

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

**1999 Crab SAFE**

Compiled by

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of the Bering Sea and Aleutian Islands

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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 (FMP) for the Commercial King and Tanner Crab Fisheries in the Bering Sea/Aleutian Islands*, 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 level (GHL) ranges, 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 and the National Marine Fisheries Service, and is available to the public and normally presented to the Council on an annual basis.

**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 minimum stock size threshold (MSST) is 50% of the mean total (male and female) spawning biomass (SB) for the period upon which the maximum sustainable yield (MSY) was based (50% Bmsy). A stock is overfished if the SB is below the MSST. The sustainable yield (SY) in a given year is the MSY rule applied to the current SB ( $F = 0.2$  for king crabs and  $F = 0.30$  for Tanner and snow crabs). Overfishing occurs if the SY is exceeded for a period exceeding one year. Guideline harvest levels (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.

**Table 1. MSST, 1999/2000 spawning biomass (SB), sustainable yield (SY), and 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>SB</b>	<b>SY</b>	<b>GHL</b>
Bristol Bay red king	44.8	117.7	23.6	10.7
Pribilof Islands red king	3.3	12.8	2.6	0
Pribilof Islands blue king	6.6	9.2	1.8	0
St Matthew blue king	11.0	4.8	.8	0
EBS Tanner	94.8	70.1	21.1	0
EBS snow	460.8	283.5	85.1	28.5

Bering Sea Tanner crab (*Chionoecetes bairdi*): The survey estimated mature biomass in 1997 at 64.2 million pounds, which was below the MSST of 94.8 million pounds resulting in this stock being defined as 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 survey estimate of mature biomass in 1998 declined to 36.9 million pounds and in 1999 increased to 70.1 million pounds. The Council will take final action on a rebuilding plan developed for this stock at its October 1999, meeting. The proposed rebuilding harvest strategy will set a threshold of 21.0 million lbs of female biomass below which the fishery will be closed. 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 lbs. The GHL will be based on the harvest rate of 10% of molting mature males when the biomass of females is  $>79$  mm CW is  $\geq 21.0$  million lbs and  $< 45.0$  million lbs. The legal harvest rate cap will be 50% of exploitable males. Although legal males are at an historic low, some recruitment is occurring.

Bering Sea snow crab (*Chionoecetes opilio*): The 1999 survey estimate of mature biomass was 283.5 million pounds (95% CI, 222.6 – 333.6). MSST is 460.8 million pounds of mature biomass. NMFS identified the stock as overfished on September 24, 1999. The Council is required to develop a rebuilding plan within one year from this date. There is no model developed at this time for snow crab, so the status of the population uses the current survey estimates only. The GHL for last year (Jan. 1999 fishery) was 196 million lbs. A 58% harvest rate on male crab over 102 mm has been used for past GHL's. The 1999 mature biomass survey estimate is below the MSST, therefore a reduced exploitation rate of about 22% was used on a biomass of 131 million pounds of male crab over 101 mm, resulting in a GHL for the year 2000 of 28.5 million pounds. Little recruitment is apparent, and the fishery may be closed in 2001.

Establishment of eastern Bering Sea snow crab guideline harvest level for the 2000 fishery season.

The 1999 survey estimates for eastern Bering Sea snow crab indicated that the stock was below the minimum stock size threshold (MSST) established in the FMP. Hence, special consideration was required for the establishment of any harvest guideline level (GHL) for the 2000 snow crab fishery. The GHL for the 2000 fishery season was established by ADF&G with the consultation and involvement of NMFS and Council staff, most of whom are Crab Plan Team members. Although some harvest from a stock that is below MSST can be permissible, a precautionary approach must be applied in development of the GHL to assure that harvest does not constitute overfishing and does not unduly impact the ability of the stock to rebuild to the  $B_{MSY}$  level. The need to apply precautionary measures when developing a GHL for eastern Bering sea snow crab in 2000 is especially important because a rebuilding plan for the stock has not yet been developed. ADF&G relied heavily on Restrepo et al. (1998) for guidance in establishing the snow crab GHL for 2000.

As background, status quo management of eastern Bering Sea snow crab is to set the GHL by applying a 58% exploitation rate on the biomass of males 4-inches (102-mm) or greater in carapace width (CW) as estimated from the summer trawl survey. The 4-inch minimum reflects the industry-standard minimum size. The 58% exploitation rate is the suggested harvest rates based on yield-per-recruit considerations (Somerton 1981, Somerton and Low 1977) adapted for the 4-inch minimum by NMFS AFSC biologists. As further background, Restrepo et al. (1998) suggest that a stock that is below 50% of the MSST should be closed to directed fishing. On the other hand, a stock that is between 50% MSST and MSST should be prosecuted with a fishing mortality at 75% of a precautionary fishing mortality rate that is below  $F_{MSY}$ . At an estimated 283.5 million pounds of spawning biomass (i.e., total mature male and female biomass), the snow crab stock is roughly 62% of the MSST value of 460.8 million pounds. Finally, the overfishing rate defined in the FMP for snow crab is defined as a fishing mortality in excess of 0.3 as applied to the spawning biomass.

As well as the survey population estimates, other information was presented and discussed during the meetings that lead to the setting of the 2000 snow crab GHL. Included in the discussions were: model predictions for number of males > 101-mm CW in summer of 2000 after varying levels of harvest during the 2000 fishery season; survivorship of mature males and females into summer of 2000 for various natural mortality and harvest scenarios; considerations and data on the impact of bycatch; considerations on the effect of various removals on the remaining ratio of mature females to mature males; and, discussions and data on the tendency of the commercial fleet to remove newshell crabs at a higher rate than oldshell crabs.

The status quo for the 2000 season was clearly not acceptable. At a 76 million pound GHL, even without any considerations of bycatch mortality the status quo approach would have produced a GHL close to the maximum sustainable yield value of 85.1 million pounds. Application of the status quo would have resulted in fishing rates that would have greatly exceeded the long term average and which would have been exceeded only by the rates estimated for the 1986 and 1987 fishery seasons. The status quo could also, under some reasonable scenarios, have resulted in a fishing mortality in excess of 0.3 for the year-long period between the 1999 and 2000 surveys.

Halving the status quo harvest rate from 58% of males > 101-mm CW to 29% of males > 101-mm CW appeared to protect from overfishing under most natural mortality scenarios. Nonetheless, the 50% reduction to the status quo cannot be considered precautionary in the present situation because the resulting harvest rate on mature males is close to the long-term average and because, under some more severe assumptions on natural mortality, the annual fishing mortality to the spawning biomass could come close to 0.3.

The 29% harvest rate dealt with above was reduced to 75% to provide a harvest rate of 22% applied to males > 101-mm CW. That harvest rate provides a GHL of 28.5 million pounds. Under realistic exceptions for bycatch rates and reasonably conservative assumptions on handling mortality, the total removal of mature biomass due to a 28.5 million pound GHL would be 30.2 million pounds. The result provides for a fishing mortality well below the overfishing definition and well below the long term average harvest rates applied to numbers of mature males, biomass of mature males, and total male and female biomass. It also provides for expected mature female to male ratios in surviving crabs that are close to the long term average. Finally, beyond the conservation concerns, the 28.5 million pound GHL is at a level that could be considered manageable for the 2000 fishery season.

Bristol Bay red king crab (*Paralithodes camtschaticus*): The model used for red king crab was the same as in the 1998 SAFE. The effective spawning biomass<sup>1</sup> in 1999 was estimated to be 47.1 million pounds (95% C.I., 33.9 – 65.6) from the LBA model. The 1999 survey estimate of mature biomass was 117.7 million pounds (95% CI). The MSST for red king crab is 44.8 million pounds of mature biomass (FMP 1998). The target rebuilding level of effective spawning biomass is 55 million pounds. A 10% harvest rate is applied to the mature male abundance for the 1999 GHL, since the effective spawning biomass is below the target level. The 1999 GHL is 10.66 million pounds of legal males. The harvest rate is 15% of mature male abundance when the effective spawning biomass is above 55 million pounds. Abundance of mature males has increased due to growth of a recruiting cohort. However, decreased abundance of mature females requires use of a 10% exploitation rate.

Pribilof Islands red king crab (*Paralithodes camtschaticus*): The 1999 mature biomass estimate from the survey was 12.8 million pounds. MSST is 3.3 million pounds of mature biomass. 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 legal males and the poor fishery performance in recent years, there will be no Pribilof crab fishery in 1999. In the trawl survey, crabs were highly concentrated and therefore index has a very low precision. Despite an increase this year, survey and fishery data indicate a long term decline.

Pribilof Islands blue king crab (*Paralithodes platypus*): The 1999 survey biomass estimate of mature biomass was 9.2 million pounds. MSST is 6.6 million pounds of mature biomass. Model estimates of mature male and legal male abundance declined in 1999 to 0.8 and 0.7 million crabs, respectively. Due to the low and declining abundance of legal males there will be no fishery in 1999. This population is low and may be declining in the long-term.

St. Matthew blue king crab (*Paralithodes platypus*): The 1999 mature biomass estimate from the survey was 4.8 million pounds, which is below the MSST of 11.0 million pounds of mature biomass. Due to the low mature biomass the fishery is overfished and will be closed in 1999. The Council is required to develop a rebuilding plan by September, 2000. The 1999 mature biomass estimate is significantly below the 1998 mature biomass estimate of 24.1 million pounds. The GHL for 1998 was 3.8 million pounds.

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<sup>1</sup> Effective Spawning Biomass is the estimated biomass of mature female crabs that the population of mature crabs successfully mate in a given year.

## 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; *C. bairdi* Tanner crab (Western Aleutian); 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. Most of these species are generally taken as bycatch in other crab fisheries. 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, Aleutian Islands golden king crab, Aleutian Islands scarlet king crab, E. Aleutian Islands Tanner crab, and E. Aleutian Islands grooved crab. The 1999 survey results are not available yet.

**Table 3. 1999/2000 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	??	7/1-9/3:11/15-5/15	0.5
St Lawrence blue king	NA	permit	0.1
Aleutian Is. golden king	5.7	9/1	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	0.2	permit	1.8
EBS tanneri	0.2	permit	1.5
W. Aleutian Is. Tanneri	0.1	permit	0.2

Aleutian Islands red king crab (Dutch harbor and Adak red king crab stocks): The Adak stock has not been surveyed since 1977 and the eastern portion of the Dutch Harbor stock was surveyed in 1999 by Alaska Department of Fish and Game. Few red king crab were caught in either the 1995 or 1999 survey of the eastern Aleutians. The eastern portion has been closed since 1987. The western fishery was closed for the 1996/97 and 1997/98 seasons due to poor fishery performance in the 1995/96 season; portions were reopened to limited exploratory fishing for the 1998/99 season. The 1999/2000 season is closed. The GHL for the eastern portion is set based on the triennial-quadrennial trawl survey. GHLs for the western portion are based on recent fishery performance.

Norton Sound red king crab: The 1996 survey estimated 1.6 million pounds of legal size male crab biomass, which was down from the 3.4 million pounds estimated in the 1991 survey. The Norton Sound crab fishery operates in the summer and in the winter. Due to low legal male abundance a harvest rate of 5% was applied to the legal biomass estimated in 1996. The 1998/1999 winter catch was 7,041 pounds and the 1999 summer catch was 23,550 pounds. The GHL is set on the basis of triennial trawl survey stock abundance estimates. The 1999 survey stock abundance estimates will be available in October. Preliminary estimates from the 1999 Norton sound survey indicate that legal males have increased by at least 50% over the 1996 level.

Aleutian Islands golden king crab (Eastern Aleutians (Dutch Harbor) and Adak golden king crab stocks): A portion of the eastern Aleutian Islands area was last surveyed with pots in 1997. The 1999/2000 GHL of

5.7 million pounds is divided into 2.7 million pounds west of 174°W, and 3.0 million pounds east of 174°W. The Aleutian Islands golden king crab stocks appear to be stable, based on the survey and fishery performance.

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. The 1995 survey estimates of the number of crabs were 29,000 legal males and 135,000 females. The 1999 survey estimate of crab abundance is not available at this time. However, preliminary survey results from 1999 indicate an increase in adult females and legal males from 1995 levels. Note that this increase is evident only within a very limited area.

### 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>Table 4. MSST, MSY, OY, and the MSY control rule estimates for BSAI king and Tanner crab stocks.</b>				
<b>Estimated values are in millions of pounds.</b>				
<b>(NA indicates that insufficient data exists at this time to estimate the value)</b>				
<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 mature biomass (MB) of a stock. A fraction of the MB 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: 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.



## Thresholds in State of Alaska harvest strategies and regulations.

As well as the minimum stock size threshold (MSST), survey results for four stocks (Pribilof blue king crab, St. Matthew blue king crab, Bristol Bay red king crab, and eastern Bering Sea Tanner crab) are compared to thresholds established in state of Alaska harvest strategies and regulations. Status of stocks and fisheries relative to those thresholds are reviewed here.

Under the harvest strategies developed for the Pribilof and St. Matthew 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 1999 catch-survey analysis (CSA) estimate for Pribilof Islands blue king crab > 119-mm CL is 0.81 million with a 95% confidence interval of 0.59-0.93 million (Table2). Although the CSA point estimate for Pribilof Islands blue king crab > 119-mm CL slightly exceeds the threshold value, the confidence interval includes the threshold and the area-swept point estimate (0.6 million) falls below the threshold. Given those considerations, coupled with the poor fishery performance in 1998 and a declining stock trend, the Pribilof blue king crab fishery was closed for the 1999 season. The St. Matthew blue king crab threshold of 0.60 million males > 104-mm CL was exceeded by two-fold in 1999 (Table 2); the fishery was, nonetheless, closed due to the spawning biomass being less than one-half of the MSST specified in the FMP.

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 21.9 million females > 89-mm CL and of 47.1 million pounds of effective spawning biomass for 1999, the Bristol Bay red king crab stock is well above the threshold for a fishery opening. The effective spawning biomass estimate falls below the 55-million-pound threshold required to increase the exploitation rate on mature-sized males from 10% to 15%, however.

Finally, the computed guideline for the 1999 open-access (i.e., non-CDQ)

Bristol Bay red king crab fishery season exceeds the minimum 4 million pounds necessary for a fishery opening.

**Table 2. Threshold Values in State of Alaska Harvest Strategies for Bering Sea King and Tanner Crabs**

<b>Pribilof blue king crab</b>	
<u>Stock threshold for fishery opening</u>	<u>1999 estimate</u>
0.77 million $\sigma$ >119-mm CL	0.81 (0.59 - 0.93) million <sup>a</sup>
<b>St. Matthew blue king crab</b>	
<u>Stock threshold for fishery opening</u>	<u>1999 estimate</u>
0.60 million $\sigma$ >104 - mm CL	1.24(1.14 - 1.87) million <sup>a</sup>
<b>Bristol Bay red king crab</b>	
<u>Stock threshold for fishery opening</u>	<u>1999 estimate</u>
• 8.4 million $\text{♀}$ >89 - mm CL and	21.9 (15.8 - 30.5) million <sup>b</sup>
• 14.5 million pounds effective spawning biomass	47.1 million pounds <sup>b</sup>
<u>Stock threshold for increasing exploitation rate on <math>\sigma</math> &gt; 119 - mm CL from 10% to 15%</u>	<u>1999 estimate</u>
55 million pounds effective spawning biomass	47.1 million pounds <sup>b</sup>
<u>GHL threshold for fishery opening</u>	<u>Computed GHL for 1999 season</u>
4 million pounds	10.127 million pounds <sup>c</sup>
<b>Eastern Bering Sea Tanner crab (<i>bairdi</i>)</b>	
<u>Stock threshold for fishery opening</u>	<u>1999 estimate</u>
21 million pounds of $\text{♀}$ > 79 - mm CW	16.9 million pounds <sup>d</sup>
<u>Stock threshold for increasing exploitation rate on molting mature <math>\sigma</math> from 10% to 15%</u>	<u>1999 estimate</u>
45 million pounds of $\text{♀}$ > 79 - mm CW	16.9 million pounds <sup>d</sup>
<u>GHL threshold for fishery opening</u>	<u>Computed GHL for 1999 season</u>
4 million pounds	0.0 million pounds

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

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

<sup>c</sup> Open-access fishery only

<sup>d</sup> Area swept estimate

The eastern Bering Sea Tanner crab fishery also 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 CW. The 1999 estimate for eastern Bering Sea Tanner crab females > 79-mm CW is below that threshold at 16.9 million pounds. Hence the fishery will not be opened for the 1999 season and the survey data do not need to be examined relative to the remaining thresholds.

## **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. (1998) will be published to provide details on the 1999 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 crabs in 1999: 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, we used data from both surveys 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 BS/AI: 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 is 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 a triennial Norton Sound area from its trawl survey schedule. Norton sound was again surveyed by ADF&G in 1999. A pot survey of Aleutians golden king crab in the area between 170° and 172° W. longitude was first performed by ADF&G in 1991 and was established as 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.

## **Analytical Methods**

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 previous years' surveys 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). We apply LBA 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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