Bering Sea Habitat Conservation

Evaluating the need for possible protection measures for St. Matthew blue king crab & Eastern Bering Sea snow crab
Prepared by NPFMC staff

Background:

In February 2005 the North Pacific Fishery Management Council (NPFMC) took action to conserve essential fish habitat (EFH) from potential adverse effects of fishing. EFH is defined as those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity. The EFH EIS concluded that fisheries do have long term effects on habitat; however these impacts were considered minimal and the analysis found no indication of detrimental effects on fish populations. Nevertheless, the Council adopted several new measures to minimize the effects of fishing on EFH in the Aleutian Islands (AI) and Gulf of Alaska (GOA). A full description of the actions taken under Essential Fish Habitat is provided in the EFH EIS. These regulations will be promulgated by August 2006.

The EIS also evaluated a suite of alternatives for the eastern Bering Sea (EBS). However, based on that analysis, the Council determined that additional habitat protection measures in the EBS were not needed, and that an expanded analysis of potential mitigations measures for the EBS should be conducted prior to taking action.

In December 2005, the Council tasked staff to develop a discussion paper to evaluate the need for possible protection measures for St. Matthew blue king crab and Eastern Bering Sea snow crab. Elements of the paper were to address the distribution of St. Matthew blue king crab and snow crab in the Eastern Bering Sea, including any information of the location of egg-bearing females, post-larval distribution and historical trawl effort in those areas.

The purpose of this discussion paper is to provide background information to assist the Council in evaluating if these two crab stocks in the Bering Sea need additional protection measures to minimize (to the extent practicable) the effects of fishing on EFH in the Bering Sea.

Effects of trawling on crab and crab habitat

Fishing activities affect several benthic features that may serve as EFH, including organisms of the infauna, epifauna that are fish prey, and organisms and nonliving forms that provide three-dimensional structure to some epibenthic environments. Fishing activities have variable effects on different organisms, which may cause changes in the composition of benthic communities. Fishing may directly remove structure, disrupt it on the seafloor, or injure structure forming organisms. The literature describing those affects was reviewed in the EFH EIS in Chapter 3.4.2.

An evaluation of the potential adverse effects of all regulated fishing activities on EFH was analyzed in the EIS. The evaluation (1) described each fishing activity, (2) reviewed and discussed all available relevant information, and (3) provided conclusions regarding where and how each fishing activity adversely affects EFH. A full description of this analysis can be found in Appendix B of the EFH EIS, and a review of habitat features and current literature was addressed in Chapters 2 & 3.2.3. The EFH EIS analysis (Chapter 4) discusses the significant benefits of prohibiting trawling in the northern Bering Sea areas, particularly to conserve snow crab habitat and habitats used by other species.

The effects of fishing on crab was addressed within Chapter 4.3.1.2.2.2 of the EFH EIS. It is summarized by the following information. The spawning and breeding of crabs was measured in terms of the overlap and fishing intensity of trawl and dredge fishing effort in nursery areas and areas where mature females occur.

Concentration of fishing effort in time and space could potentially alter the genetic diversity of a population through selective fishing (removal of certain spawning aggregations or larger and faster growing animals, for example). The effects on spatial/temporal concentration are measured in terms of changes in the distribution of the directed crab fishery and, to a lesser extent, changes in the distribution of the trawl fishery (which takes some crabs as bycatch).

Spawning and breeding success of crab species depends upon a high egg-fertilization rate, transport of pelagic larvae to nursery areas, and survival to the adult stage. Egg fertilization success depends upon the size and number of mature male crabs (and hence the amount of sperm) available. The eggs are attached to the undersides of females and carried for nearly a year prior to hatching. Transport of larvae depends upon environmental conditions, and survival depends upon the quantity and quality of nursery habitat and the presence of predators.

Settlement and nursery areas are important components of spawning success for crab species. For king crabs, selection of benthic habitat by glaucothoe appears to be an important mechanism leading to increased probability of larvae settling on an appropriate substrate. Such substrates appear to be largely rock or cobble bottoms, mussel beds, or other areas with a variety of epifauna (such as hydroids) or epiflora (such as kelp holdfasts). For snow crabs, settlement occurs on mud habitats.

From settling larvae to senescence, crabs dwell on the bottom and depend upon benthic feeding. The importance of habitat quality to crab diet intuitively seems obvious, but is not quantified for benthic life stages. Changes in diet due to habitat disturbance may impact crab survival and production; however, the effects of these changes are difficult to assess given the limited information on feeding requirements of crab species. Tanner and snow crabs feed on an extensive variety of benthic organisms including bivalves, brittle stars, crustaceans (including other snow crabs), polychaetes and other worms, gastropods, and fish. The effects of the alternatives considered in the EFH EIS on the feeding of crabs are measured in terms of the overlap and fishing intensity of trawl and dredge fishing effort in juvenile and adult areas.

Blue king crabs do not pod, but rely on cryptic coloration to avoid predators. Podding behavior has been observed for adult Tanner crabs. Pods may be particularly vulnerable to incidental and unobserved mortality caused by fishing with trawl or dredge gear. Crabs are caught incidentally in groundfish and crab fisheries, and some of these crabs die after being discarded. Other sources of mortality are unobserved interactions with trawl and dredge gear and crabs that do not come up to the surface with the catch. A review of crab bycatch mortality is provided in the annual EBS crab SAFE reports (e.g., NPFMC 2005). The effects of the fishing on the growth of crabs to maturity were measured in terms of trawl fishing effort in the areas with juvenile crabs.

Crab mortality from gear impacts

The mortality of crabs impacted by gear varies by gear type and fishery. Bycatch of crabs by fishery are summarized in the annual Crab SAFE report (NPFMC 2005). Estimates of the mortality of crabs captured annually by directed crab, groundfish and scallop fisheries in relation to total population abundance are also summarized in the Crab SAFE report. A summary of the range of mortality rates by fisheries are contained below. Specific bycatch by fishery (and indication of the relative mortality from those fisheries) are included under the description of the St Matthew blue king crab population and EBS snow crab population description contained in later sections of this paper.

Crab fisheries

The actual rates of mortality to captured crabs discarded during crab fisheries remains unknown. Deadloss rates in deliveries cannot be considered applicable because of differences between the treatment of retained and non-retained crabs. Retained crabs are dropped only a short distance directly into the holding tanks, while non-retained crabs may be thrown over the side of the vessel or swept along the deck into scuppers, which results in rougher and more prolonged handling. Additionally, mortality due to capture and discarding may not be exhibited under the conditions of a holding tank or within the time that crabs are held in tanks prior to delivery. The Crab Plan Team has estimated bycatch mortality to be higher in the snow and Tanner crab fisheries (24% and 20%, respectively) than in the king crab fisheries (8%) and that has been supported by higher incidence of pre-discard injuries during the snow crab fishery than in the red king crab fishery (Tracy and Byersdorfer 2000, Byersdorfer and Barnard 2002). Warrenchuck and Shirley (2002) estimated the bycatch mortality rate for crabs discarded during the 1998 EBS snow crab fishery to be 22.2%, which they considered to be in agreement with the rate of 25% assumed in analyses for the EBS snow crab rebuilding plan (NPFMC 2000). Given the uncertainty in true bycatch mortality rates and the sensitivity of conservation considerations to bycatch mortality rates, the Crab Plan Team's Working Group on overfishing definitions is currently (May 2006) assuming bycatch mortality rates of 20% for the red king crab fishery and 50% for the snow crab fishery.

Trawl Fisheries

There have been numerous studies conducted on crab bycatch mortality in trawl fisheries, with each study having different objectives, methodology, and results. A summary of these studies is provided below, but many questions remain unanswered. Stevens (1990) found that 21% of the king crabs and 22% of the Tanner crabs captured incidentally in BSAI trawl fisheries survived at least 2 days following capture. Blackburn and Schmidt (1988) made observations on instantaneous mortality of crab taken by domestic trawl fisheries in the Kodiak area. They found acute mortality for softshell red king crab averaged 21%, hard shelled red king crab 1.2%, and 12.6% for Tanner crab. Another trawl study indicated that trawl induced mortalities aboard ship were 12% for Tanner crab and 19% for red king crab (Owen 1988). Fukuhara and Worlund (1973) observed an overall Tanner crab mortality of 60-70% in the foreign Bering Sea trawl fisheries. They also noted that mortality was higher in the summer (95%) than in the spring (50%). Hayes (1973) found that mortality of Tanner crab captured by trawl gear was due to time out of water, with 50% mortality after 12 hours. Natural Resource Consultants (1988) reported that overall survival of red king crab and Tanner crab bycaught and held in circulation tanks for 24-48 hours was <22%. In other analyses, the estimated mortality rate of trawl bycaught red king crab and Tanner crab was 80% (NPFMC 1993, 1995).

Other Groundfish Fisheries

No field or laboratory studies have been made to estimate mortality of crabs incidentally-caught and discarded in non-trawl fisheries. However, based on condition factor information from the trawl survey, mortality of crab bycatch has been estimated and used in previous analyses (NPFMC 1993). Discard mortality rates for red king crab were estimated at 37% in longline fisheries and 37% in pot fisheries. Estimated bycatch mortality rates for Tanner crab were 45% in longline fisheries and 30% in pot fisheries. No observations had been made for snow crab, but mortality rates are likely similar to Tanner crab. In the analysis made for Amendment 37, a 37% mortality rate was assumed for red king crab taken in longline fisheries and an 8% rate for pot fisheries. Observer data on condition factors collected for crab during the 1991 domestic fisheries suggested lower mortality of red king crab taken in groundfish pot fisheries. Bycatch mortality rates used in the analysis of Amendment 37 (NPFMC 1996) for snow crabs were 45% in longline fisheries and 30% in pot fisheries.

Scallop Fishery

Observations from scallop fisheries across the state suggest that mortality of crab bycatch is low relative to trawl gear due to shorter tow times, shorter exposure times, and lower catch weight and volume. For crab taken as bycatch in the Gulf of Alaska weathervane scallop fishery, Hennick (1973) estimated that about 30% of Tanner crabs and 42% of the red king crabs bycaught in scallop dredges were killed or injured. Hammerstrom and Merrit (1985) estimated mortality of Tanner crab at 8% in Cook Inlet. Kaiser (1986) estimated mortality rates of 19% for Tanner crab and 48% for red king crab bycaught off Kodiak Island. Urban el al. (1994) reported that in 1992, 13-35% of the Tanner crab bycaught were dead or moribund before being discarded, with the highest mortality rate occurring on small (<40 mm cw) and large (>120 mm cw) crabs. Delayed mortality resulting from injury or stress was not estimated. Mortality in the Bering Sea appears to be lower than in the Gulf of Alaska, in part due to different sizes of crab taken. Observations from the 1993 Bering Sea scallop fishery indicated lower bycatch mortality of red king crab (10%), Tanner crab (11%) and snow crab (19%). As with observations from the Gulf of Alaska, mortality appeared to be related to size, with larger and smaller crabs having higher mortality rates on average than mid-sized crabs (D. Pengilly, ADF&G, unpublished data). Immediate mortality of Tanner crabs from the 1996 Bering Sea scallop fishery was 12.6% (Barnhart and Sagalkin 1998). Delayed mortality was not estimated. In the analysis made for Amendment 41, a 40% discard mortality rate (immediate and delayed mortality combined) was assumed for all crab species.

Saint Matthew Blue King Crab stock status and population distribution

Blue king crab (*Paralithodes platypus*) has a discontinuous distribution throughout their range (Hokkaido Japan to Southeast Alaska). In the Bering Sea, discrete populations exist around the Pribilof Islands, St. Matthew Island, and St. Lawrence Island. Smaller populations have been found around Nunivak and King Island. Blue king crab molt multiple times as juveniles. Skip molting occurs with increasing probability for those males larger than 100 mm carapace length. Average molt increment for adult males is 14 mm. In the Pribilof area, 50% maturity of females is attained at 96 mm (about 3.8 inches) carapace length, which occurs at about 5 years of age. Blue king crab in the St. Matthew area mature at smaller sizes (50% maturity at 81 mm CL for females) and do not get as large overall (NPFMC 2000a).

Blue king crab have a biennial ovarian cycle and a 12 to 19 month embryonic period. Female blue king crab are found in rocky habitat. According to ADF&G pot surveys and observer data, the majority of egg-bearing females are found within depths of 30m (NPFMC 2000a). Blue king crab have a biennial reproductive cycle with a 12-to-19-month period of embryonic development (Sasakawa 1975, Somerton and MacIntosh 1985, Jensen and Armstrong 1989) so that during any part of the year only a portion of the mature females are ovigerous. Females with out eggs are found in deeper waters, up to 70 m (NPFMC 2000a). Unlike red king crab, juvenile blue king crab do not form pods, instead relying on cryptic coloration for protection from predators. Adult male blue king crab occur at an average depth of 70 m and an average temperature of 0.6°C.

King crab stocks off St. Matthew and Pribilof Islands are minor stocks that have supported small catches since fishery inception in the late 1970s. In 1998, landings of St. Matthew Island blue king crabs totaled $2.8 million pounds worth $5.6 million. Peak harvest from this stock was in 1983, when 9.5-million pounds were harvested with a CPUE of 14 crabs per pot lift (ADF&G 2003). Highest fishery CPUE occurred during the 1988 season when 1.3-million pounds were harvested at a CPUE of 30 crabs per pot lift. The harvest strategy used during 1990-1999 specified a flat 20% exploitation rate on mature males when the stock exceeded a threshold of 0.6 million mature males (Pengilly and Schmidt 1995). During 1990-1998, this stock supported harvests of 1.7 million to 4.7 million pounds annually (Table 1). In 1998, the last season the fishery was opened, 2.9 million pounds were harvested (Table 1).

Table 1 St. Matthew blue king crab fishery harvest relative to harvest strategy target and guideline harvest level (GHL), 1993-2004.

Fishery Year	Harvest Strategy Target[a]	Actual[b]	Number of males >104 mm CL[c]	Number Harvested[d]	GHL[e]	Harvest[f]
1993	20%	16%	3.98	0.63	4.4	3.00
1994	20%	20%	4.11	0.83	3.0	3.76
1995	20%	17%	3.99	0.67	2.4	3.17
1996	20%	15%	4.38	0.66	4.3	3.08
1997	20%	20%	4.70	0.94	5.0	4.65
1998	20%	15%	4.13	0.63	4.0	2.87
1999	Fishery closed		1.01	0	0	0
2000	Fishery closed		1.21	0	0	0
2001	Fishery closed		1.34	0	0	0
2002	Fishery closed		1.47	0	0	0
2003	Fishery closed		1.33	0	0	0
2004	Fishery closed		1.29	0	0	0

[a] Harvest strategy in effect for 1993-1998 seasons targeted 20% of abundance of males >104-mm carapace length (CL) as estimated from preseason survey.
[b] Actual number of legal males harvested as percentage of preseason estimated abundance of males >104-mm carapace length (CL).
[c] Estimated abundance of males >104-mm carapace length (CL) from preseason survey (millions of animals). From Vining and Zheng (2004).
[d] Millions of animals.
[e] GHL established preseason (millions of pounds).
[f] Actual harvest (millions of pounds).

This stock is annually surveyed by the NMFS Crab/Groundfish annual trawl survey. Total mature biomass for the stock is computed by multiplying the area-swept estimate for each sex and 5-mm CL size group by the mean weight of the sex-size group and the estimated proportion mature in the sex-size group, dividing that product by the estimated survey catchability of the sex-size group, and summing over both sexes and each size group (NPFMC 1998b).

The limited spatial distribution of the St. Matthew blue king crab stock and presence of rocky bottom habitat within that distribution poses problems in using the NMFS EBS trawl survey to assess the stock. Although the trawl survey station density is increased in the vicinity of St. Matthew Island to better sample from the blue king crab stock, important nearshore areas are not adequately sampled to detect important trends in stock distribution (Vining et al. 2001). Females, in particular, are poorly sampled by the trawl survey and abundance estimates for females from the survey data are considered unreliable. Additionally, only a small portion of the trawl survey effort in the St. Matthew Island Section is expended within the area that the commercial fishery typically occurred or, apparently, in the area that the crabs most likely to be harvested tend to occupy preseason (Pengilly and Watson 2004). Slight changes in distribution of stock components from year to year could affect vulnerability to the trawl survey and the resulting abundance estimates.

Survey estimates for St. Matthew Island blue king crabs indicated dramatic declines of both male and female crabs in all size categories in 1999. Recruitment to this stock had been declining for several years, but the sharp decline in all sizes of crabs suggested large survey measurement errors, a large increase in natural mortality, or some combination of both.

The Saint Matthew Blue King Crab fishery was subsequently closed in 1999 due to low mature male abundance (Zheng and Kruse 1999) and to total mature biomass (TMB) being estimated as below minimum stock size threshold (MSST) (Stevens et al. 2000). It has remained closed since. The stock was declared overfished in 1999 and a rebuilding plan was implemented in 2000. This stock remains in “overfished” condition (Figure 1).

The 1999 CSA estimate of mature male abundance (1.2 million) was actually above the then-existing harvest strategy’s threshold of 0.6 million. However, conservation concerns were indicated by the stock being less than ½ of MSST and by the severe and unexpected decrease in CSA estimates of mature male abundance between 1998 and 1999. Poorer-than-expected fishery performance during 1998 and poorer-than-expected catches during the 1999 ADF&G nearshore pot survey also added to the conservation concerns (NPFMC 2000a).

Estimated TMB decreased from 7.3 million pounds in 2004 to 5.9 million pounds in 2005, but year-to-year fluctuations in estimated total mature biomass are difficult to accurately evaluate due to the low precision of the survey estimates. Total mature biomass would need to increase nearly fourfold to 22.0 million pounds from the 2005 estimate for the stock to be considered “rebuilt.” The stock is showing no significant rebuilding to its MSY biomass. The series of annually estimated TMB since the overfished declaration of 1999 shows a slow rate of recovery (Figure 1). Data from the 2005 survey do not provide any expectations for such an increase in the near-term future; the estimates from 1999 through 2005 indicate at best only a weakly increasing trend in total mature biomass. The stock is estimated to be above the threshold for a fishery opening, but with the TAC computed according to the fishery harvest strategy far below the minimum TAC of 2.5 million pounds.

Gear modifications

Under the FMP, legal fishing gear modifications are at the discretion of the state. A number of pot gear modifications designed to inhibit bycatch in the crab fisheries have been adopted by the Board and incorporated into regulatory definitions of allowable gear. All pots used in Bering Sea crab fisheries must have biodegradable twine woven into a side wall (or tunnel) to prevent "ghost fishing" whenever fished gear is lost (ADF&G 1999). Regulations for some BSAI crab fisheries also include minimum pot tunnel entrance dimensions and escape rings or mesh panels to allow egress of non-retainable crabs, including females and undersized males. Gear modification regulations for the Bering Sea snow crab fishery provide some protection against blue king crab bycatch. Regulations for the snow crab fisheries require that pots contain egress 5-inch (stretched) mesh or 3.75-in (inside diameter) rings, but additionally specify a maximum pot tunnel height opening of 3 inches to reduce bycatch of king crabs.

In March 2000, the Board adopted gear modification regulations to reduce bycatch in the directed blue king crab fishery. These regulations require pots to be fitted with escape rings or stretched mesh to allow female and sublegal male crabs to escape. The new regulations require each pot to be fitted with either 5.8-inch diameter escape rings (4 per side panel and 2-inch maximum distance for rings from bottom margin of side panel) or 8-inch stretch mesh on at least 1/3 of one vertical surface of the pot. These requirements allow males <5.5 inches and females to escape. Escape rings with a minimum inside diameter of 5.8-in or escape-mesh panels with webbing that provides a minimum opening of 5.8 in will allow passage of sublegal male crabs out of a pot. Most female St. Matthew blue king crab will also be able to pass through a 5.8-in opening.

Area Closures

In March 2000, the Alaska Board of Fisheries also adopted a closed area that includes all State waters around St. Matthew Islands, Hall Islands, and Pinnacle Island. This was established to protect egg-bearing females and their habitat. This area is closed to all fishing (Figure 2) This closure extends out to 3 nautical miles. Female St. Matthew blue king crabs tend to have a more limited distribution than do males (Blau 1996, Blau and Watson 1999, Vining et al. 1999) and are generally captured within 30 nm of the southern side of St. Matthew Island. Hence, the closed area was established for the St. Matthew blue king crab fishery on the basis of female distribution in pot surveys and observer pot samples.

Habitat Protection

Designated Essential Fish Habitat (EFH) for adult blue king crab is shown in Figure 3. General distribution is a subset of the species population and is defined as 95 percent of the population for a particular life stage, if life history data are available for the species. Where information is insufficient and a suitable proxy cannot be inferred, EFH is not described. General distribution is used to describe EFH for all stock conditions, whether or not higher levels of information exist, because the available higher level data are not sufficiently to account for changes in stock distribution (and thus habitat use) over time.

The general distribution was based on the best and most recent level of information available. Additionally new analytical tools including GIS mapping incorporated recent scientific information for each life history stage from updated scientific habitat assessment reports (contained within Appendix F). EFH descriptions include both text and a map, if information is available for a species' particular life stage. It is supported by scientific rationale, and accounts for changing oceanographic conditions, regime shifts, and the seasonality of migrating fish stocks. Detailed information for BKC EFH is defined in the EFH EIS as follows:

EFH Description for BSAI Blue King Crab

Eggs
Essential fish habitat of the blue king crab eggs is inferred from the general distribution of egg-bearing female crab (see also Adults).

Larvae—No EFH Description Determined
Insufficient information is available.

Early Juveniles—No EFH Description Determined
Insufficient information is available.

Late Juveniles

EFH for late juvenile blue king crab is the general distribution area for this life stage, l ocated in bottom habitats along the nearshore where there are rocky areas with shell hash and the inner (0 to 50), 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.

Adults

EFH for adult blue king crab is the general distribution area for this life stage, 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 sand and mud adjacent to rockier areas and areas of shell hash.

Distribution of Ovigerous Females

The annual NMFS eastern Bering Sea trawl survey visits the St. Matthew Island area in July. The trawl survey does not tow in waters shallower than 20 fm (37 m) and rarely in waters shallower than 30 fm (55 m) in the vicinity of St. Matthew Island. Ovigerous female distribution from the trawl survey (years 1990 to 2005) together with trawl effort and existing closures are shown in Figure 4. Directed crab fishery catch from 1997-2000 is shown with ovigerous females and non-pelagic trawl effort in Figure 5. Catch distribution from the 2005 NMFS survey in the vicinity of St. Matthew Island is shown in Figure 6.

Concentrations of ovigerous females with uneyed eggs are rarely encountered in standard surveys, but were, however, identified by nearshore work (<20 fm) performed by ADF&G to supplement the standard pot survey. Highest densities of ovigerous females with uneyed eggs were observed on the southern side of St. Matthew Island, and there was a general increase in their densities with decreasing depth (Pengilly 2003).

ADF&G analysis of the efficacy of the State water closure surrounding St. Matthew island concluded the following (from Pengilly 2003): “The analysis of female blue king crab distribution in the St. Matthew Island area showed the shortcomings of both the annual NMFS EBS trawl survey and the standard ADF&G triennial pot survey as platforms for gathering abundance data on reproductive females. The NMFS EBS trawl survey station grid design, coupled with a distribution of mature females that is concentrated in shallow, rocky-bottom areas south and adjacent to St. Matthew Island, results in poor recruitment of mature female blue king crab to the trawl survey. In contrast, the survey station grid design for the standard ADF&G triennial pot survey is adequate for sampling densities from the distribution of mature-barren females (i.e., those females that have hatched eggs, but have not yet extruded the next clutch of eggs). However, the standard ADF&G triennial pot survey is not adequate for sampling densities from the distribution of mature-ovigerous females. Additionally, from these analyses it can be concluded that the 3-nmi fishery closure area surrounding St. Matthew, Hall, and Pinnacle Islands is effective for protecting mature females when they are carrying clutches of eggs (ovigerous), but is not effective for protecting mature females during the extended period between hatching a clutch of eggs and extruding the next clutch of eggs.”

Bycatch of St. Matthew blue king crabs

Crab fishing seasons are scheduled to minimize the potential for excessive bycatch and associated handling mortality of molting and mating crabs. Bycatch of non-retained St. Matthew blue king crab has been observed in the St. Matthew blue king crab fishery and the eastern Bering Sea snow crab fishery. It is doubtful that the only other commercial crab fishery that is occasionally prosecuted in the St. Matthew Island Section, the St. Matthew Island Section golden king crab fishery, encounters any bycatch of blue king crab due to differences in distribution of blue and golden king crabs (NPFMC 2000a). The available observer data indicates that, unless the blue king crab fishery is closed for a season, the blue king crab fishery accounts for nearly 100% of the annual estimated number of blue king crabs that are captured and discarded during crab fisheries within the St. Matthew Island Section (NPFMC 2000a).

Table 2 Bycatch of St. Matthew blue king crabs (numbers of crab) in Bering Sea fisheries, 1995-2004.

	directed	groundfish	groundfish	scallop	
Year	crab pot	trawl	fixed gear	dredge	Total
1995	confidential	2,725	47	0	n/a
1996	1,699,333	168	574	0	1,700,075
1997	confidential	8	187	0	n/a
1998	confidential	0	774	0	n/a
1999	n/a	0	4,983	0	n/a
2000	54,300	0	n/a	0	n/a
2001	1,300	0	n/a	0	n/a
2002	600	n/a	n/a	0	n/a
2003	0	855	1,263	0	2,118
2004	0	1,416	475	0	1,891

Table 2 shows the bycatch of St. Matthew blue king crabs in directed crab fisheries, groundfish trawl and longline fisheries and scallop dredge fisheries from 1995 – 2004. Crab fisheries in recent years have not taken any St. Matthew blue king crab as bycatch. Groundfish trawl and fixed gear (including both longline and pot gear fisheries) have accounted for all of the bycatch of these crabs in 2003 and 2004. Scallop dredge fisheries are not present in the area of this blue king crab population and do not account for any of the bycatch of this species.

By applying mortality rates estimated from scientific observations to the number of crabs taken as bycatch, it is possible to estimate the relative impacts of bycatch on crab populations. Discard mortality rates have been established in previous analysis (NPFMC 1999), and may be species or fishery specific. Bycatch mortality rates in trawl, dredge, and fixed gear fisheries for all crab species were set at 80%, 40%, and 20% respectively. For crab fisheries, mortality rates were averaged across different fisheries. For the directed crab fishery the rate used was 8% for blue king crab.

Bycatch mortality estimates as total numbers and as a percentage of the annual population estimate for the St. Matthew blue king crab stock using the annual bycatch amounts by fishery in Table 2 are shown in Table 3.

Table 3 St. Matthew blue king crab bycatch mortality estimates and proportion of population abundance

Year	Total Bycatch	Bycatch mortality	Abundance (millions)	Bycatch as %
1995	n/a	conf	5.6	*
1996	1,700,075	136,196	10.0	1.36
1997	n/a	conf	10.0	*
1998	n/a	conf	8.4	*
1999	n/a	997	1.7	0.06
2000	n/a	n/a	1.7	*
2001	n/a	n/a	2.9	*
2002	n/a	48	1.2	0.001
2003	2,118	0	3.3	0
2004	1,891	1,228	2.7	0.045

Summary of Measures Considered and Adopted under Rebuilding Plan

A rebuilding plan for the St. Matthew blue king crab stock was approved in November, 2000 following the overfished declaration of 1999. Under the rebuilding plan, several measures were considered with respect to harvest strategy, bycatch controls and habitat protection. The preferred alternative which was chosen for implementation under this rebuilding plan included a new harvest strategy (approved by the Board of Fisheries), gear modifications and area closures for bycatch control (approved by the Board of Fisheries) and an area closure for habitat protection. The harvest strategy utilized under the current rebuilding plan incorporated a threshold biomass for a GHL (or TAC) to be established, as well as lower harvest rates at lower biomass levels. The state waters area closure around St. Matthew Islands, Hall Islands, and Pinnacles Island was identified by ADF&G as habitat that was necessary for the long-term maintenance of the St. Matthew blue king crab stock (NPFMC 2000a). As described previously, this area is closed to all State waters fishing.

Snow Crab stock status and population distribution

Snow crab (*Chionoecetes opilio*) are distributed on the continental shelf of the Bering Sea, Chukchi Sea, and in the western Atlantic Ocean as far south as Maine. 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.

Snow crab feed on an extensive variety of benthic organisms including bivalves, brittle stars, crustaceans (including other snow crabs), polychaetes and other worms, gastropods, and fish. In turn, they are consumed by a wide variety of predators including bearded seals, Pacific cod, halibut and other flatfish, eel pouts, sculpins, and skates (Turnock and Rugolo, 2005).

Snow crab were harvested in the Bering Sea by the Japanese from the 1960s until 1980 when the Magnuson Act prohibited foreign fishing. Retained catch in the domestic fishery increased in the late 1980's to a high of about 328 million lbs in 1991, declined to 65 million lbs in 1996, increased to 243 million lbs in 1998 then declined to 33.5 million lbs in the 2000 fishery (Table

4, Figure 7). Due to low abundance and a reduced harvest rate, retained catches remained low and were 32.7 million lbs in the 2002 fishery (36.2 million lbs total catch), 28.3 million lbs of retained catch in 2003 (39 million lbs total catch), and 23.66 million lbs of retained catch in 2004 (27.54 million lbs total catch). Retained catch in the 2005 fishery was 26 million lbs (Turnock and Rugolo, 2005).

Table 4. Eastern Bering Sea snow crab fishery harvest relative to harvest strategy target and guideline harvest level (GHL), 1994-2005 (from NPFMC 2005)

Fishery Year	Harvest Strategy Target[a]	Actual[b]	Mature Male Biomass[c]	GHL[d]	Harvest[e]
1994	N/A[f]	36.3%	412.3	105.8	149.8
1995	N/A[f]	22.6%	332.9	55.7	75.3
1996	N/A[f]	13.9%	474.0	50.7	65.7
1997	N/A[f]	17.2%	694.4	117.0	119.5
1998	N/A[f]	34.6%	729.7	234.8	252.2
1999	N/A[f]	38.3%	502.6	195.9	192.3
2000	N/A[g]	16.9%	197.1	28.6	33.3
2001	14.7%	13.8%	182.8	27.3	25.3
2002	10.2%	10.6%	308.6	31.0	32.7
2003	11.5%	12.7%	224.9	25.8	28.5
2004	11.4%	13.1%	183.2	20.8	23.9
2005	12.0%	14.1%	176.4	20.9	24.8

[a] Harvest strategy in effect since 2001 targets a percentage of the preseason survey estimate of mature male biomass.

[b] Actual harvest as a percentage of the preseason survey estimate of mature male biomass.

[c] Preseason estimate of mature male biomass provided by NMFS (millions of pounds).

[d] GHL established preseason (millions of pounds).

[e] Actual harvest (millions of pounds).

[f] GHL established as 58% percentage of males >101-mm carapace width.

[g] GHL established as 22% percentage of males >101-mm carapace width.

NMFS EBS trawl survey data are used to compute the estimates of abundance needed to apply the harvest strategy and to determine the TAC. Since 1989, the survey has sampled stations farther north than previous years. Juvenile crabs tend to occupy more inshore northern regions (up to about 63 degrees N) and mature crabs deeper areas to the south of the juveniles (Zheng et al. 2001). Survey abundance of mature females and males for 2004 and 2005 are shown in figures 8-12.

The spatial distribution of snow crab in the 2005 survey was similar to 2004 (Figures 8-12). Female crab > 49 mm occurred in higher concentration in generally three areas, just north of the Pribilof Islands, just south and west of St. Matthews Island, and to the north and west of St. Matthew Island. Males > 78 mm were distributed in similar areas to females, except the highest concentrations were between the Pribilof Islands and St. Matthews Island.

The total mature biomass estimated from the survey declined to a low of 185 million lbs in 1985, increased to a high of 1,632 million lbs in 1991, then declined to 310 million lbs in 1999, when the stock was declared overfished (Figure 7). The mature biomass increased in 2000 and 2001, mainly due to a few large catches of mature females. The 2003, 2004 and 2005 survey estimates of total mature biomass were 304 million lbs, 358 million lbs, and 505 million lbs, respectively. The total mature biomass includes all sizes of mature females and morphometrically mature males.

Stock assessment estimation is performed by NMFS. Estimation of mature female biomass, mature male biomass, and exploitable legal male abundance for comparison with threshold and computation of the TAC is performed by using area-swept estimation. A weight-carapace width relationship is applied to the size frequency distribution to obtain average weights for computing biomass.

An "LBA"-type assessment model has been developed for EBS snow crab, with its most recent draft incorporating fishery and survey data through 2005 and distributed to the NPFMC Crab Plan Team (Turnock and Rugolo 2005). This model has not yet been utilized for the biomass estimate upon which the TAC calculation is based but may be used in the future for this purpose.

In 2000, due to the decline in abundance and the declaration of the stock as overfished, the harvest rate for calculation of the GHL was reduced to 20% of male crab over 101 mm. After 2000, a harvest strategy was developed based on simulations by Zheng (2002).

At least prior to the 1999 overfished declaration, Bering Sea Snow crab had shown an apparent cyclic recruitment pattern (Turnock and Rugolo 2005). Greatest harvests in the fishery occurred during the 1991 and 1992 seasons, with harvests for both years in excess of 300 million pounds. Harvests decreased into the mid-1990s and only 66 million pounds were harvested in 1996. In 1998 the harvest had increased to over 240 million pounds. Poor recruitment of juveniles during the mid-to-late 1990s resulted in poor recruitment to the mature and harvestable stock. Consequently, by 1999 TMB for the stock was at 283.5 million pounds, only 40% of the 1998 value and well below MSST value defining an “overfished” level. More conservative management in response to the depressed stock condition and “overfished” declaration resulted in GHLs less than 30 million pounds for the 2000-2005 seasons (Table 4).

Spatial distribution of catch and survey abundance

In the 2004 and 2005 stock assessment document (Turnock 2004; Turnock and Rugolo 2005) concerns were noted with respect to the potential disproportionate harvesting of the stock in northern and southern regions and the impact this might have on the reproductive viability of the stock. The following section is excerpted from Turnock and Rugolo (2005) to explain the background behind this disproportionate harvest.

In 2003 and 2004, the majority of the fishery catch occurred south of 58.5 deg N., even though ice cover did not restrict the fishery moving farther north. In past years, most of the fishery catch occurred in the southern portion of the snow crab range possibly due to ice cover and proximity to port and practical constraints of meeting delivery schedules. In 2003, 66% of the catch was south of 58.5 deg N. (Figure 15), and in 2004 78% of the catch was south of 58.5 deg N. (Figure 16). In 2003 and 2004 the ice edge was farther north than past years, allowing some fishing to occur as far north as 60-61 deg N.

In the 2004 survey about 9.5 million new shell males >101mm were estimated south of 58.5 deg N. This indicates that survey catchability may be less than 1.0 and/or some movement occurs between the summer survey and the winter fishery. However, the exploitation rate on males south of 58.5 deg N exceeds the target rate, possibly resulting in a depletion of males from the southern part of their range. Snow crab larvae probably drift north and east after hatching in spring. Snow crab appear to move south and west as they age, however, no tagging studies have been conducted to fully characterize the ontogenetic or annual migration patterns of this stock. High exploitation rates in the southern area may have resulted in a northward shift in snow crab distribution. Lower egg production in the south from lower clutch fullness and higher percent barren females possibly due to insufficient males for mating may drive a change in distribution to the north. The northward shift in mature females is particularly problematic in terms of annual reproductive output due to lowered productivity from the shift to biennial spawning of animals in waters < 1.5 deg C in the north. The lack of males in the southern areas at mating time (after the fishery occurs) may result in insufficient males for mating (Turnock and Rugolo 2005).

Based on similar concerns as noted above in the stock assessment document by Turnock (2004), the Crab Plan Team took the following motion at their September 2004 Crab Plan Team meeting:

The CPT recognizes that the target harvest rate for opilio crab is being exceeded in certain portions of the range of the stock as discussed in Turnock's "Stock Assessment of eastern Bering Sea Snow Crab" September 2004, pgs 14-15 and 22. Based on this information and additional discussion by the CPT, the CPT recommends that an immediate analysis of the issues surrounding the differential harvest rates be developed to address the conservation issues and to also develop appropriate alternatives to protect the viability and reproductive strength of this stock. This analysis should be directed towards ensuring that the distribution of fishing effort be managed to ensure the equalization of exploitation rates over the range of the exploitable stock.

To date no analysis of this has been initiated.

Habitat Protection

Designated EFH for adult snow crab is shown in Figure 17. General distribution is a subset of the species population and is defined as 95 percent of the population for a particular life stage, if life history data are available for the species. Where information is insufficient and a suitable proxy cannot be inferred, EFH is not described. General distribution is used to describe EFH for all stock conditions, whether or not higher levels of information exist, because the available higher level data are not sufficiently to account for changes in stock distribution (and thus habitat use) over time.

The general distribution was based on the best and most recent level of information available. Additionally new analytical tools including GIS mapping incorporated recent scientific information for each life history stage from updated scientific habitat assessment reports (contained within Appendix F of the EFH EIS). EFH descriptions include both text and a map, if information is available for a species' particular life stage. It is supported by scientific rationale, and accounts for changing oceanographic conditions, regime shifts, and the seasonality of migrating fish stocks. Detailed information for snow crab EFH is defined in the EFH EIS as follows:

EFH Description for BSAI Snow Crab
Eggs
Essential fish habitat of snow crab eggs is inferred form the general distribution of egg-bearing female crab (see also Adults).

Larvae—No EFH Description Determined
Insufficient information is available.

Early Juveniles—No EFH Description Determined
Insufficient information is available.

Late Juveniles
EFH for late juvenile snow crab is the general distribution area for this life stage, 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 mainly of mud.

Adults
EFH for adult snow crab is the general distribution area for this life stage, 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 mainly of mud.

Distribution of Ovigerous females

Distribution of ovigerous females from trawl survey data together with non-pelagic trawl effort is shown in Figure 18. Average snow crab catch from 1997-2000 is shown with the ovigerous female distribution on trawl effort in Figure 19. The historic catch of snow crab overlaps with some areas of recent non –pelagic trawl effort, as well as the southern range of the ovigerous snow crab sampled during 1990-2005 EBS trawl survey.

Gear modifications

Pot gear modification in the directed crab fisheries were designated to reduce incidentally caught crab species. A 3" maximum tunnel height opening for snow crab pots is required to inhibit the bycatch of red king crab. Escape rings and mesh size requirements were adopted by the Board in 1996 and modified in 2000 to reduce capture and handling mortality of non-target crab; a minimum of four 4" rings within one mesh of the bottom of the pot are required on each of at least two sides of a snow crab pot or, instead of rings, ½ of one vertical panel must be composed of at least 5 1/4" stretched mesh. To reduce snow crab bycatch in Tanner crab fisheries, a minimum of four 5.0" rings, or 1/3 of the web on one panel of 7 1/4" stretched mesh, is required. Other gear restrictions include a requirement that crab pots be fitted with a degradable escape mechanism consisting of #30 cotton thread (max. diameter) or a 30-day galvanic timed release mechanism (NPFMC 2005)

Bycatch protection measures for snow crab

Bycatch limits for snow crab in groundfish trawl fisheries were established under amendment 40, which became effective in 1998. Snow crab PSC limits are apportioned among fisheries in anticipation of their bycatch needs for the year. A PSC limit is established for snow crab in a defined area that fluctuates with abundance except at high and low stock sizes. The PSC cap is established at 0.1133% of the total Bering Sea abundance (as indicated by the NMFS trawl survey), with a minimum PSC of 4.35 million snow crabs and a maximum PSC of 13 million snow crabs. Snow crab taken within the "C. opilio Bycatch Limitation Zone" (COBLZ) accrue towards the PSC limits established for individual trawl fisheries (Figure 20). Upon attainment of a snow crab PSC limit apportioned to a particular trawl target fishery, that fishery is prohibited from fishing within the COBLZ. In 1998 the bycatch limit for snow crab was further reduced by an additional 150,000 crabs as part of amendment 57.

The total snow crab limit in 2005 was established as 4,858,992 crabs. Fisheries in 2005 had the following bycatch (and associated fishery-specific limits) within the COBLZ (Table 5, data from NMFS Catch Accounting).

Table 5. Bycatch of EBS snow crabs in the COBLZ in 2005 bottom trawl fisheries

Fishery	**Limit**	**Total Catch**
Pacific cod	139,331	31,865
Rockfish	44,945	0
Rock sole, flathead sole, other flatfish	1,082,528	197,350
Pollock, Atka Mackerel, other species	80,903	1,623
Yellowfin sole	3,101,915	3,006,557
Greenland turbot, Arrowtooth, Sablefish	44,946	0
Opilio crab PSQ (CDQ fishery)	364,424	7,558
Total	**4,858,992**	**3,244,954**

Under the proposed amendment 80, the current bycatch limits as established by amendment 40 for *C. opilio* will be changed. Under the preferred alternative for amendment 80, once annually calculated according to the formula noted above (0.1133% of the total Bering Sea abundance), 61.44% of the cap will be allocated to the head and gut (H&G) sector of the trawl fleet. To accommodate the potential PSC savings the sector will likely enjoy from development of cooperatives, the calculated allocation (61.44%) to the H&G sector will be reduced by 20%, which will be phased in at 5% per year over a four year-period starting in the second year of the program. The remaining sectors of the trawl fleet will be limited to their sideboard amounts. The overall effect of this adjustment (and the limitation by the AFA sector to their sideboards) will be a reduction in the total limit (and overall catch) for snow crab in the COBLZ. Additional information can be found in the EA/RIR/IRFA for Amendment 80. This amendment is currently slated for final action at the June 2005 Council meeting.

Bycatch of snow crab in other fisheries

The majority of discards of snow crabs are from directed crab pot fisheries, with groundfish trawl fisheries also accounting for a substantial proportion (Table 6). Discard from the directed snow crab pot fishery was estimated from observer data since 1992 and ranged from 11% to 64% (averaged about 33%) of the retained catch of male crab biomass (Turnock and Rugolo 2005). Female discard catch is very low and not a significant source of mortality.

Table 6 shows the bycatch of snow crabs in directed crab fisheries, groundfish trawl and longline fisheries and scallop dredge fisheries from 1995 – 2004. In recent years the majority of bycatch has occurred in the directed crab fisheries and the groundfish trawl fisheries. In the groundfish trawl fisheries, most discards for 2005 came from the yellowfin sole fishery (Table 5). Some bycatch of snow crabs also occurs in both fixed gear groundfish fisheries and scallop fisheries

Table 6. Bycatch of EBS snow crabs (numbers of crab) in Bering Sea fisheries, 1995-2004.

	directed	**groundfish**	**groundfish**	**scallop**	
Year	**crab pot**	**trawl**	**fixed gear**	**dredge**	**Total**
1995	48,734,000	5,165,555	230,233	0	54,129,788
1996	56,570,785	3,643,612	267,395	104,836	60,586,628
1997	75,005,446	5,276,208	554,103	195,345	81,031,102
1998	51,591,453	4,122,648	549,139	232,911	56,496,151
1999	47,093,200	1,544,747	269,778	150,421	49,058,146
2000	5,020,800	2,207,279	270,000	105,602	7,603,681
2001	6,123,100	1,293,143	215,000	68,458	7,699,701
2002	15,823,300	882,967	n/a	70,795	n/a
2003	22,140,336	615,012	86,313	16,206	22,857,867
2004	4,800,043	1,693,101	140,428	3,843	6,637,415

Bycatch mortality rates in trawl, dredge, and fixed gear fisheries for all crab species were set at 80%, 40%, and 20% respectively for analytical purposes based on previous analyses (e.g. NPFMC 1999). For crab fisheries, mortality rates were averaged across different fisheries. Rates used were 24% for *C. opilio*, 20% for *C. bairdi*, and 8% for blue king crab and red king crab. Bycatch mortality estimates are calculated using as total numbers and as a percentage of the annual population estimate for the EBS snow stock using the annual bycatch amounts by fishery in Table 6 are shown below (Table 7). Bycatch in each year shown is less than 1% of the estimated population abundance, and in recent years is much lower.

Table 7. EBS snow crab bycatch mortality estimates and proportion of population abundance

Year	Total Bycatch	Bycatch mortality	Abundance (millions)	Bycatch as %
1995	54,129,788	15,874,651	8,655.3	0.18
1996	60,586,628	16,587,291	5,424.9	0.31
1997	81,031,102	22,411,232	4,107.5	0.55
1998	56,496,151	15,883,059	3,233.3	0.49
1999	49,058,146	11,349,869	1,401.0	0.81
2000	7,603,681	3,067,056	3,241.2	0.09
2001	7,699,701	2,589,299	3,861.3	0.07
2002	n/a	4,503,965	1,517.7	0.30
2003	22,857,867	5,805,709	2,630.8	0.22
2004	6,637,415	2,531,803	4,420.7	0.06

Summary of Measures Considered and Adopted Under Rebuilding Plan

A rebuilding plan for Bering Sea snow crab was approved in January 2001 following the overfished declaration of 1999. Consideration of the rebuilding plan included several different options for harvest strategy, bycatch controls and habitat protection. Some of these options were implemented under the rebuilding plan. The preferred options under the approved rebuilding plan included a new harvest strategy (approved by the Board of Fisheries) which included lower harvest rates at lower biomass levels and a threshold biomass level for fishery opening, bycatch controls in the form of gear modification approved by the Board of Fisheries and maintaining the existing snow crab PSC limits, and habitat protection by highlighting the EFH of snow crab and noting that to the extent feasible and practicable this area should be protected from adverse impacts.

Additional habitat protection measures were considered in the EA analysis of amendment 14 to the FMP (the snow crab rebuilding plan). These measures included changing the PSC limits for the existing area closures, developing new area closures for areas important to juvenile snow crab, developing new fishery closures for areas important to mature female snow crab, and bottom trawl closures for areas identified as important to both juvenile and mature female snow crab (NPFMC 2000b). The analysis noted that based on plots of bottom trawl intensity from observer data, the intensity of bottom trawling in the areas identified as important to juvenile and mature female snow crab is very low (NPFMC 2000b). Additional analysis was cited (Fritz et al., 1998) indicating that catch-per-unit-effort, length, and depth distributions of major groundfish species in the Bering Sea show that these are areas of marginal trawl effort. The observed bycatch of snow crabs in these areas was also low (NPFMC 2000b). Based on these observations, the analysts were unable to conclude that the areas identified as important to juvenile and mature female snow crab were in need of protection from fishing activities (NPFMC 2000b). Thus additional trawl closure options were not included as a component of the rebuilding plan.

The analysis also noted that some portion of the snow crab stock is protected by existing closure areas, noting that areas were more protective of large males than other groups, particularly during summer months (NPFMC 2000b). The Pribilof Island Habitat Conservation Zone was an area noted to be of use to mature male crabs. The analysts suggested that "bycatch trends be closely monitored in the future to determine if current PSC limits are negatively affecting stock recovery" (NPFMC 2000b). An option in the rebuilding plan was considered to reduce the snow crab bycatch limit at low levels (i.e. by removing the minimum of 4.35 million crabs). This was noted to potentially maintain tighter control on the allowable bycatch of snow crabs, particularly when the stock is at low levels (NPFMC 2000b). This option was not selected as the preferred option for bycatch control and the existing PSC limit for snow crab established as a percentage of abundance (as described previously) with a floor and a ceiling on absolute numbers, was retained.

Additional Crab Habitat and Bycatch Measures

Other measures have been enacted by the Council and the National Marine Fisheries Service over the years to protect crab stocks and crab habitat. These additional measures as described below are not specific to either the St. Matthew blue king crab stock or the EBS snow crab stock, but relate to protection measures for both habitat and decreased bycatch in related crab fisheries and may convey positive impacts to the two stocks described in this paper in relation as well.

Red King Crab Savings Area

The Red King Crab Savings Area (162° to 164° W, 56° to 57° N) is closed year-round to non-pelagic trawling (Figure 21). This was enacted under amendment 37 to the BSAI FMP with an effective implementation date of January 1, 1997. The intent of the extended duration of the closure period was to provide for increased protection of adult red king crab and their habitat. To allow some access to productive rock sole fishing areas, the area bounded by 56° to 56°10' N latitude remains pen during years in which a guideline harvest level for Bristol Bay red king crab is established. A separate bycatch limit for this area is established at no more than 35% of the red king crab prohibited species catch (PSC) limits apportioned to the rock sole fishery.

Nearshore Bristol Bay Closure

Nearshore waters of Bristol Bay the area east of 162° W are also closed to all trawling (Figure 22), with the exception of an area bounded by 159° to 160° W and 58° to 58°43' N that remains open to trawling during the period April 1 to June 15 each year. This closure was enacted to protect juvenile red king crab and critical rearing habitat while at the same time allow trawling in an area that can have high catches of flatfish and low bycatch of other species. The area north of 58°43' N was closed to reduce bycatch of herring, and also of halibut, which move into the nearshore area in June.

Crab and Halibut Protection Zone

The crab and halibut protection zone is closed to all trawling from January 1 to December 31 (Figure 23). For the period March 15 to June 15, the western border of the zone extends westward. For practical purposes this closure has been largely superseded by the Nearshore Bristol Bay closure with the exception of the western extension of the closure from March 15 to June 15.

Pribilof Islands Habitat Conservation Area

The Pribilof Islands Habitat Conservation Zone was established under amendment 21a to the BSAI FMP and became effective in January, 1995. All trawling is prohibited from the designated area (Figure 24). The purpose of the closure was to eliminate trawl activities in areas of importance to blue king crab and Korean hair crab stocks, as well as reducing the bycatch of juvenile halibut and crab and mitigate any unobserved mortality or habitat modification that occurred due to trawling. The closure area was selected as it surrounded the area with the highest blue king crab concentration.

Red King Crab PSC limits

Amendment 37 PSC limits for Zone 1 red king crab.

Abundance	PSC Limit
Below threshold or 14.5 million lbs of effective spawning biomass (ESB)	33,000 crabs
Above threshold, but below 55 million lbs of ESB	97,000 crabs
Above 55 million lbs of ESB	197,000 crabs

PSC limits are based on the abundance of Bristol Bay red king crab as shown in the adjacent table. In 1999, red king crab bycatch was reduced from previous limits by an additional 3,000 crabs. In years when red king crab in Bristol Bay are below threshold of 8.4 million mature crabs, a PSC limit of 33,000 red king crab is established in Zone 1 (Figure 25). In years when the stock is above threshold but below the target rebuilding level of 55 million pounds of effective spawning biomass, a PSC limit of 97,000 red king crab is established. A 197,000 PSC limit is established in years when the Bristol Bay red king crab stock is rebuilt (above threshold and above 55 million pounds of effective spawning biomass). Based on the 2005 estimate of effective spawning biomass (68 million pounds), the PSC limit for 2006 is 197,000 red king crabs. The regulations also specify that up to 35% of the PSC apportioned to the rock sole fishery can be used in the 56º - 56º10'N strip of the Red King Crab Savings Area. The red king crab cap has generally been allocated among the pollock/mackerel/other species, Pacific cod, rock sole, and yellowfin sole fisheries. Once a fishery exceeds its red king crab PSC limit, Zone 1 is closed to that fishery for the remainder of the year, unless further allocated by season.

Bairdi PSC limits

PSC limits are established for *bairdi* Tanner crab under amendment 41 to the BSAI FMP. These limits are established in Zones 1 and 2 based on total abundance of *bairdi* crab as indicated by the NMFS trawl survey (Figure 25). Based on 2005 abundance (763 million crabs), and an additional reduction implemented in 1999, the PSC limit for *C. bairdi* in 2006 is 980,000 (1,000,000 minus 20,000) *bairdi* crabs in Zone 1 and 2,970,000 (3,000,000 minus 30,000) crabs in Zone 2.

PSC limits for bairdi Tanner crab.

Zone	Abundance	PSC Limit
Zone 1	0-150 million crabs	0.5% of abundance
	150-270 million crabs	750,000
	270-400 million crabs	850,000
	over 400 million crabs	1,000,000
Zone 2	0-175 million crabs	1.2% of abundance
	175-290 million crabs	2,100,000
	290-400 million crabs	2,550,000
	over 400 million crabs	3,000,000

These limits may also be impacted depending upon the preferred alternative adopted by the Council under proposed amendment 80.

Other Considerations

The benefits that rationalized fisheries can bring to habitat protection efforts are discussed by the National Resource Council (NRC) in its recent report on the effects of bottom trawling and dredging on seafloor habitat. That report notes that, in an open access fishery, “the need or desire to increase catches can lead to increases in effort and expansion into new and sometimes more sensitive habitats. Effort reduction could slow or arrest this process, decrease the incentive to develop new and more intrusive gear, and limit or reduce the spatial extent of [fisheries] and hence their impacts on seafloor habitat.” (NRC 2002).

Rationalization of excess fishing capital has not been extensively explored as a means to reduce effects of fishing on EFH but a reduction in effort clearly reduces effects. Reduction of effort has occurred in Alaska fisheries via several rationalization programs: BS Crab Rationalization, American Fisheries Act (AFA), CDQ Program, and the halibut/sablefish IFQ program. The fast pace of the previous overcapitalized, high capacity fleet that significantly decreased under rationalization to longer seasons and a slower paced fishery should result in less fishing of marginal areas where habitat impacts might occur, a further reduction in gear loss, bycatch and a decrease in the disruption of community structure/behavior and other stock impacts.

The Council has addressed impacts of fishing gear on seafloor habitat through several existing measures. For example, in 1990, concerns about bycatch and seafloor habitats affected by this the EBS pollock fishery led the NPFMC to apportion 88 percent of TAC to the pelagic trawl fishery and 12 percent to the non-pelagic trawl fishery (NPFMC, 1999). Non-pelagic trawl gear is defined as trawl gear that results in the vessel having 20 or more crabs (*Chionecetes bairdi*, *C. opilio*, and *Paralithodes camstschaticus*) larger than 1.5 inches carapace width on board at any time. Crabs were chosen as the standard because they live only on the seabed and they provide proof that the trawl has been in contact with the bottom (NRC, 2002). Subsequently in 1999, with broad industry and public support, the NPFMC banned bottom trawl gear use in the Bering Sea pollock fishery. The fishery now attains TAC specifications with modest bycatch rates. Although this gear was modified to reduce bycatch, it is postulated to have had the secondary effect of diminishing the impact on seafloor habitat. However, these trawls may be frequently fished in contact with the seafloor, especially in shallow water (<50 fathoms). To confirm that this gear has reduced seafloor impacts, the extent of bottom contact and disturbance should be quantified. If the trawls never touch the bottom, the pelagic trawl definition could be set at zero crab tolerance. Further reduction in effort occurred with the passage of AFA.

Summary

The St. Matthew blue king crab stock remains in an 'overfished' condition. A weakly increasing trend in total mature biomass is seen in survey estimates from 1999-2005 (NPFMC 2005). The fishery has been closed since 1999. The habitat measures that were considered under the rebuilding plan in 2000 (i.e. State waters closure around St. Matthew Islands, Hall Island and Pinnacles Island and highlighting the important of blue king crab EFH) were adopted under the rebuilding plan at that time. These measures remain in effect today. No additional information appears available at this time to suggest additional habitat areas of importance to the St. Matthew blue king crab stock. The impact of continued groundfish trawl bycatch of St. Matthew blue king crabs is unknown, however the observer estimates of bycatch by fishery in comparison with population abundance are summarized annually in the Crab SAFE report (e.g., NPFMC 2005).

The eastern Bering Sea snow crab stock remains under a rebuilding plan, although the 2005 total mature biomass (TMB) is estimated to be above the minimum stock size threshold (MSST). The stock has not rebuilt to its B_{msy} level under the rebuilding plan, however the TMB estimate for 2005 relative to those for 2002-2004 indicated a trend towards rebuilding (NPFMC 2005). Biomass estimates for this stock however have been highly variable over the years.

Some harvest of snow crab occurs annually under the harvest strategy approved in the rebuilding plan. Conservation concerns have been noted (Turnock 2004, Crab Plan Team 2004, Turnock and Rugolo 2005) due to the differential harvest of snow crab north and south of 58.5º by the directed crab fishery. No specific conservation concerns have been noted recently with respect to the trawl bycatch of snow crabs. The groundfish trawl industry bycatch is limited by the COBLZ triggered area closure. Additional area closures were considered under the analysis of the rebuilding plan but not brought forward into the alternatives due to a lack of supporting evidence that these areas were candidates for restricting fishing activities at that time. The impact of continued trawl fishery bycatch of snow crab is unknown; however the observer estimates of bycatch by fishery in comparison with population abundance are summarized annually in the Crab SAFE report (e.g., NPFMC 2005).

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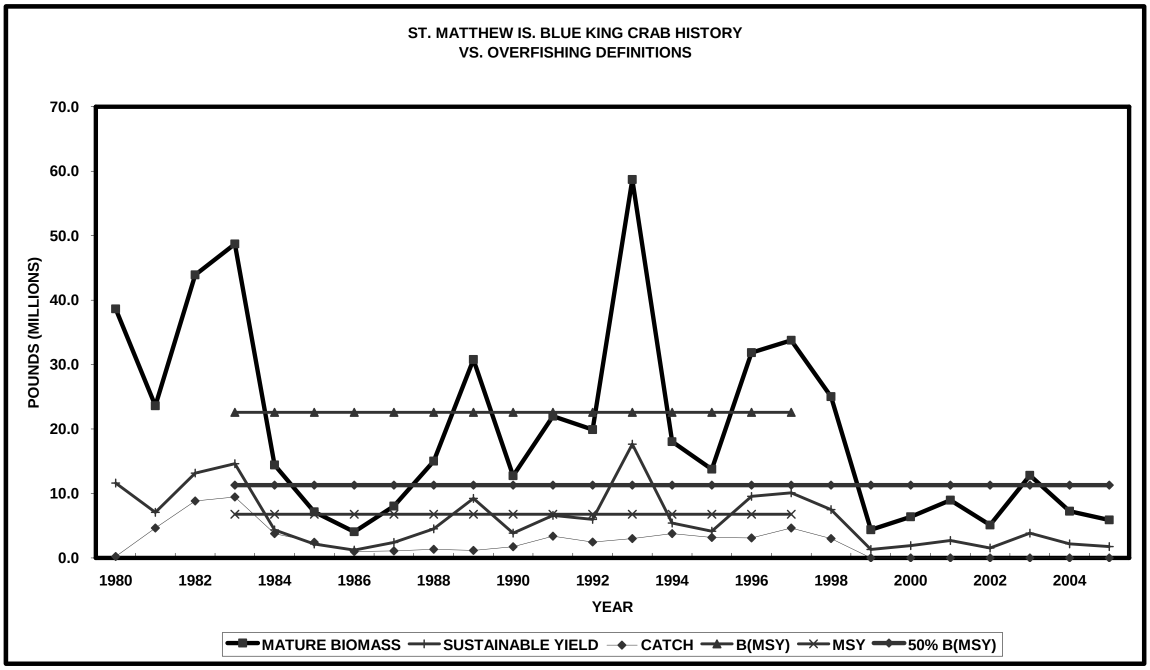

Figure 1. St. Matthew blue king crab mature biomass, catch and biological reference points in relation to overfished status 1980-2005

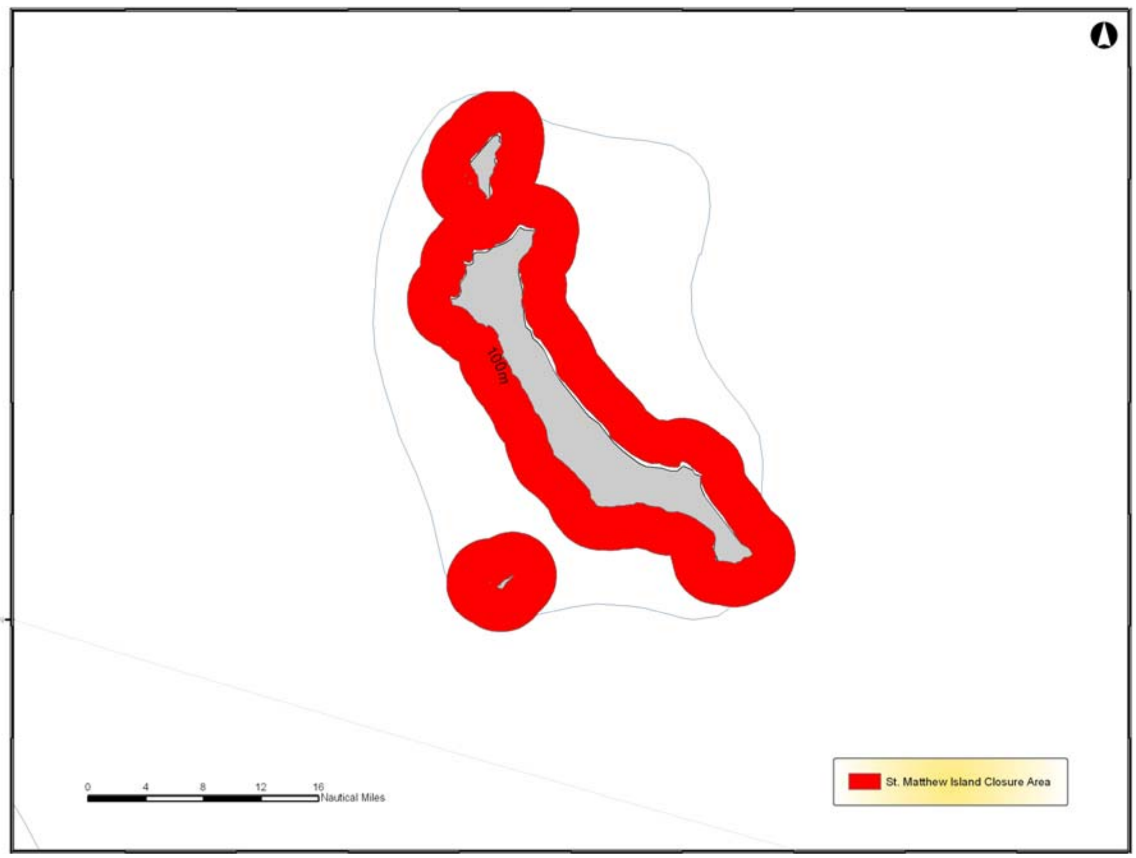

Figure 2. St Matthews Island Closure Area.

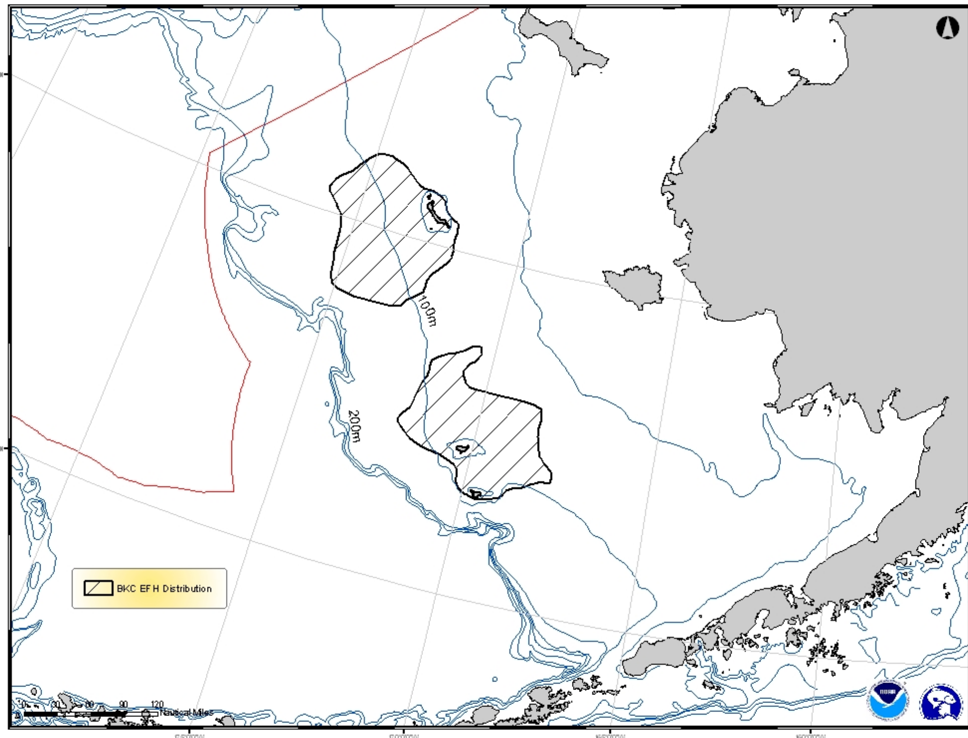

Figure 3. EFH Distribution of BSAI Blue King Crab.

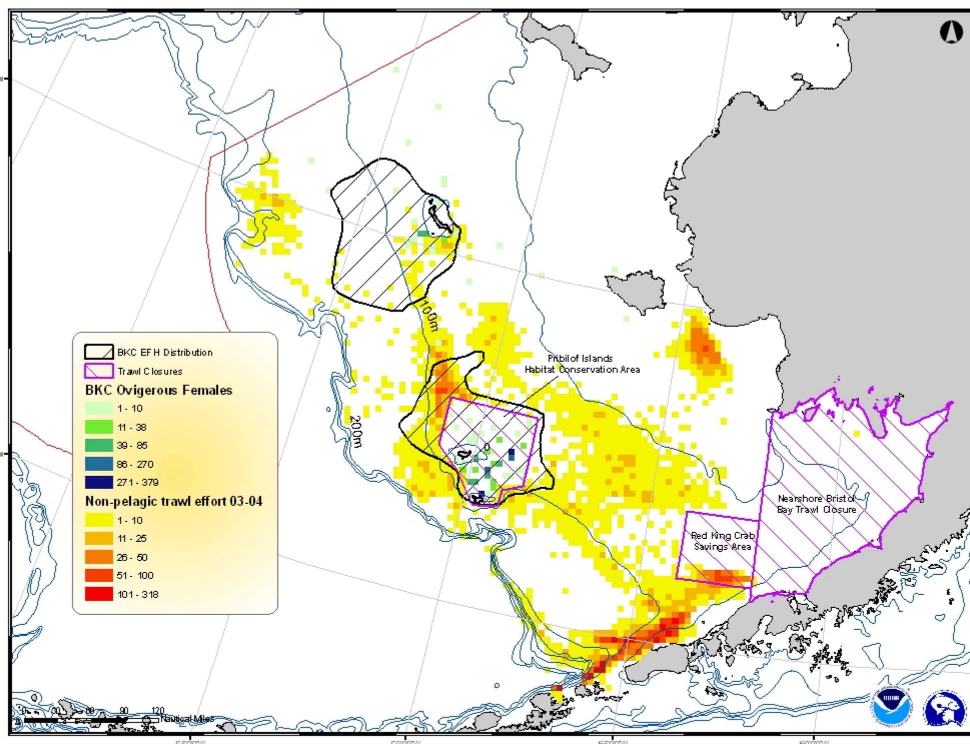

Figure 4. Map of the Eastern Bering Sea with the current fishery closures, BKC EFH, Non pelagic trawl effort from 2003-4 and locations of BKC ovigerous females from the EBS trawl survey 1990-2004.

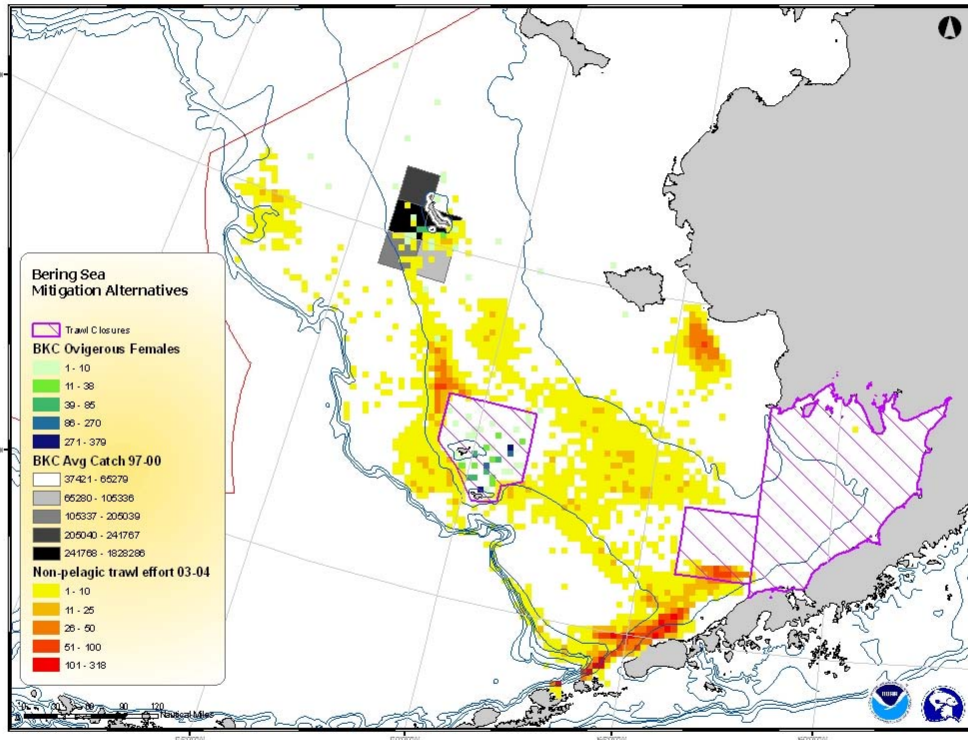

Figure 5 Map of the Eastern Bering Sea with the current fishery closures, BKC EFH, Non pelagic trawl effort from 2003-4 and locations of BKC ovigerous females from the EBS trawl survey 1990-2004, with locations of BKC catch from 1997-2000.

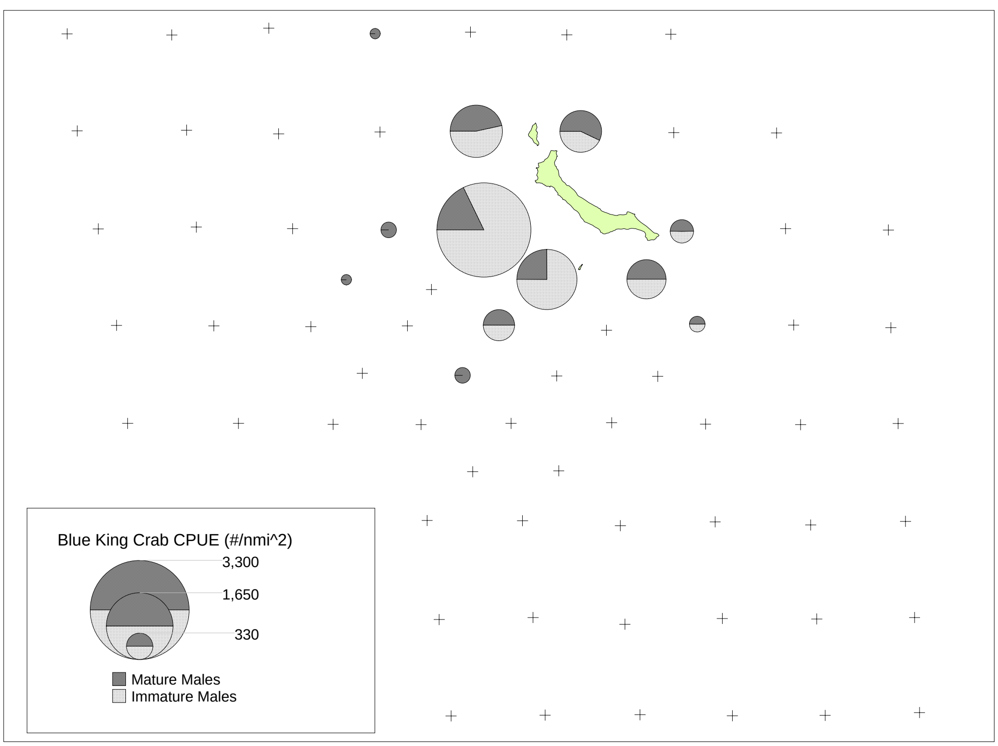

Figure 6. Catch distribution of blue king crab during the 2005 NMFS EBS trawl survey near St. Matthew Island, as summarized by ADF&G.

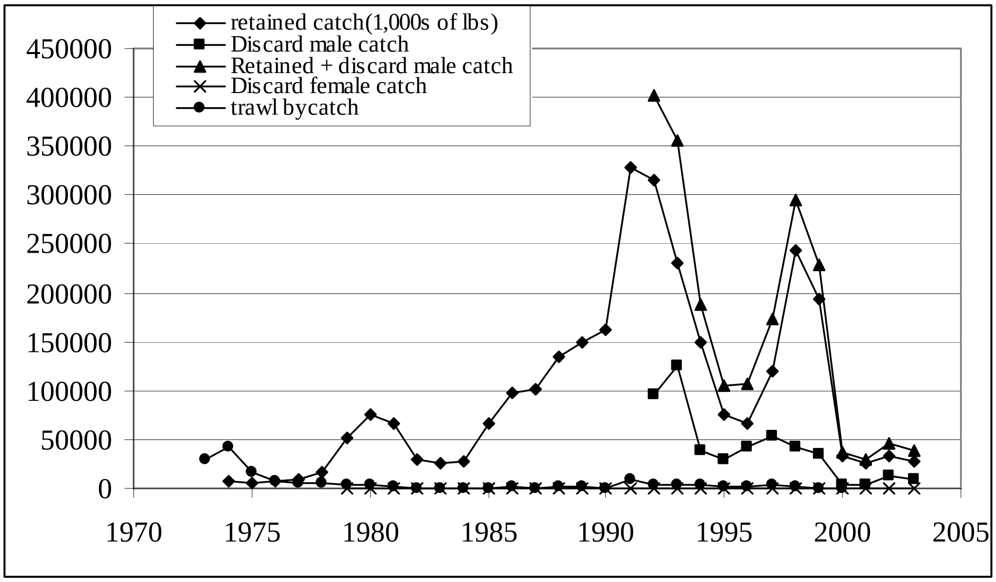

Figure 7. Catch (1,000s lbs) from the directed snow crab pot fishery and groundfish trawl bycatch. Retained and total catch are males only, female catch is the discard mortality from the directed pot fishery and trawl is male and female bycatch from groundfish trawl fisheries (from Turnock and Rugolo 2005).

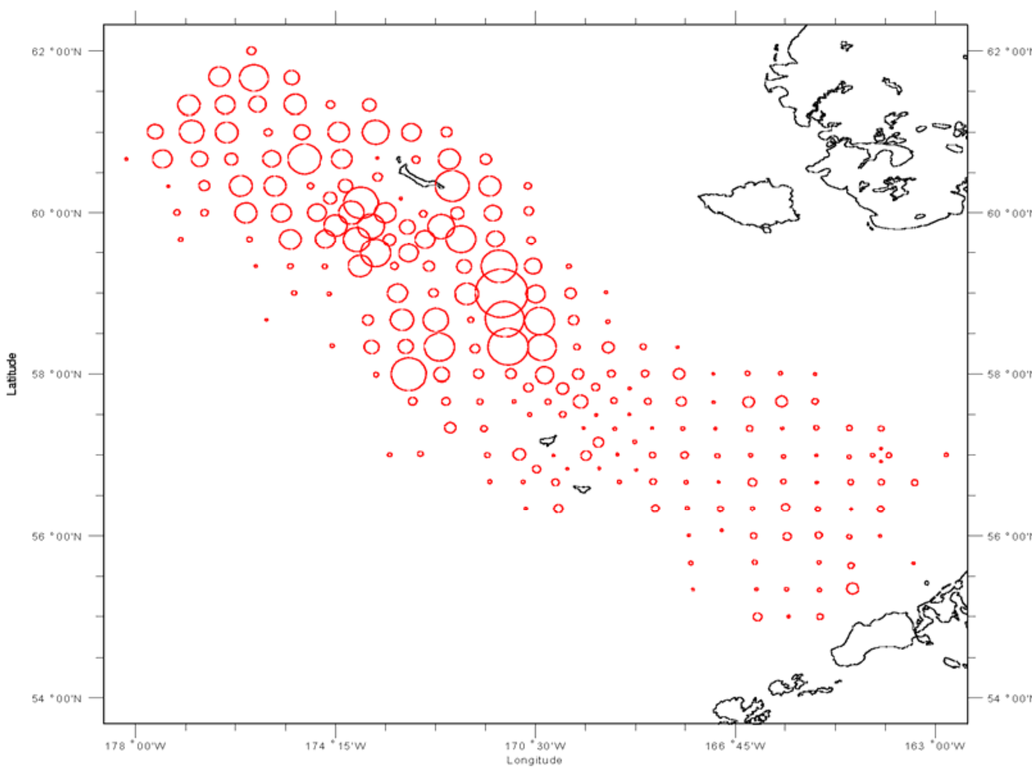

Figure 8 2004 Survey abundance of males > 79 mm (approximately mature abundance) by tow. Abundance is proportional to the area of the circle (not on same scale as female abundance in Figure 9). From Turnock and Rugolo (2005).

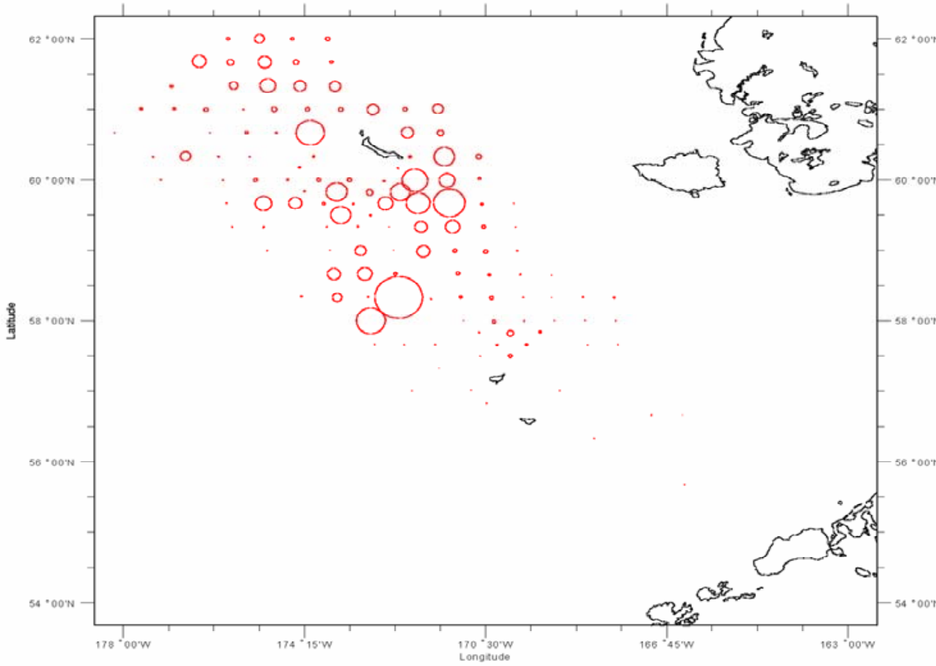

Figure 9 2004 Survey abundance of females > 49 mm (approximately mature abundance) by tow. Abundance is proportional to the area of the circle (not on the same scale as male abundance in Figure 8). From Turnock and Rugolo (2005).

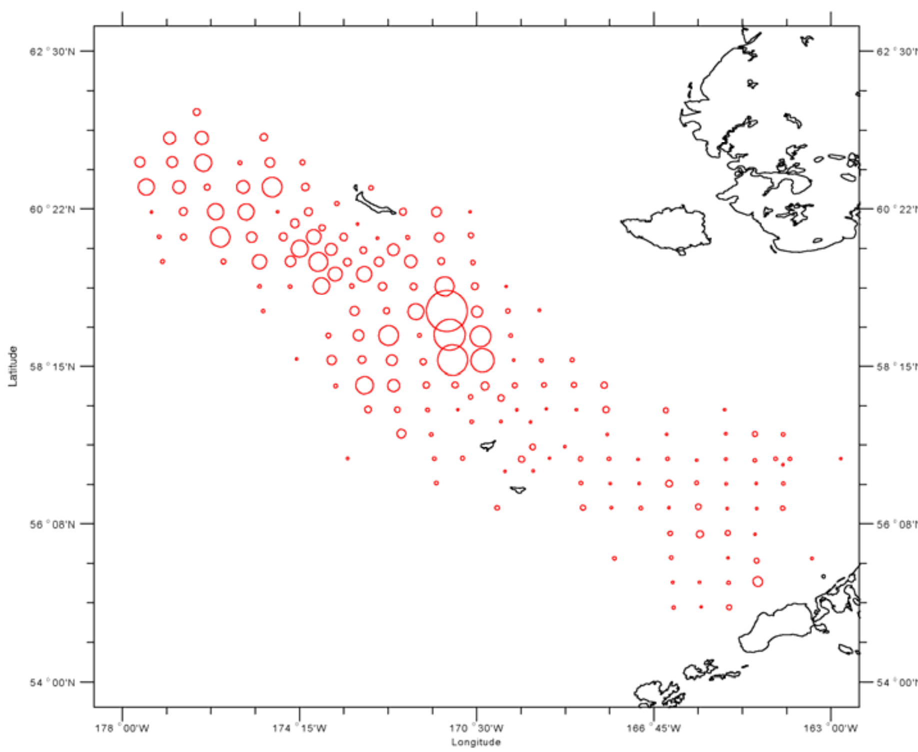

Figure 10 2004 Survey abundance of males > 101 mm by tow. Abundance is proportional to the area of the circle. From Turnock and Rugolo (2005).

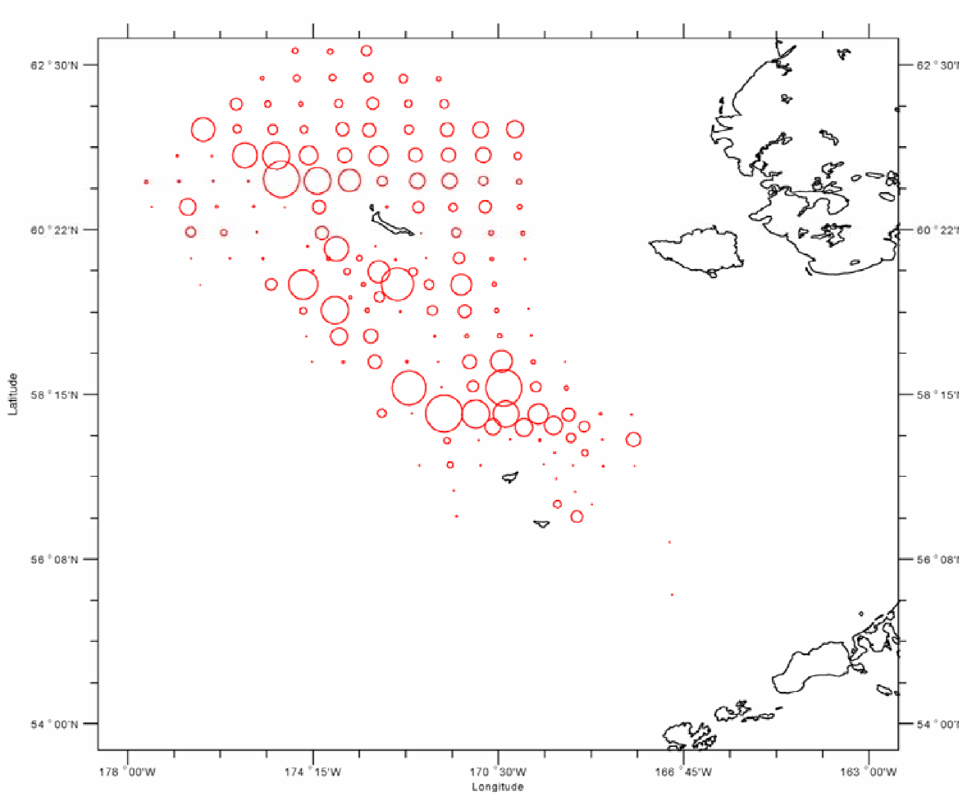

Figure 11 2005 Survey abundance of females > 49 mm (approximately mature abundance) by tow. Abundance is proportional to the area of the circle (not on the same scale as male abundance in Figure 10). Includes stations to the north of the standard survey area. From Turnock and Rugolo (2005).

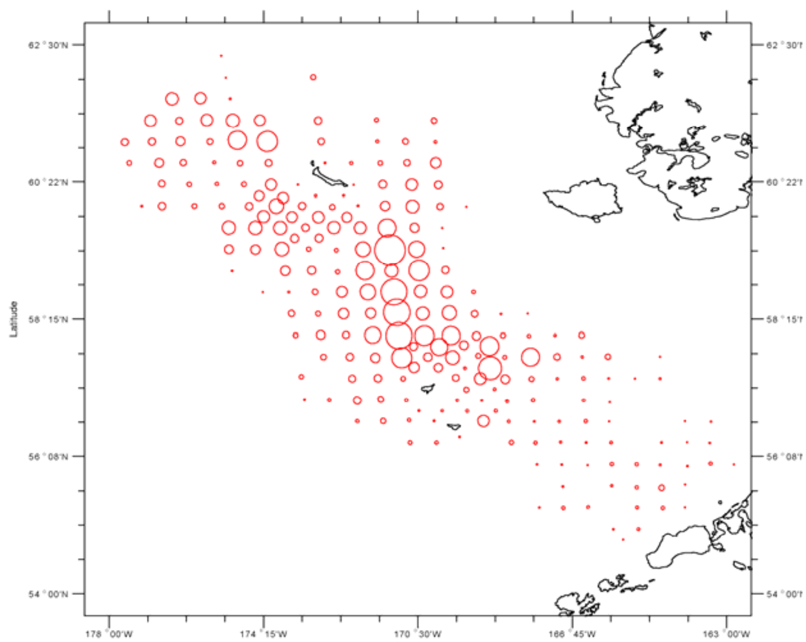

Figure 12 2005 Survey abundance of males > 79 mm (approximately mature abundance) by tow. Abundance is proportional to the area of the circle (not on same scale as female abundance in Figure 11). From Turnock and Rugolo (2005)

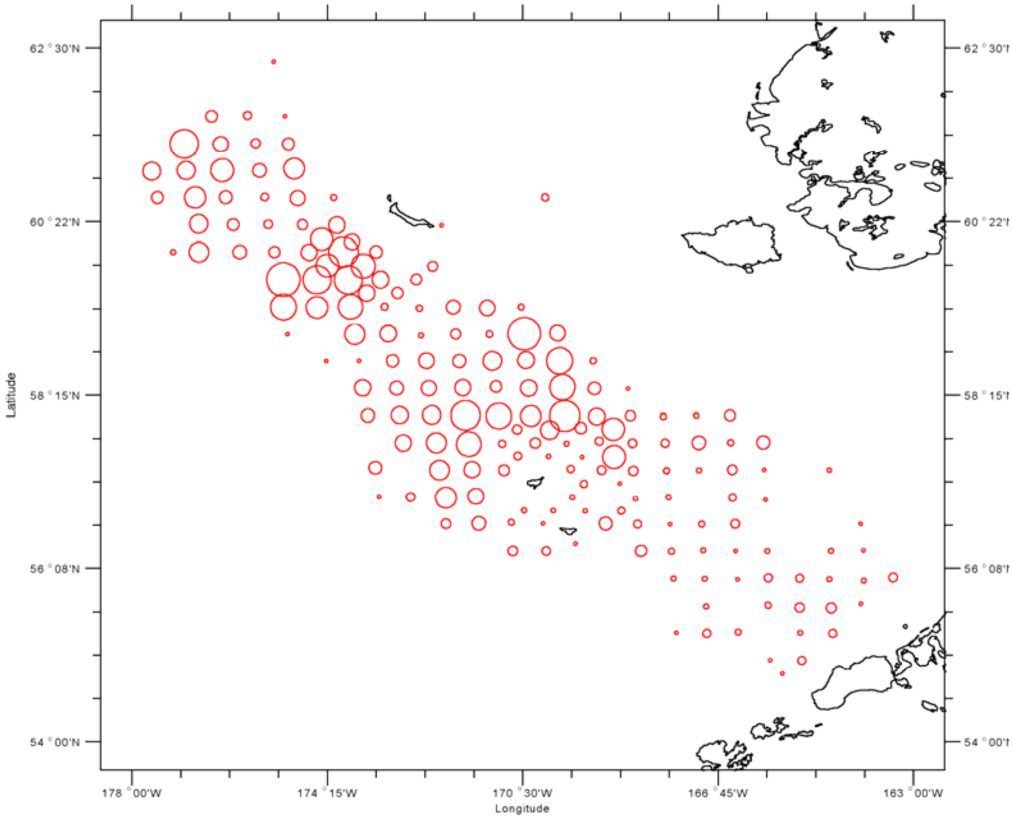

Figure 13 2005 Survey abundance of males > 101 mm by tow. Abundance is proportional to the area of the circle. From Turnock and Rugolo (2005).

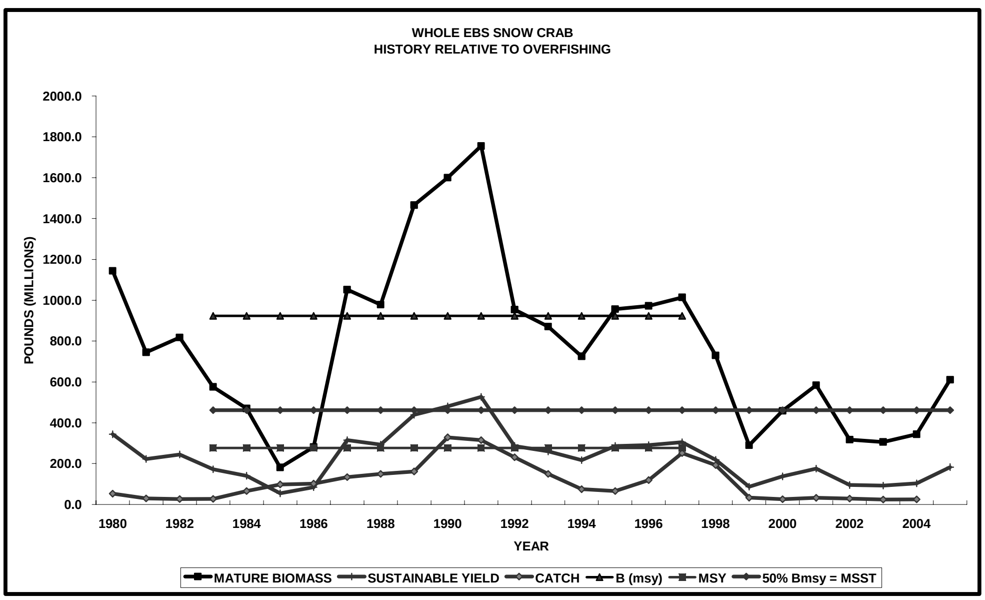

Figure 14 EBS snow crab mature biomass, catch and biological reference points in relation to overfished status 1980-2005

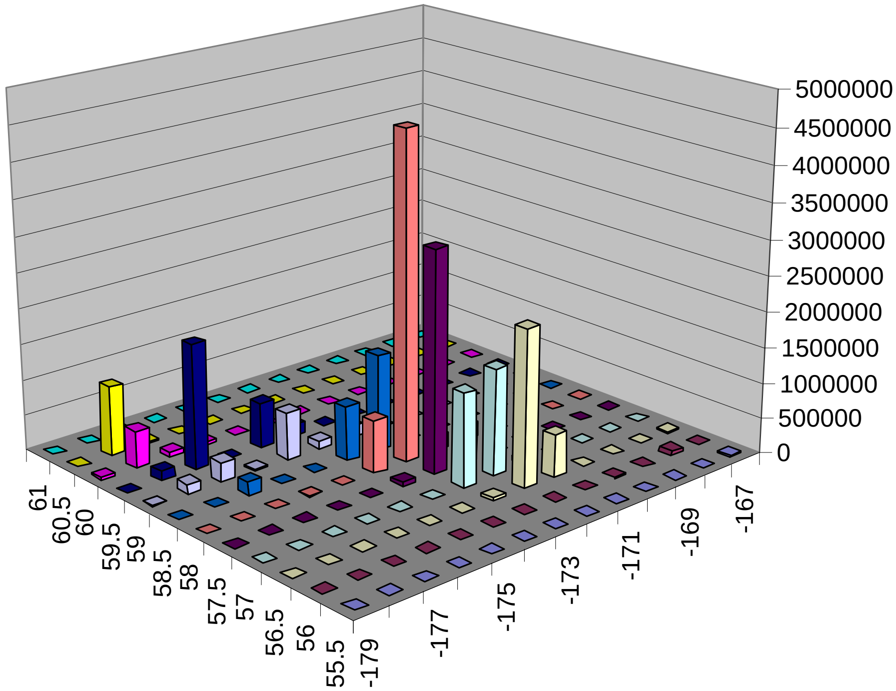

Figure 15 2003 pot fishery retained catch in numbers by statistical area. Longitude in negative degrees. Areas are 1 degree longitude by 0.5 degree latitude. From Turnock and Rugolo (2005).

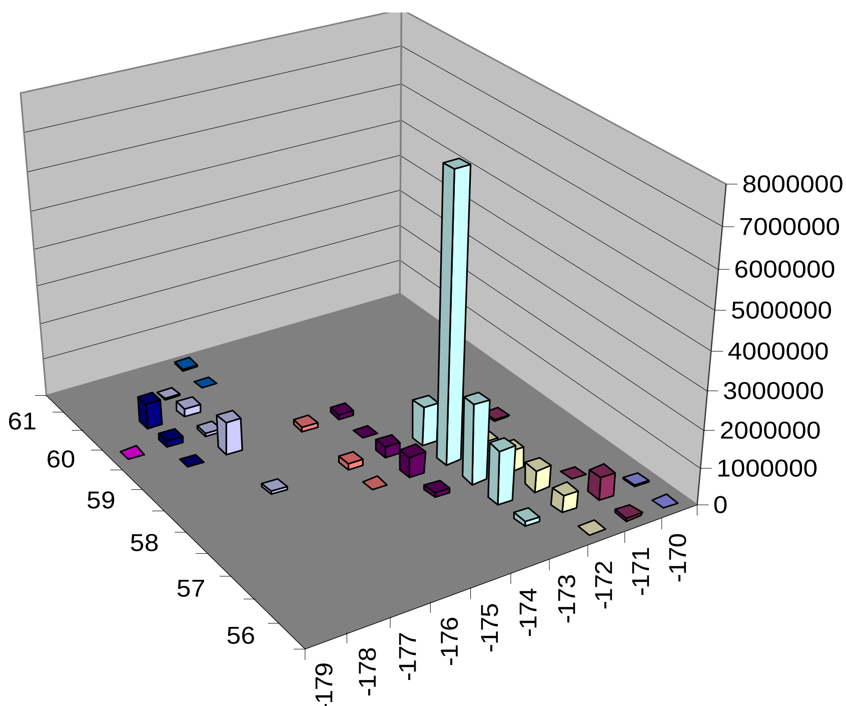

Figure 16 2004 pot fishery retained catch in numbers by statistical area. Longitude in negative degrees. Areas are 1 degree longitude by 0.5 degree latitude. From Turnock and Rugolo (2005).

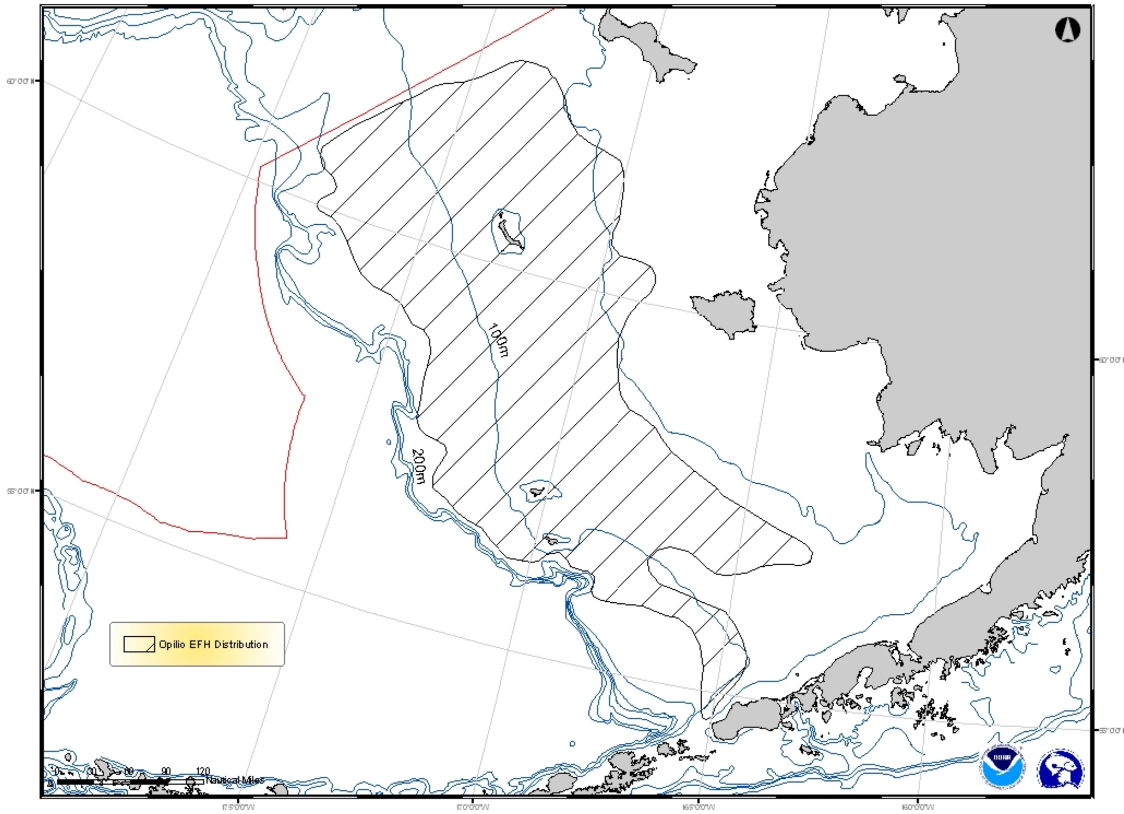

Figure 17 EFH Distribution of BSAI Opilio Crab (Snow crab).

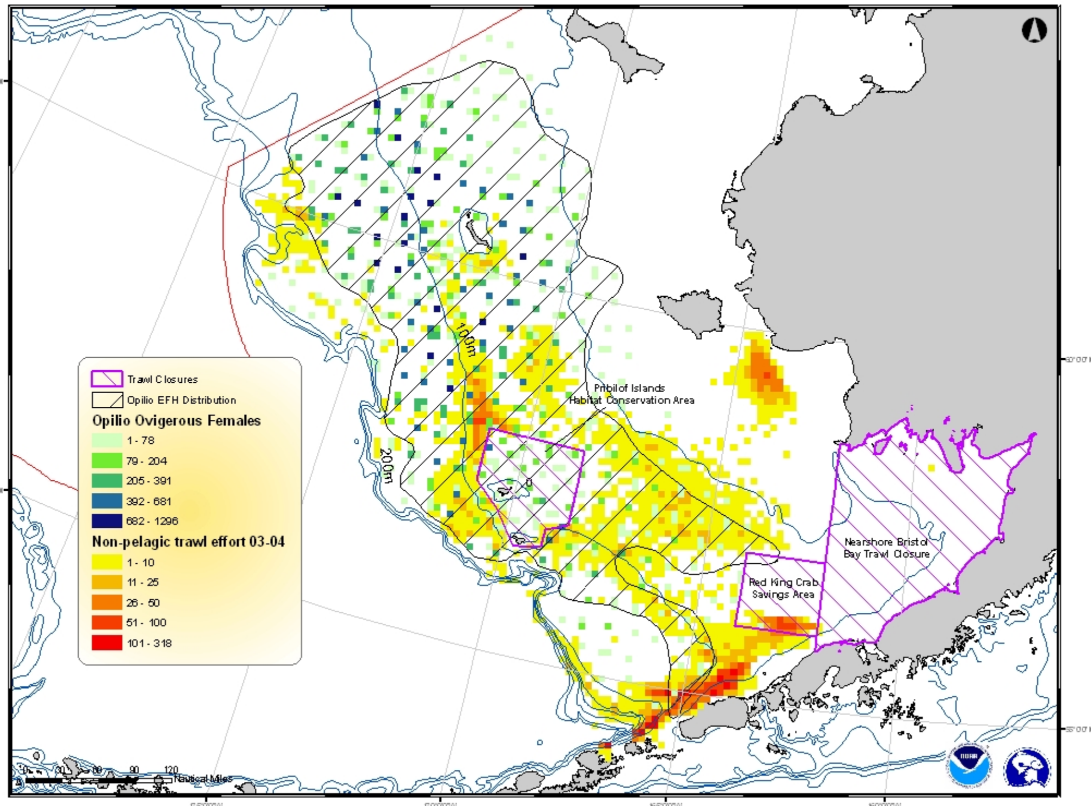

Figure 18. Map of the Eastern Bering Sea with the current fishery closures, Opilio EFH, Non pelagic trawl effort from 2003-4 and locations of Opilio ovigerous females from the EBS trawl survey 1990-2004.

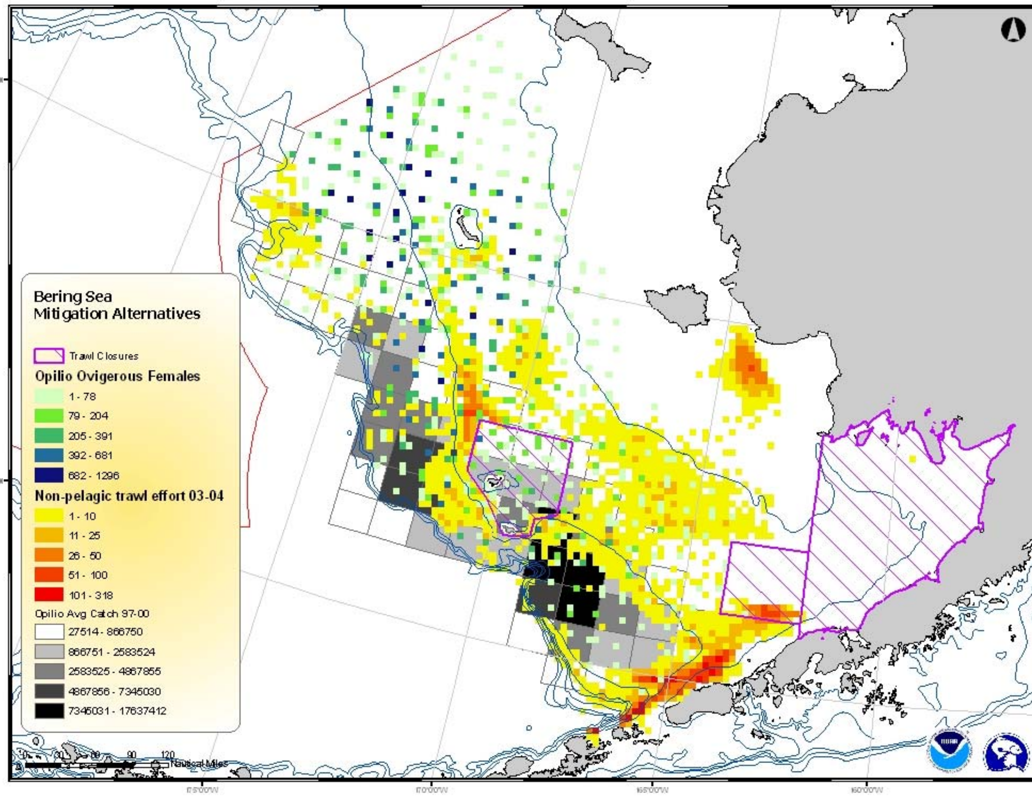

Figure 19. Map of the Eastern Bering Sea with the current fishery closures, Opilio EFH, Non pelagic trawl effort from 2003-4 and locations of Opilio ovigerous females from the EBS trawl survey 1990-2004, with locations of Opilio average catch from 1997-2000.

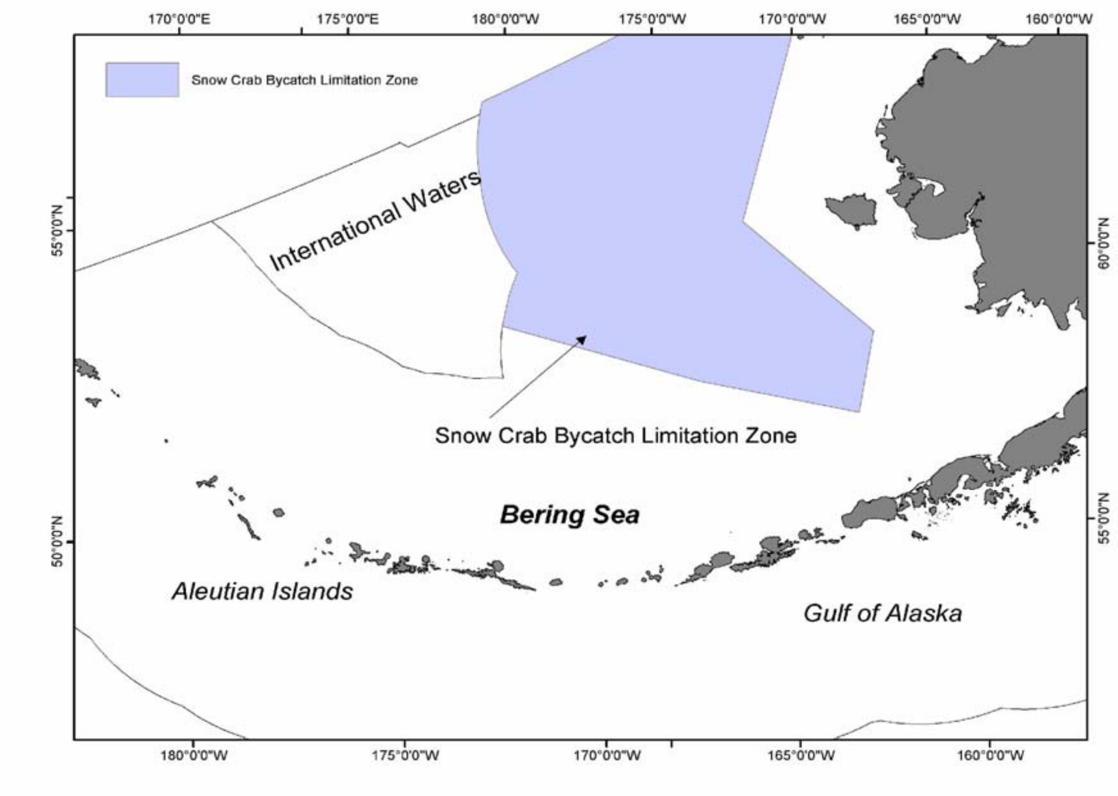

Figure 20 ***Chionoecetes opilio*** **Bycatch Limitation Zone**

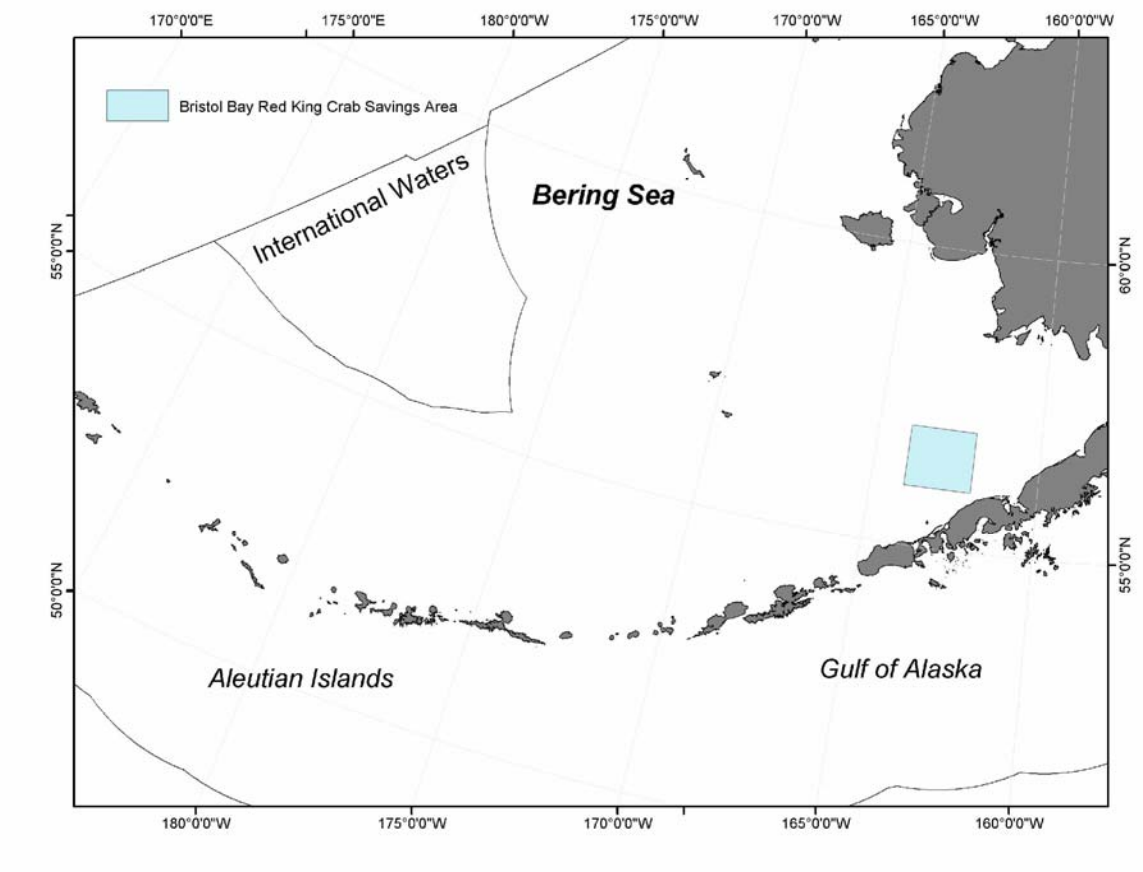

Figure 21. Red King Crab Savings Area

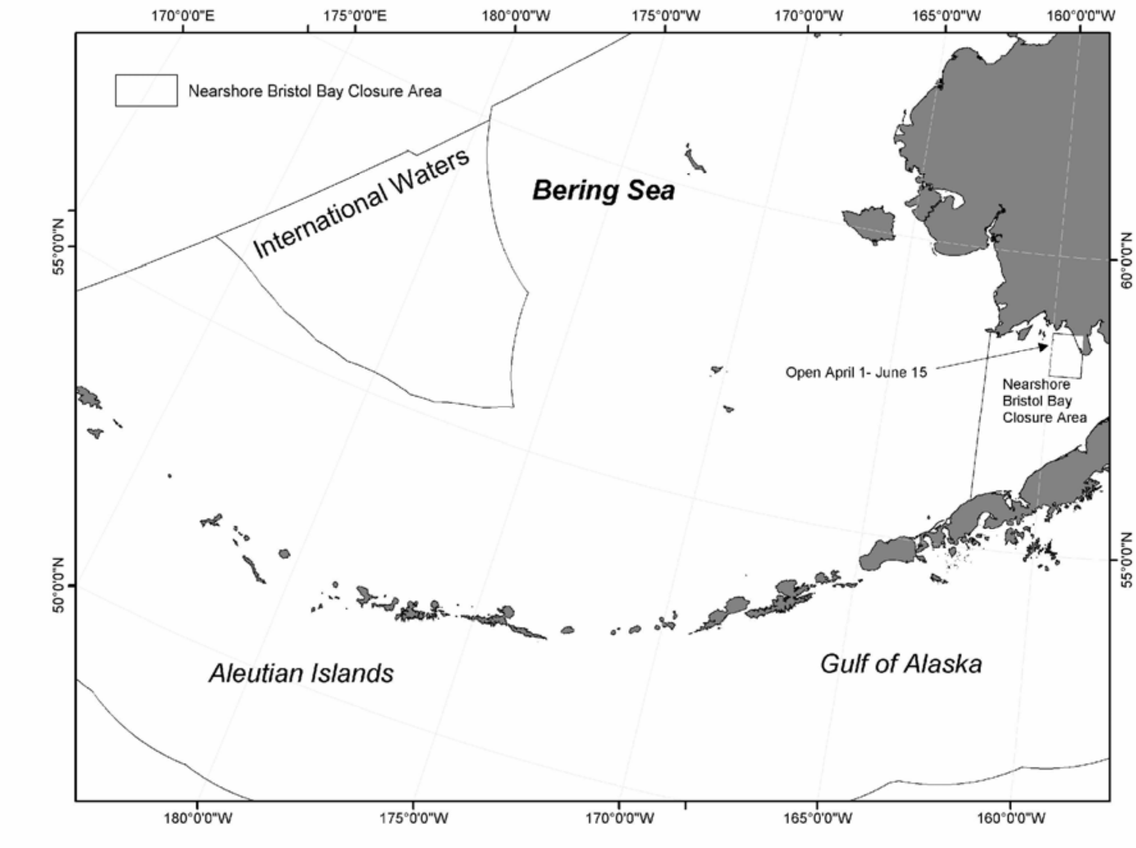

Figure 22 Nearshore Bristol Bay Closure

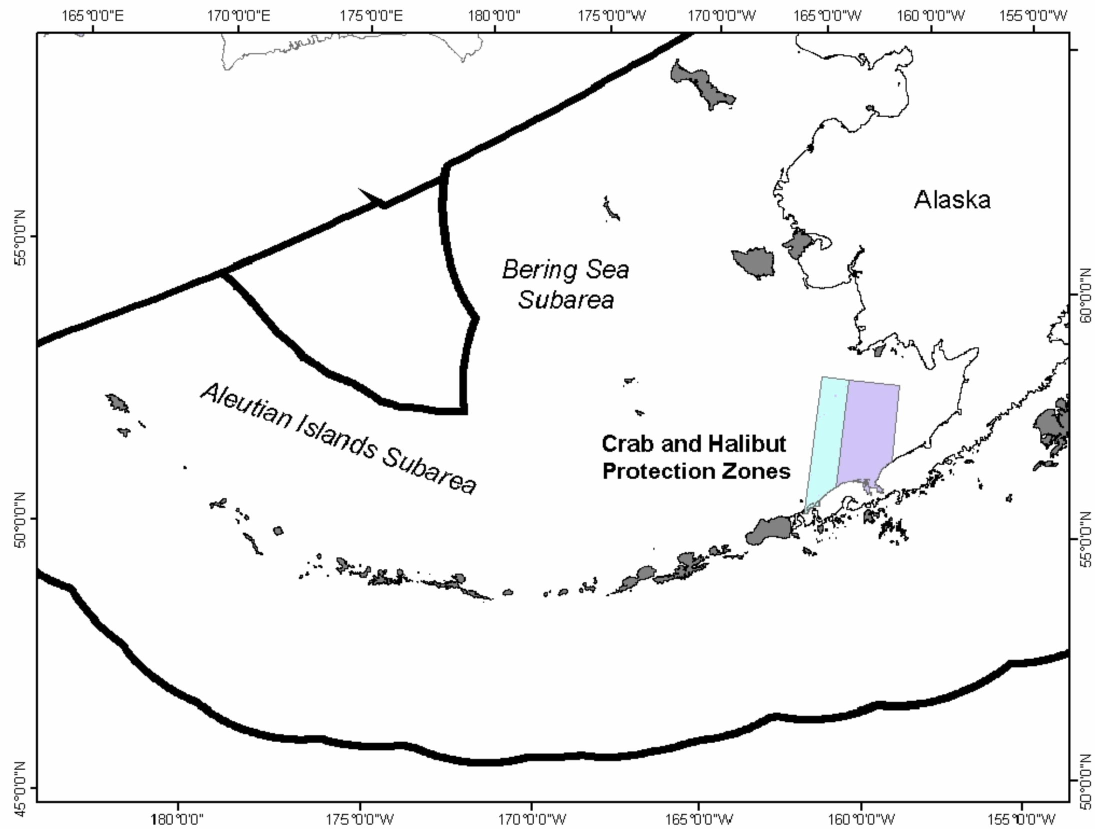

Figure 23 Crab and Halibut Protection Zones

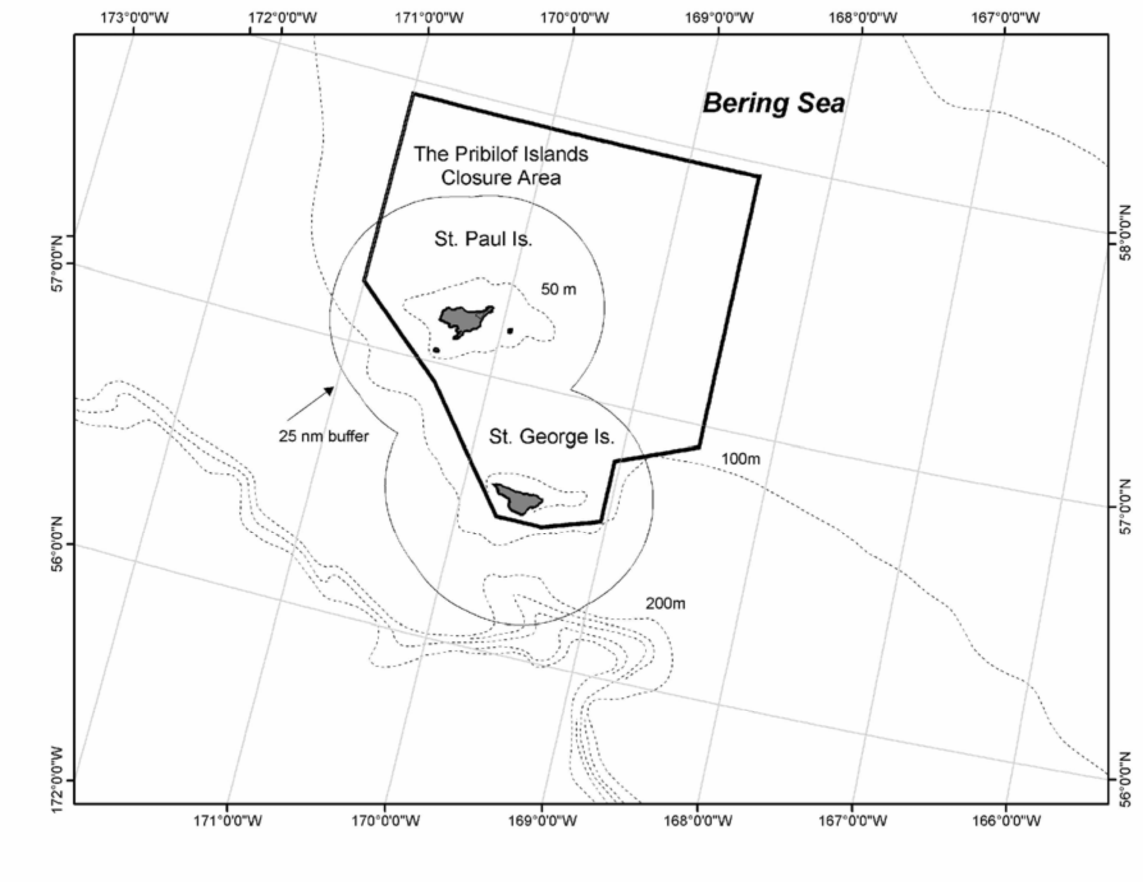

Figure 24 Pribilof Islands Habitat Conservation Zone

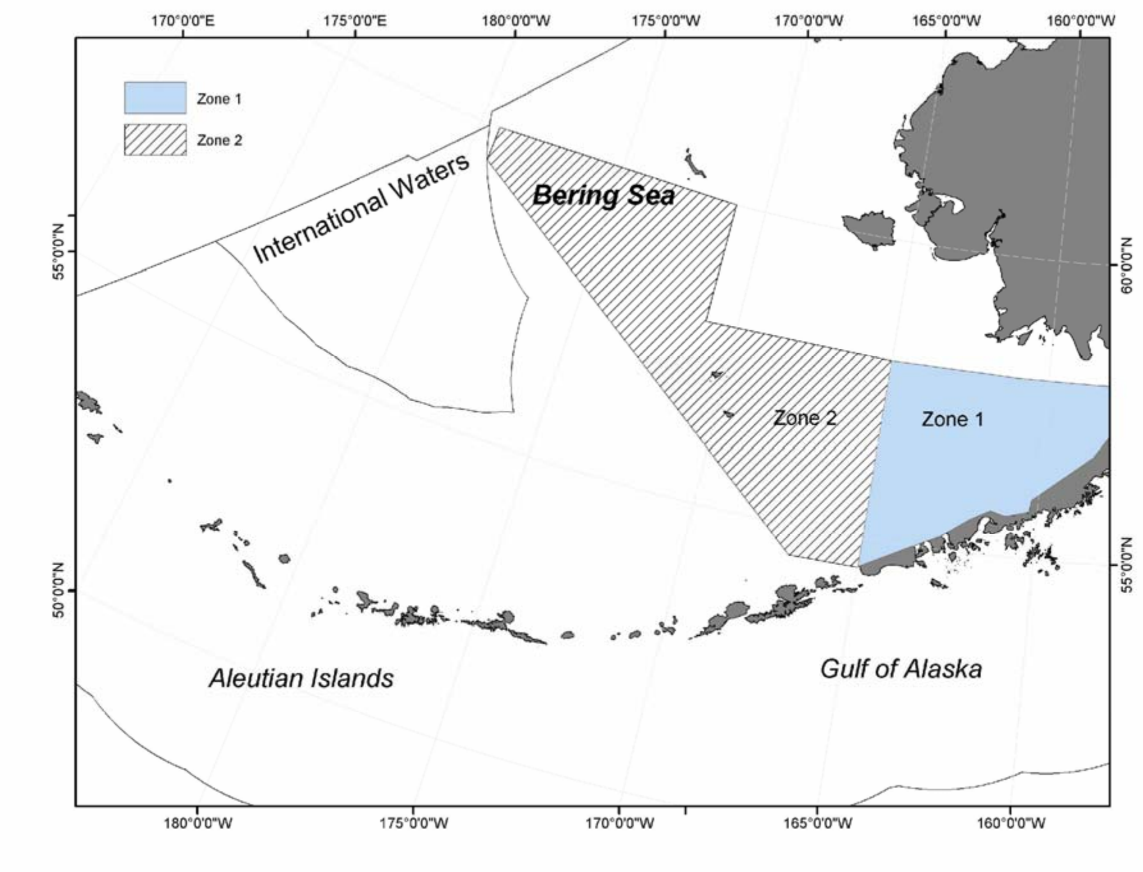

Figure 25 Zones 1 and 2 for PSC limits for red king crab and Tanner crab