2018 Stock Assessment and Fishery Evaluation Report for the Tanner Crab Fisheries of the Bering Sea and Aleutian Islands Regions

William T. Stockhausen
Alaska Fisheries Science Center
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Executive Summary

1. Stock: species/area.
Southern Tanner crab (*Chionoecetes bairdi*) in the eastern Bering Sea (EBS).

2. Catches: trends and current levels.
Legal-sized male Tanner crab are caught and retained in the directed (male-only) Tanner crab fishery in the EBS. The NPFMC annually determines the overfishing limit (OFL) and acceptable biological catch (ABC) levels for Tanner crab in the EBS, while the Alaska Department of Fish and Game (ADFG) determines the total allowable catch (TAC) separately for areas east and west of 166ºW longitude in the Eastern Subdistrict of the Bering Sea District Tanner crab Registration Area J. Following rationalization of the Bering Sea and Aleutian Islands (BSAI) crab fisheries in 2005/06, the directed fishery for Tanner crab was open through 2009/10, after which time it was determined that the stock was overfished in the EBS and directed fishing was closed. Prior to the closure, the retained catch averaged 770 t per year between 2005/06-2009/10. The directed fishery was re-opened in 2013/14 following determinations by NMFS in 2012 that the stock was rebuilt and no longer overfished and by ADFG that the stock met state harvest guidelines for opening the fishery. ADFG set the TAC at 1,645,000 lbs (746 t) for the area west of 166º W and at 1,463,000 lbs (664 t) for the area east of 166º W. On closing, 79.6% (594 t) of the TAC was taken in the western area while 98.6% (654 t) was taken in the eastern area.

TACs were steadily increased for the next two years, with concomitant increasing harvests. In 2014/15, TAC was set at 6,625,000 lbs (2,329 t) for the area west of 166º W and at 8,480,000 lbs (3,829 t) for the area east of 166º W. On closing, 77.5% (2,329 t) of the TAC was taken in the western area while 99.6% (3,829 t) were taken in the eastern area. In 2015/16, TAC was set at 11,272,000 lbs (5,113 t) for the eastern area and 8,396,000 lbs (3,808 t) for the western area. On closing, essentially 100% of the TAC was taken in both areas (11,268,885 lbs [5,111 t] in the eastern area, 8,373,493 lbs [3,798 t] in the western area based on the 5/20/2016 in-season catch report).

Although the NPFMC determined an OFL of almost 60,000,000 lbs (~25,000 t) based on the 2016 assessment (Stockhausen, 2016), mature female Tanner crab biomass fell below the threshold set in the State of Alaska's harvest strategy for opening the fishery; consequently, the fishery was closed and the TAC was set to 0. Thus, no directed harvest occurred in 2016/17. In 2017/18, ADFG determined that a directed fishery could occur in the area west of 166oW longitude. The TAC was set at 2,500,200 lbs (1,130 t), of which 100% was taken.

In addition to legal-sized males, females and sub-legal males are taken in the directed fishery as bycatch and must be discarded. Discarding of legal-sized males also occurs, primarily because the minimum size preferred by processors is larger than the minimum legal size but also because "old shell" crab are less desirable than "new shell" males. Tanner crab are also taken as bycatch in the snow crab and Bristol Bay red king crab fisheries, in the groundfish fisheries and, to a very minor extent, in the scallop fishery. Over the last five years, the snow crab fishery has been the major source of Tanner crab bycatch among these fisheries, averaging 1,500 t for the 5-year period 2012/13-2016/17. Bycatch in the snow crab fishery in 2017/18 was 1,120 t. The groundfish fisheries have been the next major source of Tanner crab bycatch over the same five year time period, averaging 360 t. Bycatch in the groundfish fisheries in 2017/18 was 143 t. Excluding the scallop fishery, the Bristol Bay red king crab fishery has typically been the smallest source of Tanner crab bycatch among these fisheries, averaging 85 t over the 5-year time period. In 2017/18, this fishery accounted for 182 t of Tanner crab bycatch.

In order to account for mortality of discarded crab, handling mortality rates are assumed to be 32.1% for Tanner crab discarded in the crab fisheries, 50% for Tanner crab in the groundfish fisheries using fixed gear, and 80% for Tanner crab discarded in the groundfish fisheries using trawl gear to account for differences in gear and handling procedures used in the various fisheries.

3. Stock biomass: trends and current levels relative to virgin or historic levels

For EBS Tanner crab, spawning stock biomass is expressed as mature male biomass (MMB) at the time of mating (mid-February). From the author's preferred model (Model 18C2a), estimated MMB for 2017/18 was 47.0 thousand t (Table 33; Appendix I7, Figure 3). This was smaller than those for the past three years (58.7, 61.0, and 57.7 thousand t, respectively), but it remains above the very low levels seen in the mid-1990s to early 2000s (1990 to 2005 average: 16.8 thousand t). However, it is considerably below model-estimated historic levels in the late 1970s (1975-1980 average: 72.2 thousand t) before it declined through 1985.

4. Recruitment: trends and current levels relative to virgin or historic levels.

From the author's preferred model (Model 18C2a), the estimated total recruitment for 2017/18 (the number of crab entering the population on July 1) is 662.47 million crab (Table 36; Appendix I7, Figure 1). Although this value is highly uncertain, it follows a similarly high estimate for 2016/17 (354.6 million crab). The average 5-year recruitment prior to 2016/17 was only 68.3 million crab while the longterm (1982+) mean is 202.6 million crab.

5. Management performance

Historical status and catch specifications for eastern Bering Sea Tanner crab.

(a) in 1000's t.

Year	**MSST**	**Biomass (MMB)**	**TAC (East + West)**	**Retained Catch**	**Total Catch Mortality**	**OFL**	**ABC**
2014/15	13.40	71.57 [A]	6.85	6.16	9.16	31.48	25.18
2015/16	12.82	73.93 [A]	8.92	8.91	11.38	27.19	21.75
2016/17	14.58	77.96 [A]	0.00	0.00	1.14	25.61	20.49
2017/18	10.93[C]	43.31[A]	1.13	1.13	2.39[C]	25.42	20.33
2018/19		23.53[B,C]				16.76[C]	13.41[C]

(b) in millions lbs.

Year	MSST	Biomass (MMB)	TAC (East + West)	Retained Catch	Total Catch Mortality	OFL	ABC
2014/15	29.53	157.78 [A]	15.10	13.58	20.19	69.40	55.51
2015/16	28.27	162.99 [A]	19.67	19.64	25.09	59.94	47.95
2016/17	32.15	171.87 [A]	0.00	0.00	2.52	56.46	45.17
2017/18	24.10 [C]	95.49 [A]	2.50	2.50	5.27 [C]	56.03	44.83
2018/19		51.87 [B,C]				36.95 [C]	29.56 [C]

A—Estimated at time of mating for the year concerned. This is a revised estimate, based on the subsequent assessment.
B—Projected biomass from the current stock assessment. This value will be updated next year.
C—Based on the author's preferred model (Model 18C2a).

6. Basis for the OFL

a) in 1000's t.

Year	Tier[A]	B_{MSY}[A]	Current MMB[A]	B/B_{MSY}[A]	F_{OFL}[A] (yr^{-1})	Years to define B_{MSY}[A]	Natural Mortality[A,B] (yr^{-1})
2014/15	3a	29.82	63.80	2.14	0.61	1982-2014	0.23
2015/16	3a	26.79	53.70	2.00	0.58	1982-2015	0.23
2016/17	3a	25.65	45.34	1.77	0.79	1982-2016	0.23
2017/18	3a	29.17	47.04	1.49	0.75	1982-2017	0.23
2018/19	3a	21.87	23.53	1.08	0.93	1982-2018	0.23

b) in millions lbs.

Year	Tier[A]	B_{MSY}[A]	Current MMB[A]	B/B_{MSY}[A]	F_{OFL}[A] (yr^{-1})	Years to define B_{MSY}[A]	Natural Mortality[A,B] (yr^{-1})
2014/15	3a	65.74	140.66	2.14	0.61	1982-2014	0.23
2015/16	3a	59.06	118.38	2.00	0.58	1982-2015	0.23
2016/17	3a	56.54	99.95	1.77	0.79	1982-2016	0.23
2017/18	3a	64.30	103.70	1.49	0.75	1982-2017	0.23
2018/19	3a	48.21	51.87	1.08	0.93	1982-2018	0.23

A—Calculated from the assessment reviewed by the Crab Plan Team in 20XX of 20XX/(XX+1) or based on the author's preferred model for 2018/19.
B—Nominal rate of natural mortality. Actual rates used in the assessment are estimated and may be different.

Current male spawning stock biomass (MMB), as projected for 2018/19, is estimated at 23.53 thousand t. B_{MSY} for this stock is calculated to be 21.87 thousand t, so MSST is 10.93 thousand t. Because current MMB > MSST, **the stock is not overfished**. Total catch mortality (retained + discard mortality in all fisheries, using a discard mortality rate of 0.321 for pot gear and 0.8 for trawl gear) in 2017/18 was 2.39

thousand t, which was less than the OFL for 2016/17 (25.42 thousand t); consequently **overfishing did not occur**. The OFL for 2018/19 based on the author's preferred model (Model 18C2a) is 16.76 thousand t. The ABC_{max} for 2018/19, based on the p^* ABC, is 16.44 thousand t. In 2014, the SSC adopted a 20% buffer to calculate ABC for Tanner crab to incorporate concerns regarding model uncertainty for this stock. Based on this buffer, the ABC would be 13.41 thousand t.

7. Rebuilding analyses summary.
The EBS Tanner crab stock was found to be above MSST (and B_{MSY}) in the 2012 assessment (Rugolo and Turnock, 2012b) and was subsequently declared rebuilt. The stock remains not overfished. Consequently no rebuilding analyses were conducted.

A. Summary of Major Changes

1. Changes (if any) to the management of the fishery.
At the March, 2015 SOA Board of Fish (BOF) meeting, the Board adopted a revised harvest strategy for Tanner crab in the Bering Sea District[1], wherein the TAC for the area east of 166ºW longitude would be based on a minimum preferred harvest size of 127 mm CW (5.0 inches), including the lateral spines. Formerly, this calculation was based on a minimum preferred size of 140 mm CW (5.5 inches). The TAC in the area west of 166ºW longitude continues to be based on a minimum preferred harvest size of 127 mm CW (including lateral spines).

The directed Tanner crab fishery east of 166ºW longitude was closed in 2017/18, as in 2016/17, because mature female Tanner crab biomass failed to meet the criteria defined in the SOA's harvest strategy to open the fisheries. However, a directed fishery was conducted in the area west of 166ºW longitude.

2. Changes to the input data
The following table summarizes data sources that have been updated for this assessment:

Updated data sources.

Data source	Data types	Time frame	Notes	Agency
NMFS EBS Bottom Trawl Survey	area-swept abundance, biomass	1975-2018	recalculated, new	NMFS
	size compositions	1975-2018	recalculated, new	
	molt-increment data	1990+	new	
NMFS/BSFRF	molt-increment data	2014-16	same as 2017	NMFS, BSFRF
Directed fishery	retained catch (numbers, biomass)	2005/06-2017/18	updated, new	ADFG
	retained catch size compositions	2013/14-2017/18	updated	ADFG
	effort	2015/16, 2016/17	updated, new	ADFG
	total catch (abundance, biomass)	1991/92-2017/18	updated, new	ADFG
	total catch size compositions	1991/92-2017/18	updated, new	ADFG
Snow Crab Fishery	effort	1990/91-2017/18	revised, new	ADFG
	total bycatch (abundance, biomass)	1990/91-2017/18	revised, new	ADFG
	total bycatch size compositions	1990/91-2017/18	revised, new	ADFG
Bristol Bay Red King Crab Fishery	effort	1990/91-2017/18	revised, new	ADFG
	total bycatch (abundance, biomass)	1990/91-2017/18	revised, new	ADFG
	total bycatch size compositions	1990/91-2017/18	revised, new	ADFG
Groundfish Fisheries (all gear types)	total bycatch (abundance, biomass)	1991/92-2017/18	revised, new	NMFS/AKFIN
	total bycatch size compositions	1991/92-2017/18	updated, new	

[1] https://aws.state.ak.us/OnlinePublicNotices/Notices/Attachment.aspx?id=100244

3. Changes to the assessment methodology.

Following a considerable development effort and substantial review by the CPT at the January 2017 Modeling Workshop and the May 2017 CPT Meeting, with additional review by the SSC at its February and June 2017 meetings, a new modeling "framework", TCSAM02, was recommended by the CPT at its May 2017 meeting (and approved by the SSC at its June 2017 meeting) for use in the 2017/18 assessment. This framework was used again for this assessment. TCSAM02, while based on the previous assessment model (TCSAM2013), constitutes a completely rewritten code library for the Tanner crab assessment model. Results presented at the May 2017 CPT meeting demonstrated that TCSAM02 could be configured to exactly match results from the TCSAM2013 code, thus providing continuity with the old model code.

The 2017 assessment model (B2b in that assessment), built on the 2016 model by: 1) fitting EBS model-increment data inside the model to inform growth parameters, b) estimating separate retention functions for three time periods (pre-1997/98, 2005/06-2009/10, and 2013/14-2015/16), and c) estimating the asymptotic value for the fraction of male crab retained in the directed fishery (in the same three time periods as (b)), rather than assuming it was 1 (i.e., 100% retention at large sizes).

The author-recommended model scenario proposed here, 18C2a, differs rather substantially from the 2017 assessment model by: 1) fixing NMFS EBS bottom trawl survey catchability and selectivity parameters in the 1982+ time period to ones equivalent to those from Somerton and Otto (1999)'s so-called "underbag" experiment; 2) adding a likelihood component to fit annual male maturity ogives determined from chela height-to-carapace width ratios in the NMFS survey; and 3) eliminating fits to survey biomass and size composition data for male crab classified as mature/immature based on a maturity ogive determined outside the model and instead fitting to time series of aggregated male survey biomass and abundance, as well as to male size compositions classified by shell condition. In addition, revised time series data for retained and total catch abundance and biomass since 1990/91 were provided by ADFG for the directed Tanner crab, snow crab and Bristol Bay red king crab fisheries and incorporated into model parameter estimation.

4. Changes to the assessment results

Given the fairly substantial changes in model configuration and input data, the results from the author's preferred model this year (Model 18C2a) are surprisingly similar to those of the previous assessment (see Appendix J for a visual comparison of population trajectories from the two models). Average recruitment (1982-present) was estimated at 214 million in last year's model, whereas it is estimated at 199 million in the author's preferred model this year. F_{MSY} is larger this year (0.93 yr^{-1} this year vs. 0.75 yr^{-1} last year), while B_{MSY} was estimated somewhat smaller than last year (21.87 thousand t vs. 29.17 thousand t).

B. Responses to SSC and CPT Comments

1. Responses to the most recent two sets of SSC and CPT comments on assessments in general.

June 2018 SSC Meeting
No general comments.

May 2018 Crab Plan Team Meeting
No general comments.

October 2017 SSC Meeting
No general comments.

September 2017 Crab Plan Team Meeting
No general comments.

2. Responses to the most recent two sets of SSC and CPT comments specific to the assessment. [Note: for continuity with the previous assessment, the following includes comments prior to the most recent two sets of comments.]

June 2018 SSC Meeting
The SSC endorsed the CPT suggestions from its May meeting.
Response: none.

The SSC requested an evaluation of all parameters estimated to be at or very near bounds, or substantially limited by priors (unless those priors can be logically defended).
Response: See response above to general comments from the June 2017 SSC Meeting.

May2018 Crab Plan Team Meeting
The CPT outlined a number of alternative models built on the 2017 assessment model (2017AM) as the base model to be evaluated.
Response: The CPT referred to these models as 2018B0, 2018B1, 2018B2, 2018B3, 2018B4 and 2018B5. These models were all run for this assessment, but renamed as 18A, 18B, 18C0, 18C1, 18D0, and 18D1, where "18" refers to the assessment year, A/B/C/D refers to different datasets included in the likelihood, and 0/1 refers to whether (1) or not (0) survey abundance time series were included in the fitting process in addition to survey biomass time series. 2017AM is subsequently referred to herein as 17AM. In addition to the alternative model scenarios requested by the CPT, several additional scenarios were also run: 17AMu, 18C0a, 18C1a, 18C2a, and 18C3a. Scenario 17AMu represents the 2017 assessment model re-run with revised (i.e., "u"pdated) data for the crab fisheries. The "a" in the remaining scenarios refers to ones in which the likelihood component for male maturity ogive data was down-weighted, whereas "2" and "3" refer to fixing the survey catchability and selectivity parameters to match ones from Somerton and Otto (1999)'s underbag experiment.

October 2017 SSC Meeting
Comment: "The SSC endorses all of the CPT recommendations with respect to the poor fits to some of the retained catch time series, poor fits to the size composition data for retained catch and survey data, and issues with the total directed fishery selectivity curve for males (in particular the 1996 'outlier')."
Response: With respect to the 1996 'outlier', this was a result of the combination of a very small sample size for the 1996 size compositions and the using the mean size-st-50%-selected for 1991-1996 as the value for the size-at-50%-selected prior to 1991. Because the sample size for 1996 was small, the 1996 size-at-50%-selected essentially became a free parameter uninformed by the 1996 data but sensitive to changes in the overall likelihood through changes in the mean value. Regarding the other issues, see the responses to CPT comments below.

September 2017 CPT Meeting

Comment: “The model fits total catch well, but does a poorer job in fitting retained catch, catch of females, and catch in the bycatch fisheries.”

Response: Catch of females was improved by estimating a female-specific offset to fully-selected male capture rates in the fisheries. There appears to be a conflict in the model between fitting total (male) catch and retained catch in the directed fishery. In this assessment, I’ve explored the use of varying the estimated retention function annually and within time blocks, as well as the possibility that retention is not 100% for the largest male crab (i.e., the retention function asymptotes at less than 1). These options seem to reduce the conflict, but not eliminate it.

C. Introduction

1. Scientific name.

Chionocoetes bairdi.Tanner crab is one of five species in the genus *Chionoecetes* (Rathbun, 1924). The common name "Tanner crab" for *C. bairdi* (Williams et al. 1989) was recently modified to "southern Tanner crab" (McLaughlin et al. 2005). Prior to this change, the term "Tanner crab" had also been used to refer to other members of the genus, or the genus as a whole. Hereafter, the common name "Tanner crab" will be used in reference to "southern Tanner crab".

2. Description of general distribution

Tanner crabs are found in continental shelf waters of the north Pacific. In the east, their range extends as far south as Oregon (Hosie and Gaumer 1974) and in the west as far south as Hokkaido, Japan (Kon 1996). The northern extent of their range is in the Bering Sea (Somerton 1981a), where they are found along the Kamchatka peninsula (Slizkin 1990) to the west and in Bristol Bay to the east.

In the eastern Bering Sea (EBS), the Tanner crab distribution may be limited by water temperature (Somerton 1981a). The unit stock is that defined across the geographic range of the EBS continental shelf, and managed as a single unit (Fig. 1). *C. bairdi* is common in the southern half of Bristol Bay, around the Pribilof Islands, and along the shelf break, although males less than the industry-preferred size (>125 mm CW) and ovigerous and immature females of all sizes are distributed broadly from southern Bristol Bay northwest to St. Matthew Island (Rugolo and Turnock, 2011a). The southern range of the cold water congener the snow crab, *C. opilio*, in the EBS is near the Pribilof Islands (Turnock and Rugolo, 2011). The distributions of snow and Tanner crab overlap on the shelf from approximately 56° to 60°N, and in this area, the two species hybridize (Karinen and Hoopes 1971).

3. Evidence of stock structure

Tanner crabs in the EBS are considered to be a separate stock distinct from Tanner crabs in the eastern and western Aleutian Islands (NPFMC 1998). Somerton (1981b) suggests that clinal differences in some biological characteristics may exist across the range of the unit stock. These conclusions may be limited since terminal molt at maturity in this species was not recognized at the time of that analysis, nor was stock movement with ontogeny considered. Biological characteristics estimated based on comparisons of length frequency distributions across the range of the stock, or on modal length analysis over time may be confounded as a result.

Although the State of Alaska's (SOA) harvest strategy and management controls for this stock are different east and west of 166^{o}W, the unit stock of Tanner crab in the EBS appears to encompass both regions and comprises crab throughout the geographic range of the NMFS bottom trawl survey. Strong evidence is lacking that the EBS shelf is home to two distinct, non-intermixing, non-interbreeding stocks that should be assessed and managed separately.

4. Life history characteristics

a. Molting and Shell Condition

Tanner crabs, like all crustaceans, normally exhibit a hard exoskeleton of chitin and calcium carbonate. This hard exoskeleton requires individuals to grow through a process referred to as molting, in which the individual sheds its current hard shell, revealing a new, larger exoskeleton that is initially soft but which rapidly hardens over several days. Newly-molted crab in this "soft shell" phase can be vulnerable to predators because they are generally torpid and have few defenses if discovered. Subsequent to hardening, an individual's shell provides a settlement substrate for a variety of epifaunal "fouling" organisms such as barnacles and bryozoans. The degree of hard-shell fouling was once thought to correspond closely to post-molt age and led to a classification of Tanner crab by shell condition (SC) in survey and fishery data similar to that described in the following table (NMFS/AFSC/RACE, unpublished):

Shell Condition Class	Description
0	pre-molt and molting crab
1	carapace soft and pliable
2	carapace firm to hard, clean
3	carapace hard; topside usually yellowish brown; thoracic sternum and underside of legs yellow with numerous scratches; pterygostomial and bronchial spines worn and polished; dactyli on meri and metabranchial region rounded; epifauna (barnacles and leech cases) usually present but not always.
4	carapace hard, topside yellowish-brown to dark brown; thoracic sternum and undersides of legs data yellow with many scratches and dark stains; pterygostomial and branchial spines rounded with tips sometimes worn off; dactyli very worn, sometimes flattened on tips; spines on meri and metabranchial region worn smooth, sometimes completely gone; epifauna most always present (large barnacles and bryozoans).
5	conditions described in Shell Condition 4 above much advanced; large epifauna almost completely covers crab; carapace is worn through in metabranchial regions, pterygostomial branchial spines, or on meri; dactyli flattened, sometimes worn through, mouth parts and eyes sometimes nearly immobilized by barnacles.

Although these shell classifications continue to be applied to crab in the field, it has been shown that there is little real correspondence between post-molt age and shell classifications SC 3 through 5, other than that they indicate that the individual has probably not molted within the previous year (Nevisi et al, 1996). In this assessment, crab classified into SCs 3-5 have been aggregated as “old-shell” crab, indicating that these are crab likely to have not molted within the previous year. In a similar fashion, crab classified in SCs 0-2 have been combined as “new shell” crab, indicating that these are crab have certainly (SCs 0 and 1), or are likely to have (SC 2), molted within the previous year.

b. Growth

Work by Somerton (1981a) estimated growth for EBS Tanner crab based on modal size frequency analysis of Tanner crab in survey data assuming no terminal molt at maturity. Somerton’s approach did not directly measure molt increments and his findings are constrained by not considering that the progression of modal lengths between years was biased because crab ceased growing after their terminal molt to maturity.

Growth in immature Tanner crab larger than approximately 25 mm CW proceeds by a series of annual molts, up to a final (terminal) molt to maturity (Tamone et al., 2007). Rugolo and Turnock (2012a) derived growth relationships for male and female Tanner crab used as priors for estimated growth parameters in this (and previous) assessments from data on observed growth in males to approximately 140 mm carapace width (CW) and in females to approximately 115 mm CW that were collected near Kodiak Island in the Gulf of Alaska (Munk, unpublished.; Donaldson et al. 1981). Rugolo and Turnock (2010) compared the resulting growth per molt (gpm) relationships with those of Stone et al. (2003) for Tanner crab in southeast Alaska in terms of the overall pattern of gpm over the size range of crab and found that the pattern of gpm for both males and females was characterized by a higher rate of growth to an intermediate size (90-100 mm CW) followed by a decrease in growth rate from that size thereafter. Similarly-shaped growth curves were found by Somerton (1981a) and Donaldson et al. (1981), as well.

Molt increment data was collected for Tanner crab in the EBS during 2015, 2016, and 2017 in cooperative research between NMFS and the Bering Sea Research Foundation (R. Foy, NMFS, pers. comm.). Previous analysis of the data suggests it is not substantially different from that obtained near Kodiak Island (Stockhausen, 2017). This data is incorporated in the assessment model to inform inferred growth trajectories in all of the alternative models evaluated in this assessment.

c. Weight at Size

Weight-at-size relationships used in this assessment were revised in 2014 based on a comprehensive re-evaluation of data from the NMFS EBS Bottom Trawl Survey (Daly et al., 2014). Weight-at-size is described by a power-law model of the form $w = a \cdot z^b$, where *w* is weight in kg and *z* is size in mm CW (Daly et al., 2016; table below). Parameter values are presented in the following table:

sex	maturity	a	b
males		0.000270	3.022134
females	immature (non-ovigerous)	0.000562	2.816928
	mature (ovigerous)	0.000441	2.898686

d. Maturity and Reproduction

It is now generally accepted that both Tanner crab males (Tamone et al. 2007) and females (Donaldson and Adams 1989) undergo a terminal molt to maturity, as in most majid crabs. Maturity in females can be determined visually rather unambiguously from the relative size of the abdomen. Females usually undergo their terminal molt from their last juvenile, or pubescent, instar while being grasped by a male (Donaldson and Adams 1989). Subsequent mating takes place annually in a hard shell state (Hilsinger 1976) and after extruding the female’s clutch of eggs. While mating involving old-shell adult females has been documented (Donaldson and Hicks 1977), fertile egg clutches can be produced in the absence of males by using sperm stored in the spermathacae (Adams and Paul 1983, Paul and Paul 1992). Two or more consecutive egg fertilization events can follow a single copulation using stored sperm to self-fertilize the new clutch (Paul 1982, Adams and Paul 1983), although egg viability decreases with time and age of the stored sperm (Paul 1984).

Maturity in males can be classified either physiologically or morphometrically, but is not as easily determined as with females. Physiological maturity refers to the presence or absence of spermataphores in the gonads whereas morphometric maturity refers to the presence or absence of a large claw (Brown and Powell 1972). During the molt to morphometric maturity, there is a disproportionate increase in the size of the chelae in relation to the carapace (Somerton 1981a). The ratio of chela height (CH) to carapace width (CW) has been used to classify male Tanner crab as to morphometric maturity. While many earlier studies on Tanner crabs assumed that morphometrically mature male crabs continued to molt and grow, there is now substantial evidence supporting a terminal molt for males (Otto 1998, Tamone et al. 2007). A consequence of the terminal molt in male Tanner crab is that a substantial portion of the population may never achieve legal size (NPFMC 2007). In this assessment, for the first time, several model scenarios are considered in which size-specific annual proportions of immature to mature male crab in the NMFS EBS bottom trawl survey, based on classification using CH:CW ratios, are fit to inform size-specific probabilities of terminal molt.

Although observations are lacking in the EBS, seasonal differences have been observed between mating periods for pubescent and multiparous females in the Gulf of Alaska and Prince William Sound. There, pubescent molting and mating takes place over a protracted period from winter through early summer, whereas multiparous mating occurs over a relatively short period during mid April to early June (Hilsinger 1976, Munk et al. 1996, and Stevens 2000). In the EBS, egg condition for multiparous Tanner crabs assessed between April and July 1976 also suggested that hatching and extrusion of new clutches for this maturity state began in April and ended sometime in mid-June (Somerton 1981a).

e. Fecundity

A variety of factors affect female fecundity, including somatic size, maturity status (primiparous vs. multiparous), age post terminal molt, and egg loss (NMFS 2004). Of these factors, somatic size is the most important, with estimates of 89 to 424 thousand eggs for females 75 to 124 mm CW, respectively

(Haynes et al. 1976). Maturity status is another important factor affecting fecundity, with primiparous females being only ~70% as fecund as equal size multiparous females (Somerton and Meyers 1983). The number of years post maturity molt, and whether or not, a female has had to use stored sperm from that first mating can also affect egg counts (Paul 1984, Paul and Paul 1992). Additionally, older senescent females often carry small clutches or no eggs (i.e., are barren) suggesting that female crab reproductive output is a concave function of age (NMFS 2004).

f. Size at Maturity

Rugolo and Turnock (2012b) estimated size at 50% mature for females (all shell classes combined) from data collected in the NMFS bottom trawl survey at 68.8 mm CW, and 74.6 mm CW for new shell females. For males, Rugolo and Turnock (2012a) estimated classification lines using mixture-of-two-regressions analysis to define morphometric maturity for the unit Tanner crab stock, and for the sub-stock components east and west of 166ºW, based on chela height and carapace width data collected during the 2008 NMFS bottom trawl survey. These rules were then applied to historical survey data from 1990-2007 to apportion male crab as immature or mature based on size (Rugolo and Turnock, 2012b). Rugolo and Turnock (2012a) found no significant differences between the classification lines of the sub-stock components (i.e., east and west of 166ºW), or between the sub-stock components and that of the unit stock classification line. Size at 50% mature for males (all shell condition classes combined) was estimated at 91.9 mm CW, and at 104.4 mm CW for new shell males. By comparison, Zheng and Kruse (1999) used knife-edge maturity at >79 mm CW for females and >112 mm CW for males in development of the current SOA harvest strategy.

g. Mortality

Due to the lack of age information for crab, Somerton (1981a) estimated mortality separately for individual EBS cohorts of immature and adult Tanner crab. Somerton postulated that age five crab (mean CW = 95 mm) were the first cohort to be fully recruited to the NMFS trawl survey sampling gear and estimated an instantaneous natural mortality rate of 0.35 for this size class using catch curve analysis. Using this analysis with two different data sets, Somerton estimated natural mortality rates of adult male crab from the fished stock to range from 0.20 to 0.28. When using CPUE data from the Japanese fishery, estimates of M ranged from 0.13 to 0.18. Somerton concluded that estimates of M from 0.22 to 0.28 obtained from models that used both the survey and fishery data were the most representative.

Rugolo and Turnock (2011a) examined empirical evidence for reliable estimates of oldest observed age for male Tanner crab. Unlike its congener the snow crab, information on longevity of the Tanner crab is lacking. They reasoned that longevity in a virgin population of Tanner crab would be analogous to that of the snow crab, where longevity would be at least 20 years, given the close analogues in population dynamic and life-history characteristics (Turnock and Rugolo 2011a). Employing 20 years as a proxy for longevity and assuming that this age represented the upper 98.5th percentile of the distribution of ages in an unexploited population, M was estimated to be 0.23 based on Hoenig's (1983) method. If 20 years was assumed to represent the 95% percentile of the distribution of ages in the unexploited stock, the estimate for M was 0.15. Rugolo and Turnock (2011a) adopted M=0.23 for both male and female Tanner because the value corresponded with the range estimated by Somerton (1981a), as well as the value used in the analysis to estimate new overfishing definitions underlying Amendment 24 to the Crab Fishery Management Plan (NPFMC 2007).

5. Brief summary of management history.

A complete summary of the management history is provided in the ADFG Area Management Report appended to the annual SAFE. Fisheries have historically taken place for Tanner crab throughout their range in Alaska, but currently only the fishery in the EBS is managed under a federal Fishery Management Plan (FMP; NPFMC 2011). The plan defers certain management controls for Tanner crab to the State of Alaska, with federal oversight (Bowers et al. 2008). The State of Alaska manages Tanner crab based on registration areas divided into districts. Under the FMP, the state can adjust districts as needed to avoid overharvest in a particular area, change size limits from other stocks in the registration area, change fishing seasons, or encourage exploration (NPFMC 2011).

The Bering Sea District of Tanner crab Registration Area J (Figure 1) includes all waters of the Bering Sea north of Cape Sarichef at 54° 36'N and east of the U.S.-Russia Maritime Boundary Line of 1991. This district is divided into the Eastern and Western Subdistricts at 173°W. The Eastern Subdistrict is further divided at the Norton Sound Section north of the latitude of Cape Romanzof and east of 168°W and the General Section to the south and west of the Norton Sound Section (Bowers et al. 2008). In this report, I use the terms "east region" and "west region" as shorthand to refer to the regions demarcated by 166ºW.

In March 2011, the Alaska Board of Fisheries (BOF) approved a new minimum size limit harvest strategy for Tanner crab effective for the 2011/12 fishery. Prior to this change, the minimum legal size limit was 5.5" (138 mm CW) throughout the Bering Sea District. The new regulations established different minimum size limits east and west of 166º W. The minimum size limit for the fishery to the east of 166ºW is now 4.8" (122 mm CW) and that to the west is 4.4" (112 mm CW), where the size measurement includes the lateral spines. For economic reasons, fishers may adopt larger minimum sizes for retention of crab in both areas, and the SOA's harvest strategy and total allowable catch (TAC) calculations are based on assumed minimum preferred sizes that are larger than the legal minimums. In 2011, these minimum preferred sizes were set at 5.5" (140 mm CW) in the east and 5" (127 mm CW) in the west, including the lateral spines. In 2015, following a petition by the crab industry, the BOF revised the minimum preferred size for TAC calculations in the area east of 166º W longitude to 5" (127 mm CW), the same as that in the western area. These new "preferred" sizes were used to set the TAC for the 2015/16 fishery season.

In assessments prior to 2016, the term "legal males" was used to refer to male crab ≥ 138 mm CW (not including the lateral spines), although this was not strictly correct as it referred to the industry's "preferred" crab size in the east region, as well as to the minimum size in the east used in the SOA's harvest strategy for TAC setting. In this assessment, I use the term "legal males" to refer to crab 125 mm CW, the minimum "preferred" size used in both eastern and western areas the SOA's harvest strategy, and larger.

Landings of Tanner crab in the Japanese pot and tangle net fisheries were reported in the period 1965-1978, peaking at 19.95 thousand t in 1969. The Russian tangle net fishery was prosecuted during 1965-1971 with peak landings in 1969 at 7.08 thousand t. Both the Japanese and Russian Tanner crab fisheries were displaced by the domestic fishery by the late-1970s (Table 1; Figure 3). Foreign fishing for Tanner crab ended in 1980.

The domestic Tanner crab pot fishery developed rapidly in the mid-1970s (Tables 1 and 2; Figure 3). Domestic US landings were first reported for Tanner crab in 1968 at 0.46 thousand t taken incidentally to the EBS red king crab fishery. Tanner crab was targeted thereafter by the domestic fleet and landings rose sharply in the early 1970s, reaching a high of 30.21 thousand t in 1977/78. Landings fell sharply after the peak in 1977/78 through the early 1980s, and domestic fishing was closed in 1985/86 and 1986/87 due to depressed stock status. In 1987/88, the fishery reopened and landings rose again in the late-1980s to a second peak in 1990/91 at 18.19 thousand t, and then fell sharply through the mid-1990s. The domestic Tanner crab fishery was closed between 1996/97 and 2004/05 as a result of conservation concerns regarding depressed stock status. It re-opened in 2005/06 and averaged 0.77 thousand t retained catch between 2005/06-2009/10 (Tables 1 and 2). For the 2010/11-2012/13 seasons, the State of Alaska closed directed commercial fishing for Tanner crab due to estimated female stock metrics being below thresholds adopted in the state harvest strategy. However, these thresholds were met in fall 2013 and the directed fishery was opened in 2013/14. TAC was set at 1,645,000 lbs (746 t) for the area west of 166º W and at

1,463,000 lbs (664 t) for the area east of 166º W in the State of Alaska's Eastern Subdistrict of Tanner crab Registration Area J. The fisheries opened on October 15 and closed on March 31. On closing, 79.6% (594 t) of the TAC had been taken in the western area while 98.6% (654 t) had been taken in the eastern area. Prior to the closures, the retained catch averaged 770 t per year between 2005/06-2009/10. In 2014, TAC was set at 6,625,000 lbs (3,005 t) for the area west of 166º W and at 8,480,000 lbs (3,846 t) for the area east of 166º W. On closing, 77.5% (2,329 t) of the TAC was taken in the western area while 99.6% (3,829 t) were taken in the eastern area. In 2015, TAC was set at 8,396,000 lbs (3,808 t) in the western area and 11,272,000 lbs (5,113 t) in the eastern area. On closing, essentially 100% of the TAC was taken in each area (3,798 t in the west, 5,111 t in the east). The total retained catch in 2015/16 (8,910 t) was the largest taken in the fishery since 1992/93 (Tables 1, 2; Figure 2). The directed fisheries in both areas were closed in 2016/17 because mature female biomass in the NMFS EBS Bottom Trawl Survey did not exceed the threshold set in the SOA's harvest strategy to allow them to open. Total retained catch was thus 0 in 2016/17. In 2017/18, the SOA allowed a limited directed fishery west of 166ºW longitude but closed the fishery east of 166ºW. Essentially, the entire TAC (1,130 t) was taken in 2017/18.

Bycatch and discard losses of Tanner crab originate from the directed pot fishery, non-directed snow crab and Bristol Bay red king crab pot fisheries, and the groundfish fisheries (Table 3; Figure 3). Within the assessment model, bycatch estimates are converted to discard mortality using assumed handling mortality rates of 32.1% for bycatch in the crab fisheries and 80% for bycatch in the groundfish fisheries. Bycatch was persistently high during the early-1970s; a subsequent peak mode of discard losses occurred in the early-1990s. In the early-1970s, the groundfish fisheries contributed significantly to total bycatch losses (although bycatch in the crab fisheries was undocumented at the time). From 1992/93 (when reliable crab fishery bycatch estimates are first available) to 2004/05, the groundfish fisheries accounted for the largest proportion of discard mortality. Since 2005/06, however, the crab fisheries have accounted for the largest proportion.

D. Data

1. Summary of new information

ADFG provided revised values for retained catch abundance and biomass by shell condition from fish ticket data for 2005/06-2016/17, with new values for 2017/18 (Appendix A). This included a breakout of incidental retained Tanner crab catch in the snow crab and BBRKC fisheries; previously, only total retained catch (assumed taken in the directed fishery) had been provided. In general, incidental retained catch of Tanner crab in the snow crab and BBRKC fisheries has been very small compared with that from the directed fishery. Retained catch size composition data from "dockside" observer sampling in the directed fishery were updated by ADFG for 2013/14-2015/16 and new data for 2017/18 were provided (Appendix A).

Revised estimates of total catch (retained + discards) abundance and biomass in all three crab fisheries, based on "at-sea" crab observer sampling, were provided by sex and shell condition by ADFG for 1990/91-2016/17, with new estimates provided for 2017/18 (Appendix B). ADFG also provided size composition data from "at-sea" crab observer sampling by sex and shell condition for 1990/91-2017/18 (Appendix B). Revised estimates of total effort (potlifts) in the three crab fisheries were also provided for 1990/91-2016/17, with new estimates for 2017/18 (Appendix C).

Tanner crab bycatch data in the groundfish fisheries (abundance, biomass, size compositions) were extracted for 1991/92-2017/18 from the groundfish observer and AKRO databases on AKFIN (Appendix D). Results for 1991/92-2016/17 were slightly different than last year, reflecting small changes in the algorithms used to expand observed bycatch to total bycatch, as well as data editing. Although the bycatch data in the groundfish fisheries available by gear type, all model scenarios examined here fit the data aggregated over gear types (see below).

Swept-area abundance, biomass and size composition data from the 2018 NMFS EBS Bottom Trawl Survey were added to the assessment. Survey results for the assessment were calculated directly from the survey "crab haul" data files and station strata file to incorporate assessment criteria (e.g., excluding crab < 25 mm CW, aggregating crab > 185 mm CW into the upper-most size bin in size compositions) and facilitate comparisons across multiple areas and population categories. More details are provided in Appendices E and F.

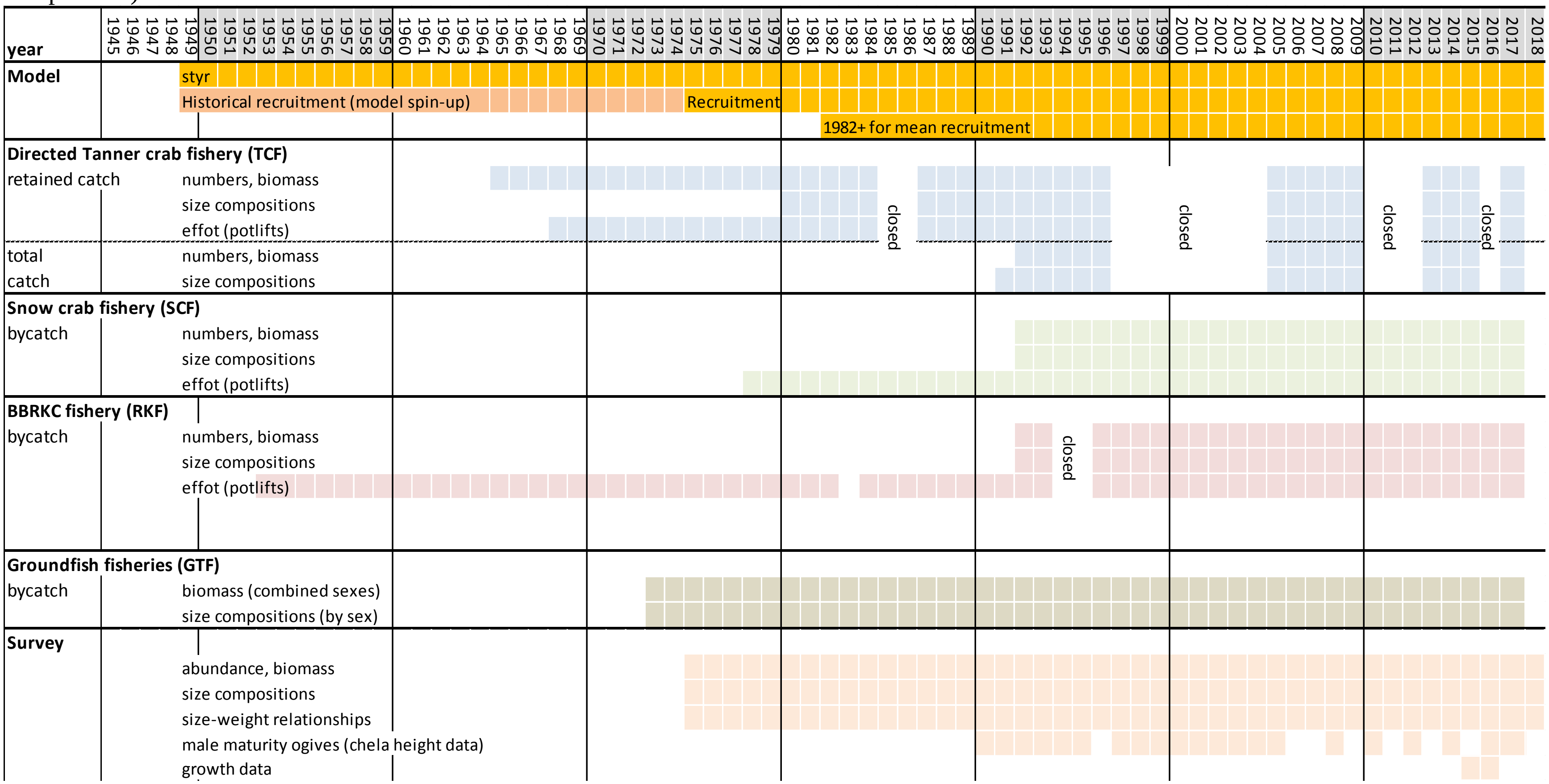
Molt increment data from growth studies conducted in the EBS as cooperative research by NMFS and BSFRF are fit in the model scenarios included in this assessment. These data are described in more detail in Appendix G.

Finally, annual maturity ogives based on classification of male crab in the NMFS EBS bottom trawl survey using CH:CW ratios are fit for the first time in a number of the model scenarios considered in this assessment. These data are described in more detail in Appendix H.

The following table summarizes data sources that have been updated for this assessment:

Data source	Data types	Time frame	Notes	Agency
NMFS EBS Bottom Trawl Survey	area-swept abundance, biomass	1975-2018	recalculated, new	NMFS
	size compositions	1975-2018	recalculated, new	
	molt-increment data	1990+	new	
NMFS/BSFRF	molt-increment data	2014-16	same as 2017	NMFS, BSFRF
Directed fishery	retained catch (numbers, biomass)	2005/06-2017/18	updated, new	ADFG
	retained catch size compositions	2013/14-2017/18	updated	ADFG
	effort	2015/16, 2016/17	updated, new	ADFG
	total catch (abundance, biomass)	1991/92-2017/18	updated, new	ADFG
	total catch size compositions	1991/92-2017/18	updated, new	ADFG
Snow Crab Fishery	effort	1990/91-2017/18	revised, new	ADFG
	total bycatch (abundance, biomass)	1990/91-2017/18	revised, new	ADFG
	total bycatch size compositions	1990/91-2017/18	revised, new	ADFG
Bristol Bay	effort	1990/91-2017/18	revised, new	ADFG
Red King Crab Fishery	total bycatch (abundance, biomass)	1990/91-2017/18	revised, new	ADFG
	total bycatch size compositions	1990/91-2017/18	revised, new	ADFG
Groundfish Fisheries	total bycatch (abundance, biomass)	1991/92-2017/18	revised, new	NMFS/AKFIN
(all gear types)	total bycatch size compositions	1991/92-2017/18	updated, new	

The following table summarizes the data coverage in the assessment model (color shading highlights different model time periods and data components):



2. Data presented as time series

For the data presented in this document, the convention is that 'year' refers to the year in which the NMFS bottom trawl survey was conducted (nominally July 1, yyyy), and fishery data are those subsequent to the survey (July 1, yyyy to June 30, yyyy+1)--e.g., 2015/16 indicates the 2015 bottom trawl survey and the winter 2015/16 fishery.

a. Retained catch

Information on retained catch is also discussed in Appendix A. Retained catch in the directed fisheries for Tanner crab conducted by the foreign fisheries (Japan and Russia) and the domestic fleet, starting in 1965/66, is presented in Table 1 and Figure 2 by fishery year. More detailed information on retained catch in the directed domestic pot fishery is provided in Table 2, which lists total annual catches in numbers of crab and biomass (in lbs), as well as the SOA's Guideline Harvest Level (GHL) or Total Allowable Catch (TAC) , number of vessels participating in the directed fishery, and the fishery season. Information from the Community Development Quota (CDQ) is included in the totals starting in 2005/06.

Directed fisheries for Tanner crab in the EBS began in 1965. Retained catch has followed a "boom-and-bust" cycle over the years, with the fishery experiencing periods of rapidly increasing catches followed by rapidly declining ones, after which it is closed for a time during which the stock partially recovers. Retained catch increased rapidly from 1965 to 1975, reaching ~ 25,000 t in 1970. It declined to ~13,000 t in 1973/74 coinciding with the termination of Russian fishing and the beginning of the domestic pot fishery. It increased again, this time to its highest level, in 1977/78 (~35,000 t) as the domestic fishery developed rapidly, but it subsequently declined again and the fishery was closed in 1985/86 and 1986/87. In the late 1980s and early 1990s, the fishery experienced another, somewhat smaller, "boom" followed by a "bust" and closure of the fishery from 1997/98 to 2004/05. From 2005/06 to 2009/10, the fishery experienced its smallest boom-and-bust cycle, peaking at only ~1,000 t retained catch, and was closed again from 2010/11 to 2012/13. The fishery was re-opened in 2013/14, and retained catch increased each subsequent year until 2016/17 as TACs increased (Figures 2 and 6). The retained catch for 2015/16 (8,910 t) was the largest since 1992/1993 (15,920 t; Table 1). However, ADFG closed the directed fishery in both areas for the 2016/17 fishing season because mature female biomass in the 2016 NMFS EBS bottom trawl survey did not meet the SOA's criteria for opening the fisheries. In 2017/18, ADFG allowed the fishery to commence in the western area (TAC was set at 1,130 t) but was closed in the eastern area. The directed fishery essentially caught the entire TAC.

b. Information on bycatch and discards

Total catch estimates for Tanner crab in the directed Tanner crab, the snow crab, and the BBRKC fisheries are provided in Table 3 and Figure 3 based on ADFG "at-sea" crab observer sampling starting in 1992/93. Annual bycatch in the groundfish fisheries, based on NMFS groundfish observer programs, is also available starting in 1973/74, but sex is undifferentiated. A value of 0.321 is used in the assessment model for "handling mortality" in the crab fisheries to convert observed bycatch to (unobserved) mortality (Stockhausen, 2014). For the groundfish fisheries, a value of 0.8 is used for handling mortality aggregated across gear types to reflect differences in groundfish gear effects and on-deck operations compared with the crab fleets. In previous assessments, estimates of "discards" were provided rather than estimates for "total catch", which allowed mortality associated with the handling process to be estimated outside the assessment model. While this generally remains true for bycatch in the groundfish and non-directed crab fisheries (most or all Tanner crab bycatch is discarded), "discard mortality" cannot be estimated outside the assessment model for males in the directed fishery.

Estimated bycatch mortality in the groundfish fisheries (without distinguishing gear type) was highest (~15,000 t) in the early 1970s, but was substantially reduced by1977 to ~2,000 t with the curtailment of foreign fishing fleets (Stockhausen, 2017). It declined further in the 1980s (to ~500 t) but increased somewhat in the late 1980s to a peak of ~2,000 t in the early 1990s before undergoing a slow but rather steady decline to the present (255 t in 2016/17). Since reliable at-sea ADFG crab observer data has been available (1992), the snow crab fishery has consistently accounted for the highest fraction of bycatch mortality among the crab fisheries, followed by the directed fishery and the BBRKC fishery. Estimated bycatch mortality was highest for all crab fisheries in the early 1990s (~12,000 t total) but subsequently declined as (presumably) the stock declined and the directed fishery was curtailed. Since the directed fishery re-opened in 2013/14, bycatch mortality has averaged 325 t in the directed fishery, 554 t in the snow crab fishery, 32 t in the BBRKC fishery, and 309 t in the groundfish fisheries (Stockhausen, 2017).

In the crab fisheries, the largest component of bycatch occurs on males (Stockhausen, 1991). In the early 1990s, female bycatch ranged between 6 and 40% of the bycatch in the directed and snow crab fisheries. Since the directed fishery re-opened in 2013/14, the fraction of bycatch that is female has ranged between 2% and 6% in the directed fishery, between 0.3 and 3% in the BBRKC fishery, and has been below 1% in the snow crab fishery. Estimates of total groundfish bycatch are not currently available by sex.

c. Catch-at-size for fisheries, bycatch, and discards

Retained (male) catch-at-size in the directed Tanner crab fishery from ADFG crab observer sampling is presented in Appendix A, Figures 7-8, by fishery region (and total) since the fishery re-opened in 2013/14. These appear to indicate a shift to retaining somewhat smaller minimum sizes since 2013/14, compared with 2005/06-2009/10 (Stockhausen, 2017). In fact, the BOF in 2014/15, in response to a petition by industry, changed its harvest strategy for calculating TACs to reflect a smaller minimum industry-preferred size of 125 mm CW east of 166^{o}W longitude.

Size compositions expanded to total catch (retained + discards) from at-sea crab fishery observer sampling in the directed fishery are presented by shell condition and fishery region in Appendix B, Figures 3-4 and 13-14, by sex. The male size compositions suggest that about half the males caught in the directed fishery in 2015/16 were less than the minimum preferred size of 125 mm CW. If old shell males really are males at least one year past their terminal molt (as assumed in the assessment model), the size compositions for these crab suggest that 30-50% of these crab (which will not grow) are less than the preferred size.

Size compositions expanded to total bycatch of Tanner crab in the snow crab fishery, based on at-sea crab fishery observer sampling, are presented by sex and shell condition in Appendix B, Figures 5-8 and 15-18. Because this fishery is prosecuted further north and west, on average, than the directed fishery, its bycatch composition consists of somewhat smaller males than in the directed fishery. Conversely, the expanded bycatch size compositions for the BBRKC fishery tend to be shifted toward somewhat larger males than the directed fisheries because the BBRKC fishery is prosecuted further to the south and east on average than the directed fishery (Appendix B, Figures 9-12 and 19-22). Size compositions expanded to total bycatch based on observer sampling in the groundfish fisheries for 1991/92 to the present are shown in Appendix D, Figures 15-18. Size compositions prior to 1991/92 have not been expanded to total bycatch; thus, the scales are incompatible with those after 1990/91. Male bycatch size compositions in the snow crab fishery clearly reflect some sort of "dome-shaped" selectivity pattern (as assumed in the assessment model), with selectivity small for small and large males and highest for intermediate-sized males. In contrast, the BBRKC fishery appears to catch mostly larger Tanner crab males (consistent with asymptotic selection), while the groundfish fisheries take a wide range of sizes as bycatch.

Raw and input sample sizes (number of individuals measured) for the various fisheries are presented in Tables 4-8.

d. Survey biomass estimates

Time series trends from the NMFS EBS bottom trawl survey suggest the Tanner crab stock in the EBS has undergone decadal-scale fluctuations (Tables 9-10, Appendix E Figures 1-14). Estimated biomass of mature crab in the survey time series started at its maximum (277,000 t) in 1975, decreased rapidly to a low (17,000 t) in 1986, and rebounded quickly to a smaller peak (157,000 t) in 1991 (Appendix E, Figure 5). After 1991, mature survey biomass decreased again, reaching a minimum of 13,100 t in 1998. Recovery following this decline was slow and mature survey biomass did not peak again until 2008 (82,900 t), after which it has fluctuated more rapidly—decreasing within two years by almost 50% and reaching a minimum in 2010 (44,600 t), followed by an increase of almost 50% to reach a peak in 2014 (97,300 t). The most recent trend in mature biomass (2014-2018) has been a declining one (Appendix E, Figure 6). Trends in the male and female components of mature survey biomass and abundance have primarily been in synchrony with one another, as have changes in the eastern and western fishery regions (east and west of 166ºW longitude), although the magnitudes differ (Appendix E, Figures 5-8). Preferred-size male survey biomass and abundance has been declining east of 166ºW (and in the EBS as a whole) since 2014, but was increasing up to 2016 in the west. In the west, it declined in 2017 and remains essentially unchanged in 2018 (Appendix E, Figures 9-12).

e. Survey catch-at-length

Plots of survey size compositions for Tanner crab by sex and fishery region, expanded to total abundance by shell condition for males and maturity state for females, in Appendix E, Figures 13-15. The absence of small (new shell) male crab in the eastern region since 2009 is notable, as is the progression of a possible cohort through both regions starting in 2009. Similar to males, a cohort progression of immature females starting in 2009 is evident in both regions, although it is much clearer in the western region. It can also be tracked into the mature female size comps starting in 2013. A potential new cohort is also evident in the size comps for both sexes in the western region, but not the eastern region, in 2017 and 2018.

Observed sample sizes for the size compositions, aggregated to the EBS regional level used in the assessment, are presented in Table 11. Given the large number of individuals sampled, a sample size of 200 is used to fit survey size compositions in the assessment model to prevent convergence issues associated with using the actual sample sizes.

f. Other time series data.

Spatial patterns of abundance in the 2012-2018 NMFS bottom trawl surveys are mapped in Appendix F for immature males, mature males, immature females, mature females and legal males. There has been some suggestion that an extensive cold pool in the middle region of the EBS shelf may act to diminish relative crab densities in this region, particularly for mature males. The cold pool on the EBS shelf was extensive during the 2017 survey but absent during the 2018 survey, but the distribution of mature males did not change remarkably (Appendix F, Figures 7-8).

Annual effort in the snow crab and BBRKC fisheries is used in the model to “project” bycatch fishing mortality rates backward in time from the period when data on bycatch in these fisheries exists (1992-present). A table of annual effort (number of potlifts) is provided for the snow crab and BBRKC fisheries (Table 12; see Appendix C, as well).

Maturity ogives for male crab, using chela height to carapace width ratios to classify male crab on which chela height measurements have been taken during the NMFS EBS bottom trawl survey, are available for a number of years since 1990 (Appendix G). These data are used in a number of the model scenarios considered for this assessment to inform the size–specific probability of terminal molt by immature male crab.

3. Data which may be aggregated over time:

a. Growth-per-molt

Molt increment data collected for Tanner crab in 2015 and 2016 in the EBS is now fit in the model (see Appendix H), but it is assumed to reflect growth rates over the entire model period.

b. Weight-at size

Weight-at-size relationships used in the assessment model for males, immature females, and mature females is depicted in Figure 4.

c. Size distribution at recruitment

The assumed size distribution for recruits to the population in the assessment model is presented in Figure 5.

4. Information on any data sources that were available, but were excluded from the assessment.

The 1974 NMFS trawl survey was dropped entirely from the standardized survey dataset in 2015 due to inconsistencies in spatial coverage with the standardized dataset. Data collected on Tanner crab abundance and size compositions collected in BSFRF surveys are not yet incorporated in the assessment.

E. Analytic Approach

1. History of modeling approaches for this stock

Prior to the 2012 stock assessment, Tanner crab was managed as a Tier-4 stock using a survey-based assessment approach (Rugolo and Turnock 2011b). The Tier 3 Tanner Crab Stock Assessment Model (TCSAM) was developed by Rugolo and Turnock and presented for review in February 2011 to the Crab Modeling Workshop (Martel and Stram 2011), to the SSC in March 2011, to the CPT in May 2011, and to the CPT and SSC in September 2011. The model was revised after May 2011 and the report to the CPT in September 2011 (Rugolo and Turnock 2011a) described the developments in the model per recommendations of the CPT, SSC and Crab Modeling Workshop through September 2011. In January 2012, the TCSAM was reviewed at a second Crab Modeling Workshop. Model revisions were made during the Workshop based on consensus recommendations. The model resulting from the Workshop was presented to the SSC in January 2012. Recommendations from the January 2012 Workshop and the SSC, as well as the authors' research plans, guided changes to the model. A model incorporating all revisions recommended by the CPT, the SSC and both Crab Modeling Workshops was presented to the SSC in March 2012.

In May 2012 and June 2012, respectively, the TCSAM was presented to the CPT and SSC to determine its suitability for stock assessment and the rebuilding analysis (Rugolo and Turnock 2012b). The CPT agreed that the model could be accepted for management of the stock in the 2011/12 cycle, and that the stock should be promoted to Tier-3 status. The CPT also agreed that the TCSAM could be used as the basis for rebuilding analyses to underlie a rebuilding plan developed in 2012. In June 2012, the SSC reviewed the model and accepted the recommendations of the CPT. The Council subsequently approved the SSC recommendations in June 2012. For 2011/12, the Tanner crab was assessed as a Tier-3 stock and the model was used for the first time to estimate status determination criteria and overfishing levels.

Modifications have been made to the TCSAM computer code to improve code readability, computational speed, model output, and user friendliness without altering its underlying dynamics and overall framework. A detailed description of the 2013 model (TCSAM2013) is presented in Appendix 3 of the 2014 SAFE chapter (Stockhausen, 2014). Following the 2014 assessment, the model code was put under version control using "git" software and is publicly available for download from the GitHub website[2].

A new model "framework", TCSAM02, was reviewed by the CPT and SSC in May/June 2017 and adopted for use in subsequent assessments as a transition to Gmacs. The new framework is a completely-rewritten basis for the Tanner crab model: substantially different model scenarios can be created and run by editing model configuration files rather than modifying the underlying code itself. Most importantly, no time blocks are "hard-wired" into the code—any time blocks are defined in the configuration files. In

[2] https://github.com/wStockhausen/wtsTCSAM2013.git

addition, the new frame work incorporates new data types (e.g., molt increment data, male maturity ogives), new survey data (e.g., the BSFRF surveys), and new fishery data (e.g., bycatch in the groundfish fisheries by gear type). The new model framework also incorporates status determination and OFL calculation directly within a model run, so a follow-on, stand-alone projection model does not need to be run, as with TCSAM2013. This approach has the added benefit of allowing a more complete characterization of model uncertainty in the OFL calculation, because the OFL calculations are now included in Markov Chain Monte Carlo (MCMC) evaluation of a model's posterior probability distribution. The code for the TCSAM02 model framework is publicly available on GitHub[3].

2. Model Description

a. Overall modeling approach

TCSAM02 is a stage/size-based population dynamics model that incorporates sex (male, female), shell condition (new shell, old shell), and maturity (immature, mature) as different categories into which the overall stock is divided on a size-specific basis. For details of the model, the reader is referred to Appendix K.

In brief, crab enter the modeled population as recruits following the size distribution in Figure 22. An equal (50:50) sex ratio is assumed at recruitment, and all recruits begin as immature, new shell crab. Within a model year, new shell, immature recruits are added to the population numbers-at-sex/shell condition/maturity state/size remaining on July 1 from the previous year. These are then projected forward to Feb. 15 ($\delta t = 0.625$ yr) and reduced for the interim effects of natural mortality. Subsequently, the various fisheries that either target Tanner crab or catch them as bycatch are prosecuted as pulse fisheries (i.e., instantaneously). Catch by sex/shell condition/maturity state/size in the directed Tanner crab, snow crab, BBRKC, and groundfish fisheries is calculated based on fishery-specific stage/size-based selectivity curves and fully-selected fishing mortalities and removed from the population. The numbers of surviving immature, new shell crab that will molt to maturity are then calculated based on sex/size-specific probabilities of maturing, and growth (via molt) is calculated for all surviving new shell crab. Crab that were new shell, mature crab become old shell, mature crab (i.e., they don't molt) and old shell crab remain old shell. Population numbers are then adjusted for the effects of maturation, growth, and change in shell condition. Finally, population numbers are reduced for the effects of natural mortality operating from Feb. 15 to July 1 ($\delta t = 0.375$ yr) to calculate the population numbers (prior to recruitment) on July 1.

Model parameters are estimated using a maximum likelihood approach, with Bayesian-like priors on some parameters and penalties for smoothness and regularity on others. Data components in the base model entering the likelihood include fits to mature survey biomass, survey size compositions, retained catch, retained catch size compositions, bycatch mortality in the bycatch fisheries, and bycatch size compositions in the bycatch fisheries.

b. Changes since the previous assessment.

Since the 2017 assessment, two principal changes have been implemented in the TCSAM02 framework. The first is a change in the way so-called "devs" vectors are handled in the code. The second is the introduction of fits to annual maturity ogive data in the model likelihood and parameter optimization.

"Devs" vectors are vectors of model parameters that have the property that the elements of each vector sums to zero (hence "deviations"). Previously, this constraint was met by allowing n-1 elements of an n-element devs vector to be estimated, while the final element was fixed at the negative sum of the preceding elements. However, this presented difficulties when bounds were placed on the values the elements could take on. The new approach is to allow all elements of a devs vector to be freely-estimable,

[3] https://github.com/wStockhausen/wtsTCSAM02.git

but with a component in the likelihood that penalizes non-zero sums across the vector elements. This approach is similar in nature to that taken in ADMB to achieve similar behavior.

Fits to annual male maturity ogives can now be included in the model likelihood (modeled as a size-specific binomial) in order to better estimate size-specific probabilities for immature crab to undergo terminal molt. This obviates, in particular, the need to impose an immature/mature classification on male crab in the NMFS survey whose chela heights have not been measured, as was done previously (e.g., Stockhausen, 2017).

i. Methods used to validate the code used to implement the model

The TCSAM02 model framework was demonstrated to produce results that were exactly equivalent to those from the 2016 assessment model incorporating the changes listed in the previous table. TCSAM02 also underwent a review in July 2017 conducted by the Center for Independent Experts and has been further reviewed by the CPT in May 2017 and September 2017.

3. Model Selection and Evaluation

a. Description of alternative model configurations

The model selected for the 2017 assessment (Model B2b from Stockhausen, 2017) provides the baseline model configuration for subsequent alternative model scenarios evaluated in this assessment. Here, the 2017 assessment model is designated "17AM". The following tables provide a summary of the baseline model configuration, 17AM, for this assessment.

Model 17AM: Description of model population processes and survey characteristics.

process	time blocks	description
Population rates and quantities		
Population built from annual recruitment		
Recruitment	1949-1974	ln-scale mean + annual devs constrained as AR1 process
	1975-2017	ln-scale mean + annual devs
Growth	1949-2016	sex-specific
		mean post-molt size: power function of pre-molt size
		post-molt size: gamma distribution conditioned on pre-molt size
Maturity	1949-2016	sex-specific
		size-specific probability of terminal molt
		logit-scale parameterization
Natural mortalty	1949-1979,	estimated sex/maturity state-specific multipliers on base rate
	1985-2016	priors on multipliers based on uncertainty in max age
	1980-1984	estimated "enhanced mortality" period multipliers
Surveys		
NMFS EBS trawl survey		
male survey q	1975-1981	ln-scale
	1982+	ln-scale w/ prior based on Somerton's underbag experiment
female survey q	1975-1981	ln-scale
	1982+	ln-scale w/ prior based on Somerton's underbag experiment
male selectivity	1975-1981	ascending logistic
	1982+	ascending logistic
female selectivity	1975-1981	ascending logistic
	1982+	ascending logistic

Model 17AM: Description of model fishery characteristics.

Fishery/process	time blocks	description
TCF	directed Tanner crab fishery	
capture rates	pre-1965	male nominal rate
	1965-2016	male ln-scale mean + annual devs
	1949-2016	ln-scale female offset
male selectivity	1949-1990	ascending logistic
	1991-1996	annually-varying ascending logistic
	2005-2016	annually-varying ascending logistic
female selectivity	1949-2016	ascending logistic
male retention	1949-1990, 1991-1996, 2005-2009, 2013-2015	ascending logistic
SCF	bycatch in snow crab fishery	
capture rates	pre-1978	nominal rate on males
	1979-1991	extrapolated from effort
	1992-2016	male ln-scale mean + annual devs
	1949-2016	ln-scale female offset
male selectivity	1949-1996	dome-shaped
	1997-2004	dome-shaped
	2005-2016	dome-shaped
female selectivity	1949-1996	ascending logistic
	1997-2004	ascending logistic
	2005-2016	ascending logistic
RKF	bycatch in BBRKC fishery	
capture rates	pre-1952	nominal rate on males
	1953-1991	extrapolated from effort
	1992-2016	male ln-scale mean + annual devs
	1949-2016	ln-scale female offset
male selectivity	1949-1996	ascending logistic
	1997-2004	ascending logistic
	2005-2016	ascending logistic
female selectivity	1949-1996	ascending logistic
	1997-2004	ascending logistic
	2005-2016	ascending logistic
GTF	bycatch in groundfish fisheries	
capture rates	pre-1973	male ln-scale mean from 1973+
	1973+	male ln-scale mean + annual devs
	1973+	ln-scale female offset
male selectivity	1949-1986	ascending logistic
	1987-1996	ascending logistic
	1997+	ascending logistic
female selectivity	1949-1986	ascending logistic
	1987-1996	ascending logistic
	1997+	ascending logistic

Model 17AM: Description of model likelihood components.

Component	Type	Distribution	Likelihood
TCF: retained catch	abundance	--	--
	biomass	norm2	males only
	size comp.s	multinomial	males only
TCF: total catch	abundance	--	--
	biomass	norm2	by sex
	size comp.s	multinomial	by sex
SCF: total catch	abundance	--	--
	biomass	norm2	by sex
	size comp.s	multinomial	by sex
RKF: total catch	abundance	--	--
	biomass	norm2	by sex
	size comp.s	multinomial	by sex
GTF: total catch	abundance	--	--
	biomass	norm2	by sex
	size comp.s	multinomial	by sex
NMFS survey	abundance	--	--
	biomass	lognormal	by sex, for mature crab only
	size comp.s	multinomial	by sex/maturity
	chela height data	--	--
growth data	EBS only	gamma	by sex

The following alternative model scenarios were evaluated as part of this assessment (previous names applied to these scenarios in the 2017 assessment and May 2018 CPT report are given in parentheses):

model scenario	number of parameters	objective function value	max gradient	description
17AM (B2b)	344	2,905.84	0.0001	2017 assessment model
17AMu	344	3,014.71	0.0007	17AM with updated crab fishery data
18A (B0)	357	3,139.58	0.0010	17AMu with 2017/18 fishery data and 2018 NMFS survey data
18B (B1)	340	3,830.91	0.0000	18A with fits to male maturity ogives. Reduced number of molt-to-maturity parameters (17 fewer)
18C0 (B2)	340	4,310.76	0.0012	Fitting male maturity ogives, survey biomass by sex, size compositions for males by shell condition and by maturity state and shell condition for females
18C0a	340	3,557.00	0.0012	18C0, but reduced weight (/100) on fitting male maturity ogives
18C1 (B4)	340	4,651.98	0.0008	18C0, but also fitting survey abundanceby sex
18C1a	340	3,911.39	0.0015	18C1, but reduced weight (/100) on fitting male maturity ogives
18C2a	334	4,234.40	0.0088	18C1a, but fixing sex-specific survey Q's and selectivity functions for 1982+ based on Somerton and Otto (1999)'s underbag experiment
18C3a	334	4,352.58	0.0193	18C2a, but fixing survey Q's 1982+ based only on Somerton and Otto (1999)'s male catchability from the underbag experiment
18D0 (B3)	340	3,706.10	0.0019	Fits to male maturity ogives, survey biomass by sex, and size compositions for males aggregated over shell condition and by maturity state for females
18D1 (B5)	340	--	--	18D0, but also fitting survey abundance by sex

Scenarios 18A, 18B, 18C0, 18C1, 18D0 and 18D1 correspond to the scenarios B0, B1, B2, B3, B4 and B5 the CPT requested (at the May 2018 CPT meeting) be evaluated for this assessment. Several other scenarios (18C0a, 18C1a) were also run which considered changes to the weighting placed on fitting the male maturity ogive data in the likelihood, as well as scenarios (18C2a, 18C3a) which used fixed values to describe catchability and selectivity for the NMFS survey data after 1981 based on the Somerton and Otto underbag experiment (Somerton and Otto, 1999). These two latter scenarios were included because estimated values for survey catchability in the other scenarios were unrealistically small and led to what appear to be unrealistically high estimates of recruitment, population biomass and MMB, and population productivity for the Tanner crab stock. Using results from the underbag experiment at least provides an empirical basis for fixing the catchability and selectivity values in scenarios C2a and C3a.

The number of estimated parameters, the final value of the objective function for each converged scenario (each based on at least 1,200 jitter runs), and the maximum gradient of the objective function at the converged solution are also listed in the table above (18D1 did not converge). The total objective function values, however, cannot be directly compared between scenarios because each scenario fits different datasets.18C2a is the author's preferred model, as explained below.

The alternative scenarios listed above primarily incorporate the same model structure but differ in the datasets used to perform the parameter optimization. As noted above, however, scenarios 18C2a and 18C3a differ from the remaining scenarios in fixing, rather than estimating, values for NMFS survey catchabilities and selectivities in the 1982-2018 time frame based on Somerton and Otto (1999)'s underbag experiment.

Scenario 17AMu fits the revised crab fishery data provided by ADFG and groundfish fishery data provided by AKFIN through 2016/17 (see Appendices A, B, C) using the same model configuration as 17AM, thus providing a means of evaluating the effects of the changes to the input data on model results. As discussed below, the effects are rather dramatic. 18A builds on 17AMu by including the new data for 2017/18. Additionally, as recommended by the CPT in May 2018, the probability of terminal molt for male crab was fixed at 0 for crab less than 60 mm CW and at 1 for crab > 150 in order to be more biologically realistic. Similarly, the probability of terminal molt for female crab less than 40 mm CW was fixed at 0. 18B builds on 18A and provides a bridging scenario by including fits to the male maturity ogive data from the NMFS EBS bottom trawl survey in the parameter optimization (even though Rugolo and Turnock's empirical maturity ogive is used to classify male abundance as immature/mature prior to input to the model).

Scenario 18C0 represents a distinct break with the previous scenarios because it removes the empirical maturity classification from the male survey data and fits total survey biomass by sex and size compositions by shell condition for males and maturity state and shell condition for females rather than fitting mature biomass by sex and size compositions by sex and maturity state. Scenario 18C0a reduces the weight placed on fits to the male maturity ogives in the model likelihood in 18C0 by a factor of 100. Scenario 18C1 includes fits to male survey abundance by shell condition and female survey abundance by maturity state and shell condition, in addition to similar components of survey biomass. Scenario 18C1a reduces the weight placed on fits to the male maturity ogives in the model likelihood in 18C1 by a factor of 100. Scenario 18C2a differs from 18C1a by fixing the survey catchability parameter values (Q's) and selectivities in the 1982-2018 time block to those estimated by Somerton in the "underbag" experiment for "males + immature females" and mature females, rather than estimating them as in prior scenarios. Scenario 18C3a is similar to 18C2a, but fixes the survey catchabilities in 1982-2018 for all crab to that estimated for "males + immature females" in the underbag experiment. Scenario 18D0 is similar to 18C0, except that the survey biomass and size composition components are aggregated over shell condition before being included in the model likelihood. Scenario 18D1 is similar that of 18D0, except that fits to survey abundance (aggregated across shell condition) are included by sex.

b. Progression of results from the previous assessment to the preferred base model

The following table summarizes basic model results from the 2017 assessment model (17AM) and the 11 scenarios considered here:

Model Scenario	average recruitment	Final MMB	B0	Bmsy	Fmsy	MSY	Fofl	OFL	projected MMB	projected MMB / Bmsy
	millions	1000's t	1000's t	1000's t		1000's t		1000's t	1000's t	
17AM (B2b)	213.96	80.58	83.34	29.17	0.75	12.26	0.75	25.42	43.32	1.49
17AMu	371.11	136.48	111.38	38.98	1.25	18.03	1.25	50.85	63.55	1.63
18A	391.22	114.10	120.00	42.00	1.22	19.24	1.22	42.01	53.87	1.28
18B	464.60	124.18	130.45	45.66	2.61	22.35	2.61	55.40	48.01	1.05
18C0	536.07	122.84	124.39	43.54	3.06	24.32	3.04	56.15	43.25	0.99
18C0a	366.37	99.63	100.92	35.32	1.07	18.13	1.07	35.44	46.25	1.31
18C1	540.64	128.64	129.28	45.25	2.79	25.90	2.78	58.26	45.12	1.00
18C1a	404.67	110.14	109.74	38.41	1.14	20.41	1.14	39.87	49.67	1.29
18C2a	199.49	50.12	63.01	22.05	0.91	11.54	0.91	16.76	24.06	1.09
18C3a	188.34	49.93	63.61	22.26	0.79	10.84	0.79	15.93	25.44	1.14
18D0	503.62	145.40	149.02	52.16	2.64	24.09	2.64	65.30	57.35	1.10

Scenario 18D1 is not included in the above table because, as mentioned above, the model failed to converge for this scenario. The author's preferred model, 18C2a, is highlighted for reference. All new model scenarios were evaluated using at least 1,200 runs with jittered initial parameter values to select the run with the smallest objective function value and smallest maximum gradient. The large number of runs for each scenario were required because randomly-selected growth parameters were frequently inconsistent with positive growth. For each converged scenario, the selected run was re-run to invert the hessian and obtain standard deviations for parameter estimates. All models except 18D1 resulted in hessians that were invertible and provided uncertainty estimates associated with the parameter estimates.

As noted previously, the substantial differences in results between scenarios 17AM and 17AMu in the above table illustrate the rather dramatic impact the revised crab fishery data provided by ADFG has on this assessment. Both scenarios fit the (same) survey biomass data equally well (Figure 6), and both scenarios fit the different input fishery data equally well (Figures 7 and 8, illustrating fits to retained catch biomass and total catch biomass for males in the directed and snow crab fisheries). The changes are substantially driven by large changes (~ *x* 0.5) in estimated survey catchability from 17AM to 17AMu (Figure 9) such that recruitment (Figure 10), mature biomass (Figure 11), and MSY-related quantities are higher using the revised data. Adding the 2017/18 data (scenario 18A) does not affect the previous fits to survey biomass (Figure 12), retained catch and total catch biomass for males in the directed and snow crab fisheries (Figures 13 and 14) or the BBRKC and groundfish fisheries (not shown). Estimated survey catchabilities in the 1982+ time frame are slightly smaller for 18A than 17AMu (Figure 15), but this has little to no effect on estimated trends in recruitment (Figure 16) and mature biomass (Figure 17). The small differences between the two scenarios in MSY-related quantities in the above table are primarily due to a slightly higher estimate of average recruitment from 18A driven by a very large estimate of recruitment (~1 billion crab) in 2018.

c. Evidence of search for balance between realistic (but possibly over-parameterized) and simpler (but not realistic) models.

It was noted at the May 2018 CPT meeting that it was not biologically realistic that male Tanner crab less than 60 mm CW had undergone their terminal molt, although this was suggested by non-zero ratios of the abundance of mature, new shell male crab to all new shell males at sizes less than 60 mm CW based on chela height data collected in the NMFS EBS bottom trawl survey. It was similarly recognized that it was probably biologically unrealistic for female crab less than 40 mm CW to have undergone terminal molt. This actually resulted in simpler, but more realistic models, in scenarios where these constraints were implemented (scenarios 18B and subsequent).

d. Convergence status and convergence criteria

Convergence in all models was assessed by running each model at least 1,200 times with randomly-selected ("jittered") initial parameter values for each run. For each model, a number of these jitter runs failed, primarily because the initial values for the growth parameters resulted in the mean post-molt size being smaller than the pre-molt size. Of those that converged, the run with the smallest objective function value and smallest maximum gradient was selected as the "converged" model, if it was also possible to invert the associated hessian and obtain standard deviation estimates for parameter values. Theoretically, all gradients at a minimum of the objective function would be zero. However, because numerical methods have finite precision, the numerical search for the minimum is terminated after achieving a minimum threshold for the max gradient or exceeding the maximum number of iterations. Typically, 5-10 jittered runs converged to the same minimum value, but sets of runs also converged to larger values—emphasizing the need to jitter to evaluate convergence to the minimum objective function value in the first place.

e. Sample sizes assumed for the compositional data

Input sample sizes used for compositional data are listed in Tables 4-8 for fishery-related size compositions. Input sample sizes for all survey size compositions were set to 200, which was also the maximum allowed for the fishery-related sample sizes. Otherwise, input sample sizes were scaled as described in Stockhausen (2014, Appendix 5):

$$SS_y^{inp} = \min\left(200, \frac{SS_y}{(\overline{SS}/200)}\right)$$

where $\overline{SS}$ was the mean sample size for all males from dockside sampling in the directed fishery.

f. Parameter sensibility

Limits were placed on all estimated parameters in all model scenarios primarily to provide ranges for jittering initial parameter values. Although these limits, for the most part, did not constrain parameter estimates in the converged models, some parameters were found to be at, or very close, to one of the bounds placed on them. These parameters are listed for the alternative scenarios in Tables 13 and 14 (values for all parameters other than annually-varying ln-scale fishery capture rate deviations are listed in Tables 15-23). The CPT and SSC have both expressed concerns regarding parameters estimated at their bounds, as such results frequently violate assumptions regarding model convergence, parameter uncertainty estimates, and suggest that model suitability may be improved by widening the bounds or re-parameterizing the model. The logit-scale parameter describing the retention of male crab at large (asymptotic) sizes prior to 1997 was estimated at its upper bound (15) in all model scenarios. Because retention can only go as high as 1 on the arithmetic scale, and a logit-scale value of 15 corresponds to an arithmetic scale value of 0.9999997, this parameter can be fixed in future models. Many of the scenarios estimated survey catchability parameters at the lower bounds placed on them (Table 13; pQ[1], pQ[3], and pQ[4]) and width of the selectivity function (pS2[2] and pS4[4] in Table 14), indicating that the data provides little information on absolute population size. These results provided the rationale for fixing the survey parameters to those from the Somerton and Otto (1999) underbag experiment.

A number of parameters related to fishery bycatch selectivity in the snow crab and BBRKC fisheries typically hit one of their bounds consistently across scenarios, as well (parameters for the size at 95% selected in the BBRKC fishery in different time blocks and parameters describing the slope of the descending limb of selectivity in the snow crab fishery). A number of other selectivity-related parameters, while not at one of their bounds, have large uncertainties associated with the estimates (e.g., the 95%-selected size for female bycatch in the BBRKC fishery, Table 22). These may reflect indeterminancy between the estimated capture rate for fully-selected crab and these parameters in determining the effective capture rates on large crab.

Finally, it may be worthwhile noting that the beta parameter (pGrBeta[1]) determining the spread of potential molt increments for a given pre-molt size was estimated at its lower bound in all of the scenarios that did not fit survey abundance (17AMu, 18A, 18B, 18C0, 18C0a and 18D0), but in none which did (18C1, 18C2a, 18C3a).

Estimates of parameter uncertainty, approximations calculated by inverting the model hessian and using the "delta" method, were obtained from each converged model's ADMB "std" file (Tables 15-23). Extremely large uncertainties were obtained for parameters related to the NMFS trawl survey selectivity for females after 1981 for all scenarios that estimated these parameters, unless the estimates hit one of the bounds (Table19). Selectivity parameters for female bycatch in the BBRKC fishery in 1997-2004 also exhibited high uncertainty when the estimates were not hitting a bound.

g. Criteria used to evaluate the model or to choose among alternative models

None of the model scenarios evaluated in this assessment were directly comparable using likelihood criteria because different datasets were fit, or different likelihood weights were used, in all scenarios. Consequently, the criteria used to evaluate the alternative models were based primarily on: 1) goodness of fit (assessed using RMSE for different datasets even when the datasets were not included in the likelihood), 2) parameter sensibility, and 3) biological realism.

The author's preferred model, 18C2a, fits all of the datasets reasonably well, incorporates empirical parameters for survey catchability and selectivity to determine absolute scale, and appear to yield more biologically-reasonable estimates of population size and stock productivity than other scenarios.

h. Residual analysis

Residuals for the author's preferred model, Model 18C2a, are discussed below under the Results section.

i. Evaluation of the model(s)

Results from the "18" scenarios (i.e., scenarios 18A, 18B, 18C0, 18C0a, 18C1, 18C1a, 18C2a, 18C3a, and 18D0) are compared amongst each other in Appendix I, which is broken into 9 sections (I1-I9) which organize different categories of results in the following manner:

Appendix	Description
I1	fits to survey and fishery biomass and abundance
I2	mean fits to survey size compositions; effective sample sizes
I3	mean fits to fishery size compositions; effective sample sizes
I4	fits to size compositions by year
I5	fits to growth and male maturity ogive data
I6	population processes (natural mortality rates, etc.)
I7	population quantities (recruitment, population abundance and biomass)
I8	survey characteristics (catchabilities, selectivities)
I9	fishery characteristics (capture rates, selectivities)

The models in all "18" scenarios matched the fishery retained catch and total catch biomass and abundance data time series nearly equally well (Figures I1.19-25; i.e., Appendix I1, Figures 19-25). Differences among the scenarios were more apparent in comparisons with survey abundance and biomass trends (Figures I1.1-18). The scenarios generally fit the data equally well after the early 1990's, with the largest differences occurring prior to that time. Scenarios 18C2a and 18C3a stood out from the others by following the large increase/decrease in abundance/biomass seen from 1987-1993.

All scenarios fit mean female survey size compositions reasonably well and in similar fashion (Appendix I2), but some differences existed for mean male survey size compositions, in particular for immature males (Figure I2.1) and for old shell males (Figure I2.5). 18A, which included fits to immature and mature male size compositions without fits to the male maturity ogives, had the best fit to the immature male size compositions whereas 18C2a and 18C3a tended to underpredict the proportion of immature males around 100 mm CW while the other scenarios overpredicted these proportions. All scenarios predicted mean proportions of new shell crab equally well, but 18C2a and 18C3a appeared to predict those mean proportions for old shell males somewhat more closely than the other scenarios (Figure I2.5). All scenarios predicted mean fishery size compositions equally well (Append I3). Comparison among the scenarios with annual size compositions (Appendix I4) generally reflects the observations regarding the fits to mean size compositions—and the scenarios generally either all do well, or all do poorly, at fitting a given annual size composition. That said, there are some "interesting"-ly poor fits to male survey size compositions by shell type at the start of the time series (late 1970s, early 1980s; see Figures I4.21 and I4.26) which may have to do with inconsistent classification of shell condition in the early years of the survey.

Scenario 18C3a exhibited the highest slope of mean post-molt size regarded as function of pre-molt size among all scenarios for both males and females, while the other scenarios were almost indistinguishable from one another (Figure I5.1). Scenarios 18C2a and 18C3a consistently estimated smaller probabilities of terminal molt for a given post-molt size than the other scenarios (Figures I5.4-8), indicating that male crab that survived were more likely to grow to larger sizes before undergoing terminal molt in scenarios 18C2a and 18C3a than in the others.

Estimated natural mortality rates are shown in Figure I6.1. Mortality rates are assumed equal by sex for immature crab, but are allowed to differ by sex for mature crab. Mortality rates for mature crab were estimated by sex across two time periods: 1949-1979/80+1985/86-2016/17 and 1980/81-1984/85. The latter period has been identified as a period of high natural mortality in the BBRKC stock (Zheng et al., 2012) and was identified as a separate period for Tanner crab in the 2012 assessment. Natural mortality rates for immature crab were similar across all scenarios, while they differed somewhat (more so in the "high" period) from one another for mature crab. 18C3a exhibited the highest rates for mature females across both time blocks while 18C2a estimated the highest rate on mature crab during the "high mortality" period.

The scenarios all exhibited similar temporal trends in recruitment, but differed as to level (Figure I7.1). 18D0 consistently exhibited the largest recruitments, while 18C2a and 18C3a exhibited the smallest. Population abundance and biomass trends among the scenarios were similar to those for recruitment (Figures I7.2-3).

Fully-selected catchability in the NMFS EBS bottom trawl survey is estimated on a sex-specific basis in two time periods: 1975-81 and 1982+. All scenarios that estimated survey catchability in the 1975-81 time period yielded identical results for males, ending at the lower bound of 0.5, as did most of the scenarios for female catchability in this time period (all except 18C2a and 18C3a; Figure I8.1). In the post-1981 time period, estimated survey catchability was lower than that in the earlier time period across all scenarios that estimated catchability (scenarios 18C2a and 18C3a fixed catchabilities in this time period). Male selectivities were similar across all scenarios in the post-1981 time period (and consequently estimated selectivities were similar to those from the underbag experiment), while female selectivity functions differed substantially at smaller sizes (Figure I8.2). When catchabilities and selectivity functions were combined as "capture probabilities" (Figure I8.3), the main factor for the differences between scenarios 18C2a and 18C3a and the other scenarios in characterizing the Tanner crab stock (i.e., recruitment and biomass trends) were apparent: the capture probabilities in the other scenarios were much smaller over all sizes, and with varied with size, than did those from 18C2a and 18C3a.

Given the previous results, it is unsurprising that, while temporal trends in fishery catchability were similar across all scenarios, scenarios 18C2a and 18C3a consistently exhibited the highest values across years for each fishery (Figures I9.1-4). Estimated selectivity functions estimated for the directed and bycatch fisheries were generally similar across scenarios (Figures I9.5-30), except for those for male bycatch in the snow crab fishery prior to 1997. Although these selectivity functions were all dome-shaped, the level at which the plateau occurred was substantially lower than 1 for 18C3a.

The model scenarios examined here are all in good agreement on the *relative* scale of fluctuations in Tanner crab stock abundance and biomass, but they are not in good agreement on the overall absolute scale. The combination of estimated (fully-selected) survey catchability and survey selectivity (i.e., survey capture probabilities), would appear to be the driver behind the absolute scale for the model's predictions of Tanner crab stock biomass under any of these scenarios. However, the estimates of this scale are highly uncertain given that the relevant parameters are frequently estimated either at one of the bounds placed on the parameter or are highly uncertain. Although the situation is not new to this assessment, what little information was formerly available in the data regarding absolute scale seems to have diminished with the revised fishery data from ADFG. Time constraints on the assessment have not allowed anywhere near a full exploration of this issue, but given the past apparent sensitivity of this stock to fishing pressure (given several cycles of a closure following a period of high catches), the rather high exploitation rates (F_{MSY}) and sustainable stock sizes (F_{OFL}) which many of the scenarios suggest for the

Tanner crab stock suggest it is necessary to impose tighter restrictions on survey capture probabilities. Scenarios 18C2a and 18C3a embody a simple, empirically-based approach to do so until further information (e.g., the BSFRF surveys) can be incorporated into the assessment that better defines absolute scale. Scenario 18C2a appears to fit the survey data somewhat better than 18C3a, and thus is the author's preferred model going forward.

4. Results (best model(s))

Model 18C2a was selected as the author's preferred model for the 2018 assessment.

a. List of effective sample sizes, the weighting factors applied when fitting the indices, and the weighting factors applied to any penalties.

Input and effective sample sizes for size composition data fit in the model are listed in Tables 26-31 from the 2017 assessment model and scenario 18C2a. A weighting factor of 20 (corresponding to a standard deviation of 0.158) was applied to all fishery catch biomass likelihood components to achieve close fits to catch biomass time series.

b. Tables of estimates:

i. All parameters

Parameter estimates and associated standard errors, based on inversion of the converged model's Hessian, are listed in Tables 15-23.

ii. Abundance and biomass time series, including spawning biomass and MMB.

Estimates for mature survey biomass, by sex, are listed in Table 32 and for mature biomass at mating, by sex, in Table 33 for the 2017 assessment model and the author's preferred model, 18C2a. Due to the size of the tables, the numbers at size for females and males by year in 5 mm CW size bins for scenario 18C2a are available online as zipped csv files (see Tables 34 and 35, respectively).

iii. Recruitment time series

The estimated recruitment time series from the 2017 assessment and Model 18C2a are listed in Table 36. The time series are compared graphically in Figure J1.

iv. Time series of catch divided by biomass.

A comparison of catch divided by biomass (i.e., exploitation rate) from the 2017 assessment and 18C2a is listed in Table 37.

c. Graphs of estimates

Graphs of estimates from the preferred scenario, 18C2a, are given in Appendix I. Most have been discussed above in the "Model Selection" section.

i. Fishery and survey selectivities, molting probabilities, and other schedules depending on parameter estimates.

Estimated natural mortality rates are shown in Figure I6-1. Mortality rates are assumed equal by sex for immature crab, but are allowed to differ by sex for mature crab. Mortality rates for mature crab were estimated by sex across two time periods: 1949-1979/80+1985/86-2016/17 and 1980/81-1984/85. The latter period has been identified as a period of high natural mortality in the BBRKC stock (Zheng et al., 2012) and was identified as a separate period for Tanner crab in the 2012 assessment. Natural mortality rates for immature crab were estimated at 0.21 yr^{-1} and, excluding the high mortality period, at 0.35 yr^{-1} for mature crab. Estimated sex- and size-specific probabilities of the terminal molt-to-maturity (Figure I1-2) were quite similar to the other models for females, but were somewhat right-shifted for males—with the consequence that the average mature male would be somewhat larger than that predicted in the other scenarios. The mean growth curves estimated in scenario 18C2a were among those implying the fastest growth (Figure I1-3).

iii. Estimated full selection F over time

Estimated time series of fully-selected F (*capture rates*, not mortality) on males in the directed fishery and bycatch in the snow crab, BBRKC and groundfish fisheries are compared among the model scenarios in Figures I9.1-4.

ii. Estimated male, female, mature male, total and effective mature biomass time series

Estimates of population biomass and abundance are shown in Figures I7.2-3. and J.5, J.9, and J.13.

iv. Estimated fishing mortality versus estimated spawning stock biomass

See Section F (Calculation of the OFL; Figure 21).

v. Fit of a stock-recruitment relationship, if feasible.

Not available.

e. Evaluation of the fit to the data:

i. Graphs of the fits to observed and model-predicted catches

See Appendix I1.

ii. Graphs of model fits to survey numbers

See Appendix I1.

iii. Graphs of model fits to catch proportions by size class

See Appendix I4 for model fits to annual catch proportions by size class.

iv. Graphs of model fits to survey proportions by size class

See Appendix I4 for model fits to annual survey proportions by size class.

v. Marginal distributions for the fits to the compositional data.

See Appendices I2 and I3 for marginal distributions of fits to the compositional data.

vi. Plots of implied versus input effective sample sizes and time-series of implied effective sample sizes.

See Appendices I2 and I3 for plots of implied and input sample sizes. For the most part, the implied effective sample sizes tend to be substantially larger than the input values.

vii. Tables of the RMSEs for the indices (and a comparison with the assumed values for the coefficients of variation assumed for the indices).

RMSEs for fits to various datasets are provided in Tables 24 and 25.

viii. Quantile-quantile (q-q) plots and histograms of residuals (to the indices and compositional data) to justify the choices of sampling distributions for the data.

Due to time constraints, quantile-quantile (q-q) plots and histograms of residuals were not completed for the assessment.

f. Retrospective and historic analyses (retrospective analyses involve taking the "best" model and truncating the time-series of data on which the assessment is based; a historic analysis involves plotting the results from previous assessments).

i. Retrospective analysis (retrospective bias in base model or models).

Due to time constraints, retrospective analyses were not completed for the assessment.

ii. Historical analysis (plot of actual estimates from current and previous assessments).

Due to time constraints, an historical analysis was not completed for the assessment.

g. Uncertainty and sensitivity analyses

MCMC runs were completed for scenario 18C0a to explore model uncertainty. The model was run for a single chain, which was set to run 5 million iterations, keeping results for every 1,000th to reduce serial autocorrelation, with a burn-in period of 1,000,000 iterations, yielding 4000 samples. Mixing appeared to be sufficient, but this can be difficult to evaluate with only single chains. This run provides empirical posterior distributions for model parameters and selected derived quantities, including OFL-related quantities.

Time constraints did not allow a full exploration of the MCMC results. Summary results for the objective function and OFL-related quantities (Figure 18) indicates that they are reasonably well-behaved and normally-distributed, and do not exhibit unexpected correlation structures (e.g., F_{OFL} and F_{MSY} are expected to be highly correlated).

F. Calculation of the OFL and ABC

1. Status determination and OFL calculation

EBS Tanner crab was elevated to Tier 3 status following acceptance of the TCSAM by the CPT and SSC in 2012. Based upon results from the model, the stock was subsequently declared rebuilt and not overfished. Consequently, EBS Tanner crab is assessed as a Tier 3 stock for status determination and OFL setting.

The (total catch) OFL for 2017/18 was 25.42 thousand t while the total catch mortality was 2.39 thousand t, based on applying mortality rates of 1.000 for retained catch, 0.321 to bycatch in the crab fisheries, and 0.800 to bycatch in the groundfish fisheries to the model-estimated catch by fleet for 2017/18. Therefore **overfishing did not occur**.

Amendment 24 to the NPFMC fishery management plan (NPFMC 2007) revised the definitions for overfishing for EBS crab stocks. The information provided in this assessment is sufficient to estimate overfishing limits for Tanner crab under Tier 3. The OFL control rule for Tier 3 is (Figure 19):

B, $F_{35\%}^{*}$, $B_{35\%}^{*}$	3	a. $\frac{B}{B_{35\%^*}} > 1$	$F_{OFL} = F_{35\%}\,{*}$	
		b. $\beta < \frac{B}{B_{35\%}\,{*}} \le 1$	$F_{OFL} = F^{*}{}_{35\%} \frac{\frac{B}{B^{*}{}_{35\%}} - \alpha}{1-\alpha}$	ABC≤(1-b_y) * OFL
		c. $\frac{B}{B_{35\%}\,{*}} \le \beta$	Directed fishery $F = 0$ $F_{OFL} \le F_{MSY}^{\dagger}$	

and is based on an estimate of "current" spawning biomass at mating (*B* above, taken as the projected MMB at mating in the assessment year) and spawning biomass per recruit (SBPR)-based proxies for F_{MSY} and B_{MSY}. In the above equations, α=0.1 and β=0.25. For Tanner crab, the proxy for F_{MSY} is $F_{35\%}$, the fishing mortality that reduces the SBPR to 35% of its value for an unfished stock. Thus, if $\phi(F)$ is the SBPR at fishing mortality F, then $F_{35\%}$ is the value of fishing mortality that yields $\phi(F) = 0.35 \cdot \phi(0)$. The Tier 3 proxy for B_{MSY} is $B_{35\%}$, the equilibrium biomass achieved when fishing at $F_{35\%}$, where $B_{35\%}$ is simply 35% of the unfished stock biomass. Given an estimate of average recruitment, $\bar{R}$, then $B_{35\%} = 0.35 \cdot \bar{R} \cdot \phi(0)$.

Thus Tier 3 status determination and OFL setting for 2018/19 require estimates of B = $MMB_{2018/19}$ (the projected MMB at mating time for the coming year), $F_{35\%}$, spawning biomass per recruit in an unfished stock ($\phi(0)$), and $\bar{R}$. Current stock status is determined by the ratio $B/B_{35\%}$ for Tier 3 stocks. If the ratio is greater than 1, then the stock falls into Tier 3a and $F_{OFL} = F_{MSY} = F_{35\%}$. If the ratio is less than one but greater than β, then the stock falls into Tier 3b and F_{OFL} is reduced from $F_{35\%}$ following the descending limb of the control rule (Figure 19). If the ratio is less than β, then the stock falls into Tier 3c and directed fishing must cease. In addition, if B is less than ½ $B_{35\%}$ (the minimum stock size threshold, MSST), the stock must be declared overfished and a rebuilding plan subsequently developed.

In 2015, the SOA's Board of Fish, under petition from the commercial Tanner crab fishing industry, changed the minimum preferred size for crab in the area east of 166ºW longitude in calculations used for setting TACs from 138 mm CW (not including lateral spines) to 125 mm CW. The minimum preferred size in the area west of 166ºW remained the same (125 mm CW). In assessments before 2017, an attempt was made to account for retention of slightly (10 mm CW) smaller crab in the directed fishery in the western area. Because the preferred size is now the same in both areas, the OFL is calculated assuming both selectivity (as previously) and retention (new) curves are the same in both areas.

In assessments before 2017, a separate "projection model" was used to determine OFL based on results from the assessment model. The estimated coefficient of variation for the estimate of final MMB was used to characterize model uncertainty and provided a calculational basis for determining an empirical probability density function (pdf) for OFL based on sampling final MMB from its assumed pdf. Since the transition to TCSAM02 in 2017, the OFL is calculated within the assessment model based on equilibrium calculations for F_{OFL} and projecting the state of the population at the end of the modeled time period one year forward assuming fishing mortality at F_{OFL}. Using MCMC, one can thus estimate the pdf of OFL (and related quantities of interest) incorporating full model uncertainty.

To calculate the F_{OFL}, the fishery capture rate for males in the directed fishery is adjusted until the longterm (equilibrium) MMB-at-mating is 35% of its unfished value. This calculation also depends on the assumed bycatch F's on Tanner crab in the snow crab, BBRKC and groundfish fisheries. As with last year, the average F over the last 5 years for each of the bycatch fisheries is used in these calculations (in previous years, a different approach was used to determine the F to use for the snow crab fishery—see e.g., Stockhausen, 2016).

Selectivity curves in the bycatch fisheries were set using the average curves over the last 5 years for each fishery, the same approach as in previous assessments (Stockhausen 2017).

The determination of B_{MSY}=$B_{35\%}$ for Tanner crab depends on the selection of an appropriate time period over which to calculate average recruitment ($\bar{R}$). Following discussion in 2012 and 2013, the SSC endorsed an averaging period of 1982+. This issue was revisited at the May 2018 CPT meeting with regard to the final year to be included in the calculation, but no definitive were made. Starting the average recruitment period in 1982 is consistent with a 5-6 year recruitment lag from 1976/77, when a well-known climate regime shift occurred in the EBS (Rodionov and Overland, 2005) that may have affected stock productivity. The value of $\bar{R}$ for this period from MCMC runs of the author's preferred model is 198.99 million. The estimates of average recruitment are reasonably similar between the 2017 assessment model (214 million) and the author's preferred model (Table 38). The value of B_{MSY}=$B_{35\%}$ for $\bar{R}$ is 21.87 thousand t, which is smaller than that from the 2017 assessment (29 thousand t).

Once F_{OFL} is determined using the control rule (Figure 19), the (total catch) OFL can be calculated based on projecting the population forward one year assuming that $F = F_{OFL}$. In the absence of uncertainty, the OFL would then be the predicted total catch taken when fishing at $F = F_{OFL}$. When uncertainty (e.g. assessment uncertainty, variability in future recruitment) is taken into account, the OFL is taken as the median total catch when fishing at $F = F_{OFL}$.

The total catch (biomass), including all bycatch of both sexes from all fisheries, was estimated using

$$C = \sum_f \sum_x \sum_z \frac{F_{f,x,z}}{F_{.,x,z}} \cdot (1 - e^{-F_{.,x,z}}) \cdot w_{x,z} \cdot [e^{-M_x \cdot \delta t} \cdot N_{x,z}]$$

where C is total catch (biomass), $F_{f,x,z}$ is the fishing mortality in fishery f on crab in size bin z by sex (x), $F_{.,x,z} = \sum_f F_{f,x,z}$ is the total fishing mortality by sex on crab in size bin z, $w_{x,z}$ is the mean weight of crab in size bin z by sex, M_x is the sex-specific rate of natural mortality, δt is the time from July 1 to the time of the fishery (0.625 yr), and $N_{x,z}$ is the numbers by sex in size bin z on July 1, 2018 as estimated by the assessment model.

Assessment model uncertainty was included in the calculation of OFL using MCMC. Conceptually, a random draw from the assessment model's joint posterior distribution for the estimated parameters was taken, and the $\bar{R}$, B_0, F_{MSY}, B_{MSY}, F_{OFL}, OFL, and "current" MMB for 2018/19 were calculated based on resulting model parameter values. This would be repeated a large number of times to approximate the distribution of OFL given the full model uncertainty. In practice, a single (due to time constraints) chain of 5 million MCMC steps was generated, with the OFL and associated quantities calculated at each step. The chain was initialized from the converged model state using a "burn in" of 1,000,000 steps and subsequently thinned by a factor of 1,000 to reduce serial autocorrelation in the MCMC sampling. This resulted in about 4,000 MCMC samples with which to characterize the distribution of the OFL. **The median value of this distribution was taken as the OFL for 2018/19. Thus, the OFL for 2018/19 from the author's preferred model (Model 18C2a) is 16.46 thousand t** (Figure 20)**.**

The B_{MSY} proxy, $B_{35\%}$, from the author's preferred model is 21.87 thousand t, so MSST = 0.5 B_{MSY} = 10.93 thousand t. Because current projected B = 23.53 thousand t > MSST, **the stock is not overfished**. The population state (directed F vs. MMB) is plotted for each year from 1965/66-2017/18 in Figure 21 against the Tier 3 harvest control rule.

2. ABC calculation

Amendments 38 and 39 to the Fishery Management Plan (NPFMC 2010) established methods for the Council to set Annual Catch Limits (ACLs). The Magnuson-Stevens Act requires that ACLs be established based upon an acceptable biological catch (ABC) control rule that accounts for scientific uncertainty in the OFL such that ACL=ABC and the total allowable catch (TAC) and guideline harvest levels (GHLs) be set below the ABC so as not to exceed the ACL. ABCs must be recommended annually by the Council's SSC.

Two methods for establishing the ABC control rule are: 1) a constant buffer where the ABC is set by applying a multiplier to the OFL to meet a specified buffer below the OFL; and 2) a variable buffer where the ABC is set based on a specified percentile (P*) of the distribution of the OFL that accounts for uncertainty in the OFL. P* is the probability that ABC would exceed the OFL and overfishing occur. In 2010, the NPFMC prescribed that ABCs for BSAI crab stocks be established at P*=0.49 (following Method 2). Thus, annual ACL=ABC levels should be established such that the risk of ovefishing, P[ABC>OFL], is 49%. In 2014, however, the SSC adopted a buffer of 20% on OFL for the Tanner crab stock for calculating ABC. Here, ABCs are provided based on both methods.

For the author's preferred scenario, 18C2a, the P* ABC (ABC_{max}) is 16.44 thousand t while the 20% Buffer ABC is 13.17 thousand t. The author remains concerned that the OFL calculation, based on $F_{35\%}$ as a proxy for F_{MSY}, is overly optimistic regarding the actual productivity of the stock. Fishery-related mortality similar to the P* ABC level has occurred only in the latter half of the 1970s and in 1992/93, coincident with collapses in stock biomass to low levels. This suggests that $F_{35\%}$ may not be a realistic proxy for F_{MSY} and/or that MMB may not be a good proxy for reproductive success, as are currently assumed for this stock. Given this uncertainty concerning the stock, **the author recommends using the 20% buffer previously adopted by the SSC for this stock to calculate ABC. Consequently, the author's recommended ABC is 13.17 thousand t**.

G. Rebuilding Analyses

Tanner crab is not currently under a rebuilding plan. Consequently no rebuilding analyses were conducted.

H. Data Gaps and Research Priorities

Information on growth-per-molt has been collected in the EBS on Tanner crab and incorporated into the assessment. More data regarding temperature-dependent effects on molting frequency would be helpful to assess potential impacts of the EBS cold pool on the stock. Information on temperature-dependent changes in crab movement and survey catchability would also be of value. In addition, it would be extremely worthwhile to develop a "better" index of reproductive potential than MMB that can be calculated in the assessment model and to revisit the issue of MSY proxies for this stock.

The characterization of fisheries in the assessment model needs to be carefully reconsidered. How, and whether or not, the differences in the directed fishery in areas east and west 166ºW longitude should be explicitly represented in the assessment model should be addressed. The question of whether or not bycatch in the groundfish fisheries should be split into pot- and trawl-related components should be revisited. Also, the appropriate weight for male maturity ogives based on NMFS survey data in the model likelihood needs to be explored.

With the implementation of TCSAM02, several research avenues can be explored much more efficiently: 1) time-varying growth; 2) decomposing the currently "lumped" directed fishery into its eastern and western components, and 3) incorporating the BSFRF surveys into the assessment. Development of a fully-Gmacs version of the Tanner crab model will also begin.

I. Ecosystem Considerations

Mature male biomass is currently used as the "currency" of Tanner crab spawning biomass for assessment purposes. However, its relationship to stock-level rates of egg production, perhaps an ideal measure of stock-level reproductive capacity, is unclear. Thus, use of MMB to reflect Tanner crab reproductive potential may be misleading as to stock health. Nor is it likely that mature female biomass has a clear relationship to annual egg production. For Tanner crab, the fraction of barren mature females by shell condition appears to vary on a decadal time scale (Rugolo and Turnock, 2012), suggesting a potential climatic driver.

1. Ecosystem Effects on Stock

Time series trends in prey availability or abundance are generally unknown for Tanner crab because typical survey gear is not quantitative for Tanner crab prey. On the other hand, Pacific cod (*Gadus macrocephalus*) is thought to account for a substantial fraction of annual mortality on Tanner crab (Aydin et al., 2007). Total P. cod biomass is estimated to have been slowly declining from 1990 to 2008, during the time frame of a collapse in the Tanner crab stock, but has been increasing rather rapidly since 2008 (Thompson and Lauth, 2012). This suggests that the rates of "natural mortality" used in the stock assessment for the period post-1980 may be underestimates (and increasingly biased low if the trend in P. cod abundance continues). This trend is definitely one of potential concern.

2. Effects of Tanner crab fishery on ecosystem

Potential effects of the Tanner crab fishery on the ecosystem are considered in the following table:

Effects of Tanner crab fishery on ecosystem			
Indicator	Observation	Interpretation	Evaluation
Fishery contribution to bycatch			
Prohibited species	salmon are unlikely to be trapped inside a pot when it is pulled, although halibut can be	unlikely to have substantial effects at the stock level	minimal to none
Forage (including herring, Atka mackerel, cod and pollock)	Forage fish are unlikely to be trapped inside a pot when it is pulled	unlikely to have substantial effects	minimal to none
HAPC biota	crab pots have a very small footprint on the bottom	unlikely to be having substantial effects post-rationalization	minimal to none
Marine mammals and birds	crab pots are unlikely to attract birds given the depths at which they are fished	unlikely to have substantial effects	minimal to none
Sensitive non-target species	Non-targets are unlikely to be trapped in crab pot gear in substantial numbers	unlikely to have substantial effects	minimal to none
Fishery concentration in space and time	substantially reduced in time following rationalization of the fishery	unlikely to be having substantial effects	probably of little concern
Fishery effects on amount of large size target fish	Fishery selectively removes large males	May impact stock reproductive potential as large males can mate with a wider range of females	possible concern
Fishery contribution to discards and offal production	discarded crab suffer some mortality	May impact female spawning biomass and numbers recruiting to the fishery	possible concern
Fishery effects on age-at-maturity and fecundity	none	unknown	possible concern

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Table captions

Figure captions

Tables

Table 1. Retained catch (males) in directed Tanner crab fisheries.

Eastern Bering Sea *Chionoecetes bairdi* Retained Catch (1,000's t)				
Year	US Pot	Japan	Russia	Total
1965/66	--	1.17	0.75	1.92
1966/67	--	1.69	0.75	2.44
1967/68	--	9.75	3.84	13.60
1968/69	0.46	13.59	3.96	18.00
1969/70	0.46	19.95	7.08	27.49
1970/71	0.08	18.93	6.49	25.49
1971/72	0.05	15.90	4.77	20.71
1972/73	0.10	16.80	--	16.90
1973/74	2.29	10.74	--	13.03
1974/75	3.30	12.06	--	15.24
1975/76	10.12	7.54	--	17.65
1976/77	23.36	6.66	--	30.02
1977/78	30.21	5.32	--	35.52
1978/79	19.28	1.81	--	21.09
1979/80	16.60	2.40	--	19.01
1980/81	13.47	--	--	13.43
1981/82	4.99	--	--	4.99
1982/83	2.39	--	--	2.39
1983/84	0.55	--	--	0.55
1984/85	1.43	--	--	1.43
1985/86	0.00	--	--	0.00
1986/87	0.00	--	--	0.00
1987/88	1.00	--	--	1.00
1988/89	3.15	--	--	3.18
1989/90	11.11	--	--	11.11
2016	18.19	--	--	18.19
2017	112.06	--	--	14.42
1992/93	15.92	--	--	15.92
1993/94	7.67	--	--	7.67
1994/95	3.54	--	--	3.54
1995/96	1.92	--	--	1.92
1996/97	0.82	--	--	0.82
1997/98	0.00	--	--	0.00
1998/99	0.00	--	--	0.00
1999/00	0.00	--	--	0.00
2000/01	0.00	--	--	0.00
2001/02	0.00	--	--	0.00
2002/03	0.00	--	--	0.00
2003/04	0.00	--	--	0.00
2004/05	0.00	--	--	0.00
2005/06	0.43	--	--	0.43
2006/07	0.96	--	--	0.96
2007/08	0.96	--	--	0.96
2008/09	0.88	--	--	0.88
2009/10	0.60	--	--	0.60
2010/11	0.00	--	--	0.00
2011/12	0.00	--	--	0.00
2012/13	0.00	--	--	0.00
2013/14	1.26	--	--	1.26
2014/15	6.22	--	--	6.22
2015/16	8.91	--	--	8.91
2016/17	0.00	--	--	0.00
2017/18	1.13	--	--	1.13

Table 2. Retained catch (males) in the US domestic pot fishery. Information from the Community Development Quota (CDQ) fisheries is included in the table for fishery years 2005/06 to the present. Number of crabs caught and harvest includes deadloss. The "Fishery Year" YYYY/YY+1 runs from July 1, YYYY to June 30, YYYY+1. The ADFG year (in parentheses, if different from the "Fishery Year") indicates the year ADFG assigned to the fishery season in compiled reports.

year (ADFG year)	Total Crab (no.)	Total Harvest (lbs)	GHL/TAC (millions lbs)	Vessels (no.)	Season
1968/69 (1969)	353,300	1,008,900			
1969/70 (1970)	482,300	1,014,700			
1970/71 (1971)	61,300	166,100			
1971/72 (1972)	42,061	107,761			
1972/73 (1973)	93,595	231,668			
1973/74 (1974)	2,531,825	5,044,197			
1974/75	2,773,770	7,028,378		28	
1975/76	8,956,036	22,358,107		66	
1976/77	20,251,508	51,455,221		83	
1977/78	26,350,688	66,648,954		120	
1978/79	16,726,518	42,547,174		144	
1979/80	14,685,611	36,614,315	28-36	152	11/01-05/11
1980/81 (1981)	11,845,958	29,630,492	28-36	165	01/15-04/15
1981/82 (1982)	4,830,980	11,008,779	12-16	125	02/15-06/15
1982/83 (1983)	2,286,756	5,273,881	5.6	108	02/15-06/15
1983/84 (1984)	516,877	1,208,223	7.1	41	02/15-06/15
1984/85 (1985)	1,272,501	3,036,935	3	44	01/15-06/15
1985/86 (1986)	---closed---				
1986/87 (1987)	---closed---				
1987/88 (1988)	957,318	2,294,997	5.6	98	01/15-04/20
1988/89 (1989)	2,894,480	6,982,865	13.5	109	01/15-05/07
1989/90 (1990)	9,800,763	22,417,047	29.5	179	01/15-04/24
2015/16	16,608,625	40,081,555	42.8	255	11/20-03/25
2016	12,924,102	31,794,382	32.8	285	11/15-03/31
2017	112	35,130,831	39.2	294	11/15-03/31
1993/94	7,235,898	16,892,320	9.1	296	11/01-11/10, 11/20-01/01
1994/95 (1994)	3,351,639	7,766,886	7.5	183	11/01-11/21
1995/96 (1995)	1,877,303	4,233,061	5.5	196	11/01-11/16
1996/97 (1996)	734,296	1,806,077	6.2	196	11/01-11/05, 11/15-11/27
1997/98-2004/05	---closed---				
2005/06	443,978	952,887	1.7	49	10/15-03/31
2006/07	927,086	2,122,589	3.0	64	10/15-03/31
2007/08	927,164	2,106,655	5.7	50	10/15-03/31
2008/09	830,363	1,939,571	4.3	53	10/15-03/31
2009/10	485,676	1,327,952	1.3	45	10/15-03/31
2010/11	---closed---				
2011/12	---closed---				
2012/13	---closed---				
2013/14	1,426,670	2,751,124	3.108	32	10/15-03/31
2014/15	7,442,931	13,576,105	15.105	100	10/15-03/31
2015/16	10,856,418	19,642,462	19.668	112	10/15-03/31
2016/17	---closed---				
2017/18	1,340,394	2,497,033	2.500	34	10/15-03/31

Table 3. Total catch (1000’s t) of Tanner crab in various fisheries, as estimated from observer data.

fishery	Directed Fishery				Snow Crab		BBRKC		Groundfish	Total
	West of 166W		East of 166W						fisheries	Catch
year	males	females	males	females	males	females	males	females		1000's t
1972/73	--	--	--	--	--	--	--	--	17.74	--
1973/74	--	--	--	--	--	--	--	--	24.45	--
1974/75	--	--	--	--	--	--	--	--	9.41	--
1975/76	--	--	--	--	--	--	--	--	4.70	--
1977/78	--	--	--	--	--	--	--	--	2.78	--
1977/78	--	--	--	--	--	--	--	--	1.87	--
1978/79	--	--	--	--	--	--	--	--	3.40	--
1979/80	--	--	--	--	--	--	--	--	2.11	--
1980/81	--	--	--	--	--	--	--	--	1.47	--
1981/82	--	--	--	--	--	--	--	--	0.45	--
1982/83	--	--	--	--	--	--	--	--	0.67	--
1983/84	--	--	--	--	--	--	--	--	0.64	--
1984/85	--	--	--	--	--	--	--	--	0.40	--
1985/86	--	--	--	--	--	--	--	--	0.65	--
1986/87	--	--	--	--	--	--	--	--	0.64	--
1987/88	--	--	--	--	--	--	--	--	0.46	--
1988/89	--	--	--	--	--	--	--	--	0.67	--
1989/90	--	--	--	--	--	--	--	--	0.94	--
1990/91	--	--	--	--	--	--	--	--	2.54	--
1992/93	7.35	0.60	29.66	1.10	2.49	0.16	1.32	0.02	2.76	45.46
1993/94	1.64	0.14	10.21	0.86	2.87	0.40	3.13	0.15	1.76	21.16
1994/95	0.36	0.11	6.96	0.73	1.35	0.19	0.00	0.00	2.10	11.79
1995/96	0.65	0.14	4.42	0.92	1.02	0.12	0.00	0.00	1.52	8.80
1996/97	0.07	0.00	0.23	0.06	1.96	0.12	0.27	0.00	1.59	4.30
1997/98	0.00	0.00	0.00	0.00	1.96	0.09	0.16	0.00	1.18	3.40
1998/99	0.00	0.00	0.00	0.00	0.66	0.08	0.12	0.00	0.94	1.79
1999/00	0.00	0.00	0.00	0.00	0.13	0.01	0.08	0.00	0.63	0.85
2000/01	0.00	0.00	0.00	0.00	0.31	0.01	0.07	0.00	0.74	1.13
2001/02	0.00	0.00	0.00	0.00	0.55	0.02	0.04	0.00	1.19	1.79
2002/03	0.00	0.00	0.00	0.00	0.17	0.01	0.06	0.00	0.72	0.96
2003/04	0.00	0.00	0.00	0.00	0.06	0.01	0.05	0.00	0.42	0.55
2004/05	0.00	0.00	0.00	0.00	0.13	0.04	0.05	0.00	0.68	0.90
2005/06	0.68	0.02	0.00	0.00	1.16	0.02	0.04	0.00	0.62	2.55
2006/07	0.58	0.07	1.13	0.05	1.53	0.09	0.03	0.00	0.72	4.19
2007/08	0.68	0.01	1.78	0.03	1.86	0.05	0.06	0.00	0.69	5.17
2008/09	0.12	0.00	1.18	0.01	1.10	0.02	0.28	0.00	0.53	3.25
2009/10	0.00	0.00	0.66	0.00	1.56	0.02	0.19	0.00	0.37	2.80
2010/11	0.00	0.00	0.00	0.00	1.45	0.01	0.03	0.00	0.23	1.73
2011/12	0.00	0.00	0.00	0.00	2.14	0.01	0.02	0.00	0.20	2.38
2012/13	0.00	0.00	0.00	0.00	1.56	0.01	0.04	0.00	0.15	1.77
2013/14	0.93	0.01	0.75	0.01	1.84	0.02	0.13	0.00	0.35	4.04
2014/15	3.06	0.03	5.31	0.01	5.33	0.05	0.31	0.00	0.44	14.53
2015/16	5.47	0.03	6.76	0.03	3.92	0.02	0.20	0.01	0.36	16.79
2016/17	0.00	0.00	0.00	0.00	2.58	0.02	0.18	0.00	0.31	3.08
2017/18	2.11	0.06	0.00	0.00	1.11	0.01	0.18	0.00	0.14	3.62

Table 4. Sample sizes for retained catch-at-size in the directed fishery. N = number of individuals. N` = scaled sample size used in assessment. The directed fishery was closed in 2016/17.

year	new + old shell	
	N	N'
1980/81	13,310	97.8
1981/82	11,311	83.1
1982/83	13,519	99.3
1983/84	1,675	12.3
1984/85	2,542	18.7
1988/89	12,380	91.0
1989/90	4,123	30.3
1990/91	120,676	200.0
1991/92	126,299	200.0
1992/93	125,193	200.0
1993/94	71,622	200.0
1994/95	27,658	200.0
1995/96	1,525	11.2
1996/97	4,430	32.6
2005/06	705	5.2
2006/07	2,940	21.6
2007/08	6,935	51.0
2008/09	3,490	25.6
2009/10	2,417	17.8
2013/14	4,760	35.0
2014/15	14,055	103.3
2015/16	24,420	200.0
2016/17	--	--
2017/18	3,470	25.5

Table 5. Sample sizes for total catch-at-size in the directed fishery from crab observer sampling. N = number of individuals. N` = scaled sample size used in assessment.

	N		N'	
year	males	females	males	females
1991/92	31,252	5,605	200.0	40.2
1992/93	54,836	8,755	200.0	62.8
1993/94	40,388	10,471	200.0	75.1
1994/95	5,792	2,132	42.6	15.3
1995/96	5,589	3,119	41.1	22.4
1996/97	352	168	2.6	1.2
2005/06	19,715	1,107	144.9	7.9
2006/07	24,226	4,432	178.0	31.8
2007/08	61,546	3,318	200.0	23.8
2008/09	29,166	646	200.0	4.6
2009/10	17,289	147	127.0	1.1
2013/14	17,291	710	127.0	5.2
2014/15	85,116	1,191	200.0	8.8
2015/16	119,843	1,622	200.0	11.9
2016/17	--	--	--	--
2017/18	18,785	1,721	138.0	12.6

Table 6. Sample sizes for total bycatch-at-size in the snow crab fishery, from crab observer sampling. N = number of individuals. N` = scaled sample size used in assessment.

year	N		N'	
	males	females	males	females
1992/93	6,280	859	46.4	6.3
1993/94	6,969	1,542	51.5	11.4
1994/95	2,982	1,523	22.0	11.2
1995/96	1,898	428	14.0	3.2
1996/97	3,265	662	24.1	4.9
1997/98	3,970	657	29.3	4.9
1998/99	1,911	324	14.1	2.4
1999/00	976	82	7.2	0.6
2000/01	1,237	74	9.1	0.5
2001/02	3,113	160	23.0	1.2
2002/03	982	118	7.2	0.9
2003/04	688	152	5.1	1.1
2004/05	848	707	6.3	5.2
2005/06	9,792	368	72.3	2.7
2006/07	10,391	1,256	76.7	9.3
2007/08	13,797	728	101.9	5.4
2008/09	8,455	722	62.4	5.3
2009/10	11,057	474	81.6	3.5
2010/11	12,073	250	89.1	1.8
2011/12	9,453	189	69.8	1.4
2012/13	7,336	190	54.2	1.4
2013/14	12,932	356	95.5	2.6
2014/15	24,877	804	183.7	5.9
2015/16	19,838	230	146.5	1.7
2016/17	19,346	262	142.8	1.7
2017/18	5,598	109	41.1	0.8

Table 7. Sample sizes for total bycatch-at-size in the BBRKC fishery, from crab observer sampling. N = number of individuals. N` = scaled sample size used in assessment.

year	N		N'	
	males	females	males	females
1992/93	2,056	105	15.1	0.8
1993/94	7,359	1,196	54.1	8.8
1996/97	114	5	0.8	0.0
1997/98	1,030	41	7.6	0.3
1998/99	457	20	3.4	0.1
1999/00	207	14	1.5	0.1
2000/01	845	44	6.2	0.3
2001/02	456	39	3.4	0.3
2002/03	750	50	5.5	0.4
2003/04	555	46	4.1	0.3
2004/05	487	44	3.6	0.3
2005/06	983	70	7.3	0.5
2006/07	798	76	5.9	0.6
2007/08	1,399	91	10.3	0.7
2008/09	3,797	121	28.0	0.9
2009/10	3,395	72	25.1	0.5
2010/11	595	30	4.4	0.2
2011/12	344	4	2.5	0.0
2012/13	618	48	4.6	0.4
2013/14	2,110	60	15.6	0.4
2014/15	3,110	32	23.0	0.2
2015/16	2,176	182	16.1	1.3
2016/17	3,048	245	22.5	1.8
2017/18	3,782	86	27.8	0.6

Table 8. Sample sizes for total catch-at-size in the groundfish fisheries, from groundfish observer sampling. N = number of individuals. N` = scaled sample size used in the assessment.

year	N		N'	
	males	females	males	females
1973/74	3,155	2,277	23.3	16.8
1974/75	2,492	1,600	18.4	11.8
1975/76	1,251	839	9.2	6.2
1976/77	6,950	6,683	51.3	49.3
1977/78	10,685	8,386	78.9	61.9
1978/79	18,596	13,665	137.3	100.9
1979/80	19,060	11,349	140.7	83.8
1980/81	12,806	5,917	94.5	43.7
1981/82	6,098	4,065	45.0	30.0
1982/83	13,439	8,006	99.2	59.1
1983/84	18,363	8,305	135.6	61.3
1984/85	27,403	13,771	200.0	101.7
1985/86	23,128	12,728	170.7	94.0
1986/87	14,860	7,626	109.7	56.3
1987/88	23,508	15,857	173.6	117.1
1988/89	10,586	7,126	78.2	52.6
1989/90	59,943	41,234	200.0	200.0
1990/91	23,545	11,212	173.8	82.8
1991/92	6,817	3,479	50.1	25.6
1992/93	3,128	1,175	23.0	8.6
1993/94	1,217	358	8.9	2.6
1994/95	3,628	1,820	26.7	13.4
1995/96	3,904	2,669	28.7	19.6
1996/97	8,306	3,400	61.0	25.0
1997/98	9,949	3,900	73.1	28.7
1998/99	12,105	4,440	89.0	32.6
1999/00	11,053	4,522	81.2	33.2
2000/01	12,895	3,087	94.8	22.7
2001/02	15,788	3,083	116.0	22.7
2002/03	15,401	3,249	113.2	23.9
2003/04	9,572	2,733	70.3	20.1
2004/05	13,844	4,460	101.7	32.8
2005/06	17,785	3,709	130.7	27.3
2006/07	15,903	3,047	116.9	22.4
2007/08	16,148	3,819	118.7	28.1
2008/09	26,171	4,235	192.3	31.1
2009/10	19,075	2,704	140.2	19.9
2010/11	15,131	2,275	111.2	16.7
2011/12	16,119	4,244	118.4	31.2
2012/13	12,987	3,083	95.4	22.7
2013/14	28,782	6,064	200.0	44.6
2014/15	39,119	4,212	200.0	31.0
2015/16	27,428	5,735	200.0	42.1
2016/17	18,313	4,299	134.6	31.6
2017/18	12,276	1,143	90.2	8.4

Table 9. Trends in Tanner crab biomass (1000’s t) in the NMFS EBS summer bottom trawl survey.

Survey	Females (1000's t)			Males (1000's t)		
Year	East of 166W	West of 166W	EBS total	East of 166W	West of 166W	EBS total
1975	27,594	13,374	40,968	214,202	80,689	294,891
1976	25,420	12,140	37,560	101,958	55,092	157,050
1977	31,435	21,613	53,048	87,463	51,038	138,501
1978	18,406	14,167	32,574	72,913	25,394	98,308
1979	3,448	19,701	23,149	17,978	32,058	50,036
1980	12,883	64,420	77,303	48,979	103,505	152,484
1981	8,577	35,525	44,102	23,390	56,540	79,930
1982	8,107	57,757	65,864	16,602	49,255	65,856
1983	5,350	17,418	22,769	13,337	24,708	38,045
1984	4,800	12,358	17,158	12,020	18,490	30,510
1985	3,160	3,393	6,554	8,231	6,676	14,907
1986	3,504	2,570	6,074	9,625	11,986	21,612
1987	15,009	5,137	20,146	28,863	16,648	45,511
1988	22,885	12,668	35,553	58,130	41,093	99,223
1989	18,975	12,254	31,230	87,718	45,106	132,824
1990	25,022	22,532	47,554	76,879	55,539	132,418
1991	31,341	20,445	51,787	89,825	55,986	145,811
1992	11,358	16,857	28,215	89,918	37,674	127,592
1993	5,325	7,382	12,707	53,394	19,877	73,271
1994	5,332	5,716	11,048	32,303	16,032	48,335
1995	5,982	7,474	13,456	19,672	15,310	34,982
1996	6,548	4,470	11,019	19,979	10,790	30,770
1997	2,914	1,893	4,806	9,088	5,561	14,649
1998	1,752	2,489	4,241	8,404	6,604	15,008
1999	3,360	3,347	6,708	14,835	6,719	21,554
2000	3,613	2,999	6,613	16,429	6,903	23,332
2001	3,931	6,989	10,920	16,231	13,089	29,320
2002	3,469	6,499	9,968	14,402	13,010	27,411
2003	2,795	10,297	13,092	17,164	20,661	37,825
2004	1,131	7,731	8,862	12,455	26,468	38,923
2005	4,493	17,469	21,962	17,443	46,313	63,756
2006	6,476	21,723	28,198	28,636	72,907	101,543
2007	6,612	12,465	19,076	27,938	76,285	104,223
2008	5,079	9,444	14,523	37,177	47,736	84,913
2009	4,553	6,495	11,048	14,786	32,653	47,439
2010	2,910	6,366	9,276	14,426	34,601	49,027
2011	6,615	9,190	15,805	23,390	39,321	62,712
2012	14,245	9,787	24,032	45,367	34,764	80,131
2013	13,398	10,866	24,264	64,580	38,839	103,420
2014	8,648	8,728	17,377	58,196	50,739	108,936
2015	5,304	7,574	12,878	35,093	39,158	74,251
2016	1,479	7,133	8,612	25,520	43,315	68,835
2017	2,144	6,274	8,418	23,952	29,685	53,637
2018	1,588	8,213	9,801	13,769	32,734	46,503

Table 10. Trends in biomass for preferred-size (> 125 mm CW) male Tanner crab in the NMFS EBS summer bottom trawl survey (in 1000's t).

survey	East 166W			West 166W			EBS
year	new shell	old shell	total	new shell	old shell	total	total
1975	152,683	6,522	159,205	56,181	2,509	58,691	217,896
1976	57,034	9,674	66,709	38,107	1,534	39,640	106,349
1977	50,855	7,543	58,399	26,511	6,808	33,319	91,717
1978	40,633	9,780	50,413	3,221	6,626	9,847	60,259
1979	9,767	3,426	13,192	4,115	3,745	7,860	21,052
1980	23,184	10,857	34,041	11,210	1,677	12,887	46,927
1981	3,445	11,286	14,731	5,884	2,167	8,050	22,781
1982	3,009	4,851	7,860	5,763	5,859	11,622	19,481
1983	5,151	2,082	7,233	2,416	3,240	5,655	12,889
1984	4,348	3,077	7,424	571	3,159	3,730	11,154
1985	4,055	1,046	5,101	588	870	1,458	6,559
1986	734	2,546	3,280	142	674	816	4,096
1987	4,911	3,473	8,385	3,505	658	4,163	12,548
1988	15,698	2,715	18,413	9,690	929	10,618	29,031
1989	37,364	3,740	41,104	13,758	2,741	16,499	57,603
1990	35,903	7,084	42,987	21,082	3,274	24,356	67,343
1991	32,973	14,476	47,449	13,386	8,430	21,816	69,265
1992	41,423	16,242	57,665	9,851	6,461	16,311	73,977
1993	22,942	11,990	34,932	3,716	2,596	6,312	41,244
1994	10,000	13,912	23,912	1,248	4,143	5,391	29,303
1995	1,241	13,516	14,757	370	5,392	5,761	20,518
1996	330	13,912	14,242	100	3,580	3,680	17,922
1997	316	4,245	4,561	163	958	1,121	5,681
1998	1,001	2,604	3,605	441	644	1,085	4,689
1999	1,645	1,838	3,483	256	356	612	4,095
2000	4,484	3,045	7,529	250	377	627	8,156
2001	4,473	3,600	8,073	418	1,361	1,780	9,853
2002	944	7,102	8,046	384	838	1,222	9,268
2003	1,558	6,433	7,991	434	2,227	2,661	10,652
2004	1,597	4,916	6,513	980	1,825	2,805	9,318
2005	2,368	5,822	8,190	8,776	5,062	13,839	22,029
2006	2,134	6,794	8,927	3,755	15,328	19,083	28,011
2007	4,143	5,314	9,457	8,523	7,757	16,281	25,737
2008	15,476	3,288	18,764	8,688	4,457	13,145	31,909
2009	2,644	5,139	7,783	6,657	4,156	10,812	18,595
2010	3,006	4,576	7,582	9,593	4,867	14,460	22,042
2011	1,513	6,987	8,500	9,023	6,637	15,660	24,160
2012	3,352	5,026	8,378	2,368	3,997	6,365	14,743
2013	10,871	3,527	14,397	5,383	2,837	8,220	22,618
2014	14,899	9,310	24,210	7,163	4,604	11,766	35,976
2015	9,084	10,217	19,301	8,380	5,925	14,306	33,607
2016	2,640	8,055	10,695	5,799	12,527	18,326	29,021
2017	1,629	10,841	12,470	894	11,659	12,553	25,024
2018	102	7,253	7,355	996	11,875	12,871	20,225

Table 11. Sample sizes for NMFS survey size composition data. In the assessment model, an input sample size of 200 is used for all survey-related compositional data.

		female								male							
		immature				mature				immature				mature			
		new shell		old shell		new shell		old shell		new shell		old shell		new shell		old shell	
year	Hauls	non-0 hauls	crab	non-0 hauls	crab	non-0 hauls	crab	non-0 hauls	crab	non-0 hauls	crab	non-0 hauls	crab	non-0 hauls	crab	non-0 hauls	crab
1975	136	73	1,040	6	7	91	1,861	39	706	127	2,895	0	0	127	3,993	80	399
1976	214	87	1,095	2	2	91	1,304	39	311	130	2,023	0	0	130	2,469	47	242
1977	155	66	765	9	11	76	1,183	60	738	114	1,778	0	0	114	1,971	79	485
1978	230	87	1,932	8	17	82	638	65	1,307	147	2,957	0	0	147	1,570	104	700
1979	307	71	725	8	8	62	735	42	341	138	1,805	0	0	138	808	68	306
1980	320	101	1,476	10	15	95	1,471	49	570	164	4,602	0	0	164	2,359	71	569
1981	305	71	579	0	0	79	1,319	94	1,206	158	3,809	0	0	158	2,293	116	886
1982	342	85	814	9	9	72	457	103	2,384	181	1,751	0	0	181	1,371	147	2,082
1983	353	102	2,108	4	5	56	201	102	2,154	166	2,484	0	0	166	983	132	1,181
1984	355	135	1,867	9	12	53	284	94	1,531	171	1,965	0	0	171	490	126	1,399
1985	353	140	846	1	1	52	228	65	601	179	1,060	0	0	179	381	86	459
1986	353	162	1,581	4	7	64	191	68	331	213	2,141	0	0	213	528	115	468
1987	355	189	4,230	0	0	105	445	73	392	226	4,659	0	0	226	1,306	103	498
1988	370	206	3,733	2	2	149	1,753	100	530	252	5,627	0	0	252	2,210	101	475
1989	373	204	3,264	4	7	144	1,241	108	882	237	4,977	0	0	237	3,201	135	1,067
1990	370	197	3,105	3	9	155	1,502	126	1,511	247	5,107	0	0	247	3,149	151	1,342
1991	371	159	2,227	9	32	138	1,283	141	2,568	227	4,361	0	0	227	2,692	181	2,893
1992	355	107	1,494	0	0	119	820	123	2,205	215	2,958	0	0	215	2,047	177	1,924
1993	374	99	865	4	4	96	545	122	1,337	207	2,051	0	0	207	1,677	180	1,865
1994	374	97	909	3	12	52	148	104	1,293	175	1,281	0	0	175	724	174	1,827
1995	375	113	830	4	4	35	140	107	1,057	153	958	0	0	153	220	137	1,611
1996	374	114	869	4	14	57	109	98	963	148	1,069	0	0	148	222	134	1,414
1997	375	116	1,325	2	4	62	168	83	504	161	1,336	0	0	161	289	125	582
1998	374	146	1,704	4	6	53	160	73	344	176	2,032	0	0	176	396	128	624
1999	372	137	2,608	6	20	52	255	85	510	170	2,816	0	0	170	550	124	567
2000	371	142	2,249	0	0	61	242	55	345	188	2,836	0	0	188	628	133	653
2001	374	164	3,675	3	3	83	364	72	644	211	4,036	0	0	211	629	145	817
2002	374	154	3,583	2	2	81	350	70	500	186	3,912	0	0	186	458	154	1,089
2003	375	153	2,830	3	4	111	923	83	752	203	4,754	0	0	203	900	153	1,349
2004	374	173	3,563	10	359	90	427	80	656	236	4,568	0	0	236	1,027	179	1,873
2005	372	201	3,349	2	3	103	634	74	928	254	4,496	0	0	254	1,280	185	1,753
2006	375	210	4,355	4	9	143	1,332	125	1,327	254	6,224	0	0	254	1,757	211	4,054
2007	375	185	2,420	6	10	138	1,311	136	1,396	261	4,697	0	0	261	1,982	201	2,907
2008	374	153	1,747	0	0	104	580	120	1,783	240	3,127	0	0	240	2,116	196	2,146
2009	375	171	2,408	0	0	75	363	115	1,317	216	2,879	0	0	216	1,144	187	1,954
2010	375	186	3,171	5	9	67	245	104	941	223	3,654	0	0	223	1,268	166	1,702
2011	375	193	5,044	0	0	90	471	102	705	210	6,095	0	0	210	1,115	167	1,941
2012	375	195	3,577	6	34	100	942	97	720	215	5,526	0	0	215	1,564	139	1,296
2013	375	163	2,900	9	17	116	1,417	101	1,002	207	5,592	0	0	207	2,675	137	1,344
2014	375	165	2,207	3	4	98	482	121	1,584	222	4,746	0	0	222	3,286	167	2,829
2015	375	118	1,455	0	0	60	445	94	1,363	225	2,737	0	0	225	1,859	200	2,817
2016	375	110	1,372	1	1	56	370	82	1,248	222	2,235	0	0	222	1,170	218	3,668
2017	375	129	2,027	1	1	50	213	99	1,125	185	2,233	0	0	185	423	204	3,529

Table 12. Effort data (1000's potlifts) in the snow crab and BBRKC fisheries.

	Effort (1000's Potlifts)			Effort (1000's Potlifts)	
Year	BBRKC Fishery	Snow Crab Fishery	Year	BBRKC Fishery	Snow Crab Fishery
1951/52	--	--	1986/87	175.753	616.113
1952/53	--	--	1987/88	220.971	747.395
1953/54	30.083	--	1988/89	146.179	665.242
1954/55	17.122	--	1989/90	205.528	912.718
1955/56	28.045	--	1990/91	262.761	1382.908
1956/57	41.629	--	1991/92	227.555	1278.502
1957/58	23.659	--	1992/93	206.815	969.209
1958/59	27.932	--	1993/94	254.389	716.524
1959/60	22.187	--	1994/95	0.697	507.603
1960/61	26.347	--	1995/96	0.547	520.685
1961/62	72.646	--	1996/97	77.081	754.14
1962/63	123.643	--	1997/98	91.085	930.794
1963/64	181.799	--	1998/99	145.689	945.533
1964/65	180.809	--	1999/00	151.212	182.634
1965/66	127.973	--	2000/01	104.056	191.2
1966/67	129.306	--	2001/02	66.947	326.977
1967/68	135.283	--	2002/03	72.514	153.862
1968/69	184.666	--	2003/04	134.515	123.709
1969/70	175.374	--	2004/05	97.621	75.095
1970/71	168.059	--	2005/06	116.32	117.375
1971/72	126.305	--	2006/07	72.404	86.288
1972/73	208.469	--	2007/08	113.948	140.857
1973/74	194.095	--	2008/09	139.937	163.537
1974/75	212.915	--	2009/10	118.521	136.477
1975/76	205.096	--	2010/11	131.627	147.244
1976/77	321.01	--	2011/12	45.166	270.602
1977/78	451.273	--	2012/13	38.159	225.489
1978/79	406.165	190.746	2013/14	45.927	225.245
1979/80	315.226	255.102	2014/15	57.725	279.183
1980/81	567.292	435.742	2015/16	48.665	199.133
1981/82	536.646	469.091	2016/17	33.126	118.548
1982/83	140.492	287.127	2017/18	48.242	118.034
1983/84	0	173.591			
1984/85	107.406	370.082			
1985/86	84.443	542.346			

Table 13.Non-selectivity parameters from all model scenarios that were estimated within 1% of bounds.

category	name	case	test	bound	description
fisheries	pLgtRet[1]	17AM	at upper bound	15	TCF: logit-scale max retention (pre-1997)
		17AMu	at upper bound	15	TCF: logit-scale max retention (pre-1997)
		18A	at upper bound	15	TCF: logit-scale max retention (pre-1997)
		18B	at upper bound	15	TCF: logit-scale max retention (pre-1997)
		18C0	at upper bound	15	TCF: logit-scale max retention (pre-1997)
		18C0a	at upper bound	15	TCF: logit-scale max retention (pre-1997)
		18C1	at upper bound	15	TCF: logit-scale max retention (pre-1997)
		18C1a	at upper bound	15	TCF: logit-scale max retention (pre-1997)
		18C2a	at upper bound	15	TCF: logit-scale max retention (pre-1997)
		18C3a	at upper bound	15	TCF: logit-scale max retention (pre-1997)
		18D0	at upper bound	15	TCF: logit-scale max retention (pre-1997)
population processes	pGrBeta[1]	17AMu	at lower bound	0.5	both sexes
		18A	at lower bound	0.5	both sexes
		18B	at lower bound	0.5	both sexes
		18C0	at lower bound	0.5	both sexes
		18C0a	at lower bound	0.5	both sexes
		18D0	at lower bound	0.5	both sexes
	pLgtPrM2M[1]	17AM	at upper bound	15	males (entire model period)
		17AMu	at upper bound	15	males (entire model period)
		18A	at upper bound	15	males (entire model period)
	pLgtPrM2M[2]	17AM	at lower bound	-15	females (entire model period)
		17AMu	at lower bound	-15	females (entire model period)
		18A	at lower bound	-15	females (entire model period)
surveys	pQ[1]	17AM	at lower bound	0.5	NMFS trawl survey: males, 1975-1981
		17AMu	at lower bound	0.5	NMFS trawl survey: males, 1975-1981
		18A	at lower bound	0.5	NMFS trawl survey: males, 1975-1981
		18B	at lower bound	0.5	NMFS trawl survey: males, 1975-1981
		18C0	at lower bound	0.5	NMFS trawl survey: males, 1975-1981
		18C0a	at lower bound	0.5	NMFS trawl survey: males, 1975-1981
		18C1	at lower bound	0.5	NMFS trawl survey: males, 1975-1981
		18C1a	at lower bound	0.5	NMFS trawl survey: males, 1975-1981
		18C2a	at lower bound	0.5	NMFS trawl survey: males, 1975-1981
		18C3a	at lower bound	0.5	NMFS trawl survey: males, 1975-1981
		18D0	at lower bound	0.5	NMFS trawl survey: males, 1975-1981
	pQ[3]	17AM	at lower bound	0.5	NMFS trawl survey: females, 1975-1981
		17AMu	at lower bound	0.5	NMFS trawl survey: females, 1975-1981
		18A	at lower bound	0.5	NMFS trawl survey: females, 1975-1981
		18B	at lower bound	0.5	NMFS trawl survey: females, 1975-1981
		18C0	at lower bound	0.5	NMFS trawl survey: females, 1975-1981
		18C0a	at lower bound	0.5	NMFS trawl survey: females, 1975-1981
		18C1	at lower bound	0.5	NMFS trawl survey: females, 1975-1981
		18C1a	at lower bound	0.5	NMFS trawl survey: females, 1975-1981
		18D0	at lower bound	0.5	NMFS trawl survey: females, 1975-1981
	pQ[4]	18B	at lower bound	0.2	NMFS trawl survey: females, 1982+
		18C0	at lower bound	0.2	NMFS trawl survey: females, 1982+
		18C1	at lower bound	0.2	NMFS trawl survey: females, 1982+
		18D0	at lower bound	0.2	NMFS trawl survey: females, 1982+

Table 14.Selectivity-related parameters from all model scenarios estimated within 1% of bounds.

pS1[1]	17AMu	at upper bound	90	z50 for NMFS survey selectivity (males, pre-1982)
	18A	at upper bound	90	z50 for NMFS survey selectivity (males, pre-1982)
	18B	at upper bound	90	z50 for NMFS survey selectivity (males, pre-1982)
	18C0	at upper bound	90	z50 for NMFS survey selectivity (males, pre-1982)
	18C0a	at upper bound	90	z50 for NMFS survey selectivity (males, pre-1982)
	18C1	at upper bound	90	z50 for NMFS survey selectivity (males, pre-1982)
	18C1a	at upper bound	90	z50 for NMFS survey selectivity (males, pre-1982)
	18D0	at upper bound	90	z50 for NMFS survey selectivity (males, pre-1982)
pS1[20]	17AM	at lower bound	40	z50 for GF.AllGear selectivity (males, 1987-1996)
	17AMu	at lower bound	40	z50 for GF.AllGear selectivity (males, 1987-1996)
	18A	at lower bound	40	z50 for GF.AllGear selectivity (males, 1987-1996)
	18B	at lower bound	40	z50 for GF.AllGear selectivity (males, 1987-1996)
	18C0	at lower bound	40	z50 for GF.AllGear selectivity (males, 1987-1996)
	18C0a	at lower bound	40	z50 for GF.AllGear selectivity (males, 1987-1996)
	18D0	at lower bound	40	z50 for GF.AllGear selectivity (males, 1987-1996)
pS1[23]	17AM	at upper bound	180	z95 for RKF selectivity (males, 1997-2004)
	17AMu	at upper bound	180	z95 for RKF selectivity (males, 1997-2004)
	18A	at upper bound	180	z95 for RKF selectivity (males, 1997-2004)
	18B	at upper bound	180	z95 for RKF selectivity (males, 1997-2004)
	18C0	at upper bound	180	z95 for RKF selectivity (males, 1997-2004)
	18C0a	at upper bound	180	z95 for RKF selectivity (males, 1997-2004)
	18C1	at upper bound	180	z95 for RKF selectivity (males, 1997-2004)
	18C1a	at upper bound	180	z95 for RKF selectivity (males, 1997-2004)
	18C2a	at upper bound	180	z95 for RKF selectivity (males, 1997-2004)
	18C3a	at upper bound	180	z95 for RKF selectivity (males, 1997-2004)
	18D0	at upper bound	180	z95 for RKF selectivity (males, 1997-2004)
pS1[24]	17AM	at upper bound	180	z95 for RKF selectivity (males, 2005+)
	17AMu	at upper bound	180	z95 for RKF selectivity (males, 2005+)
	18A	at upper bound	180	z95 for RKF selectivity (males, 2005+)
	18B	at upper bound	180	z95 for RKF selectivity (males, 2005+)
	18C0	at upper bound	180	z95 for RKF selectivity (males, 2005+)
	18C0a	at upper bound	180	z95 for RKF selectivity (males, 2005+)
	18C1	at upper bound	180	z95 for RKF selectivity (males, 2005+)
	18C1a	at upper bound	180	z95 for RKF selectivity (males, 2005+)
	18C2a	at upper bound	180	z95 for RKF selectivity (males, 2005+)
	18C3a	at upper bound	180	z95 for RKF selectivity (males, 2005+)
	18D0	at upper bound	180	z95 for RKF selectivity (males, 2005+)
pS1[25]	18C3a	at upper bound	140	z95 for RKF selectivity (females, pre-1997)
pS1[27]	17AM	at upper bound	140	z95 for RKF selectivity (females, 2005+)
	17AMu	at upper bound	140	z95 for RKF selectivity (females, 2005+)
	18A	at upper bound	140	z95 for RKF selectivity (females, 2005+)
	18B	at upper bound	140	z95 for RKF selectivity (females, 2005+)
	18C0	at upper bound	140	z95 for RKF selectivity (females, 2005+)
	18C0a	at upper bound	140	z95 for RKF selectivity (females, 2005+)
	18C1	at upper bound	140	z95 for RKF selectivity (females, 2005+)
	18C1a	at upper bound	140	z95 for RKF selectivity (females, 2005+)
	18C2a	at upper bound	140	z95 for RKF selectivity (females, 2005+)
	18D0	at upper bound	140	z95 for RKF selectivity (females, 2005+)
pS1[4]	17AMu	at lower bound	-50	z50 for NMFS survey selectivity (females, 1982+)

Table 14 (cont.).Selectivity-related parameters from all model scenarios estimated within 1% of bounds.

name	case	test	bound	label
pS2[10]	18C2a	at lower bound	0.1	ascending slope for SCF selectivity (males, pre-1997)
	18C3a	at lower bound	0.1	ascending slope for SCF selectivity (males, pre-1997)
pS2[2]	17AMu	at upper bound	100	z95-z50 for NMFS survey selectivity (males, 1982+)
	18A	at upper bound	100	z95-z50 for NMFS survey selectivity (males, 1982+)
	18B	at upper bound	100	z95-z50 for NMFS survey selectivity (males, 1982+)
	18C0	at upper bound	100	z95-z50 for NMFS survey selectivity (males, 1982+)
	18C1	at upper bound	100	z95-z50 for NMFS survey selectivity (males, 1982+)
	18D0	at upper bound	100	z95-z50 for NMFS survey selectivity (males, 1982+)
pS2[4]	17AM	at upper bound	100	z95-z50 for NMFS survey selectivity (females, 1982+)
	17AMu	at upper bound	100	z95-z50 for NMFS survey selectivity (females, 1982+)
	18B	at upper bound	100	z95-z50 for NMFS survey selectivity (females, 1982+)
	18C0	at upper bound	100	z95-z50 for NMFS survey selectivity (females, 1982+)
	18C0a	at upper bound	100	z95-z50 for NMFS survey selectivity (females, 1982+)
	18C1	at upper bound	100	z95-z50 for NMFS survey selectivity (females, 1982+)
	18C1a	at upper bound	100	z95-z50 for NMFS survey selectivity (females, 1982+)
	18D0	at upper bound	100	z95-z50 for NMFS survey selectivity (females, 1982+)
pS3[1]	18C2a	at lower bound	2	ln(dz50-az50) for SCF selectivity (males, pre-1997)
	18C3a	at lower bound	2	ln(dz50-az50) for SCF selectivity (males, pre-1997)
pS4[1]	17AM	at upper bound	0.5	descending slope for SCF selectivity (males, pre-1997)
	18C0a	at lower bound	0.1	descending slope for SCF selectivity (males, pre-1997)
	18C1a	at lower bound	0.1	descending slope for SCF selectivity (males, pre-1997)
	18C2a	at lower bound	0.1	descending slope for SCF selectivity (males, pre-1997)
	18C3a	at lower bound	0.1	descending slope for SCF selectivity (males, pre-1997)
pS4[2]	17AMu	at lower bound	0.1	descending slope for SCF selectivity (males, 1997-2004)
	18A	at lower bound	0.1	descending slope for SCF selectivity (males, 1997-2004)
	18B	at lower bound	0.1	descending slope for SCF selectivity (males, 1997-2004)
	18C0	at lower bound	0.1	descending slope for SCF selectivity (males, 1997-2004)
	18C0a	at lower bound	0.1	descending slope for SCF selectivity (males, 1997-2004)
	18C1	at lower bound	0.1	descending slope for SCF selectivity (males, 1997-2004)
	18C1a	at lower bound	0.1	descending slope for SCF selectivity (males, 1997-2004)
	18C2a	at lower bound	0.1	descending slope for SCF selectivity (males, 1997-2004)
	18C3a	at lower bound	0.1	descending slope for SCF selectivity (males, 1997-2004)
	18D0	at lower bound	0.1	descending slope for SCF selectivity (males, 1997-2004)

Table 15. Comparison of estimated growth, natural mortality, and non-vector recruitment parameters for all model scenarios.

			17AM		17AMu		18A		18B		18C0		18C0a	
process	name	label	estimate	std. error	estimate	std. error	estimate	std. error	estimate	std. error	estimate	std. error	estimate	std. error
growth	pGrA[1]	males	33.14	0.00	33.67	0.24	33.50	0.24	34.77	0.30	34.75	0.30	33.63	0.24
	pGrA[2]	females	34.42	0.00	33.94	0.31	34.00	0.31	34.18	0.34	34.34	0.35	33.95	0.33
	pGrB[1]	males	166.79	0.00	157.55	0.49	157.75	0.50	155.62	0.36	155.61	0.36	157.17	0.50
	pGrB[2]	females	115.14	0.00	114.81	0.74	114.64	0.73	114.73	0.74	115.72	0.73	115.88	0.75
	pGrBeta[1]	both sexes	0.82	0.00	0.50	0.00	0.50	0.00	0.50	0.00	0.50	0.00	0.50	0.00
natural mortality	pDM1[1]	multiplier for immature crab	1.00	0.00	0.98	0.04	0.96	0.04	0.91	0.05	0.92	0.05	0.97	0.05
	pDM1[2]	multiplier for mature males	1.15	0.00	1.29	0.04	1.28	0.04	1.38	0.04	1.61	0.03	1.46	0.04
	pDM1[3]	multiplier for mature females	1.37	0.00	1.32	0.03	1.32	0.03	1.41	0.03	1.53	0.03	1.48	0.04
	pDM2[1]	1980-1984 multiplier for mature males	2.60	0.00	2.49	0.23	2.48	0.23	2.49	0.21	2.54	0.15	2.74	0.17
	pDM2[2]	1980-1984 multiplier for mature females	1.32	0.00	1.33	0.11	1.30	0.11	1.34	0.10	1.59	0.09	1.62	0.10
	pM[1]	base ln-scale M	-1.47	0.00	-1.47	0.00	-1.47	0.00	-1.47	0.00	-1.47	0.00	-1.47	0.00
recruitment	pLnR[1]	historical recruitment period	5.62	0.00	6.29	0.37	6.33	0.36	6.52	0.37	6.47	0.38	6.11	0.37
	pLnR[2]	current recruitment period	5.12	0.00	5.68	0.07	5.72	0.07	5.90	0.07	6.08	0.07	5.70	0.08
	pRa[1]	fixed value	2.44	0.00	2.44	0.00	2.44	0.00	2.44	0.00	2.44	0.00	2.44	0.00
	pRb[1]	fixed value	1.39	0.00	1.39	0.00	1.39	0.00	1.39	0.00	1.39	0.00	1.39	0.00
	pRCV[1]	full model period	-0.69	0.00	-0.69	0.00	-0.69	0.00	-0.69	0.00	-0.69	0.00	-0.69	0.00
	pRX[1]	full model period	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

			18C1		18C1a		18C2a		18C3a		18D0	
process	name	label	estimate	std. error	estimate	std. error	estimate	std. error	estimate	std. error	estimate	std. error
growth	pGrA[1]	males	35.71	0.31	34.22	0.36	34.91	0.36	34.61	0.37	34.86	0.29
	pGrA[2]	females	34.86	0.37	34.25	0.39	34.53	0.37	33.35	0.31	34.11	0.35
	pGrB[1]	males	155.83	0.38	158.19	0.72	0.95	0.01	0.95	0.01	155.34	0.37
	pGrB[2]	females	115.80	0.76	116.18	0.77	0.89	0.01	0.92	0.01	114.87	0.75
	pGrBeta[1]	both sexes	0.57	0.05	0.51	0.06	0.61	0.06	0.52	0.05	0.50	0.00
natural mortality	pDM1[1]	multiplier for immature crab	0.90	0.05	0.98	0.05	0.91	0.04	0.95	0.04	0.93	0.05
	pDM1[2]	multiplier for mature males	1.65	0.03	1.52	0.04	1.50	0.03	1.38	0.03	1.29	0.04
	pDM1[3]	multiplier for mature females	1.54	0.03	1.50	0.04	1.51	0.03	1.75	0.03	1.39	0.03
	pDM2[1]	1980-1984 multiplier for mature males	2.55	0.14	2.80	0.16	3.15	0.16	3.25	0.17	2.09	0.21
	pDM2[2]	1980-1984 multiplier for mature females	1.63	0.09	1.69	0.09	1.79	0.09	1.82	0.08	1.47	0.12
	pM[1]	base ln-scale M	-1.47	0.00	-1.47	0.00	-1.47	0.00	-1.47	0.00	-1.47	0.00
recruitment	pLnR[1]	historical recruitment period	6.38	0.38	6.09	0.38	5.52	0.38	5.46	0.37	6.59	0.38
	pLnR[2]	current recruitment period	6.08	0.06	5.79	0.07	5.06	0.03	5.00	0.03	5.98	0.07
	pRa[1]	fixed value	2.44	0.00	2.44	0.00	2.44	0.00	2.44	0.00	2.44	0.00
	pRb[1]	fixed value	1.39	0.00	1.39	0.00	1.39	0.00	1.39	0.00	1.39	0.00
	pRCV[1]	full model period	-0.69	0.00	-0.69	0.00	-0.69	0.00	-0.69	0.00	-0.69	0.00
	pRX[1]	full model period	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 16. Comparison of historical recruitment devs estimates (1948-1974) for all model scenarios.

	17AM		17AMu		18A		18B		18C0		18C0a	
index	estimate	std. error	estimate	std. error	estimate	std. error	estimate	std. error	estimate	std. error	estimate	std. error
1	-1.424	0.000	-1.134	1.435	-1.124	1.434	-1.072	1.443	-0.848	1.455	-0.926	1.440
2	-1.424	0.000	-1.143	1.282	-1.131	1.281	-1.081	1.291	-0.862	1.303	-0.938	1.287
3	-1.423	0.000	-1.157	1.145	-1.144	1.145	-1.098	1.153	-0.887	1.165	-0.961	1.149
4	-1.419	0.000	-1.175	1.027	-1.160	1.026	-1.119	1.034	-0.921	1.044	-0.991	1.029
5	-1.409	0.000	-1.192	0.928	-1.174	0.928	-1.142	0.935	-0.961	0.942	-1.024	0.929
6	-1.390	0.000	-1.203	0.850	-1.181	0.850	-1.160	0.856	-1.001	0.860	-1.055	0.849
7	-1.356	0.000	-1.201	0.791	-1.175	0.791	-1.167	0.796	-1.033	0.797	-1.075	0.789
8	-1.300	0.000	-1.175	0.747	-1.144	0.747	-1.152	0.751	-1.048	0.750	-1.073	0.744
9	-1.210	0.000	-1.108	0.712	-1.073	0.712	-1.100	0.716	-1.027	0.714	-1.030	0.709
10	-1.066	0.000	-0.974	0.683	-0.933	0.683	-0.984	0.686	-0.942	0.683	-0.917	0.679
11	-0.836	0.000	-0.723	0.660	-0.676	0.660	-0.758	0.661	-0.742	0.657	-0.678	0.655
12	-0.459	0.000	-0.270	0.648	-0.220	0.650	-0.334	0.648	-0.329	0.644	-0.218	0.644
13	0.148	0.000	0.429	0.640	0.478	0.642	0.350	0.640	0.373	0.636	0.517	0.635
14	0.956	0.000	1.190	0.619	1.226	0.622	1.131	0.620	1.203	0.615	1.325	0.611
15	1.620	0.000	1.598	0.594	1.619	0.598	1.575	0.595	1.663	0.579	1.696	0.570
16	1.796	0.000	1.573	0.591	1.582	0.594	1.587	0.590	1.522	0.557	1.429	0.555
17	1.621	0.000	1.359	0.600	1.357	0.602	1.393	0.602	1.001	0.570	0.835	0.577
18	1.377	0.000	1.168	0.597	1.149	0.597	1.207	0.601	0.407	0.589	0.235	0.594
19	1.228	0.000	1.078	0.577	1.029	0.578	1.109	0.581	-0.060	0.586	-0.175	0.583
20	1.221	0.000	1.052	0.560	0.970	0.567	1.051	0.562	-0.201	0.555	-0.183	0.549
21	1.300	0.000	0.920	0.554	0.823	0.559	0.867	0.561	0.299	0.523	0.498	0.514
22	1.269	0.000	0.652	0.505	0.584	0.506	0.561	0.515	1.208	0.425	1.357	0.418
23	1.105	0.000	0.672	0.444	0.630	0.444	0.591	0.450	1.308	0.411	1.383	0.408
24	0.696	0.000	0.316	0.450	0.273	0.451	0.327	0.444	0.919	0.416	0.934	0.419
25	0.272	0.000	0.089	0.465	0.076	0.464	0.054	0.462	0.510	0.446	0.587	0.447
26	0.109	0.000	0.355	0.399	0.339	0.399	0.366	0.394	0.447	0.399	0.448	0.403

	18C1		18C1a		18C2a		18C3a		18D0	
index	estimate	std. error	estimate	std. error	estimate	std. error	estimate	std. error	estimate	std. error
1	-0.806	1.465	-0.873	1.452	-0.974	1.458	-1.016	1.441	-1.207	1.452
2	-0.820	1.314	-0.885	1.301	-0.989	1.307	-1.031	1.289	-1.210	1.301
3	-0.845	1.176	-0.909	1.163	-1.017	1.169	-1.059	1.152	-1.215	1.164
4	-0.880	1.055	-0.940	1.043	-1.056	1.049	-1.097	1.034	-1.219	1.045
5	-0.921	0.953	-0.976	0.942	-1.102	0.949	-1.142	0.935	-1.219	0.945
6	-0.963	0.871	-1.011	0.861	-1.150	0.869	-1.187	0.858	-1.210	0.865
7	-1.001	0.808	-1.038	0.800	-1.195	0.808	-1.227	0.800	-1.187	0.803
8	-1.023	0.761	-1.047	0.754	-1.225	0.764	-1.250	0.757	-1.139	0.756
9	-1.016	0.724	-1.021	0.719	-1.227	0.730	-1.241	0.724	-1.053	0.720
10	-0.953	0.694	-0.934	0.689	-1.178	0.701	-1.178	0.696	-0.904	0.690
11	-0.791	0.667	-0.738	0.663	-1.038	0.673	-1.017	0.669	-0.648	0.666
12	-0.442	0.649	-0.342	0.649	-0.729	0.651	-0.678	0.647	-0.208	0.654
13	0.197	0.642	0.336	0.642	-0.133	0.638	-0.048	0.634	0.475	0.648
14	1.041	0.623	1.171	0.622	0.744	0.615	0.846	0.611	1.231	0.631
15	1.612	0.593	1.675	0.585	1.505	0.587	1.579	0.583	1.649	0.609
16	1.605	0.563	1.549	0.559	1.725	0.554	1.744	0.549	1.667	0.608
17	1.149	0.570	1.008	0.575	1.438	0.551	1.399	0.549	1.507	0.618
18	0.555	0.589	0.388	0.596	0.926	0.567	0.857	0.569	1.366	0.613
19	0.039	0.593	-0.095	0.593	0.429	0.578	0.364	0.579	1.302	0.587
20	-0.212	0.568	-0.248	0.562	0.137	0.563	0.112	0.559	1.244	0.574
21	0.109	0.532	0.243	0.529	0.342	0.526	0.402	0.521	0.980	0.586
22	1.095	0.438	1.265	0.428	1.328	0.454	1.458	0.438	0.529	0.539
23	1.305	0.418	1.394	0.415	1.737	0.418	1.794	0.408	0.381	0.476
24	1.024	0.415	1.024	0.418	1.391	0.415	1.342	0.412	0.024	0.473
25	0.511	0.448	0.569	0.452	0.816	0.452	0.753	0.451	-0.137	0.476
26	0.431	0.401	0.433	0.406	0.491	0.412	0.522	0.408	0.200	0.401

Table 17. Comparison of current recruitment devs estimates (1975-2018) for all model scenarios.

	17AM		17AMu		18A		18B		18C0		18C0a	
index	estimate	std. error	estimate	std. error	estimate	std. error	estimate	std. error	estimate	std. error	estimate	std. error
1	1.334	0.000	1.061	0.262	1.032	0.267	0.944	0.243	0.917	0.225	1.072	0.243
2	2.007	0.000	1.930	0.135	1.913	0.136	1.837	0.128	1.821	0.118	1.956	0.126
3	1.749	0.000	1.687	0.146	1.664	0.147	1.701	0.133	1.840	0.112	1.902	0.119
4	0.927	0.000	0.857	0.231	0.811	0.238	1.024	0.192	1.333	0.148	1.178	0.179
5	0.064	0.000	0.074	0.336	0.061	0.337	0.095	0.305	0.021	0.288	-0.017	0.333
6	-0.426	0.000	-0.336	0.388	-0.363	0.396	-0.335	0.348	-0.337	0.294	-0.316	0.332
7	0.066	0.000	0.040	0.237	0.038	0.237	-0.075	0.230	-0.259	0.225	-0.115	0.233
8	-0.504	0.000	-0.333	0.285	-0.368	0.292	-0.291	0.243	-0.309	0.208	-0.346	0.248
9	1.077	0.000	1.049	0.104	1.045	0.104	0.917	0.103	0.703	0.103	0.840	0.105
10	0.883	0.000	0.886	0.127	0.866	0.129	0.862	0.118	0.766	0.110	0.812	0.118
11	1.180	0.000	0.927	0.132	0.898	0.134	0.933	0.121	0.872	0.112	0.857	0.125
12	1.145	0.000	0.970	0.123	0.952	0.124	0.921	0.116	0.880	0.110	0.937	0.116
13	1.137	0.000	0.912	0.117	0.883	0.118	0.905	0.106	0.901	0.099	0.918	0.107
14	0.758	0.000	0.343	0.150	0.304	0.152	0.426	0.135	0.552	0.118	0.413	0.137
15	0.025	0.000	-0.170	0.166	-0.190	0.166	-0.227	0.159	-0.093	0.142	-0.079	0.150
16	-1.158	0.000	-1.326	0.344	-1.378	0.356	-1.181	0.281	-1.047	0.246	-1.278	0.316
17	-1.383	0.000	-1.536	0.318	-1.555	0.319	-1.560	0.300	-1.593	0.286	-1.583	0.303
18	-1.504	0.000	-1.529	0.274	-1.542	0.275	-1.612	0.265	-1.548	0.236	-1.480	0.244
19	-1.502	0.000	-1.434	0.255	-1.438	0.255	-1.551	0.247	-1.427	0.213	-1.348	0.223
20	-1.227	0.000	-1.128	0.212	-1.137	0.214	-1.241	0.203	-1.228	0.189	-1.159	0.201
21	-0.979	0.000	-0.853	0.183	-0.861	0.184	-0.962	0.176	-0.959	0.162	-0.867	0.168
22	-1.063	0.000	-0.957	0.217	-0.972	0.220	-0.997	0.199	-1.016	0.183	-1.023	0.204
23	0.006	0.000	0.086	0.106	0.086	0.106	-0.026	0.102	-0.158	0.100	-0.090	0.103
24	-0.909	0.000	-0.767	0.192	-0.779	0.194	-0.808	0.177	-0.883	0.168	-0.888	0.183
25	0.299	0.000	0.431	0.102	0.438	0.102	0.297	0.100	0.184	0.097	0.294	0.098
26	-0.354	0.000	-0.192	0.188	-0.207	0.192	-0.202	0.169	-0.227	0.154	-0.262	0.175
27	0.831	0.000	0.873	0.095	0.874	0.096	0.775	0.092	0.649	0.089	0.710	0.092
28	-0.303	0.000	-0.142	0.215	-0.153	0.217	-0.143	0.195	-0.213	0.185	-0.231	0.204
29	0.796	0.000	0.881	0.105	0.880	0.105	0.802	0.102	0.800	0.094	0.854	0.097
30	0.770	0.000	0.722	0.106	0.707	0.107	0.702	0.099	0.706	0.094	0.673	0.101
31	-0.533	0.000	-0.436	0.218	-0.458	0.221	-0.421	0.198	-0.277	0.173	-0.326	0.190
32	-0.799	0.000	-0.783	0.263	-0.802	0.265	-0.768	0.239	-0.671	0.215	-0.732	0.239
33	-1.056	0.000	-0.975	0.296	-0.987	0.299	-0.981	0.275	-0.948	0.253	-0.981	0.277
34	-0.625	0.000	-0.679	0.263	-0.636	0.261	-0.817	0.257	-0.736	0.235	-0.573	0.238
35	1.249	0.000	1.338	0.094	1.327	0.091	1.175	0.089	1.140	0.085	1.260	0.086
36	1.128	0.000	1.274	0.095	1.109	0.103	1.231	0.084	1.180	0.080	1.067	0.095
37	0.234	0.000	0.052	0.181	0.026	0.176	0.118	0.162	0.170	0.146	0.078	0.158
38	-1.403	0.000	-1.181	0.381	-1.057	0.346	-0.730	0.275	-0.620	0.237	-0.899	0.290
39	-0.394	0.000	-0.362	0.184	-0.476	0.186	-0.467	0.183	-0.499	0.173	-0.498	0.176
40	-0.683	0.000	-0.637	0.208	-0.799	0.209	-0.758	0.199	-0.759	0.187	-0.813	0.198
41	-1.105	0.000	-1.014	0.266	-1.164	0.264	-1.100	0.251	-1.060	0.234	-1.141	0.248
42	-0.765	0.000	-0.701	0.246	-0.838	0.240	-0.802	0.237	-0.798	0.225	-0.845	0.230
43	1.012	0.000	1.078	0.166	1.016	0.140	1.035	0.141	0.928	0.133	0.895	0.134
44					1.230	0.217	1.353	0.218	1.299	0.198	1.176	0.204

Table 17 (cont). Comparison of current recruitment devs estimates (1975-2018) for all model scenarios.

	18C1		18C1a		18C2a		18C3a		18D0	
index	estimate	std. error	estimate	std. error	estimate	std. error	estimate	std. error	estimate	std. error
1	0.813	0.191	0.969	0.218	1.404	0.166	1.465	0.170	0.805	0.253
2	1.612	0.110	1.791	0.119	1.997	0.113	2.027	0.116	1.735	0.126
3	1.662	0.106	1.782	0.111	1.959	0.108	1.961	0.110	1.567	0.137
4	1.344	0.122	1.219	0.155	1.497	0.128	1.382	0.139	1.058	0.183
5	0.042	0.242	-0.129	0.305	0.031	0.284	-0.092	0.314	0.037	0.305
6	-0.489	0.266	-0.438	0.288	-0.444	0.285	-0.389	0.280	-0.487	0.381
7	-0.520	0.211	-0.454	0.234	-0.470	0.221	-0.451	0.231	-0.143	0.232
8	-0.545	0.189	-0.541	0.220	-0.600	0.215	-0.584	0.229	-0.243	0.220
9	0.379	0.095	0.490	0.102	0.430	0.097	0.502	0.099	0.858	0.101
10	0.469	0.105	0.538	0.111	0.446	0.121	0.537	0.121	0.779	0.117
11	0.633	0.106	0.573	0.124	0.957	0.095	0.971	0.102	0.849	0.121
12	0.881	0.100	0.941	0.107	1.180	0.092	1.203	0.096	0.913	0.115
13	1.010	0.091	1.037	0.097	1.342	0.076	1.367	0.078	0.876	0.109
14	0.797	0.100	0.658	0.123	0.894	0.107	0.777	0.115	0.478	0.130
15	0.085	0.131	0.070	0.141	0.095	0.138	0.048	0.144	-0.207	0.160
16	-0.764	0.203	-0.980	0.264	-0.804	0.224	-0.912	0.247	-1.158	0.279
17	-1.507	0.273	-1.530	0.296	-1.578	0.300	-1.591	0.313	-1.462	0.283
18	-1.535	0.228	-1.492	0.240	-1.607	0.245	-1.601	0.256	-1.540	0.254
19	-1.469	0.208	-1.396	0.219	-1.527	0.217	-1.514	0.227	-1.530	0.244
20	-1.203	0.174	-1.159	0.188	-1.291	0.181	-1.270	0.188	-1.241	0.202
21	-0.979	0.155	-0.909	0.163	-1.083	0.161	-1.034	0.163	-0.967	0.173
22	-0.925	0.162	-0.940	0.180	-1.030	0.168	-1.032	0.177	-1.015	0.197
23	-0.160	0.094	-0.127	0.098	-0.241	0.094	-0.227	0.097	-0.034	0.101
24	-0.801	0.154	-0.832	0.168	-0.912	0.160	-0.921	0.167	-0.761	0.171
25	0.207	0.090	0.291	0.093	0.117	0.090	0.141	0.091	0.318	0.099
26	-0.192	0.143	-0.240	0.162	-0.324	0.151	-0.364	0.160	-0.177	0.166
27	0.753	0.080	0.803	0.083	0.670	0.081	0.670	0.082	0.802	0.091
28	-0.142	0.171	-0.203	0.194	-0.293	0.183	-0.317	0.193	-0.085	0.190
29	0.832	0.090	0.902	0.092	0.748	0.093	0.736	0.093	0.876	0.100
30	0.846	0.084	0.788	0.094	0.794	0.086	0.705	0.090	0.780	0.099
31	-0.083	0.153	-0.124	0.168	-0.181	0.161	-0.269	0.170	-0.328	0.191
32	-0.522	0.193	-0.599	0.221	-0.602	0.200	-0.696	0.217	-0.754	0.243
33	-0.873	0.229	-0.891	0.254	-0.993	0.243	-0.979	0.251	-0.890	0.257
34	-0.881	0.230	-0.705	0.240	-0.931	0.235	-0.893	0.243	-0.767	0.246
35	0.973	0.081	1.100	0.083	0.760	0.091	0.817	0.087	1.170	0.089
36	1.243	0.068	1.172	0.077	1.211	0.072	1.228	0.071	1.245	0.084
37	0.392	0.132	0.269	0.145	0.477	0.141	0.357	0.149	0.157	0.158
38	-0.526	0.214	-0.762	0.264	-0.946	0.289	-0.887	0.286	-0.775	0.280
39	-0.421	0.161	-0.427	0.166	-0.415	0.155	-0.432	0.163	-0.442	0.178
40	-0.749	0.177	-0.771	0.189	-0.914	0.191	-0.879	0.198	-0.754	0.195
41	-1.071	0.222	-1.117	0.239	-1.196	0.233	-1.156	0.244	-1.076	0.242
42	-0.793	0.212	-0.793	0.218	-0.874	0.216	-0.784	0.219	-0.762	0.225
43	0.838	0.114	0.857	0.115	0.812	0.113	0.897	0.114	0.972	0.133
44	1.339	0.148	1.310	0.153	1.436	0.144	1.483	0.147	1.322	0.197

Table 18. Comparison of logit-scale parameters for the probability of terminal molt for all model scenarios.

			17AM		17AMu		18A		18B		18C0		18C0a	
name	label	index	estimate	std. error	estimate	std. error	estimate	std. error	estimate	std. error	estimate	std. error	estimate	std. error
pLgtPrM2M[1]	males (entire model period)	1	-12.08656803	0	-11.79151232	7.355	-11.77500682	7.377	-3.566101558	0.18182	-3.704104329	0.20508	-6.709991812	1.4393
		2	-10.89178064	0	-10.59159766	5.5279	-10.58377262	5.5503	-3.511440792	0.16371	-3.662684063	0.18118	-5.672054352	0.72549
		3	-9.696993775	0	-9.39168298	3.9298	-9.392538369	3.9523	-2.953776635	0.12011	-3.076855556	0.13214	-4.52445519	0.43923
		4	-8.503193435	0	-8.192583968	2.5948	-8.202228412	2.6156	-2.432479321	0.093244	-2.532437907	0.10247	-3.556976904	0.29155
		5	-7.320559446	0	-7.005931301	1.5373	-7.025106529	1.5501	-1.766237501	0.069573	-1.783733721	0.074153	-2.86925348	0.20746
		6	-6.162317254	0	-5.839443967	0.83379	-5.867286102	0.83369	-1.27303942	0.056521	-1.253448891	0.059202	-2.420085481	0.15656
		7	-5.104243949	0	-4.772158618	0.50178	-4.795925031	0.50111	-0.837987444	0.050976	-0.81758164	0.052987	-1.723245126	0.12812
		8	-4.477305015	0	-4.218735863	0.35435	-4.236569532	0.35544	-0.462267104	0.049284	-0.45381377	0.051264	-1.200941561	0.10718
		9	-4.08962769	0	-3.930836323	0.28649	-3.961456348	0.28683	-0.280683159	0.046891	-0.278405131	0.049028	-0.904494584	0.092242
		10	-3.448299296	0	-3.247235414	0.22061	-3.274988833	0.22074	-0.069823702	0.048915	-0.056159049	0.05116	-0.835561727	0.088683
		11	-2.913423547	0	-2.648336344	0.16782	-2.656866642	0.16729	-0.066150232	0.043301	-0.066637623	0.044836	-0.647895108	0.077569
		12	-2.487335154	0	-2.290700393	0.14073	-2.305551488	0.14046	0.486947753	0.054997	0.507694688	0.056798	0.32494847	0.104
		13	-2.020784523	0	-2.012094704	0.11963	-2.036325302	0.11929	1.304685536	0.060908	1.325717007	0.062149	1.318830729	0.10232
		14	-1.430112617	0	-1.39775611	0.10446	-1.410788519	0.10391	1.758904345	0.064089	1.781441394	0.06541	1.685580919	0.082742
		15	-0.936987619	0	-0.93887963	0.089656	-0.957790023	0.088696	1.873171909	0.070336	1.89316287	0.071959	2.057504471	0.14938
		16	-0.667894089	0	-0.684786988	0.077868	-0.665311182	0.076873	3.266426195	0.18327	3.281548597	0.18537	5.040711553	0.57982
		17	-0.536299396	0	-0.604287809	0.075218	-0.619553914	0.074405	5.164054242	0.26334	5.166897189	0.26409	8.410085976	1.0728
		18	-0.092834927	0	-0.463673593	0.068064	-0.435441927	0.067544	7.514564346	0.66908	7.511685118	0.66828	11.78930571	2.032
		19	0.512351235	0	0.442130049	0.10022	0.49955773	0.097649						
		20	1.361919764	0	1.39269893	0.096394	1.434010687	0.095836						
		21	2.70767571	0	1.64548298	0.081704	1.707904289	0.078125						
		22	4.95696935	0	2.023118542	0.15339	2.239264858	0.1718						
		23	7.095871179	0	5.07996104	0.54945	5.511785379	0.52072						
		24	8.917113578	0	8.104134028	0.86034	8.550975873	0.87501						
		25	10.41245426	0	10.48812473	1.2942	10.89667384	1.3325						
		26	11.61526392	0	12.25349008	1.6682	12.59692339	1.7069						
		27	12.5657537	0	13.48731056	1.8374	13.75056925	1.8669						
		28	13.30558155	0	14.2835698	1.7371	14.46208856	1.7554						
		29	13.8767742	0	14.73742065	1.3649	14.83695881	1.3735						
		30	14.32146498	0	14.9443574	0.77674	14.98096276	0.77903						
		31	14.68181693	0	14.99999917	0.0045555	14.99999962	0.0020821						
		32	14.99999921	0	14.9999994	0.0032814	14.99999829	0.0094277						
pLgtPrM2M[2]	females (entire model period)	1	-14.99999969	0	-14.9999997	0.0016466	-14.9999997	0.0016199	-13.12677132	3.1971	-13.07003104	3.3292	-13.15369945	3.3262
		2	-13.76426343	0	-13.77782371	0.78321	-13.78539932	0.78272	-10.71001038	2.1246	-10.6962447	2.2362	-10.77703363	2.2341
		3	-12.4745578	0	-12.50021723	1.1841	-12.51447415	1.183	-8.293790159	1.2526	-8.322896414	1.339	-8.400813228	1.3383
		4	-11.07694451	0	-11.11178	1.2859	-11.1309298	1.2843	-5.885746874	0.62147	-5.956100337	0.67789	-6.031099786	0.67944
		5	-9.517965779	0	-9.55762984	1.1499	-9.579006951	1.1479	-3.553656636	0.24897	-3.647137203	0.2825	-3.720235372	0.28582
		6	-7.748393887	0	-7.787382323	0.86172	-7.807570327	0.8599	-1.708949059	0.10965	-1.727502375	0.1217	-1.80378989	0.12272
		7	-5.743309709	0	-5.775090218	0.52645	-5.79019135	0.52531	-0.369302567	0.083748	-0.358506911	0.088513	-0.431226896	0.089137
		8	-3.583931017	0	-3.605024143	0.2447	-3.611920079	0.24437	0.3325227	0.085942	0.352260554	0.088855	0.285705821	0.08886
		9	-1.780153237	0	-1.789289302	0.10975	-1.792217373	0.10926	0.64771013	0.099175	0.700399797	0.10073	0.628635544	0.10007
		10	-0.432960578	0	-0.453875195	0.084055	-0.456085667	0.083744	1.290038053	0.14694	1.383819812	0.15212	1.304152004	0.15081
		11	0.301718676	0	0.254846265	0.086175	0.253987249	0.085919	2.370183708	0.27171	2.525340456	0.27701	2.456563202	0.27754
		12	0.586246433	0	0.568724112	0.098854	0.565815138	0.098423	3.565579032	0.47077	3.781844962	0.50466	3.741739088	0.50902
		13	1.273966791	0	1.202186017	0.14443	1.189784503	0.143	4.81321621	0.94026	5.093691861	1.019	5.087199533	1.0251
		14	2.574952965	0	2.267821647	0.26622	2.24553011	0.26274						
		15	4.024991967	0	3.454998321	0.46169	3.428497347	0.45399						
		16	5.511702016	0	4.703991672	0.92287	4.673210017	0.90942						

Table 18 (cont.). Comparison of logit-scale parameters for the probability of terminal molt for all model scenarios.

				18C1		18C1a		18C2a		18C3a		18D0	
process	name	label	index	estimate	std. error	estimate	std. error	estimate	std. error	estimate	std. error	estimate	std. error
maturity	pLgtPrM2M[1]	males (entire model period)	1	-3.71603053	0.20566	-6.533583106	1.3731	-5.198447048	0.55783	-5.445338832	0.56933	-3.247903585	0.19601
			2	-3.62472786	0.18136	-5.492147744	0.69677	-4.590525953	0.37458	-4.805506701	0.37633	-3.383531681	0.17849
			3	-3.010057588	0.13244	-4.366114821	0.43062	-3.876507801	0.28892	-4.01288084	0.28968	-2.86521286	0.13056
			4	-2.503895739	0.10249	-3.480977217	0.28843	-3.461841135	0.21902	-3.555009524	0.2205	-2.326096201	0.099356
			5	-1.801299133	0.074624	-2.855284622	0.20693	-2.870357427	0.15776	-3.002698548	0.15764	-1.684315699	0.071929
			6	-1.235924359	0.059562	-2.33416256	0.15648	-2.001187532	0.13065	-2.170392376	0.14102	-1.2166009	0.058079
			7	-0.775598779	0.053357	-1.600764235	0.12849	-1.287730689	0.10075	-1.389911467	0.10232	-0.805727555	0.052339
			8	-0.418511179	0.051801	-1.163850686	0.10696	-1.052056733	0.088616	-1.134628022	0.086617	-0.439280053	0.050674
			9	-0.277271177	0.049336	-0.83737611	0.091638	-1.059317777	0.084612	-1.119450544	0.080396	-0.273230058	0.048227
			10	-0.086574145	0.052079	-0.845922628	0.091049	-1.21603932	0.081978	-1.281972057	0.086472	-0.054507636	0.049877
			11	-0.056304045	0.046477	-0.551595068	0.089691	-0.537970345	0.11362	-0.680687026	0.13775	-0.061532073	0.044444
			12	0.549257249	0.06088	0.540286494	0.12803	0.851918156	0.13379	0.64288699	0.17295	0.470718863	0.055752
			13	1.391604873	0.066389	1.49062839	0.11503	1.540106034	0.095902	1.43908182	0.094025	1.288183734	0.062227
			14	1.809132839	0.068313	1.706334328	0.087333	1.61260665	0.11913	1.55668244	0.11817	1.75786985	0.065067
			15	1.922882175	0.078333	2.386271428	0.25527	3.626458441	0.39708	3.182913447	0.5331	1.852984595	0.068339
			16	3.425465931	0.18405	5.766308852	0.57692	6.220616439	0.4231	5.972206725	0.48165	3.159403582	0.18276
			17	5.241178766	0.26478	9.28053129	1.1914	8.361942179	0.76558	8.303930711	0.77011	5.083421723	0.26541
			18	7.522505844	0.66887	12.7926366	2.2589	10.48442474	1.6136	10.60563704	1.6287	7.480926771	0.66605
	pLgtPrM2M[2]	females (entire model period)	1	-13.03200451	3.3373	-13.08350998	3.3343	-8.623196742	3.4491	-12.28971008	3.3501	-11.8761921	2.97
			2	-10.65815026	2.2422	-10.71146294	2.2403	-7.124874236	2.3364	-10.04197122	2.2535	-9.726125754	1.9496
			3	-8.284712859	1.3424	-8.339843044	1.3419	-5.62562905	1.414	-7.794688897	1.3508	-7.577683253	1.1389
			4	-5.91771117	0.67808	-5.974645025	0.67966	-4.14588586	0.67803	-5.554659767	0.678	-5.448015983	0.56568
			5	-3.606609856	0.28127	-3.666499133	0.28395	-2.655415191	0.23871	-3.367941794	0.26869	-3.425417186	0.23143
			6	-1.682054977	0.1222	-1.747114782	0.12284	-1.16039716	0.1178	-1.499369618	0.12101	-1.751225253	0.11563
			7	-0.310975259	0.090595	-0.377663862	0.090372	0.002958934	0.091492	-0.156521027	0.089827	-0.443136033	0.087587
			8	0.39731251	0.091646	0.333344831	0.090589	0.591262714	0.092118	0.503748117	0.089679	0.266026825	0.088512
			9	0.733756168	0.10375	0.673671511	0.10154	0.929101828	0.10928	0.881884863	0.10607	0.606187154	0.10057
			10	1.445928251	0.16054	1.379551064	0.15805	1.837277043	0.18902	1.817507271	0.18505	1.219304331	0.14258
			11	2.637801491	0.29687	2.577251741	0.29413	3.358174045	0.38108	3.350591092	0.36822	2.211219896	0.24693
			12	3.937610178	0.55731	3.898683071	0.55	5.030827964	0.79166	5.031589736	0.75873	3.311146845	0.42509
			13	5.28476401	1.1097	5.274517655	1.0935	6.731825441	1.4928	6.740823419	1.444	4.494244542	0.86156

Table 19. Comparison of survey selectivity parameters and ln-scale NMFS survey catchability for all model scenarios.

process	name	label	17AM estimate	17AM std. error	17AMu estimate	17AMu std. error	18A estimate	18A std. error	18B estimate	18B std. error	18C0 estimate	18C0 std. error	18C0a estimate	18C0a std. error
selectivity	pS1[1]	z50 for NMFS survey selectivity (males, pre-1982)	52.31	0.00	90.00	0.00	90.00	0.00	90.00	0.00	90.00	0.00	90.00	0.00
	pS1[2]	z50 for NMFS survey selectivity (males, 1982+)	34.92	0.00	40.72	5.16	38.32	5.27	41.06	6.44	51.19	5.97	40.79	5.95
	pS1[3]	z50 for NMFS survey selectivity (females, pre-1982)	56.29	0.00	80.24	3.34	80.43	3.37	82.39	3.30	99.04	4.34	84.02	4.00
	pS1[4]	z50 for NMFS survey selectivity (females, 1982+)	-29.13	0.00	-50.00	0.02	22.28	54089.00	-35.87	30.78	5.52	12.88	2.14	15.11
	pS2[1]	z95-z50 for NMFS survey selectivity (males, pre-1982)	23.50	0.00	87.72	6.88	87.50	6.81	87.79	6.54	80.21	5.13	81.45	5.45
	pS2[2]	z95-z50 for NMFS survey selectivity (males, 1982+)	75.07	0.00	100.00	0.00	100.00	0.00	100.00	0.00	100.00	0.00	98.41	15.86
	pS2[3]	z95-z50 for NMFS survey selectivity (females, pre-1982)	39.98	0.00	66.13	7.00	66.54	7.06	69.45	7.42	68.83	6.21	59.45	5.60
	pS2[4]	z95-z50 for NMFS survey selectivity (females, 1982+)	100.00	0.00	100.00	0.00	0.54	6211.00	100.00	0.00	100.00	0.00	100.00	0.00
surveys	pQ[1]	NMFS trawl survey: males, 1975-1981	-0.69	0.00	-0.69	0.00	-0.69	0.00	-0.69	0.00	-0.69	0.00	-0.69	0.00
	pQ[2]	NMFS trawl survey: males, 1982+	-0.44	0.00	-0.90	0.06	-0.95	0.07	-1.04	0.05	-1.04	0.05	-0.84	0.06
	pQ[3]	NMFS trawl survey: females, 1975-1981	-0.69	0.00	-0.69	0.00	-0.69	0.00	-0.69	0.00	-0.69	0.00	-0.69	0.00
	pQ[4]	NMFS trawl survey: females, 1982+	-0.91	0.00	-1.51	0.08	-1.57	0.08	-1.61	0.00	-1.61	0.00	-1.27	0.09

process	name	label	18C1 estimate	18C1 std. error	18C1a estimate	18C1a std. error	18C2a estimate	18C2a std. error	18C3a estimate	18C3a std. error	18D0 estimate	18D0 std. error
selectivity	pS1[1]	z50 for NMFS survey selectivity (males, pre-1982)	90.00	0.00	90.00	0.00	56.57	2.84	54.64	2.19	90.00	0.00
	pS1[2]	z50 for NMFS survey selectivity (all crab, 1982+)							44.50	0.00		
		z50 for NMFS survey selectivity (males and immature females, 1982+)					44.50	0.00				
		z50 for NMFS survey selectivity (males, 1982+)	54.43	4.95	43.28	3.95					38.26	6.95
	pS1[3]	z50 for NMFS survey selectivity (females, pre-1982)	96.14	3.64	83.50	3.09	80.09	17.24	82.24	14.66	99.50	5.61
	pS1[4]	z50 for NMFS survey selectivity (females, 1982+)	14.93	8.70	23.02	10.86					2.11	14.06
		z50 for NMFS survey selectivity (mature females, 1982+)					65.50	0.00				
		z50 for NMFS survey selectivity (not applied, 1982+)							65.50	0.00		
	pS2[1]	z95-z50 for NMFS survey selectivity (males, pre-1982)	76.31	4.37	79.44	5.02	31.86	5.72	28.47	4.19	96.99	7.58
	pS2[2]	z95-z50 for NMFS survey selectivity (males, 1982+)	100.00	0.00	77.68	8.59					100.00	0.00
		z99 for NMFS survey selectivity (all crab, 1982+)							130.00	0.00		
		z99 for NMFS survey selectivity (males and immature females, 1982+)					130.00	0.00				
	pS2[3]	z95-z50 for NMFS survey selectivity (females, pre-1982)	68.73	6.23	58.32	5.33	60.43	14.10	55.92	10.91	77.52	8.45
	pS2[4]	z95-z50 for NMFS survey selectivity (females, 1982+)	100.00	0.00	100.00	0.00					100.00	0.00
		z99 for NMFS survey selectivity (mature females, 1982+)					105.00	0.00				
		z99 for NMFS survey selectivity (not applied, 1982+)							105.00	0.00		
surveys	pQ[1]	NMFS trawl survey: males, 1975-1981	-0.69	0.00	-0.69	0.00	-0.69	0.00	-0.69	0.00	-0.69	0.00
	pQ[2]	NMFS trawl survey: all, 1982+							-0.14	0.00		
		NMFS trawl survey: males and immature females, 1982+					-0.14	0.00				
		NMFS trawl survey: males, 1982+	-1.06	0.05	-0.92	0.06					-1.18	0.05
	pQ[3]	NMFS trawl survey: females, 1975-1981	-0.69	0.00	-0.69	0.00	-0.41	0.38	-0.17	0.36	-0.69	0.00
	pQ[4]	NMFS trawl survey: females, 1982+	-1.61	0.00	-1.25	0.09					-1.61	0.00
		NMFS trawl survey: mature females, 1982+					-0.60	0.00				

Table 20. Comparison of selectivity and retention parameters for the directed fishery (TCF) for all model scenarios.

		17AM		17AMu		18A		18B		18C0		18C0a	
label	index	estimate	std. error	estimate	std. error	estimate	std. error	estimate	std. error	estimate	std. error	estimate	std. error
ln(z50 devs) for TCF selectivity (males, 1991+)	1	0.03	0.00	0.06	0.02	0.07	0.02	0.07	0.02	0.08	0.02	0.09	0.03
	2	0.12	0.00	0.04	0.01	0.04	0.01	0.04	0.01	0.05	0.01	0.06	0.01
	3	0.10	0.00	0.12	0.01	0.13	0.01	0.12	0.01	0.12	0.01	0.14	0.02
	4	0.08	0.00	0.09	0.02	0.10	0.02	0.08	0.02	0.06	0.02	0.09	0.02
	5	-0.01	0.00	-0.03	0.03	-0.02	0.03	-0.02	0.03	-0.04	0.03	-0.05	0.03
	6	0.12	0.00	0.16	0.04	0.18	0.04	0.16	0.04	0.16	0.04	0.18	0.04
	7	-0.09	0.00	-0.10	0.02	-0.09	0.02	-0.08	0.02	-0.08	0.02	-0.09	0.02
	8	-0.09	0.00	-0.09	0.02	-0.08	0.02	-0.07	0.02	-0.07	0.02	-0.08	0.02
	9	-0.13	0.00	-0.15	0.02	-0.14	0.02	-0.13	0.01	-0.12	0.01	-0.14	0.02
	10	0.01	0.00	0.02	0.02	0.03	0.02	0.02	0.01	0.03	0.01	0.03	0.02
	11	0.18	0.00	0.20	0.02	0.22	0.02	0.19	0.02	0.19	0.02	0.22	0.02
	12	-0.05	0.00	-0.03	0.01	-0.02	0.01	-0.02	0.01	-0.02	0.01	-0.02	0.01
	13	-0.11	0.00	-0.11	0.01	-0.11	0.01	-0.10	0.01	-0.09	0.01	-0.11	0.01
	14	-0.15	0.00	-0.18	0.01	-0.18	0.01	-0.15	0.01	-0.15	0.01	-0.19	0.01
	15					-0.12	0.01	-0.11	0.01	-0.11	0.01	-0.13	0.01
z50 for TCF retention (2005-2009)	1	138.72	0.00	140.28	1.04	140.32	1.04	140.25	1.04	140.21	1.05	140.28	1.04
z50 for TCF retention (2013+)	1					125.06	0.13	125.33	0.13	125.29	0.14	125.07	0.13
z50 for TCF retention (2013-2015)	1	125.04	0.00	124.98	0.14								
z50 for TCF retention (pre-1991)	1	137.99	0.00	138.83	0.51	138.93	0.52	138.25	0.41	138.46	0.43	139.22	0.55
ln(z50) for TCF selectivity (males)	1	4.87	0.00	4.92	0.01	4.91	0.01	4.92	0.01	4.92	0.01	4.92	0.01
z50 for TCF selectivity (females)	1	96.58	0.00	96.80	2.75	96.63	2.71	97.13	2.76	96.02	2.51	95.58	2.46
slope for TCF retention (2005-2009)	1	0.89	0.00	0.58	0.16	0.58	0.15	0.58	0.16	0.59	0.16	0.58	0.16
slope for TCF retention (2013+)	1					0.57	0.02	0.53	0.01	0.53	0.01	0.57	0.02
slope for TCF retention (2013-2015)	1	0.58	0.00	0.57	0.02								
slope for TCF retention (pre-1991)	1	0.69	0.00	0.63	0.11	0.62	0.10	0.70	0.12	0.68	0.12	0.59	0.09
slope for TCF retention (1997+)	1	0.96	0.00	0.83	0.17	0.83	0.17	0.84	0.17	0.78	0.14	0.81	0.16
slope for TCF selectivity (males, pre-1997)	1	0.12	0.00	0.10	0.01	0.10	0.00	0.11	0.00	0.11	0.00	0.10	0.00
slope for TCF selectivity (males, 1997+)	1	0.16	0.00	0.13	0.01	0.13	0.01	0.14	0.00	0.14	0.00	0.13	0.01
slope for TCF selectivity (females)	1	0.19	0.00	0.19	0.02	0.18	0.02	0.18	0.02	0.19	0.02	0.19	0.02

		18C1		18C1a		18C2a		18C3a		18D0	
label	index	estimate	std. error	estimate	std. error	estimate	std. error	estimate	std. error	estimate	std. error
ln(z50 devs) for TCF selectivity (males, 1991+)	1	0.10	0.02	0.11	0.03	0.09	0.02	0.10	0.03	0.07	0.02
	2	0.05	0.01	0.06	0.01	0.05	0.01	0.05	0.01	0.04	0.01
	3	0.11	0.01	0.13	0.02	0.11	0.01	0.11	0.01	0.12	0.01
	4	0.05	0.02	0.07	0.02	0.09	0.02	0.10	0.02	0.08	0.02
	5	-0.05	0.03	-0.07	0.03	-0.01	0.03	-0.01	0.03	-0.02	0.02
	6	0.16	0.04	0.18	0.05	0.19	0.04	0.19	0.04	0.16	0.04
	7	-0.08	0.02	-0.09	0.02	-0.09	0.02	-0.09	0.02	-0.08	0.02
	8	-0.07	0.02	-0.08	0.02	-0.09	0.02	-0.09	0.02	-0.07	0.02
	9	-0.12	0.01	-0.13	0.02	-0.13	0.02	-0.14	0.02	-0.12	0.01
	10	0.03	0.01	0.04	0.02	0.03	0.02	0.03	0.02	0.03	0.01
	11	0.20	0.02	0.23	0.03	0.23	0.03	0.23	0.03	0.19	0.02
	12	-0.02	0.01	-0.02	0.01	-0.01	0.01	-0.01	0.01	-0.02	0.01
	13	-0.10	0.01	-0.12	0.01	-0.12	0.01	-0.12	0.01	-0.10	0.01
	14	-0.16	0.01	-0.19	0.01	-0.21	0.01	-0.22	0.02	-0.15	0.01
	15	-0.11	0.01	-0.12	0.01	-0.13	0.01	-0.13	0.01	-0.11	0.01
z50 for TCF retention (2005-2009)	1	140.24	1.04	140.31	1.04	140.07	1.05	140.05	1.05	140.31	1.04
z50 for TCF retention (2013+)	1	125.18	0.13	124.98	0.13	124.62	0.11	124.63	0.12	125.36	0.14
z50 for TCF retention (pre-1991)	1	138.06	0.37	138.86	0.50	136.94	0.38	136.80	0.39	138.52	0.44
ln(z50) for TCF selectivity (males)	1	4.92	0.01	4.92	0.01	4.91	0.01	4.91	0.01	4.92	0.01
z50 for TCF selectivity (females)	1	96.04	2.46	95.72	2.43	94.69	2.10	95.34	2.23	95.81	2.41
slope for TCF retention (2005-2009)	1	0.59	0.16	0.58	0.15	0.61	0.17	0.61	0.17	0.58	0.15
slope for TCF retention (2013+)	1	0.54	0.01	0.58	0.02	0.63	0.02	0.63	0.02	0.53	0.01
slope for TCF retention (pre-1991)	1	0.72	0.12	0.64	0.11	0.72	0.12	0.73	0.13	0.70	0.12
slope for TCF retention (1997+)	1	0.73	0.12	0.75	0.13	0.89	0.17	0.88	0.16	0.80	0.15
slope for TCF selectivity (males, pre-1997)	1	0.11	0.00	0.10	0.00	0.11	0.01	0.11	0.01	0.11	0.00
slope for TCF selectivity (males, 1997+)	1	0.13	0.00	0.12	0.00	0.13	0.01	0.13	0.01	0.14	0.00
slope for TCF selectivity (females)	1	0.19	0.02	0.19	0.02	0.20	0.02	0.20	0.02	0.19	0.02

Table 21. Comparison of selectivity parameter estimates for the snow crab fishery (SCF) for all model scenarios.

		17AM		17AMu		18A		18B		18C0		18C0a	
label	index	estimate	std. error	estimate	std. error	estimate	std. error	estimate	std. error	estimate	std. error	estimate	std. error
ascending z50 for SCF selectivity (males, pre-1997)	1	87.70	0.00	86.31	2.38	86.07	2.36	88.69	2.68	89.06	2.65	86.49	2.50
ascending z50 for SCF selectivity (males, 1997-2004)	1	95.70	0.00	98.99	3.89	98.97	3.98	101.82	4.22	102.52	4.31	98.77	3.90
ascending z50 for SCF selectivity (males, 2005+)	1	105.61	0.00	107.02	1.43	106.90	1.45	109.84	1.39	110.27	1.41	106.42	1.44
ascending z50 for SCF selectivity (females, pre-1997)	1	70.26	0.00	75.41	4.38	75.47	4.39	75.76	4.38	75.29	4.36	74.95	4.34
ascending z50 for SCF selectivity (females, 1997-2004)	1	76.29	0.00	78.91	4.59	78.95	4.60	79.24	4.62	78.96	4.61	78.77	4.55
ascending z50 for SCF selectivity (females, 2005+)	1	85.22	0.00	81.83	4.76	81.59	4.66	82.39	4.85	81.70	4.58	81.31	4.50
ascending slope for SCF selectivity (males, pre-1997)	1	0.37	0.00	0.32	0.14	0.32	0.14	0.24	0.10	0.24	0.09	0.31	0.14
ascending slope for SCF selectivity (males, 1997-2004)	1	0.21	0.00	0.19	0.05	0.19	0.05	0.17	0.04	0.17	0.04	0.19	0.05
ascending slope for SCF selectivity (males, 2005+)	1	0.17	0.00	0.17	0.01	0.17	0.01	0.17	0.01	0.17	0.01	0.18	0.01
slope for SCF selectivity (females, pre-1997)	1	0.22	0.00	0.20	0.09	0.19	0.09	0.19	0.08	0.20	0.09	0.20	0.09
slope for SCF selectivity (females, 1997-2004)	1	0.26	0.00	0.26	0.12	0.25	0.12	0.25	0.12	0.26	0.12	0.26	0.12
slope for SCF selectivity (females, 2005+)	1	0.16	0.00	0.19	0.06	0.19	0.06	0.18	0.06	0.19	0.06	0.19	0.06
ln(dz50-az50) for SCF selectivity (males, pre-1997)	1	3.96	0.00	4.15	0.07	4.15	0.07	4.12	0.08	4.13	0.07	4.06	0.14
ln(dz50-az50) for SCF selectivity (males, 1997-2004)	1	3.73	0.00	3.57	0.28	3.56	0.29	3.60	0.31	3.55	0.33	3.50	0.29
ln(dz50-az50) for SCF selectivity (males, 2005+)	1	3.45	0.00	3.41	0.09	3.41	0.09	3.35	0.10	3.34	0.10	3.41	0.09
descending slope for SCF selectivity (males, pre-1997)	1	0.50	0.00	0.36	0.41	0.37	0.41	0.44	0.50	0.50	0.33	0.10	0.00
descending slope for SCF selectivity (males, 1997-2004	1	0.13	0.00	0.10	0.00	0.10	0.00	0.10	0.00	0.10	0.00	0.10	0.00
descending slope for SCF selectivity (males, 2005+)	1	0.18	0.00	0.16	0.02	0.16	0.02	0.16	0.03	0.16	0.03	0.16	0.02

		18C1		18C1a		18C2a		18C3a		18D0	
label	index	estimate	std. error	estimate	std. error	estimate	std. error	estimate	std. error	estimate	std. error
ascending z50 for SCF selectivity (males, pre-1997)	1	89.00	2.61	87.03	2.53	109.87	1.87	110.05	1.87	89.27	2.68
ascending z50 for SCF selectivity (males, 1997-2004)	1	101.85	4.09	98.09	3.62	98.79	3.57	98.46	3.49	101.82	4.29
ascending z50 for SCF selectivity (males, 2005+)	1	109.93	1.40	106.11	1.39	106.47	1.46	106.11	1.40	109.75	1.39
ascending z50 for SCF selectivity (females, pre-1997)	1	75.51	4.35	75.39	4.28	76.69	4.03	75.84	4.45	75.26	4.37
ascending z50 for SCF selectivity (females, 1997-2004)	1	78.92	4.62	78.83	4.56	79.13	4.52	79.37	4.49	78.84	4.57
ascending z50 for SCF selectivity (females, 2005+)	1	81.35	4.47	81.18	4.40	81.04	3.89	81.61	3.93	81.64	4.61
ascending slope for SCF selectivity (males, pre-1997)	1	0.24	0.09	0.29	0.12	0.10	0.00	0.10	0.00	0.23	0.09
ascending slope for SCF selectivity (males, 1997-2004)	1	0.17	0.04	0.20	0.05	0.20	0.05	0.20	0.05	0.17	0.04
ascending slope for SCF selectivity (males, 2005+)	1	0.17	0.01	0.18	0.01	0.18	0.01	0.18	0.01	0.17	0.01
slope for SCF selectivity (females, pre-1997)	1	0.20	0.09	0.20	0.09	0.20	0.08	0.19	0.08	0.20	0.09
slope for SCF selectivity (females, 1997-2004)	1	0.25	0.12	0.26	0.12	0.26	0.12	0.26	0.12	0.26	0.12
slope for SCF selectivity (females, 2005+)	1	0.19	0.06	0.19	0.06	0.20	0.06	0.20	0.06	0.19	0.06
ln(dz50-az50) for SCF selectivity (males, pre-1997)	1	4.13	0.08	4.03	0.14	2.00	0.00	2.00	0.00	4.11	0.08
ln(dz50-az50) for SCF selectivity (males, 1997-2004)	1	3.57	0.30	3.56	0.26	3.52	0.27	3.52	0.26	3.58	0.32
ln(dz50-az50) for SCF selectivity (males, 2005+)	1	3.34	0.10	3.43	0.09	3.35	0.10	3.35	0.10	3.35	0.10
descending slope for SCF selectivity (males, pre-1997)	1	0.38	0.53	0.10	0.00	0.10	0.00	0.10	0.00	0.43	0.51
descending slope for SCF selectivity (males, 1997-2004	1	0.10	0.00	0.10	0.00	0.10	0.00	0.10	0.00	0.10	0.00
descending slope for SCF selectivity (males, 2005+)	1	0.16	0.02	0.16	0.02	0.15	0.02	0.15	0.02	0.16	0.03

Table 22. Comparison of selectivity parameter estimates for the BBRKC fishery (RKF) for all model scenarios.

		17AM		17AMu		18A		18B		18C0		18C0a	
label	index	estimate	std. error	estimate	std. error	estimate	std. error	estimate	std. error	estimate	std. error	estimate	std. error
z95 for RKF selectivity (males, pre-1997)	1	158.21	0.00	161.91	5.81	161.36	5.78	162.69	5.36	162.77	5.17	161.74	5.77
z95 for RKF selectivity (males, 1997-2004)	1	180.00	0.00	180.00	0.00	180.00	0.00	180.00	0.00	180.00	0.00	180.00	0.00
z95 for RKF selectivity (males, 2005+)	1	180.00	0.00	180.00	0.00	180.00	0.00	180.00	0.00	180.00	0.00	180.00	0.00
z95 for RKF selectivity (females, pre-1997)	1	121.57	0.00	121.67	32.41	121.96	33.24	123.30	36.93	120.90	31.06	120.08	30.10
z95 for RKF selectivity (females, 1997-2004)	1	121.22	0.00	125.40	65.48	126.49	70.41	126.80	72.07	125.15	66.09	123.45	60.17
z95 for RKF selectivity (females, 2005+)	1	140.00	0.00	140.00	0.03	140.00	0.03	140.00	0.03	140.00	0.04	140.00	0.04
ln(z95-z50) for RKF selectivity (males, pre-1997)	1	3.08	0.00	3.08	0.14	3.07	0.14	3.04	0.13	3.03	0.13	3.08	0.14
ln(z95-z50) for RKF selectivity (males, 1997-2004)	1	3.55	0.00	3.44	0.08	3.44	0.08	3.40	0.08	3.41	0.08	3.47	0.09
ln(z95-z50) for RKF selectivity (males, 2005+)	1	3.49	0.00	3.35	0.04	3.38	0.04	3.34	0.04	3.33	0.04	3.38	0.04
ln(z95-z50) for RKF selectivity (males, pre-1997)	1	2.79	0.00	2.78	0.59	2.78	0.60	2.79	0.60	2.77	0.60	2.77	0.61
ln(z95-z50) for RKF selectivity (males, 1997-2004)	1	2.85	0.00	2.89	0.88	2.90	0.88	2.89	0.87	2.89	0.90	2.88	0.90
ln(z95-z50) for RKF selectivity (males, 2005+)	1	2.99	0.00	2.96	0.22	2.96	0.21	2.94	0.21	2.97	0.21	2.98	0.21

		18C1		18C1a		18C2a		18C3a		18D0	
label	index	estimate	std. error	estimate	std. error	estimate	std. error	estimate	std. error	estimate	std. error
z95 for RKF selectivity (males, pre-1997)	1	163.00	5.30	162.02	5.77	162.15	6.01	161.72	6.13	162.59	5.45
z95 for RKF selectivity (males, 1997-2004)	1	180.00	0.00	180.00	0.00	180.00	0.00	180.00	0.00	180.00	0.00
z95 for RKF selectivity (males, 2005+)	1	180.00	0.00	180.00	0.00	180.00	0.00	180.00	0.00	180.00	0.00
z95 for RKF selectivity (females, pre-1997)	1	120.98	31.72	120.54	31.37	116.49	24.69	140.00	0.03	118.99	26.41
z95 for RKF selectivity (females, 1997-2004)	1	124.87	65.66	123.12	59.57	118.50	48.59	120.42	27.23	123.53	59.43
z95 for RKF selectivity (females, 2005+)	1	140.00	0.03	140.00	0.04	140.00	0.05	137.88	28.85	140.00	0.04
ln(z95-z50) for RKF selectivity (males, pre-1997)	1	3.05	0.13	3.09	0.14	3.08	0.15	3.08	0.15	3.05	0.13
ln(z95-z50) for RKF selectivity (males, 1997-2004)	1	3.42	0.08	3.48	0.09	3.48	0.09	3.49	0.09	3.41	0.08
ln(z95-z50) for RKF selectivity (males, 2005+)	1	3.34	0.04	3.38	0.04	3.41	0.04	3.42	0.04	3.35	0.04
ln(z95-z50) for RKF selectivity (males, pre-1997)	1	2.77	0.60	2.77	0.61	2.69	0.60	2.96	0.19	2.74	0.57
ln(z95-z50) for RKF selectivity (males, 1997-2004)	1	2.89	0.91	2.87	0.91	2.81	0.94	2.80	0.64	2.87	0.90
ln(z95-z50) for RKF selectivity (males, 2005+)	1	2.97	0.21	2.98	0.21	3.00	0.21	2.97	0.29	2.98	0.21

Table 23. Comparison of selectivity parameter estimates for the groundfish fisheries (GTF) for all model scenarios.

label	index	17AM estimate	17AM std. error	17AMu estimate	17AMu std. error	18A estimate	18A std. error	18B estimate	18B std. error	18C0 estimate	18C0 std. error	18C0a estimate	18C0a std. error
z50 for GF.AllGear selectivity (males, pre-1987)	1	55.02	0.00	57.32	2.25	57.16	2.23	60.26	3.35	68.19	4.27	59.82	2.14
z50 for GF.AllGear selectivity (males, 1987-1996)	1	59.07	0.00	64.85	7.59	64.65	7.76	82.01	11.69	86.90	9.70	61.46	5.48
z50 for GF.AllGear selectivity (males, 1997+)	1	80.84	0.00	90.45	2.63	90.09	2.58	108.53	3.41	110.06	3.20	87.45	2.31
z50 for GF.AllGear selectivity (males, pre-1987)	1	41.20	0.00	40.82	1.70	40.59	1.71	40.39	1.68	42.94	1.75	44.63	1.95
z50 for GF.AllGear selectivity (males, 1987-1996)	1	40.00	0.00	40.00	0.00	40.00	0.00	40.00	0.00	40.00	0.00	40.00	0.00
z50 for GF.AllGear selectivity (males, 1997+)	1	76.11	0.00	81.13	2.87	81.40	2.90	89.73	3.38	90.19	3.62	81.74	2.75
slope for GF.AllGear selectivity (males, pre-1987)	1	0.10	0.00	0.09	0.01	0.09	0.01	0.08	0.01	0.06	0.01	0.09	0.01
slope for GF.AllGear selectivity (males, 1987-1996)	1	0.06	0.00	0.04	0.01	0.04	0.01	0.03	0.00	0.03	0.00	0.05	0.01
slope for GF.AllGear selectivity (males, 1997+)	1	0.07	0.00	0.06	0.00	0.06	0.00	0.05	0.00	0.05	0.00	0.07	0.00
slope for GF.AllGear selectivity (females, pre-1987)	1	0.14	0.00	0.13	0.02	0.13	0.02	0.14	0.02	0.13	0.02	0.11	0.02

label	index	18C1 estimate	18C1 std. error	18C1a estimate	18C1a std. error	18C2a estimate	18C2a std. error	18C3a estimate	18C3a std. error	18D0 estimate	18D0 std. error
z50 for GF.AllGear selectivity (males, pre-1987)	1	65.16	3.86	59.55	2.19	58.09	1.98	57.33	1.87	54.44	2.69
z50 for GF.AllGear selectivity (males, 1987-1996)	1	84.46	7.26	66.69	4.79	69.43	5.03	65.08	5.20	65.34	8.09
z50 for GF.AllGear selectivity (males, 1997+)	1	107.66	3.14	86.90	2.28	86.05	2.04	84.16	1.97	108.00	3.46
z50 for GF.AllGear selectivity (males, pre-1987)	1	41.65	1.62	43.65	1.81	42.69	1.59	47.74	1.89	40.74	1.69
z50 for GF.AllGear selectivity (males, 1987-1996)	1	42.11	1.99	41.62	1.86	41.80	1.94	46.07	2.67	40.00	0.00
z50 for GF.AllGear selectivity (males, 1997+)	1	88.83	3.51	80.02	2.63	78.82	2.48	79.77	2.31	95.26	3.57
slope for GF.AllGear selectivity (males, pre-1987)	1	0.07	0.01	0.09	0.01	0.09	0.01	0.09	0.01	0.09	0.01
slope for GF.AllGear selectivity (males, 1987-1996)	1	0.04	0.00	0.05	0.01	0.05	0.01	0.05	0.01	0.03	0.01
slope for GF.AllGear selectivity (males, 1997+)	1	0.05	0.00	0.07	0.00	0.07	0.00	0.07	0.00	0.05	0.00
slope for GF.AllGear selectivity (females, pre-1987)	1	0.13	0.02	0.12	0.02	0.13	0.02	0.11	0.01	0.13	0.02

Table 24. Root mean square errors (RMSE) for fishery-related data components from the model scenarios. TCF: directed Tanner crab fishery; SCF: snow crab fishery; RKF: BBRKC fishery; GTF: groundfish fisheries. Rows consisting of all zero values indicate a data component which was not included in any of the models.

fleet	catch.type	data.type	fit.type	x	17AM	17AMu	18A	18B	18C0	18C0a	18C1	18C1a	18C2a	18C3a	18D0
GTF	total catch	abundance	BY_TOTAL	all sexes	0.00	1.23	1.19	1.34	1.33	1.18	1.28	1.17	1.27	1.31	1.41
		biomass	BY_TOTAL	all sexes	0.06	0.06	0.06	0.06	0.06	0.07	0.06	0.07	0.09	0.10	0.06
		n.at.z	BY_XE	female	411.55	375.73	374.07	370.62	392.96	401.93	386.04	394.18	390.27	378.12	364.70
				male	402.22	368.74	371.14	318.81	313.14	342.07	313.58	352.02	310.12	313.03	332.45
RKF	total catch	abundance	BY_X	female	16.84	29.73	26.16	24.43	27.50	31.38	30.15	33.22	25.63	243.70	25.37
				male	8.34	19.22	19.04	18.12	18.30	19.27	18.48	19.34	19.74	19.86	18.31
		biomass	BY_X	female	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.03	0.01
				male	0.18	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.19	0.19	0.17
		n.at.z	BY_X	female	50.11	51.08	50.27	49.28	50.43	51.18	49.65	49.89	51.16	42.02	53.59
				male	62.14	71.49	67.04	67.88	67.46	64.88	68.12	66.73	65.41	64.38	69.35
SCF	total catch	abundance	BY_X	female	11.76	12.38	12.21	12.73	12.31	13.38	11.70	12.71	11.12	14.30	12.20
				male	5.43	2.75	2.71	2.69	2.68	2.70	2.70	2.71	3.01	2.95	2.67
		biomass	BY_X	female	0.32	0.09	0.09	0.09	0.09	0.08	0.09	0.08	0.05	0.07	0.09
				male	0.08	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.08	0.08	0.07
		n.at.z	BY_X	female	63.54	68.98	69.38	71.22	69.80	68.30	70.41	69.35	72.79	74.39	69.30
				male	281.02	327.22	346.62	351.28	341.70	333.22	311.33	309.99	270.11	280.42	361.13
TCF	retained catch	abundance	BY_X	female	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
				male	3.27	3.82	3.99	3.98	4.04	4.06	4.06	4.03	4.46	4.50	3.94
		biomass	BY_X	female	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
				male	0.21	0.18	0.19	0.19	0.17	0.19	0.16	0.17	0.24	0.26	0.18
		n.at.z	BY_X	male	505.37	520.42	527.37	403.22	407.14	537.08	412.10	548.23	463.03	460.23	416.42
	total catch	abundance	BY_X	female		68.23	70.98	56.84	61.45	74.72	66.15	80.57	58.00	59.75	66.17
				male		1.22	1.16	1.09	1.11	1.20	1.12	1.20	1.10	1.09	1.06
		biomass	BY_X	female	0.56	0.29	0.28	0.28	0.30	0.30	0.31	0.31	0.28	0.28	0.29
				male	0.20	0.19	0.19	0.18	0.18	0.20	0.18	0.19	0.20	0.20	0.18
		n.at.z	BY_X	female	207.47	195.18	184.36	185.71	192.13	189.51	199.10	196.16	205.96	201.38	187.44
				male	455.17	348.77	346.02	413.43	410.06	337.85	405.06	334.33	317.20	309.97	406.67

Table 25. Root mean square errors (RMSE) for non-fishery-related data components from the model scenarios. Rows consisting of all zero values indicate a data component which was not included in any of the models.

category	fleet	catch.type	data.type	fit.type	x	17AM	17AMu	18A	18B	18C0	18C0a	18C1	18C1a	18C2a	18C3a	18D0
growth data	(blank)	(blank)	EBS	(blank)	female	0.30	0.34	0.34	0.36	0.39	0.36	0.42	0.39	0.46	0.41	0.35
					male	0.54	0.50	0.48	0.59	0.59	0.49	0.67	0.56	0.66	0.66	0.60
maturity data	(blank)	(blank)	MATURITY_OGIVES	(blank)	male	820.77	8,948.99	7,054.98	1.80	1.82	6.21	1.84	8.62	5.66	5.59	1.74
surveys data	NMFS (all by XM)	index catch	abundance	BY_XM	female	2.94	2.94	2.93	2.99	2.74	2.76	2.46	2.48	2.44	2.67	2.79
					male	3.07	3.05	3.05	3.13	3.05	3.15	2.65	2.78	2.55	2.68	3.32
			biomass	BY_X_MATONLY	female	2.28	2.37	2.37	2.43	2.28	2.25	2.30	2.29	2.03	2.37	2.42
					male	2.18	2.40	2.42	2.47	2.56	2.48	2.40	2.41	2.11	2.06	2.88
			n.at.z	BY_XME	female	444.33	433.14	425.44	400.73	400.38	403.24	317.22	335.14	414.03	226.70	370.93
					male	467.32	452.57	456.14	520.94	513.95	393.65	495.45	388.14	323.05	324.67	518.19
	NMFS (females by XM)	index catch	abundance	BY_X	female			3.02	3.01	2.72	2.78	2.36	2.40	2.47	2.49	2.75
					male			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
			biomass	BY_X	female			2.48	2.50	2.30	2.31	2.22	2.23	2.05	2.26	2.40
					male			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
			n.at.z	BY_X_ME	female			172.54	170.56	220.98	229.80	148.23	160.05	191.31	119.83	191.30
	NMFS (females by XMS)	index catch	abundance	BY_X	female			3.02	3.01	2.72	2.78	2.36	2.40	2.47	2.49	2.75
					male			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
			biomass	BY_X	female			2.48	2.50	2.30	2.31	2.22	2.23	2.05	2.26	2.40
					male			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
			n.at.z	BY_XM_SE	female			174.26	177.28	208.97	211.05	186.43	198.27	203.21	145.63	177.33
	NMFS (males by X)	index catch	abundance	BY_X	female			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
					male			3.48	3.48	3.38	3.39	2.76	2.82	2.77	2.86	3.51
			biomass	BY_X	female			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
					male			2.57	2.58	2.67	2.62	2.38	2.42	2.25	2.18	2.85
			n.at.z	BY_X	male			203.11	189.35	191.12	201.79	189.09	193.18	159.00	154.78	191.06
	NMFS (males by XS)	index catch	abundance	BY_X	female			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
					male			3.48	3.48	3.38	3.39	2.76	2.82	2.77	2.86	3.51
			biomass	BY_X	female			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
					male			2.57	2.58	2.67	2.62	2.38	2.42	2.25	2.18	2.85
			n.at.z	BY_X_SE	male			254.38	284.67	328.50	234.20	326.16	248.80	225.49	210.51	251.80

Table 26. Effective sample sizes used for NMFS EBS trawl survey size composition data for the 2017 assessment model (17AM) and the author's preferred model (18C2a). Effective sample sizes were estimated using the McAllister-Ianelli approach.

	17AM				18C2a			
	male		female		male		female	
year	input	effective	input	effective	input	effective	input	effective
1975	200	486.5	200	215.2	200	406.6	200	248.0
1976	201	531.8	201	309.2	201	580.7	201	254.3
1977	202	625.4	202	257.4	202	493.4	202	245.4
1978	203	548.6	203	348.6	203	516.5	203	348.6
1979	204	737.0	204	393.7	204	608.9	204	461.1
1980	205	385.9	205	1045.9	205	345.9	205	554.8
1981	206	947.9	206	190.9	206	693.5	206	251.0
1982	207	400.5	207	122.0	207	257.1	207	141.5
1983	208	638.7	208	415.6	208	240.2	208	190.8
1984	209	353.5	209	227.0	209	361.1	209	266.9
1985	210	170.8	210	160.4	210	177.4	210	145.6
1986	211	350.9	211	336.0	211	326.8	211	376.9
1987	212	614.8	212	187.7	212	372.7	212	391.6
1988	213	766.8	213	353.9	213	451.3	213	218.2
1989	214	2,211.2	214	275.2	214	634.7	214	393.3
1990	215	2,181.6	215	642.5	215	1242.9	215	372.3
1991	216	2,335.1	216	978.5	216	1209.4	216	478.8
1992	217	1,588.9	217	1108.2	217	909.7	217	2662.7
1993	218	1,248.3	218	693.8	218	1104.0	218	652.9
1994	219	1,306.2	219	320.7	219	672.0	219	625.7
1995	220	1,098.2	220	668.1	220	942.7	220	586.3
1996	221	1,214.6	221	786.0	221	1177.4	221	642.9
1997	222	1,355.8	222	534.6	222	507.2	222	503.4
1998	223	1,483.2	223	573.7	223	559.4	223	368.0
1999	224	576.7	224	563.7	224	398.4	224	491.1
2000	225	921.7	225	639.8	225	718.2	225	633.9
2001	226	1,532.9	226	651.4	226	721.8	226	479.6
2002	227	1,033.1	227	906.4	227	623.1	227	1117.5
2003	228	1,003.3	228	516.0	228	777.6	228	593.9
2004	229	467.3	229	500.9	229	338.2	229	479.1
2005	230	1,526.7	230	1691.6	230	978.1	230	5153.1
2006	231	745.9	231	762.2	231	897.6	231	1734.4
2007	232	496.4	232	802.7	232	461.3	232	682.3
2008	233	871.8	233	1450.9	233	1395.1	233	1376.9
2009	234	370.5	234	1082.1	234	519.5	234	2468.6
2010	235	516.2	235	11880.8	235	768.8	235	3865.0
2011	236	1,319.7	236	522.7	236	782.3	236	597.2
2012	237	755.3	237	731.4	237	701.6	237	750.0
2013	238	1,225.7	238	1442.4	238	578.9	238	1314.8
2014	239	806.5	239	447.3	239	483.2	239	583.2
2015	240	1,555.6	240	1005.3	240	825.8	240	631.2
2016	241	619.4	241	591.1	241	464.2	241	432.4
2017	242	262.6	242	878.4	242	293.2	242	621.1
2018	243	0.0	243	0.0	243	909.8	243	1048.5

Table 27. Effective sample sizes used for retained catch size composition data from the directed fishery for the 2017 assessment model (17AM) and the author's preferred model (18C2a). Effective sample sizes were estimated using the McAllister-Ianelli approach.

year	17AM		18C2a	
	input	effective	input	effective
1980	97.8	25.9	97.8	9.8
1981	83.1	1700.9	83.1	70.7
1982	99.3	1473.4	99.3	101.5
1983	12.3	49.0	12.3	279.6
1984	18.7	477.4	18.7	114.8
1988	91.0	134.6	91.0	25.1
1989	30.3	1665.3	30.3	40.7
1990	200.0	267.2	200.0	16.0
1991	200.0	155.0	200.0	38.6
1992	200.0	96.0	200.0	52.9
1993	200.0	138.3	200.0	81.5
1994	200.0	149.2	200.0	74.8
1995	11.2	187.1	11.2	79.2
1996	32.6	185.4	32.6	222.3
2005	5.2	14.2	5.2	23.8
2006	21.6	303.7	21.6	78.1
2007	51.0	1928.6	51.0	132.1
2008	25.6	967.3	25.6	242.0
2009	17.8	127.9	17.8	217.5
2013	35.0	704.9	4760.0	467.3
2014	103.3	209.1	14055.0	4671.6
2015	200.0	157.7	24420.0	3097.7
2017	0.0	0.0	3470.0	511.9

Table 28. Effective sample sizes used for total catch size composition data from the directed fishery for the 2017 assessment model (17AM) and the author's preferred model (18C2a). Effective sample sizes were estimated using the McAllister-Ianelli approach.

	17AM				18C2a			
	male		female		male		female	
year	input	effective	input	effective	input	effective	input	effective
1991	200.00	1323.53	41.19	512.91	200.00	427.09	41.19	214.98
1992	200.00	120.13	64.33	459.45	200.00	205.99	64.33	943.22
1993	200.00	266.87	76.94	346.24	200.00	281.21	76.94	461.54
1994	42.56	593.18	15.67	58.50	42.56	158.96	15.67	66.16
1995	41.07	297.71	22.92	90.45	41.07	526.66	22.92	100.21
1996	5.00	30.88	2.50	260.92	2.59	24.38	1.23	172.90
2005	144.87	97.45	8.13	39.41	144.87	292.09	8.13	40.23
2006	178.02	287.59	32.57	422.51	178.02	645.69	32.57	369.75
2007	200.00	374.32	24.38	317.54	200.00	390.77	24.38	302.29
2008	200.00	1149.76	4.75	45.79	200.00	467.14	4.75	45.83
2009	127.04	164.63	1.08	24.43	127.04	510.32	1.08	24.13
2013	127.03	1339.32	5.22	64.75	127.06	191.84	5.22	47.40
2014	200.00	199.41	8.75	188.58	200.00	222.97	8.75	168.28
2015	200.00	127.59	11.91	73.04	200.00	174.26	11.92	79.02
2017	0.00	0.00	0.00	0.00	138.04	238.55	12.65	53.46

Table 29. Effective sample sizes used for bycatch size composition data from the snow crab fishery for the 2017 assessment model (17AM) and the author's preferred model (18C2a). Effective sample sizes were estimated using the McAllister-Ianelli approach.

	17AM				18C2a			
	male		female		male		female	
year	input	effective	input	effective	input	effective	input	effective
1992	46.15	191.77	6.31	18.28	46.15	22.93	6.31	35.71
1993	51.21	118.05	11.33	30.66	51.21	43.21	11.33	34.70
1994	21.91	38.14	11.19	40.69	21.91	71.15	11.19	45.74
1995	13.95	87.31	3.15	41.80	13.95	23.77	3.15	28.10
1996	23.99	281.38	4.86	46.14	23.99	85.80	4.86	48.69
1997	29.17	446.96	4.83	111.24	29.17	204.61	4.83	218.63
1998	14.04	1013.79	2.38	21.37	14.04	470.54	2.38	133.39
1999	7.17	131.62	0.60	30.21	7.17	964.43	0.60	26.27
2000	9.09	273.09	0.54	30.53	9.09	164.16	0.54	41.20
2001	22.88	558.67	1.18	121.11	22.88	467.82	1.18	58.96
2002	7.22	59.52	0.87	45.45	7.22	600.53	0.87	190.70
2003	5.06	109.24	1.12	44.80	5.06	48.09	1.12	79.61
2004	6.23	23.03	5.20	30.57	6.23	100.23	5.20	68.31
2005	71.95	122.62	2.70	158.05	71.95	89.00	2.70	65.87
2006	76.36	77.06	9.23	51.76	76.36	77.80	9.23	31.44
2007	101.38	380.47	5.35	45.61	101.38	314.96	5.35	30.07
2008	62.13	95.87	5.31	14.70	62.13	89.39	5.31	18.57
2009	81.25	456.01	3.48	20.61	81.25	313.78	3.48	32.45
2010	88.72	370.05	1.84	74.01	88.72	372.14	1.84	97.69
2011	69.46	231.47	1.39	61.71	69.46	336.07	1.39	59.18
2012	53.91	205.80	1.40	46.53	80.86	176.76	1.98	86.06
2013	95.03	248.26	2.62	210.49	95.05	170.51	2.62	119.85
2014	182.80	537.54	5.91	65.09	182.81	477.46	5.91	147.47
2015	146.46	519.16	1.70	111.32	145.78	505.37	1.69	62.05
2016	142.83	448.51	1.71	115.68	120.28	511.10	1.93	28.79
2017	0.00	0.00	0.00	0.00	41.14	321.14	0.80	102.96

Table 30. Effective sample sizes used for bycatch size composition data from the BBRKC fishery for the 2017 assessment model (17AM) and the author's preferred model (18C2a). Effective sample sizes were estimated using the McAllister-Ianelli approach.

	17AM				18C2a			
	male		female		male		female	
year	input	effective	input	effective	input	effective	input	effective
1992	15.11	34.62	0.77	83.03	15.11	17.19	0.77	79.43
1993	54.08	34.67	8.79	279.54	54.08	21.54	8.79	265.07
1996	0.84	13.20	0.04	3.42	0.84	9.90	0.04	3.40
1997	7.57	20.27	0.30	24.25	7.57	13.72	0.30	25.76
1998	3.36	58.36	0.15	20.90	3.36	32.90	0.15	20.99
1999	1.52	50.29	0.10	17.39	1.52	46.02	0.10	17.83
2000	6.21	130.21	0.32	40.38	6.21	142.75	0.32	42.06
2001	3.35	112.01	0.29	50.48	3.35	60.08	0.29	55.91
2002	5.51	85.55	0.37	36.40	5.51	56.76	0.37	34.28
2003	4.08	57.06	0.34	53.49	4.08	54.71	0.34	52.61
2004	3.58	31.09	0.32	20.59	3.58	25.79	0.32	19.74
2005	7.22	37.83	0.51	12.73	7.22	31.99	0.51	12.01
2006	5.86	20.34	0.56	23.89	5.86	16.72	0.56	27.09
2007	10.28	73.02	0.67	102.12	10.28	64.28	0.67	78.00
2008	27.90	76.04	0.89	92.39	27.90	34.28	0.89	86.18
2009	24.95	20.48	0.53	108.02	24.95	14.64	0.53	154.77
2010	4.37	46.30	0.22	35.97	4.37	29.41	0.22	47.60
2011	2.53	59.79	0.03	5.97	2.53	42.02	0.03	5.87
2012	4.54	55.23	0.35	6.85	4.54	40.29	0.35	7.56
2013	15.50	94.38	0.44	9.65	15.50	139.71	0.44	10.57
2014	22.85	156.60	0.24	19.20	22.85	400.53	0.24	21.47
2015	16.07	139.96	1.34	86.70	15.98	196.65	1.37	111.66
2016	22.50	21.96	1.81	19.16	23.66	24.23	1.81	18.09
2017	0.00	0.00	0.00	0.00	27.79	53.65	0.63	29.82

Table 31. Effective sample sizes used for bycatch size composition data from the groundfish fisheries for the 2017 assessment model (17AM) and the author's preferred model (18C2a). Effective sample sizes were estimated using the McAllister-Ianelli approach.

	17AM				18C2a			
	male		female		male		female	
year	input	effective	input	effective	input	effective	input	effective
1973	39.92	371.37	39.92	232.67	39.92	308.38	39.92	201.35
1974	30.07	709.87	30.07	212.46	30.07	98.82	30.07	180.80
1975	15.36	333.21	15.36	199.27	15.36	129.55	15.36	167.93
1976	100.18	178.33	100.18	108.29	100.18	126.50	100.18	150.62
1977	140.14	233.89	140.14	325.53	140.14	214.78	140.14	337.34
1978	237.06	248.60	237.06	192.12	237.06	247.21	237.06	205.13
1979	223.45	584.09	223.45	875.10	223.45	622.40	223.45	775.29
1980	137.58	1080.51	137.58	424.17	137.58	656.54	137.58	783.23
1981	74.68	1035.30	74.68	56.30	74.68	451.18	74.68	62.71
1982	157.58	528.13	157.58	62.30	157.58	292.38	157.58	71.41
1983	195.96	347.14	195.96	135.20	195.96	445.54	195.96	168.16
1984	301.19	351.98	301.19	236.79	301.19	466.57	301.19	349.50
1985	263.48	169.12	263.48	280.17	263.48	183.55	263.48	290.60
1986	165.23	281.86	165.23	193.44	165.23	230.69	165.23	128.18
1987	289.26	266.60	289.26	672.50	289.26	198.16	289.26	470.49
1988	130.15	402.17	130.15	225.05	130.15	314.26	130.15	168.47
1989	400.00	810.58	400.00	606.73	400.00	457.50	400.00	852.72
1990	255.40	1013.39	255.40	312.90	255.40	649.57	255.40	306.58
1991	75.92	338.22	75.92	188.22	75.66	183.32	75.66	252.15
1992	30.53	179.85	30.53	63.30	31.62	114.87	31.62	62.18
1993	11.63	77.64	11.63	92.64	11.57	68.40	11.57	84.21
1994	40.22	241.29	40.22	426.54	40.03	210.69	40.03	598.33
1995	48.45	59.19	48.45	60.04	48.30	42.81	48.30	60.34
1996	85.93	181.81	85.93	584.16	86.02	126.48	86.02	713.26
1997	101.10	50.68	101.10	187.63	101.77	42.16	101.77	227.36
1998	119.95	124.55	119.95	325.76	121.58	96.89	121.58	322.34
1999	111.46	489.96	111.46	1176.86	114.45	313.16	114.45	990.75
2000	116.16	563.66	116.16	892.08	117.44	368.48	117.44	885.54
2001	135.38	756.03	135.38	1123.22	138.67	706.42	138.67	1245.99
2002	135.16	423.50	135.16	896.60	137.04	382.40	137.04	861.02
2003	89.37	197.86	89.37	299.08	90.42	192.77	90.42	286.79
2004	134.71	112.19	134.71	30.76	134.50	105.60	134.50	29.86
2005	157.52	1404.50	157.52	1906.46	157.94	1427.80	157.94	1306.29
2006	139.32	169.75	139.32	136.31	139.25	156.21	139.25	121.27
2007	146.56	159.69	146.56	83.73	146.72	176.60	146.72	109.52
2008	223.55	169.39	223.55	161.29	223.43	258.86	223.43	169.91
2009	160.43	292.38	160.43	514.35	160.04	224.74	160.04	463.05
2010	128.33	556.08	128.33	1997.06	127.90	436.35	127.90	1323.67
2011	150.25	86.39	150.25	69.21	149.63	71.11	149.63	62.53
2012	118.59	415.28	118.59	104.28	118.09	417.08	118.09	96.24
2013	244.77	354.67	244.77	427.18	244.56	277.86	244.56	346.96
2014	231.10	919.02	231.10	755.99	230.95	847.59	230.95	858.89
2015	242.33	204.96	242.33	201.14	242.14	276.33	242.14	194.37
2016	162.13	222.90	162.13	53.38	166.16	248.12	166.16	60.94
2017	0.00	0.00	0.00	0.00	98.61	88.47	98.61	158.03

Table 32. Comparison of fits to mature survey biomass by sex (in 1000's t) from the 2017 assessment model (17AM) and the author's preferred model (18C2a).

	17AM				18C2a			
	male		female		male		female	
year	observed	predicted	observed	predicted	observed	predicted	observed	predicted
1975	246.0	151.3	31.4	47.6	246.0	88.5	31.4	35.7
1976	126.2	135.6	31.2	42.2	126.2	103.4	31.2	35.5
1977	111.3	108.3	38.6	36.8	111.3	93.8	38.6	32.5
1978	77.9	79.5	25.8	34.1	77.9	72.0	25.8	30.8
1979	32.6	71.3	19.3	35.8	32.6	68.4	19.3	32.8
1980	86.8	74.2	63.8	38.8	86.8	79.7	63.8	36.2
1981	50.3	65.6	42.6	35.7	50.3	60.6	42.6	29.4
1982	51.7	71.8	64.1	26.1	51.7	89.1	64.1	27.3
1983	29.9	53.0	20.4	19.9	29.9	60.2	20.4	17.7
1984	25.8	36.0	14.9	15.1	25.8	32.2	14.9	11.3
1985	11.9	24.9	5.6	12.1	11.9	17.3	5.6	7.8
1986	13.3	30.2	3.4	12.3	13.3	22.8	3.4	8.4
1987	24.6	40.8	5.1	14.0	24.6	31.9	5.1	10.3
1988	61.0	55.2	25.4	16.2	61.0	45.3	25.4	13.2
1989	93.3	68.3	19.4	18.4	93.3	61.6	19.4	17.1
1990	97.8	73.2	37.7	19.8	97.8	75.2	37.7	20.8
1991	112.6	67.4	44.8	19.7	112.6	78.7	44.8	22.1
1992	105.5	60.5	26.2	17.8	105.5	80.0	26.2	19.9
1993	62.0	46.5	11.6	14.6	62.0	63.3	11.6	16.1
1994	43.8	34.9	9.8	11.3	43.8	48.2	9.8	12.2
1995	32.7	25.7	12.4	8.6	32.7	34.4	12.4	9.1
1996	27.5	19.1	9.6	6.7	27.5	24.3	9.6	6.9
1997	11.3	15.8	3.4	5.3	11.3	18.6	3.4	5.4
1998	10.9	13.9	2.3	4.5	10.9	15.6	2.3	4.6
1999	13.0	13.3	3.8	4.1	13.0	14.9	3.8	4.3
2000	16.9	14.3	4.1	4.2	16.9	15.9	4.1	4.4
2001	18.7	17.2	4.6	4.6	18.7	18.8	4.6	4.8
2002	19.0	20.8	4.5	5.2	19.0	22.1	4.5	5.5
2003	24.6	25.1	8.4	6.1	24.6	26.7	8.4	6.6
2004	27.0	31.2	4.7	7.4	27.0	33.8	4.7	8.0
2005	45.2	38.6	11.6	8.7	45.2	42.4	11.6	9.5
2006	67.9	45.7	14.9	9.9	67.9	50.4	14.9	11.0
2007	69.5	51.3	13.4	11.1	69.5	57.4	13.4	12.7
2008	65.1	57.4	11.7	11.3	65.1	66.9	11.7	12.9
2009	38.2	57.6	8.5	10.1	38.2	67.9	8.5	11.4
2010	39.1	51.0	5.5	8.6	39.1	58.7	5.5	9.5
2011	43.3	44.4	5.4	8.0	43.3	48.8	5.4	8.6
2012	42.2	42.9	12.4	9.5	42.2	43.7	12.4	9.9
2013	67.0	53.5	17.8	12.4	67.0	52.2	17.8	13.3
2014	82.4	68.9	14.9	13.9	82.4	71.2	14.9	15.2
2015	62.9	70.1	11.2	12.9	62.9	76.5	11.2	14.1
2016	61.6	58.4	7.6	10.9	61.6	62.6	7.6	11.7
2017	50.2	50.4	7.1	9.1	50.3	52.5	7.1	9.6
2018	0.0	0.0	0.0	0.0	39.7	43.0	5.0	8.0

Table 33. Comparison of estimates of mature biomass-at-mating by sex (in 1000's t) from the 2017 assessment model (17AM) and the author's preferred model (18C2a).

	17AM		18C2a	
year	male	female	male	female
1948	0	0	0	0
1949	0	0	0	0
1950	0.009753246	0.02774891	0.00874904	0.063202653
1951	0.131970629	0.234701881	0.153484831	0.507529769
1952	0.94871004	0.955164729	1.245953272	1.865309449
1953	3.611103293	2.1565015	5.116882387	3.743586777
1954	7.711396607	3.356105544	10.92030416	5.28604712
1955	11.36358993	4.289904136	15.35141915	6.302834771
1956	14.12832281	4.983967485	18.13181045	6.91177379
1957	16.23377022	5.515314578	19.73673808	7.229582135
1958	17.89033963	5.95230712	20.5047403	7.352622163
1959	19.30241872	6.361197085	20.73697447	7.368535699
1960	20.66622422	6.819618995	20.67824603	7.367338971
1961	22.21038807	7.447216376	20.55064775	7.468021182
1962	24.3603082	8.495310734	20.69920679	7.904642326
1963	28.0423788	10.61954333	21.76850483	9.317730615
1964	35.73069743	15.50247038	25.51939418	13.47019591
1965	51.93156306	26.23931466	34.84234646	23.61984104
1966	88.91861151	45.2957339	61.16149567	41.77768569
1967	140.4952734	69.41270987	99.14493065	62.70222638
1968	203.7600725	90.06541092	147.126059	76.15944763
1969	243.2097499	101.1500084	166.3206347	77.14605774
1970	258.7122044	103.8018915	155.0949832	69.48814462
1971	260.1266115	102.6802251	127.1457559	59.89244434
1972	258.1504522	101.3005337	98.32720828	54.85721617
1973	254.6861908	99.14715773	80.95080357	58.6241976
1974	242.2662247	94.6383325	85.00025941	69.18941281
1975	227.1891916	87.69785555	115.1034442	77.43643104
1976	186.473773	77.66089208	124.5354207	75.9081575
1977	129.9684253	67.54734665	99.25062151	69.16509941
1978	95.81290675	62.74041265	82.42598617	66.64668533
1979	74.51406023	65.25531191	76.57220979	71.76222219
1980	70.18970225	67.02610086	58.81168532	66.44845085
1981	75.02368911	61.86011113	53.52160482	53.24584419
1982	70.13278496	51.22428422	48.94717294	38.44339845
1983	53.38830743	39.19031505	34.10106179	24.85826882
1984	34.57446477	29.53862013	16.85432733	15.75811423
1985	32.59021079	25.25788251	15.91052502	13.15946734
1986	39.33706895	25.72031401	20.90435257	14.47862191
1987	51.54242586	29.25465741	28.27547938	17.75490823
1988	68.26934259	33.91815334	38.53393876	22.92489412
1989	74.35445555	38.16349517	43.33991811	29.51888907
1990	68.62533782	40.64741485	43.2399229	35.18588676
1991	65.90342978	40.24607632	52.52931102	36.40506185
1992	56.56527702	35.95282087	51.30683818	32.7786777
1993	48.76682348	29.7159847	48.35421119	26.44039567
1994	39.40827912	23.17953613	38.77828929	20.06072731
1995	29.66394491	17.71933308	28.19427921	14.984796
1996	23.8983033	13.72675195	20.80695368	11.27135785
1997	20.05324655	10.98545369	16.16618072	8.996619619
1998	17.68383935	9.287774047	13.96569586	7.721231384
1999	17.49505639	8.580260225	13.60086626	7.282752287
2000	19.0550529	8.852241446	14.54325435	7.624894698
2001	22.75580371	9.696135921	16.93966883	8.310527636
2002	27.79133714	11.01504722	20.34417499	9.558627064
2003	33.81032102	12.9270149	24.83492644	11.45243119
2004	41.86846477	15.5717348	31.32421886	13.9981476
2005	51.22648645	18.28719406	38.70198015	16.40227927
2006	59.78152957	20.81058775	45.41569938	19.07777358
2007	66.96955261	23.27900883	51.66465136	21.85529938
2008	75.93886678	23.67594905	61.06559399	21.93125849
2009	76.54785201	21.19296441	62.26036174	19.2000384
2010	68.34174694	18.01164494	54.36614907	16.06442724
2011	59.11264433	16.78623438	44.94389376	14.7268673
2012	57.8271061	20.06170466	40.53921435	17.49253455
2013	70.60763208	26.14124162	46.93583482	23.13170534
2014	84.80739378	29.20067585	58.70050211	25.95901614
2015	83.77828898	27.13037226	60.99617582	23.74779873
2016	77.96516575	22.90670902	57.69865264	19.74438003
2017	0	0	47.03929982	16.20287345

Table 34. Estimated population size (millions) for females on July 1 of year. from the author’s preferred model, Model B2b.
<<Table too large: available online in the zip file “TannerCrab.PopSizeStructure.csvs.zip”.>>

Table 35. Estimated population size (millions) for males on July 1 of year. from the author’s preferred mode, Model B2b.
<<Table too large: available online as a zipped csv file “TannerCrab.PopSizeStructure.csvs.zip”.>>

Table 36. Comparison of estimates of recruitment (in millions) from the 2017 assessment model (17AM) and the author's preferred model (18C2a).

year	17AM	18C2a
1948	66.59	93.87
1949	66.58	92.48
1950	66.64	89.91
1951	66.90	86.48
1952	67.56	82.58
1953	68.86	78.67
1954	71.24	75.26
1955	75.36	73.01
1956	82.49	72.86
1957	95.22	76.53
1958	119.81	88.03
1959	174.76	119.88
1960	320.74	217.60
1961	719.29	522.83
1962	1397.35	1119.44
1963	1665.55	1395.47
1964	1398.08	1046.78
1965	1095.79	627.47
1966	943.74	381.65
1967	937.10	285.05
1968	1014.12	349.91
1969	983.26	938.10
1970	834.92	1411.49
1971	554.32	999.11
1972	362.83	561.77
1973	308.42	406.02
1974	632.20	641.55
1975	1239.52	1160.31
1976	957.43	1116.79
1977	420.64	703.67
1978	177.55	162.54
1979	108.77	101.02
1980	177.84	98.44
1981	100.63	86.47
1982	488.76	242.07
1983	402.54	246.14
1984	541.74	410.08
1985	523.34	512.78

year	17AM	18C2a
1986	519.28	602.84
1987	355.29	385.04
1988	170.75	173.17
1989	52.30	70.47
1990	41.79	32.49
1991	36.99	31.57
1992	37.07	34.21
1993	48.83	43.33
1994	62.53	53.33
1995	57.52	56.23
1996	167.46	123.75
1997	67.08	63.29
1998	224.50	177.06
1999	116.92	113.95
2000	382.14	307.76
2001	122.98	117.46
2002	369.14	332.86
2003	359.66	348.56
2004	97.76	131.48
2005	74.94	86.24
2006	57.91	58.33
2007	89.13	62.10
2008	580.85	336.64
2009	514.37	528.84
2010	210.36	253.74
2011	40.96	61.14
2012	112.31	104.03
2013	84.14	63.12
2014	55.17	47.62
2015	77.52	65.74
2016	457.92	354.62
2017	0.00	662.47

Table 37. Comparison of exploitation rates (i.e., catch divided by biomass) from the 2017 assessment model 17AM) and the author's preferred model (18C2a).

year	17AM	18C2a	year	17AM	18C2a
1949	0.0018	0.0019	1986	0.0195	0.0104
1950	0.0029	0.0033	1987	0.0319	0.0199
1951	0.0045	0.0051	1988	0.0407	0.0312
1952	0.0066	0.0070	1989	0.0915	0.0861
1953	0.0097	0.0096	1990	0.1524	0.1513
1954	0.0130	0.0125	1991	0.1473	0.1319
1955	0.0152	0.0144	1992	0.1748	0.1604
1956	0.0164	0.0156	1993	0.1302	0.1023
1957	0.0167	0.0158	1994	0.0983	0.0823
1958	0.0170	0.0161	1995	0.0872	0.0723
1959	0.0168	0.0160	1996	0.0481	0.0548
1960	0.0165	0.0159	1997	0.0394	0.0415
1961	0.0160	0.0159	1998	0.0381	0.0260
1962	0.0144	0.0147	1999	0.0172	0.0151
1963	0.0123	0.0123	2000	0.0141	0.0163
1964	0.0107	0.0104	2001	0.0157	0.0215
1965	0.0167	0.0189	2002	0.0096	0.0117
1966	0.0167	0.0188	2003	0.0066	0.0070
1967	0.0452	0.0538	2004	0.0074	0.0077
1968	0.0499	0.0616	2005	0.0123	0.0140
1969	0.0656	0.0878	2006	0.0184	0.0191
1970	0.0612	0.0904	2007	0.0220	0.0213
1971	0.0521	0.0832	2008	0.0146	0.0162
1972	0.0464	0.0755	2009	0.0121	0.0142
1973	0.0561	0.0927	2010	0.0064	0.0078
1974	0.0747	0.1109	2011	0.0088	0.0095
1975	0.0648	0.0812	2012	0.0053	0.0070
1976	0.1007	0.1102	2013	0.0153	0.0189
1977	0.1398	0.1413	2014	0.0522	0.0604
1978	0.1176	0.1010	2015	0.0707	0.0833
1979	0.1509	0.1039	2016	0.0098	0.0117
1980	0.0926	0.0692	2017	0.0000	0.0245
1981	0.0468	0.0355			
1982	0.0253	0.0207			
1983	0.0132	0.0124			
1984	0.0262	0.0293			
1985	0.0156	0.0085			

Table 38. Values required to determine Tier level and OFL for the models considered here. These values are presented only to illustrate the effect of incremental changes in the model scenarios. Results from the author's preferred model 18C2a) are highlighted in green.

Model Scenario	average recruitment	Final MMB	B0	Bmsy	Fmsy	MSY	Fofl	OFL	projected MMB	projected MMB / Bmsy
	millions	1000's t	1000's t	1000's t		1000's t		1000's t	1000's t	
17AM (B2b)	213.96	80.58	83.34	29.17	0.75	12.26	0.75	25.42	43.32	1.49
17AMu	371.11	136.48	111.38	38.98	1.25	18.03	1.25	50.85	63.55	1.63
18A	391.22	114.10	120.00	42.00	1.22	19.24	1.22	42.01	53.87	1.28
18B	464.60	124.18	130.45	45.66	2.61	22.35	2.61	55.40	48.01	1.05
18C0	536.07	122.84	124.39	43.54	3.06	24.32	3.04	56.15	43.25	0.99
18C0a	366.37	99.63	100.92	35.32	1.07	18.13	1.07	35.44	46.25	1.31
18C1	540.64	128.64	129.28	45.25	2.79	25.90	2.78	58.26	45.12	1.00
18C1a	404.67	110.14	109.74	38.41	1.14	20.41	1.14	39.87	49.67	1.29
18C2a	199.49	50.12	63.01	22.05	0.91	11.54	0.91	16.76	24.06	1.09
18C3a	188.34	49.93	63.61	22.26	0.79	10.84	0.79	15.93	25.44	1.14
18D0	503.62	145.40	149.02	52.16	2.64	24.09	2.64	65.30	57.35	1.10

Figures

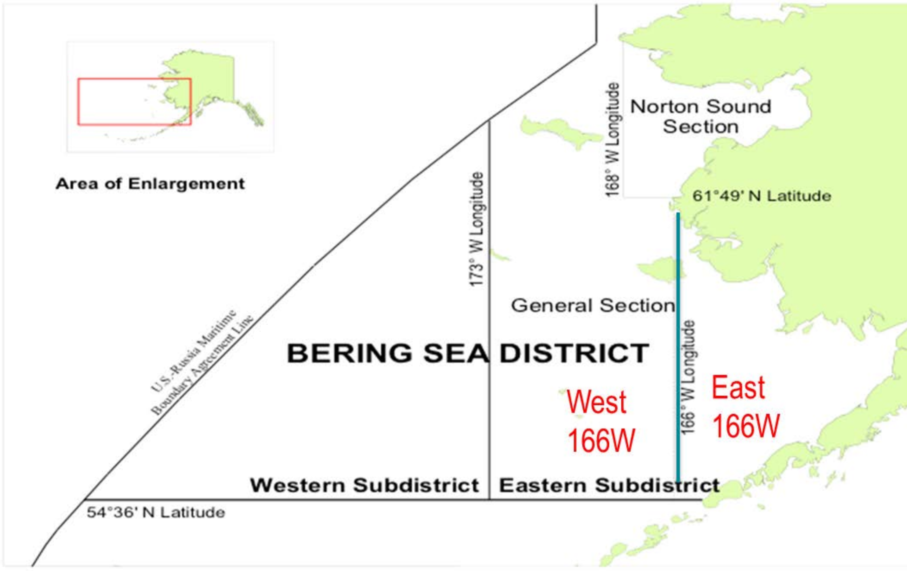


Figure 1. Eastern Bering Sea District of Tanner crab Registration Area J including sub-districts and sections (from Bowers et al. 2008).

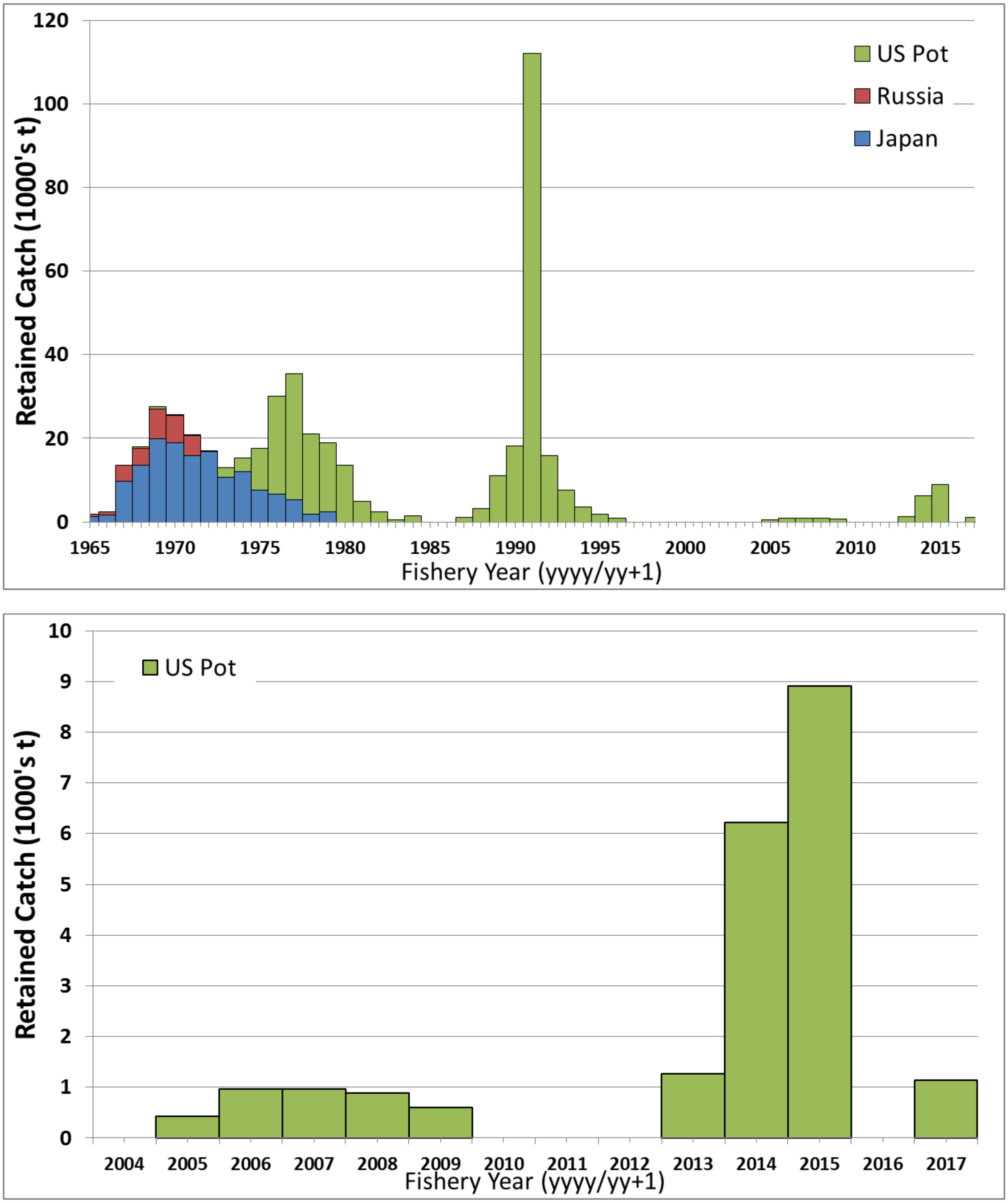
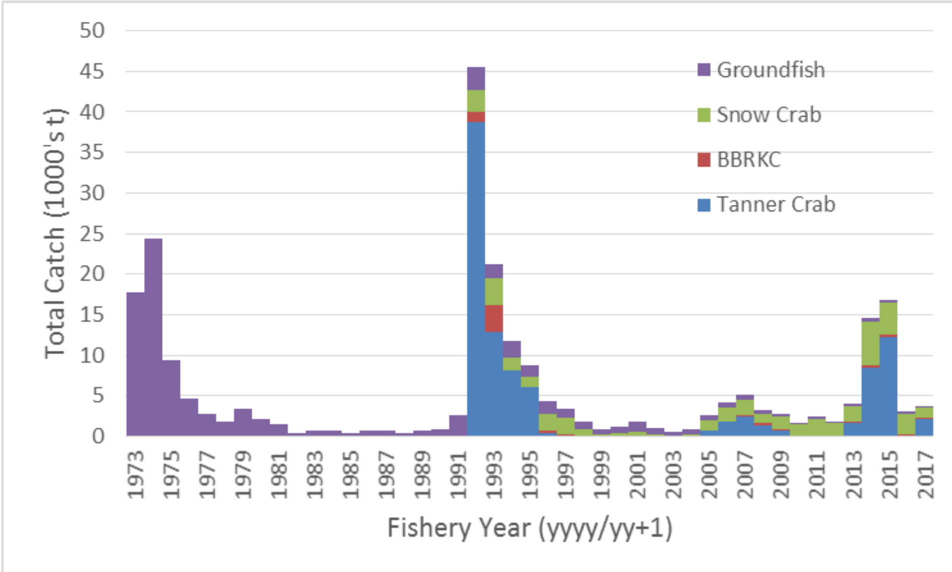


Figure 2. Upper: retained catch (males, 1000's t) in the directed fisheries (US pot fishery [green bars], Russian tangle net fishery [red bars], and Japanese tangle net fisheries [blue bars]) for Tanner crab since 1965/66. Lower: Retained catch (males, 1000's t) in directed fishery since 2001/02. The directed fishery was closed from 1996/97 to 2004/05, from 2010/11 to 2012/13, and in 2016/17.



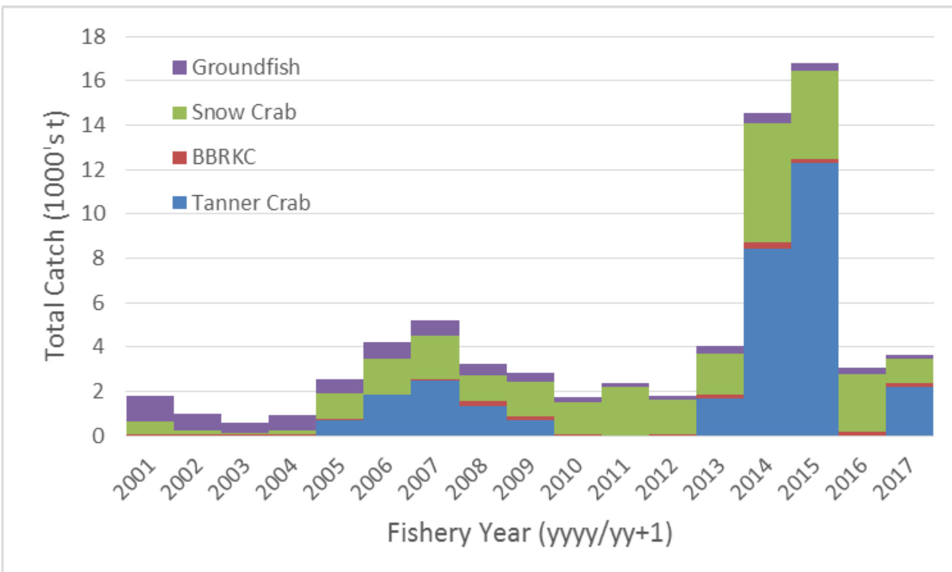


Figure 3. Upper: total catch (retained + discards) of Tanner crab (males and females, 1000's t) in the directed Tanner crab, snow crab, Bristol Bay red king crab, and groundfish fisheries. Bycatch reporting began in 1973 for the groundfish fisheries and in 1992 for the crab fisheries. Lower: detail since 2001.

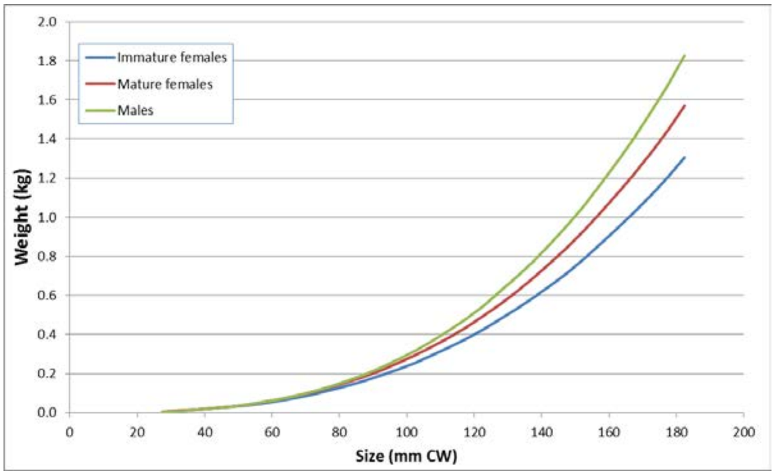


Figure 4. Size-weight relationships developed from NMFS EBS summer trawl survey data.

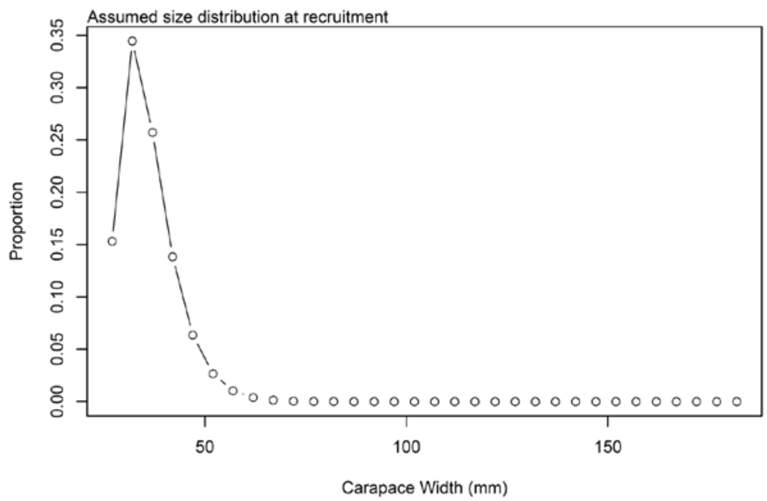


Figure 5. Assumed size distribution for recruits entering the population.

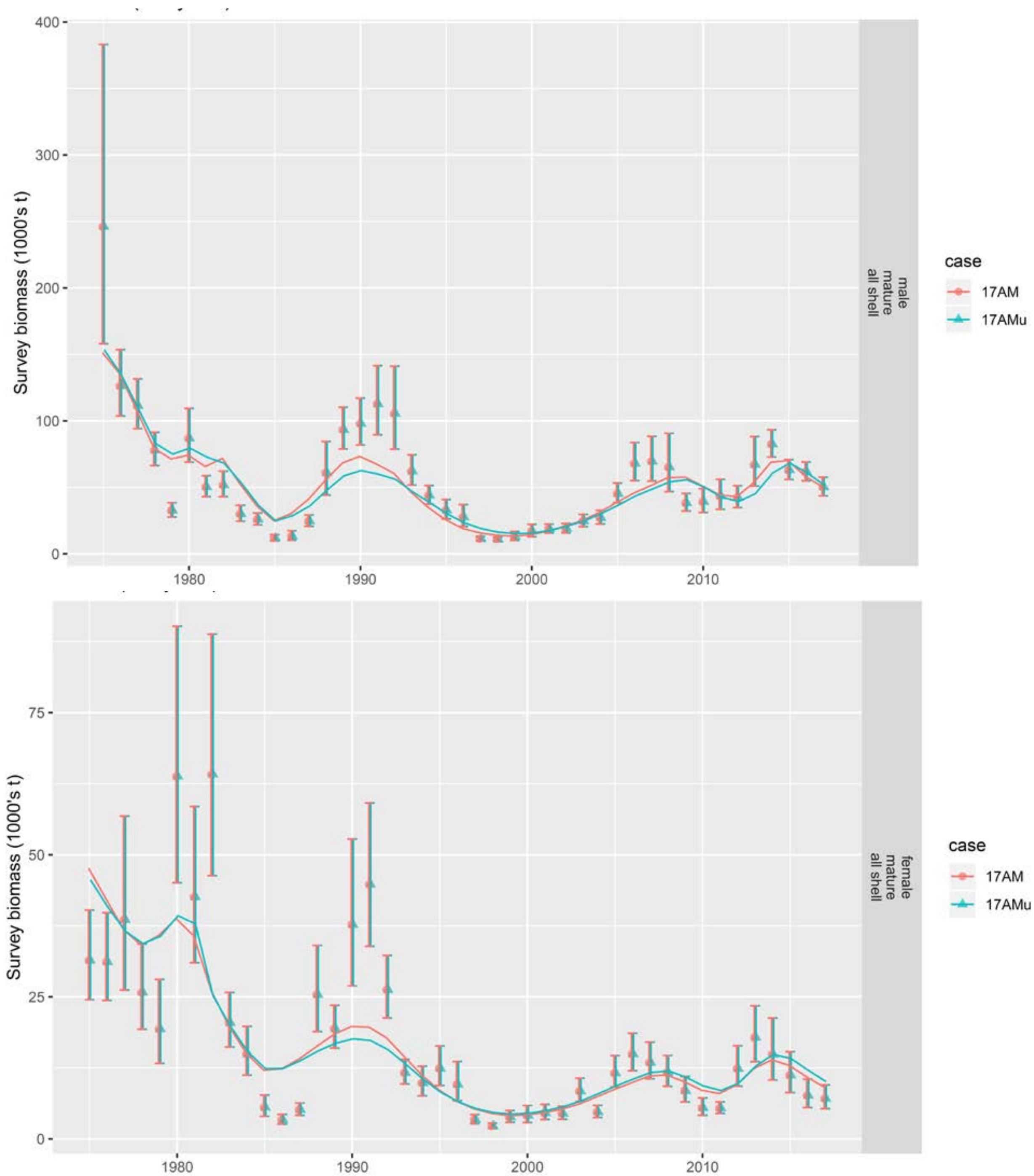


Figure 6. Fits to mature survey biomass for scenarios 17AM and 17AMu. Points: input data; lines: model estimates.

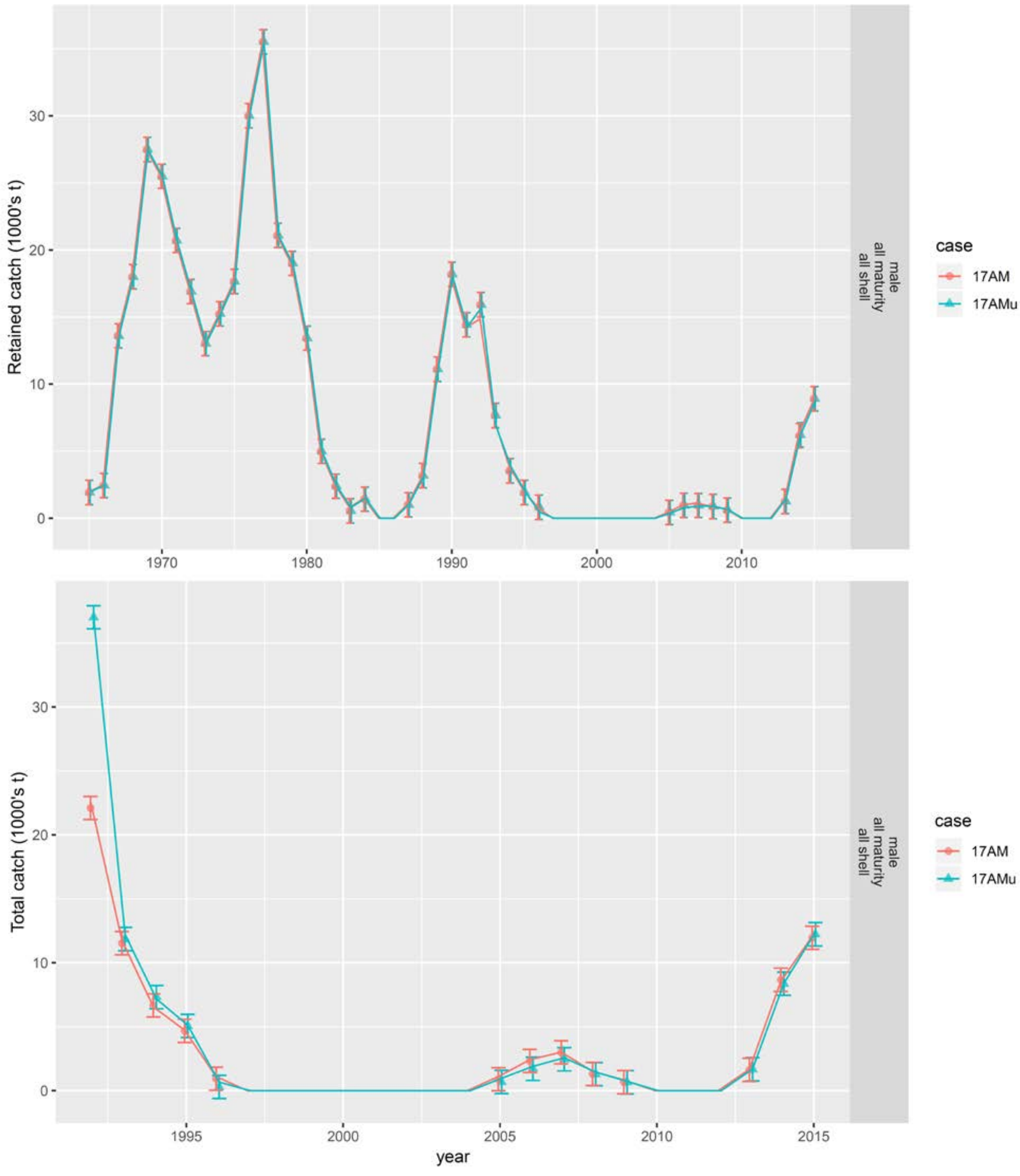


Figure 7. Fits to retained catch biomass (upper) and total male catch biomass (lower) for the directed fishery for scenarios 17AM and 17AMu. Points: input data; lines: model estimates.

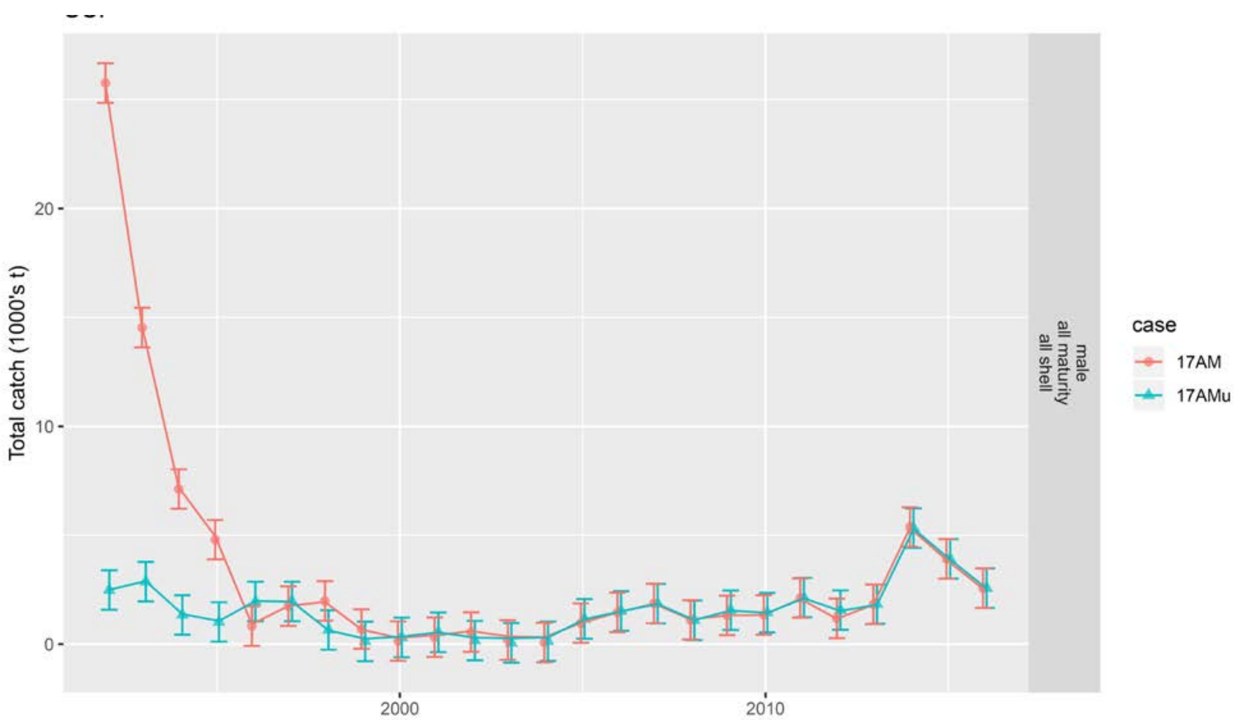


Figure 8. Fits to total male bycatch biomass for the snow crab fishery for scenarios 17AM and 17AMu. Points: input data; lines: model estimates.

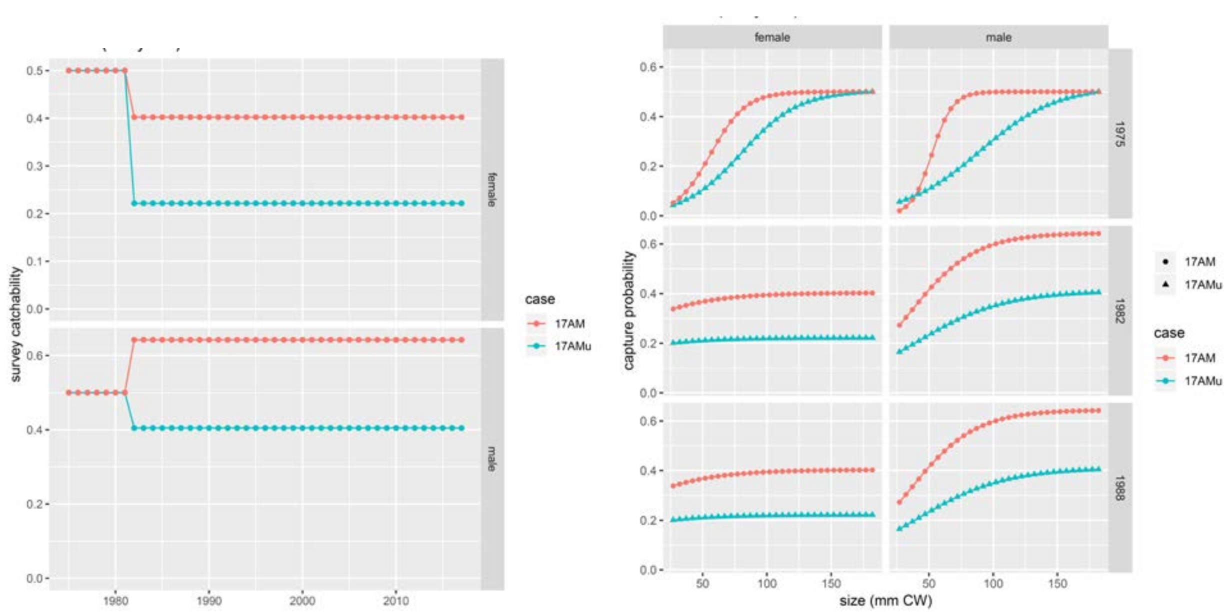


Figure 9. Estimated survey catchabilities (left) and capture probabilities (catchability x selectivity; right) for scenarios 17AM and 17AMu.

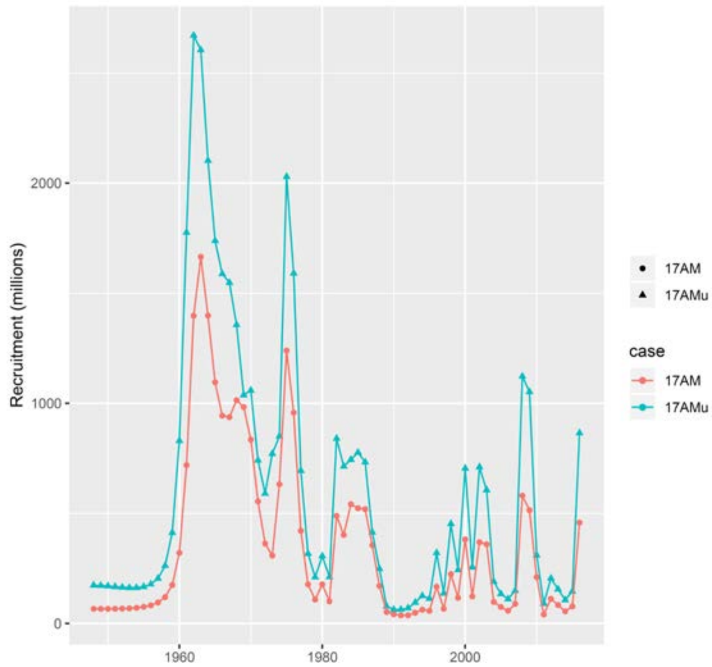


Figure 10. Estimated recruitment for scenarios 17AM and 17AMu.

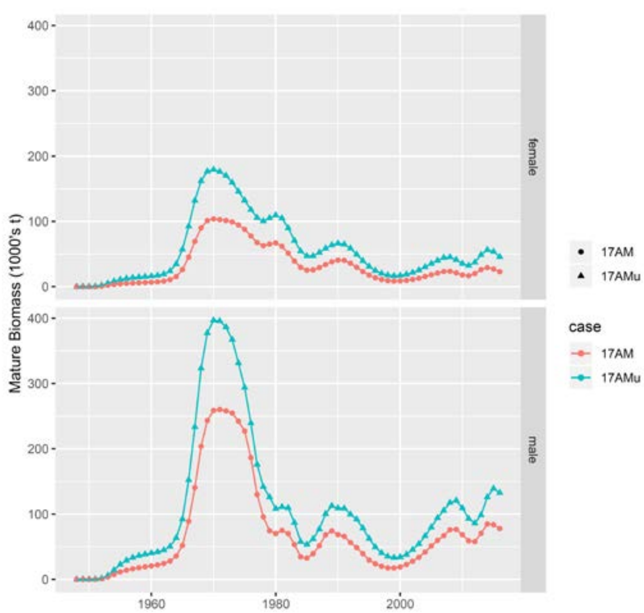


Figure 11. Estimated mature biomass for scenarios 17AM and 17AMu.

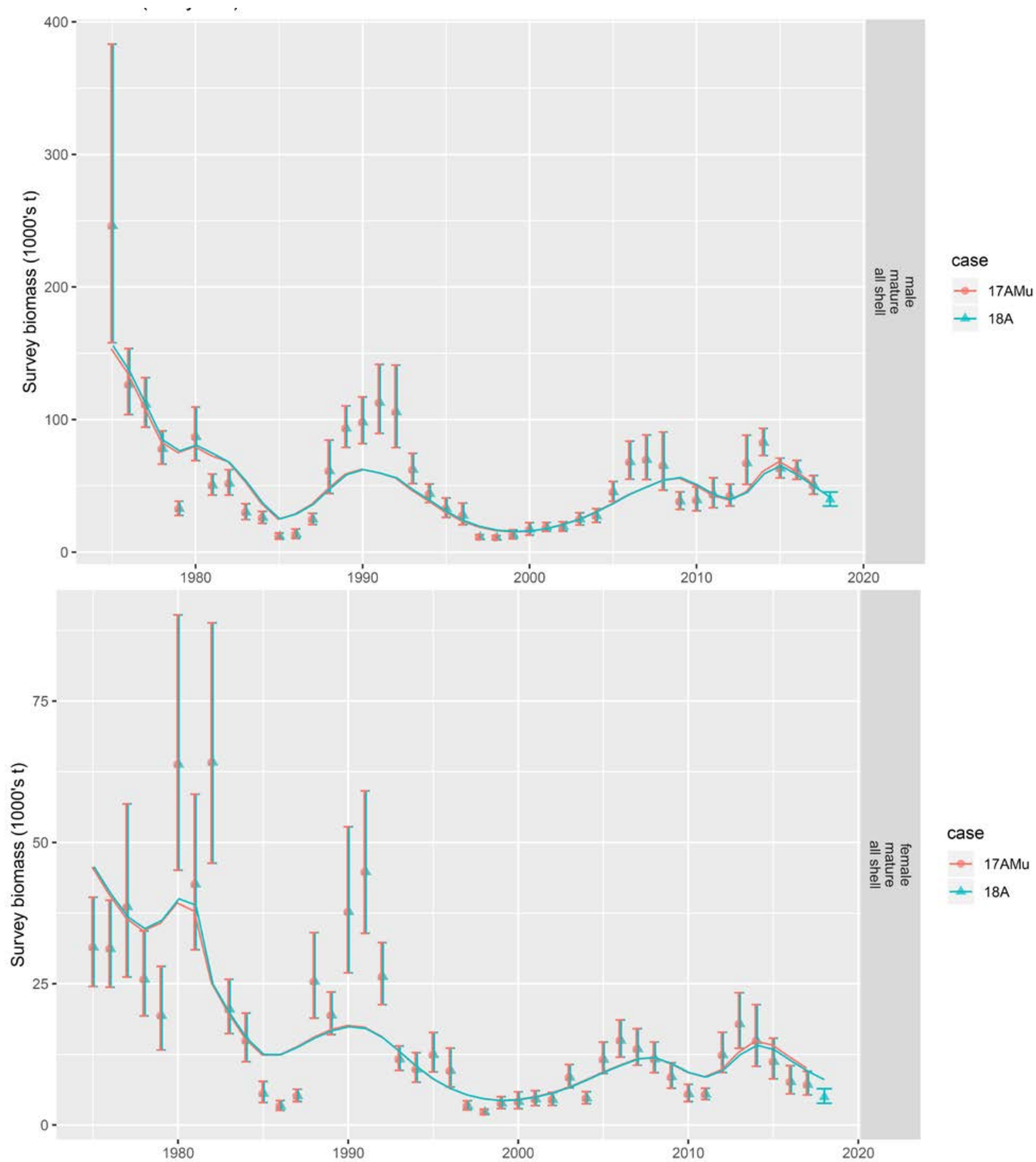
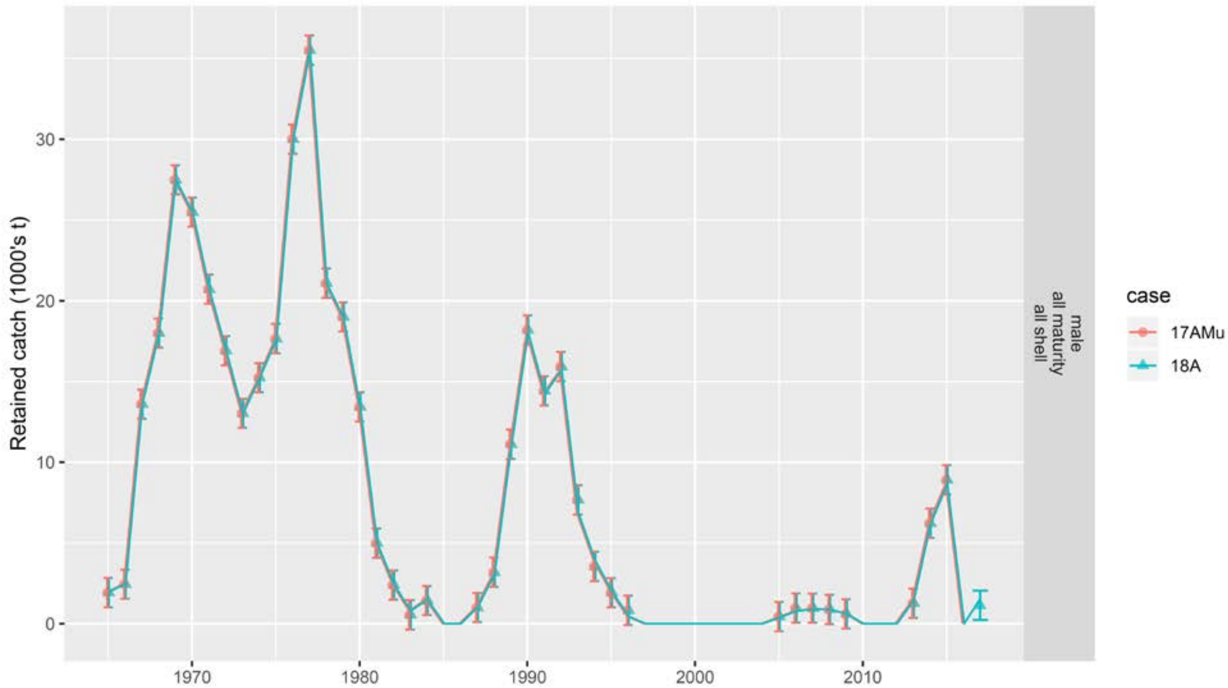


Figure 12. Fits to mature survey biomass for scenarios 17AMu and 18A. Points: input data; lines: model estimates.



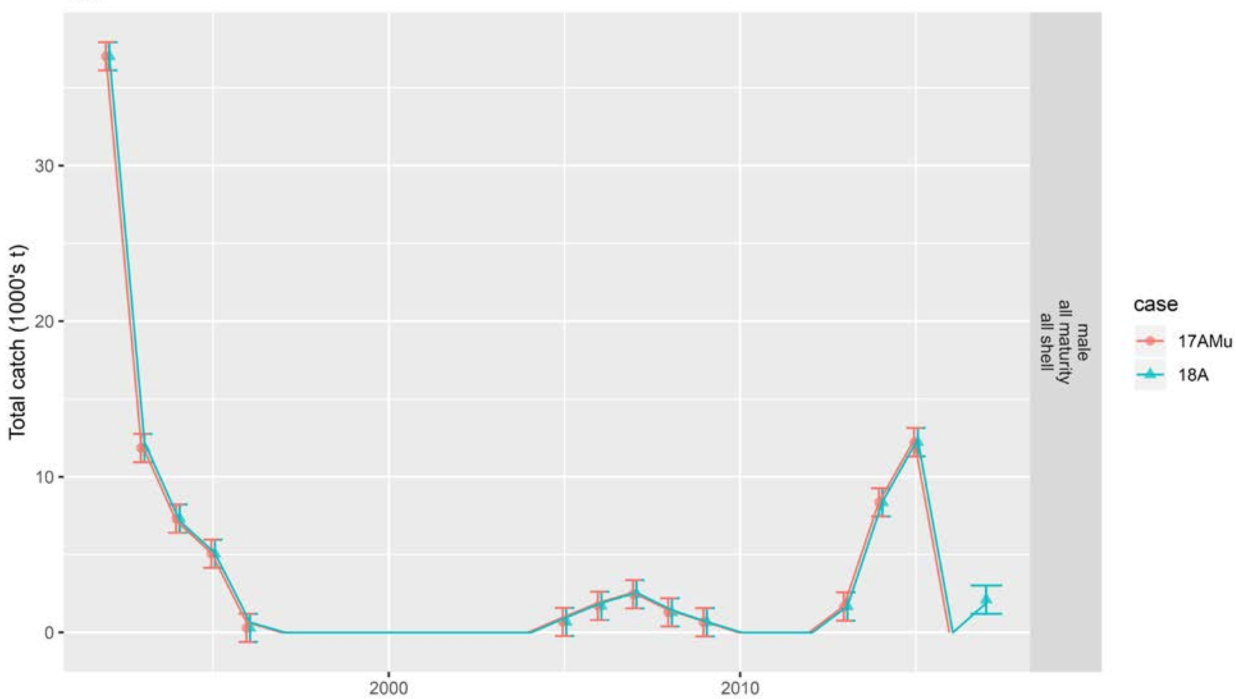


Figure 13. Fits to retained catch biomass (upper) and total male catch biomass (lower) for the directed fishery for scenarios 17AMu and 18A. Points: input data; lines: model estimates.

Figure 14. Fits to total male bycatch biomass for the snow crab fishery for scenarios 17AMu and 17AMu. Points: input data; lines: model estimates.

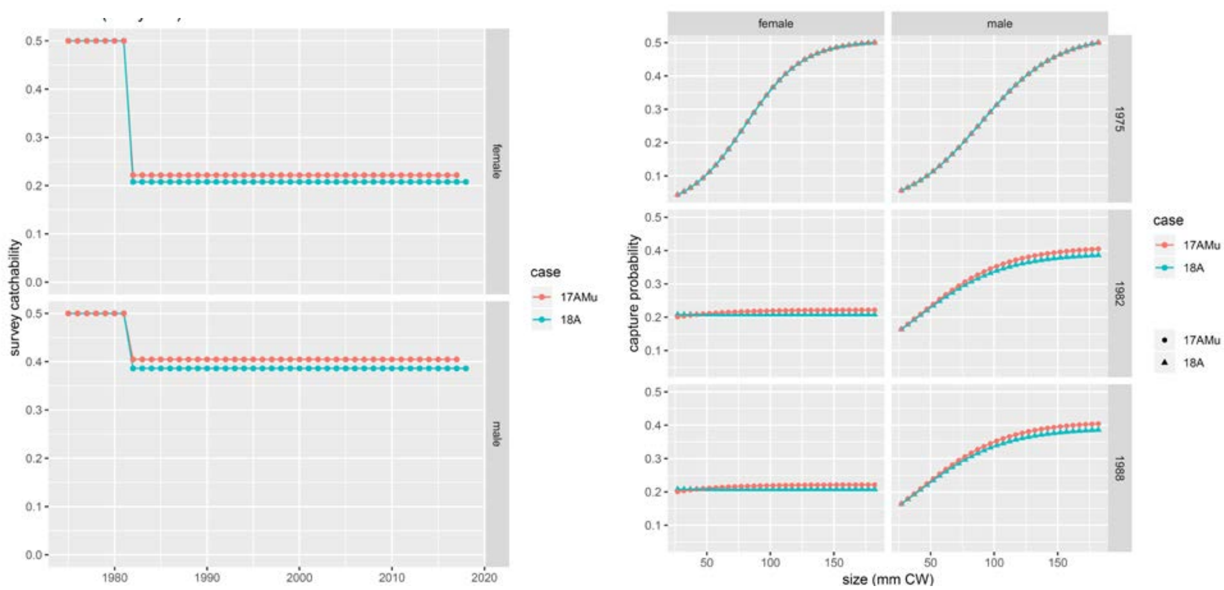


Figure 15. Estimated survey catchabilities (left) and capture probabilities (catchability x selectivity; right) for scenarios 17AMu and 18A.

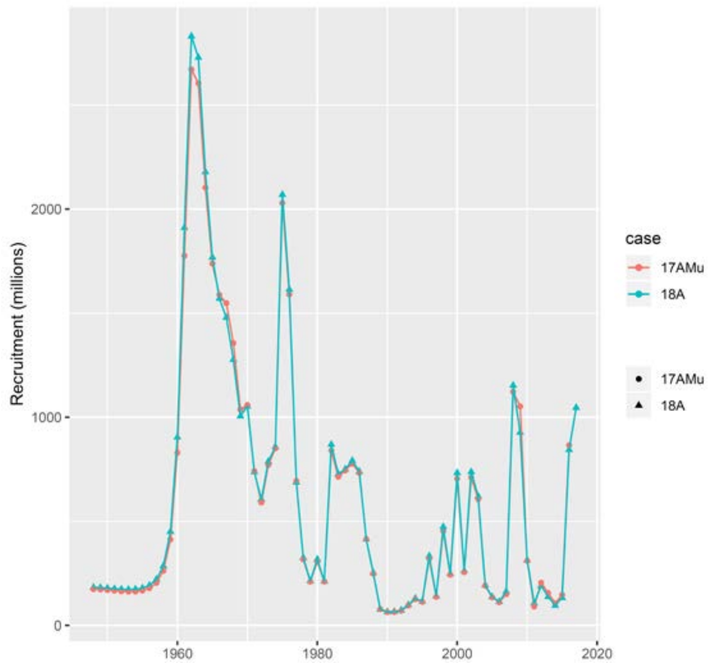


Figure 16. Estimated recruitment for scenarios 17AMu and 18A.

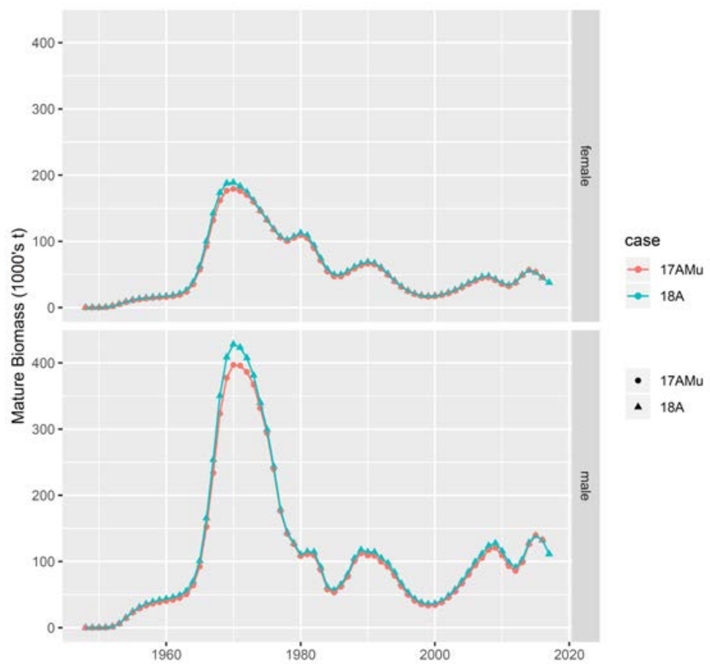


Figure 17. Estimated mature biomass for scenarios 17AMu and 18A.

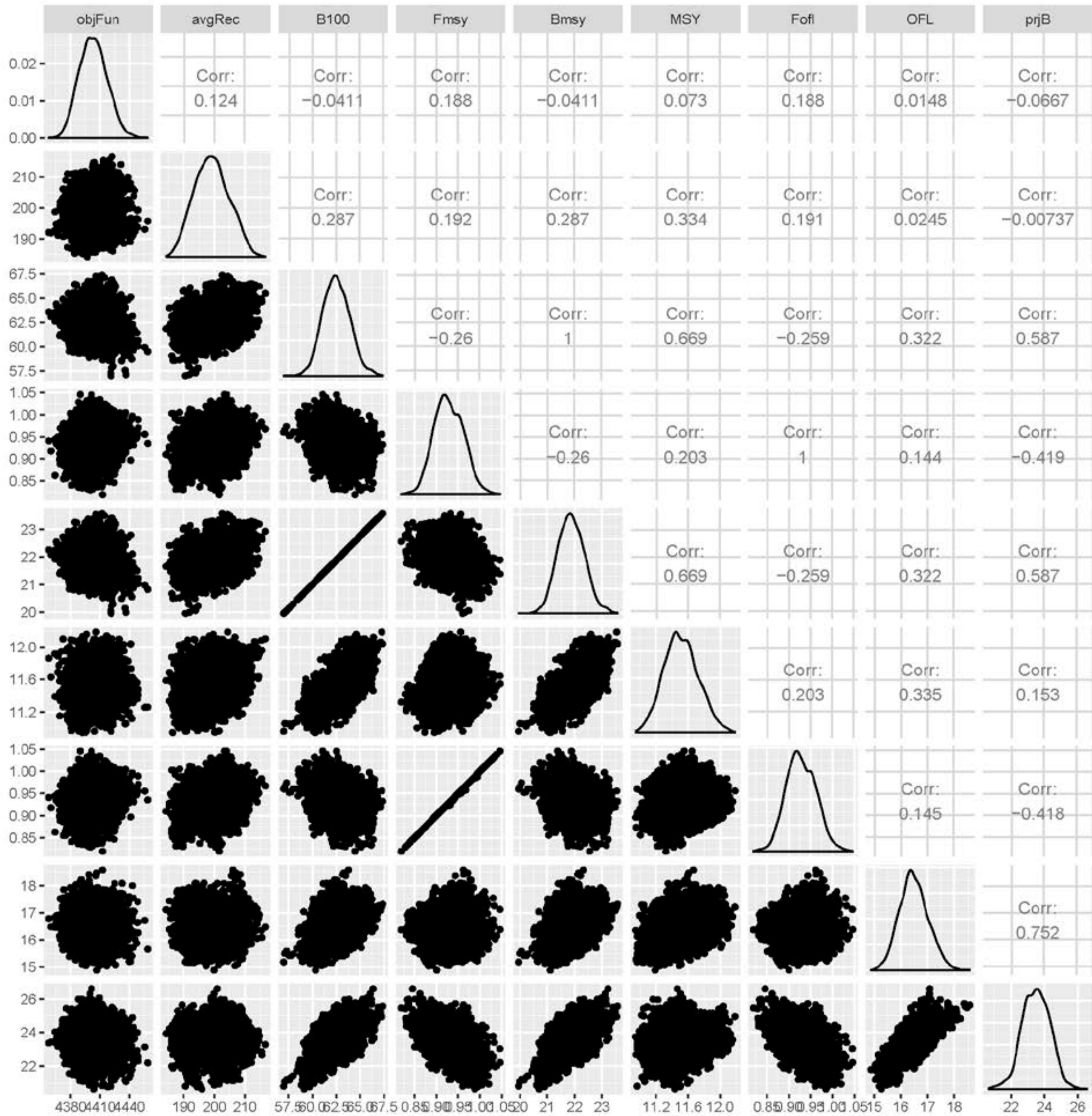


Figure 18. MCMC results from scenario 18C2a, the author’s preferred model, for OFL-related quantities.

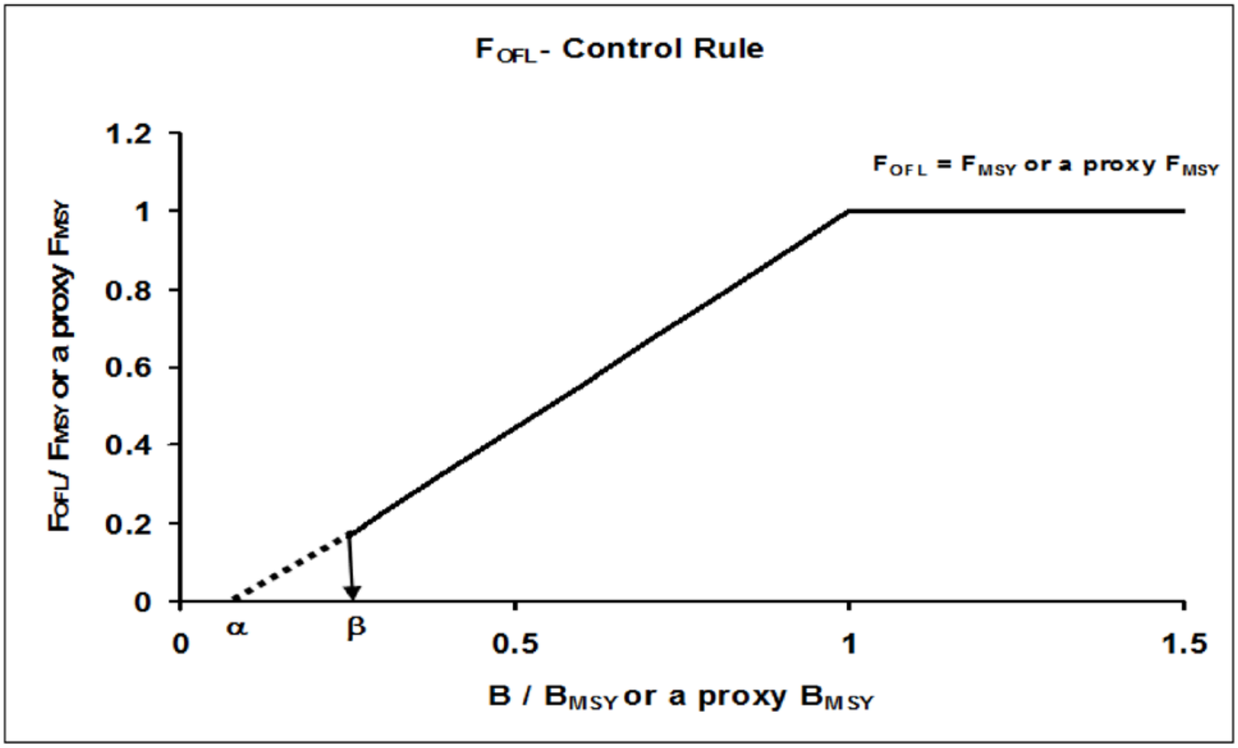


Figure 19. The F_{OFL} harvest control rule.

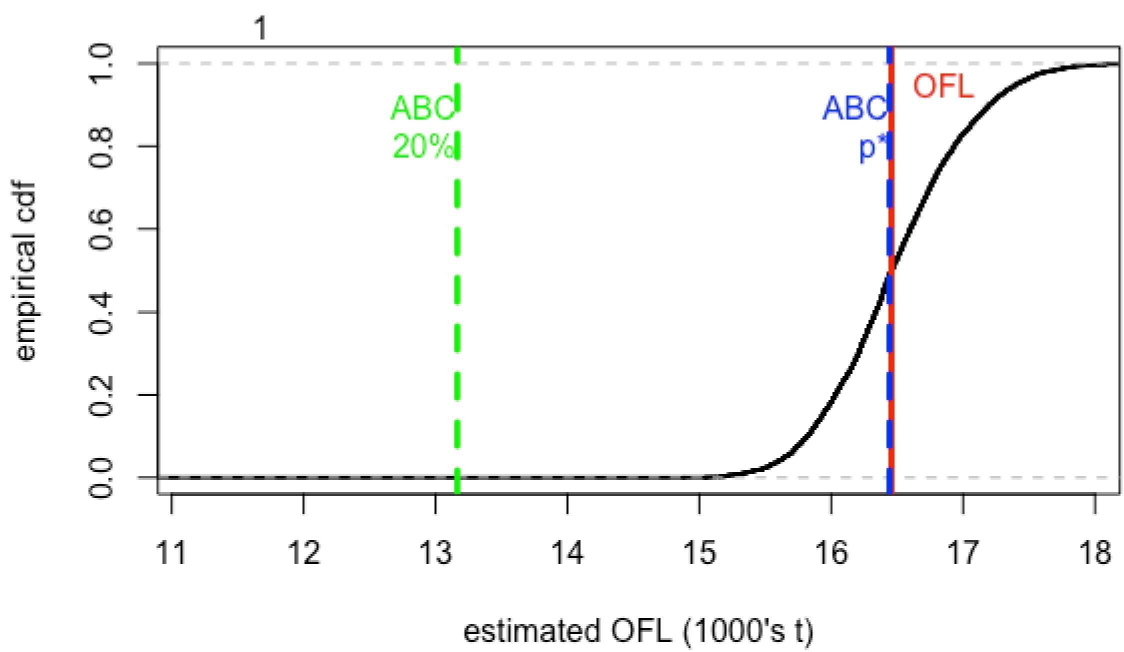


Figure 20. The OFL and ABC from the author's preferred model, scenario 18C2a.

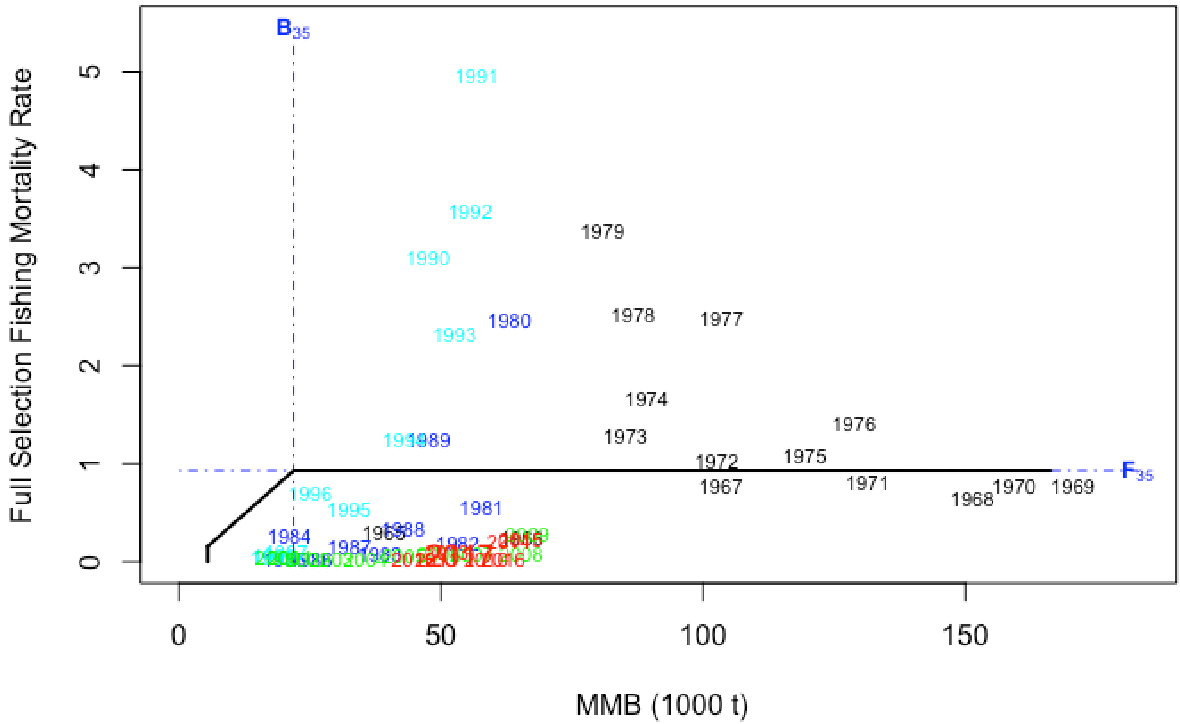


Figure 21. Quad plot for the author's preferred model, scenario B2b.