Appendix C

Norton Sound Red King Crab Summer Commercial Fishery Discard Estimation

Formal methodologies for estimating discards in the Norton Sound red king crab summer commercial fishery from observer data have not been established. Here, I describe a few methods and discuss pros and cons of each method.

Norton Sound Summer Commercial fishery observer coverage started in 2009 as a feasibility project, but formal data collection started in 2012 and terminated in 2019. **The main objective of the observer coverage was to gain information about the size composition of discarded crab, NOT to estimate total discards.** Because of this, carrying fishery observers was optional/voluntary and participation was **limited to vessels that are large enough to carry a fishery observer (a portion of the fleet are of a vessel length too small for an additional person). Thus, participating fishermen/vessels are NOT representative of the entire fleet.** The fishery observer worked as a crew member, but also recorded biological data including sex, carapace size, shell condition, etc. for all red king crab in selected pots. Fisherman sorted out discards and noted those individuals, and as such, **observed discarded crab are deemed accurate.** Because of the observer coverage is biased towards larger vessels, it is uncertain whether fishing behaviors of observed vessels are representative of unobserved vessels. Possible concerns include:

1. The participating fishermen have larger boats and are experienced. They may select better fishing grounds (e.g., higher number and proportions of legal-size crab relative to sub-legal size crabs). This leads to **higher CPUE and lower discards**.
2. The participating fisherman may allow observers when they expect higher discards. Additional free labor deckhand (i.e., observer) is always helpful. This leads to **higher discards**.
3. The participating fisherman may keep more (with catcher-seller permits) legal crab that are not accepted by NSEDC.
4. Unobserved small boat fisherman may keep more legal crab that are not accepted by NSEDC . (catcher-seller permits, personal-subsistence use).

Estimation Methods

Every discard estimation method is based on the following data (Table 1)

Observer survey data	Fish Ticket data
Sublegal crab discards (n_{sub}) and weight (w_{sub})	*NA*
Legal crab discards (n_{ld}) and weight (w_{ld})	*NA*
Legal crab retained (n_r) and weight (w_r)	Total Legal crab retained (N_R) and weight (W_R)

Female crab discards (n_f) and weight (w_f)	
Pot lifts (e)	Total Pot lifts (E)
Total discards ($n_d = n_{sub} + n_{ld}$) and weight ($w_d = w_{sub} + w_{ld}$)	*NA*
Total catch ($n_t = n_{sub} + n_{ld} + n_r$) and weight ($w_t = w_{sub} + w_{ld} + w_r$)	*NA*
Discards CPUE ($Cpue_d = n_d/e$) and by weight ($Cpue_d = w_d/e$)	*NA*
Total catch CPUE ($Cpue_t = n_t/e$) and by weight ($Cpue_t = w_t/e$)	*NA*
Discards/Retain ratio ($r_d = n_d/n_r$) and by weight ($r_d = w_d/n_r$)	*NA*
Discards size composition ($p_{dis,l}$)	*NA*

Note: female discards are not included because the NSRKC assessment model is male-only model.

LNR method

LNR method simply **expands observed discards CPUE ($cpue_d$)** to total pot lifts. This method assumes **that discarded crab are accurately accounted for** and that observed discards CPUE ($cpue_d$) is representative of all fishermen.

$$cpue_d = \frac{n_d}{e} \qquad D_{LNR} = cpue_d \cdot E \qquad (1)$$

LNR2 method

Observer bias corrected LNR method (LNR2) acknowledges that the observer discard CPUE may not be representative of all fishermen. Thus the CPUE is adjusted via taking retained CPUE by observed fishermen to all fishermen as follows:

Observed vessel retained catch $CPUE_{R,s} = \frac{N_{R.s}}{E_s}$ Entire fleet retained catch $CPUE_R = \frac{N_R}{E}$

Where $N_{R.s}$ and E_s are total number of retained crab and pot lifts of the observed fishermen from the fish ticket database, and N_R and E total number of retained crab and pot lifts by all fishermen. Then

$$D_{LNR2} = \left(\frac{CPUE_R}{CPUE_{R,s}}\right) \cdot D_{LNR} = \left(\frac{N_R}{E \cdot CPUE_{R,s}}\right) \cdot cpue_d \cdot E = \frac{cpue_d}{CPUE_{R,s}} N_R = r_{LNR2} \cdot N_R \quad (2)$$

Subtraction method

Subtraction method expands **total catch CPUE** and subtracts total retained catch. This method does **NOT** assume **accurate discarded crab** but assume **accurate total catch crab**

$$cpue_t = \frac{n_t}{e} \qquad D_{Sub} = cuep_t \cdot E - N_R$$

Subtraction2 method

Similar to LNR2, bias corrected Subtraction method is simply bias corrected total catch minus retained catch

$$D_{Sub2} = \left(\frac{CPUE_R}{CPUE_{R,s}}\right) \cdot cpue_t \cdot E - N_R = \left(\frac{cpue_t}{CPUE_{R,s}} - 1\right) \cdot N_R = r_{sub2} \cdot N_R \tag{3}$$

Ratio method

The ratio method uses the identical method used in the assessment model, that multiplies the observed discards to retained catch ratio with total retained catch. This method assumes observed discards to retained ratio is accurate and representative.

$$D_{ratio} = \frac{n_d}{n_{lr}} N_R = r_d \cdot N_R \tag{4}$$

Estimation of discard mortality biomass

One of the main objectives of estimating discard is calculating discard mortality biomass (Mb_{dis}) that is calculated as follows

$$Mb_{dis} = 0.2 \cdot D_n \cdot W_{dis} \tag{5}$$

where, D_n is the number of discards, W_{dis} is average weight discarded crab, and 0.2 is assumed handling mortality rate.
W_{dis} is calculated as

$$W_{dis} = \sum_l p_{dis,l} \cdot wm_l \tag{6}$$

where $p_{dis,l}$ is the proportion of discarded crab size class (l) and wm_l is average weight (lb) for each size class (Table 3).

Direct discard mortality biomass estimation method

Alternatively, the above methods can be converted directly to biomass using observed weights w_d and w_r or by using the equation (6), such that

$$w_d = n_d \sum_l p_{dis,l} \cdot wm_l \ , \ w_r = n_r \sum_l p_{r,l} \cdot wm_l \ , \ w_t = w_d + w_r,$$

$$CPUE_{R,s} = \frac{W_{R.s}}{E_s}, \qquad CPUE_R = \frac{W_R}{E}$$

Then all the above 5 methods can be converted to

LNR.lb method

$$cpue_d = \frac{w_d}{e} \qquad Mb_{LNR} = 0.2 \cdot cpue_d \cdot E$$

LNR2.lb method

$$Mb_{LNR2} = 0.2 \cdot \frac{cpue_d}{CPUE_{R,s}} W_R = 0.2 \cdot r_{LNR2} \cdot W_R$$

Sub.lb method

$$cpue_t = \frac{w_t}{e} \qquad Mb_{Sub} = 0.2 \cdot \left(cpue_t \cdot E - W_R \right)$$

Sub2.lb

$$Mb_{Sub2} = \left(\frac{cpue_t}{CPUE_{R,s}} - 1 \right) \cdot W_R = 0.2 \cdot r_{sub2} \cdot W_R$$

Ratio.lb

$$Mb_{ratio} = 0.2 \frac{w_d}{w_r} W_R = 0.2 \cdot r_{ratio} \cdot W_R$$

Results

Overall subtraction method appeared to give higher discard mortality than other methods. Between the number and lb methods, LNR and LNR.lb methods were identical, and discrepancies were under 5% for LNR2 and ratio methods. On the other hand, subtraction method (Sub, Sub2) had +/- 60% differences.

Discussion

As stated, the NSRKC observer survey was not designed or intended to estimate discards, and this estimation was conducted at the request of the CPT and SSC. Methods using CPUE (LNR, LNR2, Sub, Sub2) assumes that observed vessels are representative of the entire fleet. Difference between LNR and Subtraction method is that LNR method assumes that observed discards are accurate whereas subtraction method assumes that observed discards are biased but observed total catches are accurate. On the other hand, the ratio method assumes that observed discard proportions would represent total proportion or that every fisherman has a similar crab composition.

Estimates of discarded crab are more likely to be accurate on the observed vessels because retained and discarded crab are distinguished in cooperation with the fishermen. However, these estimates are likely biased low relative to the entire fleet because of the fact that observer coverage is voluntary and generally limited to larger boats which are generally more efficient in catching legal crab with fewer discards than those with small boats. In addition, fisherman may volunteer for observer coverage when catches are anticipated to be high. This is generally supported by fish ticket data where total season retained catch CPUE is generally higher by observed fishermen than unobserved fishermen (Table 2a,b). and retained catch CPUE is generally higher during periods when observers are on board. When observers were on board, fishermen went to different fishing areas from the rest of the fleet including those without observers (Table 4). Because of this nonuniformity in fishing behavior, total catch and discard estimation for the entire fishery is likely inaccurate and difficult to evaluate including the directionality of the bias. In the absence of TRUE observation, relative accuracies of the estimates among the 10 methods were highly uncertain. Furthermore, in the absence of objective criteria for selecting a method for estimation, it is difficult to choose the most appropriate method for the NSRKC fishery.

Table 1a. Observed pot lifts, catch, and total pot lifts and catch from 2012 to 2019

	Observer Survey						
Year	Pot lifts E	Sublegal n_{sub}	Legal retained n_r	Legal discards n_{ld}	Female n_f	*Discarded lb*	*Retained lb*
2012	82	1,025	1,112	177	155	1,404	3,210
2013	190	2,647	2,109	258	120	2,648	6,172
2014	141	1,472	1,752	315	103	2,684	5,252
2015	69	969	1,676	577	224	2,635	4,495
2016	67	264	1,700	169	877	710	4,840
2017	108	432	2,174	122	373	845	6,731
2018	77	547	1,095	10	573	678	3,583
2019	28	123	142	1	89	116	432

Table 1b Fish tickets

	All fishermen			Sampled fishermen		
Year	pot lifts E	Retained N_R	Retained lb	pot lifts E_s	Retained N_{Rs}	Retained lb
2012	10,041	161,113	475,990	3,595	52,185	154,444
2013	15,058	130,603	391,863	7,545	74,466	223,725
2014	10,124	129,656	389,004	3,729	53,741	161,573
2015	8,356	144,224	4,011,112	2,323	49,986	138,936
2016	8,009	138,997	420,159	1,882	45,225	135,581
2017	9,401	135,322	411,736	2,079	37,767	116,701
2018	8,797	89,613	298,396	2,494	26,031	88,095
2019	5,436	24,913	75,023	949	4,458	13,114

Table 2a. Estimated quantity: number method

Year	$cpue_d$	$cpue_t$	$CPUE_{R,s}$	$CPUE_R$	r_{LNR2}	r_{sub2}	r_d
2012	14.66	28.22	14.52	16.05	1.01	0.94	1.08
2013	15.29	26.39	9.87	8.67	1.55	1.67	1.38
2014	12.67	25.10	14.41	12.80	0.88	0.74	1.02
2015	22.41	46.70	21.52	17.26	1.04	1.17	0.92
2016	6.46	31.84	24.03	17.36	0.27	0.32	0.25
2017	5.13	25.26	18.17	14.33	0.28	0.39	0.25
2018	7.23	21.45	10.44	10.19	0.69	1.06	0.51
2019	4.43	9.50	4.70	4.58	0.94	1.02	0.87

Average	11.0	26.81	14.71	12.66	0.83	0.92	0.79

Table 2b. Estimated quantities: lb method

Year	$cpue_d$	$cpue_t$	$CPUE_{R,s}$	$CPUE_R$	r_{LNR2}	r_{sub2}	r_d
2012	17.13	56.28	42.96	47.40	0.40	0.31	0.44
2013	13.94	46.42	29.65	26.02	0.47	0.57	0.43
2014	19.04	56.29	43.33	38.41	0.44	0.30	0.51
2015	38.18	103.33	59.81	48.00	0.64	0.73	0.59
2016	10.59	82.83	72.04	52.46	0.15	0.15	0.15
2017	7.82	70.15	56.13	43.62	0.14	0.25	0.13
2018	8.81	55.34	35.32	33.92	0.25	0.57	0.19
2019	4.14	19.57	13.82	13.80	0.30	0.42	0.27
Average	14.96	61.27	44.13	37.96	0.35	0.41	0.34

Table 3 discarded crab size proportions ($p_{dis,l}$) and calculated W_{dis}.

Size class	34	44	54	64	74	84	94	104	114	124	134		W_{dis}
Average weight (lb) (wm_l)	0.09	0.18	0.32	0.52	0.82	1.20	1.70	2.32	2.99	3.69	4.37		
2012	0.00	0.01	0.12	0.20	0.12	0.16	0.28	0.10	0.01	0.00	0.00		1.17
2013	0.00	0.02	0.11	0.29	0.25	0.14	0.15	0.04	0.00	0.00	0.00		0.91
2014	0.00	0.00	0.01	0.04	0.10	0.27	0.43	0.13	0.01	0.00	0.00		1.50
2015	0.00	0.00	0.00	0.02	0.08	0.18	0.47	0.21	0.03	0.01	0.00		1.70
2016	0.00	0.00	0.01	0.04	0.05	0.17	0.53	0.18	0.02	0.00	0.00		1.64
2017	0.00	0.00	0.02	0.10	0.16	0.14	0.30	0.26	0.01	0.00	0.00		1.53
2018	0.00	0.00	0.04	0.09	0.18	0.36	0.30	0.02	0.00	0.00	0.00		1.22
2019	0.02	0.05	0.18	0.24	0.10	0.12	0.27	0.02	0.00	0.00	0.00		0.93
Average	0.00	0.01	0.06	0.13	0.13	0.19	0.34	0.12	0.01	0.00	0.00		1.33

Table 4. The number of discarded crab estimated by 5 methods via **number method**.

Year	D_{LNR}	D_{LNR2}	D_{Sub}	D_{Sub2}	D_{ratio}
2012	147,186	154,492	122,239	136,303	174,153
2013	230,229	202,324	266,770	230,229	179,896
2014	128,347	114,021	124,525	128,347	132,246
2015	187,223	150,175	245,965	187,223	133,037
2016	51,760	37,382	115,976	51,760	35,403
2017	48,424	38,212	103,125	48,424	34,484
2018	63,635	62,107	99,123	63,635	45,584
2019	24,074	23,486	26,729	24,074	21,755

Table 5a. Discard mortality (lb) by 5 methods via **number method**.

Year	*LNR*	*LNR2*	*Sub*	*Sub2*	*Ratio*
2012	34,395	36,102	28,565	31,851	40,696
2013	41,969	36,882	48,630	41,969	32,794
2014	38,560	34,256	37,411	38,560	39,731
2015	63,815	51,187	83,837	63,815	45,345
2016	16,968	12,255	38,020	16,968	11,606
2017	14,773	11,658	31,462	14,773	10,521
2018	15,492	15,120	24,131	15,492	11,097
2019	4,496	4,386	4,992	4,496	4,063

Table 5b. Discard mortality (lb) by 5 methods via **weight method.**

Year	*LNR.lb*	*LNR2.lb*	*Sub.lb*	*Sub2.lb*	*Ratio.lb*
2012	343,95	37,952	17,817	29,507	41,647
2013	41,969	36,833	61,419	44,313	33,624
2014	38,560	34,184	36,199	23,264	39,766
2015	63,815	51,218	92,456	58,370	47,025
2016	16,968	12,356	48,652	12,590	12,322
2017	14,773	11,479	50,099	20,564	10,338
2018	15,492	14,877	37,693	33,826	11,291
2019	4,496	4,490	6,267	6,239	4,021

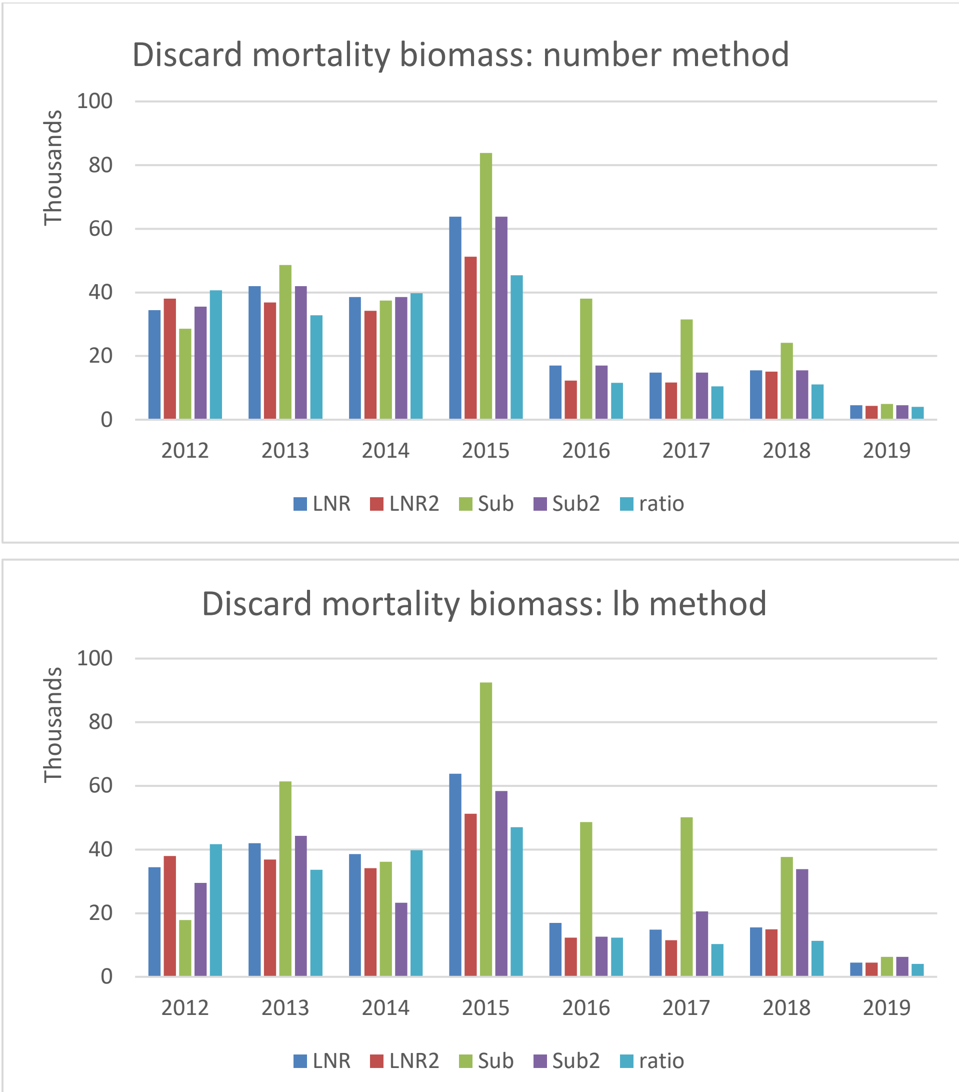

Figure 1. Discarded crab mortality biomass estimated by 5 proposed methods.

Discards Estimate without observer survey

Total catch OFL-ABC of NSRKC have been calculated since adoption of the NSRKC assessment model; however, it was not adopted because of the lack of discard estimate. Total catch OFL-ABC for NSRKC was set for the first time in 2020 based on the fact that discards could be estimated for 2012-2019, but in the same year the NSRKKC fishery observer program was terminated. This made it impossible to assess annual catch limit (ACL) overage for the NSRKC fishery. This prompted request by CPT-SSC to explore a method to estimate discards with NO DATA. Given that the NSRKC observer survey was not intended to estimate discards, developing a method is highly speculative.

There are 3 general approaches estimating discards for future fisheries in the absence of observer data:

1. Apply averages on observed retained catch and effort
2. Predict discards from observed retained catch and effort
3. Predict discards from observed crab size composition

Approaches 1 & 2

Approach 1

1. Apply averages of $cpue_d$, $cupe_t$, r_{LNR2}, r_{sub2} and r_d of the lb method (Table 2b)
2. Calculate average discards mortality/retained weight ratio of the 2012-2019 surveys.

Table 6: discard mortality weight/retained weight ratio of the 5 estimation methods.

Year	*LNR*	*LNR2*	*Sub*	*Sub2*	*Ratio*
2012	0.072	0.080	0.037	0.062	0.087
2013	0.107	0.094	0.157	0.113	0.086
2014	0.099	0.088	0.093	0.060	0.102
2015	0.159	0.128	0.230	0.146	0.117
2016	0.040	0.029	0.116	0.030	0.029
2017	0.036	0.028	0.122	0.050	0.025
2018	0.052	0.050	0.126	0.113	0.038
2019	0.060	0.060	0.084	0.083	0.054
Average	0.078	0.070	0.121	0.082	0.067

Approach 2: Construct a linear regression of predicting $cpue_d$, $cupe_t$, $CPUE_{Rs}$, and r_c from observed $CPUE_R$.

Table 7: linear regression equation

	Regression equation	R^2
$cpue_d$	$cpue_d = 0.4037 + 0.3834 CPUE_R$	0.22
$cpue_t$	$cpue_t = -1.5427 + 1.655 CPUE_R$	0.74
$CPUE_{Rs}$	$CPUE_{Rs} = -6.2385 + 1.3271 CPUE_R$	0.87
r_d	*No correlation*	

In 2022, total potlift (E) was 5154, and total number of retained crab was 125042, total weight was 317173, and $CPUE_R$ was 61.54. Applying those, estimated quantities are as follows.

Table 8: average and predicted quantities for 2022 fishery

	Average	*Regression*
$cpue_d$	14.96	24.00
$cpue_t$	61.27	100.30
$CPUE_{Rs}$		75.43
r_{LNR2}	0.35	0.32
r_{sub2}	0.41	0.33
r_d	0.34	

Applying those to the equations, estimated discard mortality biomass (lb) of 2022 was

Table 9: The number of discards and regression method.

	LNR	*LNR2*	*Sub*	*Sub2*	*Ratio*
Regression	24,737	20,181	199,797	104,594	
Average	15,416	22,055	-272	26,041	21,355
Average lb	24,806	22,055	38,261	26,041	21,355

Approach 3: Predict discards from observed trawl survey crab size composition

Trawl survey selectivity method uses the same method for estimating discards (Appendix A, equations 8). **Trawl survey length proportion data as a proxy for true length proportions.** The model estimated trawl survey selectivity is 1.0 for all lengths. This assumes that trawl survey length composition equals NSRKC length proportion subject to fishery.

Discards length proportion $p_{dis,l}$ can be estimated by multiplying model estimated fishery selectivity (S_l) and 1- retention probability ($S_{ret,l}$)

$$p_{dis,l} = p_{twl,l} \cdot S_l \cdot (1 - S_{ret.l})$$

Then calculate discards-retained ratio (r_{dis}) as

$$r_d = \frac{\sum_l p_{twl,l} \cdot S_l \cdot (1 - S_{ret,l})}{\sum_l p_{twl,l} \cdot S_l \cdot S_{ret,l}}$$

The discard biomass unit (w_{dis}) is

$$W_{dis} = \frac{\sum_{l} p_{twl,l} \cdot S_l \cdot \left(1 - S_{ret,l}\right) \cdot wm_l}{\sum_{l} p_{twl,l} \cdot S_l \cdot \left(1 - S_{ret,l}\right)}$$

During the 2012-2019 periods, trawl survey occurred in 2014, 2017, 2018, and 2019. The table below shows trawl survey length proportion, and model estimated selectivity and retention probability from the 2021 assessment model

Table 10: Table: trawl survey size composition, fishery size selectivity (S_l), retention probability (S_{ret}), and estimated discard size composition.

Size	34	44	54	64	74	84	94	104	114	124	134
Trawl											
2014	0.01	0	0.01	0.01	0.07	0.14	0.25	0.27	0.14	0.06	0.02
2017	0.11	0.02	0.01	0.06	0.12	0.11	0.06	0.09	0.13	0.23	0.07
2018	0.02	0.33	0.42	0.08	0.05	0.02	0.02	0.01	0.01	0.01	0.02
2019	0	0	0.02	0.13	0.47	0.26	0.04	0.02	0.01	0.02	0.03
2022	0.12	0.03	0.04	0.14	0.15	0.15	0.14	0.12	0.07	0.03	0.01
S_l	0	0.01	0.04	0.12	0.33	0.64	0.86	0.96	0.99	1	1
S_{ret}	0	0	0	0	0	0	0.07	0.88	1	1	1
Discard											
2014	0	0	0.00	0.00	0.07	0.26	0.58	0.09	0	0	0
2017	0	0	0.00	0.04	0.22	0.40	0.27	0.00	0	0	0
2018	0	0.04	0.22	0.13	0.22	0.17	0.21	0.02	0	0	0
2019	0	0	0.00	0.04	0.42	0.45	0.09	0.01	0	0	0
2022	0	0.00	0.01	0.06	0.17	0.32	0.39	0.05	0	0	0

Comparing the estimated with observed, the estimated r_d tend to be higher than observed, especially 2018 and 2019.

Table 11 Comparisons of parameters between trawl survey method and ratio (number) method.

	r_d	W_{dis}	Ob.r_d	Ob.W_{dis}	*Pred* Mb_{dis}	Ob. Mb_{dis}
2014	0.75	1.57	1.00	1.50	30,300	38,967
2017	0.35	1.28	0.25	1.53	12,060	11,748
2018	1.54	0.92	0.51	1.22	25,238	10,421
2019	4.70	1.05	0.87	0.93	24,842	10,852
2022	1.40	1.34			47,024	

Comparison of methods

Putting the above methods together, 21 discard catch mortality were calculated. Total catch ranged from 0.35 to 0.39 million lb and below ABC of 0.4 million lb.

Table 12 estimates of 2022 total catch based on the 15 methods.

	2022 Total Catch (million lb)
Regression	
LNR	0.36
LNR2	0.36
Sub	0.54
Sub2	0.44
Average	
LNR	0.35
LNR2	0.36
Sub	0.34
Sub2	0.37
Ratio	0.36
Average lb	
LNR	0.36
LNR2	0.36
Sub	0.38
Sub2	0.37
Ratio	0.36
Trawl	0.39

Discussion

As presented the above, overage of ACL is highly depended on *ad hoc* estimation methods being selected. This suggests that a method has to be selected on the merit of scientific accuracy and precision before total catch is calculated. The 15 alternatives presented the above are examples and there could be alternative methods that would provide more accurate and precise estimates. Same as the discussion regarding selecting a method for estimating discards with data, objective criteria for selecting a method for estimating discards without data are not established, and thus author's recommendation is not provided.

Regardless the method being ultimately selected, a question of jurisprudence should be answered first: "should ACL overage that has significant regulatory consequences be determined by an estimate based on NO data?"

The total ABC of NSRKC is calculated as

Total ABC = ABC_Buffer·(retained OFL + 0.2·discards OFL) = $Mb_{R,p} + Mb_{dis,p}$

Based on the preseason ABC, GHL is determined as

GHL < ABC_Buffer·(retained OFL) = $Mb_{R,p}$

Which assumes that discards morality (Mb_{dis}) would be

$$Mb_{dis} = \frac{Mb_{dis,p}}{Mb_{R,p}} \cdot Mb_R$$

And thus, the postseason total catch ($Mb_R + Mb_{dis}$) would be less than ABC unless Mb_R far exceeds GHL.

In reality; however, the projected discard mortality do not always match the observed one. During the 2012-2019 period, observed ratio of discard mortality/retained was up to 8.75 times greater than projected (Table).

Table: Projected and observed mort_lb and "observed" /predicted *mort_lb*$_b$ ratio during the 2012-2019 fisheries.

	2012	2013	2014	2015	2016	2017	2018	2019
Projected	0.010	0.019	0.028	0.045	0.047	0.042	0.037	0.059
Retrospective	0.062	0.091	0.110	0.069	0.035	0.029	0.039	0.083
Observed								
Obs. LNR	0.072	0.107	0.099	0.159	0.040	0.036	0.052	0.060
Obs. LNR2	0.080	0.094	0.088	0.128	0.029	0.028	0.050	0.060
Obs. Sub	0.037	0.157	0.093	0.230	0.116	0.122	0.126	0.084
Obs. Sub2	0.062	0.113	0.060	0.146	0.030	0.050	0.113	0.083
Obs. Ratio	0.087	0.086	0.102	0.117	0.029	0.025	0.038	0.054
Ob/Project ratio								
Retrospective	6.20	4.79	3.93	1.53	0.74	0.69	1.05	1.41
LNR	7.23	5.64	3.54	3.54	0.86	0.85	1.40	1.02
LNR2	7.97	4.95	3.14	2.84	0.63	0.66	1.35	1.01
Sub	3.74	8.25	3.32	5.12	2.46	2.90	3.41	1.42
Sub2	6.20	5.95	2.14	3.23	0.64	1.19	3.06	1.41
Ratio	8.75	4.52	3.65	2.61	0.62	0.60	1.02	0.91

For 2022, projected mort_lb was 0.058 and retrospective (model 21.0) mort_lb was 0.065, which can be translated into projected and retrospective total catch of 0.36 million lb.