Snow crab bycatch data evaluation
Bering Sea/Aleutian Islands Fisheries

Discussion paper[1]
January 2016

1. Introduction

The Bering Sea/Aleutian Islands (BSAI) Crab Fishery Management Plan (FMP) applies to ten crab stocks in the BSAI: four red king crab, *Paralithodes camtschaticus*, in Bristol Bay, the Pribilof Islands, Norton Sound, and Adak; two blue king crab, *Paralithodes platypus*, in the Pribilof District and around Saint Matthew Island, two golden (or brown) king crab stocks, *Lithodes aequispinus*, in the Aleutian and Pribilof Islands; the Eastern Bering Sea (EBS) Tanner crab, *Chionoecetes bairdi*; and the EBS snow crab, *C. opilio*. All other BSAI crab stocks are exclusively managed by the State of Alaska (State).

The Council has requested iterative discussions papers in 2010, 2013, 2014 to describe crab PSC in groundfish fisheries and existing closure areas and management measures for all ten BSAI crab stocks. The initial exploration of this was in response to changes in Crab Management due to ACL requirements. As described in Section 4, this investigation began in response to concerns between the lack of connectivity (and thus ability for in-season management measures) between the BSAI Groundfish FMP (where crab PSC in groundfish fisheries are managed) and the BSAI Crab FMP which provides for management of crab stocks and directed crab fisheries in conjunction with the State of Alaska.

Information provided in this paper reviews some of the background on crab PSC issues raised iteratively since the 2010. These include follow up from implementation of Crab ACLs, related estimation of bycatch mortality of crab stocks, consideration of PSC limits for all 10 BSAI crab stocks, and the more recent focus upon a subset of those stocks. Finally in order to establish a baseline of information needed to evaluate the efficacy of closure areas and management measures in groundfish fisheries of Crab PSC, this paper provides data and information specific to snow crab data and management of PSC in response to the Council's 2014 motion to that effect. Motions from 2010, 2013 and 2014 related to previous papers are attached as Appendix 1.

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2. Crab stock registration areas

Registration areas are defined by stock and are a Category 2 measure under the Crab FMP. In order to accrue appropriate stock-specific mortality estimates from the groundfish fisheries bycatch for crab stock assessments, spatial estimates of bycatch were needed at the scale of each stock. Previously, groundfish PSC was accounted for by species across the BSAI as a whole except where PSC limits in trawl fisheries necessitated a special area designation for accounting purposes (i.e., COBLZ, Zone 1, Zone 2). PSC estimates are now available by State statistical area thus more precise area-specific estimates (for stocks such as BBRKC , PIBKC, PIRKC and SMBKC) of total PSC are now available for use in estimating bycatch mortality in crab assessments. Figure 1 shows the registration areas for the Bristol Bay District (for BBRKC), the Saint Matthew Island Section (for SMBKC), while snow and Tanner crab areas are Bering Sea-wide.

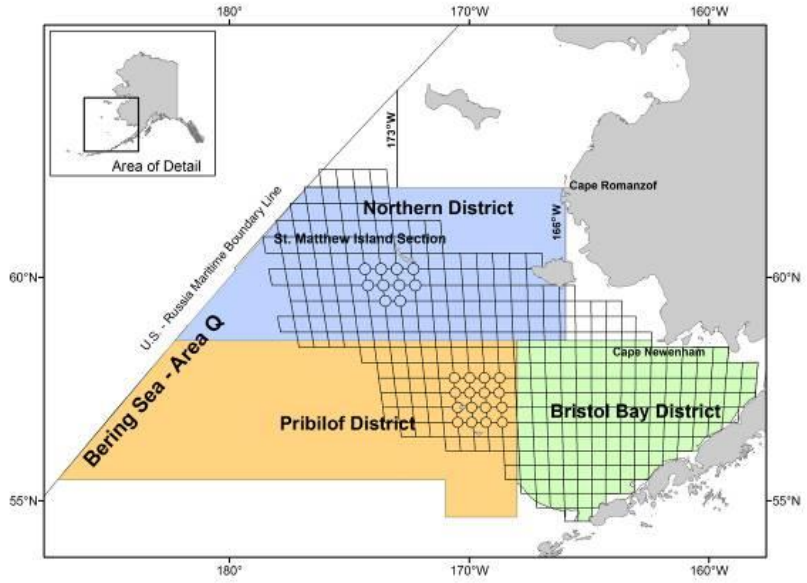

Figure 1 Registration areas for crab stocks under the Crab FMP.

3. Summary of existing PSC management measures

The BSAI groundfish FMP specifies crab bycatch management measures for protection of Bristol Bay red king crab, EBS Tanner crab, EBS snow crab, Pribilof blue king crab and St. Matthew blue king crab stocks (Table 1). These measures consist of triggered or fixed time and area closures for trawl fisheries, and one closure to Pacific cod pot fishing (PIHCZ). Additional details on the individual measures and trends in PSC catch for the 4 requested stocks are included in the stock specific overview sections. No measures are currently in place for any fixed gear fisheries (outside of the Pribilof Islands Pacific cod pot closure), nor are overall limits placed on bycatch of any crab species.

Table 1. Summary of groundfish management measures to address crab bycatch in the trawl fisheries.

Stock	Area	Gear type	Closure Timing	For trigger closures		
				Allocation by sector or target fishery in 2016	How catch accrues	2016 PSC limit in number of crabs
Bristol Bay red king crab	Red King Crab Savings Area	nonpelagic trawl	year-round except subarea	Up to 25% of Zone 1 PSC limit		
	Nearshore Bristol Bay Trawl Closure	nonpelagic trawl	year-round except Togiak subarea open 4/15-6/15			
	Zone 1	all trawl	when limit reached, area closes to target fishery	Amd. 80 sector yellowfin sole Pacific cod pollock/mackerel/ other species	RKC bycatch in Zone 1, by fishery	97,000 allocated among target fisheries
EBS Tanner crab	Zone 1	all trawl	when limit reached, area closes to target fishery	Amd. 80 sector yellowfin sole rockfish Pacific cod pollock/mackerel/ other species	Tanner crab bycatch in Zone 1, by fishery	830,000 allocated among target fisheries
	Zone 2	all trawl	when limit reached, area closes to target fishery	Amd. 80 sector yellowfin sole rockfish Pacific cod pollock/mackerel/ other species	Tanner crab bycatch in Zone 2, by fishery	2,520,000 allocated among target fisheries
Pribilof Islands blue king crab	Pribilof Islands Habitat Conservation Area	all trawl and P. cod with pot gear (as of 1/1/15)	year-round			
EBS snow crab	*C. opilio* Bycatch Limitation Zone (COBLZ)	all trawl	when limit reached, area closes to target fishery	Amd. 80 sector yellowfin sole rockfish Pacific cod pollock/mackerel/ other species	Snow crab bycatch in the COBLZ, by fishery	4,708,314 allocated among target fisheries
	Northern Bering Sea Research Area	nonpelagic trawl	currently year-round; fishing may resume in future under a research plan			
St Matthew blue king crab	St Matthew Island Habitat Conservation Area	nonpelagic trawl	year-round			

4. Annual specification of OFL, ABC and TAC

Following approval of Amendments 24 and 38 to the BSAI Crab FMP, the ten BSAI crab stocks have annually-specified overfishing limits (OFLs) and Acceptable Biological Catch (ABC) levels[2]. Total allowable catch (TAC) levels (and GHLs for the Norton Sound red king crab stock and Pribilof Islands golden king crab stock) are established exclusively by the State. All catch accrues towards the ABC (or ACL[1]). Additional bycatch outside of the directed crab fisheries occurs in the BSAI groundfish fisheries and Bering Sea scallop fishery. Total catch from all sources may not exceed the ACL thus currently the State must assume anticipated levels of bycatch for each stock in order to set TAC or GHL at a level where the total catch from directed and non-directed sources will not exceed the ACL. As noted in the accountability measures for the ACL requirements under Amendment 38, if an ACL is exceeded, the TAC or GHL in the following year will be reduced in order to prevent against exceeding the ACL. Thus all accountability measures come out of the directed crab fishery. In deference to this, in 2010 the Council began the process of developing alternatives (see Appendix 1) and initiated an analysis of PSC limits in the BSAI groundfish fisheries for BSAI crab stocks to potentially limit the overall bycatch by stock and provide the State with a hard limit for each stock to facilitate TAC-setting.

BSAI crab stocks are susceptible to three principal sources of fishery mortality: retained catch and bycatch during the directed fishery, bycatch mortality during other state-managed crab fisheries, and bycatch mortality during federally-managed groundfish fisheries. All those sources of fishery mortality are forecast with uncertainty. However, ADF&G can forecast the mortality during crab fisheries with greater confidence than it can forecast the mortality during federal groundfish fisheries because ADF&G establishes the TACs for the crab fisheries, has access to extensive observer data on crab bycatch during crab fisheries that can be used to estimate bycatch as a function of retained catch, and has the ability to close areas to crab fishing that have potential for high crab bycatch. ADF&G has no control over the bycatch mortality that occurs during the federal groundfish fisheries and no means for forecasting bycatch mortality in groundfish fisheries except for the estimates of bycatch mortality in past years. To accommodate the uncertainty on bycatch mortality in groundfish fisheries when establishing TACs, stocks, For many target stocks, ADF&G has assumed that the maximum of the annual bycatch mortality due to groundfish fisheries in the previous 20 years could occur (**Error! Reference source not found.**).

2 Under the Crab FMP, the annual catch level (ACL) is = to the annually recommended ABC level. The ABC is recommended to the Council by the SSC.

Table 2 Summary of information availability by crab stock, current management measures and bycatch by gear type between 2003/04 – 2011/12 as a proportion of the 2012/13 ABC.(from staff discussion paper in 2013 posted at: http://www.npfmc.org/wp-content/PDFdocuments/bycatch/CrabBycatchBSAI213.pdf)

Stock	Abundance estimate	Current fishery	Existing Bycatch controls	Trawl bycatch mortality as % of ABC	Fixed gear mortality as % of ABC	Assumption in TAC-setting
Bristol Bay red king crab	√	√	Trawl	0.7% - 2.1%	0.2% - 0.4%	Maximum mortality in last 20 years (0.84 million pounds)
EBS Tanner crab	√		Trawl	1.3% - 2.2%	0.6% - 2.9%	Varies based upon estimates of needs in the snow crab fishery
EBS snow crab	√	√	Trawl	0.2% - 1.1%	0.04%	Depends on stock status and buffer below ABC
St. Matthew blue king crab	√	√		0.0% - 0.1%	0.1% - 7.1%	Maximum mortality in last 20 years (0.077 million pounds)
Pribilof Island red king crab	√		Pot	1.4% - 4.7%	0.1% - 1.5%	No directed fishery due to PIBKC stock status
Pribilof Island blue king crab	√		Pot	1.9% - 11.0%	12.6% - 48%	No directed fishery, stock overfished
Norton Sound red king crab	√	√		NA	NA	NA
Aleutian Island golden king crab		√		0.0% - 0.1%	0.2% - 0.9%	TAC set in regulation and is well below current average catch ABC
Adak red king crab				1.9% - 11.8%	2.7% - 12.5%	Directed fishery closed due to poor stock status

While adopting a broad suite of alternative measures for analysis in 2010 (Appendix 1), the Council then requested several iterative discussion papers to assist in refining alternatives for analysis and adding specificity to options under consideration. At the same time the Council began analysis of a revised rebuilding plan for Pribilof Island blue king crab which was not estimated to recover from overfished status by the end of the ten year time line. Staff discussion papers covered many issues to assist the Council in developing alternative PSC measures including PSC by gear type, by fishery, bycatch as a proportion of ABCs by stock, mortality rates employed and their derivation, the existing closures, PSC limits, and origins of those amendments. A summary of some of this information is shown in **Error! eference source not found.** including all ten stocks, whether biomass information is available sufficient to estimate abundance, whether a directed fishery is currently (or in the case of SMBKC and Tanner crab periodically) prosecuted, the proportion the bycatch in groundfish fisheries comprises of the overall ABC

estimates in that year (2012/13) and the assumptions employed regarding this mortality by ADF&G to set TAC levels.

As noted, simultaneous to these discussions, the Council was considering a revised rebuilding plan for the overfished Pribilof blue king crab stock which had failed to rebuild under its rebuilding plan. Measures considered for that rebuilding plan included PSC limits in all groundfish fisheries, PSC limits by gear type, triggered area closures associated with PSC by gear or fishery, and fixed area closures for a range of fisheries and gear types. The Council and analysts at the time grappled with many issues relating to the appropriate estimation of bycatch mortality in groundfish fisheries of the PIBKC stock separate from the SMBKC and low observer coverage around the Pribilof region. This analysis was prior to the CAS estimating bycatch (as it does now) by state statistical area to facilitate stock specific bycatch mortality estimates for use in crab assessments. In deference to some of these stock boundary and estimation issues, and understanding that PIBKC was being addresse3d separately, the Council elected to focus initial attention for modified crab PSC management on four of the ten stocks which had directed fisheries (BBRKC, EBS Tanner, EBS snow and SMBKC; Appendix 1).

5. Accounting for PSC in numbers and total mortality by weight

Crab PSC in groundfish fisheries is currently accounted for in numbers. The Council had previously indicated an interest in moving to weight-based crab PSC management and a procedure has been developed for calculating PSC using weights (and extrapolation by weight to unobserved catch). These data are currently used by crab stock assessment authors for estimating annual total mortality from groundfish fisheries. Therefore for purposes of estimating annual total mortality by crab stock for use in assessments, all necessary changes have been made and are being utilized in each assessment. As the current PSC limits specified in numbers are unrelated to total bycatch mortality (i.e. by all gears and areas), there is no current assessment-level gain by re-specifying those limits into weight. However should the Council move forward at some time in specifying bycatch limits which cover the entire stock and all bycatch mortality, consideration at that time could be given to using weight instead of numbers in order to set an upper bound on the allowable bycatch from that stock for purposes of assisting ADF&G in their TAC-setting assumptions, and providing for an upper limit on total mortality of crab PSC in groundfish fisheries.

6. Mortality rates applied to crab

Handling mortality

For purposes of calculating the mortality which accrues towards crab ACLs annually, handling mortality rates of 80% for trawl gear and 50% for fixed gear are applied. The basis for those estimates are described in the previous paper and not repeated here. Stock assessment authors apply those rates in their assessments annually for calculating relative mortality by gear type. Mortality rates are not currently employed for PSC accruing toward PSC limits in groundfish fisheries.

For purposes of this paper, catch data are reported in numbers of crab as existing PSC limits for crab are currently in numbers. PSC catch data for all stocks and areas are from AKFIN (data extracted 12/18/2015 for catch data and 12/30 for size and sex composition data) and are calculated for the groundfish fishing year. No mortality rates have been applied to these data. Should the Council elect to apply mortality rates to revised PSC limits in the future (i.e. if PSC limits were to apply to total mortality) then those percentages would represent the best available information on appropriate rates.

Trawl sweeps

The use of trawl sweeps in Bering Sea flatfish fisheries has reduced adverse impacts on benthic animals by raising the sweeps off the seafloor. In studies evaluating the mortality of crab species caught in conventional sweeps compared with modified sweeps the mortality rates dropped to nearly zero for both snow crab and Tanner crab species studied (Figure 2).

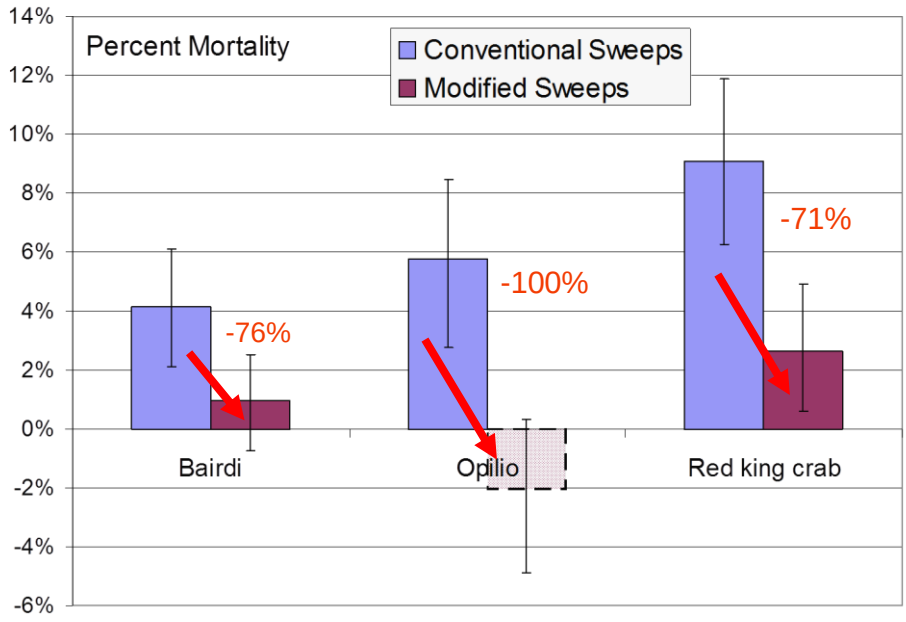

Figure 2 Estimated mortalities of *Chionoecetes opilio, C. bairdi,* and red king crab after contact with conventional and modified sweeps. From NPFMC 2009.

7. Focus of current discussion paper in relation to previous versions

As noted above, information in the 2010-2013 discussion papers[3] on existing measures and proportion of bycatch as a function of biomass and ABC levels led the Council to focus instead on four of the ten stocks for initial management consideration: Bristol Bay red king crab, EBS snow crab, EBS Tanner crab and Saint Matthew blue king crab. A subsequent discussion paper described the existing measures for those 4 stocks and issues related to examination of the efficacy of these trawl closures based on data as well as complications being resolved in the catch accounting system for estimating to crab stock boundaries to differentiate amongst the blue king crab stocks, red king crab stocks and golden king crab stocks. EBS Tanner and EBS snow are the only stocks for which there is no need to specify smaller stock boundaries than the entire Bering Sea). This information was provided to assist the Council in deciding what, if any, action to take to initiate modifications to the existing management measures for these 4 stocks. To begin this process the Council requested that evaluation be taken step-wise beginning with snow crab (as resolution of stock boundary/bycatch accounting issues complicated evaluation of other stocks) to describe the data available to evaluate modification of these measures. This paper describes existing management measures and origin thereof for snow crab PSC in BSAI groundfish fisheries and provides the specific data requests from the Council's motion (attached in appendix 1).

The information provided specific to snow crab is intended to address the following questions: Is the area of COBLZ covering the distribution of the snow crab stock as intended? Is there a large component of the snow crab PSC taken outside of COBLZ or within COBLZ by non-trawl gear? Is the PSC limit meaningful as specified? Do the existing measures (COBLZ and PSC limit to trawl gear) address all

3 June 2010: http://www.npfmc.org/wp-content/PDFdocuments/bycatch/CrabBycatchPSC510.pdf
February 2013: http://www.npfmc.org/wp-content/PDFdocuments/bycatch/CrabBycatchBSAI213.pdf
February 2014: https://npfmc.legistar.com/View.ashx?M=F&ID=2897614&GUID=A39D9DAC-4DF7-4713-8D27-0597FE29ED80

snow crab PSC in the Bering Sea? How do the size and sex composition of the snow crab PSC differ from directed snow crab fishery catch? Is groundfish snow crab PSC a concern to the overall snow crab stock status? Are management measures as specified useful in protecting the snow crab stock? Not all of these questions can be answered by a data evaluation thus many are left to interpretation and Council directive following review of the available information.

At this meeting the Council may wish to consider this and previous actions in relation to crab bycatch in groundfish fisheries to determine to what extent there is an interest and need for modified management and if so to draft a problem statement to describe what the action would address and adopt a suite of appropriate alternatives for analysis.

8. EBS Snow crab stock

Snow crab (*Chionoecetes opilio*) in the North Pacific are distributed on the continental shelf of the Bering Sea and Chukchi Sea. In the Bering Sea, snow crab are common at depths less than about 200 meters. The eastern Bering Sea population within U.S. waters is managed as a single stock; however, the distribution of the population may extend into Russian waters to an unknown degree (Turnock and Rugolo, 2015). The 2015 mature male survey distribution is shown in Figure 3 (> 77mm i.e. legal size) and Figure 4(> 101 mm, processor preferred size). Estimates of stock status were above the target $B_{35\%}$ in 2010/11 but have general declined in recent years. The snow crab stock was estimated to be at 93% of its target $B_{35\%}$ for 2015/2016.

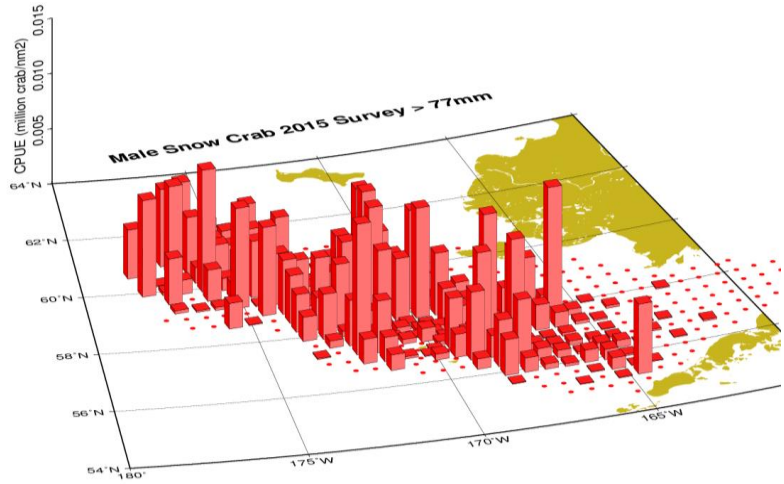

Figure 3 2015 Survey CPUE (million crab per nm2) of males > 77mm by tow. Filled circles are tows with 0 cpue (from Turnock and Rugolo, 2015).

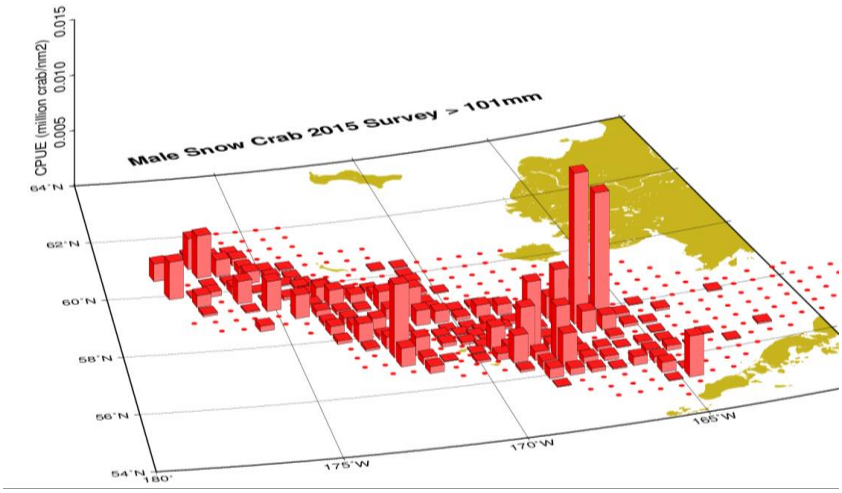

Figure 4. 2015 Survey CPUE (million crab per nm2) of males > 101mm by tow. Filled circles are tows with 0 cpue (from Turnock and Rugolo, 2015).

9. *C. opilio* Bycatch Limitation Zone (COBLZ)

The FMP contains a triggered time/area closure (described below) for trawl fisheries to protect snow crab stocks and their habitat. There are no management measures for fixed gear fisheries or additional measures for trawl bycatch outside of the time/area closure.

COLBLZ area and designation

A closure for EBS snow crab (*C. opilio*) is triggered if the limit is reached in specified trawl fisheries. The limit accrues for trawl bycatch taken within the *C. opilio* Bycatch Limitation Zone (COBLZ). That area then closes for the fishery that reaches its specified limit. (Figure 5). Fishing for that sector may continue outside of the COBLZ area however. The COBLZ area was specified under amendment 40 the FMP and was established in 1997. At that time it was designed to encompass 'nearly the entire population of snow crab' according to the 1996 NMFS summer trawl survey (NPFMC 1997).

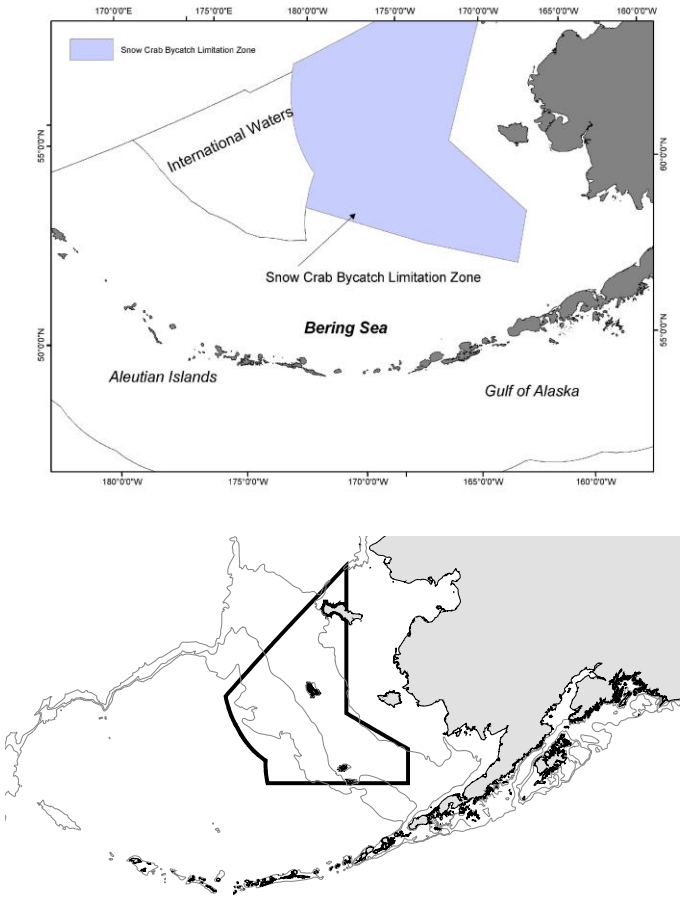

Figure 5. *C. opilio* Bycatch Limitation Zone (COBLZ) (upper and lower panels)

COBLZ PSC limit development

In June, 1996, the Council formed an industry workgroup to review proposed PSC limits for Tanner and snow crab as detailed in the analysis for Amendment 37 (Bristol Bay red king crab PSC measures amendment). This Council work group consisted of three crab fishery representatives, three trawl fishery representatives, and one shoreside processing representative. The group met over two days in August 1996 and came to consensus on bycatch limits for crab. The PSC limits (both for snow crab and additional triggered stair-step limits for Tanner crab in zones 1 and 2) were agreed upon by the workgroup and were primarily developed from historical bycatch data. Only snow crab taken within the COBLZ accrue toward the PSC limits established for individual trawl fisheries.

EBS snow crab trawl PSC limits are based on total abundance of snow crab as indicated by the NMFS standard trawl survey. In recent years, the assessment model estimate of trawl survey crab numbers is used to calculate the limit. The cap is set at 0.1133% of snow crab abundance index, with a minimum of 4.5 million snow crabs and a maximum of 13 million snow crabs; the cap is further reduced by 150,000 crabs (Figure 6). The 2015 model estimate of 4,288,000,000 crabs results in a 2016 PSC limit of 4,708,314 crabs. Snow crab taken within the "*C. opilio* Bycatch Limitation Zone" accrues toward the PSC limits established for the trawl sectors. Catch by trawl sectored from 2008-2015 is shown in

Table 3. Since 2008, only in 2010 was the apportioned limit reached (but not the overall limit) for a sector (Trawl limited access, TLAS, fishing primarily for yellowfin sole) causing that sector to continue fishing outside of COLBZ for the remainder of the year. That limit was reached February 8, 2010 (alaskafisheries.gov/node/20400).

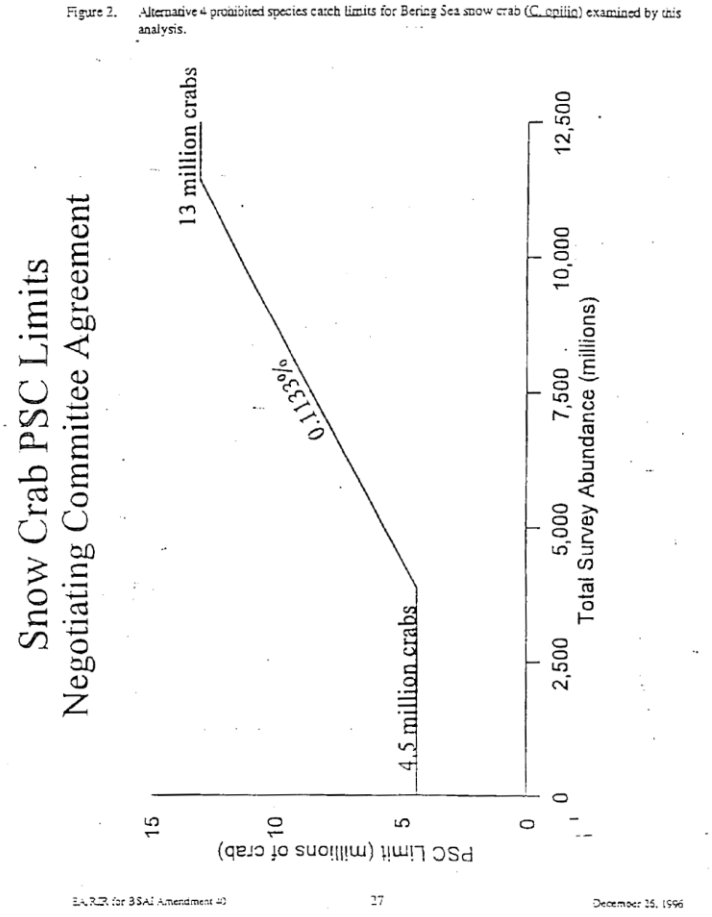

Figure 6 Negotiated control rule for snow crab PSC limit (from NPFMC 1997)

Table 3 Catch by fisheries to which COBLZ PSC limit is apportioned (2008-2015). From NMRS RO.

Year	Sector	PSC	Limit	Remaining	% of limit
2015	CDQ	41,020	1,178,282	1,137,262	3%
	A80	394,127	4,833,261	4,439,134	8%
	Pcod BSAI TRW Limited Access	71	126,994	126,923	0%
	Pollock/Atka Mackerel/Other BSAI TRW Limited Access	2,540	49,223	46,683	5%
	Yellowfin Sole BSAI TRW Limited Access	47,671	2,979,410	2,931,739	2%
	Total	485,430	9,167,170	8,681,740	5%
2014	CDQ	35,865	1,196,891	1,161,026	3%
	A80	329,062	4,909,594	4,580,532	7%
	Pollock/Atka Mackerel/Other BSAI TRW Limited Access + Pacific cod	4,977	179,000	174,023	3%
	Yellowfin Sole BSAI TRW Limited Access	79,218	3,026,465	2,900,192	3%
	Total	449,121	9,311,950	8,815,774	5%
2013	CDQ	19,777	1,123,722	1,103,945	2%
	A80	400,283	7,009,135	6,608,852	6%
	Pollock/Atka Mackerel/Other BSAI TRW Limited Access + Pacific cod	3,535	168,987	165,452	2%
	Yellowfin Sole BSAI TRW Limited Access	224,025	440,175	216,150	51%
	Total	647,621	8,742,019	8,094,398	7%
2012	CDQ	26,451	752,160	725,709	4%
	A80	326,294	3,085,323	2,759,029	11%
	Pollock/Atka Mackerel/Other BSAI TRW Limited Access + Pacific cod	2,245	113,119	110,874	2%
	Yellowfin Sole BSAI TRW Limited Access	239,436	1,901,193	1,677,168	13%
	Total	594,426	5,851,795	5,272,779	10%
2011	CDQ	29,889	753,359	723,470	4%
	A80	480,262	5,175,381	4,695,119	9%
	Pollock/Atka Mackerel/Other BSAI TRW Limited Access + Pacific cod	4,126	133,732	129,606	3%
	Yellowfin Sole BSAI TRW Limited Access	214,047	2,247,640	2,033,593	10%
	Total	728,324	8,310,112	7,581,788	9%
2010	CDQ	11,883	465,451	453,568	3%
	A80	281,729	2,148,057	1,866,328	13%
	Pollock/Atka Mackerel/Other BSAI TRW Limited Access + Pacific cod	3,944	70,000	66,056	6%
	Yellowfin Sole BSAI TRW Limited Access	1,379,116	1,176,494	(202,622)	117%
	Total	1,676,673	3,860,002	2,183,329	43%
2009	CDQ	56,334	465,451	409,117	12%
	A80	356,667	2,267,412	1,910,745	16%
	Pollock/Atka Mackerel/Other BSAI TRW Limited Access + Pacific cod	3,110	70,000	66,890	4%
	Yellowfin Sole BSAI TRW Limited Access	22,795	1,176,494	1,153,699	2%
	Total	438,906	3,979,357	3,540,451	11%
2008	CDQ	10,923	316,507	305,584	3%
	A80	601,773	2,385,827	1,784,054	25%
	Pollock/Atka Mackerel/Other BSAI TRW Limited Access + Pacific cod	5,728	70,000	64,272	8%
	Yellowfin Sole BSAI TRW Limited Access	62,966	1,176,494	1,113,528	5%
	Total	681,390	3,948,828	3,267,438	17%

Catch within and outside of COBLZ area.

Catch by gear (in numbers of crab) within and outside of COBLZ are shown in Table 3through Table 5. Only trawl catch within the COBLZ area accrues toward the PSC limit. However tables below show total bycatch by all gears inside and outside the area delineated by COBLZ as well as the relative proportion of bycatch within COBLZ in order to estimate to what extent this area accurately covers the distribution of snow crab caught as bycatch in groundfish fisheries. Within COBLZ the majority of the PSC is by non-pelagic trawl gear in all years (Table 4). In areas of the Bering Sea outside of COBLZ, pot gear comprises the majority of the PSC in nearly all years (Table 5). For comparison, snow crab PSC within COBLZ (by all gears) comprises between 39-92% of total snow crab PSC in the Bering Sea. Trawl snow crab PSC accruing toward the PSC limit within COBLZ is nearly equivalent, ranging from 39-92% of the total snow crab PSC over those years.

Table 4 Snow crab PSC (# of crabs) by gear type inside the area of COBLZ (2004-2015). Note shaded columns represent the PSC that accrues toward the PSC limit.

YEAR	COBLZ HAL	COBLZ NPT	COBLZ POT	COBLZ PTR	COBLZ Total
2004		1,753,162	1,000	433	1,754,596
2005		3,241,152	7,377	1,811	3,250,340
2006		947,380		2,528	949,908
2007	0	1,821,672	266,299	2,388	2,090,360
2008		677,361	51,793	4,658	733,812
2009		436,051		979	437,029
2010		1,656,763		4,278	1,661,041
2011		722,252	232	4,224	726,708
2012		592,386		2,520	594,907
2013		644,129		3,515	647,644
2014		445,816		2,811	448,627
2015		482,402		2,906	485,308

Table 5 Snow crab PSC (# of crabs) by gear type outside the area of COBLZ (2004-2015). This PSC does not accrue toward the PSC limit.

YEAR	Non-COBLZ HAL	Non-COBLZ NPT	Non-COBLZ POT	Non-COBLZ PTR	Non-COBLZ Total
2004	54,040	75,059	70,748	178	200,026
2005	60,831	62,638	152,686	398	276,553
2006	49,385	63,191	325,677	374	438,627
2007	23,363	78,046	1,265,011	546	1,366,966
2008	82,959	109,413	641,853	218	834,443
2009	54,504	87,256	545,794	280	687,834
2010	34,715	43,734	711,216	436	790,100
2011	37,599	24,892	142,679	653	205,823
2012	29,361	14,739	16,162	474	60,735
2013	17,963	43,239	9,929	389	71,520
2014	20,768	33,162	83,830	488	138,248
2015	15,896	6,169	117,437	32	139,534

Table Total snow crab PSC (# of crabs), PSC inside and outside of COBLZ (all gear types) and proportion of total (all gears) PSC from within COBLZ 2004-2015.

YEAR	COBLZ Total	nonCOBLZ total	Total snow crab PSC	Proportion PSC within COBLZ
2004	1,754,596	200,026	1,954,622	0.90
2005	3,250,340	276,553	3,526,893	0.92
2006	949,908	438,627	1,388,535	0.68
2007	2,090,360	1,366,966	3,457,326	0.60
2008	733,812	834,443	1,568,255	0.47
2009	437,029	687,834	1,124,864	0.39
2010	1,661,041	790,100	2,451,141	0.68
2011	726,708	205,823	932,531	0.78
2012	594,907	60,735	655,641	0.91
2013	647,644	71,520	719,164	0.90
2014	448,627	138,248	586,875	0.76
2015	485,308	139,534	624,841	0.78

Maps of crab distribution and bycatch in EBS in relation to COBLZ

The following maps (Figure 9 through Figure 13) show the recent survey distribution of snow crab by sex and size in relation to the area of COBLZ as well as observed grounfish effort, observed PSC by gear type. Note the higher distribution of snow crab to the southeast of the COBLZ boundary. This is consistent with bycatch by groundfish fisheries in this region and with the proportions shown in

Table 3through Table 5regarding bycatch outside of the region.

Size and sex composition of the bycatch

Figure 7 shows the percentage of observed female snow crabs in groundfish PSC by gear type since 2008. The highest proportion of female crab over this time was taken in the combined trawl fisheries in 2015 at 37%. Trawl generally catches a much higher proportion of females than other gear types over the years considered.

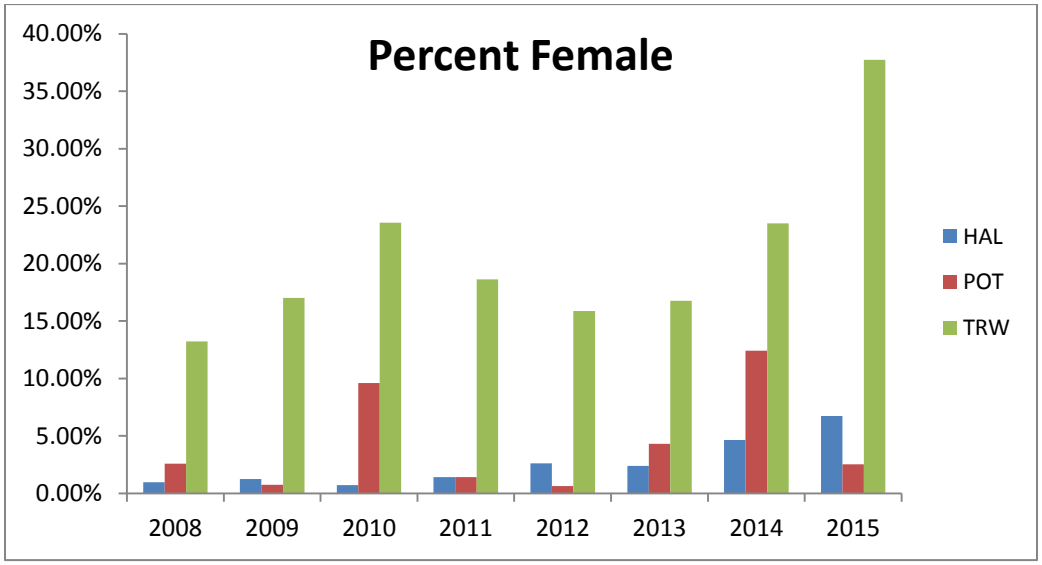

Figure 7. Percentage female snow crab in observed crab PSC in groundfish fisheries by gear type 2008-2015

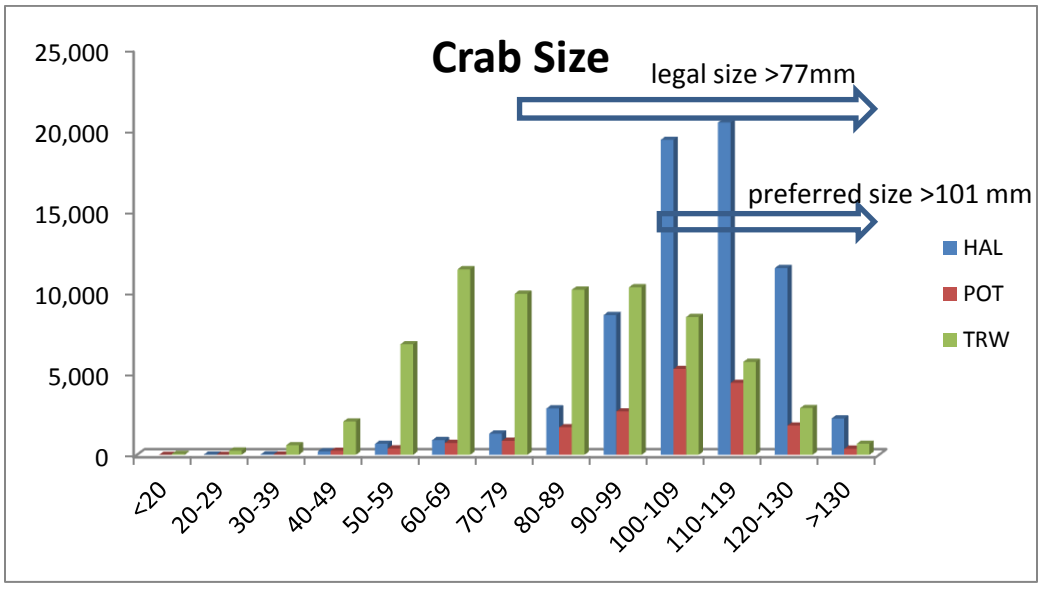

Figure 8 Snow crab carapace width by 10mm bins in observed snow crab PSC in groundfish fisheries by gear type 2008-2015. Arrows indicate legal and preferred size of landed snow crab.

Figure 8shows the observed size of crab taken (total observed from 2008-2015) by gear type in groundfish fisheries in conjunction with legal size (> 78mm) of snow crab and preferred processor size (over 101 mm). Trawl gear catches a broader range of sizes than other gear types including both below

and above landed sizes od crab. Fixed gear (hook and line and pot gear) general catch similar sizes to the directed fishery.

10. Summary of Considerations for snow crab

Based on the summary of data the following items are listed as observations relative to groundfish PSC management for snow crab:

1. COBLZ does not cover the whole distribution of the EBS snow crab stock. Both survey distribution and bycatch occur in a substantial district to the south of the COBLZ boundary.

2. The PSC limit only applies to trawl PSC and only when caught inside COBLZ. There are no measures for overall snow crab mortality nor any measures that apply to non-trawl fisheries.

3. Overall groundfish bycatch of snow crab is low in relation to total snow crab catch (~1% in 2015).

4. The Council should clarify if existing measures for snow crab should be revised to be consistent with stock distribution and stock status (i.e. if the area should cover all of the EBS and apply to all gear types) or if bycatch mortality in groundfish fisheries is low enough to not be a concern for revising management measures for snow crab.

Further consideration of other stocks

5. The Council should clarify if the intent is to provide similar information and discussion for the remaining 3 previously identified stocks of interest (SMBKC, BBRKC, EBS Tanner crab).

6. The Council motion (February 2014) requested information regarding the methodology by which abundance-based PSC limits for crab stocks could be established or revised. Abundance-based PSC limits rely on an estimate of PSC abundance and a pre-determined rate at which that abundance can be taken in groundfish fisheries. BSAI crab stocks are different from other PSC species in the Bering Sea for which there is either no overall abundance estimate (as with Chinook and chum salmon) or multiple indices (as with Bering Sea halibut). For crab stocks in Tiers 3 and 4 of the BSAI Crab tier system, there are reliable estimates of biomass as determined by the SSC by definition of Tier level status. See Table 2 for stocks with abundance estimates). Therefore biomass estimates for these stocks are available annually in the Crab SAFE report. The PSC limit that would be applied to that abundance estimate may be set as a control rule or a fixed value depending upon the Council's decisions. Should the Council intend to set or revise PSC limits for snow crab or other BSAI crab stocks, alternative PSC limits (fixed rates, control rules with or without fixed minimum and maximum values) would be developed and analyzed.

7. References

NPFMC 2009 EA/RIR/IRFA for Proposed Amendment 94 to the Fishery Management Plan for Groundfish of the Bering Sea and Aleutian Islands Management Area to Require Trawl Sweep Modification in the Bering Sea Flatfish Fishery, Establish a Modified Gear Trawl Zone, and Revise Boundaries of the Northern Bering Sea Research Area and Saint Matthew Island Habitat Conservation Area North Pacific Fishery Management Council. Anchorage, AK.

NPFMC 1997. EA/RIR/IRFA for amendment 40 to the Bering Sea Groundfish Fishery Management Plan for the Management of Snow Crab bycatch limits in groundfish fisheries. NPFMC, Anchorage, AK

Turnock J. and L. Rugolo, 2015. EBS Snow crab stock assessment chapter. In 2015 BSAI Crab SAFE Report. NPFMC, Anchorage, AK

8. Appendix 1: Council motions from 2010-2014

North Pacific Fishery Management Council
C-6 BSAI Crab PSC limits
Motion 2-7-14

The Council requests a revised discussion paper to outline the steps and information needed to consider the appropriateness of revising or implementing crab PSC limits or other management measures to minimize crab PSC in directed groundfish fisheries. This paper should include:

1. A discussion of implementing future PSC limits in weights rather than numbers.
2. A template that could be used for any crab stock that outlines the necessary information. The paper should use the snow crab stock and (COBLZ) management area as an example to develop the template.

   Information needed to evaluate current management measures could include:
   - Figures depicting sample size, sex ratio and size frequency of crab bycatch in groundfish fisheries by gear.
   - Graphs of size data including a reference to average size of crabs taken in directed crab fisheries.
   - Maps that overlay existing closure area(s) with crab stock distribution at the time of survey (by sex and size category), the directed crab fishery(s), and groundfish bycatch by trawl, pot, and hook-and-line gear from 2008 – 2013.
   - Tables showing PSC reported by groundfish fishing year; actual PSC limits for trawl gear by area/zone; total PSC and total PSC within the closure area(s) by gear type.

   Information needed to develop future management measures could include:
   - A description of the methodology that could be applied to set or revise abundance based PSC limits.
   - A discussion of the application of mortality rates to the crab PSC that accrues to trigger limits, by gear type.

Council motion on combined agenda items:
C-1(b) Discussion paper on Bristol Bay red king crab
C-2(a) Crab bycatch limits in BSAI groundfish fisheries
February 7, 2013

The Council requests an expanded discussion paper to evaluate the existing fixed and triggered closure areas for Bristol Bay red king crab, Bering Sea Tanner, Bering Sea snow crab, and St. Matthew blue king crab, including information on recent stock distribution and the distribution and amount of PSC in the trawl and fixed gear groundfish fisheries.

Elements to include:

- Proportion of PSC by trawl and fixed gear fisheries inside and outside of the closure areas.
- A more detailed history of the closures to help identify the fraction of historical fisheries that occurred in these areas as well as their crab PSC.

With regard to ACLs and TAC setting, the Council recognizes that while the State of Alaska is primarily responsible for management of the crab fisheries, they do not manage the groundfish fisheries in the EEZ and have limited ability to project crab bycatch mortality in those fisheries. The Council recommends that the BSAI Groundfish Plan Team and the State work together, such that the BSAI Groundfish Plan Team would provide estimates of crab bycatch mortality in the groundfish fisheries, to help reduce the uncertainty in the estimates used by the State during TAC setting.

C-2(c) Crab bycatch in BSAI groundfish fisheries

Council Motion

The Council moves the following problem statement and alternatives for analysis:

Problem Statement

Total catch overfishing levels (OFLs) are specified annually for the ten crab stocks included in the Fishery Management Plan for Bering Sea/Aleutian Islands King and Tanner Crabs (FMP); these OFLs account for all sources of fishing mortality including directed crab fishery discards and bycatch mortality caused by groundfish, scallop, and Pacific halibut fisheries. Requirements to comply with Annual Catch Limits (ACLs), addressing uncertainty in OFL estimates, include Accountability Measures (AMs) that trigger a management action if an ACL is exceeded.

Crab bycatch in the directed crab and scallop fisheries is controlled by the State of Alaska, however current management structure does not link the crab and groundfish FMPs; if a crab ACL is exceeded due to bycatch mortality in a groundfish fishery the resulting AM would reduce directed crab fishery harvest the following year. Crab bycatch management measures were first adopted for BSAI groundfish trawl fisheries in 1986. These measures, established in the BSAI groundfish FMP, consist of triggered or fixed time and area closures and prohibited species catch (PSC) limits; PSC limits apply only to Bristol Bay red king, Bering Sea Tanner, and Bering Sea snow crab. There are no PSC limits for the remaining seven FMP crab stocks and the existing closure areas do not circumscribe the full distributional range of stocks they are intended to protect, thereby allowing bycatch mortality to occur without accrual towards PSC limits. Furthermore no bycatch management measures are imposed on the fixed gear groundfish or Pacific halibut sectors. In order to address crab bycatch in the BSAI groundfish fisheries the BSAI groundfish FMP must be amended.

Alternative 1 - No action

Maintain existing crab PSC limits and closure areas.

Alternative 2 - Fixed PSC limits

Crab PSC limits would be fixed in the BSAI groundfish FMP.

Alternative 3 - Variable PSC limits

Crab PSC limits would be set annually based on crab abundance.

Note: Different alternatives may be chosen for each FMP crab stock.

Components with options that could be applied to alternatives 2 and 3:

Component 1: Closure areas

a) Existing closure areas

b) Expand triggered closure areas to include full distribution of each crab stock
Option: Triggered closure areas encompassing distribution of vulnerable size/sex components of crab stock

Component 2: Timing of closure areas

a) Fixed
   i. Year-round
   ii. Seasonal
   Option: based on vulnerable life history or gear susceptibility
b) Triggered
   i. Full
   ii. Stair-stepped (area closed expands as bycatch triggers are reached)

Component 3: Groundfish sectors/target fisheries included

a) All trawl sectors
b) All fixed gear sectors
c) Halibut IFQ

Component 4: Overfished stocks

a) Overfished/overfishing determination would trigger more restrictive PSC limits
b) Overfished/overfishing determination would trigger more restrictive time and area closures

Component 5: Accountability measures

a) Crab bycatch would accrue inseason towards groundfish sector PSC limit and an overage would trigger accountability measures during the subsequent season or year for that groundfish sector

Component 6: Catch accounting issues

a) Account for PSC limit accrual against time/area closure thresholds on a crab fishing year (June-May)
b) Account PSC limit accrual against time/area closure thresholds on a groundfish fishing year (January - December)

Other considerations noted in Council discussion:

Staff should consult with Crab Plan Team regarding further refinements to alternative framework noting that Council may further refine alternatives at preliminary review. Staff could consider further break-outs of sectors to fishery-levels as possible. Information in the analysis should include reporting bycatch both in numbers of crab as well as weight.

9. Appendix 2: maps of distribution of survey biomass of snow crab, COBLZ and Groundfish bycatch by gear type

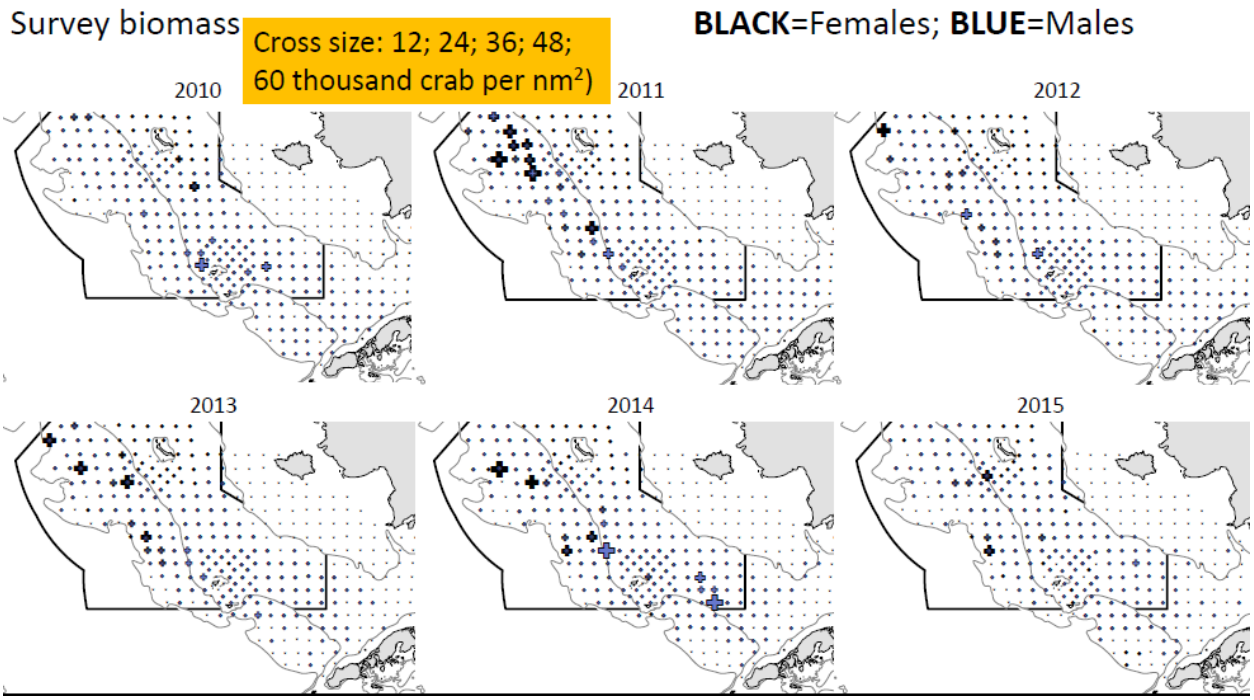

Figure 9 Survey biomass of snow crab males and females 2011-2015

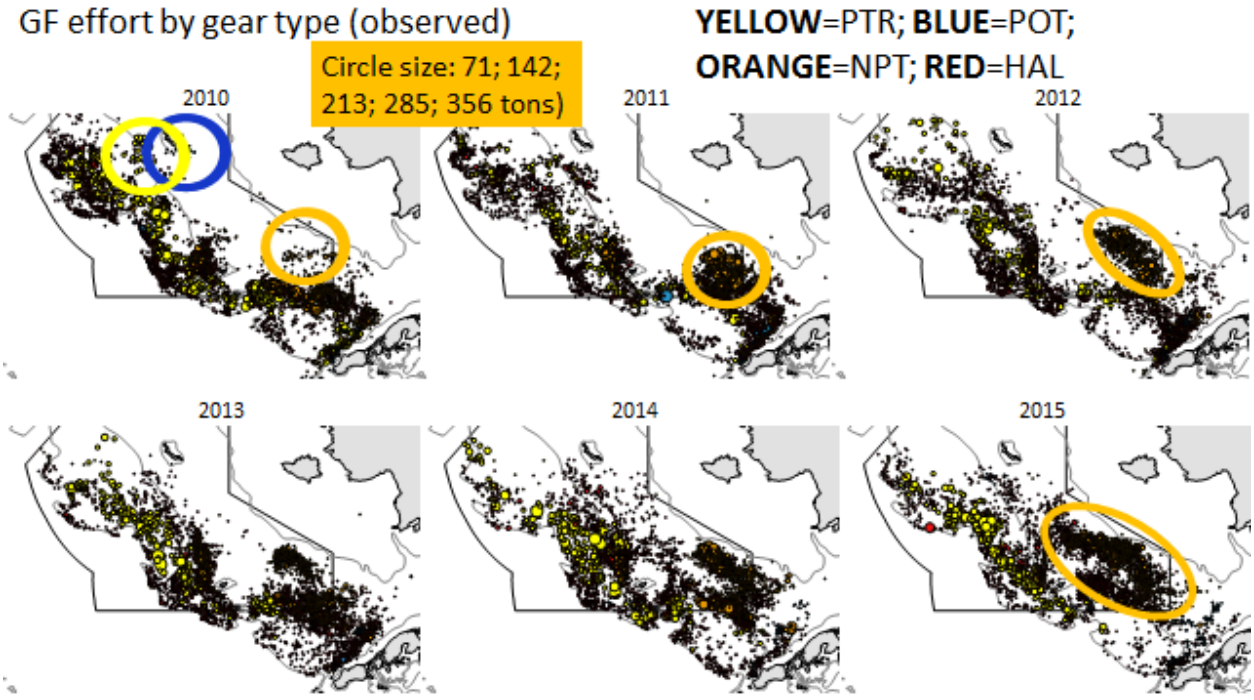

Figure 10 Observed groundfish effort (tons) by gear type 2010-2015

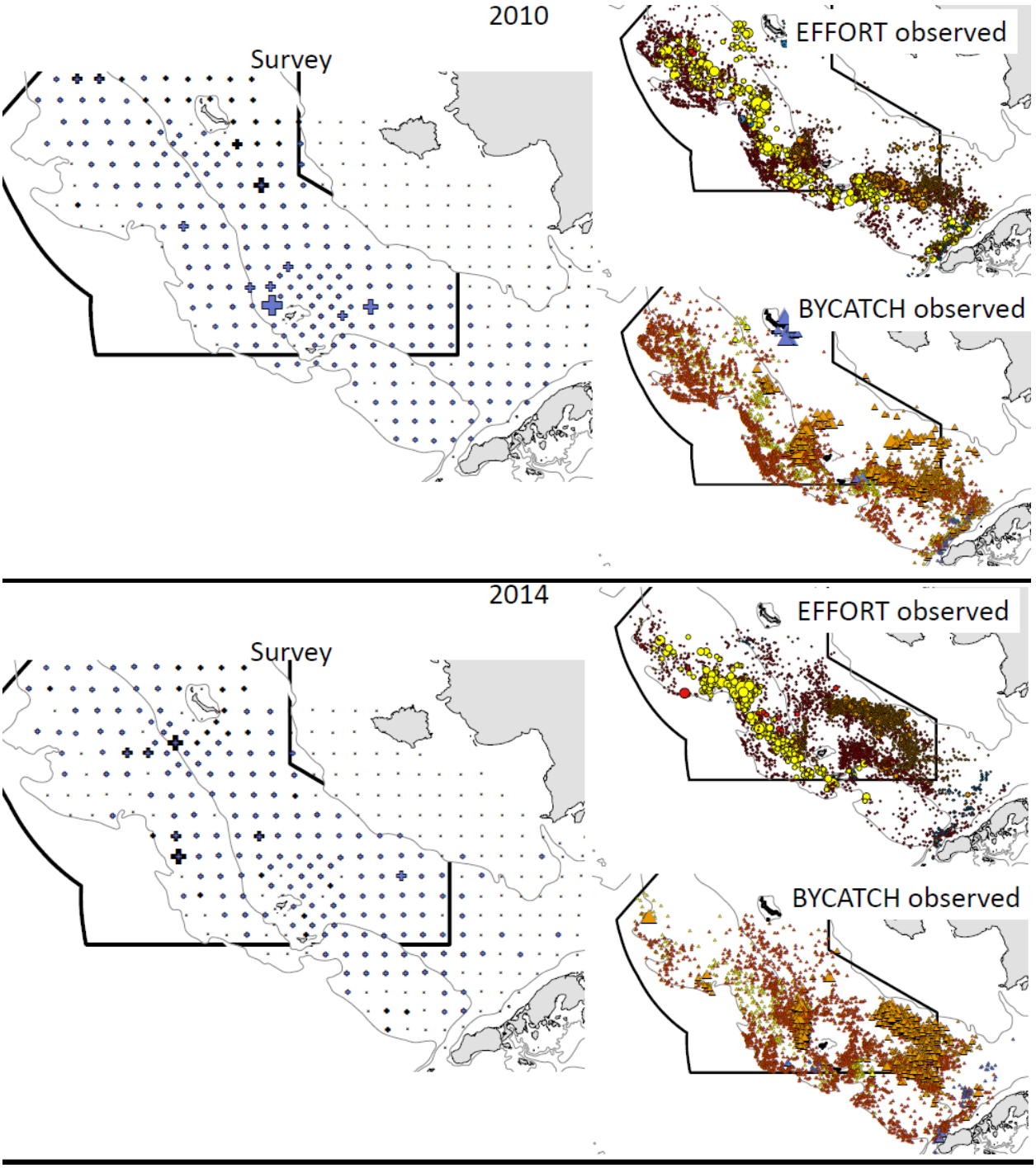

Figure 11 Observed groundfish effort, snow crab PSC and survey biomass of snow crab 2010 (upper panel), 2014 (lower panel)

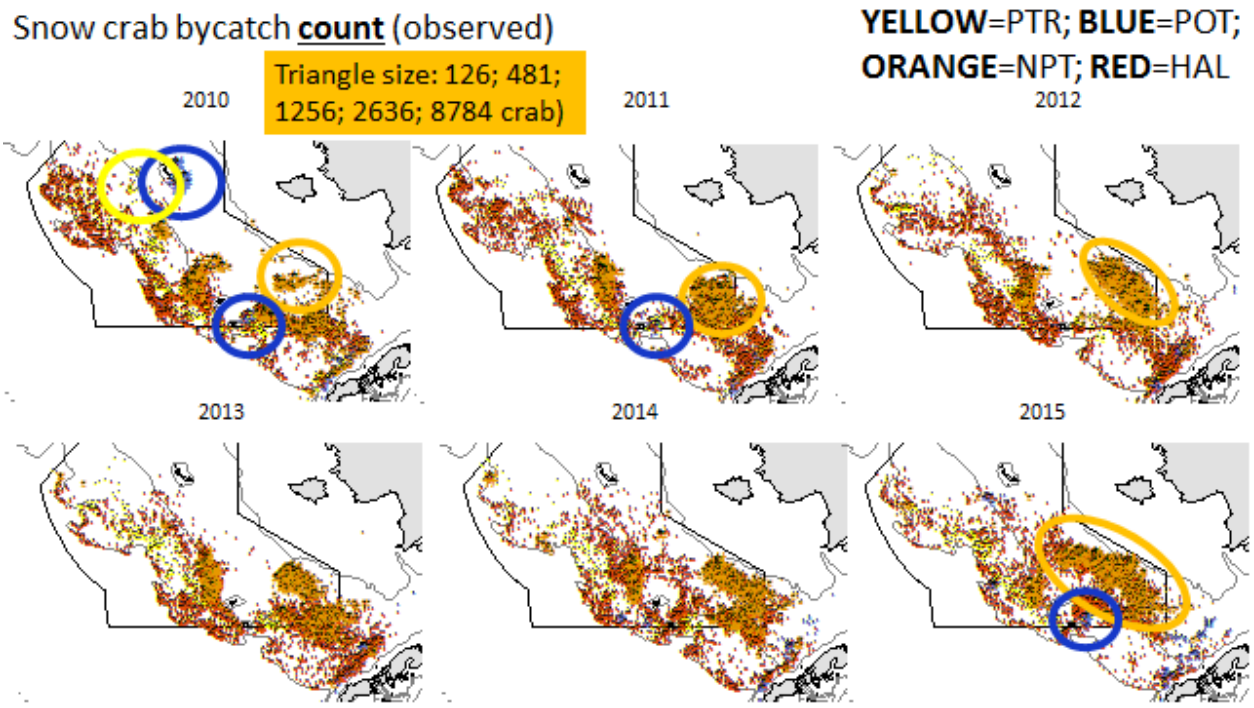

Figure 12 Snow crab PSC in groundfish fisheries by gear type 2010-2015

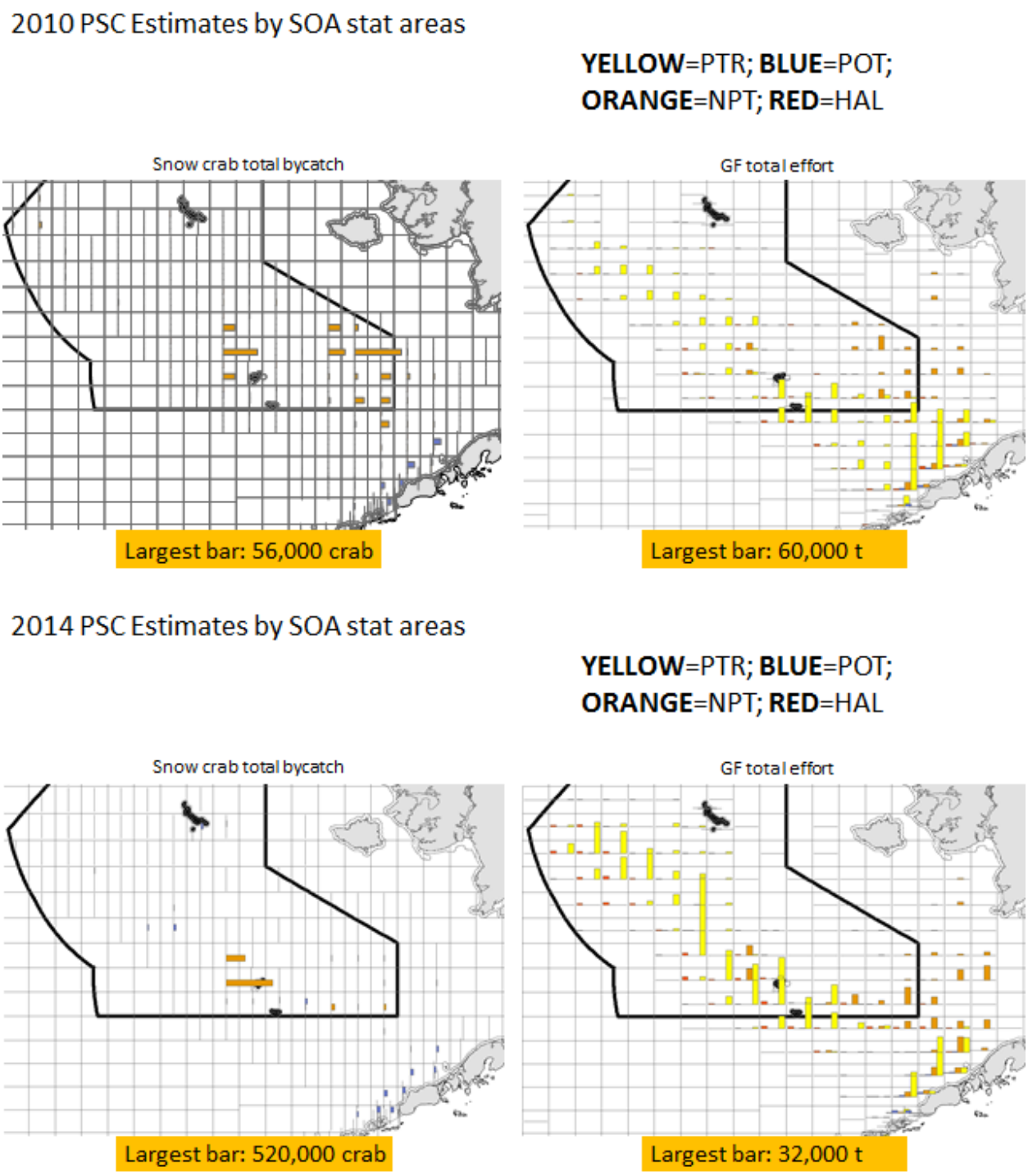

Figure 13 COBLZ area, groundfish total snow crab PSC (observed) and effort (in tons) 2010 (top panel) 2014 (lower panel).m