Aleutian Islands Golden King Crab Stock Assessment

May 2022 Crab SAFE DRAFT REPORT

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Executive Summary

1. *Stock*

   Golden king crab, *Lithodes aequispinus*, Aleutian Islands, east of 174° W longitude (EAG) and west of 174° W longitude (WAG).

2. *Catches*

   The Aleutian Islands golden king crab (AIGKC) commercial fishery has been prosecuted every year since 1981/82. Retained catch peaked in 1986/87 at 2,686 t (5,922,425 lb) and 3,999 t (8,816,319 lb), respectively, for EAG and WAG, but the retained catch dropped sharply from 1989/90 to 1990/91. The fishery has been managed separately east (EAG) and west (WAG) of 174° W longitude since 1996/97, and Guideline Harvest Levels (GHLs) of 1,452 t (3,200,000 lb) for EAG and 1,225 t (2,700,000 lb) for WAG were introduced into management. The GHL was subsequently reduced to 1,361 t (3,000,000 lb) beginning in 1998/99 for EAG. The reduced harvest levels remained at 1,361 t (3,000,000 lb) for EAG and 1,225 t (2,700,000 lb) for WAG through 2007/08, but were increased to 1,429 t (3,150,000 lb) for EAG and 1,294 t (2,835,000 lb) for WAG beginning with the 2008/09 fishing season following an Alaska Board of Fisheries (BOF) decision. The management specification changed from GHL to TAC (Total Allowable Catch) with adoption of the Crab Rationalization Program in 2005/06 (NPFMC 2007b). The TACs were increased by another BOF decision to 1,501 t (3,310,000 lb) for EAG and 1,352 t (2,980,000 lb) for WAG beginning with the 2012/13 fishing season. The below par fishery performance in WAG in 2014/15 and 2015/16 lead to reduction in TAC to 1,014 t (2,235,000 lb), which reflected a 25% reduction in the TAC for WAG, while the TAC for EAG was kept at the same level, 1,501 t (3,310,000 lb) for the 2016/17 through 2017/18 fishing seasons. With the improved fishery performance and stock status in 2017/18, the TACs were further increased to 1,134 t (2,500,000 lb) for WAG and 1,749 t (3,856,000 lb) for EAG beginning with the 2018/19 fishing season. With the implementation of a revised state harvest strategy in 2019, the TACs were further increased to 1,302 t (2,870,000 lb) for WAG and 1,955 t (4,310,000 lb) for EAG. Based on the model estimated abundances, the 2021/22 fishing season TACs were adjusted to 1,052 t (2,320,000 lb) for WAG and 1,637 t (3,610,000 lb) for EAG.

Catches have been regularly under the GHL/TAC but close to allowable levels since 1996/97. These TAC levels were set below the Allowable Catch (ABC) levels determined under Tier 5 criteria (considering 1991–1995 mean catch for the whole Aleutian Islands region, 3,145 t [6,933,822 lb], as the catch limit) under the most recent crab management plan. A new harvest strategy based on model estimated mature male abundance was accepted by the BOF in March 2019, specifying a 15% maximum harvest rate for EAG and 20% maximum harvest rate for WAG, and implemented during the 2019/20 fishery. In addition to the retained catch allotted as TAC, there was retained catch in a cost-recovery fishery towards a $300,000 goal in 2013/14 and 2014/15 to fund an onboard observer program, and towards a $500,000 goal in 2015/16 to 2021/22 to fund an onboard observer program and stock survey.

Total mortality of Aleutian Islands golden king crab includes retained catch in the directed and the cost recovery fisheries, mortality of discarded catch, and bycatch in fixed-gear and trawl groundfish fisheries, though bycatch in other fisheries is low compared to mortality in the directed fishery. Total retained catch in the post-rationalized fishery (2005/06–2021/22) has ranged from 2,387 t (5,262,000 lb) to 3,319 t (7,316,853 lb). Total mortality ranged from 2,506 t (5,525,000 lb) to 3,729 t (8,222,000 lb) for the same period. Preliminary total retained catch in 2021/22 was 2,477 t (5,460,086 lb): 1,706 t (3,761,682 lb) from the EAG fishery (which included cost-recovery catch), and 770 t (1,698,404 lb) from the WAG fishery (complete fishery data not yet available). Discarded (non-retained) catch occurs mainly during the directed fishery. Although low levels of discarded catch can occur during other crab fisheries, there have been no such fisheries prosecuted locally since 2004/05, except as surveys for red king crab conducted under an Alaska Department of Fish and Game (ADF&G) Commissioner's Permit (and no golden king crab were caught during the cooperative red king crab survey performed by industry and ADF&G in the Adak area in September 2015; Hilsinger *et al.* 2016). Estimates of the bycatch mortality during crab fisheries decreased during 1995/96–2005/06, both in absolute value and relative to the retained catch weight, and stabilized during 2005/06–2014/15. Preliminary total estimated bycatch mortality during crab fisheries in 2021/22 was 168 t (370,000 lb) for EAG and 69 t (152,000 lb) for WAG (complete fishery data not yet available). Discarded catch also occurs during fixed-gear and trawl groundfish fisheries, but is small relative to the directed fishery. Groundfish fisheries are a minor contributor to total fishery discard mortality, 10 t (22,046 lb) for EAG and 1 t (2,205 lb) for WAG in 2021/22.

Catch per unit effort (CPUE, i.e., catch per pot lift) of retained legal males decreased from the 1980s into the mid-1990s, but increased after 1994/95, particularly with the initiation of the Crab Rationalization Program in 2005/06. Although CPUE for the two areas showed similar trends through 2010/11, during 2011/12–2014/15 CPUE trends have diverged (increasing for EAG and decreasing for WAG).

A cooperative golden king crab survey was performed by the Aleutian Islands King Crab Foundation (an industry group) and ADF&G during the EAG and WAG (beginning in August 2018) fisheries, by vessels that were commercial fishing (i.e., each vessel fishing an allotted share of total allowable catch). The cooperative survey was not conducted in 2021 (2020/21 fishery) due to COVID-19, but resumed in 2022 (2021/22 fishery). The time series of data was not large enough to include in the current assessment. For catch accounting, it was assumed that bycatch mortality that occurred during any survey was accounted for by reported discards for the season's fishery.

3. *Stock biomass*

Estimated mature male biomass (MMB) for EAG under all scenarios decreased from the 1980s to the 1990s, then increased during the 2000s and systematically increased since 2014. Estimated MMB for WAG decreased during the late 1980s and 1990s, increased during the 2000s, decreased for several years since 2009 and has increased since 2014. The low levels of MMB for EAG were observed in 1995–1997 and in 1990s for WAG. Stock trends reflected the fishery standardized CPUE trends in both regions.

4. *Recruitment*

The numbers of recruits to the model size groups under all scenarios have fluctuated in both EAG and WAG. For EAG, model recruitment was high during 2017–2019, highest in 2018; and lowest in 1986. The model recruitment for WAG was high during 1984 to 1986, highest in 1985, and lowest in 2011. A slightly increasing trend in recruitment was observed since 2018 in WAG.

5. *Management performance*

King and Tanner crab stocks in the Bering Sea and Aleutian Islands are managed by the State of Alaska through a federal king and Tanner crab fishery management plan (FMP). Under the FMP, management measures are divided into three categories: (1) fixed in the FMP, (2) frame worked in the FMP, and (3) discretion of the State of Alaska. The State of Alaska is responsible for determining and establishing the GHL/TAC under the framework in the FMP. Aleutian Islands golden king crab stocks are managed under the FMP.

The size-based assessment model was accepted at the September 2016 CPT and October 2016 SSC meetings for OFL determination for the 2017/18 fishery cycle. In addition, the CPT in January 2017 and SSC in February 2017 recommended using the Tier 3 method to compute OFL and ABC. The assessment model was first used for setting OFL and ABC for the 2017/18 fishing season. The CPT in May 2017 and SSC in June 2017 accepted the authors' recommendation of using scenario 9 (i.e., model using the knife-edge maturity to determine MMB) for OFL and ABC calculation. During the May 2017 meeting, the CPT noted that a single OFL and ABC are defined for Aleutian Islands golden king crab (AIGKC), however; separate models are available by area. Hence, following previous assessments, OFLs and ABCs by area were used to determine OFL and ABC for the entire stock.

While simple sum of the area-specific OFLs and ABCs to calculate area-wide OFL and ABC was not an issue in past assessments because area-specific stock status was the same for the EAG and WAG (both in Tier 3a), this prescription was not used for this assessment because, on an area-specific basis, the EAG was found to be in Tier 3a while the WAG was in Tier 3b. Therefore, first, area-wide stock status was determined based on the ratio of area-combined current MMB to area-combined $MMB_{35\%}$; second, the area-wide stock status was used as a multiplier for the area-specific $F_{35\%}$'s using the Tier 3 control rule and calculated area-specific OFLs and ABCs; and finally, area-specific OFLs and ABCs were summed to calculate OFL and ABC for the entire stock.

All models for EAG and WAG used the previous season's fishery information (i.e., 2021/22 fishery, concluded in EAG and 73% of TAC achieved in WAG). Following the CPT/SSC suggestion, the WAG assessment considered a hypothetical completed fishery retained and total catch and an average of the last three years' groundfish bycatch removals. The WAG retained catch was set to TAC (TAC in lb was converted to number of crab by dividing by the average retained catch weight in the 2021/22 fishery. The WAG total catch was estimated based on the predicted total effort (by dividing the TAC by the current CPUE) and the current nominal total CPUE. We recommend model 21.1e2 for EAG and WAG OFL and ABC calculation. Maturity size analysis presented in Appendix C provides strong justification to increase the status quo knife-edge maturity size by one size bin. Model 21.1e2 considered a fixed period, 1987–2017, for the mean number of recruit calculation for reference points estimation, standardization of observer and fishery CPUE by the negative binomial generalized linear model, knife-edge maturity size of 116 mm carapace length (CL) for mature male biomass (MMB) estimation, and consideration of three catchability periods for CPUE calculation.

Following CPT and SSC suggestions, we presented variants of the 21.1e model: 21.1f (same as 21.1e but CPUE standardization done considering Year:Area interaction), 21.1e2 and 21.1f2 [knife-edge maturity size increased by one size bin to 116 mm CL for mature male biomass (MMB) estimation] for evaluation.

We also proposed GMACS versions of the same models (model name attached with "G") for consideration. If GMACS is accepted for golden king crab assessment, the GMACS version of the accepted model can be used for OFL and ABC determination. Differences among the GMACS and status quo models' OFL and ABC estimates are minimal.

Model 21.1a is the base model (accepted model in 2021) with two catchability periods, the knife-edge male maturity at 111 mm CL, an M of $0.21 yr^{-1}$, selection of a fixed period, 1987–2017, for mean number of recruit calculation for reference points estimation, and the addition of new data through 2021/22. Models 21.1e, 21.1e2, 21.1f, and 21.1f2, are modifications from the base model.

The data for the EAG are complete through the 2021/22 season. The fishery in the WAG was still operating when the assessment was conducted, with 73% of the TAC taken (as of the 11 March 2022 reported summary). However, this assessment considered a hypothetical completed WAG fishery catch and bycatch removals to estimate OFL and ABC.

Status and catch specifications (1000 t) of Aleutian Islands golden king crab (model 21.1e2)

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[c]	12.592[c]	2.690	2.476	2.725	4.817[d]	3.372[d,e]
2022/23		11.941[c]				3.761[c]	2.821[c,f]

Status and catch specifications (million lb) of Aleutian Islands golden king crab (model 21.1e2)

Year	MSST	Biomass (MMB)	TAC	Retained Catch	Total Catch[a]	OFL	ABC[b]
2018/19	12.964	39.348	6.356	6.536	7.433	12.157	9.118
2019/20	13.041	36.124	7.180	7.317	8.222	11.572	8.679
2020/21	13.259	34.043	6.610	6.614	7.759	10.579	7.934
2021/22	12.917[c]	27.760[c]	5.930	5.460	6.007	10.620[d]	7.434[d,e]
2022/23		26.326[c]				8.291[c]	6.219[c,f]

a. Total retained catch plus estimated bycatch mortality of discarded bycatch during crab fisheries and groundfish fisheries.
b. 25% buffer was applied to total catch OFL to determine ABC.
c. Model 21.1e2 with hypothetical completed fisheries data from WAG was used to estimate MSST, MMB, and MMB projection for 2022/23.
d. OFL and ABC were estimated by the accepted model 21.1a in May 2021 assessment when the WAG fishery was not completed.
e. 30% buffer was applied to total catch OFL to determine ABC for the 2021/22 fishing season after SSC/Council's recommendation.
f. A proposed 25% buffer was applied to total catch OFL to determine ABC for the 2022/23 fishing season.

6. *Basis for the OFL*

The length-based model developed for the Tier 3 analysis estimated mature male biomass (MMB) on February 15 each year for the period 1961 through 2022. The terminal year mature male biomass was projected by an additional year to determine OFL and ABC for the 2022/23 season. The Tier 3 approach uses a constant annual natural mortality (*M*), knife-edge maturity size, and the mean number of recruits for a selected period for OFL and ABC calculation. Previously derived *M* of 0.21 yr^{-1} from the combined data from the EAG and WAG data was used (Siddeek *et al*. 2018).

We provided stock status, OFL, and ABC estimates for EAG and WAG separately from ten models: 21.1a, 21.1e, 21.1f, 21.1e2, and 21.1f2 (CPT/SSC suggested models); and GMACS versions of the same five models for EAG, and WAG in the following four tables. The stock statuses of all models were above $MMB_{35\%}$ (Tier 3a) for EAG, but below $MMB_{35\%}$ (Tier 3b) for WAG.

EAG (Tier 3):

Basis for the OFL: Biomass, total OFL, and ABC for the next fishing season in 1000 t.

Model	Tier	$MMB_{35\%}$	Current MMB	MMB/ $MMB_{35\%}$	F_{OFL}	Recruitment Years to Define $MMB_{35\%}$	$F_{35\%}$	Natural Mortality	OFL	ABC (P*=0.49)	ABC (0.75*OFL)
EAG21.1a	3a	6.8183	8.9786	1.13	0.59	1987–2017	0.59	0.21	2.870708	2.856884	2.153031
EAG21.1e	3a	6.8248	7.6704	1.12	0.59	1987–2017	0.59	0.21	2.875508	2.860831	2.156631
EAG21.1f	3a	6.9063	8.0544	1.17	0.58	1987–2017	0.58	0.21	3.079595	3.065571	2.309696
EAG21.1e2	3a	6.6250	7.3874	1.12	0.52	1987–2017	0.52	0.21	2.602425	2.588992	1.951819
EAG21.1f2	3a	6.7150	7.7885	1.16	0.51	1987–2017	0.51	0.21	2.781799	2.769123	2.086349
21.1aG	3a	7.1425	7.8874	1.10	0.59	1987–2017	0.59	0.21	2.943906		2.207930
21.1eG	3a	7.1218	7.7954	1.09	0.59	1987–2017	0.59	0.21	2.896413		2.172310
21.1fG	3a	7.1899	8.1094	1.13	0.58	1987–2017	0.58	0.21	3.058319		2.293739
21.1e2G	3a	6.9532	7.5667	1.09	0.54	1987–2017	0.54	0.21	2.695235		2.021426
21.1f2G	3a	7.0193	7.8859	1.12	0.53	1987–2017	0.53	0.21	2.846522		2.134892

Basis for the OFL: Biomass, total OFL, and ABC for the next fishing season in millions of pounds. Current MMB = MMB on 15 Feb. 2023.

Model	Tier	$MMB_{35\%}$	Current MMB	MMB/ $MMB_{35\%}$	F_{OFL}	Recruitment Years to define $MMB_{35\%}$	$F_{35\%}$	Natural Mortality	OFL	ABC (P*=0.49)	ABC (0.75*OFL)
EAG21.1a	3a	15.032	16.932	1.13	0.59	1987–2017	0.59	0.21	6.329	6.298	4.747
EAG21.1e	3a	15.046	16.910	1.12	0.59	1987–2017	0.59	0.21	6.339	6.307	4.755
EAG21.1f	3a	15.226	17.757	1.17	0.58	1987–2017	0.58	0.21	6.789	6.758	5.092
EAG21.1e2	3a	14.605	16.286	1.12	0.52	1987–2017	0.52	0.21	5.737	5.708	4.303
EAG21.1f2	3a	14.804	17.171	1.16	0.51	1987–2017	0.51	0.21	6.133	6.105	4.600
21.1aG	3a	15.746	17.389	1.10	0.59	1987–2017	0.59	0.21	6.490		4.868
21.1eG	3a	15.701	17.186	1.09	0.59	1987–2017	0.59	0.21	6.385		4.789
21.1fG	3a	15.851	17.878	1.13	0.58	1987–2017	0.58	0.21	6.742		5.057
21.1e2G	3a	15.329	16.682	1.09	0.54	1987–2017	0.54	0.21	5.942		4.456
21.1f2G	3a	15.475	17.385	1.12	0.53	1987–2017	0.53	0.21	6.275		4.707

WAG (Tier 3):

Basis for the OFL: Biomass, total OFL and ABC for the next fishing season in 1000 t.

Model	Tier	$MMB_{35\%}$	Current MMB	MMB / $MMB_{35\%}$	F_{OFL}	Recruitment Years to Define $MMB_{35\%}$	$F_{35\%}$	Natural Mortality	OFL	ABC (P*=0.49)	ABC (0.75*OFL)
WAG21.1a	3b	5.26463	4.98178	0.95	0.53	1987–2017	0.56	0.21	1.275145	1.267133	0.956359
WAG21.1e	3b	5.24755	4.88714	0.93	0.52	1987–2017	0.56	0.21	1.210694	1.203386	0.908021
WAG21.1f	3b	5.1999	4.32669	0.83	0.46	1987–2017	0.56	0.21	0.861767	0.854071	0.646325
WAG21.1e2	3b	5.09318	4.55384	0.89	0.43	1987–2017	0.49	0.21	1.044986	1.038687	0.783740
WAG21.1f2	3b	5.04663	3.97328	0.79	0.37	1987–2017	0.49	0.21	0.730238	0.723608	0.547679
21.1aG	3b	5.2381	4.8725	0.93	0.51	1987–2017	0.56	0.21	1.249347		0.937010
21.1eG	3b	5.2499	4.8167	0.92	0.50	1987–2017	0.55	0.21	1.215451		0.911588
21.1fG	3b	5.1981	4.2330	0.81	0.44	1987–2017	0.55	0.21	0.870176		0.652632
21.1e2G	3b	5.1119	4.5434	0.89	0.44	1987–2017	0.50	0.21	1.086574		0.814931
21.1f2G	3b	5.0615	3.9495	0.78	0.38	1987–2017	0.50	0.21	0.767109		0.575332

Basis for the OFL: Biomass, total OFL, and ABC for the next fishing season in millions of pounds. Current MMB = MMB on 15 Feb. 2023.

Model	Tier	$MMB_{35\%}$	Current MMB	MMB/ $MMB_{35\%}$	F_{OFL}	Recruitment Years to Define $MMB_{35\%}$	$F_{35\%}$	Natural Mortality	OFL	ABC (P*=0.49)	ABC (0.75*OFL)
WAG21.1a	3b	11.606	10.983	0.95	0.53	1987–2017	0.56	0.21	2.811	2.794	2.108
WAG21.1e	3b	11.569	10.774	0.93	0.52	1987–2017	0.56	0.21	2.699	2.653	2.002
WAG21.1f	3b	11.464	9.539	0.83	0.46	1987–2017	0.56	0.21	1.900	1.883	1.425
WAG21.1e2	3b	11.228	10.039	0.89	0.43	1987–2017	0.49	0.21	2.304	2.290	1.728
WAG21.1f2	3b	11.126	8.759	0.79	0.37	1987–2017	0.49	0.21	1.610	1.595	1.207
21.1aG	3b	11.548	10.742	0.93	0.51	1987–2017	0.56	0.21	2.754		2.066
21.1eG	3b	11.574	10.619	0.92	0.50	1987–2017	0.55	0.21	2.680		2.010
21.1fG	3b	11.460	9.332	0.81	0.44	1987–2017	0.55	0.21	1.918		1.439
21.1e2G	3b	11.270	10.016	0.89	0.44	1987–2017	0.50	0.21	2.395		1.797
21.1f2G	3b	11.159	8.707	0.78	0.38	1987–2017	0.50	0.21	1.691		1.268

7. Probability density functions of the OFL

Assuming a lognormal distribution of total OFL, we determined the cumulative distributions of OFL and selected the median as the OFL.

8. Basis for the ABC recommendation

A x proportion buffer on the OFL, i.e., ABC = (1.0 - x) *OFL, where the authors recommended x = 0.25. (Note: The SSC recommended to use x=0.3 in the last assessment cycle).

Please see also the section G on ABC.

9. A summary of the results of any rebuilding analysis:

Not applicable.

A. Summary of Major Changes

1. *Changes (if any) to management of the fishery*
   - None.
2. *Changes to input data*
   - Commercial fisheries data were updated with values from the most recent observer and fish ticket data for 2021/22: retained catch for the directed fishery and discarded catch estimates for the directed fishery, non-directed crab fisheries, and groundfish fisheries. Thus, the time series of data used in the model are retained catch (1981/82–2021/22), total catch (1990/91–2021/22), and groundfish bycatch (1989/90–2021/22) biomass and size compositions.
   - Fish ticket retained CPUE were standardized by the generalized linear model (GLM) with the negative binomial link function for the 1985/86–1998/98 period.
   - Observer pot sample legal size crab CPUE data were standardized by the GLM with the negative binomial link function with variable selection by CAIC (modified AIC) followed by R square criterion, separately for 1995/96–2004/05 and 2005/06–2021/22 periods. A Year and Area interaction factor was considered in one model (21.1f) to estimate a set of CPUE indices. The habitat areas were determined from observer historical pot locations as fishing footprints (Appendix B).
3. *Changes to assessment methodology*

   None.
4. *Changes to assessment results*

   As expected, the addition of the 2021/22 data changed the OFL and ABC estimates, but changes in parameter or abundance estimates were not dramatic.

B. Response to January 2022 CPT comments

Comment#1. The analysts provided an estimate of the size-at-maturity based on recent chela height data and a two-regression line approach. The estimate of size-at-maturity from this analysis was 116mm CL, which is larger than the value used in previous assessments (111mm CL). The CPT requested that the document for May 2022 include details of the data on which the current size-at-maturity is based, as well as the results of fitting the two-regression line model to those data.

Response: We have analyzed the recent (2018–2020) and the older (NMFS 1985 and ADFG 1991) maturity (chela height and carapace length) data and discussed the results in Appendix C.

Comment#2. The assessment document provided information on the RACE slope survey. It was noted that the data from this survey are not separated to sex, and no size measurements are available. The sample sizes are also very low for some years and areas. Nevertheless, the slope survey occurs where there are fishery data and so a rough assessment of whether CPUE is an index of abundance can be conducted by comparing the time-series of CPUE (all sizes and sexes) versus that of survey biomass to assess whether CPUE is approximately linearly related to abundance.

Response: We have not addressed this question in this report but will investigate comparing the RACE slope survey CPUE vs. survey biomass and whether they are linearly related in the next round of the assessment.

Comment#3. The algorithm used to standardize the catch and effort data was updated based on recommendations from the CPT and the SSC, leading to more parsimonious models. The report included plots of the soak time smooth, but it did not appear to be correctly calculated. The analysis leading to this plot should be reviewed and updated results provided.

Response: We provide a soak time smooth plot for WAG1995_04 data fitted with GLM as an example.

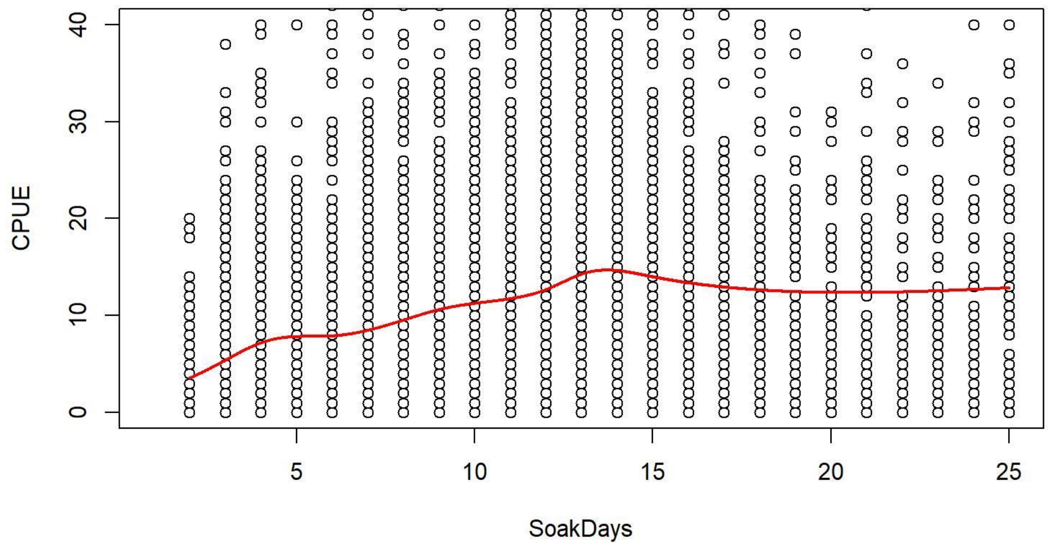


Figure B.1. Soak time spline smoother curve fitted to observer CPUE data for 1995–04 in WAG. The cubic spline degree of freedom was determined to be 8.

Comment#4. There is a need to compare the design-based estimates of CPUE by area with those predicted by the standardization model that includes year*area interactions (this is a suggestion by the SSC).

Response: Because of limited time available between January and May meetings, we could not finalize this analysis. We will complete this request in the next round of the assessment.

Comment#5. The CPT noted that all the models except model 21.1c assumed that catchability was the same for the fish ticket and early observer CPUE series, but that this was invalid. Thus, all the models for the May 2022 meeting should allow for three catchability coefficients and three additional CVs.

Response: In this report, we adopted CPT/SSC recommendations as listed in Comment#7.

Comment#6. The CPT requested the analyst to present GMACS versions of the models for EAG and WAG to be considered in May alongside the status quo model.

Response: Done.

Comment#7. The CPT listed the following model configurations for the May 2022 CPT presentation:

• Model 21.1a: The model on which the 2021 assessment was based. This model will not be considered for providing management advice but will provide a link with the previous assessment.

• Model 21.1e: As for model 21.1a, except that separate catchability coefficients and additional CV parameters are estimated for the fish ticket (1985-1998), early (1995-2004) observer, and late (2005+) observer CPUE indices.
• Model 21.1f. As for model 21.1e. except that the CPUE standardization is based on year*area interactions.
• Model 21.e2: As for model 21.1e, but with the size-at-maturity increased from 111mm to 116mm.
• Model 21.f2: As for model 21.1f, but with the size-at-maturity increased from 111mm to 116mm.

Response: Done.

Comment#8. The fits to the CPUE data should be plotted separately by model given that models 21.1e and 21.1f are based on different sets of indices.

Response: Done (see Figures 22 for EAG and 38 for WAG).

Response to February 2022 SSC comments:

Comment#1. The SSC looks forward to further updates and seeing GMACS versions of these models for both EAG and WAG in June for possible consideration for setting specifications.

Response: Done.

Comment#2. The SSC recommends the authors provide a side-by-side comparison of the area-wide indices by RACE slope survey with observer CPUE to see if trends in the time series are similar and that the authors include the survey index in the SAFE in the future for context, even if it is not used in the model.

Response: Please read our response to CPT comment#2.

Comment#3. With respect to estimating a new size-at-maturity value based on chela height/chela length relationships, the SSC recommends that the authors provide a rationale for only using the most recent data to determine size at maturity instead of the entire dataset. The SSC also recommends that, in addition to comparing the analytical approaches, the authors provide a biological rationale for their findings.

Response: In this report we have considered individual data sets (i.e., new, old) as well as all data combined for maturity analysis (Appendix C). In the absence of in-situ experiments on copulations, we used an indirect method of assigning maturity based on male chela height measurements. The morphometric maturity characteristic has been used by many researchers for male crab maturity determination (references are cited in Appendix C).

Comment#4. The SSC expressed concern over the continued retrospective pattern in the EAG model, which might be indicative of a source/sink dynamic between the EAG and WAG that is unaccounted for in the model. It was noted that increasing M did not appear to mitigate this issue. The SSC recommends that the authors examine the catchability parameters, which are about half as large in the EAG as in the WAG and explore whether this is possibly an issue with scaling of the index. The SSC found it surprising that the catchability parameters were in the range of one, which indicates that indices are on the scale of absolute abundance. It was noted that the difference in catchability estimates is about the size of the retrospective bias in the EAG.

Response: A continued retrospective pattern in the EAG model has been a concern for some time. In this run, we followed the SSC suggestion to estimate time varying catchability to address this issue:

We formulated the following time varying catchability sub-model for the post-rationalization period:

$$Q_t = \bar{Q}e^{\epsilon_t}$$

where $\bar{Q}$ is the mean catchability and ϵ_t is the catchability deviation in year *t*. Log catchability deviation was minimized to estimate catchability by year.

A variable catchability model drastically reduced the MMB retrospective pattern in EAG with a Mohn rho value of -0.0985 (Figure 21). The catchability (Q) estimates during post-rationalization period are listed in the following table:

Year	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**
Q	0.4146	0.3405	0.3720	0.3537	0.2975	0.2989	0.4323	0.4430	0.4658
Year	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	
Q	0.6536	0.7506	0.6621	0.6504	0.7441	0.6622	0.5488	0.4890	

As you have noted earlier, the catchability estimates in EAG were lower than 1 compared to WAG. Although direct in-situ evidence are lacking, we speculate that change in fishing tactics to focus on pockets of highly concentrated area might have contributed in part to change in catchability.

With the variable catchability sub model, EAG21.1eQ, the MMB were lower than those of 21.1e leading to lower OFL (2,267t, 4.997 mlb) and ABC (1,700t, 3.748 mlb) estimates.

Addition of EAG21.eQ and WAG21.1e estimates resulted in an OFL of 3,477 t (7.665 mlb) and an ABC of 2,608 t (5.749 mlb) for AI.

Comment#5. The SSC also request the authors to provide a rationale for the use of the years 1987-2017 for average recruitment rather than including more recent years given changes in environmental conditions. While it is common to not include the most recent recruitment estimates, it is expected that the recruitments from 2017-2018 should be sufficiently well established at this point.

Response: Two points to note:

1. There was hardly any difference in the MMB trends between assuming the 1987-2017 period and the 1987-2018 period for R0 and reference points calculation (see the figure below for the example EAG21.1e model):

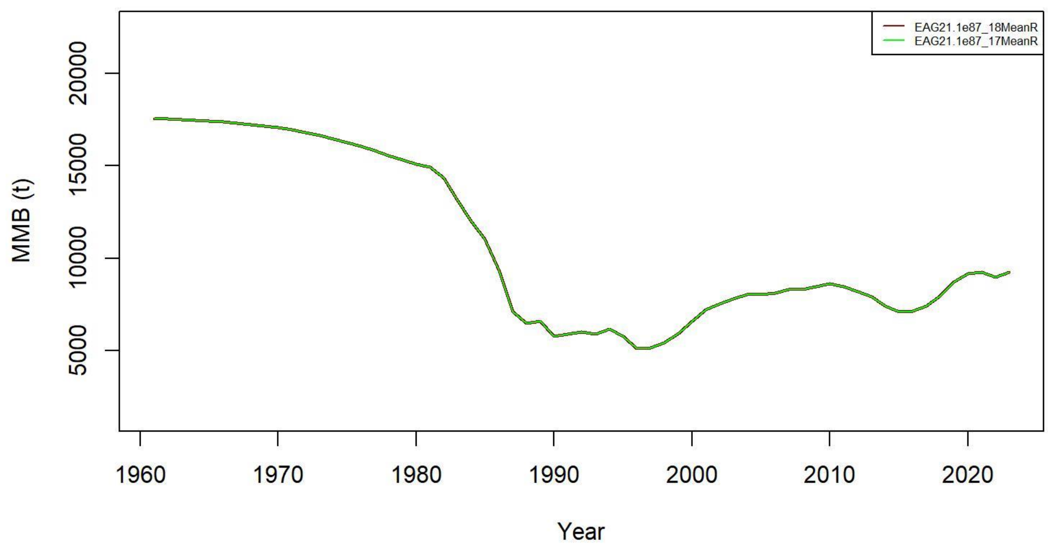


Figure B.2. Comparison of MMB trends between models with two different mean recruit calculation periods, 1987-2017 and 1987-2018, for EAG golden king crab, 1961–2022.

2. Although there was a slight difference in $MMB_{35\%}$ estimates between 1987-2018 and 1987-2017 mean R scenarios (6,901 t vs. 6,953 t), the OFL estimates were identical (2,875 t) for the example EAG21.1e model.

Comment#6. The SSC requests to explore, in the near future, a single area model for AIGKC with shared parameters from the two regions.

Response: We initiated this task. Because of limited time available between January and May meetings, we could not finalize this analysis. We will complete this request in the near future.

C. Introduction

1. **Scientific name:**
   Golden king crab, *Lithodes aequispinus* J.E. Benedict, 1895.

2. **Distribution:**
   General distribution of golden king crab is summarized by NMFS (2004). Golden king crab, also called brown king crab, occur from the Sea of Japan to the northern Bering Sea (ca. 61° N latitude), around the Aleutian Islands, generally in high-relief habitat such as inter-island passes, on various sea mounts, and as far south as northern British Columbia (Alice Arm) (Jewett *et al.* 1985). They are typically found on the continental slope at depths of 300–1,000 m on extremely rough bottom. They are frequently found on coral bottom.

   The Aleutian Islands king crab stock boundary is defined by the boundaries of the Aleutian Islands king crab Registration Area O (Figure 1). In this chapter, "Aleutian Islands Area" means the area described by the current definition of Aleutian Islands king crab Registration Area O. Nichols *et al.* (2021) define the boundaries of Aleutian Islands king crab Registration Area O:

   The Aleutian Islands king crab Registration Area O eastern boundary is the longitude of Scotch Cap Light (164°44.72'W long); the northern boundary is a line from Cape Sarichef (54°36'N lat) to 171°W long, north to 55°30'N lat; and the western boundary the United States–Russia Maritime Boundary Line of 1990.

   During 1984/85–1995/96, the Aleutian Islands king crab populations had been managed using the Adak and Dutch Harbor Registration Areas, which were divided at 171° W longitude (Figure 2), but from the 1996/97 season to present the fishery has been managed using a division at 174° W longitude (Figure 1). In March 1996, the Alaska Board of Fisheries (BOF) replaced the Adak and Dutch Harbor areas with the newly created Aleutian Islands Registration Area O and directed ADF&G to manage the golden king crab fishery in the areas east and west of 174°W longitude as two distinct stocks. That re-designation of management areas was intended to reflect golden king crab stock distribution, congruent with the longitudinal pattern in fishery production prior to 1996/97 (Figure 3). The longitudinal pattern in fishery production relative to 174° W longitude since 1996/97 is like that observed prior to the change in management area definition, although there have been some changes in the longitudinal pattern in fishery production within the areas east and west of 174° W longitude (Figure 4).

   Commercial fishing for golden king crab in the Aleutian Islands Area typically occurs at depths of 100–275 fathoms (183–503 m). Pots sampled by at-sea fishery observers in 2013/14 were fished at an average depth of 176 fathoms (322 m; N=499) in the area east of 174° W longitude and 158 fathoms (289 m; N=1,223) for the area west of 174° W longitude (Gaeuman 2014).

3. **Evidence of stock structure:**
Given the expansiveness of the Aleutian Islands Area and the existence of deep (>1,000 m) canyons between some islands, at least some weak structuring of the stock within the area would be expected. Data for making inferences on stock structure of golden king crab within the Aleutian Islands are largely limited to the geographic distribution of commercial fishery catch and effort. Catch data by statistical area from fish tickets and catch data by location from pots sampled by observers suggest that habitat for legal-sized males may be continuous throughout the waters adjacent to the islands in the Aleutian chain. However, regions of low fishery catch suggest that availability of suitable habitat, in which golden king crab are present at only low densities, may vary longitudinally. Catch has been low in the fishery in the area between 174° W longitude and 176° W longitude (the Adak Island area, Figures 3 and 4) in comparison to adjacent areas, a pattern that is consistent with low CPUE for golden king crab between 174° W longitude and 176° W longitude (Figure 5) during the 2002, 2004, 2006, 2010, and 2012 NMFS Aleutian Islands bottom trawl surveys (von Szalay *et al*. 2011, 2017). In addition to longitudinal variation in density, there is also a gap in fishery catch and effort between the Petrel Bank-Petrel Spur area and the Bowers Bank area; both of those areas, which are separated by Bowers Canyon, have reported effort and catch. Recoveries during commercial fisheries of golden king crab tagged during ADF&G surveys (Blau and Pengilly 1994; Blau *et al.* 1998; Watson and Gish 2002; Watson 2004, 2007) provided no evidence of substantial movements by crab in the size classes that were tagged (males and females ≥90-mm carapace length [CL]). Maximum straight-line distance between release and recovery location of 90 golden king crab released prior to the 1991/92 fishery and recovered through the 1992/93 fishery was 61.2 km (Blau and Pengilly 1994). Of the 4,567 recoveries reported through April 12, 2016, for the male and female golden king crab tagged and released between 170.5° W longitude and 171.5° W longitude during the 1991, 1997, 2000, 2003, and 2006 ADF&G Aleutian Island golden king pot surveys, none of the 3,807 with recovery locations specified by latitude and longitude were recovered west of 173° W longitude and only fifteen were recovered west of 172° W longitude (V. Vanek, ADF&G, Kodiak, pers. comm.). Similarly, of 139 recoveries in which only the statistical area of recovery was reported, none were recovered in statistical areas west of 173° W longitude and only one was in a statistical area west of 172° W longitude.

4. **Life history characteristics relevant to management:**
There is a paucity of information on golden king crab life history characteristics due in part to the deep depth distribution (~200–1000 m) and the asynchronous nature of life history events (Otto and Cummiskey 1985; Somerton and Otto 1986).

The reproductive cycle is thought to last approximately 24 months and at any time of year ovigerous females can be found carrying egg clutches in highly disparate developmental states (Otto and Cummiskey 1985). Females carry large, yolk-rich, eggs, which hatch into lecithotrophic (i.e., the larvae can develop successfully to juvenile crab without eating; Shirley and Zhou 1997) larvae that are negatively phototactic (Adams and Paul 1999). Molting and mating are also asynchronous and protracted (Otto and Cummiskey 1985; Shirley and Zhou 1997) with some indications of seasonality (Hiramoto 1985). Molt increment for large males (adults) in Southeast Alaska is 16.3 mm CL per molt (Koeneman and Buchanan 1985) and was estimated at 14.4 mm CL for legal males in the EAG (Watson *et al.* 2002). Annual molting probability of males decreases with increasing size, which results in a protracted inter-molt period and creates difficulty in determining annual molt probability (Watson *et al.* 2002). Male size-at-maturity varies among stocks (Webb 2014) and declines with increasing latitude from about 130 mm CL in the Aleutian Islands to 92 mm CL in Saint Matthew Island section (Somerton and Otto 1986). Along with a lack of annual survey data, limited stock-specific life history stock information prevents development of the standard length-based assessment model.

5. **Summary of management history:**

A complete summary of the management history through 2015/16 is provided in Leon *et al.* (2017). The first commercial landing of golden king crab in the Aleutian Islands was in 1975/76 but directed fishing did not occur until 1981/82.

The Aleutian Islands golden king crab fishery was restructured beginning in 1996/97 to replace the Adak and Dutch Harbor areas with the newly created Aleutian Islands Registration Area O and golden king crab in the areas east and west of 174° W longitude were managed separately as two stocks (ADF&G 2002). Hereafter, the east of 174° W longitude stock segment is referred to as EAG and the west of 174° W longitude stock segment is referred to as WAG. Table 1 provides the historical summary of number of vessels, GHL/TAC, harvest, effort, CPUE, and average weight in the Aleutian Islands golden king crab fishery.

The fisheries in 1996/97–1997/98 were managed with GHLs of 1,452 t (3,200,000 lb) in EAG and 1,225 t (2,700,000 lb) in WAG (Table 1). During 1998/99–2004/05 the fisheries were managed with GHLs of 1,361 t (3,000,000 lb) for EAG and 1,225 t (2,700,000 lb) for WAG. During 2005/06–2007/08 the fisheries were managed with a total allowable catch (TAC) of 1,361 t (3,000,000 lb) for EAG and a TAC of 1,225 t (2,700,000 lb) for WAG. By state regulation (*5 AAC 34.612*), TAC for the Aleutian Islands golden king crab fishery during 2008/09–2011/12 was 1,429 t (3,150,000 lb) for EAG and 1,286 t (2,835,000 lb) for WAG. In March 2012, the BOF changed *5 AAC 34.612* so that the TAC beginning in 2012/13 would be 1,501 t (3,310,000 lb) for the EAG and 1,352 t (2,980,000 lb) for WAG. Additionally, the BOF added a provision to *5 AAC 34.612* that allows ADF&G to lower the TAC below the specified level if conservation concerns arise. The TAC for 2016/17 (and 2017/18) was reduced by 25% for WAG to 1,014 t (2,235,000 lb) while keeping the TAC for EAG at the same level as the previous season.

During 1996/97–2021/22 the annual retained catch during commercial fishing (including cost-recovery fishing that occurred during 2013/14–2021/22) has averaged 2% below the annual GHL/TACs, but has ranged from as much as 13% below (1998/99) to 6% above (2000/01) the GHL/TAC.

A summary of other relevant State of Alaska fishery regulations and management actions pertaining to the Aleutian Islands golden king crab fishery is provided below:

Beginning in 2005/06, the Aleutian Islands golden king crab fishery has been prosecuted under the Crab Rationalization Program. Accompanying the adoption of crab rationalization program was implementation of a community development quota (CDQ) fishery for golden king crab in the eastern Aleutians (i.e., EAG) and the Adak Community Allocation (ACA) fishery for golden king crab in the western Aleutians (i.e., WAG; Hartill 2012; Nichols *et al*. 2021). The CDQ fishery in the eastern Aleutians is allocated 10% of the golden king crab TAC for the area east of 174° W longitude and the ACA fishery in the western Aleutians is allocated 10% of the golden king crab TAC for the area west of 174° W longitude. The CDQ fishery and the ACA fishery are managed by ADF&G and prosecuted concurrently with the individual fishing quota (IFQ) fishery.

Golden king crab may be commercially fished only with king crab pots (defined in state regulation *5 AAC 34.050*). Pots used to fish for golden king crab in the Aleutian Islands Area must be longlined and, since 1996, each pot must have at least four escape rings of five and one-half inches minimum inside diameter installed on the vertical plane or at least one-third of one vertical surface of the pot composed of not less than nine-inch stretched mesh webbing to permit escapement of undersized golden king crab (*5 AAC 34.625 (b)*). Prior to the regulation requiring an escape mechanism on pots, some participants in the Aleutian Islands golden king crab fishery voluntarily sewed escape rings (typically 139 mm [5.5 inches]) into their gear or, more rarely, included panels with escape mesh (Beers 1992). Regarding the gear used since the establishment of *5 AAC 34.625 (b)* in 1996, Linda Kozak, a representative of the industry, reported in a 19 September 2008 email to the Crab Plan Team, "… the golden king crab fleet has modified their gear to allow for small crab sorting," and provided a written statement from Lance Nylander, of Dungeness Gear Works in Seattle, who "believes he makes all the gear for the golden king crab harvesting fleet," saying that "Since 1999, DGW has installed 9[-inch] escape web on the door of over 95% of Golden Crab pot orders we manufactured." A study to estimate the contact-selection curve for male golden king crab was conducted aboard one vessel commercial fishing for golden king crab during the 2012/13 season and found gear and fishing practices used by that vessel were highly effective in reducing bycatch of sublegal-sized males and females

(Vanek *et al*. 2013). In March 2011 (effective for 2011/12), the BOF amended *5 AAC 34.625 (b)* to relax the "biotwine" specification for pots used in the Aleutian Islands golden king crab fishery relative to the requirement *in 5 AAC 39.145* that "(1) a sidewall ...of all shellfish and bottom fish pots must contain an opening equal to or exceeding 18 inches in length... The opening must be laced, sewn, or secured together by a single length of untreated, 100 percent cotton twine, no larger than 30 thread." Regulation *5 AAC 34.625 (b)(1)* allows the opening described in *5 AAC 39.145 (1)* to be "laced, sewn, or secured together by a single length of untreated, 100 percent cotton twine, no larger than 60 [rather than 30] thread."

Regulation (*5 AAC 34.610 (b)*) sets the commercial fishing season for golden king crab in the Aleutian Islands Area as 1 August through 30 April. That regulatory fishing season became effective in 2015/16 (the commercial fishing season was set in regulation as 15 August through 15 May during 2005/06–2014/15).

Current regulations (*5 AAC 39.645 (d)(4)(A)*) stipulate that onboard observer are required on catcher vessels during the time that at least 50% of the retained catch is captured in each of the three trimesters of the 9-month fishing season. Onboard observers are required for 100% of fishing activity on catcher-processor vessels during the crab fishing season.

In addition, the commercial golden king crab fishery in the Aleutian Islands Area may only retain males at least 6.0-inches (152.4 mm) carapace width (CW), including spines (*5 AAC 34.620 (b)*), which is at least one annual molt increment larger than the 50% maturity length of 120.8 mm CL for males as estimated by Otto and Cummiskey (1985). A carapace length (CL) ≥136 mm is used to identify legal-size males when CW measurements are not available (Table 3-5 in NPFMC 2007b). Note that the size limit for golden king crab has been 6-inches (152.4 mm) CW for the entire Aleutian Islands Area since the 1985/86 season. Prior to the 1985/86 season, the legal-size limit was 6.5-inches (165.1 mm) CW for at least one of the now-defunct Adak or Dutch Harbor Registration Areas.

We re-evaluated the male maturity size using 1991 pot survey measurements of carapace length and chela height in EAG and 1984 NMFS measurements in WAG (Siddeek *et al*. 2018). Bootstrap analysis of chela height and carapace length data provided the median 50% male maturity length estimates of 107.02 mm CL in EAG and 107.85 mm CL in WAG. We used a knife-edge maturity length of 111.0 mm CL, which is the lower limit of the next upper size bin, for mature male biomass (MMB) estimation. We analyzed the recently collected (2018 to 2020) chela height and carapace length data and proposed a higher maturity length of 116.0 mm CL (Appendix C).

Daily catch and catch-per-unit effort (CPUE) are determined in-season to monitor fishery performance and progress towards the respective TACs. Figures 6 to 8 provide the 1985/86–2021/22 time series of catches, CPUE, and the geographic distribution of catch during the 2021/22 fishing season. Increases in CPUE were observed during the late 1990s through the early 2000s, and with the implementation of crab rationalization in 2005. This is likely due to changes in gear configurations in the late 1990s (crab harvesters, personal communication, 1 July 2008) and, after rationalization due to increased soak time (Siddeek *et al.* 2015), and decreased competition owing to the reduced number of vessels fishing. Decreased competition could allow crab vessels to target only the most productive fishing areas. Trends in fishery nominal CPUE within the areas EAG and WAG generally paralleled each other during 1985/86–2010/11, but diverged thereafter (EAG CPUE exceeded one and half times of that in WAG). A moderate decreasing trend in CPUE was observed since 2014 in EAG and since 2019 in WAG (Figures 6 and 7).

6. **Brief description of the annual ADF&G harvest strategy:**
   In March 2019, the BOF adopted a revised harvest strategy (Daly *et al.* 2019). The annual TAC is set by state regulation, *5 AAC 34.612* (Harvest Levels for Golden King Crab in Registration Area O), per:

(a) In that portion of the Registration Area O east of 174° W. long., the total allowable catch level shall be established as follows:
   (1) if MMA_E is less than 25 percent of $MMA_{E,\,(1985\text{-}2017)}$, the fishery will not open;
   (2) if MMA_E is at least 25 percent but not greater than 100 percent of $MMA_{E,\,(1985\text{-}2017)}$, the number of legal male golden king crab available for harvest will be computed as (0.15) x ($MMA_E/MMA_{E,\,(1985\text{-}2017)}$) x($MMA_E$) or 25 percent of LMA_E, whichever is less; and
   (3) if MMA_E is greater than 100 percent of $MMA_{E,\,(1985\text{-}2017)}$, the number of legal male golden king crab available for harvest will be computed as (0.15) x(MMA_E) or 25 percent of LMA_E, whichever is less.

(b) In that portion of the Registration Area O west of 174° W. long., the total allowable catch level shall be established as follows:
   (1) if MMA_W is less than 25 percent of $MMA_{W,\,(1985\text{-}2017)}$, the fishery will not open
   (2) if MMA_W is at least 25 percent but not greater than 100 percent of $MMA_{W,\,(1985\text{-}2017)}$, the number of legal male golden king crab available for harvest will be computed as (0.20) x ($MMA_W/MMA_{W,\,(1985\text{-}2017)}$) x($MMA_W$) or 25 percent of LMA_W, whichever is less; and
   (3) if MMA_W is greater than 100 percent of $MMA_{W,\,(1985\text{-}2017)}$, the number of legal male golden king crab available for harvest will be computed as (0.20) x(MMA_W) or 25 percent of LMA_W, whichever is less.

(c) In implementing this harvest strategy, the department shall consider the reliability of estimates of golden king crab, the manageability of the fishery, and other factors the department determines necessary to be consistent with sustained yield principles and to use the best scientific information available and consider all sources of uncertainty as necessary to avoid overfishing.

(d) In this section,

(1) MMA_E means the abundance of male golden king crab in the portion of the Aleutian Islands Management Area O east of 174° W. long that are greater than or equal to 111 millimeters in carapace length estimated by the stock assessment model for the time prior to the start of the fishery.
(2) $MMA_{E,(1985\text{-}2017)}$ means the mean value of the abundance of male golden king crab in the portion of the Aleutian Islands Management Area O east of 174° W. long that are greater than or equal to 111 millimeters in carapace length estimated by the stock assessment model for the time prior to the start of the fishery for the period 1985 – 2017.
(3) LMA_E means the abundance of male golden king crab in the portion of the Aleutian Islands Management Area O east of 174° W. long that are greater than or equal to 136 millimeters in carapace length estimated by the stock assessment model for the time prior to the start of the fishery.
(4) MMA_W means the abundance of male golden king crab in the portion of the Aleutian Islands Management Area O west of 174° W. long that are greater than or equal to 111 millimeters in carapace length estimated by the stock assessment model for the time prior to the start of the fishery.
(5) $MMA_{W,(1985\text{-}2017)}$ means the mean value of the abundance of male golden king crab in the portion of the Aleutian Islands Management Area O west of 174° W. long that are greater than or equal to 111 millimeters in carapace length estimated by the stock assessment model for the time prior to the start of the fishery for the period 1985 – 2017; and
(6) LMA_W means the abundance of male golden king crab in the portion of the Aleutian Islands Management Area O west of 174° W. long that are greater than or equal to 136 millimeters in carapace length estimated by the stock assessment model for the time prior to the start of the fishery.

In addition to the retained catch that is limited by the TAC established by ADF&G under *5 AAC 34.612*, ADF&G has authority to annually receive receipts up to $500,000 through cost-recovery fishing on Aleutian Islands golden king crab. The retained catch from that cost-recovery fishing is not counted against attainment of the annually established TAC.

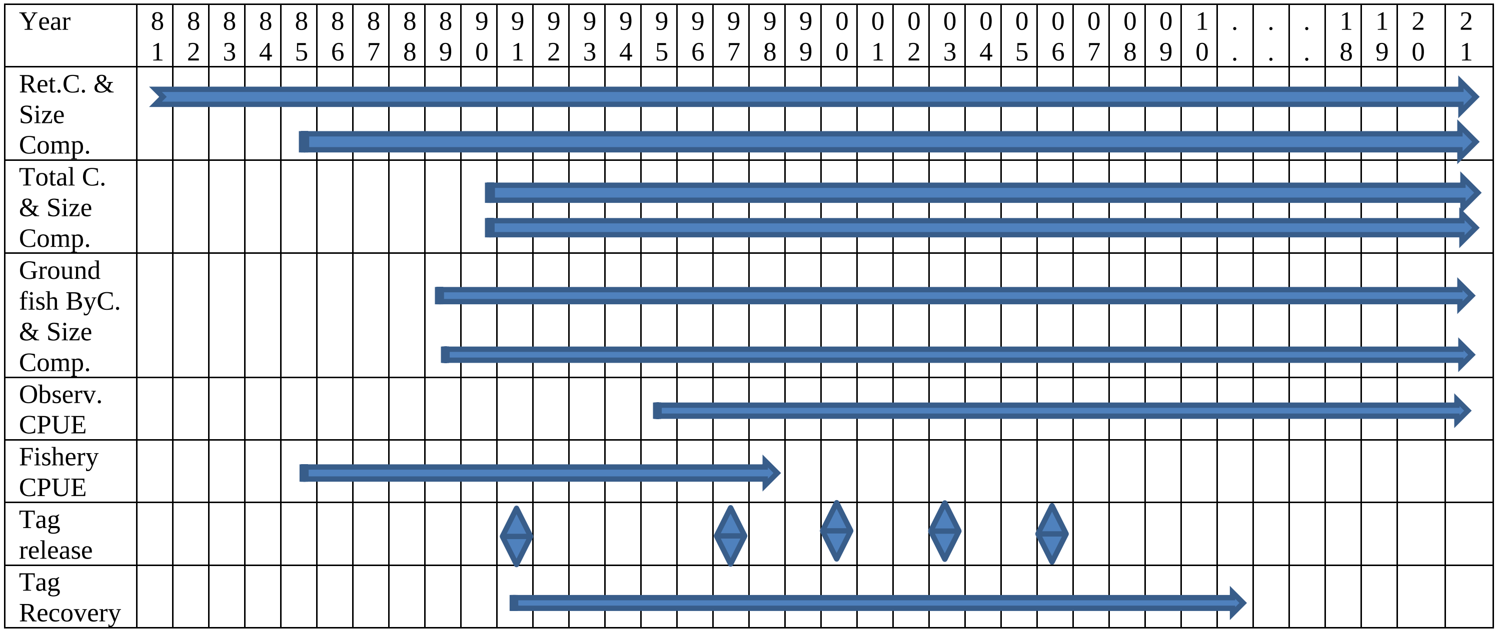
7. Summary of the history of the basis and estimates of MMB_{MSY} or proxy MMB_{MSY}:

We estimated the proxy MMB_{MSY} as $MMB_{35\%}$ using the Tier 3 estimation procedure, which is explained in a subsequent section.

D. Data

1. Summary of new information:

(a) Commercial fishery retained catch by size, estimated total catch by size, groundfish male discard catch by size, observer CPUE index, and commercial fishery CPUE index were updated to include 2021/22 information. Available data by year are shown below.


Year
81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07 08 09 10 .. .. .. 18 19 20 21
Ret.C. & Size Comp.
Total C. & Size Comp.
Ground fish ByC. & Size Comp.
Observ. CPUE
Fishery CPUE
Tag release
Tag Recovery

2. Data presented as time series:

a. **Total Catch**:

Fish ticket data on retained catch weight, catch numbers, effort (pot lifts), CPUE, and average weight of retained catch for 1981/82–2021/22 (Table 1). Estimated total catch weight for 1990/91–2021/22 (Table 2a).

b. **Bycatch and discards**:

Retained catch, bycatch mortality (male and female) separated by the crab fishery and groundfish fishery, and total fishery mortality for 1981/82–2021/22 (Table 2). Crab fishery discards are available after observer sampling was established in 1988/89. Observer data for the 1988/89–1989/90 seasons are not considered reliable. Table 2 provides crab fishery discards and groundfish fishery bycatch for 1991/92–2021/22 seasons.

c. Catch-per-unit-effort:

- Pot fishery and observer nominal retained and total CPUE, pot fishery effort, observer sample size, and estimated observer CPUE index delineated by EAG and WAG for 1985/86–2021/22 (Table 3).

- Estimated commercial fishery CPUE index with coefficient of variation (Table 4 for EAG and Table 14 for WAG). The estimation methods, and CPUE fits are described in Appendix B.

d. Catch-at-length:

Information on length compositions is provided (Figures 9a, b, c to 10a, b, c for EAG; and 25a, b, c to 26a, b, c for WAG for models 21.1a, 21.1e, and 21.1f, respectively.

e. Survey biomass estimates:

Cooperative pot survey estimates were not included in the stock assessment models evaluated.

f. Survey catch–at–length:

Data are available but yet to be processed for presentation.

g. **Other time series data**: None.

3. Data which may be aggregated over time:

- **Molt and size transition matrix:** Tag release – recapture –time at liberty records from 1991, 1997, 2000, 2003, and 2006 male tag crab releases were aggregated by year at liberty to determine the molt increment and size transition matrix by the integrated model.
- **Weight-at-length**: Male length-weight relationship: $W = aL^b$ where $a = 1.445 * 10^{-4}$, $b = 3.28113$ [$\sigma_a = 0.00737$ (bias correction for a was not required because of the very small value of σ_a); updated estimates from WAG data].

- **Natural mortality**: A previous model estimated fixed natural mortality value of 0.21 yr^{-1}, was used in the assessment.

4. **Information on any data sources that were available, but were excluded from the assessment:**
   Data from triennial ADF&G pot surveys for Aleutian Islands golden king crab in a limited area in EAG (between 170° 21' and 171° 33' W longitude) that were performed during 1997 (Blau *et al.* 1998), 2000 (Watson and Gish 2002), 2003 (Watson 2004), and 2006 (Watson 2007) are available, but were not used in this assessment. However, the tag release and recapture data from these surveys were used.

   Data from the cooperative pot surveys conducted during 2015 to 2021 are available but is limited in the time series. The EAG survey covers the full time series, but WAG survey started only in 2018.

E. Analytic Approach

1. **History of modeling approaches for this stock:**
   A size structured assessment model based on only fisheries data was under development for several years for the EAG and WAG golden king crab stocks and accepted in 2016 for OFL and ABC setting for the 2017/18 season. The CPT in January 2017 and SSC in February 2017 recommended using the Tier 3 procedure to set the OFL and ABC. They also suggested using the maturity data to estimate the male mature biomass (MMB). We followed these suggestions in this report to estimate the model based OFL and ABC.

2. **Model Description:**
   a. **Description of overall modeling approach:**
   The underlying population dynamics model is male-only and length-based (Appendix A). This model combines commercial retained catch, total catch, groundfish fishery discarded catch, standardized observer legal size catch-per-unit-effort (CPUE) indices, fishery retained catch size composition, total catch size composition, and tag recaptures by release-recapture length to estimate stock assessment parameters. The tagging data were used to calculate the size transition matrix. To estimate the MMB, we used the knife-edge 50% maturity based on the chela height and carapace length data analysis. To include a long time series of CPUE indices for stock abundance contrast, we also considered the 1985/86–1998/99 legal size standardized fishery CPUE indices as a separate likelihood component in all models (Table T1).

   There were significant changes in fishing practice associated with changes in management regulations (e.g., constant TAC since 1996/97 and crab rationalization since 2005/06), pot configuration (escape web on the pot door increased to 9-inch since 1999), and improved observer recording in Aleutian

Islands golden king crab fisheries since 1998. These changes prompted us to consider two sets of total selectivity parameters with only one set of retention parameters for the periods 1985/86–2004/05 and 2005/06–2021/22. Since CPUE standardization was carried out based on three sets of data (fish ticket CPUE for the period 1985 – 1998; and observer CPUE for two separate periods, 1995 – 2004 and 2005 – 2021), we considered models (21.1e, 21.1e2, 21.1f, and 21.1f2) with three catchability and additional CV parameters, which seems more justifiable (see Table T1).

We fitted the observer and commercial fishery CPUE indices with standard errors (estimated by GLM) and an additional assessment model estimated constant variance. The assessment model predicted total and retained CPUEs. However, we compared only the predicted retained CPUE with the observer legal size crab CPUE indices in the likelihood function because observer recordings of legal-size crab seem reliable.

The data series ranges used for the WAG are the same as those for EAG.

b. **Software**:
AD Model Builder (Fournier *et al.* 2012).

c.–f. Details are given in Appendix A.

g. **Critical assumptions and consequences of assumption failures**:
Because of the lack of an annual stock survey, we relied heavily on standardized CPUE indices (Appendix B) and catch and size composition information to determine the stock abundance trends in both regions. We assumed that the observer and fish ticket CPUE indices are linearly related to exploitable abundance. We kept M constant at 0.21 yr^{-1} and knife-edge maturity size at 111 mm CL (Siddeek *et al.* 2018). We also considered a higher knife-edge maturity size of 116 mm CL and maturity curves for MMB estimation in different model scenarios. We assumed directed pot fishery discard mortality at 0.20 yr^{-1}, overall groundfish fishery mortality at 0.65 yr^{-1} (mean of groundfish pot fishery mortality [0.5 yr^{-1}] and groundfish trawl fishery mortality [0.8 yr^{-1}]), groundfish fishery selectivity at full selection for all length classes (selectivity = 1.0). Any discard of legal-size males in the directed pot fishery was not considered in this analysis. These fixed values invariably reduced the number of model parameters to be estimated and helped in convergence. We assumed different q's (scaling parameter for standardized CPUE in the model, Equation A.13) and logistic selectivity patterns (Equation A.9) for different periods for the pot fishery.

h. **Changes to any of the above since the previous assessment:**
None.

i. **Model code has been checked and validated**.

The codes have been checked at various times by independent reviewers and the current codes are available from the first author.

3. Model Selection and Evaluation

a. Description of alternative model configurations:

We considered ten models for EAG and WAG (Table T1). We presented OFL and ABC results for all models separately for EAG, WAG, and the entire AI in the executive summary tables. We considered model 21.1a as the base model. It considers:

i) Initial abundance by the equilibrium condition considering the mean number of recruits for 1987–2012: The equilibrium abundance was determined for 1960 (Equations A.4 and A.5), projected forward with only *M* and annual recruits until 1980, then retained catches removed during 1981–1984 and projected to obtain the initial abundance in 1985.

ii) Observer CPUE indices for 1995/96–2021/22.

iii) Fishery CPUE indices for 1985/86–1998/99.

iv) Initial (Stage-1) weighting of effective sample sizes: number of vessel-days for retained and total catch size compositions, and number of fishing trips for groundfish discard size composition (the groundfish size composition was not used in model fitting); and (Stage-2) iterative re-weighting of effective sample sizes by the Francis method.

v) Two catchabilities and two sets of logistic total selectivities for the fishery CPUE periods 1985/86–2004/05 and 2005/06–2021/22, and a single set of logistic retention curve parameters.

vi) Full selectivity (selectivity =1.0) for groundfish fishery bycatch.

vii) Knife-edge maturity size of 111 mm CL.

viii) Stock dynamics $M = 0.21$ yr^{-1}, pot fishery handling mortality = 0.2 yr^{-1}, and mean groundfish bycatch handling mortality = 0.65 yr^{-1}.

ix) Size transition matrix using tagging data estimated by the normal probability function with the logistic molt probability sub-model. The tag-recaptures were treated as Bernoulli trials (i.e., Stage-1 weighting).

x) The period, 1987–2012, was used to determine the mean number of recruits for $MMB_{35\%}$ (a proxy for MMB_{MSY}) estimation under Tier 3.

The salient features and variations from the base scenario of all other scenarios are listed in Table T1. The list of fixed and estimable parameters is provided in Table A1 and detail weights with coefficient of variations (CVs) assigned to each type of data are listed in Table A2.

Best estimates of parameter values for a representative model, 21.1e, were jittered to confirm model global convergence. The results indicated that global convergence was achieved (Appendix D).

b. **Progression of results:**
The OFL and ABC estimates are like those estimates made previously, 2020/21.

c. **Label the approved model from the previous year as model:**
We used the notation 21.1a for the base model which came from the last year accepted assessment model, 21.1a.

d. **Evidence of search for balance between realistic and simpler models**:
Unlike annually surveyed stocks, Aleutian Islands golden king crab stock biomass is difficult to track, and several biological parameters are assumed based on knowledge from red king crab (e.g., handling mortality rate of 0.2 yr^{-1}) due to a lack of species/stock specific information. We fixed several model parameters after initially running the model with free parameters to reduce the number of parameters to be estimated (e.g., groundfish bycatch selectivity parameters were fixed). In CPUE standardization, instead of using the traditional AIC we used the Consistent Akaike Information Criteria (Bozdogan 1987) that considers number of parameters and data points used for fitting models when selecting the final model. The final GLM model predictor variables were tested for collinearity by the GIF statistics (Fox and Weisberg 2011) and found them to be non-collinear. The assessment models also considered different configuration of parameters to select parsimonious models. The detailed results of all models are provided in tables and figures.

e. **Convergence status and criteria**:
ADMB default convergence criteria were used.

f. Table of the sample sizes assumed for the size compositional data:
We estimated the initial input effective sample sizes (i.e., Stage-1) either as number of vessel-days for retained and total catch compositions or number of fishing trips for groundfish size composition (note: we did not use the groundfish size composition in model fitting) for all model scenarios. Then we estimated the Stage-2 effective sample sizes iteratively from Stage-1 input effective sample sizes using the Francis' (2011, 2017) mean length-based method.

We provide the initial input sample sizes (Stage-1) and Stage-2 effective sample sizes for models 21.1a, 21.1e, and 21.1f in Tables 5 to 7 for EAG and Tables 14 to 16 for WAG.

g. **Provide the basis for data weighting, including whether the input effective sample sizes are tuned, and the survey CV adjusted:**
Described previously (f).

h. **Do parameter estimates make sense and are they credible?**
The estimated parameter values are within the bounds and various plots suggest that the parameter values are reasonable for a fixed *M* value for the golden king crab stocks.

i. **Model selection criteria:**
We used several diagnostic criteria to select appropriate models for our recommendation: CPUE fits, observed vs. predicted tag recapture numbers by time at large and release size, retained and total catch, and groundfish bycatch fits. Figures are provided for all model scenarios in the Results section.

j. **Residual analysis:**
We illustrated residual fits by bubble plots for retained and total catch size composition predictions in various figures in the Results section.

k. **Model evaluation:**
Only one base model with several model variations is presented and the evaluations are presented in the Results section below.

4. Results

1. List of effective sample sizes and weighting factors:

The Stage-1 and Stage-2 effective sample sizes are listed for various models in Tables 5 to 7 for EAG and Tables 14 to 16 for WAG. The weights, with the CV specifications, for different data sets are provided in Table A2 for various models for both EAG and WAG. These weights (with the corresponding CV) adequately fitted the length compositions, and no further changes were examined.

We used weighting factors for catch biomass, recruitment deviation, pot fishery *F*, and groundfish fishery *F*. We set the retained catch biomass weight to an arbitrarily large value (500.0) because retained catches are more reliable than any other data sets. We scaled the total catch biomass weight in accordance with the observer annual sample sizes (number of pots) with a maximum of 250.0. The total catches were derived from observer nominal total CPUE and effort. In some years, observer sample sizes were low (Tables 3). We chose a small groundfish bycatch weight (0.5) based on the September 2015 CPT suggestion. We slightly increased the groundfish bycatch weight from previous 0.2 to 0.5 to obtain global convergence fits for all models (see the jitter tables in Appendix D). We used the best fit criteria to choose the lower weight for the groundfish bycatch. Groundfish bycatch of Aleutian Islands golden king crab is very low (Table 2). We set the CPUE weights to 1.0 for all models. We included a constant (model estimated) variance in addition to input CPUE variance for the CPUE fit. We used the Burnham *et al.* (1987) suggested formula for ln (CPUE) (and ln (MMB)) variance estimation (Equation A.14). However, estimated additional variance values were small for both observer and fish ticket CPUE indices for the two regions. Nevertheless, the CPUE index variances estimated from the negative binomial GLM were adequate to fit the model, as confirmed by the fit diagnostics (Fox and Weisberg 2011). Parameter estimates are provided in Tables 8 for EAG and 17 for WAG for models 21.1a, 21.1e, and 21.1f. The numbers of estimable parameters are listed in Table A1.

2. **Include tables showing differences in likelihood:**
   Tables 12 and 21 list the total and component negative log likelihood values for primary models, 21.1a, 21.1e, and 21.1f, for EAG and WAG, respectively.

3. **Tables of estimates:**
   a. The parameter estimates with coefficient of variation for models 21.1a, 21.1e, and 21.1f are summarized in Tables 8 and 17 for EAG and WAG, respectively. We have also provided the boundaries for parameter searches in those tables. All parameter estimates were within the bounds.

   b. All models considered molt probability parameters in addition to the linear growth increment and normally distributed growth variability parameters to determine the size transition matrix.

   c. The mature male and legal male abundance time series for selected models (21.1a, 21.1e, and 21.1f) are summarized in Tables 9 to 11 for EAG and Tables 18 to 20 for WAG.

   d. The recruitment estimates for those models are summarized in Tables 9 to 11 for EAG and Tables 18 to 20 for WAG.

   e. The negative log-likelihood component values and total negative log-likelihood values for models 21.1a, 21.1e, and 21.1f are summarized in Table 12 for EAG and Table 21 for WAG. Although loglikelihood values of different models are not comparable because of data weighting (i.e., different magnitude of effective sample sizes), nevertheless, model 21.1e has the minimum total negative log likelihood compared to model 21.1f (both with equal number of parameters) for EAG and WAG. However, the total negative log likelihood values for the three models were not widely different.

4. **Graphs of estimates:**
   a. **Selectivity**:
   Total selectivity and retention curves of the pre- and post-rationalization periods for models 21.1a, 21.1e, and 21.1f are illustrated in Figures 12 for EAG and Figures 28 for WAG. Total selectivity for the pre-rationalization period was used in the tagging model. The groundfish bycatch selectivity appeared flat in the preliminary analysis, indicating that all size groups were vulnerable to the gear. This is also shown in the size compositions of groundfish bycatch (Figures 11 and 27 for model 21.1a for EAG and WAG,

respectively). Thus, we set the groundfish bycatch selectivity to 1.0 for all length-classes in the subsequent analysis.

b. **Mature male biomass**:
The mature male biomass time series for models 21.1a, 21.1e, and 21.1f are depicted in Figures 24a (long time series, 1961 to 2022) and 24b (short time series, 2006 to 2022) for EAG and WAG. Mature male biomass tracked the CPUE trends well for selected models for EAG and WAG. The biomass variance was estimated using the Burnham *et al.* (1987) suggested formula (Equation A.14). We determined the mature male biomass values on 15 February each year and considered a fixed period time series of recruits (Table T1) for estimating mean number of recruits for the $MMB_{35\%}$ calculation under a Tier 3 approach.

c. **Fishing mortality**:
The full selection pot fishery F values over time for models 21.1a, 21.1e, and 21.1f are shown in Figure 23 for EAG and WAG. The F peaked in late 1980s and early to mid-1990s and systematically declined in the EAG. Slight increases in F were observed from 2014 to 2016, followed by a decline in the EAG. On the other hand, the F in the WAG peaked in late 1980s, 1990s, and early 2000s, declined in late 2000s, and slightly increased in 2013–2014 before declining.

d. **F vs. MMB:**
We provide these plots for models 21.1a, 21.1e, and 21.1f for EAG and WAG in Figure 39. The 2021/22 F was below the overfishing levels for all models in EAG but above the overfishing level for model 21.1f in WAG.

e. **Stock-Recruitment relationship:** None.

f. **Recruitment**:
Temporal changes in total number of recruits to the modeled (21.1a, 21.1e, and 21.1f) population are illustrated in Figure 14 for EAG and in Figure 30 for WAG. The recruitment distribution to the model size group (101–185 mm CL) is shown in Figures 15 and 31 for EAG and WAG, for the respective models.

5. Evaluation of the fit to the data:

g. **Fits to catches:**
The fishery retained and total catch, and groundfish bycatch (observed vs. estimated) plots are illustrated in Figure 17 for EAG and in Figure 33 for WAG for models 21.1a, 21.1e, and 21.1f. The 1981/82–1984//85 retained catch plots for respective models are depicted in Figures 18 and 34 for EAG and WAG, respectively. All predicted fits were very close to observed

values, especially for retained catch and groundfish bycatch mortality. However, pre-1995 total catch data did not fit well.

h. **Survey data plot:**
We did not provide the cooperative survey plots in this report.

i. **CPUE index data:**
The comparison of predicted CPUE with input indices (open circles with 95% confidence intervals) for models 21.1a, 21.1e, and 21.1f are shown in Figure 22 for EAG and Figure 38 for WAG. The CPUE variance was estimated using the Burnham *et al.* (1987) suggested formula (Equation A.14). These figures illustrate varying matches of CPUE predictions with input values by different models.

j. **Tagging data:**
The predicted vs. observed tag recaptures by length-class for years 1 to 6 post tagging are depicted in Figure 13 for EAG and Figure 29 for WAG. The predictions appear reasonable. Note that we used the EAG tagging information for a fixed size transition matrix estimation for both stocks (EAG and WAG). The size transition matrices estimated using EAG tagging data in the EAG, and WAG models were similar.

k. **Molt probability**:
The predicted molt probabilities vs. CL are depicted for models 21.1a, 21.1e, and 21.1f in Figures 16 for EAG and in Figure 32 for WAG. The fitted curves appear to be satisfactory.

l. **Fit to catch size compositions:**
Retained and total length compositions are shown in Figures 9a, b, c and 10a, b, c for EAG and 25a, b, c and 26a, b, c for WAG for models 21.1a, 21.1e, and 21.1f, respectively. The groundfish discard length compositions for model 21.1a are shown in Figures 11 for EAG and 27 for WAG. The retained and total catch size composition fits appear satisfactory. But the fits to groundfish bycatch size compositions are poor. Note that we did not use the groundfish size compositions in any of the model fits.

We illustrate the standardized residual plots as bubble plots of size composition over time for retained catch (Figures 19 for EAG and 35 for WAG) and for total catch (Figures 20 for EAG and 36 for WAG) for model 21.1e. The retained catch bubble plots do not appear to exhibit major pronounced patterns among residuals for the selected model.

m. **Marginal distributions for the fits to the composition data:**
We did not provide this plot in this report.

n. **Plots of implied versus input effective sample sizes and time series of implied effective sample sizes:**
We did not provide the plots or table values of implied vs. input effective sample sizes in this report. However, we provide the Stage-1 and the optimized re-weighted Stage-2 effective sample sizes in Tables 5 to 7 for EAG and in Tables 14 to 16 for WAG, respectively for models 21.1a, 21.1e, and 21.1f.

o. **Tables of RMSEs for the indices:**
We did not provide this table in this report.

p. **Quantile-quantile (Q–Q) plots:**
We did not provide these plots for model fits in this report.

6. Retrospective and historical analysis:

The retrospective fits for models 21.1a and 21.1e are shown in Figure 21 for EAG and Figure 37 for WAG. The retrospective fits for the whole time series, 1961 to 2021, did not show severe departure when nine terminal years' data were sequentially removed, especially for WAG, and hence the current formulation of the model appears stable. The modified Mohn rho (Mohn 1999; Deroba 2014) values are also given in the figure.

The low values (rule of thumb: closer to zero / between -0.2 to 0.2) of Mohn rho are indication for no severe model misspecification. In the current analysis, the Mohn rho values show no severe model misspecification for WAG. However, both models (21.1a and 21.1e) for EAG show some degree of misspecifications. Following an SSC suggestion, we created a new model 21.1eQ, which was a modification of 21.1e with annually varying catchability during the post-rationalization period. As a result, the misspecification was drastically reduced with a Mohn rho value of -0.0985 (Figure 21).

7. Uncertainty and sensitivity analysis:

The main task was to determine a plausible size transition matrix to project the population over time. In a previous study, we investigated the sensitivity of the model to determining the size transition matrix by using or not using a molt probability function (Siddeek *et al.* 2016a). The model fit improved when a molt probability model was included. Therefore, we included a molt probability sub-model for size transition matrix calculation in all model scenarios.

8. Conduct 'jitter analysis':

We conducted jitter analysis on 21.1e (Appendix D). The results indicated that global convergence was achieved for most runs in both EAG and WAG.

F. Calculation of the OFL

1. Specification of the Tier level:
In the following section, we provide the Tier 3 method to determine OFL and ABC.

2. List of parameter and stock size estimates (or best available proxies thereof) required by limit and target control rules specified in the fishery management plan:

The critical assumptions for MMB_{MSY} reference point estimation of Aleutian Islands golden king crab are:

a. Natural mortality is constant.
b. A fixed growth transition matrix is adequately estimated from tagging data and a molt probability sub-model.
c. Total fishery selectivity and retention curves are length-dependent and the 2005/06–2021/22 period selectivity estimates are applicable.
d. Groundfish bycatch fishery selectivity is kept constant at 1.0 for all length groups.
e. Model estimated recruits (in millions of crab) are valid for different periods considered in selected models.
f. Model estimated groundfish bycatch mortality values are appropriately averaged for the period 2012/13–2021/22 (10 years).
g. The knife-edge maturity size, 111 mm CL, used for MMB estimation is correct.

Method:
We simulated the population abundance starting from the model estimated terminal year stock size by length, model estimated parameter values, a fishing mortality value (*F*), and a constant number of annual recruits. Once stock dynamics were stabilized (we used the 99th year estimates) for an *F*, we calculated the MMB/R for that *F*. We computed the relative *MMB/R* in percentage, $\left(\frac{MMB}{R}\right)_{x\%}$ (where x% = $\frac{\frac{MMB_F}{R}}{\frac{MMB_0}{R}} \times 100$ and MMB_0/R is the virgin *MMB/R*) for different *F* values.
$F_{35\%}$ is the *F* value producing an MMB/R value equal to 35% of MMB_0/R.
$MMB_{35\%}$ is estimated using the following formula:

$$MMB_{35\%} = \left(\frac{MMB}{R}\right)_{35\%} \times \bar{R},$$

where $\bar{R}$ is the mean number of model estimated recruits for a selected period.

3. Specification of the OFL:

a. **Provide the equations (from Amendment 24) on which the OFL is to be based*:***

F_{OFL} uses Equation A.28. The OFL is estimated by an iterative procedure accounting for intervening total removals (Appendix A).

b. **Basis for projecting MMB to the time of mating:**
We followed the NPFMC (2007a) guideline.

c. **Specification of F_{OFL}, OFL, and other applicable measures (if any) relevant to determining whether the stock is overfished or if overfishing is occurring:**

The 2021/22 fishery data indicated that overfishing did not occur (Total Catch < OFL) and the stock did not reach an overfished status (MMB > MSST). Please see Management Performance table below. The OFL and ABC values for 2022/23 in the table below are the authors-recommended values.

Status and catch specifications (1000 t) of Aleutian Islands golden king crab (model 21.1e2)

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[c]	12.592[c]	2.690	2.476	2.725	4.817[d]	3.372[d,e]
2022/23		11.941[c]				3.761[c]	2.821[c,f]

Status and catch specifications (million lb) of Aleutian Islands golden king crab (model 21.1e2)

Year	MSST	Biomass (MMB)	TAC	Retained Catch	Total Catch[a]	OFL	ABC[b]
2018/19	12.964	39.348	6.356	6.536	7.433	12.157	9.118
2019/20	13.041	36.124	7.180	7.317	8.222	11.572	8.679
2020/21	13.259	34.043	6.610	6.614	7.759	10.579	7.934
2021/22	12.917[c]	27.760[c]	5.930	5.460	6.007	10.620[d]	7.434[d,e]
2022/23		26.326[c]				8.291[c]	6.219[c,f]

a. Total retained catch plus estimated bycatch mortality of discarded bycatch during crab fisheries and groundfish fisheries.
b. 25% buffer was applied to total catch OFL to determine ABC.
c. Model 21.1e2 with hypothetical completed fisheries data from WAG was used to estimate MSST, MMB, and MMB projection for 2022/23.
d. OFL and ABC were estimated by the accepted model 21.1a in May 2021 assessment when the WAG fishery was not completed.
e. 30% buffer was applied to total catch OFL to determine ABC for the 2021/22 fishing season after SSC/Council's recommendation.

f. A proposed 25% buffer was applied to total catch OFL to determine ABC for the 2022/23 fishing season.

4. Specification of the retained portion of the total catch OFL:
The retained catch portions of the total-catch OFL for EAG, WAG, and the entire Aleutian Islands (AI) stock were calculated for the four models, 21.1a, 21.1e, 21.1e2, and 21.1f:

Model 21.1a:
EAG: 2,756 t (6.077 million lb)
WAG: 1,193 t (2.629 million lb)
AI: 3,949 t (8.706 million lb).

Model 21.1e:
EAG: 2,876 t (6.340 million lb)
WAG: 1,132 t (2.495 million lb)
AI: 4,008 t (8.835 million lb).

Model 21.1e2:
EAG: 2,500 t (5.511 million lb)
WAG: 978 t (2.156 million lb)
AI: 3,478 t (7.667 million lb).

Model 21.1f:
EAG: 2,958 t (6.522 million lb)
WAG: 797 t (1.757 million lb)
AI: 3,755 t (8.279 million lb).

G. Calculation of ABC

We estimated the cumulative probability distribution of OFL assuming a log normal distribution of OFL. We calculated the OFL at the 0.5 probability and the maximum ABC at the 0.49 probability and considered an additional buffer by setting ABC =0.75*OFL.

We provide the ABC estimates with the 25% buffer for EAG, WAG, and AI for models 21.1a, 21.1e, 21.1e2, and 21.1f:

Model 21.1a:
EAG: ABC = 2,153 t (4.747 million lb)
WAG: ABC = 956 t (2.108 million lb)
AI: ABC = 3,109 t (6.855 million lb).

Model 21.1e:
EAG: ABC = 2,157 t (4.755 million lb)
WAG: ABC = 908 t (2.002 million lb)
AI: ABC = 3,065 t (6.757 million lb).

Model 21.1e2:
EAG: ABC = 1,952 t (4.303 million lb)
WAG: ABC = 784 t (1.728 million lb)
AI: ABC = 2,736 t (6.031 million lb).

Model 21.1f:
EAG: ABC = 2,310 t (5.092 million lb)
WAG: ABC = 646 t (1.425 million lb)
AI: ABC = 2.956 t (6.517 million lb).

1. **List of variables related to scientific uncertainty:**
    - Models rely largely on fisheries data.
    - Observer and fisheries CPUE indices played a major role in the assessment model.
    - Natural mortality, 0.21 yr^{-1}, was estimated in the previous model and not independently estimated here.
    - The period to compute the average number of recruits relative to the assumption that this represents "a period determined to be representative of the production potential of the stock."
    - Fixed bycatch mortality rates were used in each fishery (crab fishery and the groundfish fishery) that discarded golden king crab.
    - Discarded catch and bycatch mortality for each fishery in which bycatch occurred during 1981/82–1989/90 were not available.

2. **List of additional uncertainties for alternative sigma-b.**
   We recommend a buffer of 25% to account for additional uncertainties.

3. **Author recommended ABC:**
   Authors recommend four ABC options based on 25% buffer on the OFL under models 21.1a, 21.1e, 21.1e2, and 21.1f. However, authors' preferred model is 21.1e2.

H. Rebuilding Analysis

Not applicable. This stock has not been declared overfished.

I. Data Gaps and Research Priorities

1. Recruit abundances were tied to commercial catch sampling data. The implicit assumption in the analysis was that the estimated recruits come solely from the same exploited stock through growth and mortality. The current analysis did not consider that additional recruitment may occur through immigration from neighboring areas and possibly separate sub-stocks. The analysis also did not consider emigration from the study area,

which would result in an assumption of increased *M* or a reduced estimate of recruits. Extensive tagging experiments or resource surveys are needed to investigate stock distributions.

2. We estimated *M* in the model. However, an independent estimate of *M* is needed for comparison, which could be achieved with tagging experiments.
3. An extensive tagging study may provide independent estimates of molting probability and growth. We used historical tagging data to determine the size transition matrix.
4. An arbitrary 20% handling mortality rate on discarded males was used, which was obtained from the red king crab literature (Kruse *et al.* 2000; Siddeek 2002). An experimentally based independent estimate of handling mortality is needed for Aleutian Islands golden king crab.
5. ADF&G and the Aleutian King Crab Research Foundation recently initiated cooperative crab survey programs in the Aleutian Islands. This program needs to be strengthened and continued for golden king crab research to address some of the data gaps and establish a fishery independent data source.
6. It is unclear how the recent changes in environmental conditions in the Bering Sea will affect golden king crab growth and survival. Limited length-weight data from the cooperative survey and independent biological sampling in 2018 and 2020 from WAG were used in the current assessment; however, more measurements are needed from both regions to increase the sample size to refine the length-weight model.
7. We used male maturity information to determine MMB. The ADF&G observer sampling, dock side sampling, and cooperative survey programs collected male maturity data during 2018/19 through 2021/22. Preliminary analysis on these data is presented in this assessment. The CPT previously recommended to collect additional data on small size crab (sublegal) to improve maturity fit. The maturity data collection needs to be continued to accumulate more measurements on small size crab.
8. Morphometric measurements provide size at maturity. Ideally, an experimental study under natural environment conditions is needed to collect male size at functional maturity data to determine functional maturity size.

J. Acknowledgments

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K. Literature Cited

Some references are not cited in the main text but retained in this list given relevance to progression of AIGKC assessment model development over the years.

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Table T1. Features of all model scenarios: Initial condition was estimated in year 1960 by the equilibrium condition; two sets of logistic total selectivity curves were used for the pre- and post-rationalization periods; a single retention curve was used for the whole period; and a common *M* of 0.21 yr^{-1} was used. The effective sample sizes for size compositions were estimated in two stages: Stage-1: as the number of vessel days/trips and Stage-2: as the Francis re-iteration method.

Model	**CPUE Data Type and Maturity Option**	**Period for Mean Number of Recruit Calculation for (a) Initial Equilibrium Abundance and (b) Reference Points Estimations and Remarks**
21.1a (accepted model in May 2021, implemented with up to 2021/22 data)-base model	Observer data from 1995/96–2021/22 Fish ticket data from 1985/86–1998/99; Observer and fish ticket CPUE standardization by negative binomial model; a knife-edge minimum maturity size of 111 mm CL; and two catchability and additional CVs (1985–2004 and 2005–2021).	1987–2017; CPT/SSC suggested base model.
21.1e	21.1a+ three catchability and additional CVs (1985–1998; 1995–2004; and 2005–2021).	CPT/SSC suggested model.
21.1f	21.1e+ the observer CPUE data standardized including Year:Area interactions.	CPT/SSC suggested model.
21.1e2	21.1e+ a knife-edge minimum maturity size of 116 mm CL.	CPT/SSC suggested model.
21.1f2	21.1f+ a knife-edge minimum maturity size of 116 mm CL.	CPT/SSC suggested model.
GMACS version of the above five models: 21.1aG, 21.1eG, 21.1fG, 21.1e2G, 21.1f2G		

Table 1. Commercial fishery history for the Aleutian Islands golden king crab fishery 1981/82–2021/22: number of vessels, guideline harvest level (GHL; established in lb, converted to t) for 1996/97 – 2004/05, total allowable catch (TAC; established in lb, converted to t) for 2005/06 – 2021/22, weight of retained catch (harvest; t), number of retained crab, pot lifts, fishery catch-per-unit- effort (CPUE; retained crab per pot lift), and average weight (kg) of landed crab. The values are separated by EAG and WAG beginning in 1996/97. The 2021/22 WAG fishery was ongoing at the time of this report.

Crab Fishing Season	**Vessels**	**GHL/TAC**	**Harvest[a]**	**Crab**	**Pot Lifts**	**CPUE[b]**	**Average Weight[c]**
1981/82	14–20	–	599	240,458	27,533	9	2.5[d]
1982/83	99–148	–	4,169	1,737,109	179,472	10	2.4[d]
1983/84	157–204	–	4,508	1,773,262	256,393	7	2.5[d]
1984/85	38–51	–	2,132	971,274	88,821	11	2.2[e]
1985/86	53	–	5,776	2,816,313	236,601	12	2.1[f]
1986/87	64	–	6,685	3,345,680	433,870	8	2.0[f]
1987/88	66	–	4,199	2,177,229	307,130	7	1.9[f]
1988/89	76	–	4,820	2,488,433	321,927	8	1.9[f]
1989/90	68	–	5,453	2,902,913	357,803	8	1.9[f]
1990/91	24	–	3,153	1,707,618	215,840	8	1.9[f]
1991/92	20	–	3,494	1,847,398	234,857	8	1.9[f]
1992/93	22	–	2,854	1,528,328	203,221	8	1.9[f]
1993/94	21	–	2,518	1,397,530	234,654	6	1.8[f]

Crab Fishing Season	Vessels		GHL/TAC		Harvest[a]		Crab		Pot Lifts		CPUE[b]		Average Weight[c]	
1994/95	35		–		3,687		1,924,271		386,593		5		1.9[f]	
1995/96	28		–		3,157		1,582,333		293,021		5		2.0[f]	
	EAG	**WAG**	**EAG**	**WAG**	**EAG**	**WAG**	**EAG**	**WAG**	**EAG**	**WAG**	**EAG**	**WAG**	**EAG**	**WAG**
1996/97	14	13	1,452	1,225	1,493	1,145	731,909	602,968	113,460	99,267	7	6	2.04[f]	1.91[f]
1997/98	13	9	1,452	1,225	1,588	1,109	780,610	569,550	106,403	86,811	7	7	2.04[f]	1.95[f]
1998/99	14	3	1,361	1,225	1,473	768	740,011	410,018	83,378	35,975	9	11	2.00[f]	1.86[f]
1999/00	15	15	1,361	1,225	1,392	1,256	709,332	676,558	79,129	107,040	9	6	1.95[f]	1.86[f]
2000/01	15	12	1,361	1,225	1,422	1,308	704,702	705,613	71,551	101,239	10	7	2.00[f]	1.86[f]
2001/02	19	9	1,361	1,225	1,442	1,243	730,030	686,738	62,639	105,512	12	7	2.00[f]	1.81[f]
2002/03	19	6	1,361	1,225	1,280	1,198	643,886	664,823	52,042	78,979	12	8	2.00[f]	1.81[f]
2003/04	18	6	1,361	1,225	1,350	1,220	643,074	676,633	58,883	66,236	11	10	2.09[f]	1.81[f]
2004/05	19	6	1,361	1,225	1,309	1,219	637,536	685,465	34,848	56,846	18	12	2.04[f]	1.77[f]
2005/06	7	3	1,361	1,225	1,300	1,204	623,971	639,368	24,569	30,116	25	21	2.09[f]	1.91[f]
2006/07	6	4	1,361	1,225	1,357	1,030	650,587	527,734	26,195	26,870	25	20	2.09[f]	1.95[f]
2007/08	4	3	1,361	1,225	1,356	1,142	633,253	600,595	22,653	29,950	28	20	2.13[f]	1.91[f]
2008/09	3	3	1,361	1,286	1,426	1,150	666,946	587,661	24,466	26,200	27	22	2.13[f]	1.95[f]

	EAG	WAG	EAG	WAG	EAG	WAG	EAG	WAG	EAG	WAG	EAG	WAG	EAG	WAG
2009/10	3	3	1,429	1,286	1,429	1,253	679,886	628,332	29,298	26,489	26	24	2.09[f]	2.00[f]
2010/11	3	3	1,429	1,286	1,428	1,279	670,983	626,246	25,851	29,994	26	21	2.13[f]	2.04[f]
2011/12	3	3	1,429	1,286	1,429	1,276	668,828	616,118	17,915	26,326	37	23	2.13[f]	2.09[f]
2012/13	3	3	1,501	1,352	1,504	1,339	687,666	672,916	20,827	32,716	33	21	2.18[f]	2.00[f]
2013/14	3	3	1,501	1,352	1,546	1,347	720,220	686,883	21,388	41,835	34	16	2.13[f]	1.95[f]
2014/15	3	2	1,501	1,352	1,554	1,217	719,064	635,312	17,002	41,548	42	15	2.18[f]	1.91[f]
2015/16	3	2	1,501	1,352	1,590	1,139	763,604	615,355	19,376	41,108	39	15	2.09[f]	1.85[f]
2016/17	3	3	1,501	1,014	1,578	1,015	793,983	543,796	24,470	38,118	32	14	1.99[f]	1.87[f]
2017/18	3	3	1,501	1,014	1,571	1,014	802,610	519,051	25,516	30,885	31	17	1.96[f]	1.95[f]
2018/19	3	3	1,749	1,134	1,830	1,135	940,336	578,221	25,553	29,156	37	20	1.95[f]	1.96[f]
2019/20	3	3	1,955	1,302	2,031	1,288	1,057,464	649,832	30,998	42,924	34	15	1.92[f]	1.98[f]
2020/21	3	3	1,656	1,343	1,733	1,267	902,122	682,107	30,072	46,701	30	15	1.92[f]	1.86[f]
2021/22	3	3	1,637	1052	1,706	770	863,269	416,471	30,948	33,669	28	12	1.98[f]	1.85[f]

Note:

a. Includes deadloss.
b. Number of crab per pot lift.
c. Average weight of landed crab, including dead loss.
d. Managed with 6.5" carapace width (CW) minimum size limit.
e. Managed with 6.5" CW minimum size limit west of 171° W longitude and 6.0" minimum size limit east of 171° W longitude.
f. Managed with 6.0" minimum size limit.
g. Catch and effort data include cost recovery fishery.

Table 2. Annual weight of total fishery mortality to Aleutian Islands golden king crab, 1981/82 – 2021/22, partitioned by source of mortality: retained catch, bycatch mortality during crab fisheries, and bycatch mortality during groundfish fisheries. For bycatch in the federal groundfish fisheries, historical data (1991–2008) are not available for areas east and west of 174W, and are listed for federal groundfish reporting areas 541, 542, and 543 combined. The 2009– present data are available by separate EAG and WAG fisheries and are listed as such. A mortality rate of 20% was applied for crab fisheries bycatch, and a mortality rate of 50% for groundfish pot fisheries and 80% for the trawl fisheries were applied. The 2021/22 WAG fishery was ongoing at the time of this report.

			Bycatch Mortality by Fishery Type (t)						
	Retained Catch (t)		Crab		Groundfish		Total Fishery Mortality (t)		
Season	**EAG**	**WAG**	**EAG**	**WAG**	**EAG**	**WAG**	**EAG**	**WAG**	**Entire AI**
1981/82	490	95							585
1982/83	1,260	2,655							3,914
1983/84	1,554	2,991							4,545
1984/85	1,839	424							2,263
1985/86	2,677	1,996							4,673
1986/87	2,798	4,200							6,998
1987/88	1,882	2,496							4,379
1988/89	2,382	2,441							4,823
1989/90	2,738	3,028							5,766
1990/91	1,623	1,621							3,244
1991/92	2,035	1,397	515	344	0				4,291
1992/93	2,112	1,025	1,206	373	0				4,716
1993/94	1,439	686	383	258	4				2,770
1994/95	2,044	1,540	687	823	1				5,095
1995/96	2,259	1,203	725	530	2				4,719
1996/97	1,738	1,259	485	439	5				3,926
1997/98	1,588	1,083	441	343	1				3,455
1998/99	1,473	955	434	285	1				3,149
1999/00	1,392	1,222	313	385	3				3,316
2000/01	1,422	1,342	82	437	2				3,285
2001/02	1,442	1,243	74	387	0				3,146
2002/03	1,280	1,198	52	303	18				2,850
2003/04	1,350	1,220	53	148	20				2,792
2004/05	1,309	1,219	41	143	1				2,715
2005/06	1,300	1,204	22	73	2				2,601
2006/07	1,357	1,022	28	81	18				2,506
2007/08	1,356	1,142	24	114	59				2,695
2008/09	1,426	1,150	61	102	33				2,772
2009/10	1,429	1,253	111	108	18	5	1,558	1,366	2,923
2010/11	1,428	1,279	123	124	49	3	1,600	1,407	3,006
2011/12	1,429	1,276	106	117	25	4	1,560	1,398	2,957
2012/13	1,504	1,339	118	145	9	6	1,631	1,491	3,122
2013/14	1,546	1,347	113	174	5	7	1,665	1,528	3,192
2014/15	1,554	1,217	127	175	9	5	1,691	1,397	3,088
2015/16	1,590	1,139	165	157	23	2	1,778	1,298	3,076
2016/17	1,578	1,015	203	145	95	4	1,877	1,164	3,041
2017/18	1,571	1,014	219	126	46	2	1,836	1,142	2,978
2018/19	1,830	1,135	240	140	24	3	2,094	1,278	3,372
2019/20	2,031	1,288	275	112	17	6	2,323	1,406	3,729
2020/21	1,733	1,267	241	147	125	6	2,100	1,420	3,520
2021/22	1,706	770	168	69	10	1	1,884	840	2,725

Table 2a. Time series of estimated total male catch (weight of crabs on the deck without applying any handling mortality) for the EAG and WAG golden king crab stocks (1990/91–2021/22). The crab weights are for the size range ≥ 101mm CL and a length-weight formula was used to predict weight at the mid-point of each size bin. NA: no observer sampling to compute catch.

Year	**Total Catch Biomass (t) EAG**	**Total Catch Biomass (t) WAG**
1990/91	3,981	3,982
1991/92	6,597	2,118
1992/93	5,436	1,039
1993/94	NA	3,601
1994/95	3,444	5,054
1995/96	4,641	2,619
1996/97	2,563	1,972
1997/98	2,977	1,892
1998/99	3,141	1,107
1999/00	2,606	2,178
2000/01	2,760	2,273
2001/02	2,238	2,155
2002/03	1,916	1,900
2003/04	1,902	1,867
2004/05	1,695	1,886
2005/06	1,742	1,796
2006/07	1,647	1,551
2007/08	1,820	1,614
2008/09	1,824	1,733
2009/10	1,770	1,690
2010/11	1,757	1,605
2011/12	1,781	1,517
2012/13	1,947	1,839
2013/14	1,852	1,919
2014/15	1,967	1,592
2015/16	2,136	1,565
2016/17	2,234	1,570
2017/18	2,339	1,437
2018/19	2,735	1,637
2019/20	3,033	1,714
2020/21	2,608	1,844
2021/22	2,427	1,429

Table 3. Time series of nominal annual pot fishery retained, observer retained, and observer total catch-per-unit-effort (CPUE, number of crabs per pot lift), total pot fishing effort (number of pot lifts), observer sample size (number of sampled pots), and GLM estimated observer CPUE Index (for non-interaction model) for the EAG and WAG golden king crab stocks, 1985/86–2021/22. Observer retained CPUE includes retained and non-retained legal-size crabs.

Year	Pot Fishery Nominal Retained CPUE		Obs. Nominal Retained CPUE		Obs. Nominal Total CPUE		Pot Fishery Effort (no.pot lifts)		Obs. Sample Size (no.pot lifts)		Obs. CPUE Index	
	EAG	WAG	EAG	WAG	EAG	WAG	EAG	WAG	EAG	WAG	EAG	WAG
1985/86	11.90	11.90					117,718	118,563				
1986/87	8.42	7.32					155,240	277,780				
1987/88	7.03	7.15					146,501	160,229				
1988/89	7.52	7.93					155,518	166,409				
1989/90	8.49	7.83					155,262	202,541				
1990/91	8.90	7.00	6.84	8.34	13.00	26.67	106,281	108,533	138	340		
1991/92	8.20	7.40	9.84	6.14	36.91	19.17	133,428	101,429	377	857		
1992/93	8.40	5.90	10.44	4.26	38.52	16.83	133,778	69,443	199	690		
1993/94	7.80	4.40	5.91	12.75	20.81	17.23	106,890	127,764	31	174		
1994/95	5.90	4.10	4.66	6.62	12.91	19.23	191,455	195,138	127	1,270		
1995/96	5.90	4.70	6.03	6.03	16.98	14.28	177,773	115,248	6,388	5,598	0.88	1.00
1996/97	6.50	6.10	6.02	5.90	13.81	13.54	113,460	99,267	8,360	7,194	0.82	0.93
1997/98	7.30	6.60	7.99	6.72	18.25	15.03	106,403	86,811	4,670	3,985	0.88	0.99
1998/99	8.90	11.40	9.82	9.43	25.77	23.09	83,378	35,975	3,616	1,876	1.01	1.07
1999/00	9.00	6.30	10.28	6.09	20.77	14.49	79,129	107,040	3,851	4,523	0.99	0.92
2000/01	9.90	7.00	10.40	6.46	25.39	16.64	71,551	101,239	5,043	4,740	0.82	0.80
2001/02	11.70	6.50	11.73	6.04	22.48	14.66	62,639	105,512	4,626	4,454	1.08	0.86
2002/03	12.40	8.40	12.70	7.47	22.59	17.37	52,042	78,979	3,980	2,509	1.17	0.97
2003/04	10.90	10.20	11.34	9.33	19.43	18.17	58,883	66,236	3,960	3,334	1.03	1.27
2004/05	18.30	12.10	18.34	11.14	28.48	22.45	34,848	56,846	2,206	2,619	1.47	1.30
2005/06	25.40	21.20	29.52	23.89	38.55	36.23	24,569	30,116	1,193	1,365	0.97	1.22
2006/07	24.80	19.60	25.13	23.93	33.39	33.47	26,195	26,870	1,098	1,183	0.80	1.16
2007/08	28.00	20.00	31.10	21.01	40.38	32.46	22,653	29,950	998	1,082	0.89	1.03
2008/09	27.30	22.40	29.97	24.50	38.23	38.16	24,466	26,200	613	979	0.88	1.17
2009/10	25.90	23.70	26.60	26.54	35.88	34.08	26,298	26,489	408	892	0.73	1.23
2010/11	26.00	20.90	26.40	22.43	37.10	29.05	25,851	29,994	436	867	0.75	1.07
2011/12	37.30	23.40	39.48	23.63	52.04	31.13	17,915	26,326	361	837	1.08	1.13
2012/13	33.02	20.57	37.82	22.88	47.57	30.76	20,827	32,716	438	1,109	1.04	1.16

2013/14	33.67	16.42	35.94	16.89	46.16	25.01	21,388	41,835	499	1,223	1.01	0.82
2014/15	42.29	15.29	47.01	15.25	60.00	22.67	17,002	41,548	376	1,137	1.29	0.77
2015/16	39.41	14.97	43.27	15.81	58.68	22.14	19,376	41,108	478	1,296	1.31	0.77
2016/17	32.45	14.29	36.89	16.65	52.82	24.41	24,470	38,118	617	1,060	1.03	0.87
2017/18	31.46	16.81	35.18	19.30	54.62	25.54	25,516	30,885	585	760	1.03	1.01
2018/19	36.80	19.83	41.57	22.90	62.97	30.69	25,553	29,156	475	688	1.24	1.25
2019/20	34.11	15.10	40.88	16.30	57.46	22.73	30,998	42,963	540	967	1.15	1.00
2020/21	30.00	14.61	36.40	15.69	51.58	22.79	30,072	46,701	567	1,137	1.06	0.86
2021/22	27.89	12.37	33.56	15.19	42.83	22.81	30,948	33,669*	478	575*	0.99	0.75

* Complete fishery data for WAG were not available at the time of this assessment.

Table 4. Time series of negative binomial GLM estimated CPUE indices and coefficient of variation (CV) for the fish ticket based retained catch-per-pot lift for the EAG golden king crab stock. The GLM was fitted to the 1985/86 to 1998/99 time series of data.

Year	CPUE Index	CV
1985/86	1.63	0.03
1986/87	1.23	0.04
1987/88	0.96	0.05
1988/89	1.04	0.04
1989/90	1.08	0.03
1990/91	0.99	0.05
1991/92	0.90	0.05
1992/93	0.92	0.05
1993/94	0.91	0.05
1994/95	0.81	0.05
1995/96	0.78	0.06
1996/97	0.78	0.06
1997/98	1.05	0.04
1998/99	1.21	0.04

Table 5. The initial input number of vessel-days/trips and Stage-2 effective sample sizes iteratively estimated by the Francis method for retained, total, and groundfish discard catch size compositions of golden king crab for model 21.1a fit to EAG data. NA: not available.

Year	Initial Input Retained Vessel-Days Sample Size (no)	Stage-2 Retained Effective Sample Size (no)	Initial Input Total Vessel-Days Sample Size (no)	Stage-2 Total Effective Sample Size (no)	Initial Input Groundfish Trip Sample Size (no)	Stage-2 Groundfish Effective Sample Size (no)
1985/86	57	46				
1986/87	11	9				
1987/88	61	50				
1988/89	352	286				
1989/90	792	643			9	4
1990/91	163	132	22	9	13	6
1991/92	140	114	48	19	NA	NA
1992/93	49	40	41	16	2	1
1993/94	340	276	NA	NA	2	1
1994/95	319	259	34	13	4	2
1995/96	879	714	1,117	436	5	2
1996/97	547	444	509	199	4	2
1997/98	538	437	711	277	8	4
1998/99	541	439	574	224	15	7
1999/00	463	376	607	237	14	7
2000/01	436	354	495	193	16	8
2001/02	488	396	510	199	13	6
2002/03	406	330	438	171	15	7
2003/04	405	329	416	162	17	8
2004/05	280	227	299	117	10	5
2005/06	266	216	232	91	12	6
2006/07	234	190	143	56	14	7
2007/08	199	162	134	52	17	8
2008/09	197	160	113	44	15	7
2009/10	170	138	95	37	16	8
2010/11	183	149	108	42	26	13
2011/12	160	130	107	42	13	6
2012/13	187	152	99	39	18	9
2013/14	193	157	122	48	17	8
2014/15	168	136	99	39	16	8
2015/16	190	154	125	49	10	5
2016/17	247	201	155	60	12	6
2017/18	224	182	133	52	12	6
2018/19	256	208	234	91	9	4
2019/20	242	197	148	58	8	4
2020/21	227	184	155	60	6	3
2021/22	254	206	138	54	9	4

Table 6. The initial input number of vessel-days/trips and Stage-2 effective sample sizes iteratively estimated by the Francis method for retained, total, and groundfish discard catch size compositions of golden king crab for model 21.1e fit to EAG data. NA: not available.

Year	Initial Input Retained Vessel-Days Sample Size (no)	Stage-2 Retained Effective Sample Size (no)	Initial Input Total Vessel-Days Sample Size (no)	Stage-2 Total Effective Sample Size (no)	Initial Input Groundfish Trip Sample Size (no)	Stage-2 Groundfish Effective Sample Size (no)
1985/86	57	47				
1986/87	11	9				
1987/88	61	50				
1988/89	352	288				
1989/90	792	649			9	4
1990/91	163	133	22	9	13	6
1991/92	140	115	48	19	NA	NA
1992/93	49	40	41	16	2	1
1993/94	340	278	NA	NA	2	1
1994/95	319	261	34	13	4	2
1995/96	879	720	1,117	440	5	2
1996/97	547	448	509	200	4	2
1997/98	538	441	711	280	8	4
1998/99	541	443	574	226	15	7
1999/00	463	379	607	239	14	7
2000/01	436	357	495	195	16	8
2001/02	488	400	510	201	13	6
2002/03	406	332	438	172	15	7
2003/04	405	332	416	164	17	8
2004/05	280	229	299	118	10	5
2005/06	266	218	232	91	12	6
2006/07	234	192	143	56	14	7
2007/08	199	163	134	53	17	8
2008/09	197	161	113	45	15	7
2009/10	170	139	95	37	16	8
2010/11	183	150	108	43	26	13
2011/12	160	131	107	42	13	6
2012/13	187	153	99	39	18	9
2013/14	193	158	122	48	17	8
2014/15	168	138	99	39	16	8
2015/16	190	156	125	49	10	5
2016/17	247	202	155	61	12	6
2017/18	224	47	133	52	12	6
2018/19	256	9	234	92	9	4
2019/20	242	50	148	58	8	4
2020/21	227	288	155	61	6	3
2021/22	254	649	138	54	9	4

Table 7. The initial input number of vessel-days/trips and Stage-2 effective sample sizes iteratively estimated by the Francis method for retained, total, and groundfish discard catch size compositions of golden king crab for model 21.1f fit to EAG data. NA: not available.

Year	Initial Input Retained Vessel-Days Sample Size (no)	Stage-2 Retained Effective Sample Size (no)	Initial Input Total Vessel-Days Sample Size (no)	Stage-2 Total Effective Sample Size (no)	Initial Input Groundfish Trip Sample Size (no)	Stage-2 Groundfish Effective Sample Size (no)
1985/86	57	46				
1986/87	11	9				
1987/88	61	49				
1988/89	352	284				
1989/90	792	639			9	4
1990/91	163	131	22	9	13	6
1991/92	140	113	48	19	NA	NA
1992/93	49	40	41	16	2	1
1993/94	340	274	NA	NA	2	1
1994/95	319	257	34	14	4	2
1995/96	879	709	1,117	445	5	2
1996/97	547	441	509	203	4	2
1997/98	538	434	711	283	8	4
1998/99	541	436	574	229	15	7
1999/00	463	373	607	242	14	7
2000/01	436	352	495	197	16	8
2001/02	488	394	510	203	13	6
2002/03	406	327	438	175	15	7
2003/04	405	327	416	166	17	8
2004/05	280	226	299	119	10	5
2005/06	266	215	232	92	12	6
2006/07	234	189	143	57	14	7
2007/08	199	161	134	53	17	8
2008/09	197	159	113	45	15	7
2009/10	170	137	95	38	16	8
2010/11	183	148	108	43	26	13
2011/12	160	129	107	43	13	6
2012/13	187	151	99	39	18	9
2013/14	193	156	122	49	17	8
2014/15	168	135	99	39	16	8
2015/16	190	153	125	50	10	5
2016/17	247	199	155	62	12	6
2017/18	224	181	133	53	12	6
2018/19	256	206	234	93	9	4
2019/20	242	195	148	59	8	4
2020/21	227	183	155	62	6	3
2021/22	254	205	138	55	9	4

Table 8. Parameter estimates and coefficient of variations (CV) with the 2021 MMB (MMB estimated on 15 Feb 2022) for models 21.1a, 21.1e, and 21.1f for the golden king crab data from the EAG, 1985/86–2021/22. Recruitment and fishing mortality deviations and initial size frequency determination parameters were omitted from this list.

	Model 21.1a		**Model 21.1e**		**Model 21.1f**		
Parameter	Estimate	CV	Estimate	CV	Estimate	CV	Limits
log_ω_1 (growth incr. intercept)	2.536	0.006	2.536	0.006	2.536	0.006	1.0, 4.5
ω_2 (growth incr. slope)	-9.467	0.184	-9.499	0.183	-9.486	0.183	-12.0, 5.0
log_a (molt prob. slope)	-2.524	0.022	-2.519	0.023	-2.512	0.022	-4.61, -1.39
log_b (molt prob. L50)	4.953	0.001	4.952	0.001	4.952	0.001	3.869, 5.05
σ (growth variability std)	3.664	0.027	3.663	0.027	3.665	0.027	0.1, 12.0
log_total sel deltaθ, 1985–04	3.324	0.026	3.318	0.026	3.326	0.026	0.0, 4.4
log_ total sel deltaθ, 2005–21	2.958	0.028	2.954	0.028	2.932	0.028	0.0, 4.4
log_ ret. sel deltaθ, 1985–21	1.898	0.021	1.897	0.021	1.899	0.021	0.0, 4.4
log_tot sel θ_{50}, 1985–04	4.813	0.002	4.812	0.002	4.813	0.002	4.0, 5.0
log_tot sel θ_{50}, 2005–21	4.911	0.002	4.910	0.002	4.907	0.002	4.0, 5.0
log_ret. sel θ_{50}, 1985–21	4.918	0.0003	4.918	0.0003	4.918	0.0003	4.0, 5.0
log_β_r (rec.distribution par.)	-0.964	0.200	-0.966	0.198	-0.961	0.199	-12.0, 12.0
logq1 (fishery catchability, 1985–98)			-0.469	0.169	-0.463	0.174	-9.0, 2.25
logq2 (fishery/observer catchability, 1985–04)	-0.508	0.143	-0.591	0.157	-0.617	0.207	-9.0, 2.25
logq3 (observer catchability, 2005–21)	-0.750	0.151	-0.761	0.157	-0.811	0.140	-9.0, 2.25
log_mean_rec (mean rec.)	0.802	0.050	0.804	0.050	0.816	0.049	0.01, 5.0
log_mean_Fpot (Pot fishery F)	-0.961	0.066	-0.971	0.068	-0.996	0.066	-15.0, -0.01
log_mean_Fground (GF byc. F)	-8.350	0.085	-8.356	0.085	-8.377	0.085	-15.0, -1.6
σ_{e1}^2 (fishery CPUE additional var, 1985–98)			-1.571	0.144	-1.562	0.145	-8.0, 1.0
σ_{e2}^2 (fishery/observer CPUE additional var, 1985–04)	-1.501	0.118	-1.698	0.155	-1.197	0.254	-8.0, 0.15
σ_{e3}^2 (observer CPUE additional var, 2005–21)	-1.536	0.149	-1.397	0.152	-1.625	0.147	-8.0, 0.15
2021 MMB	8,979	0.18	8,971	0.19	9,566	0.17	

Table 9. Annual abundance estimates of model recruits (millions of crab), legal male biomass (t) with coefficient of variations (CV), and mature male biomass (t) with CV for model 21.1a for golden king crab in the EAG. Legal male biomass was estimated on July 1 (start of fishing year) of fishing year y. Mature male biomass for fishing year y was estimated on February 15 of year y+1, after the year y fishery total catch removal. Recruits estimates for 1961 to 2022 are restricted to 1985–2022. Equilibrium MMB_{eq} and $MMB_{35\%}$ are also listed.

Year	Recruits to the Model (≥ 101 mm CL)	Mature Male Biomass (≥ 111 mm CL)	CV	Legal Size Male Biomass (≥ 136 mm CL)	CV
		MMB_{eq} =20,785 $MMB_{35\%}$=6,818			
1985	2.20	9,355	0.04	9,589	0.06
1986	2.19	7,141	0.04	8,101	0.04
1987	2.18	6,518	0.05	6,313	0.04
1988	2.17	6,631	0.05	5,302	0.04
1989	2.15	5,842	0.06	4,570	0.07
1990	2.14	5,938	0.04	4,325	0.07
1991	2.12	6,023	0.04	4,638	0.06
1992	2.09	5,916	0.04	4,460	0.05
1993	2.06	6,159	0.03	4,458	0.05
1994	2.03	5,736	0.03	4,952	0.04
1995	2.00	5,079	0.04	4,536	0.04
1996	1.96	5,101	0.04	3,867	0.04
1997	1.92	5,356	0.05	3,957	0.04
1998	1.88	5,873	0.05	4,036	0.05
1999	1.84	6,522	0.05	4,455	0.05
2000	1.80	7,118	0.06	5,084	0.06
2001	1.77	7,427	0.06	5,688	0.06
2002	1.75	7,713	0.07	6,216	0.06
2003	1.76	7,916	0.07	6,532	0.07
2004	1.82	7,920	0.07	6,737	0.07
2005	1.940	8,007	0.07	6,870	0.08
2006	2.13	8,171	0.07	6,765	0.08
2007	2.36	8,183	0.07	6,882	0.08
2008	2.62	8,351	0.07	7,022	0.08
2009	1.832	8,535	0.07	6,985	0.08
2010	1.05	8,399	0.06	7,219	0.07
2011	3.12	8,173	0.06	7,310	0.07
2012	4.91	7,893	0.06	7,090	0.06
2013	1.73	7,414	0.06	6,813	0.06
2014	2.77	7,123	0.06	6,450	0.06
2015	3.38	7,176	0.06	5,995	0.06
2016	2.51	7,441	0.07	5,766	0.07
2017	2.08	7,991	0.08	5,926	0.07
2018	2.46	8,766	0.10	6,325	0.08
2019	2.35	9,164	0.13	6,800	0.10
2020	2.11	9,249	0.16	7,423	0.13
2021	2.88	8,979	0.18	7,910	0.15
2022	2.71				

Table 10. Annual abundance estimates of model recruits (millions of crab), legal male biomass (t) with coefficient of variations (CV), and mature male biomass (t) with CV for model 21.1e for golden king crab in the EAG. Legal male biomass was estimated on July 1 (start of fishing year) of fishing year y. Mature male biomass for fishing year y was estimated on February 15 of year y+1, after the year y fishery total catch removal. Recruits estimates for 1961 to 2022 are restricted to 1985–2022. Equilibrium MMBeq and $MMB_{35\%}$ are also listed.

Year	Recruits to the Model (≥ 101 mm CL)	Mature Male Biomass (≥ 111 mm CL)	CV	Legal Size Male Biomass (≥ 136 mm CL)	CV
		MMB_{eq} =20,814 $MMB_{35\%}$=6,825			
1985	2.20	9,322	0.04	9,551	0.06
1986	2.19	7,114	0.04	8,063	0.04
1987	2.18	6,485	0.05	6,284	0.04
1988	2.17	6,596	0.05	5,276	0.04
1989	2.16	5,807	0.06	4,540	0.07
1990	2.14	5,919	0.05	4,294	0.07
1991	2.12	6,017	0.04	4,609	0.06
1992	2.10	5,921	0.04	4,449	0.05
1993	2.07	6,182	0.03	4,458	0.05
1994	2.04	5,773	0.03	4,966	0.04
1995	2.00	5,131	0.04	4,566	0.04
1996	1.97	5,167	0.04	3,911	0.04
1997	1.92	5,433	0.05	4,013	0.05
1998	1.88	5,955	0.05	4,105	0.05
1999	1.84	6,611	0.06	4,533	0.06
2000	1.80	7,217	0.06	5,165	0.06
2001	1.77	7,533	0.07	5,777	0.07
2002	1.76	7,829	0.07	6,313	0.07
2003	1.76	8,042	0.07	6,636	0.07
2004	1.81	8,050	0.08	6,851	0.08
2005	1.93	8,142	0.08	6,990	0.08
2006	2.11	8,311	0.07	6,888	0.08
2007	2.33	8,324	0.07	7,010	0.08
2008	2.64	8,480	0.07	7,154	0.08
2009	1.84	8,638	0.07	7,114	0.08
2010	1.05	8,472	0.06	7,331	0.07
2011	3.10	8,220	0.06	7,391	0.07
2012	4.92	7,911	0.06	7,144	0.07
2013	1.74	7,412	0.06	6,841	0.06
2014	2.82	7,109	0.06	6,454	0.06
2015	3.37	7,157	0.07	5,984	0.07
2016	2.54	7,417	0.08	5,749	0.07
2017	2.10	7,967	0.09	5,906	0.08
2018	2.47	8,753	0.11	6,302	0.09
2019	2.37	9,159	0.14	6,782	0.10
2020	2.13	9,242	0.17	7,417	0.13
2021	2.90	8,971	0.19	7,907	0.17
2022	2.72				

Table 11. Annual abundance estimates of model recruits (millions of crab), legal male biomass (t) with coefficient of variations (CV), and mature male biomass (t) with CV for model 21.1f for golden king crab in the EAG. Legal male biomass was estimated on July 1 (start of fishing year) of fishing year y. Mature male biomass for fishing year y was estimated on February 15 of year y+1, after the year y fishery total catch removal. Recruits estimates for 1961 to 2022 are restricted to 1985–2022. Equilibrium MMBeq and $MMB_{35\%}$ are also listed.

Year	**Recruits to the Model (≥ 101 mm CL)**	**Mature Male Biomass (≥ 111 mm CL)**	**CV**	**Legal Size Male Biomass (≥ 136 mm CL)**	**CV**
		MMB_{eq} =21,021 $MMB_{35\%}$=6,906			
1985	2.23	9,328	0.04	9,581	0.06
1986	2.22	7,115	0.04	8,072	0.04
1987	2.21	6,483	0.05	6,282	0.04
1988	2.20	6,591	0.05	5,273	0.04
1989	2.18	5,804	0.06	4,535	0.07
1990	2.17	5,919	0.05	4,288	0.07
1991	2.15	6,015	0.04	4,605	0.06
1992	2.12	5,911	0.04	4,447	0.05
1993	2.09	6,160	0.03	4,452	0.05
1994	2.06	5,750	0.03	4,950	0.04
1995	2.03	5,108	0.04	4,540	0.04
1996	1.99	5,137	0.04	3,889	0.04
1997	1.94	5,418	0.05	3,987	0.05
1998	1.90	5,997	0.06	4,077	0.05
1999	1.86	6,722	0.06	4,535	0.06
2000	1.82	7,409	0.06	5,234	0.06
2001	1.78	7,803	0.07	5,914	0.07
2002	1.77	8,142	0.07	6,531	0.07
2003	1.77	8,364	0.07	6,915	0.07
2004	1.81	8,358	0.08	7,154	0.08
2005	1.92	8,388	0.08	7,289	0.08
2006	2.10	8,491	0.08	7,154	0.08
2007	2.33	8,484	0.08	7,201	0.08
2008	2.61	8,642	0.07	7,295	0.08
2009	1.84	8,807	0.07	7,249	0.08
2010	1.06	8,646	0.06	7,474	0.08
2011	3.09	8,408	0.06	7,544	0.07
2012	4.91	8,110	0.06	7,304	0.07
2013	1.75	7,610	0.06	7,017	0.06
2014	2.81	7,328	0.06	6,634	0.06
2015	3.36	7,399	0.07	6,167	0.07
2016	2.53	7,700	0.08	5,959	0.07
2017	2.08	8,329	0.08	6,139	0.08
2018	2.49	9,199	0.10	6,591	0.09
2019	2.35	9,689	0.12	7,155	0.10
2020	2.12	9,828	0.15	7,869	0.12
2021	2.94	9,566	0.17	8,435	0.15
2022	2.82				

Table 12. Negative log-likelihood values of the fits for models 21.1a (last year's accepted model with additional 2021/22 data), 21.1e, and 21.1f for golden king crab in the EAG. Likelihood components with zero entry in the entire rows are omitted. RetdcatchB = retained catch biomass.

Likelihood Component	**Model 21.1a**	**Model 21.1e**	**Model 21.1f**	**21.1e-21.1a**	**21.1f-21.1a**	**21.1f-21.1e**
Number of free parameters	155	157	157			
Retlencomp	-2152.14	-2154.57	-2149.68	-2.43	2.46	4.89
Totallencomp	-1382.39	-1384.49	-1387.4	-2.1	-5.01	-2.91
Observer cpue	-27.1212	-27.3412	-24.5642	-0.22	2.557	2.777
Fishery cpue	-14.3622	-14.8189	-14.7068	-0.4567	-0.3446	0.1121
RetdcatchB	4.20203	4.29123	4.03559	0.0892	-0.16644	-0.25564
TotalcatchB	15.8463	15.8261	15.4648	-0.0202	-0.3815	-0.3613
GdiscdcatchB	0.000382	0.000326	0.000322	-0.000056	-0.00006	-0.000004
Rec_dev	22.5443	22.5947	22.7422	0.0504	0.1979	0.1475
Pot F_dev	0.013029	0.013148	0.013507	0.000119	0.000478	0.000359
Gbyc_F_dev	0.02288	0.022958	0.022778	0.000078	-0.0001	-0.00018
Tag	2693.5	2693.45	2693.13	-0.05	-0.37	-0.32
RetcatchN	0.00262	0.00261	0.00269	-0.00001	0.00007	0.00008
Total	-839.891	-845.015	-840.94	-5.124	-1.049	4.075

Table 13. Time series of negative binomial GLM estimated CPUE indices and coefficient of variations (CV) for the fish ticket based retained catch-per-pot lift for the WAG golden king crab stock. The GLM was fitted to the 1985/86 to 1998/99 time series of data. GLM predictor variables were selected by R square criteria.

Year	**CPUE Index**	**CV**
1985/86	2.07	0.05
1986/87	1.59	0.04
1987/88	1.22	0.04
1988/89	1.41	0.03
1989/90	1.15	0.03
1990/91	0.87	0.03
1991/92	0.76	0.04
1992/93	0.61	0.04
1993/94	0.76	0.05
1994/95	0.83	0.04
1995/96	0.90	0.04
1996/97	0.84	0.03
1997/98	0.76	0.03
1998/99	1.06	0.03

Table 14. The initial input number of vessel-days/trips and Stage-2 effective sample sizes iteratively estimated by the Francis method for retained, total, and groundfish discard catch size compositions of golden king crab for model 21.1a model fit to WAG data. NA: not available.

Year	Initial Input Retained Vessel-Days Sample Size (no)	Stage-2 Retained Effective Sample Size (no)	Initial Input Total Vessel-Days Sample Size (no)	Stage-2 Total Effective Sample Size (no)	Initial Input Groundfish Trip Sample Size (no)	Stage-2 Groundfish Effective Sample Size (no)
1985/86	45	21				
1986/87	23	11				
1987/88	8	4				
1988/89	286	136				
1989/90	513	244			7	3
1990/91	205	97	190	64	6	3
1991/92	102	48	104	35	1	0.5
1992/93	76	36	94	32	3	1
1993/94	378	180	62	21	NA	NA
1994/95	367	174	119	40	2	1
1995/96	705	335	907	305	5	2
1996/97	817	388	1,061	357	8	4
1997/98	984	468	1,116	375	6	3
1998/99	613	291	638	215	14	7
1999/00	915	435	1,155	388	18	9
2000/01	1,029	489	1,205	405	11	5
2001/02	898	427	975	328	11	5
2002/03	628	299	675	227	16	8
2003/04	688	327	700	235	8	4
2004/05	449	213	488	164	9	4
2005/06	337	160	220	74	6	3
2006/07	337	160	321	108	14	7
2007/08	276	131	257	86	17	8
2008/09	318	151	258	87	19	9
2009/10	362	172	292	98	24	12
2010/11	328	156	222	75	13	6
2011/12	295	140	252	85	14	7
2012/13	288	137	241	81	18	9
2013/14	327	155	236	79	17	8
2014/15	305	145	219	74	18	9
2015/16	287	136	243	82	10	5
2016/17	408	194	253	85	12	6
2017/18	309	147	222	75	10	5
2018/19	291	138	318	107	5	2
2019/20	363	173	224	75	6	3
2020/21	462	220	302	102	7	3
2021/22	276	131	157	53	5	2

Table 15. The initial input number of vessel-days/trips and Stage-2 effective sample sizes iteratively estimated by the Francis method for retained, total, and groundfish discard catch size compositions of golden king crab for model 21.1e model fit to WAG data. NA: not available.

Year	Initial Input Retained Vessel-Days Sample Size (no)	Stage-2 Retained Effective Sample Size (no)	Initial Input Total Vessel-Days Sample Size (no)	Stage-2 Total Effective Sample Size (no)	Initial Input Groundfish Trip Sample Size (no)	Stage-2 Groundfish Effective Sample Size (no)
1985/86	45	21				
1986/87	23	11				
1987/88	8	4				
1988/89	286	135				
1989/90	513	242			7	3
1990/91	205	97	190	62	6	3
1991/92	102	48	104	34	1	0.5
1992/93	76	36	94	31	3	1
1993/94	378	178	62	20	NA	NA
1994/95	367	173	119	39	2	1
1995/96	705	333	907	298	5	2
1996/97	817	386	1,061	348	8	4
1997/98	984	464	1,116	366	6	3
1998/99	613	289	638	209	14	7
1999/00	915	432	1,155	379	18	9
2000/01	1,029	486	1,205	395	11	5
2001/02	898	424	975	320	11	5
2002/03	628	296	675	222	16	8
2003/04	688	325	700	230	8	4
2004/05	449	212	488	160	9	4
2005/06	337	159	220	72	6	3
2006/07	337	159	321	105	14	7
2007/08	276	130	257	84	17	8
2008/09	318	150	258	85	19	9
2009/10	362	171	292	96	24	12
2010/11	328	155	222	73	13	6
2011/12	295	139	252	83	14	7
2012/13	288	136	241	79	18	9
2013/14	327	154	236	77	17	8
2014/15	305	144	219	72	18	9
2015/16	287	135	243	80	10	5
2016/17	408	193	253	83	12	6
2017/18	309	146	222	73	10	5
2018/19	291	137	318	104	5	2
2019/20	363	171	224	74	6	3
2020/21	462	218	302	99	7	3
2021/22	276	130	157	52	5	2

Table 16. The initial input number of vessel-days/trips and Stage-2 effective sample sizes iteratively estimated by the Francis method for retained, total, and groundfish discard catch size compositions of golden king crab for model 21.1f model fit to WAG data. NA: not available.

Year	Initial Input Retained Vessel-Days Sample Size (no)	Stage-2 Retained Effective Sample Size (no)	Initial Input Total Vessel-Days Sample Size (no)	Stage-2 Total Effective Sample Size (no)	Initial Input Groundfish Trip Sample Size (no)	Stage-2 Groundfish Effective Sample Size (no)
1985/86	45	21				
1986/87	23	11				
1987/88	8	4				
1988/89	286	132				
1989/90	513	237			7	3
1990/91	205	95	190	66	6	3
1991/92	102	47	104	36	1	0.5
1992/93	76	35	94	33	3	1
1993/94	378	175	62	22	NA	NA
1994/95	367	170	119	42	2	1
1995/96	705	326	907	317	5	2
1996/97	817	378	1,061	371	8	4
1997/98	984	455	1,116	390	6	3
1998/99	613	284	638	223	14	7
1999/00	915	424	1,155	404	18	9
2000/01	1,029	476	1,205	421	11	5
2001/02	898	416	975	341	11	5
2002/03	628	291	675	236	16	8
2003/04	688	318	700	245	8	4
2004/05	449	208	488	171	9	4
2005/06	337	156	220	77	6	3
2006/07	337	156	321	112	14	7
2007/08	276	128	257	90	17	8
2008/09	318	147	258	90	19	9
2009/10	362	168	292	102	24	12
2010/11	328	152	222	78	13	6
2011/12	295	137	252	88	14	7
2012/13	288	133	241	84	18	9
2013/14	327	151	236	83	17	8
2014/15	305	141	219	77	18	9
2015/16	287	133	243	85	10	5
2016/17	408	189	253	88	12	6
2017/18	309	143	222	78	10	5
2018/19	291	135	318	111	5	2
2019/20	363	168	224	78	6	3
2020/21	462	214	302	106	7	3
2021/22	276	128	157	55	5	2

Table 17. Parameter estimates and coefficient of variations (CV) with the 2021 MMB (MMB estimated on 15 Feb 2022) for models 21.1a, 21.1e, and 21.1f for the golden king crab data from the WAG, 1985/86–2021/22. Recruitment and fishing mortality deviations and initial size frequency determination parameters were omitted from this list.

	Model 21.1a		**Model 21.1e**		**Model 21.1f**		
Parameter	Estimate	CV	Estimate	CV	Estimate	CV	Limits
log_ω_1 (growth incr. intercept)	2.536	0.006	2.536	0.006	2.535	0.006	1.0, 4.5
ω_2 (growth incr. slope)	-8.578	0.202	-8.576	0.202	-8.642	-0.201	-12.0, 5.0
log_a (molt prob. slope)	-2.619	0.026	-2.620	0.026	-2.617	0.026	-4.61, -1.39
log_b (molt prob. L50)	4.950	0.001	4.950	0.001	4.949	0.001	3.869, 5.05
σ (growth variability std)	3.674	0.027	3.673	0.027	3.673	0.027	0.1, 12.0
log_total sel deltaθ, 1985–04	3.369	0.018	3.370	0.018	3.383	0.018	0.0, 4.4
log_ total sel deltaθ, 2005–21	2.897	0.026	2.901	0.026	2.886	0.026	0.0, 4.4
log_ ret. sel deltaθ, 1985–21	1.785	0.024	1.785	0.024	1.786	0.024	0.0, 4.4
log_tot sel θ_{50}, 1985–04	4.854	0.002	4.855	0.002	4.857	0.002	4.0, 5.0
log_tot sel θ_{50}, 2005–21	4.898	0.002	4.898	0.002	4.895	0.002	4.0, 5.0
log_ret. sel θ_{50}, 1985–21	4.916	0.0002	4.916	0.0003	4.916	0.0003	4.0, 5.0
log_β_r (rec.distribution par.)	-1.026	0.162	-1.033	0.162	-1.019	0.161	-12.0, 12.0
logq1 (fishery catchability, 1985–98)			-0.064	1.136	-0.054	1.384	-9.0, 2.25
logq2 (fishery/observer catchability, 1985–04)	-0.010	7.021	0.037	2.091	0.043	2.492	-9.0, 2.25
logq3 (observer catchability, 2005–21)	-0.354	0.243	-0.342	0.255	-0.335	0.300	-9.0, 2.25
log_mean_rec (mean rec.)	0.665	0.058	0.664	0.057	0.653	0.061	0.01, 5.0
log_mean_Fpot (Pot fishery F)	-0.735	0.079	-0.736	0.079	-0.733	0.080	-15.0, -0.01
log_mean_Fground (GF byc. F)	-8.166	0.087	-8.161	0.087	-8.151	0.087	-15.0, -1.6
σ_{e1}^2 (fishery CPUE additional var, 1985–98)			-1.941	0.148	-1.910	0.149	-8.0, 1.0
σ_{e2}^2 (fishery/observer CPUE additional var, 1985–04)	-2.226	0.084	-1.986	0.148	-1.374	0.203	-8.0, 0.15
σ_{e3}^2 (observer CPUE additional var, 2005–21)	-1.998	0.167	-2.599	0.106	-1.504	0.136	-8.0, 0.15
2021 MMB	4,785	0.15	4,632	0.14	3,759	0.21	

Table 18. Annual abundance estimates of model recruits (millions of crab), legal male biomass (t) with coefficient of variations (CV), and mature male biomass (t) with CV for model 21.1a for golden king crab in the WAG. Legal male biomass was estimated on July 1 (start of fishing year) of fishing year y. Mature male biomass for fishing year y was estimated on February 15 of year y+1, after the year y fishery total catch removal. Recruits estimates for 1961 to 2022 are restricted to 1985–2022. Equilibrium MMB_{eq} and $MMB_{35\%}$ are also listed.

Year	**Recruits to the Model (≥ 101 mm CL)**	**Mature Male Biomass (≥ 111 mm CL)**	**CV**	**Legal Size Male Biomass (≥ 136 mm CL)**	**CV**
		MMB_{eq} =18,041 $MMB_{35\%}$=5,265			
1985	1.92	10,776	0.05	8,695	0.10
1986	1.91	8,832	0.04	8,244	0.08
1987	1.91	8,005	0.04	5,899	0.07
1988	1.90	6,970	0.04	5,627	0.05
1989	1.89	5,109	0.04	5,097	0.04
1990	1.88	4,427	0.04	3,292	0.05
1991	1.87	4,029	0.05	2,984	0.05
1992	1.86	4,128	0.04	2,830	0.06
1993	1.85	4,714	0.03	2,899	0.06
1994	1.84	4,332	0.03	3,502	0.04
1995	1.83	4,221	0.03	2,930	0.04
1996	1.81	4,055	0.04	2,891	0.04
1997	1.80	4,102	0.04	2,925	0.04
1998	1.79	4,368	0.03	3,007	0.04
1999	1.78	4,348	0.04	3,271	0.04
2000	1.78	4,406	0.04	3,163	0.04
2001	1.78	4,812	0.05	3,146	0.04
2002	1.79	5,380	0.05	3,436	0.05
2003	1.82	5,697	0.05	3,956	0.05
2004	1.90	5,904	0.06	4,457	0.05
2005	2.05	6,162	0.06	4,677	0.06
2006	2.27	6,648	0.06	4,907	0.06
2007	2.55	6,815	0.05	5,304	0.06
2008	3.26	6,649	0.05	5,576	0.06
2009	4.01	6,329	0.05	5,634	0.06
2010	3.59	6,088	0.05	5,293	0.06
2011	2.91	5,614	0.05	5,034	0.05
2012	1.84	5,058	0.05	4,741	0.05
2013	2.30	4,876	0.05	4,153	0.05
2014	1.74	5,024	0.06	3,695	0.06
2015	1.43	5,173	0.06	3,821	0.06
2016	2.08	5,359	0.05	4,037	0.06
2017	1.77	5,462	0.05	4,314	0.06
2018	1.95	5,450	0.06	4,459	0.06
2019	1.87	5,096	0.07	4,409	0.06
2020	1.70	4,707	0.10	4,214	0.07
2021	1.74	4,785	0.15	3,767	0.10
2022	1.78				

Table 19. Annual abundance estimates of model recruits (millions of crab), legal male biomass (t) with coefficient of variations (CV), and mature male biomass (t) with CV for model 21.1e for golden king crab in the WAG. Legal male biomass was estimated on July 1 (start of fishing year) of fishing year y. Mature male biomass for fishing year y was estimated on February 15 of year y+1, after the year y fishery total catch removal. Recruits estimates for 1961 to 2022 are restricted to 1985–2022. Equilibrium MMB_{eq} and $MMB_{35\%}$ are also listed.

Year	Recruits to the Model (≥ 101 mm CL)	Mature Male Biomass (≥ 111 mm CL)	CV	Legal Size Male Biomass (≥ 136 mm CL)	CV
		MMB_{eq} =18,027 *$MMB_{35\%}$*=5,248			
1985	1.92	10,964	0.05	9,024	0.10
1986	1.91	8,932	0.04	8,522	0.08
1987	1.91	8,090	0.04	6,045	0.06
1988	1.90	7,036	0.04	5,722	0.05
1989	1.89	5,168	0.04	5,168	0.04
1990	1.89	4,482	0.04	3,353	0.06
1991	1.88	4,081	0.05	3,042	0.05
1992	1.87	4,154	0.04	2,884	0.05
1993	1.86	4,702	0.03	2,944	0.05
1994	1.85	4,302	0.03	3,516	0.04
1995	1.84	4,184	0.03	2,907	0.04
1996	1.82	4,015	0.04	2,859	0.04
1997	1.81	4,067	0.04	2,888	0.04
1998	1.81	4,341	0.04	2,972	0.04
1999	1.80	4,329	0.04	3,242	0.04
2000	1.80	4,391	0.05	3,143	0.04
2001	1.81	4,802	0.05	3,132	0.05
2002	1.83	5,383	0.05	3,425	0.05
2003	1.87	5,719	0.06	3,950	0.06
2004	1.96	5,904	0.06	4,468	0.06
2005	2.13	6,083	0.06	4,698	0.06
2006	2.37	6,529	0.06	4,886	0.06
2007	2.64	6,707	0.06	5,207	0.06
2008	3.16	6,547	0.05	5,462	0.06
2009	3.75	6,272	0.05	5,533	0.06
2010	3.64	6,078	0.05	5,207	0.06
2011	2.88	5,600	0.05	5,004	0.05
2012	1.84	5,031	0.05	4,741	0.05
2013	2.29	4,825	0.05	4,139	0.05
2014	1.74	4,963	0.06	3,665	0.06
2015	1.43	5,149	0.06	3,766	0.06
2016	2.02	5,384	0.05	3,987	0.06
2017	1.73	5,479	0.05	4,308	0.06
2018	1.97	5,415	0.05	4,491	0.06
2019	1.85	5,012	0.06	4,413	0.06
2020	1.70	4,580	0.09	4,164	0.06
2021	1.74	4,632	0.14	3,669	0.08
2022	1.79				

Table 20. Annual abundance estimates of model recruits (millions of crab), legal male biomass (t) with coefficient of variations (CV), and mature male biomass (t) with CV for model 21.1f for golden king crab in the WAG. Legal male biomass was estimated on July 1 (start of fishing year) of fishing year y. Mature male biomass for fishing year y was estimated on February 15 of year y+1, after the year y fishery total catch removal. Recruits estimates for 1961 to 2022 are restricted to 1985–2022. Equilibrium MMB_{eq} and $MMB_{35\%}$ are also listed.

Year	Recruits to the Model (≥ 101 mm CL)	Mature Male Biomass (≥ 111 mm CL)	CV	Legal Size Male Biomass (≥ 136 mm CL)	CV
		MMB_{eq} =17,799 $MMB_{35\%}$=5,200			
1985	1.90	10,984	0.05	9,027	0.10
1986	1.90	8,947	0.04	8,528	0.08
1987	1.89	8,098	0.04	6,052	0.06
1988	1.89	7,036	0.04	5,723	0.05
1989	1.88	5,166	0.04	5,162	0.04
1990	1.87	4,486	0.04	3,343	0.06
1991	1.87	4,088	0.05	3,034	0.05
1992	1.86	4,154	0.04	2,883	0.05
1993	1.85	4,684	0.03	2,943	0.05
1994	1.84	4,275	0.03	3,504	0.04
1995	1.83	4,159	0.03	2,879	0.04
1996	1.82	3,991	0.04	2,828	0.04
1997	1.81	4,058	0.04	2,860	0.04
1998	1.81	4,359	0.04	2,947	0.04
1999	1.81	4,375	0.04	3,237	0.04
2000	1.81	4,468	0.05	3,167	0.04
2001	1.82	4,899	0.05	3,181	0.05
2002	1.84	5,487	0.06	3,499	0.05
2003	1.88	5,803	0.06	4,037	0.06
2004	1.97	6,011	0.06	4,554	0.06
2005	2.13	6,329	0.06	4,766	0.07
2006	2.37	6,860	0.06	5,010	0.07
2007	2.64	7,024	0.05	5,473	0.07
2008	3.18	6,837	0.05	5,767	0.06
2009	3.75	6,449	0.05	5,816	0.06
2010	3.63	6,170	0.05	5,441	0.06
2011	2.88	5,719	0.05	5,110	0.05
2012	1.83	5,197	0.05	4,807	0.05
2013	2.30	5,007	0.06	4,250	0.06
2014	1.75	5,091	0.06	3,823	0.06
2015	1.43	5,114	0.06	3,919	0.06
2016	2.00	5,129	0.06	4,056	0.06
2017	1.71	5,077	0.06	4,191	0.06
2018	1.98	4,895	0.07	4,172	0.06
2019	1.85	4,381	0.10	3,974	0.07
2020	1.70	3,823	0.15	3,617	0.10
2021	1.78	3,759	0.21	3,029	0.15
2022	1.82				

Table 21. Negative log-likelihood values of the fits for models 21.1a (last year's accepted model with additional 2021/22 data), 21.1e, and 21.1f for golden king crab in the WAG. Likelihood components with zero entry in the entire rows are omitted. RetdcatchB = retained catch biomass.

Likelihood Component	Model 21.1a	Model 21.1e	Model 21.1f	21.1e-21.1a	21.1f-21.1a	21.1f-21.1e
Number of free parameters	155	157	157			
Retlencomp	-2069.88	-2068.71	-2063.23	1.17000	6.65000	5.48000
Totallencomp	-1534.42	-1530.37	-1544.71	4.05000	-10.29000	-14.34000
Observer cpue	-45.5251	-48.6135	-25.0405	-3.08840	20.48460	23.57300
Fishery cpue	-20.3986	-19.7317	-19.3196	0.66690	1.07900	0.41210
RetdcatchB	4.73449	5.05622	4.86679	0.32173	0.13230	-0.18943
TotalcatchB	51.6139	51.9002	51.8865	0.28630	0.27260	-0.01370
GdiscdcatchB	0.000896	0.000965	0.000605	0.00007	-0.00029	-0.00036
Rec_dev	21.3105	21.3623	21.9683	0.05180	0.65780	0.60600
Pot F_dev	0.025786	0.025805	0.026233	0.00002	0.00045	0.00043
Gbyc_F_dev	0.042487	0.042767	0.042634	0.00028	0.00015	-0.00013
Tag	2693.86	2693.81	2693.57	-0.05000	-0.29000	-0.24000
RetcatchN	0.00127	0.00086	0.00056	-0.00041	-0.00071	-0.00030
Total	-898.633	-895.233	-879.943	3.40000	18.69000	15.29000

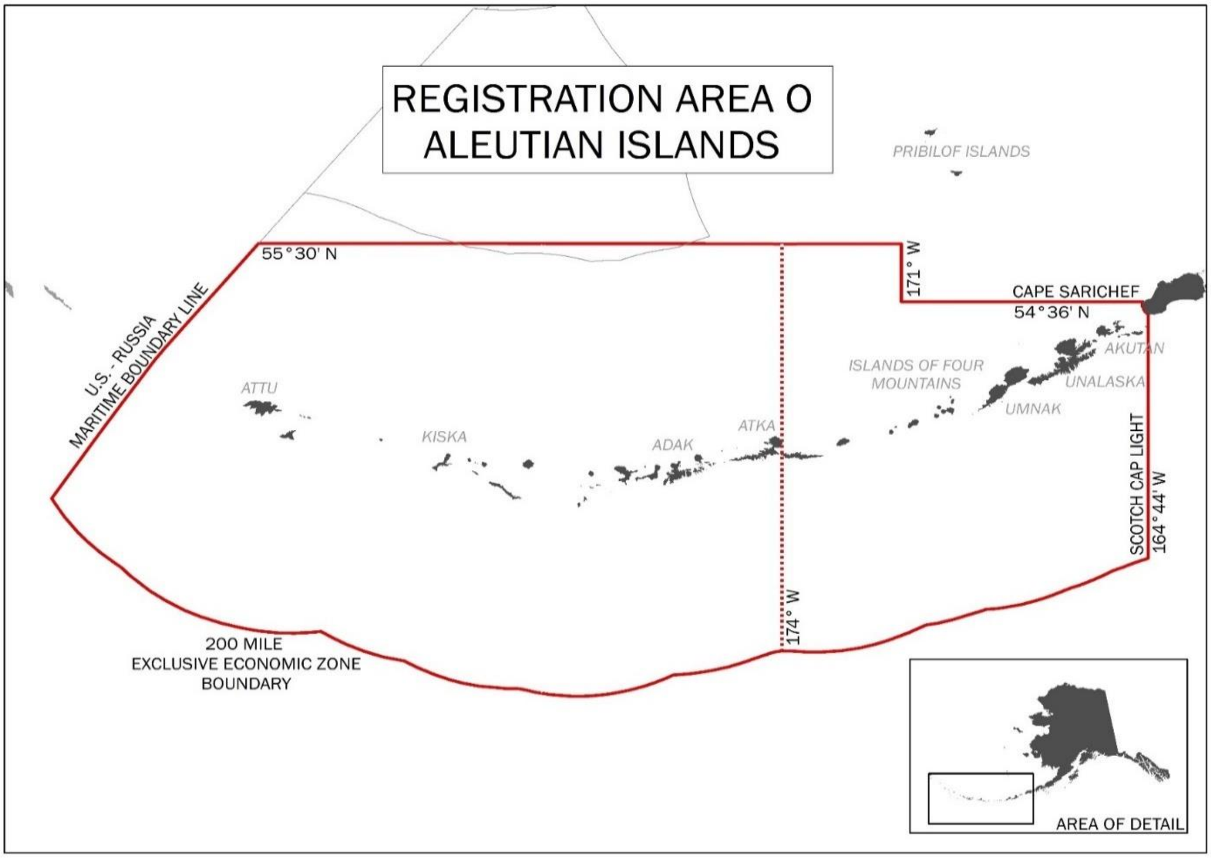


Figure 1. Aleutian Islands, Area O, red and golden king crab management area (from Nichols *et al.* 2021).

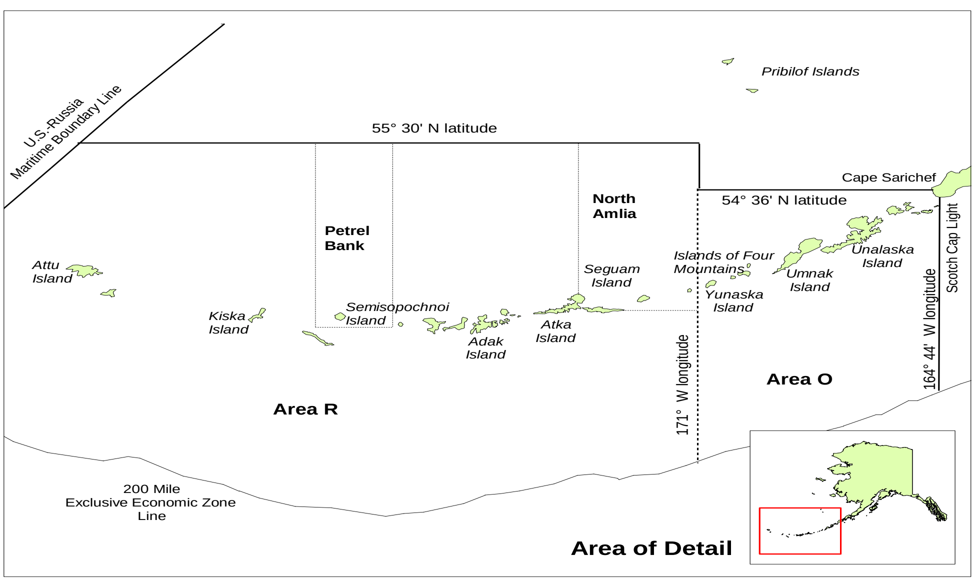


Figure 2. Adak (Area R) and Dutch Harbor (Area O) king crab registration area and districts, 1984/85–1995/96 seasons (Leon *et al.* 2017).

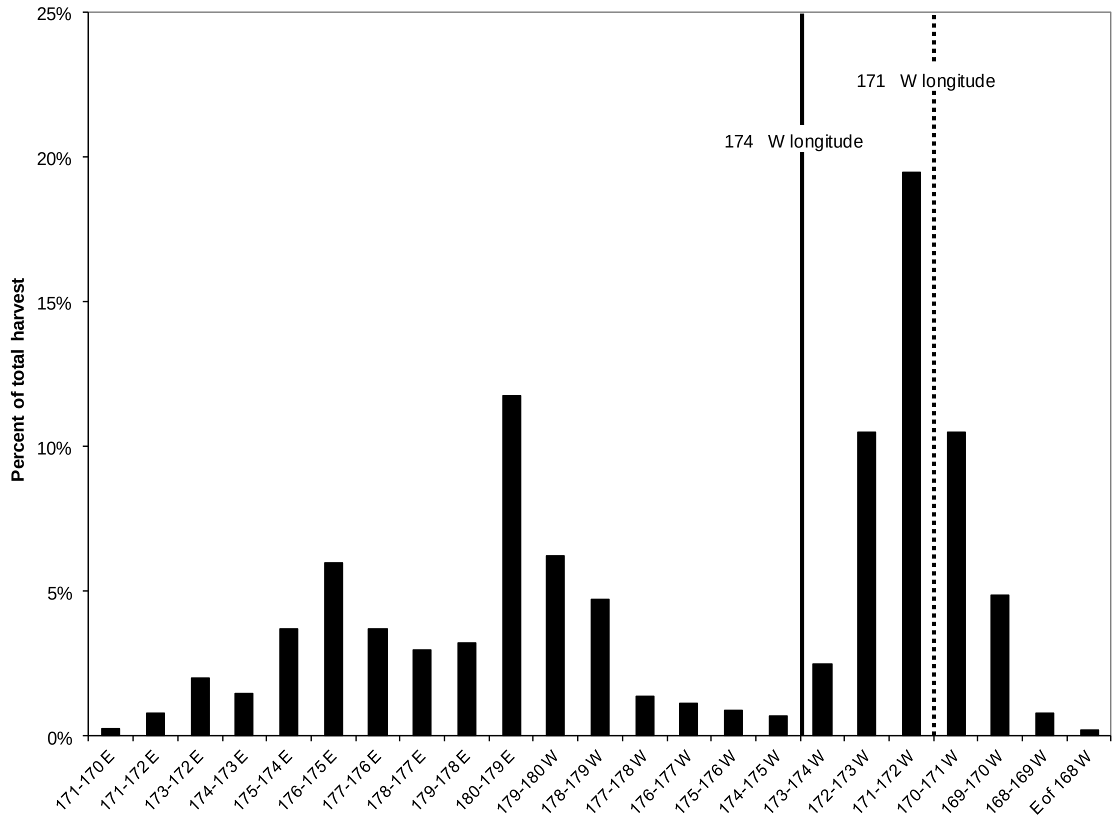


Figure 3. Percent of total 1981/82–1995/96 golden king crab retained catch weight (harvest) from one-degree longitude intervals in the Aleutian Islands, with dotted line denoting the border at 171° W longitude used during the 1984/85–1995/96 seasons to divide fishery management between the Dutch Harbor Area (east of 171° W longitude) and the Adak Area (west of 171° W longitude) and solid line denoting the border at 174° W longitude used since the 1996/97 season to manage crab east and west of 174° W longitude (adapted from Figure 4-2 in Morrison *et al.* 1998).

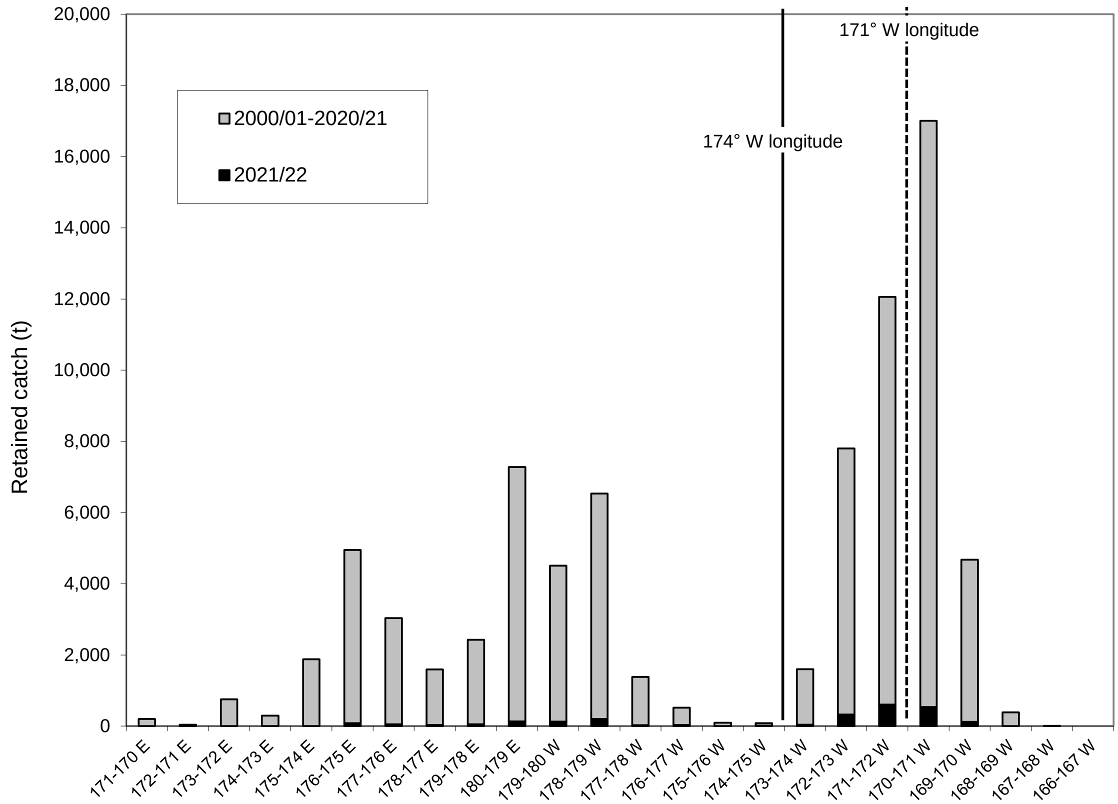


Figure 4. Retained catch (t) of golden king crab within one-degree longitude intervals in the Aleutian Islands during the 2000/01 through 2021/22 commercial fishery seasons; solid line denotes the border at 174° W longitude that has been used since the 1996/97 season to manage Aleutian Island golden king crab as separate stocks east and west of 174° W longitude and dashed line denotes the border at 171° W longitude used during the 1984/85–1995/96 seasons to divide fishery management between the Dutch Harbor Area (east of 171° W longitude) and the Adak Area (west of 171° W longitude). The 2021/22 WAG fishery was ongoing at the time of this report.

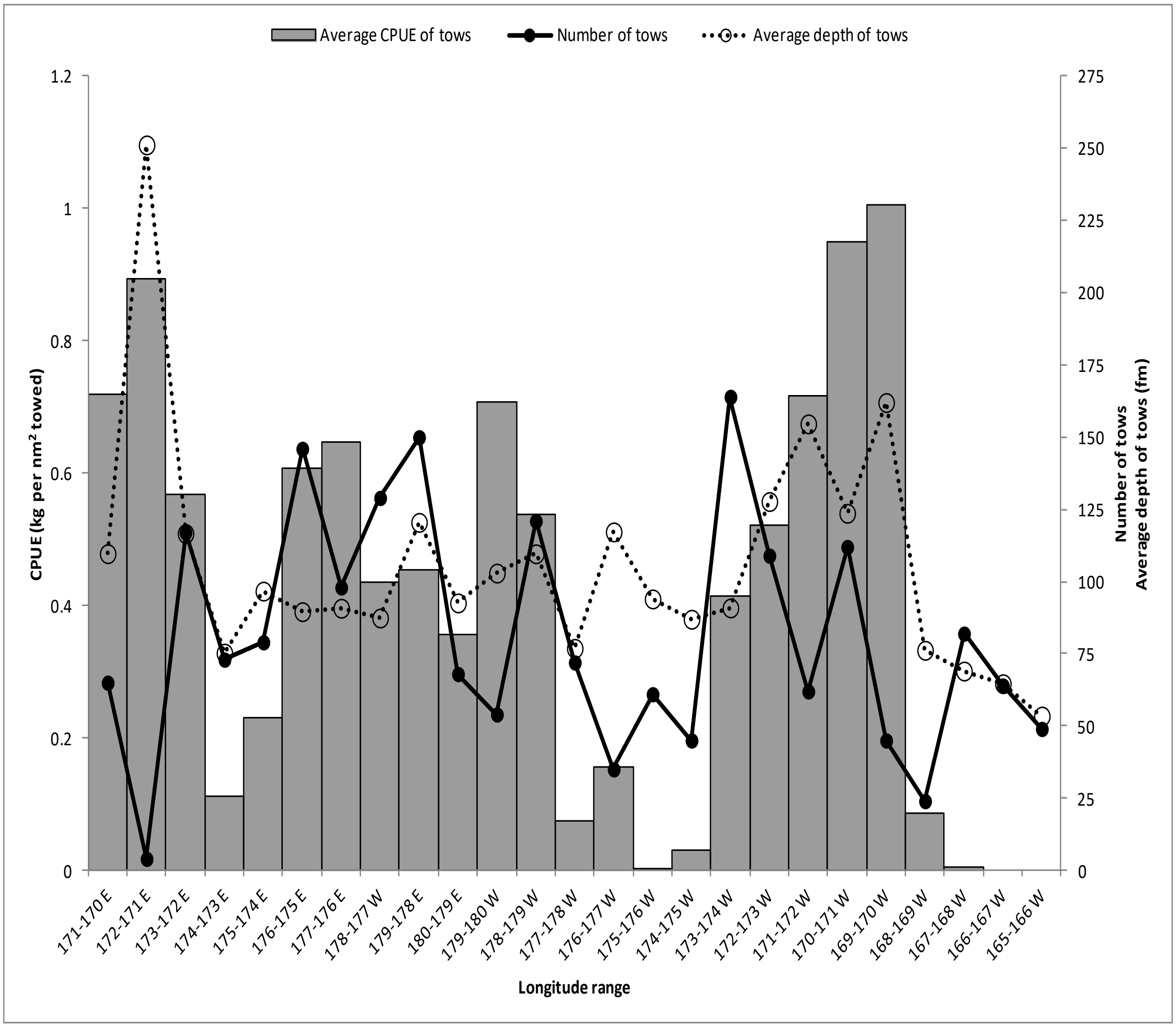


Figure 5. Average golden king crab CPUE (kg/nm2) for tows, number of tows, and average depth of tows from one-degree longitude intervals during the 2002, 2004, 2006, 2010, and 2012 NMFS Aleutian Islands bottom trawl surveys; preliminary summary of data obtained on 1 April 2013 from http://www.afsc.noaa.gov/RACE/groundfish/survey_data/default.htm.

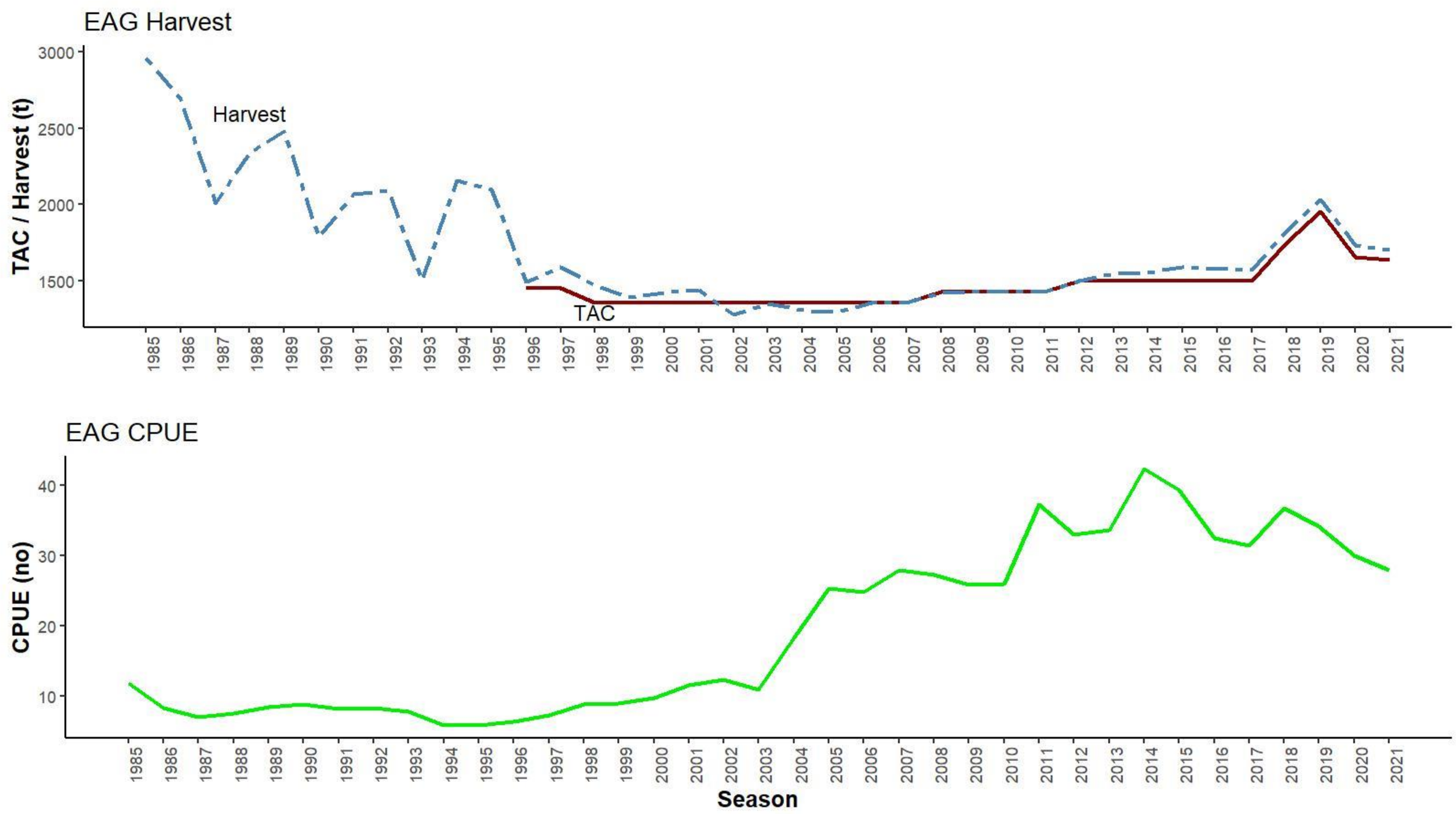


Figure 6. Historical commercial harvest (from fish tickets; metric tons), total allowable catch (TAC), and catch-per-unit effort (CPUE, number of crab per pot lift) of golden king crab in the EAG, 1985/86–2021/22 fisheries (note: 1985 refers to the 1985/86 fishing year).

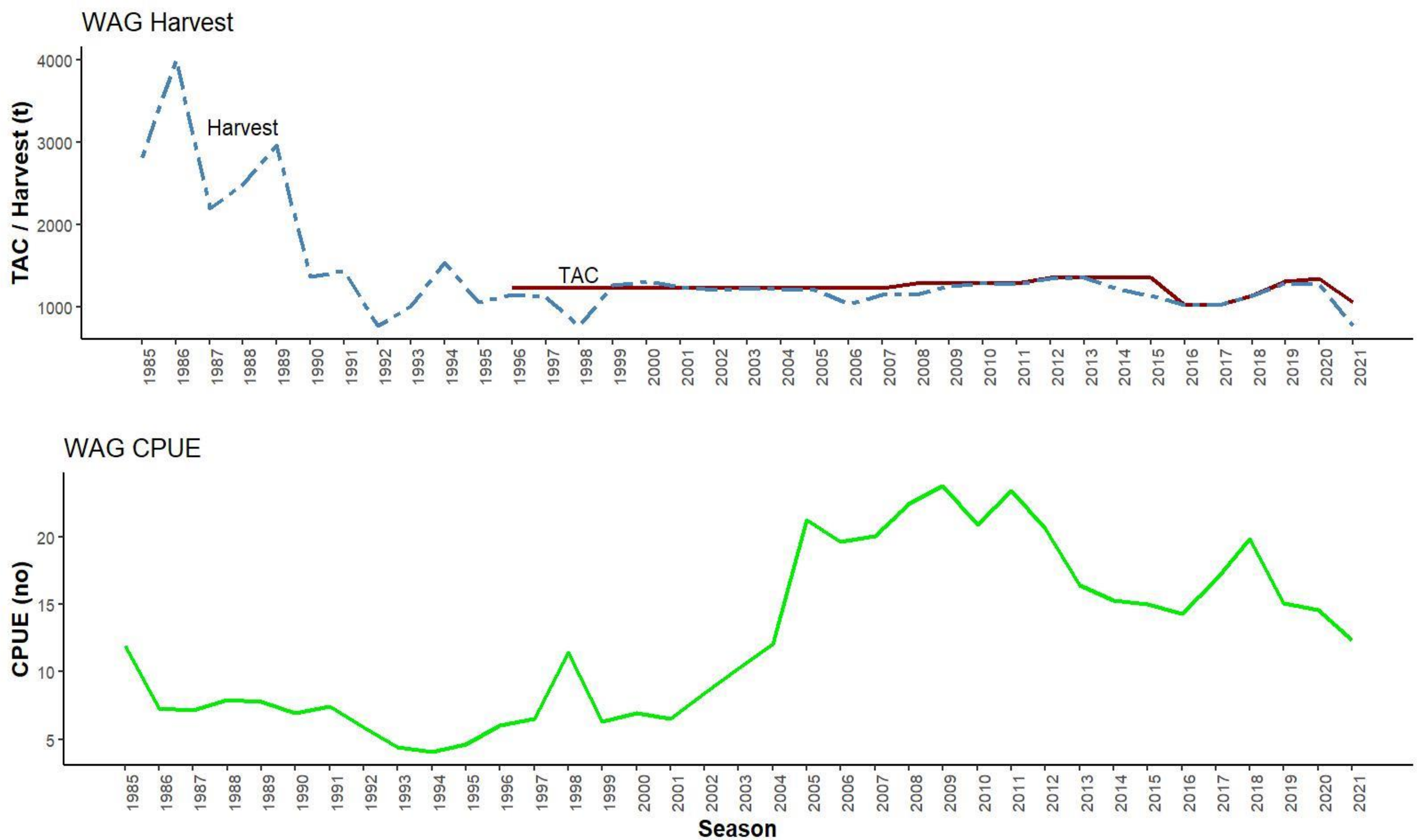


Figure 7. Historical commercial harvest (from fish tickets; metric tons)), total allowable catch (TAC), and catch-per-unit effort (CPUE, number of crab per pot lift) of golden king crab in the WAG, 1985/86–2021/22 fisheries (note: 1985 refers to the 1985/86 fishing year).

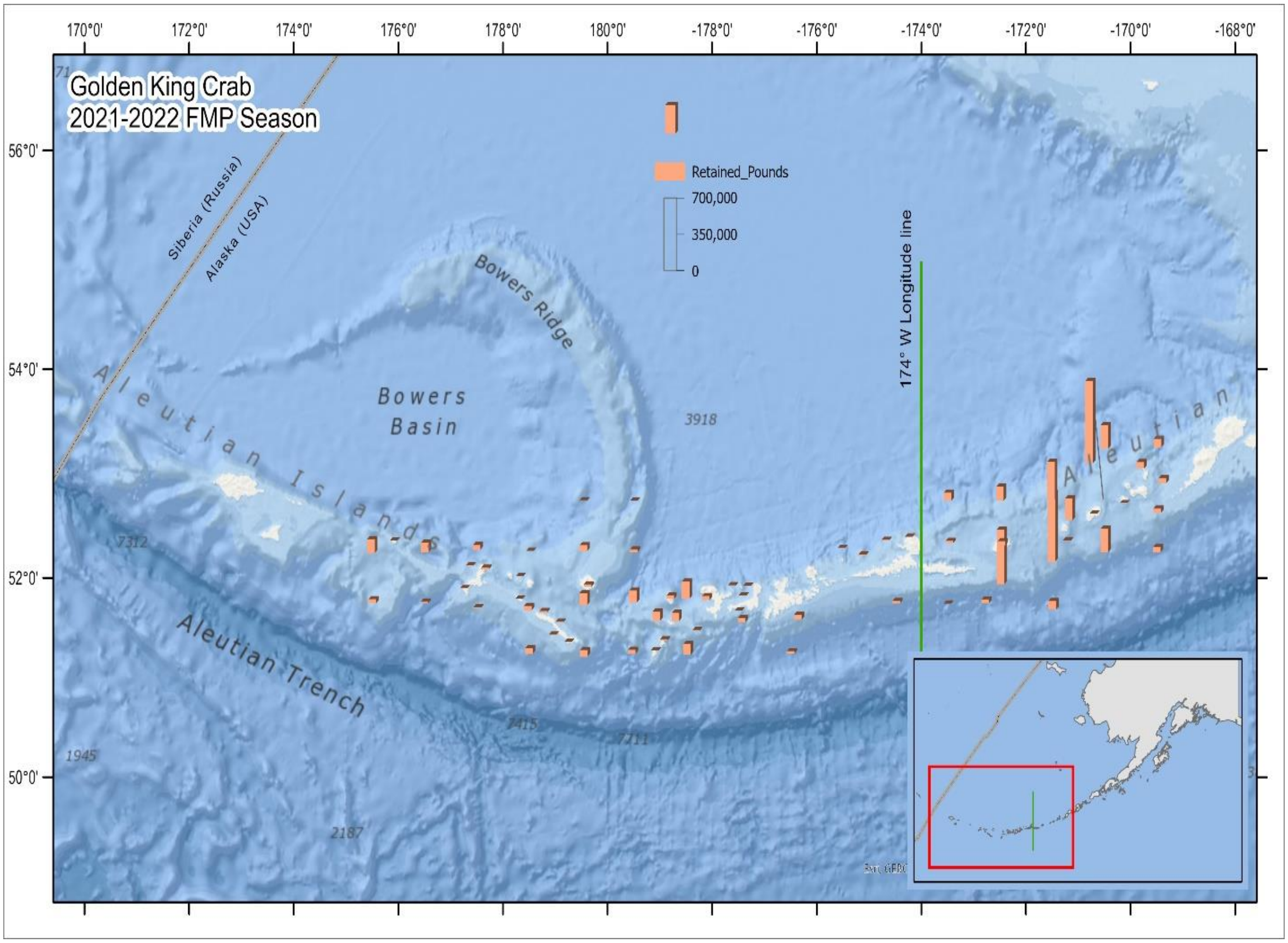


Figure 8. Catch distribution by statistical area in 2021/22.

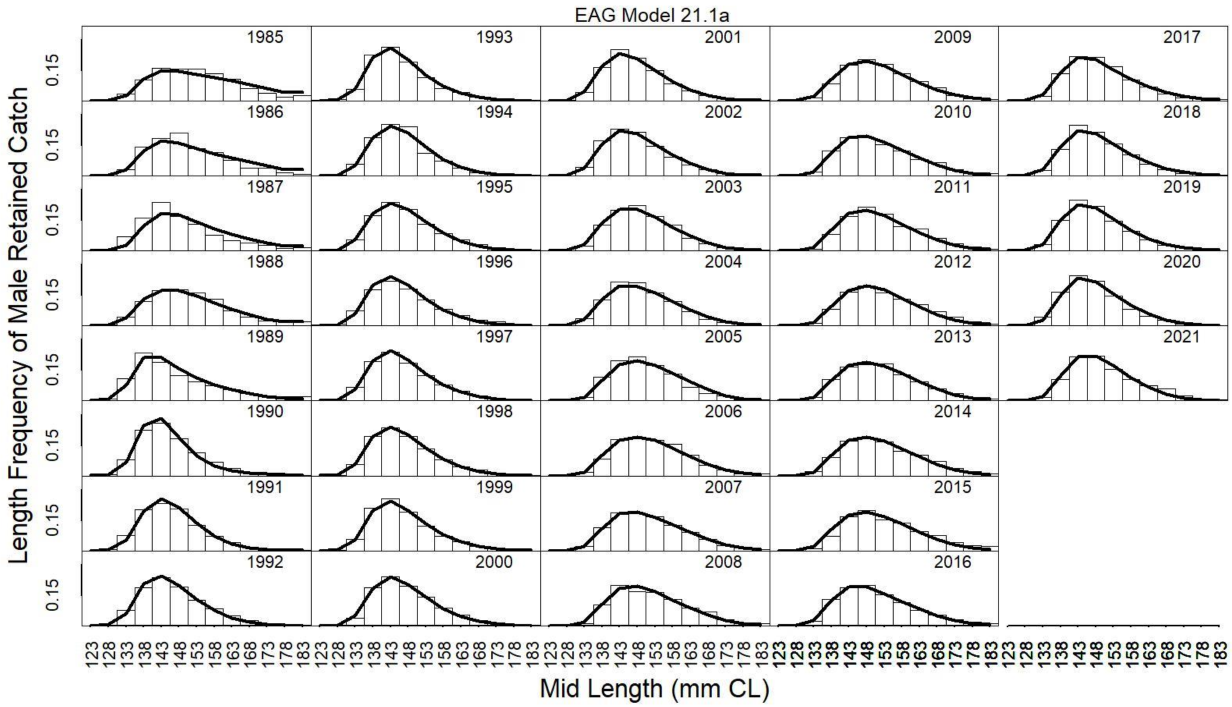


Figure 9a. Predicted vs. observed retained catch relative length frequency distributions under model 21.1a for golden king crab in the EAG, 1985/86 to 2021/22.

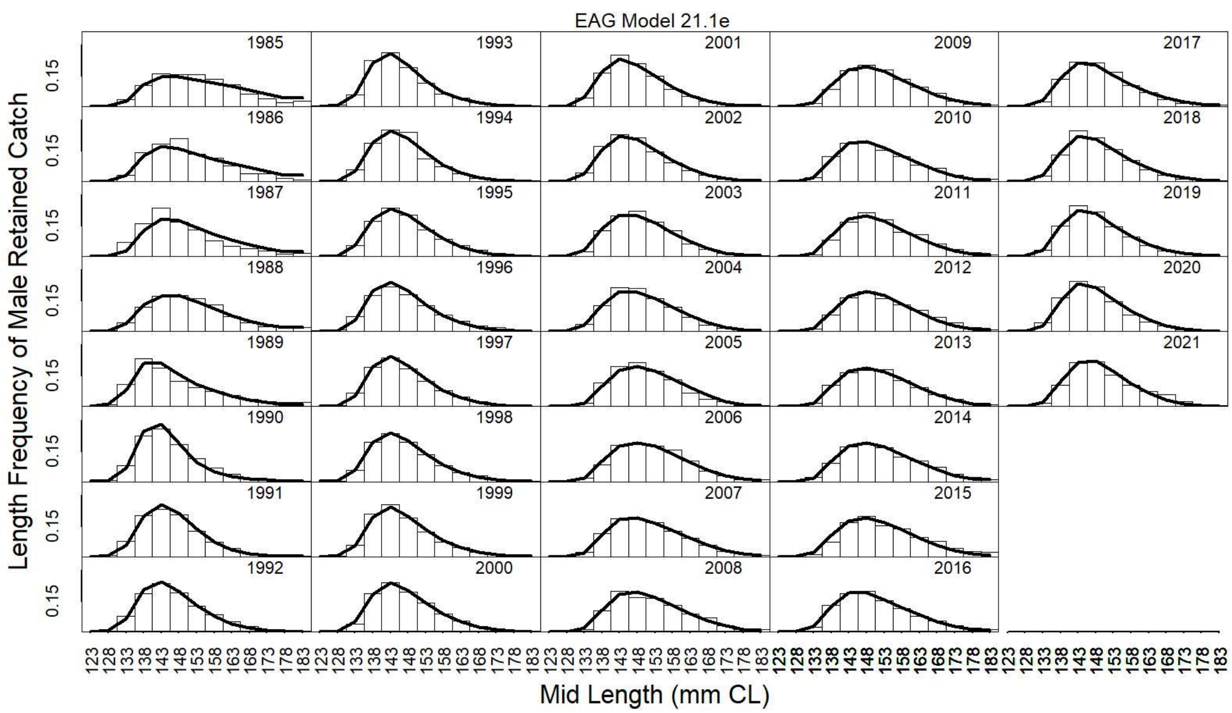


Figure 9b. Predicted vs. observed retained catch relative length frequency distributions under model 21.1e for golden king crab in the EAG, 1985/86 to 2021/22.

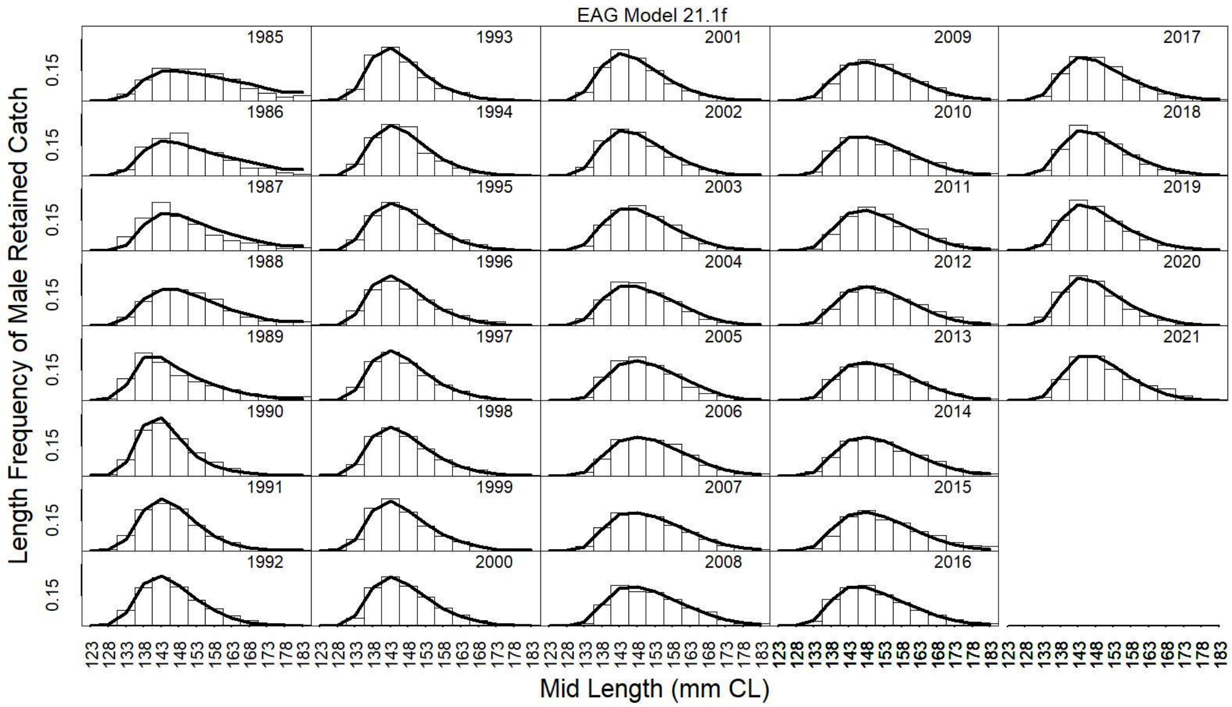


Figure 9c. Predicted vs. observed retained catch relative length frequency distributions under model 21.1f for golden king crab in the EAG, 1985/86 to 2021/22.

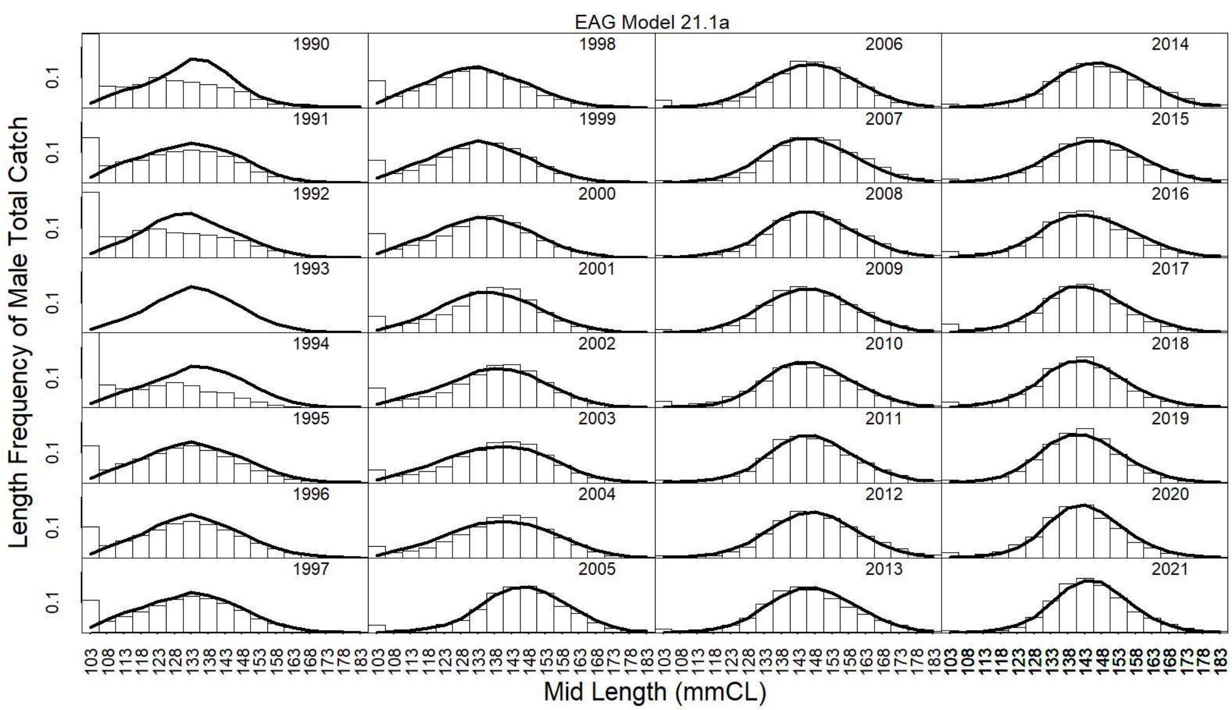


Figure 10a. Predicted vs. observed total catch relative length frequency distributions under model 21.1a for golden king crab in the EAG, 1990/91 to 2021/22.

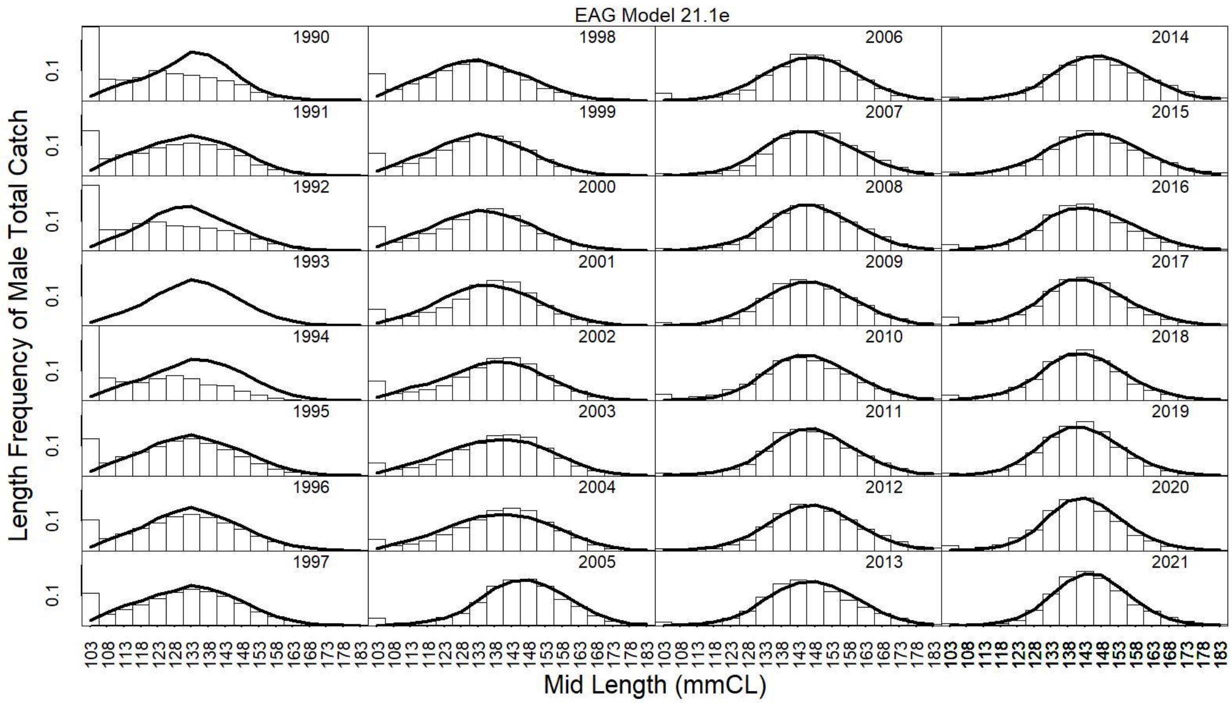


Figure 10b. Predicted vs. observed total catch relative length frequency distributions under model 21.1e for golden king crab in the EAG, 1990/91 to 2021/22.

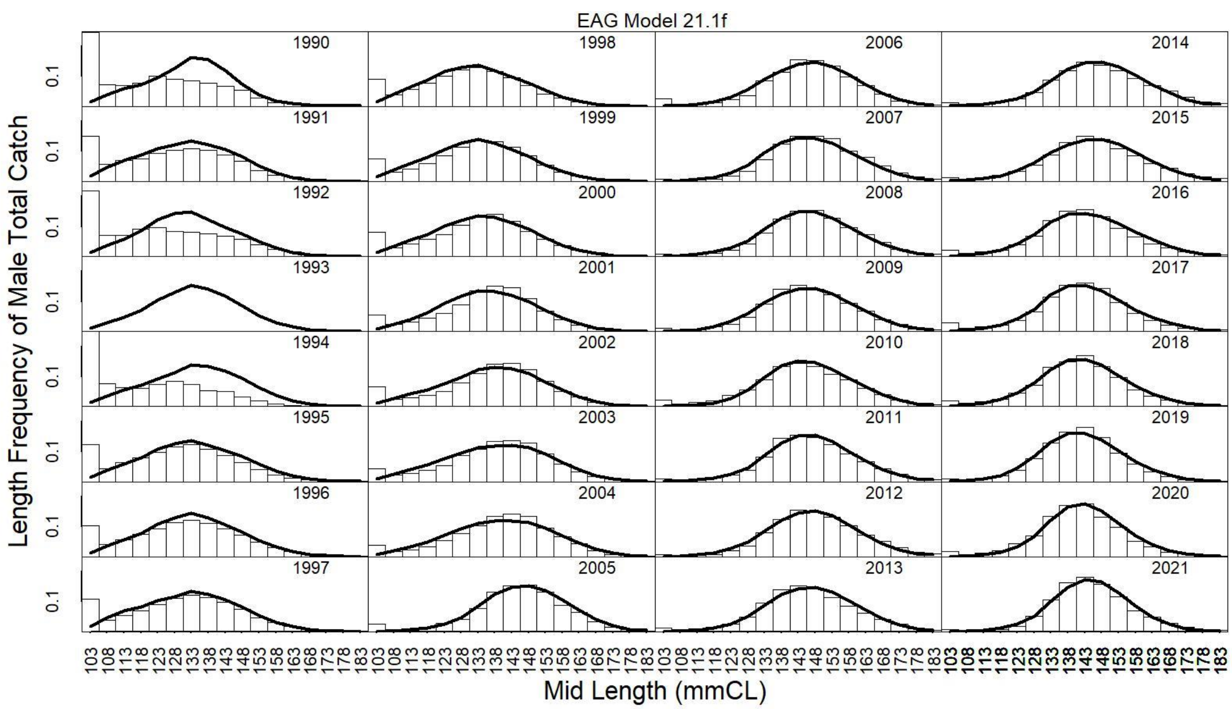


Figure 10c. Predicted vs. observed total catch relative length frequency distributions under model 21.1f for golden king crab in the EAG, 1990/91 to 2021/22.

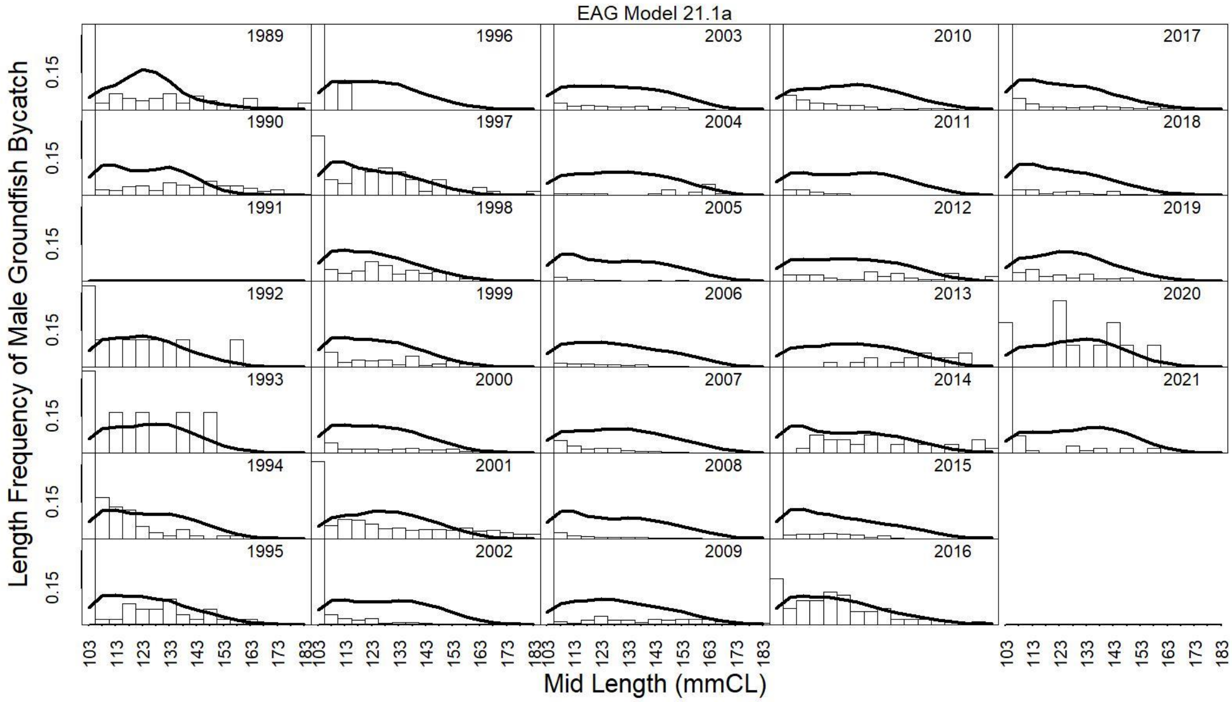


Figure 11. Predicted vs. observed groundfish discarded bycatch relative length frequency distributions under model 21.1a for golden king crab in the EAG, 1989/90 to 2021/22.

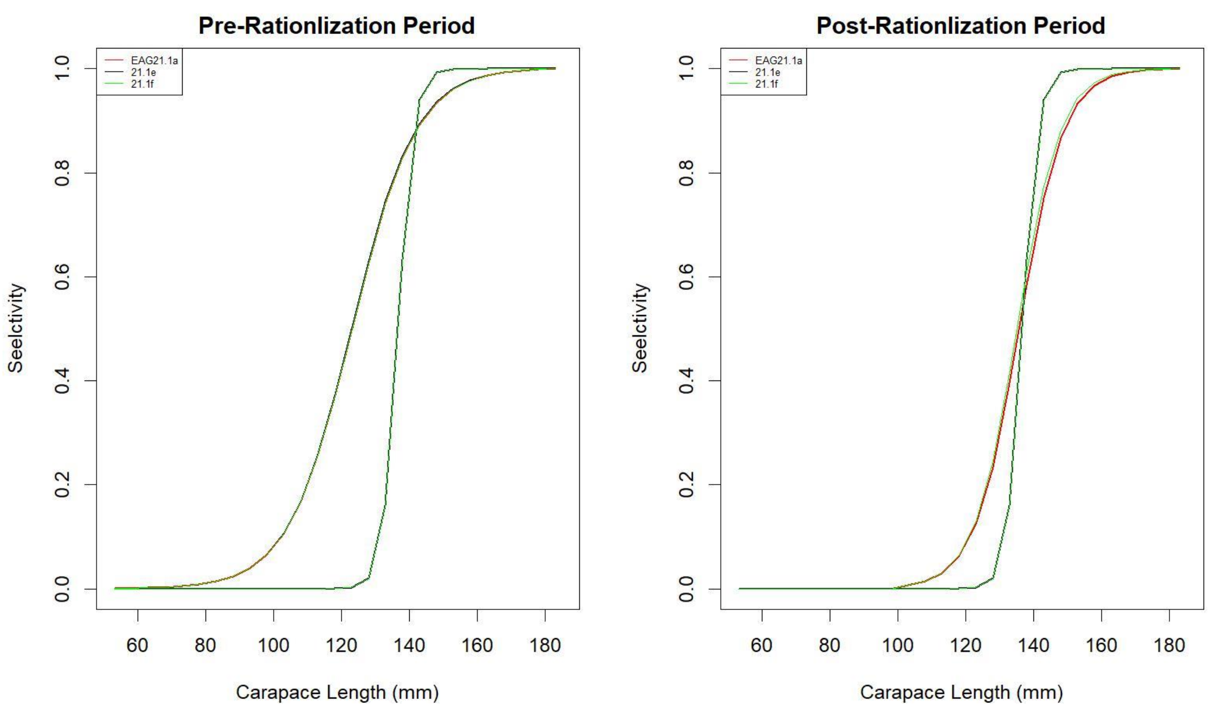


Figure 12. Estimated total (solid line) and retained (dashed line) selectivity for pre- and post-rationalization periods under models 21.1a (red), 21.1e (black), and 21.1f (green) fits to golden king crab data in the EAG.

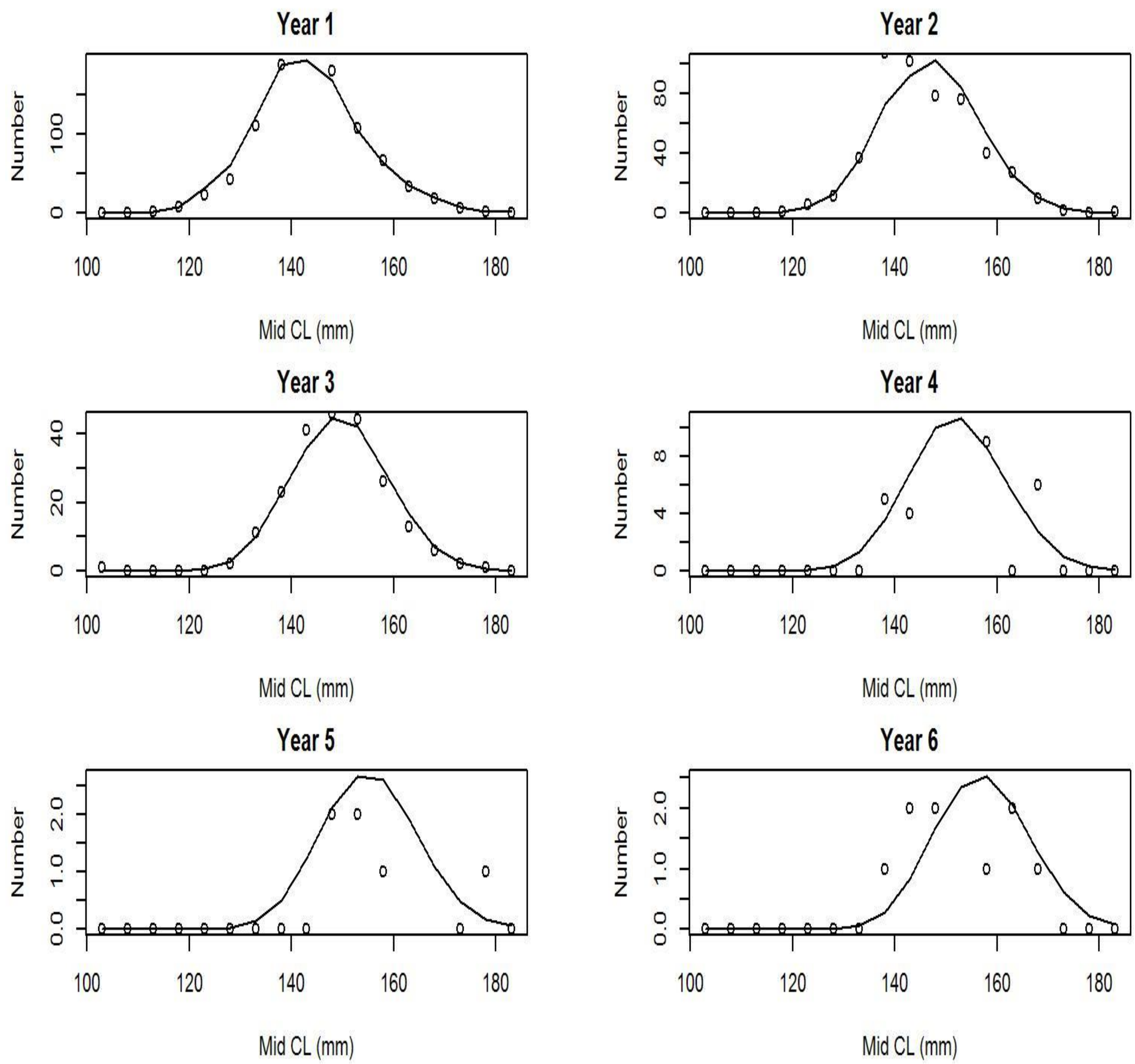


Figure 13. Observed (open circles) vs. predicted (solid line) tag recaptures by size bin for years 1 to 6 post tagging under model 21.1a for EAG golden king crab.

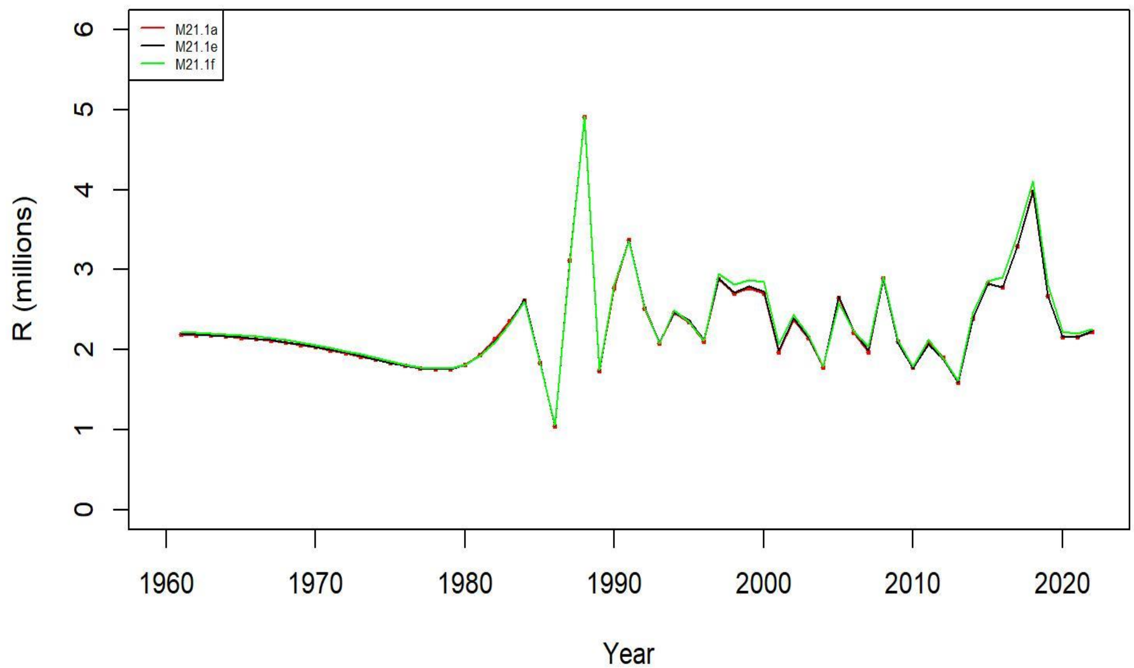


Figure 14. Estimated number of male recruits (crab size ≥ 101 mm CL) to the assessment model under models 21.1a (red), 21.1e (black), and 21.1f (green) fits to EAG golden king crab data, 1961–2022.

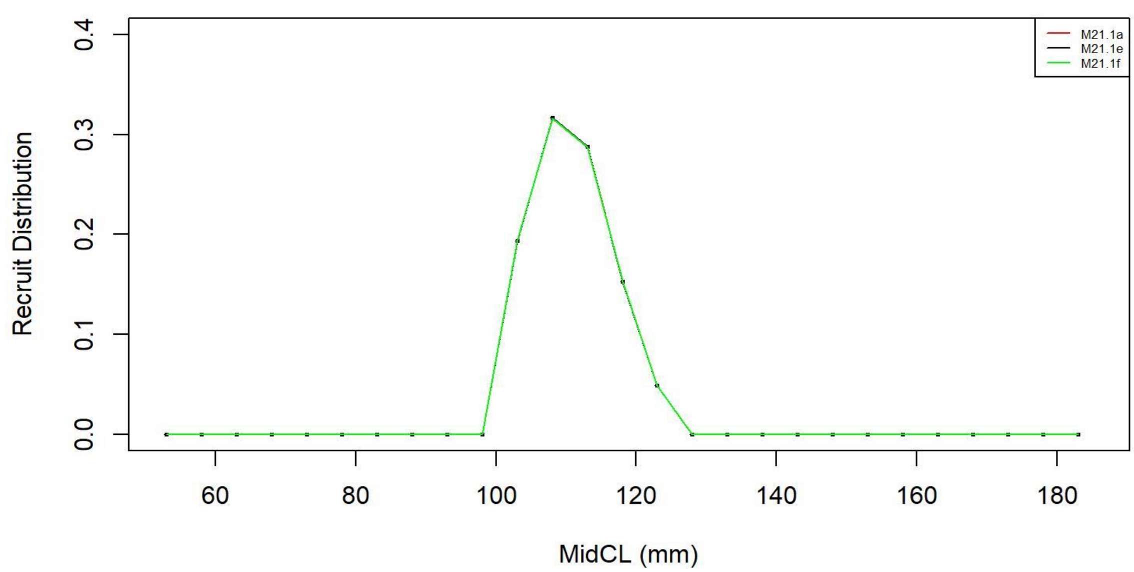


Figure 15. Recruit size distribution to the assessment model under 21.1a (red), 21.1e (black), and 21.1f (green) fits to EAG golden king crab data.

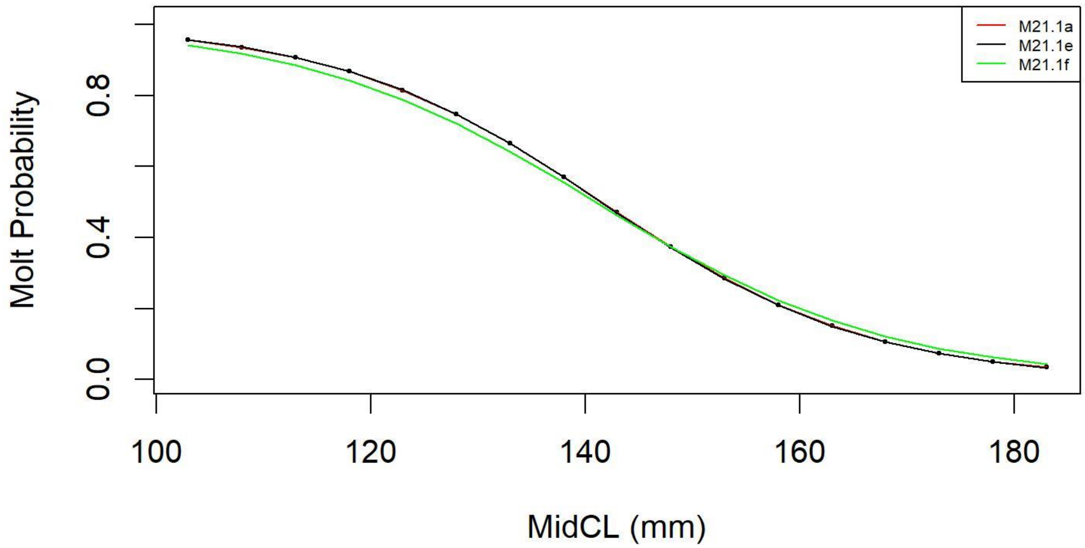


Figure 16. Estimated molt probability vs. carapace length of golden king crab under models 21.1a (red), 21.1e (black), and 21.1f (green)fits to EAG golden king crab data.

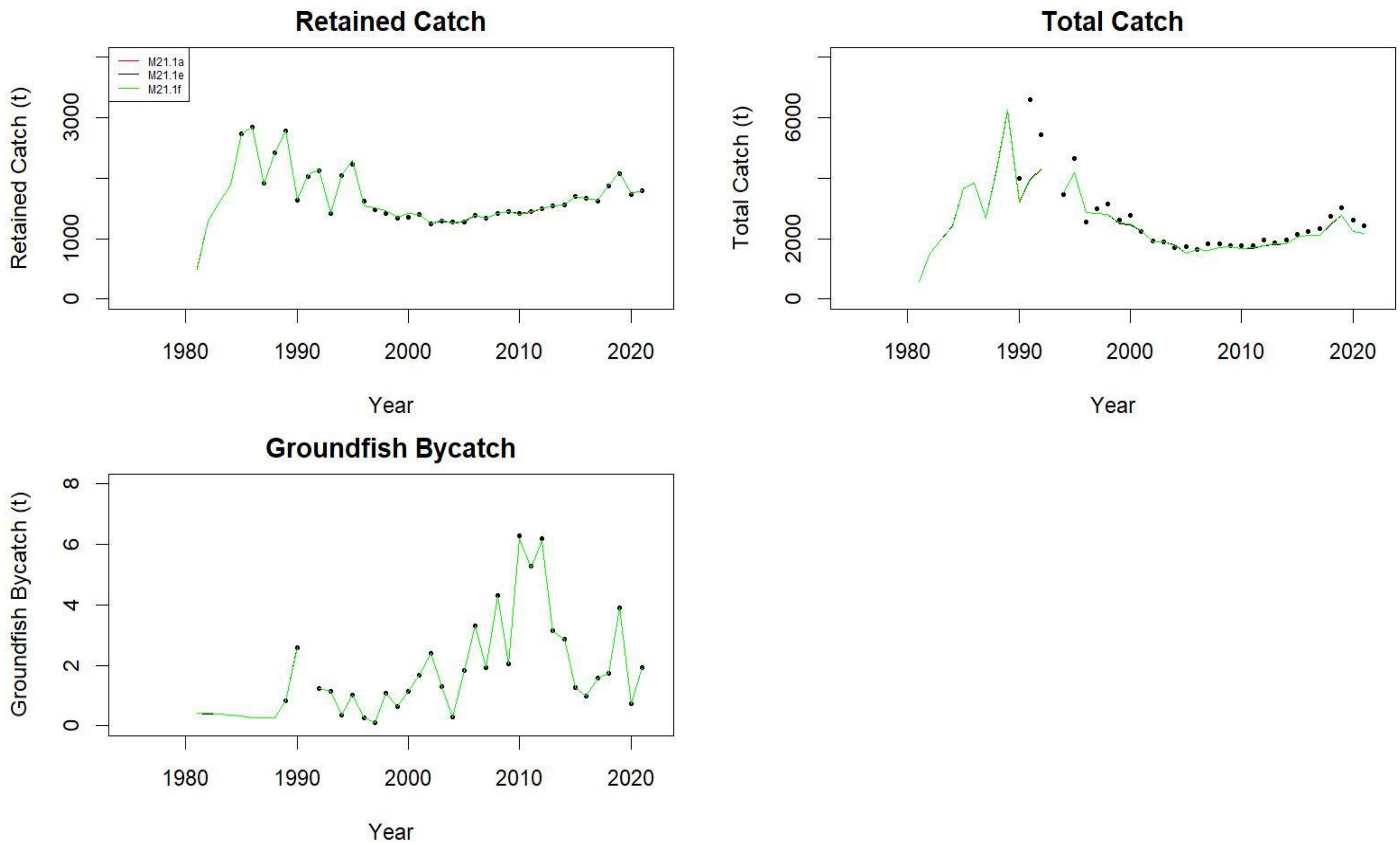


Figure 17. Observed (open circle) vs. predicted (solid line) retained catch (top left), total catch (top right), and groundfish bycatch (bottom left) of golden king crab under models 21.1a (red), 21.1e (black), and 21.1f (green) fits in EAG, 1981/82–2021/22.

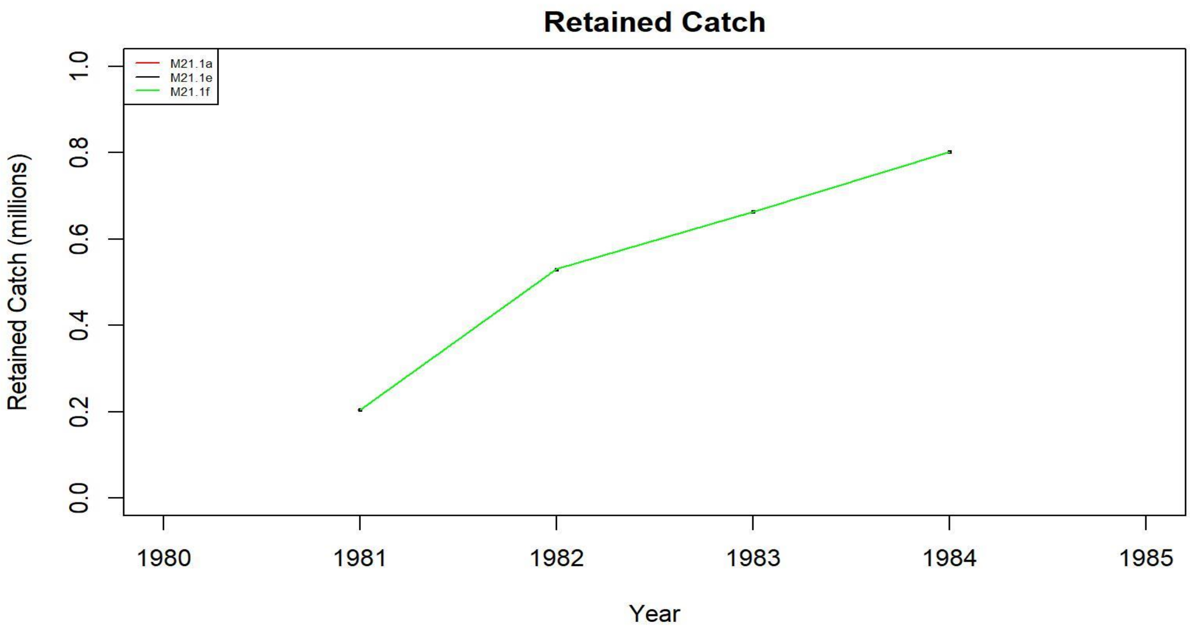


Figure 18. Observed (open circle) vs. predicted (solid line) retained catch of golden king crab for models 21.1a (red), 21.1e (black), and 21.1f (green) fits in the EAG, 1981/82–1984/85. Note: Input retained catches to the model during pre-1985 fishery period was in number of crabs.

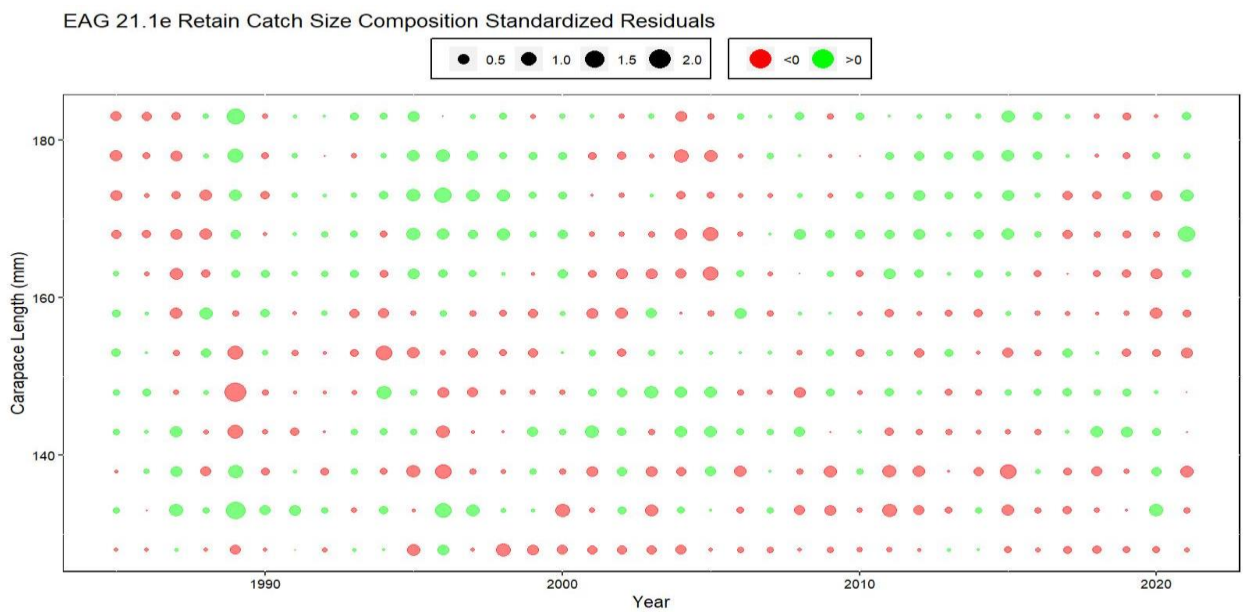


Figure 19. Bubble plot of standardized residuals of retained catch length composition for model 21.1e fit for EAG golden king crab, 1985/86–2021/22. Green circles are the positive and pink circles are the negative standardized residuals. The area of the circle is the relative magnitude of the residual.

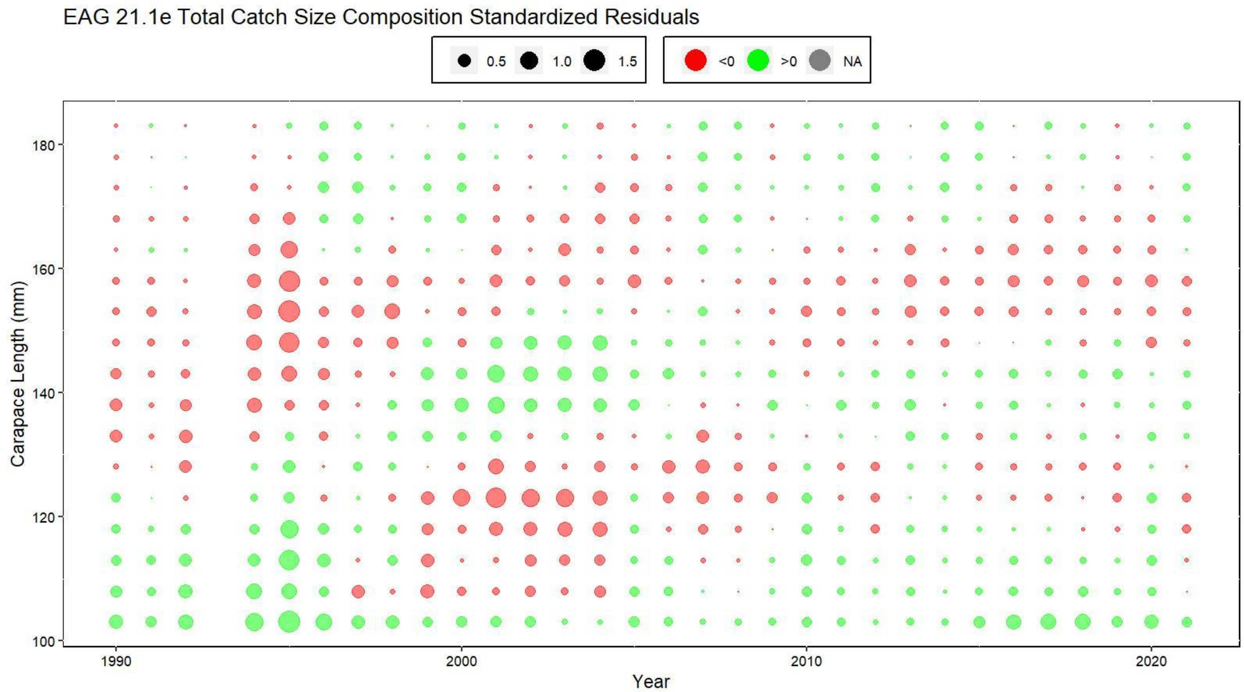


Figure 20. Bubble plot of standardized residuals of total catch length composition for model 21.1e fit for EAG golden king crab, 1990/91–2021/22. Green circles are the positive and pink circles are the negative standardized residuals. The area of the circle is the relative magnitude of the residual.

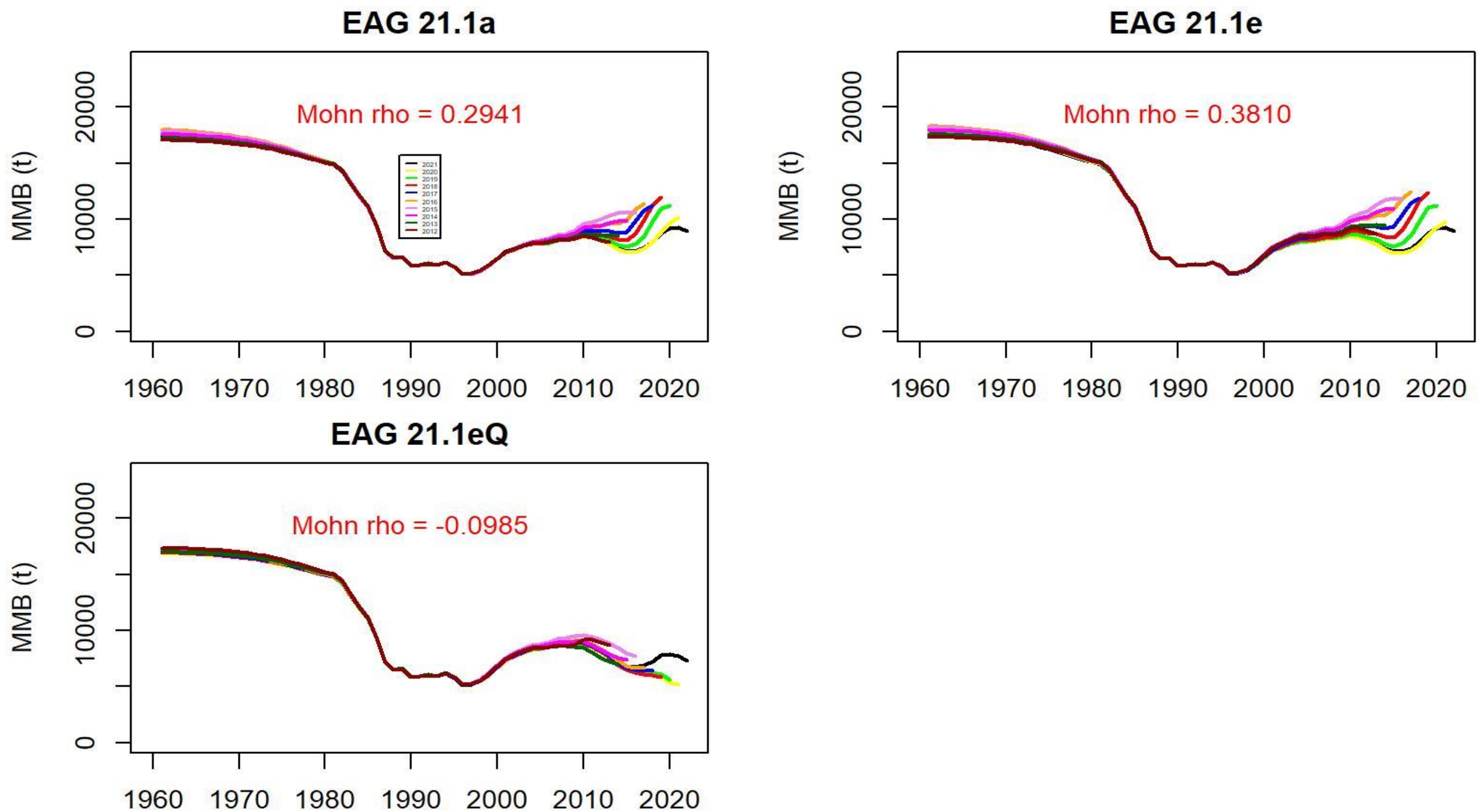


Figure 21. Retrospective fits of MMB by the model following removal of terminal year data under models 21.1a, 21.1e, and 21.1eQ (variable catchability during the post-rationalization period) for golden king crab in the EAG, 1961–2022.

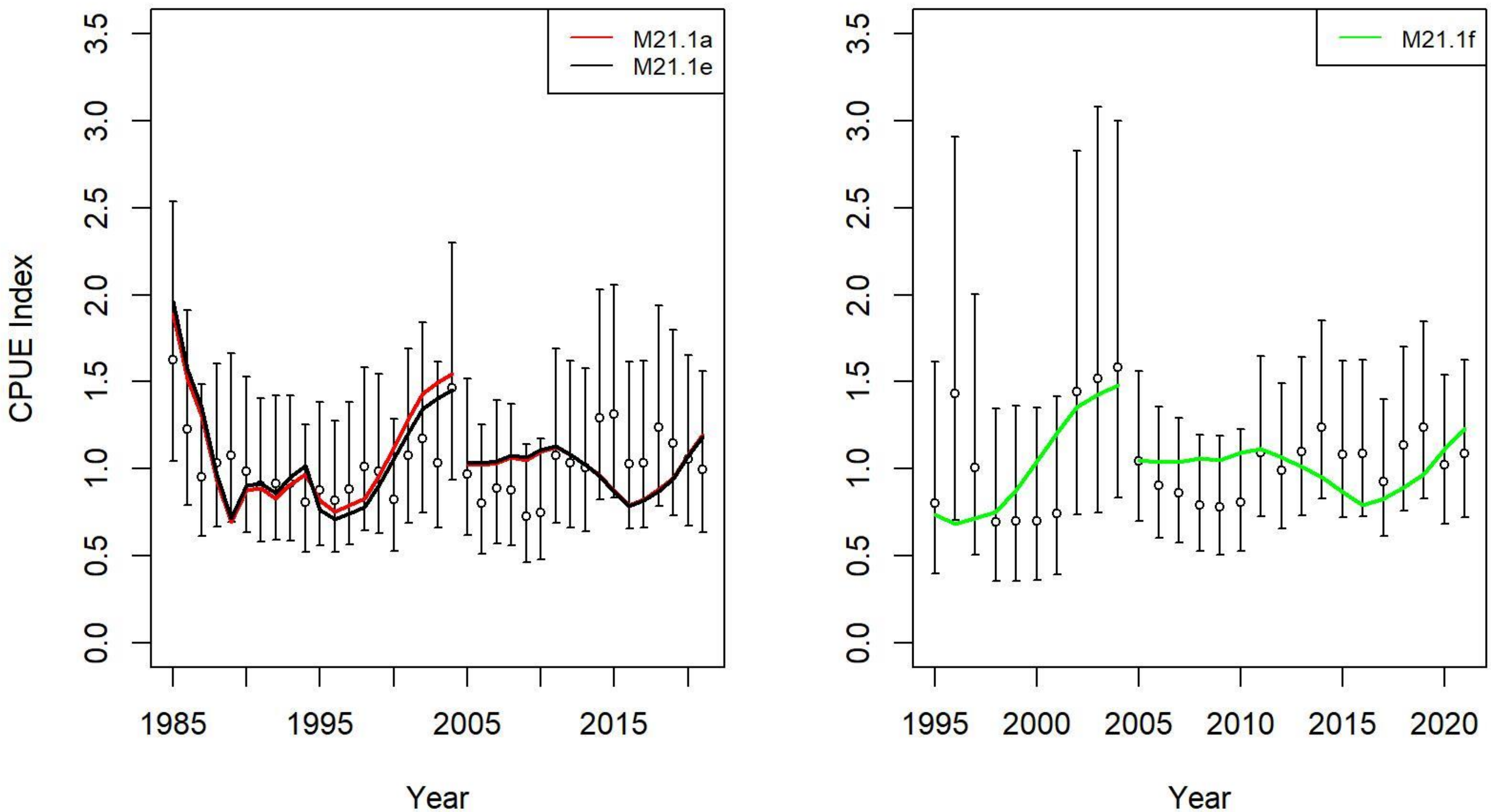


Figure 22. Comparison of input CPUE indices [open circles with +/- 2 SE for model 21.1a (left) and model 21.1f (right)] with predicted CPUE indices (colored solid lines) under 21.1a (red) and 21.1e (black)[left]; and 21.1f (green) [right] for EAG golden king crab data, 1985/86–2021/22. Model estimated additional standard error was added to each input standard error.

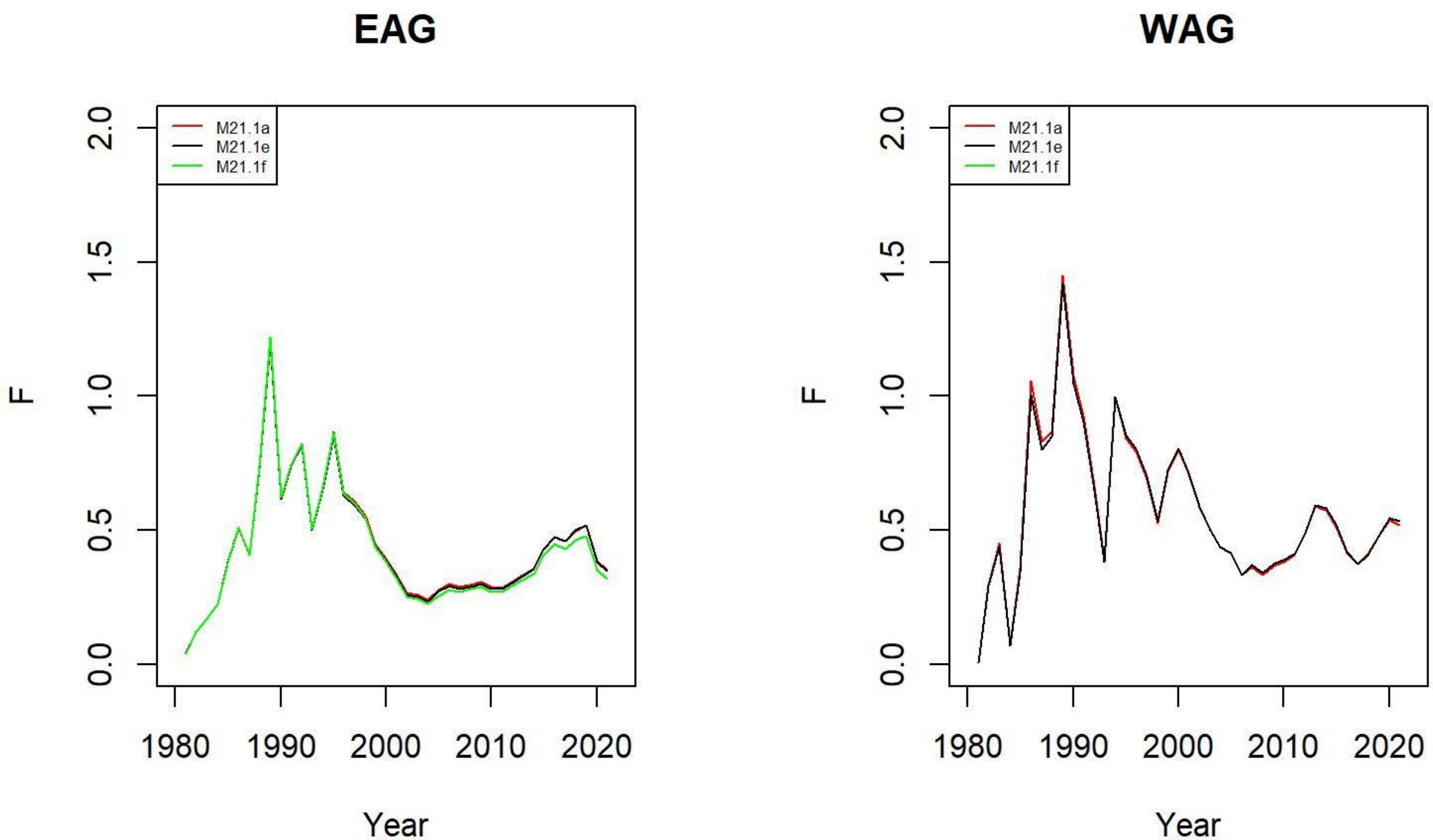


Figure 23. Trends in pot fishery full selection total fishing mortality of golden king crab for models 21.1a (red), 21.1e (black), and 21.1f (green) fits in the EAG (left) and WAG (right) data, 1981/82–2021/22.

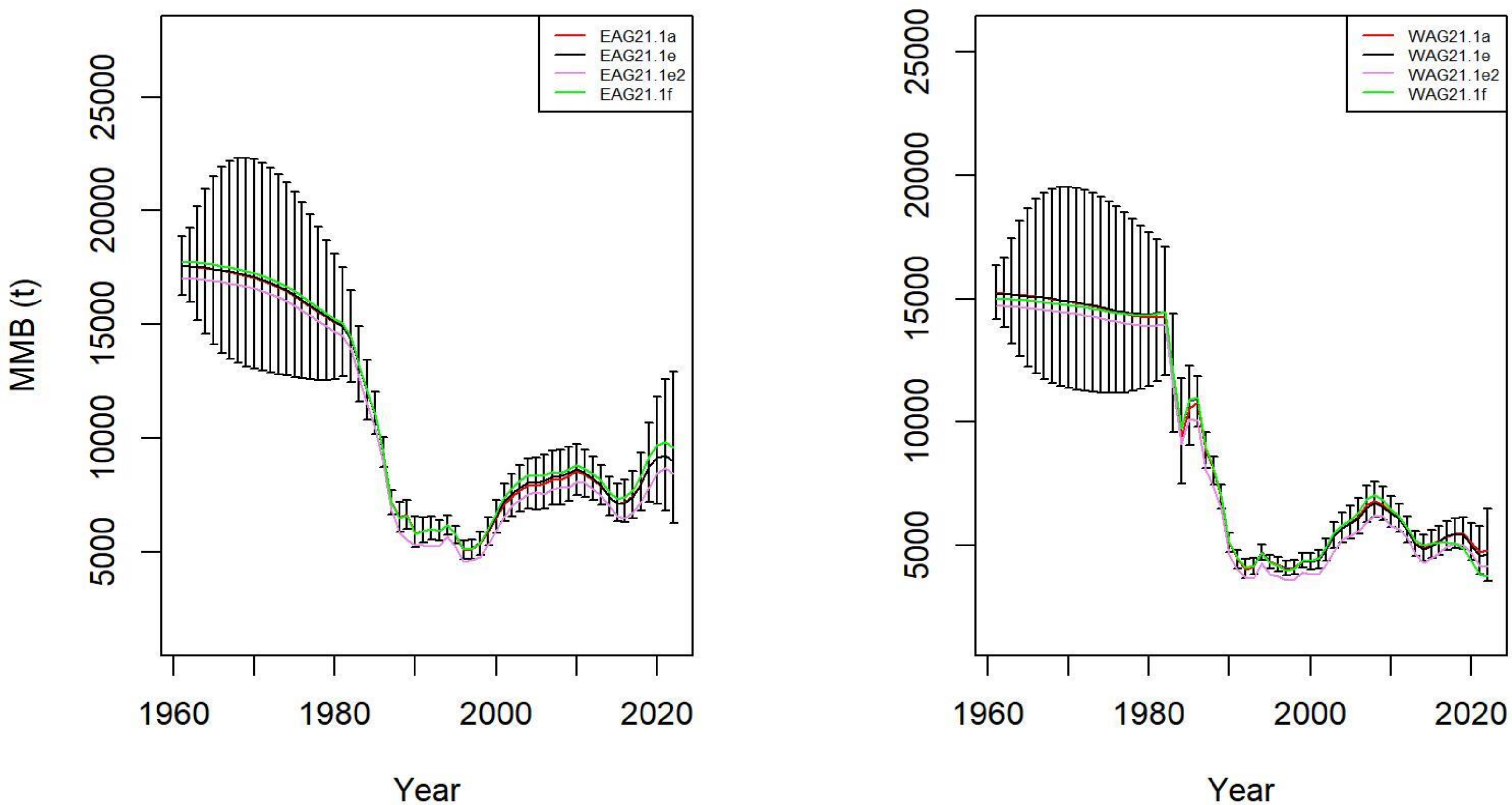
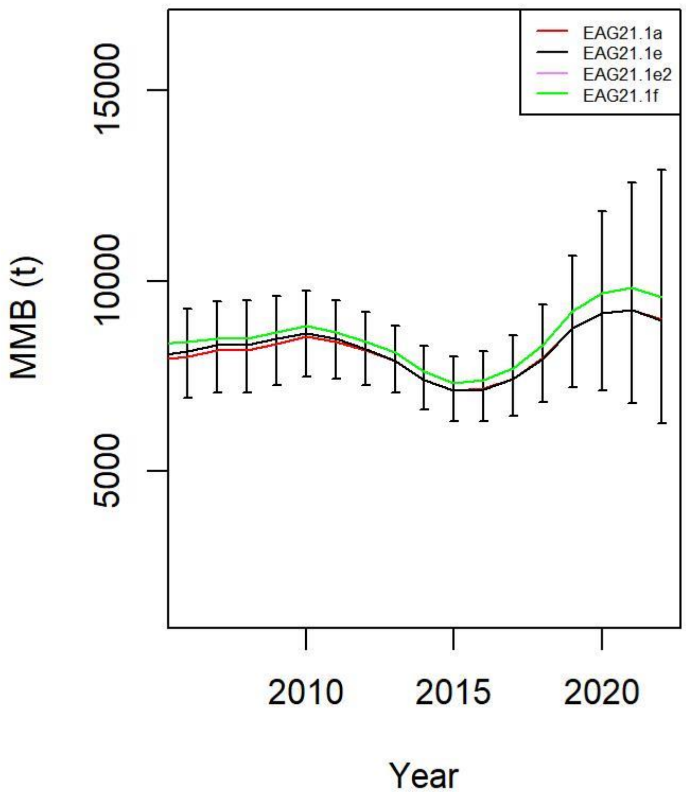


Figure 24a. Long time series trends in golden king crab mature male biomass for models 21.1a (red), 21.1e (black), 21.1e2 (violet), and 21.1f (green) fits to EAG (left) and WAG (right) data, 1961–2022. Model 21.1a estimate has two standard error confidence limits. Year 2020 refers to 2019/20 fishing season.



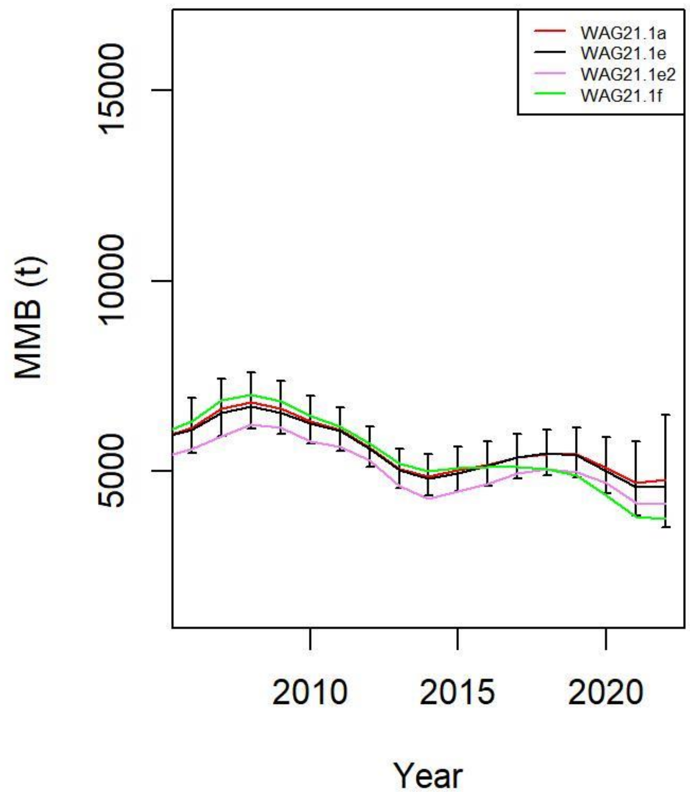


Figure 24b. Short time series trends in golden king crab mature male biomass for models 21.1a (red), 21.1e (black), 21.1e2 (violet), and 21.1f (green) fits to EAG (left) and WAG (right) data, 2006–2022. Model 21.1a estimate has two standard error confidence limits. Year 2020 refers to 2019/20 fishing season.

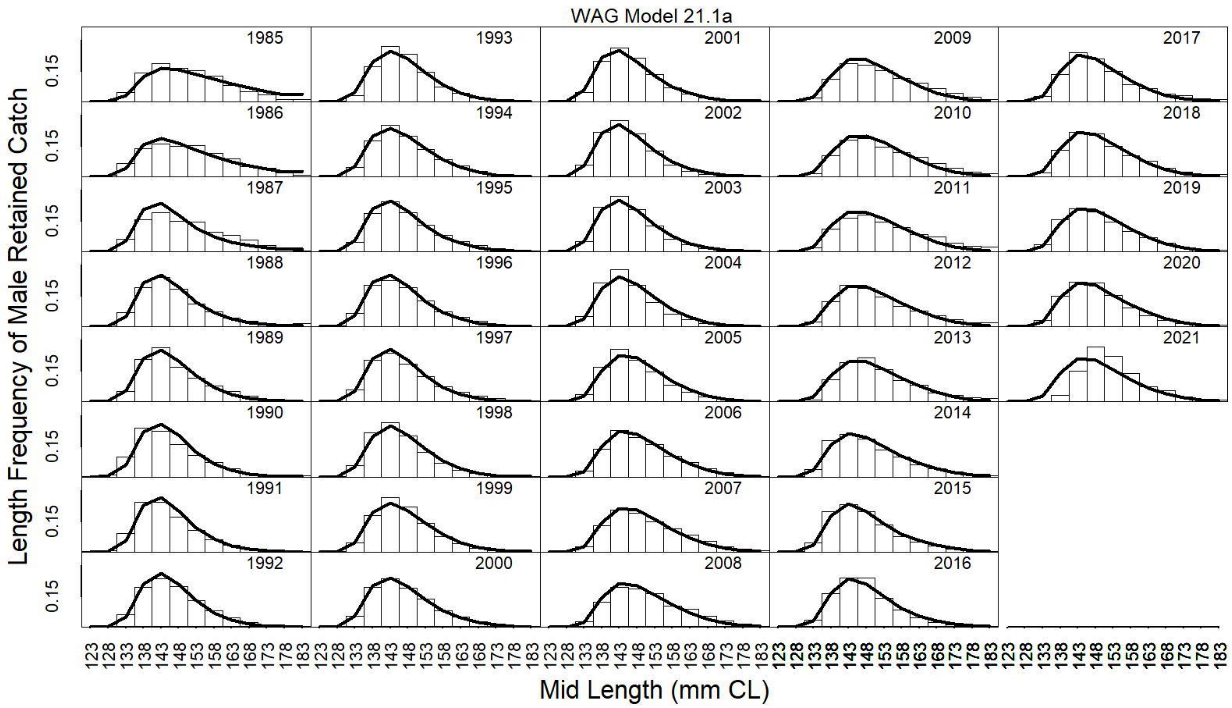


Figure 25a. Predicted vs. observed retained catch relative length frequency distributions under model 21.1a for golden king crab in the WAG, 1985/86 to 2021/22. Each year has a pair of plots with the front plot for observed and the back plot for predicted proportions.

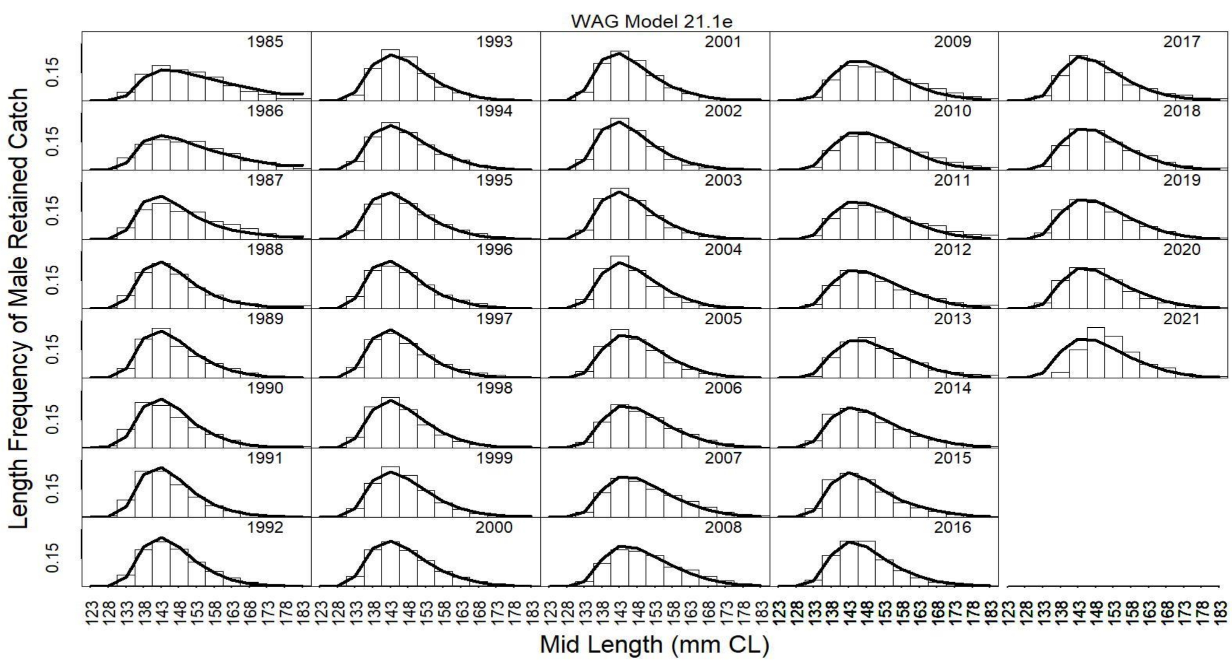


Figure 25b. Predicted vs. observed retained catch relative length frequency distributions under model 21.1e for golden king crab in the WAG, 1985/86 to 2021/22. Each year has a pair of plots with the front plot for observed and the back plot for predicted proportions.

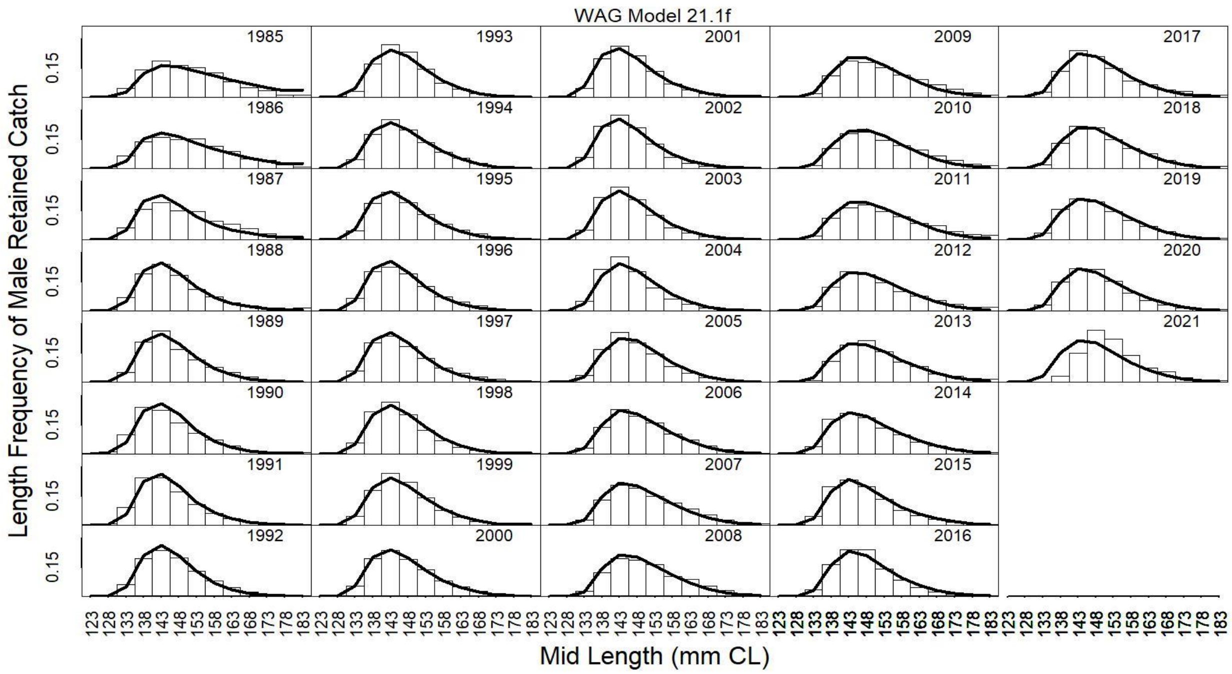


Figure 25c. Predicted vs. observed retained catch relative length frequency distributions under model 21.1f for golden king crab in the WAG, 1985/86 to 2021/22. Each year has a pair of plots with the front plot for observed and the back plot for predicted proportions.

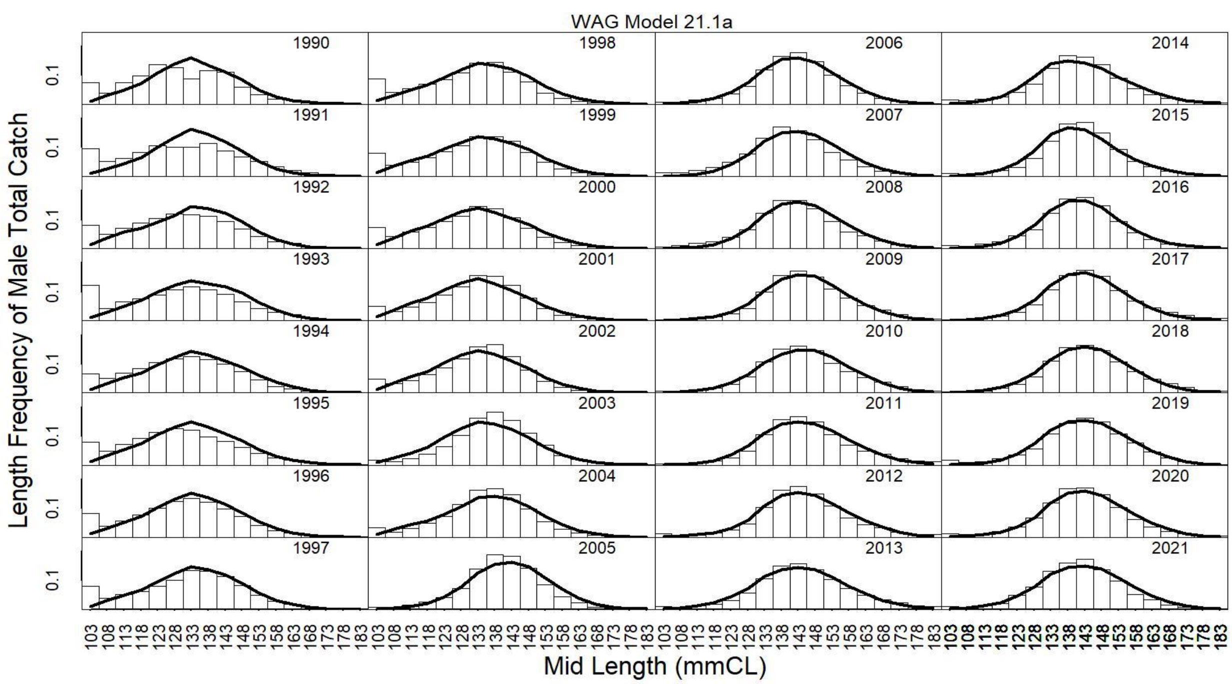


Figure 26a. Predicted vs. observed total catch relative length frequency distributions under model 21.1a for golden king crab in the WAG, 1990/91 to 2021/22. Each year has a pair of plots with the front plot for observed and the back plot for predicted proportions.

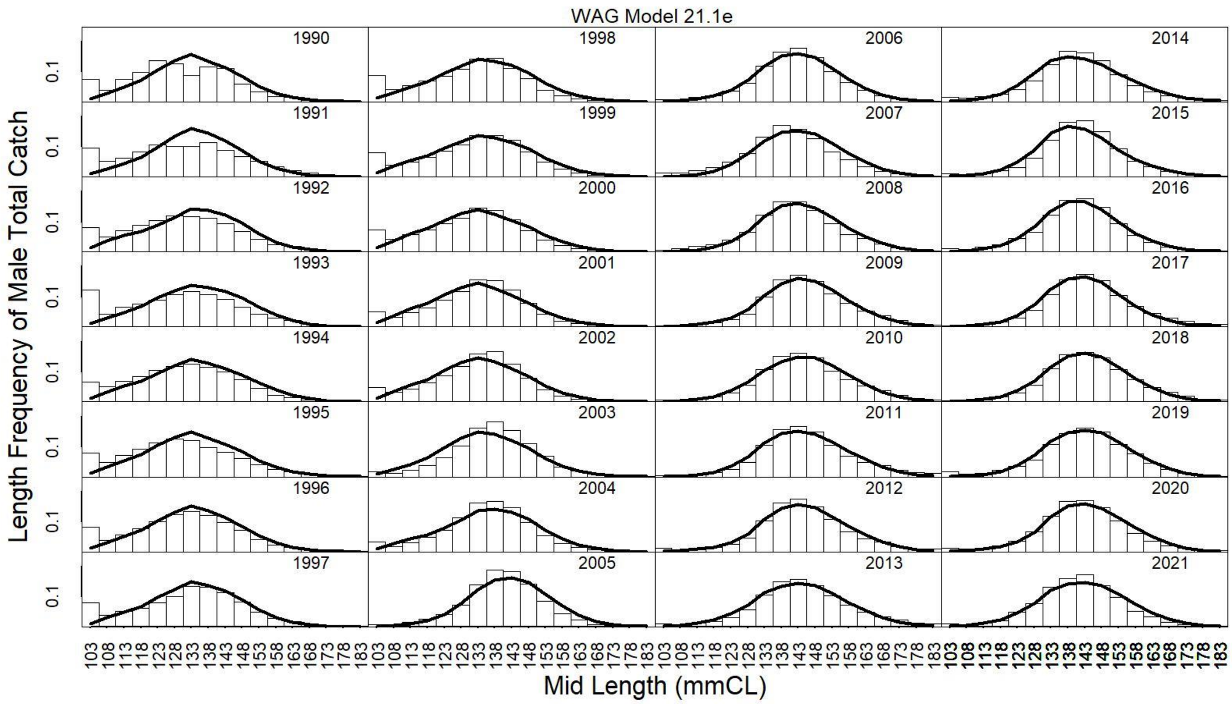


Figure 26b. Predicted vs. observed total catch relative length frequency distributions under model 21.1e for golden king crab in the WAG, 1990/91 to 2021/22. Each year has a pair of plots with the front plot for observed and the back plot for predicted proportions.

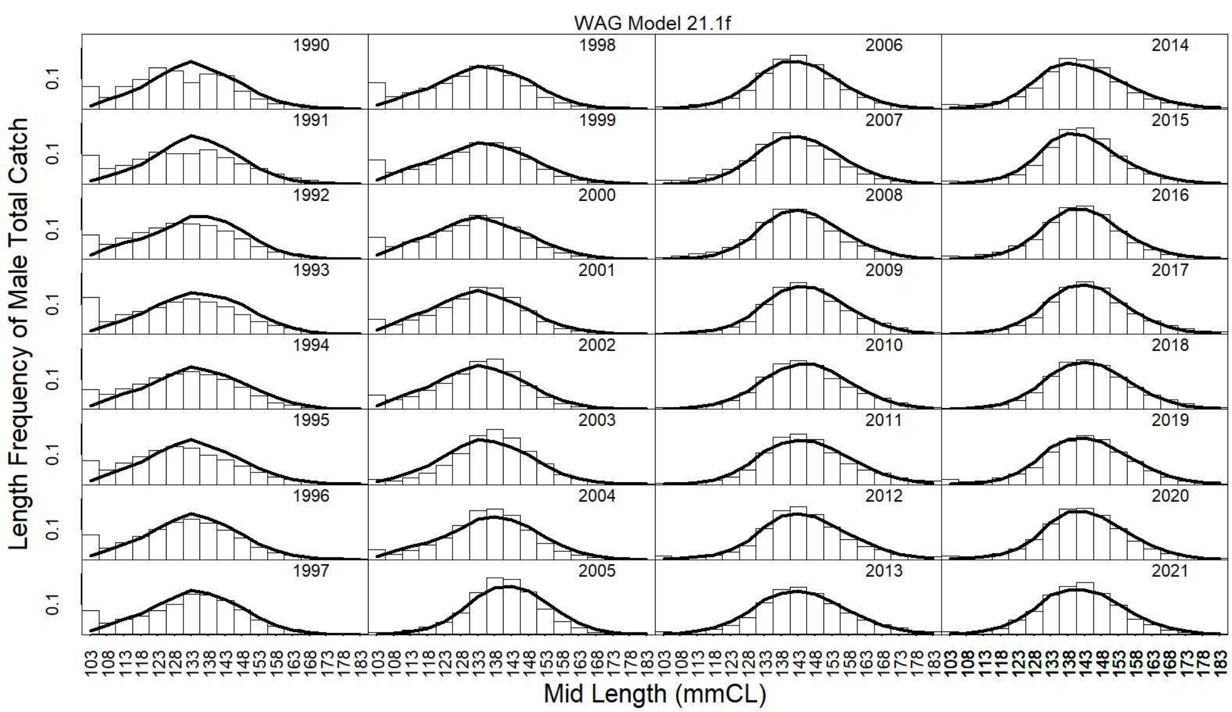


Figure 26c. Predicted vs. observed total catch relative length frequency distributions under model 21.1f for golden king crab in the WAG, 1990/91 to 2021/22. Each year has a pair of plots with the front plot for observed and the back plot for predicted proportions.

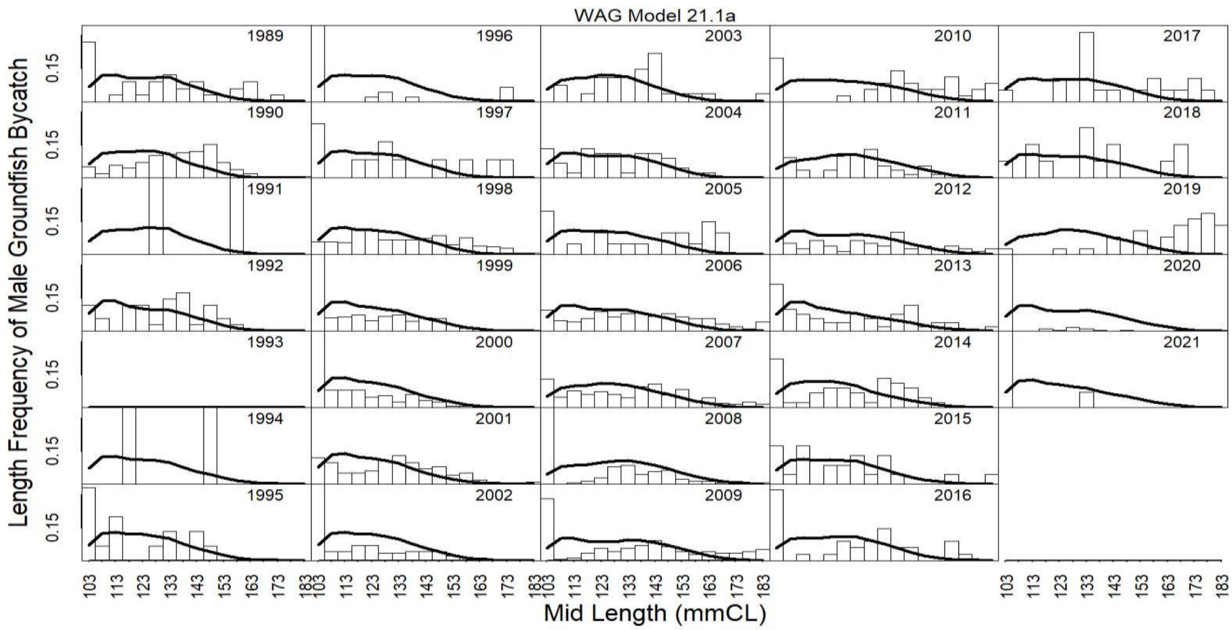


Figure 27. Predicted vs. observed groundfish discarded bycatch relative length frequency distributions under model 21.1a for golden king crab in the WAG, 1989/90 to 2021/22. Each year has a pair of plots with the front plot for observed and the back plot for predicted proportions.

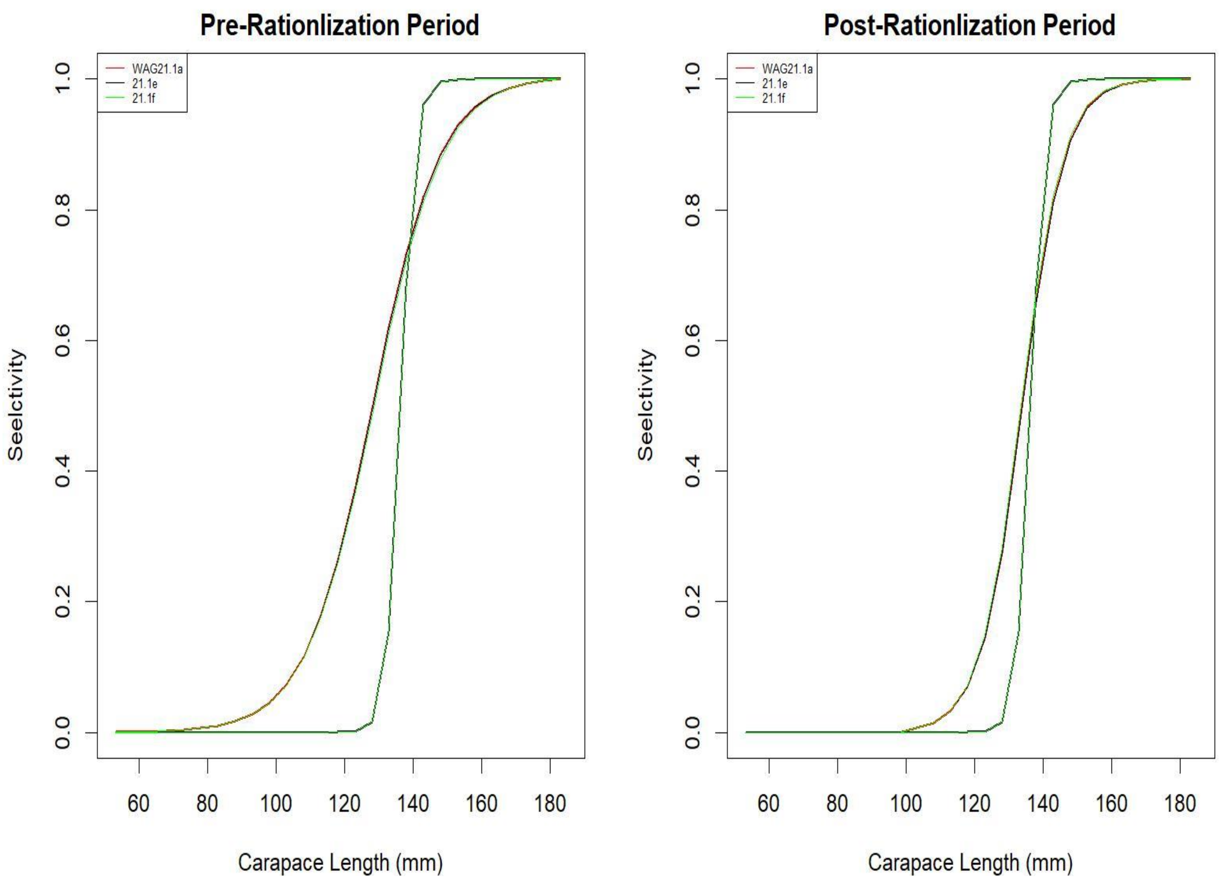


Figure 28. Estimated total (solid line) and retained (dashed line) selectivity for pre- and post-rationalization periods under models 21.1a (red), 21.1e (black), and 21.1f (green) fits to golden king crab data in the WAG.

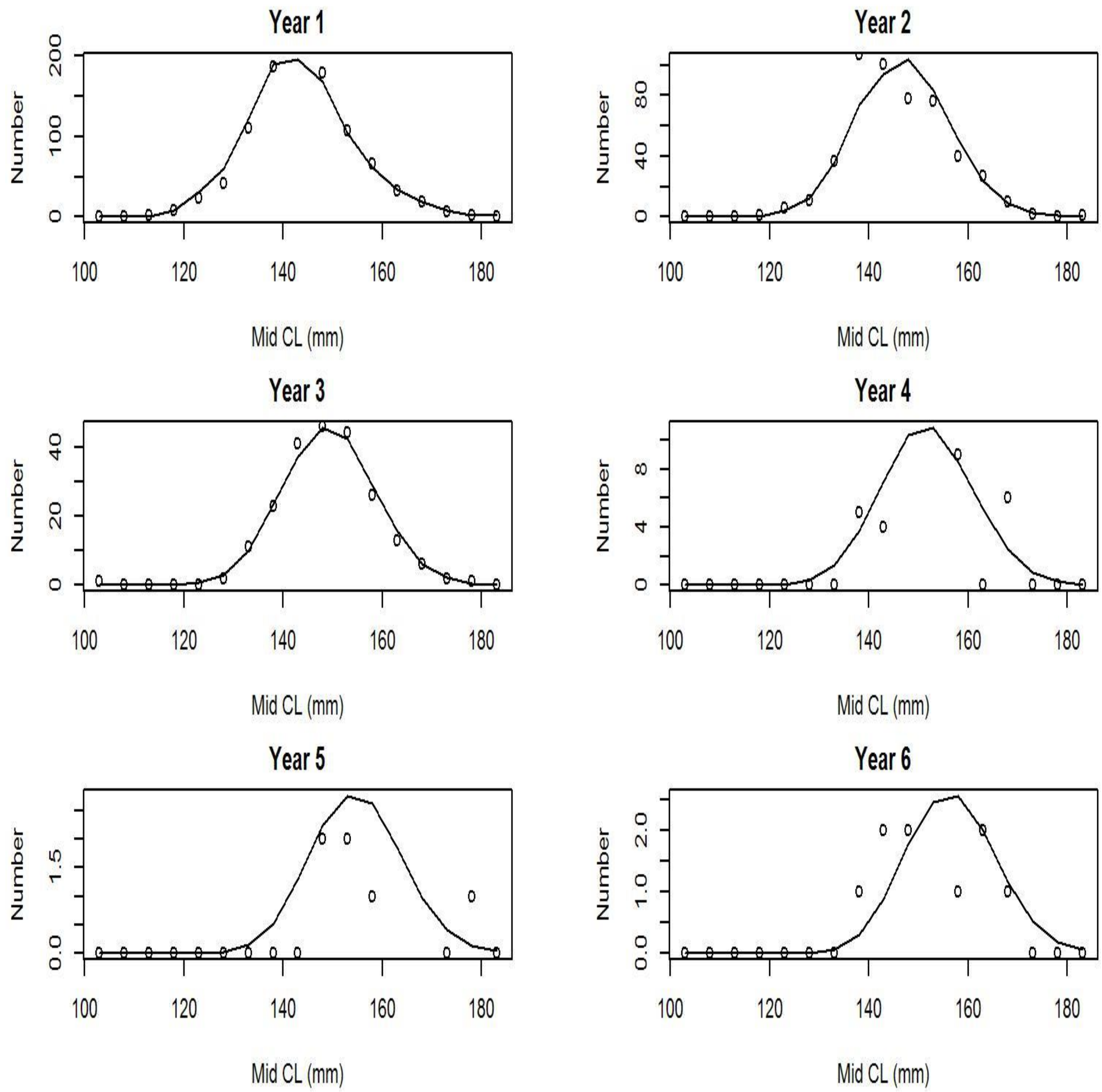


Figure 29. Observed (open circles) vs. predicted (solid line) tag recaptures by size bin for years 1 to 6 post tagging under model 21.1a fit to WAG golden king crab data.

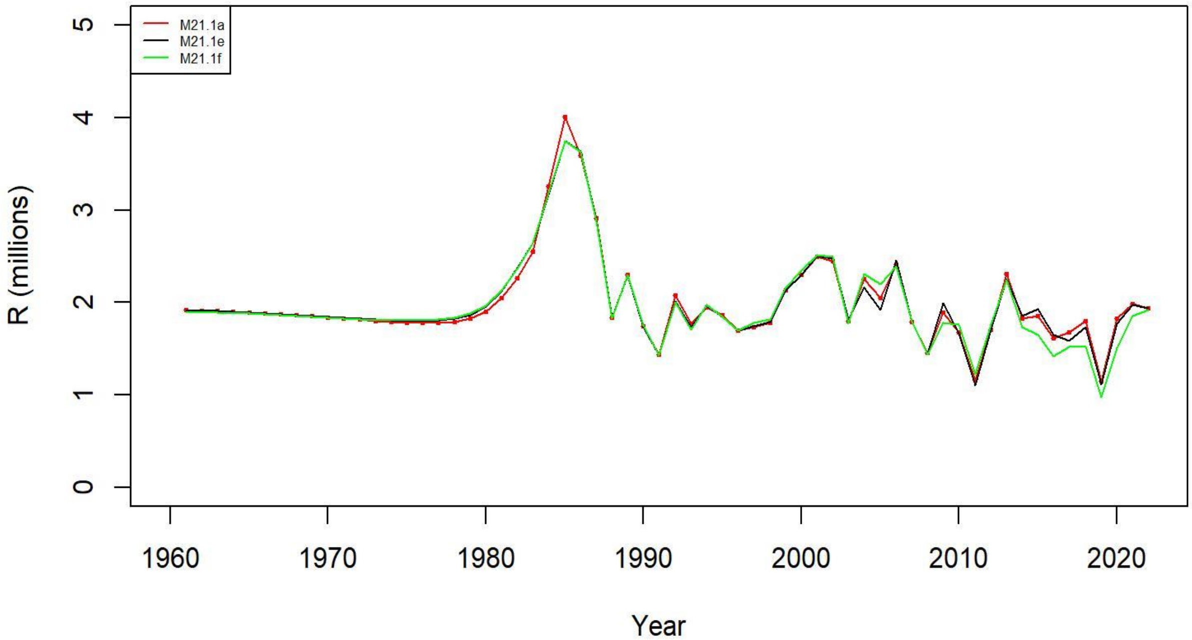


Figure 30. Estimated number of male recruits (crab size ≥ 101 mm CL) to the assessment model under models 21.1a (red), 21.1e (black), and 21.1f (green) fits to WAG golden king crab data, 1961–2022.

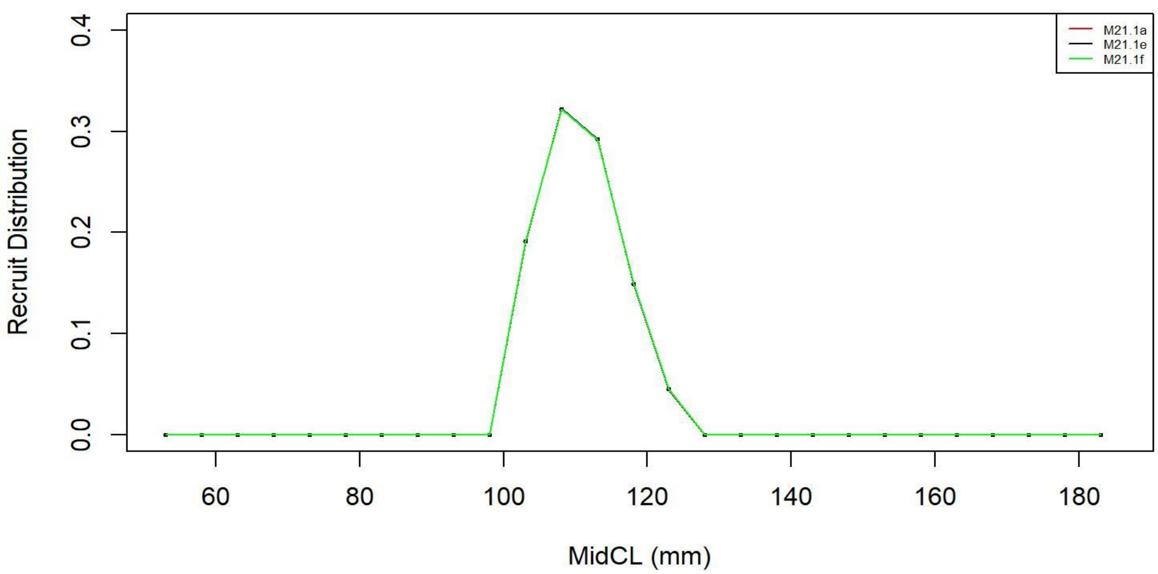


Figure 31. Recruit size distribution to the assessment model under models 21.1a (red), 21.1e (black), and 21.1f (green) fits to WAG golden king crab data.

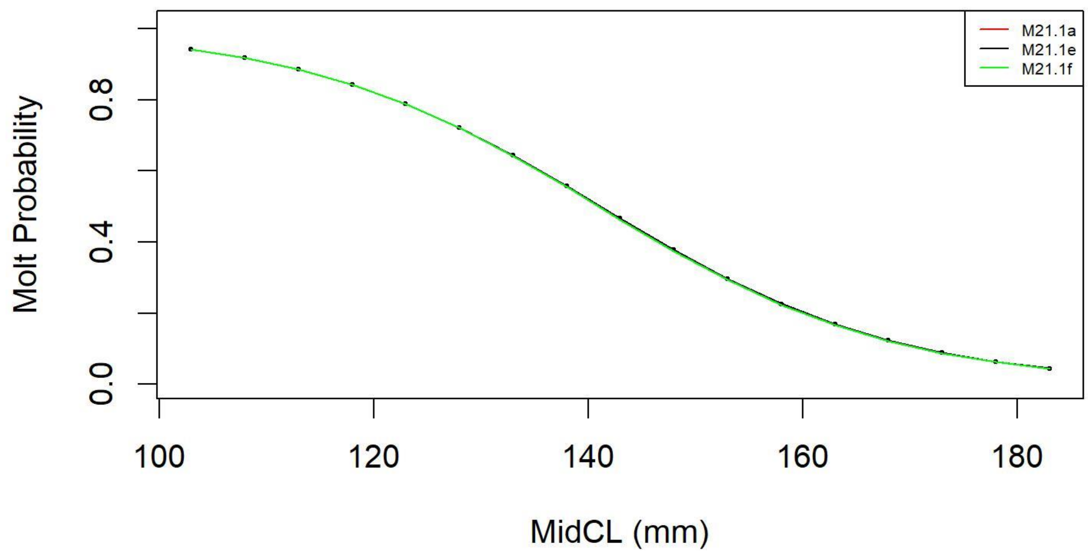


Figure 32. Estimated molt probability vs. carapace length of golden king crab for models 21.1a (red), 21.1e (black), and 21.1f (green) fits to WAG golden king crab data.

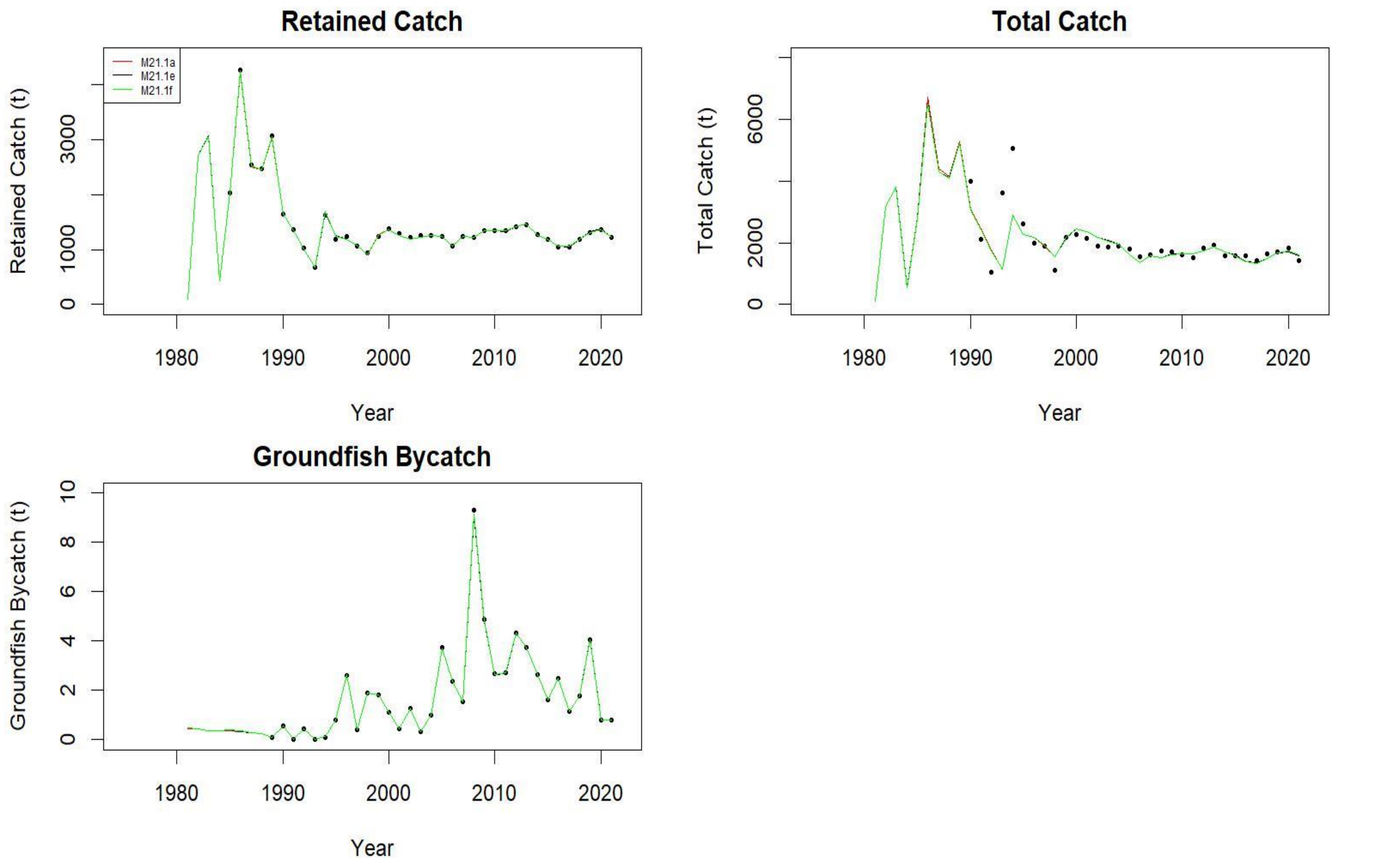


Figure 33. Observed (open circle) vs. predicted (solid line) retained catch (top left), total catch (top right), and groundfish bycatch (bottom left) of golden king crab for models 21.1a (red), 21.1e (black), and 21.1f (green) fits to WAG data, 1981/82–2021/22.

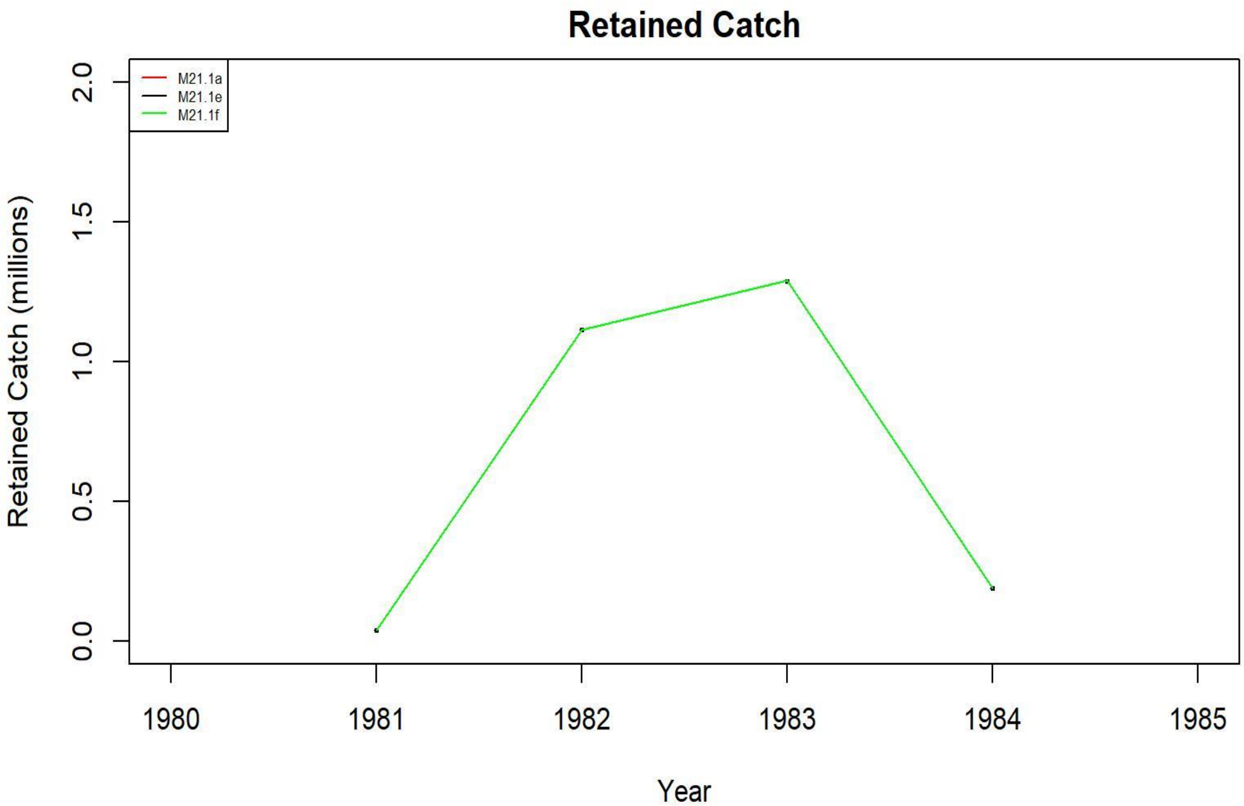


Figure 34. Observed (open circle) vs. predicted (solid line) retained catch of golden king crab for models 21.1a (red), 21.1e (black), and 21.1f (green) fits to WAG data, 1981/82–1984/85. Note: Input retained catches to the model during pre-1985 fishery period was in number of crabs.

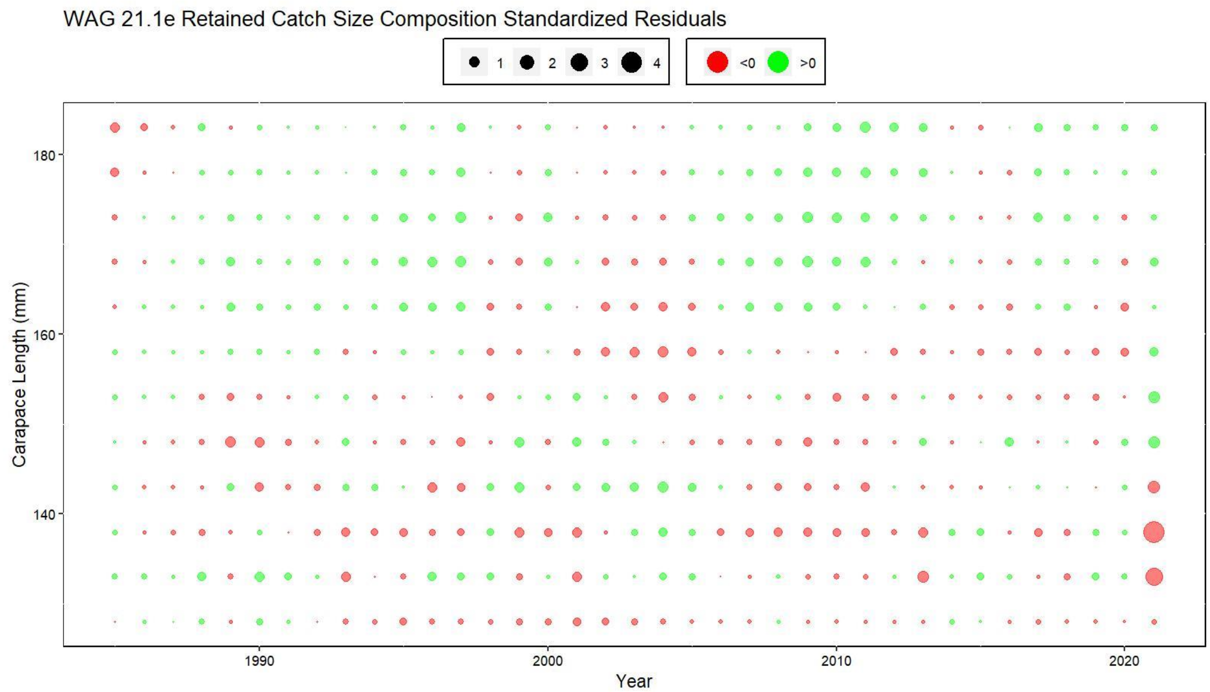


Figure 35. Bubble plot of standardized residuals of retained catch length composition for model 21.1e fit to WAG golden king crab data, 1985/86–2021/22. Green circles are the positive and pink circles are the negative standardized residuals. The area of the circle is the relative magnitude of the residual.

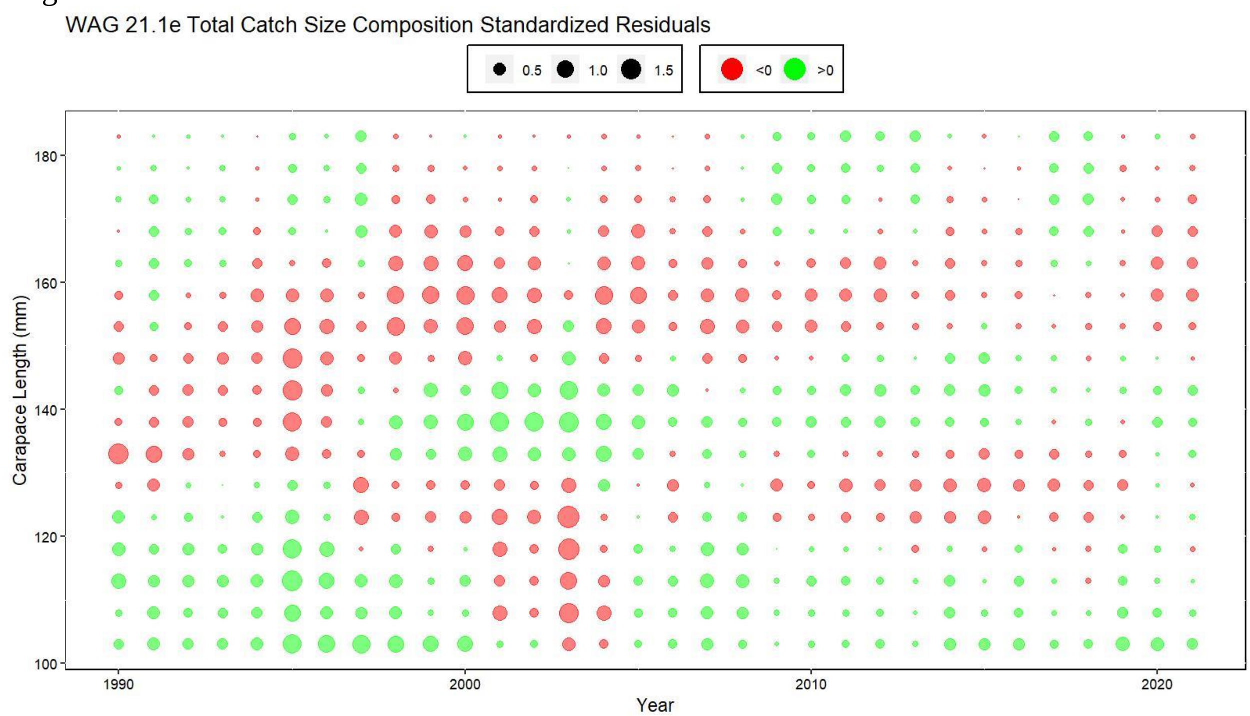


Figure 36. Bubble plot of standardized residuals of total catch length composition for model 21.1e fit to WAG golden king crab data, 1990/91–2021/22. Green circles are the positive and pink circles are the negative standardized residuals. The area of the circle is the relative magnitude of the residual.

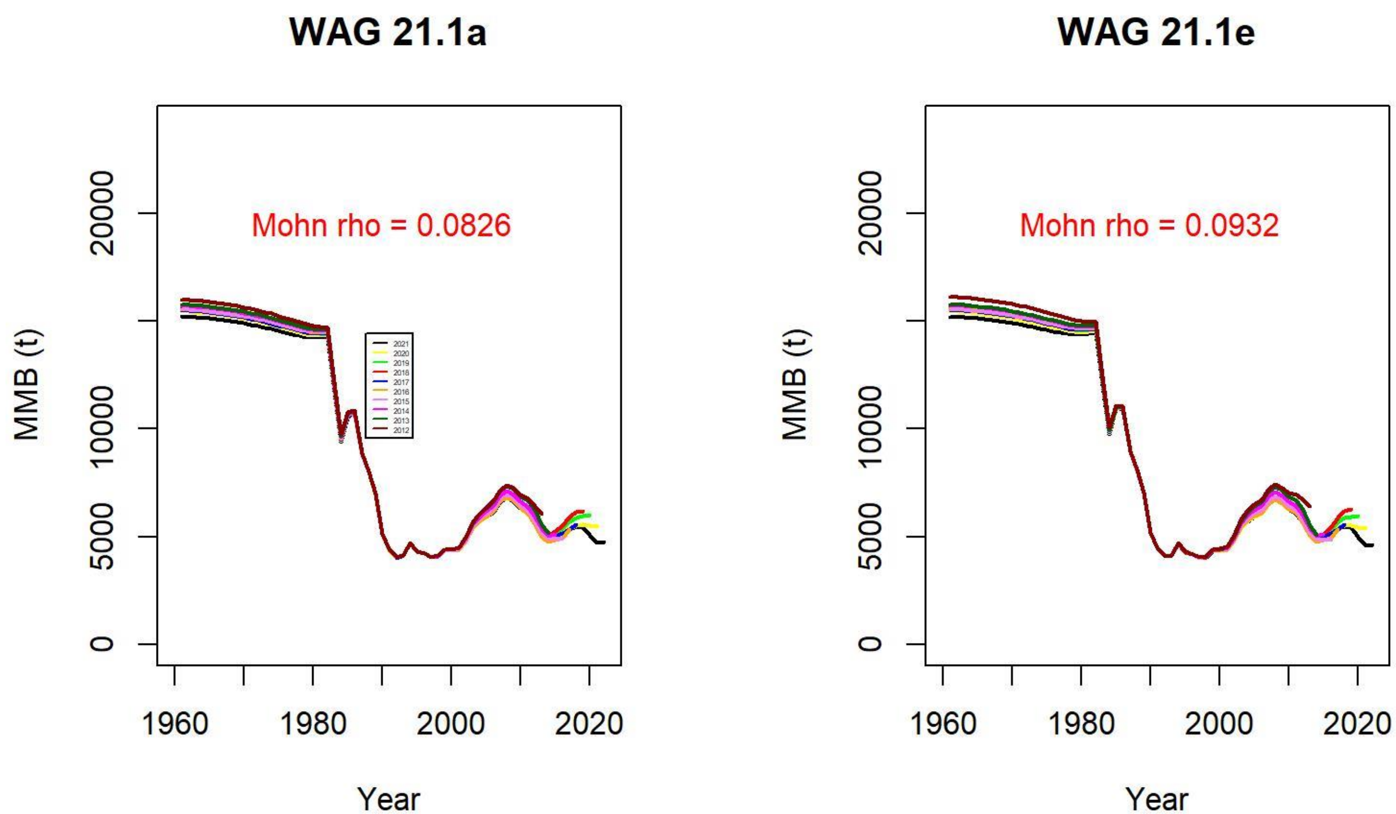


Figure 37. Retrospective fits of MMB by the model following removal of terminal year data under models 21.1a and 21.1e for golden king crab in the WAG, 1961–2022.

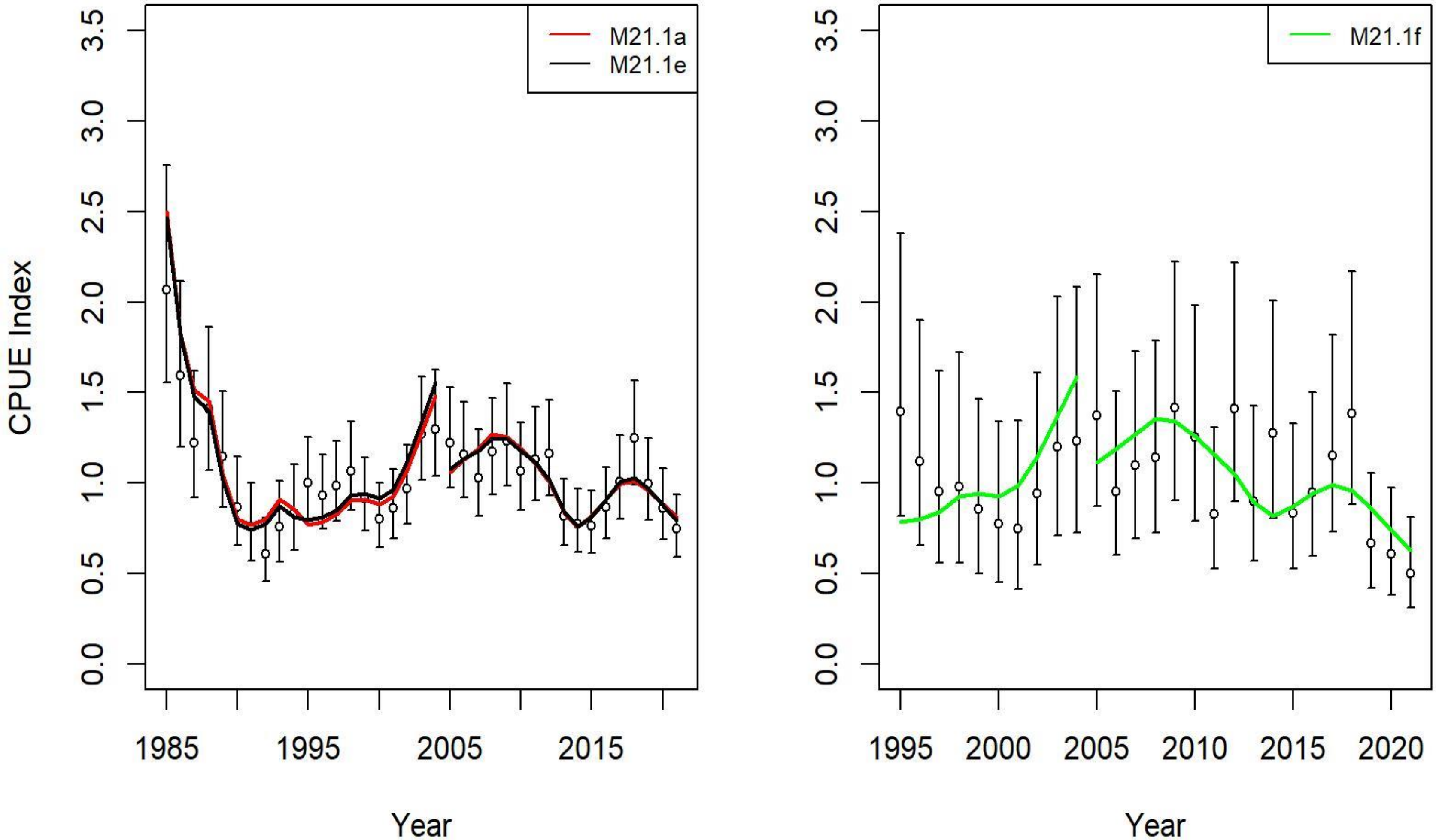


Figure 38. Comparison of input CPUE indices [open circles with +/- 2 SE for model 21.1a (left) and model 21.1f (right)] with predicted CPUE indices (colored solid lines) under 21.1a (red) and 21.1e (black)[left]; and 21.1f (green) [right] for WAG golden king crab data, 1985/86–2021/22. Model estimated additional standard error was added to each input standard error.

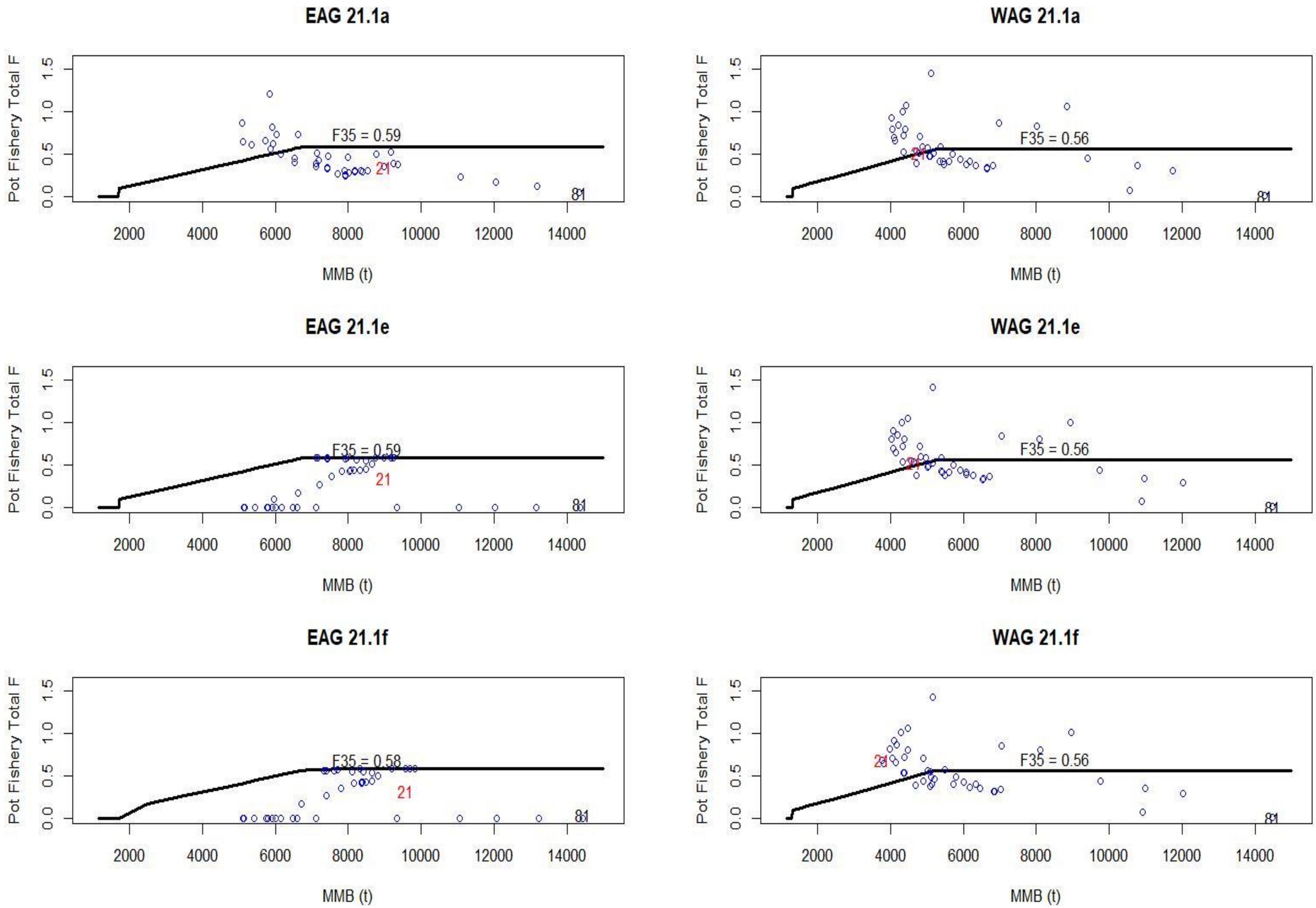


Figure 39. Relationships between full fishing mortalities for the directed pot fishery and mature male biomass during 1981/82–2021/22 under models, 21.1a, 21.1e, and 21.1f fits to EAG and WAG data. *F* in 2021/22 (red) and 1981/82 (black) are shown in the plots.

Appendix A: Integrated model

Aleutian Islands Golden King Crab (*Lithodes aequispinus*) Stock Assessment Model Development- east of 174° W (EAG) and west of 174° W (WAG) Aleutian Island stocks

Basic population dynamics

The annual [male] abundances by size are modeled using the equation:

$$N_{t+1,j} = \sum_{i=1}^{j}[N_{t,i}e^{-M} - (\hat{C}_{t,i} + \widehat{D}_{t,i} + \widehat{Tr}_{t,i})e^{(y_t-1)M}]X_{i,j} + R_{t+1,j} \quad \text{(A.1)}$$

where $N_{t,i}$ is the number of [male] crab in length class *i* on 1 July (start of fishing year) of year *t*; $\hat{C}_{t,i}$, $\widehat{D}_{t,i}$, and $\widehat{Tr}_{t,i}$ are respectively the predicted fishery retained, pot fishery discard dead, and groundfish fishery discard dead catches in length class *i* during year *t*; $\widehat{D}_{t,i}$ is estimated from the intermediate total $(\widehat{T}_{t,i\,temp})$ catch and the retained $(\hat{C}_{t,i})$ catch by Equation A.2c. $X_{i,j}$ is the probability of length-class *i* growing into length-class *j* during the year; y_t is elapsed time period from 1 July to the midpoint of fishing period in year *t*; *M* is instantaneous rate of natural mortality; and $R_{t+1,j}$ recruitment to length class *j* in year *t+1*.

The catches are predicted using the equations

$$\widehat{T}_{t,j,temp} = \frac{F_t s_{t,j}^T}{Z_{t,j}} N_{t,j}e^{-y_t M}(1 - e^{-Z_{t,j}}) \quad \text{(A.2a)}$$

$$\hat{C}_{t,j} = \frac{F_t s_{t,j}^T s_{t,j}^r}{Z_{t,j}} N_{t,j}e^{-y_t M}(1 - e^{-Z_{t,j}}) \quad \text{(A.2b)}$$

$$\widehat{D}_{t,j} = 0.2(\widehat{T}_{t,j,temp} - \hat{C}_{t,j}) \quad \text{(A.2c)}$$

$$\widehat{Tr}_{t,j} = 0.65\frac{F_t^{Tr} s_j^{Tr}}{Z_{t,j}} N_{t,j}e^{-y_t M}(1 - e^{-Z_{t,j}}) \quad \text{(A.2d)}$$

$$\widehat{T}_{t,j} = \hat{C}_{t,j} + \widehat{D}_{t,j} \quad \text{(A.2e)}$$

where $Z_{t,j}$ is total fishery-related mortality on animals in length-class *j* during year *t*:

$$Z_{t,j} = F_t s_{t,j}^T s_{t,j}^r + 0.2F_t s_{t,j}^T(1 - s_{t,j}^r) + 0.65\,F_t^{Tr} s_j^{Tr} \quad \text{(A.3)}$$

F_t is the full selection fishing mortality in the pot fishery, F_t^{Tr} is the full selection fishing mortality in the trawl fishery, $s_{t,j}^T$ is the total selectivity for animals in length-class *j* by the pot fishery during year *t*, s_j^{Tr} is the selectivity for animals in length-class *j* by the trawl fishery, $s_{t,j}^r$ is the probability of retention for animals in length-class *j* by the pot fishery during year *t*. Pot bycatch mortality of

0.2 and groundfish bycatch mortality of 0.65 (average of trawl [0.8] and groundfish pot [0.5] mortality) were assumed.

Initial abundance
The initial conditions are computed as the equilibrium initial condition using the following relations:

The equilibrium stock abundance is

$$N = X.S.N + R \quad \text{(A.4)}$$

The equilibrium abundance in 1960, N_{1960}, is

$$\underline{N}_{1960} = (I - XS)^{-1}\underline{R} \quad \text{(A.5)}$$

where X is the growth matrix, S is a matrix with diagonal elements given by e^{-M}, I is the identity matrix, and $\underline{R}$ is the product of average recruitment and relative proportion of total recruitment to each size-class.

We used the mean number of recruits from 1987 to 2012 in equation (A.5) to obtain the equilibrium solution under only natural mortality in year 1960, and then projected the equilibrium abundance under natural mortality with recruitment estimated for each year after 1960 up to 1985 with removal of retained catches during 1981/82–1984/85.

Growth Matrix
The growth matrix X is modeled as follows:

$$X_{i,j} = \begin{cases} 0 & if\ j < i \\ P_{i,j} + (1 - m_i) & if\ j = i \\ P_{i,j} & if\ j > i \end{cases} \quad \text{(A.6)}$$

where:

$$P_{i,j} = m_i \begin{cases} \int_{-\infty}^{j_2 - L_i} N(x\,|\mu_i, \sigma^2)\,dx & if\ \ j = i \\ \int_{j_1 - L_i}^{j_2 - L_i} N(x\,|\mu_i, \sigma^2)\,dx & if\ \ i < j < n\ , \\ \int_{j_1 - L_i}^{\infty} N(x\,|\mu_i, \sigma^2)\,dx & if\ \ \ i = n \end{cases}$$

$$N(x|\mu_i, \sigma^2) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-(\frac{x-\mu_i}{\sqrt{2}\sigma})^2}, and$$

μ_i is the mean growth increment for crab in size-class i:

$$\mu_i = \omega_1 + \omega_2 * \bar{L}_i. \quad \text{(A.7)}$$

ω_1, ω_2, and σ are estimable parameters, j_1 and j_2 are the lower and upper limits of the receiving length-class j (in mm CL), and $\bar{L}_i$ is the mid-point of the contributing length interval i. The quantity m_i is the molt probability for size-class i:

$$m_i = \frac{1}{1 + e^{c(\tau_i - d)}} \quad \text{(A.8)}$$

where τ_i is the mid-length of the *i*-th length-class, *c* and *d* are parameters.

Selectivity and retention

Selectivity and retention are both assumed to be logistic functions of length. Selectivity depends on the fishing period for the directed pot fishery:

$$S_i = \frac{1}{1+ e^{\left[-ln\,(19)\frac{\tau_i - \theta_{50}}{\theta_{95} - \theta_{50}}\right]}} \quad \text{(A.9)}$$

where θ_{95} and θ_{50} are the parameters of the selectivity/ retention pattern (Mark Maunder, unpublished generic crab model). In our program, we re-parameterized the denominator (θ_{95} - θ_{50}) to $log(delta\theta)$ so that the difference is always positive and transformed θ_{50} to $log\ (\theta_{50})$ to keep the estimate always positive.

Recruitment

Recruitment to length–class i during year *t* is modeled as $R_{t,i} = \bar{R}e^{\epsilon_t}\Omega_i$ where Ω_i is a normalized gamma function

$$gamma(x|\alpha_r, \beta_r) = \frac{x^{\alpha_r - 1} e^{\frac{x}{\beta_r}}}{{\beta_r}^{\alpha_r}\,\Gamma_{(\alpha_r)}} \quad \text{(A.10)}$$

with α_r and β_r (restricted to the first five length classes).

Parameter estimation

Table A1 lists the parameters of the model indicating which are estimated and which are pre-specified. The objective function includes contributions related to the fit of the model to the available data and penalties (priors on various parameters).

Tables A2 lists parameter values (with the corresponding coefficient of variations in parentheses) used to weight the components of the objective functions for EAG and WAG.

Likelihood components

Catches

The contribution of the catch data (retained, total, and groundfish discarded) to the objective function is given by:

$$LL_r^{catch} = \lambda_r \sum_t \{\ell n(\sum_j \hat{C}_{t,j} w_j + c) - \ell n(\sum_j C_{t,j} w_j + c)\}^2 \quad \text{(A.11a)}$$

$$LL_T^{catch} = \lambda_T \sum_t \{ln\,(\sum_j \hat{T}_{t,j} w_j + c) - ln\,(\sum_j T_{t,j} w_j + c)\}^2 \quad \text{(A.11b)}$$

$$LL_{GD}^{catch} = \lambda_{GD} \sum_t \{ln\,(\sum_j \widehat{Tr}_{t,j} w_j + c) - ln\,(\sum_j Tr_{t,j} w_j + c)\}^2 \quad \text{(A.11c)}$$

where λ_r, λ_T, and λ_{GD} are weights assigned to likelihood components for the retained, pot total, and groundfish discard catches; w_j is the average mass of a crab is length-class *j*; $C_{t,j}$, $T_{t,j}$, and $Tr_{t,j}$ are, respectively, the observed numbers of crab in size class *j* for retained, pot total, and groundfish fishery discarded crab during year *t*, and *c* is a small constant value. We assumed *c* = 0.001.

An additional retained catch likelihood (using Equation A.11a without *w*) for the retained catch in number of crabs during 1981/82–1984/85 was also considered in all scenarios.

Catch-rate indices

The catch-rate indices are assumed to be lognormally distributed about the model prediction. Account is taken of variation in addition to that related to sampling variation:

$$LL_r^{CPUE} = \lambda_{r,CPUE}\left\{0.5\sum_t ln\left[2\pi\left(\sigma_{r,t}^2 + \sigma_e^2\right)\right] + \sum_t \frac{\left(ln(CPUE_t^r+c) - ln\,(\widehat{CPUE}_t^r+c)\right)^2}{2\left(\sigma_{r,t}^2+\sigma_e^2\right)}\right\} \quad (A.12)$$

where $CPUE_t^r$ is the standardized retain catch-rate index for year *t*, $\sigma_{r,t}$ is standard error of the logarithm of $CPUE_t^r$,and $\widehat{CPUE}_t^r$ is the model-estimate of $CPUE_t^r$:

$$\widehat{CPUE}_t^r = q_k \sum_j S_j^T\, S_j^r\, \left(N_{t,j} - 0.5\left[\widehat{C_{t,J}} + \widehat{D_{t,J}} + \widehat{Tr_{t,J}}\,\right]\right)e^{-y_t M} \quad (A.13)$$

in which q_k is the catchability coefficient during the *k*-th period (e.g., pre-, and post-rationalization time periods), σ_e is the extent of over-dispersion, *c* is a small constant to prevent zero values (we assumed *c* = 0.001), and $\lambda_{r,CPUE}$ is the weight assigned to the catch-rate data. We used the same likelihood formula (A.12) for fish ticket and cooperative survey retained catch rate indices. However, for cooperative survey catch rate prediction we used a different catchability parameter.

Following Burnham *et al.* (1987), we computed the ln (CPUE) variance by:

$$\sigma_{r,t}^2 = ln\,(1 + CV_{r,t}^2) \quad (A.14)$$

Length-composition data

The length-composition data are included in the likelihood function using the robust normal for proportions likelihood, i.e., generically:

$$LL_r^{LF} = 0.5\sum_t\sum_j \ell n(2\pi\sigma_{t,j}^2) - \sum_t\sum_j \ell n\left[\exp\left(-\frac{(P_{t,j}-\hat{P}_{t,j})^2}{2\sigma_{t,j}^2}\right) + 0.01\right] \quad (A.15)$$

where $P_{t,j}$ is the observed proportion of crabs in length-class j in the catch during year t, $\hat{P}_{t,j}$is the model-estimate corresponding to $P_{t,j}$, i.e.:

$$\hat{L}_{t,j}^{r} = \frac{\hat{C}_{t,j}}{\sum_j^n \hat{C}_{t,j}}$$

$$\hat{L}_{t,j}^{T} = \frac{\hat{T}_{t,j}}{\sum_j^n \hat{T}_{t,j}}$$

$$\hat{L}_{t,j}^{GF} = \frac{\widehat{Tr}_{t,j}}{\sum_j^n \widehat{Tr}_{t,j}} \quad (A.16)$$

$\sigma^2_{t,j}$ is the variance of $P_{t,j}$:

$$\sigma^2_{t,j} = \left[(1-P_{t,j})P_{t,j} + \frac{0.1}{n} \right] / S_t \qquad \text{(A.17)}$$

and S_t is the effective sample size for year *t* and *n* is the number of size classes.

Tagging data

Let $V_{j,t,y}$ be the number of tagged male crab that were released during year *t* that were in size-class *j* when they were released and were recaptured after *y* years, and $\rho_{j,t,y}$ be the vector of recaptures by size-class from the males that were released in year *t* that were in size-class *j* when they were released and were recaptured after *y* years. The log-likelihood corresponding to the multinomial distribution for the tagging data is then:

$$lnL = \lambda_{y,tag} \sum_j \sum_t \sum_y \sum_i \rho_{j,t,y,i} ln\hat{\rho}_{j,t,y,i} \qquad \text{(A18)}$$

where $\lambda_{y,tag}$ is the weight assigned to the tagging data for recapture year *y*, $\hat{\rho}_{j,t,y,i}$ is the proportion in size-class *i* of the recaptures of males that were released during year *t* that were in size-class *j* when they were released and were recaptured after *y* years:

$$\underline{\hat{\rho}}_{j,t,y} \propto \underline{s}^T [\mathbf{X}]^y \underline{Z}^{(j)} \qquad \text{(A19)}$$

where $Z^{(j)}$ is a vector with $V_{j,t,y}$ at element *j* and 0 otherwise, and S^T is the vector of total selectivity for tagged male crab by the pot fishery. This log-likelihood function is predicated on the assumption that all recaptures are in the pot fishery and the reporting rate is independent of the size of crab.

Penalties

Penalties are imposed on the deviations of annual pot fishing mortality about mean pot fishing mortality, annual trawl fishing mortality about mean trawl fishing mortality, recruitment about mean recruitment, and the posfunction (fpen):

$$P_1 = \lambda_F \sum_t (\ell n F_t - \ell n \bar{F})^2 \qquad \text{(A.20)}$$

$$P_2 = \lambda_{F^{Tr}} \sum_t (\ell n F_t^{Tr} - \ell n \bar{F}^{Tr})^2 \qquad \text{(A.21)}$$

$$P_3 = \lambda_R \sum_t (\ell n \varepsilon_t)^2 \qquad \text{(A.22)}$$

$$P_5 = \lambda_{posfn} * fpen \qquad \text{(A.23)}$$

Standardized Residual of Length Composition

$$Std.Res_{t,j} = \frac{P_{t,j} - \widehat{P_{t,j}}}{\sqrt{2\sigma^2_{t,j}}} \qquad \text{(A.24)}$$

Output Quantities

Harvest rate

Total pot fishery harvest rate:

$$E_t = \frac{\sum_{j=1}^{n}(\hat{C}_{j,t} + \hat{D}_{j,t})}{\sum_{j=1}^{n} N_{j,t}} \tag{A.25}$$

Exploited legal male biomass at the start of year t:

$$LMB_t = \sum_{j=legal\ size}^{n} s_j^T s_j^r N_{j,t}\ w_j \tag{A.26}$$

where w_j is the weight of an animal in length-class j.

Mature male biomass on 15 February spawning time (NPFMC 2007a, b) in the following year:

$$MMB_t = \sum_{j=mature\ size}^{n}\{N_{j,t}e^{-y'M} - (\hat{C}_{j,t} + \hat{D}_{j,t} + \widehat{Tr}_{j,t})e^{(y_t - y')M}\}w_j \tag{A.27}$$

where y' is the elapsed time from 1 July to 15 February in the following year.

For estimating the next year limit harvest levels from current year stock abundances, an F_{OFL} value is needed. The current crab management plan specifies five different Tier formulas for different stocks depending on the strength of information available for a stock, for computing F_{OFL} (NPFMC 2007a, b). For the golden king crab, the following Tier 3 formula is applied to compute F_{OFL}:

If,
$MMB_{current} > MMB_{35\%}, F_{OFL} = F_{35\%}$

If,
$MMB_{current} \leq MMB_{35\%}\ and\ MMB_{current} > \beta MMB_{35\%}$,

$$F_{OFL} = F_{35\%}\frac{\left(\frac{MMB_{current}}{MMB_{35\%}} - \alpha\right)}{(1-\alpha)} \tag{A.28}$$

If,
$MMB_{current} \leq \beta MMB_{35\%}$,

$F_{OFL} = 0.$

where
β = a parameter with a restriction that $0 \leq \beta < 1$. A default value of 0.25 is used,
α = a parameter with a restriction that $0 \leq \alpha \leq \beta$. A default value of 0.1 is used,

$MMB_{current}$ = the mature male biomass in the current year, and
$MMB_{35\%}$ = a proxy MMB_{MSY} for Tier 3 stocks.

Because projected MMB_t (i.e., $MMB_{current}$) depends on the intervening retained and discard catch (i.e., MMB_t is estimated after the fishery), an iterative procedure is applied using Equations A.27 and A.28 with retained and discard catch predicted from Equations A.2b-d. The next year limit harvest catch is estimated using Equations A.2b-d with the estimated F_{OFL} value.

Table A1. Pre-specified and estimated parameters of the population dynamics model

Parameter	Number of parameters
Fishing mortalities:	
Pot fishery, F_t	1981–2021 (estimated)
Mean pot fishery fishing mortality, $\bar{F}$	1 (estimated)
Groundfish fishery, F_t^{Tr}	1989–2021 (the mean F for 1989 to 1994 was used to estimate groundfish discards back to 1981 (estimated)
Mean groundfish fishery fishing mortality, $\bar{F}^{Tr}$	1 (estimated)
Selectivity and retention:	
Pot fishery total selectivity, θ_{50}^{T}	2 (1981–2004; 2005+) (estimated)
Pot fishery total selectivity difference, deltaθ^{T}	2 (1981–2004; 2005+) (estimated)
Pot fishery retention, θ_{50}^{r}	1 (1981+) (estimated)
Pot fishery retention selectivity difference, deltaθ^{r}	1 (1981+) (estimated)
Groundfish fishery selectivity	fixed at 1 for all size-classes
Growth:	
Expected growth increment, ω_1, ω_2	2 (estimated)
Variability in growth increment, σ	1 (estimated)
Molt probability (size transition matrix with tag data), a	1 (estimated)
Molt probability (size transition matrix with tag data), b	1 (estimated)
Natural mortality, *M*	1 (pre-specified, 0.21yr^{-1})
Recruitment:	
Number of recruiting length-classes	5 (pre-specified)
Mean recruit length	1 (pre-specified, 110 mm CL)
Distribution to length-class, β_r	1 (estimated)
Median recruitment, $\bar{R}$	1 (estimated)
Recruitment deviations, ε_t	62 (1961–2022) (estimated)
Fishery catchability, q	2 (1985–2004; 2005+) (estimated)
Additional CPUE indices standard deviation, σ_e	1 (estimated)
Likelihood weights (coefficient of variation)	Pre-specified, varies by scenario

Table A2. Specifications for the weights with corresponding coefficient of variations* in parentheses for each model for EAG and WAG.

Weight	Models 21.1a, 21.1e, 21.1f, 21.1e2, and 21.1f2
Catch:	
Retained catch for 1981–1984 and/or 1985–2021, λ_r	500 (0.0316)
Total catch for 1990–2021, λ_T	Number of sampled pots scaled to a max 250
Groundfish bycatch for 1989 –2021, λ_{GD}	0.5 (1.3108)
Catch-rate:	
Observer legal size crab catch-rate for 1995–2021, $\lambda_{r,CPUE}$	1 (0.8054)
Fish ticket retained crab catch-rate for 1985–1998, $\lambda_{r,CPUE}$	1 (0.8054)
Penalty weights:	
Pot fishing mortality dev, λ_F	Initially 1000, relaxed to 0.001 at phases ≥ select. phase
Groundfish fishing mortality dev, $\lambda_{F^{Tr}}$	Initially 1000, relaxed to 0.001 at phases ≥ select. phase
Recruitment, λ_R	2 (0.5329)
Posfunction (to keep abundance estimates always positive), λ_{posfn}	1000 (0.0224)
Tagging likelihood	EAG individual tag returns

$*$ Coefficient of Variation, $\mathrm{CV} = \sqrt{\exp\left[\frac{1}{2\mathrm{W}}\right] - 1}$, w =weight

Appendix B: *Catch and CPUE data*

The commercial catch and length frequency distribution were estimated from ADF&G landing records and dockside sampling (Bowers *et al.* 2008, 2011). The annual retained catch, total catch, and groundfish (or trawl) discarded mortality are provided in Tables 1, 2, and 2b for EAG and WAG. The weighted length frequency data were used to distribute the catch into 5-mm size intervals. The length frequency data for a year were weighted by each sampled vessel's catch as follows. The *i*-th length-class frequency was estimated as:

$$\sum_{j=1}^{k} C_j \frac{LF_{j,i}}{\sum_{i=1}^{n} LF_{j,i}} \qquad \text{(B.1)}$$

where k = number of sampled vessels in a year, $LF_{j,i}$ = number of crabs in the i-th length-class in the sample from j-th vessel, n = number of size classes, C_j = number of crabs caught by j-th vessel. Then the relative frequency for the year was calculated and applied to the annual retained catch (in number of crabs) to obtain retained catch by length-class.

The annual total catch (in number of crabs) was estimated by the observer nominal (unstandardized) total CPUE considering all vessels multiplied by the total fishing effort (number of pot lifts). The weighted length frequency of the observer samples across the fleet was estimated using Equation B.1. Observer measurement of crab ranged from 20 to 220 mm CL. The proportion of observer total relative length frequency corresponding to this size range was multiplied by the total catch (number of crab) to get the crab number by size. Thus, the season total catch was distributed into length-classes using the weighted relative length frequency of B.1. To restrict the number of crab to model assumed size range (101–185+ mm CL), crab sizes < 101 mm CL were pooled into 101 length class and all crab >185 mm CL were pooled into a 185+ length class. Note that the total crab catches by size that went into the model did not consider retained and discard components separately. However, once the model estimated the annual total catch, then retained catch was deducted from this total and multiplied by handling mortality [we used a 20% handling mortality (Siddeek *et al.* 2005) to obtain the directed fishery discarded (dead) catch].

Observer data have been collected since 1988 (Moore *et al.* 2000; Barnard *et al.* 2001; Barnard and Burt 2004; Gaeuman 2011), but data were not comprehensive in the initial years, so a shorter time series of data for the period 1990/91–2021/22 was selected for this analysis. During 1990/91–1994/95, observers were only deployed on catcher-processor vessels. During 1995/96–2004/05, observers were deployed on all fishing vessels during fishing activity. Observers have been deployed on all fishing vessels since 2005/06, but catcher-only vessels are only required to carry observers for a minimum of 50% of their fishing activity during a season; catcher-processor vessels are still required to carry observers during all fishing activity. Onboard observers sample seven pots per day (may be different numbers of pots per string) and count and measure all crabs caught and categorize catch as females, sublegal males, retained legal males, and non-retained legal males in a sampled pot. Prior to the 2009/10 season, depending on season, area, and type of fishing vessel, observers were also instructed to sample additional pots in which all crab were only counted and categorized as females, sublegal males, retained legal males, and non-retained legal males, but were not measured. Annual mean nominal CPUEs of retained and total crabs were estimated considering all sampled pots within each season (Table 3). The observer CPUE data collection improved over the years and the data since 1995/96 are more reliable. Thus, for model fitting, the observer CPUE time series was restricted to 1995/96–2021/22. The 1990/91–2021/22 observer database consists of 119,640 records and that of 1995/96–2021/22 contains 115,361 records, For CPUE standardization, these data were further reduced by 5% cutoff of Soak time and 1% cutoff of Depth on both ends of the variable range to remove unreliable data or data from dysfunctional pot operations and restricting to vessels which have made five trips per year for at least three years during 1985/86 –2021/22.

Length-specific CPUE data collected by observers provides information on a wider size range of the stock than did the commercial catch length frequency data obtained from mostly legal-sized landed males.

There were significant changes in fishing practice due to changes in management regulations (e.g., since 1996/97 constant TAC and since 2005/06 crab rationalization), pot configuration (escape web on the pot door increased to 9” since 1999), and improved observer recording in Aleutian Islands golden king crab fisheries since 1998. These changes prompted us to consider two separate observer CPUE time series, 1995/96–2004/05 and 2005/06–2021/22, to estimate CPUE indices for model input.

To include a long time series of CPUE indices for stock abundance contrast, we also considered the 1985/86–1998/99 legal size standardized CPUE as a separate likelihood component in all scenarios. Because of the lack of soak time data before 1990, we estimated the CPUE index considering a limited set of explanatory variables (e.g., vessel, captain, area, month) and fitting the negative binomial GLM model to fish ticket data (Tables 4 and 13).

When using CPUE indices in the model fit, we compared the predicted with the observed legal male CPUE in the observer CPUE likelihoods because legal male (retained plus non-retained) data are more reliable than total in the observer samples.

The CPUE standardization followed the GLM fitting procedure (Maunder and Punt 2004; Starr 2012; Siddeek *et al*. 2018). Following a suggestion from the CIE reviewers in June 2018 we reduced the number of gear codes in the database after consulting with the fishing industry (Rip Carlton, Chad Hoefer, and Scott Goodman, personal communication December 2018; Table B1). Following an SSC suggestion in October 2018, we used a hybrid procedure: First, we selected a scope of variables set by Akike Information Criterion, AIC (Burnham and Anderson 2002). A decrease of more than 2 units in the AIC was used to identify the variable to be included successively (stepAIC program, R Core Team 2021). Then, the model parsimony was improved further by successively removing the term that explained the least proportion of deviance ($R^2 < 0.01$) (stepCPUE R function was used, Siddeek *et al*. 2018). Feenstra, *et al*. (2019) used a similar hybrid approach.

Table B.1. Updated gear codes for observer data analysis. Only gear code # 5, 6, 7, 8, and 13 were considered following crab industry suggestion. Note: Identical codes were given to those gear codes with similar catchability/selectivity. X indicates gear codes that were ignored.

Original Gear code	Pot gear description	Mark X against the code that can be ignored	Number encountered by observers during 1990–2016	Updated gear code
1	Dungeness crab pot, small & round	X	2	X
2	Pyramid pot, tunnel openings usually on sides, stackable	X	2121	X
3	Conical pot, opening at top of cone, stackable	X	2000	X
4	4' X 4' rectangular pot		60	X
5	5' X 5' rectangular pot		18032	5
6	6' X 6' rectangular pot		17508	6
7	7' X 7' rectangular pot		23806	7
8	8' X 8' rectangular pot		1936	8
9	5 1/2' X 5 1/2' rectangular pot		6934	5
10	6 1/2' X 6 1/2' rectangular pot		22085	6
11	7 1/2' X 7 1/2' rectangular pot		387	7
12	Round king crab pot, enlarged version of Dungeness crab pot		8259	X
13	10' X 10' rectangular pot		466	13
14	9' X 9' rectangular pot	X	1	X
15	8 1/2' X 8 1/2' rectangular pot	X	1	X
16	9 1/2' X 9 1/2' rectangular pot	X	Not used	X
17	8' X 9' rectangular pot	X	1	X
18	8' X 10' rectangular pot	X	1	X
19	9' X 10' rectangular pot		Not used	X
20	7' X 8' rectangular pot	X	252	X
21	Hair crab pot, longlined and small, stackable		Not used	X
22	snail pot	X	1	X
23	Dome-shaped pot, tunnel opening on top, often longlined in deep-water fisheries	X	6756	X
24	ADF&G shellfish research 7’ X 7’ X34” rectangular pot with 2.75” stretch mesh and no escapement rings or mesh		Research pot	X
80	Historical: Cod pot, any shape pot targeting cod, usually with tunnel fingers	X	711	X
81	Historical: Rectangular pot, unknown size, with escape rings	X	1123	X

All scenarios used CPUE indices estimated by the hybrid GLM method. Following a January 2019 CPT request, we considered a Year:Area interaction factor as a special case for a CPUE standardization scenario.

Thus we estimated two sets of observer CPUE indices for model input, 21.1a (reduced number of gear codes), and 21.1f (reduced number of gear codes and Year:Area interaction).

Observer CPUE index by GLM

a. Non-interaction GLM model

The CPUE standardization followed the GLM fitting procedure (Maunder and Punt 2004; Starr 2012; Siddeek *et al*. 2016b). We considered the negative binomial GLM on positive and zero catches to select the explanatory variables. The response variable CPUE is the observer sample catch record for a pot haul. The negative binomial model uses the log link function for the GLM fit.

For the non-interaction model, we assumed the null model to be:

$$\ln(\mathrm{CPUE_i}) = \mathrm{Year_{y_i}} \qquad (B.2)$$

where Year is a factorial variable.
The maximum set of model terms offered to the stepwise selection procedure was:

$$\ln\,(\mathrm{CPUE_I}) = \mathrm{Year_{y_i}} + \mathrm{ns(Soak_{si}, df)} + \mathrm{Month_{m_i}} + \mathrm{Vessel_{vi}} + \mathrm{Captain_{ci}} + \mathrm{Area_{ai}} + \mathrm{Gear_{gi}} + \mathrm{ns(Depth_{di}, df)}, \qquad (B.3)$$

where Soak is in unit of days and is numeric; Month, Area (Block) code, Vessel code, Captain code, and Gear code are factorial variables; Depth in fathom is a numeric variable; ns=cubic spline, and df = degree of freedom.

We used a log link function and a dispersion parameter (θ) in the GLM fitting process. We used the R^2 criterion for predictor variable selection (Siddeek *et al*. 2016b).

We calculated appropriate degrees of freedom and dispersion parameters by calculating AICs for a range of values and locating the best values at the minimum AIC (see Siddeek et al, 2021 SAFE report). We further reduced the spline number of degrees of freedom based on significant model fits.

Instead of using the traditional AIC (-2log_likelihood+2p) we used the Consistent Akaike Information Criteria (CAIC) (Bozdogan 1987) {-2log_likelihood+[ln(n)+1] *p} for variable selection by StepAIC, where n=number of observations and p= number of parameters to be estimated. The number of selected variables were further reduced for parsimony, if feasible, by the R^2 criterion using the StepCPUE function. i.e., a hybrid selection procedure (Feenstra *et al*. 2019).

The final main effect models for EAG were:

Initial selection by stepAIC:
$\ln(\text{CPUE}) = \text{Year} + \text{Gear} + \text{Captain} + \text{ns}(\text{Soak}, 4) + Month + Block$
AIC=203,808

Final selection by stepCPUE:
$\ln(\text{CPUE}) = \text{Year} + \text{Captain} + \text{Gear} + \text{ns}(\text{Soak}, 4) + Month$ (B.4)
for the 1995/96–2004/05 period [θ=1.38, $R^2 = 0.1693$]

Initial selection by stepAIC:
$\ln(\text{CPUE}) = \text{Year} + \text{ns}(\text{Soak}, 3) + Gear + Captain + Month$
AIC=77,173

Final selection by stepCPUE:
$\ln(\text{CPUE}) = \text{Year} + \text{Captain} + \text{Gear} + \text{ns}(\text{Soak}, 3)$ (B.5)
for the 2005/06–2021/22 period [$\theta = 2.32$, $R^2 = 0.1099$].

The final models for WAG were:

Initial selection by stepAIC:
$\ln(\text{CPUE}) = \text{Year} + \text{Captain} + \text{ns}(\text{Soak}, 8) + \text{Gear} + Area + Month + Vessel$

AIC=190,953

Final selection by stepCPUE:
$\ln(\text{CPUE}) = \text{Year} + \text{Captain} + \text{ns}(\text{Soak}, 8)$ (B.6)
for the 1995/96–2004/05 period [θ=0.97, $R^2 = 0.1427$]

Initial selection by stepAIC:
$\ln(\text{CPUE}) = \text{Year} + \text{Captain} + \text{Gear} + \text{Month} + \text{ns}(\text{Soak}, 2)$
AIC=116,552

Final selection by stepCPUE
$\ln(\text{CPUE}) = \text{Year} + \text{Captain} + \text{Gear} + \text{ns}(\text{Soak}, 2)$ (B.7)
for the 2005/06–2021/22 period [$\theta = 1.12$, $R^2 = 0.0539$, Soak forced in].

b. Year:Area interaction GLM:

For year and area interaction analysis, we divided the areas into 1 nmi x 1 nmi grids enmeshed in 10 larger blocks as follows. The number of blocks was restricted to a few to prevent GLM fitting problems (Figure B.1 and Table B.2).

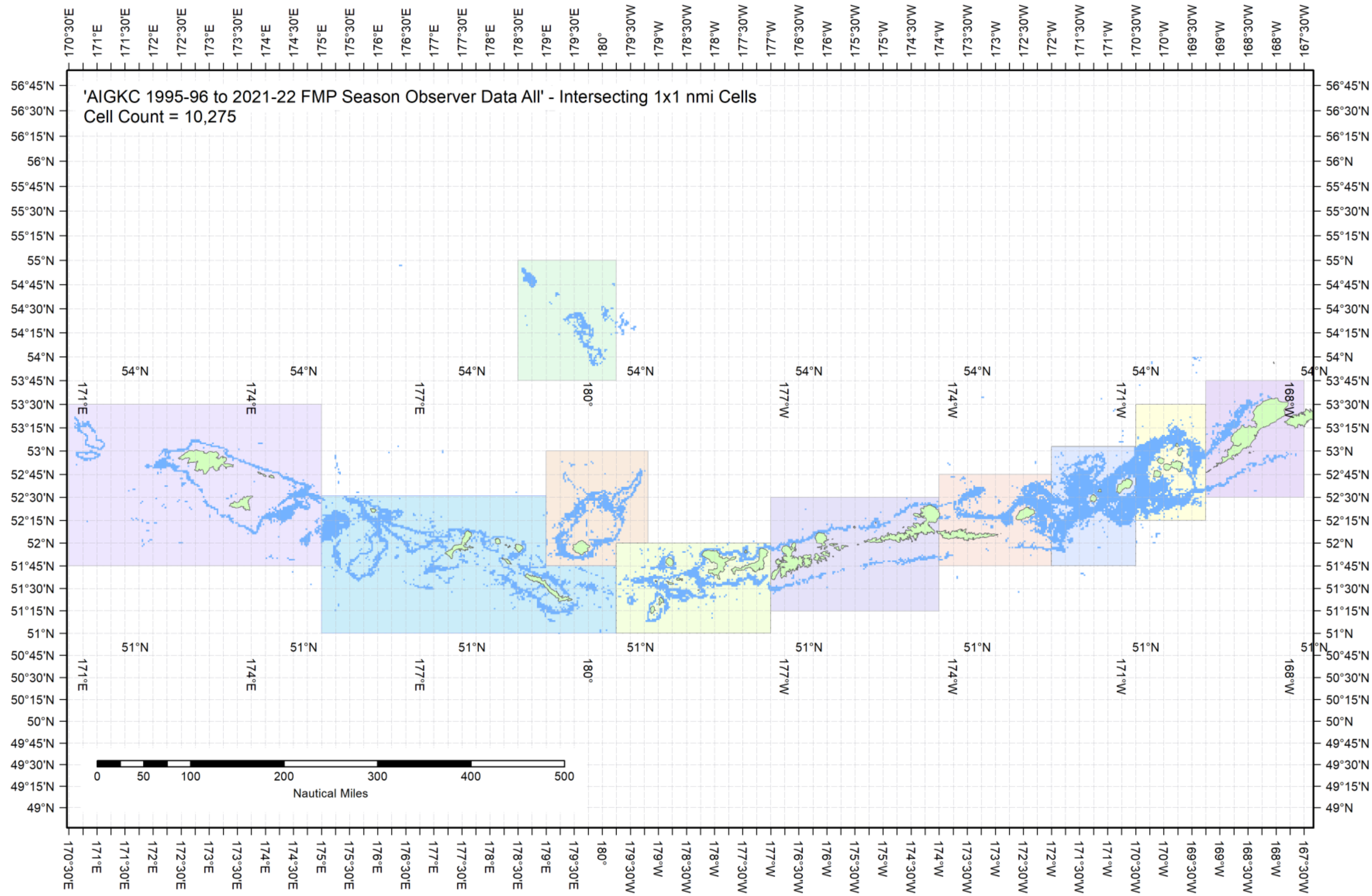


Figure B.1. The 1995/96–2021/22 observer pot samples enmeshed in 10 blocks for the Aleutian Islands golden king crab.

The blocks were determined from visually exploring each year's pot distribution locations (available with the first author). The blocks contain observed patches of crab distribution during this period.

Table B.2. Number of 1 nmi x 1 nmi grids containing observer sample locations within each block by fishing year for the Aleutian Islands golden king crab, 1995/96–2021/22 data. Blocks 1–4 belong to EAG and 5–10 to WAG. Sum of ever fished number of grids for each block is listed at the bottom row.

FMP Season	Block_1	Block_2	Block_3	Block_4	Block_5	Block_6	Block_7	Block_8	Block_9	Block_10
1995	125	529	748	379	218	373	112	722	166	122
1996	149	814	761	372	89	473	359	799	200	35
1997	116	530	755	257	202	443	104	568	274	0
1998	78	581	453	236	18	318	157	251	132	0
1999	123	593	454	231	163	476	182	627	193	145
2000	72	540	754	301	187	440	195	555	547	47
2001	123	507	507	329	45	369	288	634	256	9
2002	97	387	584	271	71	341	205	335	242	37
2003	43	492	530	299	111	347	212	465	150	61
2004	81	289	377	216	77	319	150	359	172	116
2005	0	205	221	118	8	220	83	261	54	0
2006	0	154	248	122	15	191	58	220	39	0
2007	0	111	177	110	24	228	78	173	20	0
2008	0	111	203	93	12	181	67	196	0	0
2009	0	59	146	60	6	137	95	220	25	0
2010	0	81	141	85	1	115	73	260	39	0
2011	0	126	117	33	3	83	73	266	9	0
2012	0	146	110	56	7	91	85	312	53	0
2013	2	149	129	51	12	144	105	293	86	0
2014	1	138	96	41	39	120	114	319	37	0
2015	0	135	147	61	46	163	106	280	16	48
2016	0	145	231	63	26	134	89	210	106	0
2017	0	97	170	110	11	87	79	198	118	0

2018	0	91	158	95	7	69	82	204	121	0
2019	1	112	171	101	0	0	89	316	138	0
2020	4	109	193	95	0	0	76	287	91	36
2021	0	83	156	113	0	0	66	289	14	0

Ever Fished: AIGKC All FMP Seasons	**Block_1**	**Block_2**	**Block_3**	**Block_4**	**Block_5**	**Block_6**	**Block_7**	**Block_8**	**Block_9**	**Block_10**
1995–2021 - Sum of 1x1 cells	381	1402	1799	919	459	1028	807	2104	1035	334

We assumed the null model to be

$$\ln(\mathrm{CPUE_i}) = \mathrm{Year}_{y_i}\mathrm{:Area_{ai}} \quad \text{(B.8)}$$

The maximum set of model terms offered to the stepwise selection procedure was:

$$\ln(\mathrm{CPUE_I}) = \mathrm{Year}_{y_i}{:}\,Area_{ai} + \mathrm{ns}(\mathrm{Soak_{si}}, \mathrm{df}) + \mathrm{Month}_{m_i} + \mathrm{Vessel_{vi}} + \mathrm{Captain_{ci}} + \mathrm{Area_{ai}} + \mathrm{Gear_{gi}} + \mathrm{ns}(\mathrm{Depth_{di}}, \mathrm{df}). \quad \text{(B.9)}$$

The final interaction effect models for EAG were:

Initial selection by stepAIC:
$\ln(\mathrm{CPUE}) = \mathrm{Gear} + \mathrm{Captain} + \mathrm{ns}(\mathrm{Soak}, 4) + \mathrm{Month} + Year{:}\,Area$
AIC=203,851

Final selection by stepCPUE:
$\ln(\mathrm{CPUE}) = \mathrm{Captain} + \mathrm{Gear} + Year{:}\,Area + \mathrm{ns}(\mathrm{Soak}, 4)$ (B.10)
for the 1995/96–2004/05 period [θ=1.38, $\mathrm{R}^2 = 0.3218$, Soak forced in]

Initial selection by stepAIC:
$\ln(\mathrm{CPUE}) = \mathrm{Vessel} + \mathrm{Gear} + \mathrm{ns}(\mathrm{Soak}, 3) + Month + Year{:}\,Area$
AIC=53,632

Final selection by stepCPUE:
$\ln(\mathrm{CPUE}) = \mathrm{Vessel} + Year{:}\,Area + \mathrm{ns}(\mathrm{Soak}, 3)$ (B.11)
for the 2005/06–2021/22 period [$\theta = 2.32$, $\mathrm{R}^2 = 0.1182$, Soak forced in].

The final interaction effect models for WAG were:

Initial selection by stepAIC:
$\ln(\mathrm{CPUE}) = \mathrm{ns}(\mathrm{Soak}, 8) + Gear + \mathrm{Vessel} + Month + Year{:}\,Area$
AIC=108,596

Final selection by stepCPUE:
$\ln(\mathrm{CPUE}) = \mathrm{ns}(\mathrm{Soak}, 8) + Year{:}\,Area$ (B.12)
for the 1995/96–2004/05 period [θ=0.97, $\mathrm{R}^2 = 0.1408$]

Initial selection by stepAIC:

$\ln(\mathrm{CPUE}) = \mathrm{Gear} + \mathrm{Vessel} + \mathrm{Month} + Year{:}Area + ns(Soak, 2)$
AIC=53,978

Final selection by stepCPUE:
$\ln(\mathrm{CPUE}) = \mathrm{Gear} + Year{:}Area + ns(Soak, 2)$ (B.13)
for the 2005/06–2021/22 period [$\theta = 1.12,\ \mathrm{R}^2 = 0.1287, \mathrm{Soak\ forced\ in}$].

Steps:

1. *Block-scale analysis*:

   The bias corrected estimate of CPUE index for each Year-Area (Area=Block) interaction was first obtained as:

   $$CPUE_{ij} = e^{YB_{ij} + \sigma_{ij}^2/2} \quad \text{(B.14)}$$

   where $CPUE_{ij}$ is the CPUE index in the ith year and jth block, YB_{ij} is the coefficient of the *i*th year and *j*th block interaction, and σ_{ij} is the biased correction standard error for expected CPUE value.

   The number of 1 nmi x 1 nmi grids in each block can change from year to year; so, we considered using the number of grids **ever fished** in a block, $N_{ever\,j}$ [this is equivalent to assuming that the grids fished in any year randomly sample the stock in that block (Campbell, 2004)].

   The abundance index for *j*th block in *i*th year is

   $$B_{ij} = N_{ever_j} CPUE_{ij} \quad \text{(B.15)}$$

   Notice in Table B.2 that no or very few observer samplings occurred in certain years for a whole block. We filled the B_{ij} index gaps resulting from Year:Area CPUE standardization model fit as follows:

   $$\widehat{B_{i,j}} = e^{A_i + C_j}$$

   fitted by GLM [i.e., fitting a log-linear model, $ln(\hat{B}_{i,j}) = A_i + C_j$], (B.16)
   where $B_{i,j}$ is the available index of biomass for year i and block *j*, A_i is a year factor, and C_j is a block factor, and used this model to predict the unavailable biomass index for blocks x years with no (or very limited, < 10) data.

   An example set of R codes used to predict the missing biomass index is as follows:

   library (MASS)

   To fit the log-linear model (Equation B.16):

   glm.fit<- glm(log(B_{ij})~Year$_i$ + Block$_j$, data=Bindex)

where the data frame “Bindex” contains available B_{ij},$Year_i$, and $Block_j$ column values.

To predict the missing biomass index Y:

Y<- predict.glm (glm.fit, BindexFillpredict, se.fit=TRUE)

where the new data frame “BindexFillpredict” contains $Year_i$ and $Block_j$ column values for which B_{ij} indices are needed and contains an empty B_{ij} column for fill in.

By setting se.fit=TRUE, the standard errors, σ_{ij}, of predictions are also estimated.

Bias correction was made to each predicted biomass index by $B_{i,j} = e^{\hat{Y}_{i,j} + \sigma_{ij}^2/2}$ where σ_{ij} is the standard error of predicted $Y_{i,j}$value, which is on the scale of the linear predictor (i.e., log transformed B_{ij}). The standard error for each year and area combination is estimated as follows.

If we denote the covariance matrix of the fitted “glm.fit” as Σ and write the coefficients for linear combination of a set of predictors in a vector form as C, then the standard error of prediction for that combination is $\sqrt{C'\Sigma C}$, where C' is the transpose of vector C.

Annual biomass index, B_i , was estimated as,

$$B_i = \sum_j B_{ij} \qquad \text{(B.17)}$$

The variance of the total biomass index was computed as:

$$\boldsymbol{Var}\ (\boldsymbol{B_i}) = \sum_{\boldsymbol{j}} \boldsymbol{N_{ever,j}}^{\boldsymbol{2}}\ \boldsymbol{var}(\boldsymbol{CPUE_{i,j}}) \qquad \text{(B.18)}$$

where $\boldsymbol{N_{ever,j}}$ is the total number of 1mni x 1 mni cells ever fished in block j, and $CPUE_{i,j}$ is the CPUE index for year i and block j.

To use in the assessment model, 21.1f, we rescaled the B_i indices by the geometric mean of estimated B_i values (Equation B.17) separately for the pre- and post-rationalization periods. The corresponding standard error (~CV) of B_i was estimated by

$$\sqrt{\frac{Var(B_i)}{(B_i)^2}} \qquad \text{(B.19)}$$

The rescaled biomass indices with standard errors are listed in Table B.3 for EAG and Table B.4 for WAG.

Table B.3. Steps to estimate biomass-based abundance indices with standard errors for 1995/96–2021/22 in EAG. GMScaled B_index and B_Index SE were used as CPUE index and its standard error.

Year	B_Index	GMScaled B_Index	Var(B_index)	Var(B_Index)/(B_Index)^2	B_Index SE
1995	1840.195	0.737	108308.681	0.032	0.179
1996	2377.650	0.953	193890.645	0.034	0.185
1997	2234.218	0.895	136175.712	0.027	0.165
1998	2231.215	0.894	93848.598	0.019	0.137
1999	2098.179	0.841	94391.700	0.021	0.146
2000	2287.685	0.917	94583.806	0.018	0.134
2001	2819.982	1.130	100512.412	0.013	0.112
2002	2990.150	1.198	195454.815	0.022	0.148
2003	2468.033	0.989	205602.122	0.034	0.184
2004	4304.572	1.725	214126.937	0.012	0.107
2005	5118.193	1.043	52090.812	0.002	0.045
2006	4426.798	0.902	57473.202	0.003	0.054
2007	4222.122	0.861	39510.354	0.002	0.047
2008	3890.943	0.793	43801.605	0.003	0.054
2009	3814.782	0.778	96521.033	0.007	0.081
2010	3950.164	0.805	87593.140	0.006	0.075
2011	5368.007	1.094	83252.682	0.003	0.054
2012	4857.480	0.990	69929.847	0.003	0.054
2013	5378.237	1.096	59386.851	0.002	0.045
2014	6070.666	1.237	67056.926	0.002	0.043
2015	5303.583	1.081	61333.834	0.002	0.047
2016	5324.519	1.085	60469.411	0.002	0.046
2017	4537.356	0.925	84971.583	0.004	0.064
2018	5564.205	1.134	71473.704	0.002	0.048
2019	6065.799	1.236	60599.782	0.002	0.041
2020	5031.120	1.025	67525.850	0.003	0.052
2021	5322.216	1.085	69813.333	0.002	0.050

Table B.4. Steps to estimate biomass-based abundance indices with standard errors for 1995/96–2021/22 in WAG. GMScaled B_index and B_Index SE were used as CPUE index and its standard error.

Year	B_Index	GMScaled B_Index	Var(B_index)	Var(B_Index)/(B_Index)^2	B_Index SE
1995	4871.60	1.394	182207.621	0.008	0.088
1996	3906.56	1.118	92553.712	0.006	0.078
1997	3320.47	0.950	79547.661	0.007	0.085
1998	3427.74	0.981	175201.594	0.015	0.122
1999	2984.90	0.854	80691.949	0.009	0.095

2000	2708.85	0.775	77219.827	0.011	0.103
2001	2609.07	0.747	154449.359	0.023	0.151
2002	3283.42	0.940	93255.916	0.009	0.093
2003	4200.52	1.202	80606.332	0.005	0.068
2004	4302.75	1.231	97694.323	0.005	0.073
2005	14891.708	1.371	319537.896	0.001	0.038
2006	10339.018	0.952	333559.858	0.003	0.056
2007	11916.853	1.097	341055.017	0.002	0.049
2008	12375.624	1.140	233561.648	0.002	0.039
2009	15381.622	1.417	314408.764	0.001	0.036
2010	13600.833	1.253	667118.925	0.004	0.060
2011	8994.823	0.828	235930.103	0.003	0.054
2012	15320.865	1.411	445483.711	0.002	0.044
2013	9785.857	0.901	299555.740	0.003	0.056
2014	13835.449	1.274	476830.929	0.002	0.050
2015	9076.437	0.836	359025.415	0.004	0.066
2016	10290.102	0.948	353748.747	0.003	0.058
2017	12520.410	1.153	428768.653	0.003	0.052
2018	15020.571	1.383	343029.866	0.002	0.039
2019	7228.262	0.666	204651.563	0.004	0.063
2020	6618.087	0.609	230647.559	0.005	0.073
2021	5445.203	0.501	270131.499	0.009	0.095

c. Commercial fishery CPUE index by non-interaction model

We fitted the negative binomial GLM model for fish ticket retained CPUE time series 1985/86 – 1998/99 offering Year, Month, Vessel, Captain, and Area as explanatory variables and applying the hybrid selection method. Reduced area resolution (ADF&G area codes were grouped to AreaGP) was used for model fitting.

The final model for EAG was:

Initial selection by stepAIC:
$\ln(\mathrm{CPUE}) = \mathrm{Year} + \mathrm{Vessel} + Month$
AIC=16,997

Final selection by stepCPUE:
$\ln(\mathrm{CPUE}) = \mathrm{Year} + \mathrm{Vessel} + \mathrm{Month}$ (B.20)
for the 1985/86–1998/99 period [θ=10.45, $R^2 = 0.3328$]

and that for WAG was:

Initial selection by stepAIC:

$\ln(\mathrm{CPUE}) = \mathrm{Year} + \mathrm{Vessel} + Area$
AIC=31,701

Final selection by stepCPUE:

$$\ln(\mathrm{CPUE}) = \mathrm{Year} + \mathrm{Vessel} + \mathrm{Area} \tag{B.21}$$

for the 1985/86–1998/99 period [θ=6.67, $R^2 = 0.3569$]

Appendix C: Male Maturity

Introduction

Sexual maturity is associated with alterations in both external morphology, internal physiology, and incidence of copulation on which basis different types of maturity can be defined: physiological, morphometric, and functional maturity. Functional maturity is the true way of determining maturity, but requires elaborate lab or field experiments. Hence, crab researchers often adapt an indirect detection technique via morphometric measurement for maturity determination. Chelae allometry has been used to determine morphometric male size-at-maturity among several king crab (*Lithodidae*) stocks. Male golden king crab provides a better discrimination of chelae height against size at onset of maturity than other king crab stocks (Somerton and Otto 1986). Table C.1 lists the literature reported estimates of size-at-maturity of male golden king crab (*Lithodes aequispins*) stocks in Alaska. Breakpoint analysis has been used to estimate maturity in most cases.

Table C.1. Review of estimates of male size-at-maturity of golden (*Lithodes aequispins*) king crabs by regions in Alaska. Numbers in parentheses are standard errors (SE).

Species	Sex	Size-at-Maturity (mm CL)	Method	Area	Sources
Lithodes aequispins	Male	114 (11.4)	Breakpoint analysis on ln chela height vs. ln carapace length	British Columbia, Canada	Jewett *et al*. 1985
		92 (2.4) 107 (4.6) 130 (4.0)	Breakpoint analysis on ln chela height vs. ln carapace length	St. Matthew Is. District Pribilof Is District Eastern Aleutian Is	Somerton and Otto 1986
		117.9 – 158.0	Breakpoint analysis on chela height vs. carapace length	Various water inlets in southeast Alaska	Olson et al. 2018
		108.6 (2.6) 120.8 (2.9)	Breakpoint analysis on chela height vs. carapace length	Bowers Ridge Seguam Pass	Otto and Cummiskey 1985
		110	Minimum size of successful mating (lab observation)	Prince William Sound	Paul and Paul 2001

Data

Male golden king crab carapace length (CL) was measured to the nearest mm and chela height (CH) measured to the nearest one-tenth of a mm by observers, and biologists from Alaska

Fisheries Science Center (AFSC) and Alaska Department of Fish and Game (ADF&G) during the commercial fishery and special surveys in the Aleutian Islands. Crab exhibiting abnormal growth due to limb loss or diseases were disregarded from measurements. There were 14,570 measurements taken during 1984, 1991, 2018 to 2021. This analysis considered different sets of data: (1) 1984 NMFS biological samples in WAG (508 measurements) and EAG (790 measurements); (2) 1991 ADF&G pot survey samples in EAG (2457 measurements); (3) 2018/19–2020/21 ADF&G biological samples from retained catch, observer pot samples, and co-operative survey samples (10,815 measurements for the entire Aleutian Islands); and (4) all data sets combined (14,570 measurements for the whole Aleutian Islands) (Table C.2).

Table C.2. Golden king crab male carapace length and chela height data collected during 1984/85 – 2020/21 fishing seasons in the Aleutian Islands.

Measurement type	Source and season of data collection	WAG	EAG	Aleutian Islands (AI) 2018/19–2020/21	Aleutian Islands (AI) 1984/85–2020/21
	NMFS samples (1984/85)	508	790		
	ADF&G pot survey samples (1991/92)		2457		
	Co-operative survey samples (2018/19, 2019/20)	362			
	Observer samples (2018/19, 2019/20)	2703	2449		
	Retained catch samples (2018/19, 2019/20, 2020/21)	2073	3005		
	ADFG special survey samples (2020/21)	223			
Total carapace length and chela height measurements		5869	8701	10815	14570

Method

The male size-at-maturity is determined as the breakpoint in the following model:

$$CH = \beta_0 + \beta_1 CL + \beta_2 [CL - c]^+ + \varepsilon \quad \text{(C.1)}$$

where β_0 is the intercept, β_1 is the slope, β_2 is the change in slope when $CL \geq c$, and, c is the breakpoint and ε is the error term.

The term $[CL - c]^+$ reduces to zero if $CL < c$, otherwise takes the value of the argument in the following form of the model:

$$CH = \beta_0 + \beta_1 CL + \beta_2 [CL - c] \quad \text{(C.2)}$$

The "segmented regression" package developed by Muggeo and available in R (ver 4.1, R Core Team 2021) has the same concept as equations (C.1) and (C.2). We used this package to determine breakpoints and corresponding segmented lines for different groups of data outside the assessment model.

This R package first fits a single line to CH vs CL data and then proceeds to estimate an optimum break point iteratively over the user given CL range. In the process, it estimates the parameters of equation C.2, including the breakpoint. Olson et al. (2018) followed a similar approach to analyze CH vs CL data in the southeast Alaska but did not use Muggeo's R-package.

The estimates were further refined by bootstrapping each data set (CH, CL pairs) 1,000 times and fitting 'segmented regression' lines to each boot strapped sample. The bootstrap mean and median breakpoint (i.e., knife-edge maturity size), standard error, and confidence intervals were also estimated.

Results

The four data sets produced breakpoint estimates ranging from 104.295 mm CL to 123.536 mm CL for EAG; 107.482 mm CL to 123.144 mm CL for WAG; and 107.473 mm CL to 122.738 mm CL for AI. Pre-2018 data sets produced lower breakpoint estimates (~ 107 mm CL) for EAG, WAG, and AI than those from the post-2018 data sets. The method used in the pre-2018 data analysis (ln (CH/CL) ~ CL regression) was different from that used in the post-2018 data analysis (CH ~ CL regression) although both methods used the same R package. Based on pre-2018 data analysis, the current knife-edge maturity length of 111 mm CL (lower limit of the next higher bin) has been used for MMB calculation since 2007/08.

Table C.3 lists the results from previous and current analyses. The bootstrap statistics for the four data sets by region are also provided in Table C.3. The breakpoint (mean/median) values suggest one or two 5 mm bin higher than the currently used 111 mm CL can be used. **Three options for MMB estimation are possible: (1) ≥111 mm CL (status quo knife-edge maturity size from previous analysis), (2) ≥116 mm CL (based on current analysis), or (3) ≥121 mm CL (based**

on current analysis). If a decision is made to increase the maturity cutoff size, we prefer the second option as a precaution not to adversely affect the MMB estimate.

Table C.3. Mean, median, and upper and lower 95% confidence limits of breakpoints (knife-edge maturity) for various chela height (CH) and carapace length (CL) data sets for Aleutian Islands male golden king crab.

			Breakpoint					
Source and Season	Region	Method	Mean	Median	SE	Upper Bound	Lower Bound	Remarks
NMFS samples (1984/85)	WAG	Ln (CH/CL) ~CL	108.825	107.564	0.162	126.000	103.847	CPT accepted method since 2007/08
	AI	Ln (CH/CL) ~CL	109.024	108.344	0.106	116.488	104.260	ditto
ADFG pot survey samples (1991/92)	EAG	Ln (CH/CL) ~CL	104.140	107.000	0.233	111.821	84.527	ditto
Co-operative survey, Observer and retained catch samples (2018/19 – 2020/21)	EAG	CH~CL	108.322	110.460	0.427	126.504	88.405	CPT suggested method since 2020/21
ditto	WAG	CH~CL	120.812	120.378	0.105	126.102	112.573	ditto
ditto	AI	CH~CL	116.795	118.105	0.147	122.804	105.757	ditto
All samples combined (1984/85 – 2020/21)	AI	CH~CL	122.908	122.783	0.039	125.097	120.455	ditto

Figures C.1 – C.6 depict the segmented linear regression fits for various data sets. They clearly demonstrate the existence of a bend point in Aleutian Islands male golden king crab chela heigh versus carapace length data.

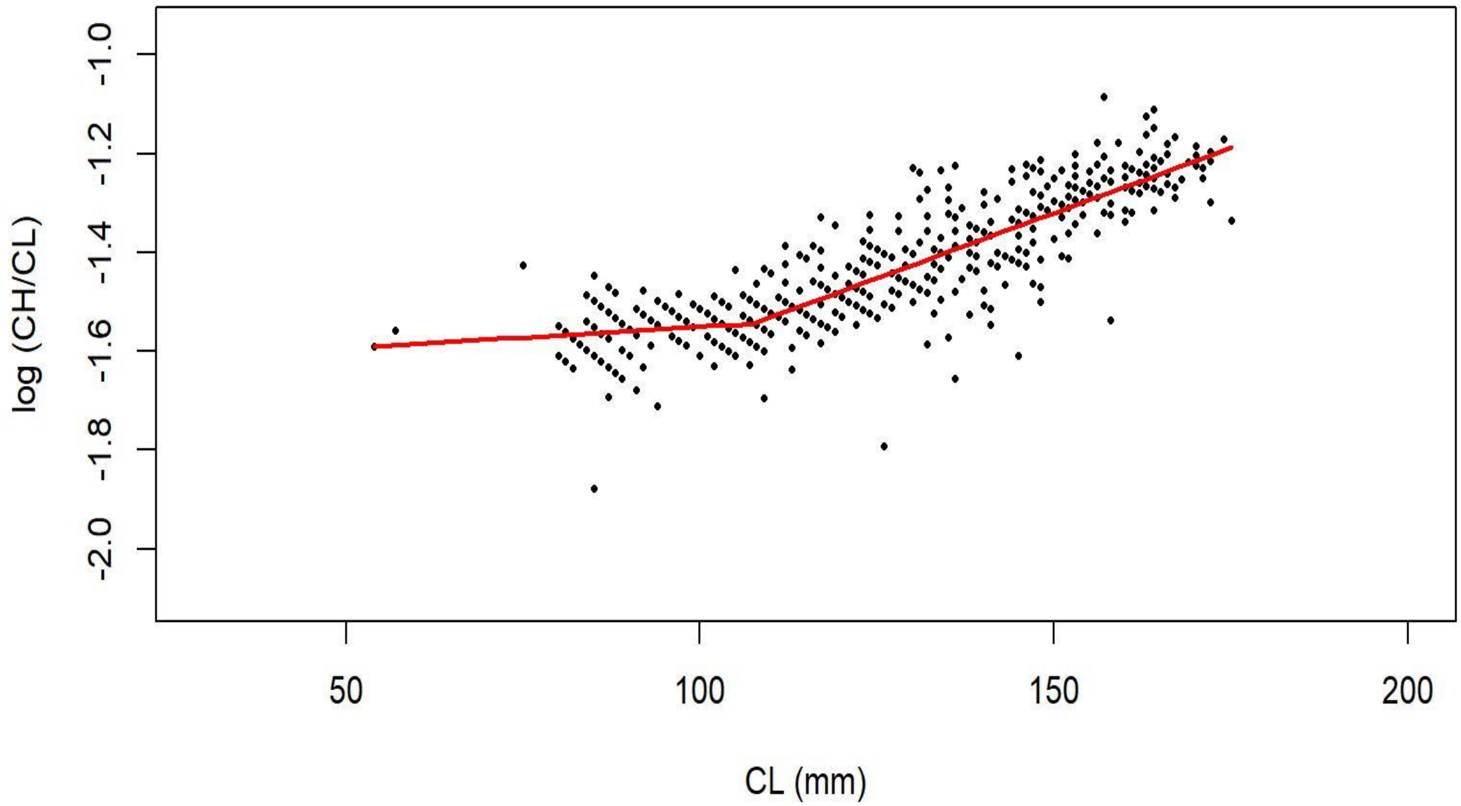


Figure C.1. Segmented linear regression fit to ln (CH/CL) vs. CL data of male golden king crab for 1984/85 in WAG.

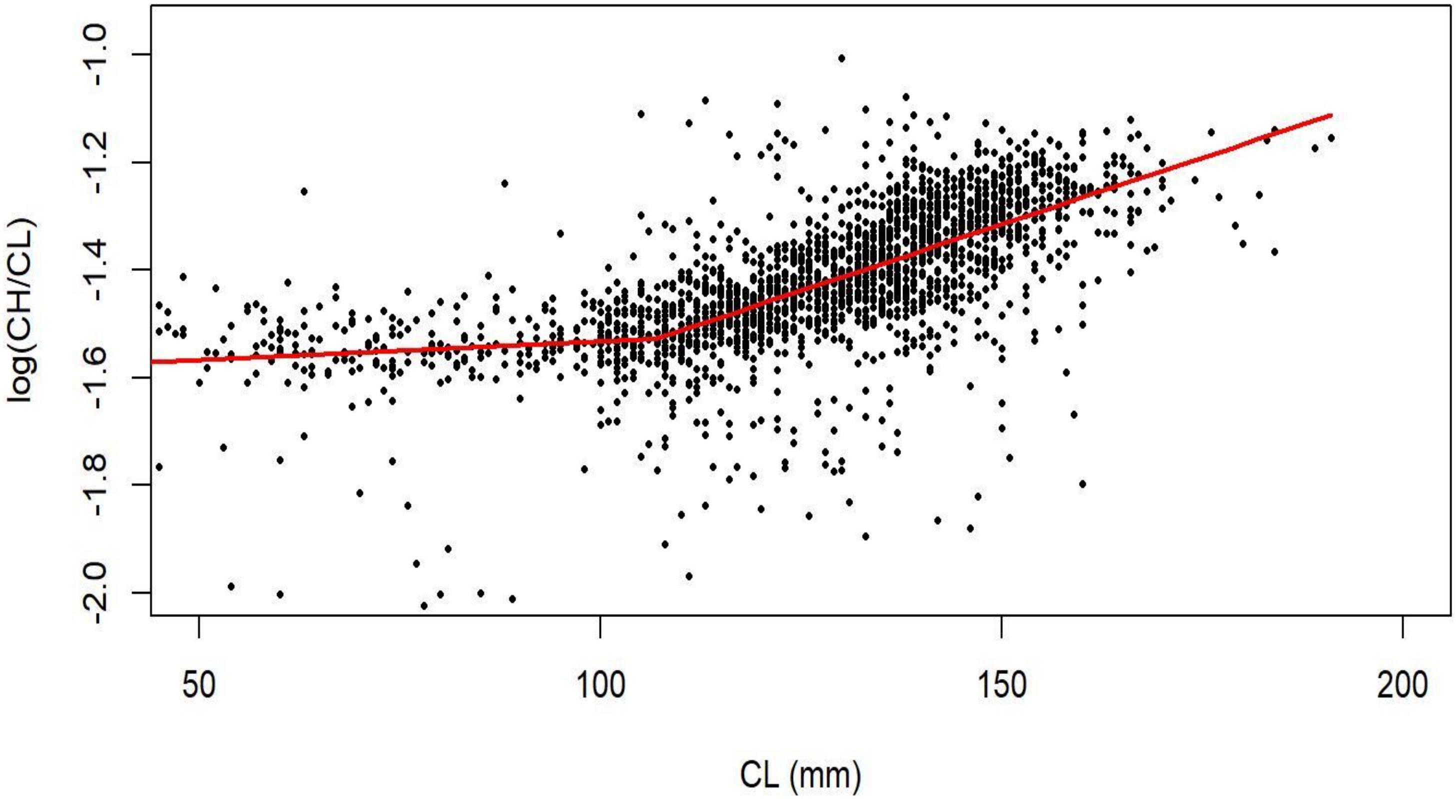


Figure C.2. Segmented linear regression fit to ln (CH/CL) vs. CL data of male golden king crab for 1991/92 in EAG.

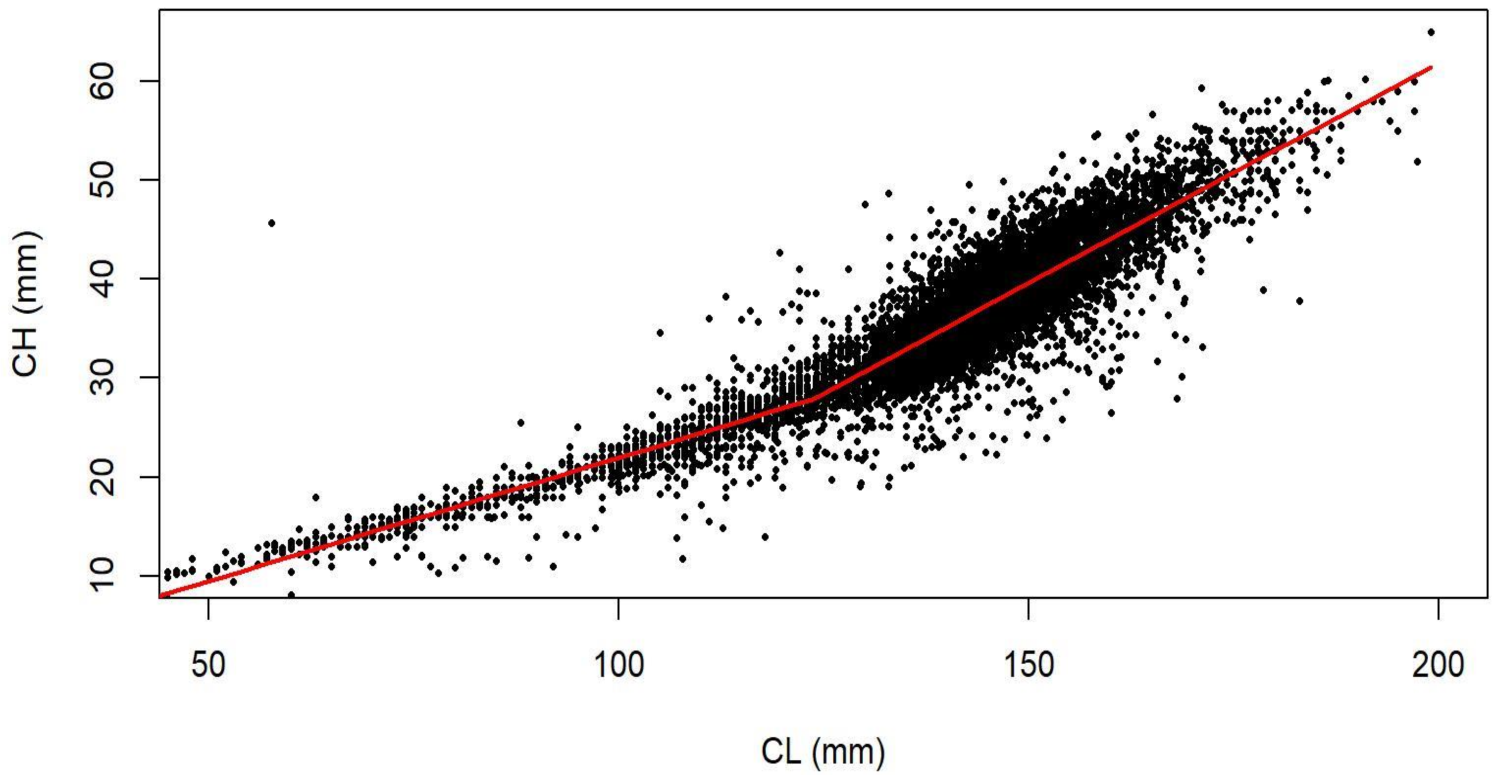


Figure C.3. Segmented linear regression fit to CH vs. CL data of male golden king crab for 1984/85–2020/21 in EAG (Note: following CPT/SSC suggestion to follow a published analytical approach, we switched over to analyzing CH vs. CL data).

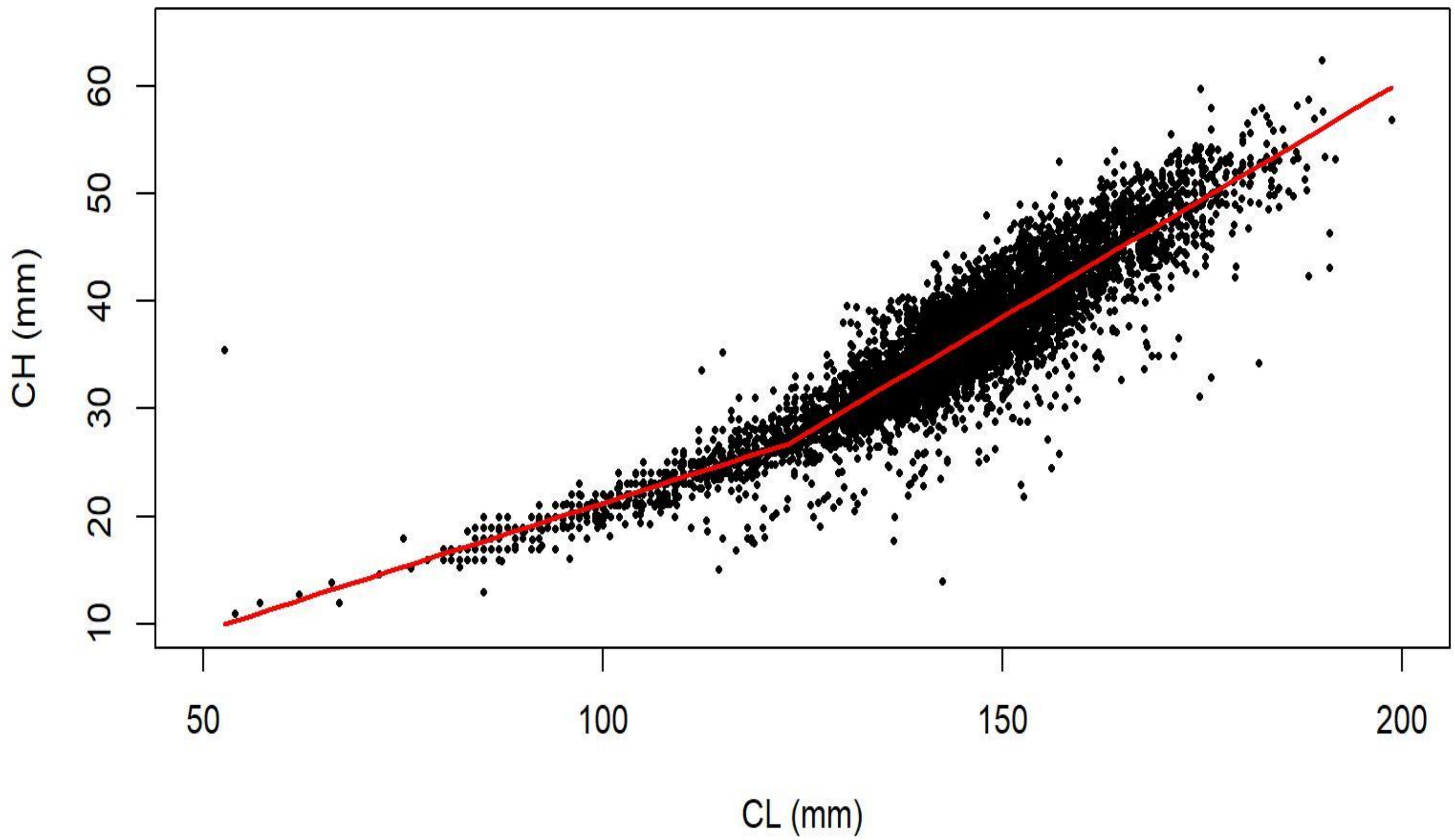


Figure C.4. Segmented linear regression fit to CH vs. CL data of male golden king crab for 1984/85–2020/21 in WAG.

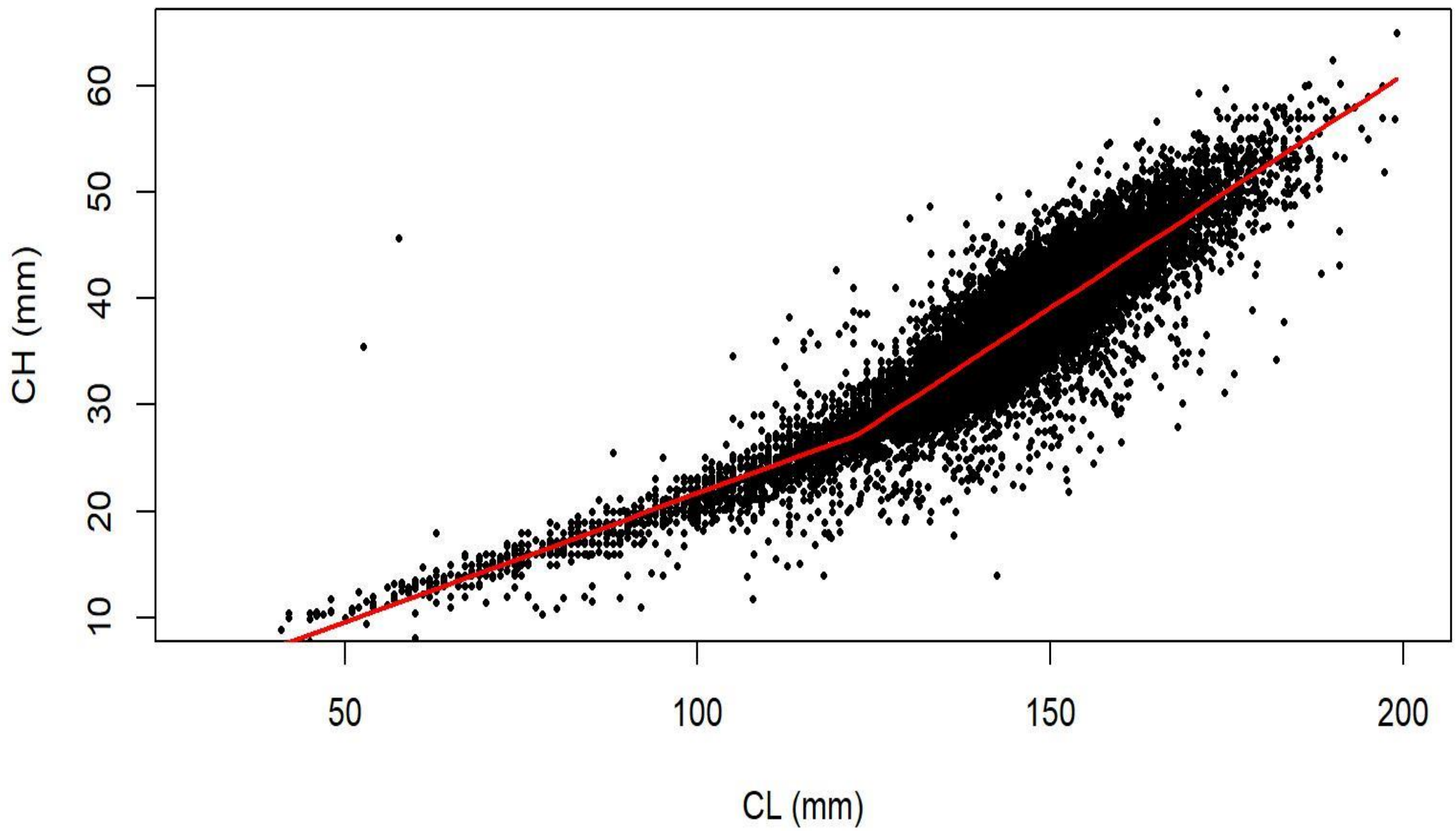


Figure C.5. Segmented linear regression fit to CH vs. CL data of male golden king crab for 1984/85–2020/21 in AI.

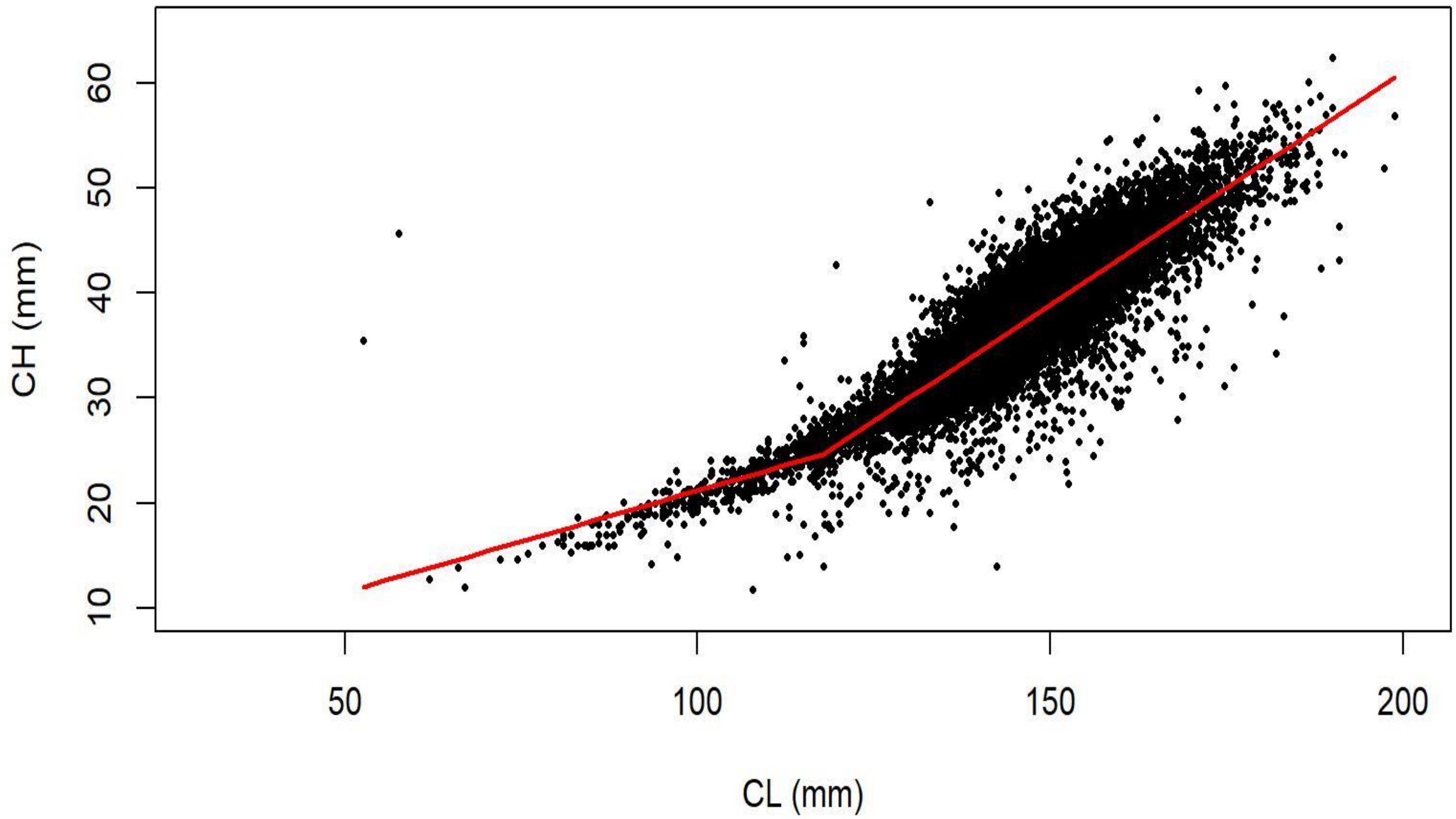


Figure C.6. Segmented linear regression fit to CH vs. CL data of male golden king crab for 2018/19–2020/21 in AI.

Appendix D: Jittering

Jittering of model 21.1e parameter estimates

We followed the Stock Synthesis approach to do 100 jitter runs using model 21.1e parameter estimates as initial parameter values (i.e., as PIN file in ADMB) to assess model stability and to determine whether a global, as opposed to local, minimum has been reached by the search algorithm:

We used 30% jittering to investigate the minimization process. We also used the 50% jittering, but it directed toward the same global minimum but with more NAs than that from 30% jittering. We only provide results for 30% jittering. In the jittering process, a *Jitter* factor of 0.3 was multiplied by a random normal deviation $rdev=N$ (0,1) to create a transformed parameter value based upon the predefined parameter:

$$temp = 0.5 * rdev * Jitterfactor * \ln\left(\frac{P_{\max} - P_{\min} + 0.0000002}{P_{val} - P_{\min} + 0.0000001} - 1\right) \quad \text{(D.1)}$$

with the final jittered initial parameter value back transformed as:

$$P_{new} = P_{\min} + \frac{P_{\max} - P_{\min}}{1.0 + \exp(-2.0\, temp)}, \quad \text{(D.2)}$$

where P_{max} and P_{min} are upper and lower bounds of parameter search space and P_{val} is the estimated parameter value before the jittering.

The jitter results are summarized for the selected model 21.1e in Tables D.1 and D.2 for EAG and WAG, respectively. The minimum negative log likelihood values realized in jitter runs coincided with optimized estimates by the 21.1e model runs for EAG and WAG, except for nonconvergent runs. We concluded from jitter results that optimization of 21.1e model achieved the global minima. Since models 21.1e2, 21.1f, and 21.1f2 have similar model structures, we concluded that their optimizations would have reached global minima.

Table D.1. Results from 100 jitter runs for scenario 21.1e for EAG. Jitter run **0** corresponds to the original optimized estimates. NA: model did not converge.

Jitter Run	Objective Function	Maximum Gradient	B35% (t)	OFL (t)	Current MMB (t)
0	**-845.0151**	**0.000233**	**6,825**	**2,875**	**7,670**
1	-845.0151	0.000029	6,825	2,875	7,670
2	-728.0387	0.000079	7,390	3,387	8,664
3	-728.5304	0.000085	7,367	3,379	8,642
4	-728.0387	0.000270	7,390	3,387	8,664
NA	NA	NA	NA	NA	NA
6	-728.0387	0.000495	7,390	3,387	8,664
7	-845.0151	0.000088	6,825	2,875	7,670
8	-728.6013	0.002375	7,357	3,381	8,641
9	-845.0151	0.000046	6,825	2,875	7,670

10	-728.0387	0.000335	7,390	3,387	8,664
11	-728.0387	0.000162	7,390	3,387	8,664
12	-728.0387	0.000063	7,390	3,387	8,664
13	-728.5304	0.000107	7,367	3,379	8,642
14	-728.6013	0.000159	7,357	3,381	8,641
15	-845.0151	0.000013	6,825	2,875	7,670
16	-728.6013	0.000073	7,357	3,381	8,641
17	-728.6013	0.000250	7,357	3,381	8,641
18	-845.0151	0.000099	6,825	2,875	7,670
19	-728.0387	0.000255	7,390	3,387	8,664
NA	NA	NA	NA	NA	NA
21	-728.0387	0.000412	7,390	3,387	8,664
22	-728.0387	0.000919	7,390	3,387	8,664
23	-845.0151	0.000035	6,825	2,875	7,670
24	-728.0387	0.000349	7,390	3,387	8,664
25	-728.0387	0.000134	7,390	3,387	8,664
26	-728.0387	0.000080	7,390	3,387	8,664
27	-799.5638	0.000054	6,882	2,862	7,696
28	-845.0151	0.000036	6,825	2,875	7,670
29	-728.0387	0.000291	7,390	3,387	8,664
NA	NA	NA	NA	NA	NA
31	-728.5304	0.000220	7,367	3,379	8,642
32	-845.0151	0.000695	6,825	2,875	7,670
33	-845.0151	0.000018	6,825	2,875	7,670
34	-845.0151	0.000003	6,825	2,875	7,670
35	-728.0387	0.000057	7,390	3,387	8,664
36	-728.0387	0.000257	7,390	3,387	8,664
NA	NA	NA	NA	NA	NA
38	-728.0387	0.000640	7,390	3,387	8,664
NA	NA	NA	NA	NA	NA
40	-845.0151	0.000069	6,825	2,875	7,670
41	-728.0387	0.000016	7,390	3,387	8,664
42	-728.0387	0.000154	7,390	3,387	8,664
43	-728.6013	0.000165	7,357	3,381	8,641
44	-845.0151	0.000162	6,825	2,875	7,670
NA	NA	NA	NA	NA	NA
46	-728.0387	0.000123	7,390	3,387	8,664
47	-728.0387	0.000122	7,390	3,387	8,664
NA	NA	NA	NA	NA	NA
49	-845.0151	0.000076	6,825	2,875	7,670
50	-728.0387	0.000037	7,390	3,387	8,664
51	-845.0151	0.000197	6,825	2,875	7,670
NA	NA	NA	NA	NA	NA
53	-845.0151	0.000165	6,825	2,875	7,670

54	-728.0387	0.000275	7,390	3,387	8,664
55	-667.7828	0.000194	7,324	3,390	8,833
56	-728.0387	0.000102	7,390	3,387	8,664
57	-845.0151	0.000338	6,825	2,875	7,670
58	-728.5304	0.000041	7,367	3,379	8,642
NA	NA	NA	NA	NA	NA
60	-728.0387	0.000287	7,390	3,387	8,664
61	-845.0151	0.000025	6,825	2,875	7,670
62	-845.0151	0.000037	6,825	2,875	7,670
63	-728.0387	0.000182	7,390	3,387	8,664
64	-728.0387	0.000291	7,390	3,387	8,664
65	-845.0151	0.000056	6,825	2,875	7,670
NA	NA	NA	NA	NA	NA
NA	NA	NA	NA	NA	NA
68	-728.0387	0.000427	7,390	3,387	8,664
69	-728.5304	0.000192	7,367	3,379	8,642
70	-728.0387	0.000037	7,390	3,387	8,664
71	-728.0387	0.000310	7,390	3,387	8,664
72	-845.0151	0.000105	6,825	2,875	7,670
NA	NA	NA	NA	NA	NA
NA	NA	NA	NA	NA	NA
75	-845.0151	0.000148	6,825	2,875	7,670
76	-728.0387	0.000350	7,390	3,387	8,664
77	-728.0387	0.000249	7,390	3,387	8,664
78	-728.0387	0.000232	7,390	3,387	8,664
79	-845.0151	0.000089	6,825	2,875	7,670
80	-728.0387	0.000126	7,390	3,387	8,664
81	-845.0151	0.000081	6,825	2,875	7,670
NA	NA	NA	NA	NA	NA
83	-728.0387	0.000369	7,390	3,387	8,664
NA	NA	NA	NA	NA	NA
85	-728.0387	0.000125	7,390	3,387	8,664
NA	NA	NA	NA	NA	NA
87	-845.0151	0.000196	6,825	2,875	7,670
88	-799.5638	0.000141	6,882	2,862	7,696
89	-728.0387	0.000042	7,390	3,387	8,664
NA	NA	NA	NA	NA	NA
91	-845.0151	0.000038	6,825	2,875	7,670
92	-728.0387	0.000675	7,390	3,387	8,664
93	-728.0387	0.000109	7,390	3,387	8,664
94	-845.0151	0.000164	6,825	2,875	7,670
95	-799.5638	0.000102	6,882	2,862	7,696
96	-845.0151	0.000264	6,825	2,875	7,670
97	-845.0151	0.000088	6,825	2,875	7,670

98	-845.0151	0.000040	6,825	2,875	7,670
99	-845.0151	0.000057	6,825	2,875	7,670
100	-728.0387	0.000161	7,390	3,387	8,664

Table D.2 Results from 100 jitter runs for scenario 21.1e for WAG. Jitter run **0** corresponds to the original optimized estimates. NA: model did not converge.

Jitter Run	Objective Function	Maximum Gradient	B35% (t)	OFL (t)	Current MMB (t)
0	**-895.2334**	**0.000065**	**5,248**	**1,211**	**4,887**
1	-675.1125	0.000342	5,544	1,541	5,319
2	-680.3088	0.000242	5,475	1,501	5,248
3	-675.1125	0.000109	5,544	1,541	5,319
4	-675.1125	0.000110	5,544	1,541	5,319
5	-675.2232	0.000089	5,516	1,503	5,276
6	-675.1125	0.000061	5,544	1,541	5,319
7	-675.1125	0.000033	5,544	1,541	5,319
NA	NA	NA	NA	NA	NA
NA	NA	NA	NA	NA	NA
10	-675.1125	0.000107	5,544	1,541	5,319
11	-895.2334	0.000194	5,248	1,211	4,887
12	-895.2334	0.000125	5,248	1,211	4,887
13	-675.1125	0.000478	5,544	1,541	5,319
14	-675.1125	0.000071	5,544	1,541	5,319
15	-680.3088	0.000619	5,475	1,501	5,248
16	-680.3088	0.000869	5,475	1,501	5,248
17	-675.1125	0.000057	5,544	1,541	5,319
NA	NA	NA	NA	NA	NA
NA	NA	NA	NA	NA	NA
20	-895.2334	0.000039	5,248	1,211	4,887
21	-895.2334	0.000066	5,248	1,211	4,887
22	-675.1125	0.000251	5,544	1,541	5,319
23	-675.1125	0.000226	5,544	1,541	5,319
24	-675.1125	0.000040	5,544	1,541	5,319
25	-680.3088	0.000173	5,475	1,501	5,248
NA	NA	NA	NA	NA	NA
27	-675.1125	0.000116	5,544	1,541	5,319
28	-675.1125	0.000132	5,544	1,541	5,319
29	-675.1125	0.000063	5,544	1,541	5,319
30	-675.1125	0.000006	5,544	1,541	5,319
31	-895.2334	0.000068	5,248	1,211	4,887
32	341.4398	0.000314	0	2	10,506
33	-675.1125	0.000101	5,544	1,541	5,319
34	-675.2232	0.000567	5,516	1,503	5,276
35	-675.1125	0.000186	5,544	1,541	5,319

36	-675.1125	0.000248	5,544	1,541	5,319
NA	NA	NA	NA	NA	NA
38	-895.2334	0.000023	5,248	1,211	4,887
39	-675.1125	0.000774	5,544	1,541	5,319
40	-675.1125	0.000063	5,544	1,541	5,319
41	-675.1125	0.000024	5,544	1,541	5,319
42	-675.2232	0.000226	5,516	1,503	5,276
43	-680.3088	0.000198	5,475	1,501	5,248
44	-895.2334	0.000028	5,248	1,211	4,887
45	-680.3088	0.000328	5,475	1,501	5,248
46	-675.1125	0.000277	5,544	1,541	5,319
47	-675.2232	0.000365	5,516	1,503	5,276
48	-675.2232	0.000779	5,516	1,503	5,276
49	-675.1125	0.000275	5,544	1,541	5,319
50	-680.3088	0.000246	5,475	1,501	5,248
51	-675.1125	0.000035	5,544	1,541	5,319
52	-675.1125	0.000067	5,544	1,541	5,319
53	-675.2232	0.000142	5,516	1,503	5,276
54	-675.1125	0.000134	5,544	1,541	5,319
55	-675.1125	0.000026	5,544	1,541	5,319
56	-895.2334	0.000085	5,248	1,211	4,887
NA	NA	NA	NA	NA	NA
58	-675.1125	0.000058	5,544	1,541	5,319
59	-675.1125	0.000054	5,544	1,541	5,319
60	-895.2334	0.000130	5,248	1,211	4,887
NA	NA	NA	NA	NA	NA
62	-675.1125	0.000605	5,544	1,541	5,319
63	-675.1125	0.000076	5,544	1,541	5,319
64	-675.2232	0.000216	5,516	1,503	5,276
65	-680.3088	0.000474	5,475	1,501	5,248
66	-675.1125	0.000239	5,544	1,541	5,319
NA	NA	NA	NA	NA	NA
NA	NA	NA	NA	NA	NA
69	-680.3088	0.000159	5,475	1,501	5,248
70	-675.1125	0.000288	5,544	1,541	5,319
NA	NA	NA	NA	NA	NA
72	-680.3088	0.000311	5,475	1,501	5,248
73	-675.1125	0.000068	5,544	1,541	5,319
74	-675.1125	0.000086	5,544	1,541	5,319
75	-675.1125	0.000528	5,544	1,541	5,319
76	-675.1125	0.000108	5,544	1,541	5,319
77	-675.2232	0.000127	5,516	1,503	5,276
78	-680.3088	0.000379	5,475	1,501	5,248
79	-675.1125	0.000025	5,544	1,541	5,319

NA	NA	NA	NA	NA	NA
81	-675.1125	0.000097	5,544	1,541	5,319
82	-675.2232	0.000041	5,516	1,503	5,276
83	-675.1125	0.000198	5,544	1,541	5,319
NA	NA	NA	NA	NA	NA
85	-675.1125	0.000181	5,544	1,541	5,319
86	-675.1125	0.000310	5,544	1,541	5,319
87	-675.1125	0.000257	5,544	1,541	5,319
88	-675.2232	0.000077	5,516	1,503	5,276
89	-675.1125	0.000176	5,544	1,541	5,319
90	-675.1125	0.000686	5,544	1,541	5,319
91	-675.1125	0.000325	5,544	1,541	5,319
92	-675.1125	0.000622	5,544	1,541	5,319
93	-675.1125	0.000091	5,544	1,541	5,319
NA	NA	NA	NA	NA	NA
95	-675.2232	0.000239	5,516	1,503	5,276
96	-895.2334	0.000069	5,248	1,211	4,887
97	-675.2232	0.000044	5,516	1,503	5,276
98	-675.2232	0.000159	5,516	1,503	5,276
99	-680.3088	0.000139	5,475	1,501	5,248
100	-675.2232	0.000242	5,516	1,503	5,276

Appendix E: Gmacs

Introduction

Implementation of Aleutian Islands golden king crab stock assessment in GMACS started in 2020 and great progress has been made since then.

Method

We implemented the status quo models 21.1a (with two catchability and two additional standard deviations (SDs)) and 21.1e (with three catchability and three additional SDs) in GMACS. Estimated parameters from modified EAG21.1a and WAG21.1a (known as EAG21.7c and WAG 21.7c) and modified EAG21.1e and WAG21.1e (known as EAG21.8c and WAG 21.8c) that were reparametrized for GMACS computational formulas were input to GMACS ctl and pin files. Parallel data and projection files were also created for GMACS runs (e.g., GMACS7cEAG21.1aCatchNo.ctl, GMACS7cEAG21.1aCatchNo.dat, and GMACS7cEAG21.1aCatchNo.prj). We compared likelihood values, time series of abundance (i.e., N- matrix), MMB, and CPUE among status quo, GMACS estimated (GMACS_EST), and GMACS estimated parameter input modified models.

We also estimated management reference points for comparing them with the status quo model results. The references points are listed in the executive summary tables. The N-matrix comparisons are not provided in this report but available with the first author.

Results

The likelihoods (Tables E.1 to E.4), MMB (Figures E.1 and E.2), and CPUE (Figures E.3 and E.4) trends compare well among the five versions of 21.1a and 21.1e models: status quo (21.1a and 21.1e), GMACS estimated (GMACS_EST [a]), one function call run with GMACS input parameters [b], full run with GMACS input parameters [c], and full run with GMACS input parameters but starting with the status quo model's initial parameter values [d].

Table E.1. Comparison of likelihood values among GMACS and modified 21.1a models (i.e., 21.7c model with two catchability and SDs) for EAG.

Likelihood Components:	[a] EAG21.7c Par. created input values GMACS_EST	[b] EAG21.7c_GAMACSinput.tpl one function call (parameters based on GMACS _EST)	[c] EAG21.7c_GAMACSinput.tpl full run	[d] EAG21.7c_GAMACSinput.tpl full run but starting from default initial parameters
like_retlencomp	318.6441156	318.606	317.834	317.834
like_totallencomp	503.6018179	503.592	504.156	504.156
like_gdiscdlencomp				
like_retcpue	-28.99600573	-29.0042	-28.6213	-28.6213
like_fishtickcpue	-15.7595163	-11.7325	-15.169	-15.169
like_retdcatchB	-411.9564351	-411.949	-411.944	-411.944
like_totalcatchB	-41.49774683	-41.4995	-41.1742	-41.1742
like_gdiscdcatchB	29.40601446	29.406	29.4061	29.4061
like_rec_dev	20.22514081	20.2271	20.1516	20.1516
like_F		0.0132587	0.0130961	0.0130961
like_gF		0.0230273	0.0229891	0.0229891
	0.03628605			
like_LLyr	2699.969307	2699.97	2700.2	2700.2
like_fpen		1.90943E-08	1.91031E-08	1.91031E-08
Total Likelihood	**3073.672978**	**3077.652186**	**3074.875285**	**3074.875285**
Reference Points:				
BMSY (B35)	7142.544233	6975.5	6903.98	6903.98
CurrB/B35	1.1042842	1.12867178	1.12069415	1.12069415
F35	0.5860294	0.59	0.6	0.6
Fofl	0.5860294	0.59	0.6	0.6
OFL	2943.906215	2959.46	2901.16	2901.16
R0 (millions)	2.587549428	2.587549428	2.566923846	2.566923846

Table E.2. Comparison of likelihood values among GMACS and modified 21.1e models (i.e., 21.8c model with three catchability and SDs) for EAG.

Likelihood Components:	[a] EAG21.8c Par. created input values GMACS_EST	[b] EAG21.8c_GAMACSinput.tpl one function call (parameters based on GMACS _EST)	[c] EAG21.8c_GAMACSinput.tpl full run	[d] EAG21.8c_GAMACSinput.tpl full run but starting from default initial parameters
like_retlencomp	316.3569864	316.319	316.336	316.336
like_totallencomp	501.4957007	501.486	501.46	501.46
like_gdiscdlencomp				
like_retcpue	-28.90113145	-28.9108	-28.9054	-28.9054
like_fishtickcpue	-15.77740218	-15.8366	-15.8379	-15.8379
like_retdcatchB	-411.9236521	-411.917	-411.919	-411.919
like_totalcatchB	-41.33748656	-41.3393	-41.3265	-41.3265
like_gdiscdcatchB	29.40598415	29.406	29.406	29.406
like_rec_dev	20.24122611	20.2432	20.2414	20.2414
like_F		0.0132328	0.0132356	0.0132356
like_gF		0.023096	0.0230935	0.0230935
	0.03632873			
like_LLyr	2700.108173	2700.11	2700.1	2700.1
like_fpen		1.90933E-08	1.90936E-08	1.90936E-08
Total Likelihood	**3069.704727**	**3069.596829**	**3069.590929**	**3069.590929**
Reference Points:	7121.802647	6918.71	6918.55	6918.55
BMSY (B35)	1.09457993	1.121154088	1.121925837	1.121925837
CurrB/B35	0.58922913	0.6	0.6	0.6
F35	0.58922913	0.6	0.6	0.6
Fofl	2896.412693	2937.83	2940.05	2940.05
OFL				
R0 (millions)	2.580470408	2.580470408	2.580319637	2.580319637

Table E.3. Comparison of likelihood values among GMACS and modified 21.1a models (i.e., 21.7c model with two catchability and SDs) for WAG.

Likelihood Components:	[a] WAG21.7c Par. created input values GMACS_EST	[b] WAG21.7c_GAMACSinput.tpl one function call (parameters based on GMACS _EST)	[c] WAG21.7c_GAMACSinput.tpl full run	[d] WAG21.7c_GAMACSinput.tpl full run but starting from default initial parameters
like_retlencomp	381.7845152	381.691	382.44	382.44
like_totallencomp	431.0681288	431.053	431.373	431.373
like_gdiscdlencomp				
like_retcpue	-42.75222692	-42.7796	-42.263	-42.263
like_fishtickcpue	-20.22331808	-19.2691	-20.536	-20.536
like_retdcatchB	-410.5541151	-410.553	-410.654	-410.654
like_totalcatchB	14.1756849	14.1786	13.6086	13.6086
like_gdiscdcatchB	29.40729558	29.4073	29.4072	29.4072
like_rec_dev	19.17847279	19.1842	19.2199	19.2199
like_F		0.0265178	0.026537	0.026537
like_gF		0.0420889	0.0419957	0.0419957
	0.0686067			
like_LLyr	2704.545953	2704.55	2704.25	2704.25
like_fpen		1.93905E-08	1.93875E-08	1.93875E-08
Total Likelihood	**3106.698997**	**3107.531007**	**3106.914233**	**3106.914233**
Reference Points:				
BMSY (B35)	5238.0768	5303.54	5309.84	5309.84
CurrB/B35	0.9302	0.919570702	0.922790517	0.922790517
F35	0.55536261	0.56	0.56	0.56
Fofl	0.51229332	0.509955	0.511958	0.511958
OFL	1249.347444	1244.76	1265.24	1265.24
R0 (millions)	2.190792107	2.190792107	2.194363123	2.194363123

Table E.4. Comparison of likelihood values among GMACS and modified 21.1e models (i.e., 21.8c model with two catchability and SDs) for WAG.

Likelihood Components:	[a] WAG21.8c Par. created input values GMACS_EST	[b] WAG21.8c_GAMACSinput.tpl one function call (parameters based on GMACS _EST)	[c] WAG21.8c_GAMACSinput.tpl full run	[d] WAG21.8c_GAMACSinput.tpl full run but starting from default initial parameters
like_retlencomp	382.7006646	382.606	382.674	382.674
like_totallencomp	430.587691	430.571	430.52	430.52
like_gdiscdlencomp				
like_retcpue	-45.0280499	-45.0548	-45.0507	-45.0507
like_fishtickcpue	-20.04119896	-20.0584	-20.0525	-20.0525
like_retdcatchB	-410.4871009	-410.485	-410.483	-410.483
like_totalcatchB	14.28756725	14.2904	14.2779	14.2779
like_gdiscdcatchB	29.40703245	29.407	29.407	29.407
like_rec_dev	19.2957958	19.3017	19.302	19.302
like_F		0.0266282	0.0266348	0.0266348
like_gF		0.0420758	0.0420693	0.0420693
	0.068704			
like_LLyr	2704.059236	2704.06	2704.04	2704.04
like_fpen		1.9397E-08	1.93975E-08	1.93975E-08
Total Likelihood	**3104.850341**	**3104.706604**	**3104.703404**	**3104.703404**
Reference Points:				
BMSY (B35)	5111.861877	5303.12	5302.87	5302.87
CurrB/B35	0.8887944	0.907720361	0.907838586	0.907838586
F35	0.4990325	0.56	0.56	0.56
Fofl	0.43737117	0.502581	0.502656	0.502656
OFL	1086.574152	1218.69	1219	1219
R0 (millions)	2.195165036	2.195165036	2.194955606	2.194955606

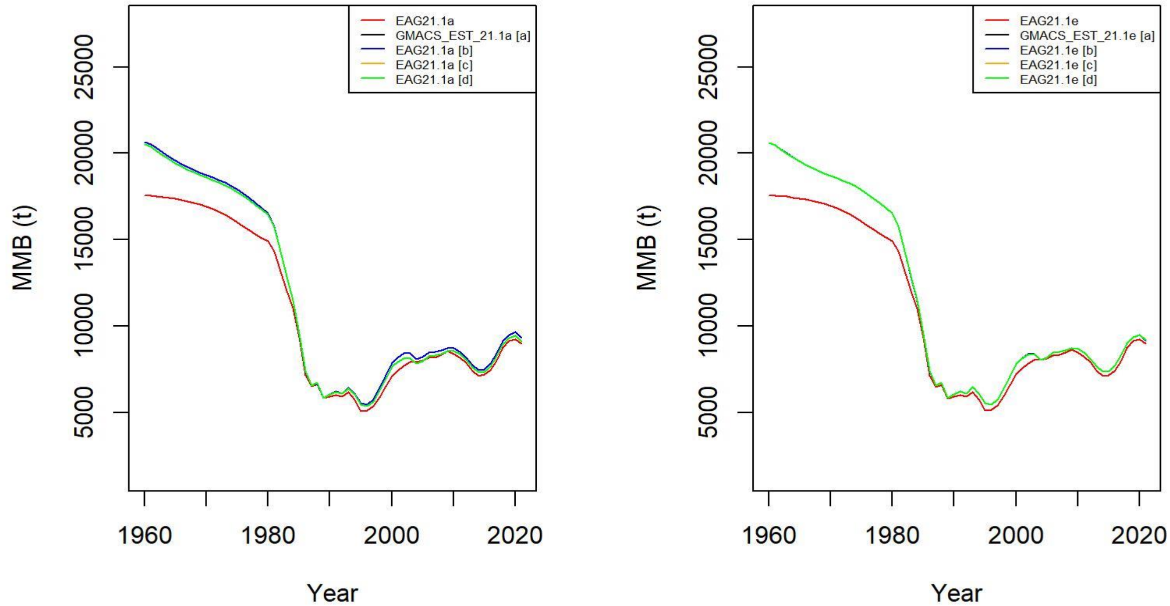


Figure E.1. Comparison of MMB trends for EAG golden king crab, 1960–2021 (black: GMACS_EST [a]; red: status quo model, EAG21.1a (left panel) or EAG21.1e (right panel); blue: one function call with GMACS input parameters [b]; orange: full run with GMACS input parameters [c]; and green: full run with GMACS input parameters but starting with status quo model's initial parameter values [d].

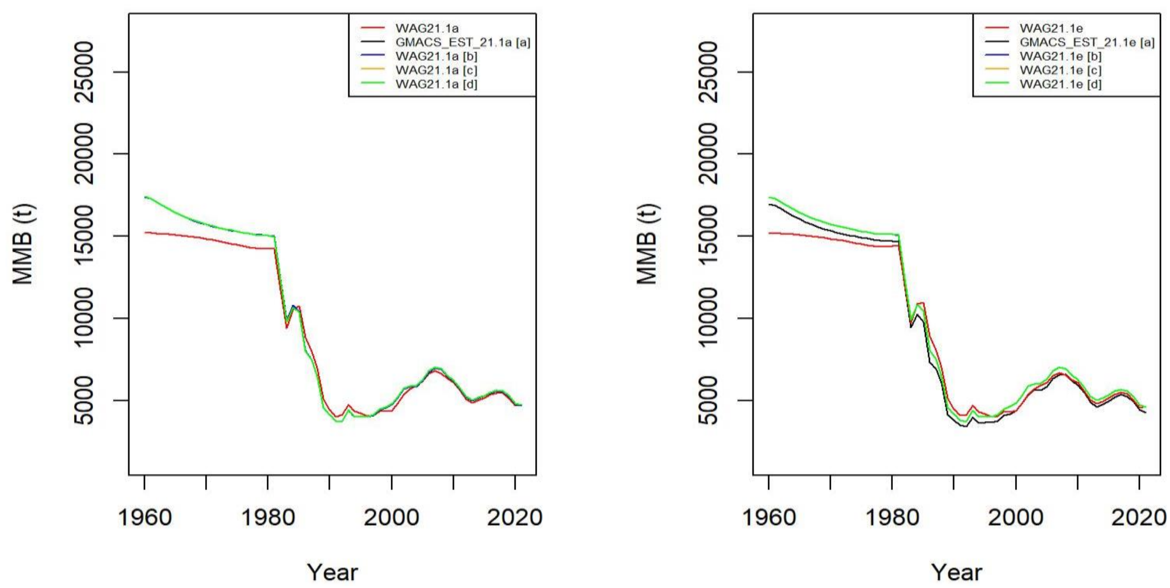


Figure E.2. Comparison of MMB trends for WAG golden king crab, 1960–2021 (black: GMACS_EST [a]; red: status quo model, WAG21.1a (left panel) or WAG21.1e (right panel); blue: one function call with GMACS input parameters [b]; orange: full run with GMACS input parameters [c]; and green: full run with GMACS input parameters but starting with status quo model's initial parameter values [d].

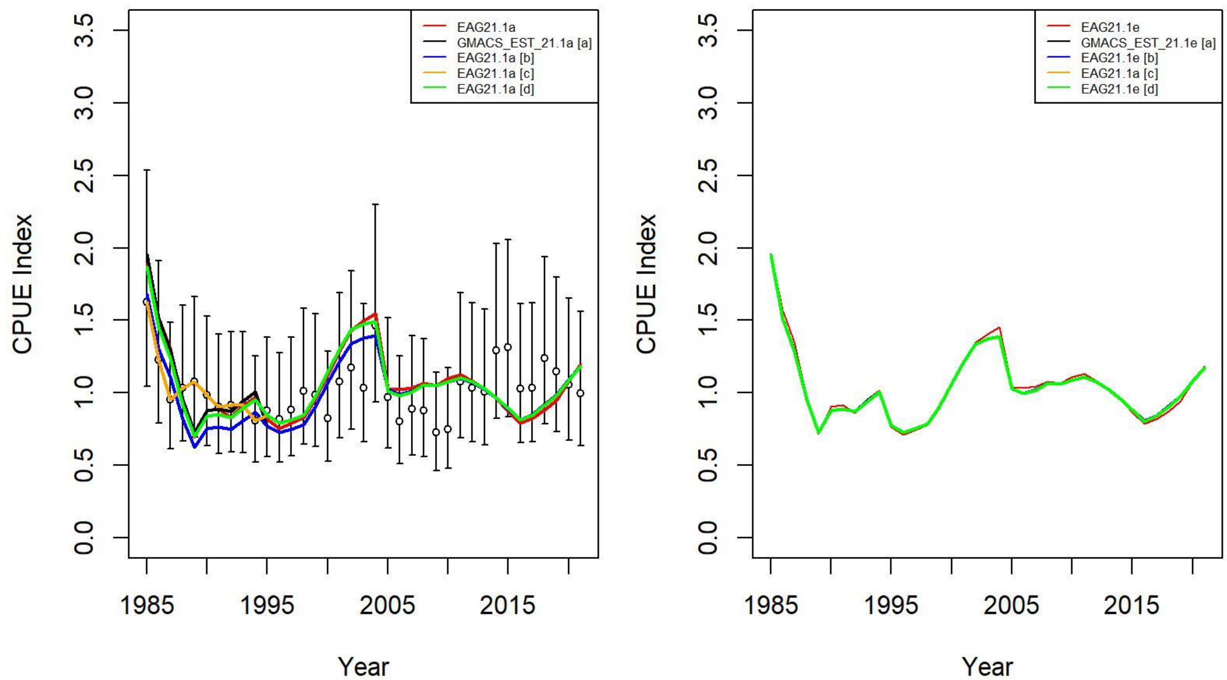


Figure E.3. Comparison of CPUE trends for EAG golden king crab, 1985–2021 (black: GMACS_EST [a]; red: status quo model, EAG21.1a (left panel) and EAG21.1e (right panel); blue: one function call with GMACS input parameters [b]; orange: full run with GMACS input parameters [c]; and green: full run with GMACS input parameters but starting with status quo model's initial parameter values [d]. Observed CPUE indices are shown in black circles with two-standard error confidence intervals.

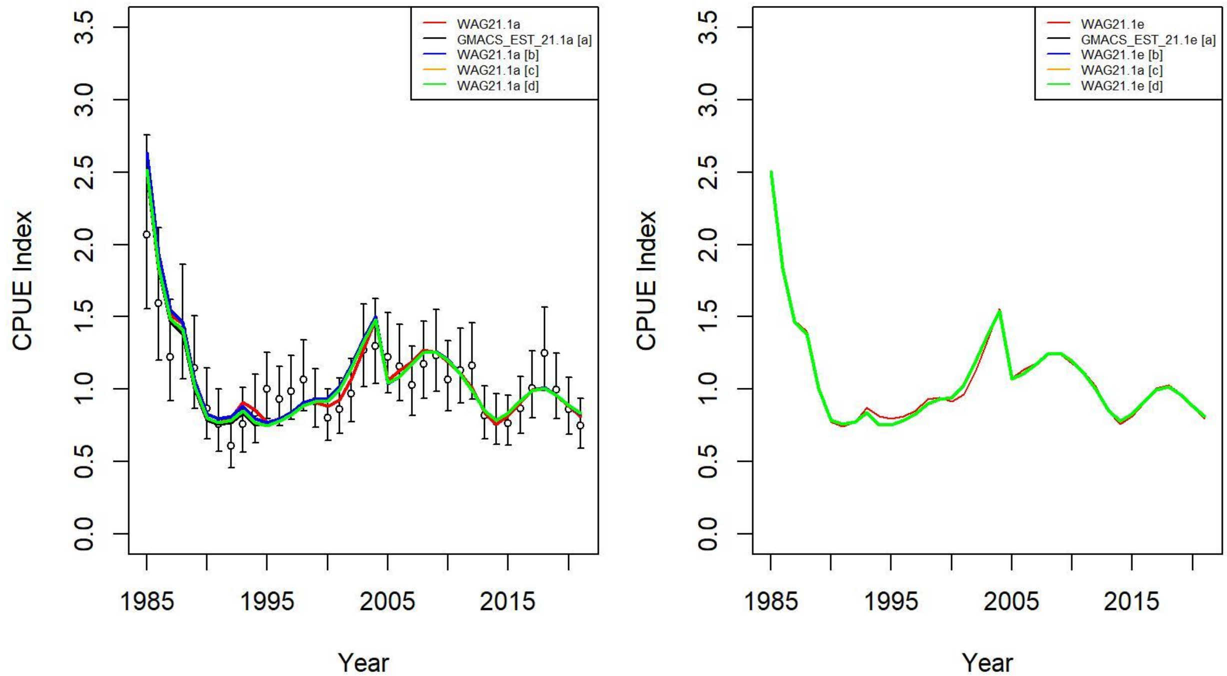


Figure E.4. Comparison of CPUE trends for WAG golden king crab, 1985–2021 (black: GMACS_EST [a]; red: status quo model, WAG21.1a (left panel) and WAG21.1e (right panel); blue: one function call with GMACS input parameters [b]; orange: full run with GMACS input parameters [c]; and green: full run with GMACS input parameters but starting with status quo model's initial parameter values [d]. Observed CPUE indices are shown in black circles with two-standard error confidence intervals.

Input data file for model 21.1a

1. *WAG21.1a dat file*

```
#==========================================================================================
=============
# Gmacs Main Data  File  Version 1.1
#
# GEAR_   INDEX   DESCRIPTION
#   1       :   Pot fishery Retained catch
#   2       :   Pot fishery total catch
#   3       :   Trawl bycatch
#   4       :   Observer CPUE
#   5       :   Fishery CPUE

# Fisheries:  1 Pot Fishery, 2 Pot Total
# Cooperative Survey:
#==========================================================================================
=============

1960 # initial (start year)
2021 # terminal (end year)
#2022 # Projection year (for forecast, OFL and ABC calculation)
6     # Number of seasons: season1 for N est, season 2 for Jul 1 to MidFishing, season 3 for inst. remove C, season 4 for to
spawning time, Feb15, season 5 for inst remove byc&estimate MMB, season 6 for remaining time to June 30 and R enter
2     # Number of distinct data groups or number of fleets (pot fishing, groundfish fishing)
```

```
1    # Number of sexes (males)
1    # Number of shell condition types
1    # Number of maturity types
17    # Number of size-classes in the model
6    # Season when recruitment occurs, end of year before growth
6    # Season when molting and growth occur, end of year after recruitment
5    # Season to calculate MMB
1    # Season for N output
# maximum size-class (males then females)
17
# size_breaks (a vector giving the break points between size intervals with dimension nclass+1, lower limits of bins)
100.5 105.5 110.5 115.5 120.5 125.5 130.5 135.5 140.5 145.5 150.5 155.5 160.5 165.5 170.5 175.5 180.5 185.5
# Natural mortality per season input type (1 = vector by season, 2 = matrix by season/year)
2
# Proportion of the total natural mortality to be applied each season (each row must add to 1)
# 1 Start biological year (Jul 1) instantaneous N estimation
# 2 to mid-fishing time
# 3 instantanous C removal
# 4 to spawning time
# 5 instantaneous byc removal and estimate MMB
# 6 Rest of the period of non-fishing from Feb 15 to June 30
#
#
#Ins N Jul1-MidFish   Inst C    MidFish-15Feb   Ins byc    Rest up to end
 0.     0.16666667    0.     0.46073059    0.     0.37260274    #1960
 0.     0.16666667    0.     0.46073059    0.     0.37260274    #1961
 0.     0.16666667    0.     0.46073059    0.     0.37260274    #1962
 0.     0.16666667    0.     0.46073059    0.     0.37260274    #1963
 0.     0.16666667    0.     0.46073059    0.     0.37260274    #1964
 0.     0.16666667    0.     0.46073059    0.     0.37260274    #1965
 0.     0.16666667    0.     0.46073059    0.     0.37260274    #1966
 0.     0.16666667    0.     0.46073059    0.     0.37260274    #1967
 0.     0.16666667    0.     0.46073059    0.     0.37260274    #1968
 0.     0.16666667    0.     0.46073059    0.     0.37260274    #1969
 0.     0.16666667    0.     0.46073059    0.     0.37260274    #1970
 0.     0.16666667    0.     0.46073059    0.     0.37260274    #1971
 0.     0.16666667    0.     0.46073059    0.     0.37260274    #1972
 0.     0.16666667    0.     0.46073059    0.     0.37260274    #1973
 0.     0.16666667    0.     0.46073059    0.     0.37260274    #1974
 0.     0.16666667    0.     0.46073059    0.     0.37260274    #1975
 0.     0.16666667    0.     0.46073059    0.     0.37260274    #1976
 0.     0.16666667    0.     0.46073059    0.     0.37260274    #1977
 0.     0.16666667    0.     0.46073059    0.     0.37260274    #1978
 0.     0.16666667    0.     0.46073059    0.     0.37260274    #1979
 0.     0.16666667    0.     0.46073059    0.     0.37260274    #1980
 0.     0.62739726    0.     0.                0.     0.37260274    #1981
 0.     0.564383562    0.     0.063013698    0.     0.37260274    #1982
 0.     0.578082192    0.     0.049315068    0.     0.37260274    #1983
 0.     0.62739726    0.     0.                0.     0.37260274    #1984
 0.     0.62739726    0.     0.                0.     0.37260274    #1985
 0.     0.62739726    0.     0.                0.     0.37260274    #1986
 0.     0.62739726    0.     0.                0.     0.37260274    #1987
 0.     0.62739726    0.     0.                0.     0.37260274    #1988
 0.     0.62739726    0.     0.                0.     0.37260274    #1989
 0.     0.62739726    0.     0.                0.     0.37260274    #1990
 0.     0.62739726    0.     0.                0.     0.37260274    #1991
 0.     0.62739726    0.     0.                0.     0.37260274    #1992
 0.     0.62739726    0.     0.                0.     0.37260274    #1993
 0.     0.62739726    0.     0.                0.     0.37260274    #1994
 0.     0.62739726    0.     0.                0.     0.37260274    #1995
 0.     0.62739726    0.     0.                0.     0.37260274    #1996
 0.     0.62739726    0.     0.                0.     0.37260274    #1997
```

```
 0.     0.62739726     0.     0.                    0.     0.37260274     #1998
 0.     0.62739726     0.     0.                    0.     0.37260274     #1999
 0.     0.516438356    0.     0.110958904    0.     0.37260274     #2000
 0.     0.435616438    0.     0.191780822    0.     0.37260274     #2001
 0.     0.405479452    0.     0.221917808    0.     0.37260274     #2002
 0.     0.364383562    0.     0.263013698    0.     0.37260274     #2003
 0.     0.317808219    0.     0.309589041    0.     0.37260274     #2004
 0.     0.430136986    0.     0.197260274    0.     0.37260274     #2005
 0.     0.494520548    0.     0.132876712    0.     0.37260274     #2006
 0.     0.530136986    0.     0.097260274    0.     0.37260274     #2007
 0.     0.505479452    0.     0.121917808    0.     0.37260274     #2008
 0.     0.524657534    0.     0.102739726    0.     0.37260274     #2009
 0.     0.436986301    0.     0.190410959    0.     0.37260274     #2010
 0.     0.471232877    0.     0.156164383    0.     0.37260274     #2011
 0.     0.504109589    0.     0.123287671    0.     0.37260274     #2012
 0.     0.509589041    0.     0.117808219    0.     0.37260274     #2013
 0.     0.501369863    0.     0.126027397    0.     0.37260274     #2014
 0.     0.463013699    0.     0.164383561    0.     0.37260274     #2015
 0.     0.42739726     0.     0.2                   0.     0.37260274     #2016
 0.     0.383561644    0.     0.243835616    0.     0.37260274     #2017
 0.     0.394520548    0.     0.232876712    0.     0.37260274     #2018
 0.     0.456164384    0.     0.171232876    0.     0.37260274     #2019
 0.     0.490410959    0.     0.136986301    0.     0.37260274     #2020
 0.     0.390410959    0.     0.236986301    0.     0.37260274     #2021
#
#
# Fishing fleet names (delimited with: no spaces in names)
Pot_Fishery Trawl_Bycatch
# Survey names (delimited with: no spaces in names) keep empty

# Are the seasons discrete-instantaneous (0) or continuous (1)
1 1 1 1 1 1
# Number of catch data frames
3
# Number of rows in  each  data  frame
# up to 2021/22 data
# retained catch 1981/82-2021/22
 41  32  32
## no groundfish bycatch in 1993, this year is omitted
##  CATCH DATA in t
##  Type of catch: 1 = retained, 2 = discard, 0= total (retained+discard, slide says 3)
##  Units of catch: 1 = biomass, 2 = numbers
# Mult: 1= use data as thy are, 2 = multiply by this number (e.g., lbs to kg)

##  Retained Catch from 1985- in tonnes
#year  seas   fleet   sex       obs   cv   type    units   mult    effort  discard_mortality
 1981    3      1      1      38.436   0.0316  1      2      1      0       0.2
 1982    3      1      1      1114.351 0.0316  1      2      1      0       0.2
 1983    3      1      1      1288.357 0.0316  1      2      1      0       0.2
 1984    3      1      1      188.782 0.0316  1      2      1      0       0.2
 1985    3      1      1      2029.52 0.0316  1      1      1      0       0.2
 1986    3      1      1      4271.83 0.0316  1      1      1      0       0.2
 1987    3      1      1      2535.35 0.0316  1      1      1      0       0.2
 1988    3      1      1      2471.07 0.0316  1      1      1      0       0.2
 1989    3      1      1      3062.63 0.0316  1      1      1      0       0.2
 1990    3      1      1      1636.5  0.0316  1      1      1      0       0.2
 1991    3      1      1      1359.1  0.0316  1      1      1      0       0.2
 1992    3      1      1      1030.34 0.0316  1      1      1      0       0.2
 1993    3      1      1      668.56  0.0316  1      1      1      0       0.2
 1994    3      1      1      1625.55 0.0316  1      1      1      0       0.2
 1995    3      1      1      1192.2  0.0316  1      1      1      0       0.2
 1996    3      1      1      1236.74 0.0316  1      1      1      0       0.2
```

```
 1997   3   1   1   1067.44 0.0316  1   1   1   0   0.2
 1998   3   1   1   934.631 0.0316  1   1   1   0   0.2
 1999   3   1   1   1240.37 0.0316  1   1   1   0   0.2
 2000   3   1   1   1385.08 0.0316  1   1   1   0   0.2
 2001   3   1   1   1287.63 0.0316  1   1   1   0   0.2
 2002   3   1   1   1217.19 0.0316  1   1   1   0   0.2
 2003   3   1   1   1249.26 0.0316  1   1   1   0   0.2
 2004   3   1   1   1265.9  0.0316  1   1   1   0   0.2
 2005   3   1   1   1237.6  0.0316  1   1   1   0   0.2
 2006   3   1   1   1055.97 0.0316  1   1   1   0   0.2
 2007   3   1   1   1241.73 0.0316  1   1   1   0   0.2
 2008   3   1   1   1218.89 0.0316  1   1   1   0   0.2
 2009   3   1   1   1348.46 0.0316  1   1   1   0   0.2
 2010   3   1   1   1353.82 0.0316  1   1   1   0   0.2
 2011   3   1   1   1349.85 0.0316  1   1   1   0   0.2
 2012   3   1   1   1420.14 0.0316  1   1   1   0   0.2
 2013   3   1   1   1456.44 0.0316  1   1   1   0   0.2
 2014   3   1   1   1266.43 0.0316  1   1   1   0   0.2
 2015   3   1   1   1180.31 0.0316  1   1   1   0   0.2
 2016   3   1   1   1050.05 0.0316  1   1   1   0   0.2
 2017   3   1   1   1054.43 0.0316  1   1   1   0   0.2
 2018   3   1   1   1184.49 0.0316  1   1   1   0   0.2
 2019   3   1   1   1309.4  0.0316  1   1   1   0   0.2
 2020   3   1   1   1358.32 0.0316  1   1   1   0   0.2
 2021   3   1   1   1223.36 0.0316  1   1   1   0   0.2
#
## Total Catch (no mortality applied) in tonnes
#year  seas   fleet   sex      obs      cv   type   units   mult   effort  discard_mortality
     1990   3   1   1   3981.87 0.207908162   0   1   1   0   0.2
     1991   3   1   1   2118.23 0.130117339   0   1   1   0   0.2
       1992   3   1   1   1039.24 0.145158877   0   1   1   0   0.2
       1993   3   1   1   3601.26 0.293606298   0   1   1   0   0.2
       1994   3   1   1   5053.58 0.106740581   0   1   1   0   0.2
       1995   3   1   1   2618.76 0.050729769   0   1   1   0   0.2
       1996   3   1   1   1972.19 0.04474373   0   1   1   0   0.2
       1997   3   1   1   1891.86 0.060142043   0   1   1   0   0.2
       1998   3   1   1   1106.87 0.087743921   0   1   1   0   0.2
       1999   3   1   1   2178.04 0.056445899   0   1   1   0   0.2
       2000   3   1   1   2272.72 0.055136691   0   1   1   0   0.2
       2001   3   1   1   2154.96 0.056882141   0   1   1   0   0.2
       2002   3   1   1   1900.34 0.075835543   0   1   1   0   0.2
       2003   3   1   1   1867.22 0.065763685   0   1   1   0   0.2
       2004   3   1   1   1886.02 0.074221412   0   1   1   0   0.2
       2005   3   1   1   1796.25 0.102938855   0   1   1   0   0.2
       2006   3   1   1   1551.24 0.110618989   0   1   1   0   0.2
       2007   3   1   1   1614.06 0.115699625   0   1   1   0   0.2
       2008   3   1   1   1733.15 0.121676438   0   1   1   0   0.2
       2009   3   1   1   1689.85 0.127517984   0   1   1   0   0.2
       2010   3   1   1   1604.74 0.129358495   0   1   1   0   0.2
       2011   3   1   1   1516.82 0.131675973   0   1   1   0   0.2
       2012   3   1   1   1839.08 0.114273251   0   1   1   0   0.2
       2013   3   1   1   1919.09 0.108784133   0   1   1   0   0.2
       2014   3   1   1   1592.18 0.112848388   0   1   1   0   0.2
       2015   3   1   1   1565.39 0.105658441   0   1   1   0   0.2
       2016   3   1   1   1569.99 0.116902199   0   1   1   0   0.2
       2017   3   1   1   1436.59 0.138245859   0   1   1   0   0.2
       2018   3   1   1   1637.42 0.145371921   0   1   1   0   0.2
       2019   3   1   1   1714.12 0.122434679   0   1   1   0   0.2
       2020   3   1   1   1844.19 0.112848388   0   1   1   0   0.2
       2021   3   1   1   1428.94 0.159180092   0   1   1   0   0.2
###
```

```
##        Trawl     fishery    discards (in 1000 crab, handling mortality rate 0.65 is already applied) in tonnes

 1989   3    2    1    0.0953342    1.3108  2    1    1.538461538    0    0.65
 1990   3    2    1    0.569417    1.3108  2    1    1.538461538    0    0.65
 1991   3    2    1    0.0285788    1.3108  2    1    1.538461538    0    0.65
 1992   3    2    1    0.442401    1.3108  2    1    1.538461538    0    0.65
 1994   3    2    1    0.115027    1.3108  2    1    1.538461538    0    0.65
 1995   3    2    1    0.793348    1.3108  2    1    1.538461538    0    0.65
 1996   3    2    1    2.59512    1.3108  2    1    1.538461538    0    0.65
 1997   3    2    1    0.41718    1.3108  2    1    1.538461538    0    0.65
 1998   3    2    1    1.88422    1.3108  2    1    1.538461538    0    0.65
 1999   3    2    1    1.80473    1.3108  2    1    1.538461538    0    0.65
 2000   3    2    1    1.09494    1.3108  2    1    1.538461538    0    0.65
 2001   3    2    1    0.440945    1.3108  2    1    1.538461538    0    0.65
 2002   3    2    1    1.2808    1.3108  2    1    1.538461538    0    0.65
 2003   3    2    1    0.314029    1.3108  2    1    1.538461538    0    0.65
 2004   3    2    1    1.00981    1.3108  2    1    1.538461538    0    0.65
 2005   3    2    1    3.74606    1.3108  2    1    1.538461538    0    0.65
 2006   3    2    1    2.37268    1.3108  2    1    1.538461538    0    0.65
 2007   3    2    1    1.54793    1.3108  2    1    1.538461538    0    0.65
 2008   3    2    1    9.3034    1.3108  2    1    1.538461538    0    0.65
 2009   3    2    1    4.86086    1.3108  2    1    1.538461538    0    0.65
 2010   3    2    1    2.66153    1.3108  2    1    1.538461538    0    0.65
 2011   3    2    1    2.70594    1.3108  2    1    1.538461538    0    0.65
 2012   3    2    1    4.339    1.3108  2    1    1.538461538    0    0.65
 2013   3    2    1    3.7373    1.3108  2    1    1.538461538    0    0.65
 2014   3    2    1    2.65644    1.3108  2    1    1.538461538    0    0.65
 2015   3    2    1    1.61523    1.3108  2    1    1.538461538    0    0.65
 2016   3    2    1    2.47563    1.3108  2    1    1.538461538    0    0.65
 2017   3    2    1    1.1635    1.3108  2    1    1.538461538    0    0.65
 2018   3    2    1    1.76314    1.3108  2    1    1.538461538    0    0.65
 2019   3    2    1    4.04095    1.3108  2    1    1.538461538    0    0.65
 2020   3    2    1    0.807148    1.3108  2    1    1.538461538    0    0.65
 2021   3    2    1    0.805314    1.3108  2    1    1.538461538    0    0.65
#
## RELATIVE ABUNDANCE DATA
## Units of abundance: 1 = biomass, 2 = numbers
## Number of relative abundance indices
## sex:1=male;2=female; 0=both
## maturity: 1=immature;2=mature;0 = both)

# Fishery CPUE index, Observer CPUE index2
3
# Index Type (1=Selectivity; 2=retention)
#
2 2 2
## Number of rows  in  each  index
41
# Fishery CPUE index NB error in GLM fits on Observer and Fish Tick data
# Sex: 1 = male, 2 = female, 0 = both" << endl;
#  Maturity: 1 = immature, 2 = mature, 0 = both
#  Units of survey: 1 = biomass, 2 = numbers
#        Observer CPUE    index
#    Index  Year   Seas   fleet  Sex   maturity   index    cv    abundance unit   timing
     1    1995   3    1    1    0    1.001427527    0.034063946    2    0.5
     1    1996   3    1    1    0    0.929544695    0.022023622    2    0.5
     1    1997   3    1    1    0    0.987686327    0.024180979    2    0.5
     1    1998   3    1    1    0    1.067707402    0.033336582    2    0.5
     1    1999   3    1    1    0    0.917071303    0.024107209    2    0.5
     1    2000   3    1    1    0    0.802399123    0.023965654    2    0.5
     1    2001   3    1    1    0    0.863396862    0.025840362    2    0.5
     1    2002   3    1    1    0    0.969453867    0.027722312    2    0.5
```

```
1 2003 3 1 1 0 1.272957978 0.028325031 2 0.5
1 2004 3 1 1 0 1.299252834 0.028364089 2 0.5
2 2005 3 1 1 0 1.220923247 0.034279197 2 0.5
2 2006 3 1 1 0 1.156132493 0.034515041 2 0.5
2 2007 3 1 1 0 1.029731651 0.040358749 2 0.5
2 2008 3 1 1 0 1.174694993 0.03275597 2 0.5
2 2009 3 1 1 0 1.234857601 0.034965166 2 0.5
2 2010 3 1 1 0 1.065483687 0.03387555 2 0.5
2 2011 3 1 1 0 1.131378881 0.034484736 2 0.5
2 2012 3 1 1 0 1.164533831 0.031469722 2 0.5
2 2013 3 1 1 0 0.816883575 0.028076205 2 0.5
2 2014 3 1 1 0 0.77366268 0.031051906 2 0.5
2 2015 3 1 1 0 0.765568356 0.029718782 2 0.5
2 2016 3 1 1 0 0.866954042 0.031740494 2 0.5
2 2017 3 1 1 0 1.006585702 0.036329047 2 0.5
2 2018 3 1 1 0 1.248491962 0.038249318 2 0.5
2 2019 3 1 1 0 0.995528283 0.033405643 2 0.5
2 2020 3 1 1 0 0.863580034 0.031476455 2 0.5
2 2021 3 1 1 0 0.745497898 0.040162062 2 0.5
#
# Observer CPUE index Year:Area interaction
# Index Year Seas fleet Sex maturity index cv abundance unit timing
# 1 1995 3 1 1 0 1.394268659 0.087621723 2 0.5
# 1 1996 3 1 1 0 1.118072008 0.07787573 2 0.5
# 1 1997 3 1 1 0 0.950329924 0.084940397 2 0.5
# 1 1998 3 1 1 0 0.981032124 0.122112685 2 0.5
# 1 1999 3 1 1 0 0.85428822 0.095166844 2 0.5
# 1 2000 3 1 1 0 0.775282111 0.102584001 2 0.5
# 1 2001 3 1 1 0 0.746724959 0.150628576 2 0.5
# 1 2002 3 1 1 0 0.939727355 0.093006074 2 0.5
# 1 2003 3 1 1 0 1.202203458 0.067589867 2 0.5
# 1 2004 3 1 1 0 1.231463194 0.07264207 2 0.5
# 2 2005 3 1 1 0 1.371447838 0.037959167 2 0.5
# 2 2006 3 1 1 0 0.952169087 0.055860857 2 0.5
# 2 2007 3 1 1 0 1.097479361 0.049006157 2 0.5
# 2 2008 3 1 1 0 1.139729785 0.039051134 2 0.5
# 2 2009 3 1 1 0 1.416566351 0.036454 2 0.5
# 2 2010 3 1 1 0 1.252565059 0.060053196 2 0.5
# 2 2011 3 1 1 0 0.828375821 0.054000658 2 0.5
# 2 2012 3 1 1 0 1.410970926 0.04356449 2 0.5
# 2 2013 3 1 1 0 0.901225865 0.055929374 2 0.5
# 2 2014 3 1 1 0 1.274171963 0.049910158 2 0.5
# 2 2015 3 1 1 0 0.835892025 0.066015695 2 0.5
# 2 2016 3 1 1 0 0.947664221 0.057799989 2 0.5
# 2 2017 3 1 1 0 1.153063759 0.052298951 2 0.5
# 2 2018 3 1 1 0 1.383315458 0.03899236 2 0.5
# 2 2019 3 1 1 0 0.665684875 0.062585486 2 0.5
# 2 2020 3 1 1 0 0.609490936 0.072567467 2 0.5
# 2 2021 3 1 1 0 0.501474465 0.095449482 2 0.5
#
# Index Year Seas fleet Sex maturity index cv abundance unit timing
3 1985 3 1 1 0 2.071043441 0.046182047 2 0.5
3 1986 3 1 1 0 1.593579212 0.040226639 2 0.5
3 1987 3 1 1 0 1.220361839 0.043228444 2 0.5
3 1988 3 1 1 0 1.412211833 0.030208311 2 0.5
3 1989 3 1 1 0 1.145065089 0.026608202 2 0.5
3 1990 3 1 1 0 0.868006925 0.033369069 2 0.5
3 1991 3 1 1 0 0.756009256 0.036578092 2 0.5
3 1992 3 1 1 0 0.609497541 0.040711053 2 0.5
3 1993 3 1 1 0 0.757061057 0.053159356 2 0.5
3 1994 3 1 1 0 0.833857875 0.035619992 2 0.5
3 1995 3 1 1 0 0.895046328 0.038180278 2 0.5
```

3 1996 3 1 1 0 0.835343642 0.031318824 2 0.5
3 1997 3 1 1 0 0.763847986 0.030723148 2 0.5
3 1998 3 1 1 0 1.064769668 0.033983872 2 0.5
#
Number of length frequency matrices
#
2
Number of rows in each matrix
37 32
#
Number of bins in each matrix (columns of size data)
17 17

SIZE COMPOSITION DATA FOR ALL FLEETS
SIZE COMP LEGEND
Sex: 1 = male, 2 = female, 0 = both sexes combined
Type of composition: 1 = retained, 2 = discard, 0 = total composition
Maturity state: 1 = immature, 2 = mature, 0 = both states combined
Shell condition: 1 = new shell, 2 = old shell, 0 = both shell types combined
Type 1 effective sample: Nsamp
Retain catch size comp

updated the effective Ns
##Year, Seas, Fleet, Sex, Type, Shell, Maturity, Nsamp, DataVec

1985 3 1 1 1 0 0 45 0.000000 0.000000 0.000000 0.000000 0.000000 0.001779
0.044090 0.139800 0.188711 0.163604 0.152817 0.127810 0.078532 0.048539 0.033765
0.010007 0.010546
1986 3 1 1 1 0 0 23 0.000000 0.000000 0.000000 0.000000 0.000000 0.007269
0.065322 0.139635 0.160400 0.149577 0.152965 0.117009 0.088900 0.048740 0.041813
0.019731 0.008640
1987 3 1 1 1 0 0 8 0.000000 0.000000 0.000000 0.000000 0.000000 0.005423
0.061702 0.159142 0.191295 0.150047 0.146096 0.098283 0.081854 0.058236 0.032244
0.011334 0.004346
1988 3 1 1 1 0 0 286 0.000000 0.000000 0.000000 0.000000 0.000222 0.007071
0.071516 0.192850 0.244429 0.184985 0.113489 0.074476 0.043376 0.027901 0.014870
0.009961 0.014855
1989 3 1 1 1 0 0 513 0.000014 0.000000 0.000000 0.000013 0.000101 0.003677
0.050292 0.210811 0.266781 0.169976 0.115880 0.079394 0.050048 0.030497 0.013281
0.006376 0.002859
1990 3 1 1 1 0 0 205 0.000017 0.000000 0.000000 0.000000 0.000745 0.011654
0.100154 0.240280 0.225196 0.161285 0.107812 0.071549 0.041358 0.019198 0.009904
0.006302 0.004545
1991 3 1 1 1 0 0 102 0.000000 0.000020 0.000060 0.000325 0.001316 0.007526
0.093017 0.244868 0.245519 0.173825 0.105867 0.061824 0.034887 0.017634 0.008044
0.003539 0.001730
1992 3 1 1 1 0 0 76 0.000000 0.000000 0.000032 0.000000 0.000293 0.003852
0.060350 0.197759 0.237800 0.199371 0.131348 0.080404 0.045223 0.024627 0.012611
0.004512 0.001816
1993 3 1 1 1 0 0 378 0.000000 0.000000 0.000000 0.000000 0.000162 0.001564
0.030740 0.173187 0.272635 0.232143 0.144654 0.070916 0.043269 0.019418 0.008295
0.002175 0.000843
1994 3 1 1 1 0 0 367 0.000000 0.000000 0.000127 0.000000 0.000024 0.001784
0.046992 0.177933 0.253944 0.198165 0.133629 0.084930 0.053384 0.028682 0.013116
0.005872 0.001417
1995 3 1 1 1 0 0 705 0.000044 0.000000 0.000334 0.000000 0.000238 0.001792
0.047010 0.189629 0.247586 0.194753 0.130339 0.082564 0.051882 0.030110 0.014359
0.006334 0.003027
1996 3 1 1 1 0 0 817 0.000000 0.000000 0.000000 0.000000 0.000000 0.003134
0.068075 0.206839 0.229461 0.192799 0.127056 0.075589 0.048745 0.028763 0.012721
0.005090 0.001728

1997 3 1 1 1 0 0 984 0.000000 0.000000 0.000000 0.000000 0.000078 0.003000
0.059292 0.204909 0.240721 0.186437 0.125003 0.075450 0.047468 0.029456 0.015703
0.007907 0.004577
1998 3 1 1 1 0 0 613 0.000000 0.000000 0.000000 0.000108 0.000000 0.002820
0.057800 0.218632 0.266244 0.203012 0.122690 0.067337 0.033865 0.016304 0.006846
0.002719 0.001625
1999 3 1 1 1 0 0 915 0.000000 0.000000 0.000000 0.000000 0.000000 0.002046
0.043548 0.178562 0.266933 0.224152 0.139925 0.077925 0.041227 0.017160 0.005705
0.001947 0.000868
2000 3 1 1 1 0 0 1029 0.000000 0.000000 0.000000 0.000055 0.000000
0.002742 0.054185 0.194604 0.239411 0.192948 0.137152 0.080274 0.048645 0.026673
0.014585 0.005697 0.003029
2001 3 1 1 1 0 0 898 0.000000 0.000000 0.000028 0.000000 0.000103 0.001500
0.045630 0.199267 0.265957 0.214346 0.135542 0.067145 0.038974 0.019746 0.007561
0.002942 0.001260
2002 3 1 1 1 0 0 628 0.000000 0.000000 0.000000 0.000000 0.000071 0.001663
0.058986 0.218218 0.276414 0.210594 0.128255 0.057707 0.027606 0.012857 0.005319
0.001734 0.000576
2003 3 1 1 1 0 0 688 0.000000 0.000000 0.000000 0.000000 0.000000 0.001895
0.049682 0.218629 0.275161 0.207658 0.127200 0.062539 0.033554 0.014795 0.005876
0.001916 0.001094
2004 3 1 1 1 0 0 449 0.000000 0.000000 0.000000 0.000000 0.000066 0.001215
0.051327 0.215030 0.283751 0.206811 0.118840 0.062679 0.034830 0.015537 0.006658
0.002026 0.001232
2005 3 1 1 1 0 0 337 0.000000 0.000000 0.000000 0.000000 0.000000 0.000485
0.034904 0.172732 0.257658 0.206822 0.147408 0.082432 0.046486 0.023695 0.016908
0.007266 0.003203
2006 3 1 1 1 0 0 337 0.000000 0.000000 0.000000 0.000000 0.000000 0.000450
0.027936 0.136486 0.228954 0.196611 0.161660 0.101178 0.070427 0.041574 0.022708
0.007786 0.004229
2007 3 1 1 1 0 0 276 0.000000 0.000000 0.000000 0.000000 0.000000 0.000573
0.025731 0.129360 0.206093 0.190896 0.150598 0.112913 0.084343 0.052940 0.026878
0.013391 0.006285
2008 3 1 1 1 0 0 318 0.000000 0.000000 0.000000 0.000000 0.000348 0.002243
0.027529 0.124737 0.196394 0.189950 0.164574 0.103519 0.086701 0.053975 0.030228
0.014680 0.005122
2009 3 1 1 1 0 0 362 0.000000 0.000000 0.000000 0.000147 0.000000 0.000396
0.019110 0.111051 0.187521 0.179921 0.154035 0.115423 0.089833 0.066136 0.043036
0.021639 0.011753
2010 3 1 1 1 0 0 328 0.000000 0.000000 0.000000 0.000000 0.000000 0.000358
0.017161 0.105370 0.182360 0.188782 0.144264 0.119206 0.095711 0.066710 0.043825
0.021922 0.014333
2011 3 1 1 1 0 0 295 0.000000 0.000000 0.000000 0.000000 0.000000 0.000810
0.020228 0.112176 0.167129 0.181274 0.144850 0.118773 0.084588 0.072303 0.044293
0.029024 0.024552
2012 3 1 1 1 0 0 288 0.000000 0.000000 0.000000 0.000000 0.000000 0.000395
0.024683 0.124402 0.203529 0.191267 0.147574 0.100955 0.078569 0.053528 0.034691
0.021014 0.019392
2013 3 1 1 1 0 0 327 0.000000 0.000000 0.000000 0.000000 0.000000 0.000770
0.010442 0.109425 0.195364 0.216476 0.161229 0.106223 0.083860 0.044186 0.032530
0.022399 0.017097
2014 3 1 1 1 0 0 305 0.000000 0.000000 0.000000 0.000000 0.000000 0.004066
0.037110 0.180855 0.211485 0.187740 0.134732 0.098282 0.060790 0.042639 0.025869
0.010910 0.005522
2015 3 1 1 1 0 0 287 0.000000 0.000000 0.000000 0.000000 0.000000 0.002504
0.047044 0.200801 0.235189 0.201087 0.132490 0.077399 0.050622 0.029030 0.014841
0.006719 0.002275
2016 3 1 1 1 0 0 408 0.000000 0.000000 0.000000 0.000000 0.000000 0.001173
0.034989 0.166920 0.240724 0.240546 0.141610 0.084137 0.044617 0.024752 0.012436
0.004111 0.003987

2017 3 1 1 1 0 0 309 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
0.026198 0.132743 0.240004 0.210512 0.147671 0.085251 0.066069 0.037995 0.028973
0.013134 0.011450
2018 3 1 1 1 0 0 291 0.000000 0.000000 0.000000 0.000000 0.000000 0.000420
0.017810 0.131101 0.220574 0.212039 0.150588 0.102787 0.078363 0.040693 0.024314
0.011658 0.009653
2019 3 1 1 1 0 0 363 0.000000 0.000000 0.000000 0.000000 0.000000 0.000307
0.035200 0.156779 0.210296 0.197707 0.148367 0.099119 0.068591 0.044726 0.021362
0.009767 0.007780
2020 3 1 1 1 0 0 462 0.000000 0.000000 0.000000 0.000000 0.000000 0.000927
0.030215 0.152912 0.222099 0.217881 0.156945 0.094998 0.056883 0.032933 0.015328
0.010220 0.008659
2021 3 1 1 1 0 0 276 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
0.000000 0.034082 0.150399 0.272690 0.224463 0.139758 0.073403 0.055048 0.026029
0.013024 0.011104
#

Total catch size comp

##Year, Seas, Fleet, Sex, Type, Shell, Maturity, Nsamp, DataVec

1990 3 1 1 0 0 0 190 0.073723 0.037744 0.074999 0.099097 0.136722 0.126059
0.088265 0.115790 0.111761 0.059640 0.034428 0.017535 0.013921 0.004977 0.003855
0.001181 0.000303
1991 3 1 1 0 0 0 104 0.096404 0.051878 0.061314 0.083508 0.105582 0.100280
0.102537 0.114662 0.087464 0.067187 0.051284 0.034247 0.020591 0.012858 0.006978
0.002687 0.000538
1992 3 1 1 0 0 0 94 0.079726 0.049518 0.069939 0.087556 0.105016 0.119770
0.116330 0.112379 0.094493 0.068848 0.042286 0.023299 0.017246 0.008540 0.003530
0.000838 0.000687
1993 3 1 1 0 0 0 62 0.121791 0.042920 0.064769 0.077288 0.089026 0.107617
0.117426 0.107186 0.091436 0.065800 0.042802 0.028239 0.022022 0.012282 0.005602
0.003170 0.000626
1994 3 1 1 0 0 0 119 0.066496 0.049957 0.067777 0.085620 0.106072 0.117794
0.124808 0.116776 0.099023 0.072835 0.045616 0.022693 0.013824 0.006108 0.003327
0.000861 0.000413
1995 3 1 1 0 0 0 907 0.080756 0.049247 0.072127 0.092308 0.112362 0.125326
0.121283 0.099034 0.081259 0.062131 0.041858 0.025905 0.016817 0.009929 0.005837
0.002474 0.001347
1996 3 1 1 0 0 0 1061 0.082275 0.038679 0.056039 0.078576 0.100896
0.124295 0.134849 0.120441 0.098377 0.071348 0.042048 0.023961 0.013812 0.007821
0.004035 0.001784 0.000764
1997 3 1 1 0 0 0 1116 0.080978 0.039608 0.051963 0.063377 0.080001
0.101270 0.135498 0.132965 0.113869 0.082249 0.049586 0.029005 0.017170 0.010643
0.006221 0.003020 0.002578
1998 3 1 1 0 0 0 638 0.087015 0.040996 0.054184 0.070011 0.086055 0.107547
0.143589 0.144568 0.110830 0.078667 0.039396 0.020540 0.010236 0.004139 0.001729
0.000353 0.000147
1999 3 1 1 0 0 0 1155 0.081455 0.038718 0.049565 0.063788 0.084574
0.105371 0.136417 0.137135 0.121003 0.084173 0.050367 0.024776 0.013410 0.005585
0.002380 0.000769 0.000514
2000 3 1 1 0 0 0 1205 0.072479 0.042978 0.058080 0.073338 0.093337
0.113380 0.146386 0.138684 0.107669 0.069622 0.040483 0.021565 0.011482 0.005701
0.003132 0.001041 0.000646
2001 3 1 1 0 0 0 975 0.049286 0.031510 0.046993 0.063469 0.090186 0.118498
0.157525 0.154639 0.123625 0.079205 0.043222 0.020092 0.012046 0.005514 0.002946
0.000824 0.000420
2002 3 1 1 0 0 0 675 0.047331 0.032284 0.043441 0.064482 0.087664 0.117964
0.158845 0.166755 0.124707 0.078778 0.040296 0.020333 0.009699 0.004525 0.001844
0.000655 0.000398

2003 3 1 1 0 0 0 700 0.016189 0.011304 0.022617 0.036805 0.062889 0.104034
0.162054 0.182594 0.156066 0.109519 0.069831 0.032289 0.019024 0.009046 0.004020
0.001330 0.000389
2004 3 1 1 0 0 0 488 0.032771 0.018499 0.029570 0.047925 0.071922 0.113717
0.162668 0.168980 0.146838 0.097763 0.054618 0.026791 0.016067 0.007368 0.003084
0.001112 0.000308
2005 3 1 1 0 0 0 220 0.007212 0.008105 0.014298 0.025638 0.042285 0.073538
0.139454 0.189359 0.185166 0.143660 0.086222 0.043347 0.024407 0.008869 0.005534
0.001977 0.000929
2006 3 1 1 0 0 0 321 0.008564 0.007975 0.014338 0.021177 0.035049 0.061568
0.118027 0.166774 0.179629 0.146809 0.101694 0.063956 0.039424 0.020687 0.008653
0.003898 0.001779
2007 3 1 1 0 0 0 257 0.013477 0.012288 0.019445 0.031747 0.048054 0.078190
0.132914 0.171009 0.157321 0.127613 0.082900 0.056266 0.034840 0.019232 0.009364
0.003840 0.001498
2008 3 1 1 0 0 0 258 0.006583 0.010077 0.017291 0.022706 0.039407 0.064583
0.121861 0.166765 0.167527 0.138247 0.093465 0.058770 0.043669 0.025953 0.013969
0.005847 0.003277
2009 3 1 1 0 0 0 292 0.002907 0.004923 0.008114 0.013334 0.024534 0.043449
0.099263 0.156744 0.172629 0.152829 0.110869 0.078254 0.053543 0.036859 0.022738
0.012110 0.006903
2010 3 1 1 0 0 0 222 0.005846 0.005467 0.012293 0.016881 0.030331 0.055579
0.107945 0.153148 0.161413 0.146545 0.101574 0.073129 0.052053 0.036455 0.022811
0.011131 0.007398
2011 3 1 1 0 0 0 252 0.005171 0.004206 0.009375 0.015204 0.025907 0.047136
0.104720 0.158389 0.169216 0.150895 0.105607 0.070516 0.049150 0.037109 0.023010
0.013629 0.010761
2012 3 1 1 0 0 0 241 0.011408 0.006900 0.010918 0.014806 0.025298 0.047426
0.102829 0.162246 0.177028 0.150756 0.109150 0.066664 0.042933 0.032731 0.018194
0.011110 0.009603
2013 3 1 1 0 0 0 236 0.009780 0.006897 0.012546 0.018360 0.032257 0.057357
0.106564 0.149594 0.158540 0.138119 0.105121 0.073268 0.050290 0.033204 0.023611
0.013188 0.011305
2014 3 1 1 0 0 0 219 0.014887 0.011977 0.018213 0.026547 0.040919 0.070874
0.124865 0.167490 0.164223 0.138519 0.089236 0.055221 0.033900 0.021203 0.011293
0.005856 0.004775
2015 3 1 1 0 0 0 243 0.009468 0.007405 0.012229 0.020974 0.030168 0.061902
0.122932 0.181589 0.186770 0.151790 0.094065 0.052921 0.032812 0.018644 0.009292
0.004854 0.002184
2016 3 1 1 0 0 0 253 0.010516 0.008992 0.016775 0.025017 0.043944 0.066502
0.123193 0.171566 0.175873 0.147281 0.092894 0.054898 0.030889 0.016020 0.009317
0.003782 0.002542
2017 3 1 1 0 0 0 222 0.004645 0.005043 0.009896 0.016614 0.030117 0.054243
0.107312 0.157000 0.174447 0.154479 0.105160 0.069304 0.045100 0.029199 0.018245
0.010417 0.008778
2018 3 1 1 0 0 0 318 0.004829 0.004975 0.007427 0.015547 0.028592 0.057059
0.110817 0.157559 0.164944 0.146429 0.108696 0.074372 0.048815 0.033214 0.019503
0.010246 0.006978
2019 3 1 1 0 0 0 224 0.016816 0.010177 0.013026 0.023035 0.036207 0.056685
0.108548 0.144626 0.163688 0.150431 0.109384 0.077848 0.045948 0.026222 0.011804
0.003148 0.002405
2020 3 1 1 0 0 0 302 0.012350 0.009114 0.011815 0.020728 0.034808 0.065998
0.118284 0.168300 0.170971 0.146774 0.102320 0.061419 0.035897 0.019480 0.012388
0.005015 0.004337
2021 3 1 1 0 0 0 157 0.010831 0.008598 0.013263 0.021310 0.050400 0.076580
0.133711 0.160949 0.174335 0.136725 0.098608 0.052135 0.033516 0.016451 0.007211
0.003695 0.001682
#
Trawl byc size comp
##Year, Seas, Fleet, Sex, Type, Shell, Maturity, Nsamp, DataVec
Not used

Growth data (increment)
Type of growth increment (0=no growth data;1=size-at-release; 2= size-class-at-release)
3
nobs_growth
222
Class-at-release; Sex; Class-at-recapture; Years-at-liberty; number transition matrix; RecaptureFleet Recapture Year (if applicable) sample size
……Tag release-recapture data entries are same as those in EAG21.1a dat file ……
……..
eof
9999

2. *WAG21.1a ctl file*

```
##
##———————————————————————————————————————— #
#  Controls for leading parameter  vector  theta
#  LEGEND FOR PRIOR:
#  0 = uniform, 1 = normal, 2 = lognormal, 3 = beta, 4 = gamma
##———————————————————————————————————————— #
#  ntheta
 9
##———————————————————————————————————————— #
# ival      lb     ub      phz   prior   p1      p2      # parameter         #
##———————————————————————————————————————— #
  0.21      0.01   1.0      -3     2     0.18    0.04     # M
 7.56931555  -10.0 20.0   1    0    -10.0    20.0      # ln R0

 12.0       -10.0   20.0     -3    0    -10.0    20.0      # ln Rini

   8.0       -10.0 20.0     -1    0    -10.0    20.0      # ln Rbar

 110.0      103.0 165.0     -2    1     72.5    7.25      # Expected value of recruitment distribution

 0.966954096 0.001 20.0    3    0     0.1     5.0    # recruitment scale

  -0.693147181 -10.0   0.75   -1    0   -10.0     0.75      # ln (SigmaR)

 0.73       0.2    1.0       -2    3     3.0     2.0         # steepness
  0.001      0.0    1.0      -3    3     1.01    1.01      # recruitment autocorrelation
##————————————————————————————————————————##

# weight-at-length input method (1 = allometry [w_l = a*l^b],  2 = vector by sex)
2
#a, in kg
# 1.445E-07
#b
# 3.281126995
# Male weight-at-length
 0.581515707          0.679328169          0.788032347          0.908278308          1.040724257          1.186036294
              1.344888179          1.517961114          1.705943543          1.90953096          2.129425732          2.366336933
              2.620980182          2.894077494          3.186357141          3.498553516          3.993657581
#
# Proportion mature by sex, males
  0.  0.  1.  1.  1.  1.  1.  1.  1.  1.  1.  1.  1.  1.  1.  1.  1.
# Proportion legal by sex, males
  0.  0.  0.  0.  0.  0.  0.  1.  1.  1.  1.  1.  1.  1.  1.  1.  1.
##
## GROWTH PARAM CONTROLS
##     Two lines for each parameter if split sex, one line if not
##———————————————————————————————————————— ##
# Use growth transition matrix option (1=read in growth-increment matrix; 2=read in size-transition; 3=gamma distribution for size-increment; 4=gamma distribution for size after increment) (1 to 8 options available)
```

```
# option 8 is normal distributed growth incrment, size after incrment is normal
8
# growth increment model (0=prespecified; 1=alpha/beta; 2=estimated by size-class;3=pre-specified/empirical)
1
# molt probability function (0=pre-specified; 1=flat;2=declining logistic)
2
# maximum size-class (males then females)
#17
# Maximum size-class for recruitment (males then females)
5
## number of size-increment periods
1
## Year(s) size-increment period changes (blank if no changes)

## number of molt periods
1
## Year(s) molt period changes (blank if no changes)

## Beta parameters are relative to a base level (1=Yes;0=no)
1 #  0 for 4 selection for gamma; for normal election 1

# Growth parameters
## ##
# ival       lb       ub    phz   prior     p1     p2       # parameter
#——————————————————————————————————————————————————— #
   25.176212148   10.0    50.0    7      0      0.0    20.0   # alpha,
  0.090104837   -0.4    20.0    7      0      0.0    10.0   # beta,
  3.669298667   0.01    5.0     7      0      0.0     3.0   # growth scale,
  141.161653321  65.0   165.0    7      0      0.0    999.0  #  moult mu
  0.103148688  -0.1      2.0     7      0      0.0     2.0   # moult cv,
#———————————————————————————————————————————————— ##

# The custom growth-increment matrix

# custom molt probability matrix
##——————————————————————————————————————————————— ##
## SELECTIVITY CONTROLS
##     Selectivity P(capture of all sizes). Each gear must have a selectivity and a
##     retention selectivity. If a uniform prior is selected for a parameter, then the
##     lb and ub are used (p1 and p2 are ignored)
## LEGEND
##     sel type: 0 = parametric (nclass), 1 = indiviudal parameter for each class(nclass)
##             2 = logistic (2, inflection point and slope), 3 = logistic95 (2, 50% and 95% selection), 4 = double normal (3
parameters),
##
##    5: Flat equal to zero (1 parameter; phase must be negative), UNIFORM1
##    6: Flat equal to one (1 parameter; phase must be negative), UNIFORM0
##    7: Flat-topped double normal selectivity (4 parameters)
##    8: Declining logistic selectivity with initial values (50% and 95% selection plus extra)
## Extra (type 1): number of selectivity parameters to be estimated
##     gear index: use +ve for selectivity, -ve for retention
##     sex dep: 0 for sex-independent, 1 for sex-dependent
##——————————————————————————————————————————————— ##
## ivector for number of year blocks or nodes ##
##   Gear-1   Gear-2
## PotFishery    Trawl Byc
       2        1                 # selectivity time periods
       0        0                 # set 0 for male only fishery, sex specific selectivity, 0 for sex independent selectivity
       2        5                 # male selectivity type model (flat equal to zero, 1 parameter) or logistic or double normal etc.
       0        0                 # within another gear insertion of fleet in another
       0        0                 # extra paramters for each pattern
## Gear-1    Gear-2
```

```
      1       1                 # retention time periods
      0       0                 # set 0 for male only fishery, sex specific retention
      2       6                 # male retention type model (flat equal to one, 1 parameter)
      1       0                 # male retention flag (0 = no, 1 = yes)
      0       0                 # extra
#
      1       1                            # determines if maximum selectivity at size is forced to equal 1 or not
##——————————————————————————————————————————##
## Selectivity P (capture  of  all  sizes)
##—————————————————————————————————————————— ##
## gear par   sel                                                   phz     start  end
# index index par sex ival      lb    ub   prior    p1     p2    mirror      period period
##—————————————————————————————————————————— ##
## Gear-1
   1     1     1   0  134.616953915 105.0 180.0   0   100.0  190.0     3    1960   2004
   1     2     2   0  18.395595743  0.01   20.0   0     0.1   50.0          3    1960   2004
   1     3     1   0  134.620113880 105.0 180.0   0   100.0  190.0     3     2005   2021
   1     4     2   0   7.455867348  0.01   20.0   0     0.1   50.0          3     2005   2021

# Gear-2
   2     5     1   0    1.00      0.99 1.02   0     10.0  200.0   -3     1960   2021
##—————————————————————————————————————————— ##
## Retained
## gear par   sel                                                      phz    start   end
# index index par sex  ival       lb    ub     prior   p1     p2     mirror     period  period
# Gear-1
 -1     6    1   0   136.015109958  105.0  180.0  0     100.0  190.0    3     1960   2021
 -1     7    2   0    1.870831281   0.0001  20.0  0     0.1    50.0         3     1960   2021

# Gear-2
 -2     8    1   0    1.00        0.99   1.01  0      10.0   200.0              -3    1960   2021
##—————————————————————————————————————————— ##
# Number of asyptotic parameters
1
# Fleet   Sex     Year      ival   lb   ub    phz
      1     1     1960   0.000001   0    1     -3
##—————————————————————————————————————————— ##
## PRIORS FOR CATCHABILITY
##     If a uniform prior is selected for a parameter then the lb and ub are used (p1   ##
##     and p2 are ignored). ival must be > 0                                ##
## only allowed to use uniform or lognormal prior
## if anlytic q estimation step is chosen, turn off estimating q by changing the estimation phase to be -ve
## LEGEND                                                              ##
##     prior: 0 = uniform, 1 = normal, 2 = lognormal, 3 = beta, 4 = gamma
##—————————————————————————————————————————— ##
#
## SURVEYS/INDICES ONLY
## fishery and observer CPUE
## Analytic (0=not analytically solved q, use uniform or lognormal prior;
## 1= analytic),
## Lambda =multilier for iput CV, Emphasis = multiplier for likelihood
##  ival       lb        ub    phz    prior   p1        p2     Analytic?   LAMBDA   Emphasis
 0.001059162  0.0000001   0.01   1      0      0.0     1.0      0          1       1   # observer cpue index 1995-2004
 0.000680835  0.0000001   0.01   1      0      0.0     1.0      0          1       1    # observer cpue index 2005-2021
 0.001059162   0.0000001  0.01   1      0      0.0     1.0      0          1       1   # fishery cpue index 1985-1998

## if a uniform prior is specified then use lb and ub rather than p1 and p2
##——————————————————————————————————————————##
## ADDITIONAL CV FOR SURVEYS/INDICES
##     If a uniform prior is selected for a parameter, then the lb and ub are used (p1
##     and p2 are ignored). ival must be > 0, lb should be>0
## LEGEND
```

```
##     prior type: 0 = uniform, 1 = normal, 2 = lognormal, 3 = beta, 4 = gamma
##——————————————————————————————————— ##
## ival                lb         ub    phz   prior   p1    p2
 0.000123209   0.0000001   0.5    6    0     0.5   100  # obs CPUE additional CV
 0.000123209   0.0000001   0.5   -1    0     0.5   100  # obs CPUE additional CV
 0.000134574   0.0000001   0.5    6    0     0.5   100  # fishery CPUE additional CV

### Pointers to how the additional CVs are used (0 ignore; >0 link to one of the parameters
1 1 3
## if a uniform prior is specified then use lb and ub rather than p1 and p2
##———————————————————————————————————##
##PENALTIES FOR AVERAGE  FISHING  MORTALITY  RATE  FOR  EACH  GEAR
##
## Trap Trawl
## Male F, Female F, early_phasepenalty_sd, later_phasepenalty_sd, meanmaleF_phase, meanfemaleF_phase,
## lb meanF, ub meanF,lbannualmaleF(F_dev), ubannual maleF(F_dev),lbannualfemaleF(F_dev), ubannual femaleF(F_dev)
## Mean_F        Fema-Offset   STD_PHZ1 STD_PHZ2 PHZ_M PHZ_F   Lb    Ub    Lb    Ub    Lb   Ub
   0.491111944      0.0             3.0             15.0          2          -1    -12     4     -10    10    -10    10   #
   0.000279387      0.0             4.0             15.0          2          -1    -12     4     -10    10    -10    10   #
##———————————————————————————————————##
## OPTIONS FOR SIZE COMPOSTION DATA
##     One column for each data matrix
## LEGEND
##     Likelihood: 1 = Multinomial with estimated/fixed sample size
##                 2 = Robust approximation to multinomial
##                 3 = logistic normal (NIY)
##                 4 = multivariate-t (NIY)
##                 5 = Dirichlet
## AUTO TAIL COMPRESSION
##     pmin is the cumulative proportion used in tail compression
##————————————————————————————————— ##
#  Ret Tot
#
   1   1         # Type of likelihood
   0   0         # Auto tail compression (pmin)
   1   1         # Initial value for effective sample size multiplier
  -4  -4        # Phz for estimating effective sample size (if appl.)
   1   2        # Composition aggregator if you put 1 for each it will merge, do not merge (why merge)
   #
   1   1         # Set to 2 for survey-like predictions; 1 for catch-like predictions
   #
  0.413525673217773 0.545393319396973 # Emphasis for Dritchlet (Ret, Tot, multiplier of stage1 ESS)
   1   1        # LAMBDA 0 to ignore the length comp
##————————————————————————————————— ##
## TIME VARYING NATURAL  MORTALIIY  RATES  ##
##—————————————————————————————————— ##
## Type: 0 = constant natural mortality
##       1 = Random walk (deviates constrained by variance in M)
##       2 = Cubic Spline (deviates constrained by nodes & node-placement)
##       3 = Blocked changes (deviates constrained by variance at specific knots)
##       4 = Changes in pre-specified blocks
##       5 = Changes in some knots
##       6 = Changes in Time blocks
 0    # M type
## M is relative (YES=1; NO=0)

## Phase of estimation
3
## STDEV in m_dev for Random walk
0.25
## Number of nodes for cubic spline or number of step-changes for option 3
1
```

```
## Year position of the knots (vector must be equal to the number of nodes)
1960
## number of breakpoints in M by size (keep it at 0)
0
# line groups for breakpoint
8
## Specific initial values for the natural mortality devs (0-no, 1=yes)
## 1
## ival     lb     ub     phz   extra
##   3.0     0.5    5.0     4      0
##————————————————————————————————————— ##
## TAGGING controls CONTROLS
##————————————————————————————————————— ##
 1       # emphasis on tagging data (1 =use tag LH, 0=ignore)
##————————————————————————————————————— ##
## Maturity specific natural mortality
###
##————————————————————————————————————— ##
# maturity specific natural mortality? (yes = 1; no = 0; only for use if nmature > 1)
 0

##————————————————————————————————————————————— ##


##        ival     lb              ub              phz            prior    p1              p2
 ##——————————————————————————————————————————— ##


          0          -1              1              -1              0         1              1
##————————————————————————————————————— ##
## OTHER CONTROLS
#
1960     # First year of recruitment estimation,rec_dev.
2021     # last year of recruitment estimation, rec_dev
   1     # phase for recruitment estimation,earlier -1. rec_dev estimation phase,
  -2     # phase for recruitment sex-ratio estimation
  0.5    # Initial value for Expected sex-ratio
  -3     # Phase for initial recruitment estimation, rec_ini phase
   1     # VERBOSE FLAG (0 = off, 1 = on, 2 = objective func; 3 diagnostics)
   0     # Initial conditions (0 = Unfished, 1 = Steady state fished, 2 = Free parameters, 3 = Free parameters (revised))
   1     # Lambda (proportion of mature male biomass for SPR reference points).
   0     # Stock-Recruit-Relationship (0 = none, 1 = Beverton-Holt)
   10    # Maximum phase (stop the estimation after this phase), 10 Maximum phase. If you put 1 it will stop after phase 1
   -1    # Maximum number of function calls, if 1, stop at fn 1 call; if -1, run as long as it takes
   1     # Calculate reference points (0=no)
   200   ### Year to compute equilibria
## EMPHASIS FACTORS (CATCH)
#Ret_male Tot_male   Groundfish
     4      2         1
## EMPHASIS FACTORS (Priors) by fleet: fdev_total, Fdov_total, Fdev_year, Fdov_year
0  0  0.001  0 # Pot fishery
0  0  0.001  0 # Groundfish


## EMPHASIS FACTORS (Priors)
##
# Log_fdevs   meanF      Mdevs  Rec_devs Initial_devs Fst_dif_dev Mean_sex-Ratio  Fvecs Fdovs
#       0      0       0.0       2          0       0         0        1    0      #
#
# Log_fdevs   meanF   Mdevs  Rec_devs Initial_devs Fst_dif_dev Mean_sex-Ratio  Molt_prob       Free selectivity Init_n_at_len
Fvecs Fdovs
               0      0       0.0       2          0       0         0            0              0              0    1    0      #
```

EOF
9999

3. ***EAG21.1a dat file***:

```
##============##
# Gmacs Main Data File
#
# GEAR_   INDEX   DESCRIPTION
#    1       :  Pot fishery Retained catch
#    2       :  Pot fishery total catch
#    3       :  Trawl bycatch
#    4       :  Observer CPUE
#    5       :  Fishery CPUE

# Fisheries:  1 Pot Fishery, 2 Pot Total
# Cooperative Survey:
##=============##

1960  # initial (start year)
2021  # terminal (end year)
#2022  # Projection year (for forecast, OFL and ABC calculation)
6    # Number of seasons: season1 for N est, season 2 for Jul 1 to MidFishing, season 3 for inst.remove C, season 4 for to spawning time,Feb15, season 5 for inst remove byc&estimate MMB, season 6 for remaining time to June 30 and R enter
2    # Number of distinct data groups or number of fleets (pot fishing, groundfish fishing)
1    # Number of sexes (males)
1    # Number of shell condition types
1    # Number of maturity types
17    # Number of size-classes in the model
6    # Season when recruitment occurs,end of year before growth
6    # Season when molting and growth occur, end of year after recruitment
5    # Season to calculate MMB
1    # Season for N output
# maximum size-class (males then females)
17
# size_breaks (a vector giving the break points between size intervals with dimension nclass+1, lower limits of bins)
100.5 105.5 110.5 115.5 120.5 125.5 130.5 135.5 140.5 145.5 150.5 155.5 160.5 165.5 170.5 175.5 180.5 185.5
# Natural mortality per season input type (1 = vector by season, 2 = matrix by season/year)
2
# Proportion of the total natural mortality to be applied each season (each row must add to 1)
# 1 Start biological year (Jul 1) instantaneous N estimation
# 2 to mid-fishing time
# 3 instantanous C removal
# 4 to spawning time
# 5 instantaneous byc removal and estimate MMB
# 6 Rest of the period of non-fishing from Feb 15 to June 30
#
#
#Ins N Jul1-MidFish   Inst C    MidFish-15Feb   Ins byc    Rest upto end
 0.     0.16666667    0.     0.46073059    0.     0.37260274     #1960
 0.     0.16666667    0.     0.46073059    0.     0.37260274     #1961
 0.     0.16666667    0.     0.46073059    0.     0.37260274     #1962
 0.     0.16666667    0.     0.46073059    0.     0.37260274     #1963
 0.     0.16666667    0.     0.46073059    0.     0.37260274     #1964
 0.     0.16666667    0.     0.46073059    0.     0.37260274     #1965
 0.     0.16666667    0.     0.46073059    0.     0.37260274     #1966
 0.     0.16666667    0.     0.46073059    0.     0.37260274     #1967
 0.     0.16666667    0.     0.46073059    0.     0.37260274     #1968
 0.     0.16666667    0.     0.46073059    0.     0.37260274     #1969
 0.     0.16666667    0.     0.46073059    0.     0.37260274     #1970
 0.     0.16666667    0.     0.46073059    0.     0.37260274     #1971
```

```
0.	0.16666667	0.	0.46073059	0.	0.37260274	#1972
0.	0.16666667	0.	0.46073059	0.	0.37260274	#1973
0.	0.16666667	0.	0.46073059	0.	0.37260274	#1974
0.	0.16666667	0.	0.46073059	0.	0.37260274	#1975
0.	0.16666667	0.	0.46073059	0.	0.37260274	#1976
0.	0.16666667	0.	0.46073059	0.	0.37260274	#1977
0.	0.16666667	0.	0.46073059	0.	0.37260274	#1978
0.	0.16666667	0.	0.46073059	0.	0.37260274	#1979
0.	0.16666667	0.	0.46073059	0.	0.37260274	#1980
0.	0.44109589	0.	0.18630137	0.	0.37260274	#1981
0.	0.483561644	0.	0.143835616	0.	0.37260274	#1982
0.	0.483561644	0.	0.143835616	0.	0.37260274	#1983
0.	0.315068493	0.	0.312328767	0.	0.37260274	#1984
0.	0.168493151	0.	0.45890411	0.	0.37260274	#1985
0.	0.252054795	0.	0.375342466	0.	0.37260274	#1986
0.	0.087671233	0.	0.539726027	0.	0.37260274	#1987
0.	0.3		0.	0.32739726	0.	0.37260274	#1988
0.	0.4		0.	0.22739726	0.	0.37260274	#1989
0.	0.265753425	0.	0.361643836	0.	0.37260274	#1990
0.	0.273972603	0.	0.353424658	0.	0.37260274	#1991
0.	0.276712329	0.	0.350684932	0.	0.37260274	#1992
0.	0.419178082	0.	0.208219178	0.	0.37260274	#1993
0.	0.249315068	0.	0.378082192	0.	0.37260274	#1994
0.	0.223287671	0.	0.404109589	0.	0.37260274	#1995
0.	0.328767123	0.	0.298630137	0.	0.37260274	#1996
0.	0.28630137	0.	0.34109589	0.	0.37260274	#1997
0.	0.263013699	0.	0.364383562	0.	0.37260274	#1998
0.	0.245205479	0.	0.382191781	0.	0.37260274	#1999
0.	0.179452055	0.	0.447945205	0.	0.37260274	#2000
0.	0.160273973	0.	0.467123288	0.	0.37260274	#2001
0.	0.156164384	0.	0.471232877	0.	0.37260274	#2002
0.	0.157534247	0.	0.469863014	0.	0.37260274	#2003
0.	0.143835616	0.	0.483561644	0.	0.37260274	#2004
0.	0.432876712	0.	0.194520548	0.	0.37260274	#2005
0.	0.331506849	0.	0.295890411	0.	0.37260274	#2006
0.	0.368493151	0.	0.25890411	0.	0.37260274	#2007
0.	0.302739726	0.	0.324657534	0.	0.37260274	#2008
0.	0.32739726	0.	0.3		0.	0.37260274	#2009
0.	0.293150685	0.	0.334246575	0.	0.37260274	#2010
0.	0.263013699	0.	0.364383562	0.	0.37260274	#2011
0.	0.275342466	0.	0.352054795	0.	0.37260274	#2012
0.	0.27260274	0.	0.354794521	0.	0.37260274	#2013
0.	0.247945205	0.	0.379452055	0.	0.37260274	#2014
0.	0.228767123	0.	0.398630137	0.	0.37260274	#2015
0.	0.420547945	0.	0.206849315	0.	0.37260274	#2016
0.	0.409589041	0.	0.217808219	0.	0.37260274	#2017
0.	0.349315068	0.	0.278082192	0.	0.37260274	#2018
0.	0.32739726	0.	0.3		0.	0.37260274	#2019
0.	0.365753425	0.	0.261643836	0.	0.37260274	#2020
0.	0.294520548	0.	0.332876712	0.	0.37260274	#2021
#
#
# Fishing fleet names (delimited with: no spaces in names)
Pot_Fishery Trawl_Bycatch
# Survey names (delimited with: no spaces in names) keep empty

# Are the seasons discrete-instantaneous (0) or continuous (1)
1 1 1 1 1 1
# Number of catch data frames
3
# Number of rows in each data frame
#	1993	total	catch	is	missing,	u
```

```
#    1991  groundfish   bycatch is   missing,
#    retained    catch  1981/82-2021/22
   41   31   32
## CATCH DATA in t
## Type of catch: 1 = retained, 2 = discard, 0= total (retained+discard, slide says 3)
## Units of catch: 1 = biomass, 2 = numbers
# Mult: 1= use data as they are, 2 = multiply by this number (e.g., lbs to kg)

## Retained Catch (numbers from 1981-1984; tonnes from 1985 onwards)
#year seas  fleet  sex    obs     cv  type  units  mult  effort discard mortality
 1981  3   1   1   203.968 0.0316  1   2   1   0   0.2
 1982  3   1   1   529.787 0.0316  1   2   1   0   0.2
 1983  3   1   1   662.28  0.0316  1   2   1   0   0.2
 1984  3   1   1   801.1   0.0316  1   2   1   0   0.2
 1985  3   1   1   2730.32 0.0316  1   1   1   0   0.2
 1986  3   1   1   2844.91 0.0316  1   1   1   0   0.2
 1987  3   1   1   1908.79 0.0316  1   1   1   0   0.2
 1988  3   1   1   2423.6  0.0316  1   1   1   0   0.2
 1989  3   1   1   2776.77 0.0316  1   1   1   0   0.2
 1990  3   1   1   1637.48 0.0316  1   1   1   0   0.2
 1991  3   1   1   2026.35 0.0316  1   1   1   0   0.2
 1992  3   1   1   2125.04 0.0316  1   1   1   0   0.2
 1993  3   1   1   1420.58 0.0316  1   1   1   0   0.2
 1994  3   1   1   2038.35 0.0316  1   1   1   0   0.2
 1995  3   1   1   2224.01 0.0316  1   1   1   0   0.2
 1996  3   1   1   1624.07 0.0316  1   1   1   0   0.2
 1997  3   1   1   1481.02 0.0316  1   1   1   0   0.2
 1998  3   1   1   1414.76 0.0316  1   1   1   0   0.2
 1999  3   1   1   1334.88 0.0316  1   1   1   0   0.2
 2000  3   1   1   1359.49 0.0316  1   1   1   0   0.2
 2001  3   1   1   1401.42 0.0316  1   1   1   0   0.2
 2002  3   1   1   1243.19 0.0316  1   1   1   0   0.2
 2003  3   1   1   1297.26 0.0316  1   1   1   0   0.2
 2004  3   1   1   1269.73 0.0316  1   1   1   0   0.2
 2005  3   1   1   1272.16 0.0316  1   1   1   0   0.2
 2006  3   1   1   1389.5  0.0316  1   1   1   0   0.2
 2007  3   1   1   1329.37 0.0316  1   1   1   0   0.2
 2008  3   1   1   1421.86 0.0316  1   1   1   0   0.2
 2009  3   1   1   1448.28 0.0316  1   1   1   0   0.2
 2010  3   1   1   1412.73 0.0316  1   1   1   0   0.2
 2011  3   1   1   1444.36 0.0316  1   1   1   0   0.2
 2012  3   1   1   1499.29 0.0316  1   1   1   0   0.2
 2013  3   1   1   1546.08 0.0316  1   1   1   0   0.2
 2014  3   1   1   1553.36 0.0316  1   1   1   0   0.2
 2015  3   1   1   1692.9  0.0316  1   1   1   0   0.2
 2016  3   1   1   1658.66 0.0316  1   1   1   0   0.2
 2017  3   1   1   1620.86 0.0316  1   1   1   0   0.2
 2018  3   1   1   1865.11 0.0316  1   1   1   0   0.2
 2019  3   1   1   2067.47 0.0316  1   1   1   0   0.2
 2020  3   1   1   1735.37 0.0316  1   1   1   0   0.2
 2021  3   1   1   1784.08 0.0316  1   1   1   0   0.2
#
## Total Catch (tonnes throughout)
#year seas  fleet  sex    obs     cv  type  units  mult  effort  discard_mortality
 1990  3   1   1   3980.73 0.358893929   0   1   1   0   0.2
 1991  3   1   1   6596.74 0.212951406   0   1   1   0   0.2
 1992  3   1   1   5435.64 0.296058703   0   1   1   0   0.2
 1994  3   1   1   3444.23 0.375117372   0   1   1   0   0.2
 1995  3   1   1   4640.82 0.051194102   0   1   1   0   0.2
 1996  3   1   1   2563.32 0.04474373    0   1   1   0   0.2
 1997  3   1   1   2976.8  0.059889204   0   1   1   0   0.2
 1998  3   1   1   3140.99 0.0680779     0   1   1   0   0.2
```

1999	3	1	1	2605.62	0.065963387	0	1	1	0	0.2
2000	3	1	1	2759.91	0.057628024	0	1	1	0	0.2
2001	3	1	1	2237.55	0.060173859	0	1	1	0	0.2
2002	3	1	1	1915.66	0.064883292	0	1	1	0	0.2
2003	3	1	1	1901.61	0.065047278	0	1	1	0	0.2
2004	3	1	1	1694.87	0.087224566	0	1	1	0	0.2
2005	3	1	1	1742.04	0.118801346	0	1	1	0	0.2
2006	3	1	1	1646.83	0.123871783	0	1	1	0	0.2
2007	3	1	1	1819.86	0.12997936	0	1	1	0	0.2
2008	3	1	1	1823.51	0.16628614	0	1	1	0	0.2
2009	3	1	1	1770.08	0.204527938	0	1	1	0	0.2
2010	3	1	1	1756.66	0.197720567	0	1	1	0	0.2
2011	3	1	1	1780.6	0.217727165	0	1	1	0	0.2
2012	3	1	1	1946.59	0.197259943	0	1	1	0	0.2
2013	3	1	1	1851.56	0.184593328	0	1	1	0	0.2
2014	3	1	1	1967.39	0.213240733	0	1	1	0	0.2
2015	3	1	1	2135.81	0.188674437	0	1	1	0	0.2
2016	3	1	1	2234.13	0.165738888	0	1	1	0	0.2
2017	3	1	1	2339.37	0.170274949	0	1	1	0	0.2
2018	3	1	1	2734.63	0.189279828	0	1	1	0	0.2
2019	3	1	1	3032.73	0.17733387	0	1	1	0	0.2
2020	3	1	1	2608.06	0.172996036	0	1	1	0	0.2
2021	3	1	1	2426.95	0.188674437	0	1	1	0	0.2

#
##Trawl fishery discards (in tonnes)

1989	3	2	1	0.826511	1.3108	2	1	1.538461538	0	0.65
1990	3	2	1	2.59394	1.3108	2	1	1.538461538	0	0.65
1992	3	2	1	1.22658	1.3108	2	1	1.538461538	0	0.65
1993	3	2	1	1.15375	1.3108	2	1	1.538461538	0	0.65
1994	3	2	1	0.357445	1.3108	2	1	1.538461538	0	0.65
1995	3	2	1	1.01804	1.3108	2	1	1.538461538	0	0.65
1996	3	2	1	0.265799	1.3108	2	1	1.538461538	0	0.65
1997	3	2	1	0.106796	1.3108	2	1	1.538461538	0	0.65
1998	3	2	1	1.06278	1.3108	2	1	1.538461538	0	0.65
1999	3	2	1	0.642352	1.3108	2	1	1.538461538	0	0.65
2000	3	2	1	1.12817	1.3108	2	1	1.538461538	0	0.65
2001	3	2	1	1.66704	1.3108	2	1	1.538461538	0	0.65
2002	3	2	1	2.38549	1.3108	2	1	1.538461538	0	0.65
2003	3	2	1	1.31099	1.3108	2	1	1.538461538	0	0.65
2004	3	2	1	0.297833	1.3108	2	1	1.538461538	0	0.65
2005	3	2	1	1.83486	1.3108	2	1	1.538461538	0	0.65
2006	3	2	1	3.3144	1.3108	2	1	1.538461538	0	0.65
2007	3	2	1	1.92908	1.3108	2	1	1.538461538	0	0.65
2008	3	2	1	4.30175	1.3108	2	1	1.538461538	0	0.65
2009	3	2	1	2.05905	1.3108	2	1	1.538461538	0	0.65
2010	3	2	1	6.27075	1.3108	2	1	1.538461538	0	0.65
2011	3	2	1	5.2775	1.3108	2	1	1.538461538	0	0.65
2012	3	2	1	6.17064	1.3108	2	1	1.538461538	0	0.65
2013	3	2	1	3.13431	1.3108	2	1	1.538461538	0	0.65
2014	3	2	1	2.86222	1.3108	2	1	1.538461538	0	0.65
2015	3	2	1	1.27709	1.3108	2	1	1.538461538	0	0.65
2016	3	2	1	0.979021	1.3108	2	1	1.538461538	0	0.65
2017	3	2	1	1.57796	1.3108	2	1	1.538461538	0	0.65
2018	3	2	1	1.74213	1.3108	2	1	1.538461538	0	0.65
2019	3	2	1	3.88518	1.3108	2	1	1.538461538	0	0.65
2020	3	2	1	0.726643	1.3108	2	1	1.538461538	0	0.65
2021	3	2	1	1.92701	1.3108	2	1	1.538461538	0	0.65

#
RELATIVE ABUNDANCE DATA
Units of abundance: 1 = biomass, 2 = numbers
Number of relative abundance indicies

```
## sex:1=male;2=female; 0=both
## maturity: 1=immature;2=mature;0 = both)

# Fishery CPUE index, Observer CPUE index2
3
# Index Type (1=Selecivity; 2=retention)
#
2 2 2
## Number of rows  in  each  index
41
# Fishery CPUE index NB error in GLM fits on Observer and Fish Tick data
# Sex: 1 = male, 2 = female, 0 = both" << endl;
#  Maturity: 1 = immature, 2 = mature, 0 = both
#  Units of survey: 1 = biomass, 2 = numbers
# Indices are in numbers
#ObserverCPUEindex
Index Year Seas fleet Sex maturity index        cv      abundance unit   timing


 1   1995   3   1   1   0   0.879282477   0.042033451   2   0.5
 1   1996   3   1   1   0   0.815849908   0.030538475   2   0.5
 1   1997   3   1   1   0   0.883862635   0.027057194   2   0.5
 1   1998   3   1   1   0   1.010117295   0.021452204   2   0.5
 1   1999   3   1   1   0   0.98666272    0.02108597    2   0.5
 1   2000   3   1   1   0   0.824118765   0.021512332   2   0.5
 1   2001   3   1   1   0   1.079064735   0.020228773   2   0.5
 1   2002   3   1   1   0   1.174935143   0.022241384   2   0.5
 1   2003   3   1   1   0   1.032293627   0.023208482   2   0.5
 1   2004   3   1   1   0   1.467173822   0.022795391   2   0.5
 2   2005   3   1   1   0   0.97045889    0.026852066   2   0.5
 2   2006   3   1   1   0   0.801226718   0.02933121    2   0.5
 2   2007   3   1   1   0   0.88962567    0.024651866   2   0.5
 2   2008   3   1   1   0   0.875644097   0.029504977   2   0.5
 2   2009   3   1   1   0   0.727156803   0.043080187   2   0.5
 2   2010   3   1   1   0   0.74994345    0.041443367   2   0.5
 2   2011   3   1   1   0   1.078537338   0.030145327   2   0.5
 2   2012   3   1   1   0   1.035053799   0.028697759   2   0.5
 2   2013   3   1   1   0   1.006949278   0.027761264   2   0.5
 2   2014   3   1   1   0   1.293596572   0.027645121   2   0.5
 2   2015   3   1   1   0   1.312147657   0.024804944   2   0.5
 2   2016   3   1   1   0   1.029671419   0.028064272   2   0.5
 2   2017   3   1   1   0   1.034979701   0.030977831   2   0.5
 2   2018   3   1   1   0   1.236166141   0.027936602   2   0.5
 2   2019   3   1   1   0   1.148280402   0.025760484   2   0.5
 2   2020   3   1   1   0   1.055298436   0.027723836   2   0.5
 2   2021   3   1   1   0   0.993935189   0.03366779    2   0.5
#
#    Year:Area interaction
#    Observer    CPUE   index
#    1   1995   3   1   1   0   0.799865481   0.223589155   2   0.5
#    1   1996   3   1   1   0   1.431892924   0.129336153   2   0.5
#    1   1997   3   1   1   0   1.005665016   0.164236961   2   0.5
#    1   1998   3   1   1   0   0.693076984   0.198102942   2   0.5
#    1   1999   3   1   1   0   0.697087824   0.210056887   2   0.5
#    1   2000   3   1   1   0   0.698506534   0.192460525   2   0.5
#    1   2001   3   1   1   0   0.742289608   0.151457285   2   0.5
#    1   2002   3   1   1   0   1.443444402   0.102430717   2   0.5
#    1   2003   3   1   1   0   1.518382814   0.120998952   2   0.5
#    1   2004   3   1   1   0   1.581339037   0.067979922   2   0.5
#    2   2005   3   1   1   0   1.043208013   0.042745753   2   0.5
#    2   2006   3   1   1   0   0.902285312   0.060020437   2   0.5
#    2   2007   3   1   1   0   0.86056767    0.054706589   2   0.5
```

#	2	2008	3	1	1	0	0.793065632	0.067823623	2	0.5
#	2	2009	3	1	1	0	0.777542162	0.104741145	2	0.5
#	2	2010	3	1	1	0	0.80513618	0.093057331	2	0.5
#	2	2011	3	1	1	0	1.094125986	0.049126823	2	0.5
#	2	2012	3	1	1	0	0.990068535	0.054986364	2	0.5
#	2	2013	3	1	1	0	1.096210978	0.041334347	2	0.5
#	2	2014	3	1	1	0	1.237344328	0.034474257	2	0.5
#	2	2015	3	1	1	0	1.080994736	0.043197352	2	0.5
#	2	2016	3	1	1	0	1.085261937	0.042555231	2	0.5
#	2	2017	3	1	1	0	0.924819641	0.069466753	2	0.5
#	2	2018	3	1	1	0	1.134115622	0.042365537	2	0.5
#	2	2019	3	1	1	0	1.236352366	0.032825038	2	0.5
#	2	2020	3	1	1	0	1.025460466	0.050367619	2	0.5
#	2	2021	3	1	1	0	1.084792633	0.045764631	2	0.5
#
#
3	1985	3	1	1	0	1.628685686	0.031256541	2	0.5
3	1986	3	1	1	0	1.228858309	0.03860399	2	0.5
3	1987	3	1	1	0	0.955170913	0.051223518	2	0.5
3	1988	3	1	1	0	1.035770885	0.03950348	2	0.5
3	1989	3	1	1	0	1.076478459	0.03179462	2	0.5
3	1990	3	1	1	0	0.986817549	0.045649076	2	0.5
3	1991	3	1	1	0	0.904618567	0.047224701	2	0.5
3	1992	3	1	1	0	0.917176073	0.047355474	2	0.5
3	1993	3	1	1	0	0.914494509	0.05332578	2	0.5
3	1994	3	1	1	0	0.808572288	0.051417951	2	0.5
3	1995	3	1	1	0	0.77981996	0.055409819	2	0.5
3	1996	3	1	1	0	0.779120743	0.055920142	2	0.5
3	1997	3	1	1	0	1.050514781	0.042865274	2	0.5
3	1998	3	1	1	0	1.214100014	0.042009806	2	0.5
#
Number of length frequency matrices
2
Number of rows in each matrix
37 31
#
Number of bins in each matrix (columns of size data)
17 17
#
SIZE COMPOSITION DATA FOR ALL FLEETS
SIZE COMP LEGEND
Sex: 1 = male, 2 = female, 0 = both sexes combined
Type of composition: 1 = retained, 2 = discard, 0 = total composition
Maturity state: 1 = immature, 2 = mature, 0 = both states combined
Shell condition: 1 = new shell, 2 = old shell, 0 = both shell types combined
Type 1 effective sample: Nsamp
##	Retain catch size comp

updated effective Ns
##Year, Seas, Fleet, Sex, Type, Shell, Maturity, Nsamp, DataVec

1985	3	1	1	1	0	0	57	0.000000	0.000000	0.000000	0.000000	0.000000	0.002122
0.034669	0.103747	0.158923	0.156292	0.157127	0.133423	0.108521	0.061545	0.038431
0.020136	0.025065
1986	3	1	1	1	0	0	11	0.000000	0.000000	0.000000	0.000000	0.000000	0.000635
0.030377	0.143149	0.183126	0.212534	0.136044	0.114523	0.075306	0.038519	0.039528
0.016971	0.009288
1987	3	1	1	1	0	0	61	0.000000	0.000000	0.003518	0.000000	0.000550	0.003212
0.070524	0.162974	0.240875	0.168335	0.132893	0.076020	0.050479	0.037065	0.026783
0.011753	0.015022

1988 3 1 1 1 0 0 352 0.000000 0.000000 0.000000 0.000000 0.000250 0.004988
0.043836 0.121611 0.173481 0.179156 0.161137 0.132840 0.073217 0.043037 0.025108
0.020902 0.020437
1989 3 1 1 1 0 0 792 0.000000 0.000000 0.000000 0.000066 0.000195 0.008435
0.108452 0.234714 0.191637 0.123151 0.094370 0.075312 0.057163 0.038218 0.026285
0.019802 0.022201
1990 3 1 1 1 0 0 163 0.000000 0.000052 0.000052 0.000000 0.000340 0.005531
0.079874 0.226018 0.260315 0.183031 0.112587 0.066439 0.038093 0.016649 0.005442
0.002781 0.002796
1991 3 1 1 1 0 0 140 0.000000 0.000000 0.000000 0.000000 0.000287 0.006172
0.074641 0.201726 0.233318 0.206834 0.127877 0.072609 0.040713 0.018307 0.009776
0.004928 0.002812
1992 3 1 1 1 0 0 49 0.000000 0.000000 0.000056 0.000120 0.000452 0.005204
0.074976 0.188394 0.240279 0.192046 0.126742 0.085203 0.048454 0.024934 0.008597
0.002697 0.001846
1993 3 1 1 1 0 0 340 0.000000 0.000000 0.000000 0.000000 0.001271 0.006339
0.057846 0.227652 0.263149 0.193126 0.115423 0.061702 0.041289 0.019439 0.008024
0.001523 0.003216
1994 3 1 1 1 0 0 319 0.000000 0.000000 0.000000 0.000000 0.000000 0.005146
0.056488 0.187163 0.253136 0.241073 0.112635 0.071796 0.038426 0.016716 0.011135
0.003629 0.002656
1995 3 1 1 1 0 0 879 0.000000 0.000000 0.000367 0.000000 0.000132 0.002554
0.053244 0.174310 0.237169 0.205691 0.131577 0.086227 0.054200 0.029541 0.014691
0.006267 0.004031
1996 3 1 1 1 0 0 547 0.000000 0.000509 0.000000 0.002673 0.004458 0.010646
0.076046 0.176767 0.219822 0.183488 0.129821 0.083593 0.049809 0.029215 0.022160
0.009716 0.001277
1997 3 1 1 1 0 0 538 0.000165 0.000000 0.000000 0.000000 0.000546 0.005501
0.067013 0.195912 0.241333 0.187580 0.126671 0.078708 0.047831 0.025562 0.014975
0.006349 0.001855
1998 3 1 1 1 0 0 541 0.000000 0.000000 0.000000 0.000000 0.000153 0.001613
0.058033 0.195363 0.237512 0.195717 0.131940 0.079974 0.046411 0.030546 0.015402
0.004854 0.002485
1999 3 1 1 1 0 0 463 0.000000 0.000000 0.000000 0.000000 0.000000 0.002647
0.056968 0.209816 0.256172 0.191463 0.123275 0.073622 0.044721 0.023946 0.011020
0.005430 0.000921
2000 3 1 1 1 0 0 436 0.000481 0.000000 0.000000 0.000000 0.000000 0.002408
0.038199 0.187100 0.243407 0.197233 0.140484 0.088336 0.054458 0.027952 0.012388
0.005379 0.002176
2001 3 1 1 1 0 0 488 0.000000 0.000040 0.000000 0.000000 0.000000 0.002185
0.043398 0.166360 0.254416 0.209148 0.150723 0.084320 0.049034 0.024928 0.010970
0.002453 0.002028
2002 3 1 1 1 0 0 406 0.000692 0.000000 0.000000 0.000000 0.000000 0.001140
0.042702 0.173724 0.231895 0.215249 0.146064 0.090496 0.052512 0.029190 0.012247
0.002809 0.001280
2003 3 1 1 1 0 0 405 0.000000 0.000000 0.000000 0.000000 0.000104 0.000939
0.025425 0.128996 0.198660 0.225076 0.168816 0.127193 0.062420 0.035472 0.017291
0.005726 0.003883
2004 3 1 1 1 0 0 280 0.000000 0.000000 0.000000 0.000000 0.000000 0.000153
0.036696 0.127904 0.215850 0.214303 0.163649 0.120783 0.069026 0.033788 0.016064
0.001630 0.000154
2005 3 1 1 1 0 0 266 0.000000 0.000000 0.000000 0.000000 0.000000 0.000885
0.018795 0.118321 0.199591 0.218250 0.176555 0.132109 0.068852 0.035158 0.023218
0.004347 0.003920
2006 3 1 1 1 0 0 234 0.000000 0.000000 0.000000 0.000000 0.000000 0.000266
0.016116 0.084749 0.179791 0.184967 0.175434 0.156561 0.101305 0.053838 0.027473
0.011261 0.008238
2007 3 1 1 1 0 0 199 0.000317 0.000000 0.000000 0.000000 0.000616 0.000000
0.023977 0.115069 0.188152 0.182646 0.168733 0.124654 0.089646 0.056234 0.027344
0.015402 0.007211

2008 3 1 1 1 0 0 197 0.000000 0.000000 0.000000 0.000000 0.000000 0.000886
0.012873 0.104580 0.201275 0.170907 0.164015 0.131524 0.089417 0.069199 0.030247
0.013294 0.011783
2009 3 1 1 1 0 0 170 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
0.012998 0.085646 0.178121 0.204593 0.179856 0.132916 0.096605 0.064687 0.026752
0.012521 0.005305
2010 3 1 1 1 0 0 183 0.000424 0.000000 0.000000 0.000000 0.000000 0.000497
0.019071 0.124157 0.190138 0.186530 0.154632 0.124061 0.080623 0.064508 0.031903
0.012549 0.010908
2011 3 1 1 1 0 0 160 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
0.006553 0.080423 0.169147 0.214179 0.181341 0.118590 0.107631 0.063368 0.033478
0.017831 0.007460
2012 3 1 1 1 0 0 187 0.000000 0.000000 0.000000 0.000000 0.000000 0.000924
0.011670 0.080888 0.167506 0.197858 0.161194 0.133335 0.105248 0.071755 0.041681
0.019324 0.008617
2013 3 1 1 1 0 0 193 0.000000 0.000000 0.000000 0.000000 0.000000 0.001621
0.015499 0.104071 0.166734 0.180076 0.184391 0.127462 0.095836 0.060360 0.035295
0.018979 0.009676
2014 3 1 1 1 0 0 168 0.000000 0.000000 0.000000 0.000000 0.000000 0.001431
0.022137 0.091465 0.171561 0.183012 0.168880 0.121834 0.102642 0.069861 0.035479
0.022149 0.009550
2015 3 1 1 1 0 0 190 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
0.011420 0.072221 0.169842 0.197348 0.152410 0.136227 0.095458 0.076222 0.042626
0.025670 0.020557
2016 3 1 1 1 0 0 247 0.000000 0.000000 0.000000 0.000000 0.000000 0.001569
0.023656 0.130969 0.187397 0.198963 0.152449 0.115449 0.076811 0.054592 0.029253
0.017759 0.011133
2017 3 1 1 1 0 0 224 0.000000 0.000000 0.000000 0.000000 0.000000 0.000256
0.023410 0.133188 0.218423 0.214067 0.169485 0.103612 0.069459 0.034132 0.016284
0.010683 0.007000
2018 3 1 1 1 0 0 256 0.000000 0.000000 0.000000 0.000529 0.000000 0.000135
0.027355 0.130823 0.248131 0.215962 0.158428 0.102995 0.058974 0.032543 0.013293
0.007461 0.003372
2019 3 1 1 1 0 0 242 0.000000 0.000000 0.000000 0.000000 0.000000 0.001065
0.031598 0.149950 0.250131 0.221410 0.144913 0.097167 0.052491 0.026653 0.018678
0.004507 0.001438
2020 3 1 1 1 0 0 227 0.000256 0.000000 0.000000 0.000000 0.000655 0.000431
0.044840 0.165445 0.247580 0.220790 0.148233 0.081651 0.045700 0.026418 0.007517
0.008112 0.002372
2021 3 1 1 1 0 0 254 0.000000 0.000000 0.000000 0.000000 0.000000 0.000828
0.018934 0.103964 0.217836 0.222929 0.154632 0.106593 0.073505 0.060579 0.026429
0.007276 0.006494
#

##Total catch size comp

##Year, Seas, Fleet, Sex, Type, Shell, Maturity, Nsamp, DataVec

1990 3 1 1 0 0 0 22 0.247057 0.0713771 0.0700192 0.077615 0.101558 0.0912419
0.0849724 0.078276 0.0682135 0.0552399 0.0270515 0.0133764 0.00962329 0.0023578 0.0014792
8.22E-05 0.000459108
1991 3 1 1 0 0 0 48 0.150747 0.0569511 0.0693395 0.0749659 0.0924522 0.103903
0.109297 0.102978 0.0877103 0.0677098 0.0362255 0.0214857 0.015996 0.00453193 0.00283495
0.00109456 0.00177659
1992 3 1 1 0 0 0 41 0.218576 0.0710539 0.0702081 0.0908626 0.097516 0.0846274
0.0812049 0.0750376 0.0673011 0.058382 0.0388833 0.0238657 0.0148029 0.00460071 0.00180984
0.00105979 0.000208438

1994 3 1 1 0 0 0 34 0.390634 0.0770537 0.0638146 0.0618622 0.0740266 0.0850102
0.074093 0.0543337 0.0516942 0.0326618 0.019531 0.00986639 0.00413091 0.00128759 0. 0.
0.
1995 3 1 1 0 0 0 1117 0.124613 0.0442733 0.0627333 0.0799967 0.0985993 0.116452
0.124387 0.107233 0.0875711 0.0651487 0.0407447 0.0231279 0.0131594 0.00656473 0.00339433
0.00116618 0.000835641
1996 3 1 1 0 0 0 509 0.103395 0.0415556 0.0569105 0.0743889 0.0931823 0.113814
0.122095 0.111671 0.0928794 0.0720616 0.0480457 0.0296772 0.0183391 0.0109164 0.00631536
0.00300188 0.00175086
1997 3 1 1 0 0 0 711 0.109124 0.0388528 0.0542848 0.0707215 0.0910392 0.11163
0.122114 0.114516 0.0975729 0.0742102 0.0466668 0.0298708 0.0187339 0.0109476 0.00603525
0.00229027 0.00139002
1998 3 1 1 0 0 0 574 0.091279 0.0396234 0.0574995 0.0785652 0.101792 0.120911
0.128335 0.117767 0.0955065 0.0692407 0.0416695 0.0271698 0.0160882 0.008442 0.00412504
0.00135657 0.000629092
1999 3 1 1 0 0 0 607 0.076032 0.0304259 0.0407786 0.060235 0.0855845 0.114671
0.136644 0.132851 0.115081 0.0863874 0.0539934 0.0306299 0.0190225 0.0102905 0.00486486
0.00188102 0.0006271
2000 3 1 1 0 0 0 495 0.0812519 0.0297586 0.0424546 0.0587412 0.0723233 0.104272
0.129143 0.140068 0.11847 0.0844907 0.0580157 0.0366426 0.0211551 0.0125915 0.00659819
0.00259604 0.00142754
2001 3 1 1 0 0 0 510 0.0560044 0.0234461 0.0328406 0.0452632 0.0604895 0.0883655
0.135255 0.152515 0.146458 0.110777 0.0675943 0.0391702 0.0223362 0.0116944 0.0045407
0.00223538 0.00101595
2002 3 1 1 0 0 0 438 0.0672552 0.0245928 0.0301661 0.0369386 0.0495942 0.0803033
0.111182 0.141262 0.143255 0.123413 0.0853576 0.050499 0.0315727 0.0143736 0.00696212
0.00228202 0.000991938
2003 3 1 1 0 0 0 416 0.043021 0.0234547 0.028494 0.0387766 0.05435 0.0870863
0.108929 0.133006 0.13769 0.129164 0.0923591 0.0576027 0.0324218 0.0176854 0.00979352
0.00396374 0.00220236
2004 3 1 1 0 0 0 299 0.0396677 0.0164496 0.0234035 0.0324723 0.0534929 0.0777852
0.103027 0.135703 0.143627 0.133979 0.0962192 0.0670814 0.0432435 0.0202071 0.00828497
0.00435757 0.000998367
2005 3 1 1 0 0 0 232 0.0253953 0.00885292 0.0100844 0.0161735 0.0288399 0.0416161
0.0787101 0.132803 0.153519 0.156458 0.131759 0.0879323 0.0660318 0.0348172 0.0167193
0.00671578 0.00357146
2006 3 1 1 0 0 0 143 0.0246625 0.00846409 0.01109 0.0137568 0.0236738 0.0371752
0.0845751 0.114118 0.155592 0.151945 0.133602 0.0970456 0.0708979 0.0405458 0.0186574
0.00897895 0.00521914
2007 3 1 1 0 0 0 134 0.00652577 0.00378906 0.0052302 0.00786267 0.018195
0.0331976 0.071528 0.124197 0.149503 0.15073 0.143045 0.100164 0.0809502 0.0507338
0.0294016 0.0159802 0.00896782
2008 3 1 1 0 0 0 113 0.00857113 0.0049083 0.00779756 0.0116225 0.0217224
0.0418616 0.0787408 0.123984 0.152078 0.153806 0.129021 0.0972501 0.0725458 0.0483485
0.0249741 0.0140889 0.00868037
2009 3 1 1 0 0 0 95 0.0113415 0.00518697 0.00881411 0.015353 0.0237856 0.0480279
0.0906078 0.13986 0.153603 0.141066 0.123676 0.0940756 0.0685207 0.0397965 0.0231241
0.00840498 0.00475553
2010 3 1 1 0 0 0 108 0.022828 0.00866797 0.013557 0.0200495 0.0368501 0.0557857
0.0905218 0.132494 0.143649 0.133755 0.108654 0.0899445 0.061541 0.0401121 0.0226787
0.0122193 0.0066932
2011 3 1 1 0 0 0 107 0.0104875 0.00697866 0.0100816 0.0137713 0.0215925 0.0390275
0.0832977 0.143807 0.155986 0.146627 0.125031 0.0913977 0.0659082 0.0435672 0.0238518
0.0119113 0.00667486
2012 3 1 1 0 0 0 99 0.00615772 0.00521303 0.00715262 0.00736057 0.0193456
0.0369768 0.0790887 0.124091 0.154593 0.149802 0.131341 0.102372 0.0726776 0.0501565
0.0303817 0.0145097 0.00878071
2013 3 1 1 0 0 0 122 0.0125185 0.00656913 0.0103487 0.015937 0.0265613 0.0505413
0.0948958 0.140513 0.154223 0.143494 0.114419 0.0849187 0.0610139 0.0423781 0.0247336
0.0108804 0.00605444

```
 2014   3   1   1   0   0   0   99   0.0114342   0.00577775   0.0097938   0.0159057   0.0267485   0.0470268
0.0886109   0.119394   0.147714   0.137175   0.119421   0.0920404   0.0706556   0.0504406   0.0317839
0.0157829   0.0102948
 2015   3   1   1   0   0   0   125   0.0126131   0.00853007   0.0139498   0.0214402   0.0325748   0.0537029
0.0885482   0.129716   0.149721   0.141136   0.108693   0.0853329   0.0588792   0.0433409   0.0264528
0.0146881   0.0106795
 2016   3   1   1   0   0   0   155   0.0221805   0.0103568   0.0158631   0.0220943   0.039383   0.0683867
0.121158   0.1522   0.157448   0.132527   0.092669   0.0648578   0.0431382   0.0286815   0.0154292
0.00865352   0.00497325
 2017   3   1   1   0   0   0   133   0.0286731   0.0105041   0.0158519   0.0226251   0.036473   0.0670006
0.116437   0.155027   0.162527   0.142692   0.0967285   0.0602004   0.0373219   0.0212888   0.0117646
0.0076865   0.00719791
 2018   3   1   1   0   0   0   234   0.0186917   0.0113587   0.0156748   0.023319   0.045141   0.0708996
0.130263   0.150488   0.168919   0.132958   0.0982731   0.0548139   0.0348002   0.0215186   0.012037
0.00677388   0.00407118
 2019   3   1   1   0   0   0   148   0.00916154   0.00612811   0.0107599   0.0187185   0.0376047
0.0765679   0.130283   0.165464   0.180549   0.14757   0.0959298   0.0578562   0.0331322   0.0176404
0.00737997   0.00375871   0.00149607
 2020   3   1   1   0   0   0   155   0.0177394   0.00714948   0.0136626   0.019769   0.0440827   0.0694093
0.135446   0.170574   0.177529   0.131859   0.0973366   0.0508625   0.0332001   0.0159713   0.00856022
0.00393227   0.00291636
 2021   3   1   1   0   0   0   138   0.00686642   0.0027576   0.00523951   0.00768031   0.019068
0.0523038   0.106167   0.16282   0.183086   0.159105   0.117981   0.0711493   0.049806   0.0288588
0.0151058   0.0074205   0.004585
#
#
## Growth data (increment)
# Type of growth increment (0=no growth data;1=size-at-release; 2= size-class-at-release)
3
# nobs_growth
222
# Class-at-release Sex Class-at-recapture Years-at-liberty
        numberTransitionMatrix  RecaptureFleet RecaptureYear SampleSize

    1   1   3   1   1   1   2004   2
    1   1   4   1   1   1   2004   2
    2   1   2   1   1   1   2004   1
    2   1   4   1   1   1   2004   4
    2   1   5   1   1   1   2004   10
    2   1   6   1   1   1   2004   1
    2   1   8   1   1   1   2004   1
    3   1   5   1   1   1   2004   4
    3   1   6   1   1   1   2004   6
    3   1   7   1   1   1   2004   2
    4   1   4   1   1   1   2004   2
    4   1   6   1   1   1   2004   7
    4   1   7   1   1   1   2004   29
    4   1   8   1   1   1   2004   12
    5   1   5   1   1   1   2004   9
    5   1   6   1   1   1   2004   10
    5   1   7   1   1   1   2004   25
    5   1   8   1   1   1   2004   90
    5   1   9   1   1   1   2004   24
    5   1   10   1   1   1   2004   3
    6   1   6   1   1   1   2004   18
    6   1   7   1   1   1   2004   12
    6   1   8   1   1   1   2004   36
    6   1   9   1   1   1   2004   96
    6   1   10   1   1   1   2004   21
    7   1   7   1   1   1   2004   43
    7   1   8   1   1   1   2004   9
    7   1   9   1   1   1   2004   37
```

7	1	10	1	1	1	2004	64
7	1	11	1	1	1	2004	23
8	1	8	1	1	1	2004	39
8	1	9	1	1	1	2004	11
8	1	10	1	1	1	2004	28
8	1	11	1	1	1	2004	44
8	1	12	1	1	1	2004	13
8	1	13	1	1	1	2004	1
9	1	9	1	1	1	2004	48
9	1	10	1	1	1	2004	7
9	1	11	1	1	1	2004	8
9	1	12	1	1	1	2004	22
9	1	13	1	1	1	2004	3
10	1	10	1	1	1	2004	56
10	1	11	1	1	1	2004	4
10	1	12	1	1	1	2004	7
10	1	13	1	1	1	2004	12
10	1	14	1	1	1	2004	1
11	1	11	1	1	1	2004	30
11	1	12	1	1	1	2004	6
11	1	13	1	1	1	2004	1
11	1	14	1	1	1	2004	5
12	1	12	1	1	1	2004	18
12	1	13	1	1	1	2004	4
12	1	14	1	1	1	2004	2
12	1	15	1	1	1	2004	2
13	1	13	1	1	1	2004	12
13	1	14	1	1	1	2004	1
13	1	15	1	1	1	2004	1
13	1	16	1	1	1	2004	1
14	1	14	1	1	1	2004	10
14	1	15	1	1	1	2004	1
15	1	15	1	1	1	2004	3
15	1	16	1	1	1	2004	1
17	1	17	1	1	1	2004	1

#Year2

1	1	4	2	1	1	2004	1
1	1	8	2	1	1	2004	1
2	1	5	2	1	1	2004	2
2	1	7	2	1	1	2004	1
2	1	8	2	1	1	2004	4
2	1	9	2	1	1	2004	3
3	1	5	2	1	1	2004	3
3	1	6	2	1	1	2004	7
3	1	7	2	1	1	2004	1
3	1	8	2	1	1	2004	1
3	1	9	2	1	1	2004	13
3	1	10	2	1	1	2004	1
4	1	6	2	1	1	2004	1
4	1	7	2	1	1	2004	16
4	1	8	2	1	1	2004	8
4	1	9	2	1	1	2004	6
4	1	10	2	1	1	2004	10
4	1	11	2	1	1	2004	4
5	1	5	2	1	1	2004	1
5	1	6	2	1	1	2004	2
5	1	7	2	1	1	2004	15
5	1	8	2	1	1	2004	61
5	1	9	2	1	1	2004	17
5	1	10	2	1	1	2004	5
5	1	11	2	1	1	2004	10
5	1	12	2	1	1	2004	4

5	1	14	2	1	1	2004	1
6	1	6	2	1	1	2004	1
6	1	7	2	1	1	2004	2
6	1	8	2	1	1	2004	24
6	1	9	2	1	1	2004	42
6	1	10	2	1	1	2004	9
6	1	11	2	1	1	2004	3
6	1	12	2	1	1	2004	6
6	1	13	2	1	1	2004	2
7	1	7	2	1	1	2004	2
7	1	8	2	1	1	2004	5
7	1	9	2	1	1	2004	11
7	1	10	2	1	1	2004	39
7	1	11	2	1	1	2004	13
7	1	12	2	1	1	2004	1
7	1	14	2	1	1	2004	1
8	1	8	2	1	1	2004	3
8	1	9	2	1	1	2004	4
8	1	10	2	1	1	2004	10
8	1	11	2	1	1	2004	38
8	1	12	2	1	1	2004	8
8	1	13	2	1	1	2004	1
9	1	9	2	1	1	2004	5
9	1	10	2	1	1	2004	1
9	1	11	2	1	1	2004	7
9	1	12	2	1	1	2004	14
9	1	13	2	1	1	2004	5
10	1	10	2	1	1	2004	3
10	1	12	2	1	1	2004	6
10	1	13	2	1	1	2004	14
10	1	14	2	1	1	2004	2
10	1	17	2	1	1	2004	1
11	1	11	2	1	1	2004	1
11	1	13	2	1	1	2004	5
11	1	14	2	1	1	2004	4
12	1	12	2	1	1	2004	1
12	1	14	2	1	1	2004	2
12	1	15	2	1	1	2004	2

#Year3

1	1	1	3	1	1	2004	1
1	1	7	3	1	1	2004	5
1	1	9	3	1	1	2004	1
2	1	7	3	1	1	2004	3
2	1	8	3	1	1	2004	11
2	1	9	3	1	1	2004	6
2	1	10	3	1	1	2004	1
3	1	6	3	1	1	2004	1
3	1	7	3	1	1	2004	1
3	1	8	3	1	1	2004	4
3	1	9	3	1	1	2004	14
3	1	10	3	1	1	2004	5
4	1	7	3	1	1	2004	1
4	1	8	3	1	1	2004	1
4	1	9	3	1	1	2004	5
4	1	10	3	1	1	2004	14
4	1	11	3	1	1	2004	3
4	1	12	3	1	1	2004	1
5	1	7	3	1	1	2004	1
5	1	8	3	1	1	2004	4
5	1	9	3	1	1	2004	5
5	1	10	3	1	1	2004	12
5	1	11	3	1	1	2004	24

5	1	12	3	1	1	2004	12
5	1	13	3	1	1	2004	2
5	1	14	3	1	1	2004	1
6	1	6	3	1	1	2004	1
6	1	8	3	1	1	2004	2
6	1	9	3	1	1	2004	8
6	1	10	3	1	1	2004	2
6	1	11	3	1	1	2004	6
6	1	12	3	1	1	2004	7
6	1	13	3	1	1	2004	3
6	1	14	3	1	1	2004	1
7	1	8	3	1	1	2004	1
7	1	9	3	1	1	2004	2
7	1	10	3	1	1	2004	11
7	1	11	3	1	1	2004	3
7	1	13	3	1	1	2004	6
7	1	14	3	1	1	2004	3
8	1	10	3	1	1	2004	1
8	1	11	3	1	1	2004	7
8	1	12	3	1	1	2004	2
8	1	14	3	1	1	2004	1
9	1	11	3	1	1	2004	1
9	1	12	3	1	1	2004	4
9	1	13	3	1	1	2004	1
9	1	15	3	1	1	2004	1
9	1	16	3	1	1	2004	1
10	1	13	3	1	1	2004	1
13	1	15	3	1	1	2004	1
#Year4							
1	1	10	4	1	1	2004	6
1	1	11	4	1	1	2004	1
2	1	8	4	1	1	2004	1
2	1	10	4	1	1	2004	1
2	1	11	4	1	1	2004	5
3	1	8	4	1	1	2004	3
3	1	9	4	1	1	2004	3
3	1	10	4	1	1	2004	3
3	1	11	4	1	1	2004	1
3	1	12	4	1	1	2004	1
3	1	14	4	1	1	2004	1
4	1	9	4	1	1	2004	1
4	1	10	4	1	1	2004	2
4	1	12	4	1	1	2004	1
4	1	14	4	1	1	2004	1
5	1	8	4	1	1	2004	1
5	1	10	4	1	1	2004	1
5	1	11	4	1	1	2004	4
5	1	12	4	1	1	2004	4
6	1	11	4	1	1	2004	1
6	1	12	4	1	1	2004	2
7	1	10	4	1	1	2004	2
7	1	12	4	1	1	2004	1
7	1	14	4	1	1	2004	2
8	1	14	4	1	1	2004	2
#Year5							
1	1	10	5	1	1	2004	2
2	1	11	5	1	1	2004	1
2	1	12	5	1	1	2004	1
2	1	16	5	1	1	2004	1
3	1	11	5	1	1	2004	1
3	1	13	5	1	1	2004	3
3	1	14	5	1	1	2004	1

```
            5      1      14      5      1      1      2004    1
            7      1      13      5      1      1      2004    1
            7      1      14      5      1      1      2004    1
#Year6
            1      1      8       6      1      1      2004    1
            1      1      9       6      1      1      2004    1
            1      1      11      6      1      1      2004    1
            1      1      12      6      1      1      2004    1
            1      1      13      6      1      1      2004    2
            2      1      11      6      1      1      2004    2
            2      1      14      6      1      1      2004    1
            3      1      9       6      1      1      2004    1
            4      1      10      6      1      1      2004    2
## eof
9999
```

4. ***EAG21.1a ctl file***:

```
#  ntheta
 9
##—————————————————————————— #
# ival      lb     ub       phz   prior   p1      p2      # parameter         #
##———————————————————————————————————————————————————————————— #
 0.21      0.01   1.0      -3     2     0.18    0.04     # M
 7.783382057  -10.0 20.0   1    0    -10.0    20.0      # ln R0,

 12.0       -10.0   20.0     -3    0    -10.0    20.0      # ln Rini,

   8.0       -10.0  20.0     -1    0    -10.0    20.0      # ln Rbar,

 110.0      103.0  165.0     -2    1     72.5    7.25      #  Expected value of recruitment distribution

 17.791817085  0.001  20.0    3    0     0.1     5.0    # recruitment scale

  -0.693147181 -10.0   0.75   -1    0   -10.0     0.75      # ln (SigmaR),

 0.73       0.2    1.0       -2    3     3.0     2.0       # steepness
  0.001      0.0    1.0      -3    3     1.01    1.01      # recruitment autocorrelation
#——————————————————————————————————————————————————————————————————————————————————————————
——————————————————————————————————————————————————————————————

# weight-at-length input method  (1 = allometry  [w_l = a*l^b],  2 = vector by sex)
2
#a, in kg
# 1.445E-07
#b
# 3.281126995
# Male weight-at-length
 0.581515707 0.679328169 0.788032347 0.908278308 1.040724257 1.186036294 1.344888179      1.517961114      1.705943543
1.90953096 2.129425732 2.366336933 2.620980182 2.894077494 3.186357141 3.498553516 3.993657581
#
# Proportion mature by sex, males
  0.  0.  1.  1.  1.  1.  1.  1.  1.  1.  1.  1.  1.  1.  1.  1.  1.
# Proportion legal by sex, males
  0.  0.  0.  0.  0.  0.  0.  1.  1.  1.  1.  1.  1.  1.  1.  1.  1.
##————————————————————————— ##
## GROWTH PARAM CONTROLS
##     Two lines for each parameter if split sex, one line if not
##————————————————————————— ##
# Use growth transition matrix option (1=read in growth-increment matrix; 2=read in size-transition; 3=gamma distribution for size-increment; 4=gamma distribution for size after increment) (1 to 8 options available)
# option 8 is normal distributed growth incrment, size after incrment is normal
```

```
8
# growth increment model (0=prespecified; 1=alpha/beta; 2=estimated by size-class;3=pre-specified/emprical)
1
# molt probability function (0=pre-specified; 1=flat;2=declining logistic)
2
# maximum size-class (males then females)
#
# Maximum size-class for recruitment (males then females)
5
## number of size-increment periods
1
## Year(s) size-increment period changes (blank if no changes)

## number of molt periods
1
## Year(s) molt period changes (blank if no changes)

## Beta parameters are relative to a base level (1=Yes;0=no)
1

# Growth parameters
##————————————————————————————————— ##
# ival       lb      ub    phz   prior     p1     p2       # parameter
## —————————————————————————————————— ##
   26.583519176   10.0    50.0    7       0       0.0    20.0   # alpha
  0.099826455   -0.4    20.0     7       0       0.0    10.0   # beta
  3.703755880   0.01    5.0      7       0       0.0     3.0   # growth scale
  141.157675494  65.0   165.0    7       0       0.0    999.0  #  moult mu,
  0.075286539  -0.1     2.0     7       0       0.0     2.0   # moult cv,
##————————————————— ##

# The custom growth-increment matrix

# custom molt probability matrix

##——————————————————  ##
## SELECTIVITY CONTROLS
##     Selectivity P (capture of all sizes). Each gear must have a selectivity and a
##     retention selectivity. If a uniform prior is selected for a parameter then the
##     lb and ub are used (p1 and p2 are ignored)
## LEGEND
##     sel type: 0 = parametric (nclass), 1 = indiviudal parameter for each class(nclass)
##             2 = logistic (2, inflection point and slope), 3 = logistic95 (2, 50% and 95% selection), 4 = double normal (3 parameters)
##
##    5: Flat equal to zero (1 parameter; phase must be negative), UNIFORM1
##    6: Flat equal to one (1 parameter; phase must be negative), UNIFORM0
##    7: Flat-topped double normal selectivity (4 parameters)
##    8: Declining logistic selectivity with initial values (50% and 95% selection plus extra)
## Extra (type 1): number of selectivity parameters to be estimated
##     gear index: use +ve for selectivity, -ve for retention
##     sex dep: 0 for sex-independent, 1 for sex-dependent
##——————————————————  ##
## ivector for number of year blocks or nodes ##
##   Gear-1   Gear-2
## PotFishery    Trawl Byc
       2        1                  # selectivity time periods
       0        0                  # set 0 for male only fishery, sex specific selectivity, 0 for sex independent selectivity
       2        5                  # male selectivity type model (flat equal to zero, 1 parameter) or logistic or double normal etc.
       0        0                  # within another gear insertion of fleet in another
       0        0                  # extra parameters for each pattern
## Gear-1    Gear-2
      1        1                   # retention time periods
```

```
     0        0                   # set 0 for male only fishery, sex specific retention
     2        6                   # male retention type model (flat equal to one, 1 parameter)
     1        0                   # male retention flag (0 = no, 1 = yes)
     0        0                   # extra
     1        1                   # determines if maximum selectivity at size is forced to equal 1 or not
##————————————————————##
## Selectivity P (capture  of  all  sizes)
##———————————————————— ##
## gear par   sel                                                        phz     start     end
# index index par sex ival      lb    ub   prior    p1      p2    mirror      period   period
## ———————————————————————————————————————————— ##
## Gear-1
   1     1     1   0  88.879812541 105.0 180.0   0   100.0  190.0     3     1960    2004 #set sex 0 for male only fishery
   1     2     2   0  0.592191796  0.01   40.0   0     0.1   50.0         3     1960   2004
   1     3     1   0  134.181319269 105.0 180.0   0   100.0  190.0   3     2005   2021
   1     4     2   0   8.209966415  0.01   20.0   0     0.1   50.0         3     2005   2021

# Gear-2
   2     5     1   0    1.00      0.99  1.02   0     10.0  200.0             -3     1960   2021
##———————————————————— ##
## Retained
## gear par   sel                                                               phz    start   end
# index index par sex ival       lb    ub     prior   p1     p2     mirror      period  period
# Gear-1
 -1     6    1   0   136.194545030  105.0  180.0  0      100.0  190.0      3     1960   2021
 -1     7    2   0    2.120704640   0.0001  20.0  0      0.1     50.0           3     1960   2021

# Gear-2
 -2     8    1   0    1.00        0.99   1.01  0       10.0   200.0                -3     1960   2021

##———————————————————— ##
# Number of asymptotic parameters
1
# Fleet   Sex     Year       ival   lb   ub    phz
     1     1     1960   0.000001   0    1     -3
##———————————————————— ##
## PRIORS FOR CATCHABILITY
##     If a uniform prior is selected for a parameter then the lb and ub are used (p1
##     and p2 are ignored). ival must be > 0
## only allowed to use uniform or lognormal prior
## if anlytic q estimation step is chosen, turn off estimating q by changing the estimation phase to be -ve
## LEGEND
##     prior: 0 = uniform, 1 = normal, 2 = lognormal, 3 = beta, 4 = gamma
##———————————————————— ##
#
## SURVEYS/INDICES ONLY
## fishery and observer CPUE
## Analytic (0=not analytically solved q, use uniform or lognormal prior;
## 1= analytic),
## Lambda =multilier for iput CV, Emphasis = multiplier for likelihood
##  ival       lb        ub    phz    prior   p1        p2     Analytic?   LAMBDA   Emphasis
 0.000370813  0.0000001   0.01   1      0      0.0     1.0      0          1       1   # observer cpue index 1995-2004
 0.000385257  0.0000001   0.01   1      0      0.0     1.0      0          1       1   # observer cpue index 2005-2021
 0.000370813   0.0000001  0.01   1      0      0.0     1.0      0          1       1   # fishery cpue index    1985-1998

## if a uniform prior is specified then use lb and ub rather than p1 and p2
##  ———————————————————————————————————————##
## ADDITIONAL CV FOR SURVEYS/INDICES
##     If a uniform prior is selected for a parameter then the lb and ub are used (p1
##     and p2 are ignored). ival must be > 0, lb should be>0
## LEGEND
##     prior type: 0 = uniform, 1 = normal, 2 = lognormal, 3 = beta, 4 = gamma
```

```
## ———————————————————————————————— ##
##  ival              lb       ub   phz   prior   p1    p2
 0.000213935   0.0000001   0.5    6      0      0.5   100   # obs CPUE additional CV
 0.000213935   0.0000001   0.5    -1     0      0.5   100   # obs CPUE additional CV
 0.000169000   0.0000001   0.5     6     0      0.5   100   # fishery CPUE additional

### Pointers to how the additional CVs are used (0 ignore; >0 link to one of the parameters
1 1 3
####
## if a uniform prior is specified then use lb and ub rather than p1 and p2
——————————————————##
##PENALTIES FOR AVERAGE FISHING  MORTALITY  RATE  FOR  EACH  GEAR
##——————————————————##
## Trap Trawl
## Male F, Female F, early_phasepenalty_sd, later_phasepenalty_sd, meanmaleF_phase, meanfemaleF_phase,
## lb meanF, ub meanF,lbannualmaleF(F_dev), ubannual maleF(F_dev),lbannualfemaleF(F_dev), ubannual femaleF(F_dev)
## BBRKC uses STD_PHZ1=0.5 STD_PHZ2=45.5
## Mean_F    Fema-Offset   STD_PHZ1 STD_PHZ2 PHZ_M PHZ_F    Lb     Ub    Lb    Ub     Lb   Ub
   0.269102103      0.0       3.0    15.0     2    -1     -12      4    -10     10     -10    10   #
   0.000206782      0.0       4.0    15.0     2    -1     -12      4    -10     10     -10    10
#——————————————————##
## OPTIONS FOR SIZE COMPOSTION DATA
##     One column for each data matrix
## LEGEND
##     Likelihood: 1 = Multinomial with estimated/fixed sample size
##              2 = Robust approximation to multinomial
##              3 = logistic normal (NIY)
##              4 = multivariate-t (NIY)
##              5 = Dirichlet
## AUTO TAIL COMPRESSION
##     pmin is the cumulative proportion used in tail compression
##
##————————————————  ##
#  Ret Tot
#
  1   1        # Type of likelihood
  0   0        # Auto tail compression (pmin)
  1   1        # Initial value for effective sample size multiplier
 -4  -4       # Phz for estimating effective sample size (if appl.)
  1   2       # Composition aggregator if you put 1 for each it will merge, do not merge (why merge)
  #
  1   1        # Set to 2 for survey-like predictions; 1 for catch-like predictions
  #
  0.58595525  0.46003275  # Emphasis for Dritchlet (Ret, Tot, multiplier of stage1 ESS)
   1   1       # LAMBDA 0 to ignore the length comp
————————————————  ##

## TIME VARYING NATURAL  MORTALIIY  RATES
##—————————————————— ##
## Type: 0 = constant natural mortality
##       1 = Random walk (deviates constrained by variance in M)
##       2 = Cubic Spline (deviates constrained by nodes & node-placement)
##       3 = Blocked changes (deviates constrained by variance at specific knots)
##       4 = Changes in pre-specified blocks
##       5 = Changes in some knots
##       6 = Changes in Time blocks
 0    # M type
## M is relative (YES=1; NO=0)

## Phase of estimation
3
## STDEV in m_dev for Random walk
```

```
0.25
## Number of nodes for cubic spline or number of step-changes for option 3
1
## Year position of the knots (vector must be equal to the number of nodes)
1960
## number of breakpoints in M by size (keep it at 0)
0
# line groups for breakpoint
8
## Specific initial values for the natural mortality devs (0-no, 1=yes)

## ival      lb      ub      phz    extra
##    3.0      0.5     5.0     4      0

## ———————————————————————————————— ##
## TAGGING controls CONTROLS
##—————————————— ##
 1                                   # emphasis on tagging data (1 =use tag LH, 0=ignore)
##—————————————— ##
## Maturity specific natural mortality
###
##—————————————— ##
# maturity specific natural mortality? (yes = 1; no = 0; only for use if nmature > 1)
 0

##—————————————————————— ##

## ival       lb   ub phz prior p1    p2       # parameter

##—————————————————————— ##

0   -1   1    -1   0    1    1
##—————————————— ##
## OTHER CONTROLS
## ——————————————————————————————————— ##
#
1960      # First year of recruitment estimation,rec_dev.
2021      # last year of recruitment estimation, rec_dev
   1      # phase for recruitment estimation,earlier -1. rec_dev estimation phase,
  -2      # phase for recruitment sex-ratio estimation
  0.5     # Initial value for Expected sex-ratio
  -3      # Phase for initial recruitment estimation, rec_ini phase
   1      # VERBOSE FLAG (0 = off, 1 = on, 2 = objective func; 3 diagnostics)
   0      # Initial conditions (0 = Unfished, 1 = Steady state fished, 2 = Free parameters, 3 = Free parameters (revised))
   1      # Lambda (proportion of mature male biomass for SPR reference points).
   0      # Stock-Recruit-Relationship (0 = none, 1 = Beverton-Holt)
   10     # Maximum phase (stop the estimation after this phase), 10 Maximum phase. If you put 1 it will stop after phase 1
   -1     # Maximum number of function calls, if 1, stop at fn 1 call; if -1, run as long as it takes
   1      # Calculate reference points (0=no)
   200    ### Year to compute equilibria
## EMPHASIS FACTORS (CATCH)
#Ret_male Tot_male   Groundfish
      4      2        1
## EMPHASIS FACTORS (Priors) by fleet: fdev_total, Fdov_total, Fdev_year, Fdov_year
0 0 0.001 0 # Pot fishery
0 0 0.001 0 # Groundfish


## EMPHASIS FACTORS (Priors)
##
# Log_fdevs   meanF      Mdevs  Rec_devs Initial_devs Fst_dif_dev Mean_sex-Ratio  Fvecs Fdovs
#        0      0        0.0       2         0         0          0         1    0      #
```

#
Log_fdevs   meanF   Mdevs Rec_devs Initial_devs Fst_dif_dev Mean_sex-Ratio Molt_prob   Free   selectivity
Init_n_at_len Fvecs Fdovs
0   0   0.0   2   0   0   0   0   0   0   1   0

EOF
9999

Input data file for model 21.1e

1. *WAG21.1e dat file*

#===========#
Gmacs Main Data File Version 1.1:
#
GEAR_   INDEX   DESCRIPTION
1   : Pot fishery Retained catch
2   : Pot fishery total catch
3   : Trawl bycatch
4   : Observer CPUE
5   : Fishery CPUE

Fisheries: 1 Pot Fishery, 2 Pot Total
Cooperative Survey:
#===
=============

1960 # initial (start year)
2021 # terminal (end year)
#2022 # Projection year (for forecast, OFL and ABC calculation)
6   # Number of seasons: season1 for N est, season 2 for Jul 1 to MidFishing, season 3 for inst.remove C, season 4 for to spawning time,Feb15, season 5 for inst remove byc&estimate MMB, season 6 for remaining time to June 30 and R enter
2   # Number of distinct data groups or number of fleets (pot fishing, groundfish fishing)
1   # Number of sexes (males)
1   # Number of shell condition types
1   # Number of maturity types
17   # Number of size-classes in the model
6   # Season when recruitment occurs,end of year before growth
6   # Season when molting and growth occur, end of year after recruitment
5   # Season to calculate MMB
1   # Season for N output
maximum size-class (males then females)
17
size_breaks (a vector giving the break points between size intervals with dimension nclass+1, lower limits of bins)
100.5 105.5 110.5 115.5 120.5 125.5 130.5 135.5 140.5 145.5 150.5 155.5 160.5 165.5 170.5 175.5 180.5 185.5
Natural mortality per season input type (1 = vector by season, 2 = matrix by season/year)
2
Proportion of the total natural mortality to be applied each season (each row must add to 1)
1 Start biological year (Jul 1) instantaneous N estimation
2 to mid-fishing time
3 instantanous C removal
4 to spawning time
5 instantaneous byc removal and estimate MMB
6 Rest of the period of non-fishing from Feb 15 to June 30
#
#
#Ins N Jul1-MidFish   Inst C   MidFish-15Feb   Ins byc   Rest upto end
 0.   0.16666667   0.   0.46073059   0.   0.37260274   #1960

0.	0.16666667	0.	0.46073059	0.	0.37260274	#1961
0.	0.16666667	0.	0.46073059	0.	0.37260274	#1962
0.	0.16666667	0.	0.46073059	0.	0.37260274	#1963
0.	0.16666667	0.	0.46073059	0.	0.37260274	#1964
0.	0.16666667	0.	0.46073059	0.	0.37260274	#1965
0.	0.16666667	0.	0.46073059	0.	0.37260274	#1966
0.	0.16666667	0.	0.46073059	0.	0.37260274	#1967
0.	0.16666667	0.	0.46073059	0.	0.37260274	#1968
0.	0.16666667	0.	0.46073059	0.	0.37260274	#1969
0.	0.16666667	0.	0.46073059	0.	0.37260274	#1970
0.	0.16666667	0.	0.46073059	0.	0.37260274	#1971
0.	0.16666667	0.	0.46073059	0.	0.37260274	#1972
0.	0.16666667	0.	0.46073059	0.	0.37260274	#1973
0.	0.16666667	0.	0.46073059	0.	0.37260274	#1974
0.	0.16666667	0.	0.46073059	0.	0.37260274	#1975
0.	0.16666667	0.	0.46073059	0.	0.37260274	#1976
0.	0.16666667	0.	0.46073059	0.	0.37260274	#1977
0.	0.16666667	0.	0.46073059	0.	0.37260274	#1978
0.	0.16666667	0.	0.46073059	0.	0.37260274	#1979
0.	0.16666667	0.	0.46073059	0.	0.37260274	#1980
0.	0.62739726	0.	0.	0.	0.37260274	#1981
0.	0.564383562	0.	0.063013698	0.	0.37260274	#1982
0.	0.578082192	0.	0.049315068	0.	0.37260274	#1983
0.	0.62739726	0.	0.	0.	0.37260274	#1984
0.	0.62739726	0.	0.	0.	0.37260274	#1985
0.	0.62739726	0.	0.	0.	0.37260274	#1986
0.	0.62739726	0.	0.	0.	0.37260274	#1987
0.	0.62739726	0.	0.	0.	0.37260274	#1988
0.	0.62739726	0.	0.	0.	0.37260274	#1989
0.	0.62739726	0.	0.	0.	0.37260274	#1990
0.	0.62739726	0.	0.	0.	0.37260274	#1991
0.	0.62739726	0.	0.	0.	0.37260274	#1992
0.	0.62739726	0.	0.	0.	0.37260274	#1993
0.	0.62739726	0.	0.	0.	0.37260274	#1994
0.	0.62739726	0.	0.	0.	0.37260274	#1995
0.	0.62739726	0.	0.	0.	0.37260274	#1996
0.	0.62739726	0.	0.	0.	0.37260274	#1997
0.	0.62739726	0.	0.	0.	0.37260274	#1998
0.	0.62739726	0.	0.	0.	0.37260274	#1999
0.	0.516438356	0.	0.110958904	0.	0.37260274	#2000
0.	0.435616438	0.	0.191780822	0.	0.37260274	#2001
0.	0.405479452	0.	0.221917808	0.	0.37260274	#2002
0.	0.364383562	0.	0.263013698	0.	0.37260274	#2003
0.	0.317808219	0.	0.309589041	0.	0.37260274	#2004
0.	0.430136986	0.	0.197260274	0.	0.37260274	#2005
0.	0.494520548	0.	0.132876712	0.	0.37260274	#2006
0.	0.530136986	0.	0.097260274	0.	0.37260274	#2007
0.	0.505479452	0.	0.121917808	0.	0.37260274	#2008
0.	0.524657534	0.	0.102739726	0.	0.37260274	#2009
0.	0.436986301	0.	0.190410959	0.	0.37260274	#2010
0.	0.471232877	0.	0.156164383	0.	0.37260274	#2011
0.	0.504109589	0.	0.123287671	0.	0.37260274	#2012
0.	0.509589041	0.	0.117808219	0.	0.37260274	#2013
0.	0.501369863	0.	0.126027397	0.	0.37260274	#2014
0.	0.463013699	0.	0.164383561	0.	0.37260274	#2015
0.	0.42739726	0.	0.2	0.	0.37260274	#2016
0.	0.383561644	0.	0.243835616	0.	0.37260274	#2017
0.	0.394520548	0.	0.232876712	0.	0.37260274	#2018
0.	0.456164384	0.	0.171232876	0.	0.37260274	#2019
0.	0.490410959	0.	0.136986301	0.	0.37260274	#2020
0.	0.390410959	0.	0.236986301	0.	0.37260274	#2021

#

```
# Fishing fleet names (delimited with: no spaces in names)
Pot_Fishery Trawl_Bycatch
# Survey names (delimited with: no spaces in names) keep empty

# Are the seasons discrete-instantaneous (0) or continuous (1)
1 1 1 1 1 1
# Number of  catch data  frames
3
# Number of rows  in  each  data  frame
# up to 2021/22 data
# retained catch 1981/82-2021/22
 41  32  32
## no groundfish bycatch in 1993, this year is omitted
##  CATCH DATA in t
##  Type of catch: 1 = retained, 2 = discard, 0= total (retained+discard, slide says 3)
##  Units of catch: 1 = biomass, 2 = numbers
# Mult: 1= use data as they are, 2 = multiply by this number (e.g., lbs to kg)

## Retained Catch from 1985- in tonnes
#year seas    fleet   sex       obs   cv   type    units   mult    effort  discard_mortality
 1981    3     1     1     38.436   0.0316  1      2      1      0      0.2
 1982    3     1     1     1114.351 0.0316  1      2      1      0      0.2
 1983    3     1     1     1288.357 0.0316  1      2      1      0      0.2
 1984    3     1     1     188.782 0.0316  1      2      1      0      0.2
 1985    3     1     1     2029.52 0.0316  1      1      1      0      0.2
 1986    3     1     1     4271.83 0.0316  1      1      1      0      0.2
 1987    3     1     1     2535.35 0.0316  1      1      1      0      0.2
 1988    3     1     1     2471.07 0.0316  1      1      1      0      0.2
 1989    3     1     1     3062.63 0.0316  1      1      1      0      0.2
 1990    3     1     1     1636.5  0.0316  1      1      1      0      0.2
 1991    3     1     1     1359.1  0.0316  1      1      1      0      0.2
 1992    3     1     1     1030.34 0.0316  1      1      1      0      0.2
 1993    3     1     1     668.56  0.0316  1      1      1      0      0.2
 1994    3     1     1     1625.55 0.0316  1      1      1      0      0.2
 1995    3     1     1     1192.2  0.0316  1      1      1      0      0.2
 1996    3     1     1     1236.74 0.0316  1      1      1      0      0.2
 1997    3     1     1     1067.44 0.0316  1      1      1      0      0.2
 1998    3     1     1     934.631 0.0316  1      1      1      0      0.2
 1999    3     1     1     1240.37 0.0316  1      1      1      0      0.2
 2000    3     1     1     1385.08 0.0316  1      1      1      0      0.2
 2001    3     1     1     1287.63 0.0316  1      1      1      0      0.2
 2002    3     1     1     1217.19 0.0316  1      1      1      0      0.2
 2003    3     1     1     1249.26 0.0316  1      1      1      0      0.2
 2004    3     1     1     1265.9  0.0316  1      1      1      0      0.2
 2005    3     1     1     1237.6  0.0316  1      1      1      0      0.2
 2006    3     1     1     1055.97 0.0316  1      1      1      0      0.2
 2007    3     1     1     1241.73 0.0316  1      1      1      0      0.2
 2008    3     1     1     1218.89 0.0316  1      1      1      0      0.2
 2009    3     1     1     1348.46 0.0316  1      1      1      0      0.2
 2010    3     1     1     1353.82 0.0316  1      1      1      0      0.2
 2011    3     1     1     1349.85 0.0316  1      1      1      0      0.2
 2012    3     1     1     1420.14 0.0316  1      1      1      0      0.2
 2013    3     1     1     1456.44 0.0316  1      1      1      0      0.2
 2014    3     1     1     1266.43 0.0316  1      1      1      0      0.2
 2015    3     1     1     1180.31 0.0316  1      1      1      0      0.2
 2016    3     1     1     1050.05 0.0316  1      1      1      0      0.2
 2017    3     1     1     1054.43 0.0316  1      1      1      0      0.2
 2018    3     1     1     1184.49 0.0316  1      1      1      0      0.2
 2019    3     1     1     1309.4  0.0316  1      1      1      0      0.2
 2020    3     1     1     1358.32 0.0316  1      1      1      0      0.2
 2021    3     1     1     1223.36 0.0316  1      1      1      0      0.2
#
```

Total Catch (no mortality applied) in tonnes

#year	seas	fleet	sex	obs	cv	type	units	mult	effort	discard_mortality
1990	3	1	1	3981.87	0.207908162	0	1	1	0	0.2
1991	3	1	1	2118.23	0.130117339	0	1	1	0	0.2
1992	3	1	1	1039.24	0.145158877	0	1	1	0	0.2
1993	3	1	1	3601.26	0.293606298	0	1	1	0	0.2
1994	3	1	1	5053.58	0.106740581	0	1	1	0	0.2
1995	3	1	1	2618.76	0.050729769	0	1	1	0	0.2
1996	3	1	1	1972.19	0.04474373	0	1	1	0	0.2
1997	3	1	1	1891.86	0.060142043	0	1	1	0	0.2
1998	3	1	1	1106.87	0.087743921	0	1	1	0	0.2
1999	3	1	1	2178.04	0.056445899	0	1	1	0	0.2
2000	3	1	1	2272.72	0.055136691	0	1	1	0	0.2
2001	3	1	1	2154.96	0.056882141	0	1	1	0	0.2
2002	3	1	1	1900.34	0.075835543	0	1	1	0	0.2
2003	3	1	1	1867.22	0.065763685	0	1	1	0	0.2
2004	3	1	1	1886.02	0.074221412	0	1	1	0	0.2
2005	3	1	1	1796.25	0.102938855	0	1	1	0	0.2
2006	3	1	1	1551.24	0.110618989	0	1	1	0	0.2
2007	3	1	1	1614.06	0.115699625	0	1	1	0	0.2
2008	3	1	1	1733.15	0.121676438	0	1	1	0	0.2
2009	3	1	1	1689.85	0.127517984	0	1	1	0	0.2
2010	3	1	1	1604.74	0.129358495	0	1	1	0	0.2
2011	3	1	1	1516.82	0.131675973	0	1	1	0	0.2
2012	3	1	1	1839.08	0.114273251	0	1	1	0	0.2
2013	3	1	1	1919.09	0.108784133	0	1	1	0	0.2
2014	3	1	1	1592.18	0.112848388	0	1	1	0	0.2
2015	3	1	1	1565.39	0.105658441	0	1	1	0	0.2
2016	3	1	1	1569.99	0.116902199	0	1	1	0	0.2
2017	3	1	1	1436.59	0.138245859	0	1	1	0	0.2
2018	3	1	1	1637.42	0.145371921	0	1	1	0	0.2
2019	3	1	1	1714.12	0.122434679	0	1	1	0	0.2
2020	3	1	1	1844.19	0.112848388	0	1	1	0	0.2
2021	3	1	1	1428.94	0.159180092	0	1	1	0	0.2

###

##Trawl fishery discards (handling mortality rate 0.65 is already applied) in tonnes

1989	3	2	1	0.0953342	1.3108	2	1	1.538461538	0	0.65
1990	3	2	1	0.569417	1.3108	2	1	1.538461538	0	0.65
1991	3	2	1	0.0285788	1.3108	2	1	1.538461538	0	0.65
1992	3	2	1	0.442401	1.3108	2	1	1.538461538	0	0.65
1994	3	2	1	0.115027	1.3108	2	1	1.538461538	0	0.65
1995	3	2	1	0.793348	1.3108	2	1	1.538461538	0	0.65
1996	3	2	1	2.59512	1.3108	2	1	1.538461538	0	0.65
1997	3	2	1	0.41718	1.3108	2	1	1.538461538	0	0.65
1998	3	2	1	1.88422	1.3108	2	1	1.538461538	0	0.65
1999	3	2	1	1.80473	1.3108	2	1	1.538461538	0	0.65
2000	3	2	1	1.09494	1.3108	2	1	1.538461538	0	0.65
2001	3	2	1	0.440945	1.3108	2	1	1.538461538	0	0.65
2002	3	2	1	1.2808	1.3108	2	1	1.538461538	0	0.65
2003	3	2	1	0.314029	1.3108	2	1	1.538461538	0	0.65
2004	3	2	1	1.00981	1.3108	2	1	1.538461538	0	0.65
2005	3	2	1	3.74606	1.3108	2	1	1.538461538	0	0.65
2006	3	2	1	2.37268	1.3108	2	1	1.538461538	0	0.65
2007	3	2	1	1.54793	1.3108	2	1	1.538461538	0	0.65
2008	3	2	1	9.3034	1.3108	2	1	1.538461538	0	0.65
2009	3	2	1	4.86086	1.3108	2	1	1.538461538	0	0.65
2010	3	2	1	2.66153	1.3108	2	1	1.538461538	0	0.65
2011	3	2	1	2.70594	1.3108	2	1	1.538461538	0	0.65
2012	3	2	1	4.339	1.3108	2	1	1.538461538	0	0.65
2013	3	2	1	3.7373	1.3108	2	1	1.538461538	0	0.65

```
 2014   3    2    1    2.65644     1.3108  2    1    1.538461538   0    0.65
 2015   3    2    1    1.61523     1.3108  2    1    1.538461538   0    0.65
 2016   3    2    1    2.47563     1.3108  2    1    1.538461538   0    0.65
 2017   3    2    1    1.1635      1.3108  2    1    1.538461538   0    0.65
 2018   3    2    1    1.76314     1.3108  2    1    1.538461538   0    0.65
 2019   3    2    1    4.04095     1.3108  2    1    1.538461538   0    0.65
 2020   3    2    1    0.807148    1.3108  2    1    1.538461538   0    0.65
 2021   3    2    1    0.805314    1.3108  2    1    1.538461538   0    0.65
#
##  RELATIVE  ABUNDANCE DATA
##  Units of abundance: 1 = biomass, 2 = numbers
##  Number  of  relative  abundance indicies
## sex:1=male;2=female; 0=both
## maturity: 1=immature;2=mature;0 = both)

# Fishery CPUE index, Observer CPUE index2
3
# Index Type  (1=Selecivity; 2=retention)
#
2 2 2
##  Number  of  rows  in  each  index
41
# Fishery CPUE index NB error in GLM fits on Observer and Fish Tick data
# Sex: 1 = male, 2 = female, 0 = both" << endl;
#  Maturity: 1 = immature, 2 = mature, 0 = both
#  Units of survey: 1 = biomass, 2 = numbers
#Observer CPUE index
# Index   Year   Seas   fleet   Sex   maturity   index   cv   abundanceunit   timing
    1    1995   3    1    1    0    1.001427527   0.034063946   2    0.5
    1    1996   3    1    1    0    0.929544695   0.022023622   2    0.5
    1    1997   3    1    1    0    0.987686327   0.024180979   2    0.5
    1    1998   3    1    1    0    1.067707402   0.033336582   2    0.5
    1    1999   3    1    1    0    0.917071303   0.024107209   2    0.5
    1    2000   3    1    1    0    0.802399123   0.023965654   2    0.5
    1    2001   3    1    1    0    0.863396862   0.025840362   2    0.5
    1    2002   3    1    1    0    0.969453867   0.027722312   2    0.5
    1    2003   3    1    1    0    1.272957978   0.028325031   2    0.5
    1    2004   3    1    1    0    1.299252834   0.028364089   2    0.5
    2    2005   3    1    1    0    1.220923247   0.034279197   2    0.5
    2    2006   3    1    1    0    1.156132493   0.034515041   2    0.5
    2    2007   3    1    1    0    1.029731651   0.040358749   2    0.5
    2    2008   3    1    1    0    1.174694993   0.03275597    2    0.5
    2    2009   3    1    1    0    1.234857601   0.034965166   2    0.5
    2    2010   3    1    1    0    1.065483687   0.03387555    2    0.5
    2    2011   3    1    1    0    1.131378881   0.034484736   2    0.5
    2    2012   3    1    1    0    1.164533831   0.031469722   2    0.5
    2    2013   3    1    1    0    0.816883575   0.028076205   2    0.5
    2    2014   3    1    1    0    0.77366268    0.031051906   2    0.5
    2    2015   3    1    1    0    0.765568356   0.029718782   2    0.5
    2    2016   3    1    1    0    0.866954042   0.031740494   2    0.5
    2    2017   3    1    1    0    1.006585702   0.036329047   2    0.5
    2    2018   3    1    1    0    1.248491962   0.038249318   2    0.5
    2    2019   3    1    1    0    0.995528283   0.033405643   2    0.5
    2    2020   3    1    1    0    0.863580034   0.031476455   2    0.5
    2    2021   3    1    1    0    0.745497898   0.040162062   2    0.5
#
#     Observer      CPUE    index   Year:Area interaction
#   Index   Year   Seas   fleet   Sex   maturity   index   cv   abundanceunit   timing
#    1    1995   3    1    1    0    1.394268659   0.087621723   2    0.5
#    1    1996   3    1    1    0    1.118072008   0.07787573    2    0.5
#    1    1997   3    1    1    0    0.950329924   0.084940397   2    0.5
#    1    1998   3    1    1    0    0.981032124   0.122112685   2    0.5
```

```
#    1    1999   3    1    1    0    0.85428822     0.095166844    2    0.5
#    1    2000   3    1    1    0    0.775282111    0.102584001    2    0.5
#    1    2001   3    1    1    0    0.746724959    0.150628576    2    0.5
#    1    2002   3    1    1    0    0.939727355    0.093006074    2    0.5
#    1    2003   3    1    1    0    1.202203458    0.067589867    2    0.5
#    1    2004   3    1    1    0    1.231463194    0.07264207     2    0.5
#    2    2005   3    1    1    0    1.371447838    0.037959167    2    0.5
#    2    2006   3    1    1    0    0.952169087    0.055860857    2    0.5
#    2    2007   3    1    1    0    1.097479361    0.049006157    2    0.5
#    2    2008   3    1    1    0    1.139729785    0.039051134    2    0.5
#    2    2009   3    1    1    0    1.416566351    0.036454       2    0.5
#    2    2010   3    1    1    0    1.252565059    0.060053196    2    0.5
#    2    2011   3    1    1    0    0.828375821    0.054000658    2    0.5
#    2    2012   3    1    1    0    1.410970926    0.04356449     2    0.5
#    2    2013   3    1    1    0    0.901225865    0.055929374    2    0.5
#    2    2014   3    1    1    0    1.274171963    0.049910158    2    0.5
#    2    2015   3    1    1    0    0.835892025    0.066015695    2    0.5
#    2    2016   3    1    1    0    0.947664221    0.057799989    2    0.5
#    2    2017   3    1    1    0    1.153063759    0.052298951    2    0.5
#    2    2018   3    1    1    0    1.383315458    0.03899236     2    0.5
#    2    2019   3    1    1    0    0.665684875    0.062585486    2    0.5
#    2    2020   3    1    1    0    0.609490936    0.072567467    2    0.5
#    2    2021   3    1    1    0    0.501474465    0.095449482    2    0.5
#
# Index   Year   Seas   fleet  Sex   maturity     index  cv   abundanceunit  timing
     3    1985   3    1    1    0    2.071043441    0.046182047    2    0.5
     3    1986   3    1    1    0    1.593579212    0.040226639    2    0.5
     3    1987   3    1    1    0    1.220361839    0.043228444    2    0.5
     3    1988   3    1    1    0    1.412211833    0.030208311    2    0.5
     3    1989   3    1    1    0    1.145065089    0.026608202    2    0.5
     3    1990   3    1    1    0    0.868006925    0.033369069    2    0.5
     3    1991   3    1    1    0    0.756009256    0.036578092    2    0.5
     3    1992   3    1    1    0    0.609497541    0.040711053    2    0.5
     3    1993   3    1    1    0    0.757061057    0.053159356    2    0.5
     3    1994   3    1    1    0    0.833857875    0.035619992    2    0.5
     3    1995   3    1    1    0    0.895046328    0.038180278    2    0.5
     3    1996   3    1    1    0    0.835343642    0.031318824    2    0.5
     3    1997   3    1    1    0    0.763847986    0.030723148    2    0.5
     3    1998   3    1    1    0    1.064769668    0.033983872    2    0.5
#
## Number of length frequency matrices
#3
2
## Number of rows in each matrix
37 32
#
## Number of bins in each matrix (columns of size data)
17 17
#
## SIZE COMPOSITION DATA FOR ALL FLEETS
## SIZE COMP LEGEND
## Sex: 1 = male, 2 = female, 0 = both sexes combined
## Type of composition: 1 = retained, 2 = discard, 0 = total composition
## Maturity state: 1 = immature, 2 = mature, 0 = both states combined
## Shell condition: 1 = new shell, 2 = old shell, 0 = both shell types combined
## Type 1 effective sample: Nsamp
##      Retain catch size comp

## updated the effective Ns
##Year, Seas, Fleet, Sex, Type, Shell, Maturity, Nsamp, DataVec
```

1985 3 1 1 1 0 0 45 0.000000 0.000000 0.000000 0.000000 0.000000 0.001779
0.044090 0.139800 0.188711 0.163604 0.152817 0.127810 0.078532 0.048539 0.033765
0.010007 0.010546
1986 3 1 1 1 0 0 23 0.000000 0.000000 0.000000 0.000000 0.000000 0.007269
0.065322 0.139635 0.160400 0.149577 0.152965 0.117009 0.088900 0.048740 0.041813
0.019731 0.008640
1987 3 1 1 1 0 0 8 0.000000 0.000000 0.000000 0.000000 0.000000 0.005423
0.061702 0.159142 0.191295 0.150047 0.146096 0.098283 0.081854 0.058236 0.032244
0.011334 0.004346
1988 3 1 1 1 0 0 286 0.000000 0.000000 0.000000 0.000000 0.000222 0.007071
0.071516 0.192850 0.244429 0.184985 0.113489 0.074476 0.043376 0.027901 0.014870
0.009961 0.014855
1989 3 1 1 1 0 0 513 0.000014 0.000000 0.000000 0.000013 0.000101 0.003677
0.050292 0.210811 0.266781 0.169976 0.115880 0.079394 0.050048 0.030497 0.013281
0.006376 0.002859
1990 3 1 1 1 0 0 205 0.000017 0.000000 0.000000 0.000000 0.000745 0.011654
0.100154 0.240280 0.225196 0.161285 0.107812 0.071549 0.041358 0.019198 0.009904
0.006302 0.004545
1991 3 1 1 1 0 0 102 0.000000 0.000020 0.000060 0.000325 0.001316 0.007526
0.093017 0.244868 0.245519 0.173825 0.105867 0.061824 0.034887 0.017634 0.008044
0.003539 0.001730
1992 3 1 1 1 0 0 76 0.000000 0.000000 0.000032 0.000000 0.000293 0.003852
0.060350 0.197759 0.237800 0.199371 0.131348 0.080404 0.045223 0.024627 0.012611
0.004512 0.001816
1993 3 1 1 1 0 0 378 0.000000 0.000000 0.000000 0.000000 0.000162 0.001564
0.030740 0.173187 0.272635 0.232143 0.144654 0.070916 0.043269 0.019418 0.008295
0.002175 0.000843
1994 3 1 1 1 0 0 367 0.000000 0.000000 0.000127 0.000000 0.000024 0.001784
0.046992 0.177933 0.253944 0.198165 0.133629 0.084930 0.053384 0.028682 0.013116
0.005872 0.001417
1995 3 1 1 1 0 0 705 0.000044 0.000000 0.000334 0.000000 0.000238 0.001792
0.047010 0.189629 0.247586 0.194753 0.130339 0.082564 0.051882 0.030110 0.014359
0.006334 0.003027
1996 3 1 1 1 0 0 817 0.000000 0.000000 0.000000 0.000000 0.000000 0.003134
0.068075 0.206839 0.229461 0.192799 0.127056 0.075589 0.048745 0.028763 0.012721
0.005090 0.001728
1997 3 1 1 1 0 0 984 0.000000 0.000000 0.000000 0.000000 0.000078 0.003000
0.059292 0.204909 0.240721 0.186437 0.125003 0.075450 0.047468 0.029456 0.015703
0.007907 0.004577
1998 3 1 1 1 0 0 613 0.000000 0.000000 0.000000 0.000108 0.000000 0.002820
0.057800 0.218632 0.266244 0.203012 0.122690 0.067337 0.033865 0.016304 0.006846
0.002719 0.001625
1999 3 1 1 1 0 0 915 0.000000 0.000000 0.000000 0.000000 0.000000 0.002046
0.043548 0.178562 0.266933 0.224152 0.139925 0.077925 0.041227 0.017160 0.005705
0.001947 0.000868
2000 3 1 1 1 0 0 1029 0.000000 0.000000 0.000000 0.000055 0.000000 0.002742
0.054185 0.194604 0.239411 0.192948 0.137152 0.080274 0.048645 0.026673 0.014585
0.005697 0.003029
2001 3 1 1 1 0 0 898 0.000000 0.000000 0.000028 0.000000 0.000103 0.001500
0.045630 0.199267 0.265957 0.214346 0.135542 0.067145 0.038974 0.019746 0.007561
0.002942 0.001260
2002 3 1 1 1 0 0 628 0.000000 0.000000 0.000000 0.000000 0.000071 0.001663
0.058986 0.218218 0.276414 0.210594 0.128255 0.057707 0.027606 0.012857 0.005319
0.001734 0.000576
2003 3 1 1 1 0 0 688 0.000000 0.000000 0.000000 0.000000 0.000000 0.001895
0.049682 0.218629 0.275161 0.207658 0.127200 0.062539 0.033554 0.014795 0.005876
0.001916 0.001094
2004 3 1 1 1 0 0 449 0.000000 0.000000 0.000000 0.000000 0.000066 0.001215
0.051327 0.215030 0.283751 0.206811 0.118840 0.062679 0.034830 0.015537 0.006658
0.002026 0.001232

2005 3 1 1 1 0 0 337 0.000000 0.000000 0.000000 0.000000 0.000000 0.000485
0.034904 0.172732 0.257658 0.206822 0.147408 0.082432 0.046486 0.023695 0.016908
0.007266 0.003203
2006 3 1 1 1 0 0 337 0.000000 0.000000 0.000000 0.000000 0.000000 0.000450
0.027936 0.136486 0.228954 0.196611 0.161660 0.101178 0.070427 0.041574 0.022708
0.007786 0.004229
2007 3 1 1 1 0 0 276 0.000000 0.000000 0.000000 0.000000 0.000000 0.000573
0.025731 0.129360 0.206093 0.190896 0.150598 0.112913 0.084343 0.052940 0.026878
0.013391 0.006285
2008 3 1 1 1 0 0 318 0.000000 0.000000 0.000000 0.000000 0.000348 0.002243
0.027529 0.124737 0.196394 0.189950 0.164574 0.103519 0.086701 0.053975 0.030228
0.014680 0.005122
2009 3 1 1 1 0 0 362 0.000000 0.000000 0.000000 0.000147 0.000000 0.000396
0.019110 0.111051 0.187521 0.179921 0.154035 0.115423 0.089833 0.066136 0.043036
0.021639 0.011753
2010 3 1 1 1 0 0 328 0.000000 0.000000 0.000000 0.000000 0.000000 0.000358
0.017161 0.105370 0.182360 0.188782 0.144264 0.119206 0.095711 0.066710 0.043825
0.021922 0.014333
2011 3 1 1 1 0 0 295 0.000000 0.000000 0.000000 0.000000 0.000000 0.000810
0.020228 0.112176 0.167129 0.181274 0.144850 0.118773 0.084588 0.072303 0.044293
0.029024 0.024552
2012 3 1 1 1 0 0 288 0.000000 0.000000 0.000000 0.000000 0.000000 0.000395
0.024683 0.124402 0.203529 0.191267 0.147574 0.100955 0.078569 0.053528 0.034691
0.021014 0.019392
2013 3 1 1 1 0 0 327 0.000000 0.000000 0.000000 0.000000 0.000000 0.000770
0.010442 0.109425 0.195364 0.216476 0.161229 0.106223 0.083860 0.044186 0.032530
0.022399 0.017097
2014 3 1 1 1 0 0 305 0.000000 0.000000 0.000000 0.000000 0.000000 0.004066
0.037110 0.180855 0.211485 0.187740 0.134732 0.098282 0.060790 0.042639 0.025869
0.010910 0.005522
2015 3 1 1 1 0 0 287 0.000000 0.000000 0.000000 0.000000 0.000000 0.002504
0.047044 0.200801 0.235189 0.201087 0.132490 0.077399 0.050622 0.029030 0.014841
0.006719 0.002275
2016 3 1 1 1 0 0 408 0.000000 0.000000 0.000000 0.000000 0.000000 0.001173
0.034989 0.166920 0.240724 0.240546 0.141610 0.084137 0.044617 0.024752 0.012436
0.004111 0.003987
2017 3 1 1 1 0 0 309 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
0.026198 0.132743 0.240004 0.210512 0.147671 0.085251 0.066069 0.037995 0.028973
0.013134 0.011450
2018 3 1 1 1 0 0 291 0.000000 0.000000 0.000000 0.000000 0.000000 0.000420
0.017810 0.131101 0.220574 0.212039 0.150588 0.102787 0.078363 0.040693 0.024314
0.011658 0.009653
2019 3 1 1 1 0 0 363 0.000000 0.000000 0.000000 0.000000 0.000000 0.000307
0.035200 0.156779 0.210296 0.197707 0.148367 0.099119 0.068591 0.044726 0.021362
0.009767 0.007780
2020 3 1 1 1 0 0 462 0.000000 0.000000 0.000000 0.000000 0.000000 0.000927
0.030215 0.152912 0.222099 0.217881 0.156945 0.094998 0.056883 0.032933 0.015328
0.010220 0.008659
2021 3 1 1 1 0 0 276 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
0.000000 0.034082 0.150399 0.272690 0.224463 0.139758 0.073403 0.055048 0.026029
0.013024 0.011104
#

##Total catch size comp

##Year, Seas, Fleet, Sex, Type, Shell, Maturity, Nsamp, DataVec

1990 3 1 1 0 0 0 190 0.073723 0.037744 0.074999 0.099097 0.136722 0.126059
0.088265 0.115790 0.111761 0.059640 0.034428 0.017535 0.013921 0.004977 0.003855
0.001181 0.000303

1991 3 1 1 0 0 0 104 0.096404 0.051878 0.061314 0.083508 0.105582 0.100280
0.102537 0.114662 0.087464 0.067187 0.051284 0.034247 0.020591 0.012858 0.006978
0.002687 0.000538
1992 3 1 1 0 0 0 94 0.079726 0.049518 0.069939 0.087556 0.105016 0.119770
0.116330 0.112379 0.094493 0.068848 0.042286 0.023299 0.017246 0.008540 0.003530
0.000838 0.000687
1993 3 1 1 0 0 0 62 0.121791 0.042920 0.064769 0.077288 0.089026 0.107617
0.117426 0.107186 0.091436 0.065800 0.042802 0.028239 0.022022 0.012282 0.005602
0.003170 0.000626
1994 3 1 1 0 0 0 119 0.066496 0.049957 0.067777 0.085620 0.106072 0.117794
0.124808 0.116776 0.099023 0.072835 0.045616 0.022693 0.013824 0.006108 0.003327
0.000861 0.000413
1995 3 1 1 0 0 0 907 0.080756 0.049247 0.072127 0.092308 0.112362 0.125326
0.121283 0.099034 0.081259 0.062131 0.041858 0.025905 0.016817 0.009929 0.005837
0.002474 0.001347
1996 3 1 1 0 0 0 1061 0.082275 0.038679 0.056039 0.078576 0.100896 0.124295
0.134849 0.120441 0.098377 0.071348 0.042048 0.023961 0.013812 0.007821 0.004035
0.001784 0.000764
1997 3 1 1 0 0 0 1116 0.080978 0.039608 0.051963 0.063377 0.080001 0.101270
0.135498 0.132965 0.113869 0.082249 0.049586 0.029005 0.017170 0.010643 0.006221
0.003020 0.002578
1998 3 1 1 0 0 0 638 0.087015 0.040996 0.054184 0.070011 0.086055 0.107547
0.143589 0.144568 0.110830 0.078667 0.039396 0.020540 0.010236 0.004139 0.001729
0.000353 0.000147
1999 3 1 1 0 0 0 1155 0.081455 0.038718 0.049565 0.063788 0.084574 0.105371
0.136417 0.137135 0.121003 0.084173 0.050367 0.024776 0.013410 0.005585 0.002380
0.000769 0.000514
2000 3 1 1 0 0 0 1205 0.072479 0.042978 0.058080 0.073338 0.093337 0.113380
0.146386 0.138684 0.107669 0.069622 0.040483 0.021565 0.011482 0.005701 0.003132
0.001041 0.000646
2001 3 1 1 0 0 0 975 0.049286 0.031510 0.046993 0.063469 0.090186 0.118498
0.157525 0.154639 0.123625 0.079205 0.043222 0.020092 0.012046 0.005514 0.002946
0.000824 0.000420
2002 3 1 1 0 0 0 675 0.047331 0.032284 0.043441 0.064482 0.087664 0.117964
0.158845 0.166755 0.124707 0.078778 0.040296 0.020333 0.009699 0.004525 0.001844
0.000655 0.000398
2003 3 1 1 0 0 0 700 0.016189 0.011304 0.022617 0.036805 0.062889 0.104034
0.162054 0.182594 0.156066 0.109519 0.069831 0.032289 0.019024 0.009046 0.004020
0.001330 0.000389
2004 3 1 1 0 0 0 488 0.032771 0.018499 0.029570 0.047925 0.071922 0.113717
0.162668 0.168980 0.146838 0.097763 0.054618 0.026791 0.016067 0.007368 0.003084
0.001112 0.000308
2005 3 1 1 0 0 0 220 0.007212 0.008105 0.014298 0.025638 0.042285 0.073538
0.139454 0.189359 0.185166 0.143660 0.086222 0.043347 0.024407 0.008869 0.005534
0.001977 0.000929
2006 3 1 1 0 0 0 321 0.008564 0.007975 0.014338 0.021177 0.035049 0.061568
0.118027 0.166774 0.179629 0.146809 0.101694 0.063956 0.039424 0.020687 0.008653
0.003898 0.001779
2007 3 1 1 0 0 0 257 0.013477 0.012288 0.019445 0.031747 0.048054 0.078190
0.132914 0.171009 0.157321 0.127613 0.082900 0.056266 0.034840 0.019232 0.009364
0.003840 0.001498
2008 3 1 1 0 0 0 258 0.006583 0.010077 0.017291 0.022706 0.039407 0.064583
0.121861 0.166765 0.167527 0.138247 0.093465 0.058770 0.043669 0.025953 0.013969
0.005847 0.003277
2009 3 1 1 0 0 0 292 0.002907 0.004923 0.008114 0.013334 0.024534 0.043449
0.099263 0.156744 0.172629 0.152829 0.110869 0.078254 0.053543 0.036859 0.022738
0.012110 0.006903
2010 3 1 1 0 0 0 222 0.005846 0.005467 0.012293 0.016881 0.030331 0.055579
0.107945 0.153148 0.161413 0.146545 0.101574 0.073129 0.052053 0.036455 0.022811
0.011131 0.007398

```
 2011    3      1      1      0      0      0      252    0.005171      0.004206      0.009375      0.015204      0.025907      0.047136
0.104720      0.158389      0.169216      0.150895      0.105607      0.070516      0.049150      0.037109      0.023010
0.013629      0.010761
 2012    3      1      1      0      0      0      241    0.011408      0.006900      0.010918      0.014806      0.025298      0.047426
0.102829      0.162246      0.177028      0.150756      0.109150      0.066664      0.042933      0.032731      0.018194
0.011110      0.009603
 2013    3      1      1      0      0      0      236    0.009780      0.006897      0.012546      0.018360      0.032257      0.057357
0.106564      0.149594      0.158540      0.138119      0.105121      0.073268      0.050290      0.033204      0.023611
0.013188      0.011305
 2014    3      1      1      0      0      0      219    0.014887      0.011977      0.018213      0.026547      0.040919      0.070874
0.124865      0.167490      0.164223      0.138519      0.089236      0.055221      0.033900      0.021203      0.011293
0.005856      0.004775
 2015    3      1      1      0      0      0      243    0.009468      0.007405      0.012229      0.020974      0.030168      0.061902
0.122932      0.181589      0.186770      0.151790      0.094065      0.052921      0.032812      0.018644      0.009292
0.004854      0.002184
 2016    3      1      1      0      0      0      253    0.010516      0.008992      0.016775      0.025017      0.043944      0.066502
0.123193      0.171566      0.175873      0.147281      0.092894      0.054898      0.030889      0.016020      0.009317
0.003782      0.002542
 2017    3      1      1      0      0      0      222    0.004645      0.005043      0.009896      0.016614      0.030117      0.054243
0.107312      0.157000      0.174447      0.154479      0.105160      0.069304      0.045100      0.029199      0.018245
0.010417      0.008778
 2018    3      1      1      0      0      0      318    0.004829      0.004975      0.007427      0.015547      0.028592      0.057059
0.110817      0.157559      0.164944      0.146429      0.108696      0.074372      0.048815      0.033214      0.019503
0.010246      0.006978
 2019    3      1      1      0      0      0      224    0.016816      0.010177      0.013026      0.023035      0.036207      0.056685
0.108548      0.144626      0.163688      0.150431      0.109384      0.077848      0.045948      0.026222      0.011804
0.003148      0.002405
 2020    3      1      1      0      0      0      302    0.012350      0.009114      0.011815      0.020728      0.034808      0.065998
0.118284      0.168300      0.170971      0.146774      0.102320      0.061419      0.035897      0.019480      0.012388
0.005015      0.004337
 2021    3      1      1      0      0      0      157    0.010831      0.008598      0.013263      0.021310      0.050400      0.076580
0.133711      0.160949      0.174335      0.136725      0.098608      0.052135      0.033516      0.016451      0.007211
0.003695      0.001682
#
##  Growth data (increment)
# Type of growth increment (0=no growth data;1=size-at-release; 2= size-class-at-release)
3
# nobs_growth
222
# Class-at-release Sex Class-at-recapture Years-at-liberty number transition matrix RecaptureFleet Recapture Year (if applicable)
Sample Size

…..Same Tag release-recapture data entry as in EAG21.1a…..
……..
## EOF
9999
```

2. ***WAG21.1e ctl file***

```
## ———————————————————— # #
#  Controls for  leading  parameter  vector  theta
#  LEGEND FOR  PRIOR:
#  0 = uniform, 1 = normal, 2 = lognormal, 3 =  beta, 4 =  gamma
##———————————————————— # #
#  ntheta
 9
———————————————————— #
# ival      lb     ub       phz   prior   p1      p2      # parameter
———————————————————— #
  0.21      0.01   1.0      -3     2     0.18    0.04      # M
 7.569555623 -10.0 20.0   1    0    -10.0    20.0      # ln R0,
```

```
 12.0       -10.0   20.0     -3    0    -10.0    20.0      # ln Rini,

  8.0       -10.0  20.0     -1    0    -10.0    20.0       # logarithm of average recruits

 110.0      103.0  165.0     -2    1     72.5    7.25      # Expected value of recruitment distribution

 0.961318631  0.001  20.0    3    0     0.1     5.0    ## recruitment scale

  -0.693147181 -10.0   0.75   -1    0   -10.0     0.75      # ln (SigmaR)

 0.73       0.2    1.0       -2    3     3.0     2.0       # steepness
  0.001      0.0    1.0      -3    3     1.01    1.01      # recruitment autocorrelation
——————————————————————

# weight-at-length input method (1 = allometry  [w_l = a*l^b],  2 = vector by sex)
2
#a, in kg
# 1.445E-07
#b
# 3.281126995
# Male weight-at-length
 0.581515707 0.679328169 0.788032347 0.908278308 1.040724257 1.186036294  1.344888179  1.517961114  1.705943543
1.90953096 2.129425732 2.366336933  2.620980182  2.894077494  3.186357141  3.498553516  3.993657581
#
# Proportion mature by sex, males
  0.  0.  1.  1.  1.  1.  1.  1.  1.  1.  1.  1.  1.  1.  1.  1.  1.
# Proportion legal by sex, males
  0.  0.  0.  0.  0.  0.  0.  1.  1.  1.  1.  1.  1.  1.  1.  1.  1.
## ———————————————————————————————————————— ##
## GROWTH PARAM CONTROLS
##     Two lines for each parameter if split sex, one line if not
———————————————————— ##
# Use growth transition matrix option (1=read in growth-increment matrix; 2=read in size-transition; 3=gamma distribution for
size-increment; 4=gamma distribution for size after increment) (1 to 8 options available)
# option 8 is normal distributed growth incrment, size after incrment is normal
8
# growth increment model (0=prespecified; 1=alpha/beta; 2=estimated by size-class;3=pre-specified/emprical)
1
# molt probability function (0=pre-specified; 1=flat;2=declining logistic)
2
# maximum size-class (males then females)

# Maximum size-class for recruitment (males then females)
5
## number of size-increment periods
1
## Year(s) size-increment period changes (blank if no changes)

## number of molt periods
1
## Year(s) molt period changes (blank if no changes)

## Beta parameters are relative to a base level (1=Yes;0=no)
1

# Growth parameters
## ————————————————————————————————————— ##
# ival       lb       ub     phz   prior      p1      p2         # parameter
## ———————————————————————————————————————— #
    25.196667522   10.0    50.0    7       0       0.0    20.0   # alpha,
    0.090287711   -0.4    20.0     7       0       0.0    10.0   # beta,
   3.667971226   0.01    5.0      7       0       0.0     3.0   # growth scale,
```

```
  141.100064775  65.0   165.0    7       0       0.0    999.0  #  moult mu,
  0.102920636  -0.1      2.0     7       0       0.0     2.0   # moult cv,
##

# The custom growth-increment matrix

# custom molt probability matrix

##———————————————————— ##
## SELECTIVITY CONTROLS
##     Selectivity P (capture of all sizes). Each gear must have a selectivity and a
##     retention selectivity. If a uniform prior is selected for a parameter then the
##     lb and ub are used (p1 and p2 are ignored)
## LEGEND
##     sel type: 0 = parametric (nclass), 1 = indiviudal parameter for each class(nclass)
##            2 = logistic (2, inflection point and slope), 3 = logistic95 (2, 50% and 95% selection), 4 = double normal (3 parameters),
##
##
##    5: Flat equal to zero (1 parameter; phase must be negative), UNIFORM1
##    6: Flat equal to one (1 parameter; phase must be negative), UNIFORM0
##    7: Flat-topped double normal selectivity (4 parameters)
##    8: Declining logistic selectivity with initial values (50% and 95% selection plus extra)
## Extra (type 1): number of selectivity parameters to be estimated
##     gear index: use +ve for selectivity, -ve for retention
##     sex dep: 0 for sex-independent, 1 for sex-dependent
## ———————————————————————————————————— ##
## ivector for number of year blocks or nodes
##    Gear-1   Gear-2
## PotFishery    Trawl Byc
      2        1                   # selectivity time periods
      0        0                   # set 0 for male only fishery, sex specific selectivity, 0 for sex independent selectivity
      2        5                   # male selectivity type model (flat equal to zero, 1 parameter) or logistic or double normal etc.
      0        0                   # within another gear insertion of fleet in another
      0        0                   # extra parameters for each pattern
## Gear-1    Gear-2
     1        1                    # retention time periods
     0        0                    # set 0 for male only fishery, sex specific retention
     2        6                    # male retention type model (flat equal to one, 1 parameter)
     1        0                    # male retention flag (0 = no, 1 = yes)
     0        0                    # extra
     1        1                     # determines if maximum selectivity at size is forced to equal 1 or not

## ————————————————————————————————————##
## Selectivity P (capture  of  all  sizes)
## ————————————————————————————————————— ##
## gear  par   sel                                                    phz     start    end
# index index par sex  ival     lb    ub   prior    p1     p2     mirror     period period
## ———————————————————————————————— ##
## Gear-1
  1     1     1   0  134.901126827 105.0 180.0   0   100.0  190.0      3     1960   2004
  1     2     2   0  18.431613644  0.01   20.0   0     0.1   50.0         3     1960   2004
  1     3     1   0  134.436890424 105.0 180.0   0   100.0  190.0      3     2005   2021
  1     4     2   0   7.435698766  0.01   20.0   0     0.1   50.0         3     2005   2021

# Gear-2
  2     5     1   0    1.00      0.99 1.02   0     10.0  200.0                 -3     1960   2021
## ————————————————————————————————— ##
## Retained
## gear par   sel                                                      phz    start    end
# index index par sex  ival       lb    ub     prior   p1     p2     mirror     period  period
# Gear-1
 -1     6    1   0   136.009505623  105.0  180.0  0      100.0  190.0    3    1960   2021
```

```
 -1     7    2   0    1.869278156   0.0001  20.0  0      0.1    50.0         3     1960   2021

# Gear-2
 -2     8    1   0    1.00        0.99   1.01  0      10.0   200.0              -3     1960   2021

##———————————————— ##
# Number of asymptotic parameters
1
# Fleet   Sex     Year      ival   lb   ub    phz
     1     1     1960   0.000001   0    1     -3
## ———————————————————————————————————— ##
## PRIORS FOR CATCHABILITY
##     If a uniform prior is selected for a parameter then the lb and ub are used (p1
##     and p2 are ignored). ival must be > 0
## only allowed to use uniform or lognormal prior
## if anlytic q estimation step is chosen, turn off estimating q by changing the estimation phase to be -ve
## LEGEND
##     prior: 0 = uniform, 1 = normal, 2 = lognormal, 3 = beta, 4 = gamma
## ————————————————————————————————————— ##
#
## SURVEYS/INDICES ONLY
## fishery and observer CPUE
## Analytic (0=not analytically solved q, use uniform or lognormal prior;
## 1= analytic),
## Lambda =multilier for iput CV, Emphasis = multiplier for likelihood
##  ival       lb        ub    phz    prior   p1        p2     Analytic?   LAMBDA   Emphasis
 0.001038534  0.0000001   0.01   1      0      0.0     1.0      0          1       1   # observer cpue index 1995-2004
 0.001080062  0.0000001   0.01   1      0      0.0     1.0      0          1       1   # observer cpue index 2005-2021
 0.000674553   0.0000001  0.01   1      0      0.0     1.0      0          1       1   # fishery cpue index 1985-1998

## if a uniform prior is specified then use lb and ub rather than p1 and p2
————————————————##
## ADDITIONAL CV FOR SURVEYS/INDICES
##     If a uniform prior is selected for a parameter then the lb and ub are used (p1
##     and p2 are ignored). ival must be > 0, lb should be>0
## LEGEND
##     prior type: 0 = uniform, 1 = normal, 2 = lognormal, 3 = beta, 4 = gamma
———————————————— ##
##  ival                lb           ub    phz   prior   p1    p2
 0.000172920   0.0000001    0.5     6     0      0.5   100  # obs CPUE additional CV
 0.000082029   0.0000001    0.5     6     0      0.5   100  # obs CPUE additional CV
 0.000140039   0.0000001    0.5     6     0      0.5   100  # fishery CPUE additional CV

### Pointers to how the the additional CVs are used (0 ignore; >0 link to one of the parameters
1 2 3
####
## if a uniform prior is specified then use lb and ub rather than p1 and p2
##  ————————————————————————————————————##
##PENALTIES FOR  AVERAGE  FISHING  MORTALITY  RATE  FOR  EACH  GEAR
##
##  ——————————————————————————————————##
## Trap Trawl
## Male F, Female F, early_phasepenalty_sd, later_phasepenalty_sd, meanmaleF_phase, meanfemaleF_phase,
## lb meanF, ub meanF,lbannualmaleF(F_dev), ubannual maleF(F_dev),lbannualfemaleF(F_dev), ubannual femaleF(F_dev)
## BBRKC uses STD_PHZ1=0.5 STD_PHZ2=45.5
## Mean_F    Fema-Offset   STD_PHZ1 STD_PHZ2 PHZ_M PHZ_F    Lb      Ub     Lb     Ub      Lb    Ub
   0.487826676       0.0        3.0    15.0     2    -1     -12      4    -10     10     -10    10   #
   0.00027863       0.0        4.0    15.0     2    -1     -12      4    -10     10     -10    10   #
————————————————##
## OPTIONS FOR SIZE COMPOSTION DATA
##     One column for each data matrix
## LEGEND
```

```
##     Likelihood: 1 = Multinomial with estimated/fixed sample size
##                 2 = Robust approximation to multinomial
##                 3 = logistic normal (NIY)
##                 4 = multivariate-t (NIY)
##                 5 = Dirichlet
## AUTO TAIL COMPRESSION
##     pmin is the cumulative proportion used in tail compression
## ——————————————————————————————————————— ##
#  Ret Tot
#
   1   1         # Type of likelihood
   0   0         # Auto tail compression (pmin)
   1   1         # Initial value for effective sample size multiplier
  -4  -4        # Phz for estimating effective sample size (if appl.)
   1   2        # Composition aggregator if you put 1 for each it will merge, do not merge (why merge)
   #
   1   1         # Set to 2 for survey-like predictions; 1 for catch-like predictions
   #
   0.41228506640625 0.5453007578125  # Emphasis for Dritchlet (Ret, Tot, multiplier of stage1 ESS)
   1   1        # LAMBDA 0 to ignore the length comp
##———————————————— ##

## TIME VARYING NATURAL  MORTALIIY  RATES
##————————————————— ##
## Type: 0 = constant natural mortality
##       1 = Random walk (deviates constrained by variance in M)
##       2 = Cubic Spline (deviates constrained by nodes & node-placement)
##       3 = Blocked changes (deviates constrained by variance at specific knots)
##       4 = Changes in pre-specified blocks
##       5 = Changes in some knots
##       6 = Changes in Time blocks
 0    # M type
## M is relative (YES=1; NO=0)

## Phase of estimation
3
## STDEV in m_dev for Random walk
0.25
## Number of nodes for cubic spline or number of step-changes for option 3
1
## Year position of the knots (vector must be equal to the number of nodes)
1960
## number of breakpoints in M by size (keep it at 0)
0
# line groups for breakpoint
8
## Specific initial values for the natural mortality devs (0-no, 1=yes)

## ival        lb        ub        phz    extra
##    3.0        0.5       5.0       4        0
——————————————————— ##
## TAGGING controls CONTROLS
##————————————————— ##
 1          # emphasis on tagging data (1 =use tag LH, 0=ignore)

##————————————————— ##
## Maturity specific natural mortality
##————————————————— ##
# maturity specific natural mortality? (yes = 1; no = 0; only for use if nmature > 1)
0
##—————————————————————————— ##
```

```
## ival      lb  ub  phz  prior  p1  p2        # parameter

       0     -1   1  -1     0      1  1
##———————————————————————— ##
## OTHER CONTROLS
##———————————————————————— ##
#
1960      # First year of recruitment estimation,rec_dev.
2021      # last year of recruitment estimation, rec_dev
   1      # phase for recruitment estimation,earlier -1. rec_dev estimation phase, BBRKC uses 2
  -2      # phase for recruitment sex-ratio estimation
  0.5     # Initial value for Expected sex-ratio
  -3      # Phase for initial recruitment estimation, rec_ini phase
   1      # VERBOSE FLAG (0 = off, 1 = on, 2 = objective func; 3 diagnostics)
   0      # Initial conditions (0 = Unfished, 1 = Steady state fished, 2 = Free parameters, 3 = Free parameters (revised))
   1      # Lambda (proportion of mature male biomass for SPR reference points).
   0      # Stock-Recruit-Relationship (0 = none, 1 = Beverton-Holt)
  10      # Maximum phase (stop the estimation after this phase), 10 Maximum phase. If you put 1 it will stop after phase 1
  -1      # Maximum number of function calls, if 1, stop at fn 1 call; if -1, run as long as it takes
   1      # Calculate reference points (0=no)
  200     # Year to compute equilibria
## EMPHASIS FACTORS (CATCH)
#Ret_male Tot_male   Groundfish
       4      2         1
## EMPHASIS FACTORS (Priors) by fleet: fdev_total, Fdov_total, Fdev_year, Fdov_year
0 0 0.001 0 # Pot fishery
0 0 0.001 0 # Groundfish


## EMPHASIS FACTORS (Priors)
##
# Log_fdevs   meanF      Mdevs  Rec_devs Initial_devs Fst_dif_dev Mean_sex-Ratio  Molt_prob    Free                    selectivity
                                                                                              Init_n_at_len Fvecs Fdovs
       0      0        0.0       2          0        0         0            0               0                0     1     0

##  EOF
9999
```

3. ***EAG21.1e dat file***

```
##========##
# Gmacs Main Data File:
# GEAR_   INDEX   DESCRIPTION
#    1       :  Pot fishery Retained catch
#    2       :  Pot fishery total catch
#    3       :  Trawl bycatch
#    4       :  Observer CPUE
#    5       :  Fishery CPUE

# Fisheries:  1 Pot Fishery, 2 Pot Total
# Cooperative Survey:
##==========##

1960  # initial (start year)
2021  # terminal (end year)
#2022  # Projection year (for forecast, OFL and ABC calculation)
6    # Number of seasons: season1 for N est, season 2 for Jul 1 to MidFishing, season 3 for inst. remove C, season 4 for to spawning time,Feb15, season 5 for inst remove byc&estimate MMB, season 6 for remaining time to June 30 and R enter
2     # Number of distinct data groups or number of fleets (pot fishing, groundfish fishing)
1     # Number of sexes (males)
```

```
1    # Number of shell condition types
1    # Number of maturity types
17    # Number of size-classes in the model
6    # Season when recruitment occurs, end of year before growth
6    # Season when molting and growth occur, end of year after recruitment
5    # Season to calculate MMB
1    # Season for N output
# maximum size-class (males then females)
17
# size_breaks (a vector giving the break points between size intervals with dimension nclass+1, lower limits of bins)
100.5 105.5 110.5 115.5 120.5 125.5 130.5 135.5 140.5 145.5 150.5 155.5 160.5 165.5 170.5 175.5 180.5 185.5
# Natural mortality per season input type (1 = vector by season, 2 = matrix by season/year)
2
# Proportion of the total natural mortality to be applied each season (each row must add to 1)
# 1 Start biological year (Jul 1) instantaneous N estimation
# 2 to mid-fishing time
# 3 instantanous C removal
# 4 to spawning time
# 5 instantaneous byc removal and estimate MMB
# 6 Rest of the period of non-fishing from Feb 15 to June 30
#
#
#Ins N  Jul1-MidFish   Inst C    MidFish-15Feb   Ins byc    Rest upto end
 0.    0.16666667    0.    0.46073059    0.    0.37260274    #1960
 0.    0.16666667    0.    0.46073059    0.    0.37260274    #1961
 0.    0.16666667    0.    0.46073059    0.    0.37260274    #1962
 0.    0.16666667    0.    0.46073059    0.    0.37260274    #1963
 0.    0.16666667    0.    0.46073059    0.    0.37260274    #1964
 0.    0.16666667    0.    0.46073059    0.    0.37260274    #1965
 0.    0.16666667    0.    0.46073059    0.    0.37260274    #1966
 0.    0.16666667    0.    0.46073059    0.    0.37260274    #1967
 0.    0.16666667    0.    0.46073059    0.    0.37260274    #1968
 0.    0.16666667    0.    0.46073059    0.    0.37260274    #1969
 0.    0.16666667    0.    0.46073059    0.    0.37260274    #1970
 0.    0.16666667    0.    0.46073059    0.    0.37260274    #1971
 0.    0.16666667    0.    0.46073059    0.    0.37260274    #1972
 0.    0.16666667    0.    0.46073059    0.    0.37260274    #1973
 0.    0.16666667    0.    0.46073059    0.    0.37260274    #1974
 0.    0.16666667    0.    0.46073059    0.    0.37260274    #1975
 0.    0.16666667    0.    0.46073059    0.    0.37260274    #1976
 0.    0.16666667    0.    0.46073059    0.    0.37260274    #1977
 0.    0.16666667    0.    0.46073059    0.    0.37260274    #1978
 0.    0.16666667    0.    0.46073059    0.    0.37260274    #1979
 0.    0.16666667    0.    0.46073059    0.    0.37260274    #1980
 0.    0.44109589    0.    0.18630137    0.    0.37260274    #1981
 0.    0.483561644    0.    0.143835616    0.    0.37260274    #1982
 0.    0.483561644    0.    0.143835616    0.    0.37260274    #1983
 0.    0.315068493    0.    0.312328767    0.    0.37260274    #1984
 0.    0.168493151    0.    0.45890411    0.    0.37260274    #1985
 0.    0.252054795    0.    0.375342466    0.    0.37260274    #1986
 0.    0.087671233    0.    0.539726027    0.    0.37260274    #1987
 0.    0.3    0.    0.32739726    0.    0.37260274    #1988
 0.    0.4    0.    0.22739726    0.    0.37260274    #1989
 0.    0.265753425    0.    0.361643836    0.    0.37260274    #1990
 0.    0.273972603    0.    0.353424658    0.    0.37260274    #1991
 0.    0.276712329    0.    0.350684932    0.    0.37260274    #1992
 0.    0.419178082    0.    0.208219178    0.    0.37260274    #1993
 0.    0.249315068    0.    0.378082192    0.    0.37260274    #1994
 0.    0.223287671    0.    0.404109589    0.    0.37260274    #1995
 0.    0.328767123    0.    0.298630137    0.    0.37260274    #1996
 0.    0.28630137    0.    0.34109589    0.    0.37260274    #1997
 0.    0.263013699    0.    0.364383562    0.    0.37260274    #1998
```

```
 0.     0.245205479    0.     0.382191781    0.     0.37260274     #1999
 0.     0.179452055    0.     0.447945205    0.     0.37260274     #2000
 0.     0.160273973    0.     0.467123288    0.     0.37260274     #2001
 0.     0.156164384    0.     0.471232877    0.     0.37260274     #2002
 0.     0.157534247    0.     0.469863014    0.     0.37260274     #2003
 0.     0.143835616    0.     0.483561644    0.     0.37260274     #2004
 0.     0.432876712    0.     0.194520548    0.     0.37260274     #2005
 0.     0.331506849    0.     0.295890411    0.     0.37260274     #2006
 0.     0.368493151    0.     0.25890411     0.     0.37260274     #2007
 0.     0.302739726    0.     0.324657534    0.     0.37260274     #2008
 0.     0.32739726     0.     0.3            0.     0.37260274     #2009
 0.     0.293150685    0.     0.334246575    0.     0.37260274     #2010
 0.     0.263013699    0.     0.364383562    0.     0.37260274     #2011
 0.     0.275342466    0.     0.352054795    0.     0.37260274     #2012
 0.     0.27260274     0.     0.354794521    0.     0.37260274     #2013
 0.     0.247945205    0.     0.379452055    0.     0.37260274     #2014
 0.     0.228767123    0.     0.398630137    0.     0.37260274     #2015
 0.     0.420547945    0.     0.206849315    0.     0.37260274     #2016
 0.     0.409589041    0.     0.217808219    0.     0.37260274     #2017
 0.     0.349315068    0.     0.278082192    0.     0.37260274     #2018
 0.     0.32739726     0.     0.3            0.     0.37260274     #2019
 0.     0.365753425    0.     0.261643836    0.     0.37260274     #2020
 0.     0.294520548    0.     0.332876712    0.     0.37260274     #2021
#
#
# Fishing fleet names (delimited with: no spaces in names)
Pot_Fishery Trawl_Bycatch
# Survey names (delimited with no spaces in names) keep empty

# Are the seasons discrete-instantaneous (0) or continuous (1)
1 1 1 1 1 1
# Number of catch data frames
3
# Number of rows in each data frame
#    1993   total   catch   is    missing, up    to    2021/22 data
#    1991   groundfish    bycatch is    missing,
#    retained     catch   1981/82-2021/22
   41    31    32
##  CATCH DATA in t
##  Type of catch: 1 = retained, 2 = discard, 0= total (retained+discard, slide says 3)
##  Units of catch: 1 = biomass, 2 = numbers
# Mult: 1= use data as thy are, 2 = multiply by this number (e.g., lbs to kg)

##  Retained Catch (numbers from 1981-1984; tonnes from 1985 onwards)
#year  seas   fleet  sex      obs        cv  type   units  mult   effort  discard_mortality
 1981   3     1     1     203.968 0.0316  1     2     1     0     0.2
 1982   3     1     1     529.787 0.0316  1     2     1     0     0.2
 1983   3     1     1     662.28  0.0316  1     2     1     0     0.2
 1984   3     1     1     801.1   0.0316  1     2     1     0     0.2
 1985   3     1     1     2730.32 0.0316  1     1     1     0     0.2
 1986   3     1     1     2844.91 0.0316  1     1     1     0     0.2
 1987   3     1     1     1908.79 0.0316  1     1     1     0     0.2
 1988   3     1     1     2423.6  0.0316  1     1     1     0     0.2
 1989   3     1     1     2776.77 0.0316  1     1     1     0     0.2
 1990   3     1     1     1637.48 0.0316  1     1     1     0     0.2
 1991   3     1     1     2026.35 0.0316  1     1     1     0     0.2
 1992   3     1     1     2125.04 0.0316  1     1     1     0     0.2
 1993   3     1     1     1420.58 0.0316  1     1     1     0     0.2
 1994   3     1     1     2038.35 0.0316  1     1     1     0     0.2
 1995   3     1     1     2224.01 0.0316  1     1     1     0     0.2
 1996   3     1     1     1624.07 0.0316  1     1     1     0     0.2
 1997   3     1     1     1481.02 0.0316  1     1     1     0     0.2
```

```
 1998   3    1    1    1414.76 0.0316  1    1    1    0    0.2
 1999   3    1    1    1334.88 0.0316  1    1    1    0    0.2
 2000   3    1    1    1359.49 0.0316  1    1    1    0    0.2
 2001   3    1    1    1401.42 0.0316  1    1    1    0    0.2
 2002   3    1    1    1243.19 0.0316  1    1    1    0    0.2
 2003   3    1    1    1297.26 0.0316  1    1    1    0    0.2
 2004   3    1    1    1269.73 0.0316  1    1    1    0    0.2
 2005   3    1    1    1272.16 0.0316  1    1    1    0    0.2
 2006   3    1    1    1389.5  0.0316  1    1    1    0    0.2
 2007   3    1    1    1329.37 0.0316  1    1    1    0    0.2
 2008   3    1    1    1421.86 0.0316  1    1    1    0    0.2
 2009   3    1    1    1448.28 0.0316  1    1    1    0    0.2
 2010   3    1    1    1412.73 0.0316  1    1    1    0    0.2
 2011   3    1    1    1444.36 0.0316  1    1    1    0    0.2
 2012   3    1    1    1499.29 0.0316  1    1    1    0    0.2
 2013   3    1    1    1546.08 0.0316  1    1    1    0    0.2
 2014   3    1    1    1553.36 0.0316  1    1    1    0    0.2
 2015   3    1    1    1692.9  0.0316  1    1    1    0    0.2
 2016   3    1    1    1658.66 0.0316  1    1    1    0    0.2
 2017   3    1    1    1620.86 0.0316  1    1    1    0    0.2
 2018   3    1    1    1865.11 0.0316  1    1    1    0    0.2
 2019   3    1    1    2067.47 0.0316  1    1    1    0    0.2
 2020   3    1    1    1735.37 0.0316  1    1    1    0    0.2
 2021   3    1    1    1784.08 0.0316  1    1    1    0    0.2
#
## Total Catch (tonnes throughout)
#year seas   fleet   sex       obs       cv   type   units   mult   effort  discard_mortality
 1990   3    1    1    3980.73 0.358893929    0    1    1    0    0.2
 1991   3    1    1    6596.74 0.212951406    0    1    1    0    0.2
 1992   3    1    1    5435.64 0.296058703    0    1    1    0    0.2
 1994   3    1    1    3444.23 0.375117372    0    1    1    0    0.2
 1995   3    1    1    4640.82 0.051194102    0    1    1    0    0.2
 1996   3    1    1    2563.32 0.04474373    0    1    1    0    0.2
 1997   3    1    1    2976.8  0.059889204    0    1    1    0    0.2
 1998   3    1    1    3140.99 0.0680779    0    1    1    0    0.2
 1999   3    1    1    2605.62 0.065963387    0    1    1    0    0.2
 2000   3    1    1    2759.91 0.057628024    0    1    1    0    0.2
 2001   3    1    1    2237.55 0.060173859    0    1    1    0    0.2
 2002   3    1    1    1915.66 0.064883292    0    1    1    0    0.2
 2003   3    1    1    1901.61 0.065047278    0    1    1    0    0.2
 2004   3    1    1    1694.87 0.087224566    0    1    1    0    0.2
 2005   3    1    1    1742.04 0.118801346    0    1    1    0    0.2
 2006   3    1    1    1646.83 0.123871783    0    1    1    0    0.2
 2007   3    1    1    1819.86 0.12997936    0    1    1    0    0.2
 2008   3    1    1    1823.51 0.16628614    0    1    1    0    0.2
 2009   3    1    1    1770.08 0.204527938    0    1    1    0    0.2
 2010   3    1    1    1756.66 0.197720567    0    1    1    0    0.2
 2011   3    1    1    1780.6  0.217727165    0    1    1    0    0.2
 2012   3    1    1    1946.59 0.197259943    0    1    1    0    0.2
 2013   3    1    1    1851.56 0.184593328    0    1    1    0    0.2
 2014   3    1    1    1967.39 0.213240733    0    1    1    0    0.2
 2015   3    1    1    2135.81 0.188674437    0    1    1    0    0.2
 2016   3    1    1    2234.13 0.165738888    0    1    1    0    0.2
 2017   3    1    1    2339.37 0.170274949    0    1    1    0    0.2
 2018   3    1    1    2734.63 0.189279828    0    1    1    0    0.2
 2019   3    1    1    3032.73 0.17733387    0    1    1    0    0.2
 2020   3    1    1    2608.06 0.172996036    0    1    1    0    0.2
 2021   3    1    1    2426.95 0.188674437    0    1    1    0    0.2
#
##Trawl fishery discards (in tonnes)

 1989   3    2    1    0.826511      1.3108  2    1    1.538461538    0    0.65
```

```
 1990   3   2   1   2.59394    1.3108  2   1   1.538461538   0   0.65
 1992   3   2   1   1.22658    1.3108  2   1   1.538461538   0   0.65
 1993   3   2   1   1.15375    1.3108  2   1   1.538461538   0   0.65
 1994   3   2   1   0.357445   1.3108  2   1   1.538461538   0   0.65
 1995   3   2   1   1.01804    1.3108  2   1   1.538461538   0   0.65
 1996   3   2   1   0.265799   1.3108  2   1   1.538461538   0   0.65
 1997   3   2   1   0.106796   1.3108  2   1   1.538461538   0   0.65
 1998   3   2   1   1.06278    1.3108  2   1   1.538461538   0   0.65
 1999   3   2   1   0.642352   1.3108  2   1   1.538461538   0   0.65
 2000   3   2   1   1.12817    1.3108  2   1   1.538461538   0   0.65
 2001   3   2   1   1.66704    1.3108  2   1   1.538461538   0   0.65
 2002   3   2   1   2.38549    1.3108  2   1   1.538461538   0   0.65
 2003   3   2   1   1.31099    1.3108  2   1   1.538461538   0   0.65
 2004   3   2   1   0.297833   1.3108  2   1   1.538461538   0   0.65
 2005   3   2   1   1.83486    1.3108  2   1   1.538461538   0   0.65
 2006   3   2   1   3.3144     1.3108  2   1   1.538461538   0   0.65
 2007   3   2   1   1.92908    1.3108  2   1   1.538461538   0   0.65
 2008   3   2   1   4.30175    1.3108  2   1   1.538461538   0   0.65
 2009   3   2   1   2.05905    1.3108  2   1   1.538461538   0   0.65
 2010   3   2   1   6.27075    1.3108  2   1   1.538461538   0   0.65
 2011   3   2   1   5.2775     1.3108  2   1   1.538461538   0   0.65
 2012   3   2   1   6.17064    1.3108  2   1   1.538461538   0   0.65
 2013   3   2   1   3.13431    1.3108  2   1   1.538461538   0   0.65
 2014   3   2   1   2.86222    1.3108  2   1   1.538461538   0   0.65
 2015   3   2   1   1.27709    1.3108  2   1   1.538461538   0   0.65
 2016   3   2   1   0.979021   1.3108  2   1   1.538461538   0   0.65
 2017   3   2   1   1.57796    1.3108  2   1   1.538461538   0   0.65
 2018   3   2   1   1.74213    1.3108  2   1   1.538461538   0   0.65
 2019   3   2   1   3.88518    1.3108  2   1   1.538461538   0   0.65
 2020   3   2   1   0.726643   1.3108  2   1   1.538461538   0   0.65
 2021   3   2   1   1.92701    1.3108  2   1   1.538461538   0   0.65
#
##  RELATIVE  ABUNDANCE DATA
##  Units of abundance: 1 = biomass, 2 = numbers
##  Number  of  relative  abundance indicies
## sex:1=male;2=female; 0=both
## maturity: 1=immature;2=mature;0 = both)

# Fishery CPUE index, Observer CPUE index2
3
# Index Type  (1=Selecivity; 2=retention)
#
2 2 2
## Number  of  rows  in  each  index
41
# Fishery CPUE index NB error in GLM fits on Observer and Fish Tick data
# Sex: 1 = male, 2 = female, 0 = both" << endl;
#  Maturity: 1 = immature, 2 = mature, 0 = both
#  Units of survey: 1 = biomass, 2 = numbers
# Indices are in numbers
#Observer CPUE index

 1   1995   3   1   1   0   0.879282477   0.042033451   2   0.5
 1   1996   3   1   1   0   0.815849908   0.030538475   2   0.5
 1   1997   3   1   1   0   0.883862635   0.027057194   2   0.5
 1   1998   3   1   1   0   1.010117295   0.021452204   2   0.5
 1   1999   3   1   1   0   0.98666272    0.02108597    2   0.5
 1   2000   3   1   1   0   0.824118765   0.021512332   2   0.5
 1   2001   3   1   1   0   1.079064735   0.020228773   2   0.5
 1   2002   3   1   1   0   1.174935143   0.022241384   2   0.5
 1   2003   3   1   1   0   1.032293627   0.023208482   2   0.5
 1   2004   3   1   1   0   1.467173822   0.022795391   2   0.5
```

```
 2    2005   3   1   1   0   0.97045889    0.026852066   2   0.5
 2    2006   3   1   1   0   0.801226718   0.02933121    2   0.5
 2    2007   3   1   1   0   0.88962567    0.024651866   2   0.5
 2    2008   3   1   1   0   0.875644097   0.029504977   2   0.5
 2    2009   3   1   1   0   0.727156803   0.043080187   2   0.5
 2    2010   3   1   1   0   0.74994345    0.041443367   2   0.5
 2    2011   3   1   1   0   1.078537338   0.030145327   2   0.5
 2    2012   3   1   1   0   1.035053799   0.028697759   2   0.5
 2    2013   3   1   1   0   1.006949278   0.027761264   2   0.5
 2    2014   3   1   1   0   1.293596572   0.027645121   2   0.5
 2    2015   3   1   1   0   1.312147657   0.024804944   2   0.5
 2    2016   3   1   1   0   1.029671419   0.028064272   2   0.5
 2    2017   3   1   1   0   1.034979701   0.030977831   2   0.5
 2    2018   3   1   1   0   1.236166141   0.027936602   2   0.5
 2    2019   3   1   1   0   1.148280402   0.025760484   2   0.5
 2    2020   3   1   1   0   1.055298436   0.027723836   2   0.5
 2    2021   3   1   1   0   0.993935189   0.03366779    2   0.5
#
#    Year:Area interaction
#    Observer    CPUE   index
#    1   1995   3   1   1   0   0.799865481   0.223589155   2   0.5
#    1   1996   3   1   1   0   1.431892924   0.129336153   2   0.5
#    1   1997   3   1   1   0   1.005665016   0.164236961   2   0.5
#    1   1998   3   1   1   0   0.693076984   0.198102942   2   0.5
#    1   1999   3   1   1   0   0.697087824   0.210056887   2   0.5
#    1   2000   3   1   1   0   0.698506534   0.192460525   2   0.5
#    1   2001   3   1   1   0   0.742289608   0.151457285   2   0.5
#    1   2002   3   1   1   0   1.443444402   0.102430717   2   0.5
#    1   2003   3   1   1   0   1.518382814   0.120998952   2   0.5
#    1   2004   3   1   1   0   1.581339037   0.067979922   2   0.5
#    2   2005   3   1   1   0   1.043208013   0.042745753   2   0.5
#    2   2006   3   1   1   0   0.902285312   0.060020437   2   0.5
#    2   2007   3   1   1   0   0.86056767    0.054706589   2   0.5
#    2   2008   3   1   1   0   0.793065632   0.067823623   2   0.5
#    2   2009   3   1   1   0   0.777542162   0.104741145   2   0.5
#    2   2010   3   1   1   0   0.80513618    0.093057331   2   0.5
#    2   2011   3   1   1   0   1.094125986   0.049126823   2   0.5
#    2   2012   3   1   1   0   0.990068535   0.054986364   2   0.5
#    2   2013   3   1   1   0   1.096210978   0.041334347   2   0.5
#    2   2014   3   1   1   0   1.237344328   0.034474257   2   0.5
#    2   2015   3   1   1   0   1.080994736   0.043197352   2   0.5
#    2   2016   3   1   1   0   1.085261937   0.042555231   2   0.5
#    2   2017   3   1   1   0   0.924819641   0.069466753   2   0.5
#    2   2018   3   1   1   0   1.134115622   0.042365537   2   0.5
#    2   2019   3   1   1   0   1.236352366   0.032825038   2   0.5
#    2   2020   3   1   1   0   1.025460466   0.050367619   2   0.5
#    2   2021   3   1   1   0   1.084792633   0.045764631   2   0.5
#
#Index Year  Seas fleet Sex  maturity  index  cv  abundanceunit  timing
 3    1985   3   1   1   0   1.628685686   0.031256541   2   0.5
 3    1986   3   1   1   0   1.228858309   0.03860399    2   0.5
 3    1987   3   1   1   0   0.955170913   0.051223518   2   0.5
 3    1988   3   1   1   0   1.035770885   0.03950348    2   0.5
 3    1989   3   1   1   0   1.076478459   0.03179462    2   0.5
 3    1990   3   1   1   0   0.986817549   0.045649076   2   0.5
 3    1991   3   1   1   0   0.904618567   0.047224701   2   0.5
 3    1992   3   1   1   0   0.917176073   0.047355474   2   0.5
 3    1993   3   1   1   0   0.914494509   0.05332578    2   0.5
 3    1994   3   1   1   0   0.808572288   0.051417951   2   0.5
 3    1995   3   1   1   0   0.77981996    0.055409819   2   0.5
 3    1996   3   1   1   0   0.779120743   0.055920142   2   0.5
 3    1997   3   1   1   0   1.050514781   0.042865274   2   0.5
```

```
 3      1998    3      1      1      0      1.214100014     0.042009806     2      0.5
#
## Number of length frequency matrices
2
## Number of rows in each matrix
37 31
## Number of bins in each matrix (columns of size data)
17 17
## SIZE COMPOSITION DATA FOR ALL FLEETS
## SIZE COMP LEGEND
## Sex: 1 = male, 2 = female, 0 = both sexes combined
## Type of composition: 1 = retained, 2 = discard, 0 = total composition
## Maturity state: 1 = immature, 2 = mature, 0 = both states combined
## Shell condition: 1 = new shell, 2 = old shell, 0 = both shell types combined
## Type 1 effective sample: Nsamp
##       Retain catch size comp

## updated the effective Ns
##Year, Seas, Fleet, Sex, Type, Shell, Maturity, Nsamp, DataVec

 1985   3   1   1   1   0   0   57   0.000000   0.000000   0.000000   0.000000   0.000000   0.002122
0.034669   0.103747   0.158923   0.156292   0.157127   0.133423   0.108521   0.061545   0.038431
0.020136   0.025065
 1986   3   1   1   1   0   0   11   0.000000   0.000000   0.000000   0.000000   0.000000   0.000635
0.030377   0.143149   0.183126   0.212534   0.136044   0.114523   0.075306   0.038519   0.039528
0.016971   0.009288
 1987   3   1   1   1   0   0   61   0.000000   0.000000   0.003518   0.000000   0.000550   0.003212
0.070524   0.162974   0.240875   0.168335   0.132893   0.076020   0.050479   0.037065   0.026783
0.011753   0.015022
 1988   3   1   1   1   0   0   352   0.000000   0.000000   0.000000   0.000000   0.000250   0.004988
0.043836   0.121611   0.173481   0.179156   0.161137   0.132840   0.073217   0.043037   0.025108
0.020902   0.020437
 1989   3   1   1   1   0   0   792   0.000000   0.000000   0.000000   0.000066   0.000195   0.008435
0.108452   0.234714   0.191637   0.123151   0.094370   0.075312   0.057163   0.038218   0.026285
0.019802   0.022201
 1990   3   1   1   1   0   0   163   0.000000   0.000052   0.000052   0.000000   0.000340   0.005531
0.079874   0.226018   0.260315   0.183031   0.112587   0.066439   0.038093   0.016649   0.005442
0.002781   0.002796
 1991   3   1   1   1   0   0   140   0.000000   0.000000   0.000000   0.000000   0.000287   0.006172
0.074641   0.201726   0.233318   0.206834   0.127877   0.072609   0.040713   0.018307   0.009776
0.004928   0.002812
 1992   3   1   1   1   0   0   49   0.000000   0.000000   0.000056   0.000120   0.000452   0.005204
0.074976   0.188394   0.240279   0.192046   0.126742   0.085203   0.048454   0.024934   0.008597
0.002697   0.001846
 1993   3   1   1   1   0   0   340   0.000000   0.000000   0.000000   0.000000   0.001271   0.006339
0.057846   0.227652   0.263149   0.193126   0.115423   0.061702   0.041289   0.019439   0.008024
0.001523   0.003216
 1994   3   1   1   1   0   0   319   0.000000   0.000000   0.000000   0.000000   0.000000   0.005146
0.056488   0.187163   0.253136   0.241073   0.112635   0.071796   0.038426   0.016716   0.011135
0.003629   0.002656
 1995   3   1   1   1   0   0   879   0.000000   0.000000   0.000367   0.000000   0.000132   0.002554
0.053244   0.174310   0.237169   0.205691   0.131577   0.086227   0.054200   0.029541   0.014691
0.006267   0.004031
 1996   3   1   1   1   0   0   547   0.000000   0.000509   0.000000   0.002673   0.004458   0.010646
0.076046   0.176767   0.219822   0.183488   0.129821   0.083593   0.049809   0.029215   0.022160
0.009716   0.001277
 1997   3   1   1   1   0   0   538   0.000165   0.000000   0.000000   0.000000   0.000546   0.005501
0.067013   0.195912   0.241333   0.187580   0.126671   0.078708   0.047831   0.025562   0.014975
0.006349   0.001855
 1998   3   1   1   1   0   0   541   0.000000   0.000000   0.000000   0.000000   0.000153   0.001613
0.058033   0.195363   0.237512   0.195717   0.131940   0.079974   0.046411   0.030546   0.015402
0.004854   0.002485
```

1999 3 1 1 1 0 0 463 0.000000 0.000000 0.000000 0.000000 0.000000 0.002647
0.056968 0.209816 0.256172 0.191463 0.123275 0.073622 0.044721 0.023946 0.011020
0.005430 0.000921
2000 3 1 1 1 0 0 436 0.000481 0.000000 0.000000 0.000000 0.000000 0.002408
0.038199 0.187100 0.243407 0.197233 0.140484 0.088336 0.054458 0.027952 0.012388
0.005379 0.002176
2001 3 1 1 1 0 0 488 0.000000 0.000040 0.000000 0.000000 0.000000 0.002185
0.043398 0.166360 0.254416 0.209148 0.150723 0.084320 0.049034 0.024928 0.010970
0.002453 0.002028
2002 3 1 1 1 0 0 406 0.000692 0.000000 0.000000 0.000000 0.000000 0.001140
0.042702 0.173724 0.231895 0.215249 0.146064 0.090496 0.052512 0.029190 0.012247
0.002809 0.001280
2003 3 1 1 1 0 0 405 0.000000 0.000000 0.000000 0.000000 0.000104 0.000939
0.025425 0.128996 0.198660 0.225076 0.168816 0.127193 0.062420 0.035472 0.017291
0.005726 0.003883
2004 3 1 1 1 0 0 280 0.000000 0.000000 0.000000 0.000000 0.000000 0.000153
0.036696 0.127904 0.215850 0.214303 0.163649 0.120783 0.069026 0.033788 0.016064
0.001630 0.000154
2005 3 1 1 1 0 0 266 0.000000 0.000000 0.000000 0.000000 0.000000 0.000885
0.018795 0.118321 0.199591 0.218250 0.176555 0.132109 0.068852 0.035158 0.023218
0.004347 0.003920
2006 3 1 1 1 0 0 234 0.000000 0.000000 0.000000 0.000000 0.000000 0.000266
0.016116 0.084749 0.179791 0.184967 0.175434 0.156561 0.101305 0.053838 0.027473
0.011261 0.008238
2007 3 1 1 1 0 0 199 0.000317 0.000000 0.000000 0.000000 0.000616 0.000000
0.023977 0.115069 0.188152 0.182646 0.168733 0.124654 0.089646 0.056234 0.027344
0.015402 0.007211
2008 3 1 1 1 0 0 197 0.000000 0.000000 0.000000 0.000000 0.000000 0.000886
0.012873 0.104580 0.201275 0.170907 0.164015 0.131524 0.089417 0.069199 0.030247
0.013294 0.011783
2009 3 1 1 1 0 0 170 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
0.012998 0.085646 0.178121 0.204593 0.179856 0.132916 0.096605 0.064687 0.026752
0.012521 0.005305
2010 3 1 1 1 0 0 183 0.000424 0.000000 0.000000 0.000000 0.000000 0.000497
0.019071 0.124157 0.190138 0.186530 0.154632 0.124061 0.080623 0.064508 0.031903
0.012549 0.010908
2011 3 1 1 1 0 0 160 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
0.006553 0.080423 0.169147 0.214179 0.181341 0.118590 0.107631 0.063368 0.033478
0.017831 0.007460
2012 3 1 1 1 0 0 187 0.000000 0.000000 0.000000 0.000000 0.000000 0.000924
0.011670 0.080888 0.167506 0.197858 0.161194 0.133335 0.105248 0.071755 0.041681
0.019324 0.008617
2013 3 1 1 1 0 0 193 0.000000 0.000000 0.000000 0.000000 0.000000 0.001621
0.015499 0.104071 0.166734 0.180076 0.184391 0.127462 0.095836 0.060360 0.035295
0.018979 0.009676
2014 3 1 1 1 0 0 168 0.000000 0.000000 0.000000 0.000000 0.000000 0.001431
0.022137 0.091465 0.171561 0.183012 0.168880 0.121834 0.102642 0.069861 0.035479
0.022149 0.009550
2015 3 1 1 1 0 0 190 0.000000 0.000000 0.000000 0.000000 0.000000 0.000000
0.011420 0.072221 0.169842 0.197348 0.152410 0.136227 0.095458 0.076222 0.042626
0.025670 0.020557
2016 3 1 1 1 0 0 247 0.000000 0.000000 0.000000 0.000000 0.000000 0.001569
0.023656 0.130969 0.187397 0.198963 0.152449 0.115449 0.076811 0.054592 0.029253
0.017759 0.011133
2017 3 1 1 1 0 0 224 0.000000 0.000000 0.000000 0.000000 0.000000 0.000256
0.023410 0.133188 0.218423 0.214067 0.169485 0.103612 0.069459 0.034132 0.016284
0.010683 0.007000
2018 3 1 1 1 0 0 256 0.000000 0.000000 0.000000 0.000529 0.000000 0.000135
0.027355 0.130823 0.248131 0.215962 0.158428 0.102995 0.058974 0.032543 0.013293
0.007461 0.003372

2019 3 1 1 1 0 0 242 0.000000 0.000000 0.000000 0.000000 0.000000 0.001065
0.031598 0.149950 0.250131 0.221410 0.144913 0.097167 0.052491 0.026653 0.018678
0.004507 0.001438
2020 3 1 1 1 0 0 227 0.000256 0.000000 0.000000 0.000000 0.000655 0.000431
0.044840 0.165445 0.247580 0.220790 0.148233 0.081651 0.045700 0.026418 0.007517
0.008112 0.002372
2021 3 1 1 1 0 0 254 0.000000 0.000000 0.000000 0.000000 0.000000 0.000828
0.018934 0.103964 0.217836 0.222929 0.154632 0.106593 0.073505 0.060579 0.026429
0.007276 0.006494
#

##Total catch size comp

##Year, Seas, Fleet, Sex, Type, Shell, Maturity, Nsamp, DataVec

1990 3 1 1 0 0 0 22 0.247057 0.0713771 0.0700192 0.077615 0.101558 0.0912419
0.0849724 0.078276 0.0682135 0.0552399 0.0270515 0.0133764 0.00962329 0.0023578 0.0014792
8.22E-05 0.000459108
1991 3 1 1 0 0 0 48 0.150747 0.0569511 0.0693395 0.0749659 0.0924522 0.103903
0.109297 0.102978 0.0877103 0.0677098 0.0362255 0.0214857 0.015996 0.00453193 0.00283495
0.00109456 0.00177659
1992 3 1 1 0 0 0 41 0.218576 0.0710539 0.0702081 0.0908626 0.097516 0.0846274
0.0812049 0.0750376 0.0673011 0.058382 0.0388833 0.0238657 0.0148029 0.00460071 0.00180984
0.00105979 0.000208438
1994 3 1 1 0 0 0 34 0.390634 0.0770537 0.0638146 0.0618622 0.0740266 0.0850102
0.074093 0.0543337 0.0516942 0.0326618 0.019531 0.00986639 0.00413091 0.00128759 0. 0.
0.
1995 3 1 1 0 0 0 1117 0.124613 0.0442733 0.0627333 0.0799967 0.0985993 0.116452
0.124387 0.107233 0.0875711 0.0651487 0.0407447 0.0231279 0.0131594 0.00656473 0.00339433
0.00116618 0.000835641
1996 3 1 1 0 0 0 509 0.103395 0.0415556 0.0569105 0.0743889 0.0931823 0.113814
0.122095 0.111671 0.0928794 0.0720616 0.0480457 0.0296772 0.0183391 0.0109164 0.00631536
0.00300188 0.00175086
1997 3 1 1 0 0 0 711 0.109124 0.0388528 0.0542848 0.0707215 0.0910392 0.11163
0.122114 0.114516 0.0975729 0.0742102 0.0466668 0.0298708 0.0187339 0.0109476 0.00603525
0.00229027 0.00139002
1998 3 1 1 0 0 0 574 0.091279 0.0396234 0.0574995 0.0785652 0.101792 0.120911
0.128335 0.117767 0.0955065 0.0692407 0.0416695 0.0271698 0.0160882 0.008442 0.00412504
0.00135657 0.000629092
1999 3 1 1 0 0 0 607 0.076032 0.0304259 0.0407786 0.060235 0.0855845 0.114671
0.136644 0.132851 0.115081 0.0863874 0.0539934 0.0306299 0.0190225 0.0102905 0.00486486
0.00188102 0.0006271
2000 3 1 1 0 0 0 495 0.0812519 0.0297586 0.0424546 0.0587412 0.0723233 0.104272
0.129143 0.140068 0.11847 0.0844907 0.0580157 0.0366426 0.0211551 0.0125915 0.00659819
0.00259604 0.00142754
2001 3 1 1 0 0 0 510 0.0560044 0.0234461 0.0328406 0.0452632 0.0604895 0.0883655
0.135255 0.152515 0.146458 0.110777 0.0675943 0.0391702 0.0223362 0.0116944 0.0045407
0.00223538 0.00101595
2002 3 1 1 0 0 0 438 0.0672552 0.0245928 0.0301661 0.0369386 0.0495942 0.0803033
0.111182 0.141262 0.143255 0.123413 0.0853576 0.050499 0.0315727 0.0143736 0.00696212
0.00228202 0.000991938
2003 3 1 1 0 0 0 416 0.043021 0.0234547 0.028494 0.0387766 0.05435 0.0870863
0.108929 0.133006 0.13769 0.129164 0.0923591 0.0576027 0.0324218 0.0176854 0.00979352
0.00396374 0.00220236
2004 3 1 1 0 0 0 299 0.0396677 0.0164496 0.0234035 0.0324723 0.0534929 0.0777852
0.103027 0.135703 0.143627 0.133979 0.0962192 0.0670814 0.0432435 0.0202071 0.00828497
0.00435757 0.000998367
2005 3 1 1 0 0 0 232 0.0253953 0.00885292 0.0100844 0.0161735 0.0288399 0.0416161
0.0787101 0.132803 0.153519 0.156458 0.131759 0.0879323 0.0660318 0.0348172 0.0167193
0.00671578 0.00357146

2006 3 1 1 0 0 0 143 0.0246625 0.00846409 0.01109 0.0137568 0.0236738 0.0371752
0.0845751 0.114118 0.155592 0.151945 0.133602 0.0970456 0.0708979 0.0405458 0.0186574
0.00897895 0.00521914
2007 3 1 1 0 0 0 134 0.00652577 0.00378906 0.0052302 0.00786267 0.018195
0.0331976 0.071528 0.124197 0.149503 0.15073 0.143045 0.100164 0.0809502 0.0507338
0.0294016 0.0159802 0.00896782
2008 3 1 1 0 0 0 113 0.00857113 0.0049083 0.00779756 0.0116225 0.0217224
0.0418616 0.0787408 0.123984 0.152078 0.153806 0.129021 0.0972501 0.0725458 0.0483485
0.0249741 0.0140889 0.00868037
2009 3 1 1 0 0 0 95 0.0113415 0.00518697 0.00881411 0.015353 0.0237856 0.0480279
0.0906078 0.13986 0.153603 0.141066 0.123676 0.0940756 0.0685207 0.0397965 0.0231241
0.00840498 0.00475553
2010 3 1 1 0 0 0 108 0.022828 0.00866797 0.013557 0.0200495 0.0368501 0.0557857
0.0905218 0.132494 0.143649 0.133755 0.108654 0.0899445 0.061541 0.0401121 0.0226787
0.0122193 0.0066932
2011 3 1 1 0 0 0 107 0.0104875 0.00697866 0.0100816 0.0137713 0.0215925 0.0390275
0.0832977 0.143807 0.155986 0.146627 0.125031 0.0913977 0.0659082 0.0435672 0.0238518
0.0119113 0.00667486
2012 3 1 1 0 0 0 99 0.00615772 0.00521303 0.00715262 0.00736057 0.0193456
0.0369768 0.0790887 0.124091 0.154593 0.149802 0.131341 0.102372 0.0726776 0.0501565
0.0303817 0.0145097 0.00878071
2013 3 1 1 0 0 0 122 0.0125185 0.00656913 0.0103487 0.015937 0.0265613 0.0505413
0.0948958 0.140513 0.154223 0.143494 0.114419 0.0849187 0.0610139 0.0423781 0.0247336
0.0108804 0.00605444
2014 3 1 1 0 0 0 99 0.0114342 0.00577775 0.0097938 0.0159057 0.0267485 0.0470268
0.0886109 0.119394 0.147714 0.137175 0.119421 0.0920404 0.0706556 0.0504406 0.0317839
0.0157829 0.0102948
2015 3 1 1 0 0 0 125 0.0126131 0.00853007 0.0139498 0.0214402 0.0325748 0.0537029
0.0885482 0.129716 0.149721 0.141136 0.108693 0.0853329 0.0588792 0.0433409 0.0264528
0.0146881 0.0106795
2016 3 1 1 0 0 0 155 0.0221805 0.0103568 0.0158631 0.0220943 0.039383 0.0683867
0.121158 0.1522 0.157448 0.132527 0.092669 0.0648578 0.0431382 0.0286815 0.0154292
0.00865352 0.00497325
2017 3 1 1 0 0 0 133 0.0286731 0.0105041 0.0158519 0.0226251 0.036473 0.0670006
0.116437 0.155027 0.162527 0.142692 0.0967285 0.0602004 0.0373219 0.0212888 0.0117646
0.0076865 0.00719791
2018 3 1 1 0 0 0 234 0.0186917 0.0113587 0.0156748 0.023319 0.045141 0.0708996
0.130263 0.150488 0.168919 0.132958 0.0982731 0.0548139 0.0348002 0.0215186 0.012037
0.00677388 0.00407118
2019 3 1 1 0 0 0 148 0.00916154 0.00612811 0.0107599 0.0187185 0.0376047
0.0765679 0.130283 0.165464 0.180549 0.14757 0.0959298 0.0578562 0.0331322 0.0176404
0.00737997 0.00375871 0.00149607
2020 3 1 1 0 0 0 155 0.0177394 0.00714948 0.0136626 0.019769 0.0440827 0.0694093
0.135446 0.170574 0.177529 0.131859 0.0973366 0.0508625 0.0332001 0.0159713 0.00856022
0.00393227 0.00291636
2021 3 1 1 0 0 0 138 0.00686642 0.0027576 0.00523951 0.00768031 0.019068
0.0523038 0.106167 0.16282 0.183086 0.159105 0.117981 0.0711493 0.049806 0.0288588
0.0151058 0.0074205 0.004585
#
#
Growth data (increment)
Type of growth increment (0=no growth data;1=size-at-release; 2= size-class-at-release)
3
nobs_growth
222
Class-at-release Sex Class-at-recapture Years-at-liberty number transition matrix RecaptureFleet Recapture Year (if applicable) SampleSize

…..Same Tag release-recapture data entry as in EAG21.1a…..

EOF
9999

4. ***EAG21.1e ctl file***

```
## —————————————————————————————————————————————— #
#  Controls for leading  parameter  vector  theta
#  LEGEND FOR PRIOR:
#  0 = uniform, 1 = normal, 2 = lognormal, 3 = beta, 4 =  gamma
##——————————————————————— #
#  ntheta
 9
##——————————————————————— #
# ival      lb     ub      phz   prior   p1      p2      # parameter
———————————————————————— #
  0.21      0.01   1.0      -3     2     0.18    0.04      # M
 7.806969358  -10.0 20.0   1    0    -10.0    20.0      # ln R0,

 12.0       -10.0   20.0     -3    0    -10.0    20.0      # ln Rini,

   8.0       -10.0  20.0     -1    0    -10.0    20.0      #ln Rbar,

 110.0      103.0  165.0     -2    1     72.5    7.25      # Expected value of recruitment distribution

 14.957480956  0.001  20.0    3    0     0.1     5.0    # recruitment scale

  -0.693147181 -10.0   0.75   -1    0   -10.0     0.75      # ln (SigmaR)

 0.73       0.2    1.0       -2    3     3.0     2.0       # steepness
  0.001      0.0    1.0      -3    3     1.01    1.01      # recruitment autocorrelation
##—————————##

# weight-at-length input method (1 = allometry  [w_l = a*l^b],  2 = vector by sex)
2
#a, in kg
# 1.445E-07
#b
# 3.281126995
# Male weight-at-length
 0.581515707 0.679328169   0.788032347 0.908278308   1.040724257   1.186036294   1.344888179   1.517961114   1.705943543
1.90953096  2.129425732  2.366336933 2.620980182  2.894077494  3.186357141  3.498553516  3.993657581
#
# Proportion mature by sex, males
  0.  0.  1.  1.  1.  1.  1.  1.  1.  1.  1.  1.  1.  1.  1.  1.  1.
# Proportion legal by sex, males
  0.  0.  0.  0.  0.  0.  0.  1.  1.  1.  1.  1.  1.  1.  1.  1.  1.
#——————————————————————— ##
## GROWTH PARAM CONTROLS
##     Two lines for each parameter if split sex, one line if not
##——————————————————————— ##
# Use growth transition matrix option (1=read in growth-increment matrix; 2=read in size-transition; 3=gamma distribution for size-increment; 4=gamma distribution for size after increment) (1 to 8 options available)
# option 8 is normal distributed growth incrment, size after incrment is normal
8
# growth increment model (0=prespecified; 1=alpha/beta; 2=estimated by size-class;3=pre-specified/emprical)
1
# molt probability function (0=pre-specified; 1=flat;2=declining logistic)
2
# maximum size-class (males then females)
#
# Maximum size-class for recruitment (males then females)
5
## number of size-increment periods
1
## Year(s) size-increment period changes (blank if no changes)
```

```
## number of molt periods
1
## Year(s) molt period changes (blank if no changes)

## Beta parameters are relative to a base level (1=Yes;0=no)
1

#  Growth parameters
##———————————————————— ##
# ival       lb       ub     phz   prior      p1      p2        # parameter
#————————————————————— #
   26.633282257   10.0    50.0    7       0       0.0    20.0   # alpha
   0.100176949   -0.4    20.0     7       0       0.0    10.0   # beta
  3.706522257   0.01    5.0      7       0       0.0     3.0   # growth scale
  140.986421569  65.0   165.0    7       0       0.0    999.0  #  moult mu
  0.074522526  -0.1      2.0     7       0       0.0     2.0   # moult cv
##—————————————————— ##

# The custom growth-increment matrix

# custom molt probability matrix

##————————————————————  ##
## SELECTIVITY CONTROLS
##     Selectivity P(capture of all sizes). Each gear must have a selectivity and a
##     retention selectivity. If a uniform prior is selected for a parameter then the
##     lb and ub are used (p1 and p2 are ignored)
## LEGEND
##     sel type: 0 = parametric (nclass), 1 = indiviudal parameter for each class(nclass)
##             2 = logistic (2, inflection point and slope), 3 = logistic95 (2, 50% and 95% selection), 4 = double normal (3 parameters)
##    5: Flat equal to zero (1 parameter; phase must be negative), UNIFORM1
##    6: Flat equal to one (1 parameter; phase must be negative), UNIFORM0
##    7: Flat-topped double normal selectivity (4 parameters)
##    8: Declining logistic selectivity with initial values (50% and 95% selection plus extra)
## Extra (type 1): number of selectivity parameters to be estimated
##     gear index: use +ve for selectivity, -ve for retention
##     sex dep: 0 for sex-independent, 1 for sex-dependent
##————————————  ##
##  ivector  for  number  of  year  blocks  or  nodes
##    Gear-1   Gear-2
## PotFishery    Trawl Byc
       2        1                    # selectivity time periods
       0        0                    # set 0 for male only fishery, sex specific selectivity, 0 for sex independent selectivity
       2        5                    # male selectivity type model (flat equal to zero, 1 parameter) or logistic or double normal etc.
       0        0                    # within another gear insertion of fleet in another
       0        0                    # extra paramters for each pattern
## Gear-1    Gear-2
      1        1                     # retention time periods
      0        0                     # set 0 for male only fishery, sex specific retention
      2        6                     # male retention type model (flat equal to one, 1 parameter)
      1        0                     # male retention flag (0 = no, 1 = yes)
      0        0                     # extra
      1        1                     # determines if maximum selectivity at size is forced to equal 1 or not

##————————————————————##
## Selectivity P (capture of  all  sizes)
##———————————————————— ##
## gear par   sel                                                        phz       start   end
# index index par sex ival      lb    ub   prior    p1     p2    mirror       period   period
#——————————————————— ##
## Gear-1
```

```
   1    1    1   0  82.733093859 105.0 180.0   0   100.0  190.0      3     1960   2004
   1    2    2   0  0.889284362  0.01   20.0   0     0.1   50.0           3     1960   2004
   1    3    1   0  133.365073404 105.0 180.0   0   100.0  190.0    3     2005   2021
   1    4    2   0   8.046215476  0.01   20.0   0     0.1   50.0           3     2005   2021

# Gear-2
  2    5    1   0    1.00      0.99  1.02   0     10.0  200.0                -3    1960   2021
##——————————————————— ##
## Retained
## gear par   sel                                                              phz    start    end
# index index par sex  ival       lb    ub     prior   p1     p2     mirror       period period
# Gear-1
 -1     6    1   0   136.164565254  105.0  180.0  0      100.0  190.0    3     1960   2021
 -1     7    2   0    2.109987098   0.0001  20.0  0      0.1    50.0         3     1960   2021

# Gear-2
 -2     8    1   0    1.00        0.99   1.01  0      10.0   200.0              -3    1960   2021

## ——————————————————————————————————————— ##
# Number of asymptotic parameters
1
# Fleet   Sex     Year       ival   lb   ub    phz
     1     1     1960   0.000001   0    1     -3
##——————————————————— ##
## PRIORS FOR CATCHABILITY
##     If a uniform prior is selected for a parameter then the lb and ub are used (p1
##     and p2 are ignored). ival must be > 0
## only allowed to use uniform or lognormal prior
## if anlytic q estimation step is chosen, turn off estimating q by changing the estimation phase to be -ve
## LEGEND
##     prior: 0 = uniform, 1 = normal, 2 = lognormal, 3 = beta, 4 = gamma
##——————————————————— ##
#
## SURVEYS/INDICES ONLY
## fishery and observer CPUE
## Analytic (0=not analytically solved q, use uniform or lognormal prior;
## 1= analytic),
## Lambda =multilier for iput CV, Emphasis = multiplier for likelihood
##  ival       lb         ub    phz    prior   p1        p2     Analytic?   LAMBDA   Emphasis
 0.000392207  0.0000001   0.01   1      0      0.0     1.0      0          1       1   # observer cpue index 1995-2004
 0.000307861  0.0000001   0.01   1      0      0.0     1.0      0          1       1   # observer cpue index 2005-2021
 0.000366319   0.0000001  0.01   1      0      0.0     1.0      0          1       1   # fishery cpue index 1985-1998

## if a uniform prior is specified then use lb and ub rather than p1 and p2
##———————————————————##
## ADDITIONAL CV FOR SURVEYS/INDICES
##     If a uniform prior is selected for a parameter then the lb and ub are used (p1
##     and p2 are ignored). ival must be > 0, lb should be>0
## LEGEND
##     prior type: 0 = uniform, 1 = normal, 2 = lognormal, 3 = beta, 4 = gamma
##——————————————————— ##
##  ival          lb        ub    phz   prior   p1    p2
 0.000160286   0.0000001    0.5     6     0      0.5   100  # obs CPUE additional CV
 0.000139629   0.0000001    0.5     6     0      0.5   100  # obs CPUE additional CV
 0.000256280   0.0000001    0.5     6     0      0.5   100  # fishery CPUE additional CV

### Pointers to how the the additional CVs are used (0 ignore; >0 link to one of the parameters
1 2 3
####
## if a uniform prior is specified then use lb and ub rather than p1 and p2
##———————————————————##
##PENALTIES FOR AVERAGE FISHING  MORTALITY  RATE  FOR  EACH  GEAR
```

```
##——————————————————————##
## Trap  Trawl
## Male F, Female F, early_phasepenalty_sd, later_phasepenalty_sd, meanmaleF_phase, meanfemaleF_phase,
## lb meanF, ub meanF,lbannualmaleF(F_dev), ubannual maleF(F_dev),lbannualfemaleF(F_dev), ubannual femaleF(F_dev)
## BBRKC uses STD_PHZ1=0.5 STD_PHZ2=45.5
## Mean_F    Fema-Offset   STD_PHZ1 STD_PHZ2 PHZ_M PHZ_F    Lb      Ub     Lb     Ub      Lb    Ub
   0.258346278       0.0        3.0    15.0     2    -1     -12      4    -10     10     -10    10
   0.000198933       0.0        4.0    15.0     2    -1     -12      4    -10     10     -10    10
##——————————————————————##
## OPTIONS FOR SIZE COMPOSTION DATA
##     One column for each data matrix
## LEGEND
##     Likelihood: 1 = Multinomial with estimated/fixed sample size
##                 2 = Robust approximation to multinomial
##                 3 = logistic normal (NIY)
##                 4 = multivariate-t (NIY)
##                 5 = Dirichlet
## AUTO TAIL COMPRESSION
##     pmin is the cumulative proportion used in tail compression
##——————————————————— ##
#  Ret Tot
#
   1   1         # Type of likelihood
   0   0         # Auto tail compression (pmin)
   1   1         # Initial value for effective sample size multiplier
  -4  -4        # Phz for estimating effective sample size (if appl.)
   1   2        # Composition aggregator if you put 1 for each it will merge, do not merge (why merge)
   #
   1   1         # Set to 2 for survey-like predictions; 1 for catch-like predictions
   ##
   0.640694300072918 0.452871947258142 # Emphasis for Dritchlet (Ret, Tot, multiplier of stage1 ESS)
   1   1        # LAMBDA 0 to ignore the length comp
##——————————————————— ##

## TIME VARYING NATURAL  MORTALIIY  RATES  ##
##———————————————————— ##
## Type: 0 = constant natural mortality
##       1 = Random walk (deviates constrained by variance in M)
##       2 = Cubic Spline (deviates constrained by nodes & node-placement)
##       3 = Blocked changes (deviates constrained by variance at specific knots)
##       4 = Changes in pre-specified blocks
##       5 = Changes in some knots
##       6 = Changes in Time blocks
 0    # M type
## M is relative (YES=1; NO=0)

## Phase of estimation
3
## STDEV in m_dev for Random walk
0.25
## Number of nodes for cubic spline or number of step-changes for option 3
1
## Year position of the knots (vector must be equal to the number of nodes)
1960
## number of breakpoints in M by size (keep it at 0)
0
# line groups for breakpoint
8
## Specific initial values for the natural mortality devs (0-no, 1=yes)
## 1
## ival        lb        ub        phz    extra
##    3.0        0.5       5.0       4        0
```

```
## ———————————————— ##
## TAGGING controls CONTROLS
## —————————— ##
 1         # emphasis on tagging data (1 =use tag LH, 0=ignore)

## ———————————————— ##
## Maturity specific natural mortality
## ———————————————— ##
# maturity specific natural mortality? (yes = 1; no = 0; only for use if nmature > 1)
0

##—————————————————————————— ##

## ival       lb  ub  phz  prior  p1  p2       # parameter    ##

##—————————————————————————— ##

0   -1   1  -1  0   1   1
——————————————————— ##
## OTHER CONTROLS
——————————————————— ##
#
1960      # First year of recruitment estimation,rec_dev.
2021      # last year of recruitment estimation, rec_dev
  1       # phase for recruitment estimation
 -2       # phase for recruitment sex-ratio estimation
 0.5      # Initial value for Expected sex-ratio
 -3       # Phase for initial recruitment estimation, rec_ini phase
  1       # VERBOSE FLAG (0 = off, 1 = on, 2 = objective func; 3 diagnostics)
  0       # Initial conditions (0 = Unfished, 1 = Steady state fished, 2 = Free parameters, 3 = Free parameters (revised))
  1       # Lambda (proportion of mature male biomass for SPR reference points).
  0       # Stock-Recruit-Relationship (0 = none, 1 = Beverton-Holt)
  10      # Maximum phase (stop the estimation after this phase), 10 Maximum phase. If you put 1 it will stop after phase 1
  -1      # Maximum number of function calls, if 1, stop at fn 1 call; if -1, run as long as it takes
  1       # Calculate reference points (0=no)
  200     # Year to compute equilibria
## EMPHASIS FACTORS (CATCH)
#Ret_male Tot_male   Groundfish
      4      2         1
## EMPHASIS FACTORS (Priors) by fleet: fdev_total, Fdov_total, Fdev_year, Fdov_year
0 0 0.001 0 # Pot fishery
0 0 0.001 0 # Groundfish


## EMPHASIS FACTORS (Priors)
##
# Log_fdevs   meanF      Mdevs  Rec_devs Initial_devs Fst_dif_dev Mean_sex-Ratio  Molt_prob    Free selectivity
                                                                                 Init_n_at_len Fvecs Fdovs
      0      0       0.0       2          0        0         0            0                0                0     1     0      #

##  EOF
9999
```