Bristol Bay Red King Crab Expanded Information

September 21, 2022[1]

Introduction and Background

In April 2022, the North Pacific Fishery Management Council (Council) tasked staff to prepare an expanded discussion paper that provides the best available information on six topics related to Bristol Bay red king crab (BBRKC).[2] The Council's motions are responsive to an ongoing decline in the BBRKC stock that culminated in the State of Alaska's inability to open a directed fishery for the 2021/2022 season. After review of this paper, the Council may request further analysis, develop alternatives to recommend actions that fall under its authority, or initiate dialogue with other management agencies at its

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[2] April 2022 Council motion

own discretion. No action is required by statute and this document is not part of a mandated program or allocation review.

The six topics, as ordered in the motion and in this paper, are described here in a summarized version of the Council's motion:

1. Analysis of the impacts of annual or seasonal closures on pelagic trawl, groundfish pot, and longline gear in the RKCSA
2. Sources of BBRKC mortality across federal fisheries
3. Scientific information needed to create dynamic closed areas
4. Information Needed for A80 to Create a Rolling Hotspot
5. Impact of groundfish predation on BBRKC
6. Impact Analyses on Hypothetical Changes to Pacific Cod Fishery

The 2021 NMFS eastern Bering Sea bottom trawl survey ("trawl survey") results were consistent with a trend of decreasing BBRKC biomass (Zacher et al. 2021). The 2021 mature female red king crab (RKC) abundance estimate was 25% less than in 2019. While the abundance of female RKC has been low in recent years, 2021 was the first year since 1995 that the mature female abundance fell below the established threshold in the State of Alaska's harvest strategy to allow a directed fishery in Registration Area T (see map of Area T in relation to other management areas if interest in Figure 1-3 and Figure 1-4). The length-based abundance estimate was 7.9 million mature female RKC in 2021, which is below the threshold of 8.4 million (Zheng et al. 2021). As a result, the directed fishery was closed for the 2021/2022 season.

Estimated mature biomass increased in the mid-1970s and then decreased precipitously in the early 1980s (Figure 0-1). Abundance increased from the mid-1980s until about 2007. Mature females were estimated to be roughly four times more abundant in 2007 than in 1985; mature males were roughly twice as abundant in 2007 than in 1985. Abundance has steadily declined since 2010 (Zacher et al. 2021). The projected mature male biomass in 2021 is less than 50% of the peak value (2002) during the last 40 years. Estimated mature female biomass has been at a low level during the four most recent years. Since 1984, recruitment has only been above the long-term historical average in six years, with the most recent above-average year occurring in 2005 (Zheng et al. 2021).

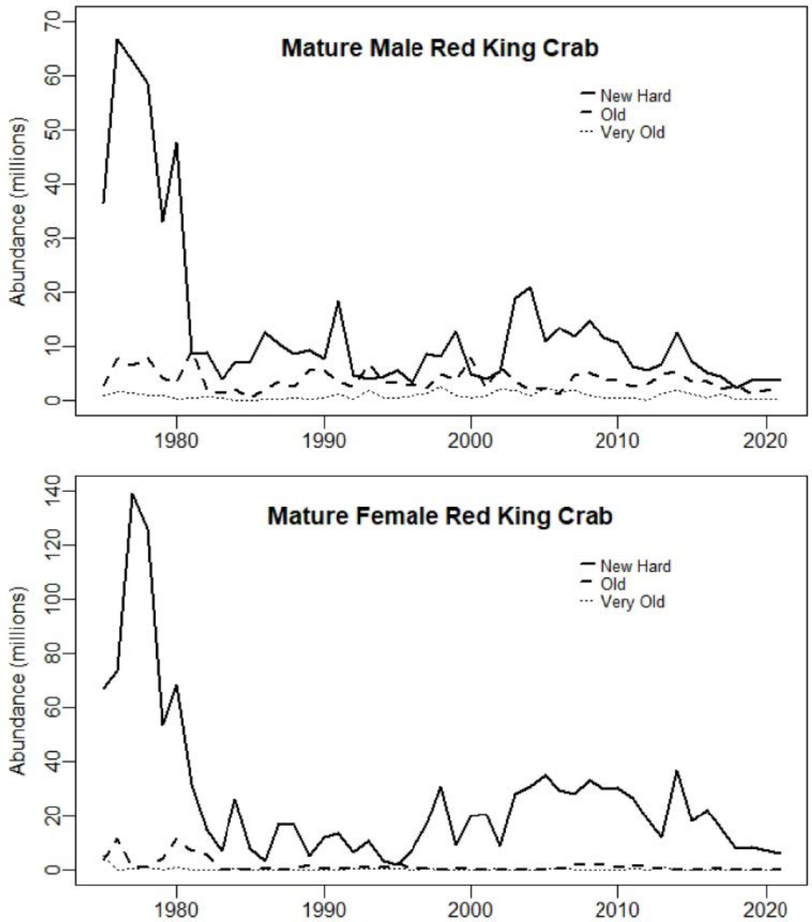


Figure 0-1 Time series of mature male (≥120 mm CL) and female (actual maturity) Bristol Bay red king crab area-swept abundance by shell condition, 1975-2021 (Zacher et al. 2021).

The Council has recently reviewed several analyses related to the abundance of BBRKC. The Council considered adjusting Bering Sea and Aleutian Islands (BSAI) groundfish trawl PSC limits for BBRKC, snow crab, and Tanner crab in February 2021 (NPFMC 2021a), and an emergency rule request for a northward expansion of the Red King Crab Savings Area (RKCSA) in December 2021 (NPFMC 2021b). Most recently the Council reviewed a discussion paper in April 2022 that examined BBRKC biology, stock assessment, interaction with gear from other fisheries and flexible management options.[3] This discussion paper builds on the April 2022 document and incorporates that information by reference with only selected information repeated for ease of reference. The Council did not pursue action following those analyses but has closely monitored the stock and requested this expanded discussion paper as a platform to contemplate actions that might address the fishery and its stakeholders, as bounded by the Council's authority. In broad terms, the topics in this paper include sources of BBRKC mortality and potential management options that could address that mortality.

[3] April 2022 BBRKC Discussion Paper

1 Analysis of the impacts of annual or seasonal closures in RKCSA

Council Motion: *Analysis of the impacts of annual or seasonal closures to pelagic trawl, groundfish pot, and longline gear in the RKCSA including impacts on target catch, fishery timing relative to crab mating/molting, crab avoidance, and other PSC and non-target species.*

1.1 Background on RKCSA

In view of the declining BBRKC stock, specifically female abundance, and the need to protect and conserve RKC in the Bristol Bay area, NMFS issued an emergency rule in 1995 (60 FR 4866, January 25, 1995) that established and closed the Red King Crab Savings Area (RKCSA) from January 20 to April 25 to all non-pelagic trawl (NPT) gear. In 1996, NMFS closed the RKCSA by inseason adjustment (60 FR 63451, December 11, 1995) from January 20 to March 31. Continued low abundance of crab stocks caused the Council to express additional concerns about opening the RKCSA, resulting in a recommendation at the January 1996 Council meeting for an extension to the 1996 inseason adjustment that closed the RKCSA until June 15, 1996 (61 FR 8889, March 6, 1996) to maximize protection for crabs and habitat. Based on information provided at its June 1996 meeting, the Council recommended expanded management measures under Amendment 37 to the BSAI Groundfish FMP to protect the declining stock of RKC in Bristol Bay. In brief, the final rule (61 FR 65985, December 16, 1996) to implement BSAI Groundfish FMP Amendment 37 closed NPT in portions of Bristol Bay including the RKCSA year-round, made adjustments to the trawl prohibited species catch (PSC) limit for BBRKC in Zone 1 of the Bering Sea, and increased observer coverage in specified areas related to the trawl closures. (Trawl PSC limit Zone 1 is identified as an area of interest in the Council's motion and is one of the areas at which crab bycatch, mortality, and sex-ratios are detailed in Section 2 of this paper). The final EA/RIR for Amendment 37, referencing data from 1993 to 1995, stated that the RKCSA would cover 40% of males and 30% of mature females in the BBRKC stock, with the western portion of the area composed almost entirely of males (NPFMC 1996).

The Red King Crab Savings Subarea (RKCSS) is a 10 nautical mile (nm) latitude strip on the southern boundary of the RKCSA that NMFS may be open to NPT trawling if a GHL fishery for BBRKC has been established for the crab season leading into that NMFS calendar fishing year.[4] The RKCSS (see Figure 1-1) was originally established to allow for productive rock sole fishing in years when the RKC biomass is sufficient. The subarea is limited by a subapportionment of the total Zone 1 RKC PSC limit that is set annually in harvest specifications and may not exceed 25% of the Zone 1 PSC limit. As with the RKCSA, the RKCSS was fully implemented as a year-round area in 1997 after having been in place as a partial-year closure under emergency rule in the prior year (61 FR 65985, linked above). Appendix 3 to this document shows the non-pelagic trawl sector's propensity to fish in the RKCSS and along the boundary lines of the RKCSA.

Figure 1-1 shows the location of the RKCSA and RKCSS. The RKCSA is defined in the BSAI Groundfish FMP at Section 3.5.2.1 and in FMP Appendix B.2 (Closed Areas), and in regulation at 679.22(a)(3) or Figure 11 to 50 CFR Part 679. The area shown in Figure 1-1 can be seen in the context of the entire Bering Sea management area in Figure 1-2, below, which also highlights the location of trawl PSC limit Zone 1. The figure below shows that part of the RKCSA/SS falls within NMFS Reporting Area 516 (area outlined in blue). Area 516 is closed to all trawl gear (pelagic and non-pelagic) from March 15 through June 15.[5] That existing seasonal closure was evident in the monthly pelagic trawl (PTR) bottom-contact maps that were presented to the Council in Appendix 2 of the April 2022 BBRKC discussion paper (NPFMC 2022).

[4] 679.21(e)(3)(ii)(B)
[5] 679.22(a)(2)

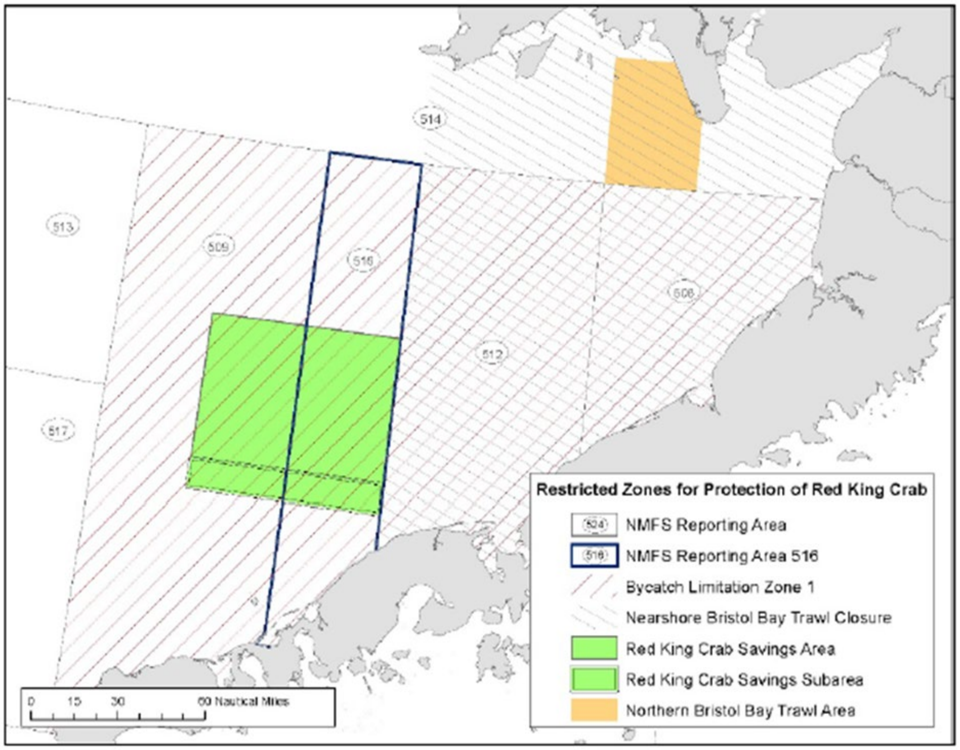


Figure 1-1 Red King Crab Savings Area and Red King Crab Savings Subarea depicted in green

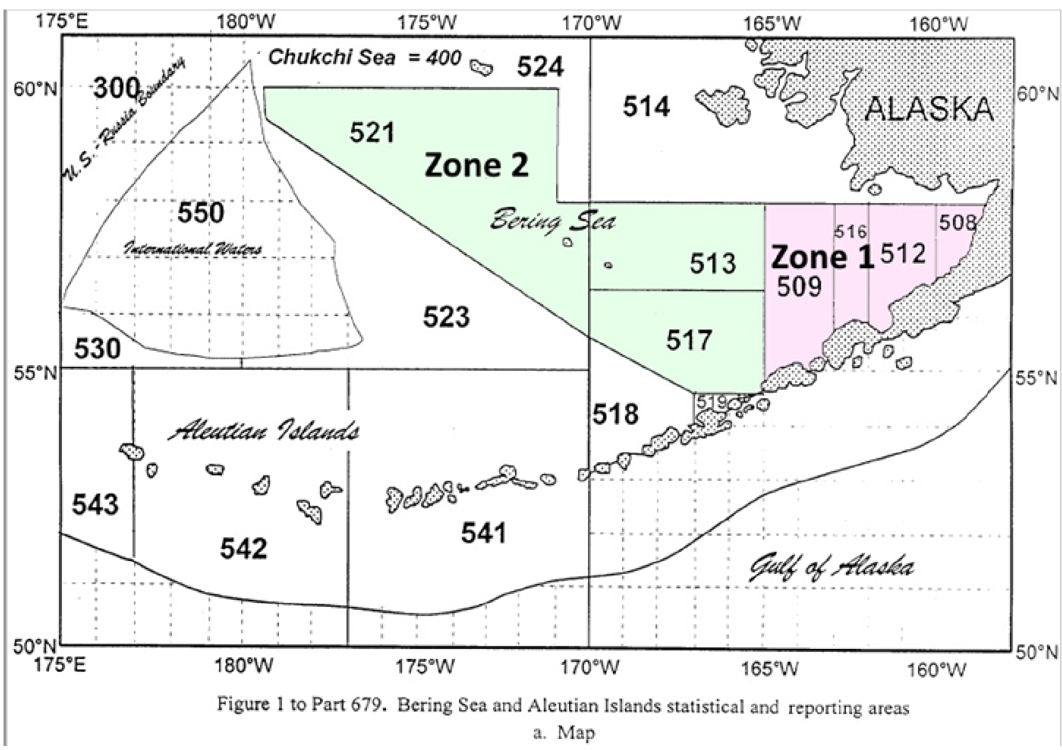


Figure 1-2 NMFS reporting areas in the Bering Sea, highlighting the eastern Bering Sea reporting areas that make up trawl PSC limit Zone 1 and contain the RKCSA/SS.

1.2 Current Fishery Seasons

The Council's April 2022 motion calls for analysis of the impacts of potential annual or seasonal closures for pelagic trawl, groundfish pot, and hook-and-line (HAL) gear in the RKCSA. The non-pelagic trawl sector is excluded from the motion because it is prohibited from the RKCSA under existing regulation. In order to examine how closures could affect the three gear sectors in the motion, current fishing seasons need to be understood. This paper describes which gear types are used in and around the RKCSA/SS, and when. The pelagic trawl sector is analogous to the directed pollock fishery. The non-pelagic trawl sector largely consists of the Amendment 80 non-pollock trawl CP sector, but also includes trawl limited access directed fisheries for species such as yellowfin sole and Pacific cod. The groundfish pot and HAL gear sectors predominantly consist of the directed fisheries for Pacific cod but do include some activity in the halibut/sablefish IFQ program.

Table 1-1 illustrates the typical seasons for each of the relevant gear types – or subsectors within gear types in the case of directed fishing for Pacific cod. There are two HAL sectors for Pacific cod in the BSAI: CVs ≥ 60 feet in length (Over-60) and catcher/processors (CPs). The Over-60 CV HAL sector has not participated in more than ten years and is therefore not listed in the table. There are also two pot sectors for Pacific cod in the BSAI: Over-60 CVs and CPs. Those two sectors have the same season dates and tend to fish around the same time and are thus listed together in the table. In addition, there is an Under-60 pot/HAL combined CV sector for BSAI Pacific cod that is listed separately in the table since seasonal constraints function differently for that sector. While, in practice, the Under-60 pot and HAL vessels fish for cod during roughly the same time of year as the larger CVs and CPs, the Under-60 season does not have a regulatory closure date in June that separates the A and B seasons.

Table 1-1 General Groundfish Commercial Fishing Seasons; Bering Sea and Aleutian Islands (50 CFR 679.23)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
BBRKC Female Mating/Molting												
Pelagic Trawl Pollock Fishery			A Season						B Season			
Pot Cod and CP Pot >= 60ft			A Season						B Season			
HAL & Pot Cod < 60ft												
HAL CP*			A Season						B Season			

Legend: Light Blue = Open Fishery, Dark Blue = Open and Active Fishery
Summary is intended as a general guide only and is non-binding
* CVs have not fished since 2009

1.3 Catch and Effort in RKCSA by Gear Type

This subsection summarizes historical groundfish catch data in and around the RKCSA for all four gear sectors, primarily relying on groundfish basis weight (GBW). GBW is the number of metric tons of groundfish catch that is used to estimate PSC based on observer data. GBW does not match perfectly to total catch as reported in the NMFS Catch Accounting System (CAS) but it is a useful measuring stick for assessing the reliance of the various groundfish gear sectors on certain identifiable areas and subareas within the Bering Sea. Using GBW in this section provides consistency in data sourcing for the tables in this section and the tables in Section 2. For HAL and pot gear, Table 1-2 and Table 1-3 aggregate across Pacific cod sectors to the gear level. CPs and CVs are combined at the gear sector level for all gears. This section also includes estimates of Pacific halibut mortality by gear type in and around the RKCSA, which is responsive to the Council's motion requesting data to understand the impact of closures of "other PSC and non-target species". Halibut are the only PSC species specifically covered in this section because RKC PSC is covered extensively in Section 2 and other PSC species for groundfish fisheries (e.g., salmon, herring) were considered beyond the scope of this discussion paper at this point. This section does not provide data on "non-target" groundfish species in the sense of FMP species that are not the intended target of directed fishing but may be retained up to maximum retainable amounts (MRA). Analysis of non-target groundfish catch by gear, target, area, and time of year could be provided for a more focused analysis but was also considered beyond the scope of this discussion paper.[6]

To orient the reader – prior to the GBW-by-area tables – this section begins with maps of pot and trawl RKC bycatch rates (crab per mt of groundfish). In addition to the bycatch rates, which tie together the groundfish catch in the tables in this section and the RKC PSC in the tables in Section 2, the maps show the nested spatial relationships between the RKCSA/SS, trawl PSC limit Zone 1, and BBRKC Registration Area T. The rate maps provide a visual summary that the reader can further interrogate through the tables in this section and in Section 2. The time scales depicted below are limited by the static nature of the maps. The maps show annual data for 2021 in isolation and period-length data for 2011-2021. The period-length data are shown three ways: year-long, "A season" (January through June), and "B season" (July through December). Finer time-slices that match with what is known about the timing or RKC molting and mating are provided in Table 1-3 and Table 2-7. Those tables group January/February, March/April, May/June, and July-December. The first three groupings cover the half of the year when RKC molt and mate. The subgroupings allow the reader to focus on times of year when males and primiparous females tend to molt (earlier) versus when multiparous females tend to molt and mate (later).[7]

Figure 1-3 and Figure 1-4 highlight ADFG statistical areas in and around the areas of interest where the rates of RKC bycatch per metric ton of GBW were highest in 2021 and over the entire analyzed period. Note that all trawl gear – pelagic and non-pelagic – is included in Figure 1-4. The amount of RKC PSC estimated for the pelagic trawl sector has been very low during the analyzed period (see Table 2-2) so splitting out the map by trawl type would not show meaningful rates for pelagic trawl and would likely include confidential information. The reader can assume that most of the trawl RKC PSC rates come from the non-pelagic sector, but Figure 1-4 does include rates inside the RKCSA, which could only have come from pelagic trawling. Two notable takeaways from Figure 1-3 are that the pot gear sector reduced its

[6] The analysts believe that the Council has a general awareness of the primary target species for each gear group and the range of FMP species that tend to be retained as secondary catch in the eastern Bering Sea. For example, pelagic trawl fishing targets pollock; non-pelagic trawl fishing targets yellowfin sole, flathead sole, Pacific cod, and other flatfish/flounders. HAL and pot gear target Pacific cod and halibut/sablefish IFQ, but also retain or discard rockfish, skates, Pacific cod and some flatfish. The preceding list is for general understanding and is not comprehensive.

[7] Pers Comm J. Zheng, ADFG, 2022; Pers Comm L. Zacher, AFSC, 2022; Table 2a in Fedewa et al. 2020.

activity in the RKCSA in 2021 relative to the entire period – which is also borne out in the PSC tables in Section 2 – and that the pot sector was less active around the RKCSA in the first half of the calendar year (i.e., molt/mate seasons) over the course of the entire period.

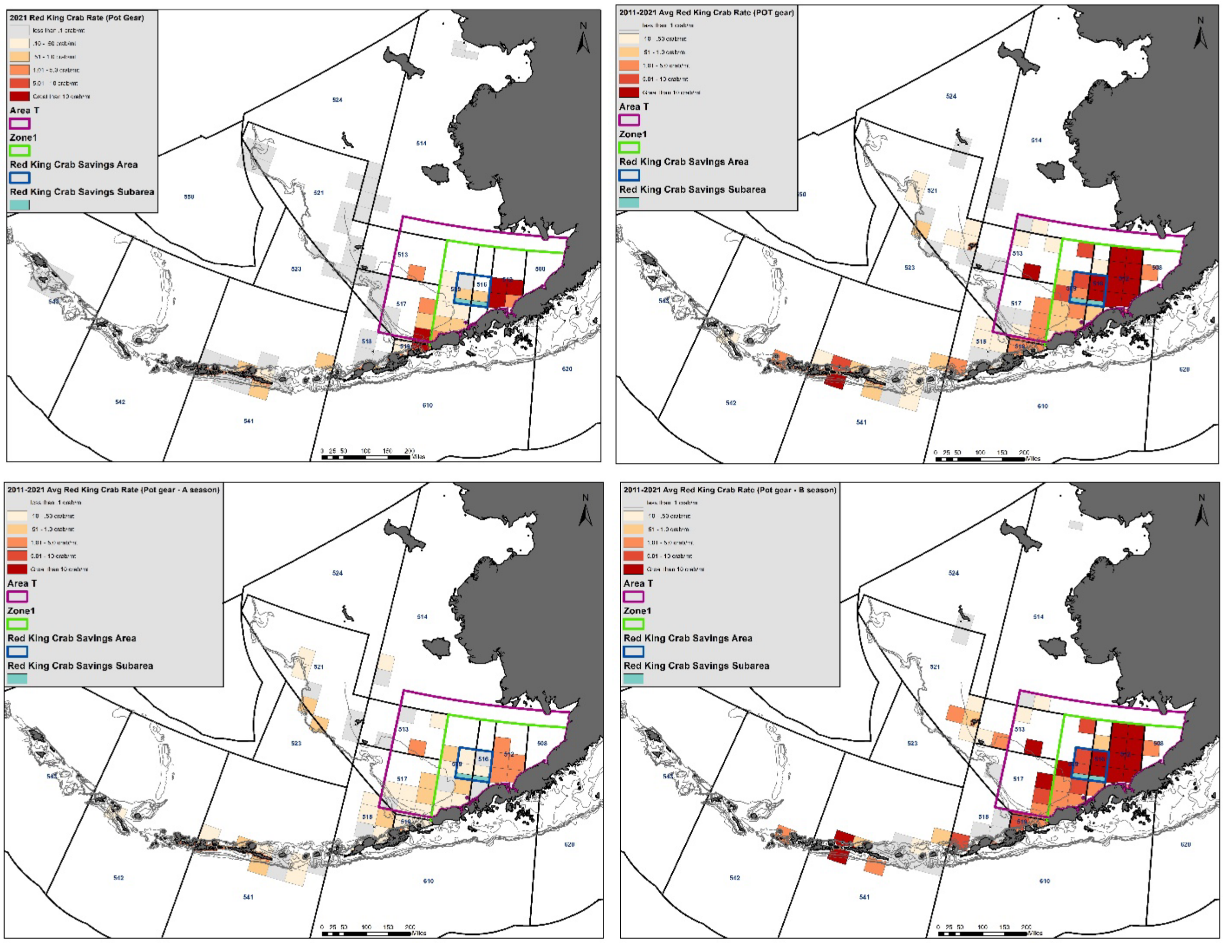


Figure 1-3 Rate of red king crab PSC by pot gear in the Bering Sea in 2021 (top left), 2011-2021 (top right), A season of 2011-2022 (bottom left), and B season 2011-2021 (bottom right) (Source: NMFS Alaska Region Catch Accounting System, data compiled by AKFIN in Comprehensive_PSC; maps created by J. Keaton, NMFS AKRO SF)

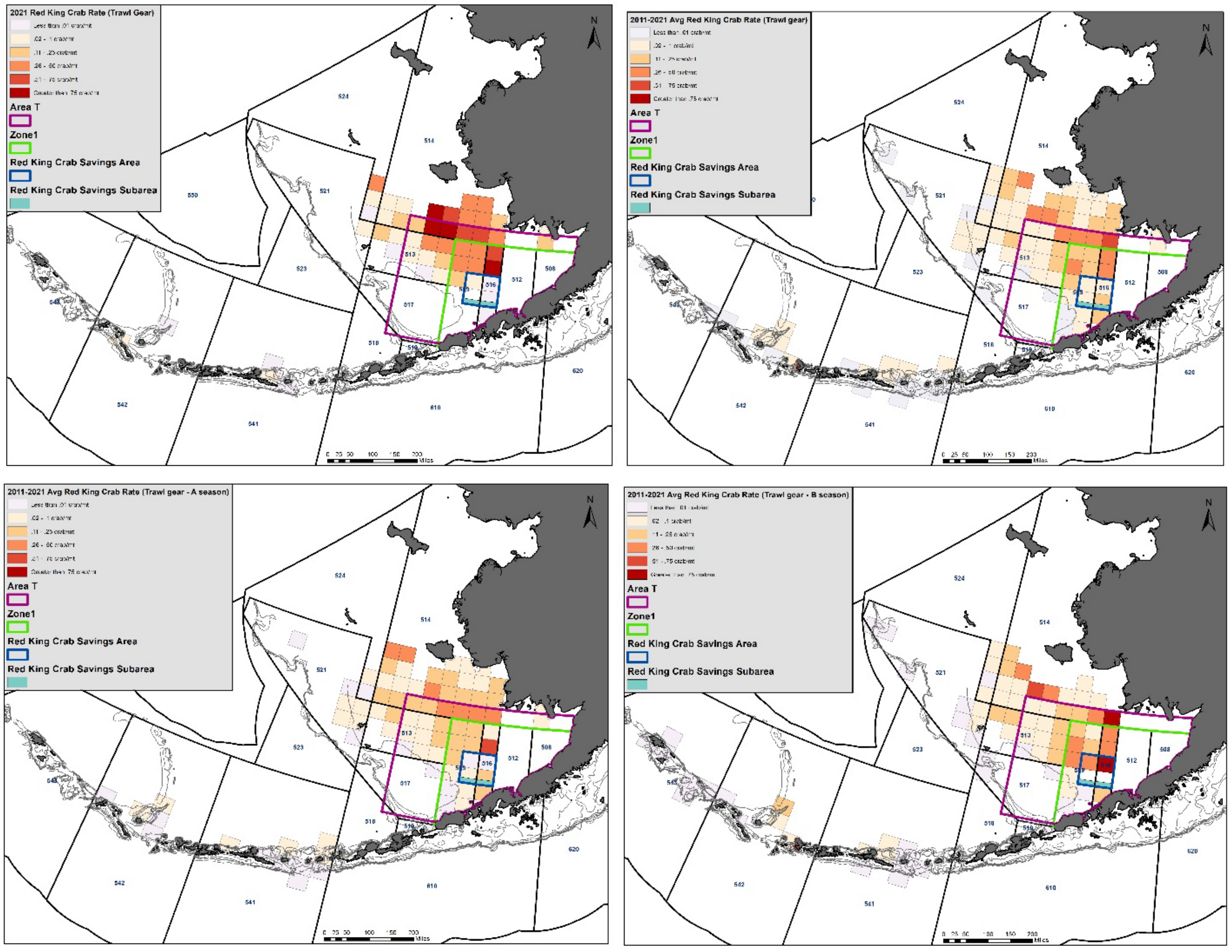


Figure 1-4 Rate of red king crab PSC by trawl gear in the Bering Sea in 2021 (top left), 2011-2021 (top right), A season of 2011-2022 (bottom left), and B season 2011-2021 (bottom right) (Source: NMFS Alaska Region Catch Accounting System, data compiled by AKFIN in Comprehensive_PSC; maps created by J. Keaton, NMFS AKRO SF)

For the purposes of data query behind the following tables, AKFIN has included the Red King Crab Savings Subarea (RKCSS) as part of the RKCSA. Data specific to each of those defined areas can be provided in future analyses, but it would be beneficial to have a more specific analytical focus before parsing fishing records at that level. Trawl tows may be classified in one area or the other based on where they start, where they end, or by the area in which the majority of the tow occurred; that is an analytically intensive task since there are many cases where trawl effort occurs along a boundary line. The decision to group RKCSA and RKCSS for this document results in the non-pelagic trawl sector appearing to have catch records in the RKCSA, where it is not permitted by regulation. The RKCSS, on the other hand, is open to non-pelagic trawl fishing as long as the directed fishery for BBRKC was open in the previous year, which had been the case in all analyzed years until 2022. A map showing non-pelagic trawl activity in the proximity of the RKCSA from 2008 through 2020 is provided in Appendix 3. Whereas one can assume based on regulations that non-pelagic trawl records listed as RKCSA occurred in the RKCSS, a separate data query is required to split out pelagic trawl (pollock) activity between those two areas. Table 1-4, below, provides pelagic trawl catch (mt) by RKCSA, RKCSS, and the rest of the BSAI from 2003 through 2021. (Note that Table 1-4 reports total catch data, not groundfish basis weight.) Pelagic trawl catch by area could provide relevant context for the Council if it considers any modification of pelagic trawl access to the RKCSA.

Table 1-2 shows the GBW for each sector, broken out by area: the Bering Sea management area, Area T, and the subset of Area T that is the RKCSA/SS. The exact species comprising the GBW varies by gear sector and is not shown in this document. The reader can make assumptions based on a general understanding of the gear groups and the prevalent directed fisheries in the eastern Bering Sea region. For example, pelagic trawl catch is predominantly pollock. Non-pelagic trawl catch would include yellowfin sole, rock sole, flathead sole, Pacific cod, other “Amendment 80 flatfish” (A80 species like Pacific ocean perch and Atka mackerel might be included in the overall BS area totals but would not be prevalent in or around Area T and the RKCSA/SS). Pot and HAL gear catch is mainly composed of Pacific cod, IFQ species (halibut/sablefish) and some retention of marketable secondary species like rockfish and skates.

Table 1-2 reflects the geographically nested nature of the areas of interest: the RKCSA/SS is contained within Area T, which itself is contained within the BS FMP area. The rows in the table are not additive. Table 1-2 reflects a general movement away from the RKCSA/SS in recent years for the HAL, pot, and non-pelagic trawl sectors. Pelagic trawl catch by area has varied annually but does not demonstrate the same move away from the RKCSA/SS. Table 2-2 in Section 2 shows that the pelagic trawl sector’s estimated RKC PSC in the Savings Areas and the BS in general are low compared to other sectors. (Another source of information on where the pelagic trawl sector has fished – but not what it caught – is Section 4 and Appendix 2 of the April 2022 BBRKC discussion paper; NPFMC 2022.)

The non-pelagic trawl sector’s recent shift away from the RKCSS could be a reflection of the fact that decreasing RKC biomass indicators were trending towards regulatory thresholds that would reduce the Zone 1 trawl PSC limit. Those thresholds were reached and the overall trawl PSC limit dropped from 97,000 to 32,000 animals. Zone 1 data are not broken out in Table 1-2 and Table 1-3 but RKC PSC for Zone 1 are shown in the tables in Section 2 per the Council motion. The Zone 1 PSC limit apportionments across trawl sectors for 2022 and previous years back to 2010 are shown in Table 2-1 in Section 2.

GBW for pot gear in the RKCSA decreased notably in 2021 and 2022 (year-to-date; YTD) relative to the trend in pot catch within Area T and the BS in general, also suggesting an intentional or coincidental move away from the savings area.

The HAL gear sector as a whole demonstrated the most notable catch reduction in the eastern BS region and the management areas of interest beginning in 2019. Though not displayed in the tables, the HAL CP sector ceased fishing in NMFS Areas 512 and 516 and dramatically reduced cod catch in Area 509; together, 509/512/516 comprise most of the area covered by Area T and the BBRKC stock assessment area (NMFS subareas are identified in Figure 1-1 and Figure 1-2). HAL CP catch in Area 509 had averaged roughly 23,000 mt annually from 2013-2018 (14,000 to 18,000 mt from 2015-2018) but was no higher than 311 mt in any year from 2019 through 2021 (2022 catch was 370 mt YTD through mid-August). During the 2013-2018 period, Area 509 had accounted for roughly 15% of total HAL CP catch, making the decline in that area noteworthy. Areas 512 and 516 had been less relied upon prior to the abrupt halt in fishing there since 2018. HAL CPs have focused consistently on Area 521 (44% of catch from 2013-2021), Area 524 (15%), Area 517 (11%) and Area 513 (9%). The HAL CP sector obviously does not comprise the entire HAL gear sector but it is the dominant source of HAL catch by volume.

Table 1-2 Groundfish basis weight (metric tons) by sector and area (BS, Area T, RKCSA/SS) – 2013-2022 (*2022 YTD 8/21)

Gear	Area	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022*	Average
HAL	RKCSA	10,849	3,257	876	1,042	4,266	7,283		26		180	3,472
	Other Area T	74,956	56,754	48,689	37,287	31,786	22,161	12,842	5,770	3,996	10,185	30,443
	BS Total	156,576	162,391	167,716	167,251	164,982	137,753	114,108	95,778	75,206	74,385	131,615
	RKCSA % of T	**13%**	**5%**	**2%**	**3%**	**12%**	**25%**	**0%**	**0%**	**0%**	**2%**	**10%**
	RKCSA % of BS	**7%**	**2%**	**1%**	**1%**	**3%**	**5%**	**0%**	**0%**	**0%**	**0%**	**3%**
NPT	RKCSA	20,865	21,890	10,801	15,183	7,731	2,592	2,222	2,126	1,075	37	8,452
	Other Area T	284,872	289,069	230,070	258,974	236,948	200,175	193,398	212,924	172,293	133,720	221,244
	BS Total	395,559	387,461	314,749	334,208	310,944	313,229	299,129	300,284	240,693	203,584	309,984
	RKCSA % of T	**7%**	**7%**	**4%**	**6%**	**3%**	**1%**	**1%**	**1%**	**1%**	**0%**	**4%**
	RKCSA % of BS	**5%**	**6%**	**3%**	**5%**	**2%**	**1%**	**1%**	**1%**	**0%**	**0%**	**3%**
Pot	RKCSA	3,256	2,974	2,914	910	520	459	611	1,202	107		1,439
	Other Area T	20,861	19,136	20,509	26,053	29,514	28,461	29,699	19,878	16,020	15,299	22,543
	BS Total	31,346	40,428	39,001	48,233	47,078	40,744	42,435	33,312	26,567	31,191	38,034
	RKCSA % of T	**14%**	**13%**	**12%**	**3%**	**2%**	**2%**	**2%**	**6%**	**1%**	**0%**	**6%**
	RKCSA % of BS	**10%**	**7%**	**7%**	**2%**	**1%**	**1%**	**1%**	**4%**	**0%**	**0%**	**4%**
PTR	RKCSA	3,304	44,442	33,867	34,302	82,003	82,771	91,451	19,595	73,581	98,896	56,421
	Other Area T	402,298	589,011	372,251	822,226	825,858	764,712	811,838	567,783	470,615	434,358	606,095
	BS Total	1,248,176	1,257,200	1,294,677	1,318,531	1,332,718	1,346,413	1,383,976	1,244,946	1,052,476	756,577	1,223,569
	RKCSA % of T	**1%**	**7%**	**8%**	**4%**	**9%**	**10%**	**10%**	**3%**	**14%**	**19%**	**9%**
	RKCSA % of BS	**0%**	**4%**	**3%**	**3%**	**6%**	**6%**	**7%**	**2%**	**7%**	**13%**	**5%**

Table 1-3 shows the distribution of GBW catch throughout the year for each gear sector. The January-June subtotal is a reasonable proxy for the relative amount of groundfish effort that occurs during the BBRKC mate/molt period, and can be further teased apart by the subgroupings of months within the first half of the year. The proportion of GBW that occurs within the RKCSA/SS versus the entire BS FMP region is shown in percentage terms. The pot gear sector consistently accumulates the majority of its BS GBW in the first half of the year – and primarily in January/February – but a small percentage of that catch occurs in the RCKSA/SS. 2020 was somewhat of an outlier with the pot sector accumulating 5% of January-June GBW in the savings area (note that this occurred in the early months of 2020 before COVID-19 restrictions would have begun to affect operational choices). The non-pelagic trawl sector's GBW in the RKCSS is weighted towards the first half of the calendar year, and slightly more so to the first four months when yellowfin sole are targeted. Non-pelagic trawl activity in the RKCSS is also weighted towards the first part of the year. Overall non-pelagic trawl activity in the RKCSS was lower from 2018 through the present compared to 2013 through 2018. The pelagic trawl sector's GBW catch in the Bering Sea is slightly higher from January-June than from July-December, but the proportion of activity in the RKCSA/SS is substantially greater in the A season, and particularly in the first few months (January-March).

Table 1-3 Groundfish basis weight (metric tons) by sector, timing, and area (BS, RKCSA/SS) – 2013-2022 (*2022 YTD 8/21)

Sector	Period		2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Average
Hook-and-Line	Jan-Feb	GFBW	46,408	38,487	32,857	42,863	42,407	37,832	29,741	26,809	16,650	19,204	33,326
		% RKCSA	13%	5%	2%	0%	2%	3%	0%	0%	0%	0%	3%
	Mar-Apr	GFBW	28,565	32,098	34,642	30,141	32,194	23,699	23,594	21,980	17,229	20,740	26,488
		% RKCSA	3%	1%	0%	0%	3%	0%	0%	0%	0%	0%	1%
	May-Jun	GFBW	9,422	16,387	14,978	14,234	13,295	8,870	6,025	4,429	9,427	16,203	11,327
		% RKCSA	3%	1%	0%	0%	0%	0%	0%	0%	0%	0%	0.4%
	Jan-Jun	GFBW	84,395	86,972	82,477	87,238	87,896	70,401	59,360	53,218	43,306	56,147	71,141
	Subtotal	% RKCSA	9%	3%	1%	0%	2%	1%	0%	0%	0%	0%	2%
	Jul-Dec	GFBW	72,181	75,419	85,239	80,013	77,086	67,352	54,748	42,560	31,900	18,238	60,474
		% RKCSA	5%	1%	0%	1%	3%	9%	0%	0%	0%	1%	2%
Non-Pelagic Trawl	Jan-Feb	GFBW	94,749	92,730	62,675	72,987	72,448	60,884	65,559	72,737	50,204	66,683	71,166
		% RKCSA	11%	21%	14%	13%	6%	3%	2%	2%	1%	0%	8%
	Mar-Apr	GFBW	91,364	94,644	81,425	82,419	70,362	73,989	76,844	88,590	69,195	80,524	80,936
		% RKCSA	10%	2%	2%	7%	5%	1%	1%	0%	1%	0%	3%
	May-Jun	GFBW	54,712	65,303	49,501	62,554	63,832	77,101	60,388	43,398	39,233	39,705	55,573
		% RKCSA	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0.1%
	Jan-Jun	GFBW	240,824	252,677	193,601	217,960	206,643	211,973	202,791	204,726	158,631	186,912	207,674
	Subtotal	% RKCSA	8%	9%	6%	7%	4%	1%	1%	1%	1%	0%	4%
	Jul-Dec	GFBW	154,735	134,783	121,148	116,248	104,301	101,256	96,338	95,559	82,061	16,672	102,310
		% RKCSA	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0.2%
Pot	Jan-Feb	GFBW	19,531	21,818	20,243	19,107	23,708	27,466	25,461	18,648	14,150	16,690	20,682
		% RKCSA	7%	2%	0%	0%	0%	0%	0%	4%	1%	0%	1%
	Mar-Apr	GFBW	1,706	7,584	8,003	17,989	11,434	2,168	2,114	5,643	6,939	12,966	7,655
		% RKCSA	0%	0%	0%	0%	0%	0%	0%	8%	0%	0%	1%
	May-Jun	GFBW	176	610	132	13	160	204	80	193	181	679	243
		% RKCSA	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
	Jan-Jun	GFBW	21,413	30,011	28,378	37,109	35,302	29,838	27,655	24,484	21,269	30,335	28,579
	Subtotal	% RKCSA	6%	2%	0%	0%	0%	0%	0%	5%	1%	0%	1%
	Jul-Dec	GFBW	9,933	10,417	10,623	11,124	11,776	10,906	14,780	8,828	5,298	856	9,454
		% RKCSA	19%	24%	27%	8%	4%	4%	4%	0%	0%	0%	10%
Pelagic Trawl	Jan-Feb	GFBW	250,528	251,867	287,717	291,160	286,671	309,805	333,011	321,207	204,987	249,781	278,673
		% RKCSA	1%	14%	12%	4%	26%	11%	20%	5%	26%	23%	14%
	Mar-Apr	GFBW	255,276	251,170	223,837	230,859	283,514	277,591	269,174	254,399	260,824	104,636	241,128
		% RKCSA	0%	3%	0%	1%	2%	17%	9%	1%	8%	39%	6%
	May-Jun	GFBW	171,740	169,654	160,661	143,085	153,165	121,854	90,377	81,077	101,975	89,612	128,320
		% RKCSA	0%	1%	0%	3%	0%	0%	2%	0%	0%	0%	1%
	Jan-Jun	GFBW	677,544	672,691	672,214	665,104	723,350	709,250	692,561	656,683	567,786	444,029	648,121
	Subtotal	% RKCSA	0%	7%	5%	3%	11%	12%	13%	3%	13%	22%	8%
	Jul-Dec	GFBW	570,632	584,508	622,463	653,427	609,368	637,163	691,416	588,263	484,690	312,548	575,448
		% RKCSA	0%	0%	0%	2%	0%	0%	0%	0%	0%	0%	0.3%

Table 1-4 reflects an overall shift in the amount of pelagic trawl catch in the RKCSA/SS beginning in 2014. While still accounting for 10% or less of total pelagic trawl catch, the combined area has become the source for a greater proportion of total BSAI pelagic trawl catch. Prior to 2014 the catch that did occur in the combined area tended to be in the RKCSS but in more recent years the majority of RCKSA/SS catch was in the Savings Area in three years (2014, 2015 and 2021).

Table 1-4 Pelagic trawl gear catch (mt) by area (RKCSA/RKCSS/other BSAI), 2003-2021

Year	RKCSA	RKCSS	Other BSAI	Total BSAI	% RKCSA/SS	RKCSA/SS Split	
						RKCSA	RKCSS
2003	922	18,868	1,300,256	1,320,046	1%	5%	95%
2004	23,105	11,654	1,262,745	1,297,504	3%	66%	34%
2005	6,426	17,565	1,285,373	1,309,364	2%	27%	73%
2006	5,257	12,532	1,311,471	1,329,260	1%	30%	70%
2007	4,936	6,657	1,181,011	1,192,604	1%	43%	57%
2008	45	11,228	864,133	875,405	1%	0%	100%
2009	116	8,778	718,856	727,750	1%	1%	99%
2010	1,057	1,695	718,205	720,957	0%	38%	62%
2011	24	5,868	1,224,151	1,230,043	0%	0%	100%
2012	242	2,045	1,228,839	1,231,126	0%	11%	89%
2013	0	4,429	1,266,472	1,270,901	0%	0%	100%
2014	27,918	22,451	1,241,131	1,291,500	4%	55%	45%
2015	29,564	8,700	1,305,808	1,344,072	3%	77%	23%
2016	19,078	41,815	1,316,231	1,377,124	4%	31%	69%
2017	50,105	56,909	1,278,602	1,385,616	8%	47%	53%
2018	67,597	67,904	1,260,240	1,395,740	10%	50%	50%
2019	30,362	101,145	1,294,386	1,425,892	9%	23%	77%
2020	13,861	16,004	1,247,469	1,277,334	2%	46%	54%
2021	42,894	35,928	998,347	1,077,169	7%	54%	46%
Total	323,510	452,173	22,303,725	23,079,408	3%	42%	58%
Avg. 2003-13	3,830	9,211	1,123,774	1,136,815	1%	29%	71%
Avg. 2014-21	35,172	43,857	1,242,777	1,321,806	6%	45%	55%

Source: NMFS Alaska Region Catch Accounting System, data compiled by AKFIN in Comprehensive_PSC.

Shifting focus to halibut PSC, Table 1-5 shows the amount of halibut mortality (metric tons) estimated to have occurred in the various BS groundfish gear sectors (non-IFQ) by area of interest: the RKCSA/SS versus the rest of Area T and the Bering Sea management area as a whole. This data is responsive to the Council motion's request to consider the impacts of area or seasonal closures to the RKCSA on "other PSC". Table 1-6 breaks out the timing of halibut mortality by the month groupings that are used to describe crab PSC data in Section 2 of this document. Those groupings are designed to reflect different phases of the crab molt/mate cycle and might provide a basis for the consideration of seasonal closures. Table 1-6 is limited to the RKCSA/SS for brevity; this is responsive to the Council motion and acknowledges that halibut bycatch mortality is not the primary focus of this paper. The pot gear sector is not included in Table 1-6 due to the minimal amount of halibut mortality accrued in the RKCSA/SS. Of the 1.3 mt of halibut mortality that occurred in the pot sector from 2013 through 2022 (YTD), 1.2 mt occurred in the July-December period (Pacific cod B season).

Table 1-5 Halibut mortality (metric tons) by sector and area (BS, Area T, RKCSA/SS) – 2013-2022 (*2022 YTD 8/21)

Gear	Area	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Average
HAL	RKCSA	18	7	2	4	6	9	0	0	0	1	5
	Other Area T	288	169	119	82	61	43	22	7	12	23	83
	Total Area T	306	175	121	86	67	52	22	7	12	23	87
	BS Total	530	449	310	218	183	125	77	80	67	101	214
NPT	RKCSA	88	167	96	95	21	17	15	14	11	0	52
	Other Area T	2,023	2,037	1,282	1,426	1,138	1,138	1,472	1,015	835	908	1,327
	Total Area T	2,111	2,204	1,378	1,522	1,158	1,155	1,488	1,029	846	908	1,380
	BS Total	2,623	2,666	1,714	1,897	1,535	1,753	2,053	1,404	1,206	1,336	1,819
Pot	RKCSA	1	1	0	0	0	0	0	0	0	0	0
	Other Area T	1	1	1	1	1	0	2	2	3	7	2
	Total Area T	1	1	1	1	1	0	2	2	3	7	2
	BS Total	4	4	3	3	2	1	3	3	8	14	5
PTR	RKCSA	2	19	10	1	24	7	29	2	32	42	17
	Other Area T	118	84	19	32	40	34	53	50	69	78	58
	Total Area T	119	103	29	32	65	41	82	52	102	120	74
	BS Total	212	157	112	91	80	49	98	86	109	123	112

Table 1-6 Halibut mortality (metric tons) by sector, timing, and area (BS, RKCSA/SS) – 2013-2022 (*2022 YTD 8/21)

	Hook-and-Line			Jan-Jun		HAL	Non-Pelagic Trawl			Jan-Jun		NPT	Pelagic Trawl			Jan-Jun		PTR
YEAR	Jan-Feb	Mar-Apr	May-Jun	Subtotal	Jul-Dec	Total	Jan-Feb	Mar-Apr	May-Jun	Subtotal	Jul-Dec	Total	Jan-Feb	Mar-Apr	May-Jun	Subtotal	Jul-Dec	Total
2013	6.2	1.5	1.9	9.7	8.0	17.7	43.4	37.9	0.9	82.2	5.6	87.8	1.4	0.2		1.6		1.6
2014	1.5	0.5	0.8	2.9	3.6	6.5	147.8	18.4	0.7	166.9	0.3	167.2	17.7	1.3	< 0.1	19.0		19.0
2015	1.5	< 0.1		1.5	0.3	1.8	71.9	23.7		95.5	0.0	95.6	9.9			9.9		9.9
2016	0.3	0.5	0.4	1.3	3.0	4.3	60.5	33.8		94.3	0.8	95.1	0.4	< 0.1	< 0.1	0.4	0.2	0.6
2017	0.6	0.5	0.1	1.1	5.2	6.3	9.4	10.1	0.6	20.0	0.8	20.8	22.8	1.5		24.3		24.3
2018	2.0			2.0	6.9	8.9	11.9	4.9	< 0.1	16.8		16.8	2.0	5.0		7.0		7.0
2019					< 0.1	< 0.1	10.8	4.4		15.2	0.2	15.3	26.7	2.1		28.8		28.8
2020			0.1	0.1	< 0.1	0.1	10.1	1.1		11.1	3.2	14.4	2.1	< 0.1		2.1		2.2
2021							9.4	1.1		10.5		10.5	29.5	2.8		32.3		32.3
2022*					0.6	0.6		0.1		0.1		0.1	34.5	7.2		41.7		41.7
Average	**1.2**	**0.3**	**0.3**	**1.8**	**2.8**	**4.6**	**37.5**	**13.6**	**0.2**	**51.3**	**1.1**	**52.4**	**14.7**	**2.0**	**< 0.1**	**16.7**	**< 0.1**	**16.7**

The second part of the Council's motion, covered in Section 2, refers to discard mortality rates (DMR) – though specifically in reference to crab handling mortality. Still, it is appropriate to briefly explain the halibut mortality estimates that generate the estimates presented in the tables above. According to the most recent recommendations report from the Interagency Halibut DMR Workgroup (Sept. 2021), the DMRs specified annually simply reflect the average of observer-estimated DMRs for the two most recent complete fishing years. Those estimates are based on observer sampling and viability/injury assessments. Sampling (observer coverage) in the pot gear sector has tended to occur at a lower rate relative to HAL gear, especially given the high volume of HAL CP activity and the low proportion of halibut in pot catch across all gear types. This DMR estimation approach can result in instances where NMFS CAS applies a DMR based on previous years' observer data that, in hindsight, does not match the viability/injury assessments that were taken in that year. For example, the 2021 halibut DMR for groundfish pot gear was set at 32% based on 2019 and 2020 assessments. After the fishing year was concluded and all observer data were debriefed/revised, it appeared that assessed mortality in pots was closer to 12% for 2021. This is an extreme example, but highlights the tension between the need to apply DMRs with an in-season approach and the benefit of better data that can be compiled after the year is complete and may better inform stock assessment or strategic management choices. Crab handling mortality rates are described more fully in Section 2 of this paper; they are not set in groundfish harvest specifications and are mainly considered as part of the stock assessment process. Where crab PSC limits exist for groundfish fisheries, they are denominated in total PSC (pre-mortality).

As a proportion of total basis weights for crab PSC, halibut/sablefish IFQ fishing accounts for a small proportion of total HAL and pot gear activity in the Bering Sea FMP area.[8] Compared to the total annual BS area values in Table 1-2, IFQ fishing accounted for between 1,764 mt (2014) and 2,596 mt (2013). The proportion of total BS IFQ groundfish basis weight caught in pots versus with HAL gear was heavily weighted toward HAL gear until 2021 when it came closer to even (60% HAL) and has flipped to majority pot catch in 2022 (YTD through August 21) at 60% pots. This shift is likely attributed to changing regulations that allow halibut retention in pots and remove pot tunnel opening restrictions for vessels with halibut IFQ onboard. Aside from less than three metric tons of IFQ catch with HAL gear recorded earlier in 2022, no IFQ groundfish basis weight appears in the RKCSA/SS. The proportion of BS IFQ activity that occurred within crab Area T is small. Since 2013, Area T accounted for 1.4% of total BS HAL IFQ activity (percentage peak of 3.5% or 10 mt out of 117 mt in 2014) and 4.8% of total BS pot IFQ activity (percentage peak of 10.7% or 27 mt out of 249 mt in 2018).

1.4 Closures that Could Protect Mature Female RKC

The Council seeks information that could help it consider the effects of annual or seasonal RKCSA closures for the various Federal groundfish gear sectors that are currently allowed to operate within its boundaries: pelagic trawl, pot, and HAL. Modifying the regulations that establish and govern the RKCSA would require the Council to consider the scope of time over which a closure would be in place. An annual closure is straightforward; future analysis would consider the sectors' reliance on the area relative to other parts of the BS, the areas to which effort might be redirected, the likelihood of forgone revenue and how that combination might affect specific participants, regional economies, and the net benefit to the nation. Those potential impacts would be weighed against the potential benefit to the BBRKC stock and other non-target species. The latter consideration is somewhat more challenging as aspects of BBRKC life-history and the acute cause(s) of the stock decline are not fully known; those information needs are the focus of Section 3 in this document.

Consideration of seasonal closures of the RKCSA requires the same analytical balance but also decision-supporting information on a more granular scale. The analysts are well-equipped to describe Federal groundfish engagement and reliance on fine spatial and time scales within the bounds of confidentiality restrictions. Balancing those potentially adverse impacts against an equally well-informed picture of the benefit to the BBRKC stock becomes more challenging since the frontier of what is known about the importance of the RKCSA to the stock is comprised of where crab are during the June AFSC trawl survey, where they are during the October/November directed crab fishery, and a general understanding of when RKC molt/mate. (New cooperative field research tracking RKC movement in, around, and through the RKCSA is ongoing but in early stages and the research goals for those projects are not specifically aligned to management decisions on PTR/pot/HAL gear closures – see Section 3 of this document.)

Closures that are tailored in their timing to balance protection and use would provide the greatest net benefit but might not be achievable with certainty given the presently available information. Given what *is* known about mate/molt timing and the trends in RKCSA use by the groundfish sectors, it may be that the most effective seasonal closures occur when RKC are most physically vulnerable. That information can hopefully be supplemented in the future by better data on when and where RKC congregate in large

[8] Despite the term "groundfish basis weights," these data do include IFQ halibut as well as sablefish. Halibut are not typically referred to as a groundfish species whereas sablefish are. For this purpose, all IFQ catch is being considered.

numbers – by sex ratio if possible. To the extent that those pieces of information are available, or become available, those times of year could be weighed against information similar to what is shown in Table 1-3.

The molting and mating cycle is when RKC are the most vulnerable, and is generally understood to span January through June. With continued advice from the Crab Plan Team and crab biology experts at ADFG and AFSC, the Council could consider closing the RKCSA and/or RKCSS for only a portion of the January-June period if it is determined that the net benefits to the BBRKC stock *and* the groundfish fisheries would be greatest by protecting a subset of the population (e.g., if multiparous females are more valuable/productive, or if primiparous females are more numerous and present an important foundation for future stock success). Though imperfectly understood, this discussion paper is provided under the assumption that primiparous females molt earlier than multiparous females.

Table 1-3 provides a starting point for understanding which gear sectors (aggregated across CV/CP categories and same-gear Pacific cod allocations) rely on the RKSCA/SS and at which point in the year. Given the focus on timing of the mate/molt cycle, a first-order question could be whether protecting crab in the RKCSA outside of the mate/molt season is important for the stock; the second-order question is whether the opportunity to fish in the RCKSA from July through December is necessary or valuable to the groundfish fisheries. Table 1-3 allows the reader to address different variations on those questions in a simplistic manner. To finish that example, Table 1-3 shows that none of the four gear sectors have accrued more than 1% of their July-December Bering Sea GBW catch in the RCKSA/SS since 2019. Another series of questions that could be tested with the information in the tables above is which sectors would have to redistribute or forgo catch in the RKCSA if it were closed in January and February. Table 1-3 would suggest that such a closure mainly affects the pelagic trawl sector. It would be up to the Council, at that time, to gather and weigh whatever information exists about the presence and relative importance of male and primiparous females that are in the RKCSA, since those are the subsets of RKC that are expected to be in the most vulnerable state during those months. The Council would consider the likely net cost to pelagic trawl vessels of keeping them out of the RKCSA at the start of the A season, where else they might fish, and bycatch species they might encounter in those non-RKCSA areas. That would form the starting point for the Council to determine how aggressive or precautionary its recommendations should be in the setting of inevitably incomplete information on the geographical distribution of RKC during those months.

1.5 Cross-Participation between Groundfish Pot and Bering Sea Crab Sectors

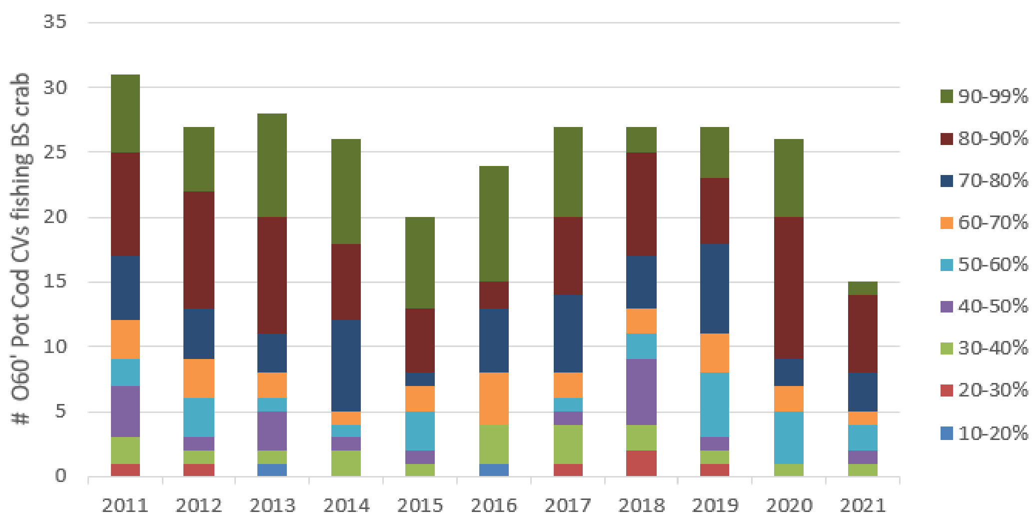
Some participants in the groundfish pot sector have direct interests in the ongoing health of crab stocks, including BBRKC, through their commercial participation in the rationalized crab fishery. This section describes the amount of cross-participation by vessels that both target crab and use pot gear to directed fish for BS Pacific cod. Those vessels are subsets of (1) pot gear CVs of length greater than or equal to 60 feet (Over-60) that directed fish for BS Pacific cod and (2) the small number of BS pot cod CPs.[9] Given that interest and shared concern about future crab stocks that has been communicated to the Council through public testimony, at least some of the Over-60 pot cod CVs enacted a voluntary stand-down from fishing in the RKCSA and RKCSS during the 2022 BS Pacific cod A season. At the time of writing, it was the analysts' understanding that those vessels planned to do the same for the B season.

The potential near- and long-term impacts of voluntary pot standdowns from the RKCSA are similar to the question being asked by the Council in this part of the discussion paper. This section accounts for the number of pot cod vessels that have also participated in directed crab fisheries and reports trends in the reliance on crab versus Pacific cod for the cross-participating Over-60 CVs and CPs. In the future, with stakeholder assistance, it might be possible to report the activities of voluntarily associated pot cod

[9] Between 15 and 35 pot gear CVs of length less than 60' have participated annually in the Federal BS pot cod fishery from 2011 through 2021, but no Pacific cod CVs in that length category participated in the BS crab fisheries.

vessels and correlate reduced 2022 activity within the RKCSA to fishing mortality. At present, the analysts have no view into which vessels' fishing decisions are shaped by ad hoc agreements. For the time being, the second-best way to reflect the likelihood of groundfish pot gear vessels taking affirmative action to reduce RKC catch is to describe how many have a partial or full dependency on the crab resource as part of their annual fishing plan.

During the 2011 through 2021 period, 23 to 39 Over-60 pot gear CVs participated in the BS Pacific cod fishery annually. In those years, the proportion of Over-60 pot CVs that also fished BS rationalized crab ranged from a peak of 96% in 2016 to a low of 65% in 2021, with the trend consistently downward after the peak. Figure 1-5 plots the number of Over-60 pot cod CVs that *also* harvested rationalized BS crab (vertical axis) and breaks down the number of cross-participating vessels in each year by the proportion of their total annual revenues that were derived from BS crab (color scale); the bottom panel shows the total number of Over-60 pot cod CVs and the proportion that fished crab. The total count of Over-60 pot cod CVs could be determined by external factors – i.e., based on the state of the BS Pacific cod fishery – or partly influenced by crab stocks if vessels that depend on both crab and cod became inactive due to the lack of opportunity in one or the other. The count of Over-60 pot cod CVs that fish crab had been stable between 20 and 30 until the most recent year when, presumably, lack of crab opportunities impacted participation. The color scale in Figure 1-5 shows that most of the drop-off in participation since the peak was from vessels that generated less than 40% of their total revenues from crab. The cross-participating vessels that have historically depended on crab for half or more of their gross activity appear more likely to remain invested in both fisheries as much as possible.



	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
# O-60 PCod pot CVs	33	29	31	31	23	25	34	34	35	39	23
% fished BS Crab	94%	93%	90%	84%	87%	96%	79%	79%	77%	67%	65%

Figure 1-5 Participation (# vessels) in Bering Sea crab fisheries by Pacific cod pot gear CVs ≥ 60 feet and proportion of revenues (legend) from directed crab fishing, 2011-2021. Source: ADFG/CFEC Fish Tickets, data compiled by AKFIN in Comprehensive_FT.

Three to five pot cod CPs fished BS Pacific cod pots during the last ten years. Since 2016, two of the four-to-five pot cod CPs that were active also fished for crab in a given year. At least one pot cod CP has participated in the BS crab fishery in every year since 2011. For whichever two pot cod CPs were active in the crab fishery in a given year, those vessels derived at least 60% of their total gross Alaska fishing revenues from BS crab in that year. This qualitative assessment, as limited by confidentiality, reflects that there is always some portion of the relatively small pot cod CP sector that is directly invested in the future of crab stocks, including BBRKC.

2 Sources of BBRKC mortality across federal fisheries

Council Motion: *Tables for all sources of BBRKC mortality across federal fisheries:*

- *For the pot, longline and trawl groundfish fisheries, total estimated PSC in Registration Area T in numbers, proportion of total PSC in Zone 1, proportion of total PSC in RKCSA, estimated PSC mortality, and estimated proportion of the PSC that are female. Information should also be provided on fishery timing in relation to BBRKC molting and mating, estimated bottom contact of the gear, observer coverage rates, and assumed discard mortality rates.*
- *For the directed BBRKC fishery and the Tanner fishery in the eastern subdistrict, estimated mortality presented in a revised version of Table 3-3 from the April 2022 discussion paper that contains total retained catch, total discards, discard mortality, proportion of discards that are female, observer coverage rate, and assumed discard mortality rate.*

2.1 Sources of Mortality: Pot, Longline and Trawl Groundfish Fisheries

The data in this section are derived from NMFS Alaska Region Catch Accounting System (CAS), as compiled by AKFIN.[10] In the tables, 'PSC' is the count of the estimated number of crab that were taken as bycatch in groundfish gear; 'kilograms of PSC' applies a weight estimate to the number of crab using the same methodology employed by crab stock assessment authors; 'kilograms of PSC mortality' applies the DMRs that are shown below in Table 2-12 (50% for HAL and pot; 80% for trawl); and 'kilograms of female mortality' applies the sex ratio derived from observer data in each year.[11] All data for 2022 are year-to-date through August 21; the reader should note that PSC estimation is subject to revision over a three month period as observer data are debriefed and some previous extrapolations can be replaced with better-matched rates. The tables in the body of this section are focused on the questions directly asked in the Council's motion. Expanded tables for each area (BS, Area T, Zone 1, RKCSA) are included in Appendix 2. As stated in Section 1, the reader is reminded that the RKCSA and RKCSS are combined in the data query that generated the tables below; this explains why a query for RCKSA returns values for the non-pelagic trawl sector which is not allowed to fish in the Savings Area but was permitted in the Savings Subarea in most of the analyzed years.

The Council motion calls for data from Registration Area T, trawl PSC limit Zone 1, and the RKCSA to be presented relative to one another. As shown in Figure 1-3 and Figure 1-4 in the previous section, the RKCSA/SS is nested within Zone 1, which is nested within Area T, which itself represents only a portion of the BS FMP area. The reader should understand that, unless otherwise stated, totals for Area T would include Zone 1, and so on. In other words, the values in each row are not additive. Percent-differences are provided where those values provide a useful shorthand.

The Council's interest in Area T is obvious, as it is the area in which the BBRKC fishery occurs and *generally* aligns with the NMFS trawl survey areas that are used in the BBRKC stock assessment (see Figure 3-1 in NPFMC 2022). Zone 1 PSC has unique implications for the non-pelagic trawl sector because attainment of the area's PSC limit would close directed fishing to that gear sector. By regulation, the decline in mature female RKC abundance and effective spawning biomass has caused the Zone 1 PSC limit to reach the lowest level in 2022. The PSC limit had been in the middle state of three possible

[10] Citation for all groundfish tables: NMFS Alaska Region Catch Accounting System, data compiled by AKFIN in Comprehensive_PSC.

[11] The dataset includes all activity in the Bering Sea. AKFIN uses an algorithm to estimate the sex ratio of PSC at finer levels of spatial and temporal granularity by first looking at observer data at the month and statistical area level, then by month if area data is not available, then by stat area, and finally by year for data cells where sex ratio is not available in the observer data. Estimated crab weights are drawn from observer data.

levels[12] from 2012 through 2021 (97,000 animals) but the 2022 limit dropped to the lowest level (32,000 animals). Additional detail on how the overall Zone 1 PSC limit is apportioned across directed trawl fisheries was provided in Section 3.4 of the April 2022 discussion paper (NPFMC 2022) and is incorporated here by reference.[13] Table 2-1 shows the current state of RKC Zone 1 trawl PSC limits compared to the preceding decade. The Council's interest in the RKCSA is clear through the discussion in the previous section of this document. The RKCSA excludes non-pelagic trawl gear but does not exclude pelagic trawl gear or non-trawl gears such as hook-and-line or pots.

Table 2-1 Zone 1 red king crab prohibited species catch limits for trawl gear, 2010-2022.

Year	A80 Limit	A80 Not Allocated	CDQ	TLAS Pollock/Atka/Other	TLAS Pacific Cod	TLAS Yellowfin	TLAS Total	Total
2010	98,920	23,204	21,079	400	6,000	47,397	53,797	197,000
2011	93,432	28,692	21,079	400	6,000	47,397	53,797	197,000
2012-2021	43,293	16,839	10,379	197	2,954	23,338	26,489	97,000
2022	14,282	5,555	3,424	65	975	7,700	8,739	32,000

Table 2-2 reports the number of RKC PSC that were estimated for four groundfish gear sectors (aggregating across CP and CV). The table shows PSC estimates for the entire Bering Sea, Area T, Zone 1, and the RKCSA/SS (not additive). The general trends within each gear sector mirror what was described for groundfish basis weight in Section 1, except for the pelagic trawl sector where the amount of estimated RKC PSC was so low that it would not be expected to correlate with a trend in groundfish catch by year or area. Each of the other three gear sectors displays a reduction in the amount of PSC recorded in the RKCSA/SS in the most recent years. RKC PSC in the pot gear sector displayed the most year-to-year variation; the trend of decreasing PSC within the RKCSA/SS is not apparent when looking at Zone 1 or Area T as a whole. In most years, Zone 1/Area T comprised a high proportion of the sector's total BS RKC PSC. The value itself, however, ranged from 14,795 in 2020 to 264,753 in 2018 (Area T values). This variability is discussed again in Section 6 of this document as a reason that establishing a hard cap PSC limit for the pot sector could be challenging as a tool that provides useful incentives to the pot fleet balanced with meaningful protections for BBRKC.

Table 2-3 is responsive to the Council's request to express estimated PSC in Zone 1 and in the RKCSA/SS as proportions of total estimated PSC in Area T. The reader should note that percentage differences are less informative when based on small numbers of observations, as is the case with the pelagic trawl category and the HAL category from 2019 through 2022. The percentage values in the table for each sector/year combination are not additive; the RKCSA is contained within Zone 1. To calculate the percentage of Area T PSC that occurred in Zone 1 *but outside of the RKCSA/SS*, subtract the RKCSA/SS percentage from the Zone 1 percentage.

[12] See § 679.21(e)(1)(i)

[13] In brief, a portion of the limit is apportioned to the CDQ PSQ reserve and can be used for any gear type. The Amendment 80 sector receives an apportionment, some of which is not allocated and thus remains unused by any sector as part of the original implementation design of A80. The remainder is apportioned to the trawl limited access sector (TLAS), which includes subapportionments for directed fishing for yellowfin sole, Pacific cod, and a combined category consisting of "pollock/Atka mackerel/other". The latter subapportionment of the TLAS PSC limit notably encompasses all of the fishing that occurs with pelagic trawl gear (i.e., pollock directed fishery).

Table 2-2 Estimated red king crab PSC (# animals) by groundfish gear sector in the Bering Sea management area, Area T, PSC Zone 1, and RKCSA/SS – 2013-2022 (*2022 YTD 8/21)

Gear		2013	2014	2015	2016	2017	2018	2019	2020	2021	2022*	Average
Hook and Line	Bering Sea	12,737	16,721	7,177	9,732	8,184	19,518	95	61	226	474	7,493
	Area T	12,509	15,870	6,470	8,833	7,755	19,209	19	8	0	6	7,068
	Zone 1	12,495	15,816	6,306	8,334	7,610	17,754	0	2	0	6	6,832
	RKCSA	5,452	4,173	1,006	3,896	5,527	9,180	0	2		5	3,249
Non-Pelagic Trawl	Bering Sea	31,497	32,221	19,903	41,004	59,527	30,109	69,597	64,390	40,500	6,871	39,562
	Area T	26,756	31,496	18,321	38,185	56,671	21,942	58,891	59,497	34,840	6,684	35,328
	Zone 1	25,186	28,213	12,754	23,319	35,032	12,725	25,008	42,745	19,171	3,153	22,731
	RKCSA	6,821	12,979	3,704	8,163	2,285	796	1,890	2,187	533	0	3,936
Pot	Bering Sea	93,138	136,667	177,722	22,427	30,053	291,184	46,102	20,793	281,903	12,937	111,292
	Area T	71,511	84,132	114,767	22,065	21,002	264,753	43,309	14,795	260,459	8,347	90,514
	Zone 1	65,476	80,770	104,440	21,812	18,164	243,456	41,964	14,030	234,539	7,468	83,212
	RKCSA	6,280	17,619	61,213	14,514	384	12,516	953	249	97		12,647
Pelagic Trawl	Bering Sea	0	7	0	6	23	14	25	10	27	13	13
	Area T	0	7	0	6	23	14	25	10	27	13	13
	Zone 1	0	7	0	6	23	14	25	9	27	13	12
	RKCSA	0	7	0	2	20	5	23	3	18	7	8
Total	Bering Sea	137,372	185,616	204,802	73,168	97,787	340,825	115,819	85,254	322,656	20,295	158,359
	Area T	110,776	131,506	139,558	69,089	85,451	305,918	102,244	74,310	295,326	15,051	132,923
	Zone 1	103,157	124,806	123,500	53,471	60,828	273,949	66,997	56,786	253,737	10,640	112,787
	RKCSA	18,553	34,777	65,923	26,574	8,216	22,497	2,866	2,440	647	12	18,251

Table 2-3 Proportion of Area T total estimated red king crab PSC that occurred in PSC Zone 1 or the RKCSA/SS – 2013-2022 (*2022 YTD 8/21)

Gear	% Area T	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022*	Average
HAL	Zone 1	99.9%	99.7%	97.5%	94.4%	98.1%	92.4%	0.2%	23.0%	0.0%	99.4%	96.7%
	RKCSA	43.6%	26.3%	15.5%	44.1%	71.3%	47.8%	0.0%	23.0%	0.0%	80.8%	46.0%
NPT	Zone 1	94.1%	89.6%	69.6%	61.1%	61.8%	58.0%	42.5%	71.8%	55.0%	47.2%	64.3%
	RKCSA	25.5%	41.2%	20.2%	21.4%	4.0%	3.6%	3.2%	3.7%	1.5%	0.0%	11.1%
Pot	Zone 1	92%	96%	91%	99%	86%	92%	97%	95%	90%	89%	92%
	RKCSA	9%	21%	53%	66%	2%	5%	2%	2%	0%	0%	14%
PTR	Zone 1		100%		100%	100%	100%	100%	93%	100%	100%	99%
	RKCSA		100%		30%	88%	35%	90%	31%	67%	54%	68%
Total	Zone 1	93%	95%	88%	77%	71%	90%	66%	76%	86%	71%	85%
	RKCSA	17%	26%	47%	38%	10%	7%	3%	3%	0%	0%	14%

Table 2-4 displays the estimated RKC PSC that was female, using the same sector and area definitions. The gross total of PSC (Table 2-2) and the amount that is estimated to be female based on observer data (Table 2-4) can be translated to mortality in “number of animals” by applying the 80% handling mortality rate to trawl sector estimates and the 50% handling mortality rate to non-trawl sectors (pot and HAL). Table 2-5 presents estimated mortality in kilograms to reflect the methodology used in the stock assessment. Table 2-5 shows the proportion of mortality that was female in each year, as requested by the Council. The table shows nested area values for Area T, Zone 1, and the RKCSA. The averages reported in percentages (right-hand column) are weighted by annual mortality so years with more estimated PSC factor more heavily into the period average than years with less PSC.

The sector with the highest proportion of mortality that was female was pot gear; amounts varied annually but were often above 70%. Those proportions for pot gear were similar both inside and outside of the RKCSA/SS. The proportion for pot gear was higher than the female mortality proportion for HAL gear, which was the only other sector with a non-trivial amount of estimated PSC that fished inside the Savings Area. That said, it is difficult to envision that pot gear selects for females in some way that HAL gear does not. A possible explanation for the difference between pot and HAL results could be the areas *within* the RKCSA where each gear fishes; spatial data were not analyzed at that level of granularity for this discussion paper. The non-pelagic trawl sector – where "RKCSA" represents fishing in the RKCSS – was the only sector where catch around the Savings Area showed a higher average proportion of female mortality than the greater areas of Zone 1 and Area T.

Table 2-4 Estimated *female* red king crab PSC (# animals) by groundfish gear sector in the Bering Sea management area, Area T, PSC Zone 1, and RKCSA/SS – 2013-2022 (*2022 YTD 8/21)

Gear		2013	2014	2015	2016	2017	2018	2019	2020	2021	2022*	Average
Hook and Line	Bering Sea	6,042	7,154	3,546	4,527	5,471	8,270	26	31	52	0	3,512
	Area T	5,913	6,836	3,336	4,298	5,286	8,088	4	3	0	0	3,376
	Zone 1	5,912	6,797	3,279	4,079	5,209	7,559	0	1	0	0	3,284
	RKCSA	3,083	1,779	502	1,371	3,506	3,626	0	1		0	1,541
Non-Pelagic Trawl	Bering Sea	12,093	14,408	7,893	19,068	12,440	12,814	25,688	18,938	11,661	4,274	13,928
	Area T	10,793	14,039	7,419	17,496	11,468	9,323	21,516	17,117	9,720	4,200	12,309
	Zone 1	10,054	12,366	4,724	13,271	8,195	5,894	10,933	12,565	6,196	1,503	8,570
	RKCSA	3,547	5,813	2,110	5,684	1,626	520	1,223	1,195	141	0	2,186
Pot	Bering Sea	48,470	99,086	154,825	16,249	27,431	209,108	37,614	17,563	254,980	10,165	87,549
	Area T	37,258	64,458	99,390	15,919	19,209	190,385	35,514	12,216	235,628	6,559	71,654
	Zone 1	33,634	62,373	90,323	15,671	16,417	175,709	34,496	11,457	212,236	5,867	65,818
	RKCSA	4,826	10,841	51,456	9,568	54	9,343	522	248	91		9,661
Pelagic Trawl	Bering Sea	0	7	0	0	22	0	0	7	27	0	6
	Area T	0	7	0	0	22	0	0	7	27	0	6
	Zone 1	0	7	0	0	22	0	0	7	27	0	6
	RKCSA	0	7	0	0	20	0	0	3	18	0	5
Total	Bering Sea	66,605	120,656	166,264	39,844	45,365	230,192	63,328	36,539	266,720	14,439	104,995
	Area T	53,964	85,340	110,145	37,713	35,985	207,796	57,033	29,344	245,375	10,759	87,346
	Zone 1	49,600	81,544	98,326	33,020	29,843	189,162	45,429	24,029	218,460	7,370	77,678
	RKCSA	11,456	18,439	54,068	16,623	5,206	13,489	1,745	1,446	250	0	12,272

Table 2-5 Estimated red king crab PSC mortality (kilograms) and percentage of mortality that was female, by groundfish gear sector in Area T, PSC Zone 1, and RKCSA/SS – 2013-2022 (*2022 YTD 8/21)

Gear		2013	2014	2015	2016	2017	2018	2019	2020	2021	2022*	Average
Hook and Line	Area T	14,141	16,583	7,957	9,579	7,131	14,878	18	16		11	7,813
	%Female	*47%*	*43%*	*52%*	*48%*	*68%*	*40%*	*18%*	*38%*		*0%*	*48%*
	Zone 1	14,123	16,513	7,745	8,973	6,976	13,185	0	2		11	7,503
	%Female	*47%*	*43%*	*52%*	*49%*	*68%*	*41%*		*38%*		*0%*	*48%*
	RKCSA	6,006	4,312	1,214	4,222	4,938	7,622		2		9	3,541
	%Female	*56%*	*43%*	*50%*	*35%*	*63%*	*38%*		*38%*		*0%*	*47%*
Non-Pelagic Trawl	Area T	46,272	50,971	29,244	55,271	114,208	41,113	95,014	94,624	59,356	10,567	59,664
	%Female	*40%*	*44%*	*41%*	*44%*	*18%*	*42%*	*36%*	*28%*	*27%*	*64%*	*33%*
	Zone 1	44,524	45,705	21,563	31,692	67,786	21,918	37,421	65,736	31,356	4,717	37,242
	%Female	*40%*	*44%*	*38%*	*56%*	*21%*	*46%*	*43%*	*29%*	*32%*	*48%*	*36%*
	RKCSA	12,179	21,089	6,040	10,291	3,249	1,246	2,579	2,925	755		6,035
	%Female	*52%*	*45%*	*59%*	*69%*	*68%*	*65%*	*64%*	*56%*	*27%*		*55%*
Pot	Area T	32,990	52,966	67,406	11,800	14,045	143,588	28,905	9,751	96,956	5,313	46,372
	%Female	*53%*	*77%*	*87%*	*72%*	*92%*	*72%*	*83%*	*83%*	*90%*	*79%*	*79%*
	Zone 1	30,254	50,798	67,406	11,667	12,211	131,689	28,267	9,249	87,319	5,313	43,417
	%Female	*52%*	*77%*	*87%*	*72%*	*91%*	*72%*	*83%*	*83%*	*90%*	*79%*	*79%*
	RKCSA	3,041	11,455	39,242	8,222	191	7,058	459	179	36		7,765
	%Female	*78%*	*61%*	*84%*	*66%*	*14%*	*75%*	*55%*	*100%*	*95%*		*77%*
Pelagic Trawl	Area T		5		4	21	18	25	15	23	6	15
	%Female		*100%*		*0%*	*97%*	*0%*	*0%*	*70%*	*100%*	*0%*	*50%*
	Zone 1		5		4	21	18	25	15	23	6	15
	%Female		*100%*		*0%*	*97%*	*0%*	*0%*	*70%*	*100%*	*0%*	*50%*
	RKCSA		5		1	19	2	23	5	15	3	9
	%Female		*100%*		*0%*	*99%*	*0%*	*0%*	*100%*	*100%*	*0%*	*60%*
Total	Area T	93,404	120,525	104,607	76,654	135,405	199,598	123,962	104,406	156,334	15,896	113,079
	%Female	*46%*	*58%*	*71%*	*49%*	*28%*	*63%*	*47%*	*33%*	*66%*	*69%*	*53%*
	Zone 1	88,901	113,021	96,714	52,336	86,995	166,810	65,713	75,003	118,697	10,046	87,424
	%Female	*45%*	*59%*	*73%*	*58%*	*34%*	*66%*	*60%*	*36%*	*75%*	*64%*	*58%*
	RKCSA	21,225	36,861	46,496	22,736	8,396	15,929	3,061	3,111	807	12	15,863
	%Female	*57%*	*50%*	*80%*	*62%*	*64%*	*56%*	*62%*	*58%*	*31%*	*0%*	*63%*

Table 2-6 and Table 2-7 break out RKC PSC by timing within Area T and within the subset of Area T that makes up the RKCSA/SS. The timing component relates to the susceptibility of RKC to observed and/or unobserved mortality during their molting phase. Molt/mate timing was previously discussed in Section 2 of the April 2022 discussion paper (NPFMC 2022). The within-population details of molt/mate timing are not fully settled, but it is generally understood that BBRKC molt between January and June (Pers Comm J. Zheng, ADFG, 2022; see also Table 2a in Fedewa et al. 2020). Acknowledging some degree of uncertainty, it is thought that males and primiparous females (individuals bearing first offspring) molt during the January-March period. Multiparous females (individuals that have previously borne offspring) are more likely to molt/mate in the March-June period, due partly to the fact that they might be hatching a clutch prior to the current-year molt/mate (Pers Comm L. Zacher, AFSC, 2022). Despite uncertainties about the exact timing of mature female molt/mate, it is accepted that primiparous females molt earlier, closer to the timing of male molt. Mating occurs at the same time as molting for mature females.

Table 2-6 Estimated red king crab PSC (#animals) by month and groundfish sector in Registration Area T – 2013-2022 (*2022 YTD 8/21)

Hook-and-Line	Jan-Feb	Mar-Apr	May-Jun	Jan-Jun Subtotal	Jul-Dec	HAL Total	% Jan-Jun
2013	6,727	1,319	247	8,293	4,216	12,509	66%
2014	6,486	5,272	252	12,010	3,861	15,870	76%
2015	4,581	1,287	15	5,884	586	6,470	91%
2016	1,983	227	174	2,384	6,449	8,833	27%
2017	1,331	1,534	56	2,922	4,833	7,755	38%
2018	793	99	11	903	18,306	19,209	5%
2019	9	11	0	19	0	19	99%
2020	6	0	2	8	0	8	100%
2021	0	0	0	0	0	0	100%
2022*	0	0	0	0	6	6	1%
Average	2,192	975	76	3,242	3,826	7,068	46%

Non-Pelagic Trawl	Jan-Feb	Mar-Apr	May-Jun	Jan-Jun Subtotal	Jul-Dec	NPT Total	% Jan-Jun
2013	9,960	6,651	455	17,066	9,690	26,756	64%
2014	17,083	7,631	1,206	25,920	5,577	31,496	82%
2015	8,412	4,414	1,138	13,964	4,356	18,321	76%
2016	11,610	12,175	2,933	26,718	11,467	38,185	70%
2017	8,176	13,391	3,914	25,481	31,191	56,671	45%
2018	4,765	5,228	2,976	12,969	8,973	21,942	59%
2019	12,920	21,829	5,041	39,790	19,101	58,891	68%
2020	12,088	16,514	732	29,334	30,163	59,497	49%
2021	3,981	11,499	4,584	20,064	14,776	34,840	58%
2022*	325	3,024	1,588	4,937	1,747	6,684	74%
Average	8,932	10,235	2,457	21,624	13,704	35,328	61%

POT	Jan-Feb	Mar-Apr	May-Jun	Jan-Jun Subtotal	Jul-Dec	POT Total	% Jan-Jun
2013	4,627	0	0	4,627	66,884	71,511	6%
2014	4,869	2,449	408	7,726	76,406	84,132	9%
2015	3,056	1,838		4,894	109,873	114,767	4%
2016	635	0		635	21,430	22,065	3%
2017	14,038	2,865	0	16,903	4,099	21,002	80%
2018	5,061	0	5	5,066	259,687	264,753	2%
2019	2,694	46		2,740	40,569	43,309	6%
2020	4,818	849	0	5,667	9,128	14,795	38%
2021	8,003	12,233	0	20,236	240,223	260,459	8%
2022*	7,698	649	0	8,347	0	8,347	100%
Average	5,550	2,093	59	7,684	82,830	90,514	8%

Pelagic Trawl	Jan-Feb	Mar-Apr	May-Jun	Jan-Jun Subtotal	Jul-Dec	PTR Total	% Jan-Jun
2013	0	0	0	0	0	0	
2014	7	0	0	7	0	7	100%
2015	0	0	0	0	0	0	
2016	0	3	2	5	1	6	76%
2017	20	3	0	23	0	23	100%
2018	9	5	0	14	0	14	100%
2019	25	0	0	25	0	25	100%
2020	5	0	0	5	5	10	51%
2021	11	16	0	27	0	27	100%
2022*	5	8	0	13	0	13	100%
Average	8	3	0	12	1	13	95%

Table 2-7 Estimated red king crab PSC (#animals) by month and groundfish sector in the RKCSA/SS – 2013-2022 (*2022 YTD 8/21)

Hook-and-Line	Jan-Feb	Mar-Apr	May-Jun	Jan-Jun Subtotal	Jul-Dec	HAL Total	% Jan-Jun
2013	3,295	624	63	3,982	1,470	5,452	73%
2014	1,612	745	72	2,430	1,743	4,173	58%
2015	889	0		889	117	1,006	88%
2016	51	14	139	204	3,692	3,896	5%
2017	564	406	43	1,014	4,513	5,527	18%
2018	448			448	8,732	9,180	5%
2019				0	0	0	
2020			2	2	0	2	98%
2021				0			
2022*				0	5	5	0%
Average	1,143	358	64	897	2,252	3,249	28%

Non-Pelagic Trawl	Jan-Feb	Mar-Apr	May-Jun	Jan-Jun Subtotal	Jul-Dec	NPT Total	% Jan-Jun
2013	4,324	2,264	62	6,649	172	6,821	97%
2014	12,301	604	74	12,979	0	12,979	100%
2015	3,516	187		3,704	0	3,704	100%
2016	4,803	2,959		7,762	400	8,163	95%
2017	1,386	774	0	2,160	125	2,285	95%
2018	651	139	6	796		796	100%
2019	1,389	425		1,814	76	1,890	96%
2020	1,434	118		1,552	635	2,187	71%
2021	254	278		533		533	100%
2022*		0		0		0	
Average	3,340	775	35	3,795	201	3,936	96%

POT	Jan-Feb	Mar-Apr	May-Jun	Jan-Jun Subtotal	Jul-Dec	POT Total	% Jan-Jun
2013	1,458			1,458	4,822	6,280	23%
2014	414			414	17,205	17,619	2%
2015	105			105	61,108	61,213	0%
2016				0	14,514	14,514	0%
2017				0	384	384	0%
2018				0	12,516	12,516	0%
2019				0	953	953	0%
2020	215	33		249		249	100%
2021	97			97		97	100%
2022*				0			
Average	458	33		232	15,929	12,647	2%

Pelagic Trawl	Jan-Feb	Mar-Apr	May-Jun	Jan-Jun Subtotal	Jul-Dec	PTR Total	% Jan-Jun
2013	0	0		0		0	
2014	7	0	0	7		7	100%
2015	0			0		0	
2016	0	0	0	0	1	2	18%
2017	19	1	0	20		20	100%
2018	0	5	0	5		5	100%
2019	23	0	0	23		23	100%
2020	3	0		3		3	100%
2021	10	8		18		18	100%
2022*	2	5		7		7	100%
Average	6	2	0	8	1	10	85%

Table 2-8 and Table 2-9 supplement Table 2-5 with the timing of when red king crab mortality and female mortality occurred in groundfish fisheries in Area T and in the RKCSA/SS. The tables are slightly abbreviated by the exclusion of the pelagic trawl sector (all years), the years when the HAL sector was estimated to have fewer than 100kg of red king crab mortality in Area T (2019-2022), the years when the pot sector had fewer than 100kg of red king crab mortality in the RKCSA (2021-2022), and the year when the non-pelagic trawl sector had fewer than 100kg of mortality in the RKCSS (2022). Information on the annual amount of RKC mortality and female mortality for those sectors/years is provided in Table 2-2 and Table 2-4 and in Appendix 2; timing information for total PSC counts by sector is provided in Table 2-6 and Table 2-7. Further decomposition of those small crab counts has limited analytical value.

Table 2-8 Estimated red king crab PSC mortality (kilograms) and percentage of mortality that was female, by month and by groundfish gear sector in Area T – 2013-2022 (*2022 YTD 8/21)

		Jan-Feb		Mar-Apr		May-Jun		Jul-Dec	
		Mortality	% Female	Mortality	% Female	Mortality	% Female	Mortality	% Female
Hook-and-Line	2013	7,500	63%	1,517	44%	285	5%	4,839	26%
	2014	6,686	54%	5,485	35%	269	24%	4,142	37%
	2015	5,616	58%	1,579	33%	18	11%	744	41%
	2016	2,086	75%	231	61%	191	64%	7,072	40%
	2017	1,232	88%	1,474	84%	53	52%	4,372	57%
	2018	725	85%	95	99%	10	93%	14,049	38%
	2013-22	**23,866**	**62%**	**10,390**	**44%**	**829**	**29%**	**35,228**	**39%**
Non-Pelagic Trawl	2013	17,610	57%	11,569	34%	577	19%	16,515	27%
	2014	27,732	47%	12,310	33%	1,879	56%	9,050	50%
	2015	13,386	39%	7,958	34%	1,540	32%	6,360	55%
	2016	14,853	65%	16,642	38%	4,337	44%	19,439	34%
	2017	12,967	48%	27,966	18%	7,645	22%	65,631	12%
	2018	7,953	54%	9,716	19%	6,080	39%	17,364	50%
	2019	18,392	52%	32,941	30%	7,247	32%	36,434	34%
	2020	17,018	38%	27,415	21%	994	36%	49,197	28%
	2021	6,734	36%	18,623	28%	6,333	26%	27,666	25%
	2022	516	53%	4,617	46%	2,630	76%	2,804	84%
	2013-22	**137,162**	**49%**	**169,756**	**28%**	**39,263**	**36%**	**250,460**	**28%**
Pot	2013	2,293	92%					30,697	50%
	2014	2,684	81%	1,303	67%	217	67%	48,762	77%
	2015	1,919	84%	1,161	48%			64,326	87%
	2016	351	100%					11,450	71%
	2017	9,559	95%	1,976	85%			2,510	85%
	2018	2,801	71%			3	71%	140,784	72%
	2019	1,473	77%	22	75%			27,411	83%
	2020	3,416	100%	611	100%			5,724	72%
	2021	2,985	90%	4,563	90%			89,408	90%
	2022	4,844	79%	469	79%				
	2013-22	**32,325**	**88%**	**10,104**	**81%**	**220**	**67%**	**421,072**	**78%**

Table 2-9 Estimated red king crab PSC mortality (kilograms) and percentage of mortality that was female, by month and by groundfish gear sector in the RKCSA/SS – 2013-2022 (*2022 YTD 8/21)

		Jan-Feb		Mar-Apr		May-Jun		Jul-Dec	
		Mortality	% Female	Mortality	% Female	Mortality	% Female	Mortality	% Female
Hook-and-Line	2013	3,587	80%	714	23%	72	5%	1,633	22%
	2014	1,640	47%	771	59%	77	25%	1,824	32%
	2015	1,071	50%					144	53%
	2016	56	80%	15	72%	153	70%	3,998	33%
	2017	495	87%	363	87%	40	54%	4,039	58%
	2018	401	86%					7,221	35%
	2013-22	**7,250**	**69%**	**1,864**	**51%**	**345**	**45%**	**18,867**	**38%**
Non-Pelagic Trawl	2013	7,810	56%	3,948	46%	106	13%	314	41%
	2014	19,994	45%	975	42%	120	44%		
	2015	5,684	60%	356	47%				
	2016	5,975	73%	3,706	68%			610	42%
	2017	1,903	72%	1,117	71%			229	22%
	2018	1,019	72%	217	35%	10	60%		
	2019	1,881	65%	575	67%			123	36%
	2020	1,843	38%	184	26%			898	98%
	2021	342	11%	413	39%				
	2013-22	**46,451**	**54%**	**11,493**	**55%**	**236**	**31%**	**2,174**	**62%**
Pot	2013	741	92%					2,300	74%
	2014	220	80%					11,235	61%
	2015	66	100%					39,176	84%
	2016							8,222	66%
	2017							191	14%
	2018							7,058	75%
	2019							459	55%
	2020	155	100%	24	100%				
	2013-22	**1,219**	**91%**	**24**	**100%**			**68,640**	**76%**

2.2 Sources of Mortality: Directed Crab Fisheries (BBRKC and Tanner East)

Table 2-10 reports estimated RKC discard mortality in the directed fishery for BBRKC that takes place in State Registration Area T (Bristol Bay). ADFG estimates total discards by summing estimated catch of females and males based on fishing effort multiplied by sex-specific observer catch-per-unit-effort (CPUE) data. All female catch is discarded and male discards are estimated as the remainder after subtracting retained catch from total male catch. Most discarded males are of sublegal size, though some legal-size males are discarded due to shell condition or if they are very close to the legal size threshold. Estimated discard mortality is calculated by applying a 20% "handling mortality rate" to total discards. Reliable discard estimates are available back to 2005 when the fishery was rationalized and observer data improved. The table shows that total discards were greater than retained catch in most years, but not all. On average, retained catch was about 80% of the number of discarded crab, though the annual range varied from 42% (2018) to 185% (2012). In the three most recently reported years when there were fewer crab retained (2018-2020), discards outweighed retained catch by a greater margin, possibly reflecting that the fishery was sorting through a higher relative proportion of sublegal males.

Table 2-10 Estimated discards, discard mortality, and retained catch of red king crab (number of animals) in the directed BBRKC fishery, 2005-2021 (Source: B. Daly, ADFG. July 2022. Pers. Comm.)

	Female catch (discard)	Male sublegal catch (discard)	Total discards	Discard mortality	Male catch (retained)
2005	1,682,031	3,181,024	4,863,056	**972,611**	2,763,147
2006	221,623	1,572,174	1,793,797	**358,759**	2,502,786
2007	731,651	3,498,460	4,230,111	**846,022**	3,162,287
2008	662,313	3,772,206	4,434,519	**886,904**	3,066,286
2009	350,730	3,118,571	3,469,302	**693,860**	2,556,645
2010	470,492	2,321,052	2,791,545	**558,309**	2,409,952
2011	118,511	1,338,976	1,457,486	**291,497**	1,298,023
2012	46,511	590,033	636,545	**127,309**	1,175,752
2013	409,457	908,106	1,317,563	**263,513**	1,272,273
2014	275,901	1,704,433	1,980,333	**396,067**	1,525,581
2015	801,260	1,107,517	1,908,777	**381,755**	1,526,974
2016	432,824	946,875	1,379,699	**275,940**	1,281,194
2017	233,063	730,783	963,846	**192,769**	997,214
2018	591,898	910,903	1,502,801	**300,560**	629,907
2019	151,967	813,686	965,653	**193,131**	548,516
2020	64,575	662,986	727,561	**145,512**	455,262
2021*	21,065	9,940	31,005	**6,201**	6,230
Average	452,800	1,698,612	2,151,412	430,282	1,698,237
Median	380,094	1,223,246	1,648,299	329,660	1,411,802

* 2021 catch and discards are not figured into the average and median summary statistics. The 2021 data occurred during the State of Alaska cost recovery fishery in October 2021. The state cost recovery fishery is part of each year's annual totals, but the fact that it was the only BBRKC activity in 2021 makes the year unique and not appropriate to include in period summaries. The State of Alaska uses the cost recovery fishery to fund the Bering Sea crab observer program and the ADFG Bering Sea crab research program.

Table 2-11 reports estimated RKC discards, mortality, and retained catch in the eastern subdistrict of the Tanner crab fishery. The Tanner crab fishery area is the portion of the State of Alaska's Bering Sea district that is west of 163 degrees W longitude (slightly east of False Pass) and east of 173 W longitude (map: ADFG Registration Area J)[14]. The area spans north of 53 degrees 36 minutes N latitude (~Unimak Island) to areas north of St. Lawrence Island (excluding Norton Sound). The Tanner crab fishery area is subdivided into eastern and western subdistricts at 166 degrees W, referred to here as Tanner East and Tanner West. The Tanner crab fishery area fully contains the BBRKC area (Area T) as shown in Figure 2-1, but parts of Tanner West fall outside the BBRKC fishery area (to the west and north) and parts of Tanner East fall outside as well (to the north). ADFG shellfish analysts determined that catch of retained or discarded RKC in the Tanner fishery occurred entirely – or almost entirely – in the Tanner East subdistrict, and that estimating the sex ratios of any RKC that were encountered in Tanner West would be challenging due to the need to account for differences in the rates of Tanner West effort and realized observer coverage that does or does not occur in the portion that overlaps Area T. The analysts

[14] The Area J map shows a boundary at 165 degrees W longitude that is the eastern boundary of the snow crab fishery.

determined that focusing on data from Tanner East is consistent with the Council's intent, thus the data in Table 2-11 includes only catch from 163 to 166 degrees W longitude.

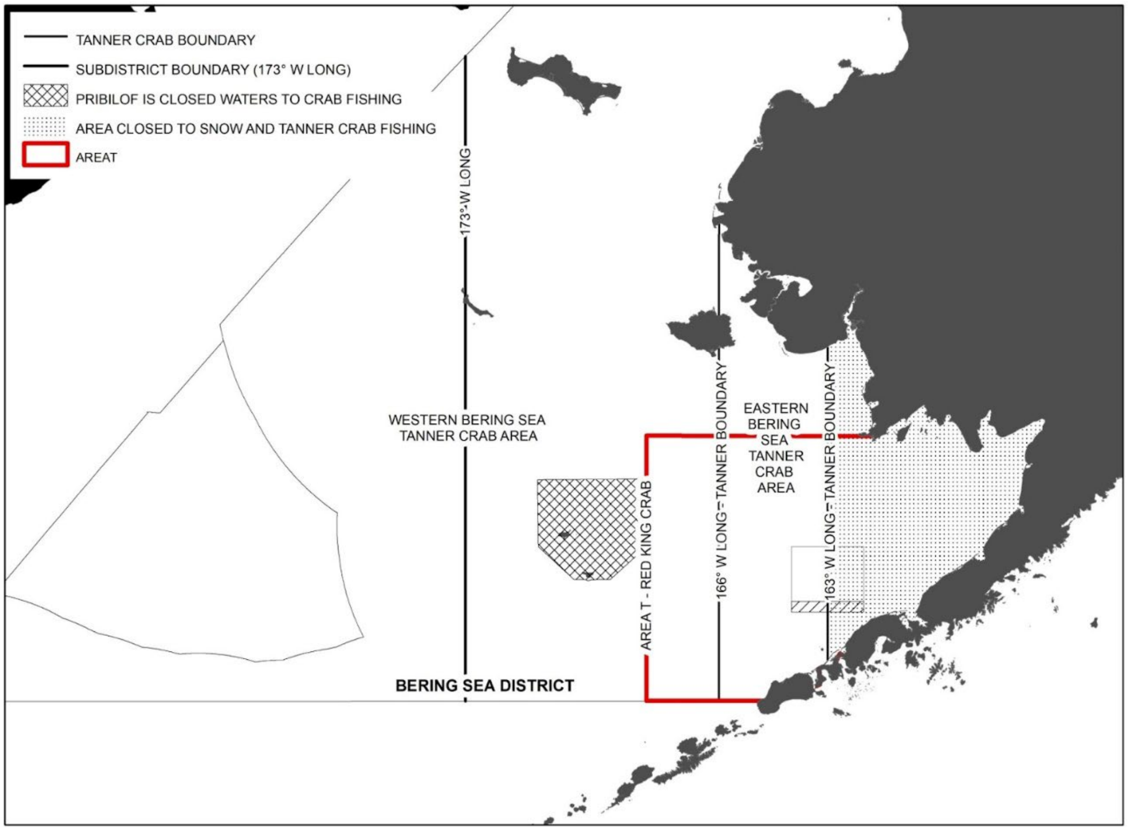


Figure 2-1 Bristol Bay red king crab fishery area (Area T) overlaid on Tanner crab fishery area. Area between 163 W and 166 W longitude is referred to in this paper as "Tanner East"

Table 2-11 summarizes RKC catch and discards within the Tanner East fishery. Total RKC encounters in the Tanner East fishery peaked dramatically from 2013 to 2015, but those years were bookended by three to five year periods where RKC were not encountered in the Tanner crab fishery at all. RKC discard mortality in the Tanner fishery is calculated based on a 25% handling mortality rate (see Table 2-12). As with RKC handling mortality in the directed Area T BBRKC fishery, estimated mortality in the Tanner fishery is a function of observer-based total catch estimation by sex minus retained male catch.

Retained catch of legal-size male RKC was negligible in every year compared to total catch. Under current State of Alaska regulations, BBRKC cannot be retained in the Tanner crab fishery.[15] Any RKC that were illegally retained would have been counted as deadloss. Few RKC were ever retained in the Tanner East fishery because Tanner crab are often targeted in February and March, after the BBRKC directed fishery closes by State regulation on January 15. The rationalized crab fleet tends to fish RKC when the season opens for most crab species on October 15. Tanner crab might be targeted directly after RKC quotas are harvested but before snow crab are targeted closer to the end of the calendar year, or they might be targeted after snow crab (and after Pacific cod for crab vessels that also target cod with pots in January). The latter case is most common and the February/March period tends to align with better CPUE

[15] 5 AAC 35.020. Tanner crab area registration (i): Other species may not be retained unless specified in that chapter.
5 AAC 35.506. Area J registration (i): Lists which crab can be retained in the Tanner crab registration fishery and BBRKC is not listed.

for Tanner crab. The setup of the typical Tanner crab pot ensures RKC that do enter the pots are likely to be sublegal size. Whether legally retainable or not, few legal-size RKC would be found in pots used to target Tanners because those pots are rigged with “Tanner boards” that reduce the tunnel eye height for the explicit purpose of preventing large RKC from entering.[16] Appendix 4 includes photos and diagrams that highlight pot gear modifications that are designed to sort out small crab or prevent large crab from entering pots based on the species being targeted.

Table 2-11 Estimated discards, discard mortality, and retained catch of red king crab (number of animals) for the eastern subdistrict of the bairdi Tanner crab fishery, 2005-2021 (Source: B. Daly, ADFG. July 2022. Pers. Comm.)

	Female catch (discard)	Male discard	Total discards	Discard mortality	Male catch (retained)
2005	No estimated catch or discards of RKC				
2006	982	7,811	8,793	**2,198**	44
2007	1,779	4,413	6,191	**1,548**	0
2008	5,210	6,201	11,410	**2,853**	0
2009	2,643	1,612	4,255	**1,064**	0
2010-2012	No estimated catch or discards of RKC				
2013	68,980	20,273	89,253	**22,313**	0
2014	65,623	34,403	100,026	**25,006**	1
2015	433,284	116,810	550,094	**137,523**	0
2016-2021	No estimated catch or discards of RKC				

2.3 Crab Handling Mortality Rates

Crab handling mortality is a term similar to the use of discard mortality rate (DMR) in directed groundfish fisheries. Once returned to the ocean, a portion of discarded crab dies. Estimating this mortality is necessary to estimate total fishing mortality for catch accounting and to avoid overfishing.

Table 2-12 reports the RKC handling mortalities currently applied in the directed crab fisheries that were mentioned in the Council’s motion and mortality rates that are applied to RKC that come onboard groundfish vessels using trawl or non-trawl gear. At its May 2022 meeting, the Crab Plan Team (CPT) reviewed the history of the rates that are currently used for catch accounting, stock assessment, and analysis. The CPT summarized that hearing in Section 9 (p.13) of its May 2022 meeting report.

At the May 2022 CPT meeting, ADFG staff described handling mortality estimation for the directed crab fisheries (see presentation by B. Daly, ADFG 2022). Sources of handling mortality include physical injury on deck, anoxia, and temperature stress in freezing air conditions. Short-term mortality is better understood and estimated. The long-term effects on crab that are handled on deck and returned to the sea are a source of uncertainty and require a buffer in the total mortality estimate that is ultimately used for catch accounting. The presentation linked above summarizes published research from 1990 to 2006 and provides the history of the rates that have been used over the last three decades. The handling mortality rate applied to RKC in the directed fishery was increased from less than 1% prior to 1996 to the current rate of 20% in 2004, with an intermediate step in between. The current rate appears to be based on published estimates of short-term mortality around 6% and then buffered to account for uncertain long-term effects. The higher mortality rate applied to king crab discards in other directed crab fisheries are the

[16] Tanner boards are a term of art and a practical measure used in the fishery, but are not part of State regulation. 5 AAC 35.525. Lawful gear for Registration Area J (b)(1) defines minimum mesh and escape ring sizes to sort for small Tanner crab.

result of higher estimated short-term mortality due to colder air temperatures during the times when those fisheries are conducted. For example, a 25% mortality rate is applied to RKC caught in the Tanner fishery since it typically occurs in February and March, when air temperatures are colder than they are during the October/November directed RKC fishery.

Deadloss of retained crab catch in directed fisheries is less than 2% according to ADFG/CFEC Fish Ticket data. Deadloss is likely lower – and thus not a good approximation of discard handling mortality – for several reasons: retained crab are likely biased towards good condition (larger, more robust); deadloss does not inform long-term mortality; crab discarded for regulatory reasons (female, sublegal size) are subject to repeated capture; and predation by fish can occur as crab descend through the water column or are lethargic on the bottom after capture and release.

At the same meeting, NPFMC staff provided the CPT with a history of the mortality rates applied to crab bycatch in groundfish fisheries (see presentation by D. Stram and S. Rheinsmith, NPFMC 2022). The 80% mortality rate applied to crab bycatch in trawl gear is primarily based on the Stevens (1990) publication linked in Table 2-12. The groundfish species being targeted during field studies leading to that publication were yellowfin sole, rock sole, and Pacific cod, which would be more indicative of non-pelagic trawl gear than pelagic trawl gear (pollock). That difference may be of little concern because the prior research relied upon in the Stevens publication attributed mortality mostly to shell condition and the time that crab spend out of the water. The presentation cites a 2010 NPFMC paper showing the histories of studies relied upon to calculate crab mortality rates in groundfish fisheries and the rates that the Council utilized (NPFMC 2010). The May 2022 presentation also noted that the non-trawl mortality rate of 50% is not based on direct research studies of bycatch in the longline or pot groundfish fisheries; the rate is a combination of approximations based on the work of Stevens. The current rate of 50% has been in use since 2008.

The May 2022 CPT meeting report concluded that there is currently no objective basis to change handling mortality rates, but encouraged studies that could inform new estimates. The CPT highlighted one study that would utilize a "reflex action mortality predictor" (RAMP) approach to assess post-discard mortality rates of RKC, which has not previously been done. The CPT also encouraged crab assessment authors to provide documentation on the rates used in their assessments.

Table 2-12 BBRKC handling mortality rates for red king crab by gear type

Fishery	BBRKC Handling Mortality	Source
BBRKC Fishery	20%	J. Zheng (ADFG 2020) assumed value based on published literature (see Slides 10-29 in B. Daly (ADFG 2022) presentation to Crab Plan Team
Tanner Fishery	25%	J. Zheng (ADFG 2020) assumed value based on published literature (see Slides 10-29 in B. Daly (ADFG 2022) presentation to Crab Plan Team
Groundfish Trawl	80%	Stevens, B. G. "Survival of king and Tanner crabs captured by commercial sole trawls." Fishery Bulletin 88.4 (1990): 731-744.
Groundfish Non-Trawl (pot; hook-and-line)	50%	Stevens, B. G. "Survival of king and Tanner crabs captured by commercial sole trawls." Fishery Bulletin 88.4 (1990): 731-744.

2.4 Fishery timing in relation to BBRKC molting and mating

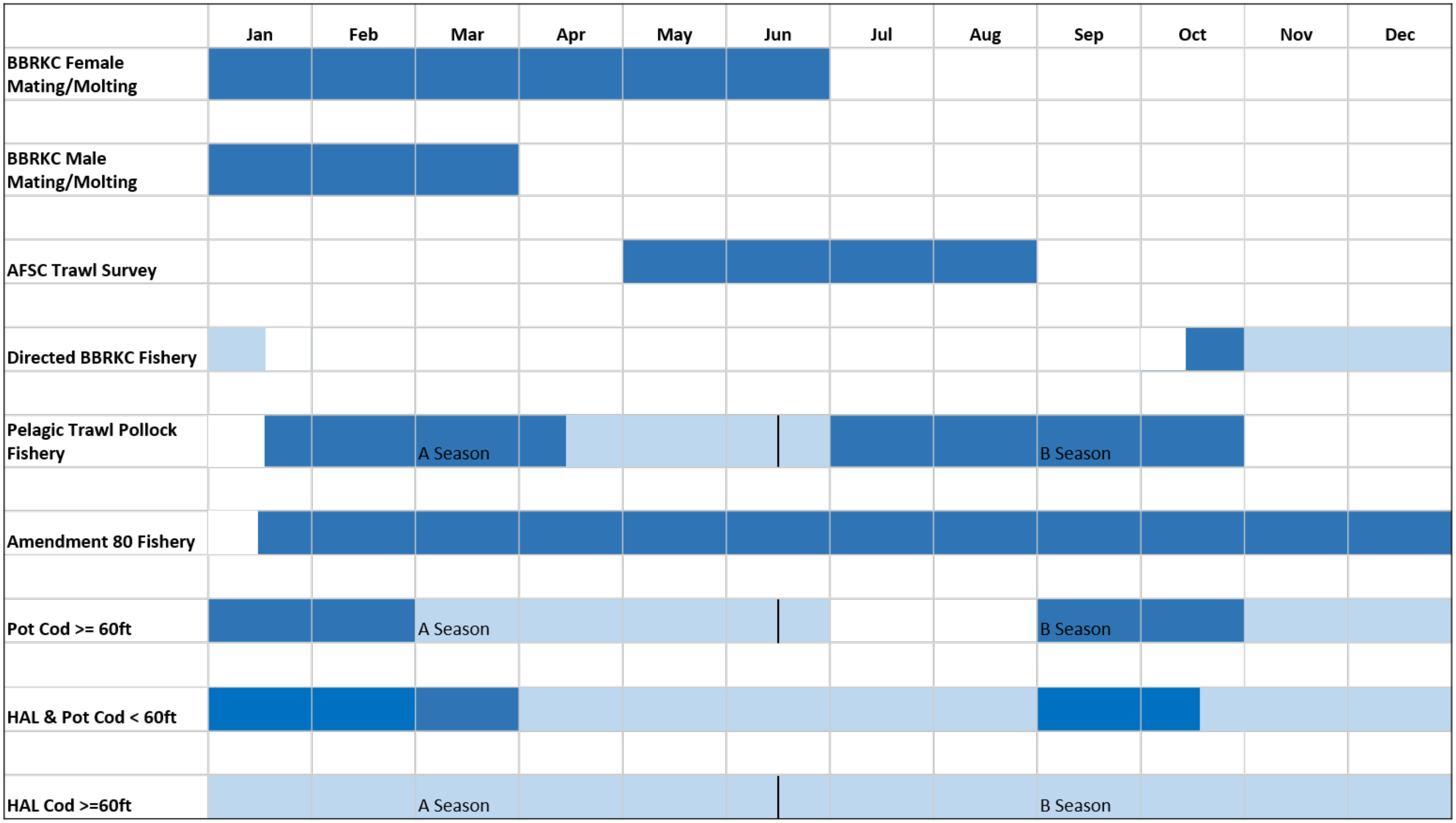


Figure 2-2 Fishery seasons and timing in relation to BBRKC molting and mating

2.5 Estimated bottom contact by groundfish gear

The Council motion lists "estimated bottom contact of the gear" in its request for tables on sources of BBRKC mortality across Federal groundfish fisheries. Per the Council's previous request, the April 2022 NPFMC discussion paper (Section 4.1) and Appendix 2 to that paper provided an original analysis of when and where pelagic trawl gear may have contacted the seafloor in the BBRKC stock area during an analyzed period spanning 2003 through 2021.[17] That time period covers the full span of the Catch-In-Areas database. The critical limitation of that study is the lack of a linkage between when and where pelagic trawl gear contacted the seafloor and the impact that it had on certain stocks of crab that were both present and in a state of susceptibility to capture or injury from trawl gear. That information is incorporated here by reference but not repeated because the previous discussion paper was solely focused on just one of the groundfish gear sectors identified in the Council's motion for this paper. The methodology, in brief, was to take all Vessel Monitoring System (VMS) pelagic gear trawl tracks that occurred in the area of interest and translate them to estimated bottom contact based on a sequence of adjustments that account for the type/size of trawl nets being used and factors based on fishing time/depth/location/target that are correlated to actual bottom contact through parameters developed through pilot studies and direct industry input. That methodology was built off of work that has supported the Council's periodic Essential Fish Habitat (EFH) review, called the Fishing Effects (FE) model. The FE model uses spatially-explicit data (VMS gear tracks) to estimate cumulative impacts on benthic habitat while accounting for the nature of the seafloor substrate and its ability to regenerate (Smeltz et al., 2019). FE utilizes parameters that translate gear tracks to estimated bottom contact; these parameters have been reviewed by the SSC. The most recently reviewed Council publication on FE methodology was published as Agenda Item D5 on the SSC's February 2022 agenda (Olson et al. 2022); the SSC is reviewing FE and EFH at its October 2022 meeting with new materials currently available under Agenda Item D8. If the Council is seeking a tabularized version of estimated bottom contact by groundfish gear – as suggested in the motion – the reader is referred to Appendix 2 ("Gear Parameter Table") of the February 2022 FE discussion paper linked above as "D5" (Olson et al. 2022).

Policy approaches to balancing productive groundfish fisheries while mitigating impacts on crab and other benthic species may be informed by the type of data modeling and visualization work that contributed to the April 2022 BBRKC discussion paper – strictly limited to pelagic trawl gear – and has been applied to the EFH review process in recent years for all gear types. An advanced understanding of bottom contact distribution and cumulative impacts for all gears will serve decision-makers well as additional information becomes available on the seasonal distribution and recruitment value of RKC or other benthic species of interest. The following overview of the FE model and its recent applications was provided by associates of the Fisheries, Aquatic Science & Technology (FAST) Laboratory at Alaska Pacific University (APU) who did the primary data work presented in Section 4 of the April 2022 NPFMC discussion paper; the following has been lightly edited and paraphrased by Council staff for inclusion here. The purpose of inclusion is to give the Council and the public a clear understanding of *one* tool or approach that is available, its potential application, limitations, and aspects that could be built upon with encouragement and support. Neither the authors of this discussion paper nor the APU staff who worked on the April 2022 data visualization for the BS pelagic trawl fishery mean to imply that this

[17] "Pelagic trawl" gear is defined in regulation (679.2) as a trawl that has no discs, bobbins or rollers, which are elements of non-pelagic trawls that elevate gear off the seafloor. Pelagic trawls cannot have chafe protection gear attached to the footrope or other lines. The physical aspects of the gear, as is noted by onboard observers or enforcement officers, is what determines whether a vessel may directed fish for pollock or trawl in areas closed to non-pelagic gear (e.g., RKCSA). The term "pelagic" is sometimes used informally to describe the midwater pollock target in NMFS Catch Accounting System (CAS) data as it relates to catch/bycatch estimation. This paper strictly adheres to the definition of pelagic that describes the physical gear, thus the data included reflects all pollock trawling regardless of whether classified in CAS as midwater or bottom pollock targets.

approach or the investigators previously involved are the only avenues available to the Council for developing management approaches that connect bottom contact and impacts on benthic species. The following was provided at the analysts' request.[18]

The Fishing Effects model is a tool designed to assess environmental impacts from fishing and evaluate potential trade-offs when seeking strategies to reduce those impacts. The FE model was initially developed by the FAST Lab at Alaska Pacific University for the 2017 Essential Fish Habitat review to assess habitat impacts to EFH and is also in use for the current 2022 EFH review. The Council has also used the Fishing Effects model to evaluate impacts to corals in the Bering Sea canyons. Beyond the NPFMC, FE has been adopted by the New England Fisheries Management Council for use in their EFH reviews, been used to evaluate large-scale effects of gear modifications, and been used as a framework to evaluate trade-offs between food production and environmental impacts of fishing at the global scale.

At its core, the Fishing Effects model uses high resolution information about the locations and methods of fishing activity coupled with dynamics that govern how the environment responds. While initially developed to assess disturbances to habitat, the model framework can be leveraged to help address nearly any issue that depends on where, when, and how vessels fish. For example, FE could help assess the habitat effects of a marine protected area that displaces fishing elsewhere. FE could be used to evaluate the extent of bottom fishing in crab habitat that may lead to unobserved mortality. FE could be used to evaluate how avoidance of salmon bycatch affects the distribution and efficiency of pollock harvest.

In the North Pacific, the underlying fishing data required to run the FE model come from the Catch-In-Areas database produced and curated by NMFS Alaska Regional Office. This database contains the VMS-derived spatial locations of nearly all fishing gear deployments in the North Pacific since 2003 along with robust information about these gear deployments. Catch-In-Areas is one of the highest quality regional databases of fishing throughout the world and is key to the high-resolution outputs of the FE model in the North Pacific. Looking forward, there is ample opportunity to leverage the Catch-In-Areas database and the FE model to address many issues currently facing the Council.

The April 2022 discussion paper also described the state of research on bottom contact by non-pelagic trawl gears and the extent to which it has been observed to directly impact benthic species, including crab (see NPFMC 2022, Section 4.3). The topic of bottom contact by trawl gear is often tied to discussions about the challenges associated with estimating unobserved crab mortality. The state of research on unobserved mortality from trawl gear was described in Section 4.4 of NPFMC 2022. Since April, the Council's Crab Plan Team received a presentation in May on estimating rates of crab mortality from trawl encounters by Dr. Craig Rose (formerly of AFSC's Conservation Engineering Program, presently an independent researcher). That presentation covered studies of crab injuries related to non-capture encounters with trawl gear, methods to measure unobserved crab mortality rates, and measurements of crab discard/handling mortality rates. The CPT's summary of, and comments on, Dr. Rose's presentation is provided on Page 34 of its May 2022 meeting summary. The CPT's summary emphasized interest in the difficult task of quantifying delayed mortality following interactions with trawl gear. The CPT noted that predicted mortality rates for crab caught in pot gear and handled on deck differ from rates based on studies of unobserved/uncaught mortality based on underwater cameras and secondary nets. Some of the challenges associated with unobserved mortality field studies in the eastern Bering Sea include poor visibility for cameras towed in soft sediment and the fact that auxiliary recapture nets designed to assess crab that would normally be impacted by a trawl but not brought onboard can change how the main net fishes. The CPT did not provide specific research recommendations but emphasized that the timing of crab/gear encounters relative to the annual mate/molt stage of vulnerability is an important area for quantified research. One aspect of Dr. Rose's past research that came before the CPT was the high

[18] T.S. Smeltz. APU FAST Lab. Personal Communication. August 2022.

predicted mortality rate for crab that encounter a trawl footrope. For future discussion papers or analyses, the Council could consider the potential effect of modifying regulations that prohibit “pelagic” trawl gear from using measures that would elevate the footrope off the seafloor (see previous footnote regarding pelagic trawl gear definition at 679.2). Published NOAA work on the quantification and reduction of unobserved mortality rates after encounters with trawl gear that was previously cited in the April 2022 discussion paper include – in specific reference to footropes – Rose et al. 2013.

Finally, the Council requested the inclusion of several publication references that were not included in the April 2022 discussion paper. The April 2022 discussion paper relied heavily on papers authored by C. Rose as the best available publications on unobserved mortality in the Bering Sea, focusing primarily on non-pelagic trawl gear (Rose 1995, Rose 1999, Rose et al. 2013). The addition of several studies examining the subject in the Barents Sea was thought necessary to round out the current research on unobserved mortality of crab by trawl gear. These studies in the Barents Sea focused on snow crab interactions with bottom trawl gear and employed the use of various retainer bags and underwater cameras to assess capture and injury. Broadly, these studies discussed trawl gear modifications to avoid bycatch, possible correlations between trawl gear injury and sex of crab, correlations with the lunar cycle, reported that 95-97% of captured crab (i.e., ended up in retainer bag or codend) went under the groundrope verses over, and found that for crabs collected in retainer bags (i.e., crabs that went under the groundrope) serious injuries occurred (Brinkhof 2015, Djesteland 2017, Nguyen et al. 2014, Luettel 2015).

2.6 Groundfish observer coverage

This section provides a brief overview of groundfish observer coverage and tables summarizing realized coverage rates by fishery and gear type from 2013 through 2021. Appendix 1 to this document details how crab bycatch is estimated in groundfish fisheries.

The North Pacific Observer Program is implemented by regulations at Subpart E of 50 CFR part 679 which authorize the deployment of observers and electronic monitoring (EM) to collect information necessary for the conservation and management of the BSAI and GOA groundfish and halibut fisheries. The information collected by observers provides the best available scientific information to manage the fisheries and to develop measures to minimize bycatch. Observers collect biological samples and fishery-dependent information on total catch and interactions with protected species. Managers use data collected by observers and electronic monitoring to monitor quotas, manage groundfish and prohibited species catch, and document and reduce fishery interactions with protected resources. Scientists use observer-collected data for stock assessments and marine ecosystem research.

Observer coverage refers to whether a vessel fishing with a federal fisheries permit is required to have fishing activity monitored as is outlined at 50 CFR 679.51(a). Monitored vessels are either in the full or partial coverage category. Vessels may be monitored by human observers or, in some cases, by EM systems. Table 2-13 and Table 2-14 show observer coverage by year, gear, sector, coverage and monitoring type from 2013 through 2021. Table 2-13 shows the number of total trips and monitored trips. Table 2-14 shows the proportion of trips that were monitored. Of note in Table 2-13, trips for non-cod pot CVs have increased recently due to an uptick in sablefish pot fishing. The Observer Program Annual Deployment Plan (ADP) does not differentiate based on what species a vessel is targeting. Selection rates are based on gear type and whether the vessel is in the EM or observer coverage strata. In Table 2-13 the different realized coverage rate for non-cod trips versus cod trips can be attributed to selection through the Observer Deploy and Declare System (ODDS), as cod and non-cod trips fall into the same strata (either POT or EM_POT) and have the same selection rates (probabilities) applied to them within each strata. The “ALL” rows in Table 2-13 combine across strata so if there are more EM trips then the overall realized coverage rate will be higher because the selection rate is much higher for EM than for observer coverage.

Table 2-13 The number of monitored (M) and total (T) trips in the BSAI by year, gear, sector, coverage (Full, Partial, All), and monitoring type (Observer, EM, All), 2013-2021

				2013		2014		2015		2016		2017		2018		2019		2020		2021	
Gear	Sector	Coverage	Monitoring	M	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T	M	T
HAL	Catcher Vessel	FULL	OBSERVER	3	3	2	2			6	6	2	2	3	3	4	7	2	9	1	1
HAL	Catcher Vessel	PARTIAL	OBSERVER	20	1,507	53	1,015	38	739	33	834	28	829	32	771	33	973	10	461	14	294
HAL	Catcher Vessel	PARTIAL	EM											5	24	23	70	18	40	10	33
HAL	Catcher Vessel	ALL	ALL	23	1,510	55	1,017	38	739	39	840	30	831	40	798	60	1,050	30	510	25	328
HAL	Catcher/ Processor	FULL	OBSERVER	357	357	348	348	355	355	360	360	312	312	230	230	206	206	160	160	128	128
HAL	Catcher/ Processor	PARTIAL	OBSERVER	1	25			0	7	0	10	0	19	0	6	0	7				
HAL	Catcher/ Processor	ALL	ALL	358	382	348	348	355	362	360	370	312	331	230	236	206	213	160	160	128	128
NPT	Catcher Vessel	FULL	OBSERVER	327	327	307	307	176	176	137	137	133	133	149	149	80	80	95	95	38	38
NPT	Catcher Vessel	PARTIAL	OBSERVER	20	86	11	97	49	188	69	224	35	138	31	112	48	139	18	89	13	78
NPT	Catcher Vessel	ALL	ALL	347	413	318	404	225	364	206	361	168	271	180	261	128	219	113	184	51	116
NPT	Catcher/ Processor	FULL	OBSERVER	561	561	532	532	511	511	525	525	484	484	501	501	475	475	425	425	384	384
NPT	Catcher/ Processor	ALL	ALL	561	561	532	532	511	511	525	525	484	484	501	501	475	475	425	425	384	384
NPT	Mothership	FULL	OBSERVER	33	33	28	28	61	61	87	87	95	95	84	84	103	103	94	94	58	58
NPT	Mothership	ALL	ALL	33	33	28	28	61	61	87	87	95	95	84	84	103	103	94	94	58	58
POT	Catcher/ Processor	FULL	OBSERVER	28	28	37	37	46	46	37	37	34	34	30	30	26	26	23	23	26	26
POT	Catcher/ Processor	ALL	ALL	28	28	37	37	46	46	37	37	34	34	30	30	26	26	23	23	26	26
POT	Cod Catcher Vessel	PARTIAL	OBSERVER	39	330	72	433	93	409	70	438	29	449	66	411	61	337	31	214	27	172
POT	Cod Catcher Vessel	PARTIAL	EM													10	40	19	45	16	32
POT	Cod Catcher Vessel	ALL	ALL	39	330	72	433	93	409	70	438	29	449	66	411	71	377	50	259	43	204
POT	Other Catcher Vessel	PARTIAL	OBSERVER	7	49	4	45	4	31	5	29	3	41	6	41	4	37	7	49	11	100
POT	Other Catcher Vessel	PARTIAL	EM													0	2	1	6	1	7
POT	Other Catcher Vessel	ALL	ALL	7	49	4	45	4	31	5	29	3	41	6	41	4	39	8	55	12	107
PTR	Catcher Vessel	FULL	OBSERVER	1,941	1,941	1,888	1,888	1,911	1,911	1,956	1,956	1,973	1,973	2,014	2,014	2,077	2,077	1,722	1,723	841	841
PTR	Catcher Vessel	FULL	EM															470	470	999	999
PTR	Catcher Vessel	PARTIAL	OBSERVER											1	2	3	3	5	5	0	1
PTR	Catcher Vessel	ALL	ALL	1,941	1,941	1,888	1,888	1,911	1,911	1,956	1,956	1,973	1,973	2,015	2,016	2,080	2,080	2,197	2,198	1,840	1,841
PTR	Catcher/ Processor	FULL	OBSERVER	168	168	170	170	172	172	173	173	174	174	172	172	172	172	166	166	150	150
PTR	Catcher/ Processor	ALL	ALL	168	168	170	170	172	172	173	173	174	174	172	172	172	172	166	166	150	150
PTR	Mothership	FULL	OBSERVER	28	28	27	27	26	26	27	27	24	24	28	28	35	35	39	39	40	40
PTR	Mothership	ALL	ALL	28	28	27	27	26	26	27	27	24	24	28	28	35	35	39	39	40	40

Table 2-14 Realized coverage rates (number of monitored trips/total number of trips) in the BSAI by year, gear, sector, coverage (Full, Partial, All), and monitoring type (Observer, EM, All), 2013-2021

Gear	Sector	Coverage	Monitoring	2013	2014	2015	2016	2017	2018	2019	2020	2021
HAL	Catcher Vessel	FULL	OBSERVER	100	100		100	100	100	57.1	22.2	100
HAL	Catcher Vessel	PARTIAL	OBSERVER	1.3	5.2	5.1	4	3.4	4.2	3.4	2.2	4.8
HAL	Catcher Vessel	PARTIAL	EM						20.8	32.9	45	30.3
HAL	Catcher Vessel	ALL	ALL	1.5	5.4	5.1	4.6	3.6	5	5.7	5.9	7.6
HAL	Catcher/Processor	FULL	OBSERVER	100	100	100	100	100	100	100	100	100
HAL	Catcher/Processor	PARTIAL	OBSERVER	4		0	0	0	0	0		
HAL	Catcher/Processor	ALL	ALL	93.7	100	98.1	97.3	94.3	97.5	96.7	100	100
NPT	Catcher Vessel	FULL	OBSERVER	100	100	100	100	100	100	100	100	100
NPT	Catcher Vessel	PARTIAL	OBSERVER	23.3	11.3	26.1	30.8	25.4	27.7	34.5	20.2	16.7
NPT	Catcher Vessel	ALL	ALL	84	78.7	61.8	57.1	62	69	58.4	61.4	44
NPT	Catcher/Processor	FULL	OBSERVER	100	100	100	100	100	100	100	100	100
NPT	Catcher/Processor	ALL	ALL	100	100	100	100	100	100	100	100	100
NPT	Mothership	FULL	OBSERVER	100	100	100	100	100	100	100	100	100
NPT	Mothership	ALL	ALL	100	100	100	100	100	100	100	100	100
POT	Catcher/Processor	FULL	OBSERVER	100	100	100	100	100	100	100	100	100
POT	Catcher/Processor	ALL	ALL	100	100	100	100	100	100	100	100	100
POT	Cod Catcher Vessel	PARTIAL	OBSERVER	11.8	16.6	22.7	16	6.5	16.1	18.1	14.5	15.7
POT	Cod Catcher Vessel	PARTIAL	EM							25	42.2	50
POT	Cod Catcher Vessel	ALL	ALL	11.8	16.6	22.7	16	6.5	16.1	18.8	19.3	21.1
POT	Other Catcher Vessel	PARTIAL	OBSERVER	14.3	8.9	12.9	17.2	7.3	14.6	10.8	14.3	11
POT	Other Catcher Vessel	PARTIAL	EM							0	16.7	14.3
POT	Other Catcher Vessel	ALL	ALL	14.3	8.9	12.9	17.2	7.3	14.6	10.3	14.5	11.2
PTR	Catcher Vessel	FULL	OBSERVER	100	100	100	100	100	100	100	99.9	100
PTR	Catcher Vessel	FULL	EM								100	100
PTR	Catcher Vessel	PARTIAL	OBSERVER						50	100	100	0
PTR	Catcher Vessel	ALL	ALL	100	100	100	100	100	100	100	100	99.9
PTR	Catcher/Processor	FULL	OBSERVER	100	100	100	100	100	100	100	100	100
PTR	Catcher/Processor	ALL	ALL	100	100	100	100	100	100	100	100	100
PTR	Mothership	FULL	OBSERVER	100	100	100	100	100	100	100	100	100
PTR	Mothership	ALL	ALL	100	100	100	100	100	100	100	100	100

Crab PSC estimation is like other types of catch and bycatch estimation where extrapolation of observed catch records onto unobserved effort is required for total catch accounting (see Appendix 1). Catch estimation methods are vetted often through the SSC and Council process and are designed to do the best possible job of using the information that is gathered within the operational and financial constraints of the Observer Program. Catch on full coverage vessels (all CPs, pelagic trawl CVs in the AFA pollock fishery, and some non-pelagic trawl CVs) involves extrapolation between hauls. Catch on partial coverage vessels involves extrapolation between observed and unobserved vessel trips. The variability of bycatch estimates is higher for fleets that have less total observer coverage (this is also addressed in Section 6 of this paper where a PSC hard cap for Pacific cod pot vessels is considered). The pot gear sectors stand out with respect to the amount of monitoring information that is available from this fleet.

In addition to the tables shown above, AKFIN examined all 2013-2021 fishing records with estimated RKC PSC in the Bering Sea and compared the amount of PSC estimated from trips with monitoring to the total amount (monitored trips plus trips for which PSC was estimated based on rates derived from monitored trips). All RKC PSC that was estimated for the pelagic trawl sector came from records where monitoring was present. Virtually all PSC estimated for the non-pelagic trawl sector occurred on monitored trips (never more than 0.125% of annual PSC from unmonitored trips). On average, 0.9% of the HAL sector's RKC PSC occurred on unmonitored trips (never more than 2.2% annually). By contrast, the proportion of the pot sectors' total estimated BS RKC PSC that occurred on unmonitored trips averaged 62% on an annual basis from 2013 through 2021 (median 68%), ranging from a low of 15% in 2016 to over 95% in 2020 and 2021. The Council and its advisory bodies may wish to consider whether relatively low observer coverage in the pot sectors poses a significant management challenge in the context of RKC bycatch. Crab are characterized by an over-dispersed data distribution that has a high frequency of low values and, on occasion, has a large estimated value. This is due to patchy distribution or "clumping" of crabs. When there are large differences in the amount of crab PSC between trips and there are very few monitored trips, then the total crab PSC estimate will be highly variable. The nature of how crab behave, aggregate in some cases, and encounter pot gear might mean that estimation methods that give one signal for a species like halibut give a different signal for a species like RKC. The pot sectors are currently the only BS groundfish sectors where estimated PSC on unobserved trips makes up a significant share of the final estimate.

The analysts are not questioning the data collection and estimation methods employed by NMFS FMA division and the Catch Accounting System. Rather, the question posed is whether the Council should consider the trade-offs in observer deployment across partial coverage sectors that would be required to use less extrapolation in pot bycatch estimation and better represent all fishing activity in the pot fleet.

The existing coverage rates in the partial coverage fleet have been established through extensive, iterative reviews of the Annual Deployment Plans that have come before the Council. Current coverage rates are constrained by the limited amount of resources to deploy. Any change to the deployment plan to allocate more observers to pot vessels in the Bering Sea would likely mean that fewer resources are available for other monitoring priorities.

2.7 Crab fishery observer coverage

Observer coverage in the BSAI crab fishery is managed by the State of Alaska under regulations at 5 AAC 39.645 – Shellfish onboard observer program. The Alaska Board of Fisheries (Board) determined that, as the crab fisheries evolved away from predominantly CP vessels and floating processor vessels where catch sampling and biological data collection had occurred, onboard observers on catcher vessels are the only practical data-gathering mechanism that would not unduly disrupt the operation of the crab fisheries. The Board also determined that onboard observers are the only effective means to enforce crab size and sex regulations. The cost of providing onboard observers for CVs and at-sea processors in the BSAI registration areas crab fisheries is borne by ADFG through the harvest and sale of crab.[19]

All CP vessels must carry observers 100% of the time. For catcher vessels, State regulations "require onboard observers for an adequate number of CVs, or during the harvest of a percentage of the total harvest weight of each catcher vessel." For Registration Area T (Bristol Bay), an observer must be onboard a CV "during harvest of 20 percent of the total red king crab weight harvested by each catcher vessel while operating fishing gear, during each registration year, or the department may randomly select 20 percent of the catcher vessels harvesting Bristol Bay red king crab to carry onboard observers for 100 percent of the fishing time of each selected catcher vessel." The State currently employs the option to randomly select 20% of vessels fishing BBRKC to carry an observer for 100% of their fishing time. Other crab fisheries are subject to higher rates of observer coverage. Snow and Tanner crab are observed at rates that vary between 30% and 100% depending on the period in the year. AI golden king crab have a 50% coverage rate. BS golden king crab and king crabs in the Pribilof, St. Matthew Island, and Adak districts are subject to 100% observer coverage.

The 20% observer coverage rate target for BBRKC was established in the years prior to the implementation of crab rationalization to achieve pre-existing coverage rates and maintain continuity in observer data collections. Since rationalization, the coefficients of variation for BBRKC observed pot CPUEs for discarded and retained crab are each around 5%, indicating that estimates generated from observer data adequately represent total fishery effort.[20] A lower target coverage rate compared to other BS crab fisheries can achieve adequately precise estimates for BBRKC because the fishery is prosecuted by a homogenous fleet and takes place in a relatively small area over a short period of time. Crab fisheries that do not have those characteristics require a higher level of observer coverage.

In a presentation given at the September 2021 Crab Plan Team meeting, ADFG staff included a graphical summary of realized crab CV observer coverage rates from 2004 through 2020. Figures from that presentation show observer coverage by vessel and by pot (Figure 2-3 and Figure 2-4). For all crab fisheries, the percentage of pot hauls that are observed is lower than the vessel coverage rate because the observer onboard does not sample every pot. For BBRKC, the percentage of pots observed has fluctuated between 1% and 2% each year. In 2020, the percentage of BBRKC pot hauls observed was roughly 1.5%, which ranked below AI golden king crab fisheries (50% vessel coverage rate) but above the Tanner and snow crab fisheries (vessel coverage rates varying between 30% and 100%). According to ADFG presentations made to the Crab Plan Team, the daily sampling goal for observers on BBRKC CVs is seven measured pots (zero counted pots). That sampling goal is higher than the goal for Tanner crab (three measured, three counted) and snow crab (one measured, three counted). The BBRKC goal is the same as the goal for AI golden king crab, but slightly lower than the goal for St. Matthews Island blue king crab and Pribilof Islands golden king crab (10 measured, zero counted).[21]

[19] Vessels may bear the cost of onboard observers in limited cases, such as a CP vessel that retains processed crab after a fishery is closed (see 5 AAC 34.031(e)(4) and (c)(4)).
[20] M. Stichert, ADFG. Pers. Comm. 2022.
[21] See presentation slide 10, Jan. 2020.

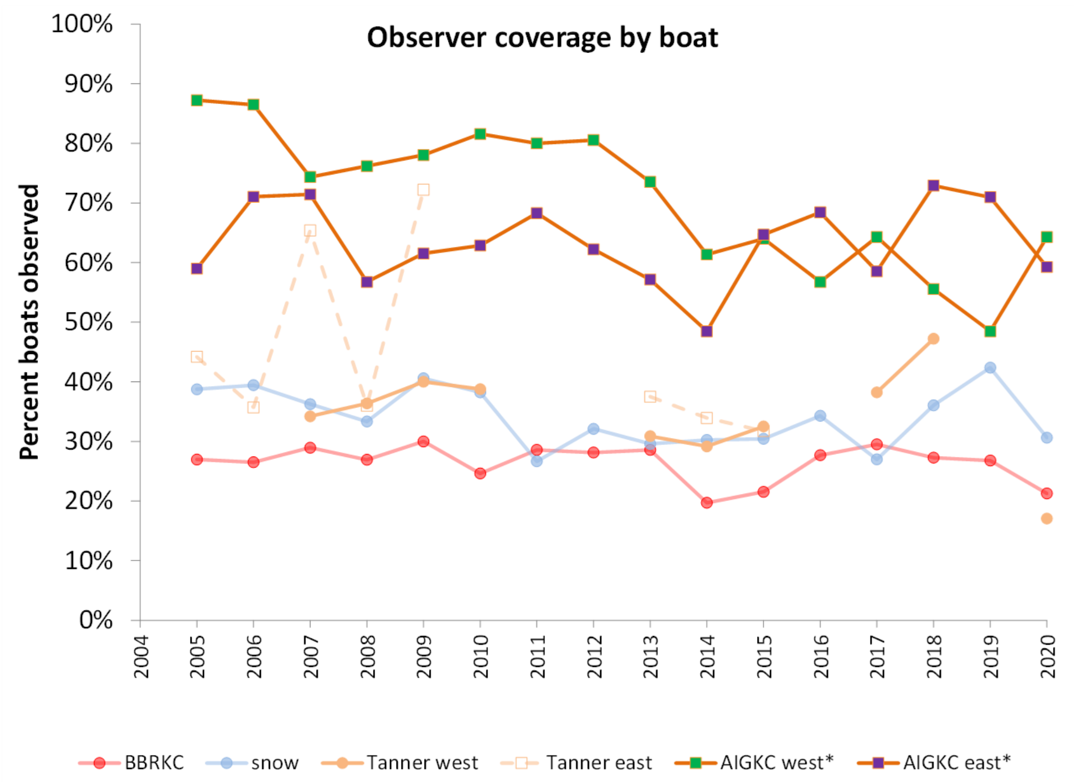


Figure 2-3 Percentage of BSAI crab vessels observed, by fishery, 2004-2020 (source: ADFG)

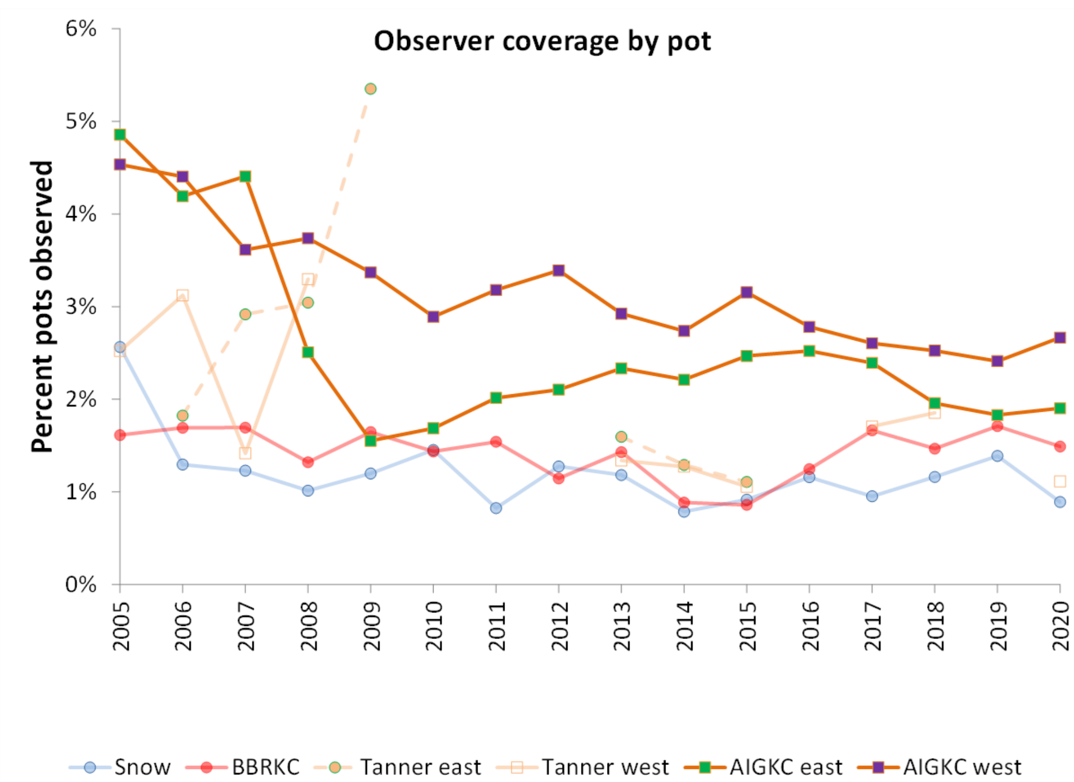


Figure 2-4 Percentage of BSAI crab pots observed, by fishery, 2004-2020 (source: ADFG)

3 Scientific information needed to create dynamic closed areas

Council Motion: *A discussion of scientific information needed to create dynamic closed areas, such as seasonal or annual shifting closed areas, to protect mature female BBRKC.*

At the April 2022 Council meeting, the Council motion requested detail on "scientific information needed to create dynamic closed areas, such as seasonal or annual shifting closed areas, to protect mature female BBRKC. The extent to which area-closures for the purpose of crab protection can be dynamic within a calendar year is limited by existing regulations that set out the public process followed by the Council and NMFS. The public process is subject to the requirements of the Administrative Procedure Act (APA), the National Environmental Policy Act (NEPA), the Regulatory Flexibility Act (RFA), Executive Order 12866, and other applicable laws. NMFS has "in-season" authorities to make management adjustments, which are defined in regulation (679.25(a)) and in the BSAI Groundfish FMP (FMP Section 3.8.1), and also detailed in Section 5.1 of the April 2022 BBRKC discussion paper (NPFMC 2022).[22] The statutes listed above generally require Council and NMFS analyses and provide for periods of public comment that may be submitted to the Agency through the Federal Register. NMFS's inseason authority gives it the ability to take inseason actions that manage to goals or bounds that are established annually through the harvest specifications process that receives SSC/Council review and public comment prior to implementation for the year. "Dynamic" management actions that are more ad hoc in nature are no less subject to the governing statutes. The Council could go through the process to develop regulations that predicate a seasonal area closure based on fishery or survey outcomes from the previous year (e.g., the Zone 1 trawl PSC limit is determined based on the BBRKC stock assessment; the open/closed status of the RKCSS to non-pelagic trawl gear is determined based on whether a crab GHL fishery occurred in the previous year). However, the Council could not set up "if/then" scenarios in regulation that restrict harvest access in a certain area based on in-year metrics without allowing for prior notice, public comment, and rulemaking before those restrictions go into effect.

With the above limitations in mind, there are several layers of information needed when designing closure areas of different types. First, to have effective fixed year-round closure areas one should first understand the general spatial distribution of BBRKC at different life-stages. Second, to have effective fixed partial-year closure areas one should understand how distributions of all life stages shift intra-annually, determine the extent to which seasonal patterns are consistent across years, and identify seasons of particular importance for the biology of the crab (e.g., molting and mating; larval settlement). Third, to have effective dynamic closures that shift in both time and space, all of the above information is needed plus predictive variables that inform distribution in an upcoming season, which would trigger the opening/closing of certain areas (e.g., summer distribution of RKC predicting winter distribution, or temperature/extent of cold pool predicting winter distribution). In addition, if closures are shifting in time and/or space it is essential to understand the importance of habitat and how long that habitat will take to recover after impact from fisheries and how important this is to the crab of different life stages. The resiliency aspect of benthic habitats is something that is already incorporated into the Council's EFH

[22] To summarize: Inseason adjustments can include season closures; extensions or openings in all or part of a management area; modification of the allowable gear in all or part of a management area; adjustment to TAC or PSC limits; or interim closures of statistical areas to directed fishing for specific groundfish species. The FMP acknowledges that NMFS managers are constrained in their choice of management response in several ways. First, data on catch/bycatch rates might not be timely enough to implement effective closures or to determine whether a rate-spike is reflecting natural variability or a change in the mode of fishing and bycatch precaution/minimization. Second, NMFS is subject to procedural requirements to consider "least restrictive" measures and then -- in most cases -- go through the process of publishing notice of proposed adjustments in the Federal Register with a comment period. And third, when applicable, NMFS must coordinate inseason adjustments with the State of Alaska to assure uniformity of management in State and Federal waters.

review process through the Fishing Effects model, as briefly described in Section 2 of this document. After conversations with RKC biologists, inseason managers and a review of current RKC literature, three areas of research emerged as being data deficient when thinking about the above criteria and considering scientific information needed to inform dynamic closed areas. These areas are stock distribution throughout the year for various age classes, climatic impacts on distribution and physiology, and habitat mapping and impacts of fisheries on that habitat. Each subsection below broadly discusses what is known about each of these topic areas and what would be needed to fill information gaps.

3.1 Stock Distribution

Information on stock distribution is lacking for BBRKC, especially when examining sex-specific locations. While certain times of the year (i.e. late spring/early summer and fall) are more data rich than others, a complete picture of BBRKC stock movement and distribution throughout the year has not been developed. This is especially problematic for times when RKC are most vulnerable, such as during mating and molting when groundfish fisheries can unknowingly impact soft, recently molted RKC that are less active and likely do less to avoid mobile fishing gear. While information on all aspects of BBRKC stock distribution would enhance stock assessment and management decisions, the areas deemed the most important and data deficient are the spatial distribution of mature females, particularly during times of larval release, mating and molting (i.e., winter/spring), and the distribution during times of high trawl activity west and south of existing trawl closure areas.

The best information currently available on BBRKC stock distribution is derived from the NMFS EBS trawl survey which has been conducted annually during the summer since 1975 (Zacher et al. 2021). As such, a long term dataset of RKC high density areas can be constructed, but only for this summer snapshot in time (see Figure 15.a in Zacher et al. 2021). Information on the location of females the rest of the year is patchy. Other sources of information on the location of females include bycatch in the directed BBRKC fishery – a relatively short window of time in the fall (i.e. October/November) – and bycatch in non-target fisheries such as trawl, HAL and pot fisheries. While data from the directed fishery is likely a good indicator of higher concentrations of RKC, RKC are known to segregate by sex outside of the molt/mate periods (ADFG 2022). Because the directed fishery does not target females, it likely does not provide a complete understanding of the distribution of females during October/November. Additionally, the directed crab fishery does not provide a good estimate of areas of high juvenile concentrations as the directed fishery does not target juvenile RKC as pot designs allow for juvenile escapement. Likewise, because groundfish fisheries are not actively targeting RKC, relying on bycatch from these fisheries as a means to determine RKC distribution is incomplete since they presumably try to avoid areas of high RKC concentrations. Collectively, these data sources provide a brief snapshot of RKC distribution in the fall, an incomplete look at non-targeted RKC in the winter/spring and a more complete understanding of distribution in the summer.

Recent RKC tagging efforts are attempting to better understand winter and spring distributions of female and male RKC. The Alaska Fisheries Science Center, ADF&G, and the Bering Sea Fisheries Research Foundation (BSFRF) have collaborated to develop and test tagging techniques for BBRKC that will contribute to the understanding of stock distribution and movement patterns outside the summer trawl survey period. These methods have included the use of pop-up satellite tags, traditional spaghetti tags[23] and acoustic tags. Each tagging method has different strengths in terms of cost, deployment duration, recovery method, and tag retention through the molt. Initial efforts focused on mature male movement from summer into fall, when the directed crab fishery begins. Tagging results are currently being analyzed and prepared for publication. Thus far, results for males show similar patterns in fall distribution

[23] "Spaghetti tags" are a piece of tough plastic that is attached to an animal. The tag has an identification code that a person can report when the tag is retrieved.

compared with fishery-derived data. One published study of fishery data used logbooks to track legal males in the fall months from 2005 through 2016 (Zacher et al., 2018). The purpose of the logbook study, and winter tagging studies that are ongoing, is to fill the information gap on where RKC are distributed outside of the summer survey season. Zacher et al. found that, on average, roughly 60% of commercially caught BBRKC were harvested in areas that are closed to all trawling (e.g., NBBTCA) or non-pelagic trawling (RKCSA) but that percentage fluctuated based on temperature regime. RKC were found farther south, towards the Alaska Peninsula, in cold years but tended to cluster in the middle of Bristol Bay in warm years. The study authors noted that “it is difficult to evaluate the placement of no-trawl zones, because most crab bycatch occurs in trawl fisheries during winter when crab distributions are unknown.”

More recent tagging efforts have focused on the winter and early spring when BBRKC distributions are less well understood. The winter/spring period is of particular interest because of increased expected interactions with trawl fisheries at the same time that crab are mating and molting. In November 2021, pop-up satellite tags were placed on both mature male and female RKC in Bristol Bay. Tags were released from male crab in January 2022 (just prior to anticipated molting periods) and were released from females in late-April/early-May 2022 (to approximate timing of larval hatching and to minimize chances of sea-ice interactions). The two plots below show preliminary tag data for male and female RKC (Figure 3-1 & Figure 3-2). However, 2021/22 is the first season of this tagging study and, while it has provided novel data, a longer dataset is needed to form a more complete picture of stock distribution.

Recruitment variability is not well understood; however, larval release areas have important implications for supply to nursery habitat. The nearshore area in southwest Bristol Bay was hypothesized as having historically (i.e., prior to 1980) been the most important spawning ground for supplying recruits to the population because the predicted location of settling post-larvae corresponds with favorable nearshore benthic habitat (Armstrong et al. 1986; Armstrong et al. 1993; Evans et al. 2012; Haynes 1974; Hebard 1959; Hsu 1987; Loher 2001). Mature females have been largely absent from this area in recent years and recruitment has been low since 2010. Recent modeling efforts suggest local retention and fine-scale oceanographic features such as storm events and associated wind-driven changes to current may be more important for recruitment strength than previously thought (Daly et al 2020). An improved understanding of larval release locations will aid in developing conservation measures to extend or establish annual or seasonal closures in southwestern Bristol Bay, based on the probability that oceanographic currents along the Alaska peninsula provide essential pelagic habitat for larval and early juvenile stages.

Considering the data at hand and as stated earlier, we have a good understanding of female RKC distribution in the summer, a snapshot look of distribution in October, a very rough sense of distribution in the winter and a first cut of distribution in the spring. As mating and molting, and larval release are arguably the two most biologically critical times for the BBRKC stock biomass, distribution information during these times is critical. The tagging study discussed above is beginning to scratch the surface of female distribution during larval release, but additional years of data, larger sample sizes, a longer time frame (i.e., more months in spring/early summer in addition to May), and an evaluation during contrasting environmental conditions (i.e., years) are needed. Information on the distribution of female RKC during mating and molting (i.e., winter) is almost entirely lacking. Additional tagging studies that focus on the winter distribution could begin to address this data gap; however, tags are susceptible to loss during molting. An annual winter survey over a gridded spatial pattern could provide valuable data but would incur financial costs that are not currently budgeted within existing survey programs.

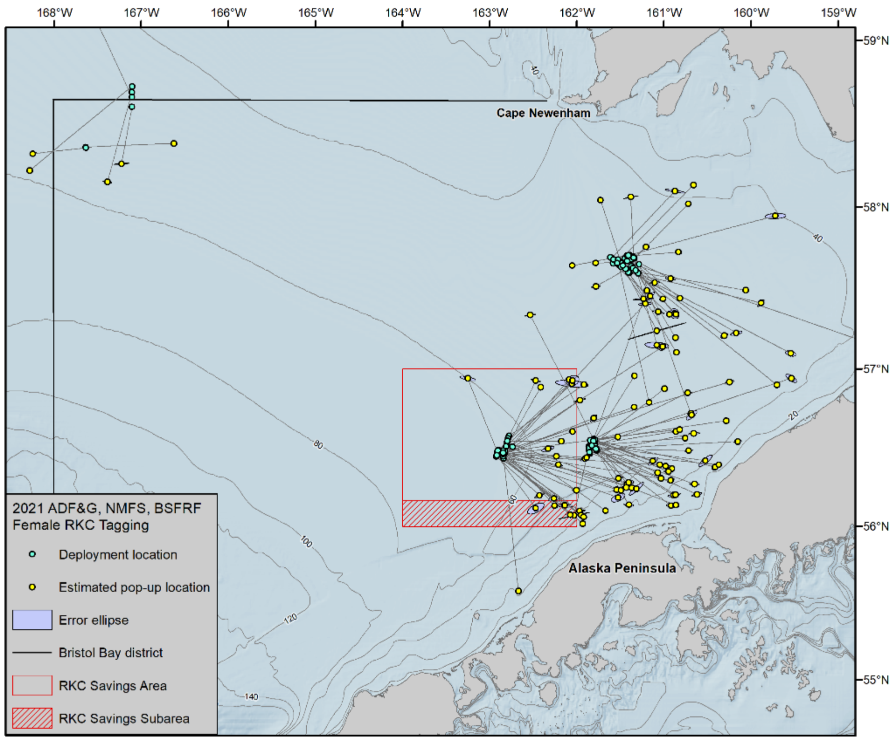


Figure 3-1 Movement of female crab from fall (November 2021) to spring (late-April/early-May 2022) based on pop-up satellite tag results from the ADFG/NMFS/BSFRF study

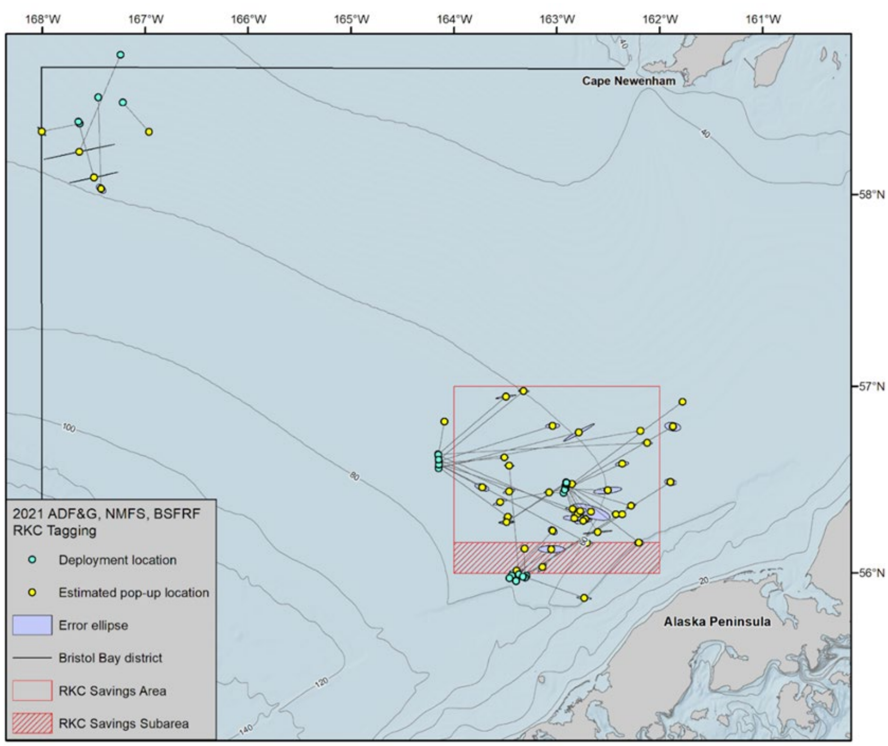


Figure 3-2 Movement of male crab from fall (November 2021) into winter (January 2022) based on pop-up satellite tag results from the ADFG/NMFS/BSFRF study

3.2 Climate Impacts

Similar to information on stock distribution, effects of climatic impacts on RKC are broadly understood but precise and localized information is limited. Many climatic factors can affect RKC, yet there are two areas that emerge as being particularly important for understanding RKC movement and physiology. These two areas are sea ice extent and the cold pool variability. Both of these climatic events can, among other effects, affect currents and therefore crab distribution, as well as delay growth and reproductive events.

Sea ice extent and the cold pool are inextricably linked, with sea-ice extent being the primary determinant of the cold pool. The Bering Sea experiences a seasonal sea ice cover, which is important to the biophysical environment found there. A pool of cold bottom water is formed on the shelf each winter as a result of cooling and vertical mixing. The cold pool is approximately a 30-m layer of cold, salty and dense water that is 2°C or less and occurs near the seafloor (Wyllie-Echeverria et al. 1998). It results from melting sea ice in the winter and spring and often covers a large area from close to shore out to the deep ocean. The extent and distribution of the cold pool is largely controlled by the winter extent of sea ice in the Bering Sea, which can vary considerably and recently has been much lower than average (Clement et al. 2022). In 2017 and 2018 the maximum extent of sea ice in the Bering Sea was the lowest on record and the cold pool was dramatically smaller than usual[24].

Sea ice extent and the duration of the cold pool can affect RKC in several ways. RKC distributions vary over both seasonal and interannual time scales in part due to variable environmental factors (Zacher et al. 2018). In general, the Bering Sea oscillates between warm and cold temperature regimes, largely driven by sea ice extent (Stabeno et al. 2012). Cold and warm years can affect both the recruitment success for BBRKC and the area to which they recruit. Northerly shifts in stock distribution are generally associated with both warmer temperatures and high Pacific Decadal Oscillation values during the summer (Loher and Armstrong, 2005; Zheng and Kruse, 2006). Fall distributions during the BBRKC fishery tend to contract to the center of Bristol Bay during warm years (Zacher et al. 2018).

The location of ovigerous females at larval release impacts post-larval settlement success and subsequent recruitment strength. Southwestern Bristol Bay has long been considered the most important area for larval release, since larvae released in that area are expected to drift into favorable juvenile habitat in nearshore Bristol Bay (McMurray et al. 1984, Armstrong et al. 1993, Dew and McConnaughey 2005). This hypothesis predicts increased settlement success in cold years when the female center of distribution is shifted southwest (Evans et al. 2012). This prediction is supported by observations that high year-class strengths in the 1970s occurred when the spawning stock was located in southern Bristol Bay (Armstrong et al. 1993). However, despite relatively cold years and an extensive cold pool in 2008-2012, BBRKC abundance has remained low. A recent study modeling larval trajectories under different climate scenarios suggests that fine-scale features likely affect local current vectors such that overall advection trajectories differ from those that are forced by long-term average currents (Daly et al 2020). Higher proportions of modeled larvae hatched in central and nearshore Bristol Bay reached high-quality habitat compared to those hatched in more southwest Bristol Bay, particularly in warm years (Daly et al. 2020). While this result does not eliminate the importance of southwestern Bristol Bay as a critical spawning area, it suggests that local retention may be increasingly important with warming conditions due to possible changes in current structure and/or due to a shorter larval pelagic duration. This further elevates the importance of protecting mature females during spawning periods.

All of this to say is that it is broadly known that sea ice extent and the cold pool affect the distribution and recruitment of RKC, but exactly how and where these impacts are felt and the weight they have on overall RKC biomass is not yet fully understood. The best data we have on the effects of sea ice extent and the

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[24] Time-lapse of sea ice extent in the Bering Sea (source: NOAA)

cold pool is largely the result of modeling efforts, without accompanying long term datasets. An understanding of how climatic events affect RKC distribution, recruitment and reproduction could aid in identifying essential habitat for each life stage of RKC.

3.3 Benthic Habitat

Characterizing benthic habitat is critical information in understanding important areas of refuge for various age classes of RKC and to better quantify the effects that fisheries may have on RKC and their habitat. In order to better quantify each of these data deficient areas, improved resolution of benthic composition, and spatial and temporal estimation of bottom contact by various fishing gear types is required.

The most recent essential fish habitat (EFH) review for crab (NPFMC 2021c, Appendix F) describes broadly what is currently known about key habitat areas for RKC. No EFH description for larvae has been determined, whereas the general distribution area for early juvenile RKC is demersal habitat along the intertidal and subtidal zones, and inner and middle shelf (0 to 100 m). In addition, early juveniles have specific habitat requirements based on their anti-predator strategy and can only occur in places where there is significant habitat structure either in the form of substrates such as rock, cobble, and gravel, or biogenic habitats such as bryozoans, ascidians, hydroids, or shell hash. In the BS, these habitats generally only occur in nearshore areas along the north side of the AI and the Alaskan Peninsula, around Bristol Bay, around the Pribilof Islands, and in nearshore areas of Norton Sound. For late stage juveniles EFH is located in bottom habitats along the inner (0 to 50 m), middle (50 to 100 m), and outer shelf (100 to 200 m) throughout the BSAI wherever there are substrates consisting of rock, cobble, and gravel and biogenic structures such as Boltenia spp., bryozoans, ascidians, and shell hash. Finally, EFH for adults is located in bottom habitats along the nearshore (spawning aggregations) and the inner (0 to 50 m), middle (50 to 100 m), and outer shelf (100 to 200m) throughout the BSAI wherever there are substrates consisting of sand, mud, cobble, and gravel.

The best data available on benthic habitat comes from the 1980s (NOAA and MMS 1986); however, that information only provides qualitative data on nearshore habitat through trawl and dredge bycatch. While the broad details of habitat characterized in these studies has not changed drastically, a finer resolution is needed in order to characterize extremely complex macro and micro habitats. From laboratory studies and smaller scale in situ studies, we have an idea on the types of habitats required by each early-stage age category of RKC (as described above), but knowledge of where these areas occur in Bristol Bay and elsewhere in the Bering Sea is not complete. Finer resolution details of benthic habitat, especially nearshore areas, will allow researchers to better characterize patchiness and identify key areas of vulnerability for RKC or that are key for early survival of RKC. Future work could be camera based to assess relative patchiness of nursery habitat with the goal of assessing habitat quantity (area of good habitat) and quality (complexity, cover, food and potential change via climate/fishery impacts).

Understanding the spatial and temporal estimation of bottom contact by various fishing gear types is also critical when thinking about benthic substrate and its use by RKC. In the April 2022 BBRKC discussion paper, the Fishing Effects (FE) model was introduced as a tool that could assess the presence and impact of pelagic trawl fishing in the BBRKC management area and help decision-makers evaluate potential tradeoffs when seeking strategies to reduce these impacts, such as effects of fishing on RKC and their habitat. Past, present, and potential uses of the FE model concerning fishing impacts on benthic species was previously discussed in Section 2.5 of this document. Finer resolution maps that identify key habitat areas for RKC, paired with an understanding of the effects that various fisheries have on these areas would be useful datasets for determining dynamic closed areas.

4 Information needed for A80 to create a rolling hotspot

Council Motion: *Information needed to allow the A80 sector to create rolling hotspot closure systems to avoid and reduce BBRKC PSC as well as the potential tradeoffs of doing so on encounter rates of halibut.*

This section is brief because many of the pieces of information covered in the previous section also apply to the question of how A80 vessels would have the knowledge necessary to successfully and meaningfully avoid or move away from RKC.

The motion's use of the term "rolling hotspot closure system" is presumably in reference to how the BSAI pollock fishery uses real time data on catch and bycatch rates to avoid and minimize salmon PSC; that system was described in Section 5.2 of the April 2022 discussion paper (NPFMC 2022). If that is the model, one of the first things that would need to be established is how similar or dissimilar is the interaction between non-pelagic trawl gear and RKC compared to the interaction between pelagic trawl gear and salmon. A real-time hotspot system is heavily reliant on *observed* bycatch that captains can see and react to immediately and share that information with the rest of their fleet. If A80 non-pelagic trawl gear is less retentive of crab – i.e., if a greater proportion of the total impact on crab comes from unobserved mortality, or crab that do not end up on-deck – then a real-time hotspot strategy is at least marginally less effective. Non-pelagic trawl gear is regulated and designed for crab not to end up in the codend of the net. If it were agreed that unobserved mortality is reasonably well accounted for in the stock assessment as "natural mortality" then an observation-based hotspot system would be more acceptable. Whether that is the case, however, seems to be an open research question at this point. On the other hand, if it is thought that unobserved non-pelagic trawl mortality is a significant enough factor in RKC stock health that reactions to crab on deck are not effective on their own, then a successful system would rely on resolution to the biological, ecological and life-history questions posed in Section 3.

An important word in the Council's motion for this section is "allow". As noted at the beginning of Section 3, NMFS would be challenged to define a hotspot closure system in regulations given the need to follow administrative procedures that allow for public review and comment before areas are closed by the agency. The Council and NMFS could explore options that create a facsimile of a rolling hotspot system through a series of time/area closures that are set in regulation because they have already been implemented through the full public process. An analogy to this is the closure of the RKCSS to non-pelagic trawl gear if the BBRKC fishery was not open in the preceding year. If the Council pursues this type of approach, it would need to leverage the type of information that is highlighted in Section 3.1 (stock distribution) to identify the most critical times and areas to avoid and set them in regulation before the A80 fishery is taking place.

The A80 fleet's operation in 2022, thus far, has some similarities to what one might expect from a hotspot closure system – though the fleet has made decisions based on *expected* bycatch rather than observed bycatch, as well as other factors that weigh into where A80 vessels fish. The A80 sector's 2022 RKC PSC limit for Zone 1 is 67% lower than it was in 2021 and years prior (Table 2-1). Table 3-2 in the April 2022 discussion paper shows that the A80 sector would have exceeded the 2022 Zone 1 PSC limit in all but two years since 2010 if the limit had been at its current level. The sector's RKC PSC in the RKCSS had declined sharply in 2021 relative to previous years and went to zero in 2022 (YTD August 21). This might not be the situation in future years since 2022 activity thus far is also driven by very productive A80 fishing in other areas (e.g., yellowfin sole). Also, it would be premature to judge the A80 sector's 2022 fishing year prior to the return to BS yellowfin sole that will likely occur after the time of writing. In some sense, the regulatory reduction in the Zone 1 PSC limit based on female RKC abundance is sending the same signal as a "hotspot closure" for the present year, and that signal is being heeded on a voluntary basis by vessel operators who work through a cooperative structure to preserve to opportunity to fish in areas with expected RKC PSC later in the year. If the A80 fleet returns to areas with RKC bycatch later in the season, their primary incentive would be not to exceed the annual Zone 1 hard cap; there would be no "move-along" provisions for vessels that get into crab bycatch other than internal cooperative rules that might be developed outside of the Council's purview. One other factor to consider for 2022 is that further halibut PSC limit reductions under the abundance-based management framework have not been implemented yet, so even if all else is equal in 2023 the fleet might respond to different signals when making area-fished decisions early in the year.

If the Council looked at 2022 as a model of A80 fleet behavior to build a program around – stipulating that there might not always be good A80 fishing outside of Bristol Bay early in the year – the Council would be interested in scientific information that describes the distribution, importance, and vulnerability of RKC is the BBRKC stock area during the September/October time frame. RKC distribution in September and the first part of October constitutes a data gap. RKC distribution starting with the October 15 opening of the directed BBRKC fishery is somewhat better understood but also biased because the data are fishery-dependent and thus only tell biologists about crab where they are being targeted, which likely skews towards expected catch of mature males.

Similar to what was described in Section 3, the information that would give the Council the most comfort in allowing an industry-led hotspot system is a link-up of an extended time-series tagging effort and survey data. Presuming that tagging productive females is the most valuable information, a key impediment to investing in more tagging is the lack of knowledge on where mature females are at certain points in the year. The most valuable information that could be gained would likely come through trawl surveys that occur outside of the traditional June period and are repeated over a series of years. Opportunistic tagging in relatively small volumes – a set of dual constraints caused by a lack of surveys throughout the year and the financial cost of tagging programs – would improve the knowledge base on which A80 captains operate but might not provide the certainty in expected RKC bycatch levels in a time/area that would outweigh or overtake the move/avoid incentives that are already in place. Those existing incentives that cause A80 vessels to move in real-time are the Zone 1 hard cap PSC limit, their halibut PSC limits, and the need to preserve flexibility to be in RKC areas later in the year.

5 Impact of groundfish predation on BBRKC

Council Motion: *Provide information on the impact of groundfish predation on BBRKC.*

Data on predation of RKC is sparse and few dedicated studies have occurred. Predator guilds that are often associated with RKC predation include demersal groundfish, pelagic sockeye salmon, and conspecifics (i.e. cannibalism) (Davis et al 2000; Livingston 1988; Long et al. 2012; Wespestad et al. 1994). The most extensive RKC predation dataset available is sourced from groundfish stomach analyses conducted annually by the AFSC-REEM program using samples obtained from the summer, grid-based EBS bottom trawl survey. However, these records are currently unable to produce reliable estimates of predator consumption of BBRKC. Juvenile and adult RKC are an uncommon prey item during the summer survey, though likely biases exist due to survey spatial extent and crab vulnerability at timing of survey (e.g. density-dependent effects and few recently molted soft-shell crab). Several fish predators are identified across the time series, these include skates, sculpin (plain, great, shorthorn and yellow Irish lord), cod, halibut, and soles (northern rock and yellowfin). Of note, greater than 90% of RKC predation biomass is attributed to Pacific cod in summary analysis of this data (pers. comm. AFSC-REEM lab).

Benthic predation is inferred to change with RKC size, habitat use, and behavior; driven ultimately by predator abundance, size, and feeding ecology in natural settings. Early benthic predation of juvenile RKC is thought to occur from smaller fish species such as greenling, sculpin, Northern rock sole, and yellowfin sole (Loher and Armstrong, 2000, Pirtle et al., 2012, Daly et al., 2013, Weems et al., 2020 NPRB Report). Predation on larger RKC (approx. age-2+) is attributed more to Pacific cod, halibut, and skates (Livingston, 1989, Zheng and Kruse, 2006). Survival of early-benthic-phase (age-0 to age-2) juvenile RKC increases with the complexity of physical structure in settlement habitats (Stoner, 2009; Pirtle etal., 2012), presumably to increase foraging opportunities while providing adequate cover (Pirtle and Stoner, 2010). Juveniles older than age-2 (approximately >25 mm carapace length) begin to display social-aggregative "podding" behavior as an antipredator defense strategy (Powell and Nickerson, 1965, Dew 1990). Throughout early life, juvenile RKC molt several times a year and thus ontogenetic shifts in behavior from crypsis to herd defense differentially protect crab during molting, foraging, and movement bouts at all size classes (Pirtle and Stoner, 2010; Powell and Nickerson, 1965). It is also generally assumed (i.e. anecdotal observations from scientists, observers, fishers and historical literature) that the bulk of predation occurs in the spring when adult crab are softshell during molting (Fedewa et al. 2020; Livingston 1988; Long et al. 2012; Wespestad et al. 1994; Zheng et al. 2021). Hardshell, large adult RKC are aggressive, armored keystone species with few natural predators in North Pacific benthic systems, as evidenced by their expanding invasive status in the North Atlantic (Boudreau and Worm 2012; Jørgensen et al. 2005).

Demersal groundfish predation has been hypothesized as a mechanism driving RKC recruitment variability. Previous studies indicate a strong negative relationship between Pacific cod biomass and RKC recruitment from the 1970s to early 2000s (Zheng and Kruse, 2006; Betchol and Kruse, 2010). Estimated RKC recruitment was high during the early period when harvests were at their maximum, yet decreased post-1985 (1979 year class) and are now at much lower levels. During this same period, there was strong evidence of a shift in benthic biomass and community structure in the Bering Sea. During this period, substantial increases in the abundances of walleye pollock, Pacific cod, rock sole, flathead sole, cartilaginous fishes (skates) and non-crab benthic invertebrates were observed, with increases in Pacific cod biomass documented as increasing 10 times previous estimates between the late 1970s and early 1980s (Conners et al. 2002; Zheng et al. 2021). Recently, recruitment for BBRKC has declined to historically low levels since 2010 and specific determining factors remain unresolved (Zheng et al. 2021). As mentioned above, accurate quantification of groundfish predation of RKC is not possible, but fish biomass indices can be used to cautiously approximate predation pressure applied by abundant groundfish species (Figure 5-1 & Figure 5-2). Figure 5-1and Figure 5-2 depict the mean CPUE of major predators of both juvenile and adult RKC. While these figures are not able to inform on actual levels of predation of RKC, they can serve as a proxy for predation with the assumption that as biomass of known predators of RKC increase, that predation of RKC is also likely to increase. Such a predation index for larval RKC is not possible at this time due to the limited number of groundfish diet studies available that overlap with RKC larval duration (i.e. spring/early summer). A discussion of how sockeye salmon may impact larval RKC is discussed below.

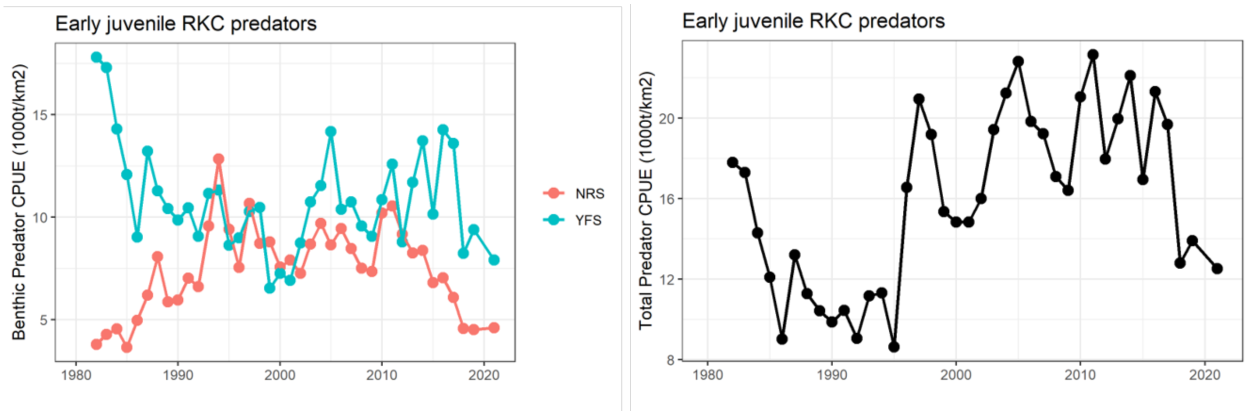

Figure 5-1 A time series of mean CPUE of major early benthic juvenile RKC predators, spatially subset within the BBRKC management area. The left plot breaks the time series down into predator guilds including northern rock sole and yellowfin sole. The plot on the right is the summed total predator mean CPUE of all predator guilds (Plots generated 8/22/22 by E. Fedewa (AFSC)).

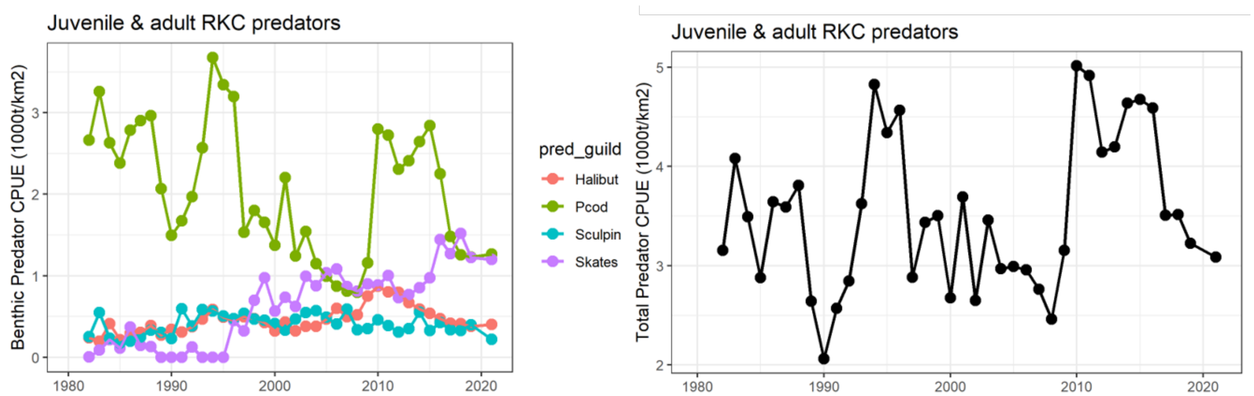

Figure 5-2 . A time series of mean CPUE of major juvenile and adult RKC predators, spatially subset within the BBRKC management area. The left plot breaks the time series down into predator guilds including Pacific cod, halibut, Alaska skate and sculpin complex (staghorn sculpin, yellow Irish lord, shorthorn sculpin, great sculpin and plain sculpin). The plot on the right is the summed total predator mean CPUE of all predator guilds. Note that Pacific cod dominates this trendline. (Plots generated 8/22/22 by E. Fedewa (AFSC)).

Pelagic Bristol Bay sockeye salmon have also been documented as preying on larval and post-larval RKC. Best available data on sockeye salmon diet is from the NOAA Bering Arctic Subarctic Integrated Surveys (BASIS) in the EBS conducted semi-annually from August to September. This program deploys large pelagic trawl nets at grid-based survey stations to study juvenile salmon ocean ecology. For juvenile sockeye smolts (age 1 or age 2) entering the ocean in early summer, their dominant prey items include age-0 pollock, forage fish and euphausiids. Pelagic crustaceans are present in smolts diets, but are not a large percentage of the overall diet. In recent years (2011 - Current), however, other crustaceans (including a small proportion of decapods, the lowest taxonomic identification available that may include RKC) have made up a slightly higher proportion of juvenile sockeye diet (Figure 5-3). Decapods were only present in the diets of juvenile sockeye salmon during 2011, 2012, and 2016. Peak abundance of larval RKC in the middle domain of the southern Bering Sea occurs earlier than the BASIS surveys and the collection of the presented juvenile sockeye diet information. Previous studies that surveyed earlier in the year (i.e. July) have documented a higher percentage of crab larvae in sockeye salmon diet (Davis et al. 2000). Adult, returning sockeye are rarely caught in the survey due to the late timing of the BASIS survey, however adult sockeye do consume crab larvae when present and in high enough densities (e.g. in the Gulf of Alaska, unpublished data) and return to Bristol Bay during peak larval periods. Recent data has shown that more juvenile sockeye are showing up in the NBS during late summer (Ormseth et al. 2021, Figure 7). This could be in part due to warmer temperatures, as both juvenile sockeye and age-0 pollock are known to move farther north and increase in abundance during warm years (Yasumiishi et al. 2020). Coinciding with recent warmer temperatures, Bristol Bay sockeye have returned to the bay in historic amounts over the past 7 years (Figure 5-4). Recent significant increases in sockeye salmon runs could apply significant predation pressure to dense aggregations of larvae and post-larval stage RKC and may be partially responsible for historically depressed RKC juvenile recruitment.

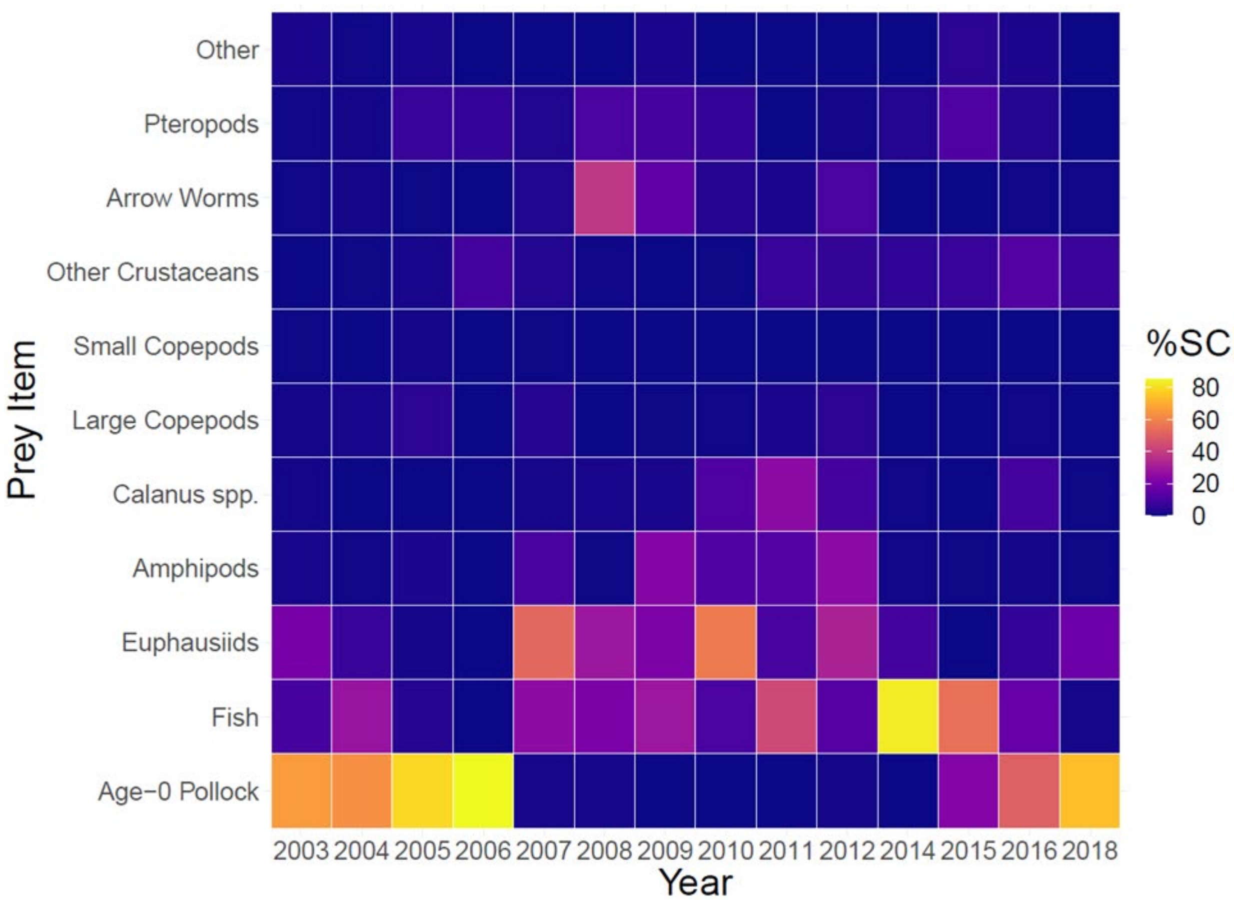

Figure 5-3 Diet proportions of juvenile sockeye salmon given as a stomach content index (%SCI) in the southeastern Bering Sea during late summer (Yasumiishi et al. In Revision).

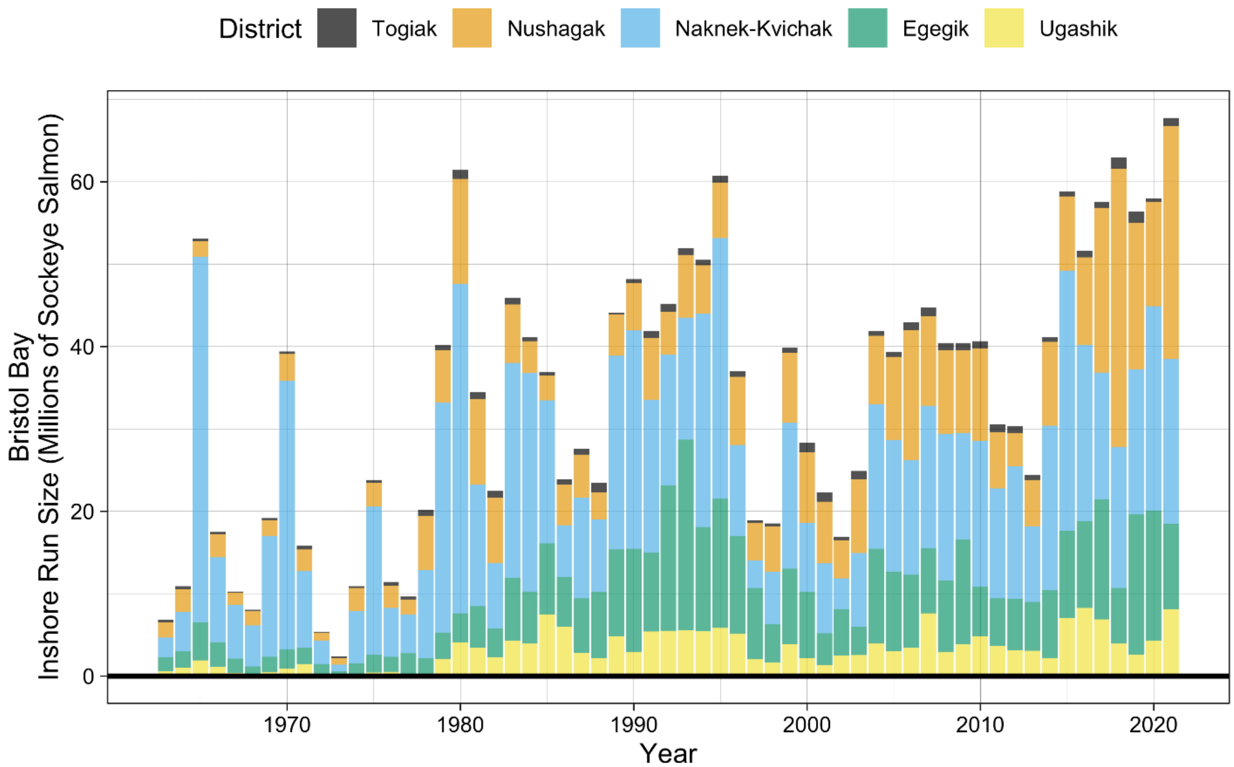

Figure 5-4 Inshore run size of Bristol Bay sockeye salmon by district (2021 EBS Ecosystem Status Report (Siddon, 2021), Figure 65).

Cannibalism may also be a contributing factor in BBRKC stock declines. As the stock has consolidated northward (Szuwalski et al. 2021), incidence of overlap of multiple age classes may increase as crabs inhabit a smaller area and competition increases. Much uncertainty exists surrounding RKC cannibalism in nature, however. In laboratory studies, juvenile RKC have relatively high rates of cannibalism in both high density culture and small-scale experiments (Long et al. 2012, 2013). Crab are typically held together and in close proximity in the lab with multiple age classes present. Maintenance of lower culture densities, increased habitat complexity, lower temperatures and molting crab isolation generally ameliorate cannibalism and likely represent a more natural case-study of juvenile crab interactions and feeding behavior (Long et al. 2013; Stoner et al. 2010, 2013). Cannibalism may occur in the wild, yet it is not likely to occur at levels that would have population level impacts.

6 Impact analyses for Pacific cod fishery

Council Motion: *Analysis of the impacts of:*

- *Prohibiting fishing for Pacific cod with pot gear in Area 512*
- *Establishing a PSC hard cap for the under 60' fixed gear sector and over 60' pot sector*

This section entails a preliminary impact analysis of two policy options that are within Federal management authority: (1) closing a portion of the Bristol Bay region of the Bering Sea FMP area to directed fishing for Pacific cod with pot gear; and/or (2) implementing "hard cap" red king crab PSC limits for groundfish pot gear sectors in the Bering Sea. The part of the Bering Sea area that would be closed to Pacific cod pot gear under the first option is NMFS reporting Area 512 (see Figure 1-2). At its April 2022 meeting, the Council described these potential actions as means to protect the BBRKC stock by limiting or reducing the amount of non-target fishing mortality – in the case of a PSC limit – or by moving a source of fishing mortality (i.e. groundfish pots) out of a biologically important area for

BBRKC – in the case of a gear-area closure. This section does not address the biological questions of whether NMFS Area 512 is uniquely critical to BBRKC or whether reducing fishing mortality in that area is a necessary or sufficient action to improve stock health. Per the Council's direction, this section reports area-specific groundfish catch and crab bycatch data from the different sectors that fish BS Pacific cod with pot gear and introduces the range of factors that would need to be considered for the potentially "directly regulated" cod fishery.

The analysts have made several assumptions, based on April 2022 Council deliberations, about the intent of the motion that affect the data and discussion that follows. First, this section only addresses pot gear used in the directed fishery for Pacific cod. Pot gear – in either single-pot or longline-pot configurations – is authorized for other groundfish (e.g., sablefish IFQ, Greenland turbot) but the Council's reference to gear "sectors" clearly invokes BSAI FMP Amendment 85 Pacific cod sectors. Greenland turbot are not targeted in the Bristol Bay region, so the relevance of this clarification is that the analysts are not considering pot gear used to fish for sablefish IFQ. Second, this section includes data on the historical activity of the Pacific cod pot CP sector that will allow the Council to consider whether the management measures in its motion should apply to that sector as well. The closure of Area 512 would clearly apply to pot CPs but, based on the specificity of the definitions in Amendment 85 – as now captured in Table 8 of the 2022/23 BSAI groundfish harvest specifications – it was unclear whether the Council intended to include pot CPs as part of the "over 60' pot sector" (O60) to which a PSC limit could be applied under the second bullet. The O60 pot sector commonly refers only to CVs, but if the purpose of this discussion is to scope the potential benefits, costs, and efficacy of a hard cap crab PSC limit then it would make sense to consider all Pacific cod pot fishing in the region. Third, the analysts assume that the idea of a crab PSC hard cap for the "under 60' fixed-gear sector" (U60; which includes both pot and hook-and-line gear) means, in practice, a PSC limit that would apply only to fishing with pot gear. The assumption is that the Council's motion used the term "fixed-gear" to follow the sector naming conventions that resulted from Amendment 85, but that the intent was to set a PSC limit for pot fishing. As a result, this section includes catch and bycatch data for pot activity within the U60 pot and hook-and-line Pacific cod sector.

In exploring available options, the analysts noted PSC limit specifications (below) that may be of interest to Council. The analysts did not do an in-depth analysis of these options; a brief summary is provided for each specification that could be considered for a PSC limit. The Council has the discretion to define the parameters of a PSC limit that would guide how to quantify the impact of approaching or reaching a PSC limit.

PSC Limit Specifications:

- *Location* – The Council could consider an area-based PSC limit or closure. For example, in the trawl fishery, the PSC limit is restricted to Zone 1 (Figure 1-2). The Council could choose to implement a BS- or BSAI-wide PSC limit; however, if the goal is to restrict bycatch of RKC specific to what is generally considered BBRKC, a BSAI-wide PSC limit may put further restrictions on other RKC species within the BSAI that do not contribute to the BBRKC stock. The Council could consider whether a location-based PSC limit is the management goal.

- *Season* – The Council should consider whether the proposed PSC limit or closure is annual or seasonal. For O60 CVs and CPs, the Pacific cod fishery operates in two seasons (A and B) that start in January and September, respectively. There is technically only one annual "season" – in regard to TAC – for U60 CVs; NMFS has the authority to close and re-open the U60 HAL/pot CV sector as needed to manage the initial TAC and additional TAC that becomes available to the sector through in-season reallocations. Historically, the U60 CV sector had openings in January, April/May, and September. More recently, with less overall TAC and smaller in-season reallocations available, the U60 sector has had January/September openings like the larger vessel sectors.

- *Sector* – When considering a PSC limit or closure, the Council could distinguish limits by gear/operational-type sector, given the variability in historical catch data among pot CPs, O60 pot CVs, and pot gear component of the U60 pot/HAL CVs.

Description of Data

Two types of datasets are used in this discussion. The first includes 2011-2021 activity for all vessels that targeted Pacific cod with fixed-gear (non-trawl) in the BSAI. The data are a combination of CAS and PSC data merged at the vessel/month level. Not all PSC is merged with CAS due to differences in the week-end date and catch activity date (this occurs in less than 1% of the data). The parameters used for calculating the target fishery in the CAS are different for CPs and CVs depending on the amount of observer coverage and if the delivery is being made to a shoreside processing facility or a mothership.

The Pacific cod pot fishery has varying levels of observer coverage on CVs and the level of coverage on pot CV fishing has tended to lag behind other gear strata in the partial coverage category (see Table 2-13 and Table 2-14 and the following discussion of observer coverage for pot gear in Section 2.6 of this document). Pot CPs are in the full coverage category, while pot CVs are assigned to the partial coverage category. Additionally, some of these vessels participate in electronic monitoring (EM). There are specific challenges when it comes to estimating crab PSC; Appendix 1 describes the crab bycatch estimation methods in groundfish fisheries. The caveats to these data influence the ways in which the data can be used.

The other dataset used in this section comes from ADFG/CFEC Fish Tickets. This dataset includes 2011-2021 activity for all vessels targeting Pacific cod with pots in Area 512. All revenue is ex-vessel value in 2021 real dollars (inflation-adjusted). The Pacific cod target is defined differently in these data, and therefore vessels that have very limited harvest of Pacific cod that did not show up in the CAS data may show up in this dataset.

6.1 Prohibiting Pacific Cod Harvest with Pot Gear in NMFS Area 512

6.1.1 Background: Pacific cod harvest in Area 512

Area 512 lies inside the Nearshore Bristol Bay Trawl Closure Area (NBBTCA) and, as such, only vessels using non-trawl gear fish for groundfish species in this area. Table 6-1 shows the number of unique vessels that NMFS CAS credited as having targeted Pacific cod from 2011 through 2021. No CDQ fishing for Pacific cod with pot gear occurred in Area 512 during those years. The O60 CV sector comprised the majority of vessels fishing in Area 512 during recent years. As a result, that sector has been responsible for the majority of Pacific cod harvest in the area since 2018 (Table 6-3). The predominance of harvest by the O60 fleet, rather than U60 vessels, is likely due to the relatively distant nature of the fishing grounds from ports like Unalaska, necessitating larger vessels. Many of these larger vessels deliver to tenders; 75% of catch from 2018 through 2021 was delivered to tenders. The availability of tender buyers would seem to suggest that smaller vessels could prosecute this area. The fact that they largely have not – though a small number of vessels has begun to do so since 2019 – could reflect the need to deploy more pots to be economical in this area, or could reflect that U60 vessels have different options like state-waters GHL fisheries that are restricted to the smaller vessel class.

Vessel activity in Area 512 increased substantially starting in 2019 when the number of active vessels increased from seven to 18. Prior to 2018, only two vessels fished in Area 512 with pot gear. Prior to 2017, all pot vessels fishing Pacific cod in Area 512 were CPs. There is no ready explanation as to why CPs have not fished this area in recent years, but the number of active pot cod CPs active in the entire BSAI area is small (typically 2 to 4 active in a given year) so some annual variation in fishing presence is expected. Table 6-3, which shows Area 512 retained groundfish harvest in the Pacific cod target fishery by sector, indicates that total retained groundfish harvest increased by 49% from 2018 to 2019. Table 6-3 also indicates that the majority of Area 512 Pacific cod harvest was taken with pot gear (92% since 2017, 100% since 2019). Area 512 has recently constituted a larger but seemingly stable portion of groundfish catch in the BSAI Pacific cod target fishery (11-13% from 2019-2021, Figure 6-1). Pot cod fishery participants who were consulted by the analysts attributed the increase in Area 512 effort simply to fishing where and when CPUE was found to be the greatest in that year.

The majority of non-trawl vessels harvesting Pacific cod in Area 512 self-report an owner address outside of Alaska (Table 6-2)

Table 6-1 Number of vessels in Pacific cod target fishery in Area 512

	HAL	Pot CP	Pot CV O60	Pot CV U60	Distinct # vessels
2011	2	1			3
2012	6	1			7
2013	4	1			5
2014	2	1			3
2015	3	3			6
2016	2	1			3
2017	2	1	1		4
2018	2	1	4		7
2019		1	15	2	18
2020			14	2	16
2021			15	1	16
TOTAL	**14**	**3**	**25**	**3**	**44**

Note: All HAL vessels were CPs.
Source: NMFS Alaska Region Catch Accounting System, data compiled by AKFIN in Comprehensive_BLEND_CA and Comprehensive_PSC.

Table 6-2 Location of owner address for vessels targeting Pacific cod with pots in Area 512, 2011-2021

	ALASKA	WA/OTHER STATES
POT CP		3
O60	7	18
U60	3	1

Source: NMFS Alaska Region Catch Accounting System, data compiled by AKFIN in Comprehensive_BLEND_CA and Comprehensive_PSC

Table 6-3 Metric tons of groundfish catch in the Pacific cod target fishery by fixed gear sectors in Area 512

	HAL	Pot O60 *includes CPs	Pot CV U60	Total	% Harvested by Pot
2011	16	502*		517	97%
2012	829	1,749*		2,577	68%
2013	126	2,175*		2,300	95%
2014	72	747*		819	91%
2015	849	504*		1,353	37%
2016	13	686*		700	98%
2017	21	479*		500	96%
2018	1,365	2,299*		3,663	63%
2019		5,108*	c	c	100%
2020		3,881	c	c	100%
2021		4,046	c	c	100%
TOTAL	3,290	22,175*	816	26,281	86%

Note: No Pacific cod harvest with jig gear occurred in Area 512. "c" denotes confidential data.
Source: NMFS Alaska Region Catch Accounting System, data compiled by AKFIN in Comprehensive_BLEND_CA and Comprehensive_PSC.

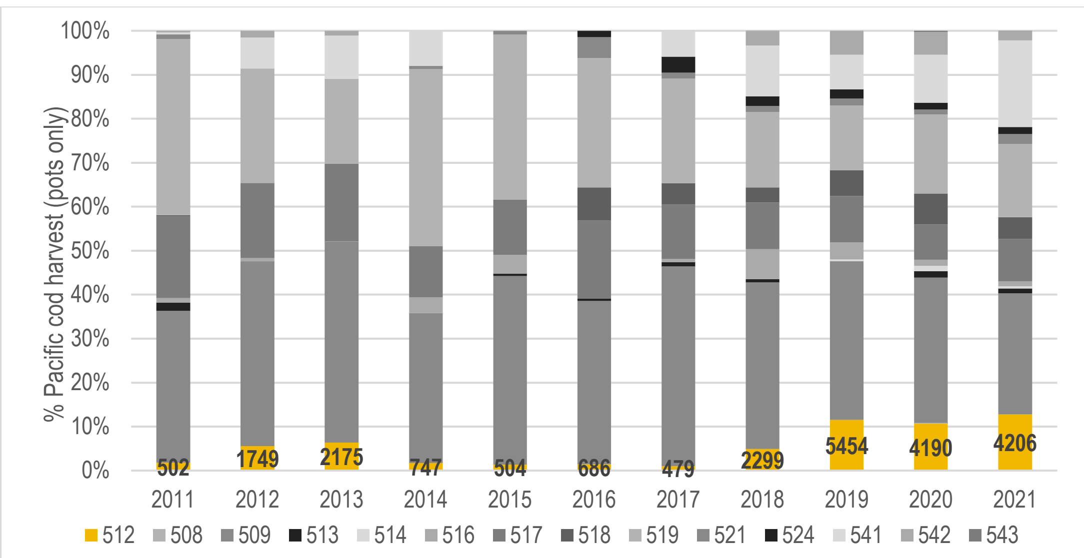

Figure 6-1 Pacific cod harvest in pot gear, 2011-2021 (Source: NMFS Alaska Region Catch Accounting System, data compiled by AKFIN in Comprehensive_BLEND_CA and Comprehensive_PSC; Note: data labels indicate Pacific cod in metric tons for Area 512)

6.1.2 Red king crab PSC in the Area 512 Pacific cod pot fishery

Over the last ten years, among Bering Sea areas, Area 512 accounted for the highest average proportion of total annual estimated RKC PSC (43%) in the Pacific cod pot gear target fishery (Figure 6-2, Table 6-4). The increase in recent years coincides with somewhat higher cod harvest levels in Area 512 (Figure 6-1). Due to the differences in Pacific cod harvest across the BSAI cod sectors in Area 512 (Table 6-3), the sectors have varied in their gross amount of RKC PSC. The increased activity (vessel count) by the O60 pot CV sector shown in Table 6-1 parallels the trend in the RKC PSC data shown in Table 6-5. PSC rates for pots used to target cod (number of RKC animals per groundfish ton) were also highest in Area 512, though rates tend to vary more by year and reporting area (Table 6-6).

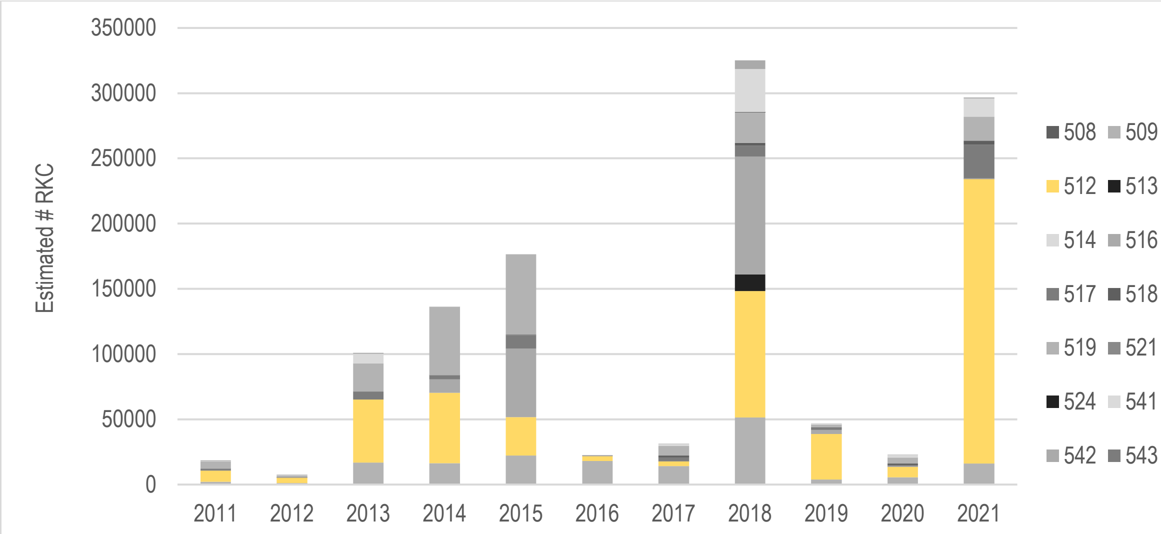

Figure 6-2 **Estimated number of RKC PSC in Pacific cod target fishery by reporting area (pot gear only); Source: NMFS Alaska Region Catch Accounting System, data compiled by AKFIN in Comprehensive_BLEND_CA and Comprehensive_PSC**

Table 6-4 **Estimated number of RKC PSC (# animals) in the Pacific cod target fishery by NMFS reporting area (pot gear only)**

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Total
508										170		170
509	2,143	1,166	16,912	16,291	22,179	18,000	14,177	51,501	3,944	5,400	16,162	171,969
513	27	1			0	0	21	12,930	22	15	14	13,070
514			0						29	23	0	52
516	307	37		10,335	52,622		365	90,180	2,946	291	276	157,360
517	1,194	288	5,960	3,136	10,327	247	2,733	8,361	1,294	750	25,907	60,999
518	1			1	428	25	1,461	2,157	647	1,198	3,033	9,660
519	5,290	1,481	21,627	52,523	61,587	239	7,272	23,598	2,031	4,585	18,403	202,045
521	257			0	0	76	0	21	16	8	0	378
524						0	0	5	0	0	0	5
541	495	403	7,395	170			1,548	33,187	1,061	2,226	14,006	61,588
542	262	81	796				5	6,644	0	179	710	8,855
543								0		0		0
Subtotal	9,977	3,456	52,690	82,457	147,143	18,586	27,582	228,585	11,990	14,845	78,511	686,150
512	8,479	4,043	48,338	53,988	29,463	3,813	3,587	96,706	34,977	8,168	218,101	512,562
Total	18,456	7,500	101,027	136,445	176,605	22,398	31,169	325,291	46,967	23,013	296,612	1,198,712
% Total RKC in 512	46%	54%	48%	40%	17%	17%	12%	30%	74%	35%	74%	43%

Source: NMFS Alaska Region Catch Accounting System, data compiled by AKFIN in Comprehensive_BLEND_CA and Comprehensive_PSC

Table 6-5 Number of RKC PSC in Pacific cod target fishery by pot sector in Area 512

	Pot CP	Pot CV O60	Pot CV U60	Total
2011	8,479			8,479
2012	4,043			4,043
2013	48,338			48,338
2014	53,988			53,988
2015	29,463			29,463
2016	3,813			3,813
2017	3,587	0		3,587
2018	341	96,365		96,706
2019	794	32,357	1,825	34,977
2020		7,546	622	8,168
2021		203,404	14,696	218,101
TOTAL	152,846	339,673	17,144	509,662

Source: NMFS Alaska Region Catch Accounting System, data compiled by AKFIN in Comprehensive_BLEND_CA and Comprehensive_PSC

Table 6-6 RKC PSC Rates (# of crab per groundfish ton) in Pacific cod target pot fisheries in BSAI

Year	508	509	512	513	514	516	517	518	519	521	524	541	542	543	Annual rate across areas
2011		0.6	16.9	0.5		0.6	0.3	0.0	0.8	0.9		2.0	0.9		0.8
2012		0.2	2.0	0.5		0.2	0.2		0.3			0.1	0.1		0.2
2013		2.6	16.9		0.7		2.8		3.2			1.1	1.1		2.7
2014		1.5	53.4			6.4	1.7	0.2	4.6	0.0		0.0			3.5
2015		4.4	71.1	0.0		85.6	4.8	9.5	4.9	0.0					8.6
2016		2.7	5.7	0.0			0.3	0.0	0.4	0.0	0.0				1.2
2017		17.6	7.9	0.3		0.8	0.3	0.4	90.1	0.0	0.0	0.3	0.6		32.8
2018		4.9	29.2	41.0		22.1	4.8	9.8	5.6	0.1	0.0	6.8	2.4	0.0	7.0
2019		0.2	5.9	0.6	0.1	1.6	0.4	0.1	0.2	0.2	0.0	0.2	0.0		0.6
2020	2.0	0.3	1.8	0.1	0.0	0.8	0.3	0.2	0.4	0.0	0.0	0.3	0.1	0.0	0.4
2021		1.1	55.8	0.2	0.0	0.7	2.8	4.1	2.9	0.0	0.0	2.0	0.9	0.0	5.8
2022		0.3	3.1	0.0		0.0	0.2	0.2	0.2	0.0		0.2	0.6		0.3
Average	**2.0**	**3.8**	**23.7**	**2.5**	**0.0**	**13.7**	**1.6**	**1.4**	**10.1**	**0.1**	**0.0**	**1.5**	**0.7**	**0.0**	**5.7**

Source: NMFS Alaska Region Catch Accounting System, data compiled by AKFIN in Comprehensive_BLEND_CA and Comprehensive_PSC

RKC PSC rates for Pacific cod pots in Area 512 have been higher during the cod B season.

Figure 6-3 illustrates this by looking at November for 512 across all analyzed years (2011-2021); however, those data are heavily influenced by a few pot CP trips prior to 2016, when at least one CP was active in the area and where vessels may have run into "lightning strike" RKC events. Despite the recent lack of CP effort in Area 512 – without knowing why those vessels have not fished the area in recent years – it is important to consider older data without overweighting them when thinking about possible management measures. Lacking the ability to predict whether the most recent fishery participation trends are a good predictor of future behavior, it could be sensible to weight more recent data because no CPs have fished in Area 512 over the past two years and the composition of the fishery has changed with increase participation of O60 CVs (Table 6-1). Data from 2017 through 2021 (yellow in

Figure 6-3) show higher RKC PSC rates in Area 512 in September, coinciding with the start of the BSAI Pacific cod B season. If it is the case – or becomes the case as environmental conditions change – that the Pacific cod biomass move north then CPs are less likely to fish in Area 512 because they are not as tied to the area by the need to stay within deliver-distance of shoreside processing ports like Unalaska and Akutan.

Figure 6-4 shows cumulative RKC PSC in Area 512 by month and by sector from 2018 through 2021. Based on those data, the O60 pot sector records the highest RKC PSC in September with substantially more PSC than other months of the year. While some of this increase can be attributed to increased Pacific cod harvest in September, the higher rates of RKC bycatch could reflect the presence of BBRKC in the area at that time.

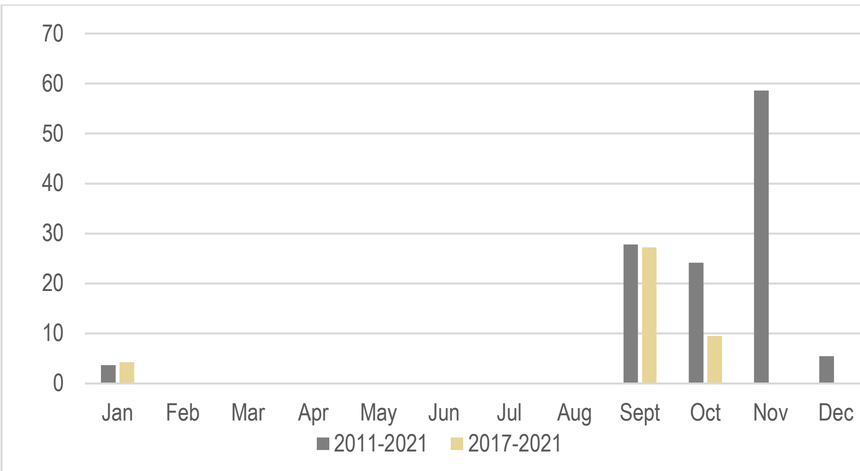

Figure 6-3 Average RKC PSC rates in Pacific cod target (pots only). Note: Rate is average by month per vessel (Source: NMFS Alaska Region Catch Accounting System, data compiled by AKFIN in Comprehensive_BLEND_CA and Comprehensive_PSC)

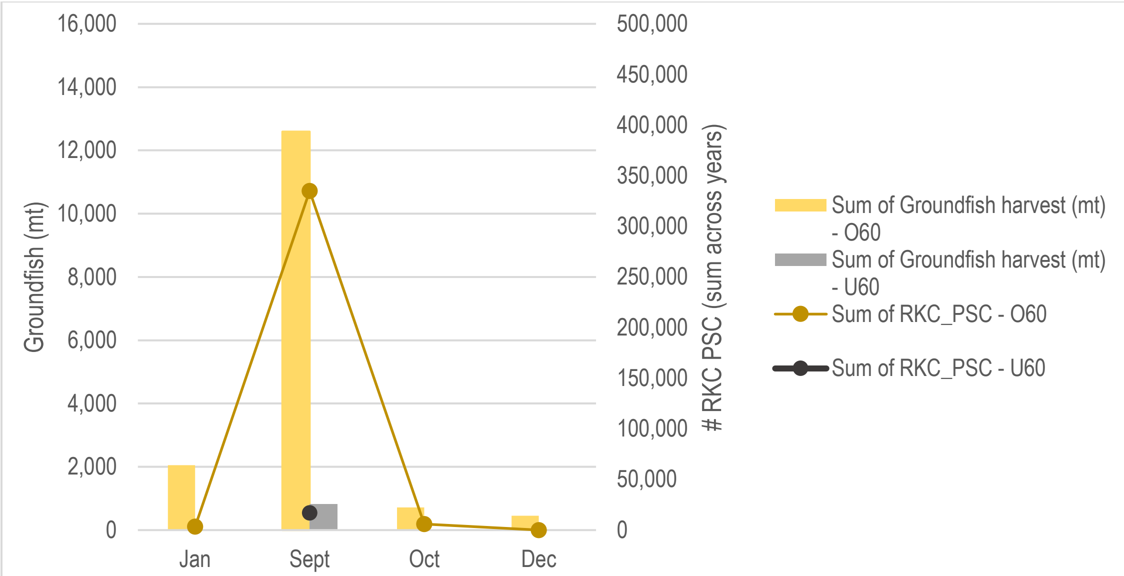

Figure 6-4 Total estimated RKC PSC by month in Area 512 Pacific cod target by sector (pots only) 2018-2021 (Source: NMFS Alaska Region Catch Accounting System, data compiled by AKFIN in Comprehensive_BLEND_CA and Comprehensive_PSC)

6.1.3 Revenue Impacts

Table 6-7 shows the percentage of ex-vessel gross revenues derived from Pacific cod harvest in Area 512 for the O60 CVs that were active in the area. Data on U60 vessels and CPs are confidential and cannot be shown. From 2018 through 2021, there was one O60 CV for which Area 512 Pacific cod harvest represented 40-50% of total ex-vessel revenue. For most O60 pot vessels, Pacific cod harvest from Area 512 represents less than 30% of total ex-vessel value.

While Table 6-7 illustrates how many of the O60 pot vessels earn a certain percent of their revenue from Area 512 Pacific cod and the range of dependence on Area 512 Pacific cod, Table 6-9 provides the context of other sources of the sector's total gross ex-vessel revenue in recent years. The columns in Table 6-9 are not additive; revenues from Area 512 are included in revenues from Pacific cod across all areas. Many of the vessels in the O60 sector participate in crab fisheries and have derived a substantial portion of their revenue from those fisheries when they are open (Figure 1-5). In general, revenue from Pacific cod in Area 512 is not the primary revenue source for the active participants from the O60 sector, but the relative importance of Area 512 cod catch will vary by vessel. Furthermore, in years when directed crab fisheries are closed, vessels are likely more dependent on cod revenues. The cumulative revenue impacts from closing Area 512 to pots, combined with BBRKC directed fishery closures, are partly determined by the quality of cod fishing opportunities in other areas and whether those areas are operationally viable for CVs that must deliver shoreside or have a tender vessel market.

Table 6-8 shows the ex-vessel and wholesale values that could have been forgone if pot vessels had been prohibited from Area 512 in recent years. If pot vessels were prohibited from fishing in Area 512, fishing effort would likely be redistributed to other areas rather than eliminated altogether, so harvesters would have made up some of those revenues fishing cod in other areas. Data from recent Pacific cod harvests might not be a perfect predictor of future harvests or market conditions. Given those caveats, historical data provide a potential maximum adverse economic impact of prohibiting fishing for Pacific cod with pot gear in Area 512 for each sector if vessels do not redistribute effort to offset reduced opportunity. As noted in the following subsection, most of the pot cod vessels that have fished Area 512 exceed the length restrictions for the state-waters cod fisheries, so redistributed effort would most likely occur in other Federal cod areas, in crab (if open, but limited by rationalized quota holdings), or to the Gulf of Alaska.

Table 6-7 Number of vessels in Area 512 Pacific cod target and associated percent of gross revenue (ex-vessel value in 2021$)

	2018	2019	2020	2021
O60	**5**	**15**	**14**	**15**
0-10%	3	4	5	5
10-20%		7	4	7
20-30%		3	3	2
30-40%	2		1	
40-50%		1	1	1

Source: ADFG/CFEC Fish Tickets, data compiled by AKFIN in Comprehensive_FT

Table 6-8 Ex-vessel and wholesale value of Area 512 Pacific cod harvest by sector ($2021)

	Pot CP		Pot CV O60		Pot CV U60	
	Ex-vessel ($)	Wholesale ($)	Ex-vessel ($)	Wholesale ($)	Ex-vessel ($)	Wholesale ($)
2011	*					
2012	*					
2013	*					
2014	*					
2015	432,838	897,988				
2016	*					
2017	*		*			
2018	*		2,070,678	5,499,412		
2019	*		4,733,655	8,588,778	*	*
2020			3,496,768	6,297,359	*	*
2021			3,494,157	6,979,611	*	*

* denotes confidential data.
Source: NMFS Alaska Region Catch Accounting System, data compiled by AKFIN in Comprehensive_BLEND_CA and Comprehensive_PSC

Table 6-9 Revenue sources for vessels 60' or greater in length targeting Pacific cod with pots in reporting area 512 by geography of vessel ownership (ex-vessel revenue, 2018-2021)

Geography	Annual Average Ex-Vessel Gross Revenues from 512 Pacific cod (millions 2021 real $)	Annual Average Ex-Vessel Gross Revenues from Pacific cod (millions 2021 real $)	Annual Average Ex-Vessel Revenues from All Crab (millions 2021 real $)	Annual Average Total Ex-Vessel Revenues from All Areas, Gears, and Species Fisheries (millions 2021 real $)
Homer/Kodiak/Anchor Point/Anchorage	$0.7	$1.0	$2.7	$4.1
Washington/Other States	$2.1	$3.6	$13.8	$18.4
Grand Total	$2.8	$4.5	$16.5	$22.5

Source: ADFG/CFEC Fish Tickets, data compiled by AKFIN in Comprehensive_FT

6.1.4 Discussion

Excluding certain gear types from an area can displace effort to other locations. Harvesters are expected to make strategic choices about the location and timing of harvest. The net effect of relocating effort on the BBRKC stock depends on biological conclusions about the relative value of the 512 area for crab productivity. The effect on cod harvesters is direct. (Note that Section 1.5 of this document describes the partial overlap in pot cod and crab harvest participation.) Given that Area 512 is already a non-trawl area and that HAL participation has tailed off in recent years, a pot cod closure would leave the area largely undisturbed by groundfish gear.

When fishing effort could be geographically displaced it is necessary to consider potential changes in operational costs, like time and fuel. Area 512 is relatively far to the east from the commercial ports along the Aleutian chain (e.g., Unalaska/Dutch Harbor, Akutan) so moving effort west to other popular pot cod areas – e.g., to Areas 509 or 516 – could reduce travel (see areas in Figure 1-2). The economic effect of closing Area 512 to pot gear likely has more to do with target groundfish catch rates in the westward areas to which effort is likely to shift. The areas to which pot cod effort might shift could also be dictated by non-regulatory agreements. For example, a portion of the O60 pot cod fleet voluntarily stood down from fishing groundfish pots in the RKCSA during the 2022 A season (see Section 1.5). The durability of – and extent of fleet participation in – such agreements is not predictable in the future and the Council is best informed on those plans through public testimony by active stakeholders. In short, closing Area 512 to pot gear would likely reduce fishing mortality in an area where RKC PSC has been relatively high (Table 6-6), but the areas to which that effort is redirected is as important when considering the net effect of the action.

The analysts do not predict how RKC will be distributed across Area 512 and other areas relevant to the pot cod fishery in the near future, nor does this document assign relative importance of those areas to the health of the BBRKC stock. Nevertheless, if future fishing patterns and crab distributions resemble data from the recent past, a Pacific cod pot gear closure in Area 512 would be most effective at avoiding RKC PSC in the month of September (Figure 6-4). A closure for the month of September would also overlap with when the majority of Pacific cod harvest in the area has historically occurred.

When analyzing impacts of closing an area to a gear type, it is important to consider whether harvesters would or could respond by switching gear. In order to fish Pacific cod in the BSAI, vessel operators must hold an LLP license with a Pacific cod endorsement for each gear type. NMFS Restricted Access Management (RAM) data indicate that only one LLP license with a BSAI Pacific cod endorsement for pot gear also holds a Pacific cod endorsement for HAL gear. Therefore, it is unlikely that an Area 512 closure (or a PSC hard cap for pot gear) would substantially increase HAL gear effort. It is more likely that pot gear effort will shift to other areas in the Bering Sea or that vessels will seek opportunities in the Gulf of Alaska as permitted by the licenses they hold and the opportunities available in those fisheries.

The analysts also considered whether an Area 512 closure could push additional effort into the state-waters Pacific cod fisheries managed by ADFG. The closest state-waters fishery that could conceivably be affected is the Dutch Harbor Subdistrict (DHS) state-waters and parallel Pacific cod fishery. Background on that fishery and its regulations are detailed in the 2022 DHS Pacific cod fishery management plan, published by ADFG. The state-managed fishery is only open to pot and jig gear. Figure 1 in that document (p.14) shows that the DHS area lies well west of NMFS Area 512. More important than location – given that most vessels would be embarking from Dutch Harbor or Akutan – are the limitations on which vessels can fish the DHS catch limit and the lack of overlap with the larger size vessels that have historically fished in Area 512 (see Table 6-1). The DHS fishery is only open to vessels of 58’ LOA or less.

If the Pacific cod pot gear fishery in Area 512 is closed by Federal regulation amendment, it is likely that the State would close the parallel pot gear fishery inside state-waters adjacent to 512. That approach would be in keeping with a general policy to align crab protection measures across the State/Federal management boundary. The parallel waters fishery and its management is described on page 2 of the DHS management plan linked above.

One ancillary issue related to an Area 512 closure and state management is the existing permission for vessels directed fishing for RKC to fish a limited number of Pacific cod pots at the same time. ADFG allows crab vessels to fish up to 10 cod pots; these pots are typically fished to catch bait for the crab pots. If State managers mirror Federal regulations, it is possible that this option would be eliminated in the waters encompassed by Area 512. According to ADFG staff, around 400 pots were used to fish for cod on vessels targeting rationalized crab on average over the past five years; that count is not exclusive to Area 512.

6.2 "Hard Cap" PSC Limit for Red King Crab (Non-Trawl)

6.2.1 Historical red king crab PSC data for Under-60 non-trawl gear and Over-60 pot gear Pacific cod sectors

This section provides historical data on RKC PSC broken out by the relevant gear and vessel length-based Pacific cod sectors that were defined in BSAI Groundfish FMP Amendment 85. These PSC data differ from what was presented in Part 2 of this document, which aggregated PSC by gear group (e.g., HAL or pot), regardless of vessel length or operational type (CP/CV). The Council's motion does not specify whether a PSC hard cap would only apply to RKC caught in pot gear within a certain geographical boundary (e.g., specific NMFS reporting areas that approximate ADFG Registration Area T or the BBRKC stock assessment area), so the data presented in this subsection cover a more expansive area: the BSAI (unless otherwise stated).

The reader should note that, while BBRKC is the focus of this document, RKC PSC is not identified and accounted for at the stock level. RKC PSC mortality that occurs in the areas overlapping or near the stock assessment or directed crab fishery boundaries are more likely to have contributed to the BBRKC stock, but some taken in those may have been contributors to other stocks or destined to recruit to other stocks (e.g., Pribilof Islands, Norton Sound). Portions of the PSC totals reported in this section occurred in parts of the BSAI that are less likely to contribute to the BBRKC stock.

Vessel participation within the BSAI Pacific cod pot fishery has varied since 2011 (Table 6-10). Vessel participation peaked from 2018 through 2020 but has remained high relative to the beginning of the analyzed period due to greater participation by U60 pot cod CVs. Historical catch from 2011 through 2021 in the Pacific cod pot fishery shows that the majority of RKC PSC occurred in the O60 vessel-size category of the pot cod fishery (estimated 854,032 crab). That total includes both O60 CVs and all CPs (Table 6-11). Within the O60 CV/CP grouping, CVs accounted for 68% of the cumulative 2011-2021 RKC PSC in pot gear, and the other 32% is attributed to the Pot CP sector. The high proportion of overall O60 RKC PSC that comes from the CP sector, relative to the number of CPs participating, is driven by years of disproportionately high RKC encounter in 2013 through 2016 when CPs accumulated between 21,000 and 95,000 RKC annually. During the other analyzed years, pot cod CPs' RKC PSC was between 9,000 and 13,000 (two years) or otherwise below 4,500; CPs' RKC PSC dropped to around 1,800 in 2019 and numbered in hundreds in 2020 and 2021. Annual RKC PSC by the CV sectors was no less variable. O60 CVs recorded years as low as 300 RKC and as high as 240,000 PSC. The U60 pot CVs totaled 331,452 RKC during the analyzed period, with annual amounts estimated as low as 550 RKC and as high as 85,000 PSC (Figure 6-5). Appendix 1 to this document describes the crab bycatch estimation process for BSAI groundfish fisheries.

RKC PSC was highest in 2018 and 2021 for both U60 pot CVs and O60 pot vessels but RKC PSC was highly variable across years (Table 6-11; Figure 6-5. The lowest RKC PSC across sectors occurred in 2012 (7,500) and the highest occurred in 2018 (325,291). In addition to annual variation, RKC PSC varies monthly, and exhibited a trend of higher RKC PSC in both sector groupings during September and, to a lesser extent, October (Figure 6-6) which coincides with the opening of the Pacific cod B season and inseason reallocations of annual Pacific cod TAC to the sectors that are generally more active towards the end of the calendar year. O60 RKC PSC was highest in September 2018 and 2021, with cumulative monthly totals of 255,095 and 210,881 RKC respectively. The annual and monthly data shown in the following tables and figures are useful for understanding the timing of PSC encounter but are not sufficient to make conclusions about the degree of impact on the BBRKC stock. PSC data are driven to a great extent by the amount of fishing effort; the fact that RKC PSC spikes in September likely tells the reader more about the number of cod pots in the water than it does about the movement of crab, the potential productivity of crab, and the stocks to which those crab are contributing. Because the pot sectors do not have a hard cap PSC limit, inseason TAC reallocation decisions between Pacific cod sectors are not necessarily driven by the potential for crab bycatch. Wide variation in PSC estimates could also be an artifact of lower observer coverage rates in the pot sectors. As noted throughout this paper, PSC estimates that rely on a high ratio of unobserved to observed effort are prone to fluctuate if the observed vessels are clustered in low or high PSC encounter time/areas by chance.

Table 6-10 Vessel participation in the BSAI O60 pot gear fishery (O60 CP and CV), and the U60 fixed gear fishery (pot gear only) from 2011-2022

YEAR	POT_CP	POT_CV O60	POT CV U60	Total
2011	4	33	15	**52**
2012	5	29	20	**54**
2013	3	31	25	**59**
2014	4	31	21	**56**
2015	4	23	21	**48**
2016	4	25	27	**56**
2017	4	34	26	**64**
2018	5	34	39	**78**
2019	5	35	43	**83**
2020	5	39	50	**94**
2021	4	23	38	**65**
2022	3	27	31	**61**
Total	**7**	**55**	**69**	**131**

Source: NMFS Alaska Region Catch Accounting System, data compiled by AKFIN in Comprehensive_BLEND_CA and Comprehensive_PSC

Table 6-11 Annual BSAI RKC PSC by sector

YEAR	O60 Pots	U60 Pots	TOTAL
2011	16,945	1,511	18,456
2012	5,944	1,556	7,500
2013	74,448	26,579	101,027
2014	92,420	44,025	136,445
2015	115,020	61,585	176,605
2016	21,848	550	22,398
2017	12,682	18,487	31,169
2018	255,095	70,196	325,291
2019	36,854	10,113	46,967
2020	11,894	11,120	23,013
2021	210,881	85,731	296,612
AVERAGE	77,639	30,132	
TOTAL	854,032	331,452	

Source: NMFS Alaska Region Catch Accounting System, data compiled by AKFIN in Comprehensive_BLEND_CA and Comprehensive_PSC

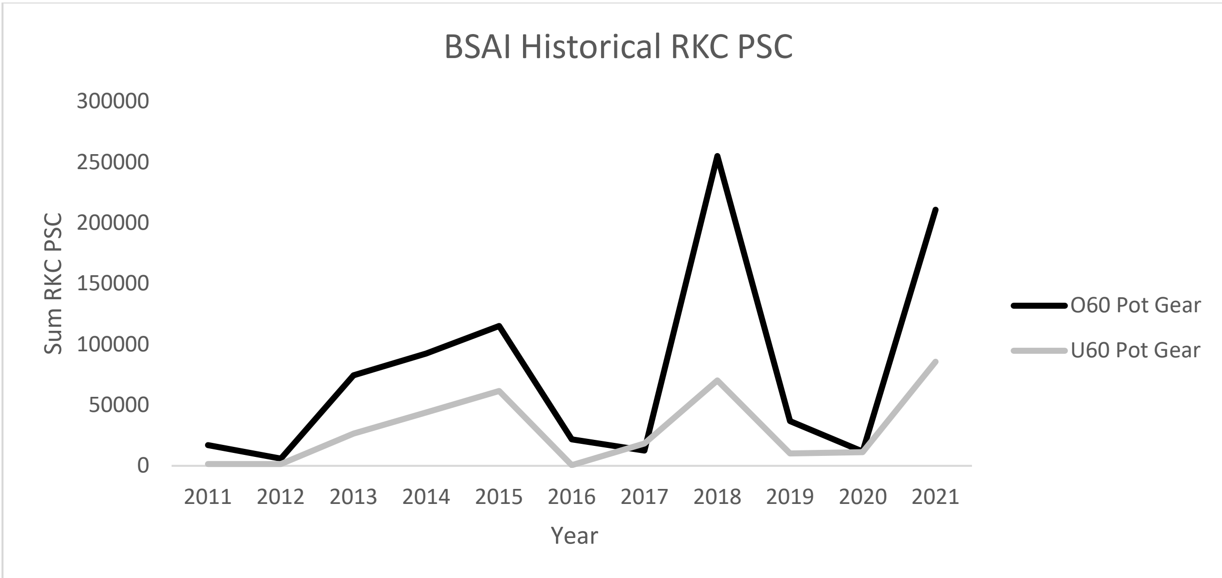

Figure 6-5 Annual RKC PSC within the Pacific Cod pot fishery by sector grouping. "O60 pot gear" includes O60 CVs and all CPs (Source: NMFS Alaska Region Catch Accounting System, data compiled by AKFIN in Comprehensive_BLEND_CA and Comprehensive_PSC)

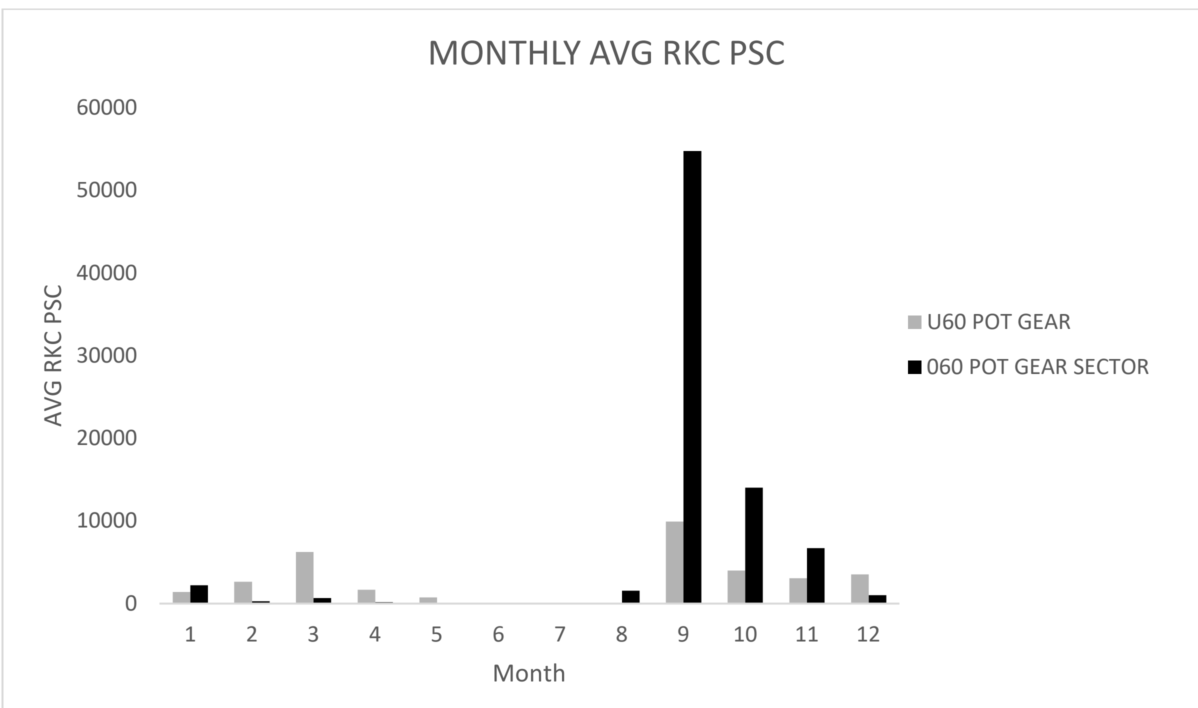

Figure 6-6 Average monthly RKC PSC from 2011-2022. "O60 pot gear" includes O60 CVs and all CPs (Source: NMFS Alaska Region Catch Accounting System, data compiled by AKFIN in Comprehensive_BLEND_CA and Comprehensive_PSC)

6.2.2 Potential impact of RKC PSC Limits for Pot Gear

The Council motion requested that staff "analyze the impacts of establishing a PSC hard cap for the under 60' fixed-gear sector and the over 60' pot sector". To provide context for the Council, this subsection provides a hypothetical scenario using PSC limits based on each sector's estimated average historical RKC PSC usage in the BSAI. A PSC limit is applied to each sector based on average historical RKC PSC for both the U60 fixed-gear sector (pot gear only) and the O60 pot sector (CVs plus CPs). Unlike with halibut PSC, DMRs (i.e., crab handling mortality rates) are not applied to the RKC PSC limits that currently exist for trawl gear ("Zone 1 PSC limit"). For consistency with other PSC limits, the analysts do not apply a mortality rate estimate to this PSC limit scenario.[25]

The hypothetical scenario below is not intended to place a value on retrospective forgone revenue under a PSC limit; rather, it provides historical bycatch data in the context of a maximally applied PSC limit – encompassing all pot gear activity in the BSAI – with no adjustment in fishing behavior. O60 pot gear CVs and CPs are combined into a single PSC limit category, absent further Council direction. Data on the U60 CV sector include only records that occurred while fishing with pot gear, even though the U60 Pacific cod TAC apportionment to that vessel-size sector is shared by vessels using either pot or HAL gear.

Showing scenarios based on historical data is a useful way to present relevant contextual information while also discussing the general scale of potential impacts on the groundfish fisheries. This section is not meant to imply that the Council could only – or should only – consider a PSC hard cap that is tied to historical use, though historical use certainly informs the range of maximum potential impacts for whatever cap level is being analyzed. Historical use patterns are somewhat less useful when inter-annual variation is as great as it has been for the BSAI Pacific cod pot sectors' RKC PSC, where annual totals were in the hundreds in one year and the hundreds of thousands in another. Basing a hard cap threshold on recent average use – or even on percentages bands above/below recent average use – may feel arbitrary and may not provide the desired behavioral incentives if annual variation can sometimes be measured in orders of magnitude, as shown in Figure 6-5. If a vessel operator feels that their fishing behavior is relatively similar from year to year but their sector's PSC total has extreme variability, they are not likely to take on opportunity costs to try to affect an outcome over which they feel little individual control. The Council process will benefit from participant input on why RKC PSC in the pot cod sector appears so volatile. As noted above, one of the analysts' leading suppositions is that PSC estimates are more variable when the rate of observer coverage for a gear sector is low relative to the total amount of effort.

Instead of starting with historical PSC use – which makes it easier to assess impacts on the groundfish fishery – the Council could start from the vantage point of what RKC PSC total is acceptable. The latter approach could be more tailored to impacts on the crab stock. The challenge of that approach is the gap in knowledge about how PSC translates to BBRKC stock success. To take the latter approach, the Council might need to pare down the geographical area to which the limit applies – focusing on an area smaller than the BSAI. The most difficult and most important step is defining the PSC limit threshold that has a meaningful impact on the stock. Defining the relevant area is somewhat easier, but is not without unresolved biological questions. The Zone 1 trawl PSC limit is an example of how this approach has been applied: an area was defined and PSC limit "steps" were established; annual PSC limits are applied based on indicators of the relevant crab stock status. Defining an area relevant to the BBRKC stock should not be difficult. The Council could consider trawl PSC limit Zone 1, the BBRKC stock assessment area, or Registration Area T. Defining a maximum acceptable PSC amount – which is the crux of a "hard cap" – would likely require conjecture in a setting of limited information with significant potential consequences

[25] A 50% handling mortality rate is applied to RKC PSC taken with groundfish pot gear for the purpose of estimating total fishing mortality for the BBRKC stock assessment.

for the directly-capped Pacific cod pot fishery participants. If the Council knew that the BBRKC stock could tolerate a certain annual amount of RKC PSC within a defined geographical area, then a hard cap would be a clean approach that prevents drastic harm and guides the behavior of the pot cod fishery to stay below that limit. Incentive measures could be layered on to improve PSC performance (often described as “PSC savings” in other Council programs). Unfortunately, this is not the information situation in front of the Council.

Scenario: PSC hard cap based on average historical RKC PSC

U60 fixed-gear sector (pot gear RKC PSC)

Pot gear accounts for the majority of RKC PSC in the U60 Pacific cod fixed-gear sector, averaging 30,132 RKC annually (Table 6-11). If an RKC PSC limit were to be established for the U60 sector based on the estimated average annual catch of 30,132 RKC, a subsequent closure of the Pacific cod pot gear fishery would have occurred in 2014, 2015, 2018, and 2021 (Table 6-13). Total RKC PSC was highly variable across years and by monthly distribution. September averaged the most RKC PSC with 9,912 individuals (Table 6-13). Of the four years that exceeded the hypothetical, average-based RKC PSC limit, two years (2014 and 2018) would have reached that limit in September. In 2015, the hypothetical limit would have been reached in November, and in 2021 the limit would have been reached the earliest, in April. A fishery closure for the years of 2014, 2015, 2018, 2021 for the U60 pot gear CVs would have resulted in an ex-vessel revenue loss of approximately 11%, 7.5%, 9% and 4%, respectively. Both wholesale and ex-vessel values are reported for U60 pot CVs in Table 6-15. Revenue is represented as a total monthly sum by sector.

2021 was the only year in which RKC PSC would have exceeded 30,132 individuals in the A season. Based on historical RKC PSC catch data, in the years that a hard cap would have been reached, it would likely be reached early in the B season, if at all. The result of reaching a PSC limit would differ depending on the structure of the PSC limit that the Council might design – i.e. the locations and timing to which the limit and any subsequent closure might apply. If the PSC limit was area/location based, reaching the PSC limit would result in vessels moving out of the designated area and fishing elsewhere, similar to how the RKC PSC limit in the trawl fishery is established for Zone 1.

O60 pot gear fisheries (O60 pot CVs & pot CPs)

A hypothetical PSC limit for the O60 pot sector (CPs and CVs) based on estimated average historical (2011-2021) RKC PSC usage would be 77,639 RKC (Table 6-11). Historical catch data differs significantly between CPs and CVs. As noted above, O60 CVs accounted for 68% of 2011-2021 RKC PSC while CPs accounted for 32%. The Council should consider whether these operational type sectors should be grouped under a single PSC limit if the approach is analyzed further. To the analysts’ knowledge, the O60 CV sector is generally organized under two distinct voluntary, non-regulatory cooperatives. The CP sector consists of a small number of vessels that are not formally organized into a voluntary cooperative. Vessels within both groups have cross-cutting commonalities including reliance on directed fishing for king crab that may unite some vessels in their approach to cooperative measures but do not apply as much to vessels for which RKC would only be viewed as a PSC constraint.

If an RKC PSC limit were established for the O60 sector based on the average annual historical catch of 77,639 RKC individuals, the limit would have constrained those sectors’ BSAI Pacific cod fishing in 2014, 2015, 2018, and 2021 (Table 6-14). Again, the extent of the constraint depends on the scope of the limit in terms of areas and seasons that accrue to, and are subject to, the limit. Total RKC PSC usage varied widely across years and months, but PSC was consistently highest in September (Figure 3 2). In 2018 and 2021, respectively 199,411 and 201,191 RKC were caught in the O60 sector during the month of September. That catch would have far exceeded the hypothetical allotted 77,639 RKC in a single month. Over the last 10 complete years, an O60 CV/CP PSC limit set at average historical use would typically be reached early in the B season in the years that it was reached at all. The hypothetical PSC limit for the O60 pot gear sector would have been reached in September of 2014, 2018 and 2021. In 2015, the PSC limit would have been reached in early November, depending on weekly fishing effort (Table 6-14; weekly data not shown). The Council could consider A/B seasonal PSC limits. A disadvantage of shortening the time-scale of an intra-annual PSC apportionment is the time required to debrief, reconcile, and update observer-derived data and to complete species identification for EM trips. These will be familiar issues to the Council and NMFS from their experience with Chinook salmon PSC limit monitoring in the GOA trawl fisheries that are not subject to full observer coverage. It is possible that timely RKC PSC usage information could come in to managers at a pace that does not allow precise in-season management for a relatively fast-paced limited access cod fishery; as a result, managers might need to close directed fishing early, out of precaution, to ensure that a hard cap limit is not reached. Early closures would exacerbate the economic effects of a hard cap closure, and intermittent reopenings would accrue operational costs or render some vessels unwilling to return to fishing grounds that are fairly distant from the main BSAI hub ports.

A PSC limit closure could directly impact revenues if vessels are not able to compensate for the lost opportunity with other fisheries, or indirectly if the possibility of a cap closure results in higher variable costs associated with crab avoidance measures. Future analysis would need to further explore the costs associated with crab bycatch avoidance in the Pacific cod pot fishery. Those measures would likely include area avoidance, dumping and resetting gear in areas that are resulting in high crab encounter, and gear hardware modifications. It is the analysts' understanding that cod pots are already rigged with devices intended to prevent some crab from entering pots and allow small crab to exit pots.

For the O60 pot sectors, a fishery closure after September, when the proposed PSC limit would have been reached in 2014, 2015, 2018 and 2021, would have resulted in a 23%, 0.01%, 16.5%, and 29.7% loss of ex-vessel value, respectively (Table 6-16). Annual wholesale values for the O60 pot gear sector, including both pot CVs and CPs is reported in Table 6-16. However, Table 6-11 shows that there were also years when the O60 pot gear fishery did not approach the hypothetical PSC limit and thus would have experienced minimal direct economic impacts.

<u>Hard cap scenario discussion and supporting historical data</u>

Compared to other fisheries for which the Council has considered or implemented hard cap PSC limits, the BSAI (or BS) Pacific cod pot fishery is a challenging fit. The primary challenges are the extreme inter-annual variability in historical estimated PSC levels and the lack of clarity on what would constitute an effective (or even precautionary) maximum acceptable PSC amount for BBRKC. The latter challenge is the joint result of a changing environment that has sparked a stock decline that is not fully understood and gaps in knowledge about the life-history of BBRKC and their movement and dispersal patterns throughout the entire calendar year such that they might interact with groundfish pot gear.

In general, PSC hard caps carry the dual risk of being either too constraining or not constraining enough to meet biological objectives or properly incentivize desired fleet behavior. A tight constraint relative to expected or typical PSC encounter – to the extent that there is a "typical" amount – results in shortened seasons and direct economic impacts. The relative impact across pot cod vessels would vary depending on the other fishing opportunities available to each individual vessel, noting that some – but not all – pot cod vessels have been co-dependent on directed crab fishing. A PSC hard cap that is only constraining in extreme years of RKC encounter provides less benefit to the BBRKC stock; the weight of that consideration is dependent on the best assessment that the Council can make on whether pot cod bycatch is a significant driver of the BBRKC decline.

The Council might mitigate some risk to the Pacific cod pot fleet, as a whole, by designing a cap that applies only to fishing in certain areas. Shrinking the application of the hard cap could result in a smaller PSC limit that is more difficult to manage from an in-season perspective. On the other hand, if fewer partially observed vessels are fishing subject to a hard cap there might be less volatility in near-real-time PSC estimation, in which case a cap might be marginally less difficult to manage.

Annual variability in historical RKC PSC meant that, retrospectively, pot sectors would not have closed in many of the analyzed years but, in years when a cap based on average use was met, the closure generally landed early in the B season. If the Council were to pursue this policy option, analysts would provide weekly data for a more granular approach to potential forgone catch. As it is, Table 6-12 shows that there are already some years in recent history where the B season was curtailed based on TAC availability alone – being currently unconstrained by an RKC PSC limit.[26] The relative effect of a PSC hard cap would be greater if TAC availability is high and the fishery would otherwise have continued longer; the effect of a hard cap is lower if the fishery was going to close regardless of crab encounter rates.

Current management and monitoring of the BSAI Pacific cod pot gear fishery is not conducive to real-time PSC reporting or bycatch closures that need to be managed on a fine time-scale. Appendix 1 describes challenges with collection of PSC data and real-time PSC reporting. A basic challenge is that the CV pot cod fleet is in the partial observer coverage category, so PSC estimates are reliant on onboard observers being able to submit their data. That process takes time, and as additional observer data become available previous weekly estimates may be revised for a period of weeks.[27] Also, there are times when observers cannot identify crab to the species level, possibly resulting in a less accurate (higher/lower) representation of RKC PSC within the fishery. As described in Appendix 1, EM data is particularly challenging when trying to identify crab to the species level.

The discussion in this section has been predicated on the assumption that the Council can apply a PSC limit only to catch that occurs with pot gear, even though the U60 pot cod sector shares a cod allocation between vessels using pot and HAL gear. It is the analysts' understanding – in consultation with NMFS staff – that a PSC limit could be defined in this way. Any further analysis of this policy option would highlight the extent to which the limitations on real-time monitoring and PSC estimation would hamper the practical implementation of such a limit. If the number of vessels fishing without observers at a given point in time could conceivably reach the PSC limit before NMFS is able to issue a fishery closure then preemptive closures might be required. This could significantly disrupt the flow of a fishery that typically occurs over a short period of time and in areas distant enough from ports that short-lived closures and subsequent reopenings are impractical for the fleet.

Hard cap PSC limits apply to an entire sector – however defined by the Council. The cost of reaching a PSC limit that closes a directed fishery prematurely is shared by all active participants. In some cases,

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[26] By regulation, the A season for pot gear sectors that have seasonal TAC apportionments starts January 1 and concludes on June 10. The B season starts September 1 and concludes December 31. Once a sector – as defined by Amendment 85 – reaches its TAC, and absent any inseason reallocations by NMFS, directed fishing is closed for that sector. In the last five years, the A season has generally been shorter in duration than the B season. In some years, season lengths have been shorter than two weeks.

[27] Observers on pot CVs only submit data when they are in a port with internet access, which sometimes happens for the first time once the fishery is over. CVs come to port even less frequently when delivering to tenders, which is relatively common in this fishery. Post-season data reporting does not provide NMFS inseason managers with the information needed to close the fishery on account of PSC. The general shortening of the pot cod seasons increases the difficulty of managing a PSC limit within a season. As noted elsewhere, these challenges are exacerbated where observer coverage is low and managers rely on a small number of onboard observer reports to make immediate decisions.

hard caps in an unrationalized fishery can increase the pace of fishing, which may have adverse consequences in terms of individual incentives to mitigate bycatch. The BSAI Pacific cod pot fisheries are relatively fast-paced already (Table 6-12), but it is possible for the fishery to grow even shorter if vessels race to harvest TAC before a high-PSC event closes the fishery and strands all uncaught TAC. The uncertainty of fishing under a hard cap in a partially observed sector could lead to industry-requests to increase observer coverage and, potentially, decrease the volatility of PSC estimates that could close the fishery in short order. In the past, individual participants that have lobbied, at times, for higher observer coverage rates in unrationalized fisheries were vessels whose PSC accrued to limits that they had to maintain as part of their cooperative bycatch allocations in other rationalized fisheries in which they participate (e.g., halibut PSC for TLAS Pacific cod CVs that are also members of AFA pollock cooperatives). Higher rates of observer coverage on the pot sector could ameliorate some of the challenges of implementing a hard cap, but the Observer Program has limited resources to expend across all fisheries and a wide array of management and scientific data collection goals to achieve.

Table 6-12 Recent directed fishing season lengths in the BSAI Pacific cod pot fishery by sector

	HAL/Pot CV U60	Pot CP	Pot CV O60
2016			
A Season	36 days	30 days	140 days
B Season	122 days	93 days	122 days
2017			
A Season	33 days	26 days	26 days
B Season	122 days	122 days	122 days
2018			
A Season	24 days	21 days	20 days
B Season	106 days	21 days	61 days
2019			
A Season	13 days	16 days	16 days
B Season	122 days	16 days	22 days
2020			
A Season	20 days	13 days	16 days
B Season	13 days	13 days	17 days
2021			
A Season	27 days	17 days	22 days
B Season	122 days**	122 days	122 days**
2022			
A Season	27 days	140 days	24 days

** Bering Sea closed to directed fishing on September 17 (18 days); AI remained open.

Table 6-13 and Table 6-14 report monthly RKC PSC totals for the U60 and O60 sector groupings as they have been defined for the purpose of this section. The years during which an average use-based cap would have constrained the fishery are highlighted and the months marking when the limit was reached are shown in red. Table 6-15 and Table 6-16 are formatted in the same way. They show ex-vessel and gross first wholesale values of catch in the BSAI Pacific cod target fisheries.

Table 6-13 Red king crab PSC in the BSAI from 2011-2021 for the U60 fixed gear sector by month (pot gear catch only)

U60 POT	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	TOTAL	AVERAGE
MONTH													
1	22	102	947	4,373	43	365	4,639	0	222	1,624	3,123	15,460	**1,405**
2	59	173	860	3,661	5,806	186	5,523	0	2,440	4,597	5,789	29,094	**2,645**
3	118	166	1,923	4,263	4,557	0	5,548	24,811	1,086	2,137	24,219	68,829	**6,257**
4	c	189	6,054	5,146	c	0	2,238	c	c	c	3,132	16,770	**1,677**
5	539	48		1,821			c					2,930	**732**
6	c	c					c			c	c	104	**21**
7		c								c	0	13	**4**
8									c	c	c	0	**0**
9	196	368	4,660	11,188	5,010	0	0	31,473	3,913	2,763	49,467	109,037	**9,912**
10	547	337	6,229	9,551	8,949	0	0	8,246	2,227			36,087	**4,010**
11		42	4,445	3,248	13,212	0	0	3,668	64			24,680	**3,085**
12		49	1,459	775	24,008	0	0	1,997	159			28,446	**3,556**
TOTAL	1,511	1,556	26,579	44,025	61,585	550	18,487	70,196	10,113	11,120	85,731	331,452	**30,132**

Note: Shaded boxes indicated the years that would have been affected by the hypothetical PSC limit of 30,132 RKC. Red text indicates the month in which the PSC limit would have been reached. 'c' denotes confidential data.
Source: NMFS Alaska Region Catch Accounting System, data compiled by AKFIN in Comprehensive_BLEND_CA and Comprehensive_PSC.

Table 6-14 Red king crab PSC in the BSAI from 2011-2022 for the O60 pot gear fisheries by month (CV and CP)

O60	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	TOTAL	AVERAGE
MONTH													
1	171	402	3,643	3,183	538	182	8,584	341	924	2,285	4,342	24,595	**2,236**
2		c	c	c	23	160	c	c	c	164	1,065	2,828	**283**
3		c		c	276	0	c	2,429	21	275	2,999	6,000	**667**
4	c	c		c	111	0	c	c			c	1,407	**176**
5	c	c		c	c							1	**0**
6												0	**0**
7												0	**0**
8					c	c				c		4,747	**1,582**
9	5,022	3,510	32,438	74,378	27,218	11,104	3,569	199,411	35,546	9,103	201,191	602,492	**54,772**
10	10,994	1,775	20,984	12,054	35,683	5,589	313	52,913		c	c	140,305	**14,030**
11	c	c	11,621	1,665	46,147	0	76		c		c	60,525	**6,725**
12	c	43	5,436	50	c	281	141	c	305	c	c	11,131	**1,012**
TOTAL	16,945	5,944	74,448	92,420	115,020	21,848	12,682	255,095	36,854	11,894	210,881	854,032	**77,639**

Note: Shaded boxes indicated the years that would have been affected by the hypothetical PSC limit of 77,639 RKC. Red text indicates the month in which the PSC limit would have been reached

Source: NMFS Alaska Region Catch Accounting System, data compiled by AKFIN in Comprehensive_BLEND_CA and Comprehensive_PSC.

Table 6-15 U60 ex-vessel and wholesale revenue in US dollars ($) for 2011-2021 by month

U60 Revenue Table	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Total
U60 Ex- Vessel Revenue ($)												
1	1,128,774	2,738,354	3,562,821	3,878,189	4,180,134	3,781,387	4,723,077	6,562,266	8,090,028	4,161,795	2,532,370	**45,339,197**
2	2,492,194	3,800,757	2,153,522	3,118,861	2,865,472	4,045,694	4,346,867	13,188,575	12,399,956	8,902,417	6,004,337	**63,318,651**
3	1,648,203	1,867,348	1,796,976	3,515,092	3,176,916	6,136,654	6,954,471	2,988,057	3,610,306	6,991,836	7,167,011	**45,852,871**
4	c	1,454,760	1,029,406	3,666,979	407,228	3,100,383	2,597,420	c	c	c	947,372	**14,064,987**
5	1,268,336	284,837	0	c	0	0	c	0	0	0	0	**2,520,003**
6	c	c	0	0	0	0	c	0	0	c	c	**279,741**
7	0	c	0	0	0	0	0	0	0	c	40,631	**115,625**
8	0	0	0	0	0	0	71,383	55,587	c	c	c	**157,213**
9	173,876	639,008	263,825	624,231	793,564	891,539	429,461	624,592	1,555,517	1,291,436	653,850	**7,940,900**
10	350,778	603,343	791,286	585,924	536,001	644,663	256,979	638,404	1,325,895	0	0	**5,733,273**
11	0	34,606	463,148	647,382	412,269	436,738	540,299	622,746	1,685,489	0	0	**4,842,678**
12	0	246,779	210,691	1,161,092	996,490	975,800	1,842,380	952,409	809,754	0	0	**7,195,394**
Total Ex-vessel Revenue ($)	**7,469,580**	**11,958,200**	**10,271,675**	**17,537,332**	**13,368,075**	**20,012,858**	**22,398,779**	**25,678,643**	**29,754,904**	**21,551,265**	**17,359,219**	**197,360,532**
U60 Wholesale Revenue ($)												
1	2,609,834	5,730,544	7,997,686	9,167,749	9,609,733	9,450,433	11,738,124	16,732,899	14,597,749	7,753,060	5,295,323	**100,683,135**
2	5,834,043	7,973,344	4,977,451	7,197,723	6,576,493	10,053,138	10,886,749	33,675,911	22,407,607	15,880,131	12,475,536	**137,938,125**
3	3,759,124	4,140,478	4,322,969	7,735,357	7,313,103	15,303,801	17,421,731	7,761,504	6,879,262	12,641,892	14,919,901	**102,199,121**
4	c	3,259,371	2,548,127	8,265,722	928,332	7,729,106	6,455,859	114,223	457,142	c	1,970,300	**32,912,841**
5	2,892,588	669,510	0	c	0	0	c	0	0	0	0	**5,921,061**
6	c	c	0	0	0	0	c	0	0	c	c	**619,786**
7	0	c	0	0	0	0	0	0	0	c	81,638	**237,507**
8	0	0	0	0	0	0	174,514	139,058	30,511	c	c	**367,894**
9	399,140	1,344,565	608,846	1,484,765	1,808,706	2,229,033	1,049,430	1,557,425	2,827,943	2,386,959	1,314,409	**17,011,222**
10	801,737	1,271,088	1,781,997	1,390,663	1,223,051	1,602,465	634,947	1,649,300	2,392,841	0	0	**12,748,089**
11	0	71,839	1,063,099	1,557,376	962,070	1,066,913	1,217,125	1,582,159	2,906,588	0	0	**10,427,168**
12	0	507,766	472,939	2,793,433	2,317,212	2,384,922	4,280,810	2,390,103	1,400,536	0	0	**16,547,721**
Total Wholesale Revenue ($)	**17,218,241**	**25,647,248**	**23,773,114**	**40,394,767**	**30,738,701**	**49,819,811**	**55,439,135**	**65,602,581**	**53,900,178**	**38,995,364**	**36,084,529**	**437,613,670**

Source: NMFS Alaska Region Catch Accounting System, data compiled by AKFIN in Comprehensive_BLEND_CA and Comprehensive_PSC

Note: Shaded boxes indicated the years that would have been affected by the hypothetical PSC limit of 30,132 RKC. Red text indicates the month in which the PSC limit would have been reached.

Table 6-16 O60 pot gear fishery ex-vessel and wholesale revenue in US dollars ($) for 2011-2021 by month

O60 Revenue Table	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Total
O60 Ex-Vessel Revenue ($)												
1	9,315,402	9,798,615	7,915,997	7,640,195	4,499,760	2,986,061	8,152,271	8,628,326	7,593,924	5,710,269	4,445,348	**76,686,169**
2	0	c	c	c	2,524,269	2,246,809	c	c	c	531,434	1,213,423	**8,285,474**
3	0	c	0	c	1,897,683	2,022,498	c	543,163	409,656	865,008	1,042,283	**7,376,193**
4	c	c	0	c	124,509	1,223,750	c	c	0	0	c	**2,167,404**
5	c	c	0	c	67,989	0	0	0	0	0	0	**167,887**
6	0	0	0	0	0	0	0	0	0	0	0	**0**
7	0	0	0	0	0	0	0	0	0	0	0	**0**
8	0	43,558	0	0	c	c	0	0	0	c	0	**650,240**
9	5,157,606	2,753,038	1,002,753	1,424,052	1,983,916	1,606,604	1,615,805	5,396,872	7,767,594	6,144,004	2,641,936	**37,494,180**
10	1,497,488	672,314	1,242,571	790,583	1,663,402	922,616	1,472,138	2,920,504	0	c	c	**11,403,850**
11	c	c	731,919	374,061	723,654	519,288	1,075,637	0	c	0	c	**3,735,599**
12	c	218,755	747,721	109,647	c	933,901	1,395,099	c	384,475	c	c	**4,295,302**
Total Ex-Vessel Revenue ($)	**16,061,635**	**14,131,724**	**11,813,416**	**11,187,143**	**14,022,973**	**12,656,861**	**14,308,841**	**18,023,517**	**16,533,158**	**13,513,174**	**10,009,857**	**152,262,297**
O60 Wholesale Revenue ($)												
1	22,674,893	22,066,628	18,609,283	19,220,444	10029,518	7,553,312	20,836,690	22,122,933	14,338,620	10,536,102	9,374,251	**177,362,673**
2	0	c	c	c	5,719,373	5,707,697	c	c	c	1,192,986	2,607,752	**21,120,126**
3	0	c	0	c	4,156,113	5,087,623	c	1,471,423	990,037	1,893,245	2,227,265	**17,863,672**
4	c	c	0	c	263,794	3,044,953	c	c	0	0	c	**5,744,435**
5	c	c	0	c	139,795	0	0	0	0	0	0	**527,399**
6	0	0	0	0	0	0	0	0	0	0	0	**0**
7	0	0	0	0	0	0	0	0	0	0	0	**0**
8	0	95,133	0	0	c	c	0	0	0	c	0	**1,463,756**
9	12,701,999	6,759,221	2,855,832	4,546,555	4,162,868	4,104,189	4,269,838	14,408,620	14,874,541	11,600,503	5274,137	**85,558,302**
10	4,230,739	2,193,670	3,499,207	2,677,177	3,481,704	2,347,673	3,933,702	7,440,870	0	c	c	**30,307,082**
11	c	c	2,183,802	1,252,380	1,516,788	1,289,634	2,835,670	0	c	0	c	**10,160,533**
12	c	454,669	1,733,278	279,973	c	2,352,469	3,477,486	c	951,212	c	c	**10,332,143**
Total Wholesale Revenue ($)	**40,026,665**	**34,100,360**	**29,493,396**	**31,276,784**	**30,599,641**	**31,997,837**	**37,063,960**	**46,975,038**	**32,223,334**	**25,721,901**	**20,961,203**	**360,440,119**

Source: NMFS Alaska Region Catch Accounting System, data compiled by AKFIN in Comprehensive_BLEND_CA and Comprehensive_PSC

Note: Shaded boxes indicated the years that would have been affected by the hypothetical PSC limit of 77,639 RKC. Red text indicates the month in which the PSC limit would have been reached.

7 Contributors and Persons Consulted

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Appendix 1: Crab bycatch estimation methods in groundfish fisheries

This section provides an overview of the data collection and estimation methods that NMFS uses to assess the amount and type of crab bycatch in Federal groundfish and halibut fisheries off Alaska.

The NMFS Alaska Catch Accounting System (CAS) quantifies total catch to allow the inseason monitoring and management of the groundfish fisheries. Total catch means both the catch that is retained and the catch that is discarded at sea, as well as estimates of prohibited species catch (PSC) and other non-groundfish bycatch. To generate the total catch estimates, CAS relies on observer data and information from Electronic Monitoring (EM) systems.

A1.1 Observer Program

The North Pacific Observer Program (Observer Program) provides the regulatory framework to deploy observers and EM systems to collect data necessary for the conservation, management, and scientific understanding of the commercial groundfish and Pacific halibut fisheries of the BSAI and GOA management areas. Data collection through the Observer Program provides a reliable and verifiable method for NMFS to gain fishery discard and biological information on fish, and data concerning seabird and marine mammal interactions with fisheries. Observers and EM systems provide fishery-dependent information that is used to estimate total catch and interactions with protected species. Managers use these data to manage groundfish and prohibited species catch within established limits and to document and reduce fishery interactions with protected species. Scientists also use fishery-dependent data to assess fish stocks, evaluate marine mammal interactions with fishing gear, characterize fishing impacts on habitat, and provide data for fisheries and ecosystem research and fishing fleet behavior.

All vessels and processors that participate in federally managed groundfish and Pacific halibut fisheries off Alaska are assigned to one of two categories: (1) the full observer coverage category; or (2) the partial observer coverage category.

Vessels and processors in the full coverage category have at least one observer present during all fishing or processing activity. The full coverage category includes the following:

- Catcher/processors (with limited exceptions)
- Motherships[28]
- Catcher vessels participating in programs that have transferable prohibited species catch (PSC) allocations as part of a catch share program. These programs include Bering Sea pollock (both American Fisheries Act and Community Development Quota (CDQ) programs), the groundfish CDQ fisheries (CDQ fisheries other than Pacific halibut and fixed gear sablefish; only vessels greater than 46 ft LOA), and the Central GOA Rockfish Program.
- Catcher vessels using trawl gear that have requested placement in the full coverage category for all fishing activity in the BSAI for one year; and
- Inshore processors receiving or processing Bering Sea pollock.

All vessels and processors that are not in full coverage are in the partial coverage category and are assigned observer coverage according to the scientific sampling plan described in the Annual Deployment Plan (ADP). The ADP outlines the science-driven method for deployment of observers and EM systems using established random sampling methods to collect data on a statistically reliable sample of fishing

[28] Catcher vessels delivering unsorted codends to a mothership are not required to carry observers since the catch is monitored on the mothership.

vessels in the partial coverage category. Each year, the ADP describes the deployment strata and how vessels are assigned to specific partial coverage selection pools. Since 2020, the strata in the ADP have been:

- Observer trip-selection pools. There are three sampling strata for deployment of observers:
    - Hook-and-line vessels greater than or equal to 40 ft LOA,
    - Pot vessels greater than or equal to 40 ft LOA, and
    - Trawl vessels making a trip not covered by the EM EFP.
- EM fixed-gear, trip-selection pool: fixed-gear vessels that request to be in the EM pool that are approved by NMFS. EM is used for catch accounting of catch and bycatch.
    - Trawl EM trip-selection pool: vessels fishing under an Exempted Fishing Permit (EFP) to evaluate the efficacy of EM on pollock catcher vessels using pelagic trawl gear. The goal for EM is compliance monitoring of maximized retention. Catch accounting for the vessel's catch and bycatch is done via eLandings reports and shoreside plant observers.
- No-selection pool: fixed-gear vessels less than 40 ft LOA and vessels fishing with jig gear. These vessels have no probability of being selected for monitoring.

A1.1.1 Coverage Rates

Each year, the ADP also defines the coverage rate—the portion of trips that are sampled in each of the partial coverage strata. The trip selection rate for vessels in the EM selection pool is based on recommendations from the Council and the selection rate is 30% of trips. The sampling rate for observers is dependent on available revenue generated from fees on groundfish and halibut landings and can change from one calendar year to the next to achieve efficiency, cost savings, and data collection goals. The ADP process allows NMFS to adjust deployment in each year so that sampling can be achieved within financial constraints.

Starting in 2018, NMFS has implemented the observer allocation strategy of 15% threshold plus optimization, where observer sea days are first allocated equally up to a threshold coverage rate and the remaining sea-days are allocated using an optimal allocation algorithm that maximizes precision for chosen metrics for the least cost (NMFS 2021). The optimization is based on discarded groundfish, Pacific halibut PSC, and Chinook PSC. The method balances the need to minimize data gaps and collect information across all gear types and areas and the goal to prioritize PSC-limited fisheries. The optimization approach results in higher observer coverage rates for vessels fishing with trawl gear and the lowest rates for vessels fishing with pot gear. In 2022, for example the ADP allocated each dollar that was available for spending above the baseline of 15% in the following way: 62 cents to trawl, 33 cents to hook-and-line, 5 cents to pot. Raw data on the number of trips observed by sector and historical observer or EM coverage rates from 2013 through 2021 are provided in Table 2-13 and Table 2-14 in Section 2 of this paper.

A1.1.2 Timeliness of Data

Observers enter the data they have collected onboard vessels and processors using the NMFS-supplied data entry software, ATLAS. The ATLAS software is also used by observers to electronically transmit their data to NMFS; however, the timing of data transmission varies.

Observers deployed on vessels in the partial coverage category are equipped by their observer provider company with a laptop that has ATLAS installed. Observers transmit data to NMFS from these computers at the completion of a trip by utilizing electronic communications available while at port. Vessels in the partial coverage category generally do not provide a computer for observers to enter or transmit observer data electronically while they are at sea. Therefore, PSC data from the partial coverage fleet is not available until after the end of the trip and after an observer has been able to obtain communication capabilities such as a cell phone service, wi-fi at the processing plant, or wi-fi at a hotel or other housing.

Observers deployed on vessels in the full coverage category have access to a computer provided by the vessel and some vessels in full coverage are also required to provide data transmission capabilities so that observers can transmit their data throughout a trip. Trawl CVs in the full coverage category that are greater than or equal to 125 ft LOA are required to provide both a computer with ATLAS and effective at-sea data transmission capabilities. The operator of a CV participating in the Rockfish Program or CV less than 125 ft LOA directed fishing for pollock in the BS must provide a computer with ATLAS but are not required to provide at-sea transmission capability. However, many owners of CV's less than 125 LOA either provide at-sea transmission because of their participation in other fisheries or choose to provide at-sea transmission to limit time spent at the processor or to enable their own communication while at sea. Data that are electronically submitted during a trip are available to the fishing industry and fishery managers within two hours after an observer transmits data to NMFS. In addition, built-in quality assurance measures prevent inaccurate data from entering NMFS databases, which reduces the time spent correcting errors during the debriefing process.

A1.2 Crab PSC Estimation Methods

NMFS estimates PSC in the groundfish fisheries using at-sea data from observers and EM. NMFS manages the harvest of crab PSC by number, not weight, therefore CAS produces estimates of crab PSC in numbers only. Observer data are used to create crab bycatch rates (a ratio of the estimated number of crab to the estimated total catch in sampled hauls). The observed information from the at-sea samples is used to create bycatch rates that are applied to unobserved vessels. For trips that are unobserved, the bycatch rates are applied to industry supplied landings of retained catch. Expanding on the observer data that are available, the extrapolation from observed vessels to unobserved vessels is based on varying levels of aggregated data (post-stratification). Within each sampling strata defined in the ADP, data are matched based on processing sector (e.g., catcher/processor or catcher vessel), week, target fishery, gear, and Federal reporting area.

In some situations, CAS is unable to match an unobserved trip with sampled hauls (either from observers or EM) within the strata. In that scenario, an estimate is generated using data within the FMP area (BSAI or GOA) from trips with the same gear, trip target code. For example, in the fall of 2020, there was reduced observer coverage in the pot trip selection pool due to COVID. During that time, PSC estimates were generated for the pot trip selection pool using information NMFS received from EM vessels fishing with pot gear.

All the estimated crab PSC caught in any gear type is considered dead. In other words, CAS does not apply mortality rates to crab PSC. Further detail on the estimation procedure is available in Cahalan et al. (2014).

A1.2.1 Broken Crab

Unlike other species encountered in the North Pacific, NMFS regulates the harvest of crab PSC by number and not weight. For this reason, it is important the NMFS obtains a number of crab, along with a weight for every prohibited species crab encountered in samples. On trawl vessels, however, it is common for crab species to break apart, making it difficult to count crab. The Observer Program trains observers (AFSC 2022) to collect counts of PSC crab species by:

- Counting, weighing and identifying all whole crab in their samples to species;
- Counting, weighing and identifying all crab carapaces in their samples to species;

- Weighing and identifying as many prohibited species crab legs in their samples to genus (group code) as possible;
- Identifying other crab parts in their samples to the crab unidentified species group.

Once those data have been collected, NMFS uses the weight of the broken crab (by species) and converts it to an estimated number of crab by applying the mean weight per crab for whole crab to the weight of broken crab. For example, if there was 1 kg of broken parts and pieces of Tanner crab in a sample. And the average weight of a whole Tanner crab that was also collected in that sample is 1 kg. Then NMFS would count the 1 kg of crab parts as 1 Tanner crab.

A1.2.2 Unidentified crab

Observers are trained to identify crab to species, especially prohibited species. However, in some cases, crab cannot be identified to species and can only be identified to genus group codes (e.g., "king crab unidentified" and "Tanner crab unidentified"). Example scenarios when this occurs are when crabs are damaged in a trawl tow, or when a crab drops off a longline and the observer was not able to examine the crab closely. In other cases, there may be so many crab that the observer cannot identify them all to species but can count the total number and identify the crab to genus. The unidentified king and tanner crab recorded by observers are speciated and extrapolated to the haul by using information on other crabs that observers were able to identify to species in that haul. NMFS uses the proportion of crab that were identified to species and applies that to the unidentified crab. If there are no crab within the haul that the observer was able to identify to species, then the crab remains unidentified. When crab is recorded as unidentified, it does not accrue towards any PSC limit.

Vessels in the fixed-gear EM pool are another situation that result in unidentified crabs. In many cases, reviewers for the fixed gear EM program are unable to positively identify crab to species during review of the video. As a result, they often record crab as "crab unidentified", "king crab unidentified" and "Tanner crab unidentified". These crab are not included in estimates of crab PSC and create a data gap for crab estimates in the EM pool.

A1.3 Crab Estimates for Stock Assessment

Starting in 2017, NMFS has estimated crab bycatch from the groundfish fisheries by crab stock. These estimates are specific for crab stock assessments and crab bycatch is estimated in both weight (metric tons) and count (number of animals). Estimates are only created within crab stock assessment areas, for the species of crab that applies to the area. For example, if a fishing event occurred within the "Bristol Bay Red King Crab Stock Assessment" area, estimates will be created using only sampled hauls for this data and only for Red King Crab. If other crab discards (i.e., tanner) are present in the hauls they are ignored.

Similar to the PSC estimation method, the crab stock assessment estimates are generated using observer data. The observed information from the at-sea samples is used to create bycatch rates that are applied to unobserved vessels. For trips that are unobserved, the bycatch rates are applied to industry supplied landings of retained catch. However, the extrapolation from observed vessels to unobserved vessels and the post-stratification factors vary between the PSC estimation methods and the crab stock assessment methods. As a result, estimates from the two methods are different. This difference is most apparent in hook-and-line and pot fisheries because there is less observer coverage and more extrapolation occurring causing greater variability. The prevalence of full coverage in trawl in BSAI means that there is a lot more observer data and less extrapolation and more similarity in the estimates.

References for Appendix 1

Cahalan, J., J. Gasper, and J. Mondragon. 2014. Catch sampling and estimation in the federal groundfish fisheries off Alaska, 2015 edition. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-286, 46 p. Available at: https://repository.library.noaa.gov/view/noaa/4833.

NMFS (National Marine Fisheries Service). 2021. 2022 Annual Deployment Plan for Observers and Electronic Monitoring in the Groundfish and Halibut Fisheries off Alaska. National Oceanic and Atmospheric Administration, 709 West 9th Street. Juneau, Alaska 99802. Available at: https://media.fisheries.noaa.gov/2021-12/2022-annual-deployment-plan-akro.pdf.

AFSC (Alaska Fisheries Science Center). 2022 Observer Sampling Manual. Fisheries Monitoring and Analysis Division, North Pacific Groundfish Observer Program. AFSC, 7600 Sand Point Way N.E., Seattle, Washington, 98115. Available at: https://www.fisheries.noaa.gov/resource/document/north-pacific-observer-sampling-manual.

Appendix 2: Expanded tables of BBRKC PSC, female PSC, kilograms of PSC, kilograms of PSC mortality, and kilograms of female PSC mortality

The following tables provide the all of the RKC PSC estimates (all; female) and PSC mortality estimates (all; female) that were presented in Section 2.1, but organized primarily by area. The citation for each of the tables is: NMFS Alaska Region Catch Accounting System, data compiled by AKFIN in Comprehensive_PSC. All data for 2022 are year-to-date through August 21. Period averages exclude the 2022 partial year.

Table A2-1 BBRKC prohibited species catch estimates for the BERING SEA FMP AREA by gear sector; 2013 through 2022 (YTD 8/21)

Gear		2013	2014	2015	2016	2017	2018	2019	2020	2021	2022*	Average 2013-2021
Hook and Line	PSC	12,737	16,721	7,177	9,732	8,184	19,518	95	61	226	474	8,272
	Female PSC	6,042	7,154	3,546	4,527	5,471	8,270	26	31	52	0	3,902
	Kilograms of PSC	28,291	33,602	16,513	19,721	14,613	29,927	108	76	0	21	15,872
	Kilograms of PSC Mortality	14,146	16,801	8,257	9,860	7,306	14,963	54	38	0	11	7,936
	Kilograms of Female Mortality	6,618	7,231	4,232	4,726	4,913	6,077	11	14	0	0	3,758
Non-Pelagic Trawl	PSC	31,497	32,221	19,903	41,004	59,527	30,109	69,597	64,390	40,500	6,871	43,194
	Female PSC	12,093	14,408	7,893	19,068	12,440	12,814	25,688	18,938	11,661	4,274	15,000
	Kilograms of PSC	58,268	64,450	39,037	72,557	148,241	71,875	139,852	125,873	84,469	13,572	89,402
	Kilograms of PSC Mortality	46,614	51,560	31,230	58,045	118,593	57,500	111,881	100,699	67,575	10,857	71,522
	Kilograms of Female Mortality	18,691	22,981	12,564	25,701	22,410	24,287	40,473	28,908	18,833	6,834	23,872
Pot	PSC	93,138	136,667	177,722	22,427	30,053	291,184	46,102	20,793	281,903	12,937	122,221
	Female PSC	48,470	99,086	154,825	16,249	27,431	209,108	37,614	17,563	254,980	10,165	96,147
	Kilograms of PSC	65,981	105,932	134,812	23,601	28,117	287,176	57,810	19,529	193,911	10,626	101,874
	Kilograms of PSC Mortality	32,990	52,966	67,406	11,800	14,059	143,588	28,905	9,764	96,956	5,313	50,937
	Kilograms of Female Mortality	17,359	40,624	58,370	8,485	12,910	103,326	23,982	8,146	87,712	4,174	40,102
Pelagic Trawl	PSC	0	7	0	6	23	14	25	10	27	13	12
	Female PSC	0	7	0	0	22	0	0	7	27	0	7
	Kilograms of PSC	0	6	0	5	27	23	31	19	29	8	15
	Kilograms of PSC Mortality	0	5	0	4	21	18	25	15	23	6	12
	Kilograms of Female Mortality	0	5	0	0	21	0	0	10	23	0	7
Total	PSC	137,372	185,616	204,802	73,168	97,787	340,825	115,819	85,254	322,656	20,295	173,700
	Female PSC	66,605	120,656	166,264	39,844	45,365	230,192	63,328	36,539	266,720	14,439	115,057
	Kilograms of PSC	152,540	203,990	190,363	115,883	190,998	389,001	197,801	145,497	278,409	24,227	207,165
	Kilograms of PSC Mortality	93,750	121,332	106,892	79,710	139,979	216,070	140,866	110,516	164,554	16,187	130,408
	Kilograms of Female Mortality	42,668	70,841	75,166	38,912	40,254	133,690	64,466	37,079	106,569	11,009	67,738

Table A2-2 BBRKC prohibited species catch estimates for ADFG REGISTRATION AREA T by gear sector; 2013 through 2022 (YTD 8/21)

Gear		2013	2014	2015	2016	2017	2018	2019	2020	2021	2022*	Average 2013-2021
Hook and Line	PSC	12,509	15,870	6,470	8,833	7,755	19,209	19	8	0	6	7,853
	Female PSC	5,913	6,836	3,336	4,298	5,286	8,088	4	3	0	0	3,752
	Kilograms of PSC	28,282	33,165	15,913	19,158	14,261	29,757	36	32	0	21	15,623
	Kilograms of PSC Mortality	14,141	16,583	7,957	9,579	7,131	14,878	18	16	0	11	7,811
	Kilograms of Female Mortality	6,618	7,157	4,110	4,637	4,859	6,024	3	6	0	0	3,713
Non-Pelagic Trawl	PSC	26,756	31,496	18,321	38,185	56,671	21,942	58,891	59,497	34,840	6,684	38,511
	Female PSC	10,793	14,039	7,419	17,496	11,468	9,323	21,516	17,117	9,720	4,200	13,210
	Kilograms of PSC	57,841	63,714	36,555	69,089	142,760	51,392	118,768	118,280	74,195	13,208	81,399
	Kilograms of PSC Mortality	46,272	50,971	29,244	55,271	114,208	41,113	95,014	94,624	59,356	10,567	65,119
	Kilograms of Female Mortality	18,577	22,631	11,952	24,427	20,811	17,223	33,949	26,641	16,155	6,720	21,374
Pot	PSC	71,511	84,132	114,767	22,065	21,002	264,753	43,309	14,795	260,459	8,347	99,644
	Female PSC	37,258	64,458	99,390	15,919	19,209	190,385	35,514	12,216	235,628	6,559	78,886
	Kilograms of PSC	65,981	105,932	134,812	23,601	28,090	287,175	57,810	19,502	193,911	10,626	101,868
	Kilograms of PSC Mortality	32,990	52,966	67,406	11,800	14,045	143,588	28,905	9,751	96,956	5,313	50,934
	Kilograms of Female Mortality	17,359	40,624	58,370	8,485	12,896	103,326	23,982	8,133	87,712	4,174	40,099
Pelagic Trawl	PSC	0	7	0	6	23	14	25	10	27	13	12
	Female PSC	0	7	0	0	22	0	0	7	27	0	7
	Kilograms of PSC	0	6	0	5	27	23	31	19	29	8	15
	Kilograms of PSC Mortality	0	5	0	4	21	18	25	15	23	6	12
	Kilograms of Female Mortality	0	5	0	0	21	0	0	10	23	0	7
Total	PSC	110,776	131,506	139,558	69,089	85,451	305,918	102,244	74,310	295,326	15,051	146,020
	Female PSC	53,964	85,340	110,145	37,713	35,985	207,796	57,033	29,344	245,375	10,759	95,855
	Kilograms of PSC	152,104	202,817	187,280	111,853	185,138	368,346	176,645	137,833	268,134	23,863	198,906
	Kilograms of PSC Mortality	93,404	120,525	104,607	76,654	135,405	199,598	123,962	104,406	156,334	15,896	123,877
	Kilograms of Female Mortality	42,553	70,417	74,432	37,548	38,587	126,573	57,934	34,790	103,890	10,895	65,191

Table A2-3 BBRKC prohibited species catch estimates for TRAWL PSC LIMIT ZONE 1 by gear sector; 2013 through 2022 (YTD 8/21)

Gear		2013	2014	2015	2016	2017	2018	2019	2020	2021	2022*	Average 2013-2021
Hook and Line	PSC	12,495	15,816	6,306	8,334	7,610	17,754	0	2	0	6	7,591
	Female PSC	5,912	6,797	3,279	4,079	5,209	7,559	0	1	0	0	3,648
	Kilograms of PSC	28,246	33,026	15,490	17,945	13,953	26,370	0	5	0	21	15,004
	Kilograms of PSC Mortality	14,123	16,513	7,745	8,973	6,976	13,185	0	2	0	11	7,502
	Kilograms of Female Mortality	6,617	7,107	4,033	4,370	4,778	5,408	0	1	0	0	3,590
Non-Pelagic Trawl	PSC	25,186	28,213	12,754	23,319	35,032	12,725	25,008	42,745	19,171	3,153	24,906
	Female PSC	10,054	12,366	4,724	13,271	8,195	5,894	10,933	12,565	6,196	1,503	9,355
	Kilograms of PSC	55,656	57,132	26,953	39,615	84,733	27,398	46,776	82,170	39,194	5,896	51,070
	Kilograms of PSC Mortality	44,524	45,705	21,563	31,692	67,786	21,918	37,421	65,736	31,356	4,717	40,856
	Kilograms of Female Mortality	17,796	20,021	8,226	17,772	14,030	10,082	16,063	19,083	10,170	2,252	14,805
Pot	PSC	65,476	80,770	104,440	21,812	18,164	243,456	41,964	14,030	234,539	7,468	91,628
	Female PSC	33,634	62,373	90,323	15,671	16,417	175,709	34,496	11,457	212,236	5,867	72,480
	Kilograms of PSC	60,508	101,596	134,812	23,334	24,423	263,377	56,534	18,499	174,637	10,626	95,302
	Kilograms of PSC Mortality	30,254	50,798	67,406	11,667	12,211	131,689	28,267	9,249	87,319	5,313	47,651
	Kilograms of Female Mortality	15,715	39,280	58,370	8,354	11,092	95,126	23,498	7,635	79,016	4,174	37,565
Pelagic Trawl	PSC	0	7	0	6	23	14	25	9	27	13	12
	Female PSC	0	7	0	0	22	0	0	7	27	0	7
	Kilograms of PSC	0	6	0	5	27	23	31	19	29	8	15
	Kilograms of PSC Mortality	0	5	0	4	21	18	25	15	23	6	12
	Kilograms of Female Mortality	0	5	0	0	21	0	0	10	23	0	7
Total	PSC	103,157	124,806	123,500	53,471	60,828	273,949	66,997	56,786	253,737	10,640	124,137
	Female PSC	49,600	81,544	98,326	33,020	29,843	189,162	45,429	24,029	218,460	7,370	85,490
	Kilograms of PSC	144,410	191,760	177,255	80,900	123,134	317,168	103,342	100,692	213,860	16,551	161,391
	Kilograms of PSC Mortality	88,901	113,021	96,714	52,336	86,995	166,810	65,713	75,003	118,697	10,046	96,021
	Kilograms of Female Mortality	40,128	66,413	70,629	30,497	29,920	110,616	39,561	26,730	89,208	6,426	55,967

Table A2-4 BBRKC prohibited species catch estimates for RED KING CRAB SAVINGS AREA & SAVINGS SUBAREA by gear sector; 2013 through 2022 (YTD 8/21)

Gear		2013	2014	2015	2016	2017	2018	2019	2020	2021	2022*	Average 2013-2021
Hook and Line	PSC	5,452	4,173	1,006	3,896	5,527	9,180	0	2	0	5	3,248
	Female PSC	3,083	1,779	502	1,371	3,506	3,626	0	1	0	0	1,541
	Kilograms of PSC	12,011	8,625	2,429	8,443	9,876	15,244	0	5	0	17	6,293
	Kilograms of PSC Mortality	6,006	4,312	1,214	4,222	4,938	7,622	0	2	0	9	3,146
	Kilograms of Female Mortality	3,377	1,837	608	1,483	3,111	2,889	0	1	0	0	1,479
Non-Pelagic Trawl	PSC	6,821	12,979	3,704	8,163	2,285	796	1,890	2,187	533	0	4,373
	Female PSC	3,547	5,813	2,110	5,684	1,626	520	1,223	1,195	141	0	2,429
	Kilograms of PSC	15,223	26,361	7,550	12,864	4,061	1,558	3,224	3,656	944	0	8,382
	Kilograms of PSC Mortality	12,179	21,089	6,040	10,291	3,249	1,246	2,579	2,925	755	0	6,706
	Kilograms of Female Mortality	6,353	9,428	3,568	7,151	2,210	814	1,658	1,634	201	0	3,668
Pot	PSC	6,280	17,619	61,213	14,514	384	12,516	953	249	97	0	11,382
	Female PSC	4,826	10,841	51,456	9,568	54	9,343	522	248	91	0	8,695
	Kilograms of PSC	6,082	22,910	78,484	16,444	381	14,115	917	358	72	0	13,976
	Kilograms of PSC Mortality	3,041	11,455	39,242	8,222	191	7,058	459	179	36	0	6,988
	Kilograms of Female Mortality	2,383	7,024	33,004	5,420	27	5,268	251	178	34	0	5,359
Pelagic Trawl	PSC	0	7	0	2	20	5	23	3	18	7	9
	Female PSC	0	7	0	0	20	0	0	3	18	0	5
	Kilograms of PSC	0	6	0	2	23	3	28	7	19	4	10
	Kilograms of PSC Mortality	0	5	0	1	19	2	23	5	15	3	8
	Kilograms of Female Mortality	0	5	0	0	19	0	0	5	15	0	5
Total	PSC	18,553	34,777	65,923	26,574	8,216	22,497	2,866	2,440	647	12	20,277
	Female PSC	11,456	18,439	54,068	16,623	5,206	13,489	1,745	1,446	250	0	13,636
	Kilograms of PSC	33,317	57,902	88,463	37,753	14,342	30,921	4,170	4,025	1,036	21	30,214
	Kilograms of PSC Mortality	21,225	36,861	46,496	22,736	8,396	15,929	3,061	3,111	807	12	17,625
	Kilograms of Female Mortality	12,112	18,295	37,180	14,054	5,367	8,971	1,909	1,819	250	0	11,106

Appendix 3: Non-Pelagic Trawl sector activity in proximity to the RKCSA and RKCSS, 2008-2020

Figure A3-1 shows a sample of non-pelagic trawl activity by the Amendment 80 (BSAI non-pollock trawl CP) sector near the RKCSA and in the RKCSS from 2008 through 2020. This figure was developed by Pacific States Marine Fisheries Commission (PSMFC) to support a 2021 NPFMC analysis of Bering Sea Crab PSC limits (NPFMC 2021a). PSMFC labeled the non-pelagic trawl sector as "Amendment 80" and labeled the RKCSA as the "Red King Crab Closure Area". The reason for inclusion in this document is to show that the non-pelagic trawl data provided in Sections 1 and 2 of this document that are represented as "RKCSA" are largely reflecting activity in the RKCSS. That area is open to non-pelagic trawl gear when a directed BBRKC fishery was open in the preceding season, which was the case throughout the analyzed period with the exception of 2022.

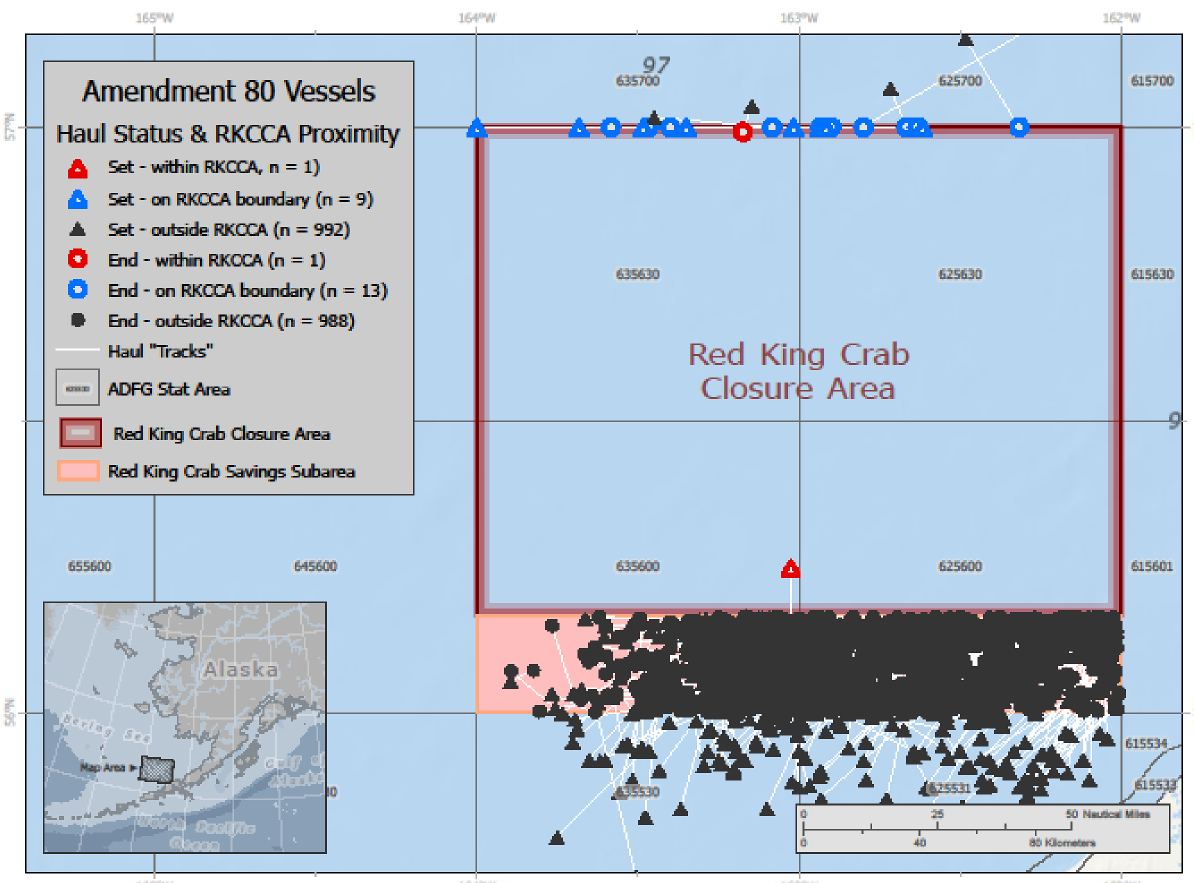

Figure A3-1 **Non-pelagic trawl gear activity in proximity to the RKCSA – 2008-2020 (Source: Observer data sourced through AKFIN, compiled by PSMFC)**

Appendix 4: Examples of crab pot features to sort small crab or exclude larger non-target crab species

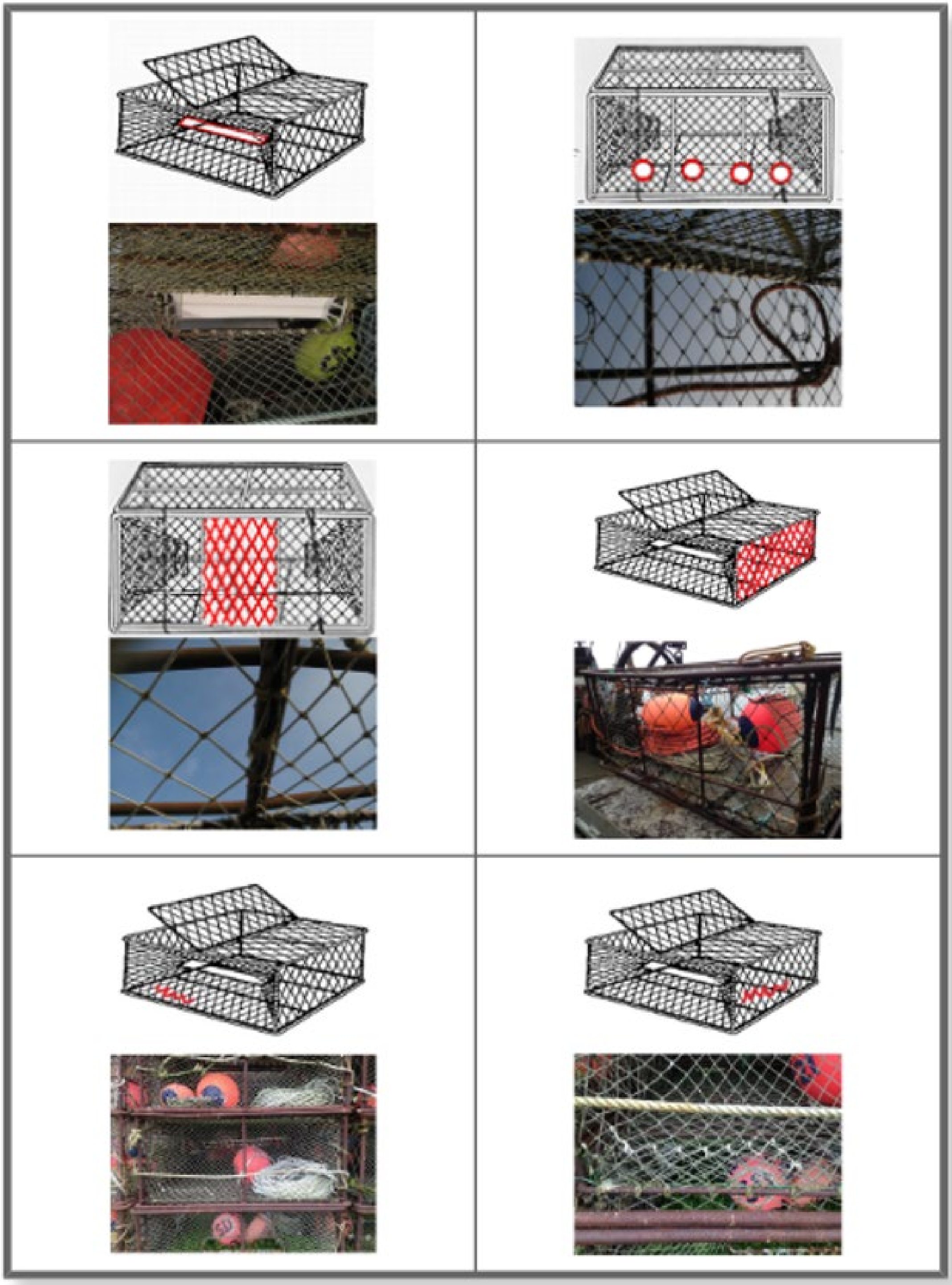

Figure A4-1 Crab pots demonstrating tunnel eye opening, escape rings, escape mesh, and biotwine. Top photos show Tanner boards (left) and escape rings (right). Middle photos show escape mesh. Bottom photos show biotwine examples.