C1 BSAI CRAB STOCKS
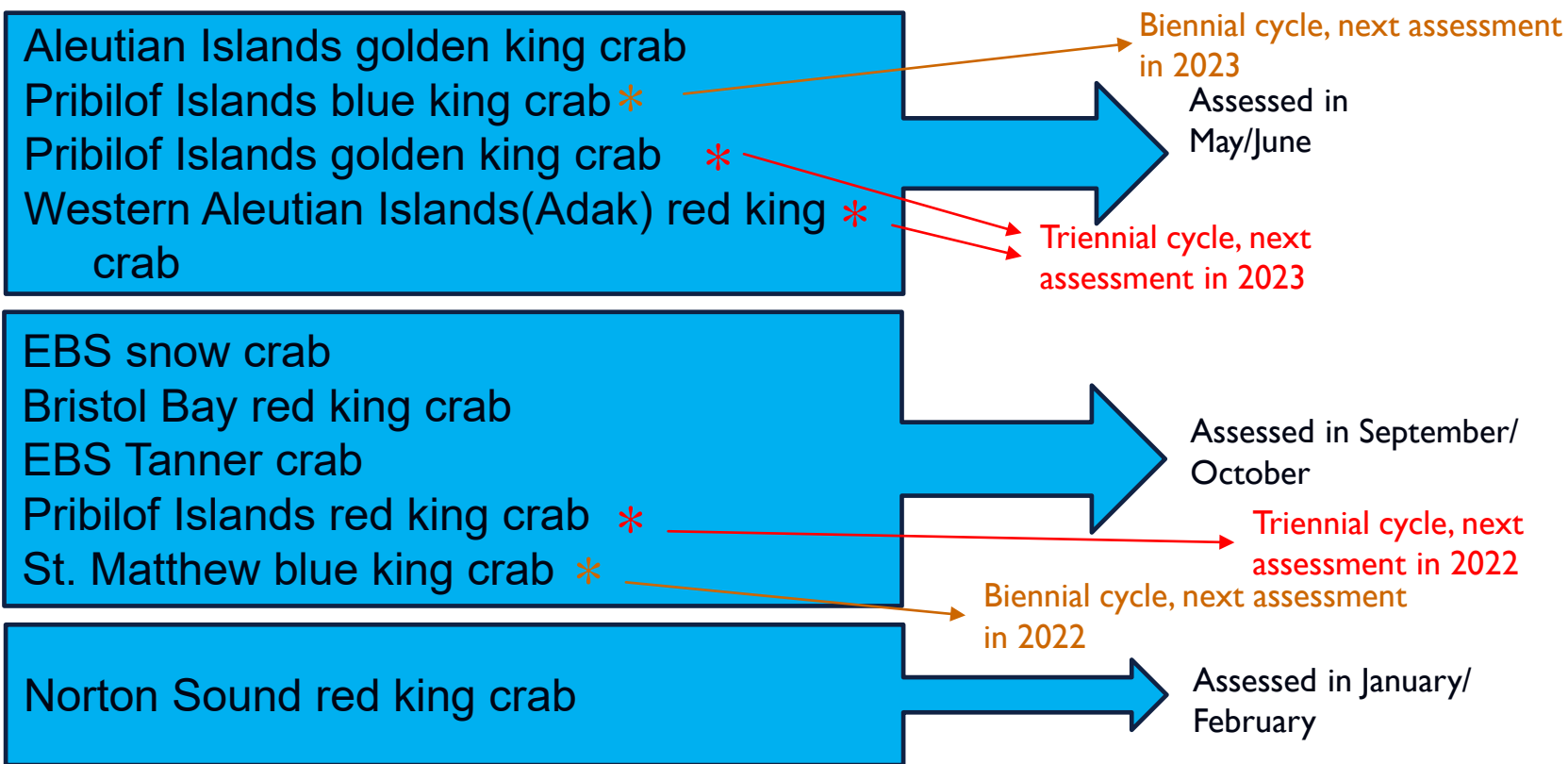
KATIE PALOF & MIKE LITZOW

CPT MEETING MINUTES – SEPT 12-15TH, 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

Information available	Tier level	OFL	
			ABC buffer

More information

Biomass estimate

Reliable stock-recruitment relationship (S/R) → Tier 1 / Tier 2

Precision of estimates

Estimated F_{OFL} applied to model biomass

F_{OFL} is computed using the sloping control rule

Life history information Estimates of maturity, recruitment, mortality → Tier 3

Some limited life history information → Tier 4

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

Less information

ABC buffer

10-20%

10-25%

25-40%

3

SEPT 2022 AGENDA

- **BBRKC final assessment, OFL and ABC, ESP report card update**
- **Tanner crab final assessment, OFL and ABC**
- **SMBKC final assessment, OFL and ABC, ESP report card update**
- **PIRKC final assessment, OFL and ABC**
- **Snow crab final assessment, OFL and ABC, ESP**
- Snow crab rebuilding projections (decisions for initial review in Dec.)
- NSRKC, proposed model runs
- 2022 bottom trawl survey results
- Fishery summary 2021/22
- Overfishing updates: WAIRKC, PIGKC, PIBKC, AIGKC
- EFH fishing effects model – comments/recommendations from CPT
- Ecosystem status report
- Climate model updates
- BSFRF research updates
- GMACS updates

BERING SEA BOTTOM TRAWL SURVEY

2022 RESULTS OVERVIEW

MATURE MALE BIOMASS
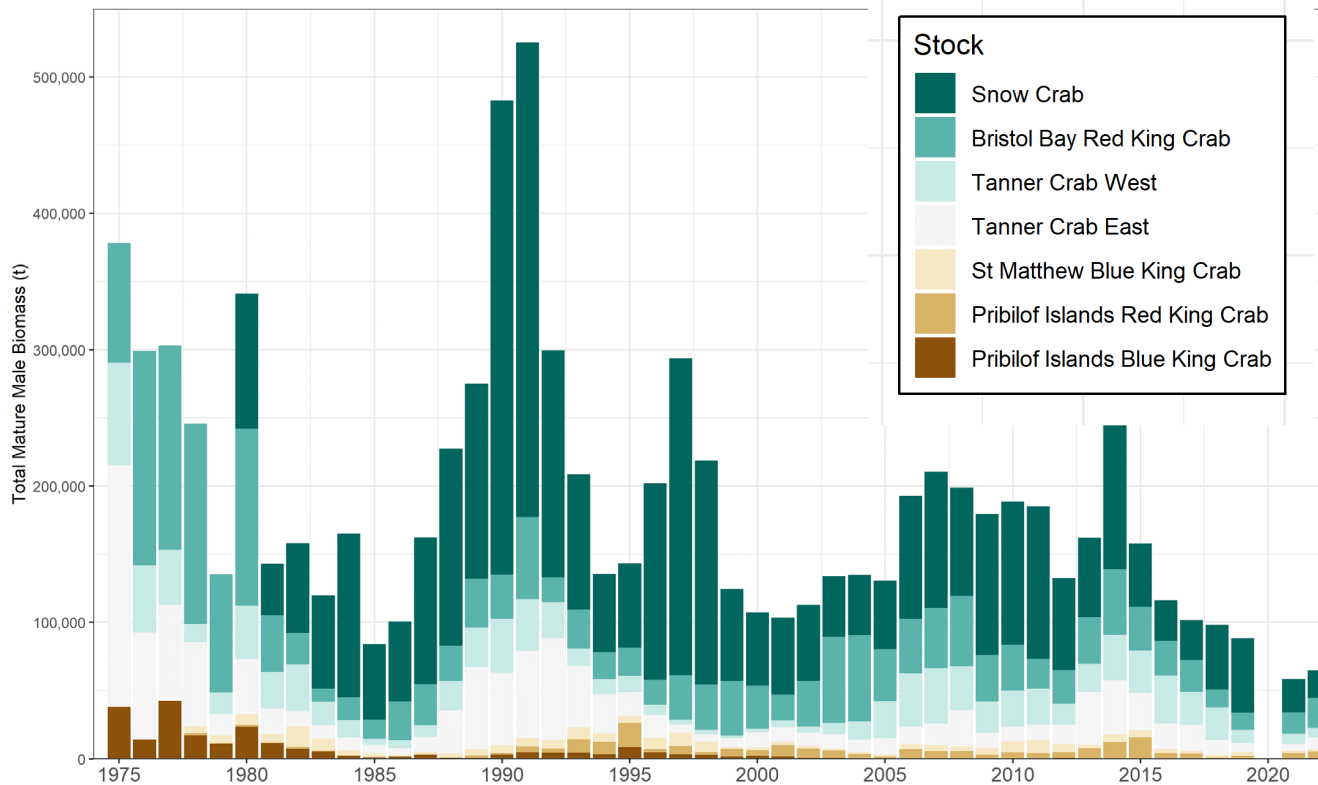
- Total mature male biomass 11% higher than 2021

- Second-lowest value in time series

BRISTOL BAY RKC BIOMASS

Mature female:
+3% from 2021
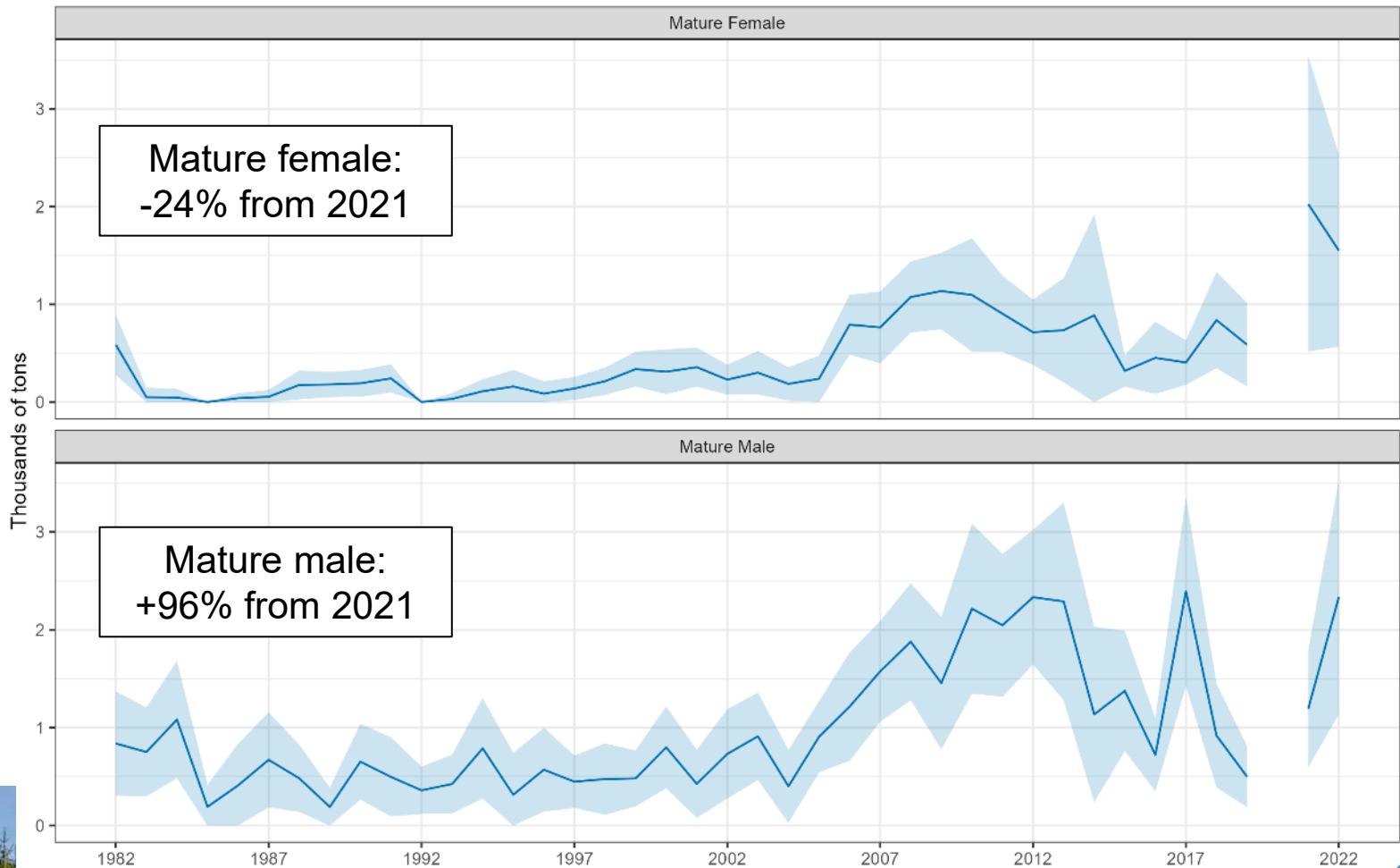
Mature male:
+38% from 2021
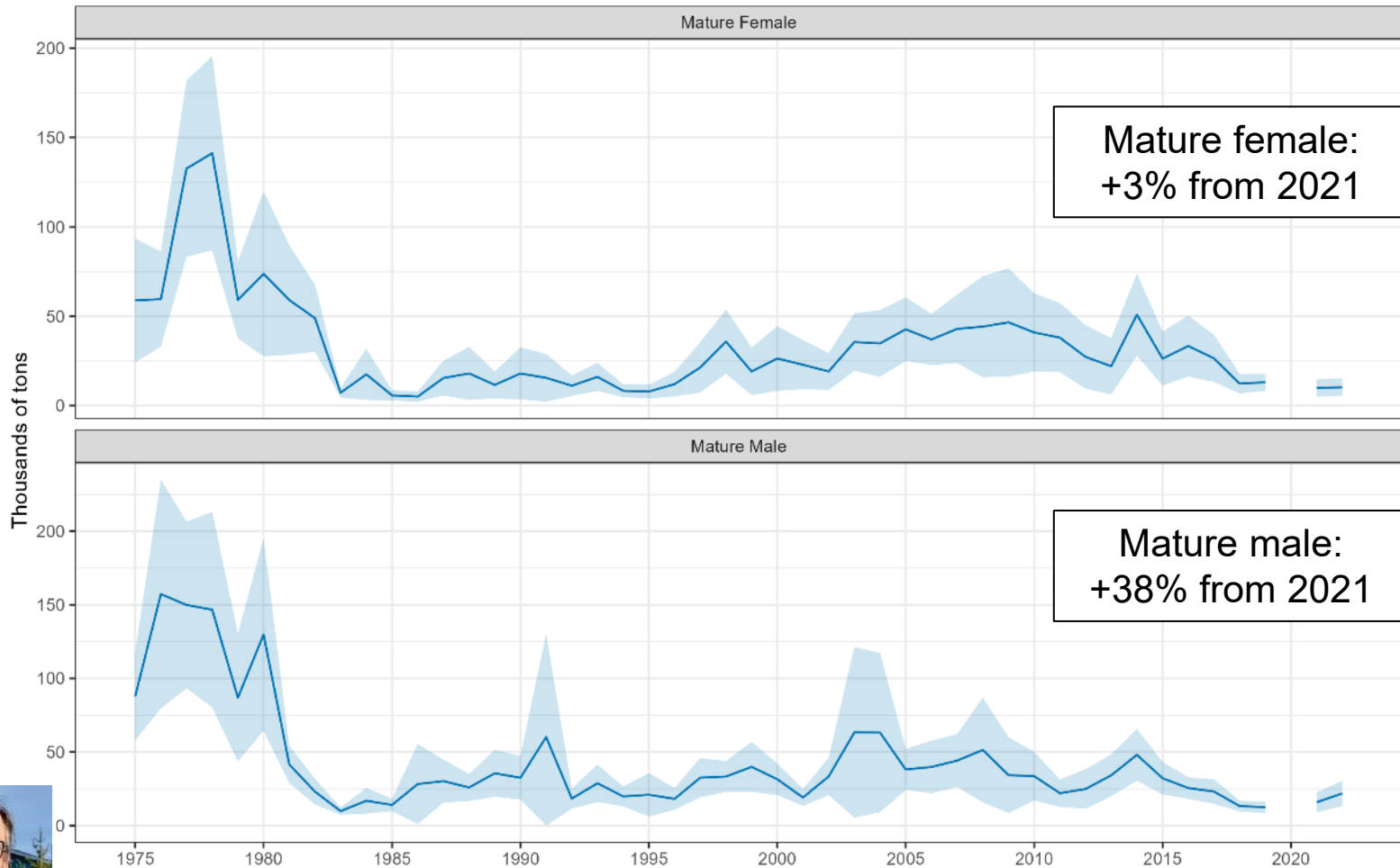
BBRKC MATURE MALE CENTER OF ABUNDANCE
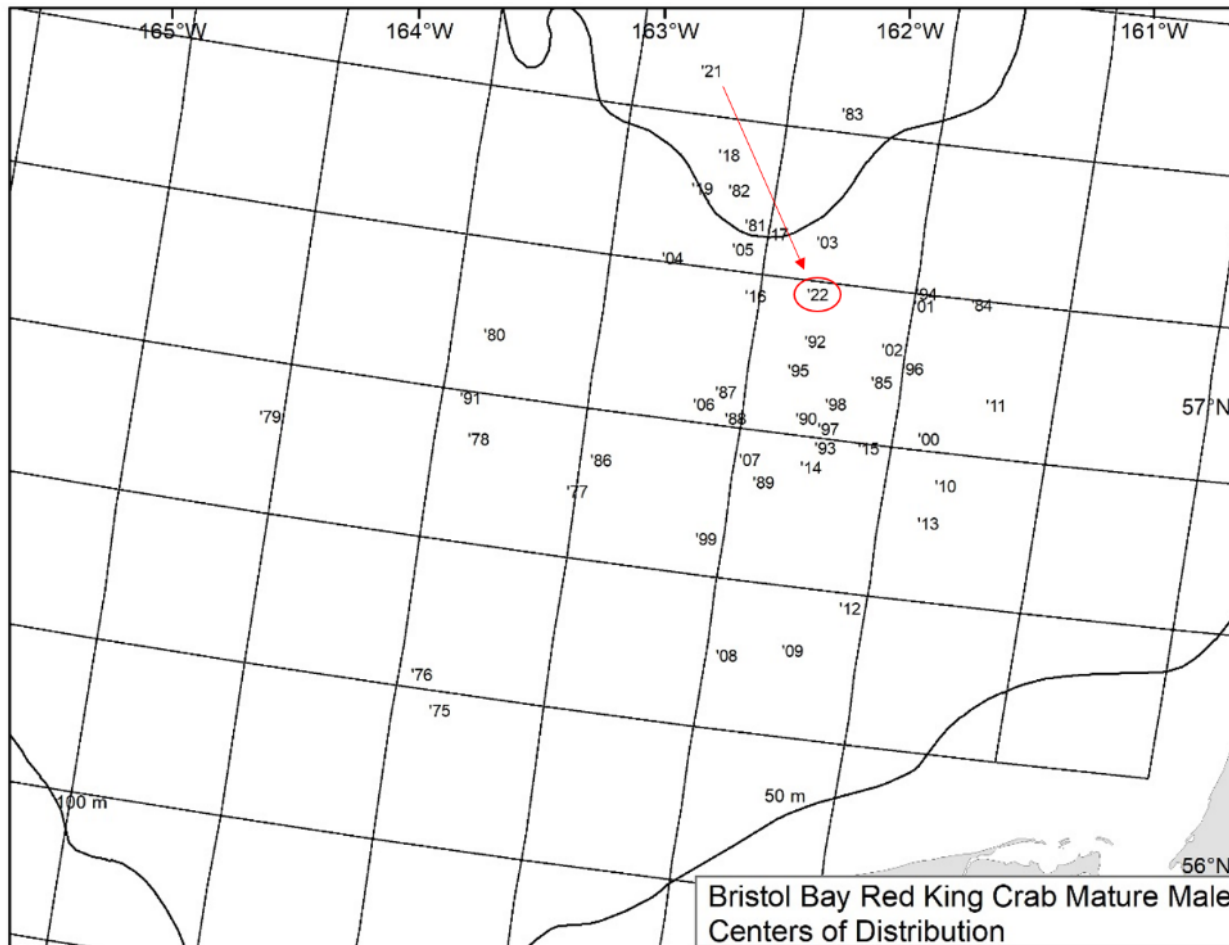
Bristol Bay Red King Crab Mature Male
Centers of Distribution

- Southward shift from 2021 center

8

BBRKC MATURE FEMALE CENTER OF ABUNDANCE

Bristol Bay Red King Crab Mature Female Centers of Distribution

- Southward shift from 2021 center

NORTHERN DISTRICT RKC BIOMASS

Mature female:
-24% from 2021

Mature male:
+96% from 2021

PRIBILOF ISLANDS RKC BIOMASS

Mature female:
-30% from 2021

Mature male:
+36% from 2021
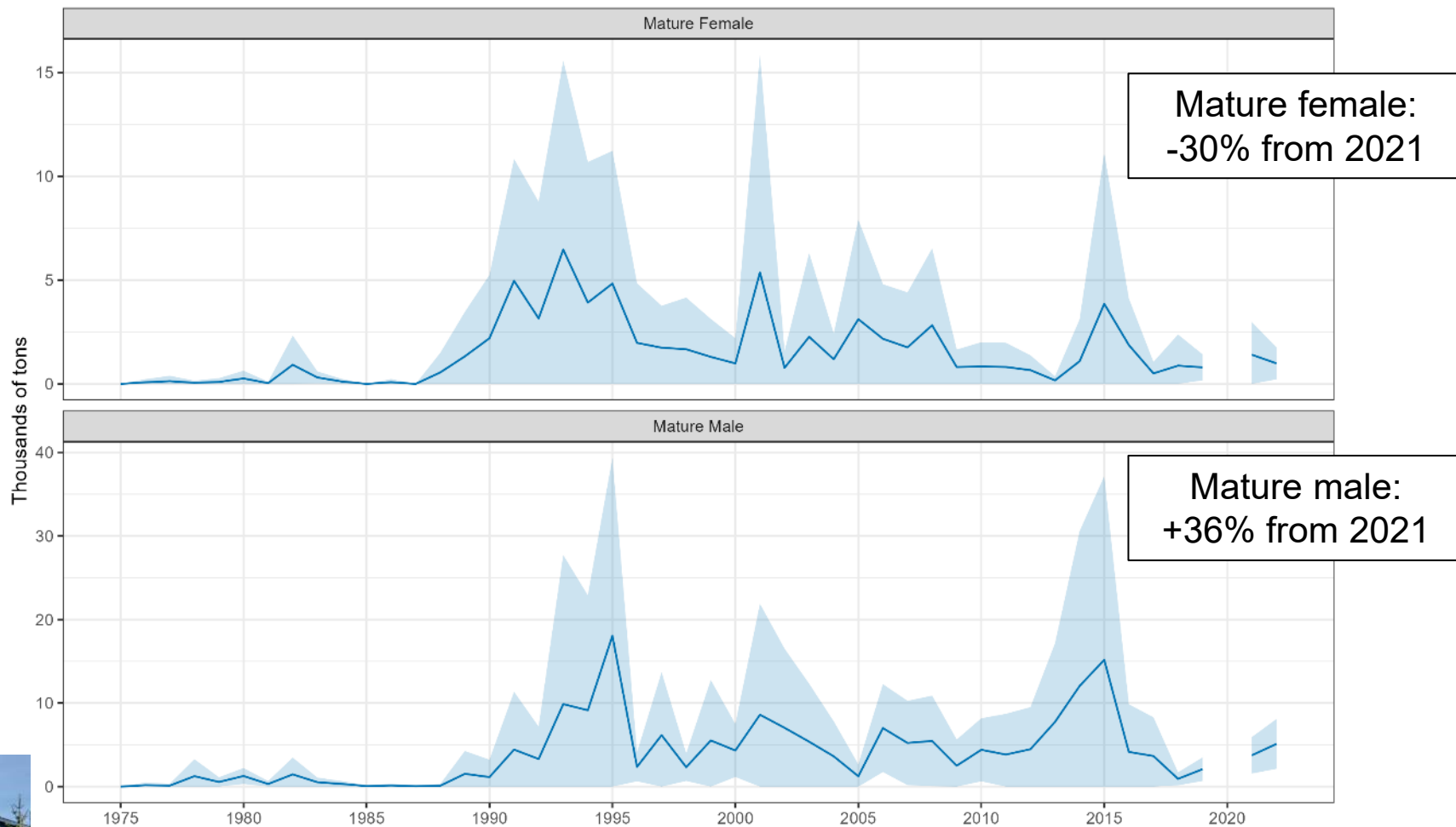
ST. MATTHEW ISLAND BKC BIOMASS

Mature female: +59% from 2021

Mature male: +17% from 2021
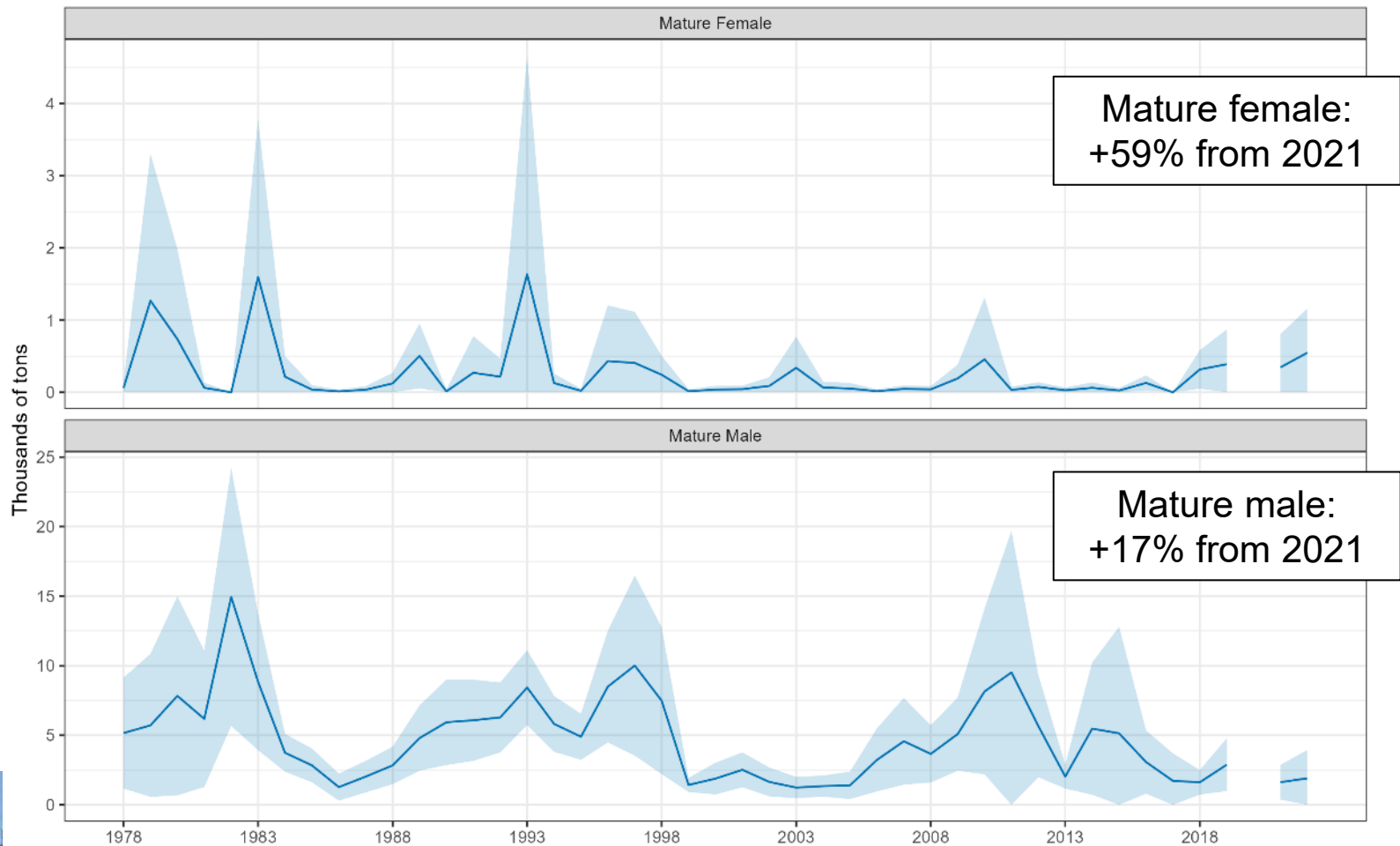
TANNER CRAB BIOMASS – WEST OF 166°W

Tanner Crab West

Mature female:
-15% from 2021

Mature male:
-9% from 2021
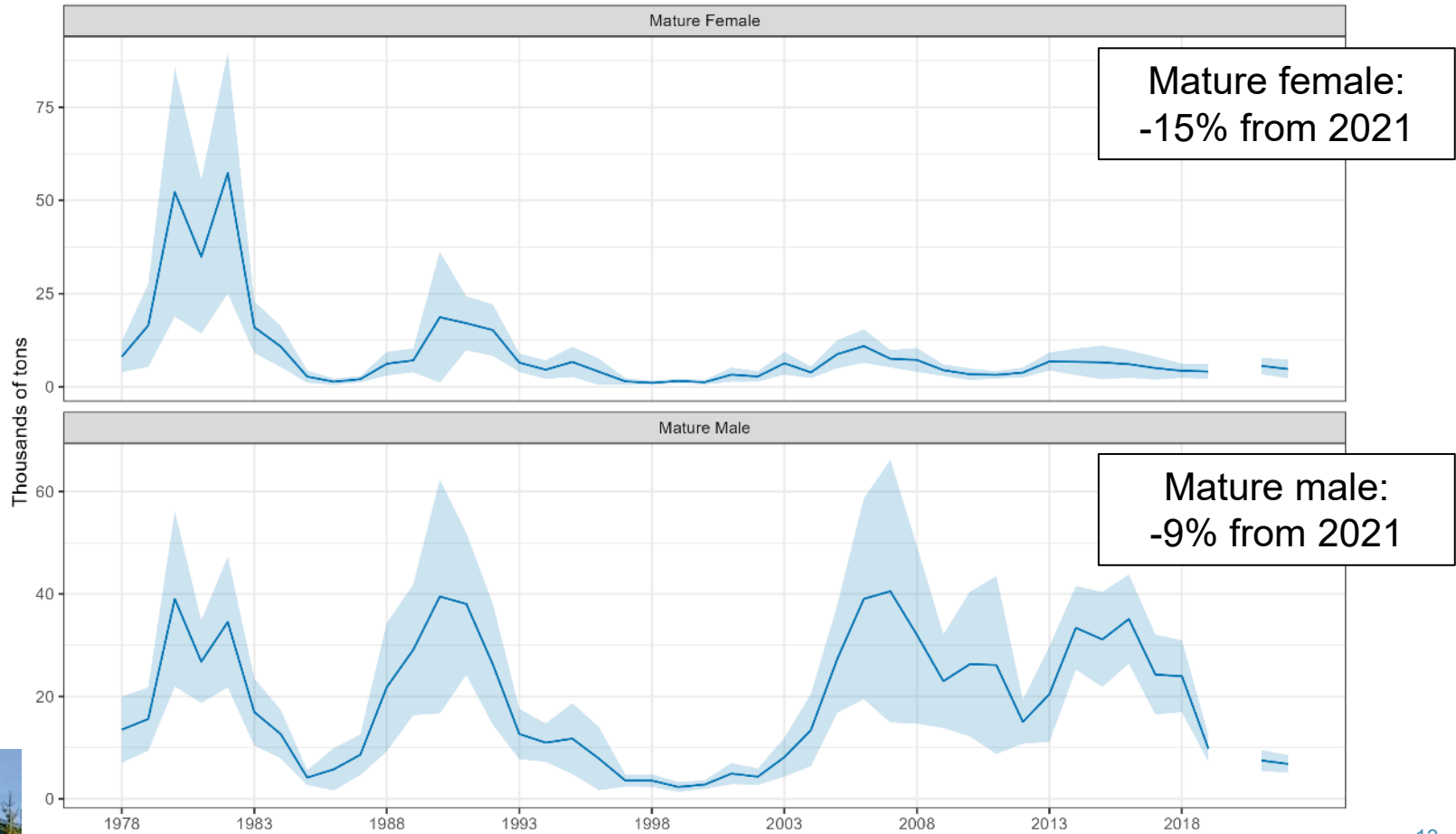
TANNER CRAB BIOMASS – EAST OF 166°W

Tanner Crab East

Mature female: -36% from 2021

Mature male: +74% from 2021
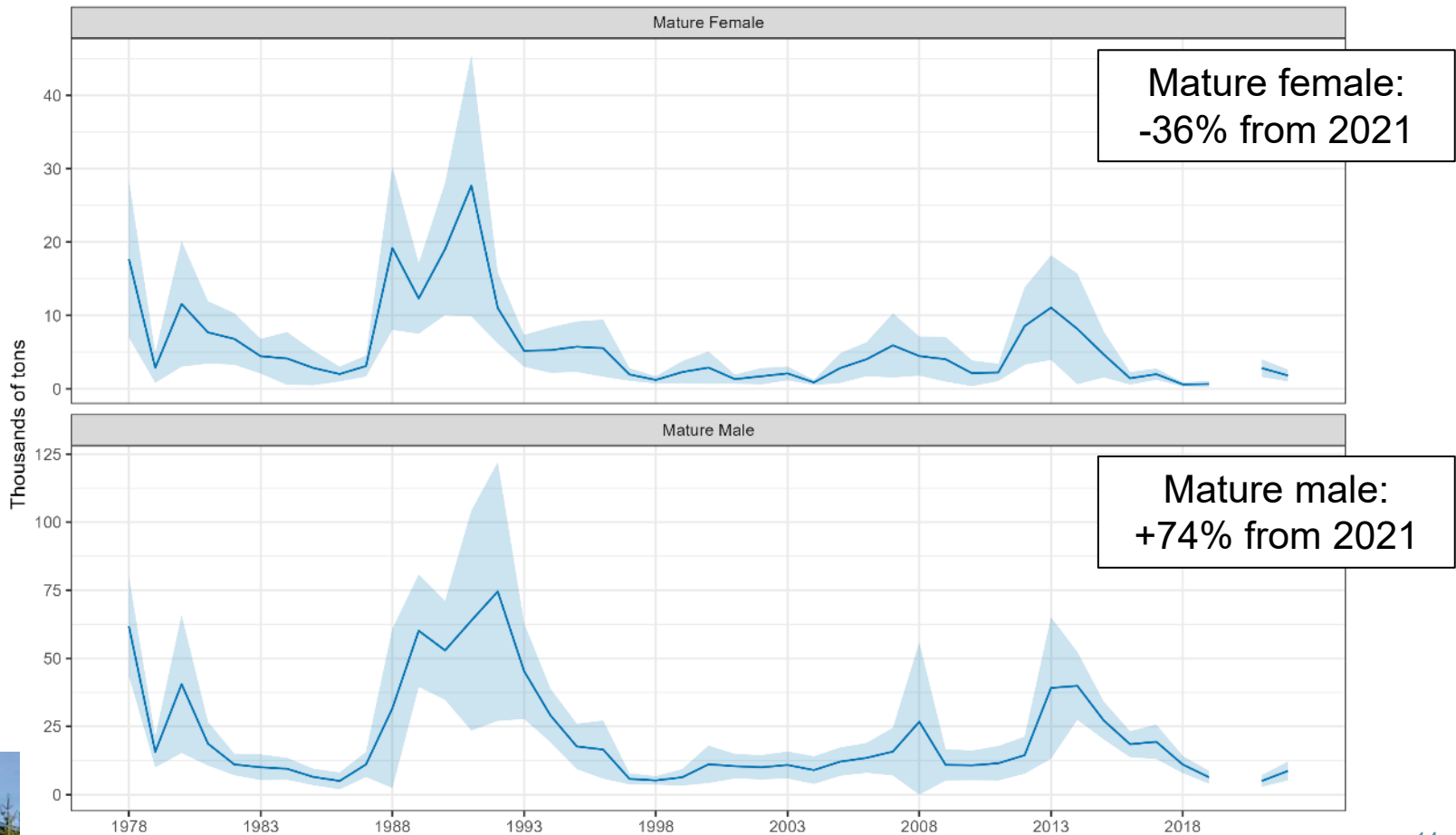
TANNER CRAB MALE SIZE COMPS & SHELL CONDITION

Male Tanner Crab West
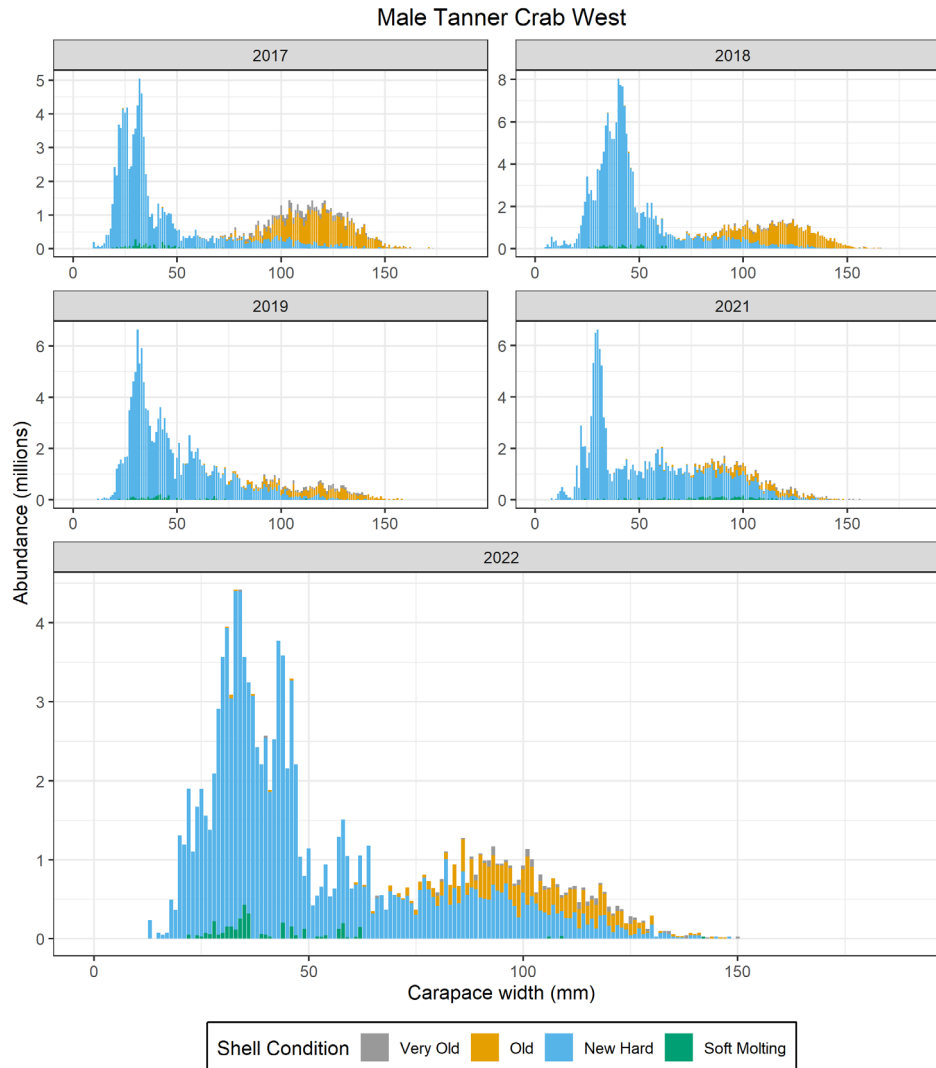
- Abundance dominated by small crab in most years

TANNER CRAB ABUNDANCE BY SIZE
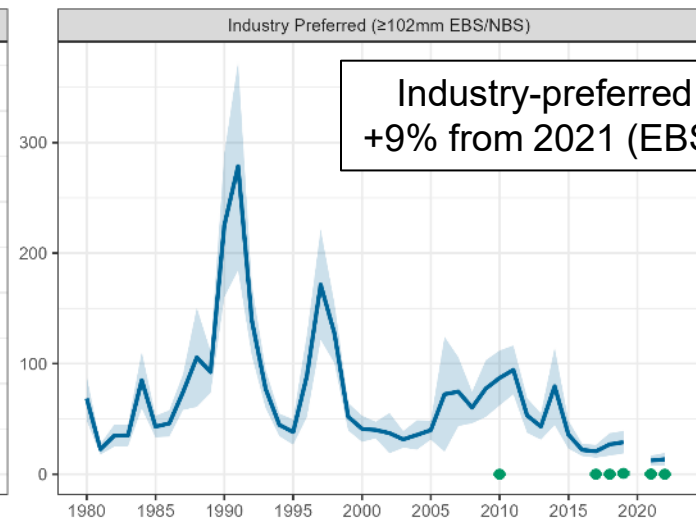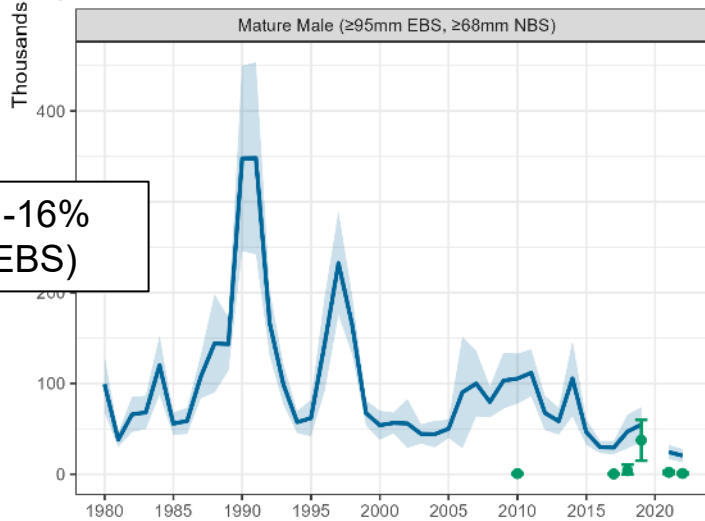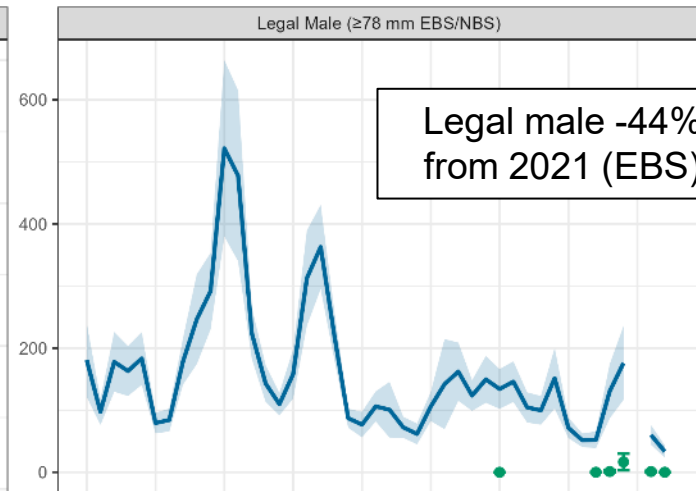
Male Tanner Crab West
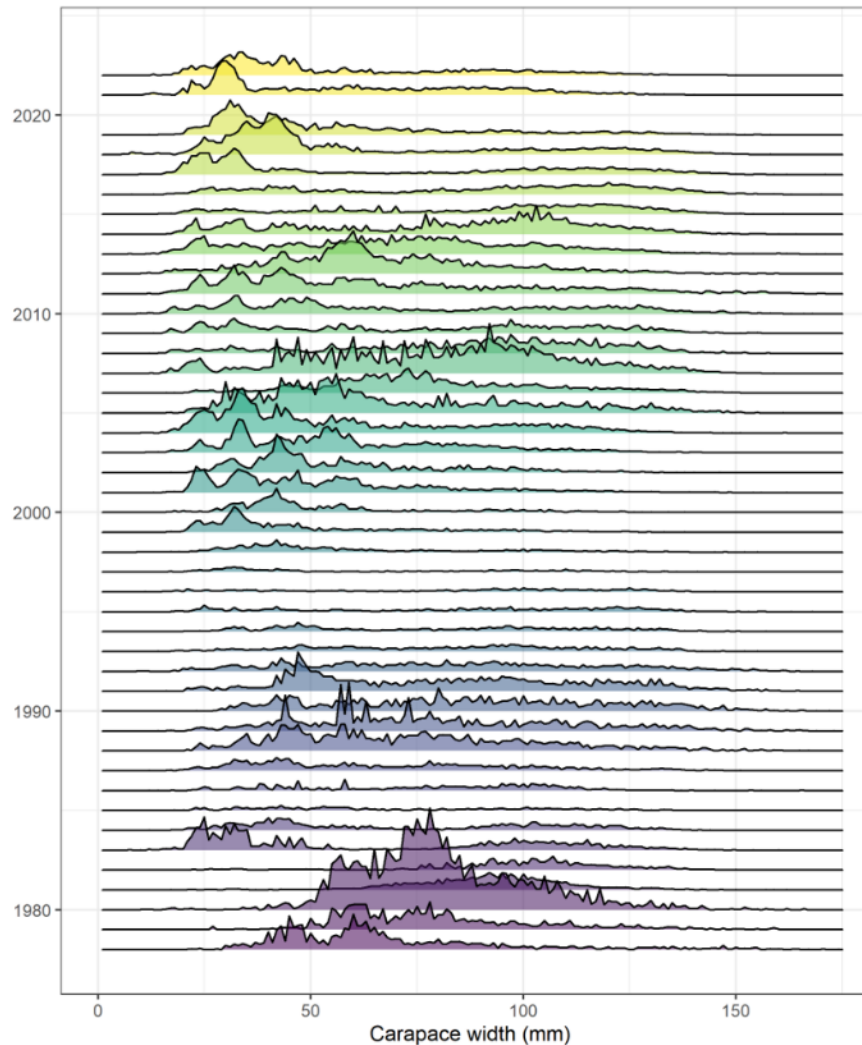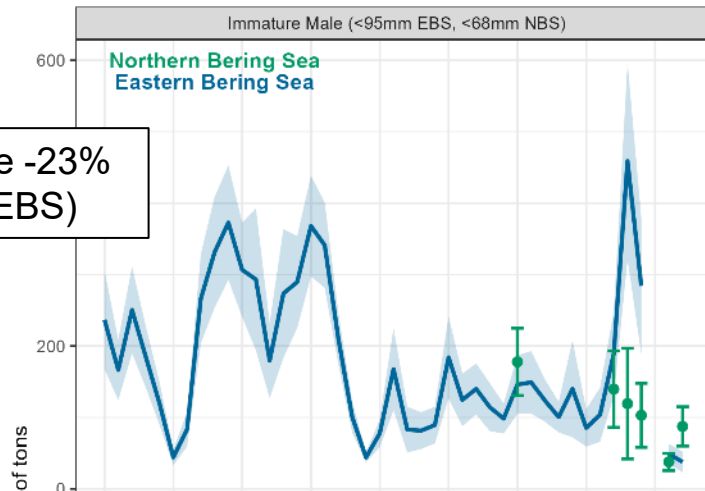

- Apparent recruitment failing to result in higher abundance at larger sizes in recent years

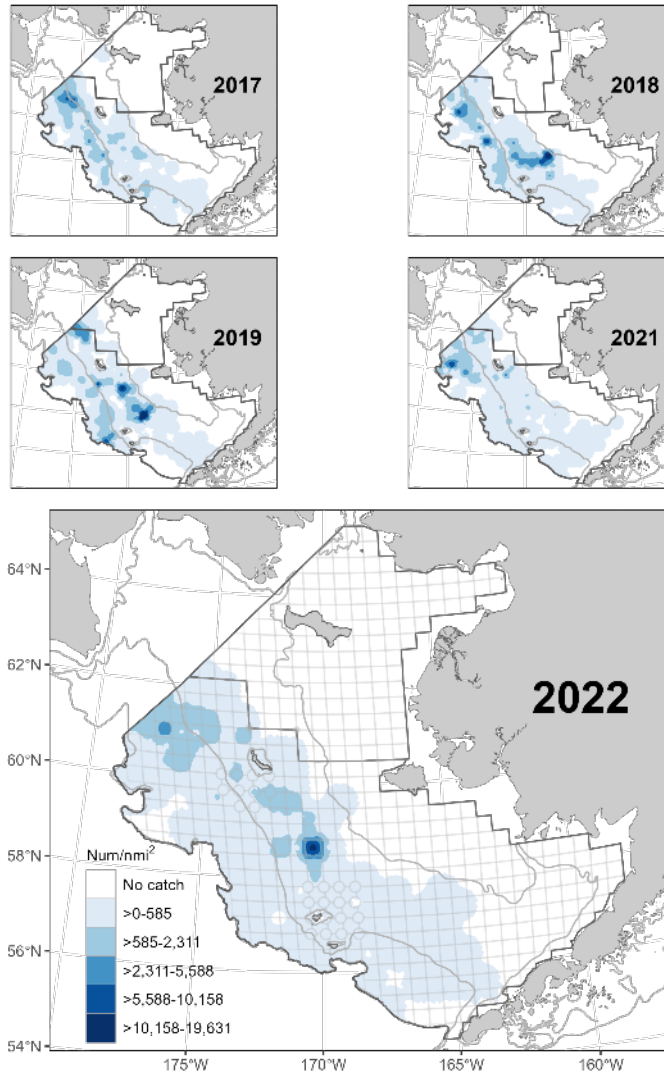# FEMALE SNOW CRAB BIOMASS

Immature female +8,700% from 2021 (EBS)

Mature female -16% from 2021 (EBS)

MALE SNOW CRAB BIOMASS

Immature male -23% from 2021 (EBS)

Legal male -44% from 2021 (EBS)

Mature male -16% from 2021 (EBS)
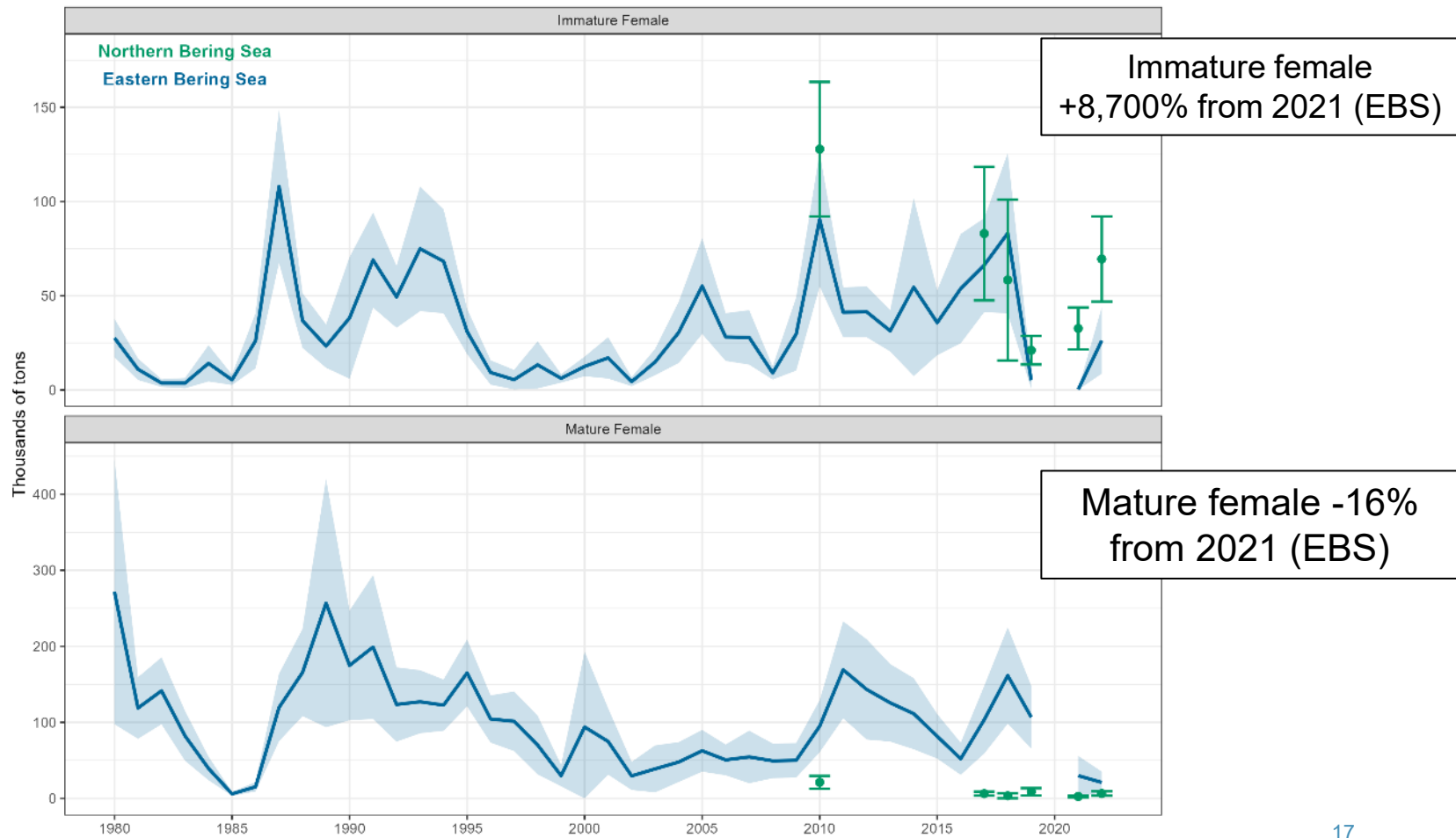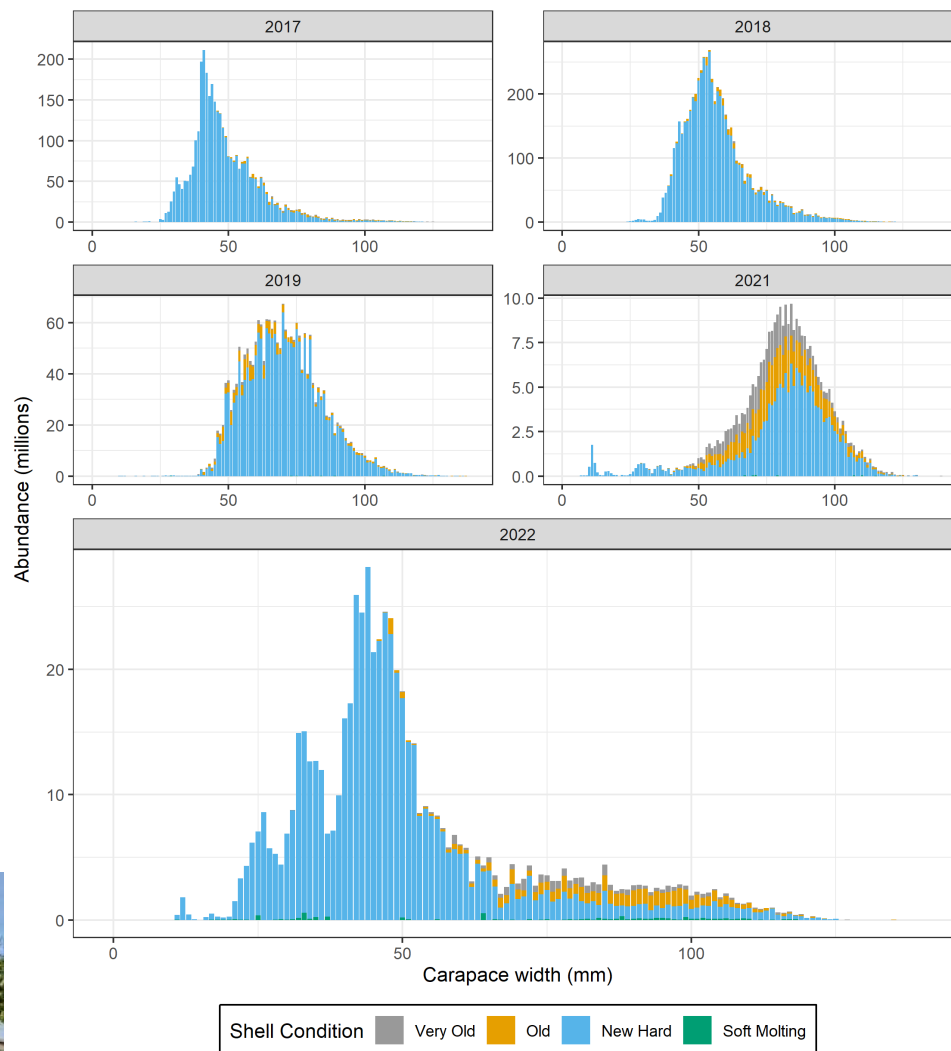
Industry-preferred +9% from 2021 (EBS)

INDUSTRY-PREFERRED MALE SNOW CRAB ABUNDANCE

- Distribution not as far northwest as 2021
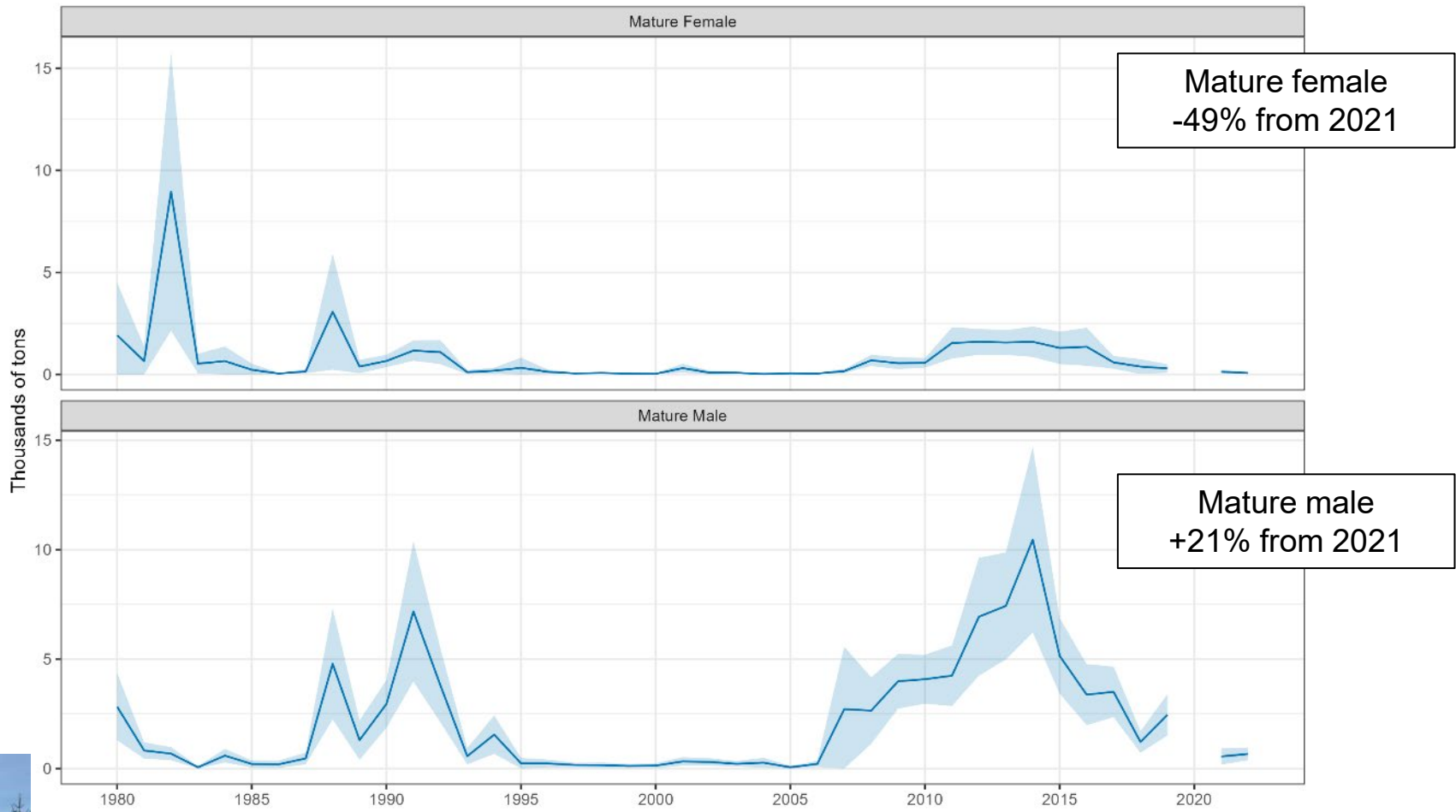
- Largest size class almost absent from NBS

MALE SNOW CRAB SIZE COMPOSITION AND SHELL CONDITION

- Increase in the smallest size classes

- Immature *abundance* +138% from 2021 (immature *biomass* -23%)

HYBRID *CHIONOECETES* BIOMASS

Mature female
-49% from 2021

Mature male
+21% from 2021

BBRKC

FINAL ASSESSMENT 2022

Ecosystem:
- In 2022, **bottom temperatures returned to near-average** and the cold pool extended into the Bristol Bay management area.
- Red king crab have experienced a **steady decline in bottom water pH** in the past two decades, reaching 7.89 in 2022. Continued declines to threshold pH levels of 7.8 could negatively affect juvenile red king crab growth, shell hardening and survival.
- BBRKC **recruitment remains well below the long-term average**. Concurrent declines in Pacific cod and benthic invertebrate densities in the past 7 years may suggest shared processes that drive productivity of Bristol Bay benthic communities.
- **Spatial extent** of mature male red king crab in Bristol Bay was **above average** in 2022, coinciding with increases in abundance.

Socioeconomic:
- The BBRKC fishery was closed to targeted fishing for the 2021/2022 season.
- Incidental catch of BBRKC biomass in EBS groundfish fisheries during 2021 increased moderately from the previous year to slightly above average for the 2010-current period.

BBRKC FINAL ASSESSMENT 2022 - SUMMARY

- Survey estimated mature male biomass increase from 2021 (+30%), still low compared to long term average

- Directed fishery was closed in 2021/22 season due to low mature female abundance.

- Estimated mature female biomass is higher than 2021 but still lower than it's been since the mid-90s

- 2022 mature female abundance estimate does NOT meet the minimum threshold of mature female abundance (8.4 million) in the State Harvest Strategy

    - 2022 area-swept = 8.004

    - 2022 model estimate = 7.840

- Low recruitment in recent years (last 8-12 years); biomass is projected to decline without a large recruitment event (with fishing mortality >0)

LENGTH COMPOSITION FROM NMFS SURVEY
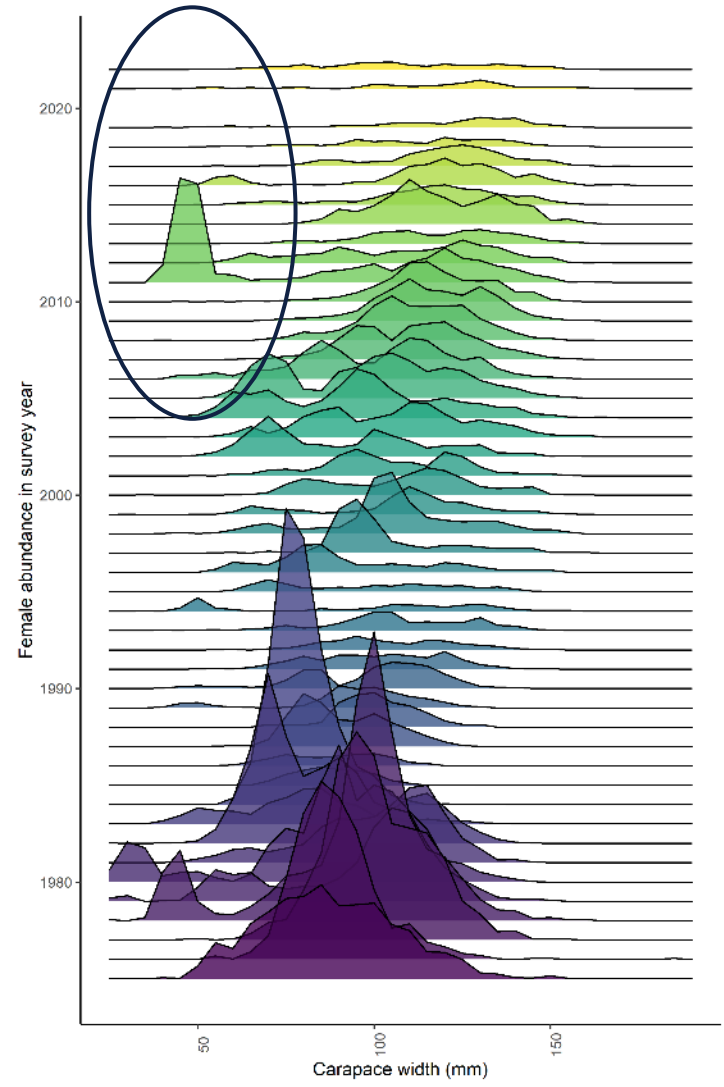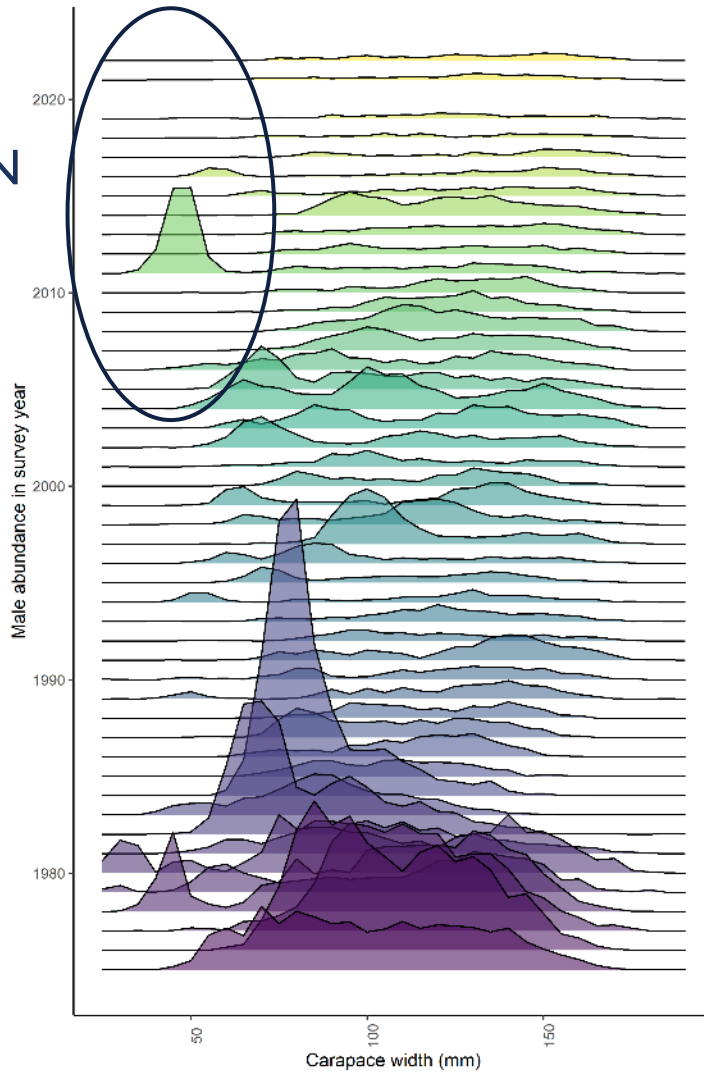
BBRKC CONT.

CPT /SSC COMMENTS:

- No new comments addressed this cycle; many addressed in May 2022, work will be continued for 2023 proposed model work
- June 2022 comments:
    - Produce a stock structure template for RKC (June 2023)
    - CPT develop guidelines for when to change model data start date (Jan 2023?)
- Explored alternative configurations for the start date for input into the model (status quo 1975 or move to 1985)

Model options:
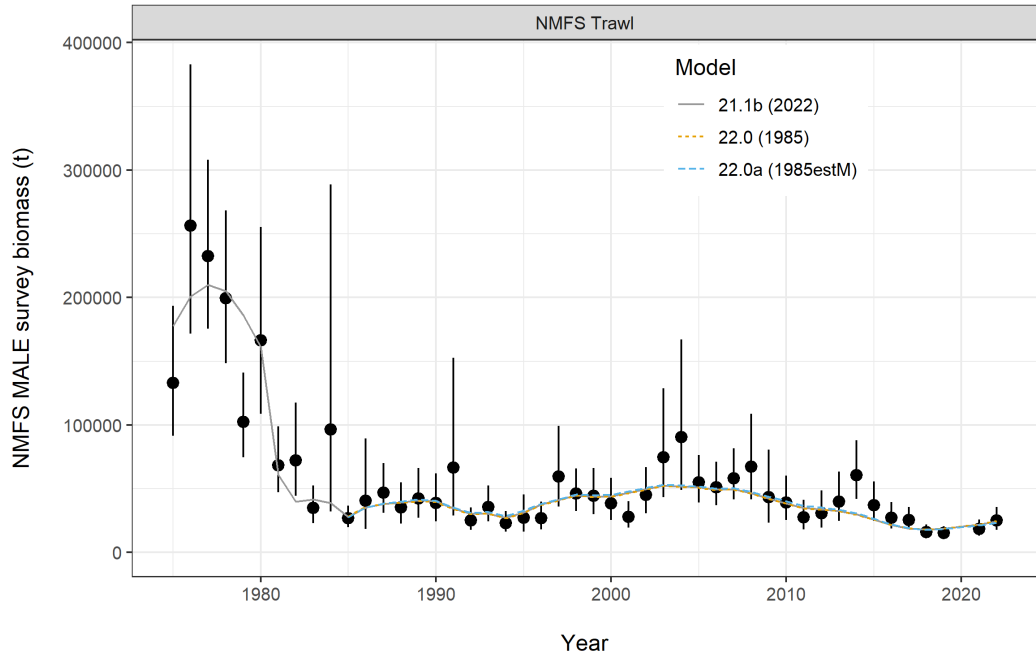**21.1b**: model 21.1 (2021 accepted model – base M for males fixed at 0.18, mortality event in 80s)
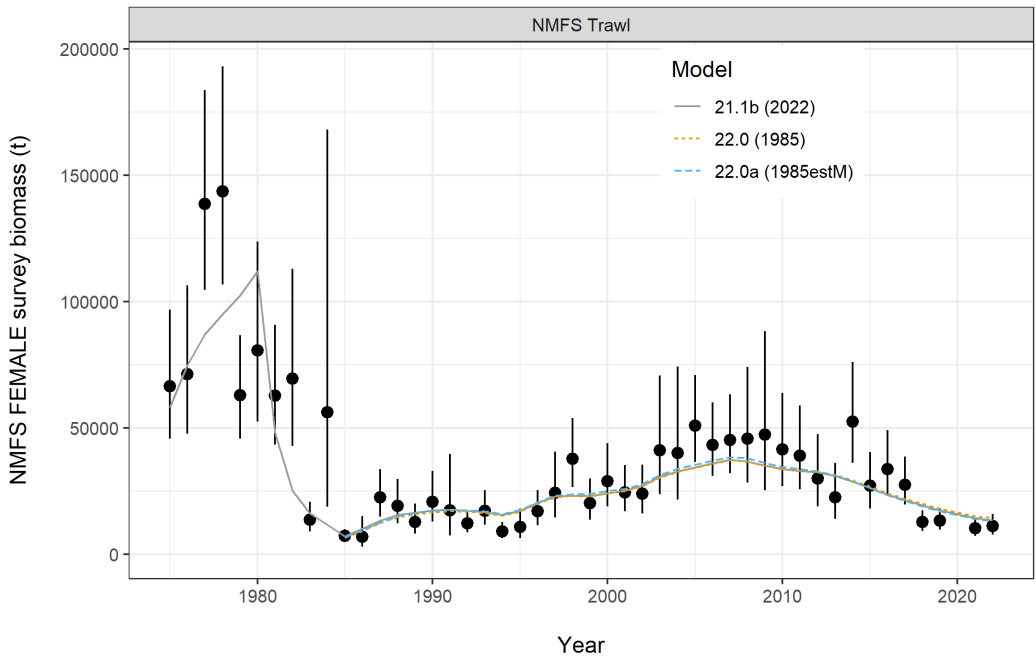
+ **GMACS updated version** (version 2.01.E)

+ **updated groundfish fisheries bycatch** data.

22.0: model 21.1b + starting in 1985.

22.0a: model 22.0 (start in 1985) + estimating a constant M for males.

✓ Model fits to survey data are similar in all 3 models.

✓ Mature females still declining in modeled survey estimate (top)

✓ Mature males small increase in modeled survey (bottom)
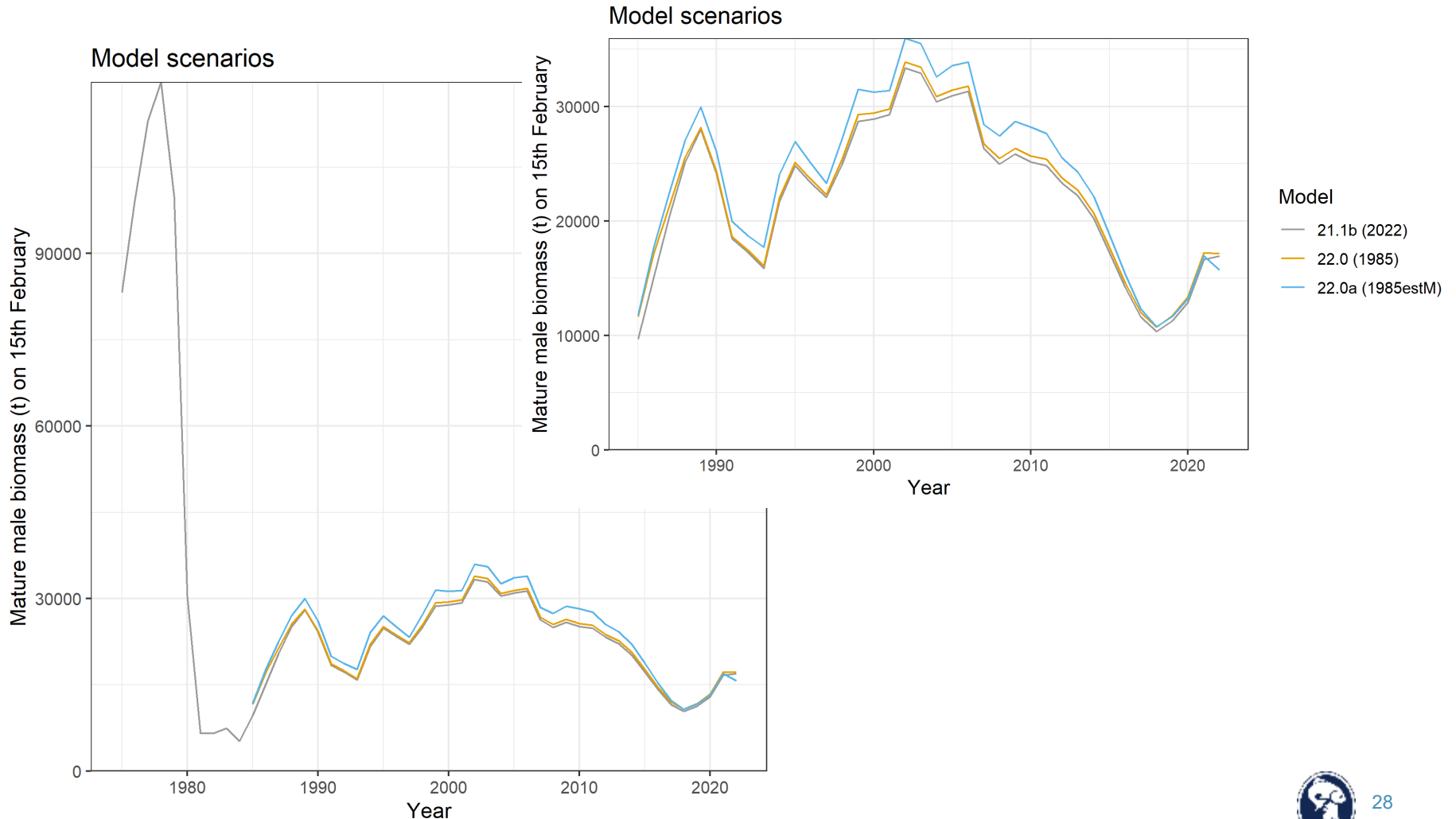
27

MATURE MALE BIOMASS – FEB 15TH

Table 7. Natural mortality estimates for three model scenarios during different year blocks.

Model	Sex	1975-1979, 1985-2022	1980-1984	1985-2022
21.1b	Males	0.180	0.886	
	Females	0.238	1.174	
22.0	Males			0.180
	Females			0.232
22.0a	Males			0.228
	Females			0.261
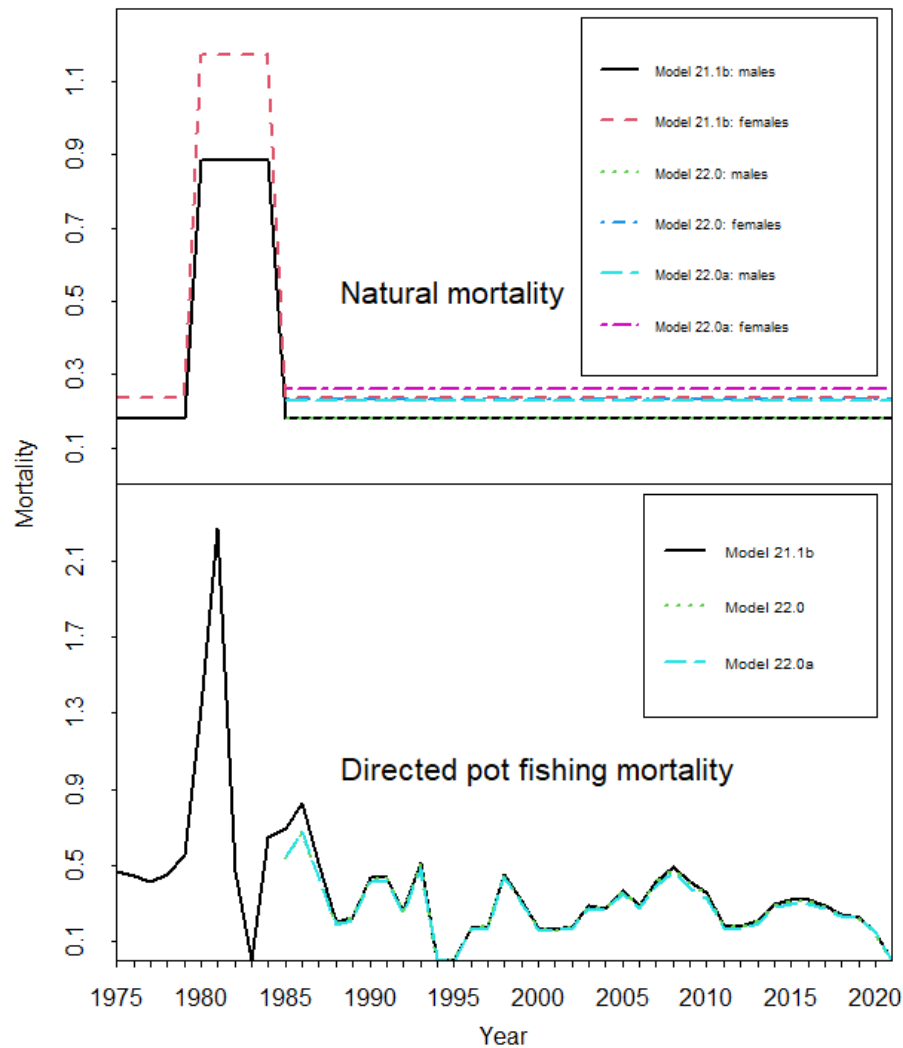
SURVEY SELECTIVITY (including catchability):
- 22.0A (ESTIMATED BASE M) LARGEST DIFFERENCE
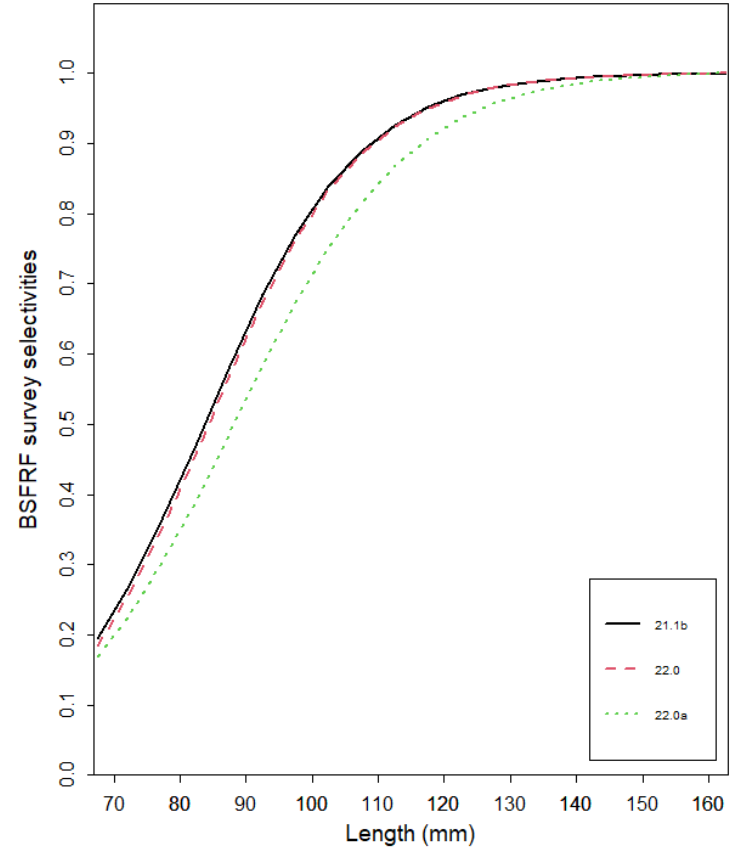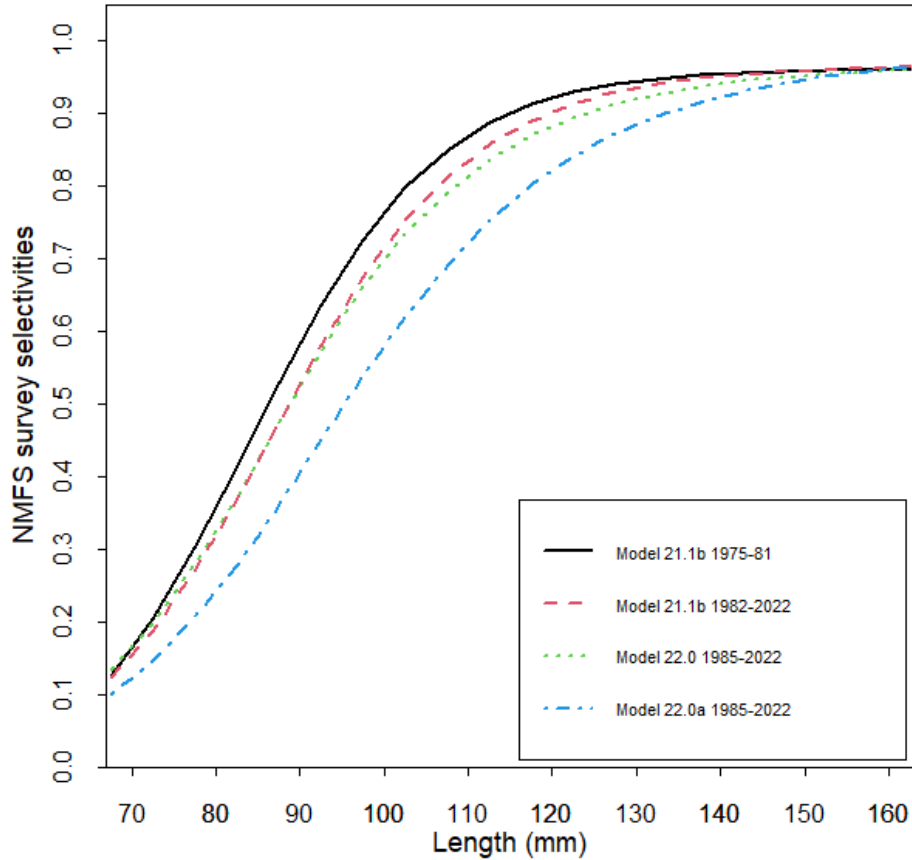
RECRUITMENT

✓Model recruitment estimates similar in all 3 models.
✓Low recruitment in past ~10 years

31

RETROSPECTIVE PATTERNS

Model 21.1b

Model 22.0

Model 22.0a

✓Retrospective pattern in MMB
✓1985 start date does NOT reduce retrospective pattern (note scale of y-axis is different in models 22.0 and 22.0a)
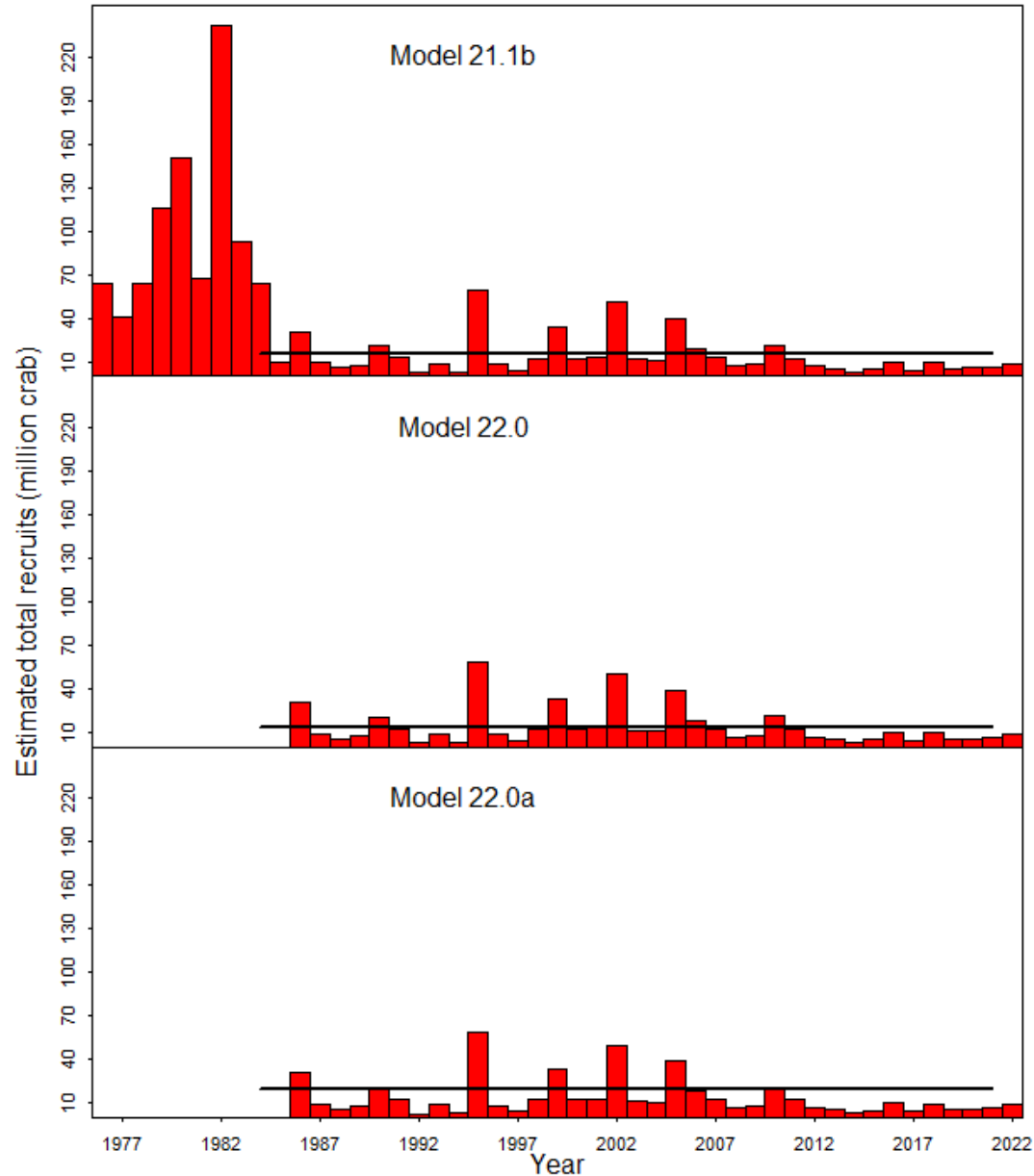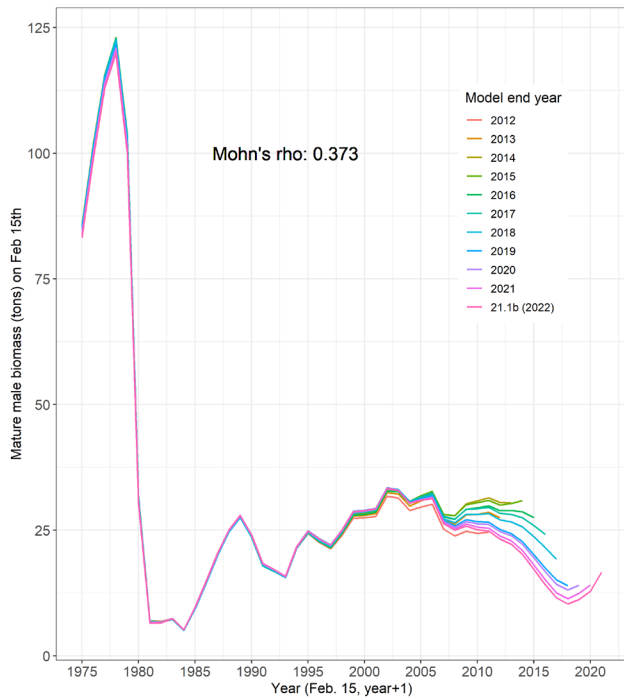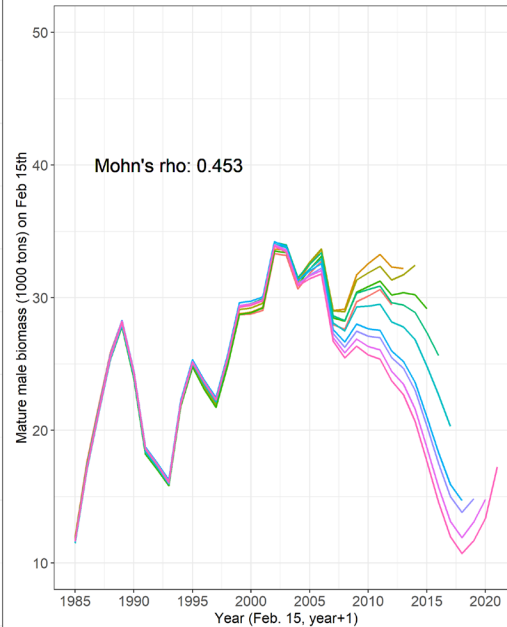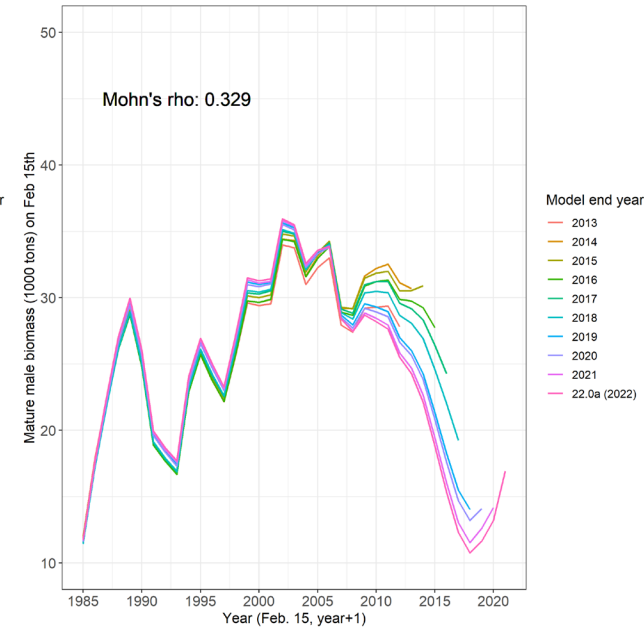
32

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

Year	MSST	Biomass (MMB)	TAC	Retained Catch	Total Catch	OFL	ABC
2018/19	10.62[B]	16.92[B]	1.95	2.03	2.65	5.34	4.27
2019/20	12.72[C]	14.24[C]	1.72	1.78	2.22	3.40	2.72
2020/21	12.12[D]	13.96[D]	1.20	1.26	1.57	2.14	1.61
2021/22	12.01	16.64	0	0.02	0.10	2.23	1.78
2022/23		16.95				3.04	2.43

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

Year	Tier	B_{MSY}	Current MMB	B/B_{MSY} (MMB)	F_{OFL}	Years to define B_{MSY}	Natural Mortality
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
2022/23	3b	24.03	17.0	0.71	0.20	1984-2021	0.18

Model 21.1b, base ABC buffer 20%

CPT RECOMMENDATIONS

<u>20 % ABC Buffer</u>

- Similar uncertainties exist as previously for this assessment:

    - Cold pool distributional shifts

    - Declining trends (females) or low levels (males) in mature biomass

    - Lack of recruitment events

    - Retrospective patterns

    - Poor recent environmental conditions

- Future work

    - Work on retrospective pattern differences between models

    - Investigate influence of directed fishing closures on stock dynamics

    - Stock structure template for Bering Sea red king crab

    - Investigate molting probability and tagging data differences

IS BBRKC APPROACHING OVERFISHED CONDITION?

- NS 1 guidelines: "A stock or stock complex is approaching an overfished condition when it is projected that there is more than a 50 percent chance that the biomass of the stock or stock complex will decline below the MSST within two years."

Model 21.1b
Not approaching overfished condition during 2022-2025
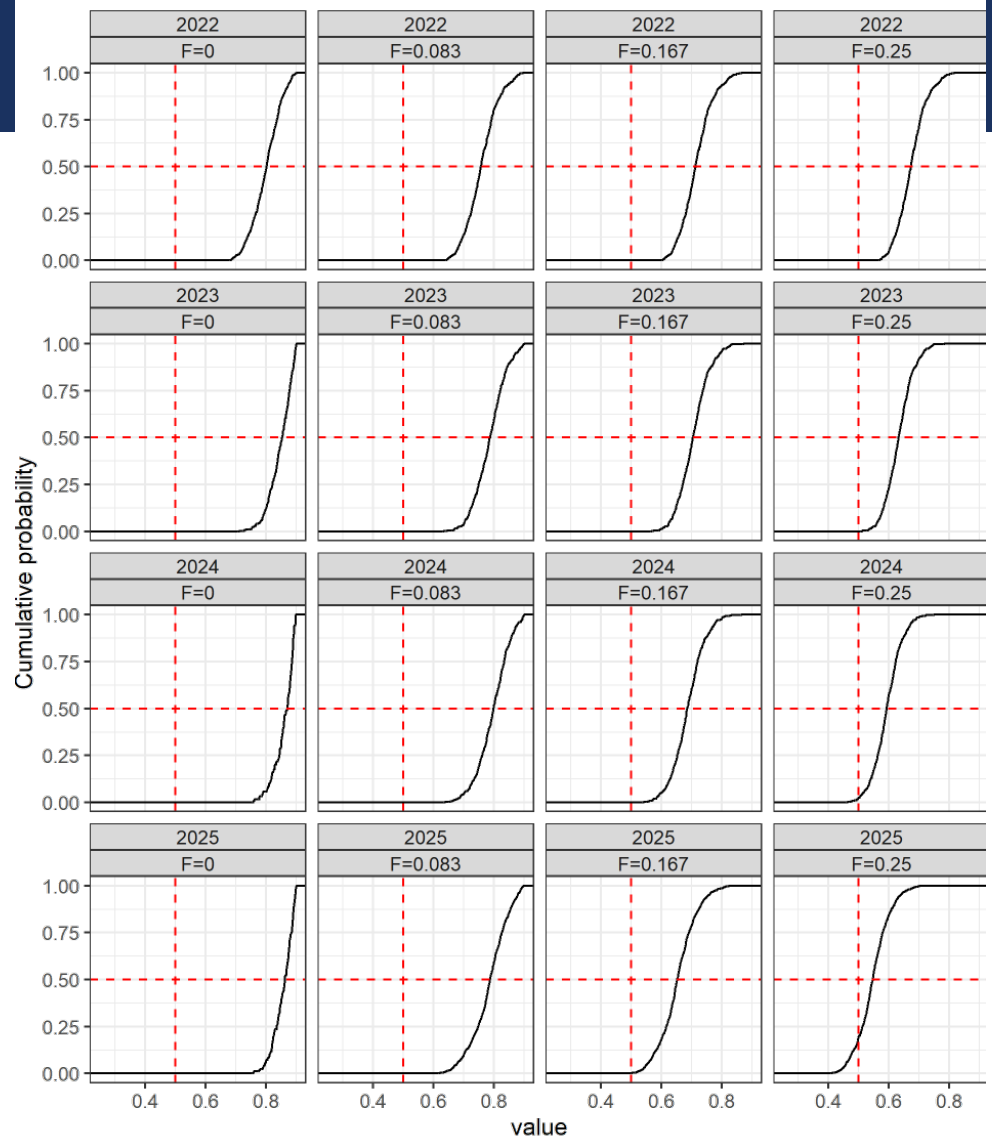
TANNER CRAB

FINAL ASSESSMENT, OFL/ABC SPECS

OVERVIEW

- 2021/22 Federal management
  - OFL: 27,170 t
  - ABC: 21,740 t
  - Total catch mortality: 780 t (< OFL)
    - **overfishing did not occur**
    - mostly taken in directed fishery
  - 2021/22 MMB: 62,050 t (> MSST = 17,370 t)
    - **stock is not overfished**

- ADFG management
  - Eastern Area closed
    - MMB failed to meet threshold
  - Western Area
    - TAC: 499 t
    - Retained catch: 494 t
    - 19,252 potlifts
    - CPUE: 26 kg/pot (+25%)
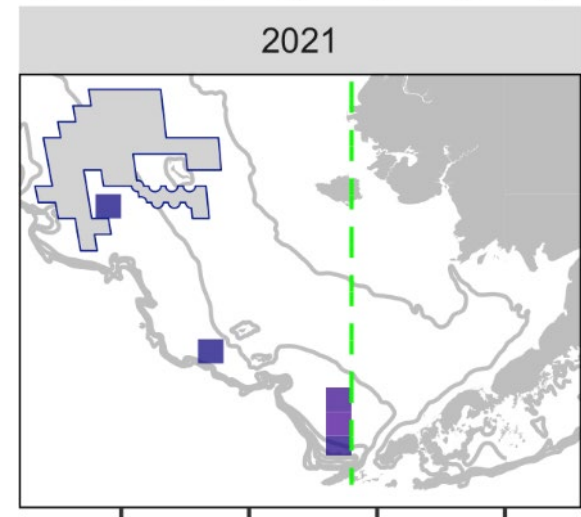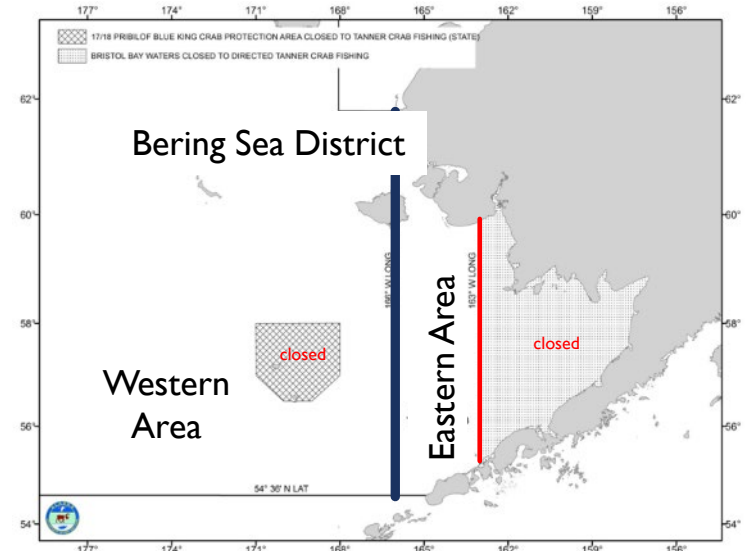
2021/22 TANNER CRAB RETAINED CATCH
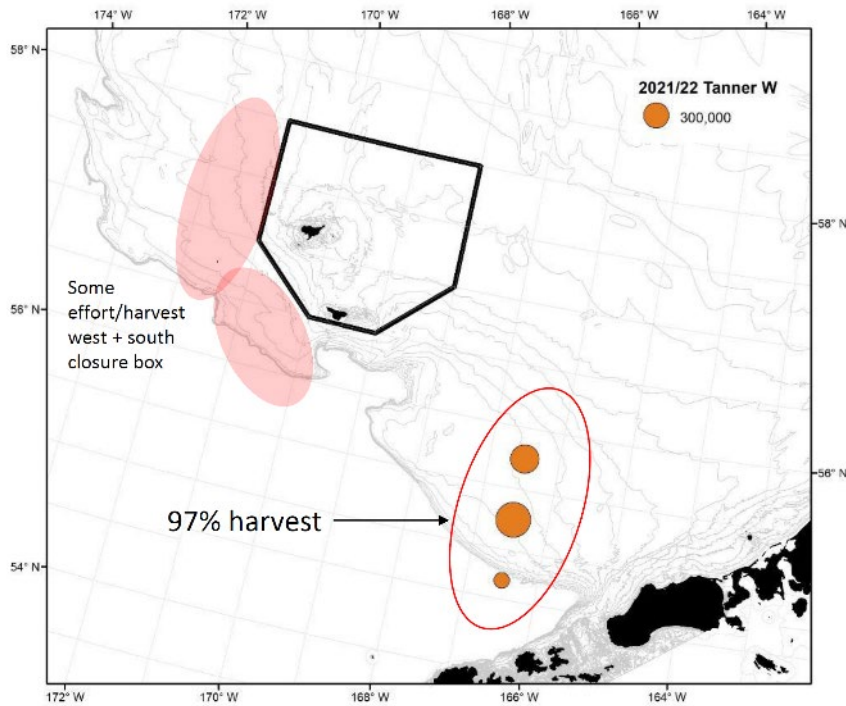
*Excludes stat areas with <3 vessels

Fleet observations:
- CPUE approximately at rationalized time series average
- Good fishing at the 166 W long boundary
- Retention of more (~35%) sub industry preferred size crab (5 inches, legal is 4.4 inches)
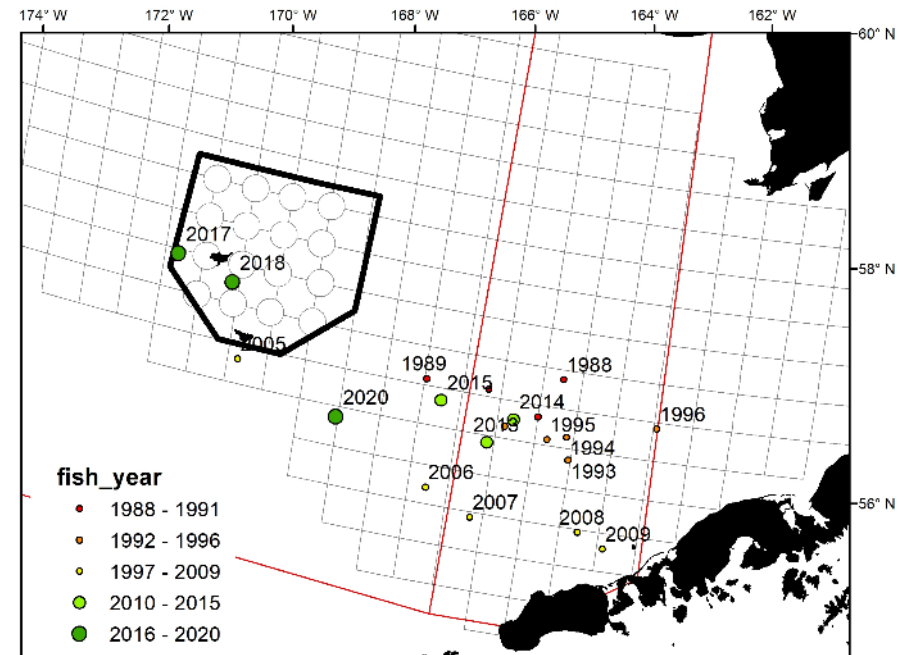
Surveys

- 2022 NMFS EBS Shelf Survey Biomass
  - 29,254 t male biomass (+7%)
  - 6,252 t industry-preferred males (-3% [-21%W])
  - 9,232 t female biomass (+10%)
- Concern:
  - evidence for recent recruitment
  - not moving into larger size classes

2022/23 Management

- Based on preferred model (20.03)
  - Tier 3a (B>B_{MSY}; not overfished)
  - OFL: 32,810 t (+21%)
  - ABC: 26, 250 t (20% buffer)

NMFS EBS SURVEY DATA

- all females
- all males
- males >= 125mm CW

M. : -6%
F : -21%
PM: +42%. (+142% NS)
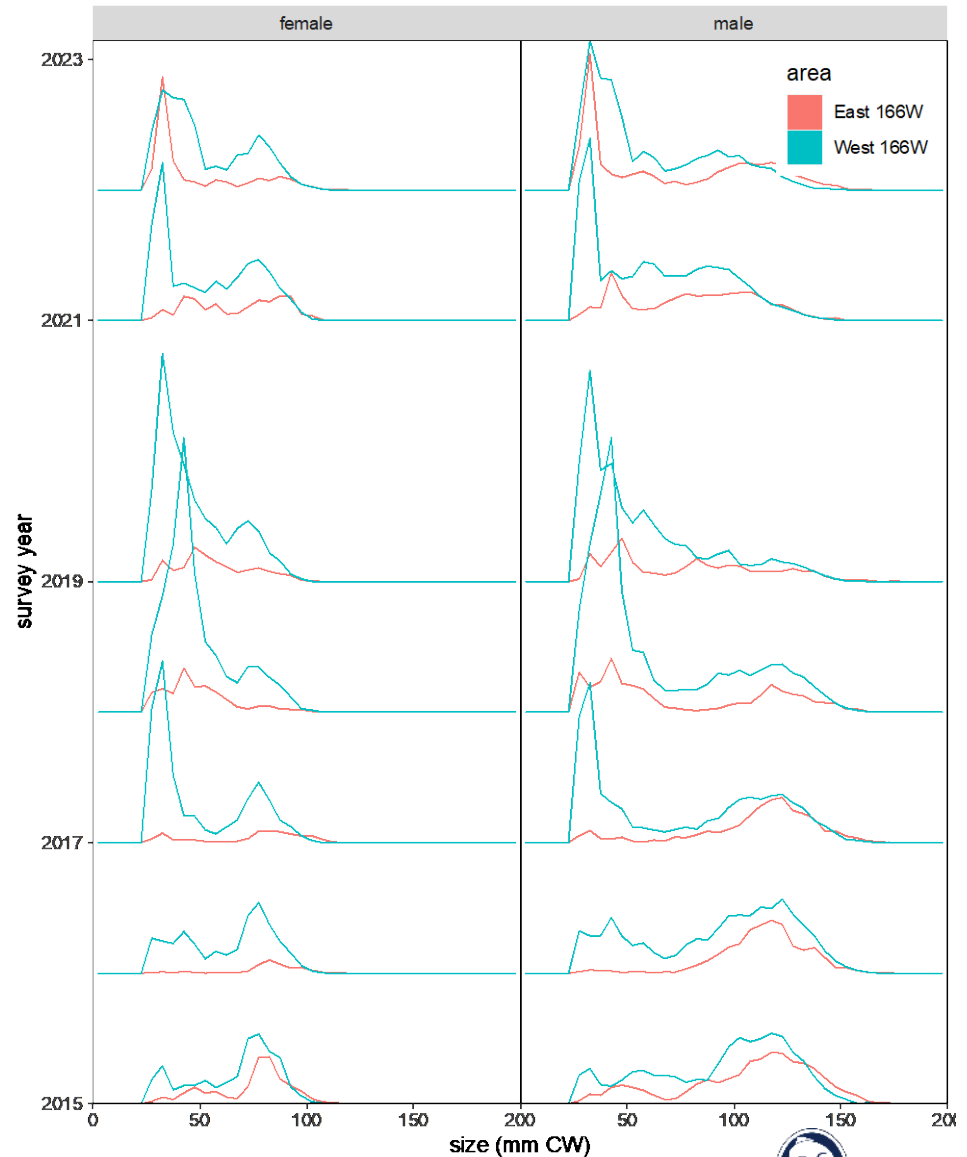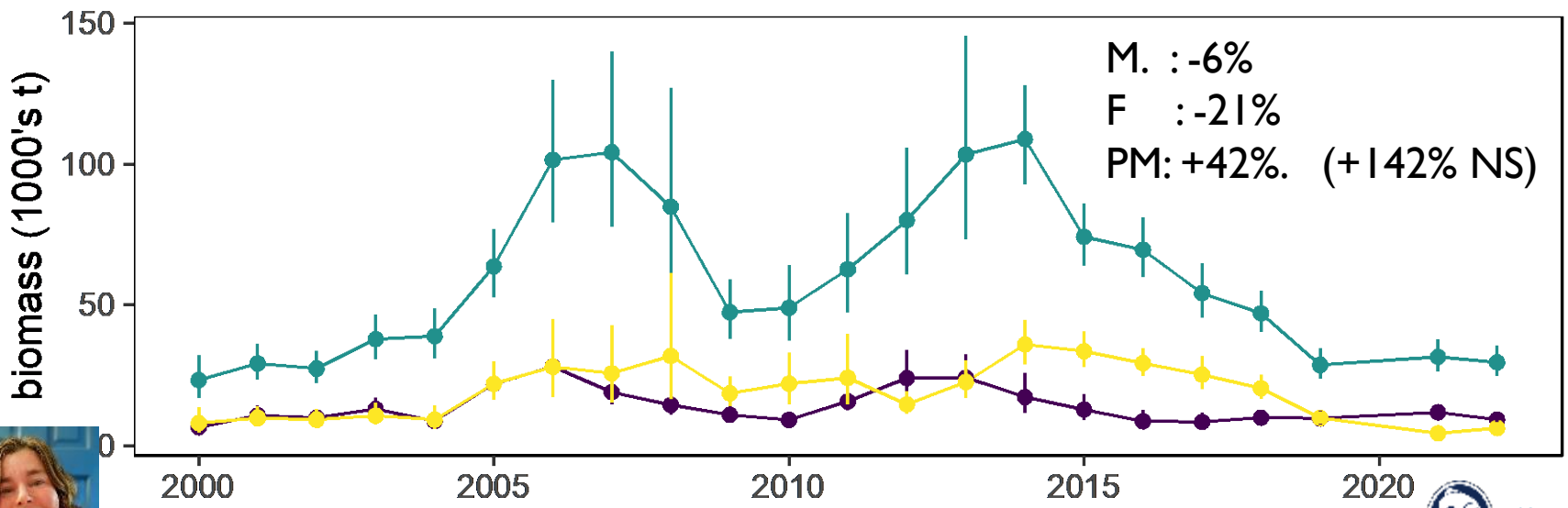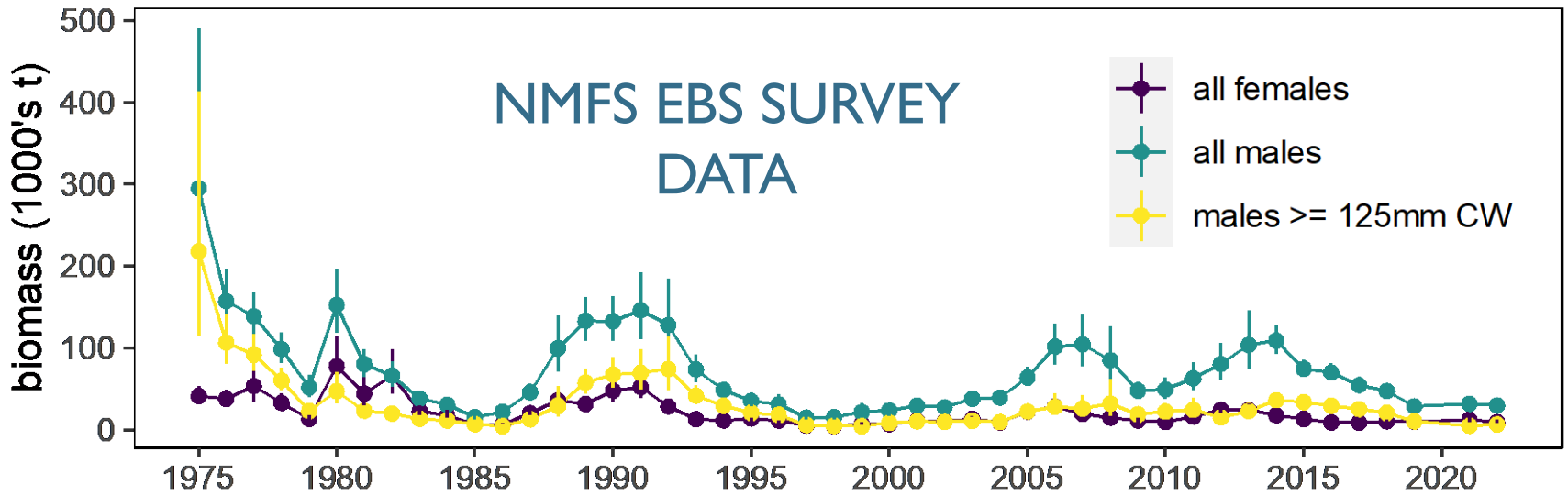
TANNER CRAB OVERVIEW

- SSC/CPT comments

  - Many addressed in May, many are continued work

  - Start date for the data (dependent on Jan 2023 CPT discussion)

  - Continued work on VAST and BSFRF/NMFS side-by-side trawl survey selectivity and availability in the future

  - Separate selectivity/retention for 2021/22

  - Bootstrap effective sample sizes for NMFS data input sample sizes

- SAFE structure – converting to Rmarkdown so some style issues may be present this year

Assessment: Tier 3 size-structured model

Fits to

- Survey data
  - biomass, size comps
  - NMFS EBS shelf survey
    - 1975-present (no 2020)
    - male maturity ogives (2006+)
  - BSFRF side-by-side haul studies
    - 2013-2017 (2018 not obtained)
- Molt increment data
- Fishery data (biomass, size comps)
  - directed fishery (areas combined)
    - retained catch (1965+)
    - total catch (1991+)
  - bycatch in
    - snow crab fishery (1990+)
    - BBRKC fishery   (1990+)
    - groundfish fisheries (1973+)

Molting/Growth/Mating — Fisheries

$(\delta t_y^m - \delta t_y^F)$

$(1 - \delta t_y^m)$

δt_y^F

Feb. 15

June 30 — July 1

Recruitment — NMFS Survey
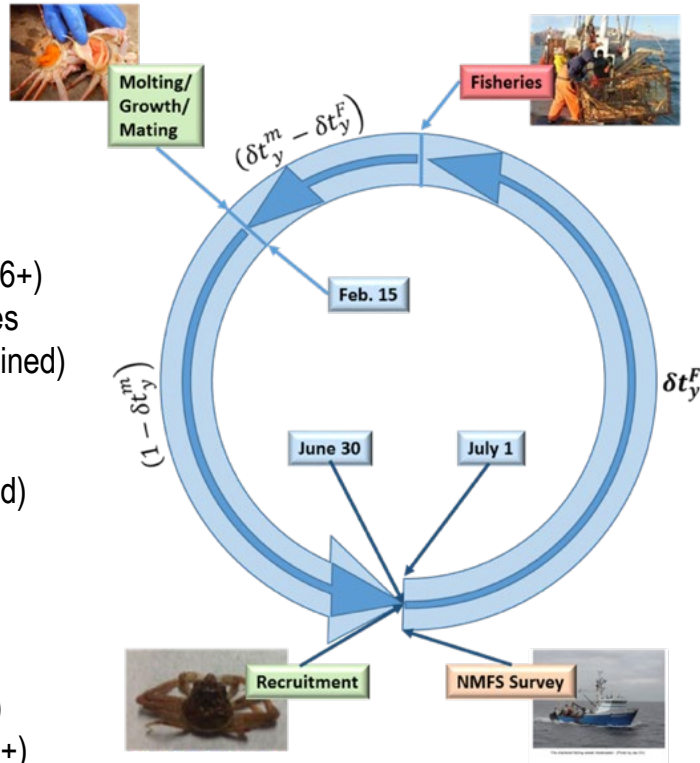
Model estimates

- Natural mortality (M)
- growth (molt increment)
- probability of molt to maturity
- initial abundance
- recruitment
- fully-selected capture rates
- size-specific fishery selectivity
- size-specific retention
- NMFS survey catchability
- NMFS survey selectivity

Fixed parameters
- weight-at-size
- handling mortality rates
- availability to BSFRF survey
- fully-selected sizes

Determines
- Avg. Rec., F_{msy}, B_{msy},
- F_{OFL}, OFL, ABC

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NOAA FISHERIES

Model Scenarios

Estimate separate retention function for 2021/22

22.09 → 22.10 → 22.11

21.21a → 22.01 → 22.03 → 22.07 → 22.08

new AKRO expansion for bycatch in groundfish fisheries (2016/17+)

fit to combined male+female (by)catch fishery biomass data

1982 model start

Bootstrapped effective sample sizes for NMFS survey data input sample sizes

Model Evaluation

- 22.08: higher input (bootstrapped) sample sizes put too much weight on NMFS survey size comps
  - smaller survey Q's->increased scale->increased recruitment, MMB trajectories

- 22.09, 22.10, 22.11: 2022-specific retention curve estimated
  - ad hoc adjustment not reviewed by CPT
  - little impact on results
  - "not ready for prime time"

- 22.07: model starts in 1982
  - ~50 more parameters than base model
  - SSC identified standardizing criteria for changing model start time as issue for CPT
  - "not ready for prime time"

- 22.01: last year's assessment model with updated groundfish fisheries bycatch estimation
  - balances **proportional** errors in fitting male and female catch biomass time series
  - inflates **arithmetic** errors

- 22.03: fits total catch (males+females) catch biomass time series
  - balances arithmetic errors
  - otherwise very similar to 22.01

Diagnostic fits to NMFS Survey Biomass

FITS TO NMFS SURVEY BIOMASS

Fits to Data: NMFS Survey Male Size Comps

Population Results
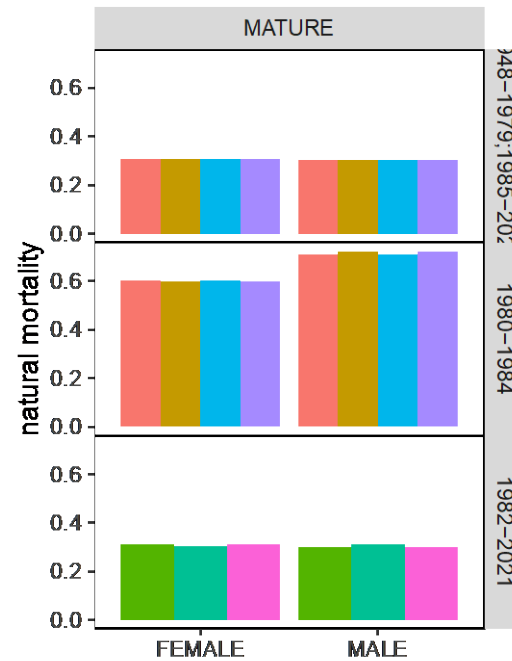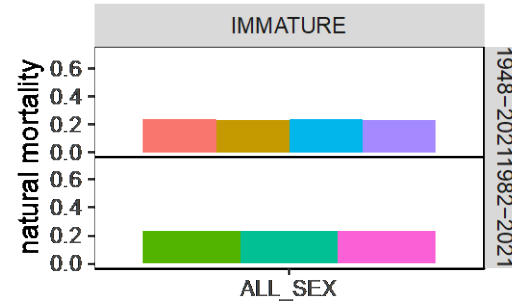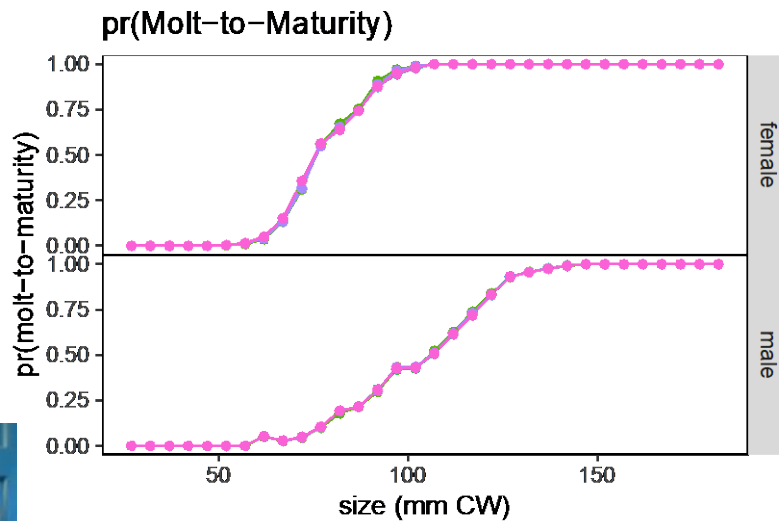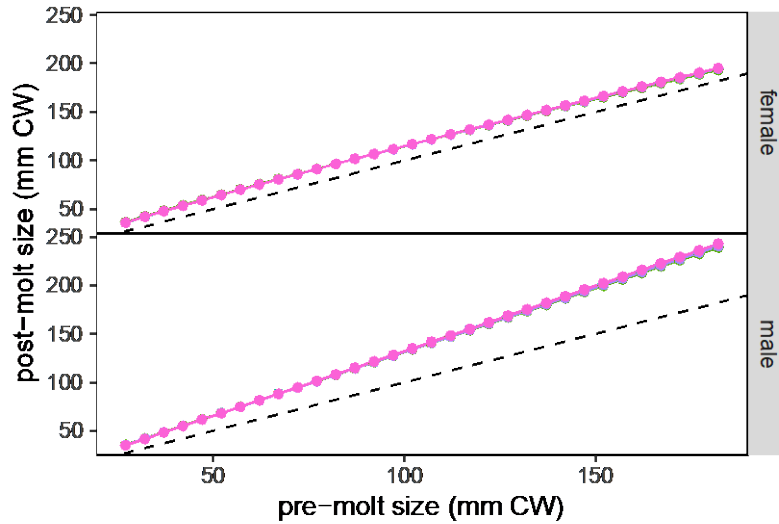
Population Results: recruitment and MMB
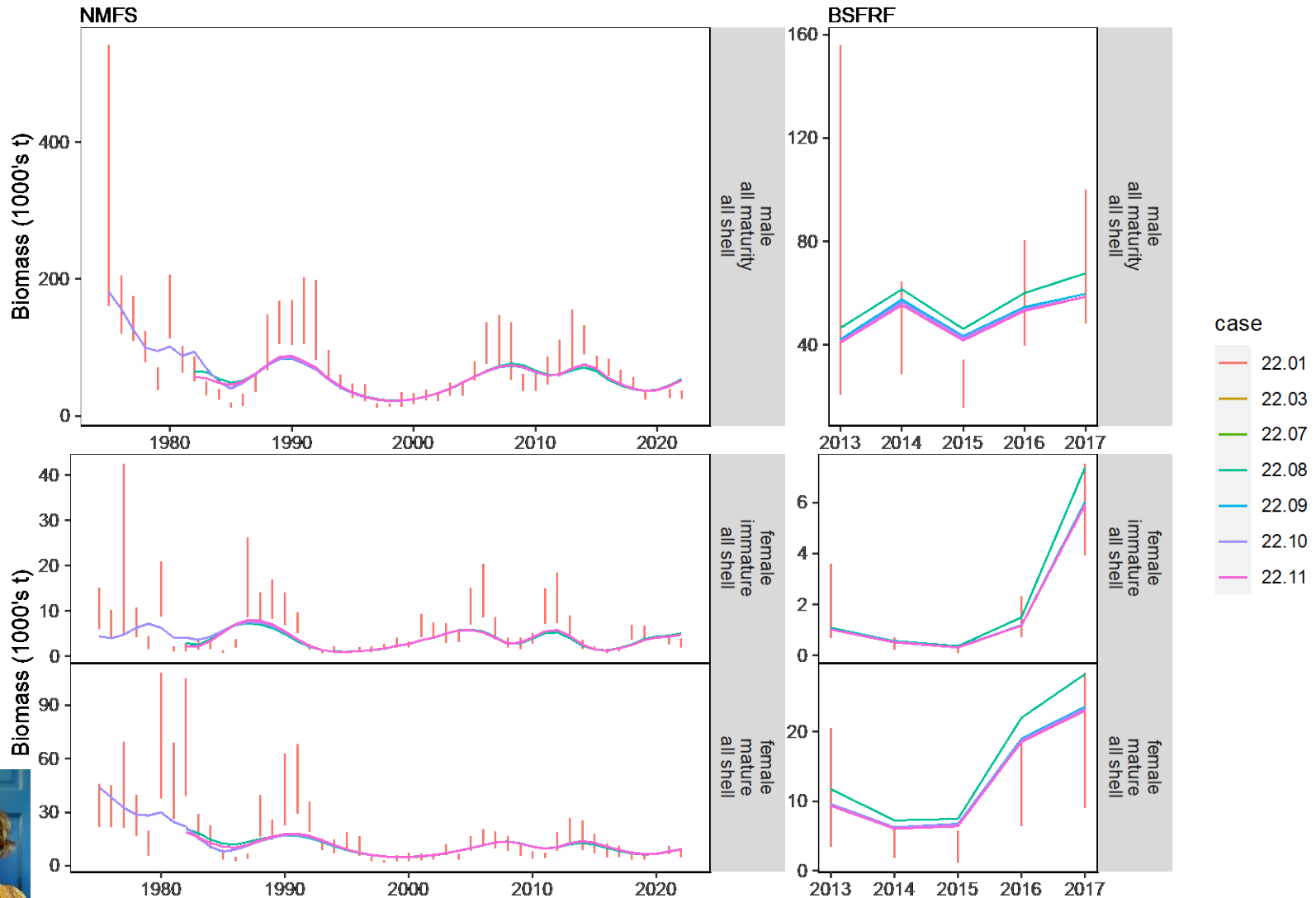
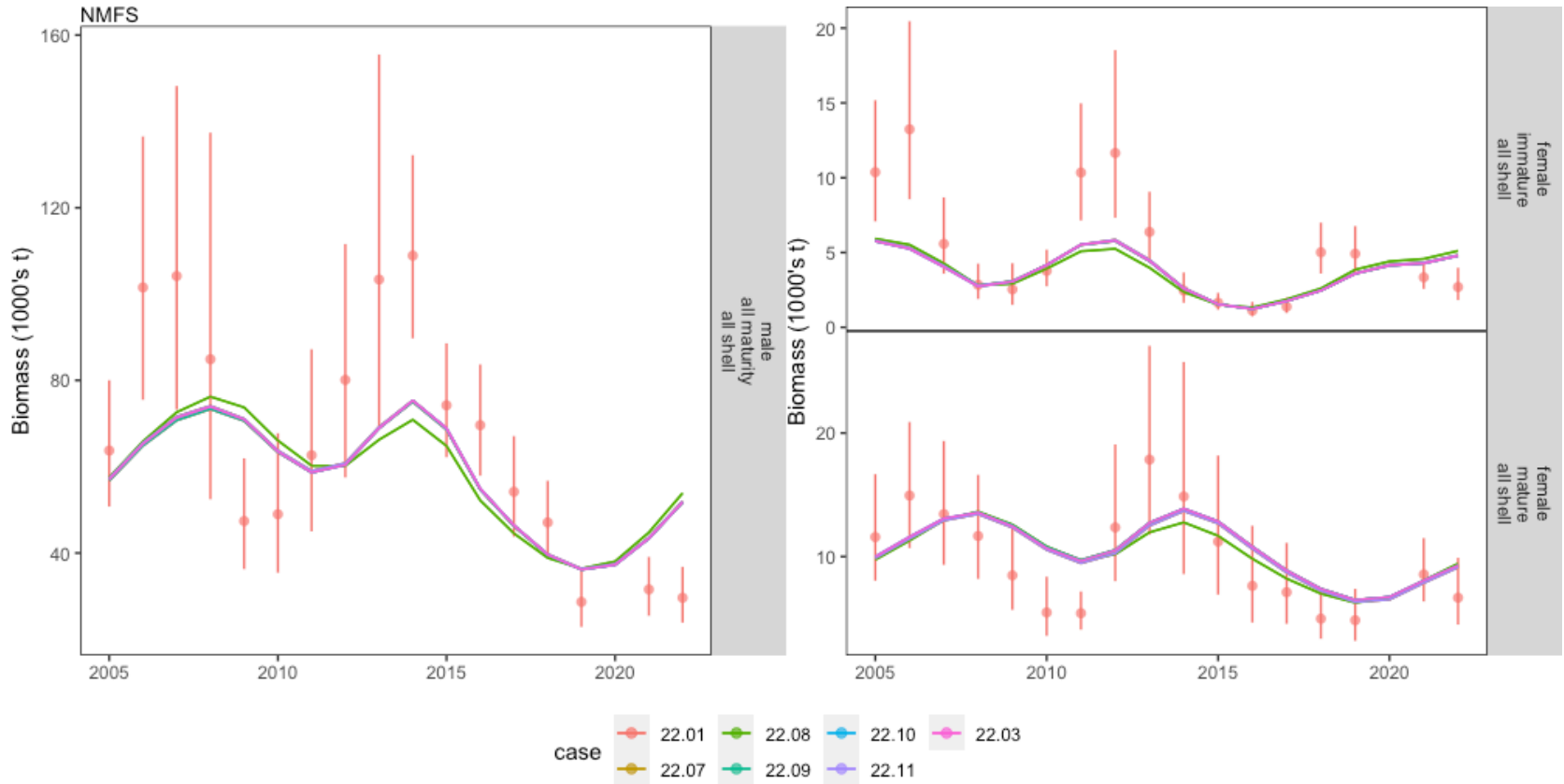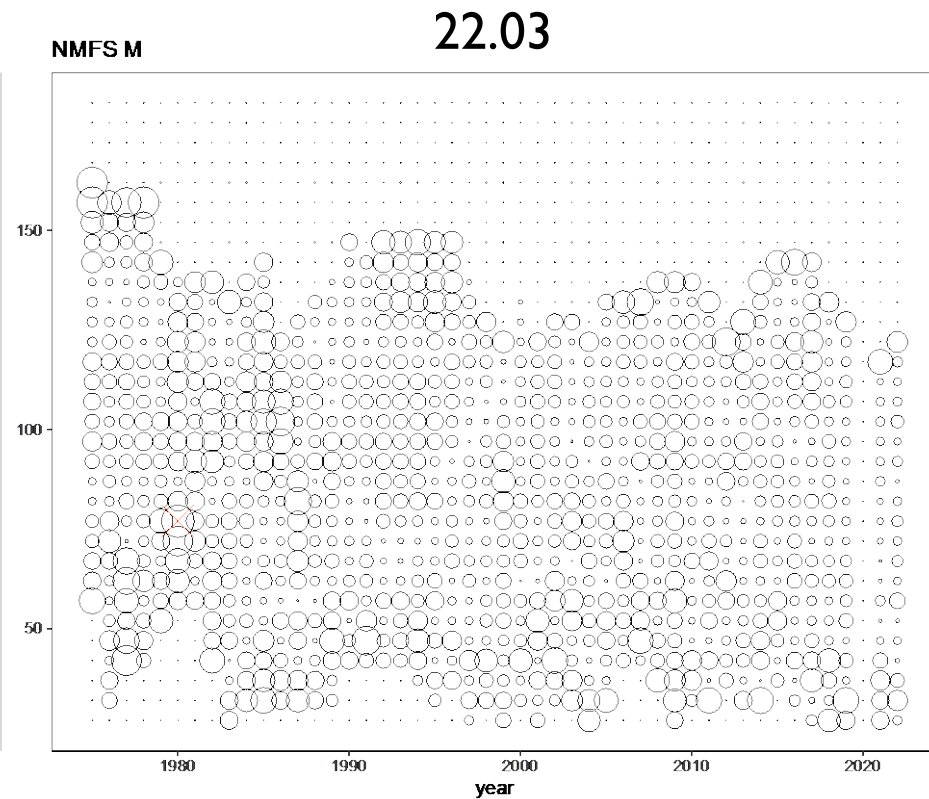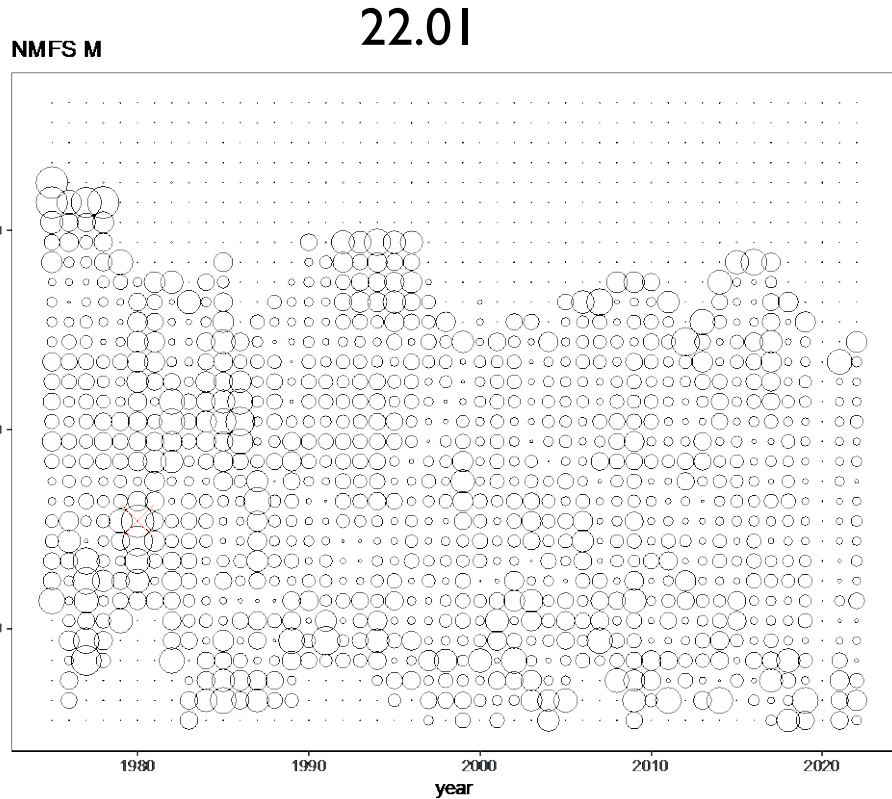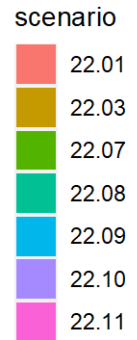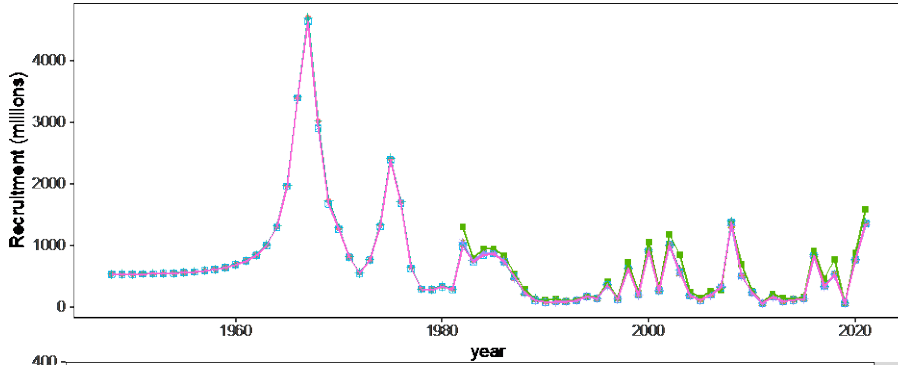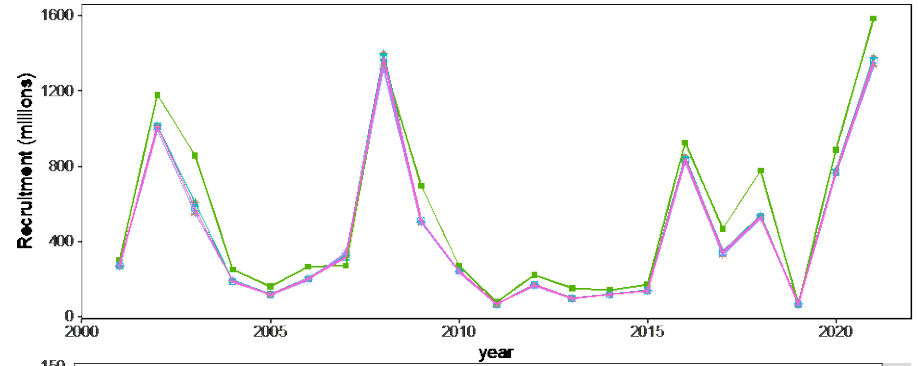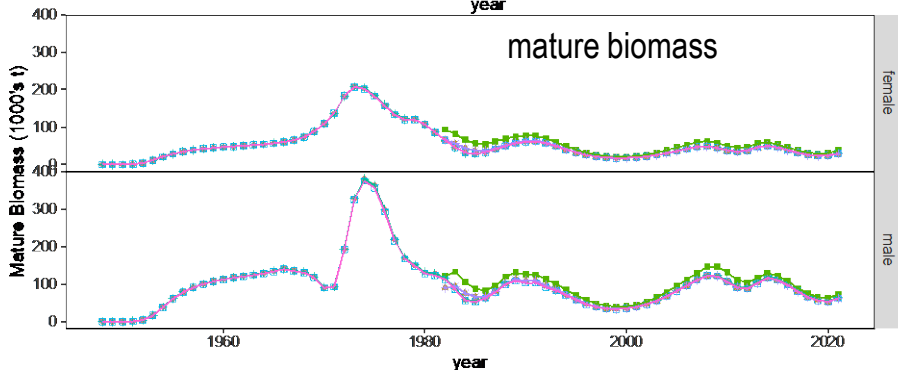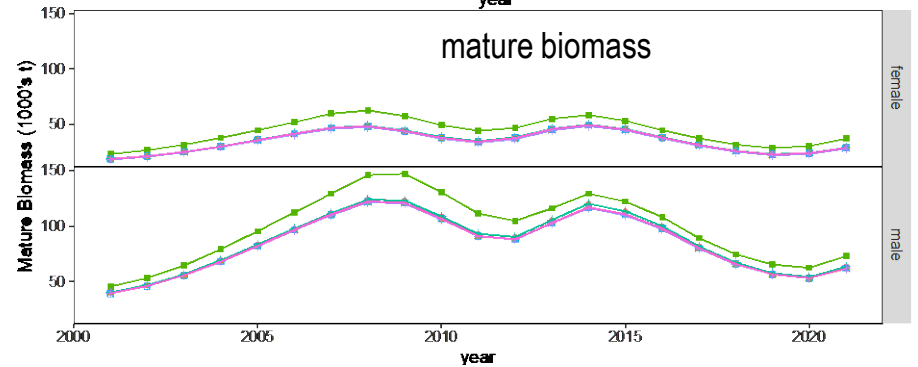# RETROSPECTIVE ANALYSIS

MODEL EVALUATION

- 22.08: higher input (bootstrapped) sample sizes put too much weight on NMFS survey size comps
  - smaller survey Q's->increased scale->increased recruitment, MMB trajectories

- 22.09, 22.10, 22.11: 2022-specific retention curve estimated
  - ad hoc adjustment not reviewed by CPT
  - little impact on results
  - "not ready for prime time"

- 22.07: model starts in 1982
  - ~50 more parameters than base model
  - SSC identified standardizing criteria for changing model start time as issue for CPT
  - "not ready for prime time"

- 22.01: last year's assessment model with updated groundfish fisheries bycatch estimation
  - balances **proportional** errors in fitting male and female catch biomass time series
  - inflates **arithmetic** errors

- 22.03: fits total catch (males+females) catch biomass time series
  - balances arithmetic errors
  - otherwise very similar to 22.01

SPECIFICATIONS FOR 2022/23

MLE Results (22.03)

- $MMB_{2021/22}$ = 62.05 kt

- Avg Rec. = 396 million

- $B_{MSY.}$ = 34.73 kt

- F_{MSY} = 1.17 yr^{-1}

- F_{OFL} = 1.17 yr^{-1}

- OFL = 32.80 kt

- ABC = 26.24 kt

- $MMB_{2022/23}$ = 47.58 kt

- Tier 3a

CPT recommended 20% buffer

- Same as last year (author recommended 25%)

- Negative:

  - Missing 2020 survey continues to affect results

  - Smaller survey q estimates

  - Issues with overestimating large crab

  - Overestimating terminal survey biomass

  - Lack of full recruitment potential (disappearing recruitment for the 3rd year)

STOCK STATUS (22.03)

- Tier 3a
- Not overfished
- No overfishing
- 20% ABC buffer

Year	MSST	Biomass (MMB)	TAC	Retained Catch	Total Catch	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	17.37	62.05	0.50	0.49	0.78	27.17	21.74
2022/23	NA	47.58	NA	NA	NA	32.81	26.25

Year	Tier	Bmsy	Projected MMB	B/Bmsy	Fofl	Years to Define Bmsy
2017/18	3a	29.17	47.04	1.49	0.75	1982-2017
2018/19	3a	21.87	23.53	1.08	0.93	1982-2018
2019/20	3b	41.07	39.55	0.96	1.08	1982-2019
2020/21	3b	36.62	35.31	0.96	0.93	1982-2019
2021/22	3a	35.94	42.57	1.18	1.17	1982-2020
2022/23	3a	34.73	47.58	1.37	1.17	1982-2021 *

M: immature: 0.24, females: 0.31, males: 0.31 (Table 52, p. 132)

FUTURE RECOMMENDATIONS

- BSFRF/NMFS SBS selectivity analysis

- Model simplification:

  - Start in 1982 (after CPT discussion on changing input data start date Jan 2023)

- EBS tanner implementation into GMACs

- Exploring time-varying natural mortality

- Investigate nonparametric approaches to selectivity

- Revisit previous CPT/SSC suggestions/comments

SNOW CRAB – C1 PART 2

FINAL ASSESSMENT, OFL/ABC SPECS, REBUILDING

ST. MATTHEW BLUE KING CRAB

FINAL ASSESSMENT, OFL/ABC SPECS

ESP REPORT CARD SUMMARY:

Ecosystem Considerations
- In 2022, **bottom temperatures returned to near-average** and the cold pool extended into the majority of the St. Matthew Island management area.
- **Above-average chlorophyll-a biomass** in the St. Matthew Island management area indicates suitable primary production conditions for larval survival
- Despite repeated fishery closures, **SMBKC recruitment remains below-average**, although recruit abundance increased from 2021 to 2022
- **Persistent, corrosive bottom waters** surrounding St. Matthew Island suggest potential impacts on shell formation, growth and survival of BKC if declines in pH continue
- **Above average chlorophyll-a biomass and benthic invertebrate density** in recent years suggests optimal foraging conditions for both larval and benthic stages of SMBKC

Socioeconomic Considerations:
- The SMBKC fishery has remained **closed to targeted fishing** since 2015 (the 2015/2016 crab season).
- **Incidental catch** of SMBKC biomass in EBS groundfish fisheries during 2021 **declined substantially** from the previous year to the lowest value in the available time series, continuing a declining trend observed since a recent high in 2017.

SMBKC FINAL ASSESSMENT 2022: SUMMARY

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

- Overfished

- Under rebuilding plan to be updated at this meeting (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+)

  - SSC/CPT comments concerning these were addressed in May 2022

    - May/June 2022 recommendations – reference model for Sept. 2022

Survey fits:

- 2022 ADF&G data point should help with conflicting survey trends
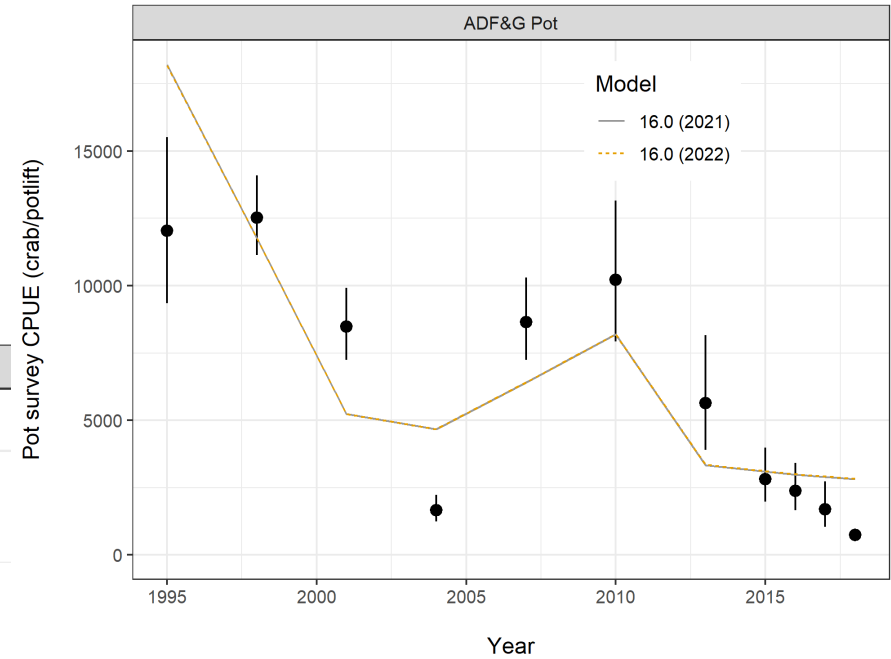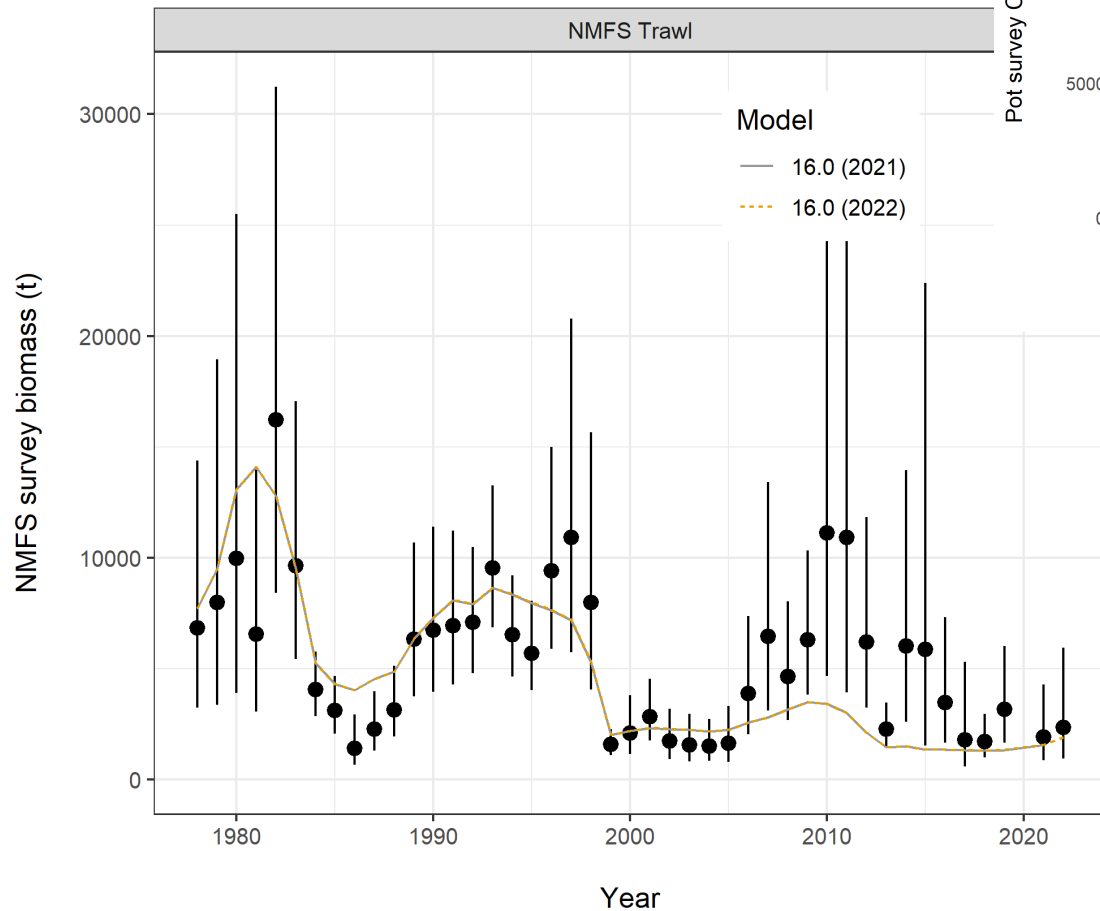
Mature male biomass:

- No discernable difference with updated reference model

- Retrospective pattern
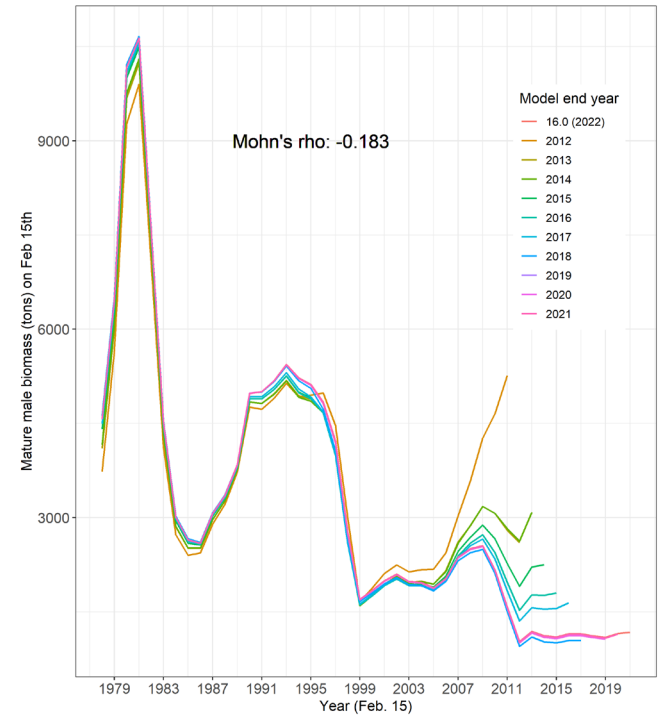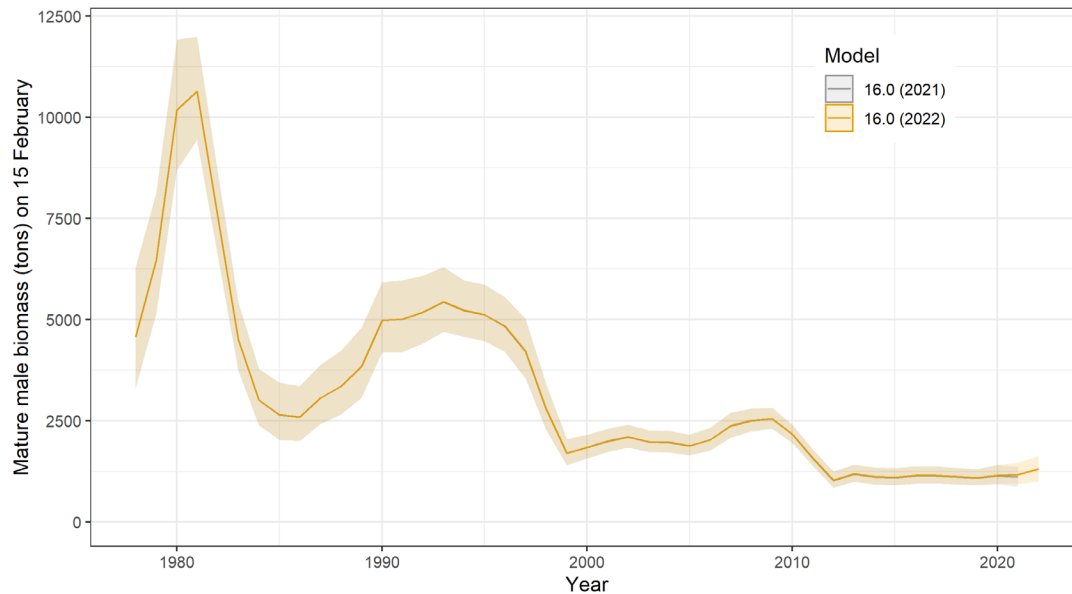
Recruitment

- Increase in 2021 & 2022

- Trending up

Recruitment model scenarios
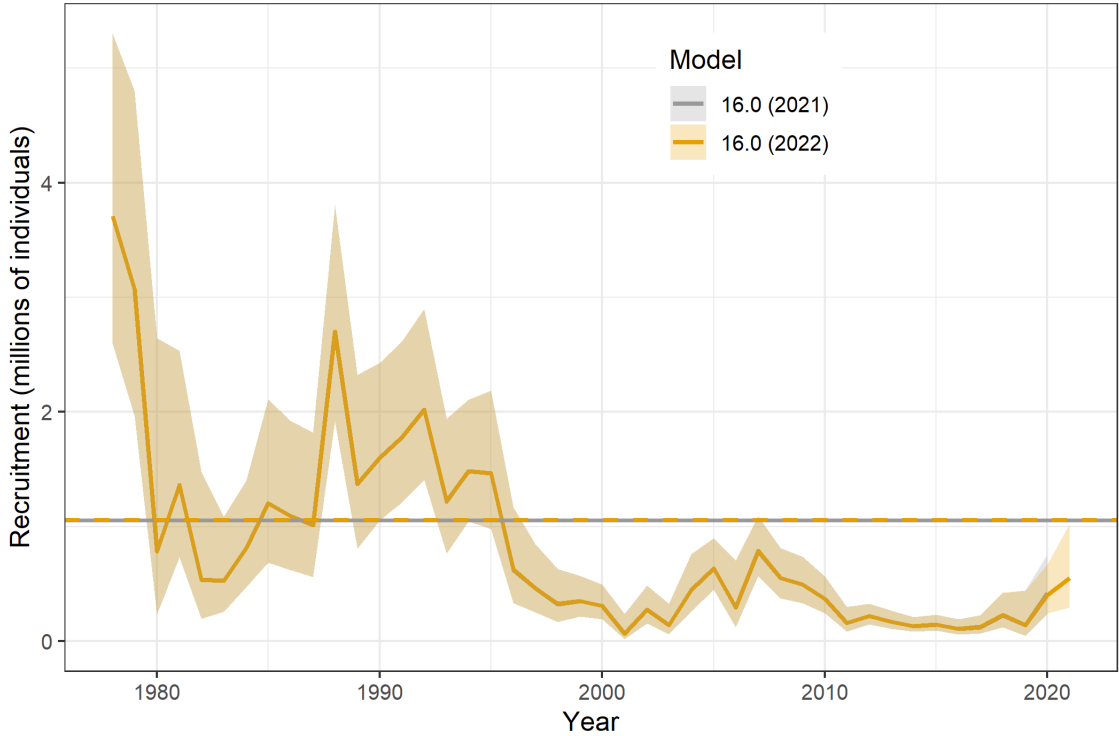
2022/23 & 2023/24 SPECIFICATIONS

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

Year	MSST	Biomass (MMB_{mating})	TAC	Retained catch	Total male catch	OFL	ABC
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	1.65	1.14	0.00	0.00	0.001	0.05	0.04
2021/22	1.63	1.18	0.00	0.00	0.001	0.05	0.04
2022/23		1.31				0.07	0.05

Table 4: OFL and ABC are in tons.

Component	Ref
MMB_{2022}	1175.056
B_{MSY}	3255.221
MMB/B_{MSY}	0.404
F_{OFL}	0.061
OFL_{2022}	66.333
ABC_{2022}	49.749

25 % ABC buffer
- Overfished
- Retrospective pattern MMB
- Poor recruitment
- Two survey trends diverge
- Limited stock specific life history information

SUMMARY / PROGRESS TOWARDS REBUILDING

- Reference model fit as expected; increased recruitment in last two survey data points, reflected in recruitment estimations

- Future work (highlights)

  - Further work on the two survey comparisons

  - Sensitivity/review of life history parameters in the model

  - Focus on Q – random walk or time blocks or alternative ways to address survey differences

- Rebuilding progress (required every two years)

  - Highly dependent on recruitment

  - New ADF&G data point will ground truth recruitment increases observed in NMFS survey

  - Projections using two different recruitment time frames both have likely increases, magnitude depends on recruitment potential.

SMBKC final assessment 2022

Model 16.0 (2022)

- Recruitment from the entire time series 1978-2021

B_{MSY}

50% Bmsy

Fishing mortalit
- F=0
- F=0.09
- F=0.18

MMB (t)

Year
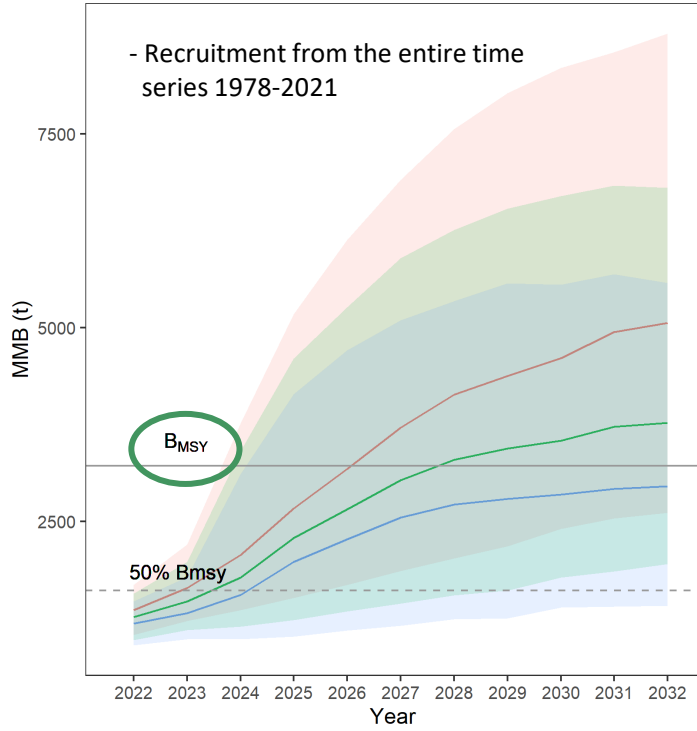
Model 16.0 (2022) - recent recruitment (1996-2021)

B_{MSY}

50% Bmsy

Fishing mortality
- F=0
- F=0.09
- F=0.18

MMB (t)

Year

Recruitment model scenarios

Model
- 16.0 (2021)
- 16.0 (2022)

Recruitment (millions of individuals)

Year
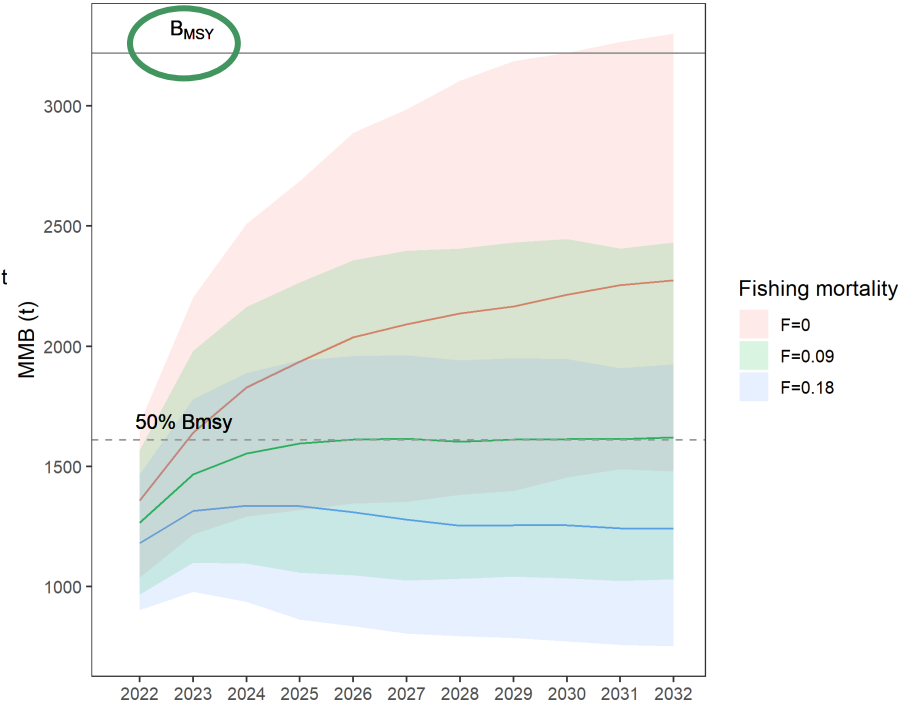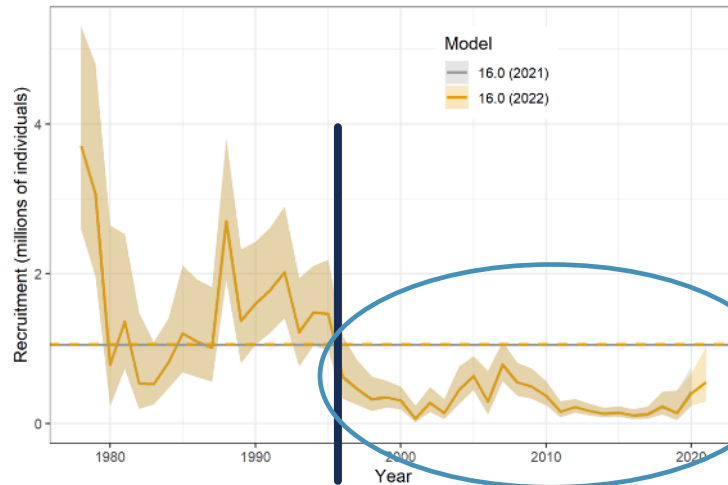
PRIBILOF ISLANDS RED KING CRAB (PIRKC)

FINAL ASSESSMENT 2022

PIRKC OVERVIEW

- **Management**: This is the first assessment since PIRKC shifted to a triennial management cycle in 2019.

- **Fishery**: No retained catch since 1998/99. Total bycatch is typically a small fraction of OFL.

- **Input data**:

  - Updated survey and bycatch data, small adjustments to the recent years of bycatch data after a new download from AKFIN.

  - Two models uses size composition data from bycatch.

- **Assessment methodology**:

  - Tier 4 stock

  - GMACS adopted in 2019.

  - B_{MSY} was redefined in 2019 as 35% of the average MMB observed from 2000-present, which was a period of no fishing.

  - F_{msy} proxy = natural mortality (0.21)

  - MMB is >120 mm carapace length estimated from an integrated assessment

  - One model estimates a constant (rather than linear) growth increment.

- **Assessment results**: Overfishing did not occur during 2019-2021 and the stock was not overfished as of the summer of 2022.

Table 1. Stock status in relation to status determination criteria for 2021/22 as estimated in October 2022. Units are thousands of metric tons (kt).

Chapter	Stock	Tier	MSST[1]	B_{MSY} or $B_{MSYproxy}$	2021/22[2] MMB	2021/22 MMB/ MMB_{MSY}	2021/22 OFL	2021/22 Total Catch	Rebuilding Status
4	Pribilof Islands red king crab	4	0.86	1.71	3.88	2.22	0.86	0.001	Not overfished

Table 2. CPT recommendations for Eastern Bering Sea crab stocks.

SAFE Ch.	Stock	Tier	F_{OFL}	B_{MSY} or $B_{MSYproxy}$	B_{MSY} basis years[1]	2022/23[2] MMB	2022/23 MMB / MMB_{MSY}	γ	Natural Mortality (M)	2022/23 OFL	2022/23 ABC	ABC Buffer
4	Pribilof Is. red king crab	4a	0.21	1.71	2000- 2021	3.88	2.27	1	0.21	0.685	0.51	25%

PIRKC MODELS CONSIDERED

Three models presented this cycle:

22.1   Model 19.1 updated with new data

22.1a   22.1 + bycatch size composition data, allowing estimates bycatch selectivity

22.1b   22.1a + constant growth increment; more consistent with approach for other RKC stocks

- CPT/SSC comments

  - Include ADF&G pot survey data: *planned for next assessment*

  - Bering Sea wide exploration of RKC stock structure: *initial size composition comparisons presented for three RKC socks; continuing work planned*

  - Development of PIRKC-specific life history characteristics: *inclusion of trawl selectivity a step towards PIRKC-specific population processes*

Fixed growth increment estimates.
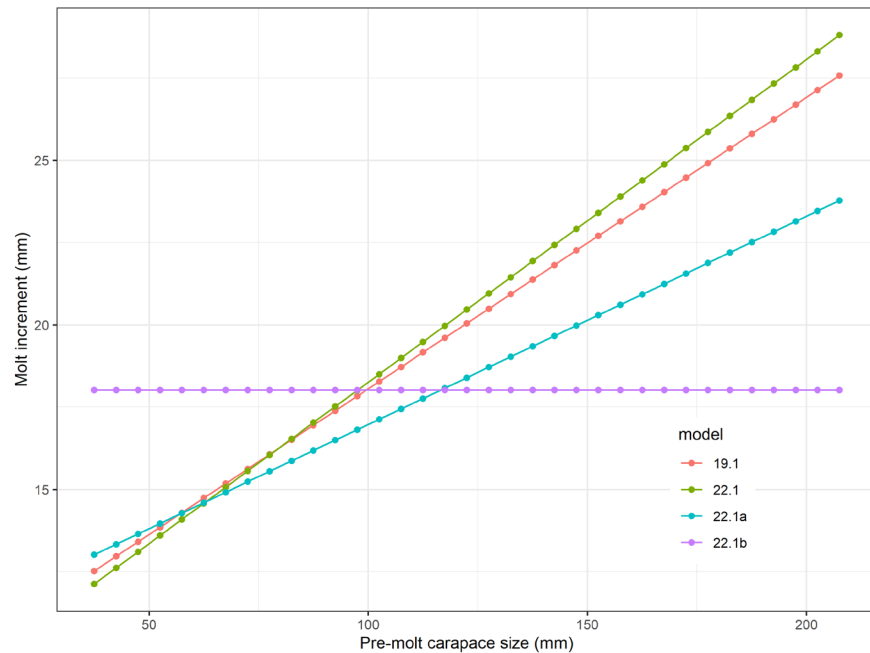
BBRKC tag study estimates of growth increment by size.
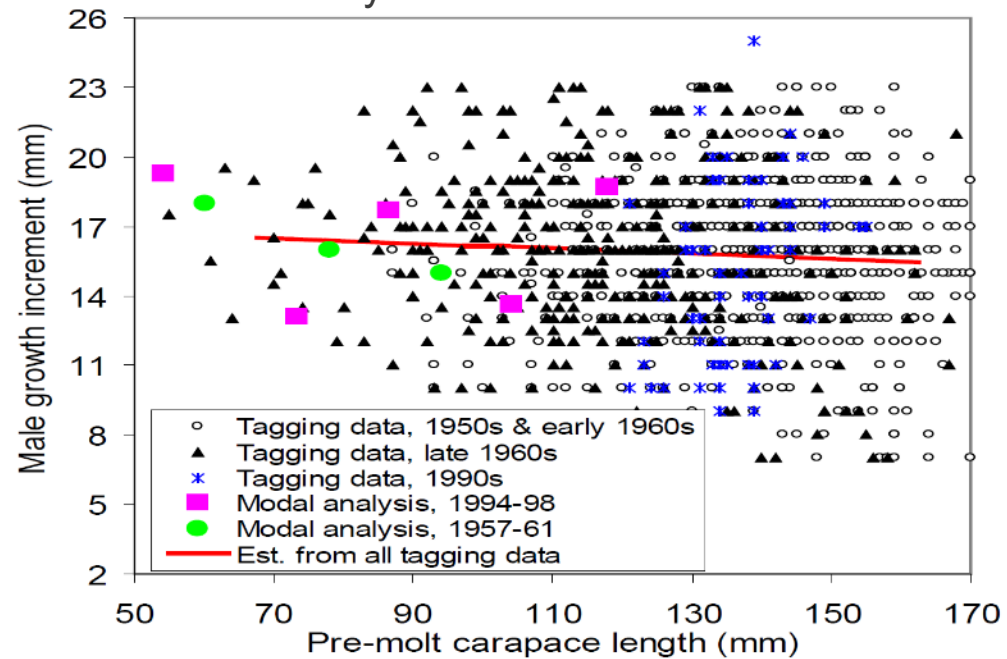
22.1b: slope of growth fixed at 0, intercept estimated

PIRKC MODEL FITS TO SURVEY DATA
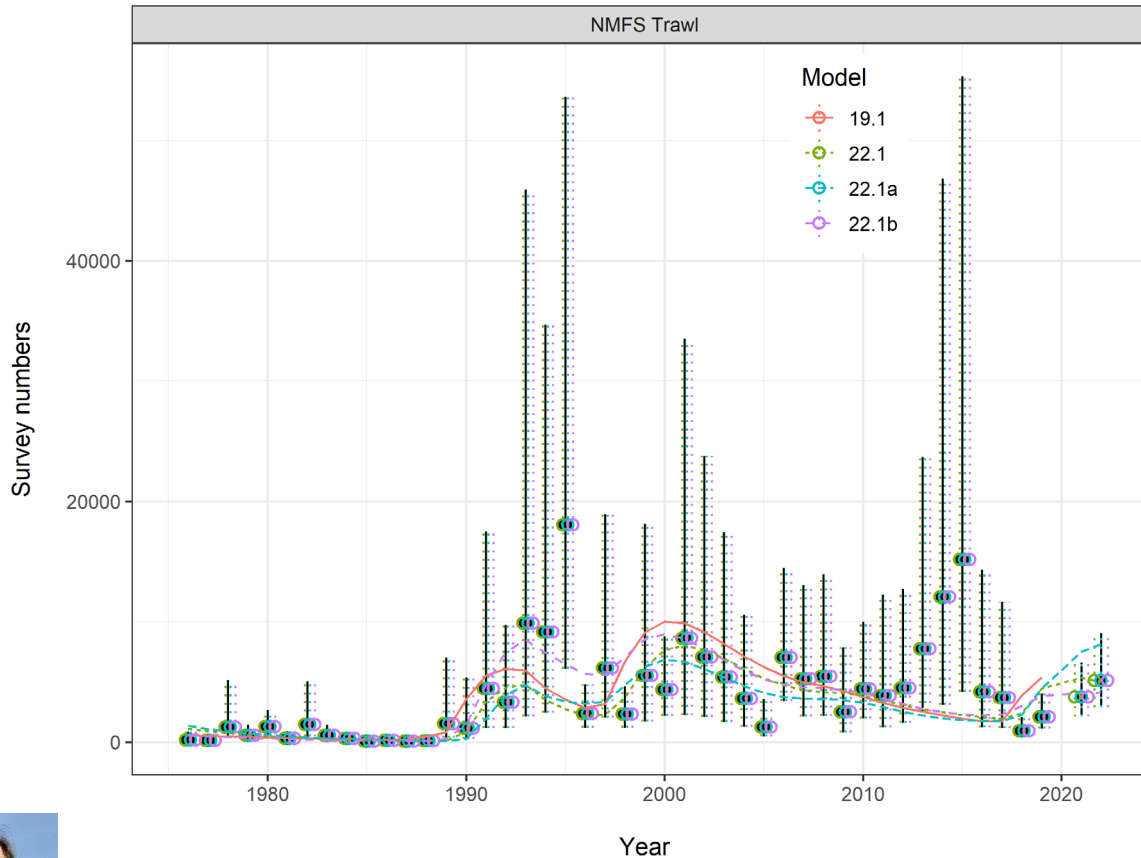
- 22.1a misses CIs for 2019 / 2021

- 22.1, 22.1b similar fits

- All models miss 2014/15 peaks (peaks produced by single large tow in each year)

PIRKC SELECTIVITY
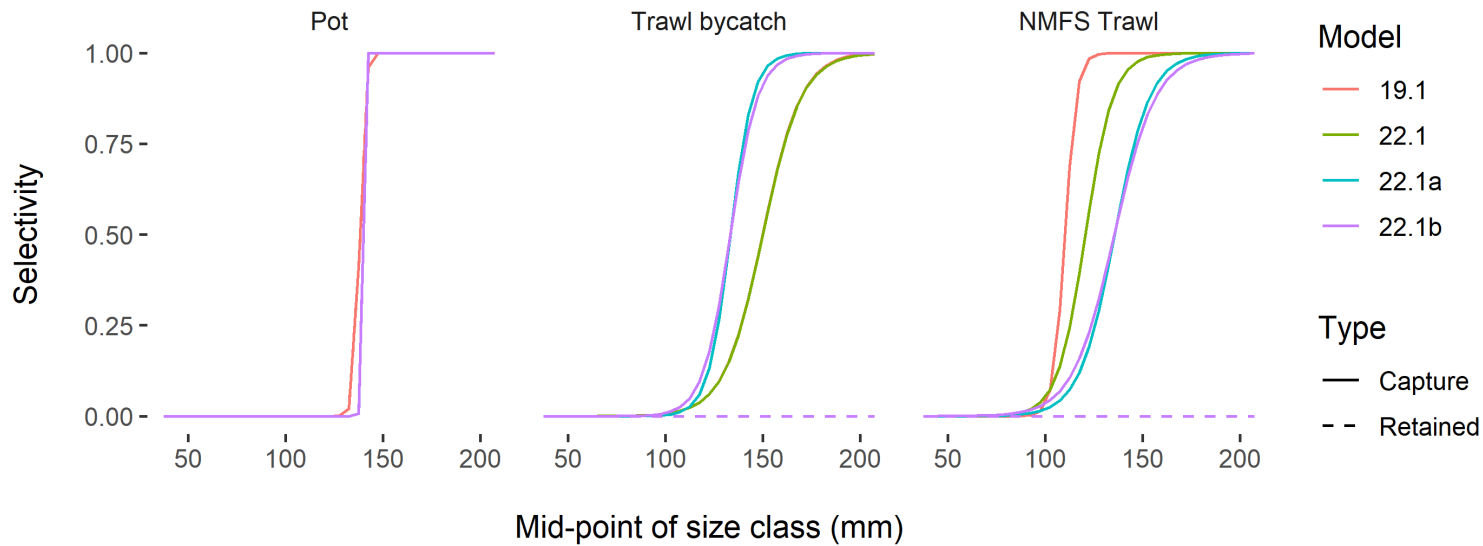
Reflects different selectivity in 22.1a and 22.1b

PIRKC ESTIMATED MATURE MALE BIOMASS
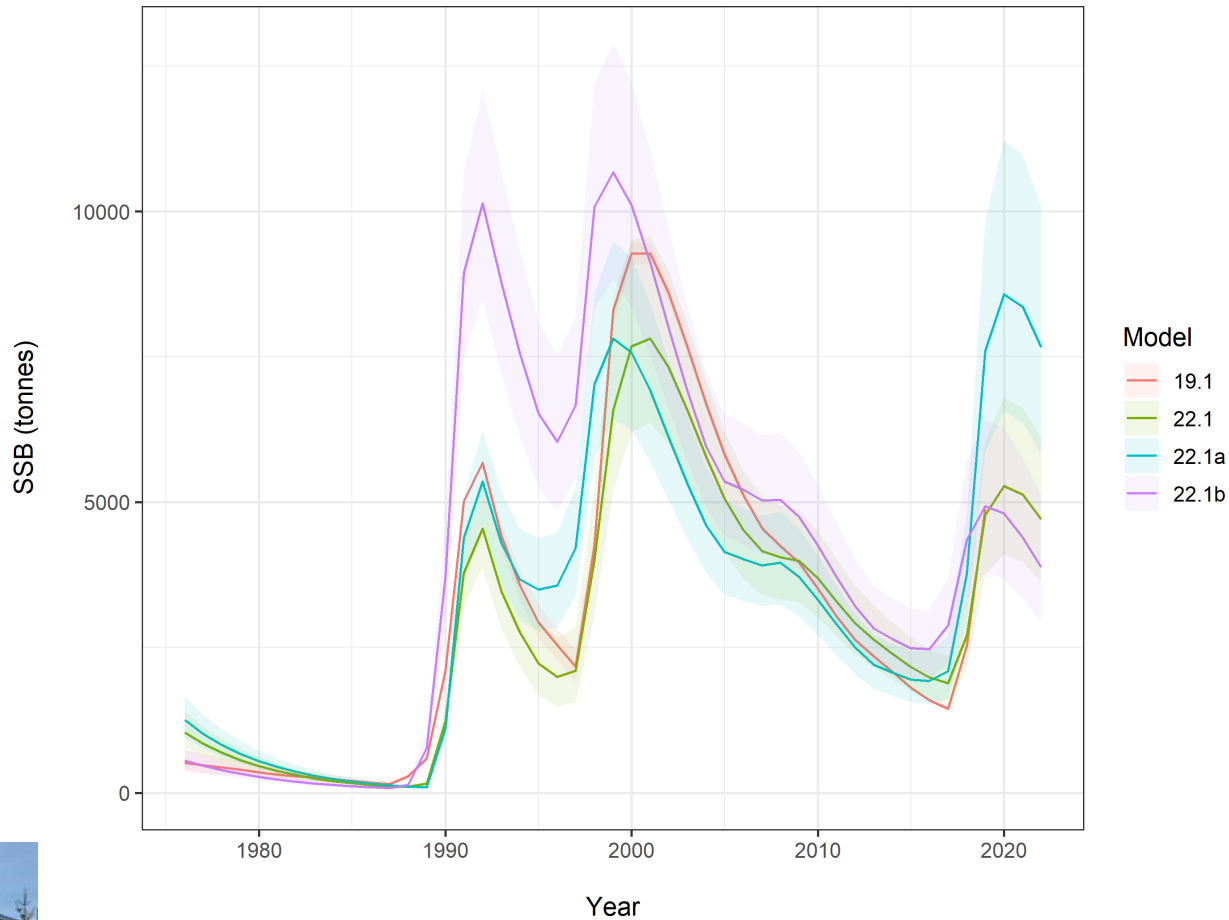
- 22.1a highest, 22.1 intermediate, 22.1b lowest

- All models show decline consistent with aging in the dominant cohort

PIRKC ESTIMATED FISHING MORTALITY
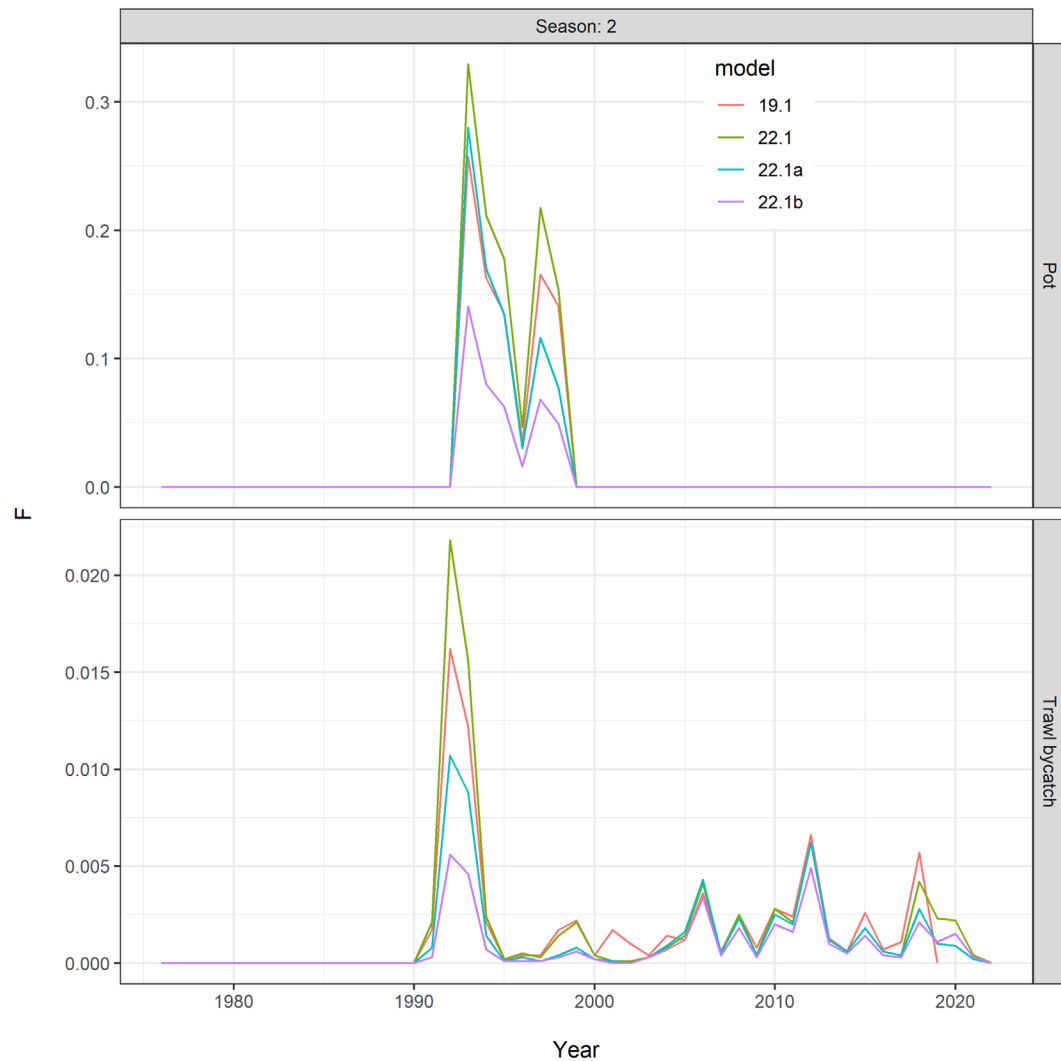
- Estimated *F* low, reflecting the absence of a directed fishery

PIRKC ESTIMATED RECRUITMENT
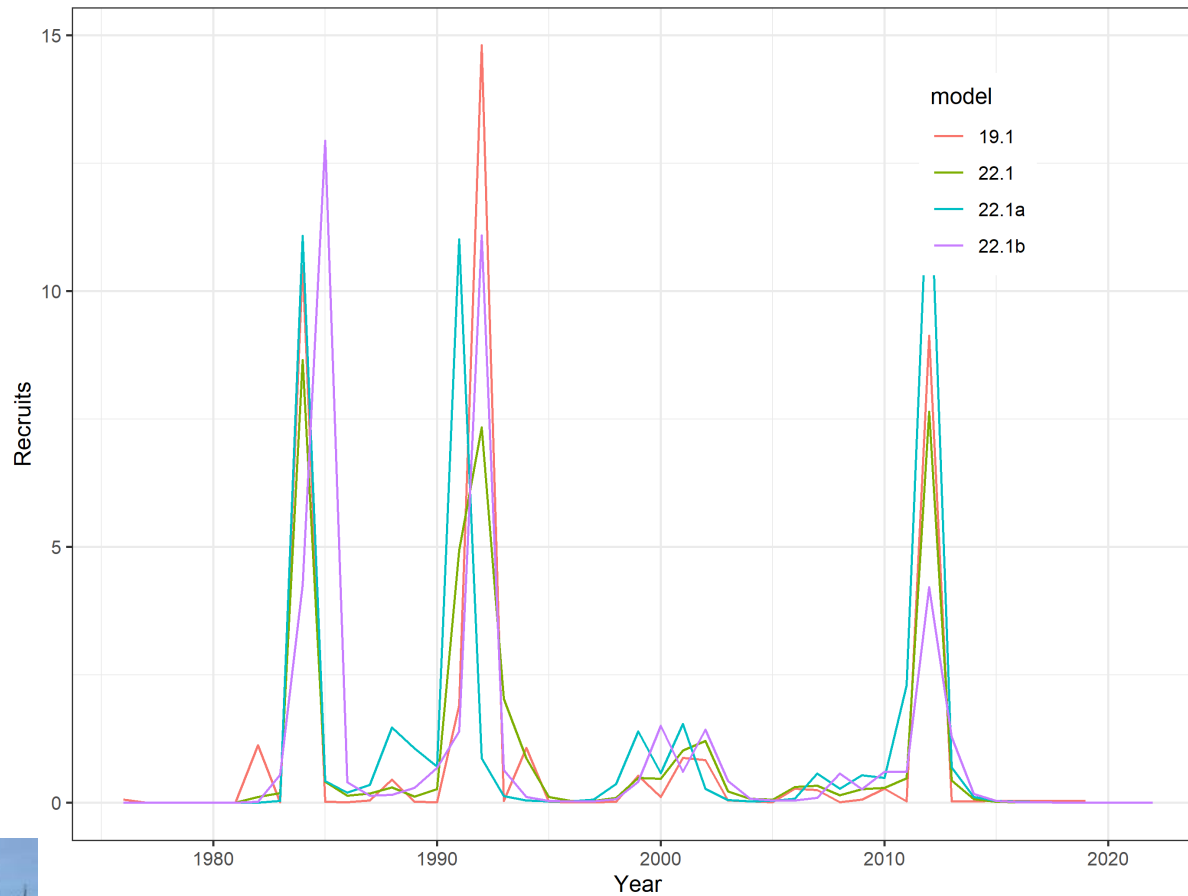
- Magnitude of *R* estimates differed among models, as expected due to difference in MMB estimates

MODEL SELECTION, BUFFER, AND CPT RECOMMENDATIONS

- **Model 22.1b recommended by CPT**

  - Fits data well

  - Includes additional data source (bycatch size comps); improvement over 22.1 (base model)

  - Treats biology (molt increments) more realistically given current understanding of Bering Sea RKC life history

- **25% buffer recommended**

  - Model borrows life history information from other stocks

  - Buffer is consistent with other low-information king crab stocks (SMBKC, PIBKC)

- **Additional CPT recommendations**

  - Review additional sources of growth information (e.g., Kodiak lab studies)

  - Examine the standard deviation around the growth increment in 22.1b for consistency with variability in tagging estimates of growth increment

PIRKC SPECIFICATIONS

Management quantities for each scenario considered. Status and MMB were estimates for February 15 of the completed crab year. Values are in units of tons.

Model	MMB	B35	F35	FOFL	OFL	M	avg_rec	Status
19.1	4893.79	1594	0.21	0.21	864.29	0.21	0.97	3.07
22.1	4703.93	1529	0.21	0.21	830.76	0.21	0.84	3.08
22.1a	7661.25	1601	0.21	0.21	1353.05	0.21	1.06	4.79
22.1b	3878.98	1709	0.21	0.21	685.07	0.21	0.96	2.27

PIRKC STATUS AND CATCH SPECIFICATIONS

Values in t, shaded areas indicate new projections or estimates based on the current assessment.

Year	MSST	Biomass (MMB)	TAC	Retained Catch	Total Catch	OFL	ABC
2018/19	866	5,368	0	0	7.22	404	303
2019/20	866	6,431	0	0	3.84	864	648
2020/21	866	6,431	0		5.09	864	648
2021/22	854	3,879	0		1.47	864	648
2022/23	854	3,879	0			685	514
2023/24		3,879	0			685	514
2024/25		3,879	0			685	514

- Based on 22.1b
- Tier 4
- Not overfished
- No overfishing
- 25% ABC buffer

BALANCE OF CPT REPORT

NORTON SOUND RED KING CRAB (NSRKC)

PROPOSED MODEL RUNS

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 trawl survey (abundance, length-shell compositions) - NBS data not available for September meeting, planned for inclusion in 2023 SAFE

- **Models presented**

    - 21.0 – previous model with updated data

    - 22.0 – model 21.0 with shell-specific retention probabilities

    - 22.1 – model 21.0 with individual M estimates for each of 8 length bins

    - 22.2 – model 22.0 with individual M estimates for each of 8 length bins

MODELING APPROACH: SHELL CLASS RETENTION PROBABILITY

Estimated $M = 0$ for two smallest size classes
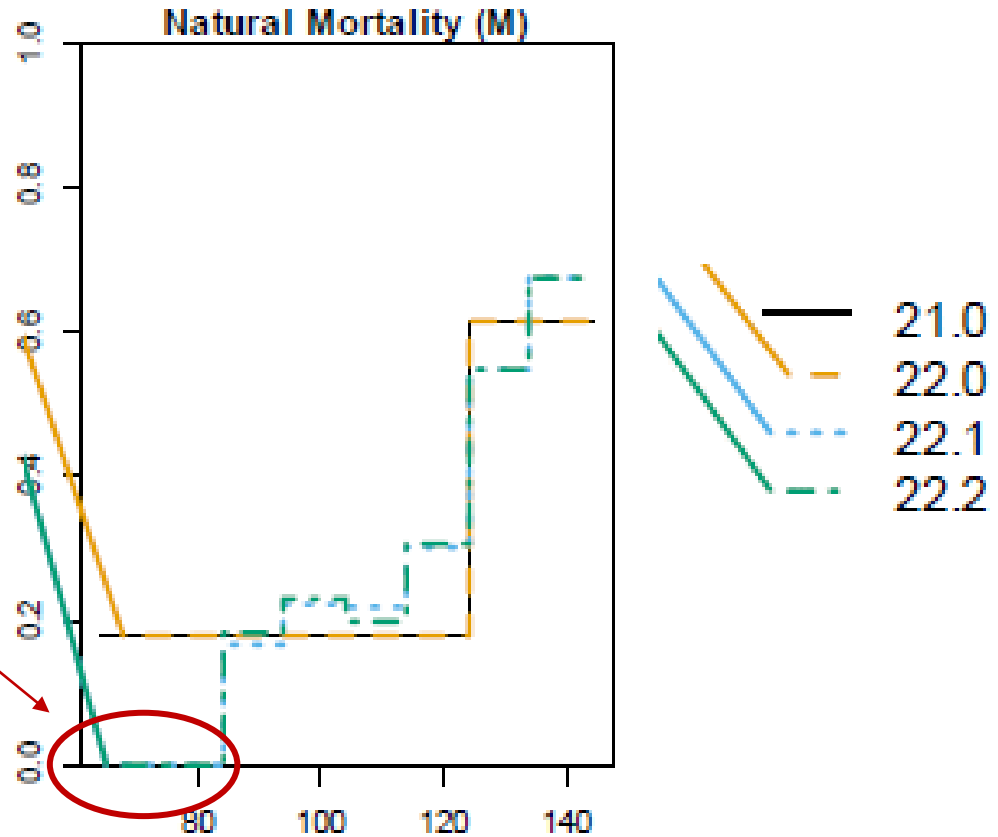
MODEL COMPARISON: SURVEY SIZE COMPOSITION

Trawl length New Shell & Old Shell: observed vs predicted

BMSY: 1982- 2023

Mature: > 94mm CL

Lab data (2022)
Functional maturity > 75mm CL
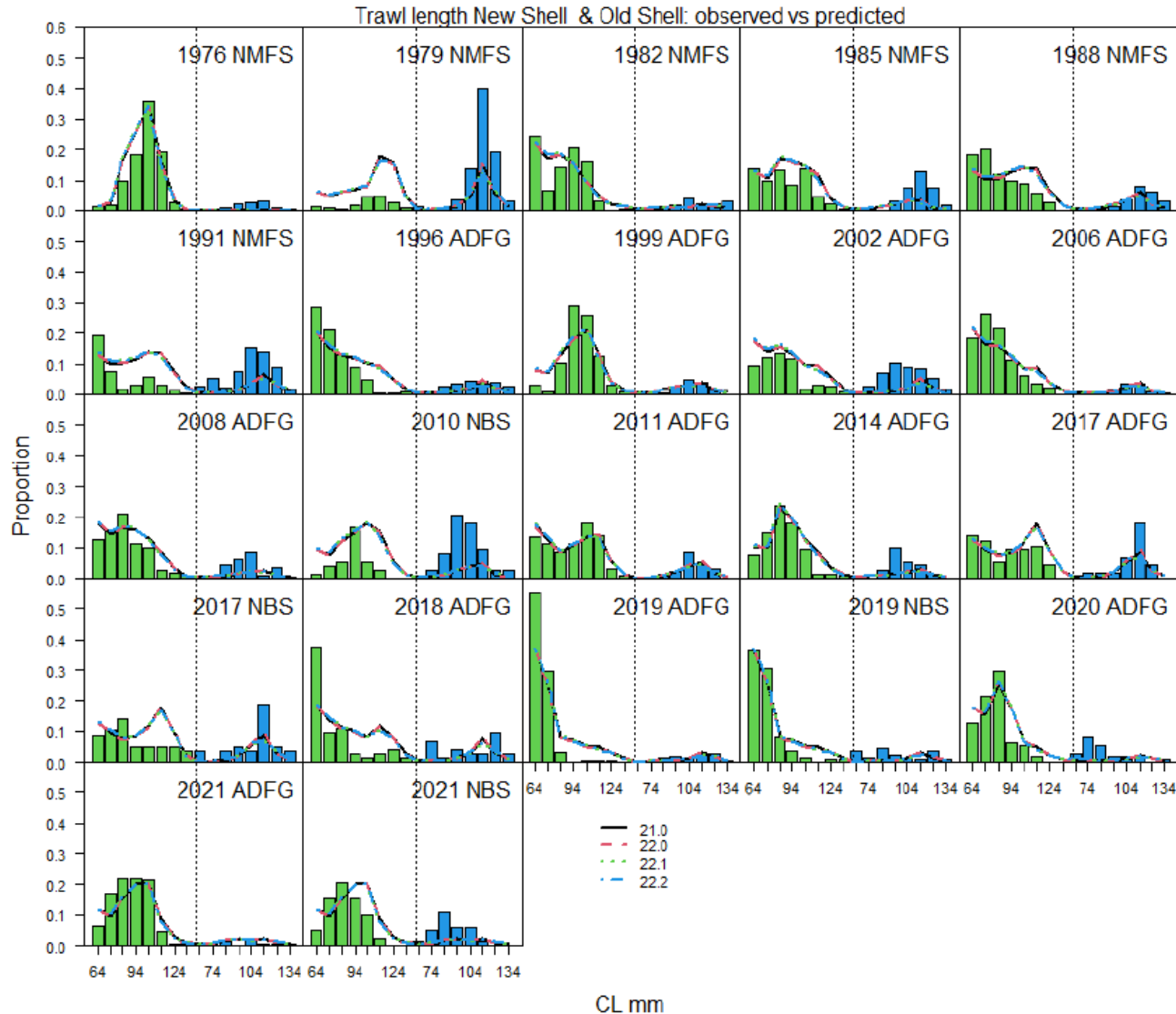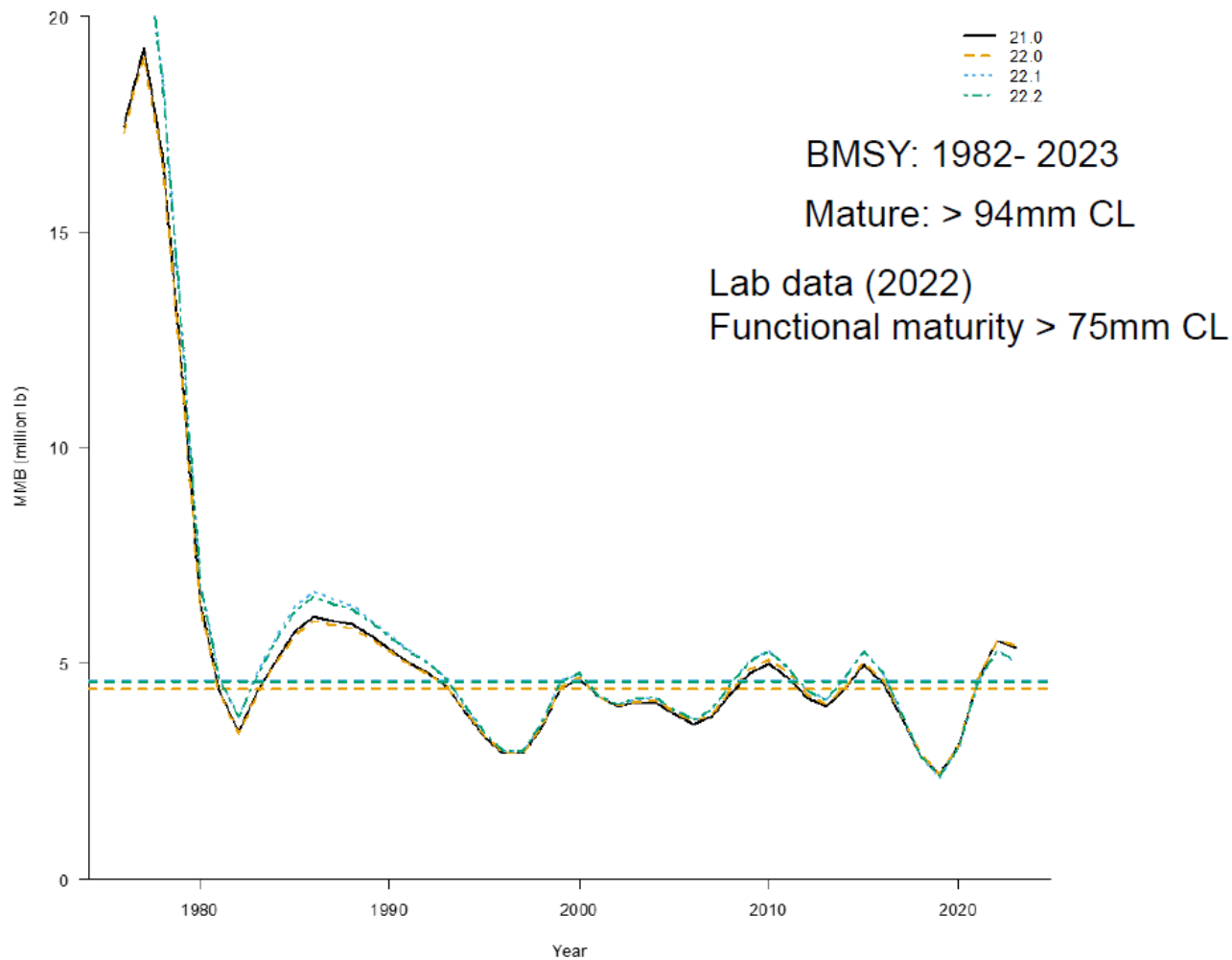
MODEL RECOMMENDATION FOR JANUARY 2023

- **CPT recommends 21.0 be brought forward in January**

  - All models fit data similarly well, had similar log-likelihood values

  - With no substantive benefits from more complicated models (22.0, 22.1, 22.2), 21.0 was selected based on model parsimony

- **F_{OFL} recommendations**

  - The author requested guidance as to whether length-independent M should be used for F_{OFL} calculations, or length-dependent M matching the two size bins in 21.0

  - CPT requested that both values of F_{OFL} be brought forward in January (traditional length-independent and length-dependent)

- **Additional recommendations**

  - Jittering analysis to evaluate model convergence

  - Future explorations of 22.1 and 22.2 use a prior on M to avoid estimates of $M = 0$ for smallest size bins

NSRKC TOTAL CATCH OFL

- Traditionally managed with retained catch OFL

- Virtually all bycatch is in the directed fishery

- Opportunistic observer coverage during 2012-2019, no coverage since 2020

- Author expressed concern over the potential for a biased bycatch estimate with sparse data, requested guidance whether and how to move to a total catch OFL

- CPT requested that the author provide information in January 2023 on different methods for estimating discards, providing both the discard rate (i.e., as a proportion of the retained catch) and associated total catch with each method. Methods identified in the January 2022 CPT report include the LNR2, subtraction, and proportional approaches.

PIGKC, PIBKC, AIGKC, WAIRKC OVERFISHING UPDATES

PIGKC

Overfishing did not occur in 2021.

Four vessels participated in the 2021 directed fishery. Estimated total fishery mortality in 2021 (21.08 t) resulted from retained catch (15.52 t), bycatch in the directed fishery (3.57 t) and bycatch in groundfish fisheries (1.99 t).

Management Performance Table (values in t)

Calendar Year	MSST	Biomass (MMB)	GHL[a]	Retained Catch	Total Catch[b]	OFL	ABC
2016	N/A	N/A	59	0	0.24	91	68
2017	N/A	N/A	59	Conf.[c]	Conf.[c]	93	70
2018	N/A	N/A	59	Conf.[c]	Conf.[c]	93	70
2019	N/A	N/A	59	Conf.[c]	Conf.[c]	93	70
2020	N/A	N/A	59	49	52	93	70
2021	N/A	N/A	59	16	21	93	70
2022	N/A	N/A				93	70
2023	N/A	N/A				93	70

a. Guideline harvest level, established in lb and converted to t.
b. Total retained catch plus estimated bycatch mortality of discarded catch during crab fisheries and bycatch mortality due to groundfish fisheries are included here, but not for 2017-2019 because the directed fishery is confidential.
c. Confidential under Sec. 16.05.815 (SOA statute).

PIBKC

Overfishing did not occur in 2021.

Table 1: Management performance; all units in metric tons.

Year	MSST	Biomass (MMBmating)	TAC	Retained Catch	Total Catch Mortality	OFL	ABC
2018/19	2,053	230	closed	0	0.400	1.16	0.87
2019/20	2,049	180	closed	0	0.420	1.16	0.87
2020/21	2,049	181	closed	0	0.000	1.16	0.87
2021/22	NA	180	closed	0	0.102	1.16	0.87
2022/23	NA	180	NA	NA	NA	1.16	0.87

AIGKC

Overfishing did not occur in 2021/22.

Estimated total fishery mortality in 2021/22 was 3.056 kt, which was less than the OFL of 4.817 kt, and resulted from 2.699 kt retained catch in the directed fishery, 0.343 kt bycatch mortality in the directed fishery, and 0.014 kt bycatch mortality in the groundfish fisheries.

Year	MSST	Biomass (MMB)	TAC	Retained Catch	Total Catch[a]	OFL	ABC[b]
2018/19	5.880	17.848	2.883	2.965	3.372	5.514	4.136
2019/20	5.915	16.386	3.257	3.319	3.729	5.249	3.937
2020/21	6.014	15.442	2.999	3.000	3.520	4.798	3.599
2021/22	5.859[d]	12.592[d]	2.690	2.699[e]	3.056[e]	4.817[c]	3.372[c]
2022/23		11.941[d]				3.761[d]	2.821[d]

The mature male biomass (13.065 kt) is above MSST (5.821 kt) in 2021/22; hence, **the stock is not overfished**.

WAIRKC

Overfishing did not occur in 2021/22.

The directed fishery was closed in 2021/22.

Estimated total fishery mortality in 2021/22 (0.16 t) resulted from bycatch in the AIGKC fishery (0.00 t) and bycatch in groundfish fisheries (0.16 t).

Management Performance Table (values in t)

Fishing Year	MSST	Biomass (MMB)	TAC[a]	Retained Catch	Total Catch	OFL	ABC
2015/16	N/A	N/A	Closed	0	1.2	56	34
2016/17	N/A	N/A	Closed	0	<1	56	34
2017/18	N/A	N/A	Closed	0	<1	56	14
2018/19	N/A	N/A	Closed	0	<1	56	14
2019/20	N/A	N/A	Closed	0	<1	56	14
2020/21	N/A	N/A	Closed	0	<1	56	14
2021/22	N/A	N/A	Closed	0	<1	56	14
2022/23	N/A	N/A				56	14