Norton Sound Red King Crab SAFE 2024

Jan 10 2024

Crab Plan Team:
NPFMC-Online
Anchorage, AK

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Division of Commercial Fisheries

CPT NSRKC Decision Agenda

- Recommend final model, OFL, ABC

Model Selection for Jan 2024

- Final model selection for Jan 2024
  - Model 21.0: Default baseline model (CPT recommended for Final OFL)
  - Model 23.0: SSC requested alternative model
    - Length independent model estimate M.
  - Model 23.1: New SSC request in Oct 2023.
    - 23.0 WITH M prior.
- Other Issues to discuss (as time allows)

New Data: Catch (Winter, Summer), CPUE , and Trawl abundance

- Winter Com: 3,580 (10,013 lb)
- Winter Subsistence (1,604 lb) (43% returned)
- Summer Com: 146,087 (413, 327 lb)
- Bycatch from other fisheries (ignorable lb)
- Discards mortality 18,866 lb (model estimate)
- Total Catch 0.444 million lb < ABC (0.450).
- ADF&G Trawl abundance
  - 3.44 million (CV 0.325)
- NOAA NBS abundance
  - 1.74 million (CV 0.379)

Response to the CPT-SSC (Sept-Oct 2023)

- *A small-scale observer program should be considered for the NSRKC fishery.*

- Author Reply (Addition)….
  - Under the North Pacific Observer Program vessel size under 40 ft is not selected for observer coverage
  - In NSRKC fishery, all but 2 vessels are under 40 ft.

Response to the CPT-SSC (Sept-Oct 2023)

- *Explore using existing tagging data to estimate maximum age and use it in the Barefoot Ecologist's natural mortality calculation*

- Author Reply
  - Maximum age and *M* can range from 13 to 29 years and from 0.18 to 0.41 using various assumptions and estimation techniques.
  - This range encompasses NSRKC estimated *M*
  - Definition of "Maximum age?"
    - The maximum age that a crab can live biologically?
    - The maximum age that an average crab can live?
  - How about a long-term growth study?
    - 13 years (Matsuura and Takeshita 1989).

Response to the CPT-SSC (Sept-Oct 2023)

- *Include maps of all of the survey years, a figure that shows how many stations were used for each year to develop the index of abundance. Include the total number of crab observed by year.*
- *Compare the index of abundance currently used to an index of abundance that uses only stations that were consistently sampled over the length of the time series.*

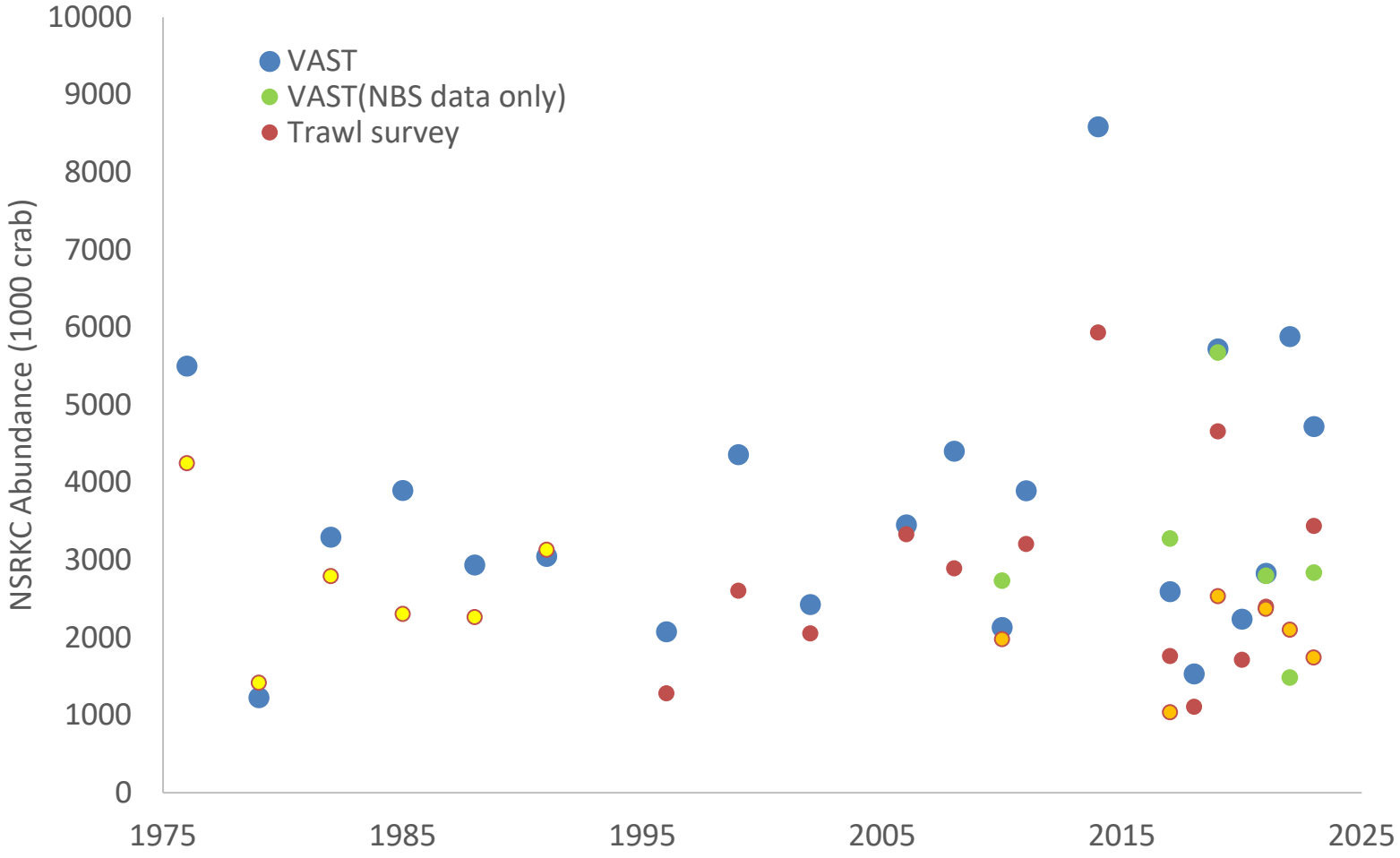
- Author Reply
  - Table 3 and Figures 18-19.
  - ADF&G trawl survey explained by Jen B's presentation

Response to the CPT-SSC (Sept-Oct 2023)

- *Compare the current index of abundance to one developed using VAST .*

- Author Reply
  - Similar to the one done in 2021.
  - Issues to be resolved
    - Spatial extents of NSRKC
    - Trawl data to be used for VAST
      - NMFS (1976-1991), ADFG (1996-2023),NBS (2010-2023).

Response to the CPT-SSC (Sept-Oct 2023)



Response to the CPT-SSC (Sept-Oct 2023)

- *Eliminate shell condition (new shell vs. old shell) for model simplification due to difficulties identifying new and old shell.*

- Author Reply
  - Author trusts biologists
  - Author will discard data if they are deemed uninformative (e.g., biologists assign shell conditions at random).
  - Biologists can identify new and old shells very well.
    - Accuracy 87%, Specificity 90% for new a75% for old
  - No reason to discard good informative data.

Response to the CPT-SSC (Sept-Oct 2023)

- *Consideration of an ABC based on the long-term average F.*

- Author Reply
  - Will be presented later

NSRKC Final Assessment Models

- Model 21.0:
- Model 23.0:
- Model 23.1: Not reported. Eliminated.
  - *M* estimates strongly influenced by choice of *M* prior (expectedly)
  - What is the level of appropriate prior and what are the methods?

NSRKC Final Assessment Models

	Final	
Model	21.0	23.0
Additional Parameters		0
AIC change		+14.9
Total	368.3	383.2
Trawl abundance	12.57	13.03
Discards abundance	3.67	3.27
St.CPUE	-15.14	-14.79
Trawl length-shell	142.68	146.15
Winter pot	39.49	39.90
Summer com retain	51.02	55.05
Summer com total/dic	24.64	28.17
Winter com retain	2.99	2.39
Recruit	21.20	21.79
Tag	85.12	88.26
M	0.18 0.613	0.408
Total OFL	0.73	1.17

NSRKC Final Assessment Model parameters

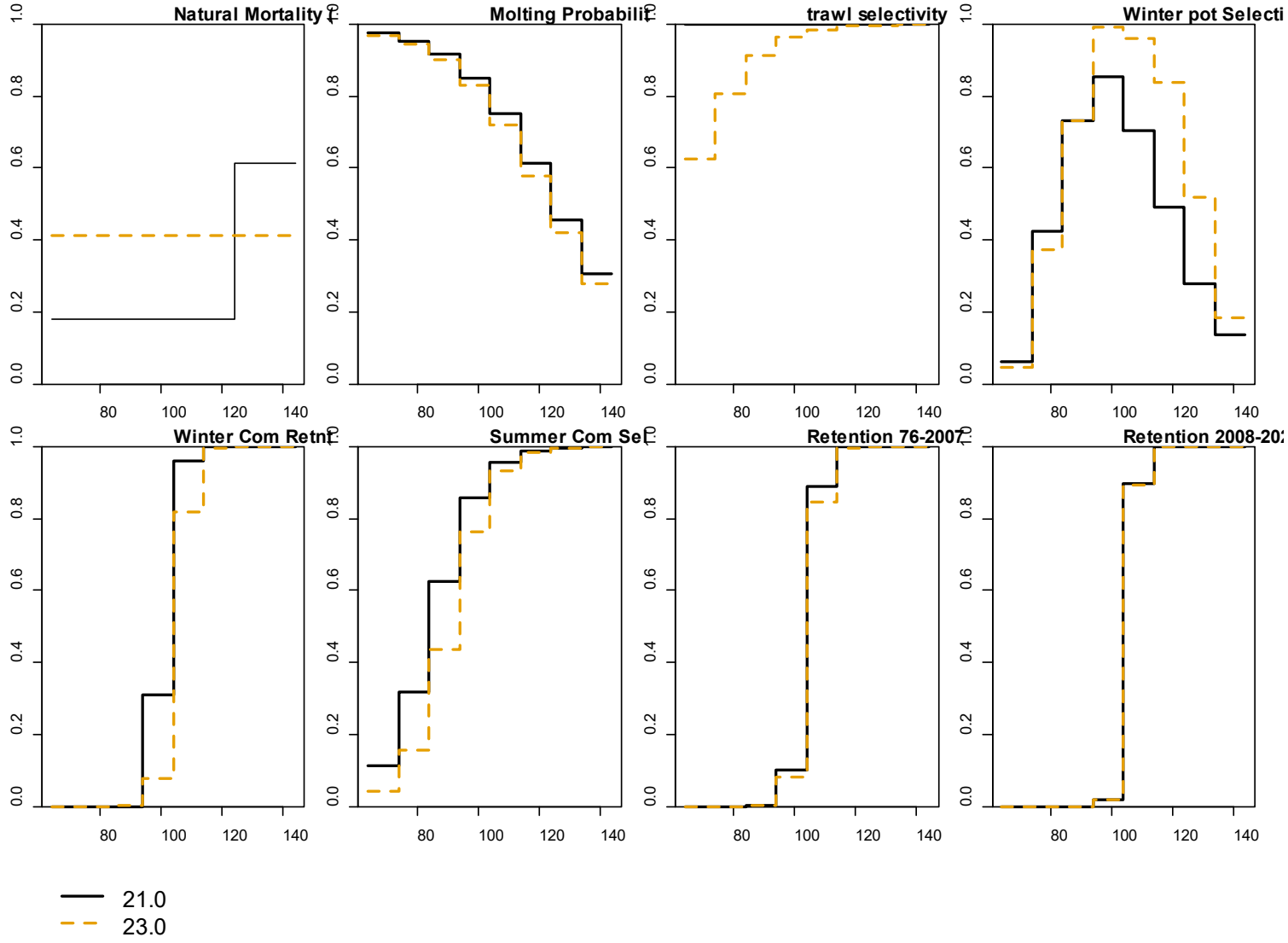
	21.0		23.0	
Name	Estimate	std.dev	Estimate	std.dev
log_q_1	-7.301	0.194	-7.162	0.191
log_q_2	-6.717	0.165	-6.576	0.169
log_q_3	-6.862	0.150	-6.757	0.156
log_N_{76}	9.119	0.136	9.440	0.156
R_0	6.441	0.079	7.072	0.149
a_1	-0.091	0.300	-0.222	0.293
a_2	-0.760	0.360	-0.847	0.356
a_3	1.021	4.451	2.637	4.512
a_4	1.753	4.181	2.917	4.322
a_5	3.495	3.922	4.378	4.083
a_6	3.980	3.900	4.682	4.062
a_7	4.242	3.891	4.827	4.053
r1	5.000	0.002	5.000	0.002
r2	4.645	0.161	4.510	0.165
log_a	-2.737	0.087	-2.753	0.093
log_b	4.829	0.015	4.812	0.015
log_f_{st1}	-5.000	0.038	-2.385	0.076
log_f_{wa}	-2.402	0.425	-1.866	0.425
log_f_{wb}	4.772	0.069	4.859	0.028

Model 23.0
Better trawl survey selectivity parameter

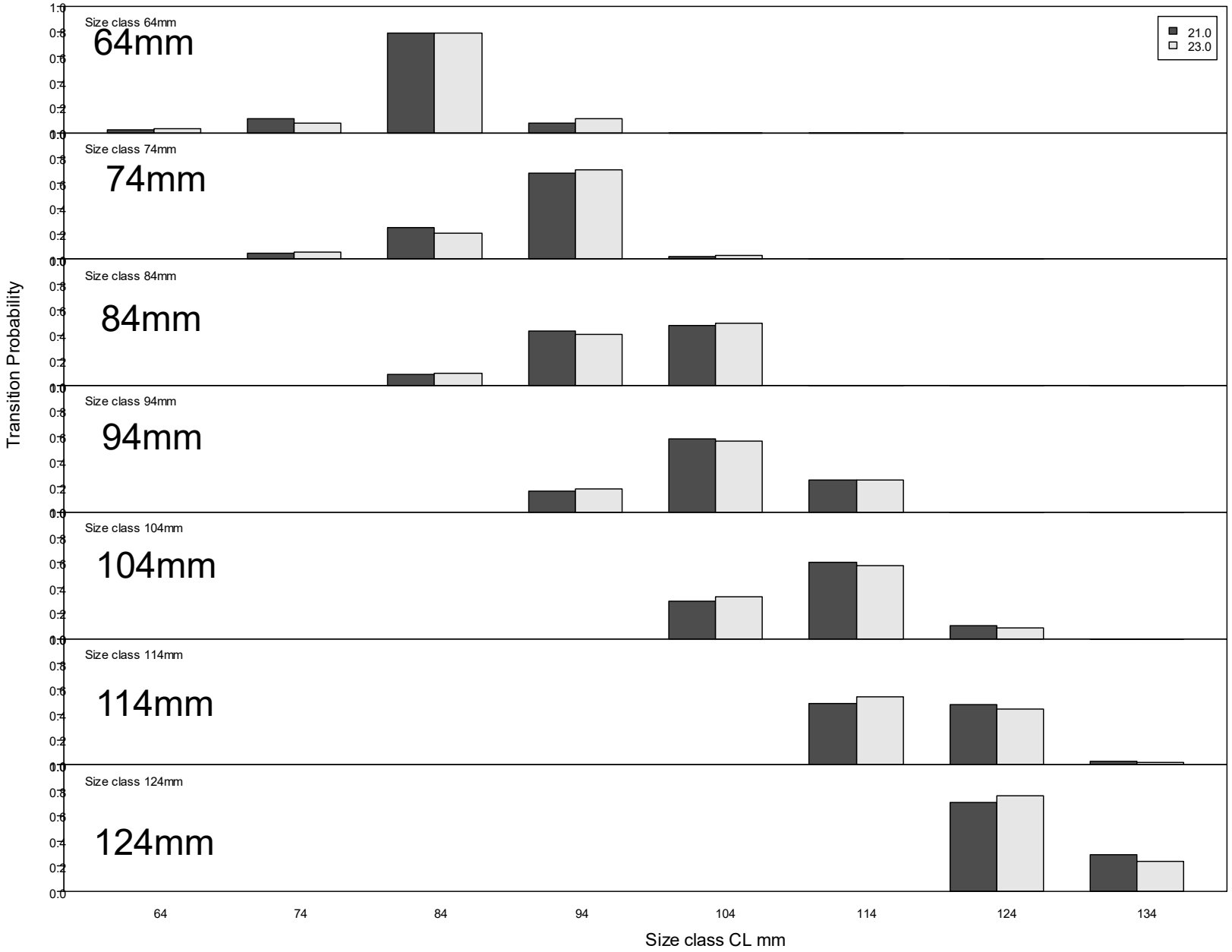
NSRKC Draft Assessment Model parameters

	21.0		23.0	
Name	Estimate	std.dev	Estimate	std.dev
Sw1	0.061	0.034	0.046	0.022
Sw2	0.422	0.147	0.375	0.089
Sw3	0.733	0.238	0.734	0.142
log_f_1	-2.052	0.043	-1.940	0.041
log_fra1	-0.854	0.143	-0.884	0.143
log_frb1	4.641	0.008	4.647	0.009
log_fra2	-0.507	0.266	-0.500	0.261
log_frb2	4.654	0.013	4.655	0.013
log_fwra	-0.951	0.558	-0.926	0.584
log_fwrb	4.654	0.038	4.652	0.039
w^2_t	0.143	0.039	0.144	0.040
q.1	0.726	0.129	0.726	0.126
q.2	0.777	0.141	0.772	0.140
σ	3.778	0.208	3.773	0.203
β_1	11.838	0.692	12.782	0.723
β_2	7.811	0.170	7.570	0.176
M			0.408	0.027
m8	3.405	0.260		

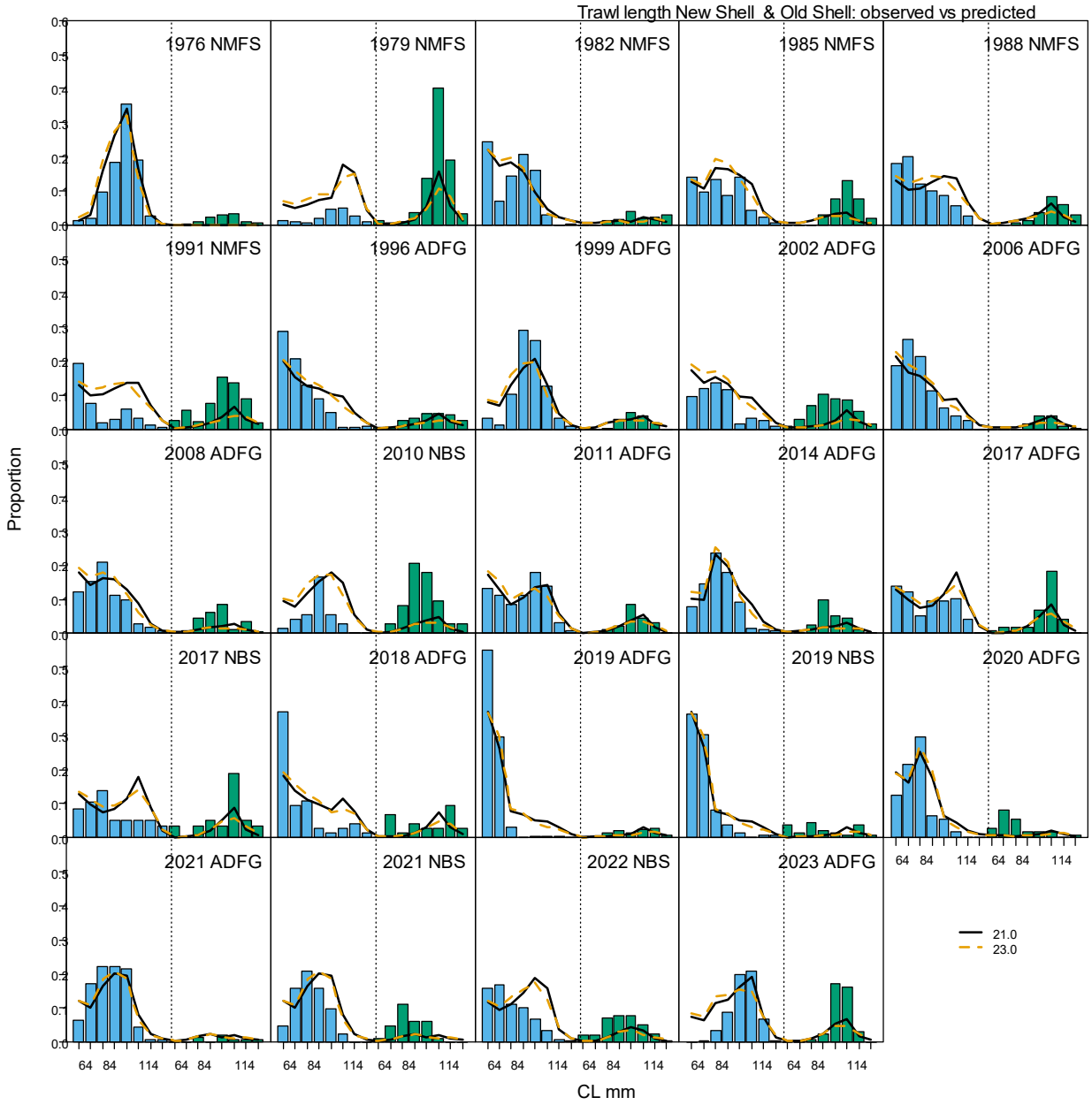
Selectivity, Molting probability



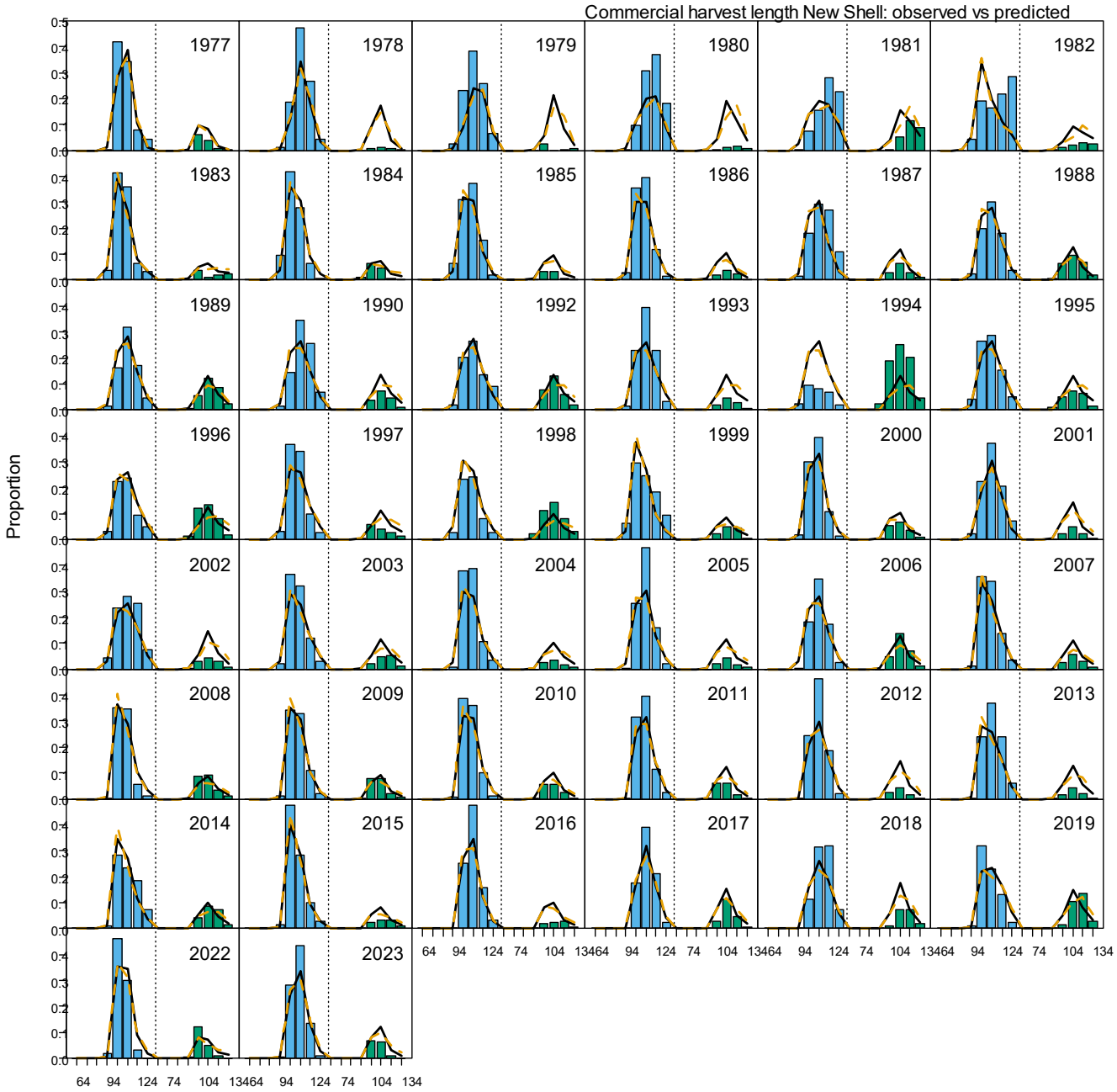
Size transition probability



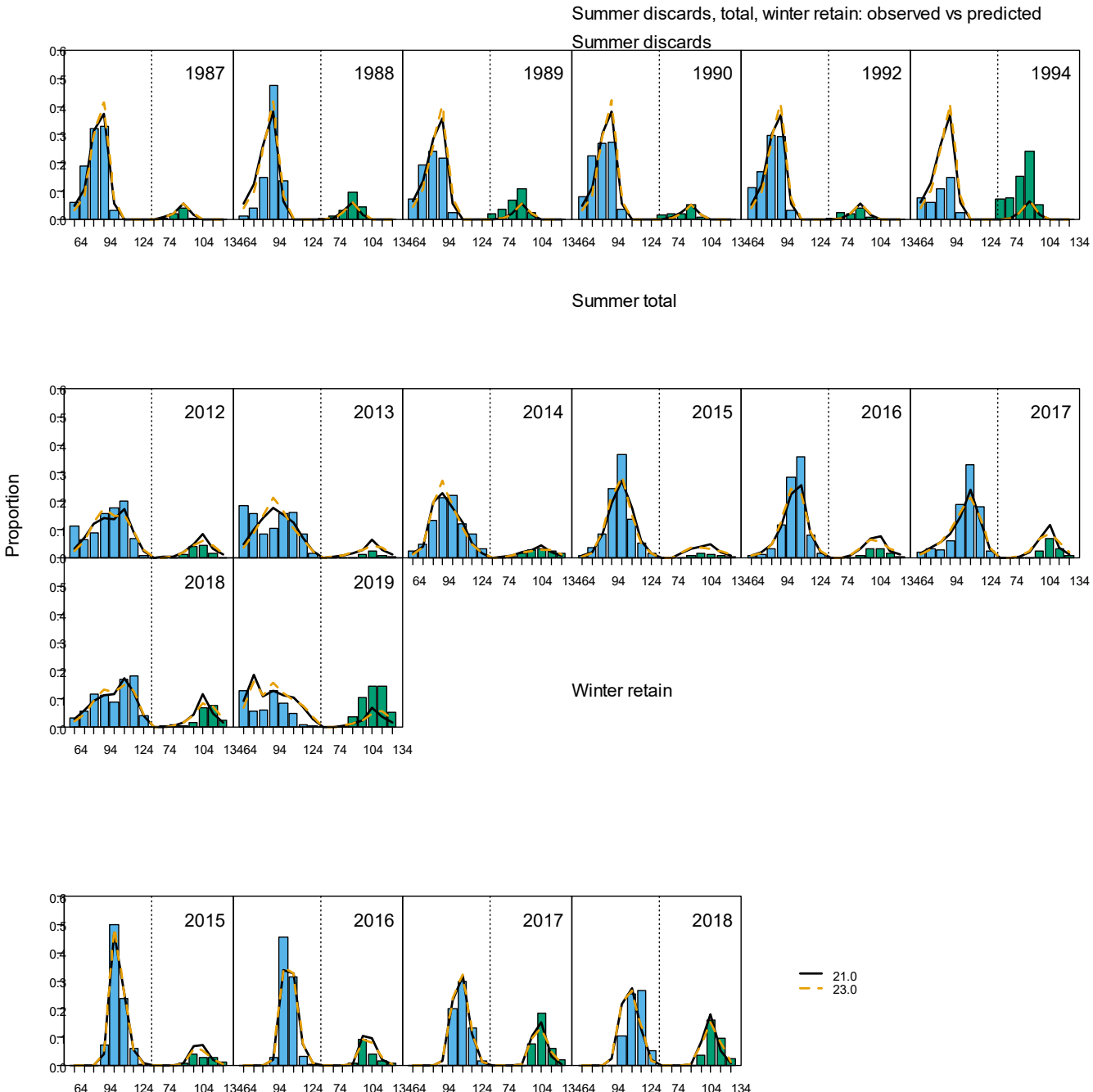
NSRKC Trawl Survey



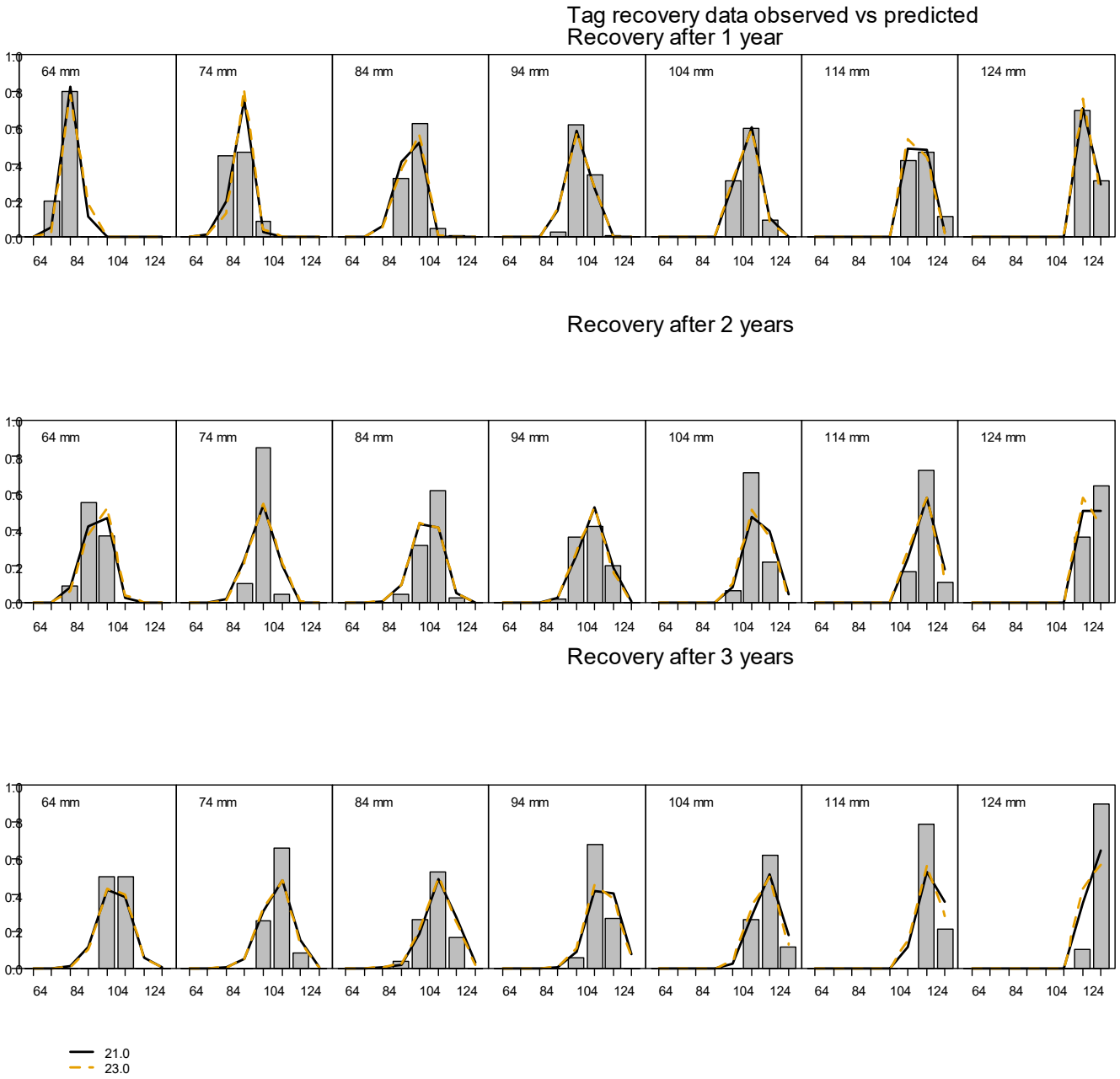
NSRKC Commercial Catch



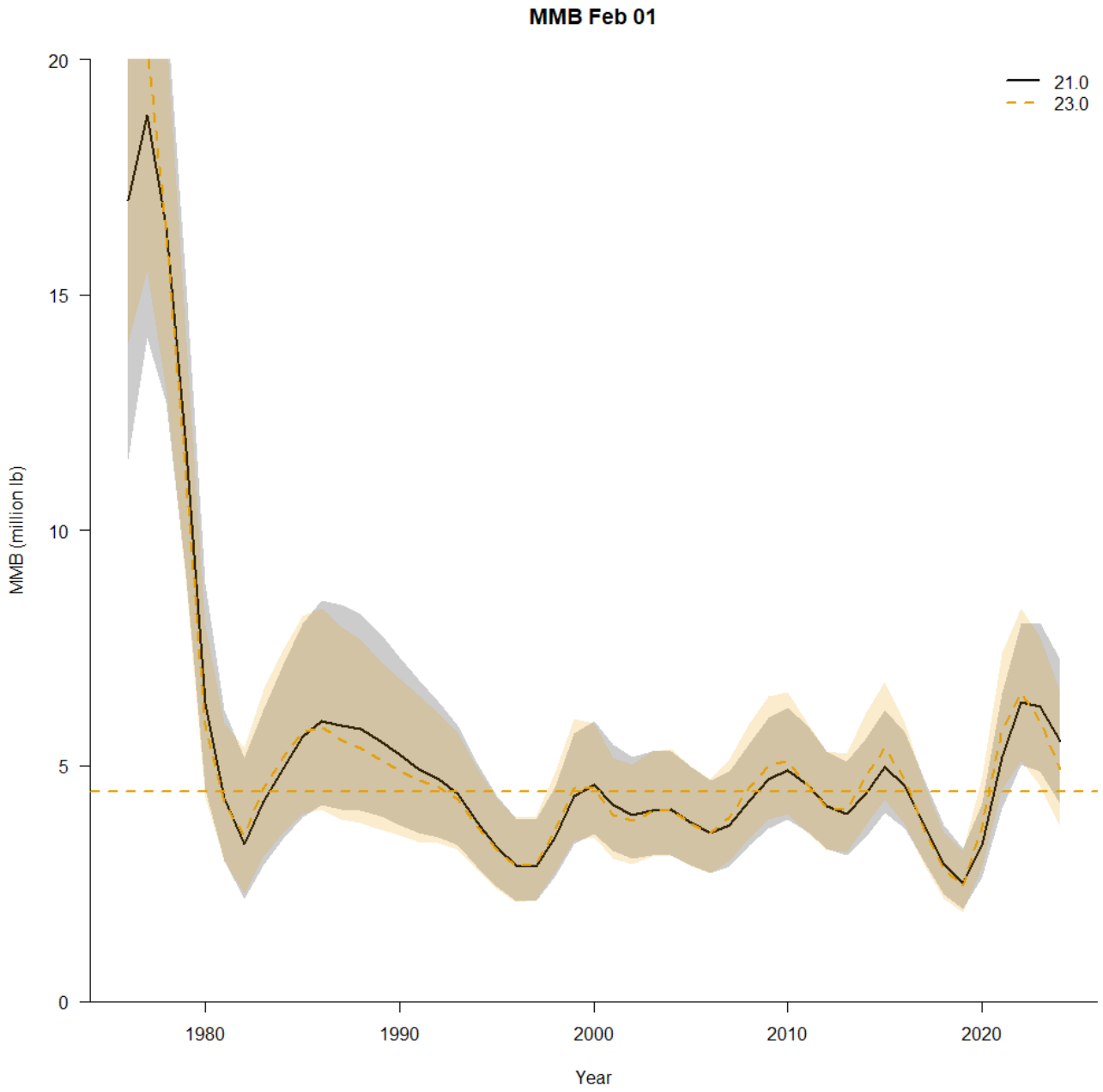
NSRKC Observer



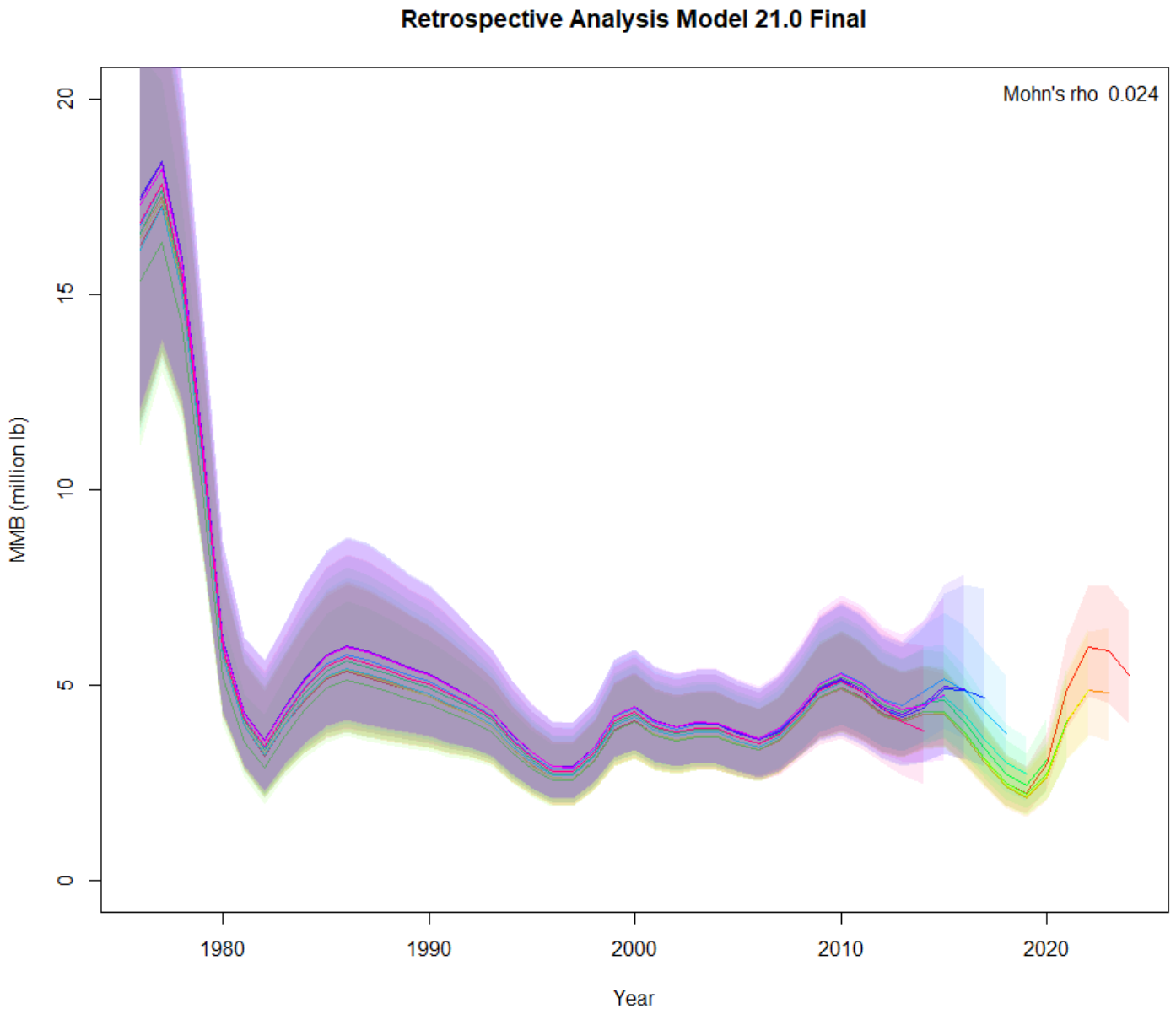
NSRKC Tag recovery size distribution



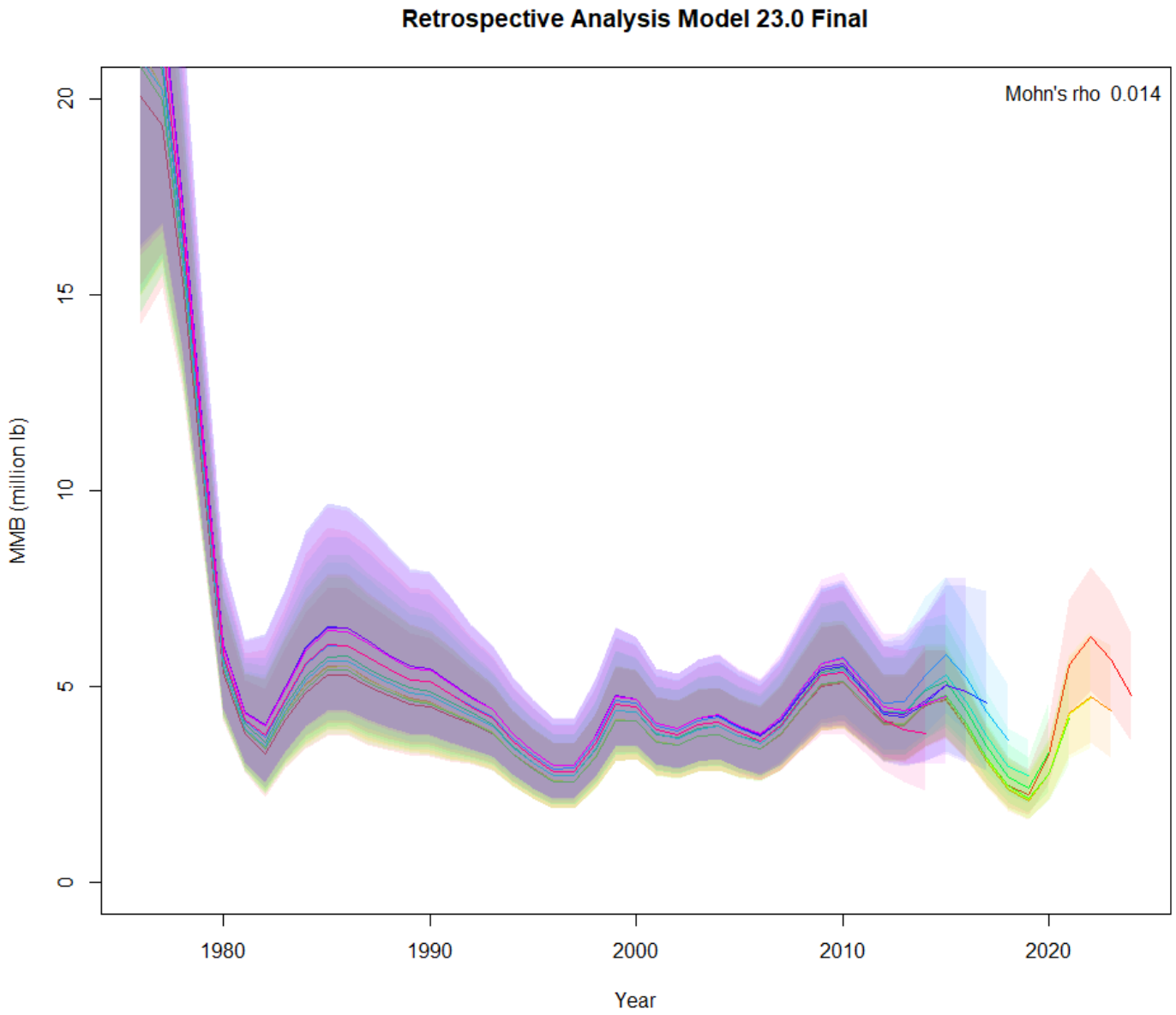
MMB


MMB Feb 01
21.0
23.0
MMB (million lb)
0
5
10
15
20
1980
1990
2000
2010
2020
Year

Retrospective



Retrospective



NSRKC OFL Explained (NPFMC 2017)

- $OFL = (1-e^{-F_{OFL}})B$
- $OFL = OFL_{(winter)} + OFL_{(Summer)}$
- $OFL = (1-e^{-x \cdot F_{OFL}})B_w + (1-e^{-(1-x) \cdot F_{OFL}})B_s$
- Where B_w, B_s Winter and Summer Crab biomass
- x: fraction of F_{OFL} applied to winter fishery
-
- Summer Crab biomass =
- (Winter Crab biomass – Winter fishery mortality)*Natural mortality (5 months from Feb 01 to July 01 = 0.42M)
- $B_s = [B_w - (1-e^{-x \cdot F_{OFL}})B_w]\, e^{-0.42M}$
- $OFL = [1-e^{-(F_{OFL}+0.42M)} - (1-e^{-0.42M})e^{-x \cdot FOFL}]B_w$

NSRKC OFL Explained

- 2017 CPT-SSC proposed OFL formula: Assume p% of OFL is from winter fishery.
- OFL = p*OFL + (1-p) *OFL

$$OFL = B_w\left[1 - e^{-(F_{OFL}+0.42M)} - (1 - e^{-0.42M})\left(\frac{1-p(1-e^{-(FOFL+0.42M)})}{1-p(1-e^{-0.42M})}\right)\right]$$

NSRKC OFL Explained

- FOFL = M = 0.18 (21.0), 0.408 (23.0)

OFL (million lb)	Total	Retained	Unretained
Model 21.0	0.733	0.709	0.024
Model 23.0	1.254	1.213	0.042

- ABC 30% buffer

ABC (million lb)	Total	Retained	Unretained
Model 21.0	0.513	0.496	0.017
Model 23.0	0.878	0.849	0.029

Empirical F

$$F = -ln\left(\left(1-\frac{Hs}{B_s}\right)\left(1-\frac{Hw}{B_w}\right)\right)$$

Hw: Winter Fishery Harvest Biomass (retain + discards*discards mortality)
Bw: Winter Crab Biomass
Hs: Summer Fishery Harvest Biomass (retain + discards*discards mortality)
Bs: Winter Crab Biomass

$$ABC = B_w\left(1-e^{-(F_{ABC}+0.42M)}-(1-e^{-0.42M})\left(\frac{1-p(1-e^{-(F_{ABC}+0.42M)})}{1-p(1-e^{-0.42M})}\right)\right)$$

ABC Alternative (SSC)

- Use the OFL formula but replace F_{OFL} with F_{ABC}
- F_{ABC} = Empirical long-term fishing mortality
  = 0.102 (Model 21.0), 0.103 (Model 23.0)

ABC.alt (million lb)	Total	Retained	Unretained
Model 21.0	0.432	0.418	0.014
Model 23.0	0.371	0.382	0.011

Equivalent to buffer 41% (Model 21.0) and 70% (Model 23.0)

CPT discussion (Suggested by SSC)

1. Evaluate if this is a legitimate form of ABC determination method
2. Decide whether to recommend the alternative ABC for NSRKC
3. SSC can override CPT….

CPT NSRKC Decisions

- Recommend final model, OFL, ABC