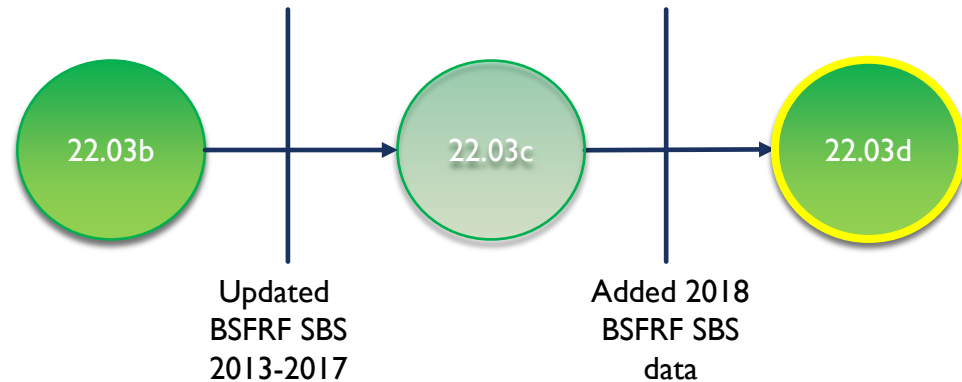


TANNER CRAB PROPOSED MODEL WORK

- Author provided feedback to SSC / CPT comments
 - Focus of model development was GMACS transition
- Updated BSFRF data into model (updates from 2013-2017 and new 2018 data)
- Proposed models include: TCSAM02 and GMACS models



TCSAM02 models



model configuration	parent	number of estimated parameters	changes to parent model
22.03b	--	354	--
22.03c	22.03b	354	updated 2013-2017 BSFRF data & availability curves
22.03d	22.03c	354	2018 BSFRF data & availability curves

GMACS models

- Author recommended G24.03 and G24.06 as alternative GMACS models
- Some GMACS modifications still needed for a full bridging model
- Spikes in fishing mortality in bycatch fleets troubling
- CPT did not recommend GMACS models for specifications this fall



CPT RECOMMENDATIONS

- Fall models
 - Base model 22.03d: 23.02b 2023 accepted model with BSFRF data input data updates
 - Tier 4 option from 2023 (REMA model on NMFS survey data) will be brought forward in Sept.
- Future work
 - GMACS transition – full bridging analysis
 - CPT recommended dynamics in TCSAM02 model be replicated in GMACS
 - Included features authors would use in the future and would allow for a full bridging analysis



BBRKC PROPOSED MODEL WORK

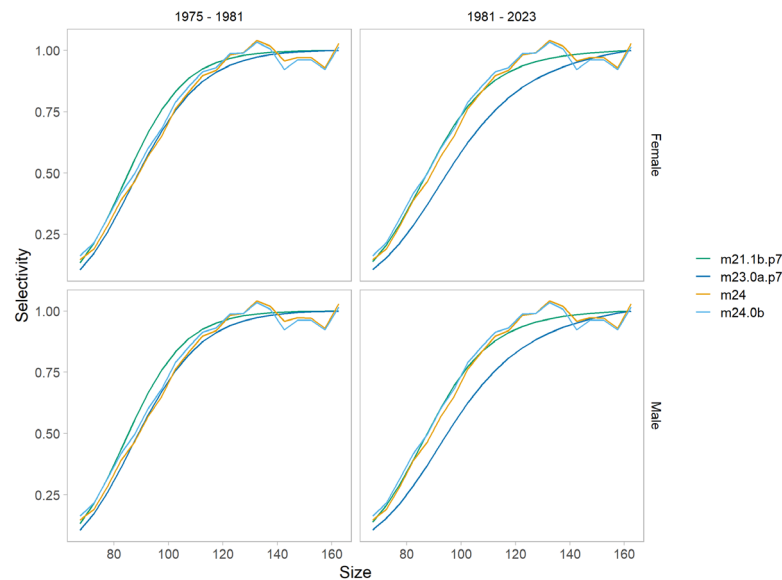
- Stable model in GMACS since 2018
- Directed fishery was open in 2023/24 after being closed for 2 seasons (2021/22, 2022/23) due to low mature female abundance
- Low recruitment in recent years (last 8-12 years), projected decline in biomass without a large recruitment event
- Model explorations around a few themes:
 - GMACS updates
 - Selectivity estimation using BSFRF data as a prior for NMFS survey
 - Molting probability time blocks



MODEL EXPLORATIONS

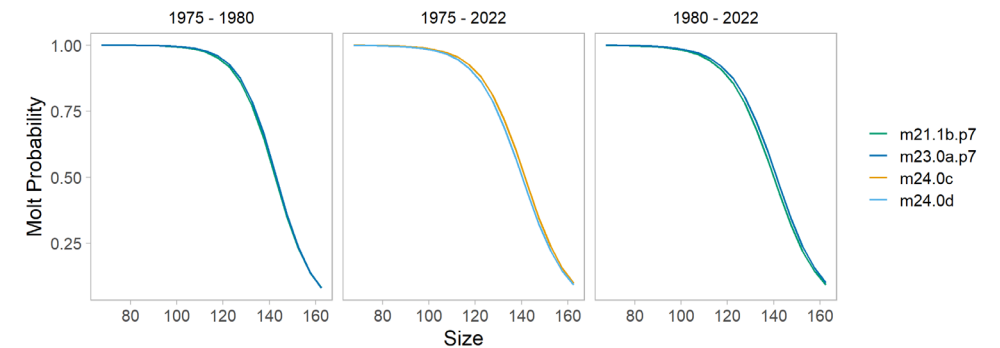
Selectivity (vulnerability)

- Selectivity with BSFRF prior estimated to be very similar to base model.
- Future explorations needed.
- Author /CPT did NOT recommend these models.



Molt probability time block

- Similar results
- Historic time block (1975 to 1980) not significantly different
- Recommend moving to no time blocks (model 24.0c)



CPT RECOMMENDATIONS

- Fall models
 - Base model 23.0a (with corrections in .p7 version, estimated male M)
 - Model 24.0c – model 23.0a with reduced time block for molt probability
 - Tier 4 option from 2023 (REMA model on mature males in NMFS survey data) will be brought forward in Sept.
- Future work
 - Explore BSFRF influence in model
 - Selectivity using BSFRF data in alternative model configurations
 - Sensitivity of model to growth assumptions (size bins, growth inputs)
 - Remove shell condition from the model (not currently being used)
 - Retrospective patterns



SMBKC PROPOSED MODEL WORK

- New primary author Caitlin Stern (ADF&G Juneau)
- GMACS stable model since 2016; bi-annual assessment (last assessment 2022)
- Declared overfished in 2018
 - No directed fishery since 2015/2016
 - Under a rebuilding plan since 2020
- Core model issues
 - Differences between the pot and trawl surveys
 - Poor fit of models to recent years' survey data (2010+)
- New data:
 - 2022 ADF&G pot survey (slight increase from 2018 pot survey)
 - 2023 NOAA survey and groundfish bycatch
- Model explorations around natural mortality – SSC suggested RKC stocks use similar methods to BBRKC



GMACS and model updates

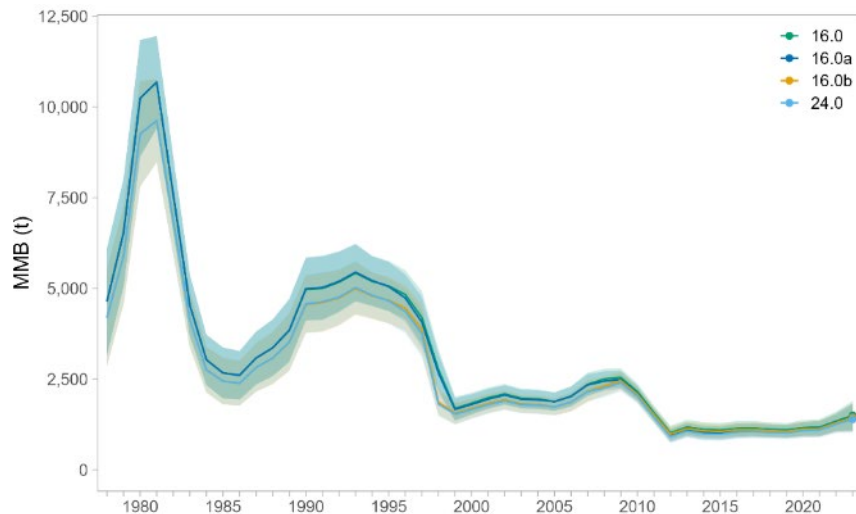
16.0 - 2022: 2022 accepted model with updated GMACS version

16.0: 2022 accepted model with updated data and GMACS version

16.0a: model 16.0 with updated historical ADF&G pot survey time series

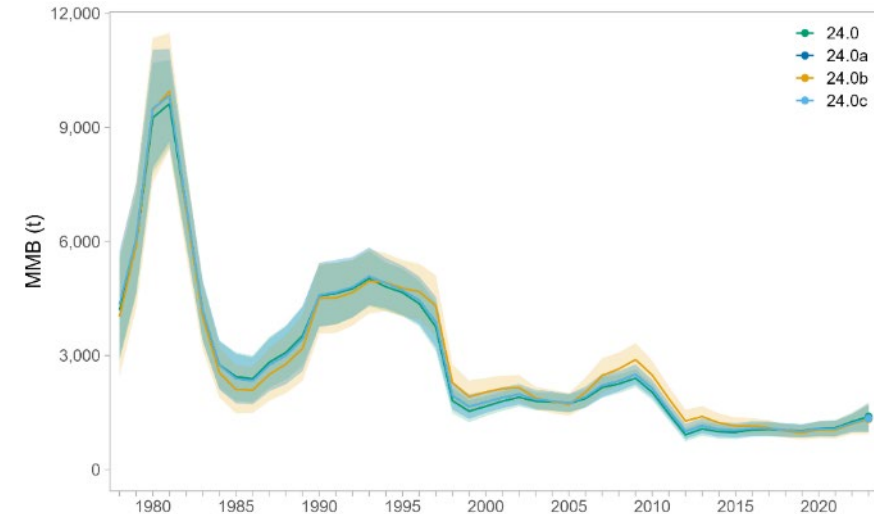
16.0b: model 16.0 with SSB estimated in season 5 of the model rather than season 4

~~16.1~~ 24.0: new base model, combining changes made in models 16.0a and 16.0b.



Natural mortality exploration

- 24.0a (estimate M using BBRKC prior): $M = 0.20$
- 24.0b (estimate M with less restrictive prior): $M = 0.31$
- 24.0c (M fixed at higher value): $M = 0.20$
- All models indicate M would like to be higher than default 0.18



CPT RECOMMENDATIONS

- Fall models
 - Base model 16.1 (16.0 with corrections to historic pot survey data, updated data, and season timing change for MMB in GMACS). Change in model numbering to be consistent with CPT policies
 - Model 24.1: 16.1 as base but with a fixed value of M from BBRKC assessment in 2023 ($M = 0.23$)
- Future work
 - Model runs without the NMFS survey corner stations to match the 2024 survey
 - Work using geo-spatial tools for the two surveys (combined index or separate?)
 - Explore increasing size bins, and what this means to the assumed size transition matrix
 - Likelihood profile on selectivity





BALANCE OF CPT REPORT



BERING SEA FISHERIES RESEARCH FOUNDATION

RESEARCH UPDATE

■ CPS2

- 646 pot lifts, 128 Nephrops trawl sets
- ~7,000 RKC captured
- Pot: 76% male / 24% female
- Trawl: 44% male / 56% female

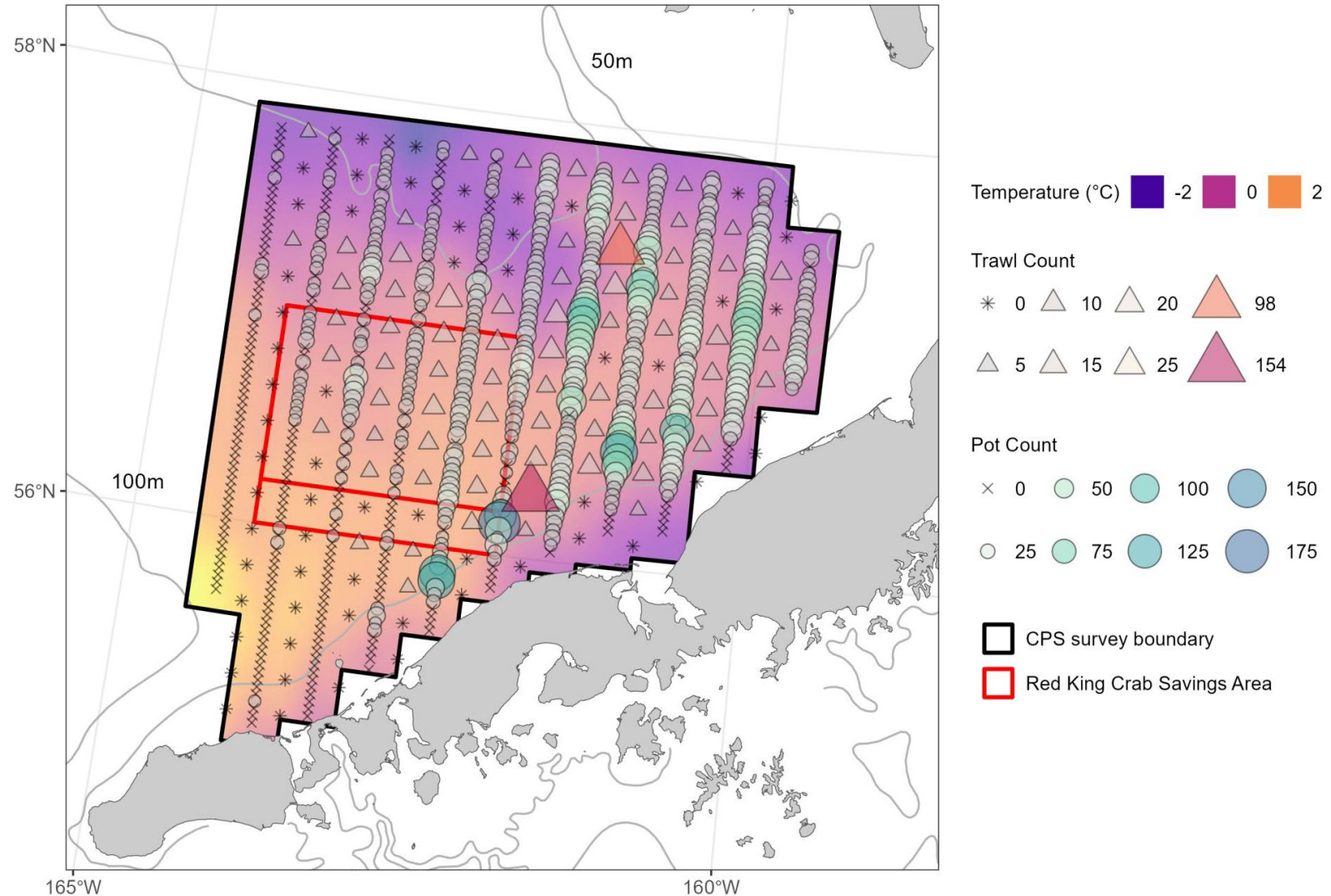
■ Other BBRKC work

- Camsled / larval collectors
- Sat tags



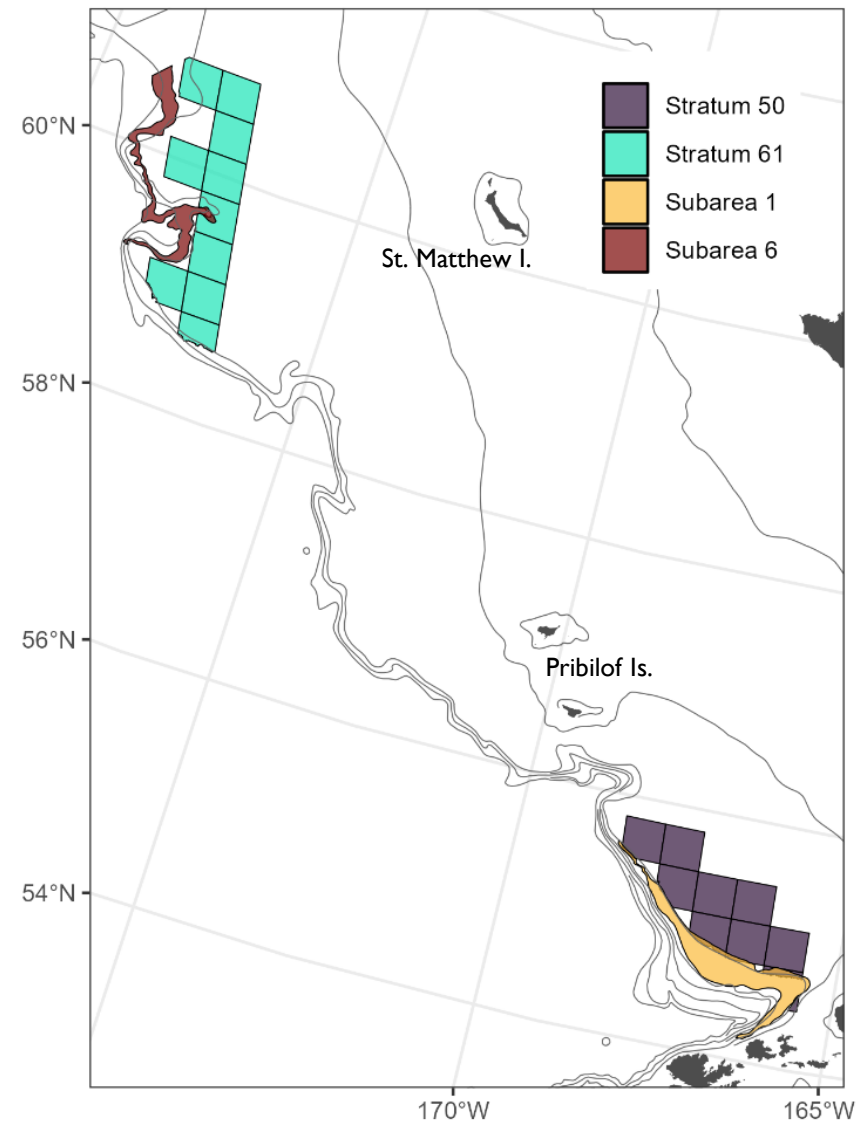
2024 BBRKC Collaborative Pot Sampling

Total BBRKC



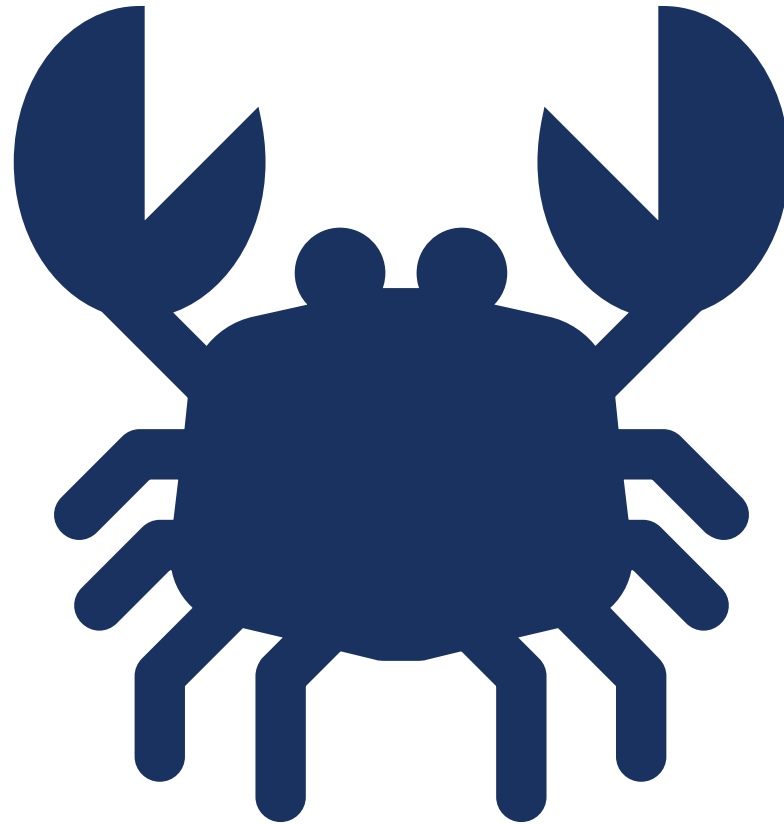
BERING SEA FISHERIES RESEARCH FOUNDATION RESEARCH UPDATE

- Slope:shelf gear comparison to 400m for survey modernization (August 2024)
- *Opilio* collaborative sampling tentatively planned alongside NMFS, using pots & Nephrops trawl



QUESTIONS?

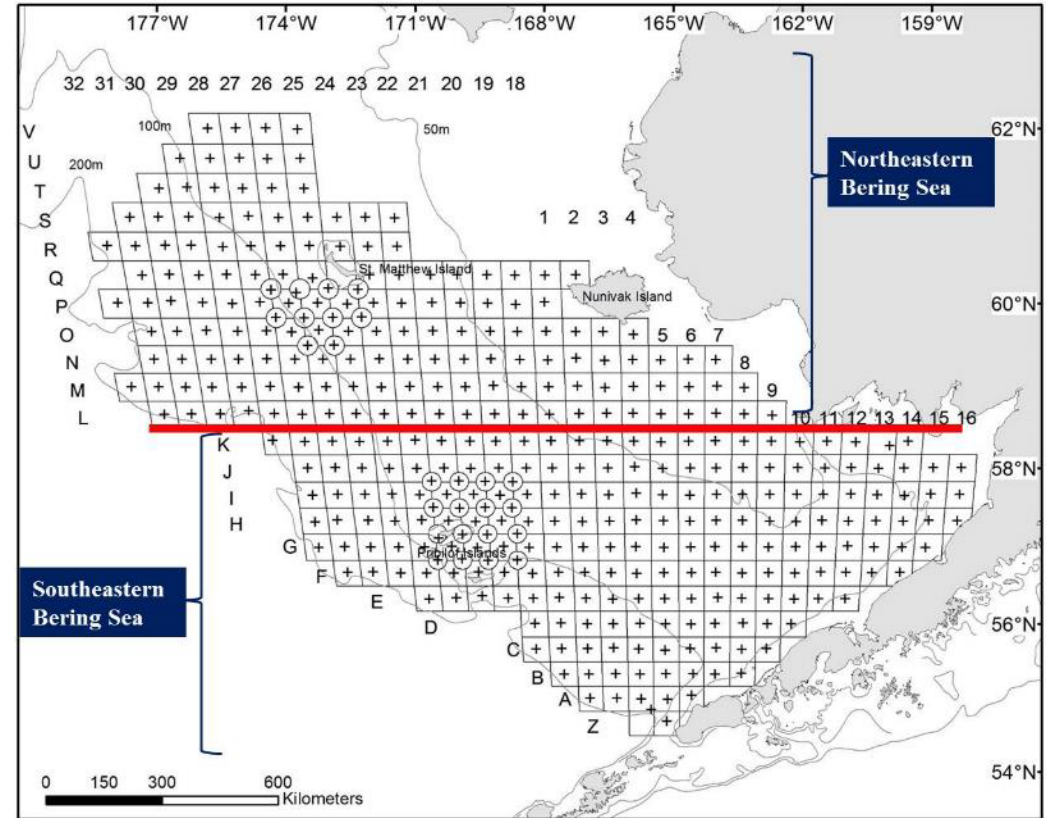
- Thanks to all CPT members and crab assessment authors.
- Thanks to Sarah Rheinsmith for ALL of her work as our plan team coordinator!



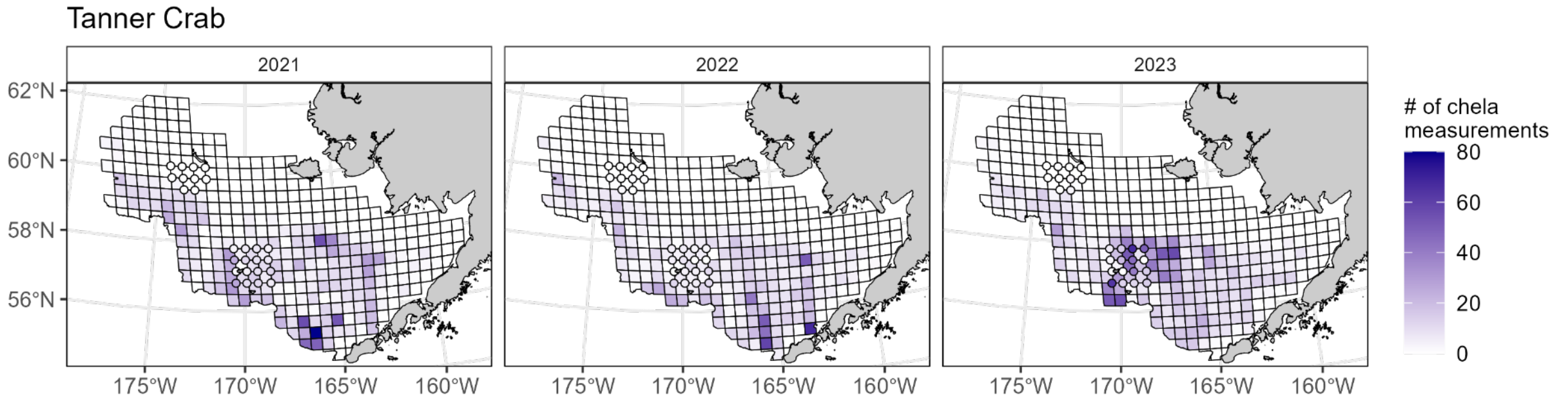
3. Chela measurement protocol

Survey protocol

- Tanner
 - Each tow: 5 measurements each for three size classes (< 85 mm CW, 85-124 mm CW, > 124 mm CW)
 - Entire survey: at least 10 measurements per 5mm bin (50-165 mm range) in southern and northern areas of EBS grid
- Snow
 - Each tow: 5 measurements each for three size classes (40-59 mm CW, 60-99 mm CW, 100-119 mm CW)
 - Entire survey: at least 10 measurements per 5mm bin (40-119 mm range) in southern and northern areas of EBS grid



Tanner crab chela measurements 2021-2023



Snow crab chela measurements 2021-2023

