

Stock Assessment and Fishery Evaluation Report  
for the  
**KING AND TANNER CRAB FISHERIES**  
of the  
Bering Sea and Aleutian Islands Areas

**2001 Crab SAFE**

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of the Bering Sea and Aleutian Islands

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**Table of Contents**

Executive Summary

Summary of Crab Data from the 2001 NMFS Bottom Trawl Survey

Status of King Crab Stocks in the Eastern Bering Sea in 2001

BSAI Crab Bycatch

Annual Management Report for the Shellfish Fisheries of the Bering Sea

Annual Management Report for the Shellfish Fisheries of the Aleutian Islands

ADF&G News Releases

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**Executive Summary**

The annual stock assessment and fishery evaluation (SAFE) report is a requirement of the North Pacific Fishery Management Council's *Fishery Management Plan for the Bering Sea/Aleutian Islands King and Tanner Crabs (FMP)*, and a federal requirement at 50 CFR Section 602.12(e) for a SAFE. The SAFE details the current biological and economic status of fisheries, guideline harvest levels (GHL), and analytical information used for management decisions or changes in harvest strategies. The report is assembled by the crab plan team with contributions from the State of Alaska Department of Fish and Game (ADF&G) and the National Marine Fisheries Service (NMFS), and is available to the public and presented to the Council on an annual basis. Additional information on Bering Sea/Aleutian Islands (BSAI) king and Tanner crab is available on the NMFS web page at <http://www.fakr.noaa.gov/sustainablefisheries/crab/default.htm>.

**Status of Annually Surveyed Crab Stocks**

Table 1 provides summary information on the basic elements of stock condition for the six stocks that are surveyed annually by NMFS. The Federal requirements for determining the status of the stocks are the minimum stock size threshold (MSST) and the maximum fishing mortality threshold (MFMT). These requirements are contained in the FMP and outlined in the following section, overfishing parameters. The MSST is 50% of the mean total spawning biomass (SB = total biomass of mature males and females) for

**Table 1. MSST, 2001 spawning biomass (SB), sustained yield (SY), and 2001/2002 guideline harvest level (GHL) estimates for BSAI king and Tanner crab stocks. Estimated values are in millions of pounds.**

<b>Stock</b>	<b>MSST</b>	<b>2001 SB</b>	<b>2001 SY</b>	<b>2001/2002 GHL</b>
Bristol Bay red king	44.8	88	17.6	7.15
Pribilof Islands red king	3.3	25.5	5.1	0
Pribilof Islands blue king	6.6	7	1.4	0
St Matthew blue king	11.0	9	1.8	0
EBS Tanner	94.8	67.7	20.31	0
EBS snow	460.8	571	171.3	30.82

the period 1983-1997, upon which the maximum sustainable yield (MSY) was based. A stock is overfished if the SB is below the MSST. The MFMT is represented by the sustainable yield (SY) in a given year, which is the MSY rule applied to the current SB (the MSY control rule is  $F = 0.2$  for king crabs and  $F = 0.3$  for Tanner and snow crabs). Overfishing occurs if the harvest level exceeds the SY in one year. GHLs are developed from joint NMFS and ADF&G assessment of stock conditions based on harvest strategies developed by ADF&G. Figures 1-6 show each crab stock's spawning biomass and catch history relative to overfishing.

As well as the Federal requirements, survey results for five stocks (Pribilof blue king crab, St. Matthew blue king crab, Bristol Bay red king crab, eastern Bering Sea Tanner crab, and eastern Bering Sea snow crab) are compared to thresholds established in State of Alaska harvest strategies and regulations. ADF&G uses these thresholds to determine if a fishery should be opened and to calculate the GHL. Please refer to the report "Status of King Crab Stocks in the Eastern Bering Sea in 2000" (Zheng and Kruse 2000), contained in the 2000 SAFE, for more detail on the population estimations for Bristol Bay red king crab, Pribilof Islands red and blue king crab, and St. Matthew blue king crab.

**Bering Sea Tanner crab**  
(*Chionoecetes bairdi*):

The 2001 survey estimate of spawning biomass increased to 67.7 million pounds from the 2000 estimate of 59.1 million pounds. This is still below the 1999 estimate of 70.1 million pounds. Although legal males are at an historic low, the survey indicates some moderate recruitment of juveniles.

In 1997, the Tanner crab spawning biomass of 64.2 million pounds was below the MSST of 94.8 million pounds, thus NMFS declared this stock overfished. ADF&G closed the fishery in 1997 and will reopen the fishery when the female biomass is above the threshold and the fishery GHL is above the minimum identified in the rebuilding harvest strategy. The Council adopted a rebuilding plan for this stock in October 1999. NMFS approved the rebuilding plan in June 2000 (65 FR 38216). Given the 2001 survey data, the stock is not anticipated to be above the “rebuilt” level (MSY biomass of 189.6 million-pounds) in the next year.

Estimated abundance of mature females in 2001 (20.703 million crabs) is down from that in 1999, but comparable to that in 2000 (19.373 million crabs). Legal male abundance and exploitable legal male abundance in 2001 (6.469 million crabs and 4.514 million crabs, respectively) are higher than in 1998 and 1999, but comparable to that in 2000. Mature male abundance and molting mature male abundance in 2001 (21.940 million

crabs and 11.275 million crabs) are higher than in 1997-1999, but comparable to 2000. The difference between the mature male abundance and molting mature male abundance in 2001 is due to 49% of the mature-sized males being in old-shell or older condition; the difference between the legal male abundance and the

**Table 2. Threshold Values in State of Alaska Harvest Strategies for Bering Sea King and Tanner Crabs (estimates in millions of pounds)**

<b>Pribilof blue king crab</b>	
<u>Stock threshold for fishery opening</u>	<u>2001 estimate</u>
0.77 million crab $\sigma^2 > 119$ -mm CL	.443 million crab <sup>a</sup>
<b>St. Matthew blue king crab</b>	
<u>Stock threshold for fishery opening</u>	<u>2001 estimate</u>
2.9 million $\sigma^2 > 104$ - mm CL	- 4.93 <sup>a</sup>
<u>Stock threshold for increasing exploitation rate on molting mature males</u> [(B-2.9)/8.7]*0.1+0.1 when 11.6 > B $\geq$ 2.9 million lbs. 0.2 when B $\geq$ 11.6 million lbs.	
<u>GHL threshold for fishery opening</u>	<u>GHL for 2001 season</u>
2.5	0.0
<b>Bristol Bay red king crab</b>	
<u>Stock threshold for fishery opening</u>	<u>2001 estimate</u>
• 8.4 million $\sigma^2 > 89$ - mm CL and	21.2 million crab <sup>b</sup>
• 14.5 million pounds effective spawning biomass	40.6 <sup>b</sup>
<u>Stock threshold for increasing exploitation rate from 10% to 15%</u> 55 million pounds effective spawning biomass	
<u>GHL threshold for fishery opening</u>	<u>GHL for 2001 season</u>
4	7.15
<b>Eastern Bering Sea Tanner crab (<i>bairdi</i>)</b>	
<u>Stock threshold for fishery opening</u>	<u>2001 estimate</u>
21 million pounds of $\sigma^2 > 79$ - mm CW	15.5 <sup>c</sup>
<u>Stock threshold for increasing exploitation rate from 10% to 15%</u> 45 million pounds of $\sigma^2 > 79$ - mm CL	
<u>GHL threshold for fishery opening</u>	<u>GHL for 2001 season</u>
4	0.0
<b>Eastern Bering Sea snow crab (<i>opilio</i>)</b>	
<u>Stock threshold for fishery opening</u>	<u>2001 estimate</u>
230.4 million pounds of spawning biomass	571 <sup>c</sup>
<u>Stock threshold for increasing exploitation rate on molting mature males</u> 0.75*0.3 = 22.5%, for SB $\geq$ 921.6 0.75*22.5% = 16.875%, for SB $\geq$ 460.8 and SB < 921.6 (SB/460.8)*16.875%, for SB $\geq$ 230.4 and SB < 460.8	
<u>GHL threshold for fishery opening</u>	<u>GHL for 2001 season</u>
25	30.82

<sup>a</sup> Catch-survey analysis estimate

<sup>b</sup> Length-based analysis estimate

<sup>c</sup> Area swept estimate

exploitable legal male abundance is due to 44% of the legal males being in old-shell or older condition. The proportion of old-shelled males in both the mature-size and legal-size classes in 2001 is only slightly higher than that in 2000 (44% and 39%, respectively).

Although a sign of recruitment of males and females in the 1999 survey (a size-frequency mode at 80 to 90-mm CW) disappeared in the 2000 and 2001 survey, there is indication of juveniles recruiting to the stock in the 2001 survey that tracks well with 1999 and 2000 data. A mode of small (30-mm CW) juveniles that appeared in the 1999 survey has tracked through the 2000 data and appears as a mode at roughly 50-mm CW in the 2001 data (Figure 2). Additionally, the 2001 survey data show a new, larger mode representing small (30-mm CW) juveniles. Together, those two modes in juvenile size classes provide the best indications of future recruitment to the mature stock that has been seen since at least 1996.

**Harvest Strategy:** The Tanner crab fishery has three thresholds against which survey data must be compared (Table 2; ADF&G 1999): one for a fishery opening; one for increasing the exploitation rate on mature males; and a minimum GHL to assure manageability. The minimum stock threshold for a fishery opening is 21 million pounds of females > 79-mm carapace width (CW). The 2001 estimate for Tanner crab females > 79-mm CW is below the threshold at 15.9 million pounds. When the female biomass is above the threshold, the GHL will be based on the harvest rate of 20% of molting mature males when the biomass of females >79 mm CW is  $\geq 45.0$  million pounds. The GHL will be based on the harvest rate of 10% of molting mature males when the biomass of females >79 mm CW is  $\geq 21.0$  million pounds and < 45.0 million pounds. The legal harvest rate cap will be 50% of exploitable males. The first year the stock is above the female threshold, the GHL is reduced by one-half the value as computed by this rule. The minimum GHL for a fishery is 4 million pounds to ensure manageability, which prevents exceeding the GHL.

**Bering Sea snow crab** (*Chionoecetes opilio*):

The 2001 survey estimate was 571 million pounds, an increase from the 2000 estimate of 472.7 million pounds of spawning biomass and from the 1999 survey estimate of 283.5 million pounds. The 2001 spawning biomass estimate is above the MSST. In 1999, NMFS identified the stock as overfished because the stock was below the MSST. The stock will be considered 'rebuilt' when the spawning biomass is above the MSY biomass (Bmsy) of 921.6. The Council adopted a rebuilding plan in June 2000. NMFS approved the rebuilding plan in January 2001 (66 FR 742). For the 2002 fishery, the snow crab GHL will be 30.82 million pounds, of which 2.31 million pounds are available to the CDQ fishery.

The increase in spawning biomass for 2001 relative to the 1999 and 2000 surveys is due largely to recruitment of males and females in the size-range of approximately 70-mm CW. Unlike 2000, mature males account for more of the spawning biomass in 2001 than females. Overall, the increase in spawning biomass to a level above MSST is more credible than the spawning biomass estimated for 2000. Mature male biomass increased to 302.0 million pounds in 2001 from 186.1 million pounds in 2000 and that is also due to the new recruitment of mature sized males. Estimated abundance of males  $\geq 4$ -in CW in 2001 (78 million) is the same as that in 2000. Old-shell males constitute 61% of the males  $\geq 4$ -in CW.

The size-frequency data for 2001 suggests that spawning biomass should continue to increase above the present level in 2002. The increased recruitment to mature size classes seen in 2001 is promising, and there is some indication that more recruitment can be expected in the year to come. Given the history of trends in spawning biomass for this stock, however, it is difficult to predict whether the increase in 2001 will continue to increase to the "rebuilt" level in the near future. Note that the recruitment to maturity in the 2001 survey data is not as strong as in 1987, when the stock quickly rebuild from low stock levels.

**Harvest Strategy:**

The harvest strategy adopted by the Alaska Board of Fisheries in March 2000 was used to estimate the GHL for 2002. The harvest strategy determines a GHL for snow crabs by the application of three rules: an exploitation rate that is applied to mature male biomass; a 50% cap on the removals of “exploitable legal males”, and a minimum GHL for fishery opening of 25 million pounds. Relative to the previous harvest rate, the new harvest strategy is much more conservative, particularly at low stock sizes, and would be expected to help maintain long term stock productivity, as well as increase the probability of stock rebuilding.

**Exploitation rate on mature males.** The harvest strategy applies an exploitation rate to the estimated biomass (B) of mature male snow crab. The exploitation rate that is applied to the mature male biomass varies with the estimated spawning biomass (SB) according to:

$$\begin{aligned} 0.75 \times 0.3 &= 22.5\%, \text{ for } SB \geq 921.6 \text{ million pounds} \\ 0.75 \times 22.5\% &= 16.875\%, \text{ for } SB \geq 460.8 \text{ million pounds and } SB < 921.6 \text{ million pounds} \\ (SB/460.8) \times 16.875\% &, \text{ for } SB \geq 230.4 \text{ million pounds and } SB < 460.8 \text{ million pounds} \\ 0\% & \text{ (fishery closed), when } SB < 230.4 \text{ million pounds.} \end{aligned}$$

The spawning biomass benchmarks, 921.6 and 460.8 million pounds, for determining the exploitation rate are the MSY biomass ( $B_{MSY}$ ) and minimum stock size threshold (MSST), respectively, for eastern Bering Sea snow crab as specified in the FMP; 230.4 million pounds is one-half the MSST. Overfishing is avoided under this harvest strategy by applying an exploitation rate  $< 30\%$  only to the mature male biomass portion of the SB.

Avoidance of overfishing is further assured by a maximum exploitation rate on mature male biomass of 75% of 30% -- when the SB reaches or exceeds  $B_{MSY}$ . When the SB falls below  $B_{MSY}$ , but exceeds MSST, the exploitation rate is reduced by an additional 25% to 16.875%. The exploitation rate on mature male biomass decreases linearly from 16.875% when SB is below MSST to an exploitation rate of 8.4375% when SB falls to one-half MSST. Below one-half MSST the directed snow crab fishery is closed.

**50% removal cap on “exploitable legal males”.** Besides determining an exploitation rate on mature male biomass, the harvest strategy also caps the removals of “exploitable legal males” to 50%. The 50% value is based on the 50% removal cap on “exploitable legal males” that was developed for the harvest strategy in the eastern Bering Sea Tanner crab rebuilding plan (Zheng and Kruse 1999). The cap assures that removals from a single sex-size class are controlled over all population and size-frequency scenarios, avoids the sorting that can accompany high harvest rates on a single sex-size class, and adjusts for the disproportionately high harvest of new-shell males. “Exploitable legal males” for snow crab are defined for this harvest strategy on the basis of carapace width (CW) and shell age. The minimum size of “exploitable legal male” snow crabs is defined by the 4-in (102-mm) CW industry standard for processing Alaska snow crab (Morrison et al. 1999); note, however, that the minimum legal size is 3.1-in (79-mm) CW (ADFG 1999). A shell-age component to the “exploitable legal male” definition reflects the disproportionate harvest of new-shell males relative to their representation in stock assessment survey data. Hence, “exploitable legal males” for eastern Bering Sea snow crab are defined as 100% of the population estimate of new-shell males  $>4$ -in CW plus 25% of the old-shell males  $>4$ -in CW. The discounting of old-shell males in the definition of “exploitable legal males” was computed using the proportion of new-shell animals estimated for males  $>4$ -in CW in the snow crab population during the pre-season surveys and the proportion of new-shell crabs in sampled deliveries for the 1991 through 1999 seasons.

**25 million pound minimum GHL.** The fishery season will not be opened if the GHL is less than 25 million pounds. The minimum GHL addresses the inability to adequately manage the fishery towards a low GHL under the current fleet size, pot limit conditions, in-season data collection, and end-of-season gear requirements.

**Application of Harvest Strategy for 2002 GHL.** With a SB of 571.0 million pounds, which is between 460.8 million pounds and 921.6 million pounds, an initial GHL is determined by applying a 16.875% exploitation rate to the biomass of mature males. Estimated mature male biomass for 2001 is 302.0 million pounds. Applying the 16.875% yields an initial GHL of 51 million pounds ( $0.16875 \cdot 302.0$  million pounds = 51.0 million pounds).

However, the 50% harvest cap on exploitable legal male abundance requires a downward adjustment to this initial GHL estimate. The estimated number of new-shell males  $\geq 4$ -in CW from the 2001 survey is 30.26 million animals. The estimated number of old-shell males  $\geq 4$ -in CW is 47.29 million animals. Hence, the exploitable legal male abundance from the 2001 survey data is 42.08 million animals ( $30.26$  million animals +  $0.25 \cdot 47.29$  million animals = 42.08 million animals).

Catch-sampling data from the 2001 fishery was used to provide an estimated average weight of 1.4 pounds for landed males  $\geq 4$ -in CW. If only males  $\geq 4$ -in CW were harvested in the 2002 fishery, the maximum number of males to be harvested would be 21.04 million animals ( $0.5 \times 42.08$  million animals = 21.04 million animals) and the maximum GHL would be computed as 29.46 million pounds ( $21.04 \times 1.4$  million pounds = 29.46 million pounds).

However, we expect that some legal males  $< 4$ -in CW will also be harvested. Seven percent of all harvested males in the 2001 season were less than 4-in CW. Catch-sampling data from the 2001 fishery also provides an estimated average weight of 0.86 pounds for landed males  $< 4$ -in CW. From the 2001 fishery catch-sampling data, the expected number of males  $< 4$ -in CW to be landed, given a landing of 21.04 million males  $\geq 4$ -in CW, would be 1.58 million animals ( $21.04 \times 0.07 / (1 - 0.07)$  million animals = 1.58 million animals). Using the expected average weight of 0.86 pounds, those 1.58 million males  $< 4$ -in CW would weigh 1.36 million pounds ( $0.86 \times 1.58$  million males = 1.36 million pounds).

Hence, to meet the 50% harvest cap on exploitable legal males abundance, the GHL is 30.82 million pounds ( $29.46$  million pounds +  $1.36$  million pounds = 30.82 million pounds).

**Bristol Bay red king crab** (*Paralithodes camtschaticus*):

The 2001 survey estimate of spawning biomass was 88 million pounds, a decrease from the 2000 survey estimate of 89.7 million pounds and the 1999 survey estimate of 111.7 million pounds of spawning biomass. The 2001 survey indicated some recruitment to the immature stock that should recruit to the mature stock in the next two years. The assessment model used for red king crab was the same as in the 1998 SAFE. The Bristol Bay red king crab survey data must be examined relative to three thresholds (Table 2; ADF&G 1999): one for a fishery opening; one for increasing the exploitation rate on mature-sized males; and a minimum GHL to assure manageability. With length-based analysis (LBA) estimates of 21.2 million females  $> 89$ -mm CL and of 40.6 million pounds of effective spawning biomass for 2001, the Bristol Bay red king crab stock is above the threshold for a fishery opening.

A 10% harvest rate is applied to the mature male abundance for the 2001 GHL, since the effective spawning biomass is below the target level of 55 million pounds. The 2001 GHL is 7.15 million pounds of legal males. The harvest rate would be 15% of mature male abundance if the effective spawning biomass is above 55 million pounds. The computed guideline for the 2001 Bristol Bay red king crab fishery season exceeds the minimum 4 million pounds necessary for a fishery opening.

Spawning biomass in 2001 remained essentially unchanged from the 2000 value and at roughly the MSY

biomass level, although it is close to one-half of the spawning biomass estimated for 1998 (163.6 million pounds). Spawning biomass would have to decrease to one-half of its current level in the next year for the stock to be below MSST in 2002.

The LBA estimates indicate that ESB remained stable between 2000 and 2001 and that mature male and female abundance showed little or no decrease between 2000 and 2001; estimated mature male abundance decreased by 10% of the 2000 estimate and estimated mature female abundance increased by 12%. Note, however, that area-swept estimates would indicate a 45% decrease in mature male abundance (from 13.66 million in 2000 to 7.62 in 2001; ADF&G area-swept estimates). Some modest recruitment of males and females 90-110-mm CL is also indicated in the 2001 survey data. Abundance of males and females in that size class is small in 2001 relative to 1997, however, and may not be expected to result in future recruitment of mature and legal males comparable to that seen in 1998 and 1999. The 2001 survey provides little expectation for any sizable recruitment to the mature female size class in 2002. Likewise, there should be no expectation for a sizeable recruitment to the legal male size class from the 2001 size frequency distribution, although some modest recruitment to the mature male size class may be anticipated that may provide stability to the mature male abundance. Overall, some decline in mature female abundance, ESB, and legal abundance should be anticipated for 2002. From the LBA, which estimates both mature female abundance and ESB to be more than two times greater than the fishery threshold levels, the stock should not be expected to fall below fishery threshold in 2002. Given the disparity between the LBA and area-swept estimates for mature males, however, any projection of stock status into 2002 is dependent on the credibility that is assigned to either estimate.

In summary, this stock was estimated to be above the fishery threshold. With ESB estimated as less than 55.0 million pounds, a 10% exploitation rate on mature males was used to determine the GHL. A 6.5-pound average weight for legal males was used to compute the GHL. The 6.5-pound average was derived from the size distribution in this year's trawl survey; it is also equal to the average weight of landed crabs in the 2000 fishery. ESB and total mature biomass estimates for 2001 are essentially unchanged from the 2000 estimates. That stability is due largely to some recruitment to maturity of females in 2001. There is evidence from the 2001 survey that some modest recruitment of males to the mature size class will occur next year, but probably not of the level that was seen in the late 1990s.

**Pribilof Islands red king crab** (*Paralithodes camtschaticus*):

The 2001 spawning biomass estimate from the survey was 25.5 million pounds, an increase from the 2000 survey estimate of 10.2 million pounds of spawning biomass. The MSST is 3.3 million pounds of spawning biomass. In the NMFS trawl survey, crabs were highly concentrated and therefore the survey index has a very low precision. Low precision in the survey index means that we are not confident that the 2001 spawning biomass is really as large as 25.5 million pounds and that the reality of apparent trends indicated by biomass and abundance estimates cannot be established. Questions have been raised about the appropriateness of the MSST and MSY biomass levels established for this stock; given the estimates for 1993-2001, the MSST and MSY biomass levels estimated for this stock from the 1983-1997 data may be too low for current conditions.

The Pribilof red king crab fishery is concurrent with the Pribilof blue king crab. Due to the low and declining abundance of Pribilof Island blue king crab, the low precision of the abundance estimates, and the poor fishery performance in recent years, the Pribilof king crab fishery will remain closed in 2001. No formal harvest strategy has been developed for this stock. The stock was closed to fishing in 1999 and 2000 on abundance estimates of 1.6 million and 1.3 million mature males, respectively, due to imprecision of abundance estimates and concerns about bycatch of blue king crab. If the 20% exploitation rate on mature-sized males, similar to that established for Pribilof blue king crab, were to be applied to this year's abundance estimate, the computed



GHL would be 2.3 million pounds. However, this fishery will remain closed due to concerns about bycatch effects on blue king crab and the poor precision of red king crab abundance estimates. The Pribilof District blue king crab stock is below threshold for a fishery opening and only slightly above the FMP minimum stock size threshold (MSST) defining an overfished condition. The Magnuson-Stevens Act is clear in its direction to managers of federal FMP fisheries to prevent stocks from reaching overfished levels. Past fishery data and current stock assessment data indicate that bycatch of blue king crab during a directed fishery on the Pribilof red king crab stock has the potential to reduce the Pribilof blue king crab stock significantly closer to, or below, MSST.

**Pribilof Islands blue king crab** (*Paralithodes platypus*):

The 2001 survey biomass estimate of spawning biomass was 7.0 million pounds, a decrease from the 2000 survey estimate of 7.4 million pounds and the 1999 survey estimate of 9.2 million pounds. MSST is 6.6 million pounds of spawning biomass. Under the harvest strategy developed for the Pribilof blue king crabs, fisheries are not opened unless the stocks exceed a threshold level of abundance (Pengilly and Schmidt 1995). The thresholds established for Pribilof Islands blue king crab is 0.77 million males > 119-mm carapace length (CL). The 2001 catch-survey analysis (CSA) estimate for Pribilof Islands blue king crab > 119-mm CL is 0.443 million crab, therefore the fishery will remain closed in 2001. The fishery was also closed in 1999 and 2000 because the stock did not exceed the threshold level of abundance. Therefore, this population is declining in the absence of fishing pressure. There is no evidence from this year's survey results that recruitment to the mature stock will occur in the near future; no recruit-sized legal males were captured and most legal-sized males were in old-shelled condition. If population trends continue into the next year, this population could fall below MSST within the next two years.

**St. Matthew blue king crab** (*Paralithodes platypus*):

The 2001 spawning biomass estimate from the survey was 9.0 million pounds, an increase from the 2000 survey estimate of 5.2 million pounds and the 1999 survey estimate of 4.8 million pounds. The apparent increasing trend must be tempered with an appreciation of the low precision of the total mature biomass estimate. The 2001 survey indicated poor prospects for recruitment to mature stock in the near future.

The fishery was closed in 1999 and 2000 and will remain closed in 2001. This fishery is overfished because the estimate of spawning biomass is below the MSST of 11.0 million pounds. The Council adopted a rebuilding plan in June 2000. Total mature biomass would need to more than double to 22.0 million pounds from the 2001 estimate for the stock to be considered "rebuilt". Data from the 2001 survey do not provide any expectations for such an increase in the near-term future. Although the stock is above the ADF&G threshold for a fishery opening, the GHL computed according to the fishery harvest strategy (0.717 million pounds) is far below the minimum GHL of 2.5 million pounds that is considered manageable.

ADF&G developed the rebuilding harvest strategy for the St. Matthew Island blue king crab fishery that the Board adopted in March 2000. The harvest strategy includes four components: a stock threshold, a minimum GHL, variable mature harvest rates, and a cap on legal male harvest rate. A stock abundance threshold was set to promote rebuilding and prevent against future instances of stock declines to "overfished" status. A minimum GHL was chosen because small GHLs are not manageable given the current size of the fishing fleet. A maximum legal harvest rate cap was set to prevent high removal rates of legal crabs when most mature males are sublegal size such as would be the case when a strong year class has yet to recruit to the fishery. The harvest strategy is closely based on NMFS technical guidance for implementing precautionary harvest strategies and rebuilding plans of Restrepo et al. (1998). The harvest strategy is detailed in the ADF&G report

“Overview of Stock Assessment and Recommended Harvest Strategy for St. Matthew Island Blue king Crabs” (Zheng and Kruse 2000).

The harvest strategy is conservative, particularly at low stock sizes, and would be expected to help maintain long term stock productivity, as well as increase the probability of stock rebuilding. The harvest strategy’s four components are as follows:

- 1) A minimum stock threshold of 2.9 million lbs of mature male (105 mm carapace length) biomass. This is 25% of the equivalent mature male biomass capable of producing maximum sustainable yield ( $B_{msy}=11.6$  million lbs).
- 2) The GHL is determined by directed mature male harvest rates of: (1) 0 when mature male biomass ( $B$ ) < 2.9 million lbs, (2)  $[(B-2.9)/8.7]*0.1+0.1$  when  $11.6 > B \geq 2.9$  million lbs, and (3) 0.2 when  $B \geq 11.6$  million lbs.
- 3) The harvest rate on legal males is capped at 40%.
- 4) The minimum GHL for a fishery opening is 2.5 million pounds.

## Crab Stocks With No Annual Survey

Stock status for the following stocks is unknown due to no survey biomass estimates: Pribilof Islands golden king crab (*Lithodes aequispinus*); Saint Lawrence Island blue king crab; Northern District golden king crab; Western Aleutian Tanner crab (*C. bairdi*); Aleutian Islands scarlet king crab (*Lithodes couesi*); Bering Sea triangle Tanner crab (*Chionoecetes angulatus*); Eastern Aleutian Islands triangle Tanner crab; Eastern Aleutian Islands grooved Tanner crabs (*Chionoecetes tanneri*); Western Aleutian Islands grooved Tanner crabs; Bering Sea grooved Tanner crabs. The permit fisheries for the species identified in Table 3 are by ADF&G commissioner's permit only with observer requirements. Estimation of MSST for these stocks is not possible at this time because of insufficient data on the basic stock abundance. The ADF&G Gulf of Alaska Marine Resource Assessment Survey is a triennial trawl survey east of 170°W that provides some information on Dutch Harbor red king crab and E. Aleutian Islands Tanner crab.

**Table 3. 2000/2001 Guideline harvest levels (GHL), status of the fishery, and MSY estimates for BSAI king and Tanner crab stocks not annually surveyed. Estimated values are in millions of pounds.**

(NA indicates that insufficient data exists at this time to estimate the value)

Stock	GHL	Fishery/Season	MSY
Adak red king	0	closed	1.5
Dutch Harbor red king	0	closed	NA
Norton Sound red king	.336	7/1-9/3:11/15-5/15	0.5
St Lawrence blue king	NA	permit	0.1
Aleutian Is. golden king	5.7	8/15	15.0
Pribilof Is. golden king	0.15	permit	0.3
St. Matthew golden king	0.015	permit	0.3
Aleutian Is. scarlet king	NA	permit	NA
EBS scarlet king	NA	permit	NA
E. Aleutian Is. Tanner	0	closed	0.7
W. Aleutian Is. Tanner	0	closed	0.4
E. Aleutian Is. angulatus	NA	permit	1.0
EBS angulatus	NA	permit	0.1
E. Aleutian Is. tanneri	.05 to 0.2	permit	1.8
EBS tanneri	.05 to 0.2	permit	1.5
W. Aleutian Is. tanneri	NA	permit	0.2

**Aleutian Islands red king crab** (Adak and Dutch Harbor red king crab stocks) The GHL for the eastern portion (Dutch Harbor stock) is based on the results of surveys performed by ADF&G on a triennial basis; the most

recent survey was performed in 2000. Few red king crabs were caught in surveys of the eastern Aleutians since 1995. The eastern portion has been closed since 1983. The GHL for the western portion (Adak stock) has been based on the most recent fishery performance. The western portion was closed for the 1996/97 and 1997/98 seasons due to poor performance and poor sign of recruitment during the 1995/96 season. The western portion was reopened for limited exploratory fishing in some areas in 1998/99. Based on the results of the 1998/99 season, the fishery in the western portion was closed in 1999/2000. In 1999 the Crab Plan Team identified the need for a standardized surveys in areas of historical production prior to reopening the fishery in the western portion; prior to that meeting, the western portion had not been surveyed since 1977. A cooperative ADF&G-Industry pot survey was performed in the Petrel Bank-Semisopochnoi Island area under the provisions of a permit fishery in January-February of 2001. Results of that surveyed show high densities of legal crabs within limited portions of the surveyed area, but little indication of prerecruit-sized or female crabs. ADF&G is developing another cooperative survey with Industry in this area in November of 2001 under provisions of a permit fishery to better determine the condition of red king crab in this area and the potential for a fishery in 2002/2003.

**Norton Sound red king crab:** The Norton Sound red king crab legal male abundance is estimated from the triennial trawl survey. The 1999 ADF&G trawl survey estimated 4.3 million pounds of legal crab, a significant increase from the 1996 survey estimate of 1.6 million pounds of legal male crab. This increase in abundance

was the result of strong recruitment over the previous three years. Recruitment is not anticipated to be as strong over the next three years. However, the current biomass is the largest biomass estimate produced from a trawl survey since the commercial fishery began. Only the trawl survey conducted in 1976 produced a larger biomass estimate. The Norton Sound crab fishery operates in the summer and in the winter. Due to increasing legal male abundance, a harvest rate of 8% was applied to the legal biomass estimated in 1999. The 2000 GHL was 336,000 lbs, based on the triennial trawl survey stock abundance estimates. The GHL was 303,000 pounds for the 2001 summer fishery. The open access fishery was open July 1 by regulation and was closed by emergency order Sept 1. The open access goal was 280,000 lbs, and the harvest was 288,199 lbs. The CDQ portion opened Sept 2 and closed Sept 9. ADF&G had begun to see double shell and molting crab at the end of the open access fishery. There was no harvest for the CDQ portion. ADF&G has never set a GHL for the winter fishery. The 2001 commercial fishery had a harvest of 2,942 lbs of crab (season runs Nov 15, 2000 until May 15, 2001).

**Aleutian Islands golden king crab** (Eastern Aleutians (Dutch Harbor) and Adak golden king crab stocks): A standardized triennial pot survey for golden king crab in a portion of the eastern Aleutian Islands (in the vicinity of Amukta, Chagulak, and Yunaska Islands) was initiated in 1997. Preliminary results from the recently completed 2000 survey of that area indicate that catch per unit effort (CPUE) of legal male crabs has dropped by roughly one-third from the 1997 CPUE, whereas female and pre-recruit male CPUEs remained roughly stable at their 1997 levels. Analysis of 1996-2000 golden king crab fishery performance and observer data from the entire area east of 174° W longitude, on the other hand, indicate that the golden king crab stock has remained stable in that larger area. The 2001/2002 GHL for the Aleutian Islands has again been set at 5.7 million pounds, with 2.7 million pounds for the area west of 174°W, and 3.0 million pounds for the area east of 174°W.

**Eastern Aleutian Islands *C. bairdi* Tanner crab:** The fishery has been closed since 1995 due to declining stock size estimated from surveys and poor fishery performance. In the 2000 survey, prerecruit and recruit sized Tanner crabs declined from the 1999 survey in the Eastern Aleutian District. The 1995 survey estimates of the number of crabs were 29,000 legal males and 135,000 females. 2000 survey data is not available at this time.

## Overfishing Parameters

The FMP identifies the following overfishing definitions to provide objective and measurable criteria for identifying when the BSAI crab fisheries are overfished or overfishing is occurring, as required by the Magnuson-Stevens Fishery Conservation and Management Act. Table 4 provides the MSST, MSY, OY and MSY control rule estimates for the BSAI king and Tanner crab stocks. The Crab Plan Team will reevaluate these estimates every five years or when environmental conditions indicate a regime shift.

<b>Stock</b>	<b>MSST</b>	<b>MSY</b>	<b>OY range</b>	<b>MSY control rule</b>
Adak red king	NA	1.5	0 - 1.5	0.2
Bristol Bay red king	44.8	17.9	0 - 17.9	0.2
Dutch Harbor red king	NA	NA	NA	0.2
Pribilof Islands red king	3.3	1.3	0 - 1.3	0.2
Norton Sound red king	NA	0.5	0 - 0.5	0.2
Pribilof Islands blue king	6.6	2.6	0 - 2.6	0.2
St Matthew blue king	11.0	4.4	0 - 4.4	0.2
St Lawrence blue king	NA	0.1	0 - 0.1	0.2
Aleutian Is. golden king	NA	15.0	0 - 15.0	0.2
Pribilof Is. golden king	NA	0.3	0 - 0.3	0.2
St. Matthew golden king	NA	0.3	0 - 0.3	0.2
Aleutian Is. scarlet king	NA	NA	NA	0.2
EBS scarlet king	NA	NA	NA	0.2
<b>TOTAL king crab</b>		<b>43.9</b>	<b>0 - 43.9</b>	
E. Aleutian Is. Tanner	NA	0.7	0 - 0.7	0.3
EBS Tanner	94.8	56.9	0 - 56.9	0.3
W. Aleutian Is. Tanner	NA	0.4	0 - 0.4	0.3
<b>TOTAL Tanner crab</b>		<b>58.0</b>	<b>0 - 58.0</b>	
EBS snow	460.8	276.5	0 - 276.5	0.3
<b>TOTAL snow crab</b>		<b>276.5</b>	<b>0 - 276.5</b>	
E. Aleutian Is. angulatus	NA	1.0	0 - 1.0	0.3
EBS angulatus	NA	0.3	0 - 0.3	0.3
E. Aleutian Is. tanneri	NA	1.8	0 - 1.8	0.3
EBS tanneri	NA	1.5	0 - 1.5	0.3
W. Aleutian Is. Tanneri	NA	0.2	0 - 0.2	0.3
<b>TOTAL other Tanners</b>		<b>4.8</b>	<b>0 - 4.8</b>	

Maximum sustainable yield (MSY) is the largest long-term average catch or yield that can be taken from a stock or stock complex under prevailing ecological and environmental conditions. MSY is estimated from the best information available. Proxy stocks are used for BSAI crab stocks where insufficient scientific data exists to estimate biological reference points and stock dynamics are inadequately understood. MSY for crab species is computed on the basis of the estimated biomass of the mature portion of the male and female population or

total spawning biomass (SB) of a stock. A fraction of the SB is considered sustained yield (SY) for a given year and the average of the SYs over a suitable period of time is considered the MSY.

Overfishing and Overfished: The term “overfishing” and “overfished” mean a rate or level of fishing mortality that jeopardizes the capacity of a fishery to produce MSY on a continuing basis. Overfishing is defined for king and Tanner crab stocks in the BSAI management area as any rate of fishing mortality in excess of the maximum fishing mortality threshold,  $F_{msy}$ , for a period of 1 year or more. Should the actual size of the stock in a given year fall below the minimum stock size threshold, the stock is considered overfished. If a stock or stock complex is considered overfished or if overfishing is occurring, the Secretary will notify the Council to take action to rebuild the stock or stock complex.

MSY control rule means a harvest strategy which, if implemented, would be expected to result in a long-term average catch approximating MSY. The MSY control rule for king and Tanner crabs is the mature biomass of a stock under prevailing environmental conditions, or proxy thereof, exploited at a fishing mortality rate equal to a conservative estimate of natural mortality. Sustainable yield (SY) in a given year is the MSY rule applied to the current spawning biomass. Overfishing occurs if the SY is exceeded for more than one year.

MSY stock size is the average size of the stock, measured in terms of mature biomass of a stock under prevailing environmental conditions, or a proxy thereof. It is the stock size that would be achieved under the MSY control rule. It is also the minimum standard for a rebuilding target when remedial management action is required. For king and Tanner crab, the MSY stock size is the average mature biomass observed over the past 15 years, from 1983 to 1997.

Maximum fishing mortality threshold (MFMT) is defined by the MSY control rule, and is expressed as the fishing mortality rate. The MSY fishing mortality rate  $F_{msy} = M$ , is a conservative natural mortality value set equal to 0.20 for all species of king crab, and 0.30 for all *Chionoecetes* species.

Minimum stock size threshold (MSST) is whichever is greater: one half the MSY stock size, or the minimum stock size at which rebuilding to the MSY level would be expected to occur within 10 years if the stock or stock complex were exploited at the maximum fishing mortality threshold. The minimum stock size threshold is expressed in terms of mature biomass of a stock under prevailing environmental conditions, or a proxy thereof.

**Management Programs**

**Community Development Quota Crab Fisheries**

The Magnuson-Stevens Act mandates that the Council and NMFS establish a Community Development Quota (CDQ) program under which a percentage of the total allowable catch for Bering Sea and Aleutian Island crab fisheries is allocated to the CDQ program (16 U.S.C. 1855 (i)(1)(A)). The Council and NMFS deferred management authority of the BSAI king and Tanner crab fisheries, including the CDQ fisheries, to the State, with federal oversight. The State/Federal cooperative management regime established in the FMP specifies three categories of management measures which provide the framework for Federal/State management of the crab fisheries, including the determination of the GHs and fishery seasons. Additionally, the FMP authorizes the State to allocate the crab CDQ reserve among CDQ groups and to manage crab harvesting activity of the BSAI CDQ groups (§8.1.4.2 of the FMP).

**Table 5. CDQ program percent allocation by group.**

<b>Fishery</b>	<b>APICDA</b>	<b>BBEDC</b>	<b>CBSFA</b>	<b>CVRF</b>	<b>NSEDC</b>	<b>YDFDA</b>
Bristol Bay red king crab	20	20	0	20	20	20
Pribilof red & blue king	0	0	100	0	0	0
St. Matthew blue king	50	12	0	12	14	12
Norton Sound red king	0	0	0	0	50	50
Tanner crab	10	19	19	17	18	17
Snow crab	10	19	19	17	18	17

**Table 6. 2001/2002 CDQ reserve (in pounds).**

<b>Fishery</b>	<b>CDQ</b>
Bristol Bay red king crab	536,000
Pribilof red & blue king	0
St. Matthew blue king	0
Norton Sound red king	23,260
Tanner crab	0
Snow crab	2,310,000

Sixty-five communities along the Bering Sea are eligible for the CDQ program. These villages aligned into six CDQ groups: Aleutian Pribilof Island Community Development Association (APICDA), Bristol Bay Economic Development Corporation (BBEDC), Central Bering Sea Fishermen’s Association (CBSFA), Coastal Villages Regional Fund (CVRF), Norton Sound Economic Development Corporation (NSEDC), and Yukon Delta Fisheries Development Association (YDFDA). The CDQ reserve is 7.5% of the GH

for the following Bering Sea fisheries: Bristol Bay red king crab, Pribilof red and blue king crab, Norton Sound red king crab, snow crab, and Tanner crab. ADF&G divides the 7.5% reserve among the six CDQ groups.

**License Limitation Program**

Fishing under the crab license limitation programs (LLP) began in January 2000. The goal of the LLP is to limit access to the crab fisheries to the historic participants or to people who purchase licenses from historic participants. Owners of vessels must have a valid LLP license in order to participate in the BSAI crab fisheries. NMFS issued licenses based on fishing history during a general qualifying period, with area/species endorsements based on additional qualifying periods for each species by area. Licenses also limit the size of the vessel deployed under the license. Interim licenses were also issued to any applicant that had a valid moratorium qualification for crab in 1999. Interim licenses are temporary and the total numbers of licenses will decrease as interim licenses either are denied or licenses granted. Interim licenses are issued if any part of a person’s claim is contested. Also, the number of licenses may change as a result of a small number of new

licenses issued from late filed claims.

**Table 7: Crab Licenses Limitation Program: number of licenses issued as of July 2001**

Number of crab licenses: 457 (151 of which are interim licenses)

**Number of crab licenses with specific endorsements, by crab fishery:**

<u>Endorsement</u>	<u>Licenses</u>	<u>Interim</u>	<u>Total</u>
Aleutian Is. golden king	26	23	49
Aleutian Is. red king	23	27	50
EBS Tanner	231	132	363
Bristol Bay red king	232	126	358
Norton Sound king	57	11	68
Pribilof Is. king	99	66	165
St. Matthew Is. blue king	134	82	216

**Notes:** A crab license may contain more than one endorsement. EBS Tanner endorsements included both snow crab (*C. opilio*) and Tanner crab (*C. bairdi*).

The LLP is still being modified and the implementing regulations will change because of an amendment (Amendment 10) recommended by the Council that included changes to the basic eligibility criteria for crab. Amendment 10 would require recent participation in the BSAI king and Tanner crab fisheries in order to qualify for a license under the crab LLP. The recent participation requirement would apply to the general licenses only; if a vessel

satisfies the recent participation criteria, the owner would receive the original license and all of the species/area endorsements for which it qualified under the original criteria. No new species/area endorsements could be earned during the recent qualification. The Secretary approved Amendment 10, but has yet to implement regulations. The total number of crab licenses will decrease when Amendment 10 is implemented.

**American Fisheries Act Crab Sideboards**

In 1998, Congress passed the American Fisheries Act (AFA) to establish a new allocation scheme for the BSAI pollock fishery. The AFA required harvest restrictions (commonly known as “sideboards”) on the pollock fishermen who received exclusive harvesting privileges under the AFA to protect the interests of fishermen who are not directly benefitted by the AFA. The sideboards for the AFA vessels to participate in the crab fisheries are as follows.

Under regulations implementing the AFA, a vessel is ineligible to participate in any BSAI crab fishery unless that specific vessel participated in a specific crab fishery during certain qualifying years. AFA vessel permits could be endorsed for the Bristol Bay red king crab, snow crab, *C. bairdi* Tanner crab, St. Matthew blue king crab, Pribilof Islands king crab, Aleutian Islands red king crab, and Aleutian Islands golden king crab fisheries. To participate in a BSAI crab fishery, the operator of an AFA vessel would have to

**Table 8: Participation requirements for AFA catcher vessels to determine eligibility to harvest crab species. An AFA vessel must have participated in the directed crab fishery below during the participating years listed in order to be eligible to participate in that fishery in the future.**

<u>Fishery</u>	<u>Participating years</u>
Bristol Bay red king	Made landings of BSAI king or Tanner crab species in 1996, 1997, <i>or</i> on or before February 7, 1998
St. Matthew blue king	1995, 1996, <i>or</i> 1997
Pribilof Islands king	1995, 1996, <i>or</i> 1997
Aleutian Is. golden king	1997/1998 <i>and</i> 1998/1999
Aleutian Is. red king	1995/1996 <i>and</i> 1998/1999
Snow crab	Made landing in each of four or more years from 1988-1997
<i>C. bairdi</i> Tanner	1995 <i>or</i> 1996



have a valid LLP license for that crab fishery as well as an AFA vessel permit containing an endorsement for that crab fishery.

In addition to the historic participation requirements, there is a cap on the amount of Bristol Bay red king crab and *C. bairdi* Tanner crab that the AFA vessels can harvest. The Bristol Bay red king crab harvest cap is based on the aggregate 5-year (1991-1997, excluding 1994-1995) weighted average share. Under this cap, AFA vessels may harvest up to 10.96% of the regular commercial GHL, which equals 724,867 pounds for the 2001 fishery. The amount of the harvest cap may change if the number of AFA vessels with Bristol Bay red king crab endorsements changes. An aggregate harvest cap will be established for *C. bairdi* Tanner crab once the stock rebuilds. This harvest cap will be based on the aggregate historic catch of the endorsed *C. bairdi* Tanner crab vessels for 1995-1996. Management and implementation of these crab harvest cap sideboards is deferred to the State of Alaska.

**Table 9: Number of AFA vessels eligible to harvest crab and 2001 harvest cap for AFA vessels, by crab fishery:**

<u>Fishery</u>	<u>AFA Endorsements</u>	<u>2001 Harvest Cap</u>
Aleutian Is. golden king	0	-
Aleutian Is. red king	0	-
<i>C. bairdi</i> Tanner	28	NA
Bristol Bay red king	41	724,867 pounds
Snow crab	6	-
Pribilof Is. king	2	-
St. Matthew Is. blue king	1	-

**Note:** NA indicates a harvest cap is not applicable because the fishery is closed for 2001.

### Capacity Reduction Program

NMFS is developing a proposed rule to implement a capacity reduction program for the BSAI crab fisheries, excluding Norton Sound, pursuant to Section 144(d) of Public Law 106-554 (section 144), as amended by Public Law 107-20. NMFS has yet to publish the proposed rule. Section 144 mandates a specific capacity reduction program. The objective of the program is to permanently remove harvesting capacity from the BSAI crab fisheries by permanently reducing the number of license limitation program licenses issued pursuant to the FMP. The action is necessary because the BSAI crab fisheries are over capitalized. The program will: 1) prevent certain crab vessels from fishing again anywhere in the world; 2) revoke the crab LLP licenses based on the vessels' fishing history; 3) revoke any NMFS issued non-crab licenses that the vessels' owners still hold; and, 4) revoke the vessels' fishing histories upon which NMFS based the licenses to be revoked.

## **Survey Methods**

**NMFS Annual Eastern Bering Sea Trawl Survey:** NMFS has performed annual trawl surveys of the eastern Bering Sea since 1968. Two vessels, each equipped with an eastern otter trawl with 83 ft headrope and 112 ft footrope, conduct this multispecies, crab-groundfish survey during summer. Stations are sampled in the center of a systematic 20 X 20 nm grid overlaid in an area of »140,000 nm<sup>2</sup>. The towed area is estimated, and fish and invertebrate catches from each station are sampled, enumerated, measured and weighed. An update of Stevens et al. (2000) will be published to provide details on the 2001 survey results for: Bristol Bay and Pribilof Islands red king crabs, St. Matthew and Pribilof Islands blue king crabs, and eastern Bering Sea Tanner, snow, and hair crabs.

Two surveys were conducted for Bristol Bay red king crab in 2000: standard survey about two weeks earlier than the past surveys and resurvey of 31 stations with high female density. Differences in area-swept estimates of abundance between the standard survey and resurvey of these 31 stations can be attributed to survey measurement errors. The size distribution of females was significantly larger in the resurvey than during the standard survey because most mature females had not molted prior to the standard survey. Therefore, data from both surveys was used to assess male abundance but only the resurvey data plus the standard survey data outside the 31 stations to assess female abundance.

**King and Tanner crab stock surveys regularly performed by ADF&G in the BSAI:** ADF&G performs four regularly scheduled stock assessment surveys: a pot survey for blue king crab in the St. Matthew Island area; a trawl survey for red king crab in Norton Sound; a pot survey for golden king crab in the Aleutians between 170° and 172° W. longitude; and, a trawl survey for red king crab and Tanner crab in the eastern Aleutians. Each of the surveys is performed on a triennial basis. Trawl survey data are used to generate area-swept population estimates of abundance. Pot survey data, on the other hand, cannot be used at present to generate population estimates, but can serve to provide population indices. The St. Matthew pot survey was first performed in 1995 and was performed again in 1998. That survey is performed south of St. Matthew Island in an area of relatively shallow waters that supports most of the blue king commercial fishery and the mature female population, but which is not accessible to the annual NMFS trawl survey. ADF&G began performing a triennial trawl survey for red king crab in Norton Sound in 1996, after NMFS removed the Norton Sound area from its triennial trawl survey schedule. Norton sound was again surveyed by ADF&G in 1999. ADF&G first performed a pot survey of Aleutians golden king crab in the area between 170° and 172° W. longitude in 1991 and established a standardized triennial survey in 1997. The eastern Aleutians are surveyed for Tanner crab and red king crab on a triennial basis as an extension of the annual Westward Region bottom trawl survey of Kodiak Island and the south Alaska Peninsula. The area covered by that survey includes waters encompassing Unalaska Island and eastern Umnak Island and Akun and Akutan Bays. Due to survey conflict, the scheduled 1998 trawl survey of the eastern Aleutians was not performed, but was rescheduled for and performed in 1999 and 2000.

## **Analytical Methods**

Detailed descriptions of the analytical methods are contained in: "Status of King Crab Stocks in the Eastern Bering Sea in 2000" (Zheng and Kruse 2000).

**Overview.** The annual trawl survey is an essential data-gathering tool on the status of crab stocks in the eastern Bering Sea. Yet, year-to-year variation in oceanographic conditions leads to changes in species distributions and availability to survey gear. These changes and other measurement errors can lead to unexpected shifts in area-swept abundance estimates unrelated to true changes in population size. Estimates from surveys in

previous years and commercial catches provide valuable auxiliary information to help decipher real population changes from survey measurement errors. Population estimation models were developed to incorporate crab size, sex, and shell condition data from annual surveys, commercial catches and catch samples. Model estimates based on multiple years of data and multiple data sources are generally more accurate than area-swept estimates from current-year survey data alone. ADF&G uses these estimates for fishery management of the modeled stocks.

Because the quantity and quality of data vary among crab stocks, no single analytical model is ideally suited for all situations. Therefore, the following approaches were developed for use with eastern Bering Sea king crabs that are tailored to differing levels of information: *length-based analysis (LBA)* for stocks with high-quality size composition data; and *catch-survey analysis (CSA)* for stocks lacking detailed size composition data or where the survey catchability coefficient is unknown (Zheng et al. 1997; Collie and DeLong 1998). LBA is applied to Bristol Bay red king crabs and *C. bairdi* Tanner crabs, and CSA to St. Matthew and Pribilof Islands blue king crabs. A brief description of these two methods and their application to king crab stocks in the eastern Bering Sea follows.

Length-based Analysis. The LBA is an analytical procedure to estimate annual abundance of crab stocks for which extensive high-quality data are available. The LBA makes use of detailed annual data on size, sex, and shell condition from trawl surveys, onboard and dockside catch samples, and annual commercial harvests. Males and females are modeled separately by 5 mm carapace length (CL) intervals as newshell (i.e., those that molted within the past year) and oldshell crabs (i.e., those that have not molted within the past year). The annual abundance of crabs at each length group is a combined result of recruitment, growth, natural mortality, and harvest. Note that this is a size-based analysis, not an age-based analysis that is commonly used for fish stocks. An overview of the approach is provided in Zheng et al. (1996), Zheng et al (1998), and Zheng and Kruse (1999). The LBA is used to estimate annual abundance of Bristol Bay red king crab and *C. bairdi* Tanner crab.

Benefits of the LBA are that it provides relatively precise abundance estimates for male and female crabs for fishery management, yields information needed to estimate Stock-Recruit relationships, and provides a means to analyze alternative harvest strategies. Another benefit of the LBA is that it smooths out measurement error in the survey. Often, high measurement errors were caused by an extremely high catch in one or two survey stations. By smoothing out survey measurement errors, the LBA provides a more consistent interpretation of stock changes over time than do survey area-swept estimates.

Catch-survey Analysis. Collie and DeLong (1998) updated the two-stage CSA model (Collie and Kruse 1998) to a three-stage (i.e., three age-size groups) approach. As with the LBA, the CSA estimates survey measurement errors and “true” stock abundance. The CSA model is less complex, is only applied to male crabs, and requires less detailed size composition data than the LBA. Instead of tracking multiple 5 mm size groups as the LBA does, CSA considers only three age-size groups of crabs: *prerecruits*, mature crabs that are one molt away from attaining legal size; *recruits*, mature newshell crabs that molted to legal size within the past year; and *postrecruits*, crabs that have been legal for more than one year. The previous two-stage CSA considered only recruit and postrecruit crabs. In the three-stage version, mature and legal abundance and associated 95% confidence intervals can be estimated each year. These improvements are important because GHLs for eastern Bering Sea king crabs are based on estimates of both mature and legal crabs. The updated model provides a new series of abundance estimates over the years that the St. Matthew and Pribilof Islands stocks have been surveyed.

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