Fishery Management Report No. 06-29

Status of King Crab Stocks in the Eastern Bering Sea in 2005

by

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and

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Alaska Department of Fish and Game Divisions of Sport Fish and Commercial Fisheries

Symbols and Abbreviations

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Measures (fisheries)

fork length	FL
mideye-to-fork	MEF
mideye-to-tail-fork	METF
standard length	SL
total length	TL

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$log_{2,}$ etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

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ABSTRACT

Population estimation models were used to estimate annual abundance of red king crabs *Paralithodes camtschaticus* in the Bristol Bay Area during 1972-2005, red king crabs in the Pribilof District during 1988-2005, blue king crabs *P. platypus* in the St. Matthew Island Section during 1978-2005, and blue king crabs in the Pribilof District during 1975-2005. A length-based analysis (LBA) was applied to male and female red king crabs in Bristol Bay, a four-stage catch-survey analysis (CSA) was applied to males and females for the Pribilof District blue king crab stock, and a four-stage CSA was applied to males only for the Pribilof District red and St. Matthew Section blue king crab stocks. The total allowable catch (TAC) in 2005 for the Bristol Bay red king crab fishery was set at 18.329 million pounds. Both stocks of blue king crabs are in a depressed condition and classified as overfished. Both stocks of blue king crabs were closed to fishing in 2005. The red king crab fishery in the Pribilof District was also closed due to low precision of the abundance estimate and concerns on potential bycatch of blue king crabs.

Key words: king crab, abundance estimates, stock-assessment model, Bering Sea.

INTRODUCTION

The National Marine Fisheries Service (NMFS) conducts annual trawl surveys of crab and groundfish abundance in the Eastern Bering Sea (EBS). For each crab stock, the Alaska Department of Fish and Game (ADF&G), in consultation with NMFS, sets total allowable catch (TAC). For most commercially exploited stocks in the EBS, abundance is estimated by area-swept methods and reported annually by NMFS. For some stocks, ADF&G developed population estimation models to minimize the effects of annual survey measurement errors on current-year abundance estimates by incorporating survey and fishery data from prior years into the estimation process. Abundance estimates from these models are used to manage the crab fisheries and to set annual crab bycatch limits in the groundfish fisheries.

The goal of this report is to provide concise information on the stock status of EBS red king crab *Paralithodes camtschaticus* and blue king crab *P. platypus* stocks. This provides the industry and public with access to information used by the agencies to evaluate status of stocks as estimated by population models. In this report we briefly review estimation methods, current stock status, implications for crab fishery management and regulation of crab bycatch in groundfish fisheries, and a brief outlook for the future. Trawl survey data used in this year's analyses were provided by Dr. Lou Rugolo of NMFS, Kodiak, AK.

METHODS

SURVEY METHODS

NMFS has performed annual trawl surveys of the EBS since 1968. Two vessels, each equipped with an eastern otter trawl with an 83-ft headrope and a 112-ft footrope, conduct this multispecies, crab-groundfish survey during summer. Most stations are sampled in the center of a systematic 20 X 20 nm grid overlaid in an area of approximately 140,000 nm^2. Some stations near the Pribilof Islands and St. Matthew Island are sampled at the corners of the grid as well to more accurately capture the density of blue king crab in these areas (Brad Stevens, personal communication, NMFS, Kodiak, AK). The towed area is estimated and fish and invertebrate catches from each tow are sampled, enumerated, measured, and weighed. Additionally, shell condition of commercial crab species are recorded. Status of Bering Sea groundfish stocks are also assessed by this survey and will be reported in an update to NPFMC (2005a).

During the EBS trawl survey in 2005, three tows were determined to have unsatisfactory-performance. Two of the tows were in the Pribilof District and the other in the St. Matthew Island Section. Area-swept abundance estimates were calculated including the unsatisfactory-performance tows and not including those tows.

ANALYTICAL METHODS

Overview

The annual trawl survey is an essential data-gathering tool on the status of crab stocks in the EBS. However, 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 of abundance are 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 EBS king crabs that are tailored to differing levels of information: *length-based analysis (LBA)* for stocks with high-quality size frequency 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 CSA to St. Matthew Island Section and Pribilof District blue king crabs and Pribilof District red king crabs. A brief description of these two methods and their application to king crab stocks in the EBS follow.

Length-based Analysis

The LBA is an analytical procedure to estimate annual abundance of crab stocks for which extensive high-quality data are available, such as Bristol Bay red king crabs. 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 new-shell (i.e., those that molted within the past year) and old-shell 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. Collie and Kruse (1998) estimated the trawl survey catchability coefficient *(q)* to be near unity for legal-sized red king crabs in Bristol Bay and $q = 1$ is assumed for area-swept and LBA methods. An overview of the approach is provided in Zheng et al. (1996).

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. Zheng and Kruse (2000) extended it to a four-stage CSA by adding a second prerecruit size group. As with the LBA, the CSA estimates survey measurement errors and "true" stock abundance. The CSA model is less complex, and requires less detailed size composition data than the LBA. For male crabs, instead of tracking multiple 5-mm size groups as the LBA does, the four-stage CSA considers only four age-size groups of crabs: *prerecruit two*, immature-sized crabs that are two molts away from legal size and one molt away from mature size; *prerecruit one*, mature-sized crabs that are one molt away from attaining legal size; *recruits*, new-shell crabs that molted to legal size within the past year; and *postrecruits*, crabs that have been legal-sized for more than one year. The previous three-stage CSA considered only prerecruit one, recruit, and postrecruit crabs. In the four-stage version, more historical data are used to smooth abundance estimates of the current mature-sized and legal crabs. The updated model provides a new series of abundance estimates over the years that the St. Matthew Island Section and Pribilof District stocks have been surveyed.

A four-stage CSA model was also used to estimate mature-sized female blue king crab relative abundance in the Pribilof District. The mature-sized female crabs were grouped into four size groups: Group 1, 100-109 mm CL; Group 2, 110-119 mm CL; Group 3, 120-129 mm CL; and Group 4, > 129 mm CL. There are no plans to use CSA models to estimate relative abundance of female red king crabs in the Pribilof District or female blue king crabs in the St. Matthew Island Section due to low survey catchability and the high uncertainty in selectivity of these crabs in the EBS trawl survey.

CURRENT STOCK STATUS

BRISTOL BAY RED KING CRABS

Two scenarios of natural mortality (M) were used in the LBA to estimate Bristol Bay red king crab abundance: (1) three levels of M for males (3 M) and four levels of M for females (4 M) over time and (2) a constant M over time (1 M), measured separately for males and females. Under scenario (2), model estimates of mature-sized abundance are generally lower than the survey estimates during 1973-1982 (Figure 1). Scenario (1) fit the data much better than scenario (2) (Figure 1), thus the results from scenario (1) were used in this report and for setting the TAC.

LBA estimates of Bristol Bay red king crab abundance and 95% bootstrap confidence limits for 2005 are shown in Table 1. Historical changes in mature-sized male and female abundance are graphed in Figure 1. Mature-sized males and legal males estimated by the model continued an upward trend from 2001 and mature-sized females increased to 42.67 million crabs in 2005 from 35.45 million crabs in 2004, continuing a trend of annually increasing abundance since 2000 (Table 1; Figure 1). The 2005 LBA estimates for mature-sized males, mature-sized females, effective spawning biomass (ESB), and legal male abundance are the highest since 1981. New recruits to the size-classes modeled for both males and females were similar to those last year. Pre-recruit male abundance increased to 13.05 million crabs in 2005 from 9.34 million crabs in 2004.

Insights into changes in annual survey results can be gained by examining the size frequency distributions over the past five years (Figure 2). The modal progresses from two year classes can be followed. The modes of the 1994 year class for males were approximately between 90-mm and 105-mm CL in 2001, between 105-mm and 125-mm CL in 2002, between 125-mm and 145-mm CL in 2003, and between 135-mm and 160-mm CL in 2004. The modes of the 1997 year class for males were observed between 60-mm and 80-mm CL in 2002, progressed to 75-100-mm CL in 2003, grew to 90-120-mm CL in 2004, and were between 105-mm and 140-mm CL in

2005. There are not enough data to follow the modes between 60-mm and 80-mm CL observed in 2004 and 2005. The modes for females are similar to those for males, but growth increments for mature-sized females are much smaller than those for males, and thus its modes are less distinguishable than those for males.

Just as historical survey results enter into the LBA and modify the interpretation of data from 2005, the 2005 survey results also provide additional information about reconstructed stock size in recent years. This is a common feature of contemporary estimation procedures for fish and invertebrate populations. Thus, historical abundance estimates generated with data from 1972-2005 (Table 1) differ somewhat from estimates generated with data from 1972-2003 (see Table 1 in Vining and Zheng 2003). Estimates for recent years change the most; older estimates remain most stable. Likewise, next year's assessment will bring new data to bear on the status of the stock in 2005.

PRIBILOF DISTRICT RED KING CRABS

The survey precision is very low for Pribilof District red king crabs and, as such, the CSA model and area-swept estimates of mature-sized males can be quite different. For example, the CSA estimated peak abundance in 1991, while the area-swept estimates indicate a peak in 2001 (Figure 3). The low precision is partially due to very high variability of trawl survey catch-per-unit-effort (CPUE) for red king crab in the Pribilof District.

Based on the model results, the mature-sized male abundance had increased from 0.93 million crabs in 1997 to 1.52 million crabs in 2002 (Figure 3). However, since 2002 the stock has decreased back to 0.86 million crabs as estimated in 2005. Legal abundance estimates had increased from 0.86 million in 1997 to 1.19 million crabs in 2003 (Table 2). Similar to mature-sized male crabs, the legal abundance has decreased to 0.86 million crabs in 2005. However, the precision of the estimates for mature-sized and legal-sized male abundance is poor; the 95% confidence intervals include the point estimates for annual abundance back to the mid 1990s. Hence, it is difficult to specify any specific trends in abundance for this stock.

PRIBILOF DISTRICT BLUE KING CRABS

For blue king crabs in the Pribilof District, there has been a decline in mature-sized male estimated abundance from 1.71 million crabs in 1993 to 0.12 million crabs in 2005 (Figure 4). A similar decrease in legal male estimated abundance has occurred with 1.16 million crabs estimated for 1994 to 0.11 million crabs estimated for 2005 (Table 3). Survey catches of male crabs were very low in all size categories from 2002 to 2004 (Figure 5). In 2005, though there continued to be very few crabs larger than 70-mm CL, there was a substantial increase in small crabs (< 70-mm CL). These small crabs were caught at several stations; however, it is too early to reliably estimate the contribution these crabs will have in the future.

The estimated abundance of mature-sized female blue king crabs from the Pribilof District follows a similar trend as the estimated mature-sized male abundance with an estimate of 3.35 million crabs in 1994 decreasing to 0.34 million crabs in 2005 (Table 4; Figure 4). The model abundance estimate indicates the decline was steeper for mature-sized female blue king crabs than either legal-sized or mature-sized male blue king crabs. However, the model is considered less precise for female blue king crabs because survey variability is greater. As with the male blue king crabs from the Pribilof District, there were many small female blue king crabs (< 70-mm CL) caught in the survey during 2005 (Figure 5).

The two unsatisfactory-performance tows in the Pribilof District caught no mature-sized male and few mature-sized female blue king crab. Inclusion of those two tows had no effect on the model estimates of abundance or area-swept estimate of abundance for male blue king crab. Those tows also had little effect (< 0.2% change) on the model estimates of abundance or area-swept estimate of abundance for female blue king crab. Because the estimates were virtually indistinguishable, only abundance estimates not including the two unsatisfactory-performance tows are shown in this report (Tables 3 and 4; Figures 4 and 5).

ST. MATTHEW ISLAND SECTION BLUE KING CRABS

Owing to low survey abundances in 1999 through 2005, poor in-season fishery performance in 1998, and low catch rates from the ADF&G nearshore pot survey in 1999, we suspect that natural mortality may have increased dramatically between 1998 and 1999 compared to other years. To accommodate this apparent high natural mortality in the assessment model, we estimated two natural mortality parameters using CSA: M = 1.50 for 1998/99 (that is, the year between the 1998 and 1999 surveys) and M = 0.38 for all other years. We also conducted a CSA under a model that estimated constant natural mortality (M = 0.48) for all years. The two models produce disparate estimates of mature-sized male abundance over 1996-2000 (Figure 6). However, the two models seem to be nearly identical in the estimates of mature-sized male abundance from 2002 to 2005.

CSA estimates of St. Matthew Island Section blue king crab abundance and 95% confidence limits for 2005 are shown in Table 5. There has been little change in mature-sized male abundance from 1999 to 2005 for the two-mortality model (2-M) and from 2001 to 2005 for the single mortality (1-M) model (Figure 6). Based on the best fit of the data, we chose the scenario with two natural mortality parameters to estimate abundance trends and abundance in 2005. There was an increase in prerecruit-2 estimated abundance in 2005, but this will not likely affect the mature-sized male abundance significantly in the near future. The low abundances across all male size groups have continued from 1999 through 2005 (Figure 7). The highest number of small crabs (65 – 80 mm CL) in 5 years was observed in 2003. However, these crabs have not, nor are they expected to, improve the mature-sized male abundance significantly. There have been 4 pot surveys of the St. Matthew Island Section (Watson 2005), and the general trend is constituent with the trawl survey (Table 6; Figure 8).

The one unsatisfactory-performance tow in the St. Matthew Section captured nearly 20% of the mature-sized male blue king crabs observed in the St. Matthew Section during the trawl survey, and nearly 50% of the prerecruit-2s. The area-swept mature-sized male abundance estimate when including the unsatisfactory-performance tow was 1.00 million crabs, while not including the unsatisfactory-performance tow led to an area-swept abundance of 0.84 million crabs. By not including the unsatisfactory-performance tow, the CSA model abundance estimate for mature-sized males changed from 1.02 to 0.98 million crabs, using the 2 mortality model (Tables 5 and 7 for trawl survey estimates and Tables 6 and 8 for pot survey estimates). The overall trend did not change and overall estimates were relatively close in all years (Figures 9 and 10).

FISHERY MANAGEMENT IMPLICATIONS

BRISTOL BAY RED KING CRABS

Directed Crab Fishery

The Alaska Board of Fisheries harvest strategy for Bristol Bay red king crabs sets a TAC by a harvest rate coupled with a fishery threshold (ADF&G 2005). When the stock is not above the threshold of 8.4 million mature-sized females (>89-mm CL) and 14.5 million pounds of ESB, the fishery is closed. When the stock is above the threshold, the TAC is determined by the ESB and abundance of mature and legal-sized males. A mature-sized male harvest rate of 10% or 12.5% is applied to promote stock rebuilding when ESB is below the target rebuilt level of 55 million pounds. Once the stock is at or above 55 million pounds of ESB, a 15% harvest rate is applied to mature-sized male abundance. To prevent a disproportionate harvest of large male crabs, the TAC is capped so that no more than 50% of the legal-male crabs may be harvested in any one year.

In 2005, ESB is estimated to be 68 million pounds, so a 15% harvest rate is applied to the estimated mature male abundance of 18.037 million crab, resulting in a harvest of 2.706-million legal male crabs. A harvest of 2.706-million legal male crabs would represent 25% of the estimated abundance of legal male crabs (10.77 million animals). With an estimated mean weight of 6.45 pounds for legal male crabs from the survey abundance data and a projected mean weight of 6.7725 pounds (6.45*1.05) for legal male crabs from the fishery, ADF&G derived a TAC of 18.329 million pounds. Ten percent of the TAC, or 1.8329 million pounds, is allocated to the community development quota (CDQ) fishery, and the remaining TAC, or 16.4961 million pounds, is set for the individual fishing quota (IFQ) fishery.

Implications on the Bering Sea Groundfish Trawl Fisheries

Prohibited species catch (PSC) limits for red king crabs caught during groundfish trawl fisheries are set annually as a function of estimated ESB of Bristol Bay red king crabs (NPFMC 2005c). When ESB exceeds 14.5 million pounds but is less than 55 million pounds, the PSC is 100,000 crabs. When ESB exceeds 55 million pounds, the PSC is 200,000 crabs. Given the estimate of 68 million pounds of ESB for 2005, the red king crab PSC limit for the EBS will be set at 200,000 crabs for groundfish trawl fisheries in 2006.

A portion of the year-round closure to non-pelagic trawling in the Red King Crab Savings Area (162^{o} to 164^{o} W, 56^{o} to 57^{o} N) is open to the rock sole fishery in years when there is a red king crab fishery in Bristol Bay (NPFMC 2005c). Thus, the portion of the Red King Crab Savings Area bounded by 56^{o} to 56^{o} 10' N latitude will remain open to the rock sole fishery in 2006. A separate bycatch limit is established for this area not to exceed 35% of the red king crab PSC limits apportioned to the rock sole fishery by the NPFMC.

PRIBILOF DISTRICT KING CRABS

The harvest strategy for Pribilof District blue king crabs specifies spawning biomass must be greater than or equal to 13.2 million pounds for two years (ADF&G 2005). No threshold is specified for Pribilof District red king crabs. During 1995-1998, trends in survey and fishery performance data had been used to set an aggregate guideline harvest level (GHL) for a combined blue and red king crab fishery to avoid bycatch problems that would occur if each stock were harvested with separate fisheries. The fishery for these two stocks has been closed since 1999 based on a number of factors: declining abundance, low level of prerecruits, low precision of abundance estimates, avoid bycatch of blue king crab, and past fishery performance below expectations (Zheng and Kruse 1999). The NMFS estimated spawning biomass for 2005 to be 1.6 million pounds, which is below 13.2 million pounds. So the fishery for this stock was closed in 2005. The fishery for Pribilof District red king crabs was also closed in 2005/06, due primarily to low precision of abundance estimates, the fishery closure for blue king crabs, and concern for bycatch of blue king crabs.

ST. MATTHEW ISLAND SECTION BLUE KING CRABS

The St. Matthew Island Section harvest strategy for blue king crabs has four components: (1) a minimum stock threshold of 2.9 million pounds of mature-sized male (≥105-mm CL) biomass, (2) a minimum TAC of 2.5 million pounds, (3) variable mature-sized male harvest rates based on the mature-sized male biomass level, and (4) a cap of legal male harvest rate at 40% (ADF&G 2005). The mature-sized male biomass was estimated to be above threshold at 4.7 million pounds in 2005. However, application of the harvest strategy specifies a TAC of 0.64 million pounds for the 2005 season, which is below the minimum TAC. Thus, the fishery for this stock was closed in 2005/06.

FUTURE OUTLOOK

Based on the length frequency distribution, some minor recruitment in 2006 to the mature-sized male population can be expected for Bristol Bay red king crabs (Figure 2). However, mature-sized female abundance may decrease in 2006. The modes that have contributed to recruitment to the mature-sized female population during 2003-2005 surveys appear to be fully recruited to the mature-sized female population in 2005 (Figure 2). Although part of the juvenile-sized female crabs in the new mode between 60-80 mm may recruit to the mature-sized population in 2006, it is uncertain how much this cohort will contribute to the mature-sized population.

Recruitment to the Bristol Bay red king crab mature-sized population during the next 2-3 years depends mainly on the cohort strength observed with modes between 60-80 mm in 2004 and 2005 (Figure 2). Length modes for crabs of that size do not always track into future surveys, i.e. in the future the mode may decrease more quickly than natural mortality would suggest. However, if those juveniles do continue to track into future surveys, they would begin providing recruitment to the mature-sized female population by 2006 and to the mature-sized male population by 2007.

Population trends for Pribilof District red king crabs since the early 1990s are difficult to specify due to the low precision of annual abundance estimate. In 2005, as in previous years, most of the abundance estimate is based on the catch occurring in only one or two tows during the survey.

Both EBS blue king crab stocks are depressed. The Pribilof District blue king crab stock had an estimated mature-sized biomass of 1.6 million pounds, second only to 2004 as the lowest level observed, and well below the minimum stock size threshold (MSST) for this stock 6.6 million pounds (NPFMC 2005b). The NMFS declared this stock overfished in 2002. Based on trends in prerecruits and recruits for blue king crabs within the Pribilof District, the stock will not likely increase above the MSST in the near future. However, for the first time in over a decade many small blue king crabs were caught in the Pribilof District during the EBS trawl survey, this could enhance the stock in several years, though it is too early to tell.

Although we are still not certain about the level of high natural mortality from 1998 to 1999 for the St. Matthew blue king crab stock, the low survey abundance from 1999 through 2005 greatly strengthens the argument for the high natural mortality. Unlike the Pribilof District blue king crab stock, the EBS trawl survey did not catch significant numbers of small crabs from the St. Matthew Section blue king crab stock. Therefore, the stock is likely to stay in the current depressed state for at least the near-term.

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TABLES AND FIGURES

Table 1.–Annual abundance estimates (in millions of crabs), effective spawning biomass (ESB, millions of pounds), and 95% confidence intervals for 2005 red king crabs in Bristol Bay estimated by length-based analysis from 1972-2005. *Size measurements are in mm CL.*

	Males					Females		
		Small	Prerecruit	Mature	Legal		Mature	ESB
Year	Recruits	(95-109)	(110-134)	(>119)	(>134)	Recruits	(>89)	(millions of lbs)
1972	NA	13.553	15.091	18.556	10.027	NA	59.569	55.612
1973	31.024	21.647	25.685	22.633	10.809	34.687	70.742	63.575
1974	22.415	16.193	34.473	34.173	15.003	29.102	71.959	93.844
1975	33.643	23.480	35.607	40.971	20.932	22.413	66.040	116.875
1976	45.644	31.953	45.393	49.112	25.537	34.237	74.299	128.249
1977	55.176	38.800	59.649	62.433	30.777	73.738	118.762	166.936
1978	22.741	17.253	59.371	76.565	40.392	49.877	121.741	203.573
1979	13.221	9.732	36.932	74.403	48.541	21.716	95.522	171.094
1980	24.937	17.288	25.677	59.744	44.584	36.426	94.431	168.351
1981	17.902	12.976	16.887	18.118	9.528	14.207	71.468	59.044
1982	22.255	15.687	15.186	9.733	2.942	17.953	30.170	23.101
1983	12.317	9.125	12.521	8.469	2.426	4.604	9.743	16.397
1984	18.642	13.049	11.859	7.458	2.275	7.988	9.650	14.472
1985	9.385	7.010	9.954	6.491	1.694	5.610	7.250	10.786
1986	6.702	4.938	11.885	11.226	4.279	4.074	9.082	14.416
1987	6.676	4.795	10.567	13.131	6.577	10.238	16.529	25.942
1988	6.767	4.851	9.810	13.895	8.027	6.296	17.729	29.554
1989	5.538	4.026	9.280	15.132	9.516	6.060	18.352	31.902
1990	1.523	1.267	7.108	14.960	10.155	0.956	13.682	26.373
1991	4.345	3.003	4.859	11.884	8.733	3.827	13.337	25.802
1992	5.925	4.179	5.969	9.990	6.875	3.387	12.639	24.695
1993	2.490	2.175	6.917	10.203	6.106	2.274	11.043	22.227
1994	1.155	1.035	5.429	8.785	4.999	0.414	8.081	17.615
1995	2.974	2.139	4.634	9.459	6.318	1.614	9.159	20.196
1996	3.290	2.496	5.201	10.301	7.149	4.276	12.818	26.508
1997	13.393	9.196	8.612	11.590	7.540	16.379	28.316	39.277
1998	3.019	3.230	13.185	15.206	7.775	1.809	28.122	51.082
1999	1.415	1.132	8.221	15.931	9.667	0.677	20.225	43.153
2000	3.804	2.699	5.859	13.089	8.960	4.791	18.853	39.487
2001	7.921	5.663	7.308	11.973	8.011	7.910	20.992	41.159
2002	2.078	2.135	9.234	13.605	8.057	2.640	22.183	46.083
2003	5.440	3.799	7.438	14.944	9.997	7.627	28.325	57.800
2004	10.168	7.110	9.342	15.075	10.175	9.060	35.454	59.307
2005	8.735	6.361	13.054	18.037	10.769	9.627	42.669	67.991
	95% Confidence Limits of Estimates for 2005							
Lower Bound	6.117	NA	10.291	14.008	7.961	7.698	35.224	NA
Upper Bound	16.779	NA	16.188	21.354	13.141	15.546	53.684	NA

Table 2.–Annual abundance estimates (in millions of crabs) and 95% confidence intervals for 2005 male red king crabs in the Pribilof District estimated by a 4-stage catch-survey analysis from 1988-2005. *Size measurements are in mm CL.*

Year	Prerecruit 2 (105-119)	Prerecruit 1 (120-134)	Mature (≥120)	Recruit New-shell (135-149)	Postrecruit Old-shell (≥135)	Legal (≥135)
1988	0.293	0.046	0.069	0.023	0.000	0.023
1989	0.290	0.224	0.293	0.047	0.021	0.068
1990	2.326	0.258	0.470	0.145	0.066	0.212
1991	0.362	1.754	2.256	0.317	0.186	0.502
1992	0.060	0.649	2.135	0.993	0.493	1.486
1993	0.567	0.187	1.797	0.362	1.248	1.610
1994	0.171	0.462	1.619	0.151	1.006	1.157
1995	0.136	0.216	1.328	0.283	0.828	1.112
1996	0.048	0.144	1.109	0.134	0.830	0.964
1997	0.742	0.063	0.927	0.088	0.776	0.863
1998	0.397	0.581	1.310	0.095	0.634	0.729
1999	0.339	0.409	1.358	0.381	0.569	0.950
2000	0.352	0.334	1.406	0.273	0.799	1.072
2001	0.376	0.329	1.456	0.232	0.896	1.127
2002	0.040	0.346	1.518	0.232	0.941	1.172
2003	0.004	0.085	1.279	0.215	0.978	1.193
2004	0.001	0.019	1.051	0.051	0.982	1.033
2005	0.019	0.004	0.862	0.011	0.847	0.858

	95% Confidence Limits of Estimates for 2005					
Lower Bound	NA	NA	0.314	NA	NA	0.312
Upper Bound	NA	NA	1.410	NA	NA	1.404

Table 3.–Annual abundance estimates (in millions of crabs) and 95% confidence intervals for 2005 male blue king crabs in the Pribilof District estimated by a 4-stage catch-survey analysis from 1975-2005. *Size measurements are in mm CL***.**

Year	Prerecruit 2 (105-119)	Prerecruit 1 (120-134)	Mature (≥120)	Recruit New-shell (135-149)	Postrecruit Old-shell (≥135)	Legal (≥135)
1975	2.125	3.871	13.325	4.344	5.109	9.454
1976	1.052	2.540	11.316	2.087	6.689	8.776
1977	5.591	1.482	8.670	1.439	5.749	7.188
1978	1.647	3.345	9.021	1.070	4.606	5.676
1979	0.736	2.095	7.515	1.847	3.573	5.420
1980	0.226	1.174	5.625	1.119	3.332	4.451
1981	0.502	0.552	3.279	0.653	2.075	2.728
1982	0.479	0.465	1.855	0.346	1.044	1.390
1983	0.354	0.423	1.290	0.298	0.569	0.867
1984	0.083	0.342	1.048	0.277	0.430	0.707
1985	0.028	0.152	0.879	0.235	0.493	0.727
1986	0.002	0.052	0.648	0.124	0.472	0.596
1987	0.002	0.013	0.458	0.041	0.403	0.444
1988	0.000	0.003	0.262	0.013	0.246	0.259
1989	1.738	0.001	0.190	0.002	0.187	0.189
1990	0.319	1.090	1.337	0.111	0.136	0.247
1991	0.635	0.533	1.463	0.711	0.220	0.930
1992	0.733	0.538	1.588	0.361	0.690	1.051
1993	0.421	0.582	1.705	0.347	0.776	1.123
1994	0.507	0.431	1.591	0.332	0.828	1.160
1995	0.525	0.412	1.507	0.246	0.849	1.095
1996	0.294	0.403	1.286	0.215	0.668	0.883
1997	0.110	0.298	1.037	0.187	0.552	0.739
1998	0.155	0.181	0.786	0.118	0.487	0.605
1999	0.069	0.140	0.595	0.067	0.388	0.455
2000	0.033	0.094	0.468	0.044	0.330	0.374
2001	0.016	0.059	0.358	0.027	0.271	0.299
2002	0.007	0.034	0.274	0.023	0.217	0.239
2003	0.003	0.018	0.207	0.015	0.173	0.189
2004	0.016	0.009	0.153	0.008	0.137	0.145
2005	0.005	0.011	0.121	0.005	0.104	0.109

	95% Confidence Limits of Estimates for 2005					
Lower Bound	NA	NA	0.065	NA	NA	0.054
Upper Bound	NA	NA	0.177	NA	NA	0.165

Table 4.–Annual abundance estimates (in millions of crabs) and 95% confidence intervals for 2005 female blue king crabs in the Pribilof District estimated by a 4-stage catch-survey analysis from 1975-2005. *Size measurements are in mm CL.*

Year	Group 1 (100-109)	Group 2 (110-119)	Group 3 (120-129)	Group 4 (≥130)	Mature (≥100)
1975	1.686	2.311	1.514	0.786	6.297
1976	3.637	1.779	1.546	0.769	7.732
1977	2.799	2.260	1.462	0.785	7.305
1978	1.935	2.081	1.568	0.790	6.374
1979	0.899	1.671	1.560	0.801	4.930
1980	2.091	1.115	1.419	0.796	5.421
1981	0.974	1.321	1.171	0.763	4.230
1982	0.510	1.022	1.059	0.700	3.292
1983	0.557	0.713	0.910	0.635	2.814
1984	0.250	0.580	0.742	0.570	2.142
1985	0.120	0.391	0.607	0.506	1.624
1986	0.073	0.238	0.478	0.449	1.237
1987	0.041	0.141	0.358	0.394	0.935
1988	0.046	0.082	0.258	0.340	0.726
1989	0.595	0.058	0.180	0.287	1.119
1990	0.857	0.305	0.126	0.237	1.524
1991	0.896	0.540	0.167	0.193	1.797
1992	1.458	0.659	0.265	0.167	2.550
1993	0.920	0.974	0.365	0.162	2.422
1994	1.804	0.839	0.535	0.176	3.354
1995	1.091	1.200	0.592	0.213	3.096
1996	0.622	1.016	0.739	0.247	2.624
1997	0.362	0.736	0.753	0.288	2.139
1998	0.244	0.503	0.670	0.315	1.732
1999	0.417	0.344	0.551	0.323	1.635
2000	0.242	0.351	0.434	0.316	1.343
2001	0.145	0.264	0.369	0.298	1.076
2002	0.055	0.173	0.305	0.280	0.814
2003	0.020	0.090	0.238	0.261	0.608
2004	0.007	0.042	0.168	0.235	0.452
2005	0.003	0.021	0.113	0.199	0.336

	95% Confidence Limits of Estimates for 2005				
Lower Bound	NA	NA	NA	NA	0.249
Upper Bound	NA	NA	NA	NA	0.423

Table 5.–Annual abundance estimates (in millions of crabs) and 95% confidence intervals for 2005 male blue king crabs in the St. Matthew Island Section estimated by a 4-stage catch-survey analysis from 1978-2005. *Size measurements are in mm CL.*

Year	Prerecruit 2 (99-104)	Prerecruit 1 (105-119)	Mature (≥105)	Recruit New-shell (135-149)	Postrecruit Old-shell (≥135)	Legal (≥135)
1978	0.955	1.506	3.643	1.431	0.707	2.138
1979	2.410	1.296	3.604	1.084	1.224	2.308
1980	2.194	2.641	5.412	1.169	1.603	2.772
1981	0.869	2.797	6.867	2.070	2.000	4.070
1982	0.973	1.527	5.801	2.081	2.193	4.274
1983	0.472	1.315	4.146	1.192	1.639	2.831
1984	0.279	0.801	2.337	0.922	0.614	1.536
1985	0.512	0.483	1.512	0.539	0.490	1.029
1986	0.397	0.601	1.346	0.369	0.376	0.745
1987	0.724	0.534	1.382	0.466	0.381	0.847
1988	0.658	0.812	1.740	0.490	0.439	0.929
1989	1.607	0.789	1.975	0.723	0.463	1.186
1990	1.186	1.693	3.196	0.826	0.677	1.503
1991	1.181	1.479	3.786	1.467	0.840	2.307
1992	1.236	1.444	3.850	1.279	1.126	2.405
1993	1.278	1.507	4.065	1.230	1.328	2.558
1994	1.230	1.580	4.197	1.251	1.366	2.617
1995	1.598	1.569	4.102	1.270	1.263	2.533
1996	1.427	1.906	4.559	1.328	1.324	2.653
1997	0.952	1.836	4.790	1.528	1.426	2.954
1998	0.659	1.391	4.141	1.332	1.418	2.750
1999	0.359	0.325	1.089	0.309	0.456	0.764
2000	0.319	0.412	1.191	0.243	0.537	0.779
2001	0.389	0.397	1.224	0.278	0.550	0.828
2002	0.127	0.427	1.249	0.241	0.580	0.821
2003	0.332	0.249	1.055	0.230	0.576	0.806
2004	0.212	0.339	1.065	0.166	0.560	0.726
2005	0.600	0.285	1.022	0.226	0.511	0.737

	95% Confidence Limits of Estimates for 2005					
Lower Bound	NA	NA	0.597	NA	NA	0.399
Upper Bound	NA	NA	1.447	NA	NA	1.075

Table 6.–Annual catch per unit effort estimates (number of crabs per pot) for male blue king crabs in the St. Matthew Island Section estimated by a 4-stage catch-survey analysis from 1978-2005, for the ADF&G pot surveys of 1995, 1998, 2001, and 2004. *Size measurements are in mm CL.*

Year	Prerecruit 2 (99-104)	Prerecruit 1 (105-119)	Mature (≥105)	Recruit New-shell (120-133)	Postrecruit Old-shell (≥120)	Legal (≥120)
1995	2.347	3.462	11.440	3.999	3.979	7.978
1998	0.968	3.069	11.732	4.195	4.467	8.663
2001	0.571	0.875	3.482	0.875	1.731	2.607
2004	0.311	0.748	3.036	0.523	1.765	2.288

Table 7.–Annual abundance estimates (in millions of crabs) and 95% confidence intervals for 2005 male blue king crabs in the St. Matthew Island Section estimated by a 4-stage catch-survey analysis from 1978-2005, without inclusion of one unsatisfactory performance tow during the 2005 EBS trawl survey. *Size measurements are in mm CL.*

Year	Prerecruit 2 (99-104)	Prerecruit 1 (105-119)	Mature (≥105)	Recruit New-shell (135-149)	Postrecruit Old-shell (≥135)	Legal (≥135)
1978	0.961	1.496	3.646	1.439	0.711	2.150
1979	2.430	1.284	3.594	1.078	1.231	2.309
1980	2.208	2.617	5.386	1.167	1.602	2.769
1981	0.871	2.776	6.847	2.075	1.997	4.072
1982	0.978	1.515	5.792	2.083	2.193	4.277
1983	0.476	1.307	4.139	1.192	1.640	2.832
1984	0.281	0.796	2.333	0.922	0.615	1.537
1985	0.517	0.480	1.509	0.539	0.490	1.029
1986	0.399	0.597	1.343	0.369	0.376	0.746
1987	0.729	0.531	1.378	0.466	0.381	0.847
1988	0.660	0.808	1.736	0.490	0.438	0.928
1989	1.621	0.784	1.970	0.723	0.463	1.186
1990	1.192	1.686	3.189	0.826	0.677	1.503
1991	1.187	1.473	3.780	1.468	0.840	2.308
1992	1.243	1.438	3.843	1.280	1.126	2.406
1993	1.286	1.500	4.057	1.231	1.327	2.558
1994	1.235	1.573	4.189	1.252	1.364	2.616
1995	1.593	1.560	4.093	1.271	1.262	2.533
1996	1.438	1.881	4.533	1.328	1.323	2.652
1997	0.958	1.825	4.769	1.521	1.424	2.945
1998	0.655	1.380	4.125	1.334	1.411	2.745
1999	0.362	0.320	1.083	0.309	0.455	0.764
2000	0.321	0.409	1.186	0.242	0.536	0.777
2001	0.389	0.393	1.219	0.278	0.548	0.826
2002	0.128	0.422	1.241	0.241	0.578	0.819
2003	0.321	0.246	1.048	0.228	0.574	0.802
2004	0.193	0.325	1.045	0.163	0.557	0.720
2005	0.325	0.261	0.981	0.214	0.505	0.720

	95% Confidence Limits of Estimates for 2005					
Lower Bound	NA	NA	0.579	NA	NA	0.391
Upper Bound	NA	NA	1.382	NA	NA	1.048

Table 8.–Annual catch per unit effort estimates (number of crabs per pot) for male blue king crabs in the St. Matthew Island Section estimated by a 4-stage catch-survey analysis from 1978-2005, for the ADF&G pot surveys of 1995, 1998, 2001, and 2004, without inclusion of one unsatisfactory performance tow haul during the 2005 EBS trawl survey. *Size measurements are in mm CL*.

Prerecruit 1 (105-119)	Mature (≥105)	Recruit New-shell (120-133)	Postrecruit Old-shell (≥120)	Legal (≥120)
3.499	11.509	4.019	3.991	8.009
3.096	11.776	4.218	4.462	8.680
0.882	3.493	0.878	1.732	2.611
0.728	3.005	0.516	1.761	2.277

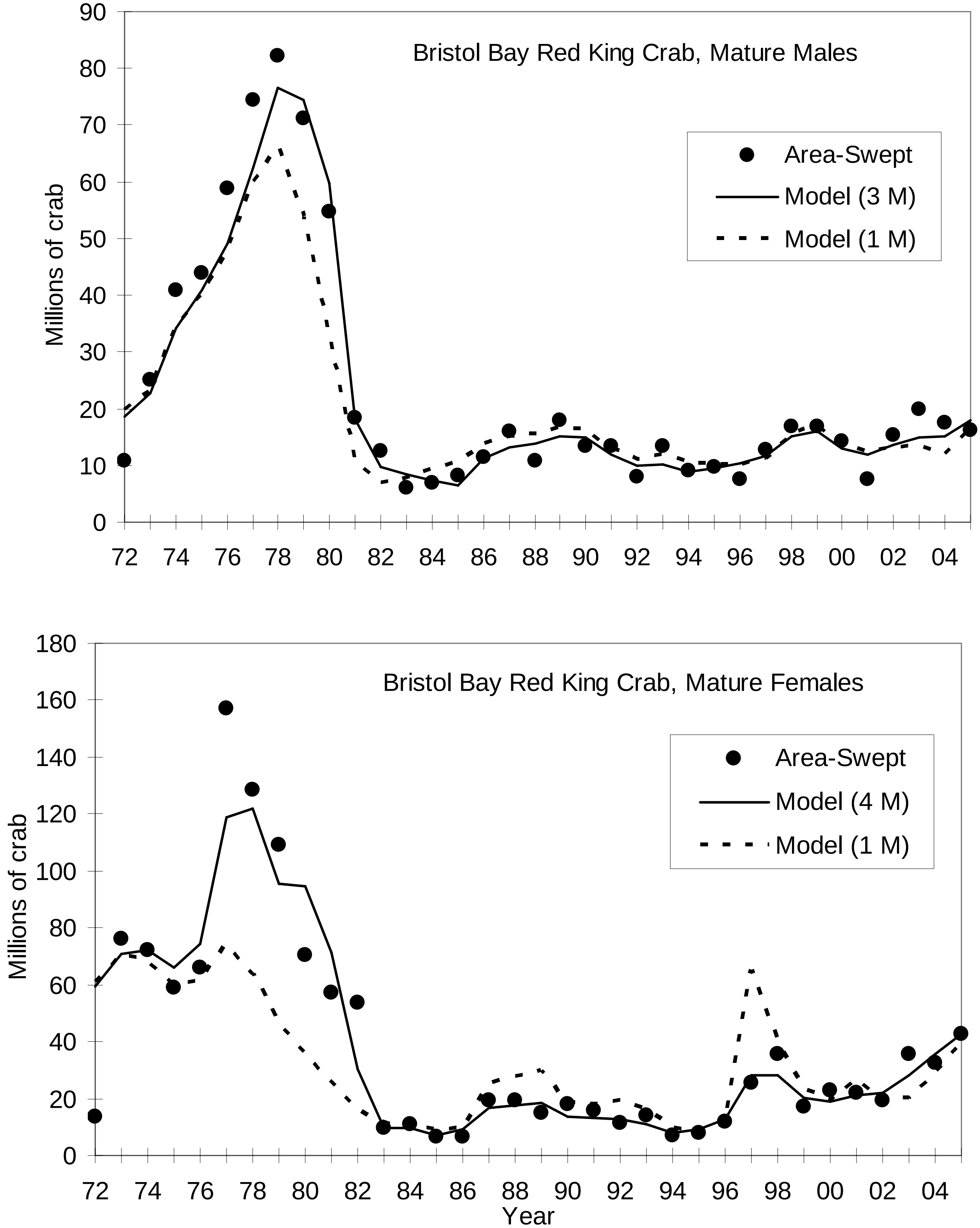


Figure 1.–The length-based analysis model fit (line) to area-swept estimates (dots) of mature-sized male (top panel) and mature-sized female (bottom panel) Bristol Bay red king crab abundance (millions of crab), 1972-2005.

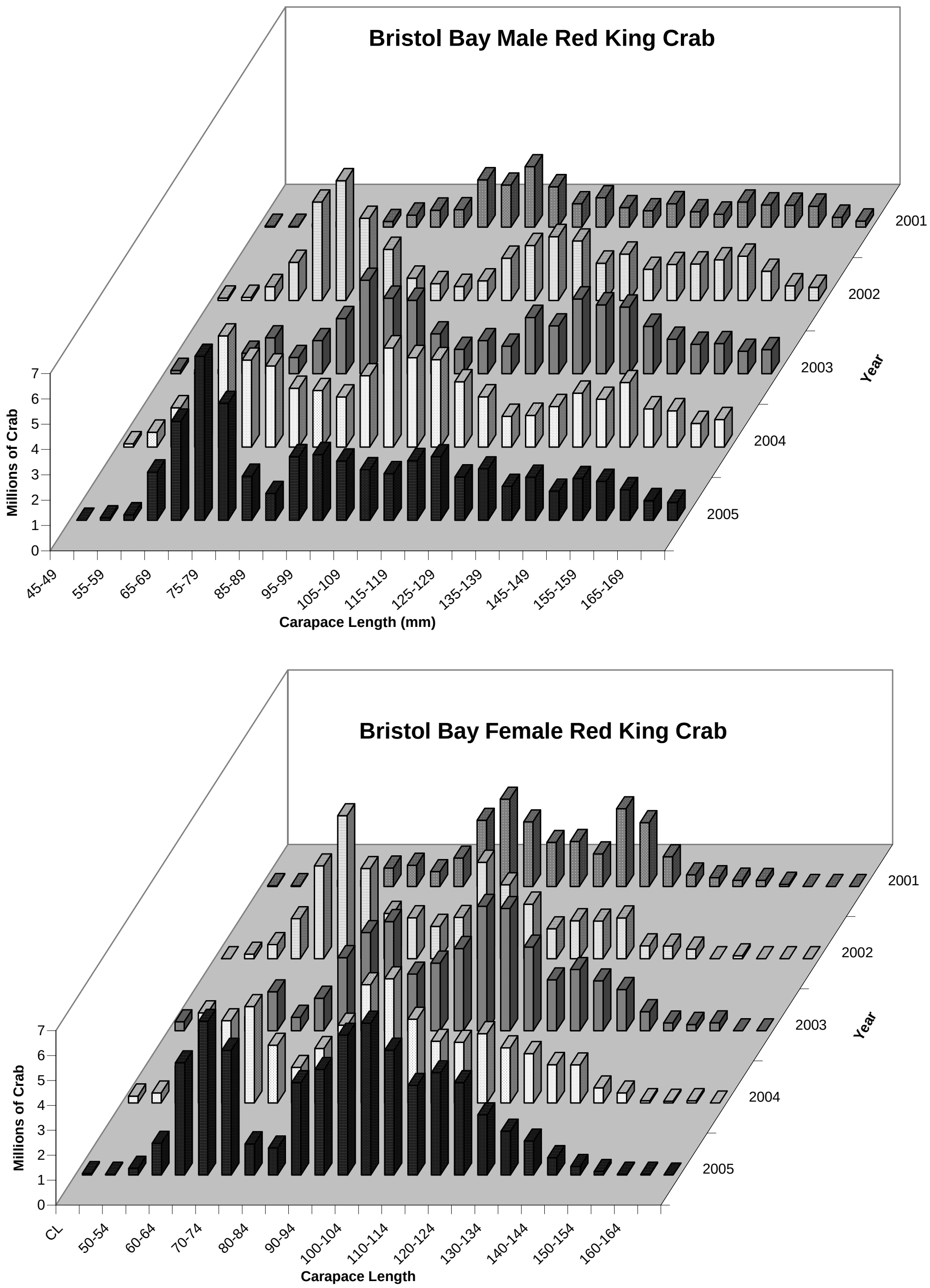


Figure 2.–Length frequency distributions of male (top panel) and female (bottom panel) Bristol Bay red king crabs (in millions of crab) during 2001-2005. For purposes of these graphs, abundance estimates are based on area-swept methods, not LBA, because the LBA is confined to males ≥95-mm CL and females ≥90-mm CL.

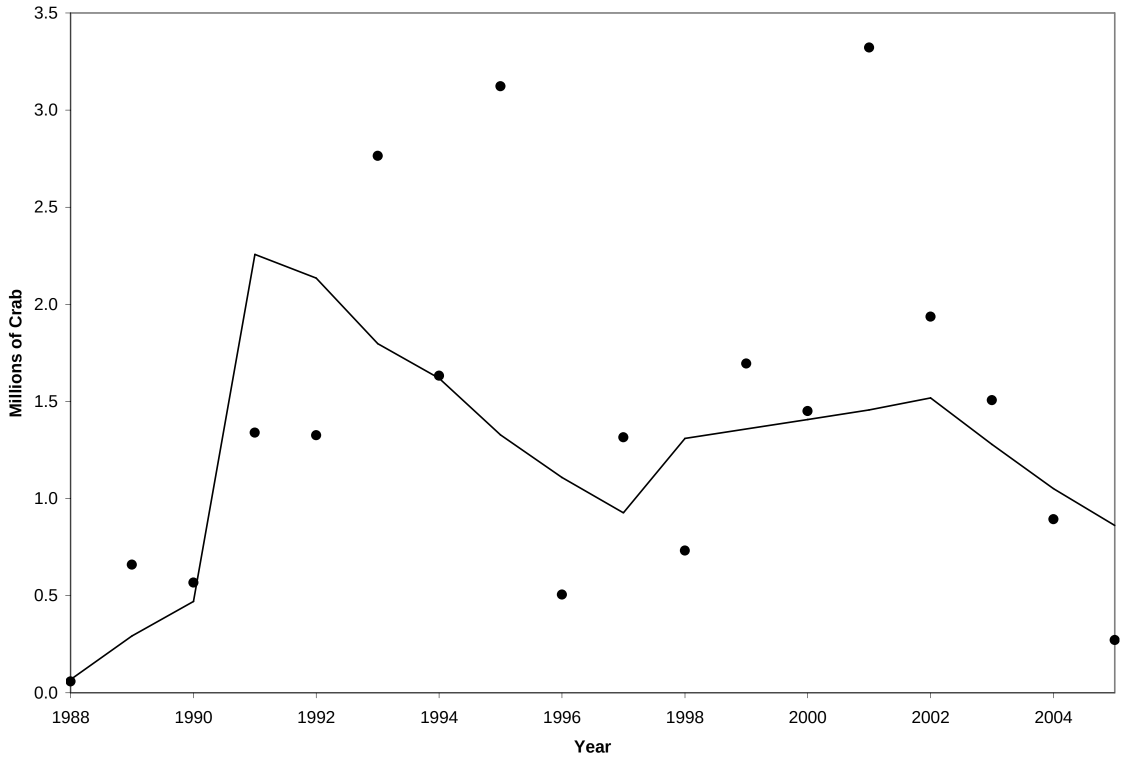


Figure 3.–The catch-survey analysis model fit (line) to area-swept estimates (dots) of mature-sized male Pribilof District red king crab abundance (in millions of crab), 1988-2005.

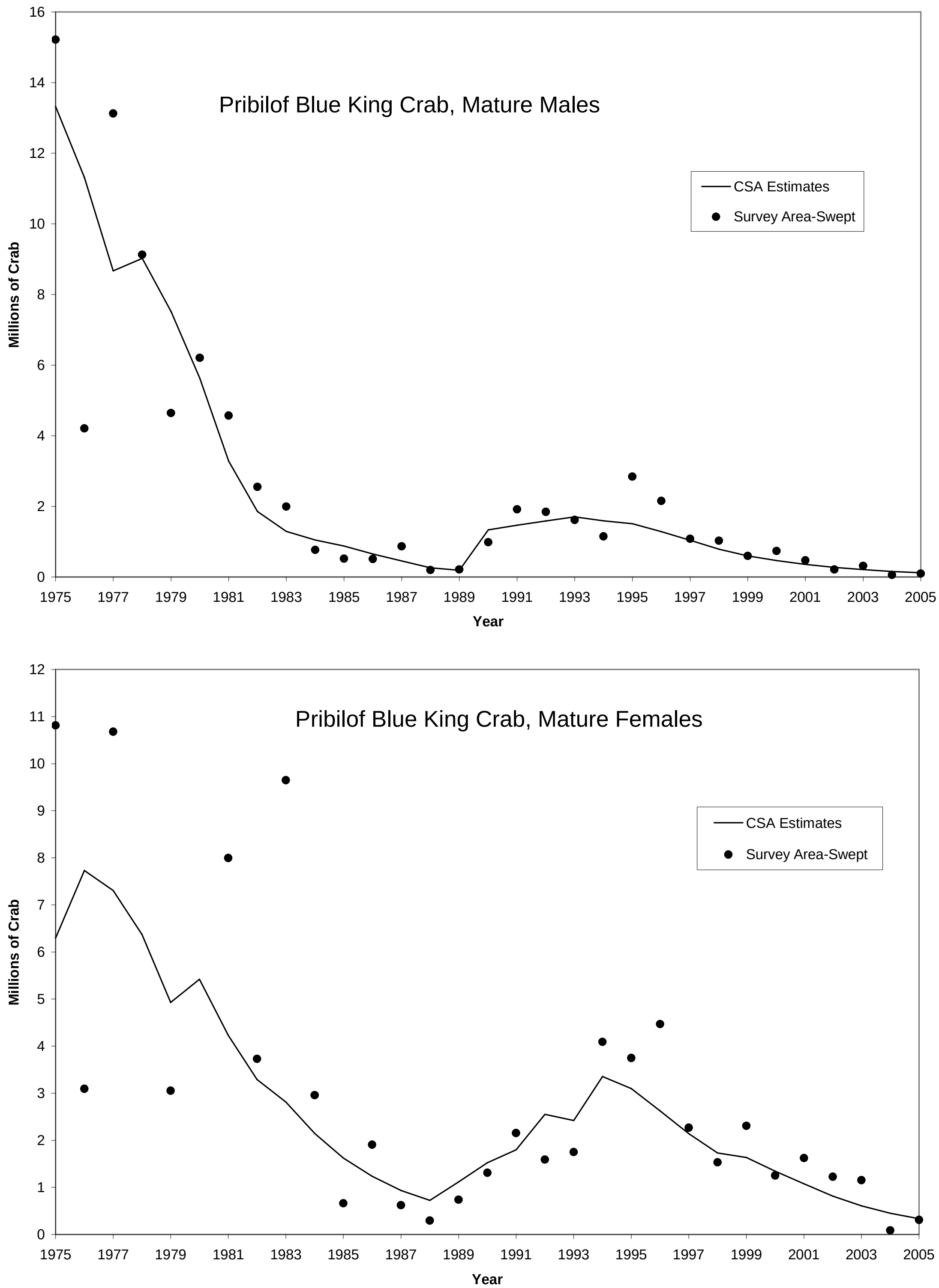
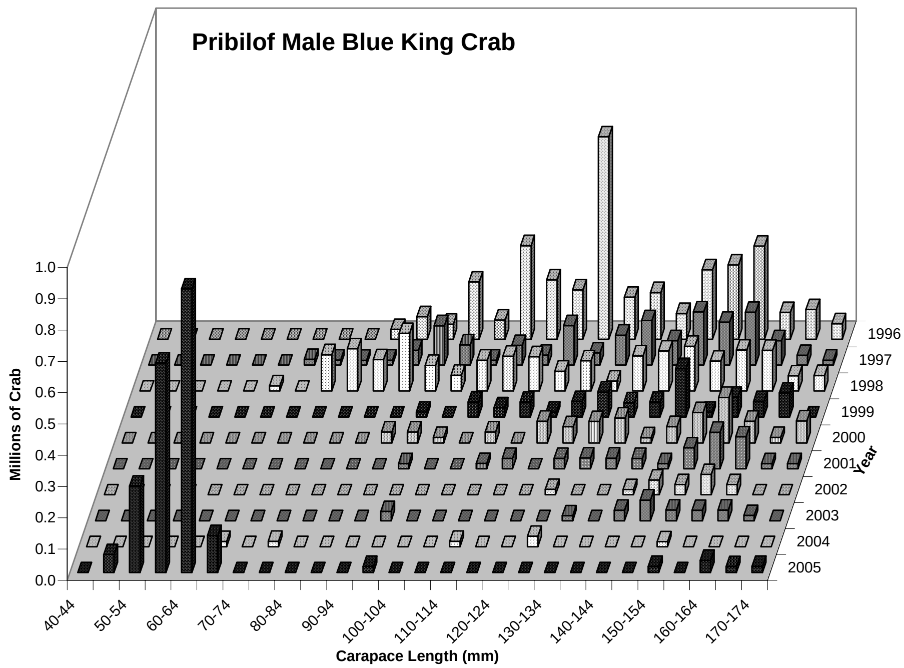


Figure 4.–The catch-survey analysis model fit (line) to area-swept estimates (dots) of mature-sized male (top panel) and mature-sized female (bottom panel) Pribilof District blue king crab abundance (in millions of crab), 1975-2005.



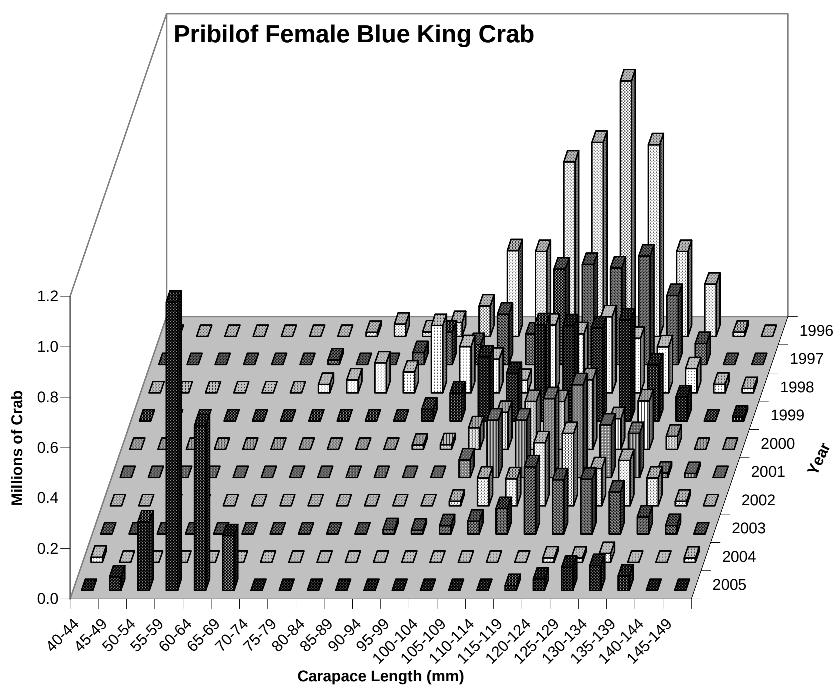


Figure 5.–Length frequency distributions of male (top panel) and female (bottom panel) Pribilof District blue king crabs (in millions of crab) during 1996-2005. For purposes of these graphs, abundance estimates are based on area-swept methods, not CSA, because the CSA is confined to males ≥105-mm CL and females ≥100-mm CL.

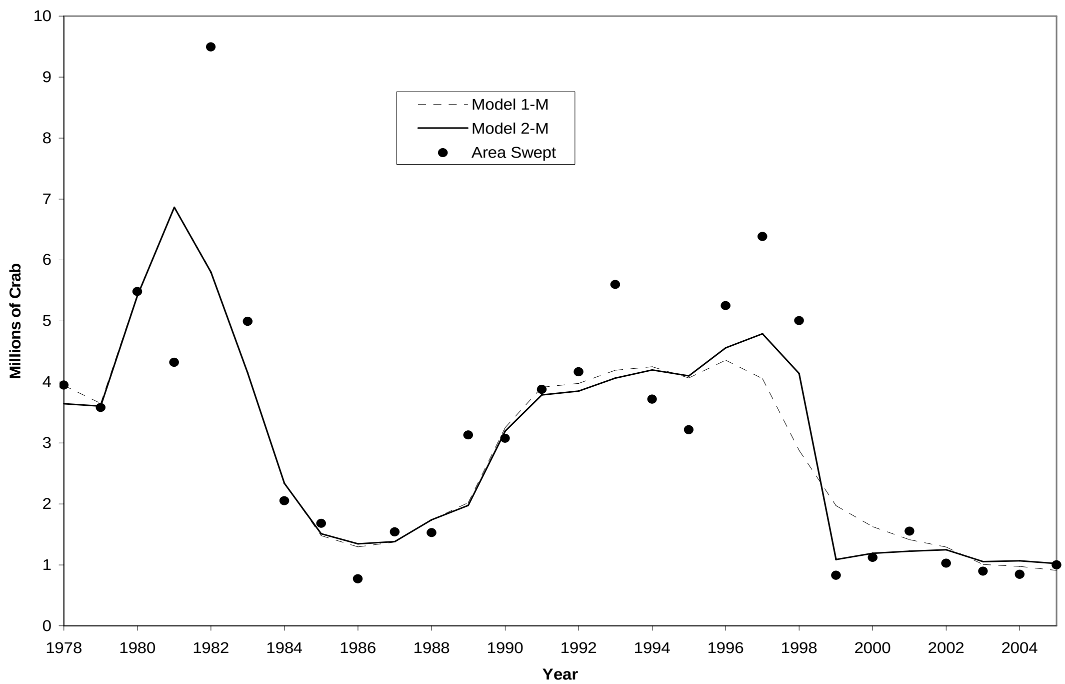


Figure 6.–The catch-survey analysis model fit (line) to area-swept estimates (dots) of mature-sized male St. Matthew Island Section blue king crab abundance (in millions of crab), 1978-2005. The 1-M model estimates a single constant natural mortality for all years (dashed line), and the 2-M model estimates a natural mortality for 1998/1999 and another for all other years (solid line).

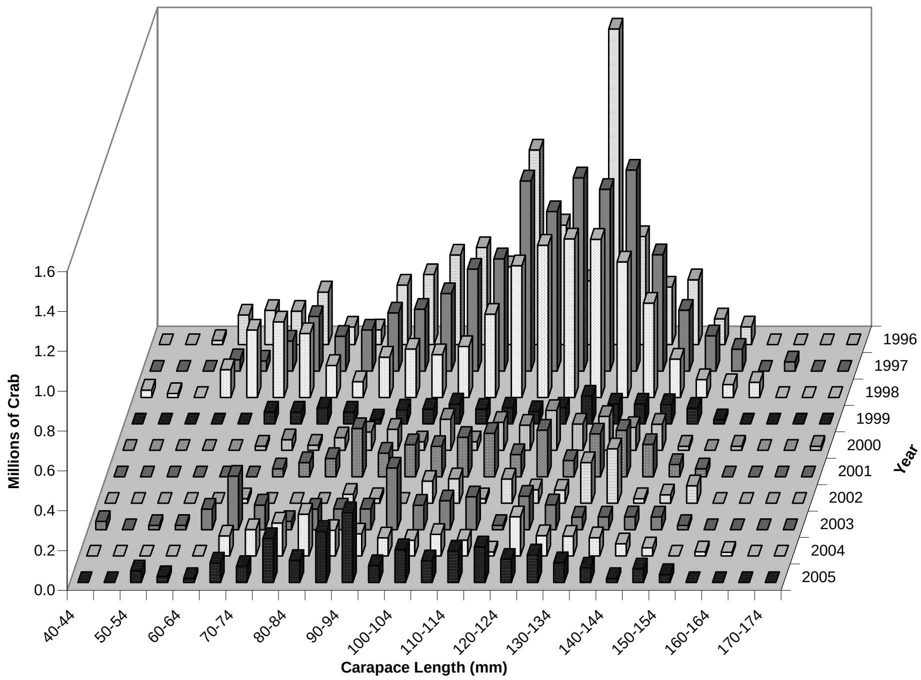


Figure 7.–Length frequency distributions of male St. Matthew Island Section blue king crabs (in millions of crab) during 1996-2005. For purposes of these graphs, abundance estimates are based on area-swept methods, not CSA, because the CSA is confined to males ≥99-mm CL.

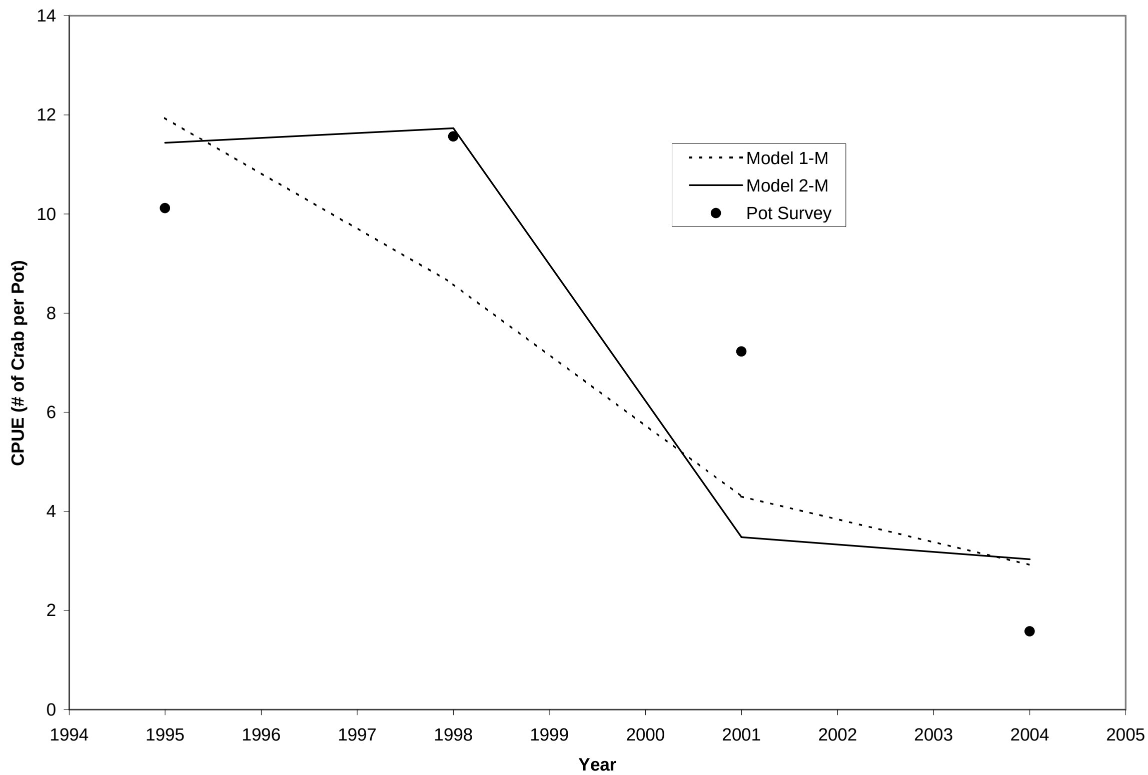


Figure 8.–The catch-survey analysis model fit (line) to CPUE estimates (dots) of mature-sized male St. Matthew Island Section blue king crab (crab per pot), 1995, 1998, 2001, and 2004. The 1-M model estimates a single constant natural mortality for all years (dashed line), and the 2-M model estimates a natural mortality for 1998/1999 and another for all other years (solid line).

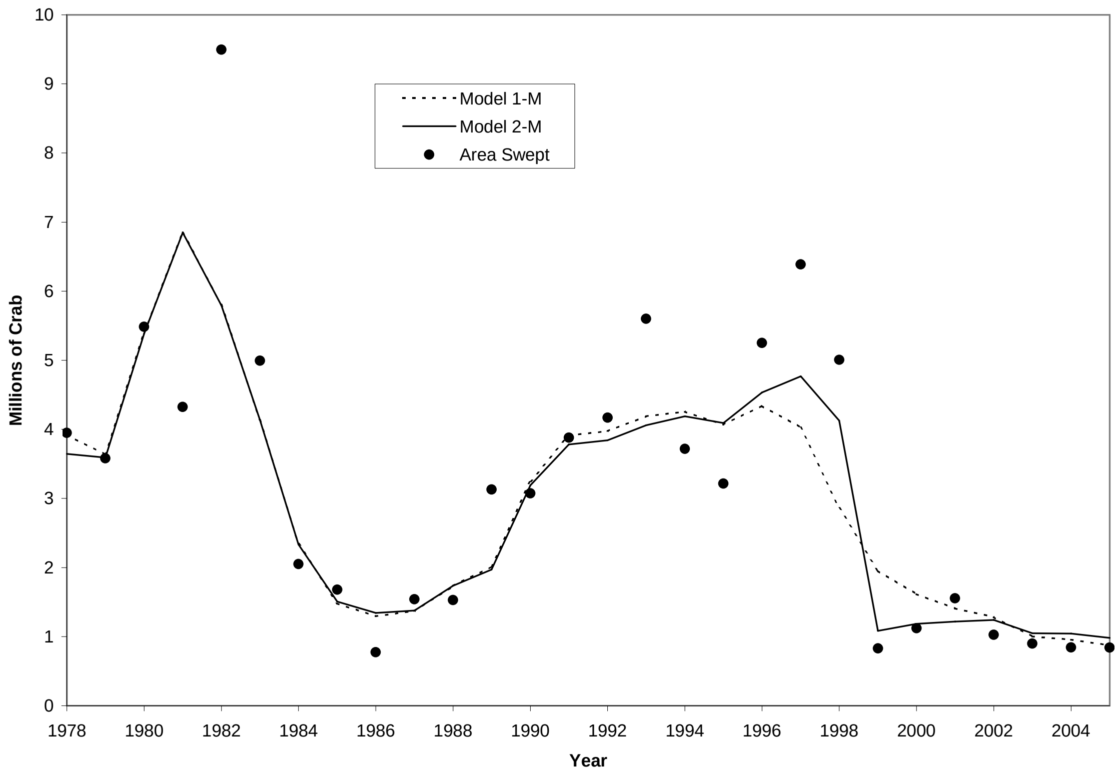


Figure 9.–The catch-survey analysis model fit (line) to area-swept estimates (dots) of mature-sized male St. Matthew Island Section blue king crab abundance (in millions of crab), 1978-2005, without the problem haul during the 2005 EBS trawl survey. The 1-M model estimates a single constant natural mortality for all years (dashed line), and the 2-M model estimates a natural mortality for 1998/1999 and another for all other years (solid line).

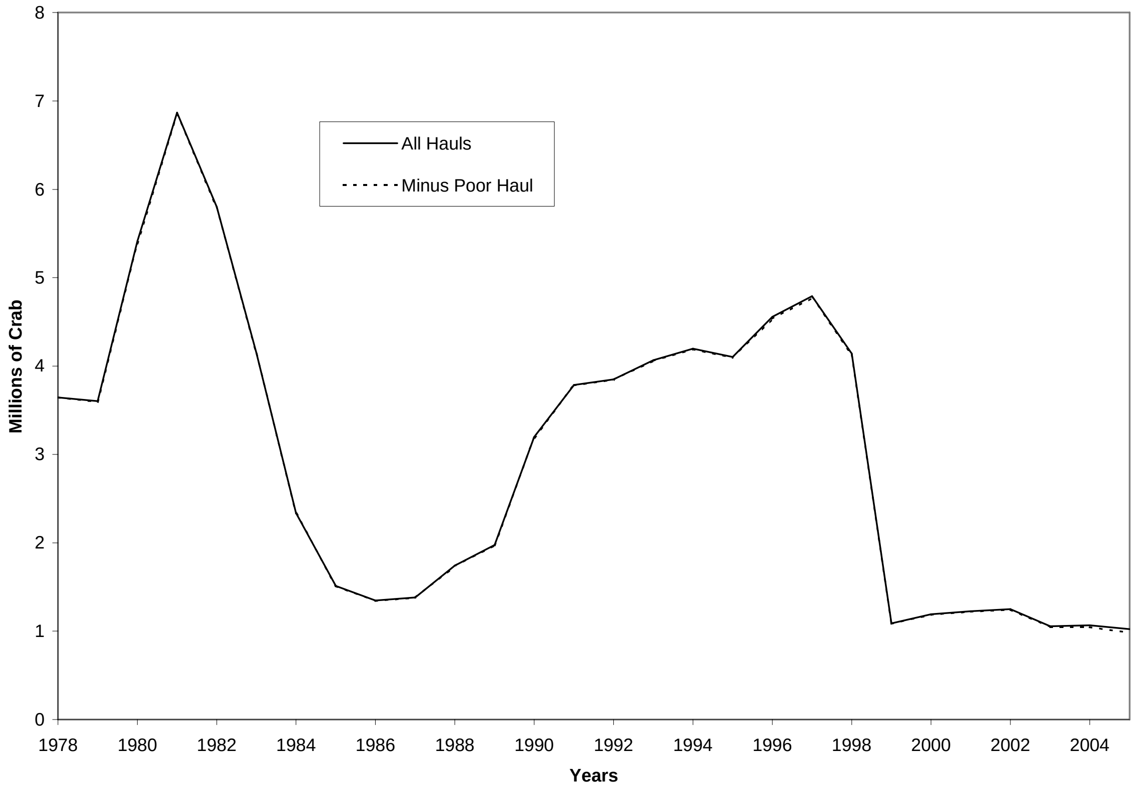


Figure 10.–The catch-survey analysis 2-M models fit of mature-sized male St. Matthew Island Section blue king crab abundance (in millions of crab), 1978-2005. The All Hauls model (solid line) uses the blue king crab abundance estimate from all hauls in the St. Matthew Island Section during the 2005 EBS trawl survey, and the Minus Poor Haul model (dashed line) uses all the hauls except the one problem haul.