

Review of TACs

Bering Sea Crab 2023/24 Season

ADF&G presentation to BSAI crab industry, 12 Oct 2023

Join by ZOOM

<https://us02web.zoom.us/j/87976095228?pwd=SVB0ajF4dXlLUjNPRzNDTTg2eDRXdz09>

Meeting ID: 879 7609 5228

Passcode: 183867

2023/24 Specifications Summary

Fishery	OFL (mill lb)	ABC (mill lb)	TAC (mill lb)
Pribilof blue king crab	0.0026 (total catch)	0.0020 (total catch)	0 (directed fishery closed)
Pribilof red king crab	1.51 (total catch)	1.13 (total catch)	0 (directed fishery closed)
St. Matthew blue king	0.15 catch)	0.11 (total male catch)	0 (directed fishery closed)
Bristol Bay red king crab	9.75 (total catch)	7.80 (total catch)	2.15 (retained catch)
Bering Sea Tanner crab	79.82 (total catch)	63.85 (total catch)	0.759 (EBT), 1.318 (WBT) (retained catch)
Bering Sea snow crab	34.04 (total catch)	17.02 (total catch)	0 (directed fishery closed)

Tanner crab: CPT recommended 25% ABC buffer. SSC/council adopted 20% ABC buffer.

Snow crab: CPT recommended Tier 4 OFL (0.683 lbs) and ABC (.551 lbs).

BSAI Crab Management Process

May

- Fisheries conclude – fishery data summarized for assessments
- NPFMC Crab Plan Team (CPT) meets (AK) to discuss model scenarios for September

June-August

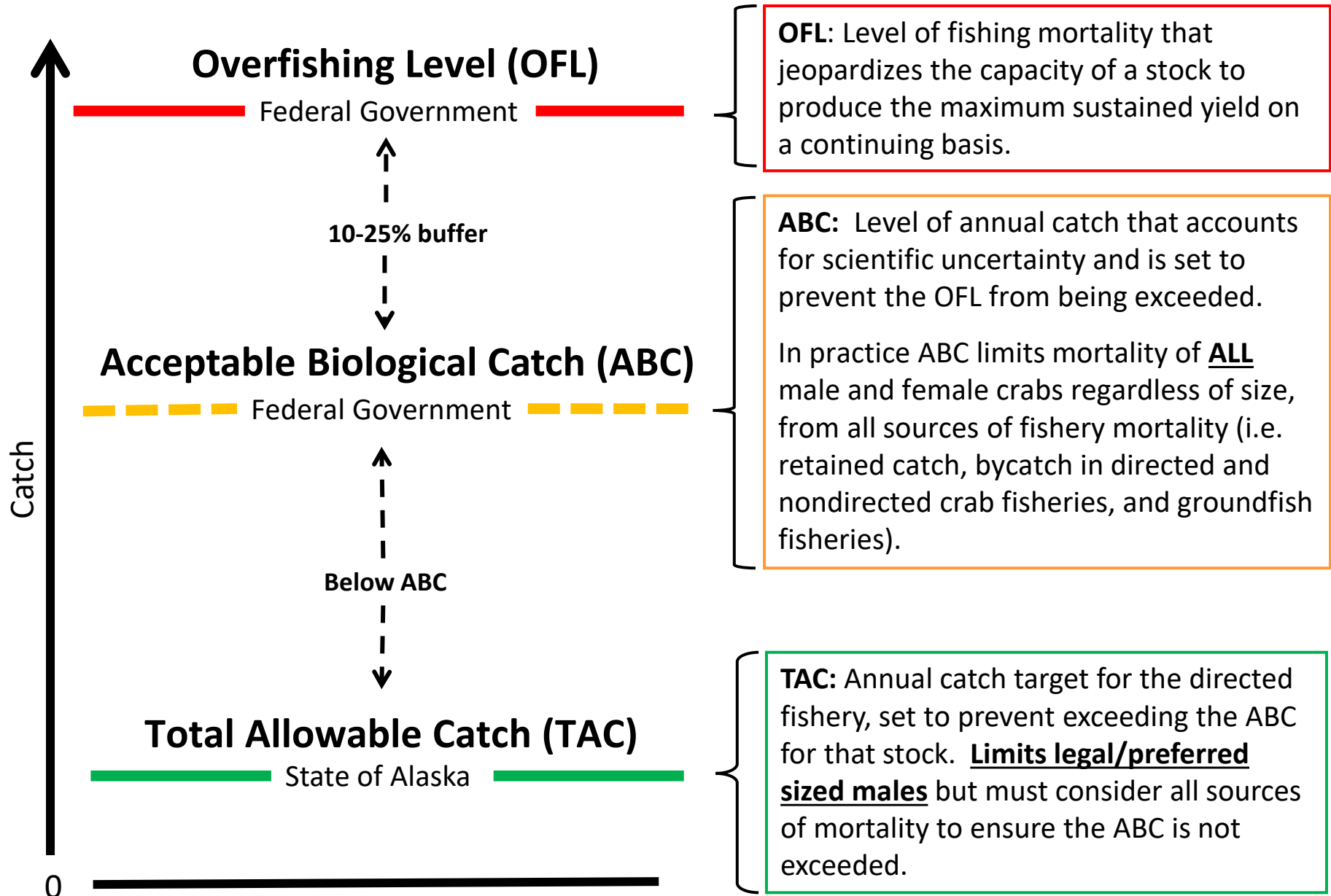
- NOAA EBS bottom trawl survey

August

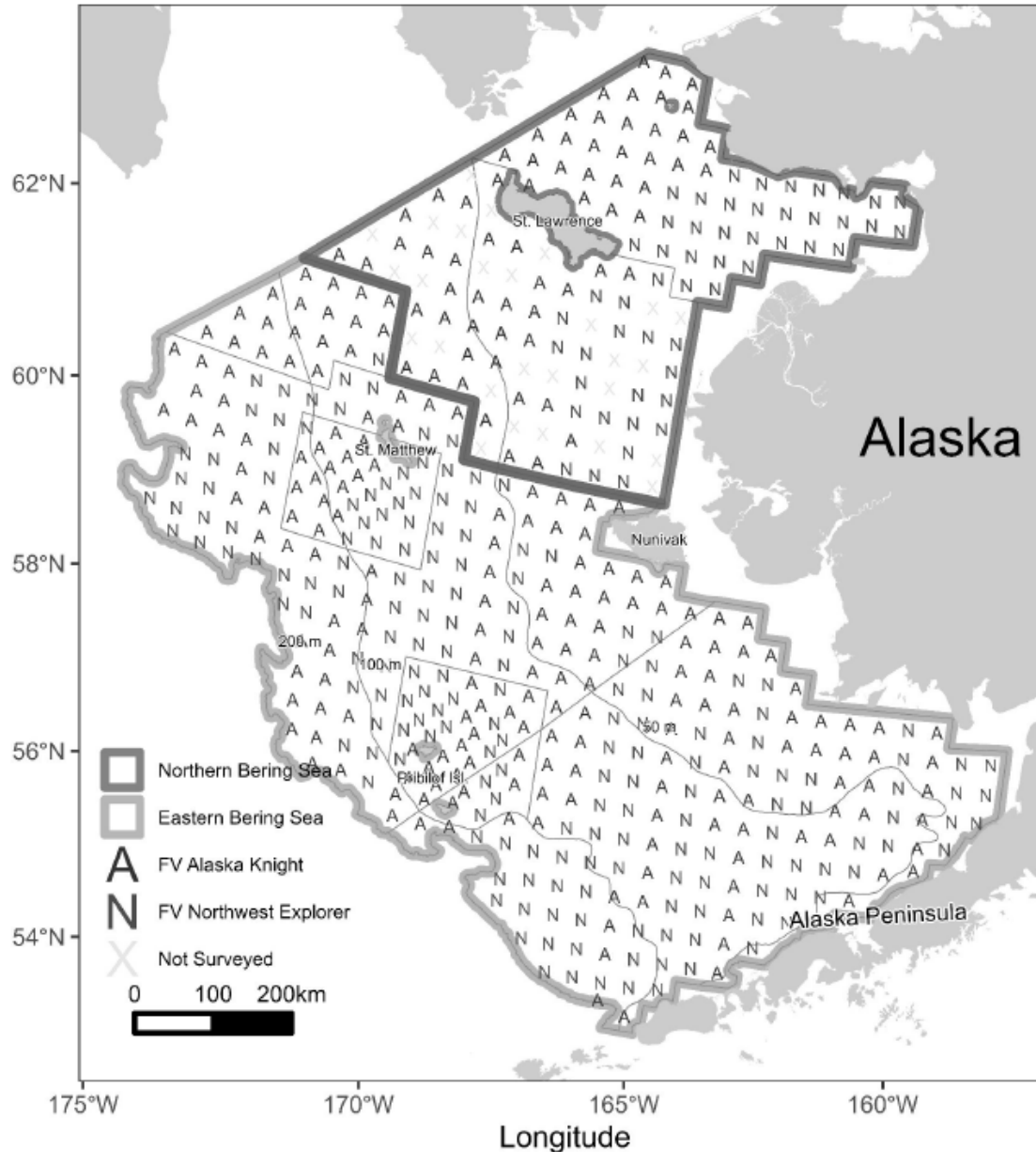
- Survey data summarized for assessment authors
- Preliminary survey results made public ~Sept 1.

September/October

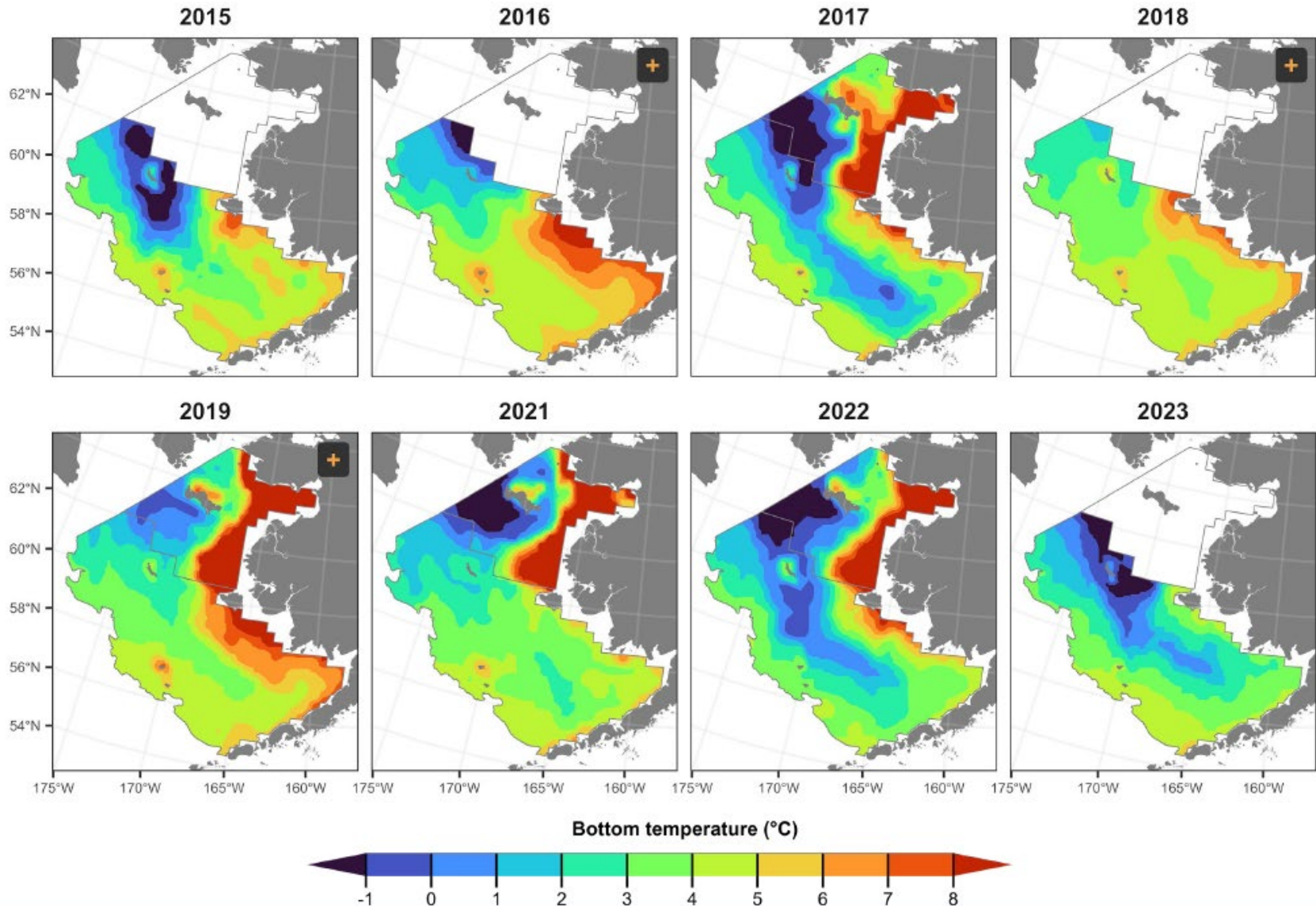
- CPT meets in September (Seattle) to recommend OFLs/ABCs
- NPFMC Scientific and Statistical Committee (SSC) reviews CPT recommendations early October – Council adopts OFLs/ABCs
- ADF&G reviews all survey, assessment, fishery, environmental information and sets TACs after Council adopts OFLs/ABCs
- Seasons open October 15



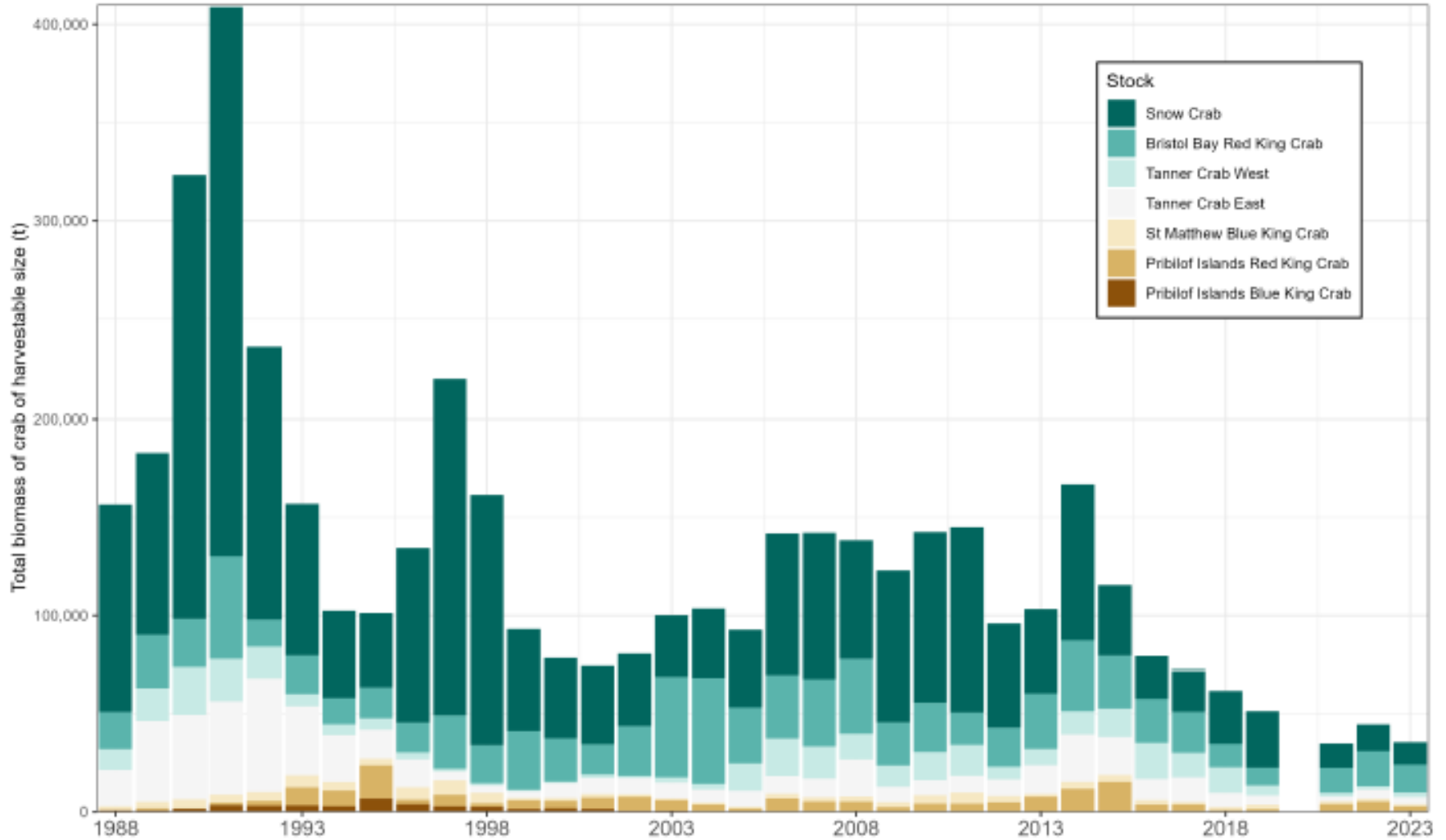
NOAA EBS + NBS bottom trawl surveys



2023 EBS trawl survey bottom temperature



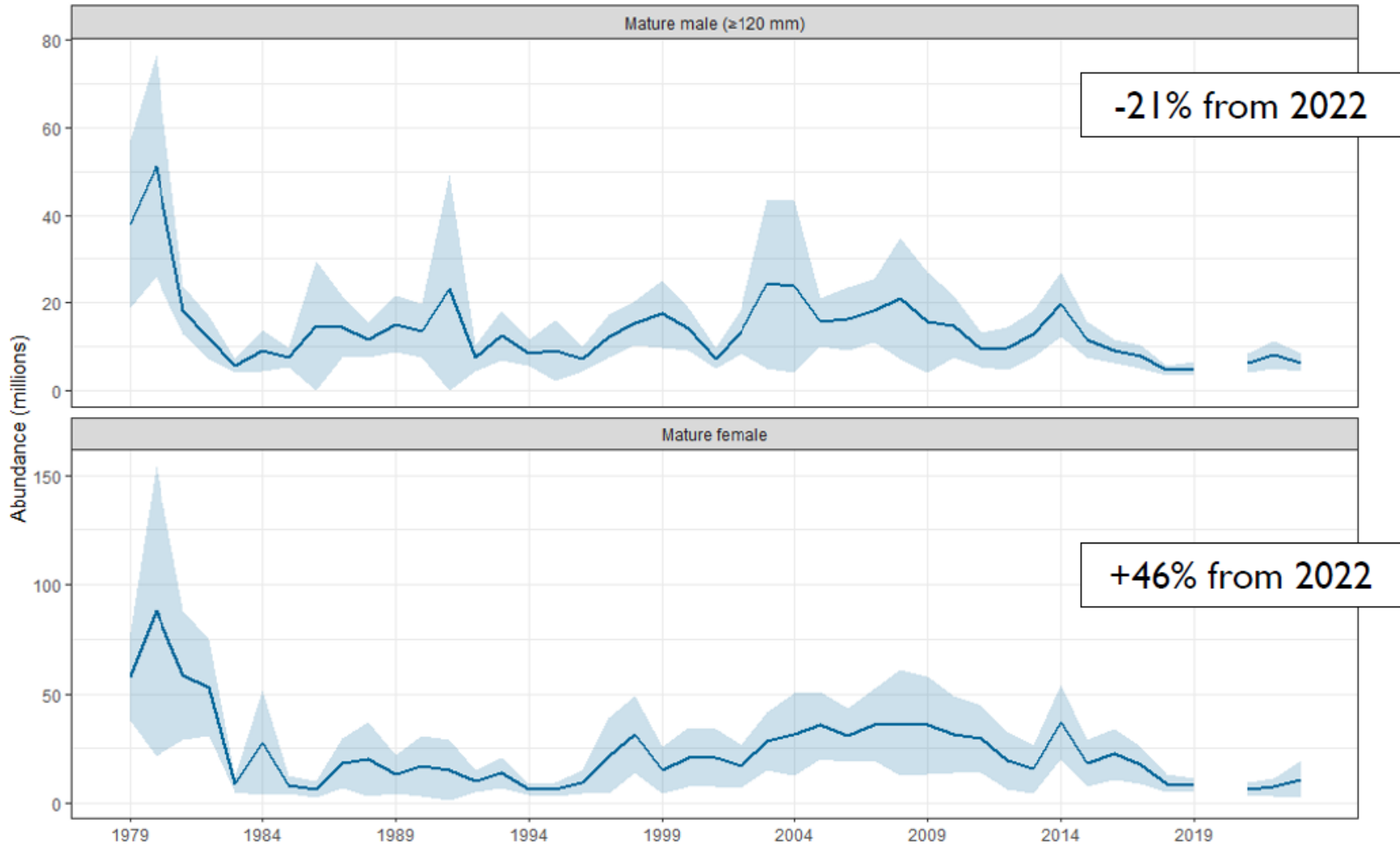
EBS trawl survey crab results



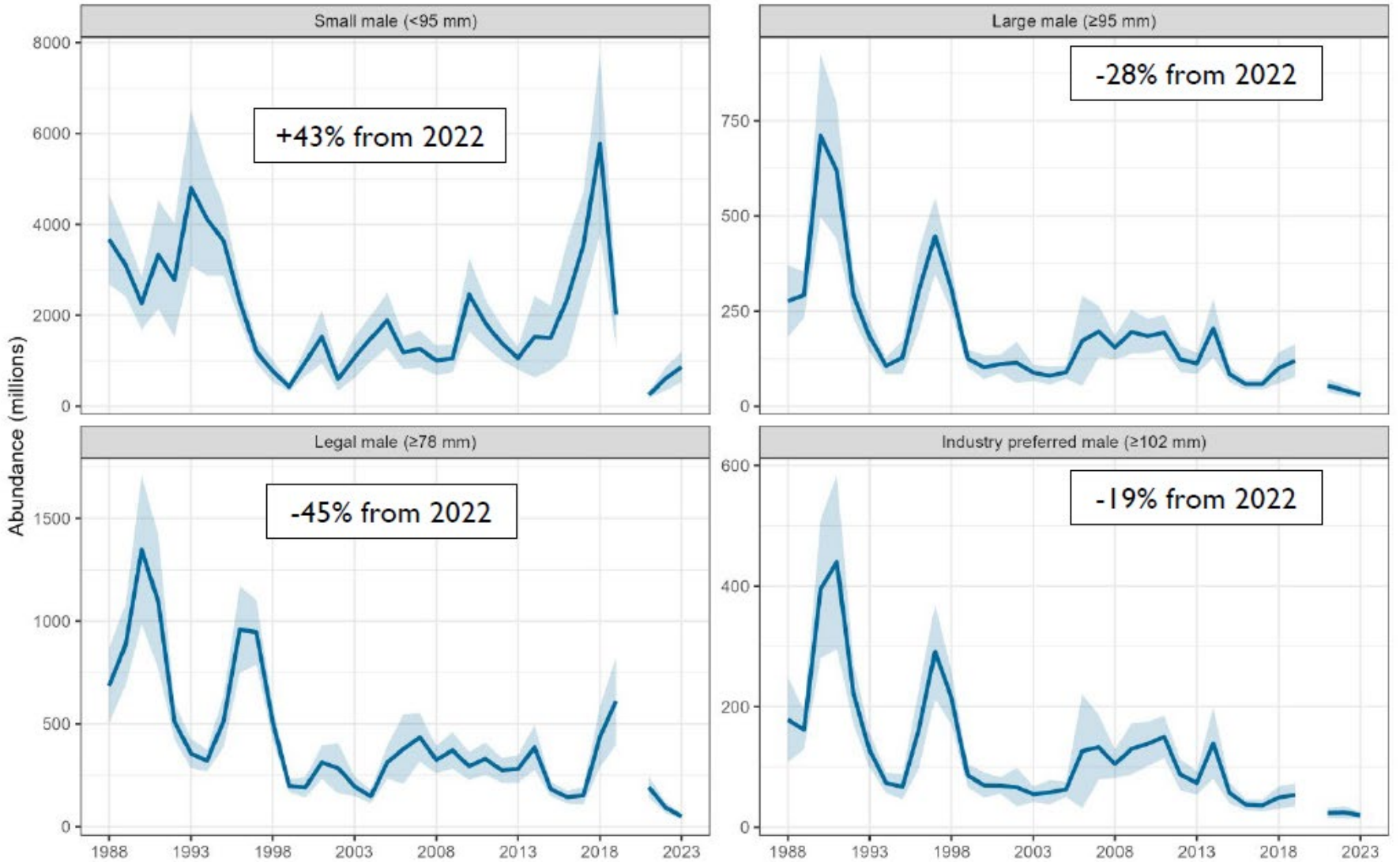
Take Aways - 2023 EBS trawl survey

- BBRKC: Mature crab abundance was mixed: **females higher** while **males lower** = **small fishery**
- Snow crab: Mature female and preferred male abundance at **all-time low abundance** = **fishery closed**
- Tanner crab: East/west combined generally **neutral** but large abundance increase for **small males in Tanner west area** = **status quo fishery**

Bristol Bay Red King Crab



Snow Crab



Snow Crab

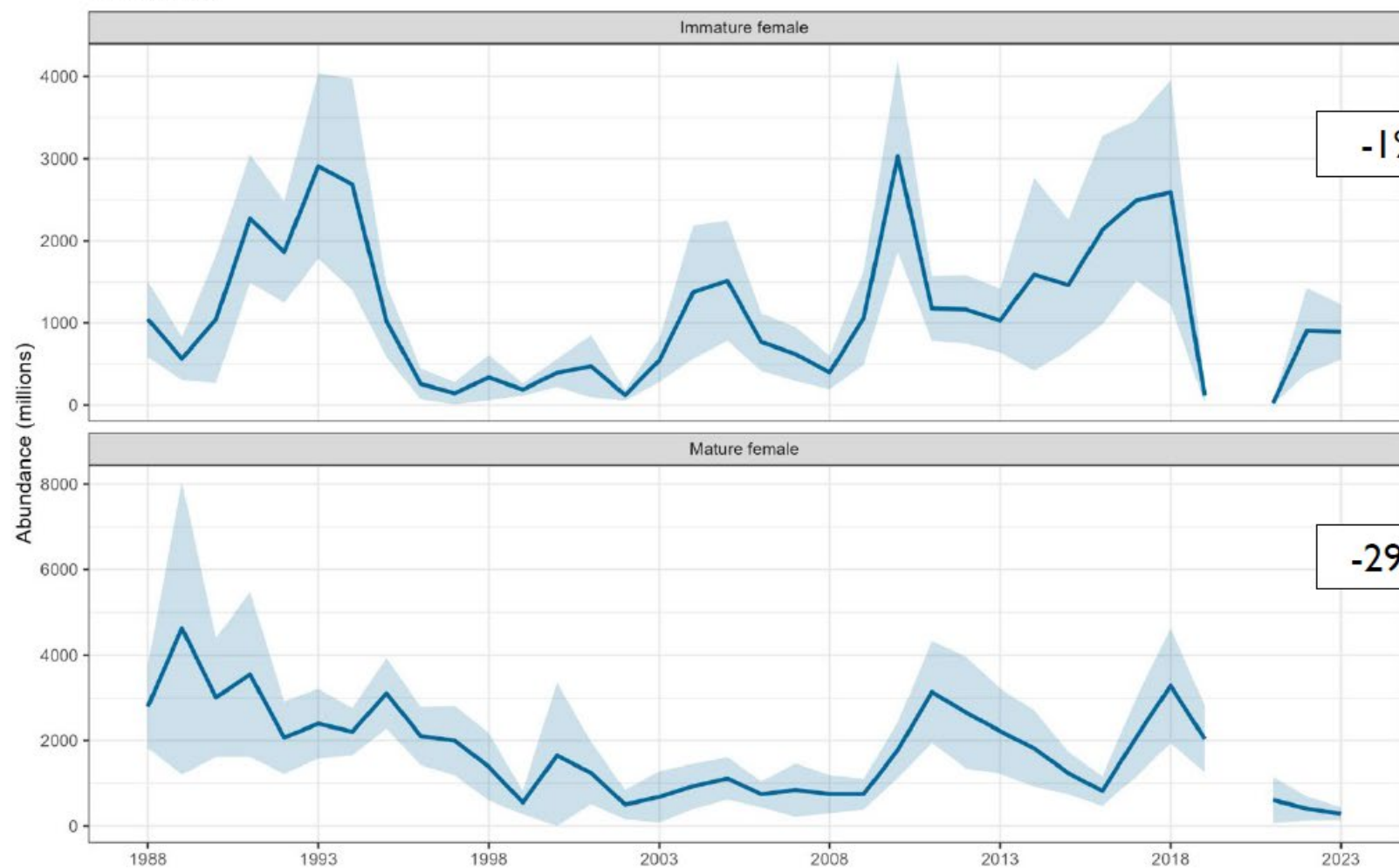
Immature female

-1% from 2022

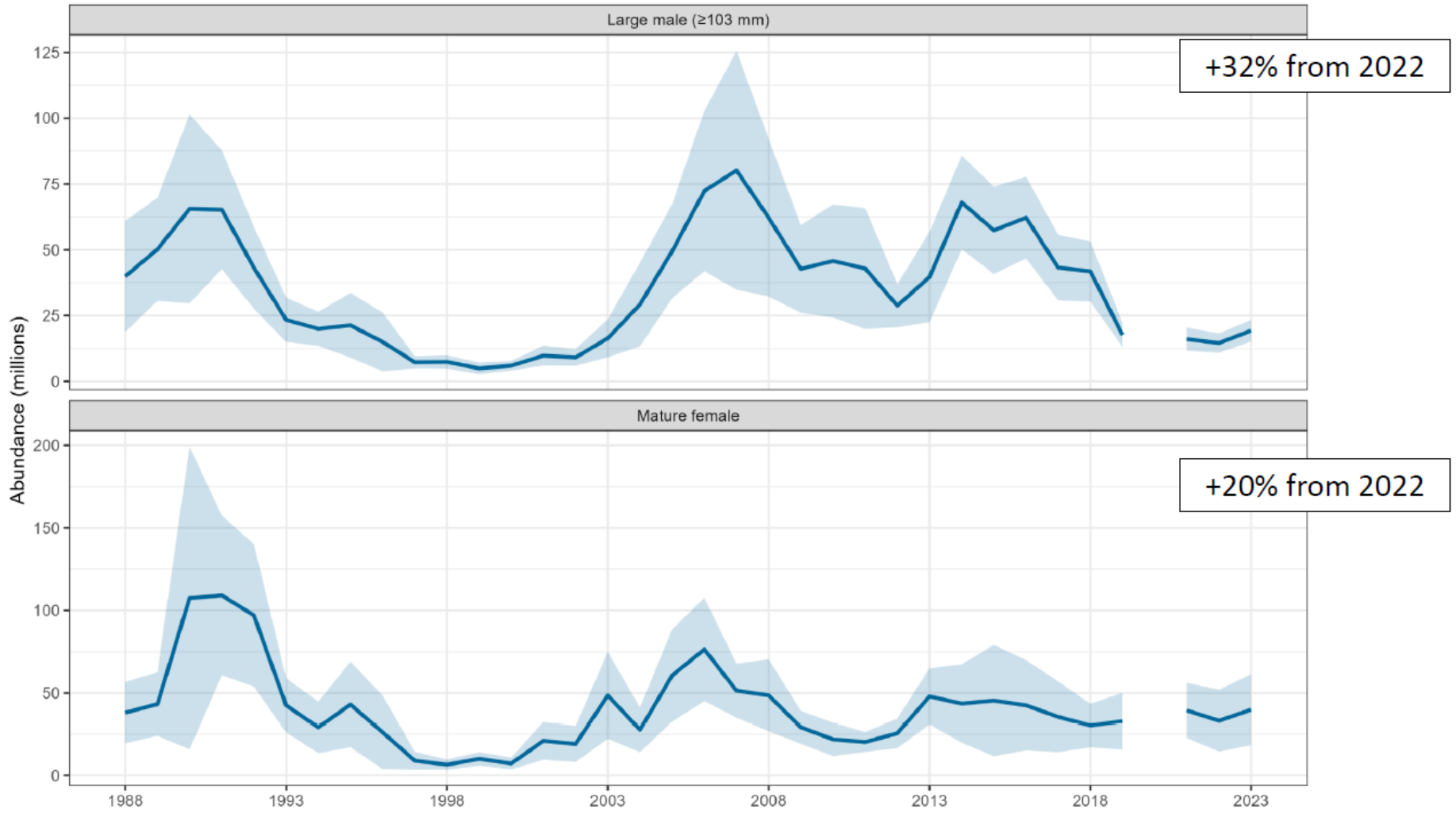
Mature female

-29% from 2022

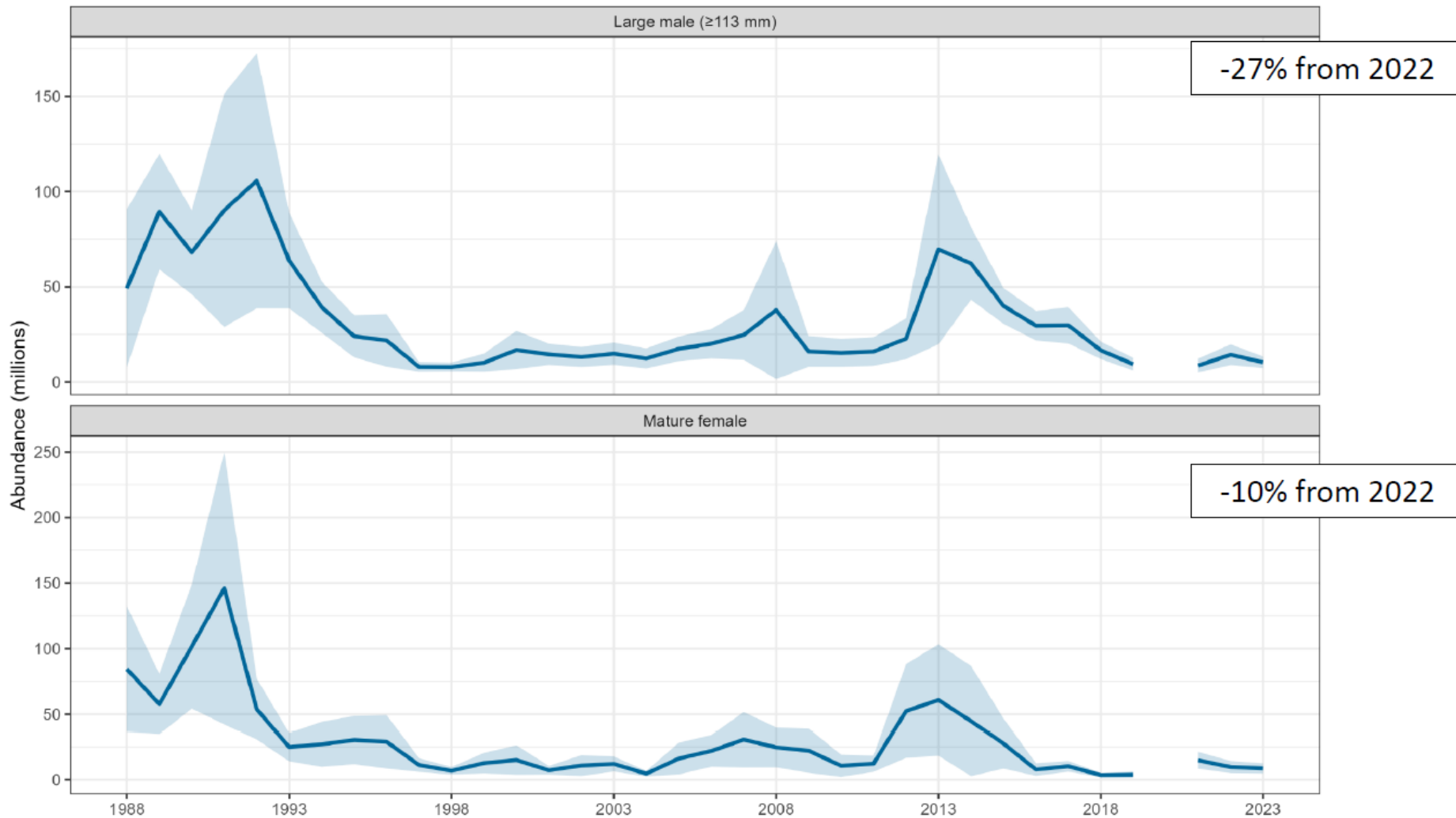
10



Tanner Crab West



Tanner Crab East



-27% from 2022

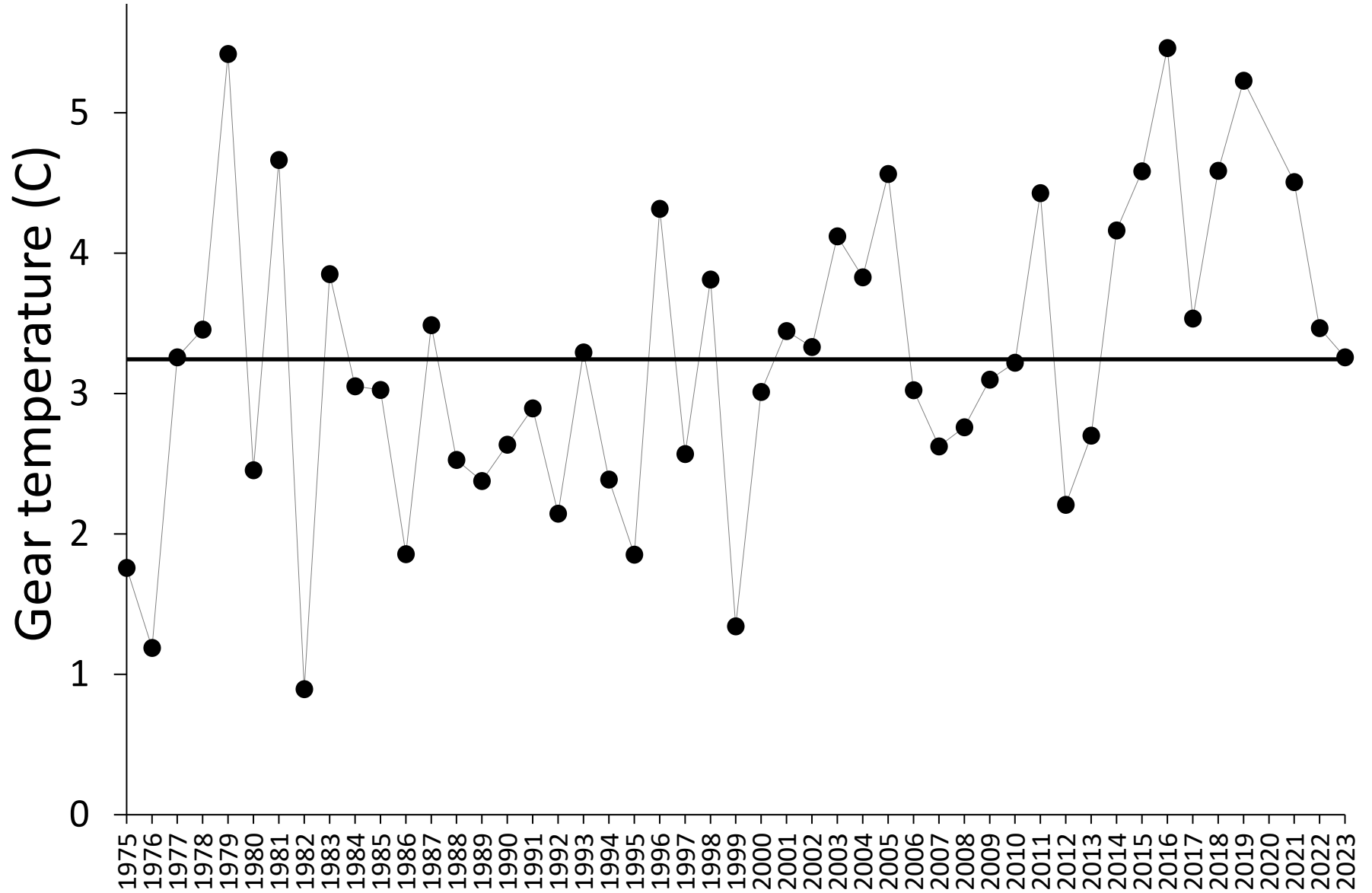
-10% from 2022

Bristol Bay Red King Crab

RKC life history

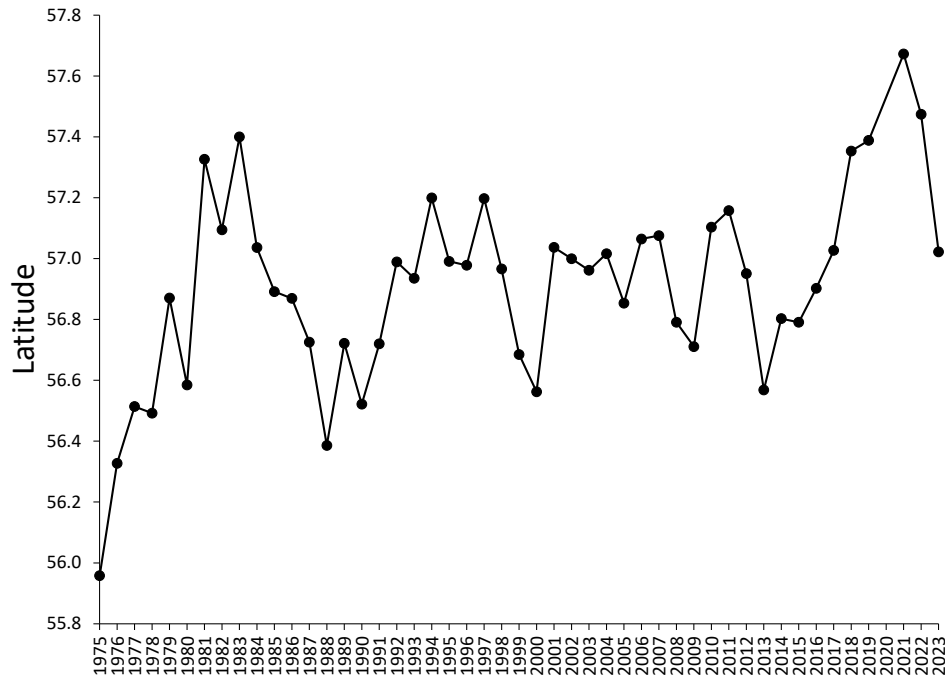
- Several months as pelagic (water column) larvae
 - Larvae: food availability (spring bloom timing), predation, larval advection, thermal tolerance, OA, ...
- Juveniles - Require specific nursery habitat (first 2 years)
 - Juveniles: habitat availability, predation, thermal tolerance, disturbance/fishing mortality, OA,
- Mature at ~5-12 years, may live >20 years
 - No terminal molt
- Must mate to produce clutch (no sperm reserves)
- Podding behavior
 - Patchy distribution – bycatch and survey precision considerations

Bristol Bay Trawl Survey Bottom Temp

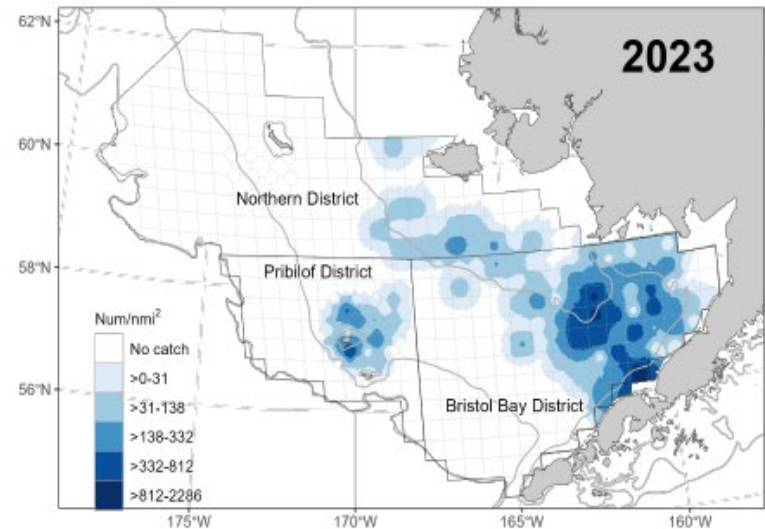
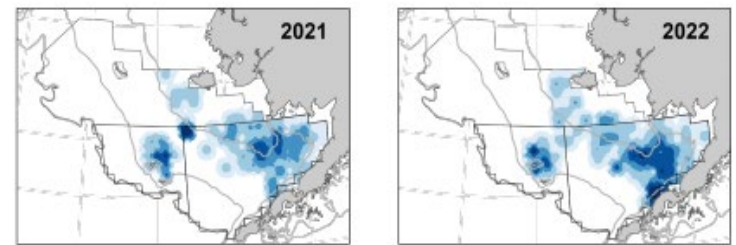
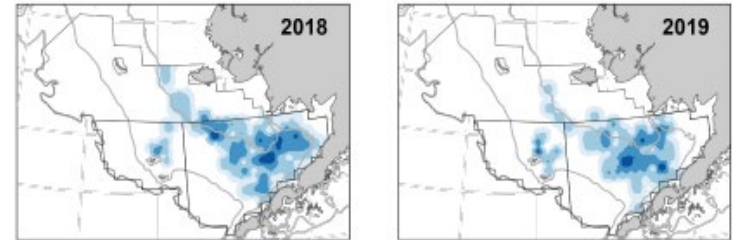


BBRKC Distribution

Weighted center of distribution



Red King Crab Legal Male



2023 NOAA-AFSC EBS Trawl Survey Tech Memo

2023 Assessment: Scenario 22.03a

- SSC + Council adopted CPT recommendations
- Stock status:
 - Current: 95% of B_{MSY}
 - Projected: 77% of B_{MSY}
- OFL: 9.75 million pounds
- ABC: 7.80 million pounds
 - Total fishery mortality across all fisheries
 - Based on a 20% buffer on OFL

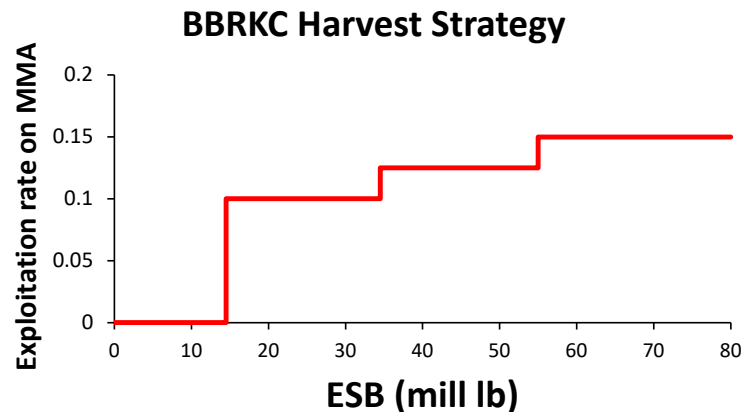
BBRKC State Harvest Strategy

1. Stock thresholds for opening fishery:

- Mature-sized females (≥ 90 mm CL), and
- Effective spawning biomass (ESB)

2. Exploitation rate on mature-sized (≥ 120 -mm CL) male abundance:

- 10%, when ESB < 34.75 -million pounds
- 12.5%, when ESB is between 34.75-mill lb and 55.0-million pounds
- 15%, when ESB ≥ 55.0 -million pounds



3. Harvest capped at 50% of legal male abundance

Thresholds for Opening the Fishery

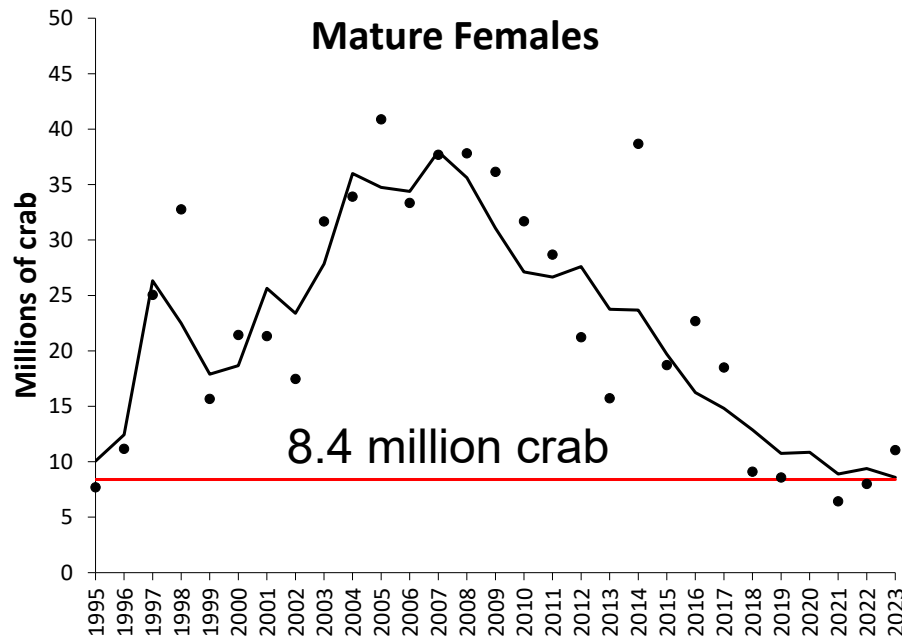
8.4-million mature females

+

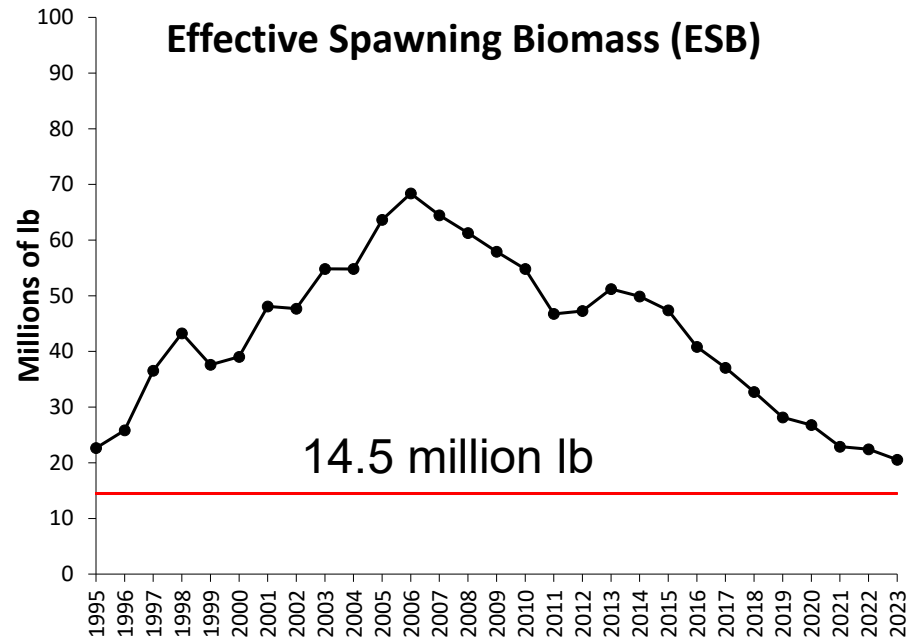
14.5 million pounds
effective spawning biomass, ESB

Both threshold values are specified in state regulation

Harvest Strategy Closure Thresholds



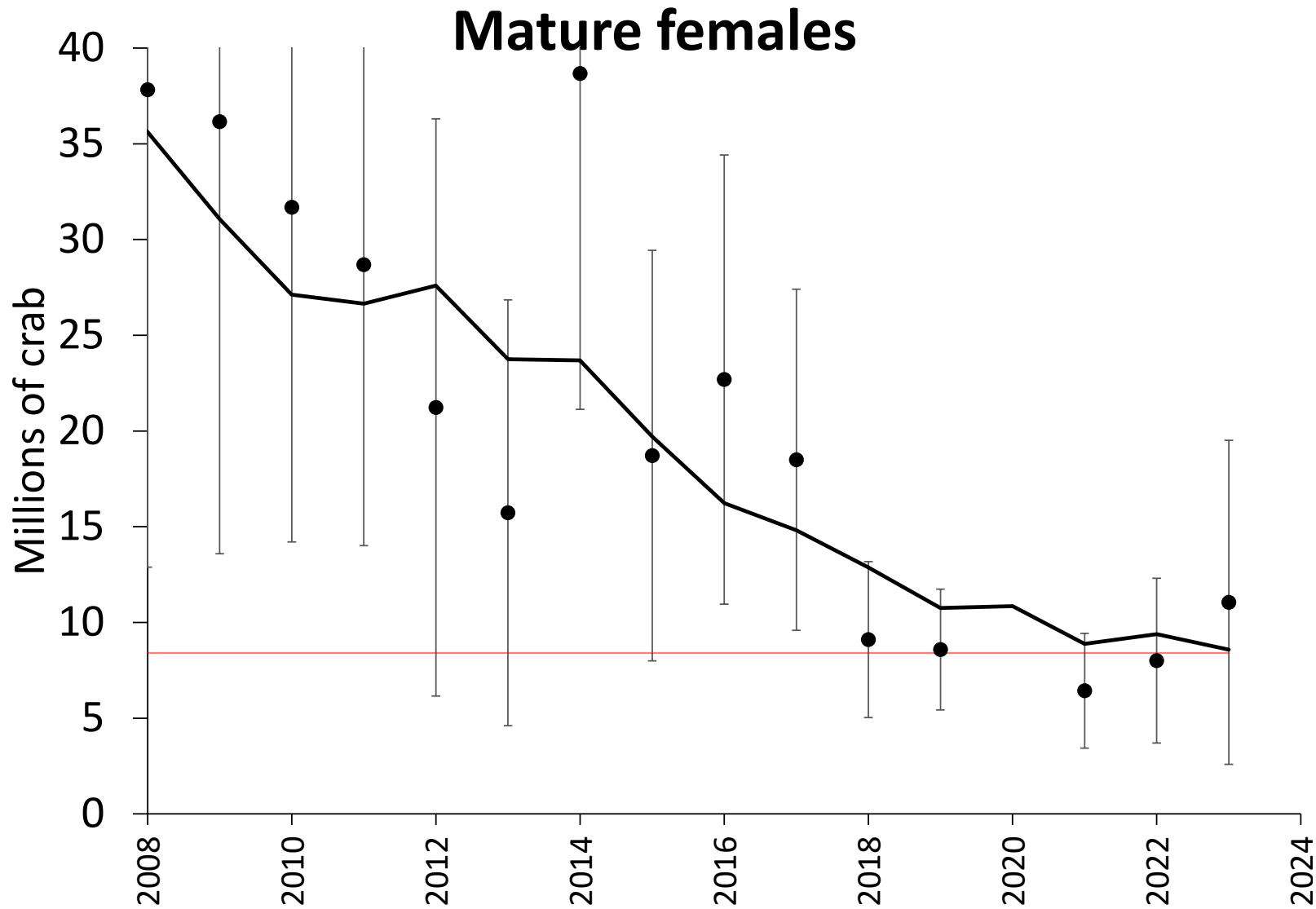
2023 model: **8.59** million
2023 area-swept: 11.05 million



2023 model: **20.55** million pounds

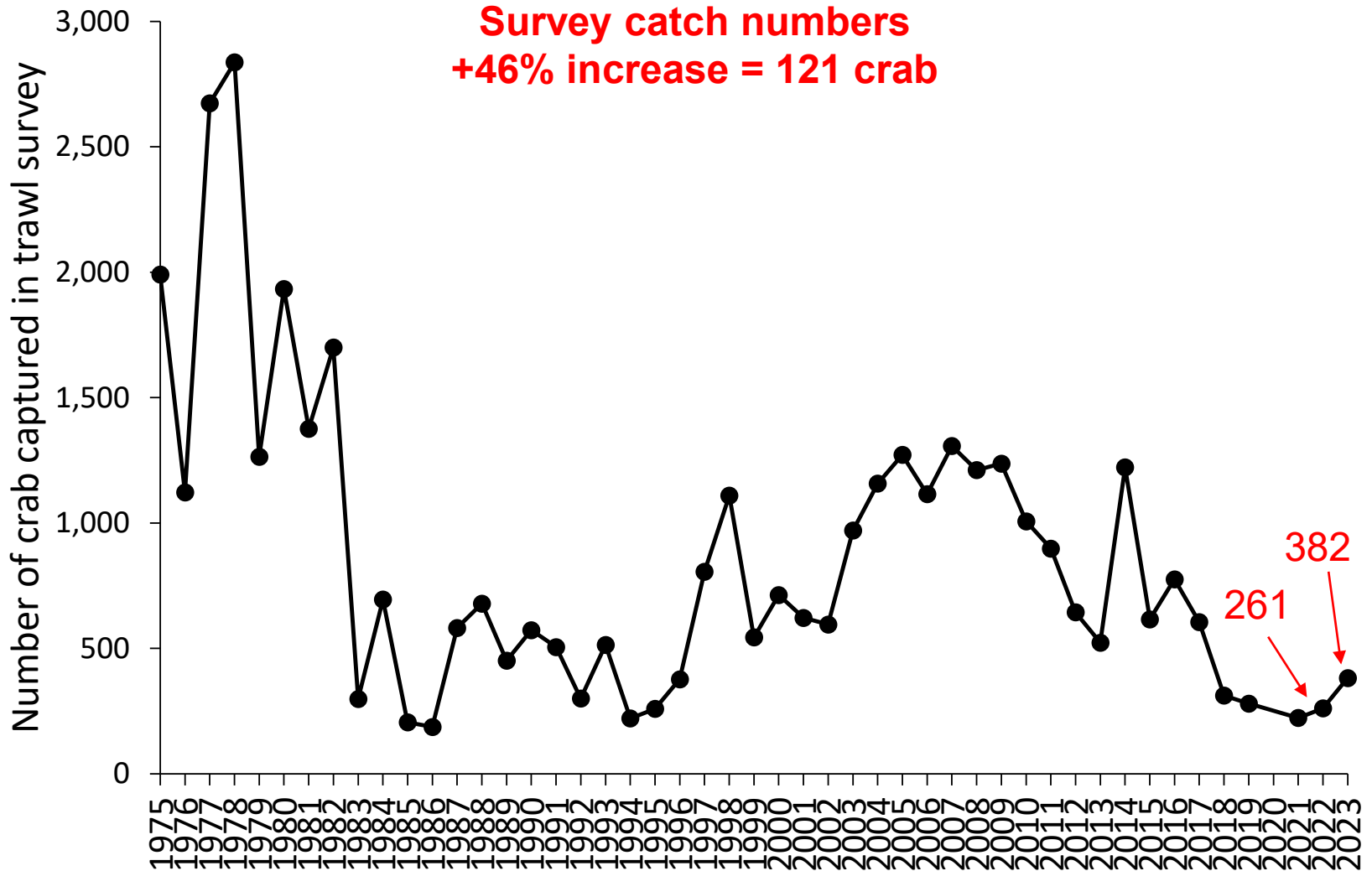
2023 estimates above BOTH thresholds

Survey area-swept + model estimates

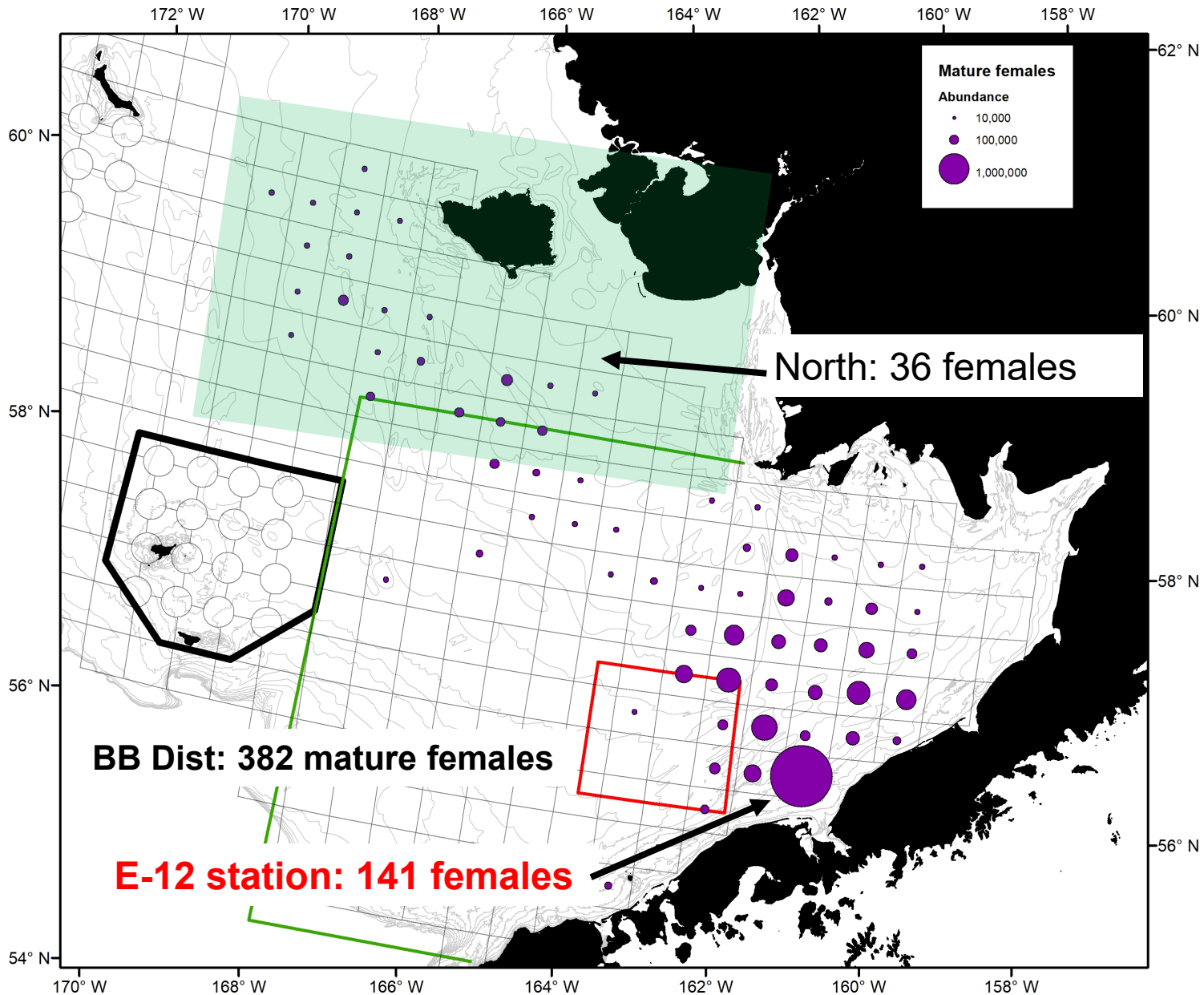


Magnitude of area-swept expansions

BBRKC mature females (>90mm)

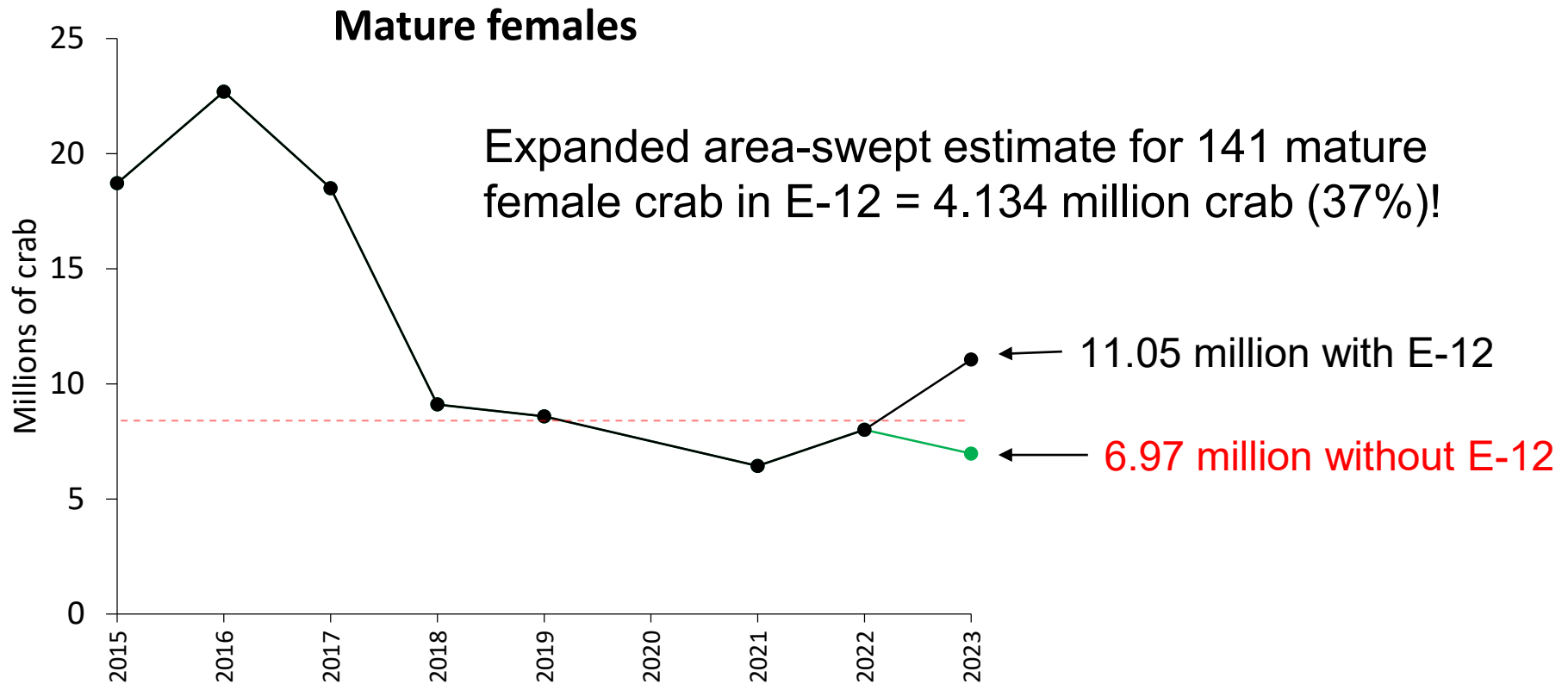


2023 NOAA EBS Survey



Impact of Station E-12

Survey expanded area-swept



Impact of Station E-12

E-12 hotspot

- Not considered biological anomaly
 - Expect to see mature females in Bristol Bay central and nearshore areas during summer
 - Generally believed to molt/mate in nearshore areas
 - Recent CPS1 satellite tagging data shows seasonal movement to these areas
- Hotspots are common in historical surveys and magnitude of single hotspots generally correspond to higher estimates of population abundance

BBRKC State Harvest Strategy

1. Stock threshold for opening fishery:

- 8.4-million mature-sized females (≥ 90 mm CL), and
- 14.5-million pounds of effective spawning biomass (ESB)



2. Exploitation rate on mature-sized (≥ 120 -mm CL) male abundance:

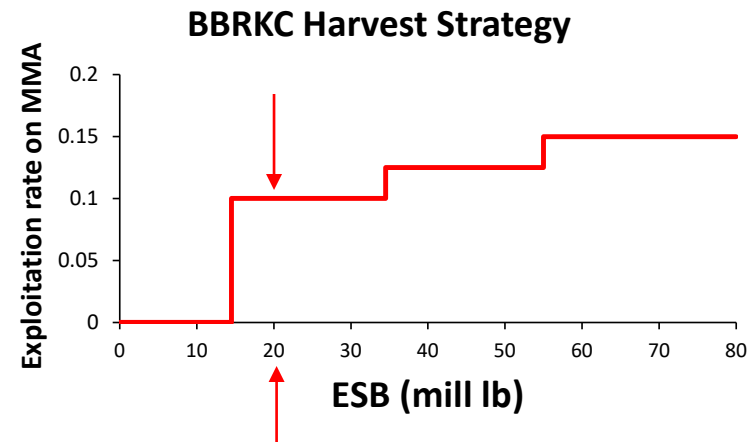
- 10%, when ESB < 34.75 -million pounds
- 12.5%, when ESB is between 34.75-million pounds and 55.0-million pounds
- 15%, when ESB ≥ 55.0 -million pounds

2023 ESB = 20.55 million pounds

Computation

- 2023 MMA = 6.619 million
- 0.1×6.619 million = 0.6619 million crabs
- 0.6619×6.51 lb (ave wt) =

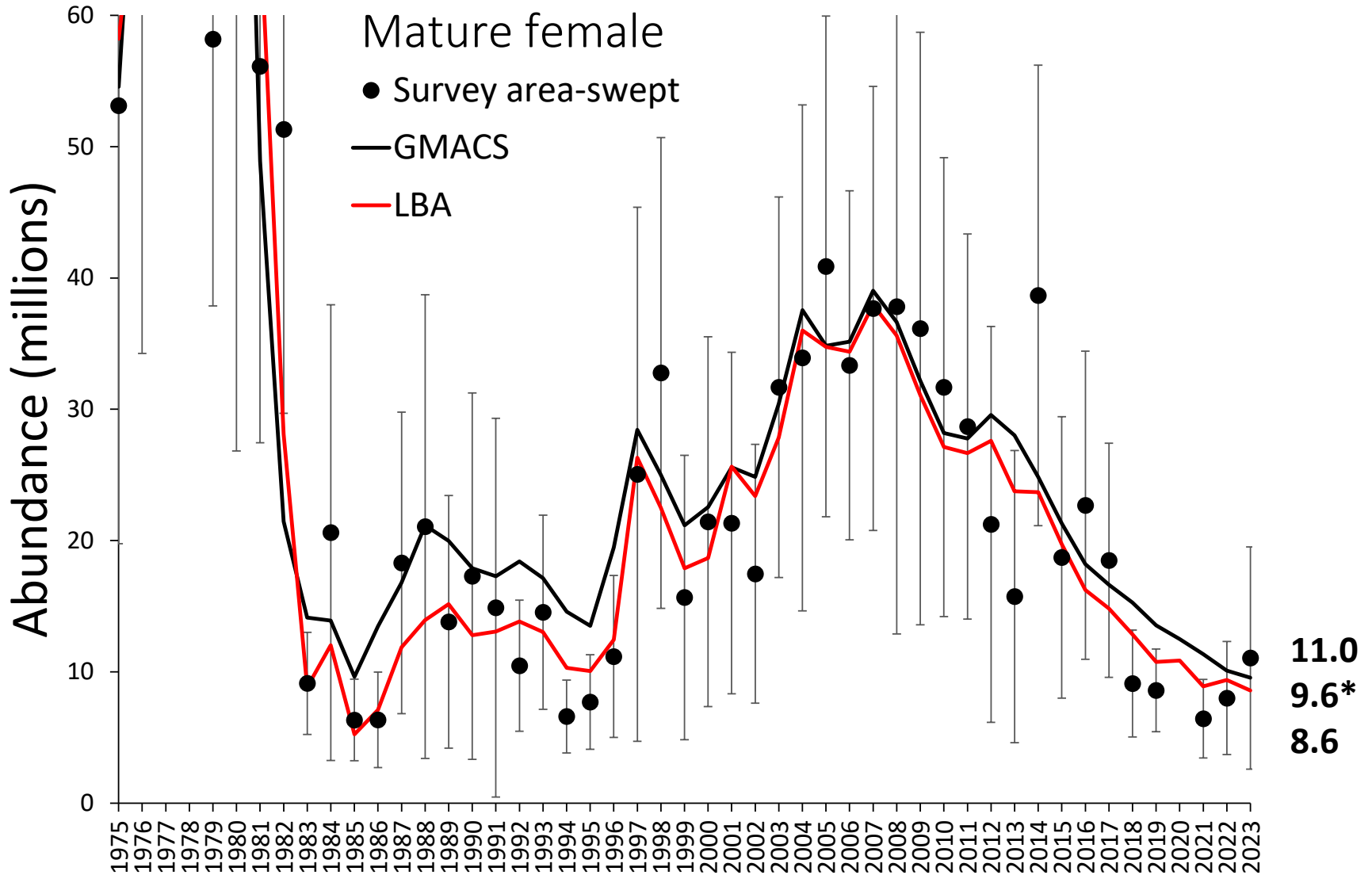
4.31-million-pound TAC



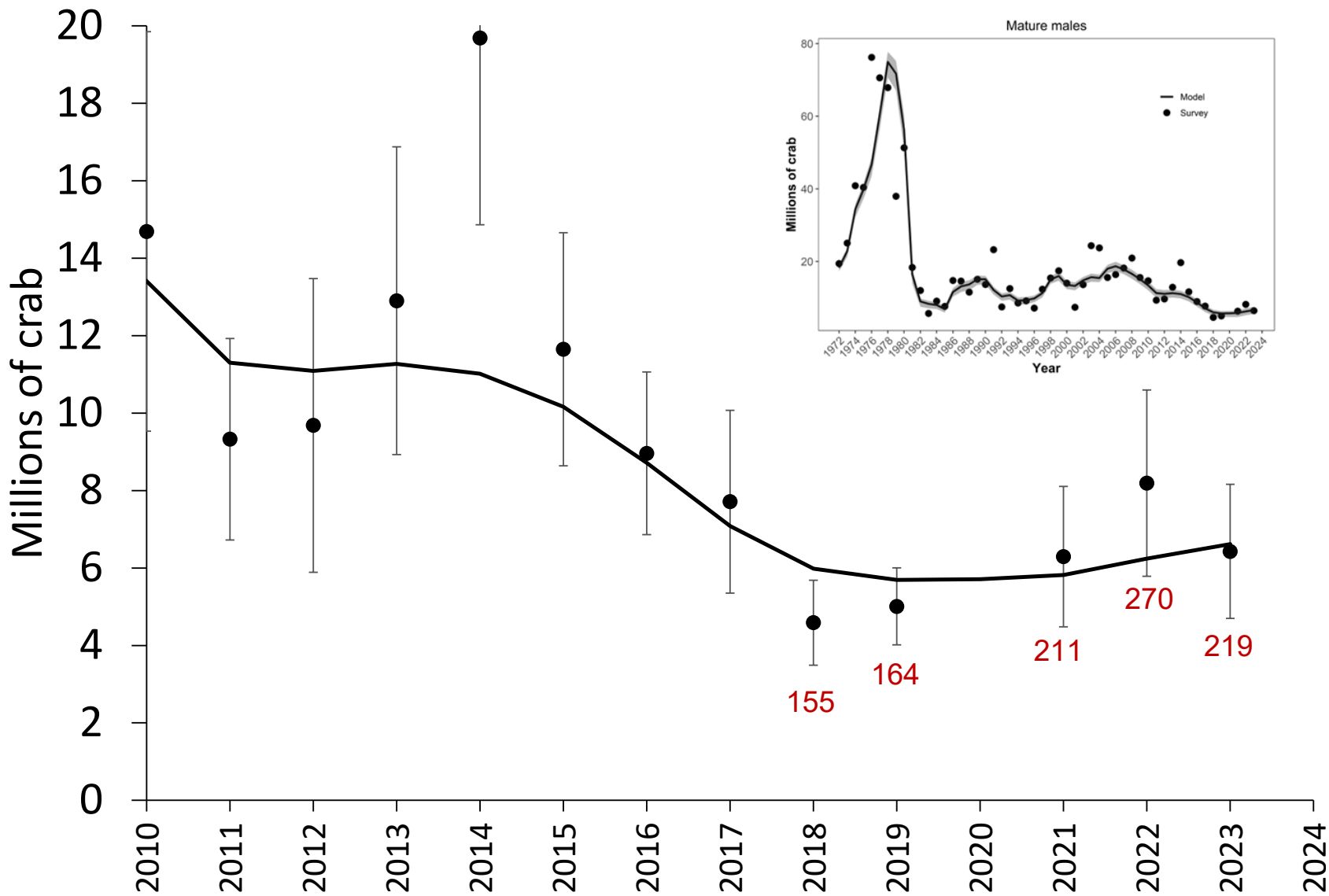
3. Harvest capped at 50% of legal male abundance

4.925 million $\times 0.5 = 2.46$ million crabs..... > 0.6619 million crabs

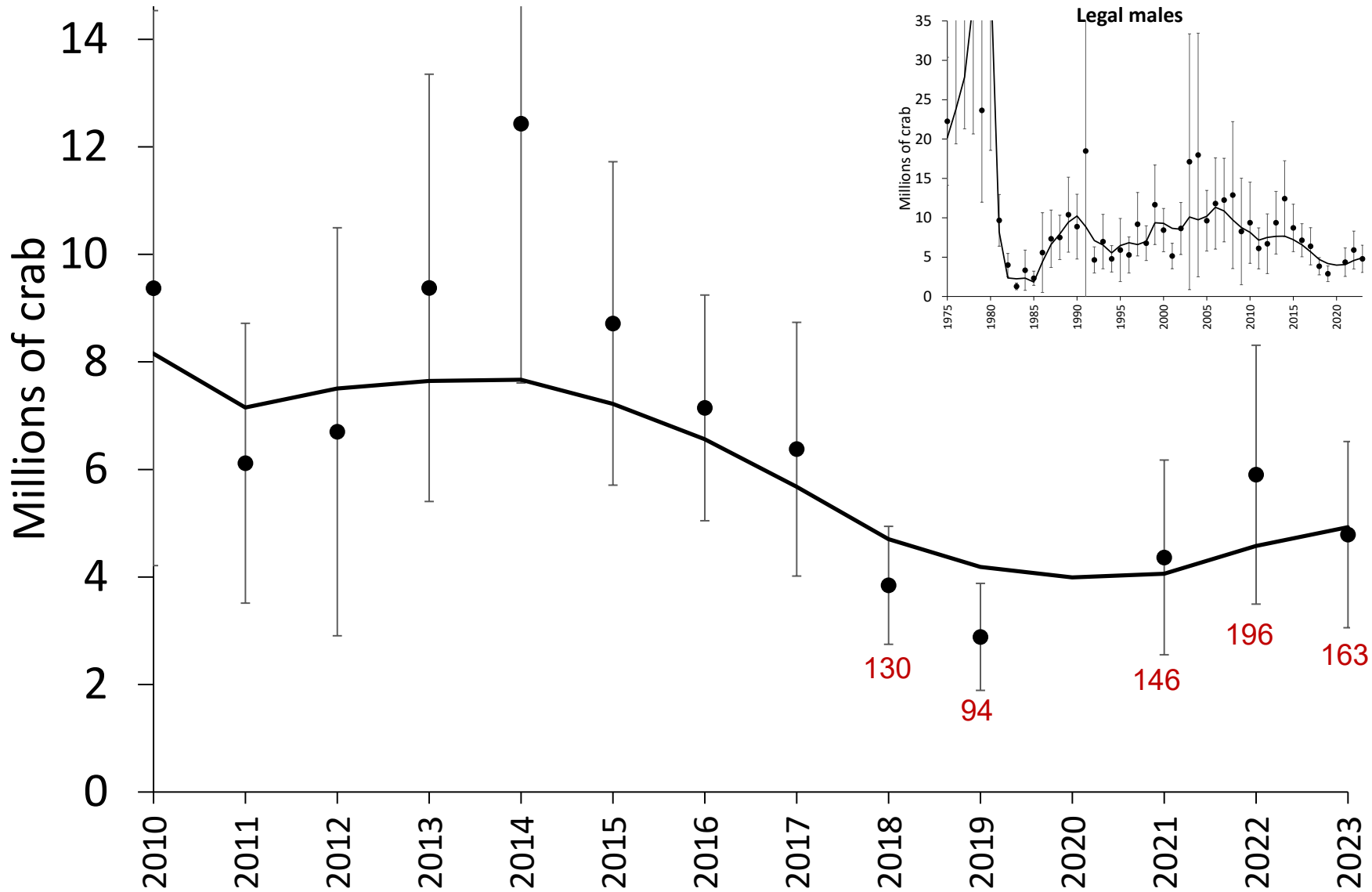
What data should we use?



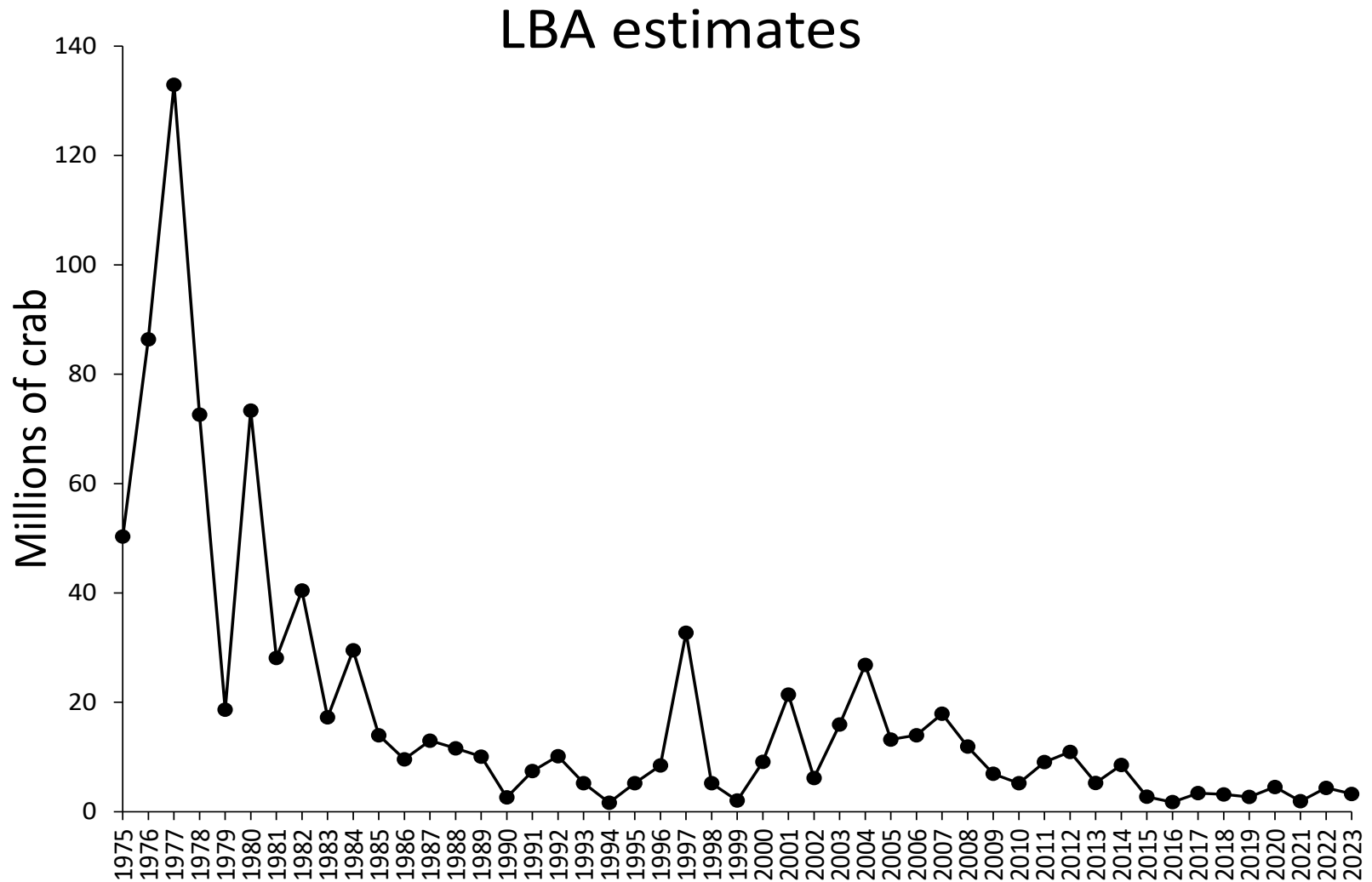
Mature Males



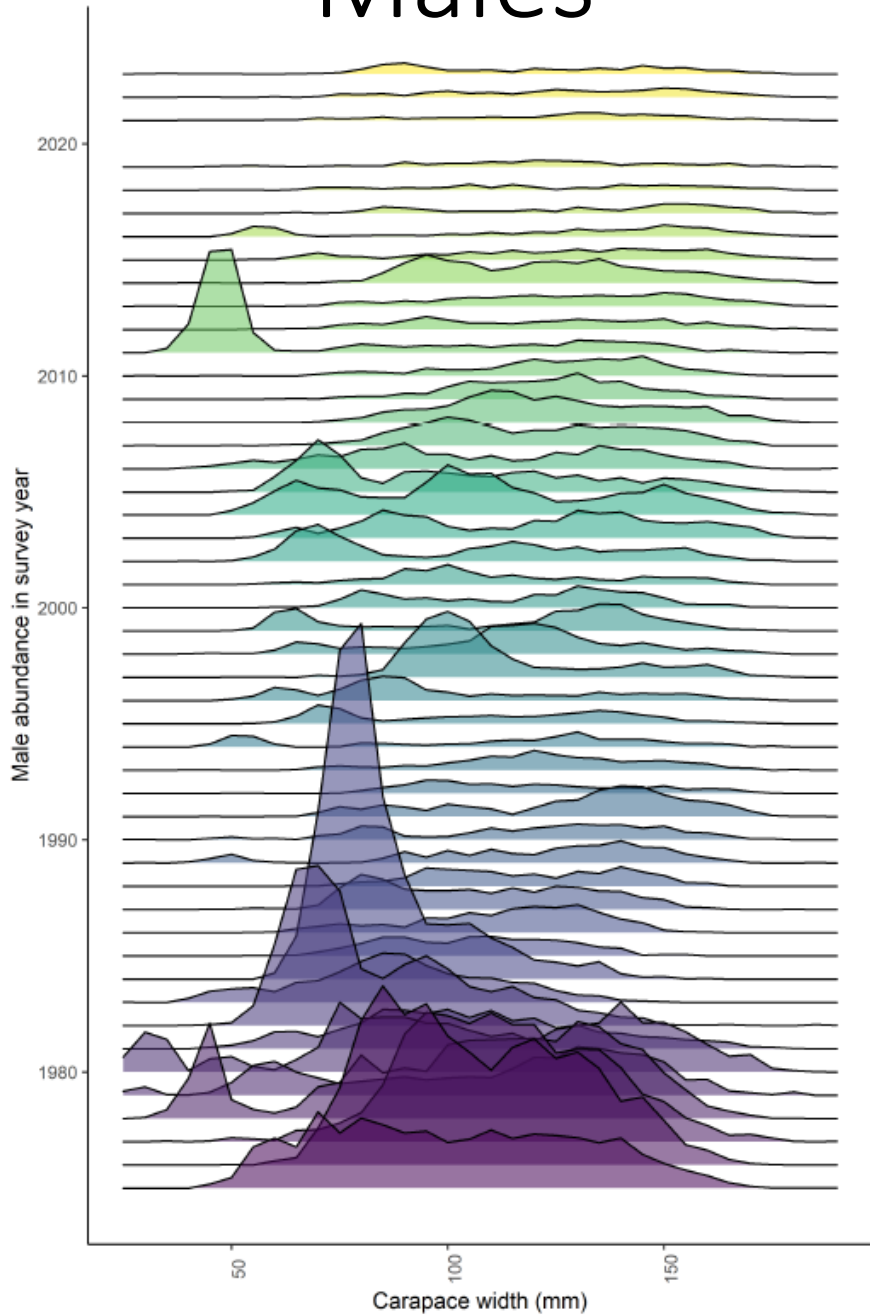
Legal Males



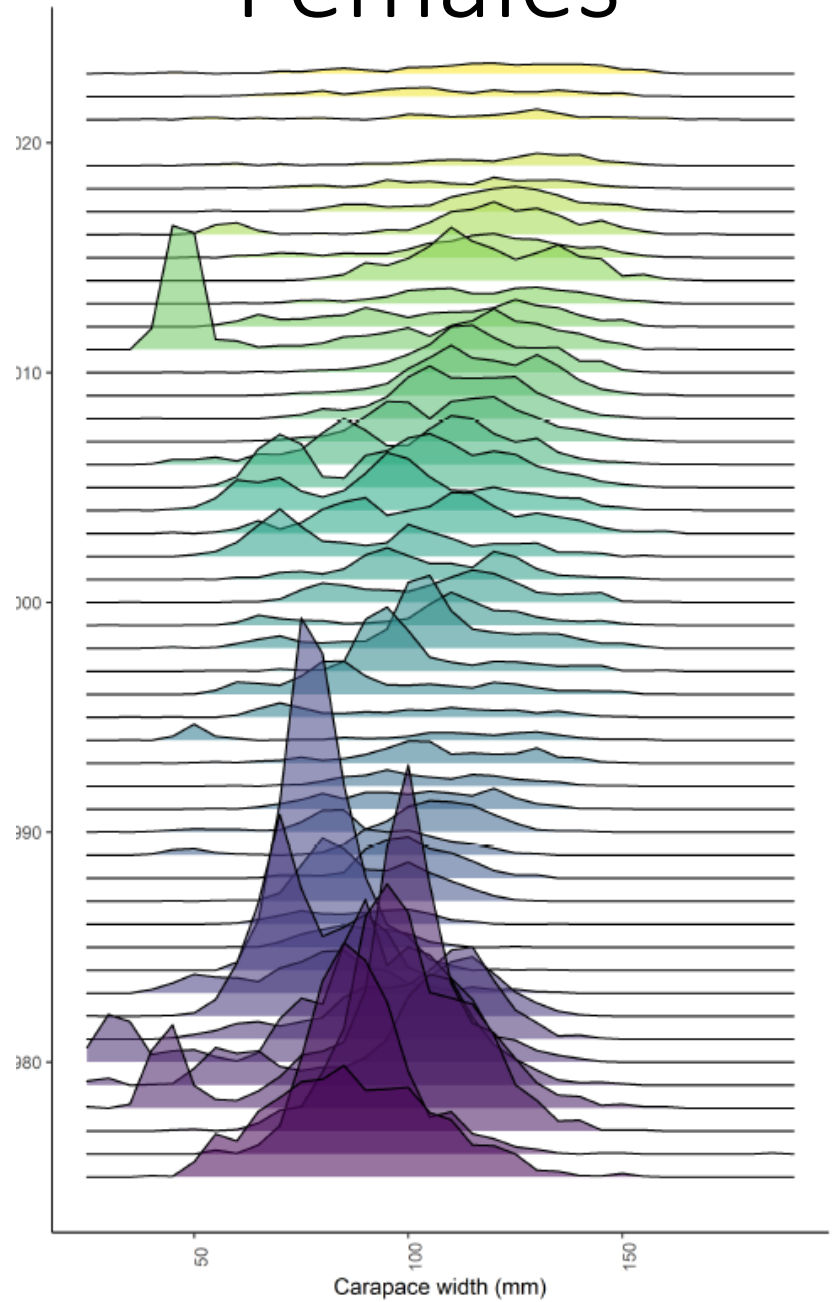
Low Recruitment



Males



Females



BBRKC Stock Condition

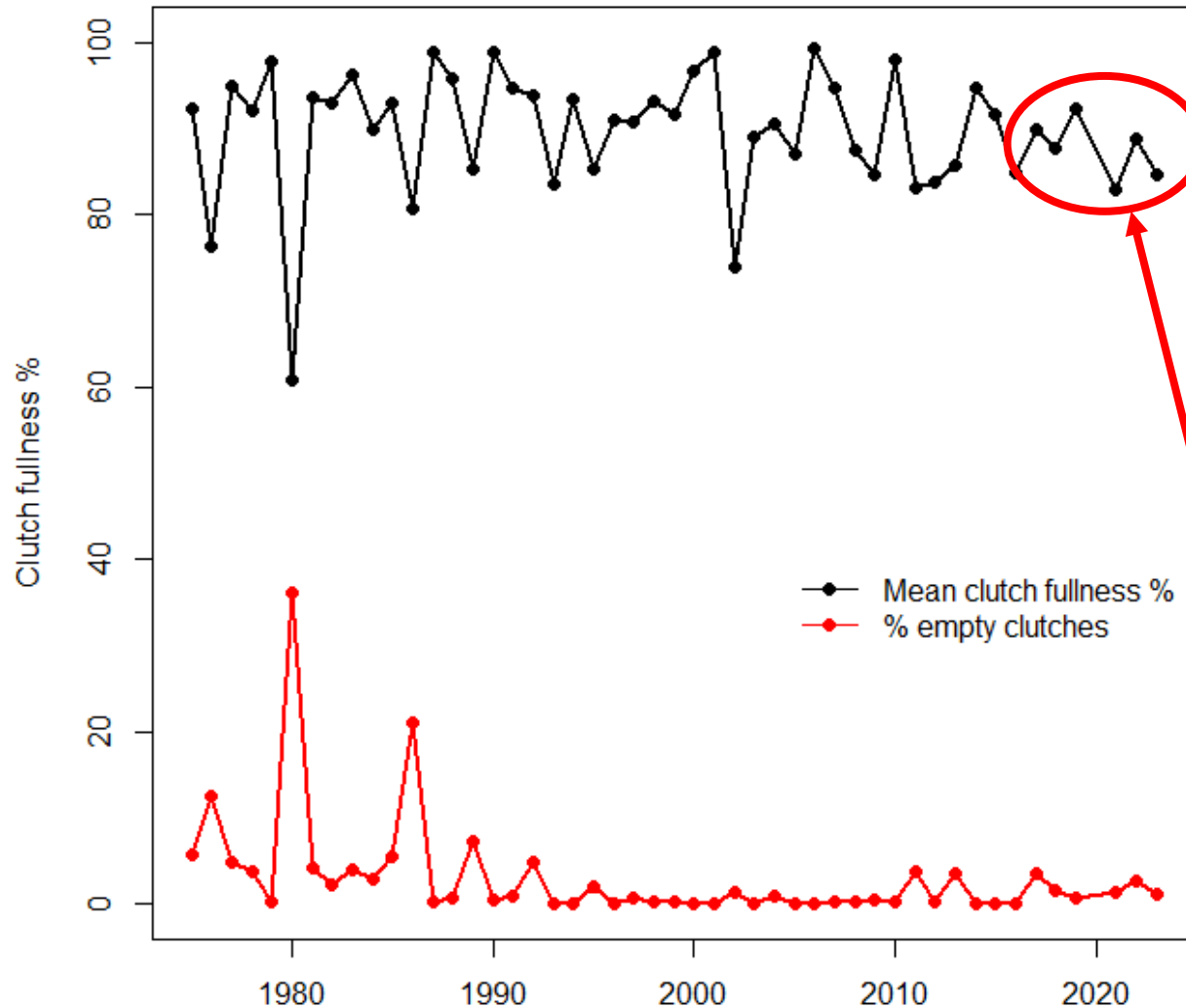
- Big picture, stock still at low density
 - Most 2023 abundance estimates – bottom 20%
- Females:
 - 2023 survey uncertainty (E-12)
 - Continued model decline
- Males:
 - 2 years of fishery closures
 - 2023 survey decrease/modest model increase
- Very low recruitment
- Uncertain future environmental conditions
- Appropriate harvest strategy advise?

Risks of fishery removals at low population levels

Depensation: lower than expected recruitment success at low population levels

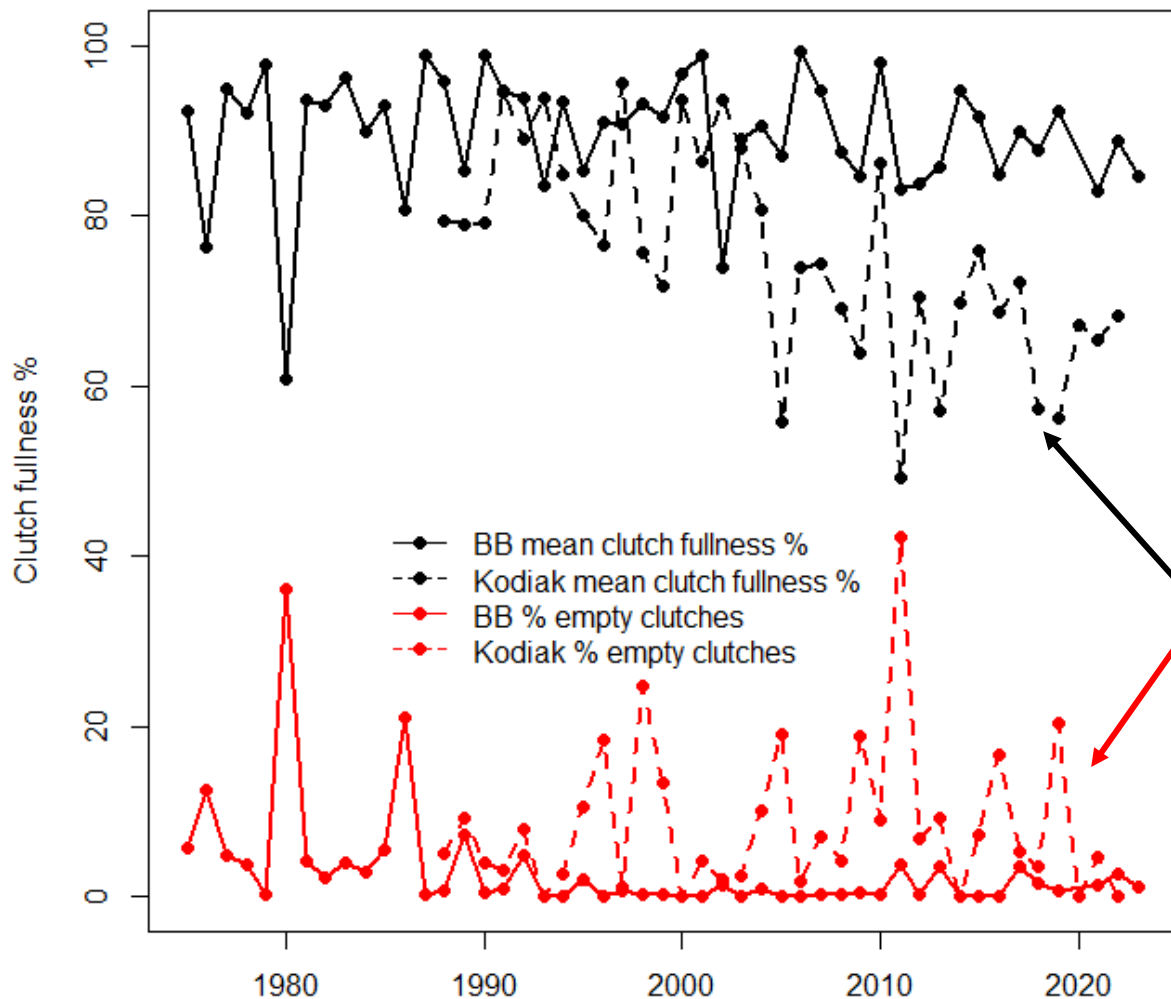
- Could occur if some females fail to find mates at low densities – low resiliency to stress
- **Danger:** at a certain point, stock may not recover even without fishing
 - natural mortality = recruitment → GOA RKC
- How might we detect reproductive failure?

Are we seeing signals of reproductive failure?



No obvious signs of reproductive failure via clutch fullness scores but lower than average fullness in recent years

Are we seeing signals of reproductive failure? (Kodiak RKC)



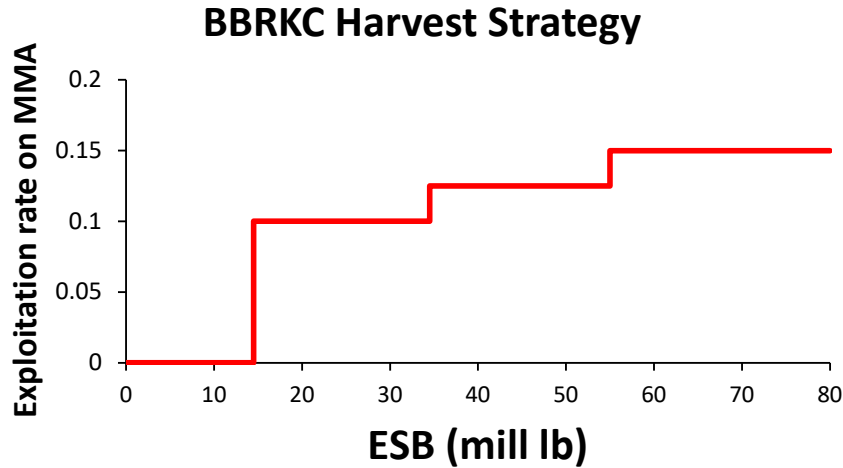
Kodiak RKC
severely depressed
(low density)

Might expect to see
depensation effects

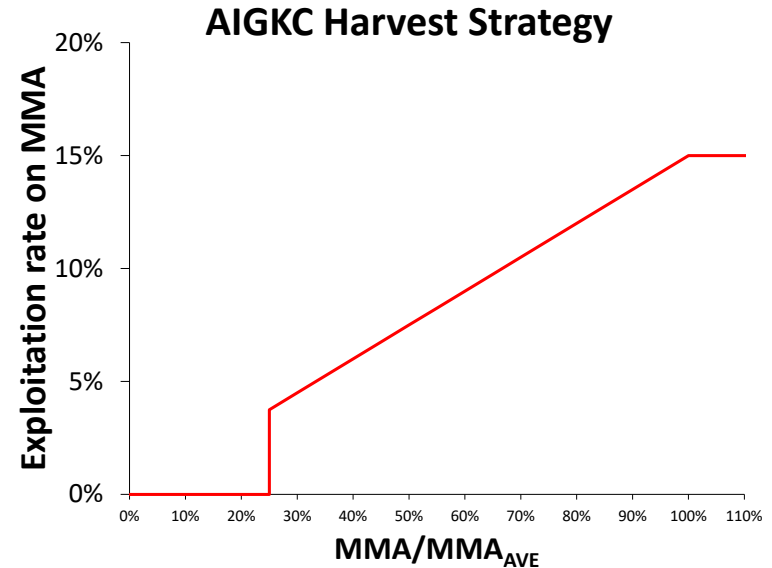
**Obvious lower
mean clutch
fullness and more
empty clutches**

Seems precaution is appropriate:
Comparison to other BSAI
king crab harvest strategies

Harvest strategy comparisons

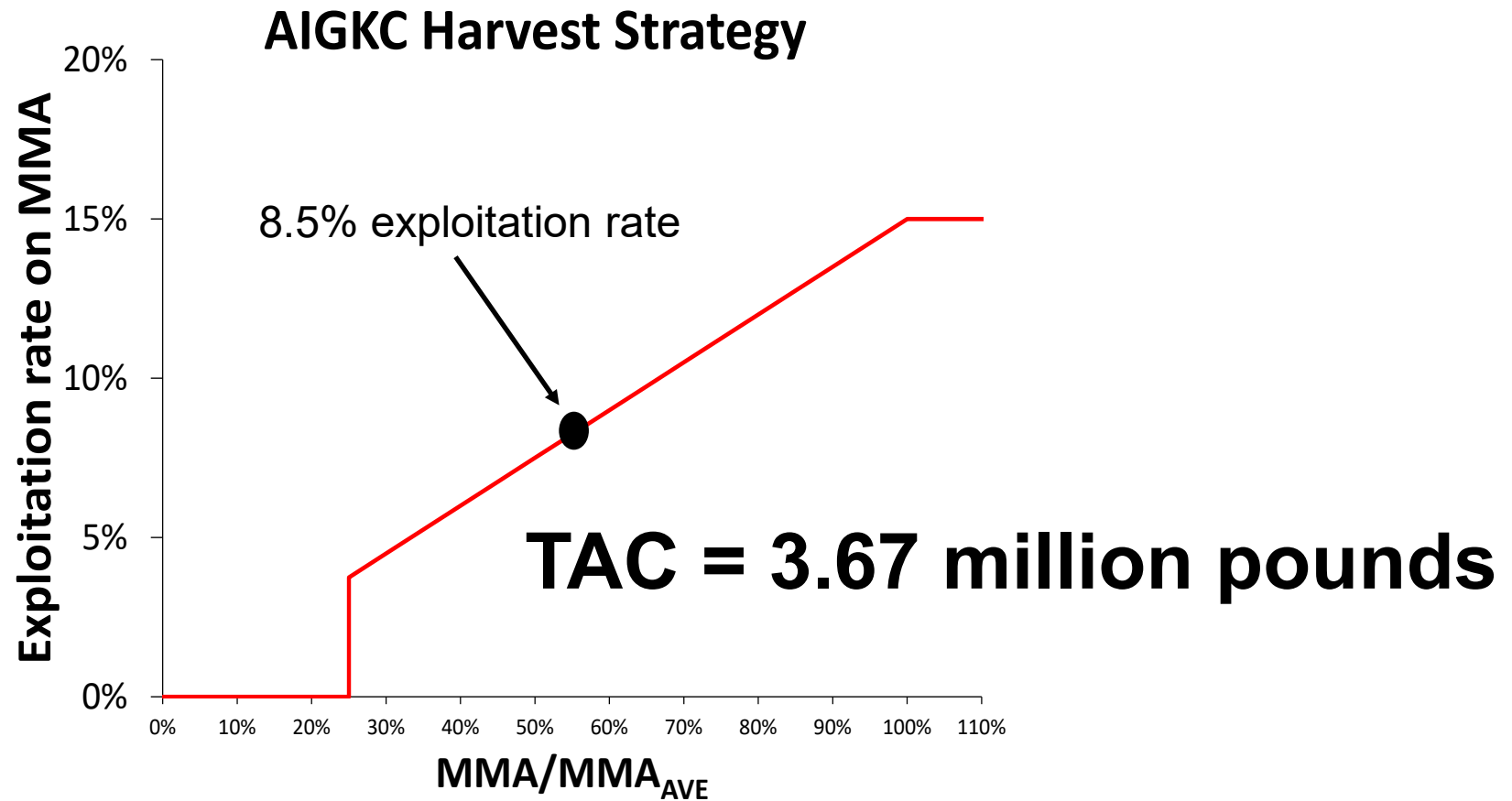


- Stairstep
- 10% floor
- 15% ceiling
- Female threshold

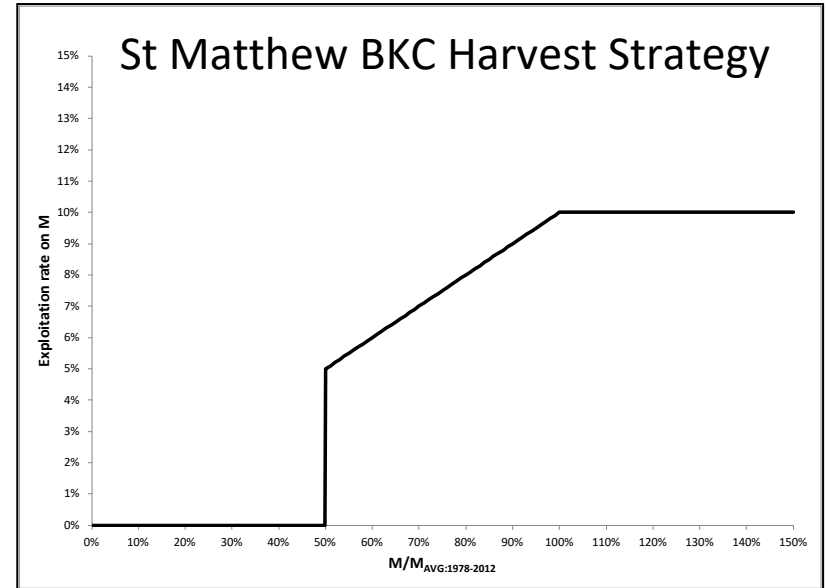
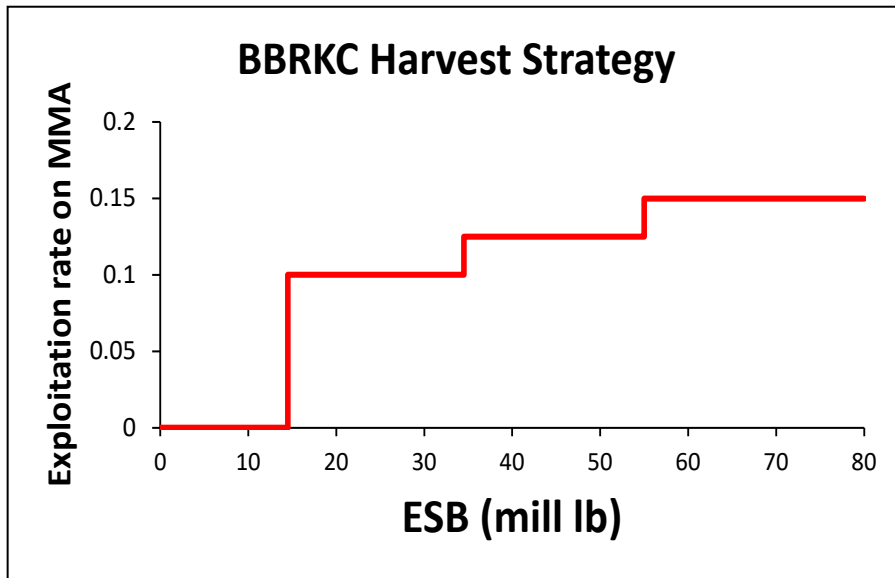


- Ramp
- 3.75% floor
- 15% ceiling
- No female threshold

Application of AIGKC Harvest Strategy



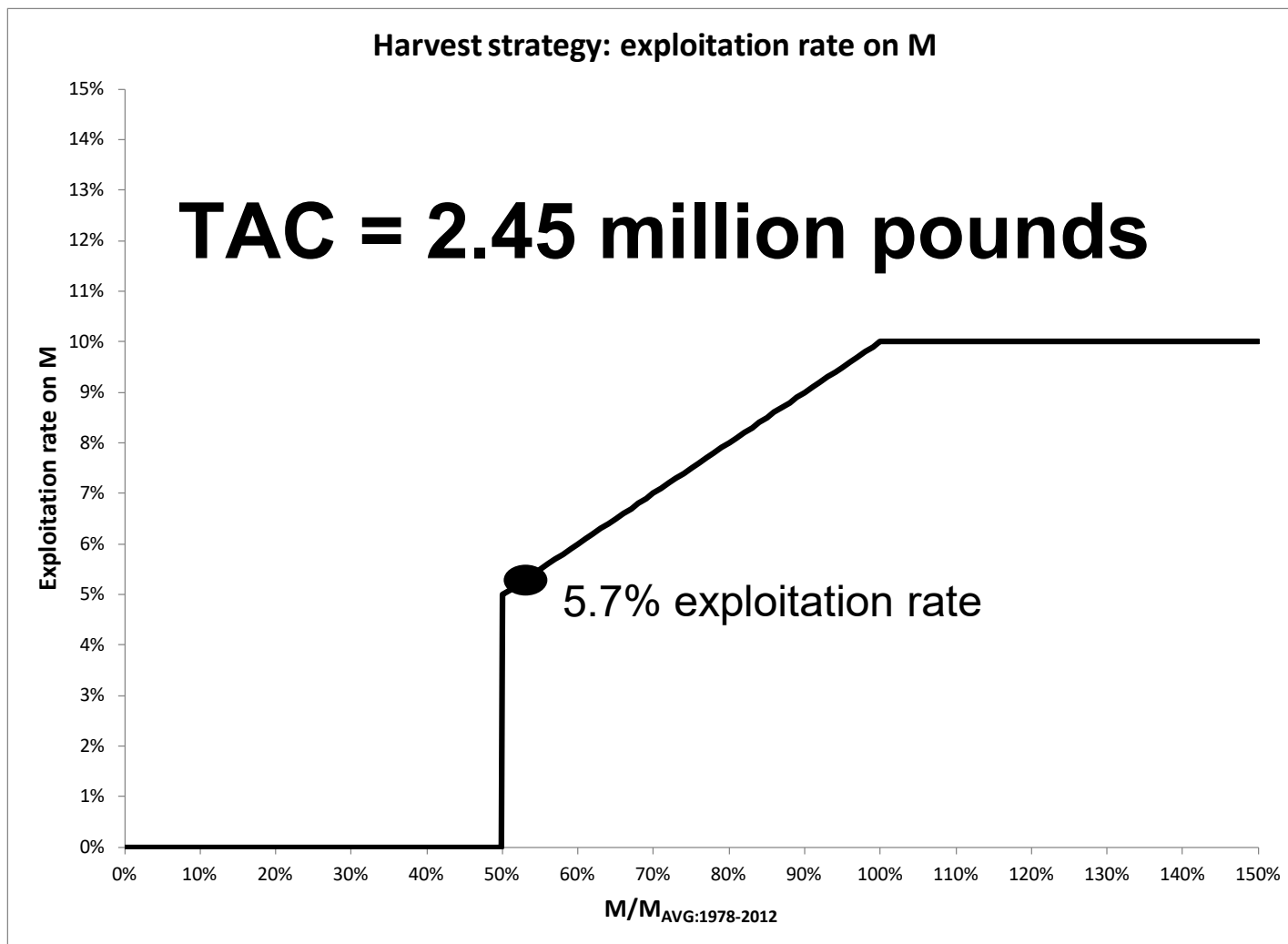
Harvest strategy comparisons



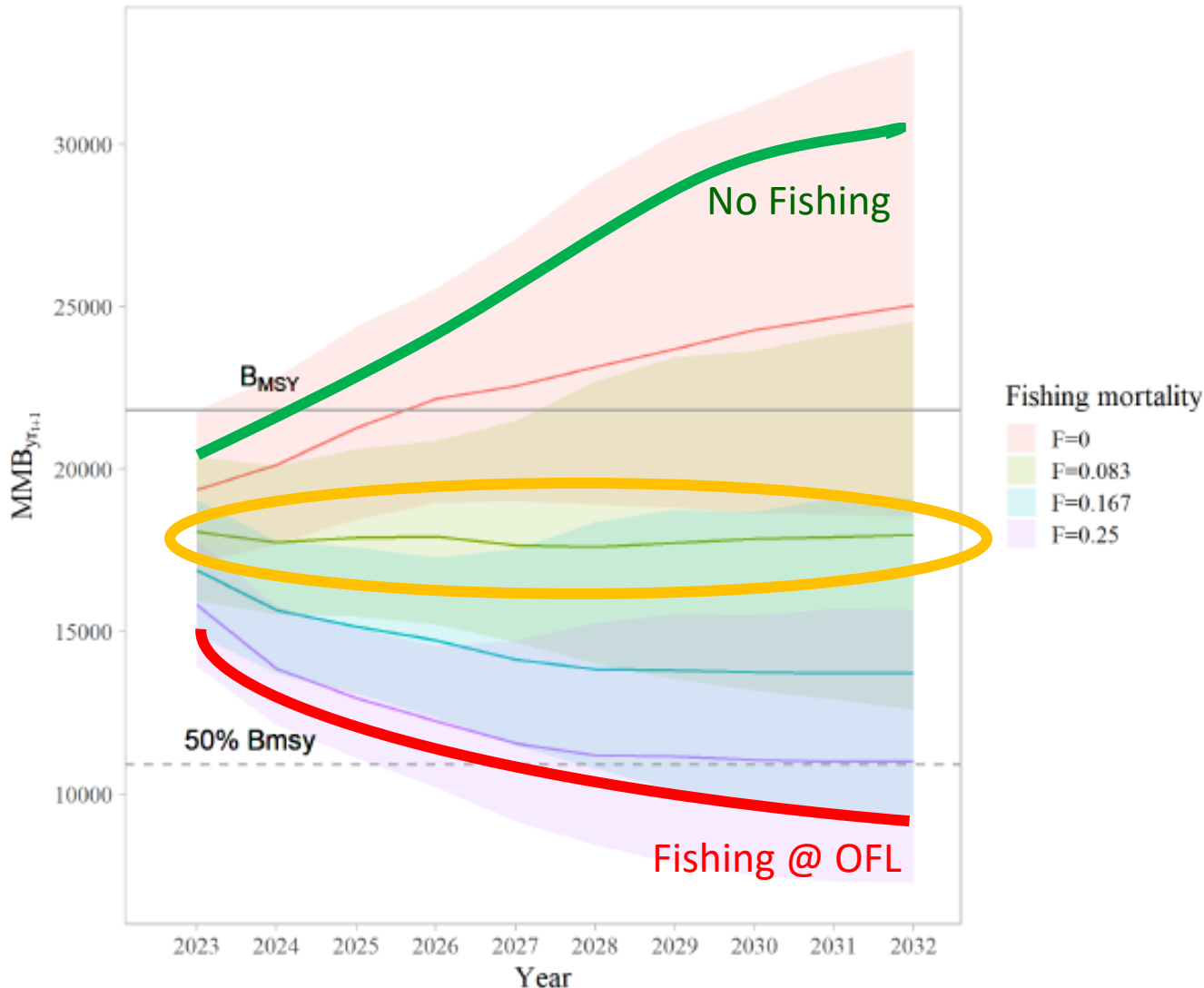
- Stairstep
- 10% floor
- 15% ceiling
- Female threshold

- Ramp
- 5% floor
- 10% ceiling
- No female threshold

Application of SMBKC Harvest Strategy

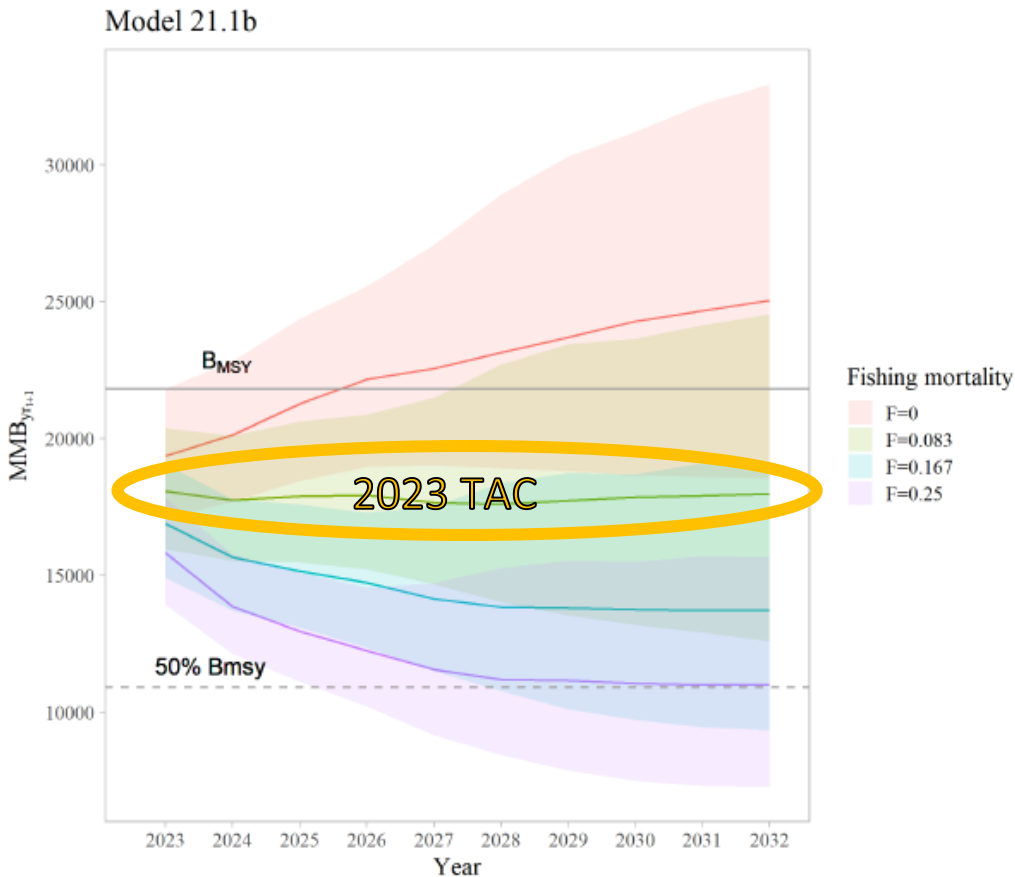


GMACS MMB projections under different BBRKC fishery mortalities



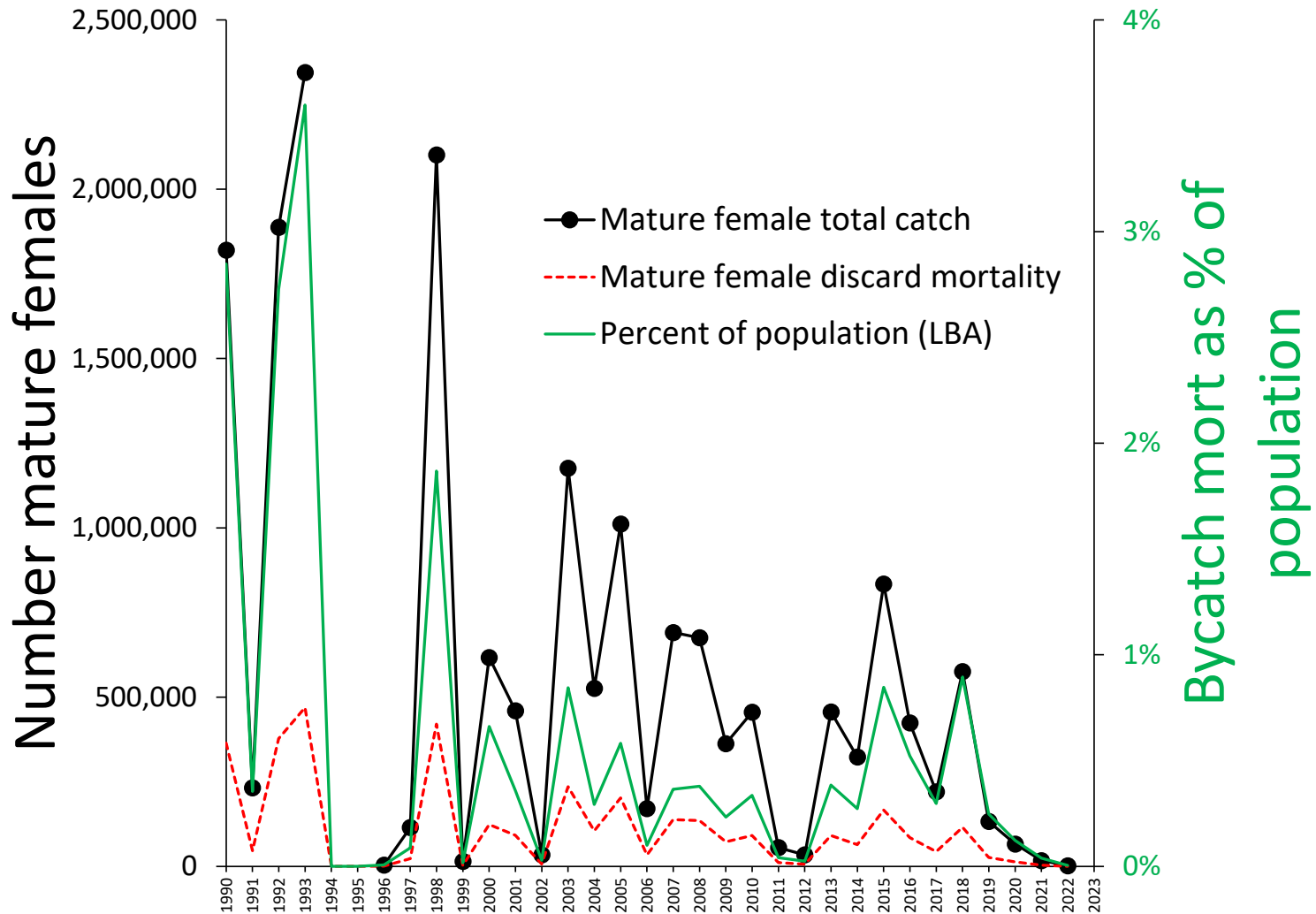
- 9.75 OFL calculated at $F_{OFL}=0.30$
- Fishery mortality rates above 0.083 result in declining population
- F=0.083 risk neutral

GMACS MMB projections under different BBRKC fishery mortalities

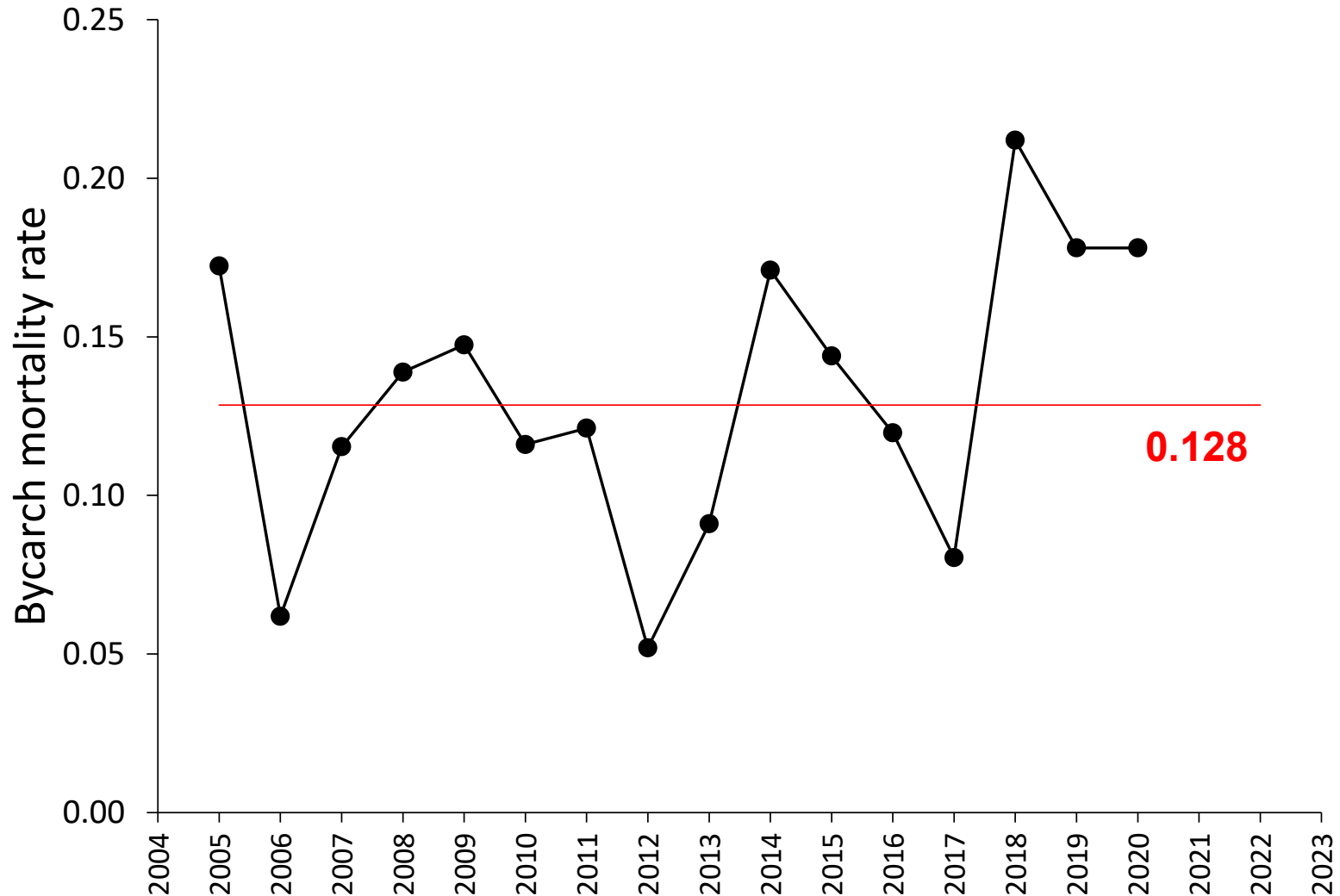


- F= 0.083 projection implies total removal of **~2.6 million pounds** could allow for stable population even at low recruitment levels
- Must account for discard mortality

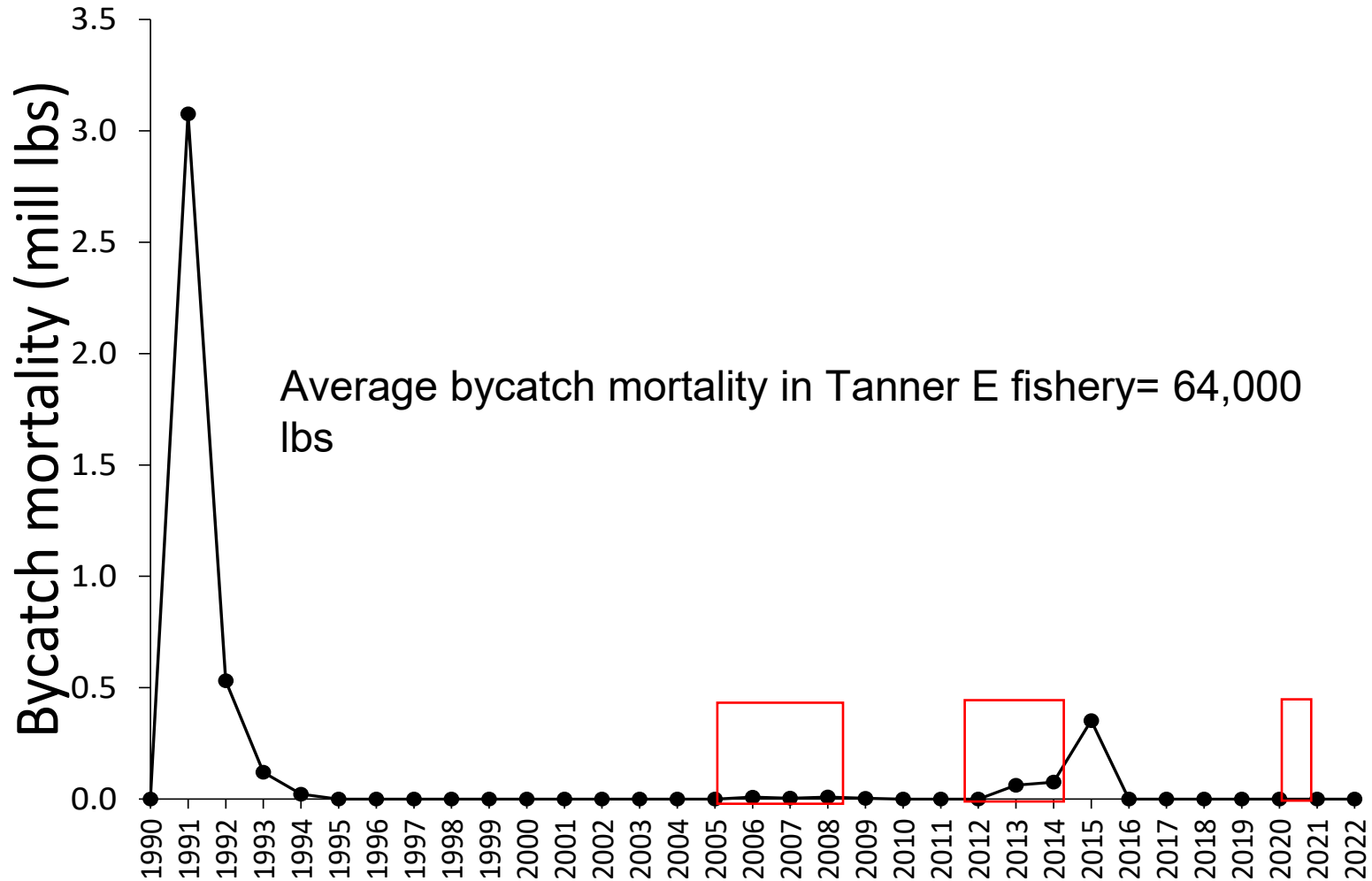
Mature female discard mortality



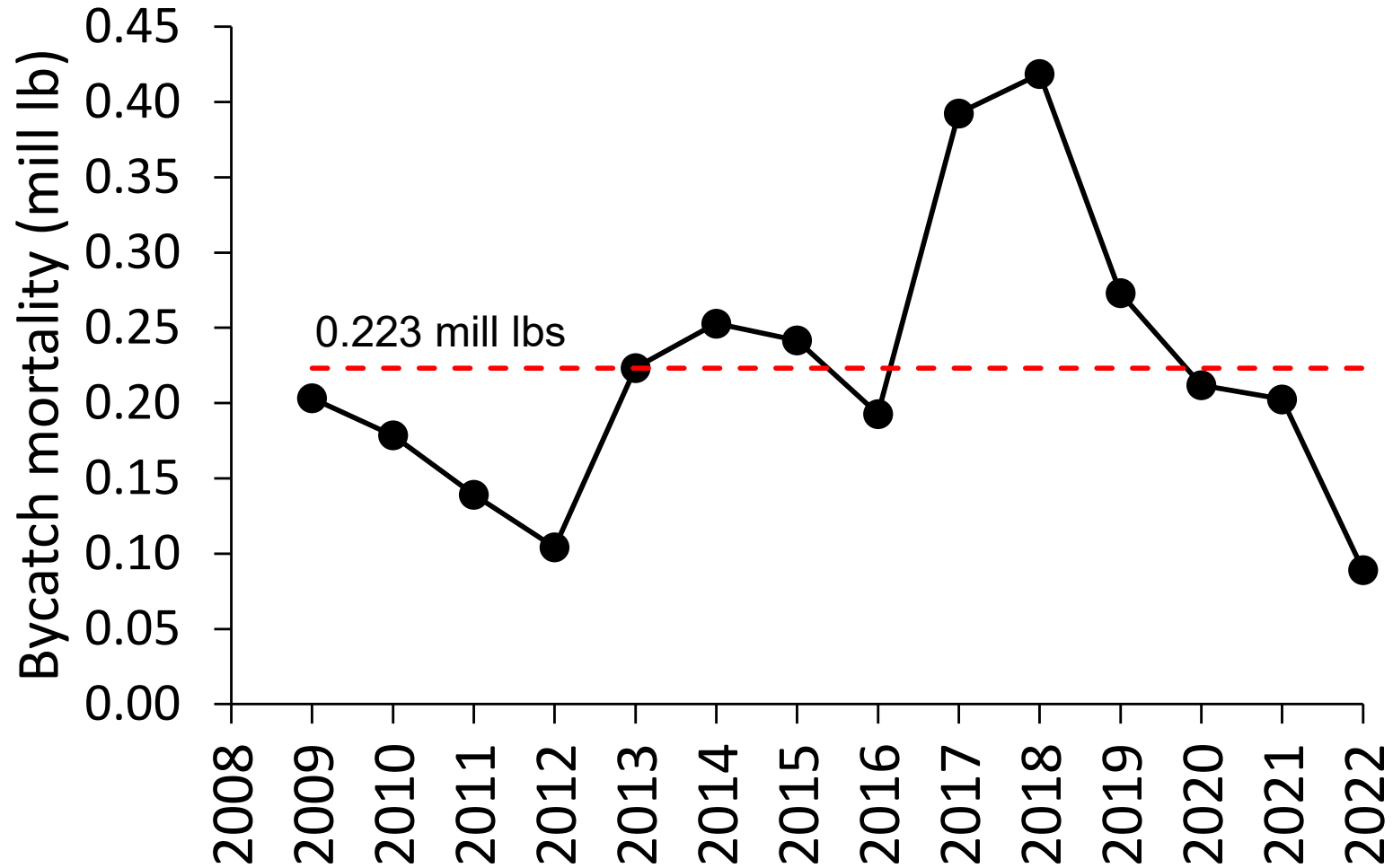
Directed fishery discard mortality



Discard mortality in Tanner fishery



BBRKC discard mortality in groundfish fisheries

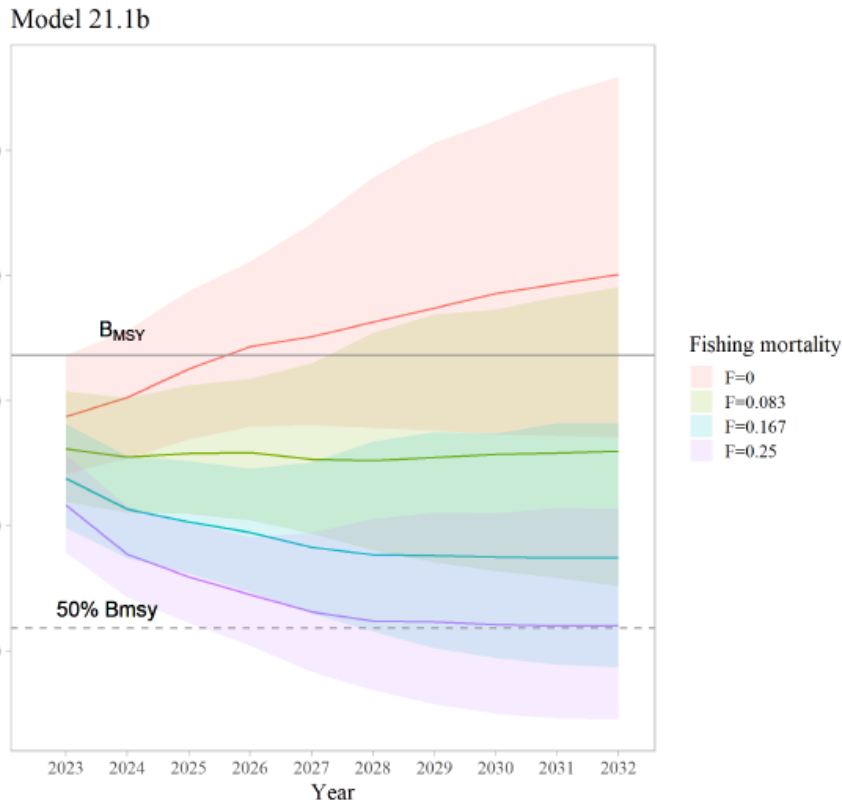


Exploitation rate on MMA

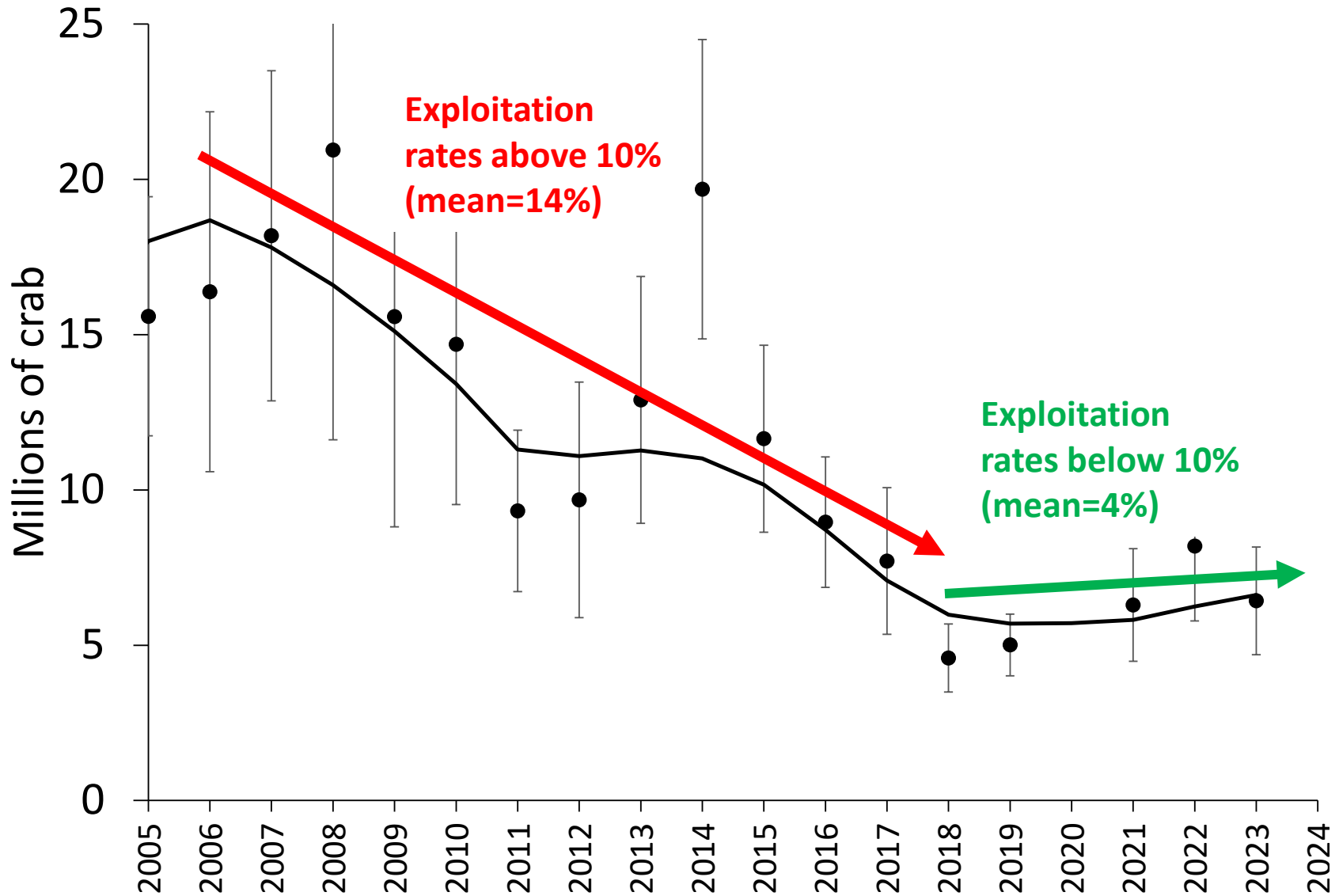
2.6 million pounds reduced by the sum of estimated fishery discard mortality:

TAC: 2.15 million lbs

5% exploitation rate on MMA



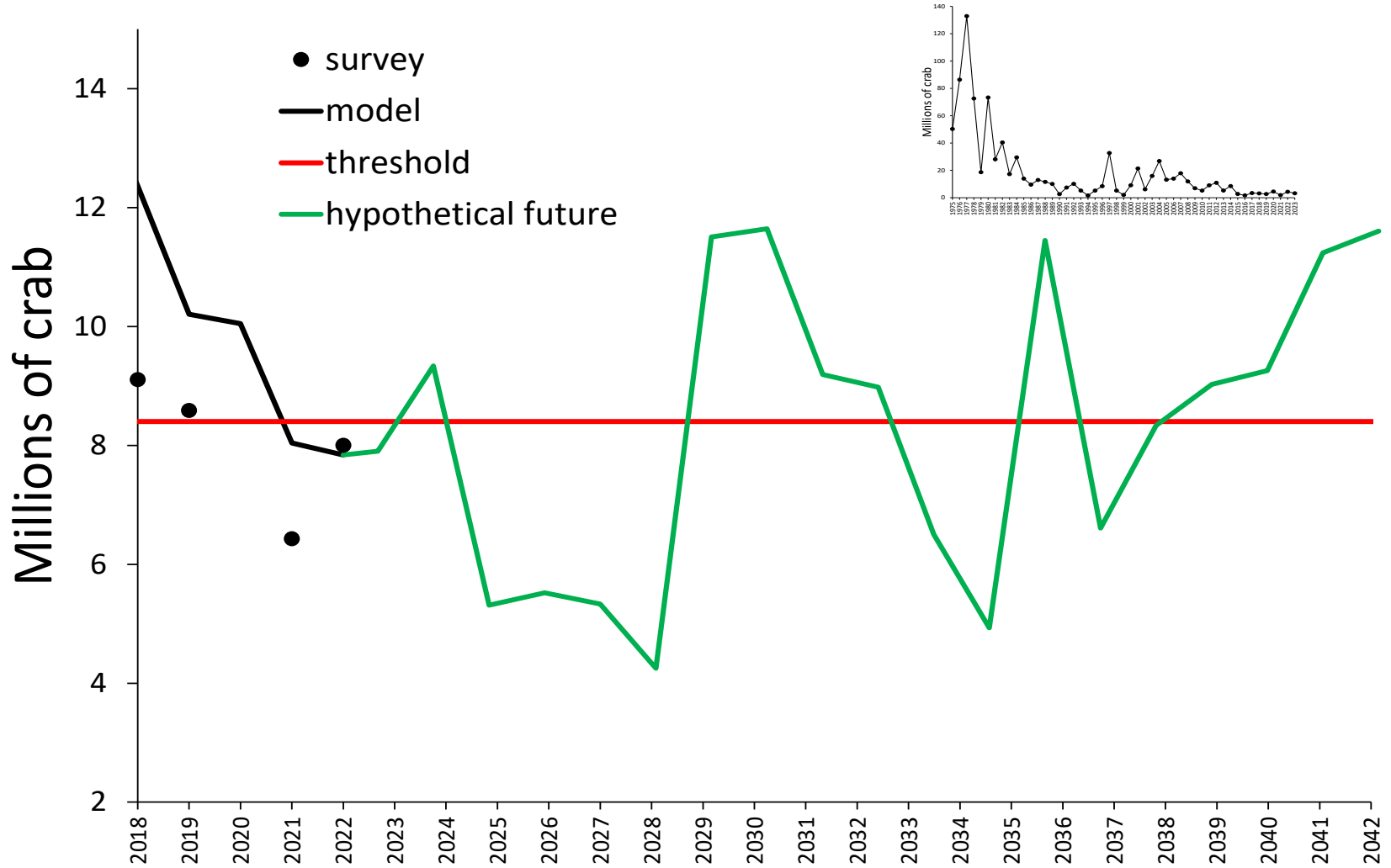
Mature males



In Summary

- Recent environmental conditions do not appear to be favorable for BBRKC
- Opening the fishery has risk
 - Low recruitment limits population growth
 - Depensation concerns?
- Need to reconsider exploitation rates for contemporary population conditions
 - Sub-10% exploitation likely needed at low stock status

What's next?



Can we promote population growth?

- Continue to reduce fishery removals?

Thresholds close and open fisheries.

- 1- or 2-year closures likely not enough given the life history; stanzas of fishery closures might be needed for cohort rebuilding
 - Absent stanzas, add *more* thresholds or error bounds to reopen to ensure rebuilding is occurring
 - Is doing 'more of the same' meaningful?
 - Are we missing other forms of fishery mortality?
- 2.15 million pounds best attempt to balance fishing opportunity without further risk to stock

Snow crab

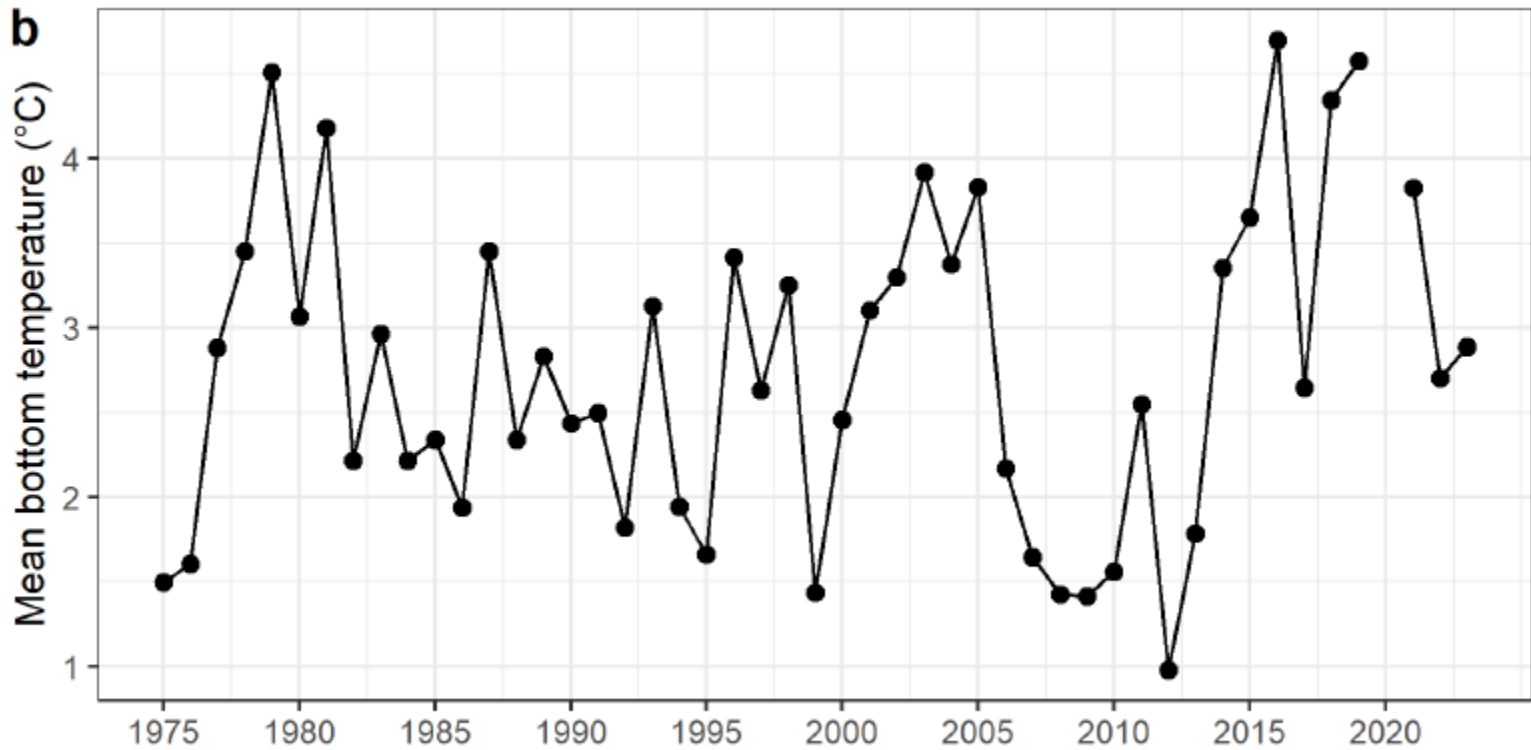
2023 big-picture

- Population severely depressed (“overfished”)
 - Natural mortality event in 2018-2019 related to elevated temperature (e.g., high energetic demands resulting in starvation/cannibalism)
 - 2023 at *new* timeseries lows (survey data) for most components of population
 - Modest increase in small males
- Assessment model changes - improved
 - How terminal molt is modeled: year-specific vs single
 - How BSFRF data is used to inform NMFS survey selectivity
 - Differences in opinion on 2023 reference point calculations: Tier 3/4 approach

2023 big-picture: federal management quantities

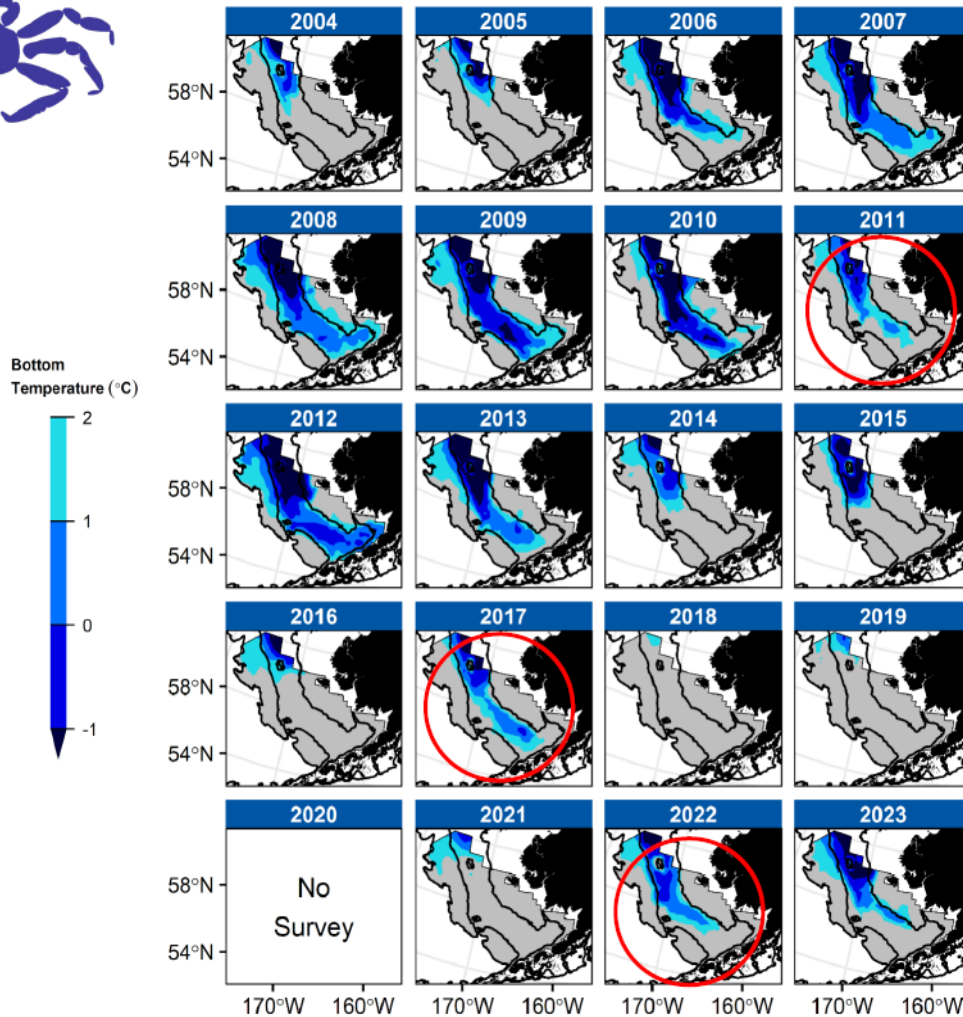
- **Tier 3** proxies for fishing mortality and biomass targets result in ~100% exploitation of 4-inch males
 - Terminal molt at small sizes (large portion of population never reaches 4 inches), thus higher exploitation on large sizes
 - OFL= 34 million pounds is questionable given status of stock
 - ABC= OFL buffered by 50%: 17 million pounds
- **Tier 4** calculations result in lower fishing mortality overall
 - Might be more appropriate given stock is at unprecedented lows and a 100% removal of large males highly undesirable
 - OFL= 680,000 pounds
 - ABC= OFL buffered by 20%: 550,000 pounds

Bottom temperature



Bottom temperature

Cold Pool
Rohan & Barnett

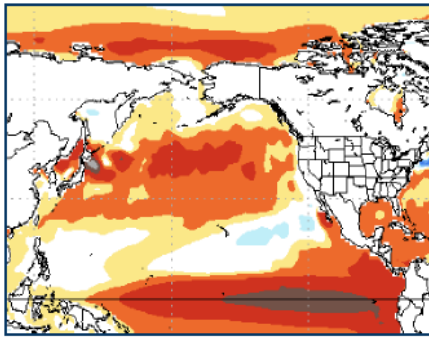


- Average cold pool extent
 - Slightly larger than 2022
- Footprint of the cold pool was similar to 2011, 2017, and 2022
- Cold tongue along the inner front was shifted inshore

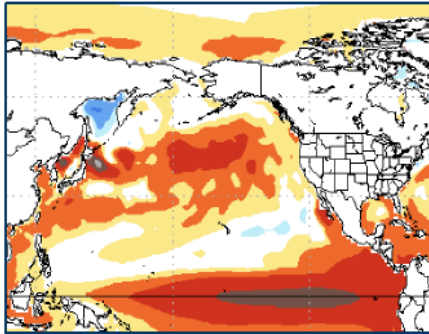
Sea Surface Temp Projections

SST Projections from the National Multi-Model Ensemble Bond

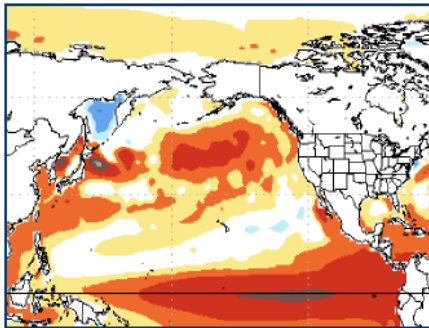
Oct - Dec
2023



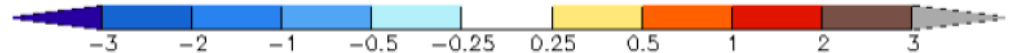
Dec 23 -
Feb 24



Feb -
April
2024

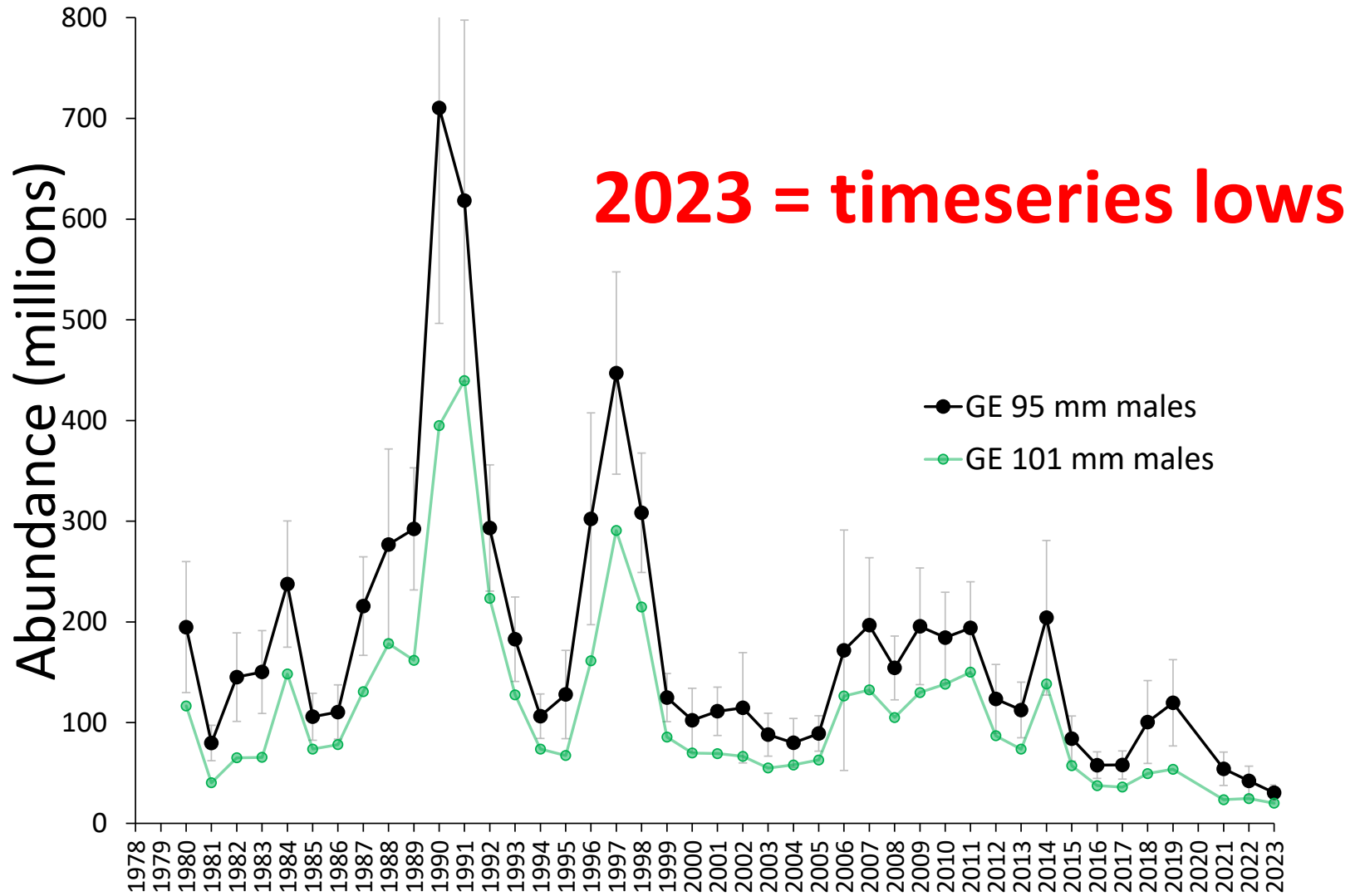


- **TOP:** El Niño in tropical Pacific. Modest warming for western Aleutian Islands, southeast Bering Sea shelf, and Gulf of Alaska.
- **MIDDLE:** Similar to earlier period (Oct-Dec 2023). Tropical Pacific has SST anomalies $>2^{\circ}\text{C}$, representing a strong El Niño.
- **BOTTOM:** Moderation of tropical Pacific SSTs; warming along PNW coast and SEAK (typical response to El Niño). Sea ice could extend south of 60°N and as far south as Bristol Bay.

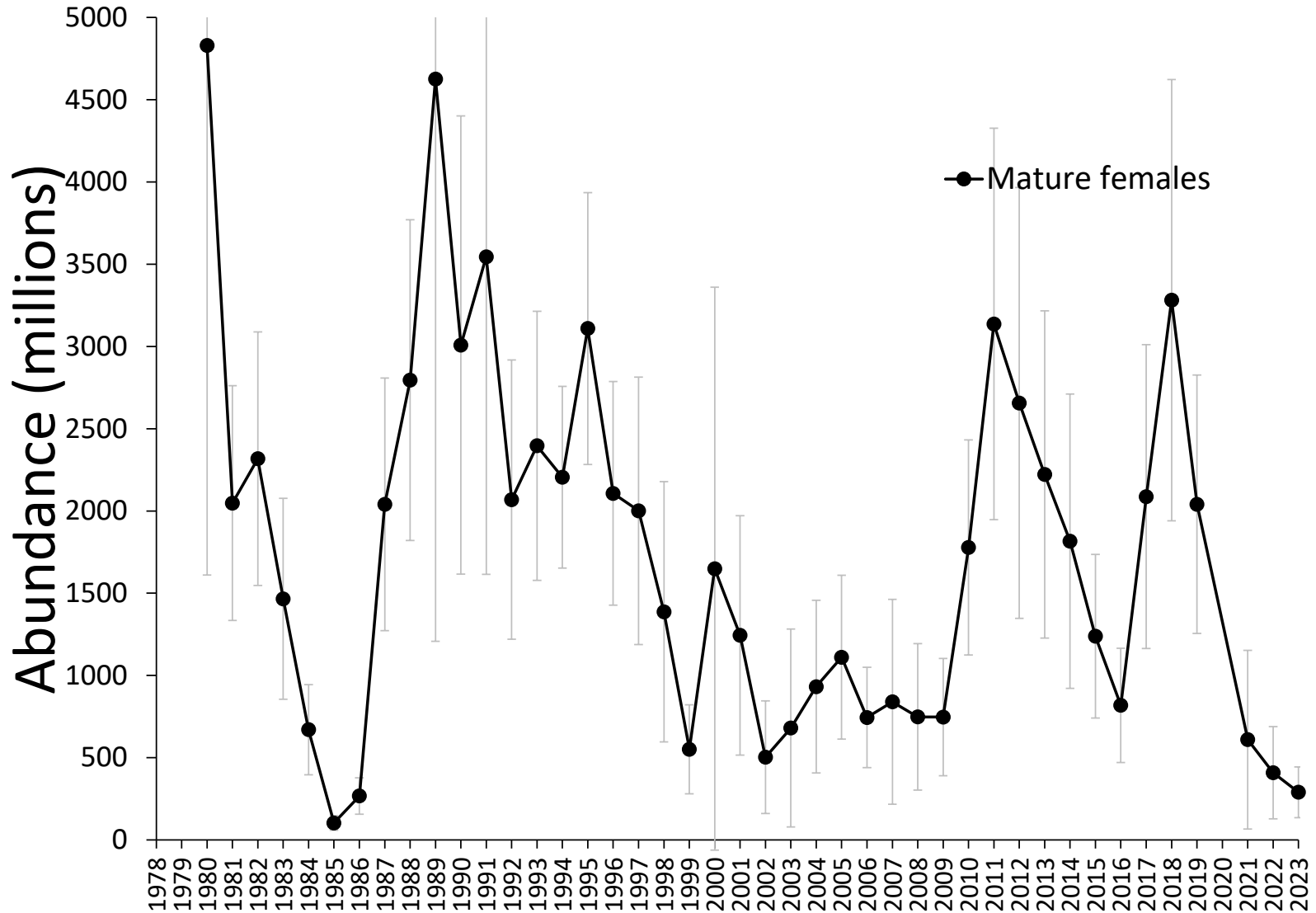


SURVEY DATA:
Population at or near *new*
all-time lows

Survey data – mature and preferred males



Survey data: mature females (abdomen)



State Snow Crab Harvest Strategy

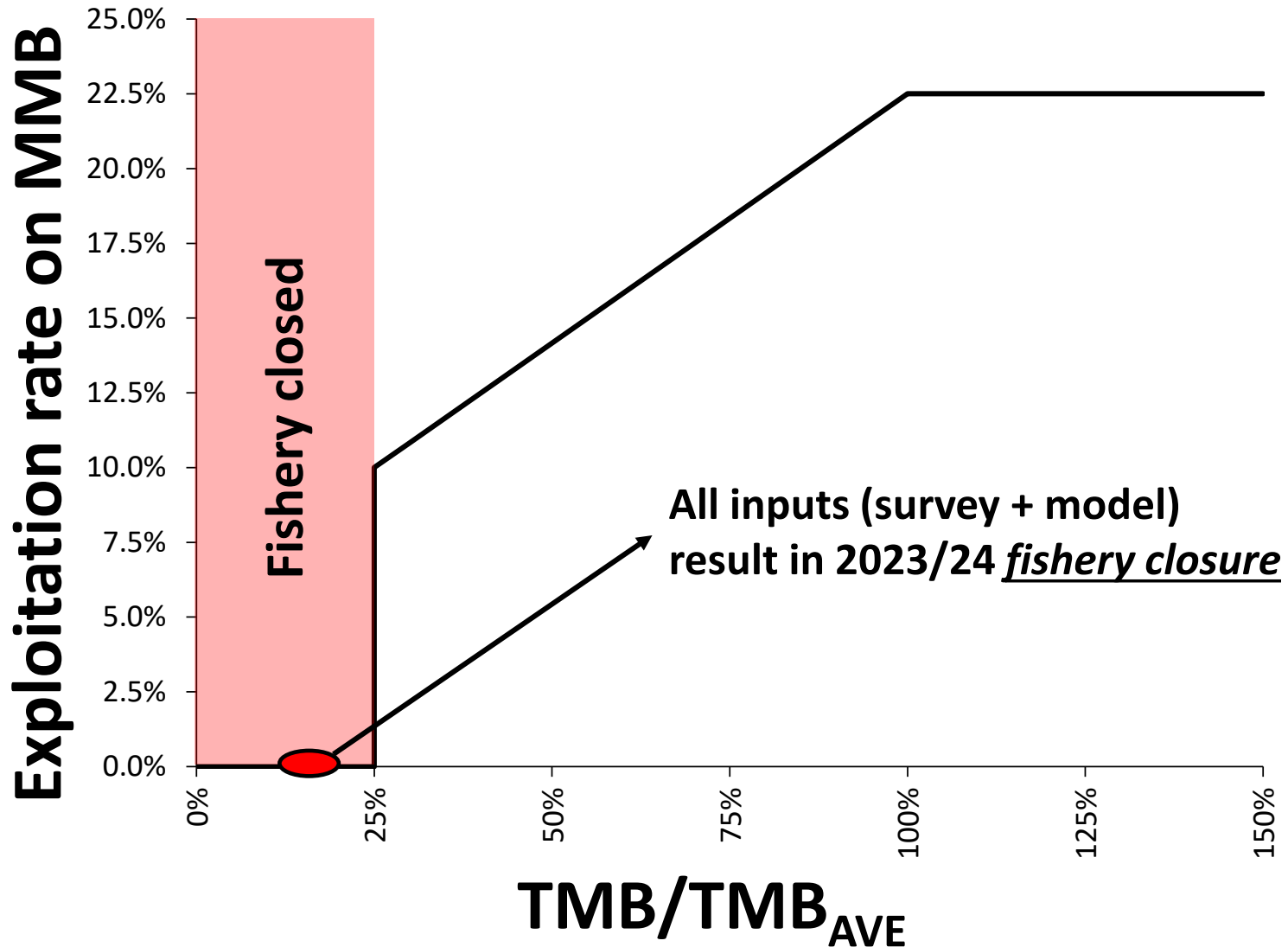
1. TMB threshold for opening fishery: $25\%B_{MSY}$
2. Exploitation on MMB:
 - $B < 25\% B_{MSY}$, = 0%
 - $0.25 * B_{MSY} \leq B < B_{MSY}$, exploitation increases linearly from $1/3 F_{MSY}$ to $0.75 * F_{MSY}$, by equation:
 $[F_{MSY}/3 + (B - 0.25 * B_{MSY}) * 0.417 * F_{MSY} / (0.75 * B_{MSY})] * 100\%$.
 - $B > B_{MSY}$, = 75% of $F_{MSY} = 0.75 * 0.3 = 22.5\%$
3. Max Cap: 58% harvest rate on exploitable legal males (4-inch males: 100% new shell + **25% (or other)** old shell)

Application of State Harvest Strategy

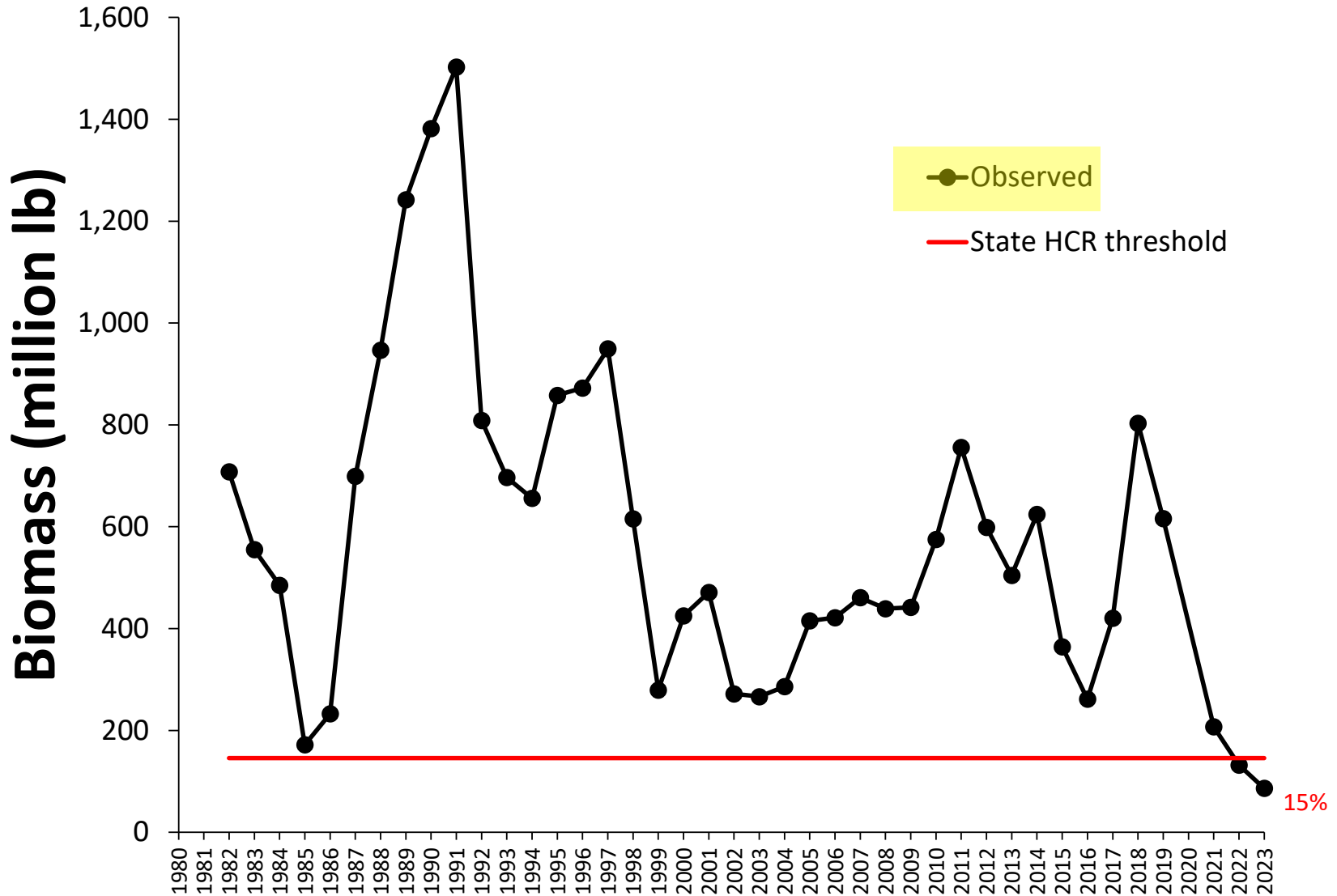
Three TAC calculations for comparison

- 1. Survey area-swept:** survey area-swept, size cut for male maturity
- 2. Model survey:** model estimates of survey, estimated maturity
- 3. Model population:** accounts for survey selectivity

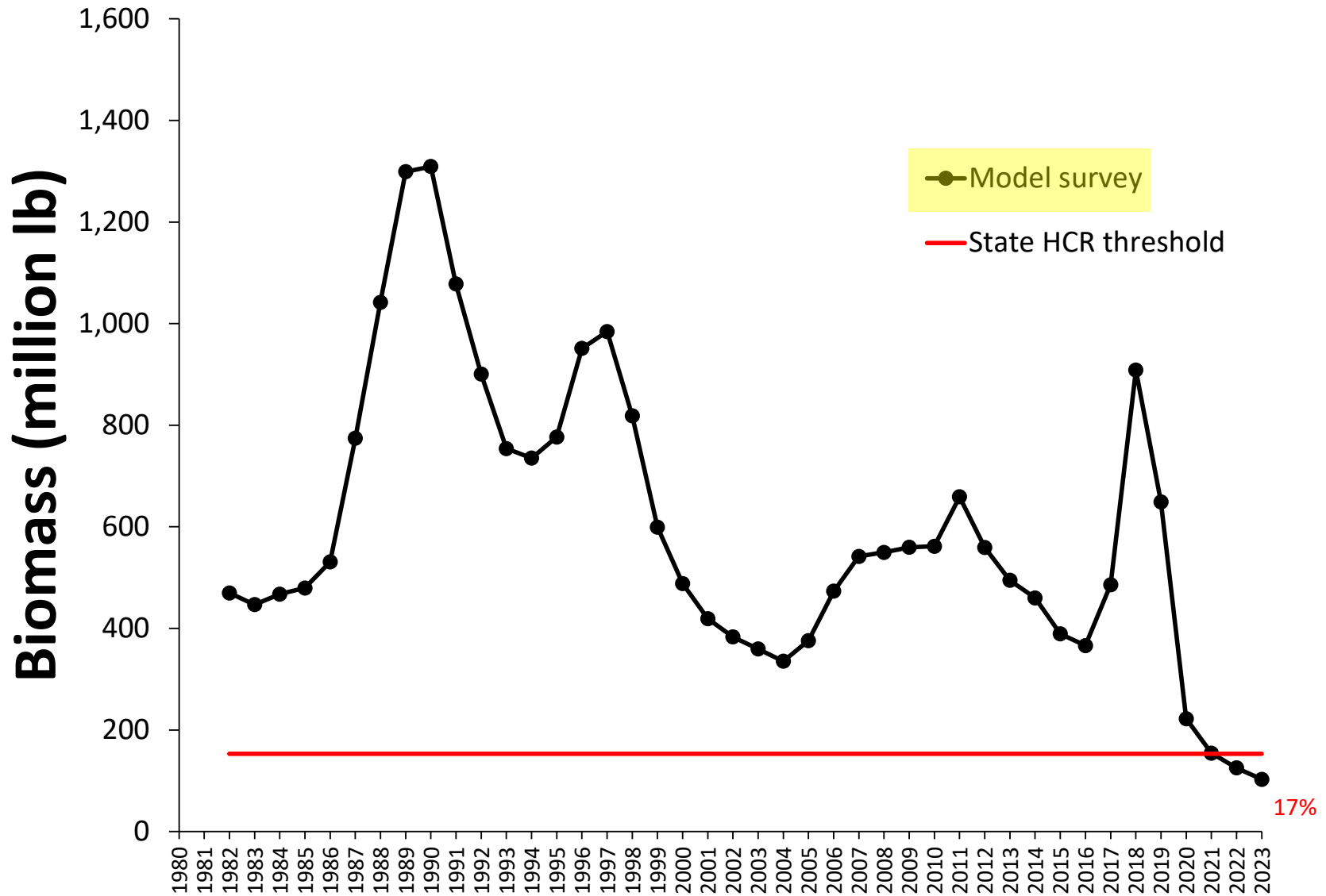
State harvest strategy



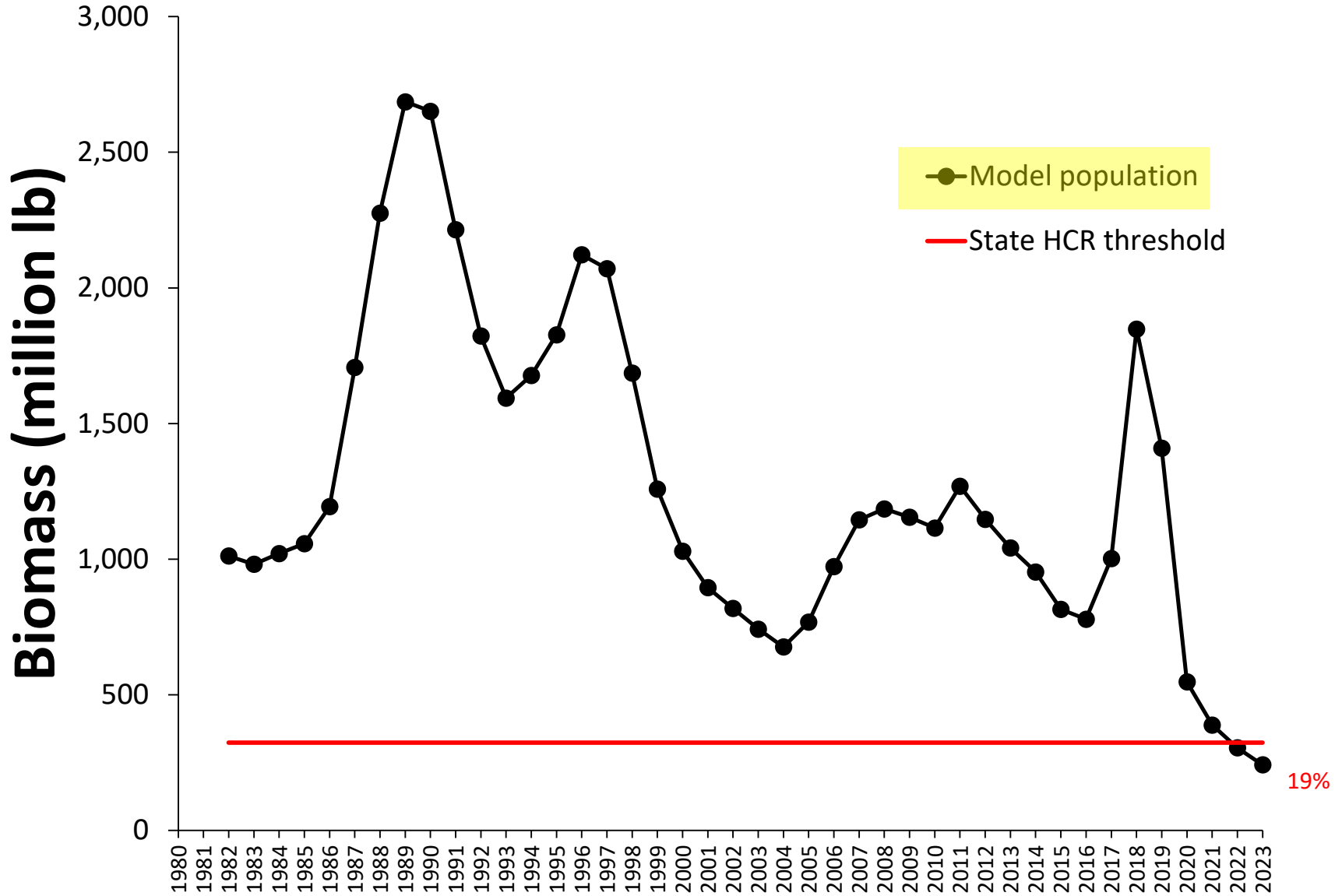
Total Mature Biomass: Survey data



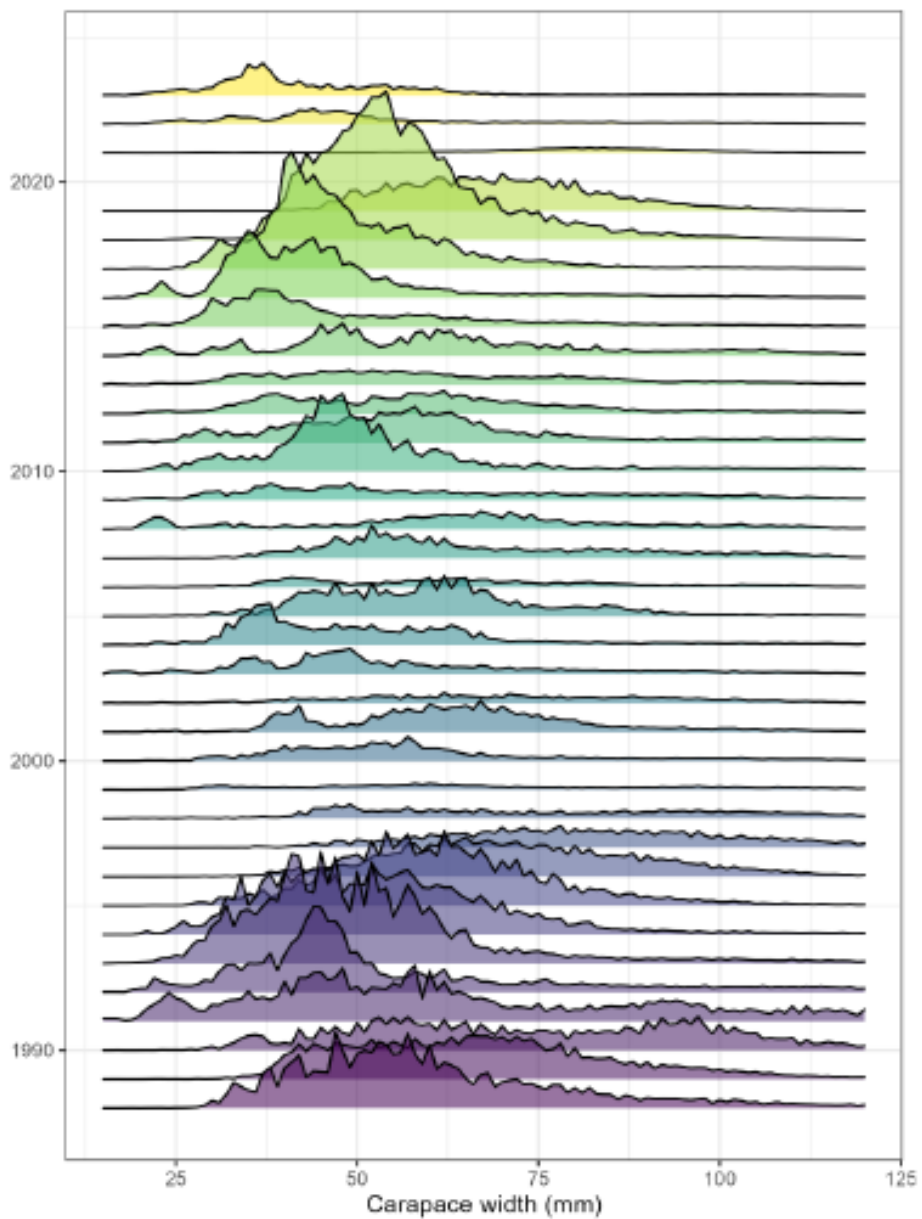
Total Mature Biomass: Model-Survey



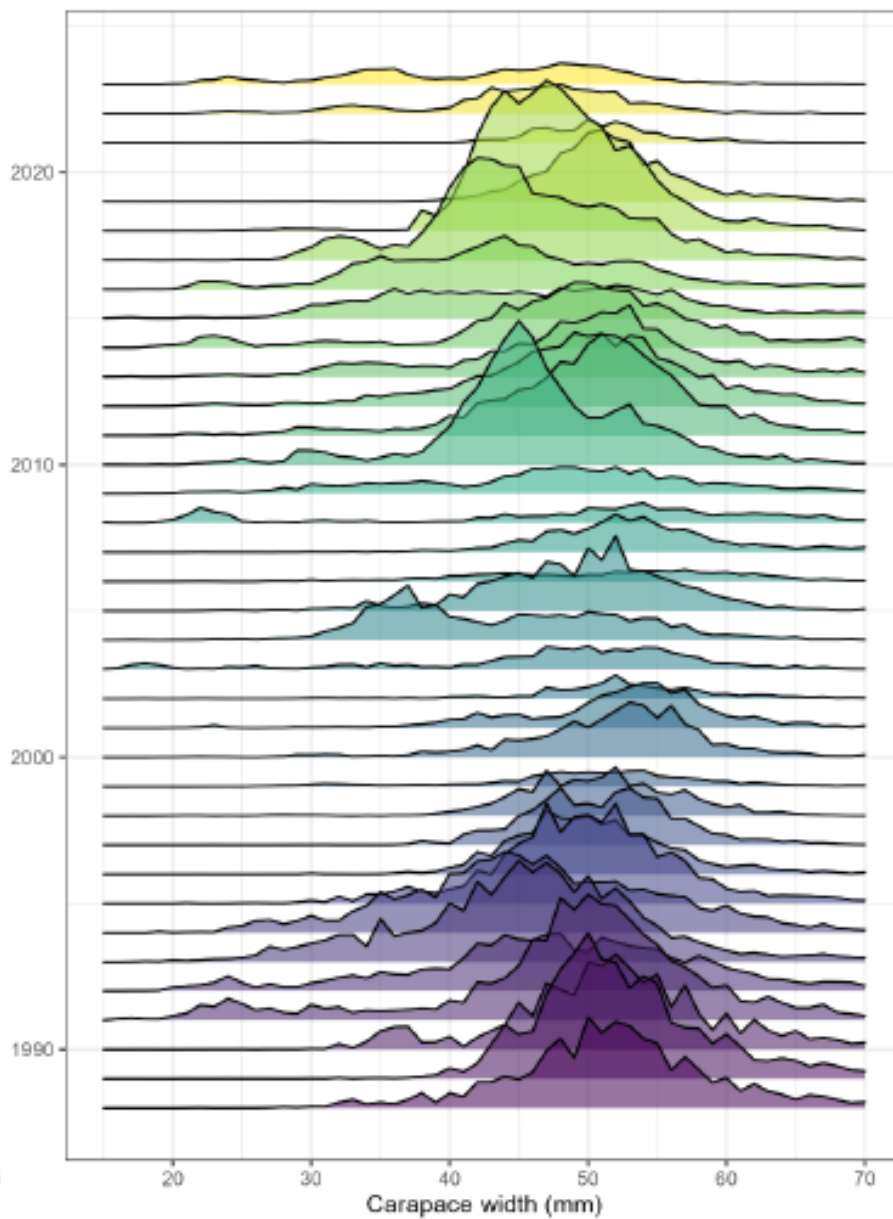
Total Mature Biomass: Model-Population



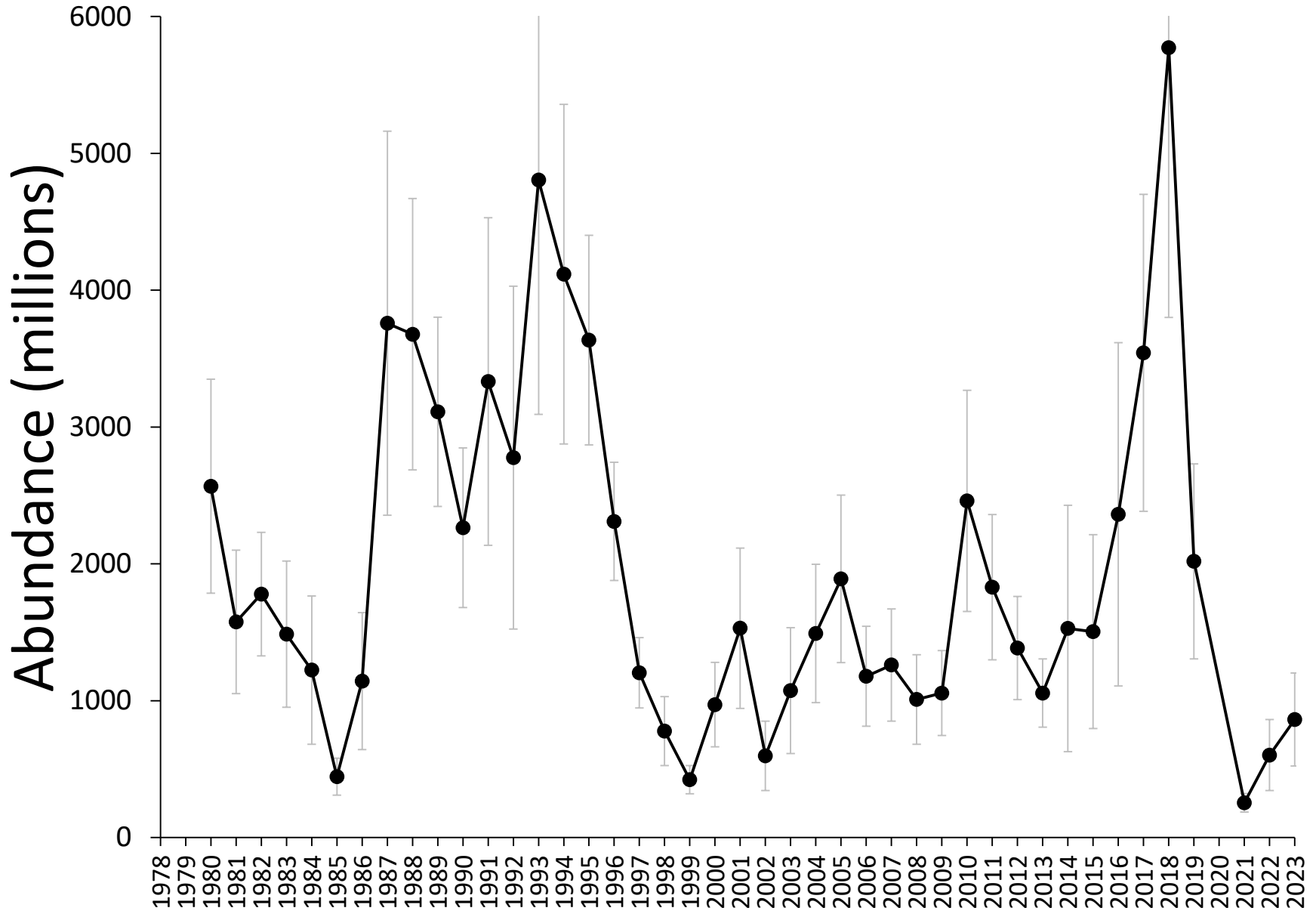
Male Snow Crab



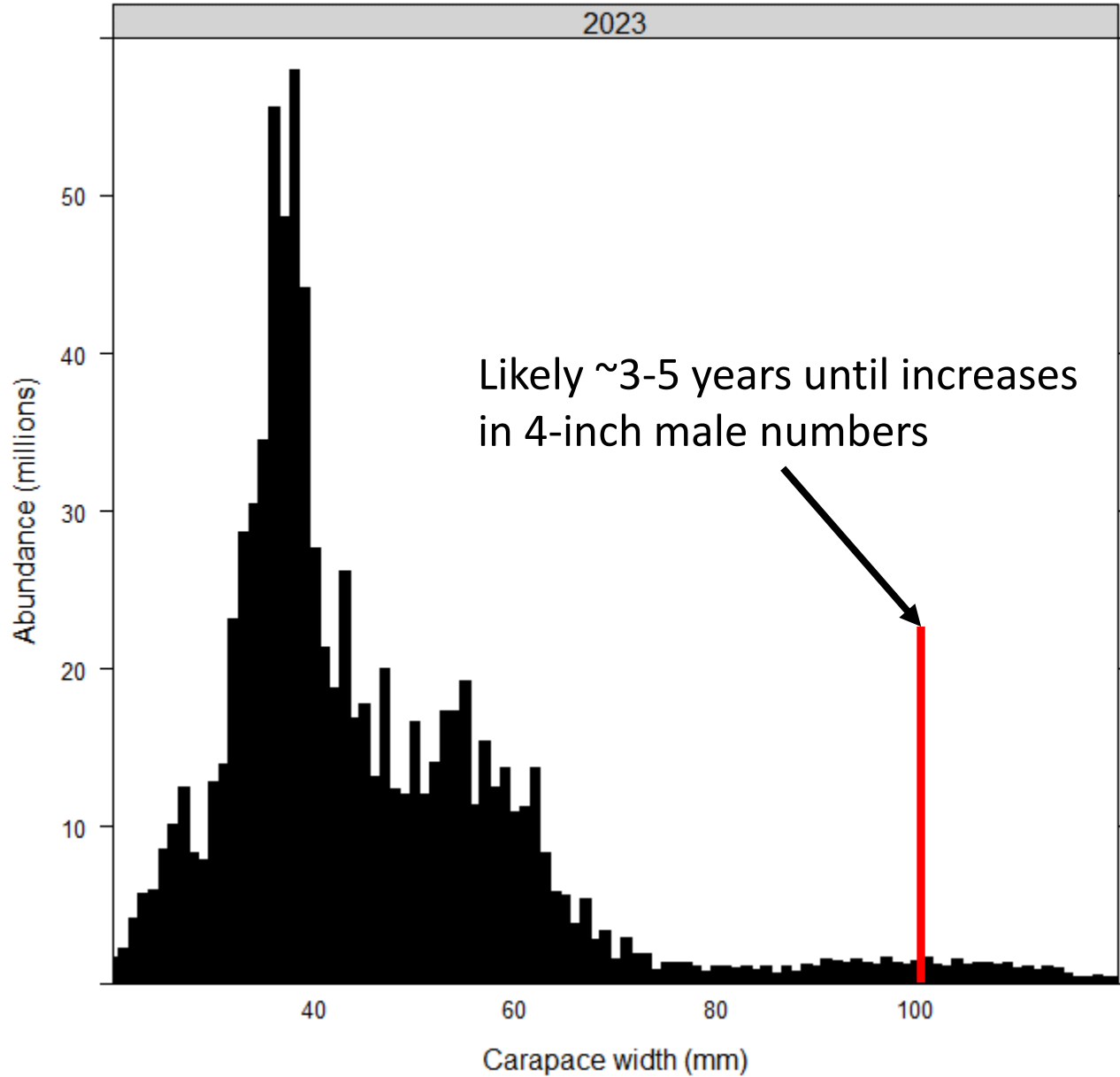
Female Snow Crab



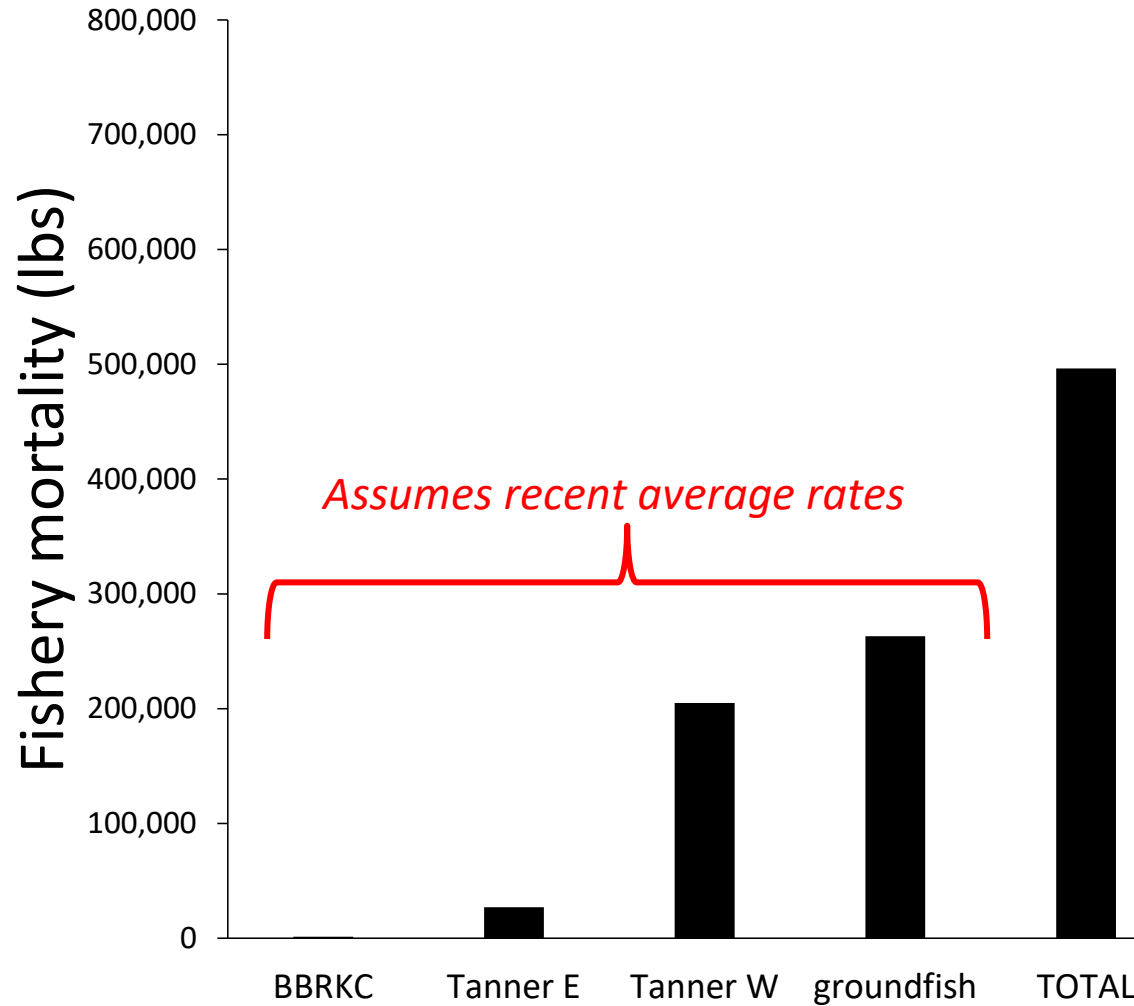
Some Hope: Small males



Male snow crab



2023/24 discard mortality projections



Snow Crab Summary

- 2023/24 fishery closed due to state harvest strategy threshold for second consecutive year
- Population at historic lows but some increase in small crab abundance
- Recent model improvements better capture stock dynamics, but how we define MMB as “currency of management” needs to be reevaluated

Snow Crab Summary

- Future of snow crab population unknown
 - 2023/24 projected to be modestly warm in response to El Nino
- Several years until realized increases to larger size classes (~4 years until small crab reach 4 inches)
- Need good survival of existing juvenile crab and good larval settlement for future population growth
- Consideration for bycatch mortality in Tanner West and groundfish fisheries warranted given current stock condition

Tanner crab

2023 Assessment: Scenario 22.03b

- SSC + Council recommendations
- Stock status
 - Current: 204% of B_{MSY}
 - Projected: 134% of B_{MSY}
- OFL: 79.82 million pounds
- ABC: 63.85 million pounds
 - Total fishery mortality of males and females
 - Based on a 20% buffer on OFL

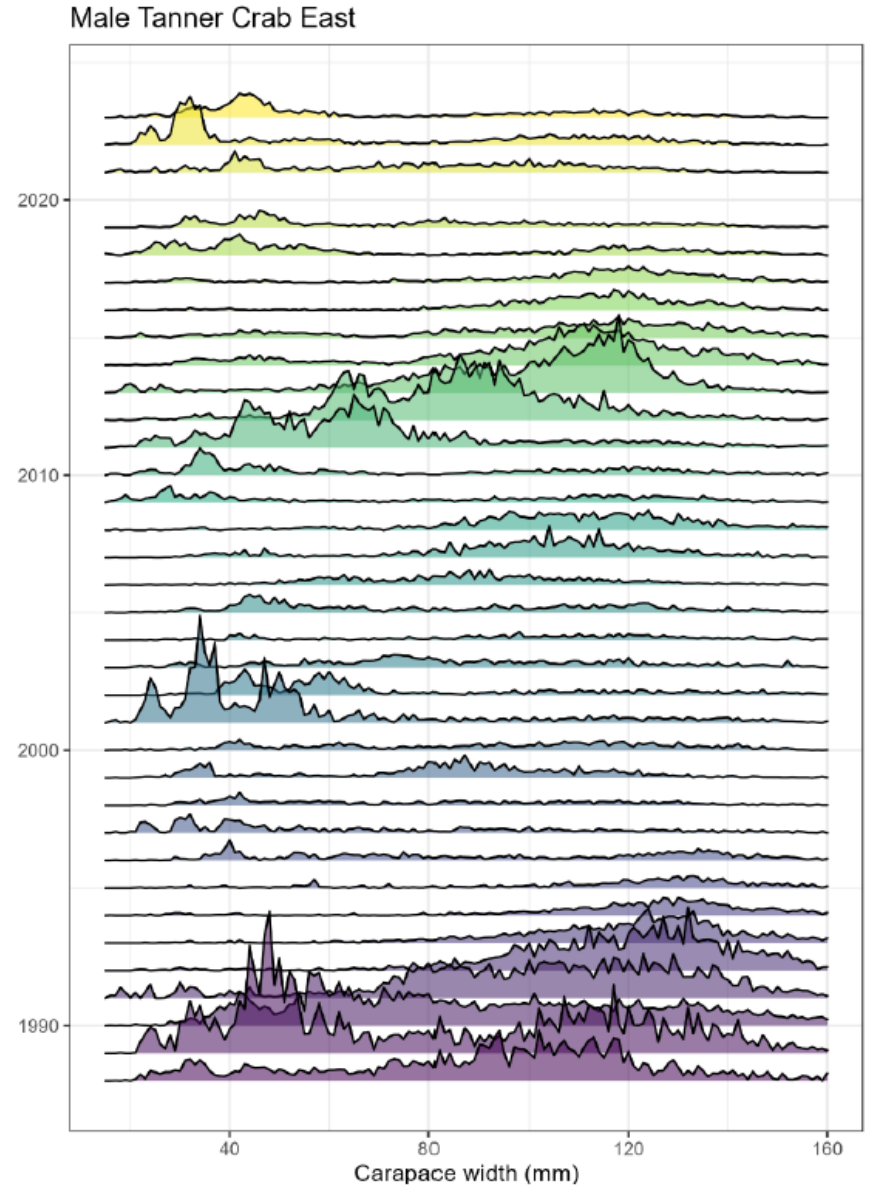
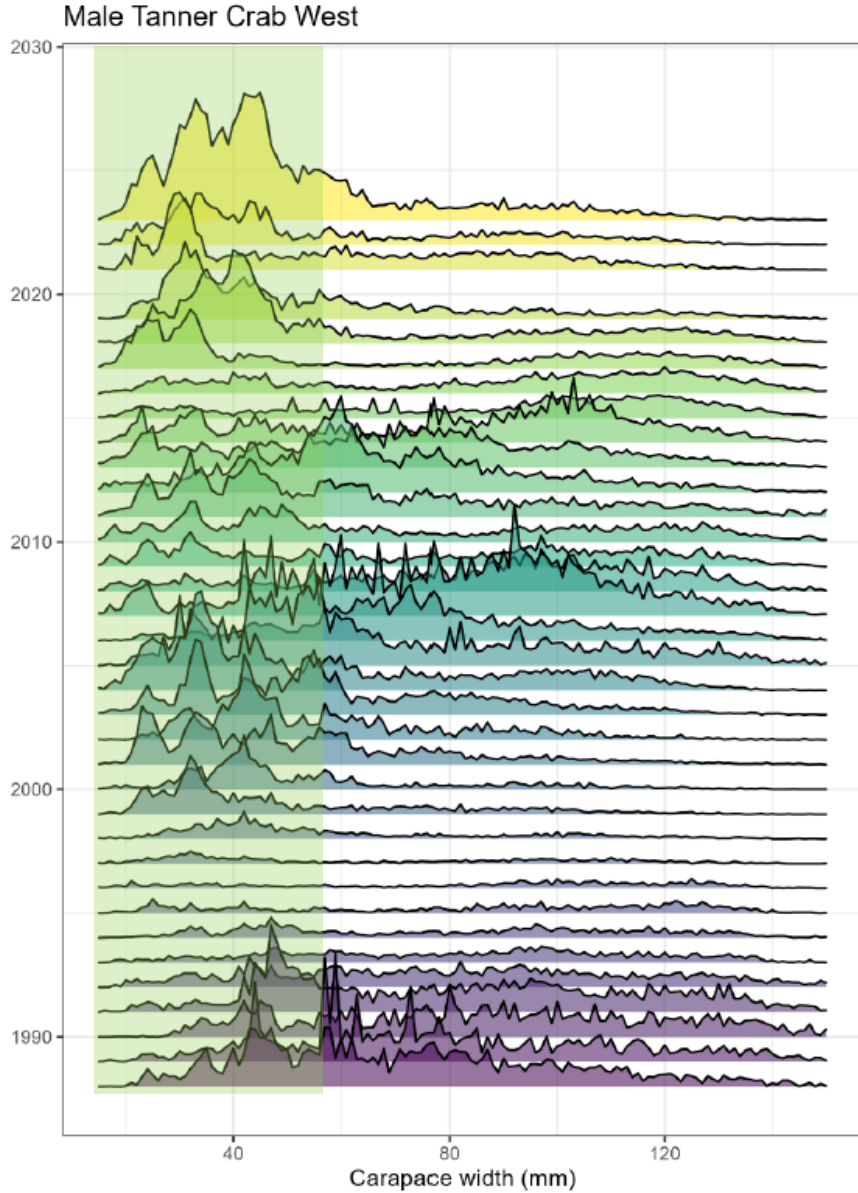
2023 assessment model performance

- Improvement over last years model
- Good convergence - no parameters hitting bounds
- Retrospective pattern for MMB is small
- Similar results as 2022 assessment

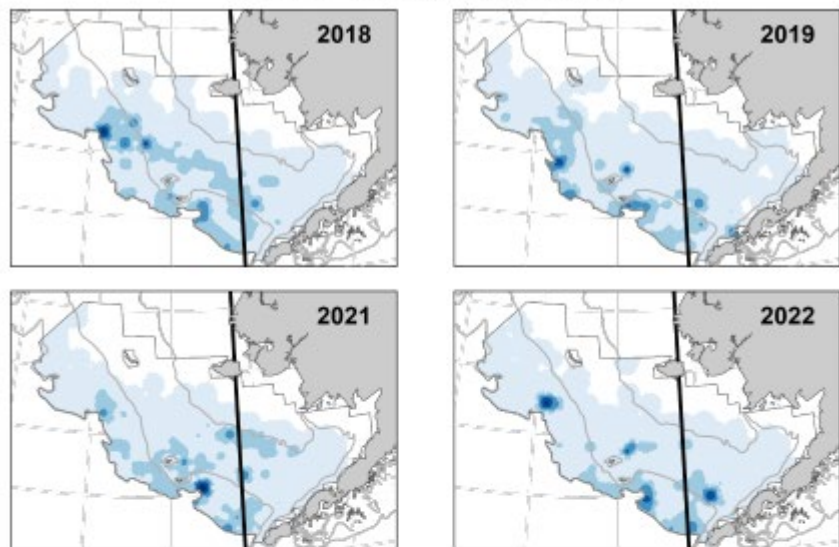
But...

- Recruits not propagating to larger sizes
- Poor fit to terminal year biomass
- Poor fit for large crab
- Concern that Tanner (and snow) harvest control rules do not adequately reflect reproductive potential of different-sized males

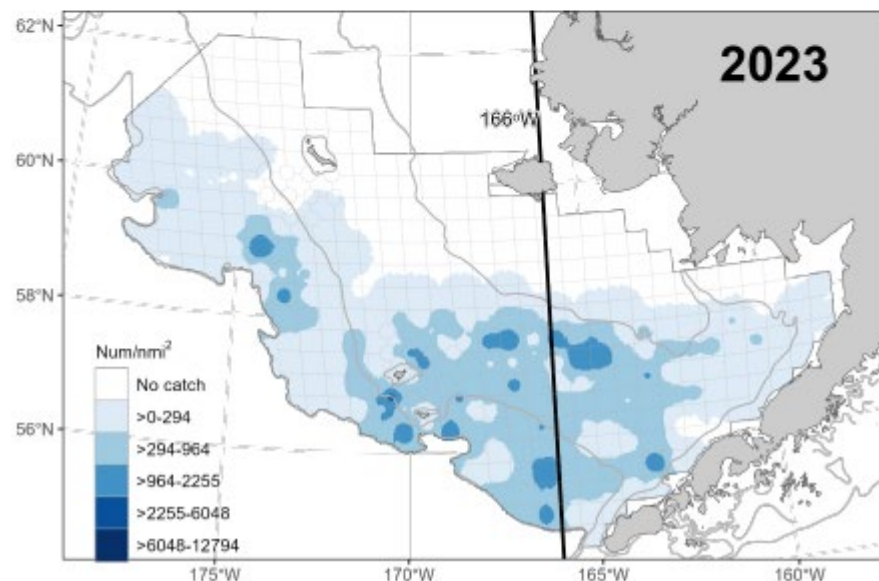
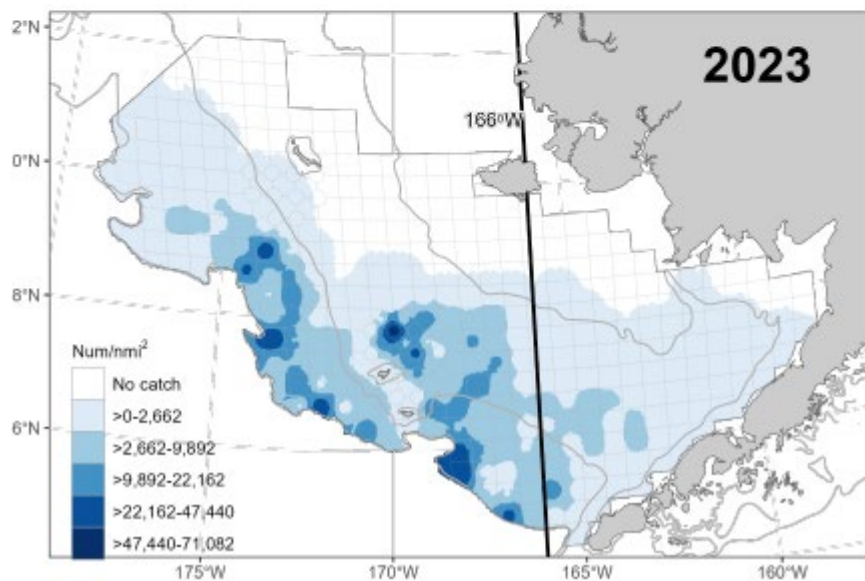
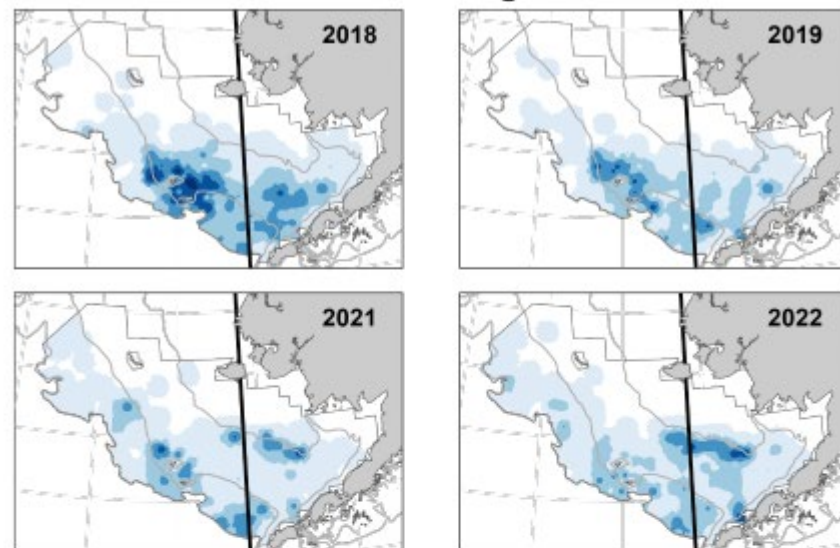
Survey size composition



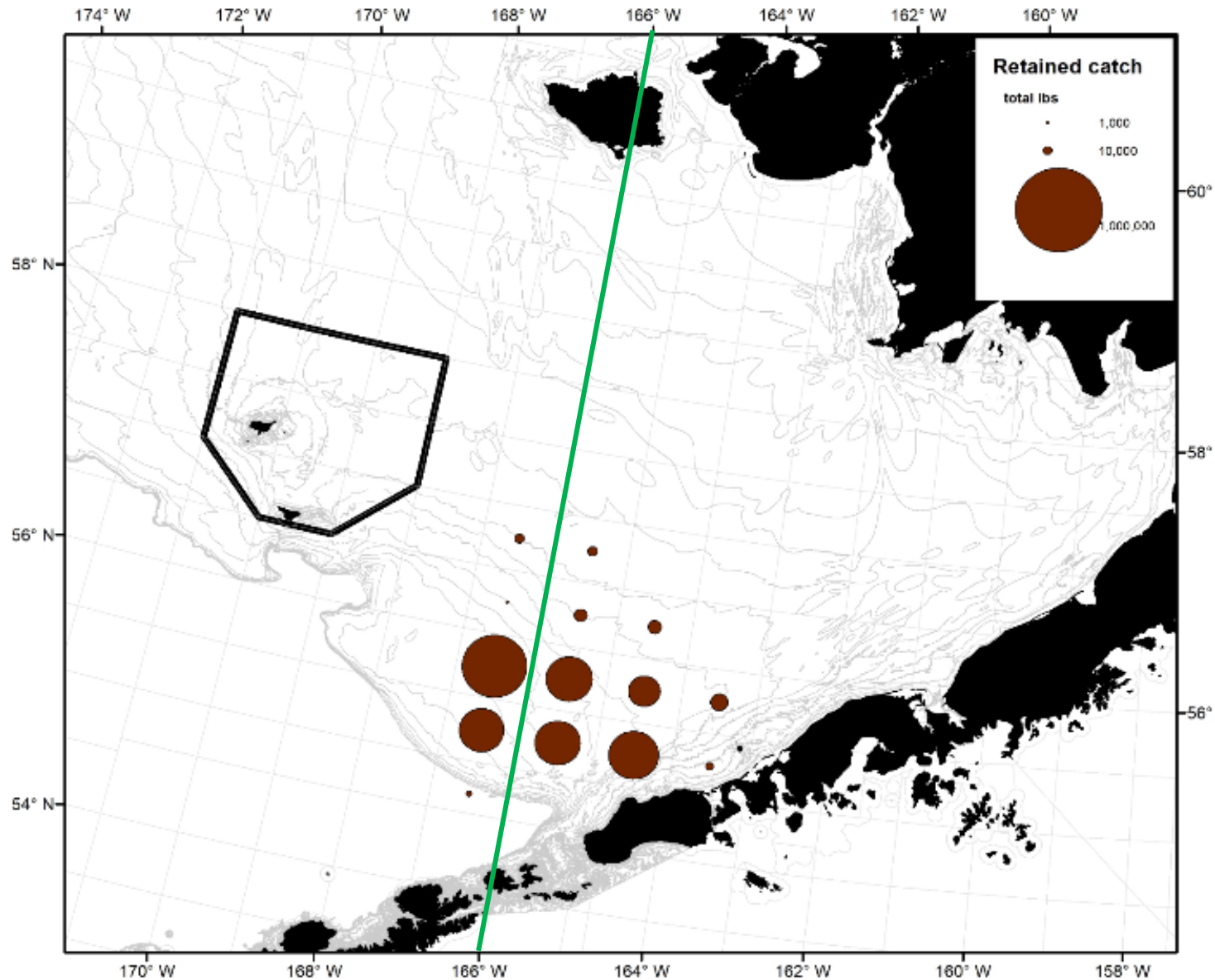
Tanner Crab Small Male



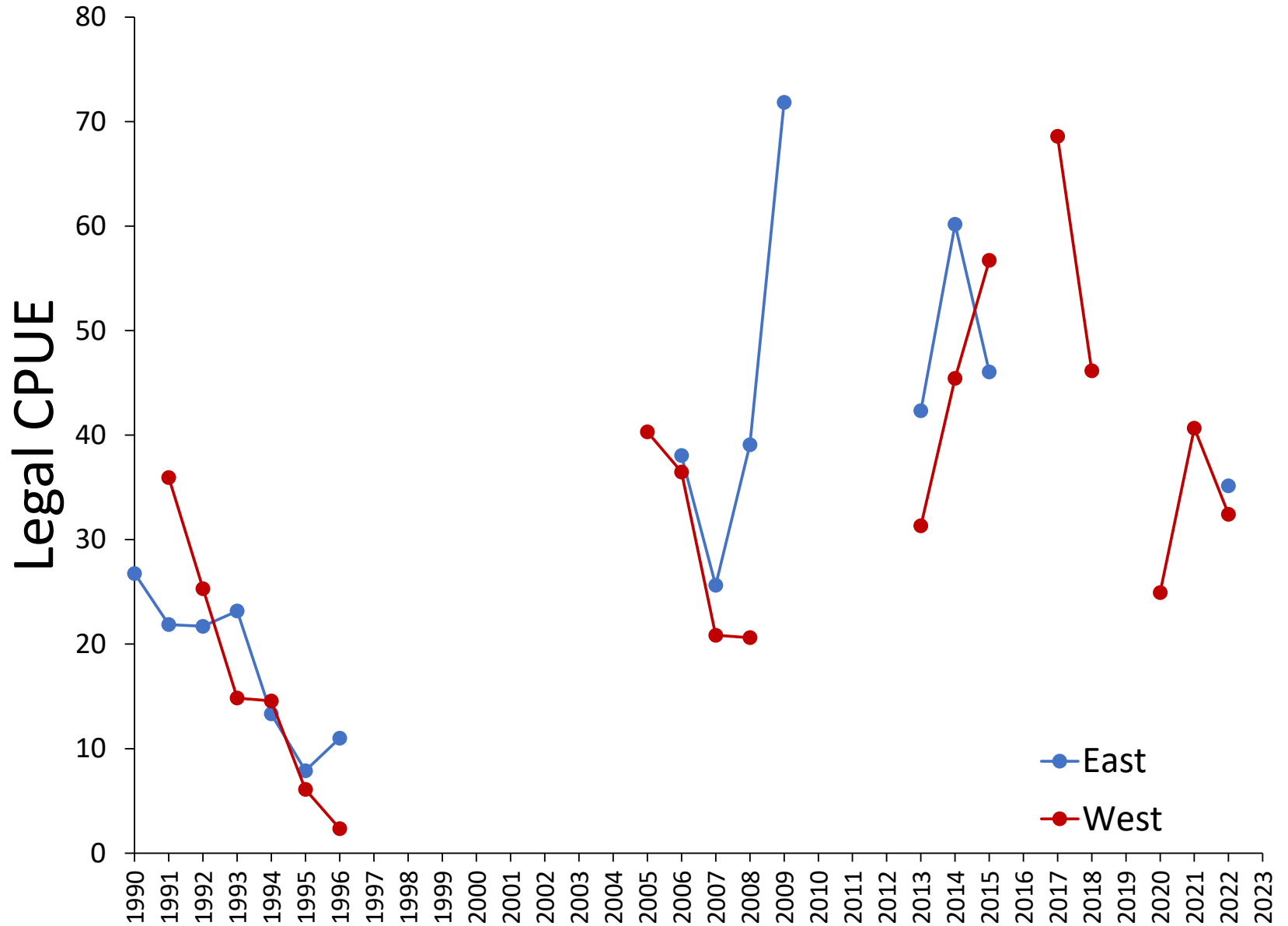
Tanner Crab Large Male



2022/23 Tanner crab fishery retained catch

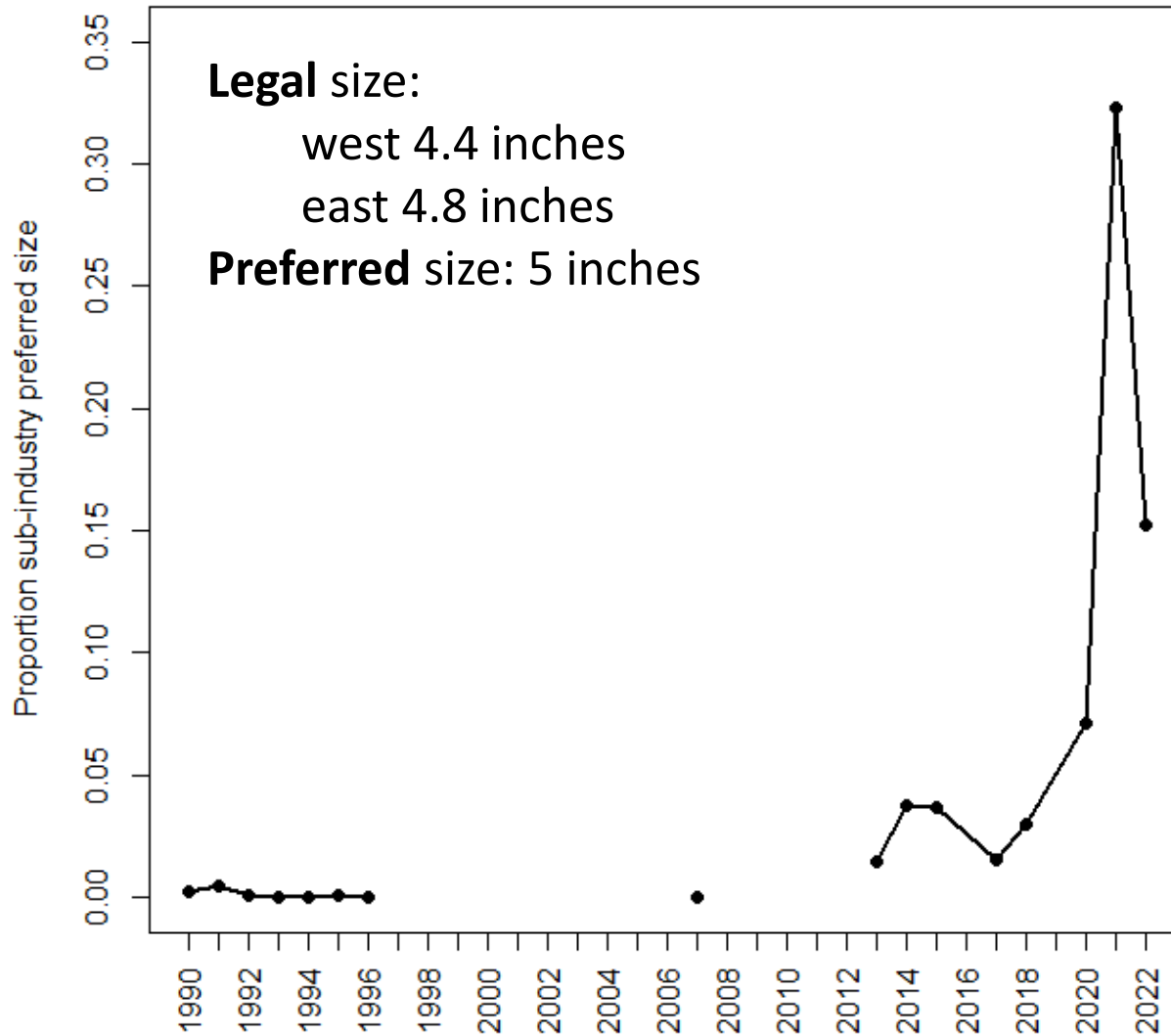


2022/23 Tanner crab retained catch CPUE

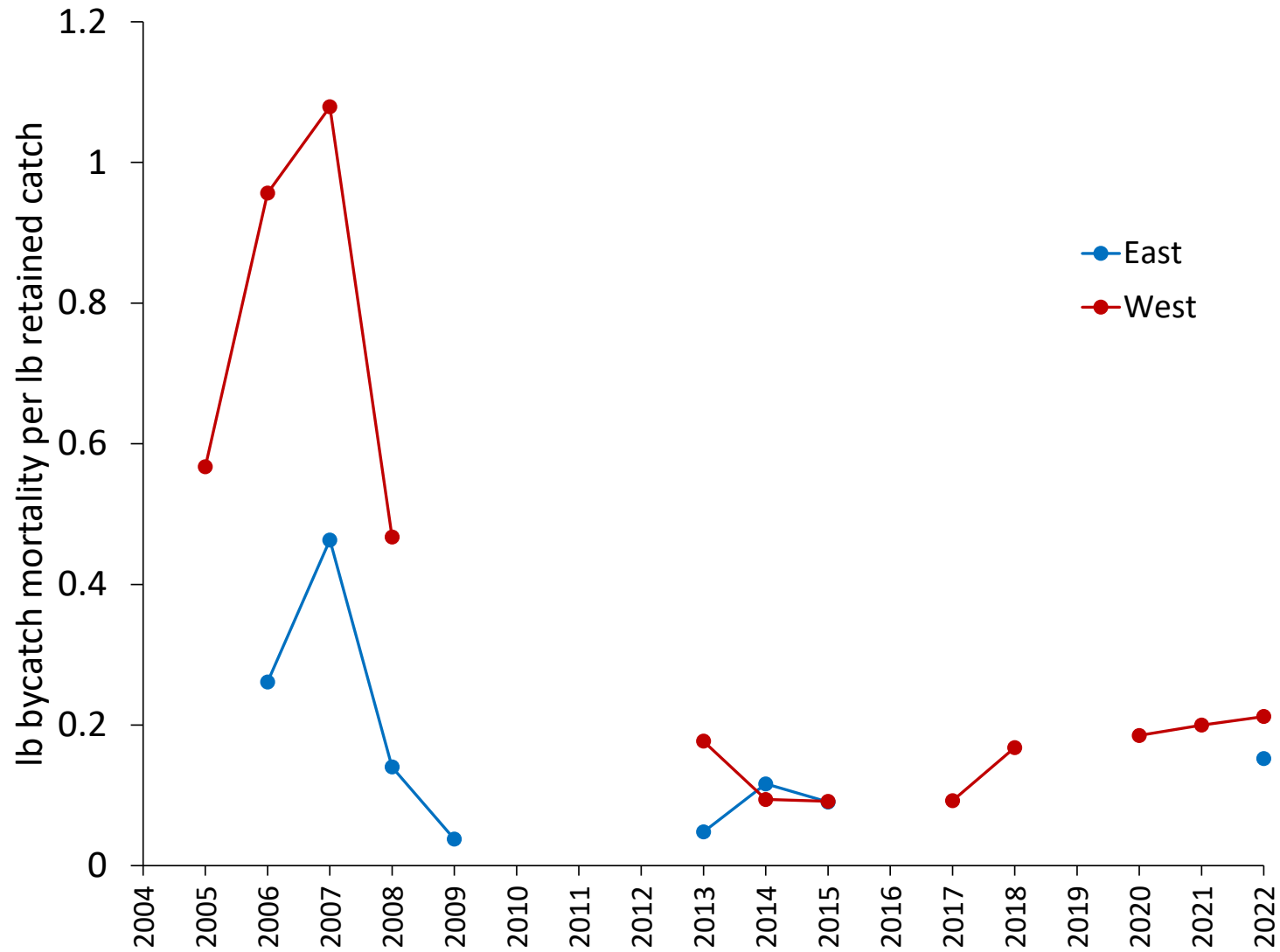


Retained Catch Size

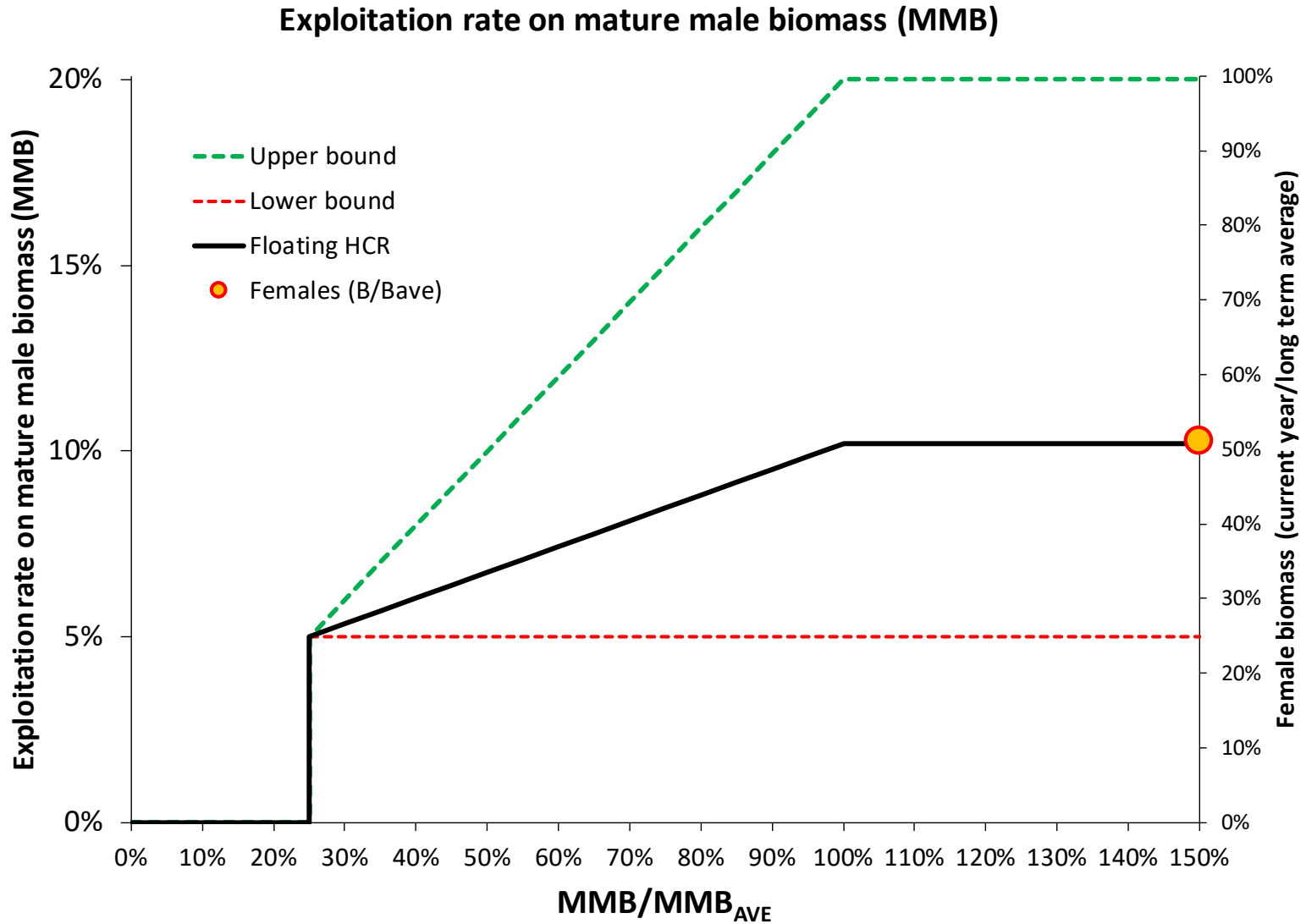
Retained catch (dockside data)



Tanner crab discard mortality rate



Harvest Strategy - Female Dimmer



Harvest Strategy 50% ELM Cap

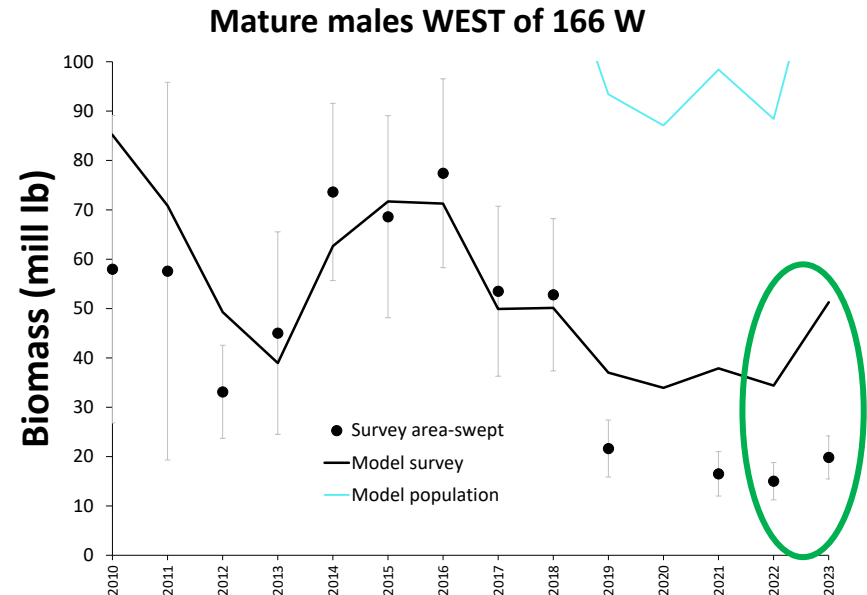
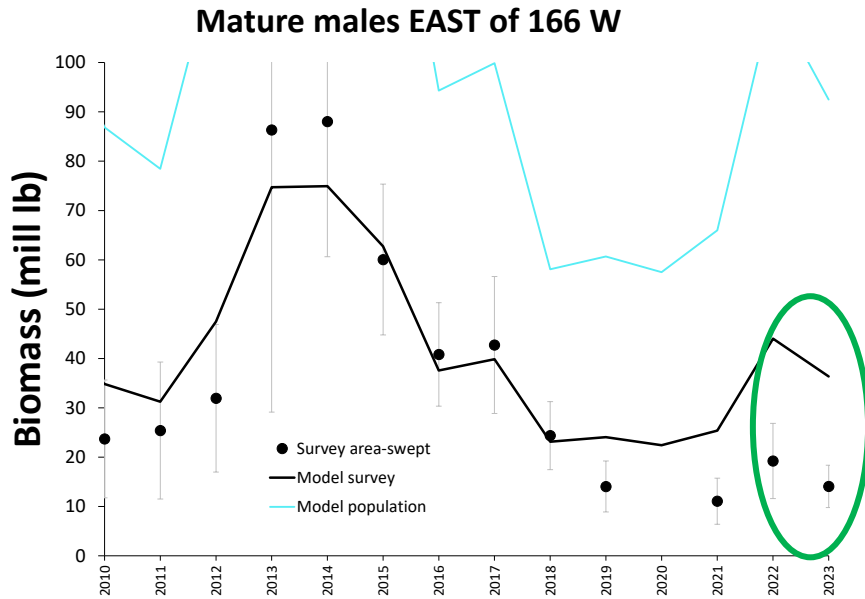
- Prevents overexploitation of large newshell males when small mature male (<5-inch) biomass is high
- ELM= exploitable legal males
 - 5 inch males: 100% newshell + 40% oldshell
 - Considers selectivity of oldshell crabs: industry generally prefers “clean” crab (i.e., mostly newshell)
 - Mean OS selectivity = ~40%
- Sensitive to industry preferred size
- TAC capped at 50% of ELM: **$0.5 * \text{ELM} * \text{ave wt}$**

Application of State Harvest Strategy

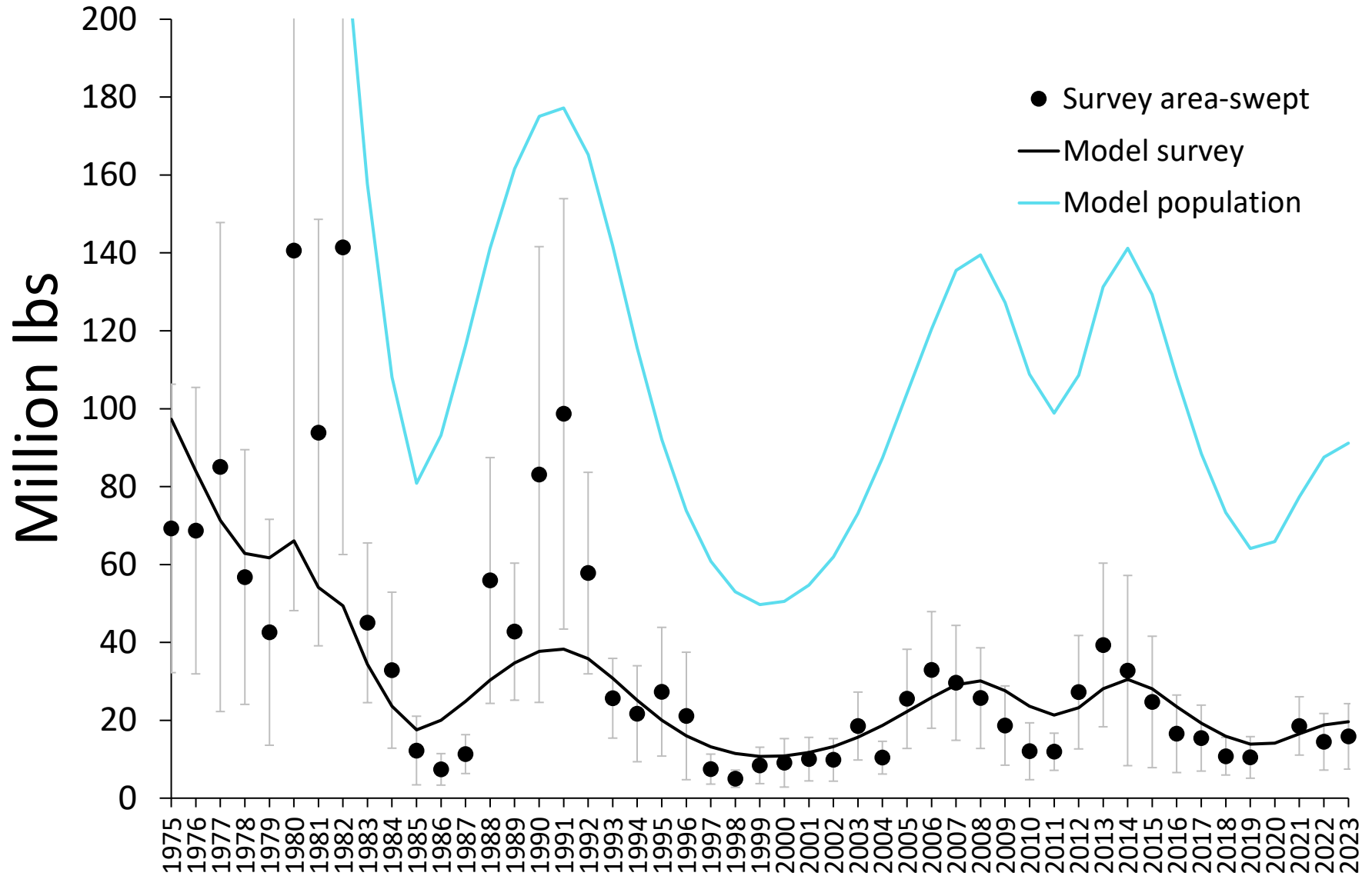
Three TAC calculations for comparison

- 1. Survey area-swept:** survey area-swept, size cut for male maturity
- 2. Model survey:** model estimates of survey, estimated maturity
- 3. Model population:** accounts for survey selectivity

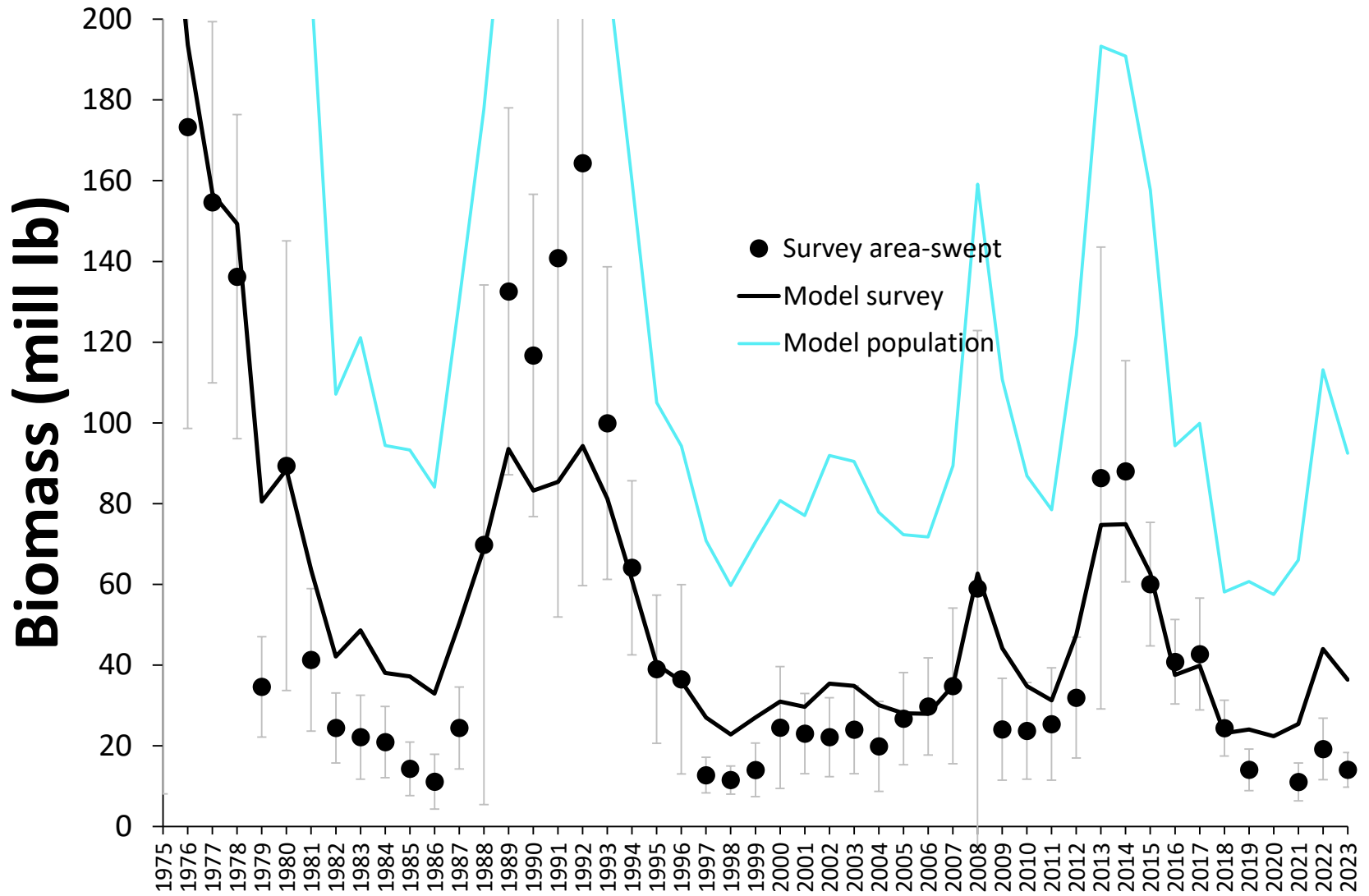
2023 model survey MMB $\sim 2.5X$ survey estimate



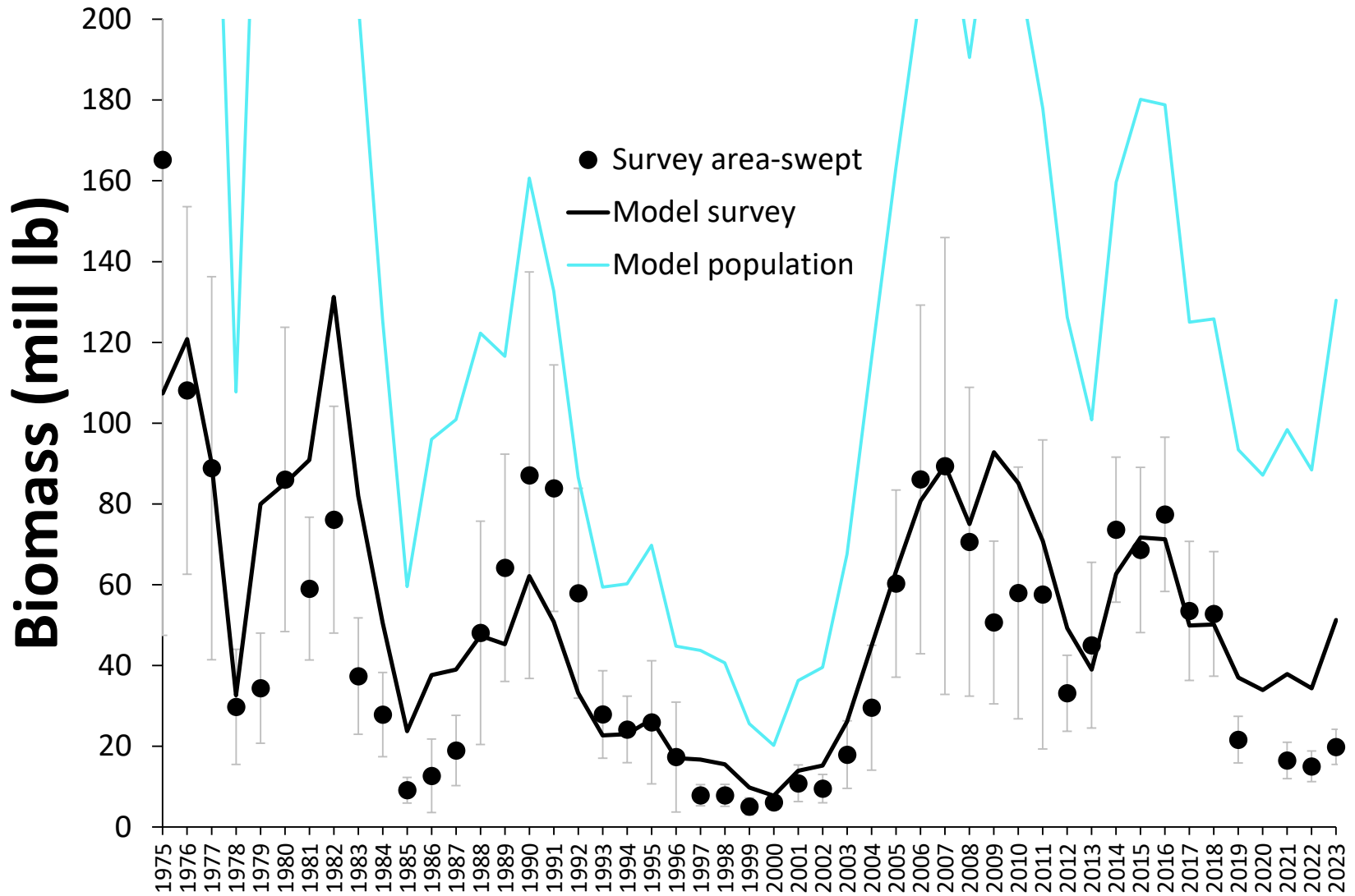
Mature female biomass **Entire EBS**



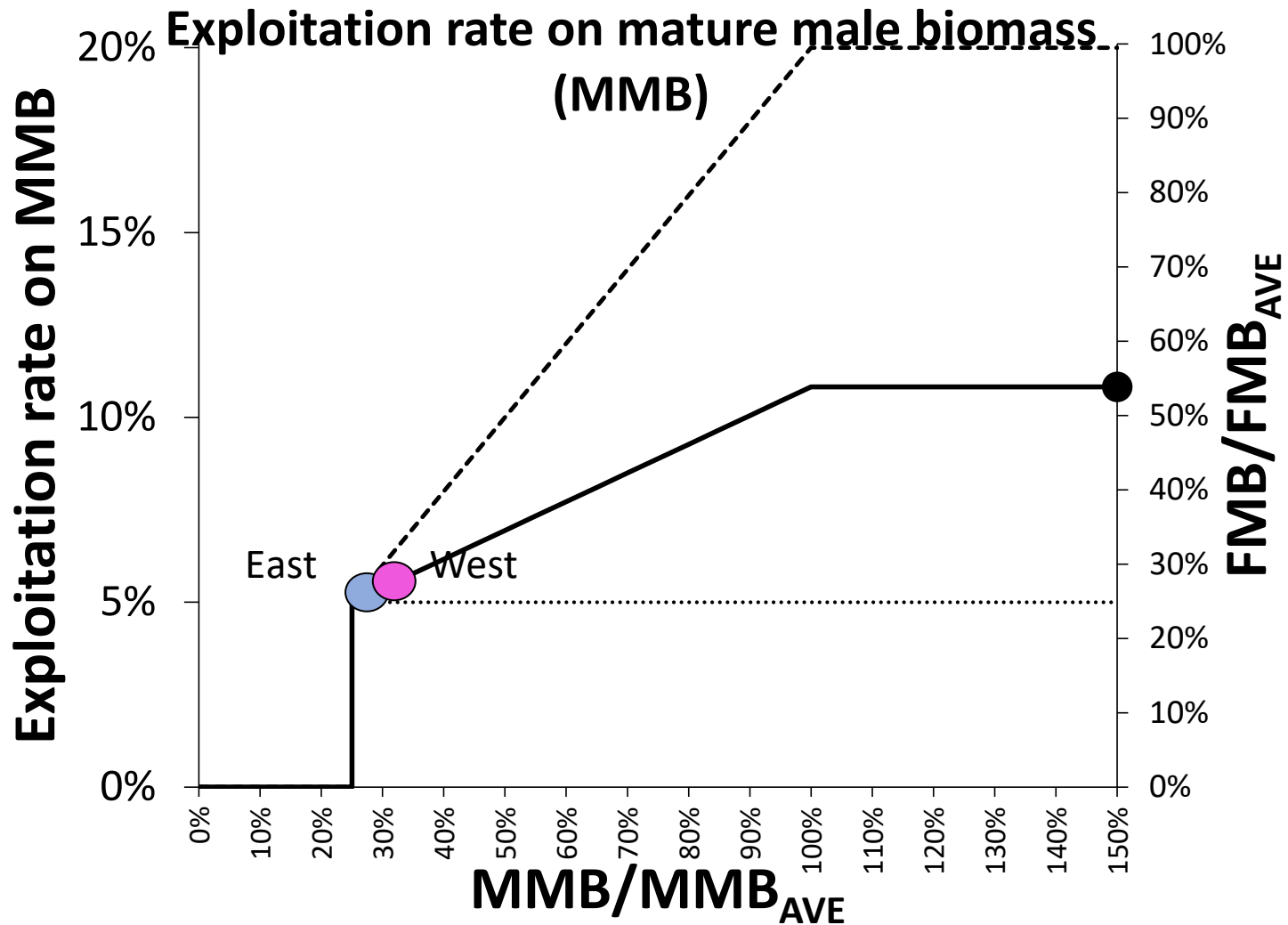
Mature males EAST of 166 W



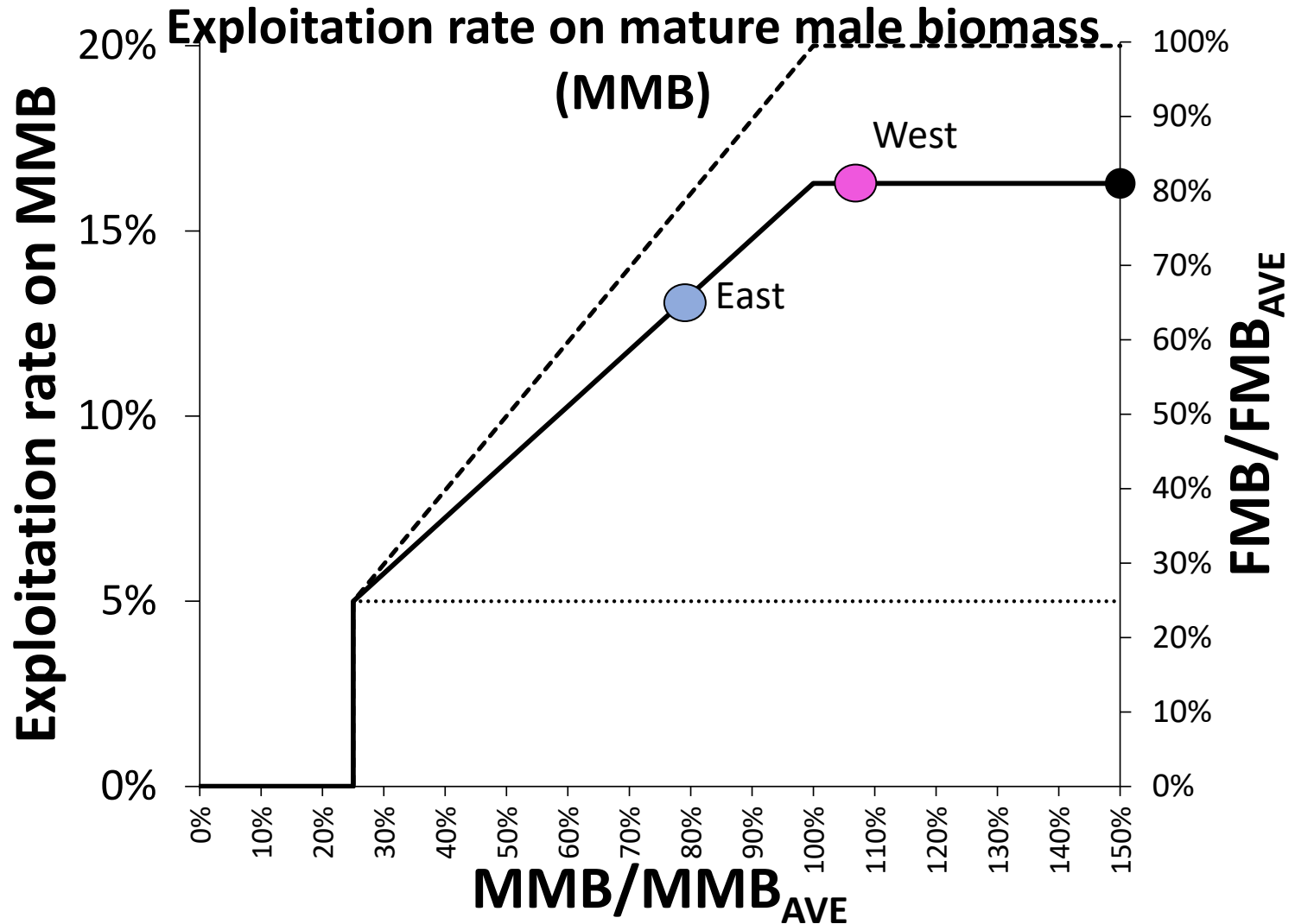
Mature males WEST of 166 W



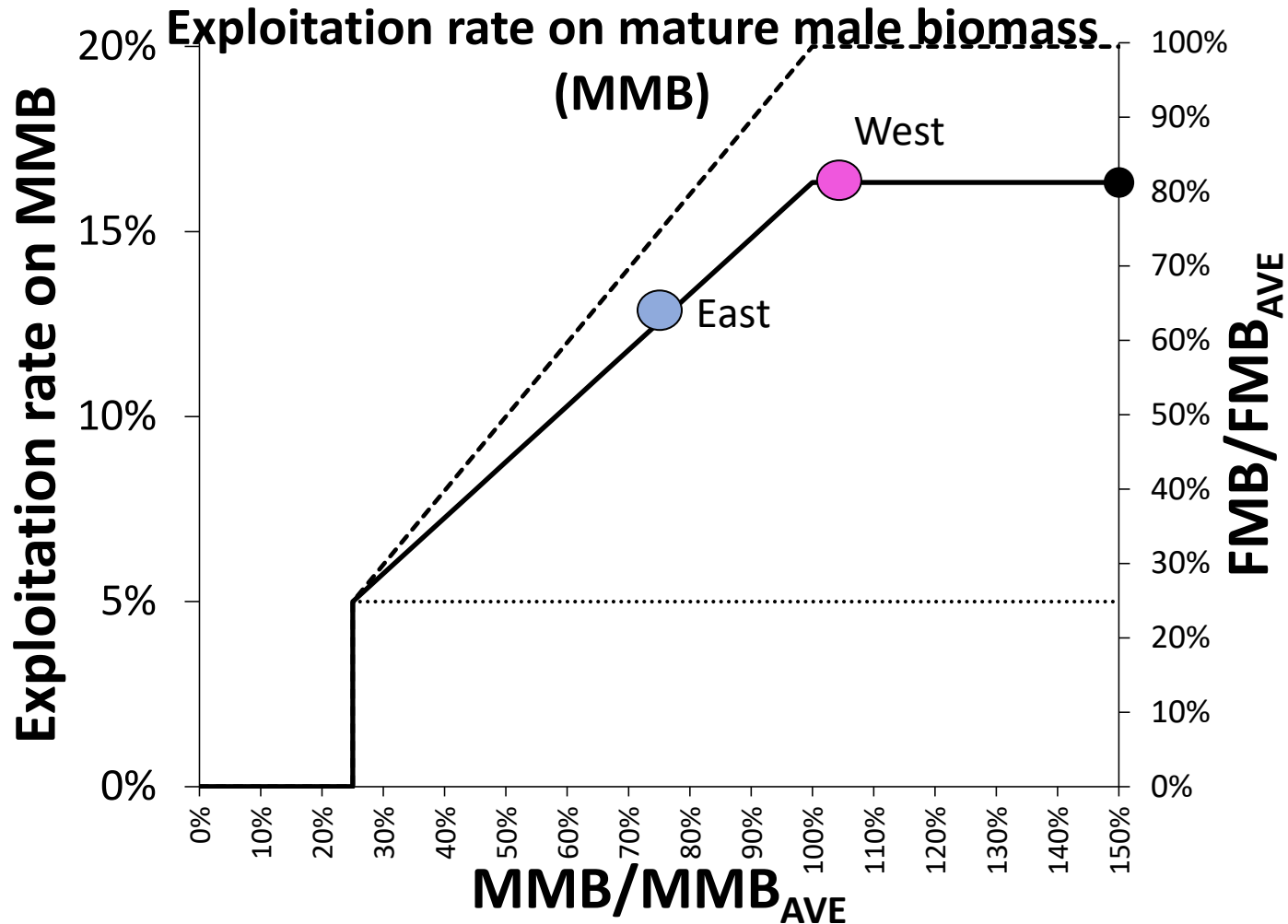
Survey Data



Model Survey Data



Model Population Data



Tanner East TAC Calculations

Computed 2023/24 TACs: area-swept and Model estimates. Assumed old-shell fishery selectivity = 0.40 relative to new-shell.

	Raw area-swept (size cut)		Survey (Model Predicted)		Population (Model Estimated)	
	MFB	MMB	MFB	MMB	MFB	MMB
	1982-2018 Average (millions lb)	29.4	46.8	24.1	47.4	111.7
2023 Estimate (millions lb)	15.9	14.1	19.7	36.4	91.2	92.5
(2023 Est)/(1982-2018 Avg)	54%	30%	81%	77%	82%	76%
Exploitation Rate on MMB		0.054		0.128		0.127
Computed TAC = Exp Rate X MMB (millions lb)		0.76		4.65		11.74
Max TAC (50% cap on exploited legal males (million lb)		3.19		10.36		23.77
TAC		0.759		4.645		11.74

	Area-swept (Raw NOAA values)	Survey (Model Predicted)	Population (Model Estimated)
Abundance of ♂♂ ≥ 5-in CW (millions)	4.7	15.3	35.2
Average wt (W; from survey; lb)	1.671	1.671	1.671
% old shell (from area-swept)	32%	32%	32%
Expected old shell selectivity	0.4	0.4	0.4
Exploited legal males ("ELM"; millions)	3.8	12.4	28.5
Max TAC (= 0.5xELMxW; millions lb)	3.19	10.36	23.77

Tanner West TAC Calculations

Computed 2023/24 TACs: area-swept and Model estimates. Assumed old-shell fishery selectivity = 0.40 relative to new-sh

	Raw area-swept (size cut)		Survey (Model Predicted)		Population (Model Estimated)	
	MFB	MMB	MFB	MMB	MFB	MMB
	1982-2018 Average (millions lb)	29.4	43.0	24.1	48.5	111.7
2023 Estimate (millions lb)	15.9	19.8	19.7	51.3	91.2	130.5
(2023 Est)/(1982-2018 Avg)	54%	46%	81%	106%	82%	106%
Exploitation Rate on MMB		0.066		0.163		0.163
Computed TAC = Exp Rate X MMB (millions lb)		1.32		8.35		21.30
Max TAC (50% cap on exploited legal males (million lb)		1.79		5.81		13.32
TAC		1.318		5.806		13.32

	Area-swept (Raw NOAA values)	Survey (Model Predicted)	Population (Model Estimated)
Abundance of ♂♂ ≥ 5-in CW (millions)	3.4	11.1	25.5
Average wt (W; from survey; lb)	1.531	1.531	1.531
% old shell (from area-swept)	53%	53%	53%
Expected old shell selectivity	0.4	0.4	0.4
Exploited legal males ("ELM"; millions)	2.3	7.6	17.4
Max TAC (= 0.5xELMxW; millions lb)	1.79	5.81	13.32

EAST TAC = **0.759 million pounds**

WEST TAC = **1.318 million pounds**

- Uncertainty with model 2023 estimates
 - Model MMB ~2.5x survey
 - Model 5-inch male ~3.25x survey
- Survey abundance for MMB + 5-inch males decreased in the East and increased in the West compared to 2022

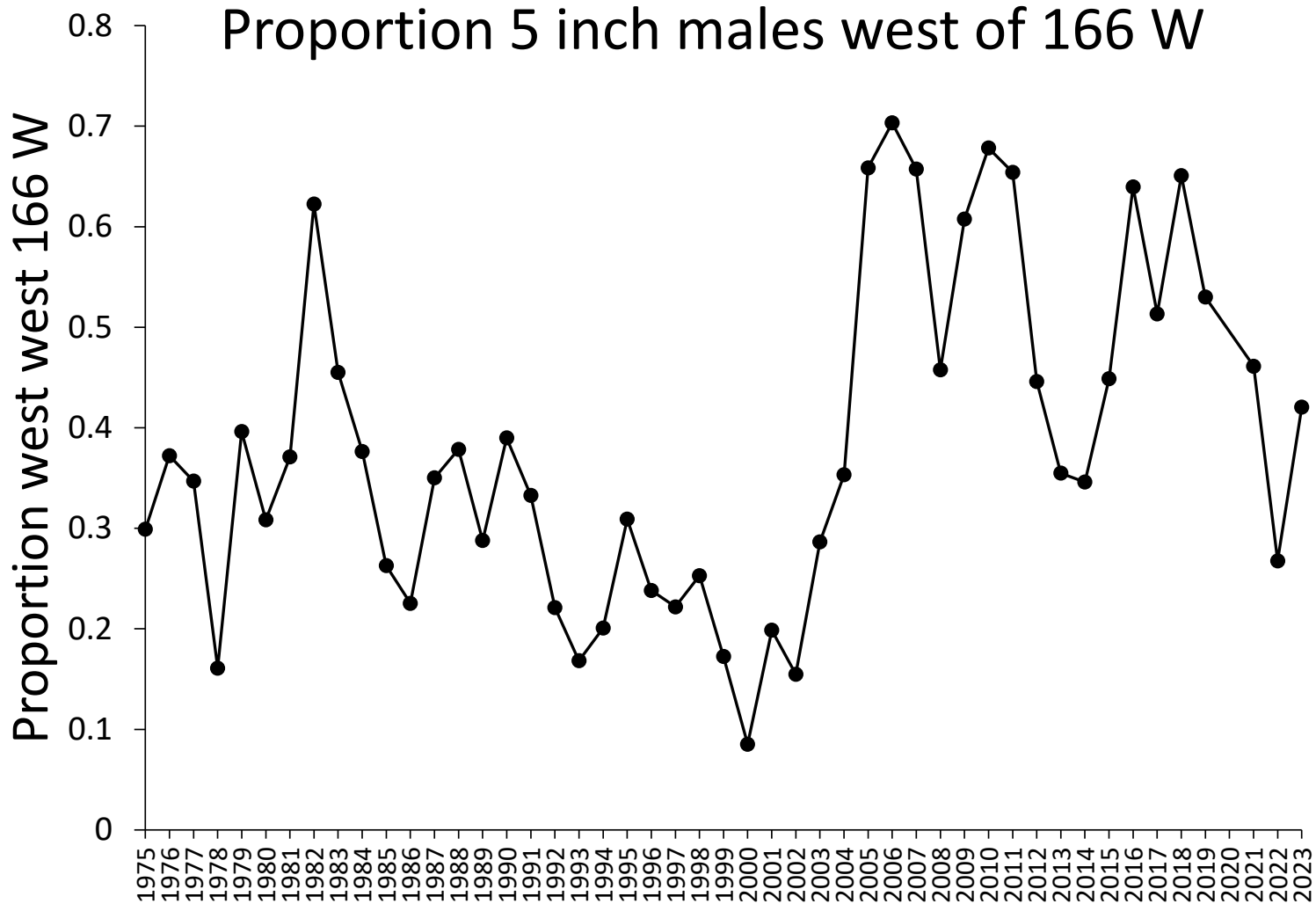
Tier 4 OFL calculations

- Not recommended for 2023/24 assessment
- Requested by CPT/SSC at simpler modelling workshop as fallback option
- Uses M and MMB_{AVE} as proxies for F_{MSY} and B_{MSY}
- **OFL = 3.46 million pounds** (Tier 3 = 80 million pounds)
- **ABC = 3.12 million pounds** (Tier 3 = 64 million pounds)
- **Combined TAC = 2.08 million pounds**
 - 3% of Tier 3 ABC
 - 67% of Tier 4 ABC

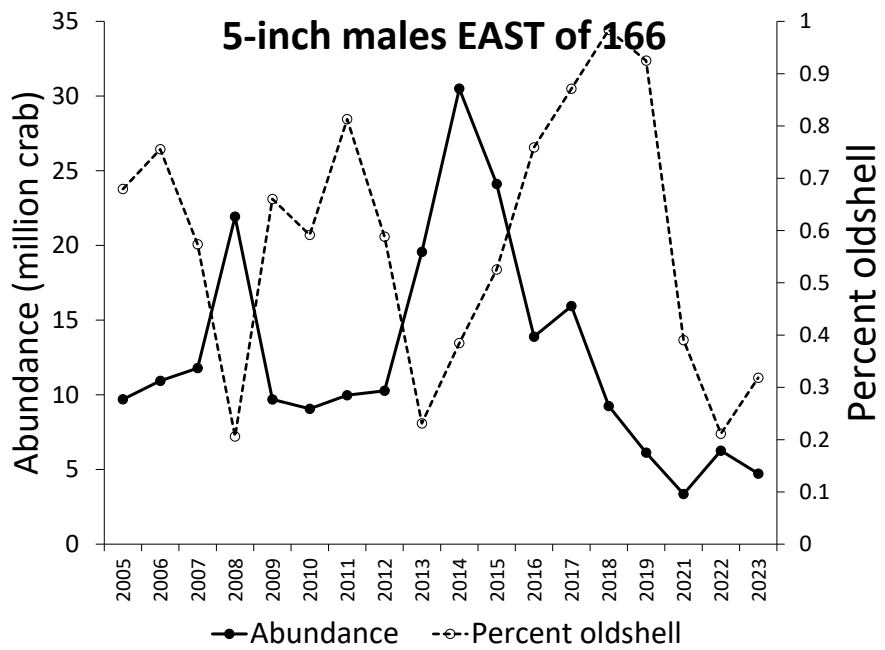
Summary

- Combined TACs **2.08 million pounds**
 - Approximately the same as in 2022 (2.01 million lbs)
 - Same logic used to set TACs
 - Large difference with Tier 3 OFL/ABC due to terminal year over-estimation
 - TACs have closer alignment to Tier 4 OFL/ABC
- Good signs of recruitment, but strong juvenile cohorts not propagating to larger sizes
 - Unclear what is causing bottleneck
 - Large cohort of Tanners could compete with snow crab
- Warm conditions likely to become more frequent in future
 - Tanners seem to show some resiliency

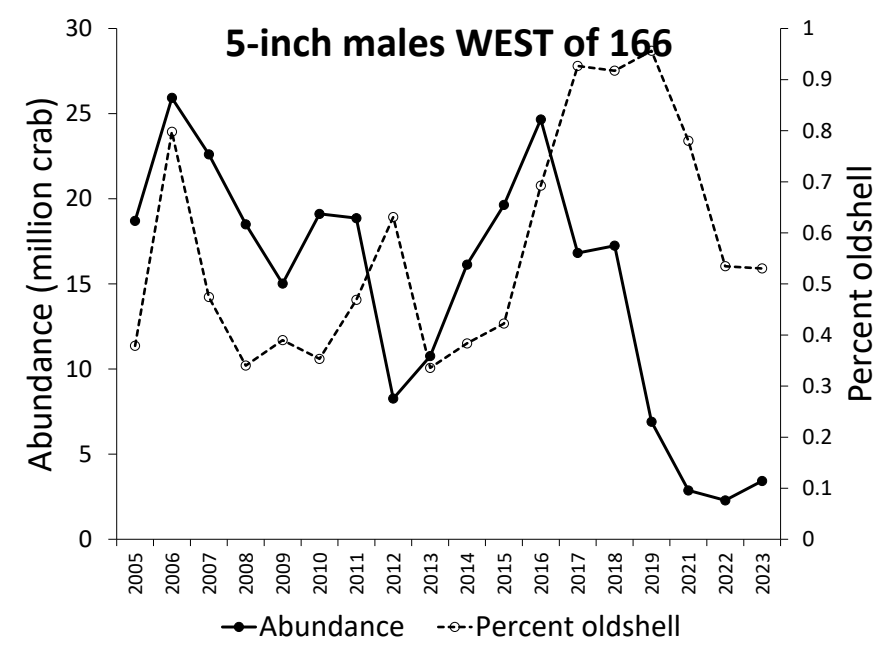
2023/24 Fishery Expectations



2023/24 Fishery Expectations



2023 survey: 32% oldshell 5-inch males



2023 survey: 53% oldshell 5-inch males

Questions