Norton Sound Red King Crab SAFE 2023

Jan 18 2023

Crab Plan Team:
NPFMC Building-Online
Anchorage AK

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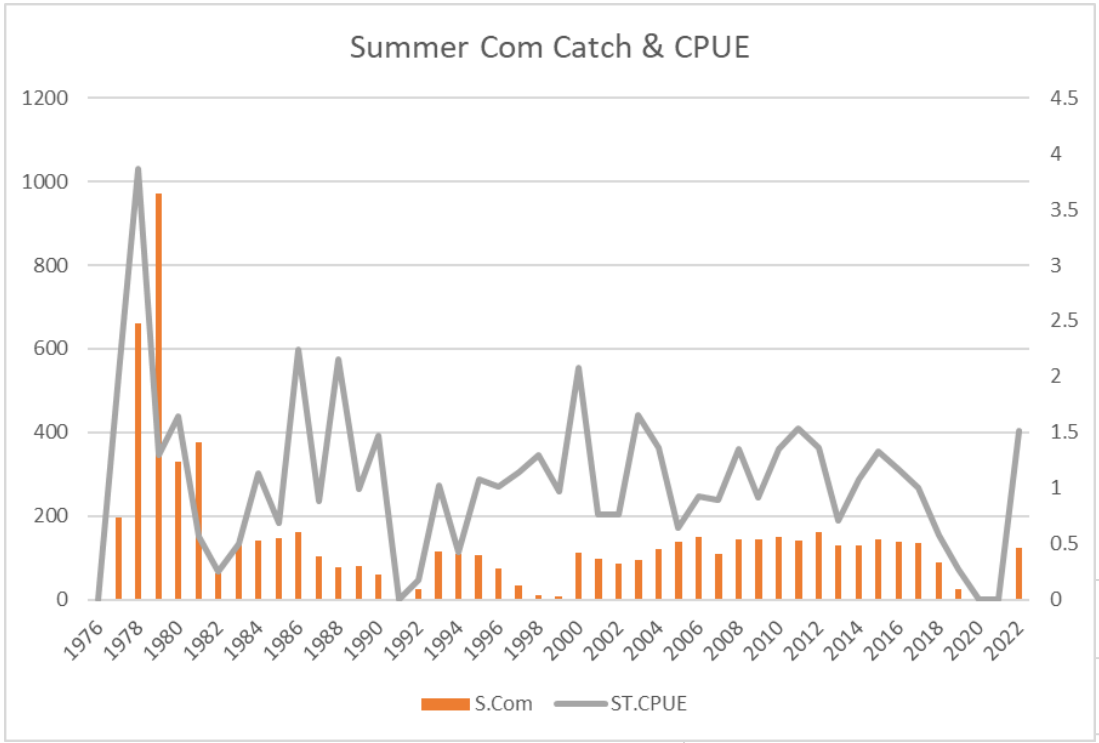
Issues to Determine – Discuss

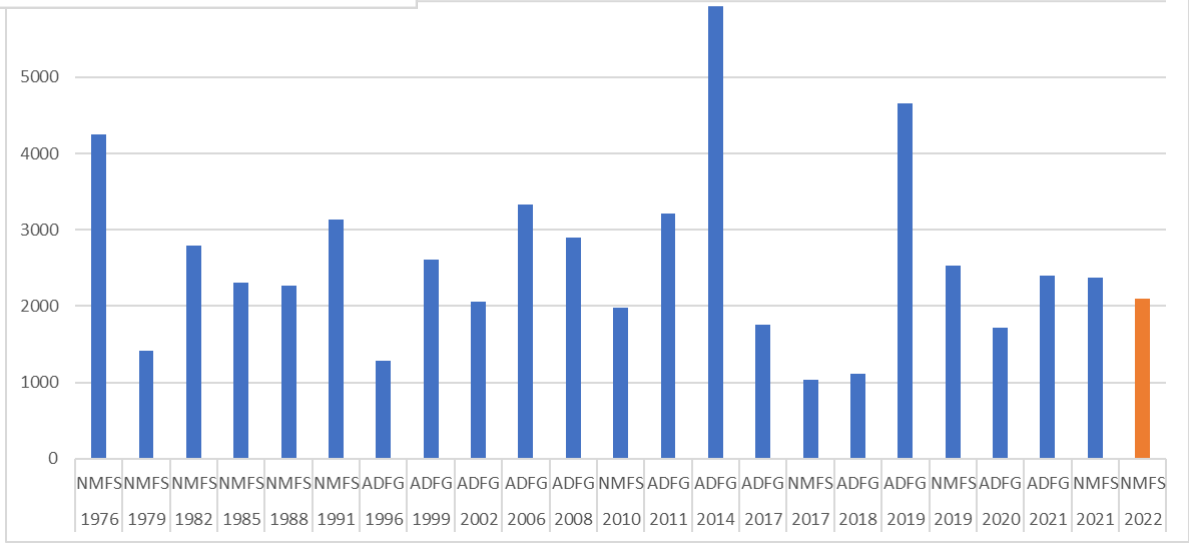
- Issue to Determine
  - OFL-ABC recommendation based on the recommended Model 21.0
    - With final updated data: Trawl survey data

- Issue to Discuss (As time and willingness allows)
  - Length-independent vs. length-dependent OFL-ABC
  - Discards Estimate: with and WITHOUT data.

Summer Com Catch and CPUE , and Trawl abundance



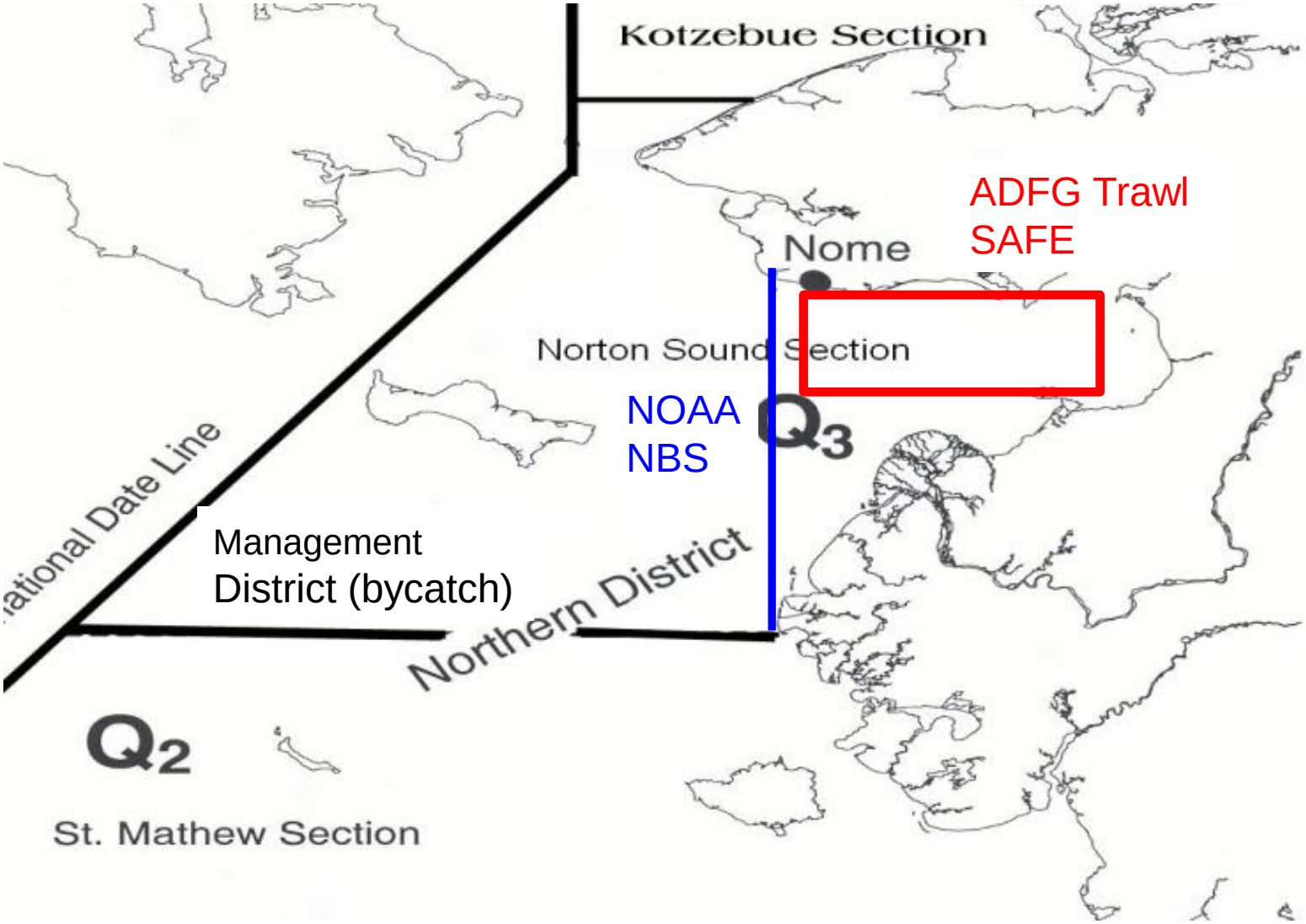
Abundance



Fishery & Data Sept 2022

- ABC: 0.40 mil. lb. Total catch: 0.34 + 0.00 – 0.20 mil. lb depending on discards estimation method.
  - Overfishing did not occur
- NOAA 2022 NBS trawl survey
  - 8/3,4,11,12 : 2,103,000 (CV: 0.368) (CL > 64mm)
  - Differ from “Official” NOAA estimates

Where is Norton Sound?



NSRKC Final Assessment Models

- Model 21.0: 2022 final model with data update

- Model 22.0: Model 21.0 + shell specific retention probability
  - CPT: Oldshell crabs are more likely to be discarded)

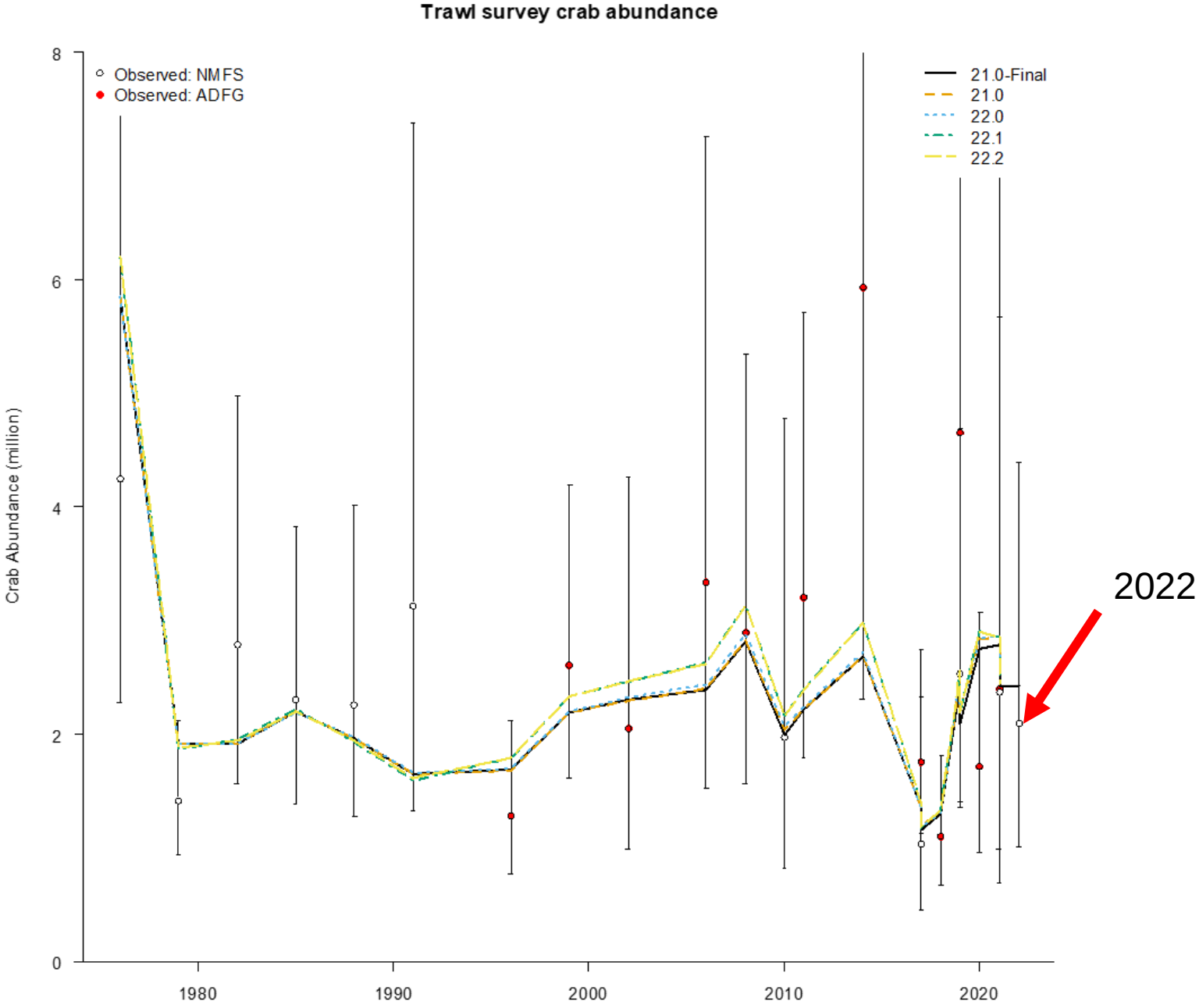
- Model 22.1: Model 21.0 + individual *M* estimate
  - SSC: May explain the lack of model fit to trawl and Com retain size-shell composition

- Model 22.2: Model 22.0 + individual *M* estimate

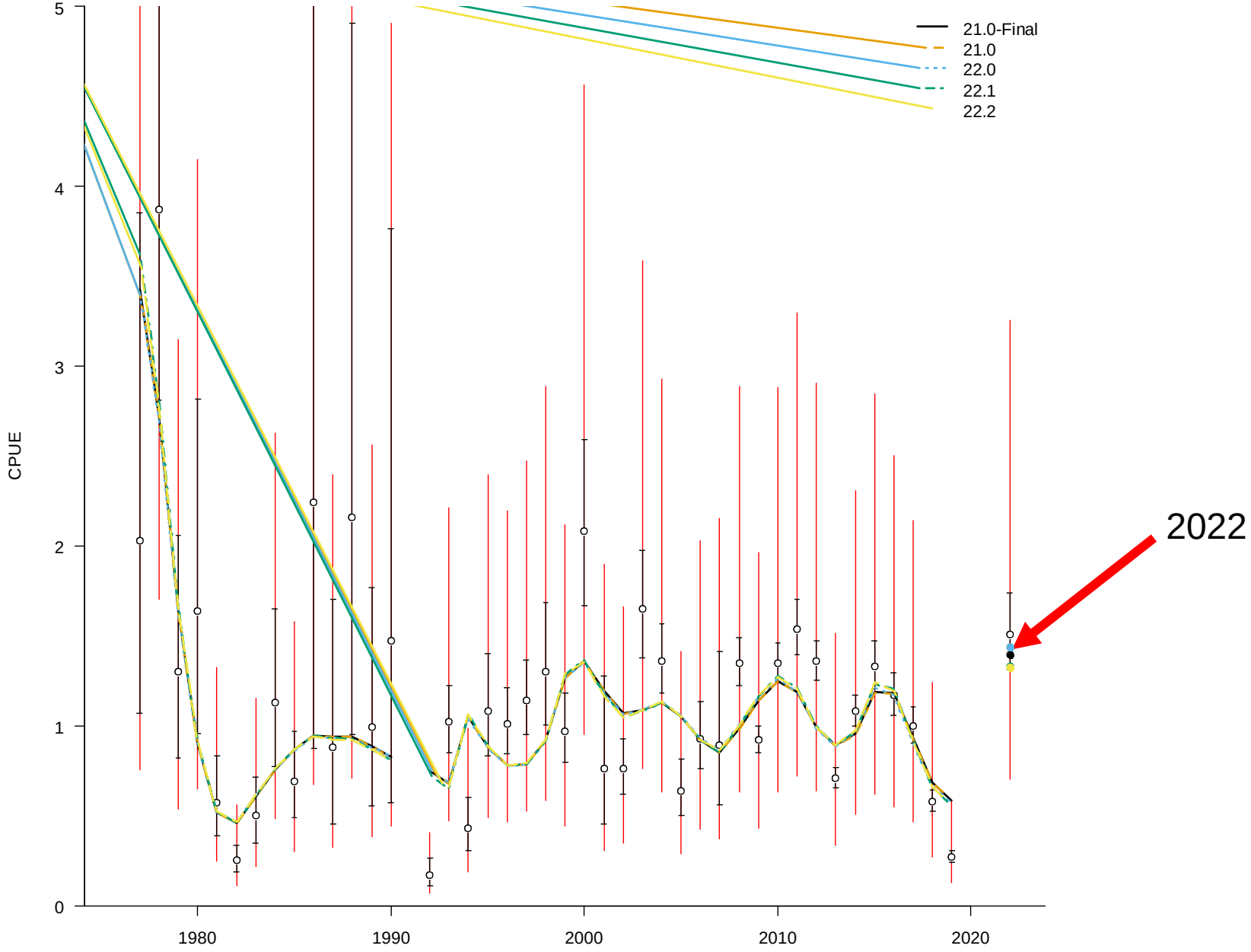
NSRKC Final Assessment Models Likelihood

	Final	Sept 2022			
Model	21.0	21.0	22.0	22.1	22.2
Additional Parameters			+4	+8	+12
AIC change			+6	+5.4	+24
Total	354.1	347.9	346.1	342.6	341.1
TSA	11.0	11.0	10.8	10.5	10.5
DIS	3.4	3.5	4.5	3.3	3.6
St.CPUE	-14.8	-14.8	-14.9	-15.1	-15.0
TLP	134.0	129.0	126.4	125.5	123.7
WLP	39.6	39.5	39.3	39.3	39.1
CLP	49.5	49.3	48.5	48.7	48.9
OBS	24.3	24.3	25.0	24.9	25.1
WCLP	2.8	2.7	2.9	2.5	2.7
REC	19.4	19.5	19.6	20.1	20.1
TAG	85.0	83.9	83.9	82.9	83.4
Max gradient (e-6)	7.6	4.9	2009	14.7	4.55
RMSE Trawl	0.34	0.34	0.34	0.33	0.33
RMSE CPUE	0.44	0.44	0.44	0.44	0.44

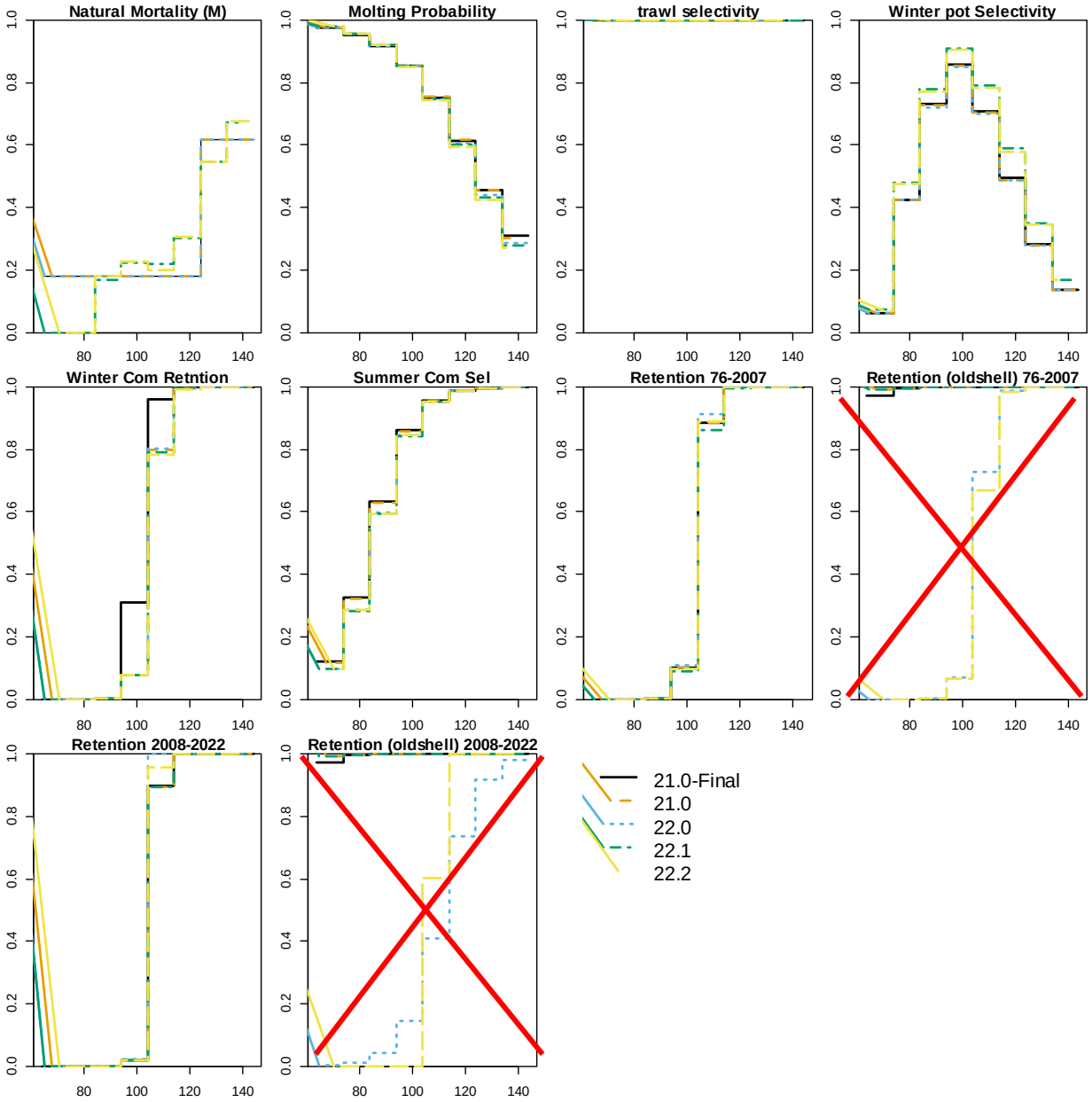
NSRKC Trawl Survey



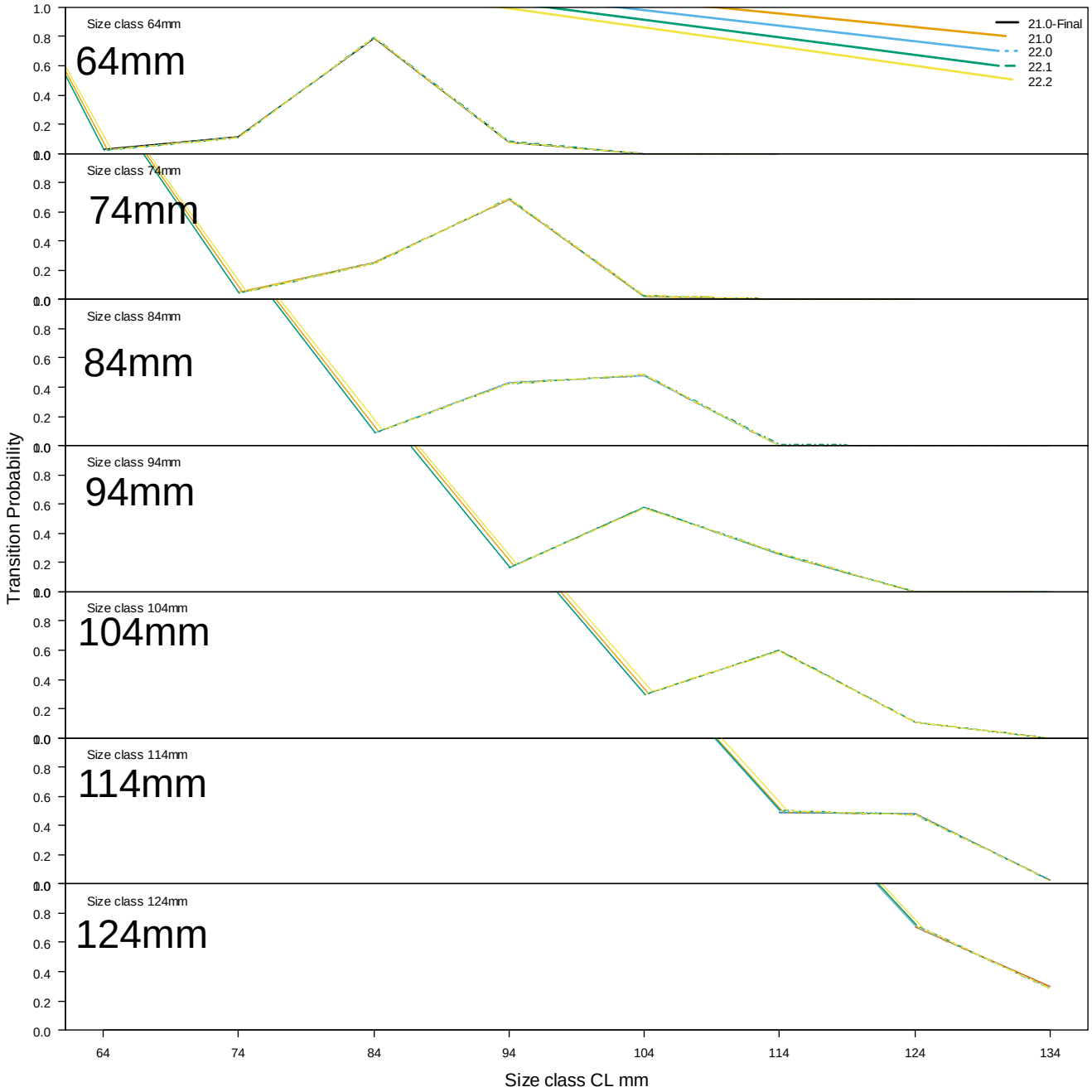
St CPUE


Summer commercial standardized cpue
CPUE
0
1
2
3
4
5
1980
1990
2000
2010
2020
21.0-Final
21.0
22.0
22.1
22.2
2022

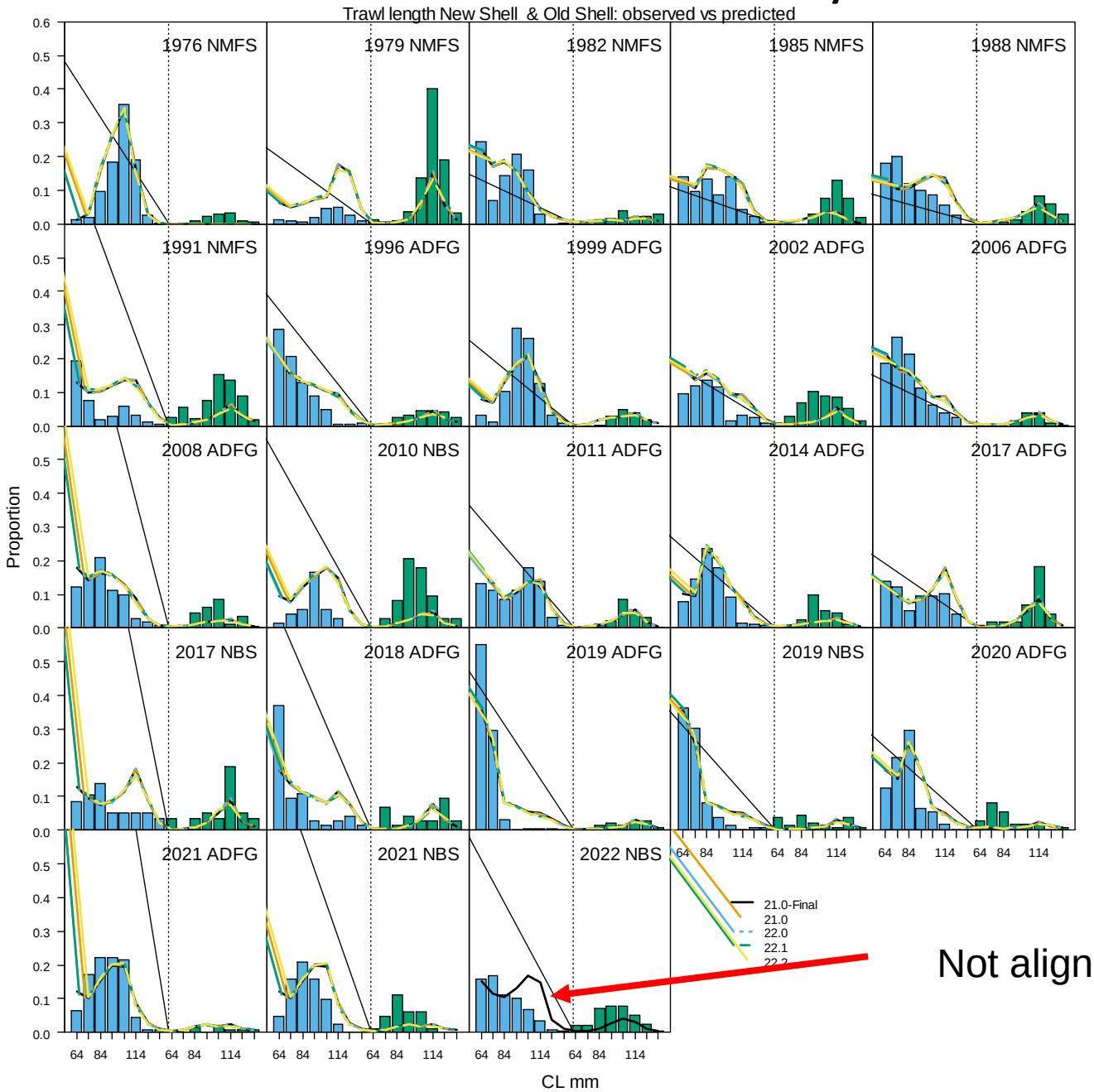
M, molting, selectivity, retention



Size transition probability

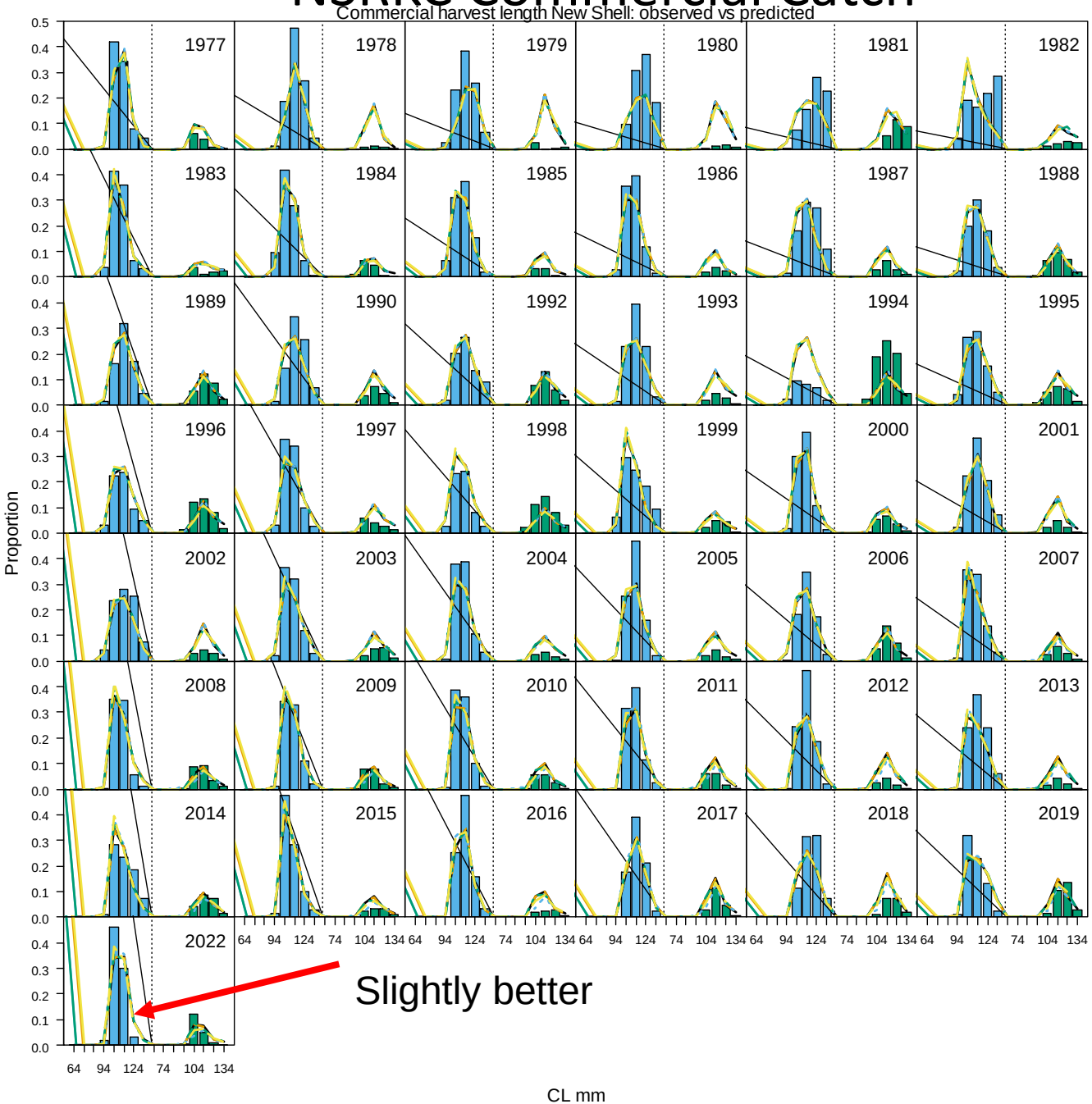


NSRKC Trawl Survey

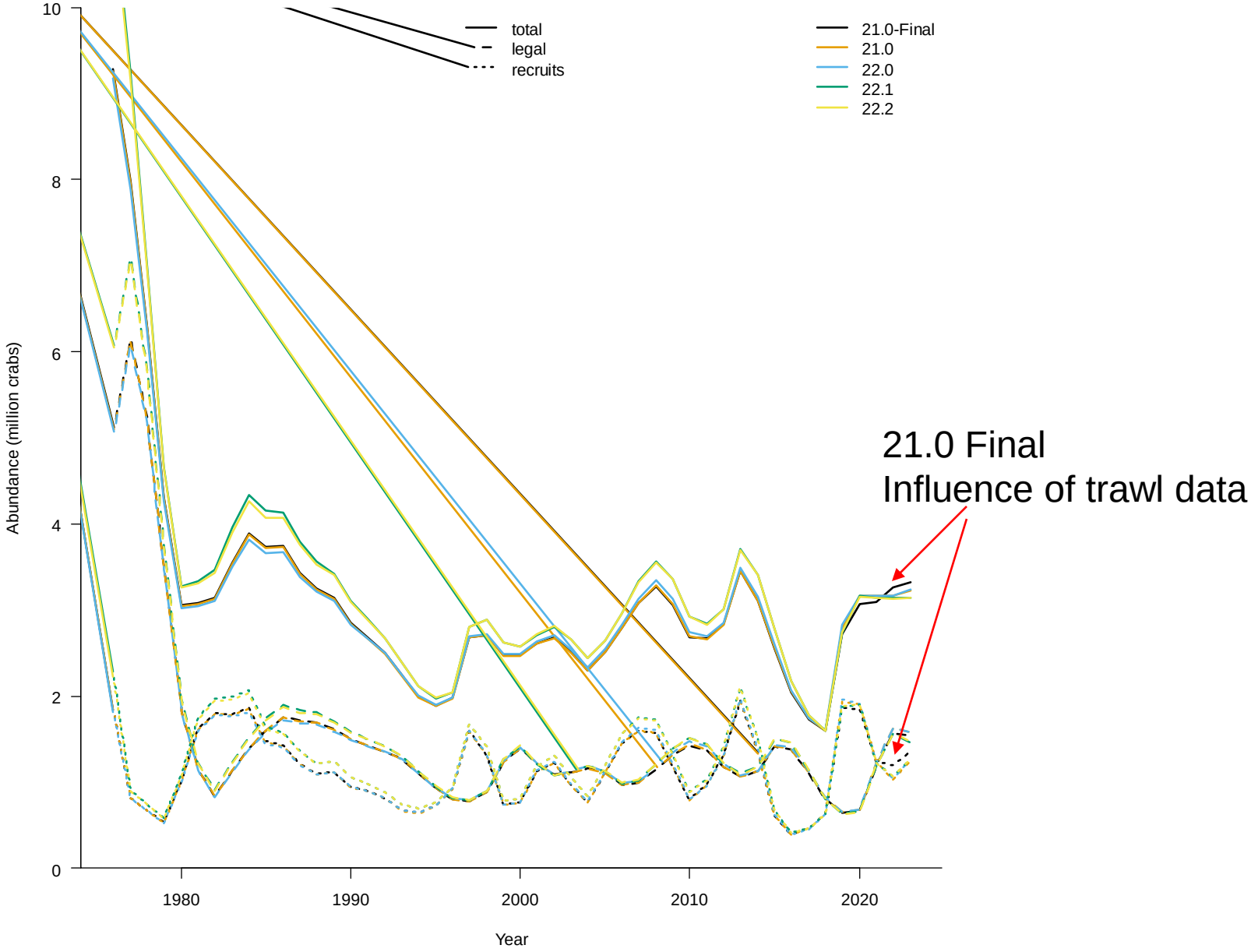


Not aligning well

NSRKC Commercial Catch

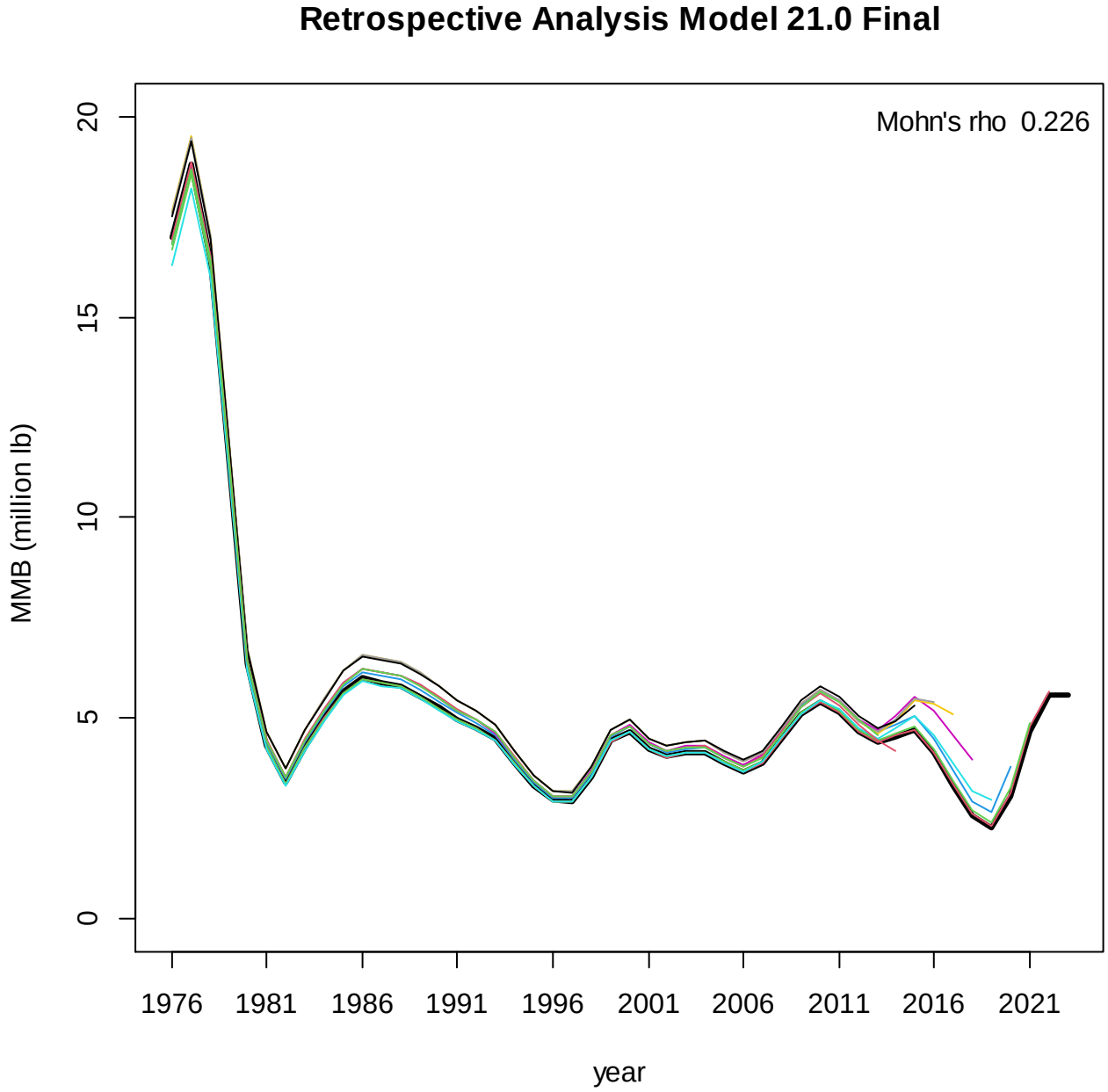


Abundance

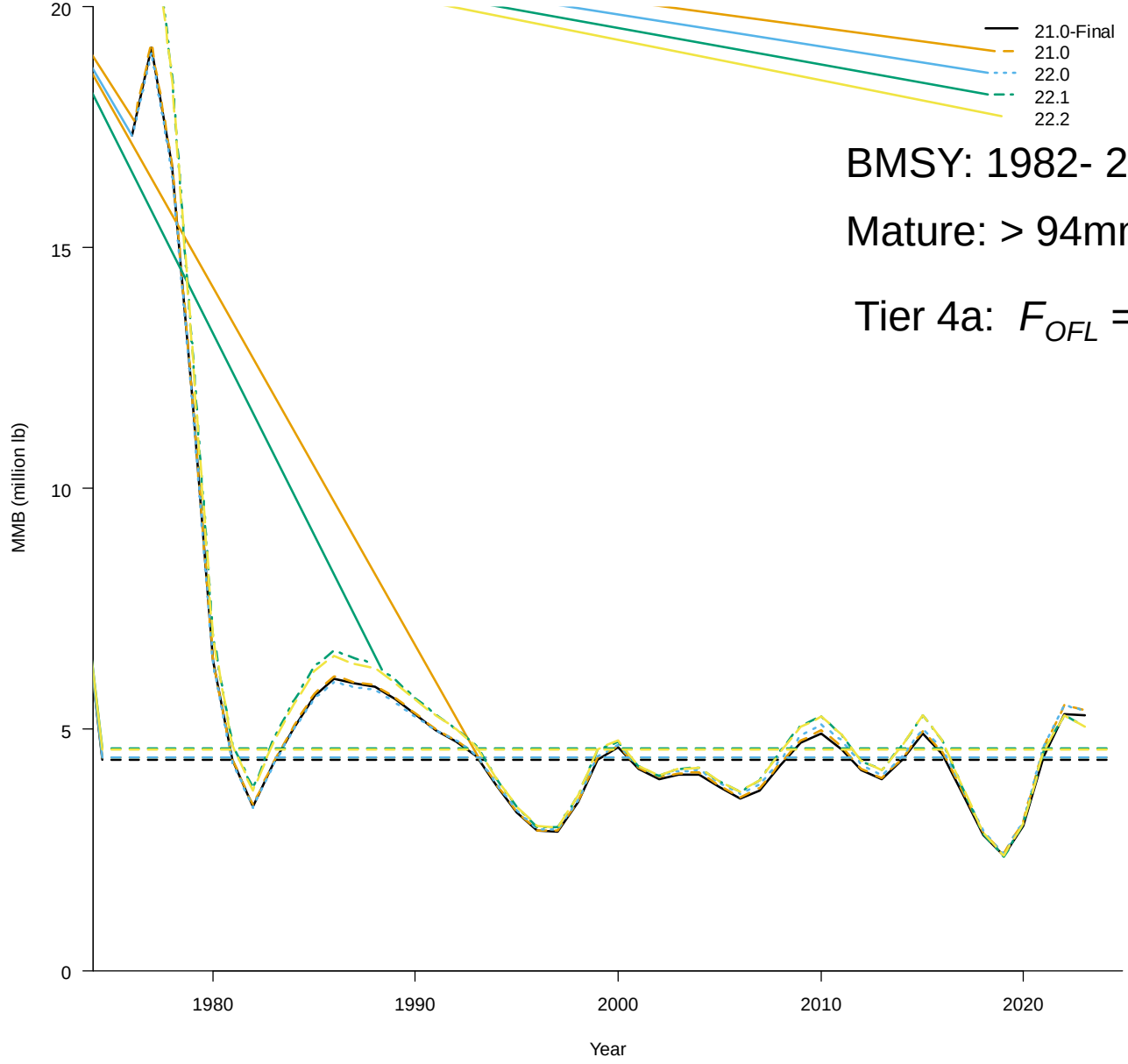


21.0 Final
Influence of trawl data

Retrospective



MMB



BMSY: 1982- 2023: 4.37 million lb

Mature: > 94mm CL: 5.29 million lb

Tier 4a: $F_{OFL} = M$

BMSY

F_{OFL}

- $F_{OFL,l} = \Upsilon M_l$
- $OFL_{.t} = \sum F_{OFL,l} * B_l S_l R_l + 0.2 * \sum F_{OFL,l} * B_l S_l (1-R_l)$

$$F_{OFLa,l} = \left(1 - e^{-(F_{OFL,l} + 0.42 M_l)} - (1 - e^{-0.42 M_l}) \left(\frac{1 - p \cdot (1 - e^{-(F_{OFL,l} + 0.42 M_l)})}{1 - p \cdot (1 - e^{-0.42 M_l})} \right) \right)$$

- Length independent : $F_{OFL,l} = \Upsilon M_l = 0.18_{(l=1-6)}$
- Length dependent: $F_{OFL,l} = \Upsilon M_l = 0.18_{(l=1-6)}, 0.62_{(l=7,8)}$

Length-independent OFL

Length	N	Wlb	B	S	R	M	FOFL	FOFL.a	OFL.r	OFL.nr	OFL.t
64-73	525	0.52	275	0.12	0.00	0.18	0.18	0.15	0	1	1
74-83	412	0.82	338	0.33	0.00	0.18	0.18	0.15	0	3	3
84-93	417	1.20	500	0.63	0.00	0.18	0.18	0.15	0	10	10
94-103	431	1.70	734	0.86	0.02	0.18	0.18	0.15	2	19	21
104-113	537	2.32	1247	0.96	0.90	0.18	0.18	0.15	166	4	169
114-123	650	2.99	1947	0.99	1.00	0.18	0.18	0.15	297	0	297
124-133	285	3.69	1052	1.00	1.00	0.62	0.18	0.13	138	0	138
>134	70	4.37	307	1.00	1.00	0.62	0.18	0.13	40	0	40
									0.643	0.037	0.68

OFL = 0.68 million lb

ABC (40% buffer) = 0.41 million lb

End of the NSRKC Final SAFE

- Discussions as time allows
  - Length independent vs. length dependent OFL-ABC
  - Discards mortality estimates
    - With field observer data
    - Without field observer data
    - Back to basics

Length-independent vs. Length dependent OFL

Back to F_{OFL} calculation

- $F_{OFL,l} = \Upsilon M_l$
- $OFL_{.t} = \sum F_{OFL,l} * B_l S_l R_l + 0.2 * \sum F_{OFL,l} * B_l S_l (1-R_l)$

$$F_{OFLa,l} = \left(1 - e^{-(F_{OFL,l}+0.42M_l)} - (1-e^{-0.42M_l})\left(\frac{1-p\cdot(1-e^{-(F_{OFL,l}+0.42M_l)})}{1-p\cdot(1-e^{-0.42M_l})}\right)\right)$$

- Length independent : $F_{OFL,l} = \Upsilon M_l = 0.18_{(l=1-6)}$
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>134	70	4.37	307	1.00	1.00	0.62	0.18	0.13	40	0	40
									0.643	0.037	0.68

OFL = 0.68 million lb

Length-dependent OFL

Length	N	Wlb	B	S	R	M	FOFL	FOFL.a	OFL.r	OFL.nr	OFL.t
64-73	525	0.52	275	0.12	0.00	0.18	0.18	0.15	0	1	1
74-83	412	0.82	338	0.33	0.00	0.18	0.18	0.15	0	3	3
84-93	417	1.20	500	0.63	0.00	0.18	0.18	0.15	0	10	10
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124-133	285	3.69	1052	1.00	1.00	0.62	0.62	0.37	387	0	387
>134	70	4.37	307	1.00	1.00	0.62	0.62	0.37	113	0	113
									0.965	0.037	1.00

OFL = 1.00 million lb

Length independent vs. length dependent OFL

- Tier 4 F_{MSY} definition: Natural mortality of a stock is F_{MSY} proxy
- Length dependent F_{OFL} is more adherent to the definition.
- CPT-SSC can set higher ABC buffer if OFL is too uncertain

  ABC = (1-0.4)*0.68 = 0.41 mil lb (length independent)

  ABC = (1-0.6)*1.00 = 0.40 mil lb (length dependent)

  Arbitrary buffer?

  No prescriptive ABC buffer setting formula (e.g. ABC buffer = f($OFL._{SE}$))

Discards Estimate: Why do we care?

- Estimating total catch mortality for better assessment and management
  - Total Catch OFL – ABC
  - ACL overage based on total catch mortality

- Does NSRKC model estimate discards mortality when without data?

$N_{t+1} = N_t - C_t - Dis_t + Rec_t$

Pred C $= \sum_{l=1}^{8} N_l S_l R_l$ Pred Dis $= \sum_{l=1}^{8} N_l S_l (1 - R_l)$

Pred Dis lb $= 0.2 \left(\frac{Pred\ Dis}{Pred\ Ret} Ob\ Ret \right) \sum_{l=1}^{8} P_l\ w_l$

P_l = Normalized predicted discards size prop: $\sum_{l=1}^{8} P_l = 1$

W_l = Mean weight for each size class

Discards Estimate: Why do we care?

- Do we need discards data to project and estimate total catch OFL?
- NSRKC assessment model projects total catch OFL with or without data.

Retain OFL $= \sum_{l=1}^{8} N_l F_{OFL} S_l R_l \, w_l$

Dicards OFL $= 0.2 \sum_{l=1}^{8} N_l F_{OFL} S_l (1 - R_l) \, w_l$

But we don't know how good or realistic those numbers are…..

How do we estimate discards?

Discards Estimate: with field data number method

LNR Method: Use observed discards *cpue* (n/pot lifts),

$$\text{Pred Dis lb} = 0.2\left(\frac{cpue_{dis}}{cpue_{ret}} CPUE_{T.ret}\right)\sum_{l=1}^{8} P_l\, w_l$$

Subtraction Method: Use observed total catch CPUE

$$\text{Pred Dis lb} = 0.2\left(\frac{cpue_{T}}{cpue_{ret}} CPUE_{T.ret} - C_{T.ret}\right)\sum_{l=1}^{8} P_l\, w_l$$

Ratio Method (NSRKC): Use observed dis/retain catch number ratio (Same as NSRKC assessment model)

$$\text{Pred Dis lb} = 0.2\left(\frac{Catch_{dis}}{Catch_{ret}} C_{T.ret}\right)\sum_{l=1}^{8} P_l\, w_l$$

Discards Estimate: with field data weight method

If biomass is the final quantity for ACL overage, why not calculate it directly?

LNR Method: Use observed discards weight *cpue.w* (w/pot lifts),

$$\text{Pred Dis lb} = 0.2\left(\frac{cpue.w_{dis}}{cpue.w_{ret}} CPUE.W_{T.ret}\right)$$

Subtraction Method: Use observed total catch weight CPUE

$$\text{Pred Dis lb} = 0.2\left(\frac{cpue.w_{T}}{cpue.w_{ret}} CPUE.W_{T.ret} - C.W_{T.ret}\right)$$

Ratio Method: Use observed dis/retain catch weight ratio

$$\text{Pred Dis lb} = 0.2\left(\frac{Catch.w_{dis}}{Catch.w_{ret}} C.W_{T.ret}\right)$$

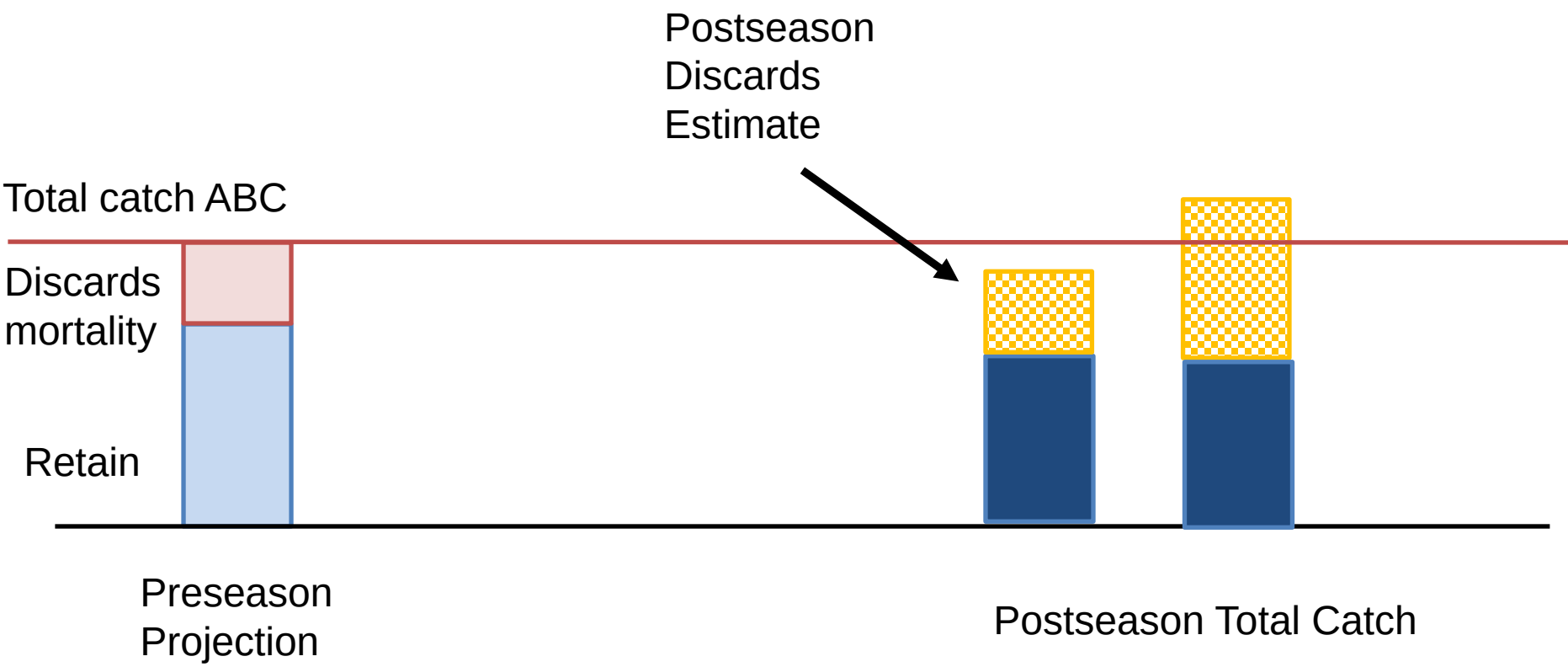
NSRKC Discards Estimate without field data

- Why do we need to estimate discards catch mortality for NSRKC without field data?
  - NSRKC ABC is Total catch (Retain + discards mortality)
  - Need to evaluate ACL (ABC-OFL) overage
- Will the estimates be used for the assessment model?
  - No. The estimates are not data
- Will ADFG resume field observer survey?
  - Highly unlikely: No budget, no personnel, no priority.
  - Better spend money: NSRKC crab trawl survey, NSRKC biology researches. We really don't know NSRKC biology….
- Can we estimate discards without field data?
  - Not really, but I can try…..
  - How do we estimate unobserved crab abundance, size class, and weight?

Total OFL-ABC vs. Fishery management

Success!!

Failure!!



NSRKC Discards Estimate without field data

- Option 1: Use proxy quantities that are used for the estimation method
  - Use historical average (discards-total CPUE, discards/retain ratio)
  - Construct regression model and predict

  Discards-total CPUE, discards/retain ratio ~ b0+b1*(Total retain Catch Weight CPUE)

NSRKC Discards Estimate
without field data

- Option 2: Use trawl survey data and use assessment model discards estimation method.

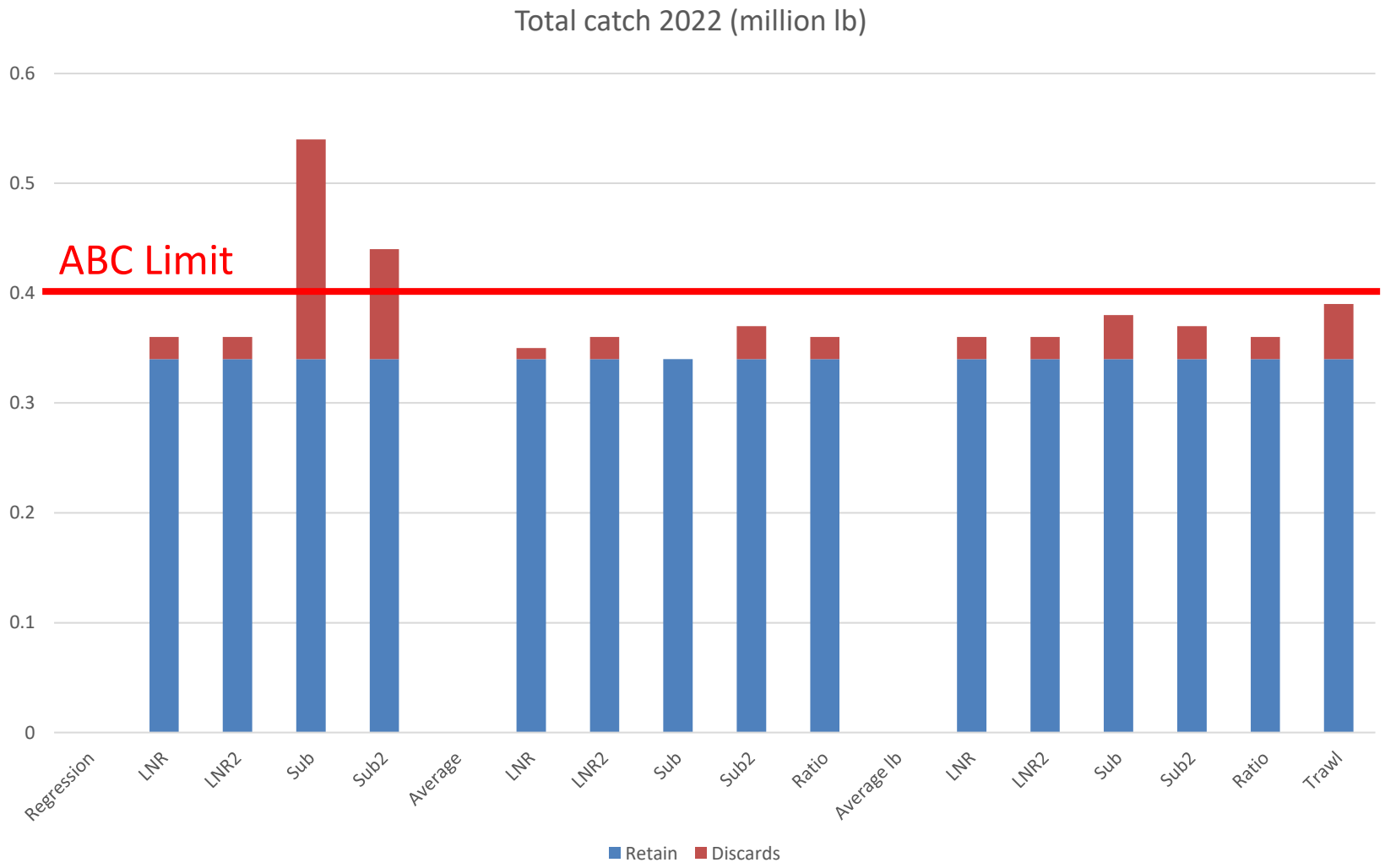
Pred Ret $= \sum_{l=1}^{8} N_{t.l} S_l R_l$ Pred Dis $= \sum_{l=1}^{8} N_{t.l} S_l (1 - R_l)$

P_l= $N_{t.l} S_l (1 - R_l)$/Pred Dis

Pred Dis lb $= 0.2 \left(\frac{Pred\ Dis}{Pred\ Ret} Ob\ Ret \right) \sum_{l=1}^{8} P_l\ w_l$

NSRKC Discards Estimate

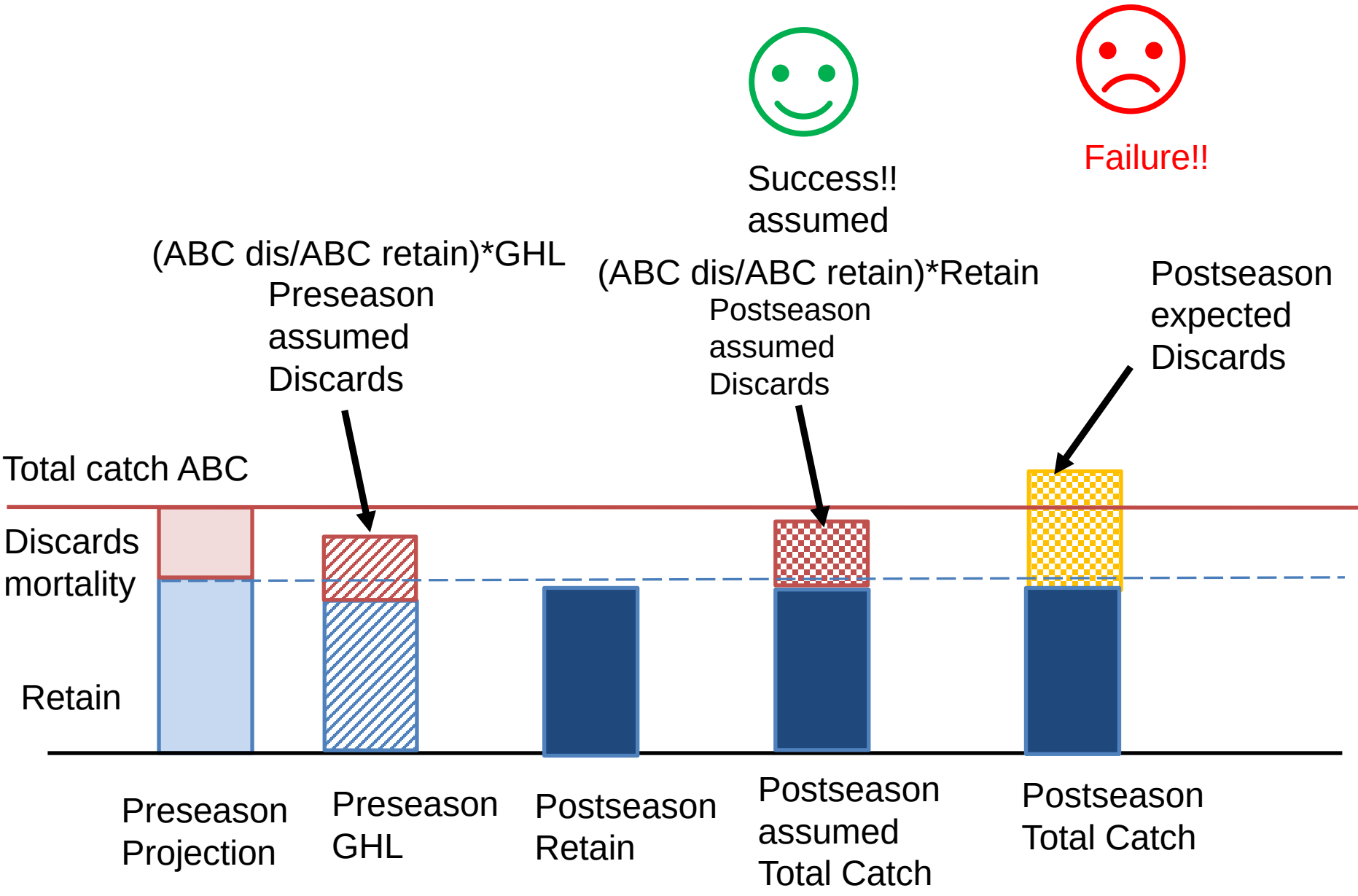
Total Catch vs ABC 2022



NSRKC Discards Estimate without field data

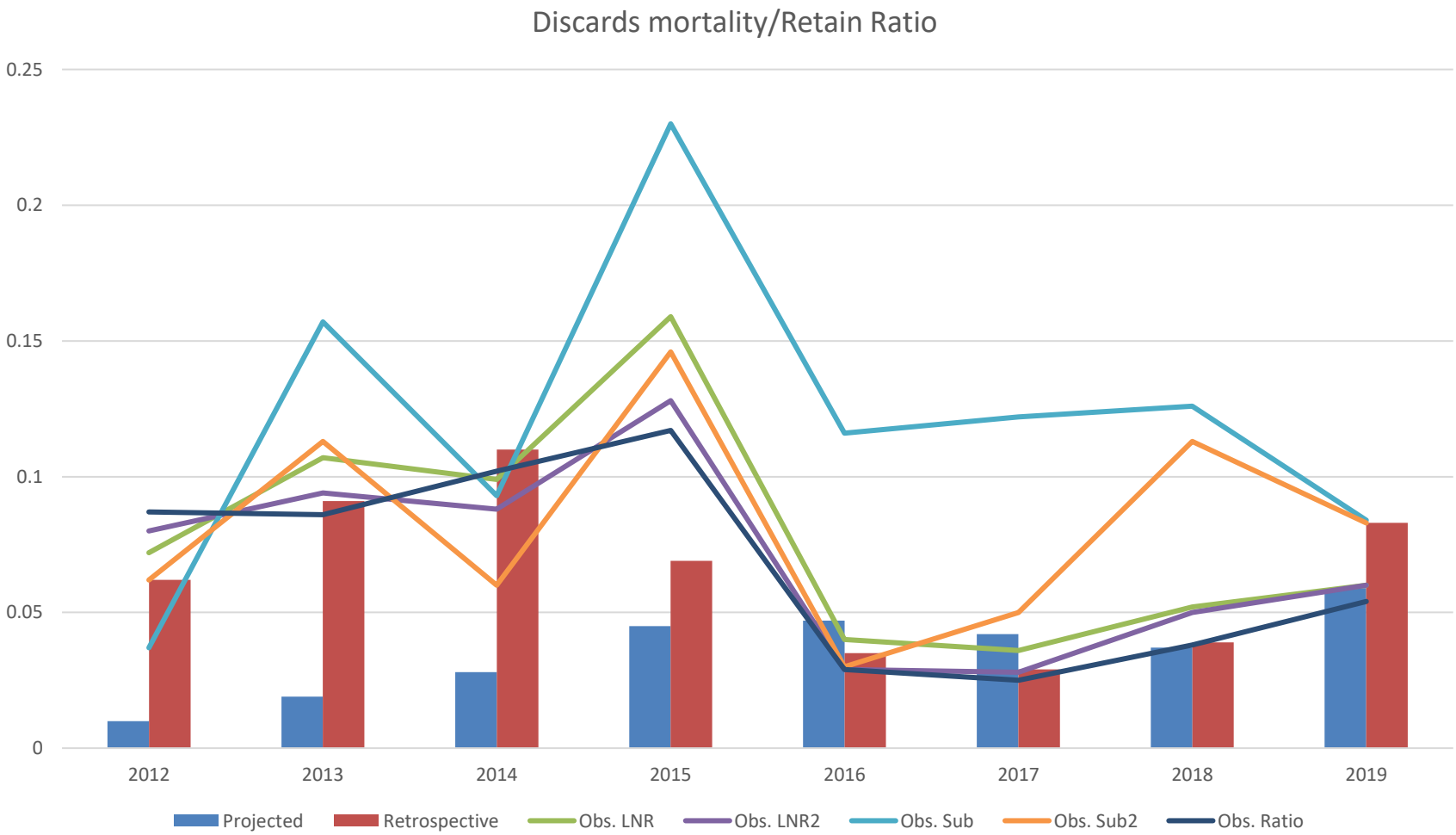
- ACL overage: depends on discards estimation method.
  - Which method should be selected?
  - What are selection criteria?
- Consideration for management implications.
  - Let's look at how preseason GHL is set

Total OFL-ABC vs. Fishery management



How good is preseason projected discards mortality biomass?

Preseason Projection (ABC) vs. Retrospective vs. Observer



Discards Estimate

- In some yeas, preseason discards lb/retain lb ratio is >50% lower than observed-retrospective ratio
  - Post-season discards can be > 2 times higher than projected
  - Projection model underestimates discards?
  - Observer data overestimate discards?
- ACL overage can be caused by preseason underestimate.
  - Not due to management failure
  - But due to the goal post moved in postseason

NSRKC Discards Estimate without field data

- Should ACL overage be determined by an ad hoc method without data?
  - Option 1 : No. go back to retained ABC.
  - Option 2: Choose a method and stick to it.
  - Option 3: Use preseason estimate

    Total catch = (1 + (ABC dis/ABC ret))*Retained Catch lb
  - Option 4: Change preseason discards projection method, so that pre and post season estimates will be similar.

Total OFL-ABC vs. Fishery Options