STOCK STATUS OF BRISTOL BAY RED KING CRABS IN 1996

By

Jie Zheng, Gordon H. Kruse, and Margaret C. Murphy

Regional Information Report No. 5J96-12
Alaska Department of Fish & Game
Commercial Fisheries Management and Development Division
P.O. Box 25526
Juneau, Alaska 99802-5526

September 5, 1996

STOCK STATUS OF BRISTOL BAY RED KING CRABS IN 1996

By

Jie Zheng, Gordon H. Kruse, and Margaret C. Murphy

Regional Information Report[1] No. 5J96-12
Alaska Department of Fish & Game
Commercial Fisheries Management and Development Division
P.O. Box 25526
Juneau, Alaska 99802-5526

September 5, 1996

---

[1]The Regional Information Report Series was established in 1987 to provide an information access system for all unpublished divisional reports. These reports frequently serve diverse ad hoc informational purposes or archive basic uninterpreted data. To accommodate timely reporting of recently collected information, reports in this series undergo only limited internal review and may contain preliminary data; this information may be subsequently finalized and published in the formal literature. Consequently, these reports should not be cited without prior approval of the author or the Commercial Fisheries Management and Development Division. This report was funded in part by cooperative agreement NA37FL033 from the National Oceanic and Atmospheric Administration. The views expressed herein are those of the authors and do not necessarily reflect the views of NOAA or any of its subagencies.

PURPOSE

The purpose of this report is to provide timely information to the fishing industry and public on the status of the Bristol Bay stock of red king crabs *(Paralithodes camtschaticus)* in 1996. We briefly review stock assessment methodology, current stock status, implications for the crab fishery and bycatch management, and an outlook for the future. The Alaska Department of Fish and Game (ADF&G) plans this report as the first in a series of annual reports on stock status on Bering Sea and Aleutian Islands crab stocks for which population estimation models are applied.

STOCK ASSESSMENT METHODS

The National Marine Fisheries Service (NMFS) has conducted annual trawl surveys of the eastern Bering Sea since 1968. This multispecies survey is conducted during summer by two vessels each equipped with an eastern otter trawl with 83 ft headrope and 112 ft footrope. Stations are sampled in the center of a systematic 20X20 nm grid overlaid in an area of approximately 141,000 nm^2. The sampled area is estimated, and fish and invertebrate catches from each station are sampled, enumerated, measured and weighed. Survey results and area-swept estimates of abundance are published annually (Stevens et al. 1996) for the major stocks: Bristol Bay and Pribilof Islands red king crabs, St. Matthew and Pribilof Islands blue king crabs *(Paralithodes platypus)*, and eastern Bering Sea Tanner *(Chionoecetes bairdi)*, snow *(C. opilio)*, and hair crabs *(Erimacrus isenbeckii)*. Status of Bering Sea groundfish stocks are reported separately (NPFMC 1995).

The annual NMFS trawl survey is an essential tool for gathering good data on the status of crab and groundfish stocks in the eastern Bering Sea. Yet, year-to-year variation associated with shifts in oceanographic conditions lead to changes in species distribution and subsequent availability to survey gear. These changes cause measurement errors in area-swept abundance estimates unrelated to true changes in population size. Estimates from previous year's surveys coupled to commercial catch records and onboard observer data provide extremely valuable information to decipher real population changes from survey measurement errors. To accomplish this, we developed a length-based analysis (LBA) that makes use of detailed size, sex, and shell condition data from trawl surveys, onboard and dockside catch samples, and annual commercial harvest data. We feel that LBA 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. Accordingly, the LBA estimates are used to manage the red king crab fishery in Bristol Bay.

CURRENT STOCK STATUS

LBA estimates of Bristol Bay red king crab abundance and 95% bootstrap confidence limits for 1996 are shown in Table 1. Historical changes in legal male and mature female

abundance are graphed in Figure 1. Because trawl survey catches of small juveniles are unreliable, we restricted our analysis to males ≥95 mm carapace length (CL) and females ≥90 mm CL that appear to be fully recruited to the surveyed stock (Zheng et al. 1995a). Abundance estimates of all recruited size classes of males and females show slight increases from 1995. Estimated recruitment of males to the surveyed stock increased from 2.2 to 3.6 million crabs whereas estimated recruitment of females jumped from 1.8 to 3.9 million crabs. The most significant change for fishery management purposes was the increase of estimated mature female abundance to 10.2 million crabs. In 1995 the estimated abundance of mature females was 8.451 which was judged to be at the threshold of 8.4 million females, and the commercial fishery remained closed for the second consecutive year (Zheng et al. 1996). Using the most recent (1996) survey data, the hindcast abundance of mature females in 1995 increased slightly to 8.565 million (Table 1). The difference between the two estimates of 1995 abundance are attributable to growth of small females to the fully-recruited size classes and the collection of a second year of data on these young females.

LBA estimates compare very favorably with our preliminary area-swept survey estimates for 1996. The LBA estimate of 7.7 million mature males is slightly greater than the area-swept estimate of 7.6 million, whereas the LBA estimate of 5.3 million legals is slightly lower than the area-swept estimate of 5.6 million. The LBA estimate of 10.2 million mature females is less than the area-swept estimate of 12.0 million. Because LBA attempts to smooth out measurement errors, LBA estimates will be sometimes higher and sometimes lower than area-swept estimates.

Much of the change in stock status from 1995 to 1996 is attributable to recruitment of young crabs to the surveyed stock (Figure 2). Over the past three years there has been a general increase in the abundance of small males (<115 mm CL) and females (<105 mm CL). Larger females have generally been declining slowly since 1994 due to senescence and a recent lack of successful year classes. Males between 120-140 mm CL have declined for the same reasons. On the other hand, the absence of a commercial fishery has permitted the population to accrue more large males (>140 mm CL) during 1994-1995. Reduced trawl bycatch of red king crabs from 280,000 in 1994 to 45,000 in 1995 (NPFMC 1996) may well have contributed to the favorable changes in stock.

Despite stock improvements, the Bristol Bay stock of red king crabs remains quite low (Table 1). The current effective spawning biomass (ESB)[1] of 20.3 million pounds is less than half of the target rebuilding level of 55 million pounds. Recruitment levels of males and females are the 5th and 8th lowest, respectively, among the 24 years of recruitment estimates. Nonetheless, these recruitment levels are the highest seen since 1992 (males) and 1989 (females).

[1] ***Effective spawning biomass*** is the estimated biomass of mature female crabs that the population of mature male crabs could successfully mate in a given year.

FISHERY MANAGEMENT IMPLICATIONS

Bristol Bay Red King Crab Fishery

In March 1996 the Alaska Board of Fisheries adopted a new fishery management strategy to promote stock rebuilding and optimal harvest of the Bristol Bay red king crab stock. The strategy sets an annual guideline harvest level (GHL) by harvest rate coupled to a fishery threshold. When the stock is at or below threshold of 8.4 million mature females (>90 mm CL) or 14.5 million pounds of ESB, the fishery is closed. When the stock is above both of these criteria, GHL is determined by the abundance of mature and legal-sized males. A reduced mature male harvest rate of 10% is applied to promote stock rebuilding when ESB is below the target rebuilding level of 55 million pounds. Once the stock is rebuilt (at or above 55 million pounds of ESB) a 15% harvest rate is applied to mature male abundance. To prevent a disproportionate harvest of large male crabs, the GHL is capped so that no more than 50% of the legal male crabs may be harvested in any one year.

In 1996, the Bristol Bay red king crab stock is above threshold because the mature female abundance estimate was 10.2 million crabs and ESB was 20.3 million pounds. By applying bootstrapping procedures to our LBA, we estimated that the 95% confidence levels of mature female abundance were 8.145 to 13.788 million females. Thus, there is some small chance (about 5%) that the true abundance of mature females is less than the threshold of 8.4 million mature females. However, this risk is tolerable, because a conservative (10%) harvest rate promotes stock rebuilding. By applying the 10% harvest rate times the mature male abundance of 7.795 million crabs, we estimate a harvest of 779,500 crabs. Because 779,500 is only 15% of the legal male abundance, the 50% cap is not required. By multiplying 779,500 crabs times an average weight of 6.36 pounds per legal crab, we estimated a GHL of 5.0 million pounds for 1996. This GHL was announced by ADF&G news release on August 14, 1996. The fishery will open at noon on November 1, 1996.

Eastern Bering Sea Tanner Crab Fishery

The status of the Bristol Bay red king crab stock has implications on the eastern Bering Sea Tanner crab fishery. In years, such as 1994 and 1995, when the red king crab fishery was closed, the waters of the eastern Bering Sea east of 163° West longitude do not open for Tanner crab fishing by regulation 5 AAC 35.519. This area closure, coupled to regulation 5 AAC 35.525 that restricts vertical tunnel entrances to 3 inches, reduces potential impacts of the Tanner crab fishery on depressed king crab stocks. Because the red king crab fishery will open in 1996, the Tanner crab fishery will not be restricted to areas west of 163° W by this regulation. In 1996, the Tanner crab season in waters east of 168° W will open and close concurrent with the red king crab fishery. This promotes efficiency in these crab fisheries while reducing handling and bycatch. A news release issued August 29, 1996 stated that 10 days after the closure of the Bristol Bay red king crab season the Tanner crab fishery will reopen between 163° and 173° W with a GHL of 6.2 million pounds.

Bering Sea Groundfish Trawl Fisheries

In June 1996, the North Pacific Fishery Management Council (NPFMC) recommended to the Secretary of Commerce two crab bycatch measures that depend on the status of red king crabs in Bristol Bay. First, the NPFMC established new guidelines for setting annual prohibited species catch (PSC) limits for red king crabs caught during groundfish trawl fisheries. Previously, the PSC limit was 200,000 red king crabs in Bycatch Limitation Zone 1 in the eastern Bering Sea. Pending approval by the Secretary of Commerce, the new PSC limit for any year is set as a function of estimated ESB of Bristol Bay red king crabs in the prior year (Figure 3). PSC limits are linked to the same ESB levels that lead to adjustments in harvest rate for the crab fishery. When the ESB is less than or equal to 14.5 million pounds or mature females are less than or equal to 8.4 million crabs, the crab fishery is closed and the PSC is set at 35,000 crabs. When ESB exceeds 14.5 million pounds but is less than 55 million pounds, the PSC is 100,000 crabs. Finally, when ESB is greater than or equal to 55 million pounds the PSC becomes 200,000 crabs. Given the estimates of mature female abundance and ESB for 1996, the PSC limit for groundfish trawl fisheries in the Bering Sea is set at 100,000 crabs for 1997.

Second, to protect adult red king crabs and their habitat the NPFMC established a year-round closure to non-pelagic trawling in the Red King Crab Savings Area (162° to 164° W, 56° to 57° N). In years in which there is a red king crab fishery in Bristol Bay, the portion of the Red King Crab Savings Area bounded by 56° to 56° 10' N latitude remains open to the rock sole fishery. Therefore, owing to the red king crab fishery in November 1996, the rock sole fishery will have access to this 10' area during the 1997 fishery. For this area a separate bycatch limit is established not to exceed 35% of the red king crab prohibited species catch (PSC) limits apportioned to the rock sole fishery.

FUTURE OUTLOOK

Accurate predictions of future status of the Bristol Bay stock of red king crabs are not possible at this time. In 1997, the eastern Bering Sea survey will be repeated, results will be incorporated into the LBA, and the fishery will be managed by current harvest strategy.

We can offer some speculations about future stock status. Indeed, there are reasons for cautious optimism and other reasons for pessimism. For instance, many other red king crab stocks (e.g., Cook Inlet, Kodiak, Dutch Harbor) failed to recover today -- more than 15 years after a stock collapse in the early 1980s. On the other hand, stocks in Norton Sound and Southeast Alaska show that depressed red king crab stocks are capable of recovery.

An examination of the recruitment time series for Bristol Bay red king crabs (Table 1) shows that the data are highly autocorrelated. That is, good years tend to follow good years and poor years tend to follow poor years. It is conceivable that improved recruitment during 1996 may represent the leading edge (i.e., fastest growing segment) of a year class that

has not yet fully recruited to the survey gear. If so, it is possible that the stock may experience increasing recruitment over the next couple of years. However,. note that increasing recruitment from 1990 to 1992 was followed by a decline from 1992 to 1994.

An understanding of year class success would be a great asset to predictions of future crab stock changes. Research is currently being conducted into the roles of spawning stocks and environmental factors on recruitment of red king crabs (Zheng et al. 1995a,b; Tyler and Kruse, in press). A stock-recruit curve was fit to data on ESB and recruitment that incorporates both stock (density-dependent) and environmental (autocorrelated) effects (Figure 4). Implications of the density-dependent component are that low recruitment results from low spawning stocks and moderate recruitment results from high spawning stocks. When stocks are intermediate, the probability of strong recruitment is greatest.

In fact, there has been slight improvement in recruitment from the 1987, 1988 and 1989 year classes (Figure 4). These were associated with increasing parental ESB levels of 24.5, 28.4, and 31.2 million pounds, respectively (Table 1). Yet, the recruits during these three years are less than expected from the stock-recruitment curve (Figure 4). ESB levels during spawning years 1990-1993 were 24.6 to 27.0 so there is some reason to believe that resultant year classes will be of similar magnitude to the 1987-1989 year classes. Given the low probability of a strong year class in the near future, the key to stock rebuilding will be to patiently accumulate effective spawning biomass toward the 55 million pound target level. It is hoped that recent changes in crab harvest strategy, trawl bycatch management, and crab habitat protection measures will promote this outcome.

A number of hypotheses have been proposed about effects of predation, food, and physical oceanographic conditions on king crab recruitment (Tyler and Kruse, in press). However, the general decline of crab recruitment since the late 1970s in Bristol Bay corresponds to broad trends in many physical and ecological factors, and it is not yet possible to draw definitive conclusions about cause and effect. Shifts in some physical oceanographic and ecological conditions of the Bering Sea and Gulf of Alaska seem related to the Aleutian Low Pressure System. Yearly trends in atmospheric pressure for January reveal a deepening of the Aleutian Low during the late 1960s through mid-1970s and a weakening of the Aleutian Low during the late 1970s through the late 1980s (Tyler and Kruse, in press). Thus, there is a general correspondence between air pressure and recruitment. The strength of the Aleutian Low Pressure System explains about 36% of the variability in red king crab recruitment in Bristol Bay. During recent years, 1989-1994, the Aleutian Low deepened again reminiscent of the late 1960s to mid-1970s, so there is some reason to think that environmental conditions may favor higher survival of the 1989-1994 year classes than occurred in the previous decade. However, more years of data are required to know whether the barometric pressure relationship with recruitment has true predictive value, and, if so, further research is needed to identify the underlying causes.

The current harvest strategy for Bristol Bay red king crabs should promote stock rebuilding regardless of whether improved future recruitment results from increased effective

spawning biomass, higher survival associated with more favorable environmental conditions, or a combination of both. Also, the threshold buffers against stock collapse should the recent increase in recruitment prove not to be sustained.

LITERATURE CITED

NPFMC (North Pacific Fishery Management Council). 1995. Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea/Aleutian Islands regions as projected for 1996. North Pacific Fishery Management Council, Anchorage, Alaska.

NPFMC (North Pacific Fishery Management Council). 1996. Additional analysis for amendment 37 (Bristol Bay red king crab savings area) and an environmental assessment/regulatory impact review/initial regulatory flexibility analysis for amendment 41: management of red king crab *(P. camtschaticus),* Tanner crab *(C. bairdi),* and snow crab *(C. opilio)* bycatch limits in Bering Sea groundfish trawl fisheries and establishment of a trawl closure area in nearshore waters of Bristol Bay. North Pacific Fishery Management Council, Anchorage, Alaska.

Stevens, B.G., J.A. Haaga, and R.A. MacIntosh. 1996. Report to industry on the 1995 Eastern Bering Sea crab survey. U.S. Department of Commerce, National Marine Fisheries Service, Alaska Fisheries Science Center Processed Report 96-01, Kodiak.

Tyler, A.V., and G.H. Kruse. In Press. Conceptual modeling of brood strength of red king crabs in the Bristol Bay region of the Bering Sea. Proceedings of the International Symposium on Biology, Management and Economics of Crabs from High Latitude Habitat. University of Alaska Fairbanks, Alaska Sea Grant Program Report, Fairbanks, AK.

Zheng, J., M.C. Murphy, and G.H. Kruse. 1996. Overview of population estimation methods and recommended harvest strategy for red king crabs in Bristol Bay. Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division, Regional Information Report 5J96-04, Juneau.

Zheng, J., M.C. Murphy, and G.H. Kruse. 1995a. A length-based population model and stock-recruitment relationships for red king crab, *Paralithodes camtschaticus*, in Bristol Bay, Alaska. Canadian Journal of Fisheries and Aquatic Sciences 52:1229-1246.

Zheng, J., M.C. Murphy, and G.H. Kruse. 1995b. Updated length-based population model and stock-recruitment relationships for red king crab, *Paralithodes camtschaticus,* in Bristol Bay, Alaska. Alaska Fishery Research Bulletin 2(2):114-124.

Table 1. Annual abundance estimates (millions of crabs), effective spawning biomass (millions of pounds), and 95% confidence intervals for red king crabs in Bristol Bay as calculated by length-based analysis. Size measurements are carapace length.

	Males					Females		
Year	Recruits	Small (95-109 mm)	Pre-rec. (110-134 mm)	Mature (>119mm)	Legal (>134 mm)	Recruits	Mature (>89 mm)	Effective Spawning Biomass
a. Abundance Estimates and Spawning Biomass								
1972	NA	13.635	15.182	18.668	10.088	NA	59.632	55.949
1973	33.561	21.708	28.440	23.626	10.588	32.855	69.667	65.373
1974	21.878	14.974	36.869	35.869	15.185	28.173	71.223	97.343
1975	32.985	21.330	37.480	43.008	21.243	21.755	65.804	116.186
1976	48.805	31.563	47.984	51.076	26.035	34.298	75.024	128.791
1977	57.745	37.775	64.589	65.327	30.957	72.172	118.540	171.947
1978	21.549	15.842	61.576	78.543	40.876	46.737	119.878	199.930
1979	12.681	8.809	37.795	75.326	48.378	18.837	92.982	166.904
1980	24.681	15.798	26.556	60.160	44.213	35.990	93.616	166.383
1981	17.188	11.653	17.541	18.618	9.467	13.618	71.523	59.787
1982	23.277	15.132	16.720	10.685	2.912	17.154	29.724	24.940
1983	12.927	8.980	13.733	9.183	2.477	4.828	10.030	16.728
1984	18.106	11.764	13.087	8.430	2.320	11.704	13.461	16.961
1985	11.225	7.706	11.136	7.152	1.784	4.798	7.146	10.699
1986	6.525	4.662	13.386	12.108	4.334	3.917	9.101	14.474
1987	7.002	4.693	11.784	14.203	6.683	8.911	15.532	24.525
1988	6.599	4.457	10.645	14.771	8.260	5.705	16.987	28.427
1989	5.448	3.727	9.729	15.684	9.670	5.515	17.885	31.232
1990	1.466	1.208	7.261	15.043	10.103	0.895	13.923	26.921
1991	4.007	2.564	5.173	11.923	8.452	3.762	13.931	27.062
1992	5.820	3.806	6.072	9.907	6.641	3.473	13.625	26.709
1993	1.994	1.791	6.620	9.724	5.787	2.191	12.122	24.601
1994	0.923	0.827	5.053	8.047	4.476	0.420	9.263	20.329
1995	2.220	1.488	3.915	7.837	5.116	1.799	8.565	18.640
1996	3.604	2.443	4.334	7.795	5.258	3.937	10.183	20.263
b. 95% Confidence Limits in 1996:								
Lower	2.879	NA	3.535	6.408	4.201	2.900	8.145	NA
Upper	4.509	NA	4.943	8.704	5.993	6.277	13.788	NA

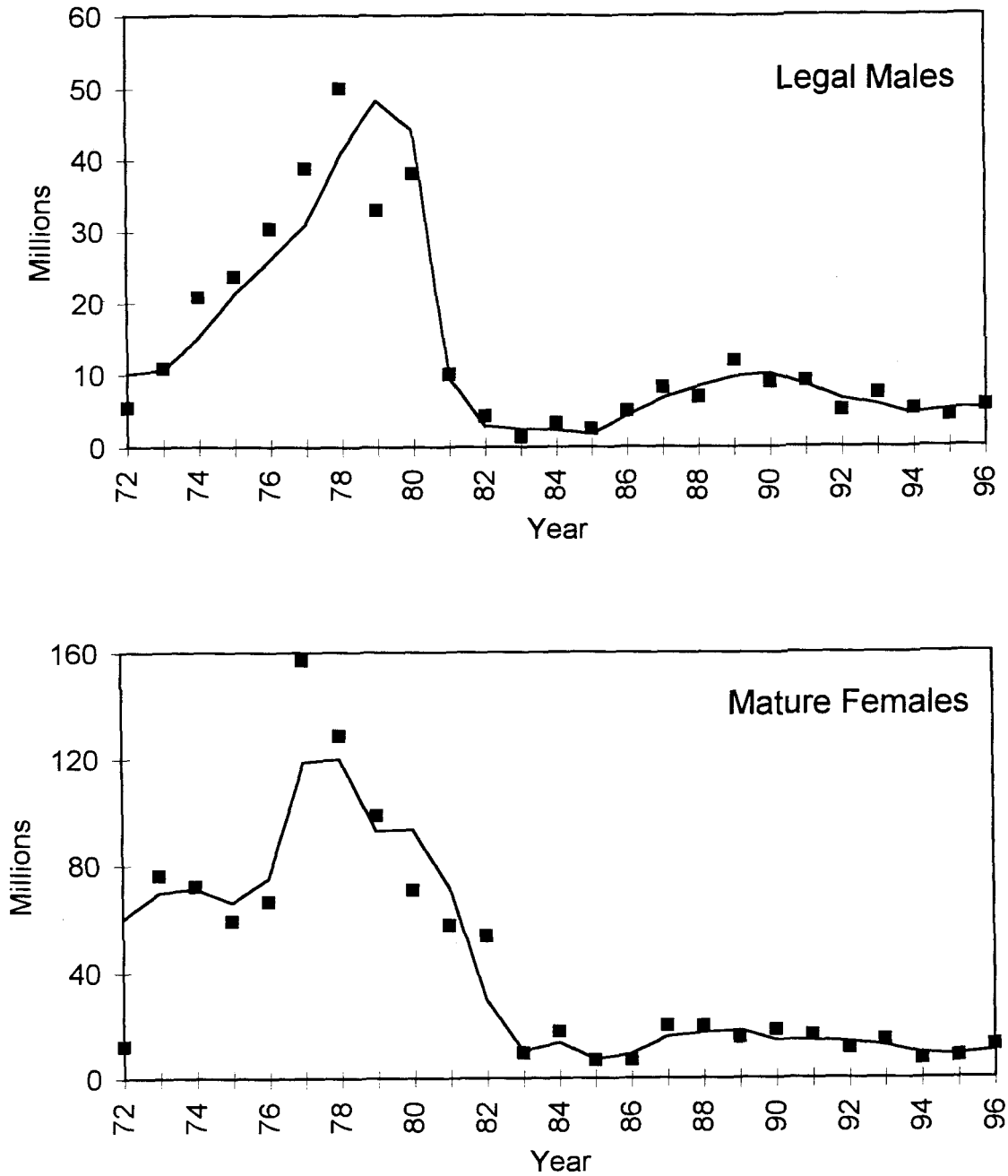

Figure 1. Comparison of abundance estimates (millions of crabs) of Bristol Bay red king crabs from area-swept estimates (dots) and length-based analysis (line) for legal males (top panel) and mature females (bottom panel).

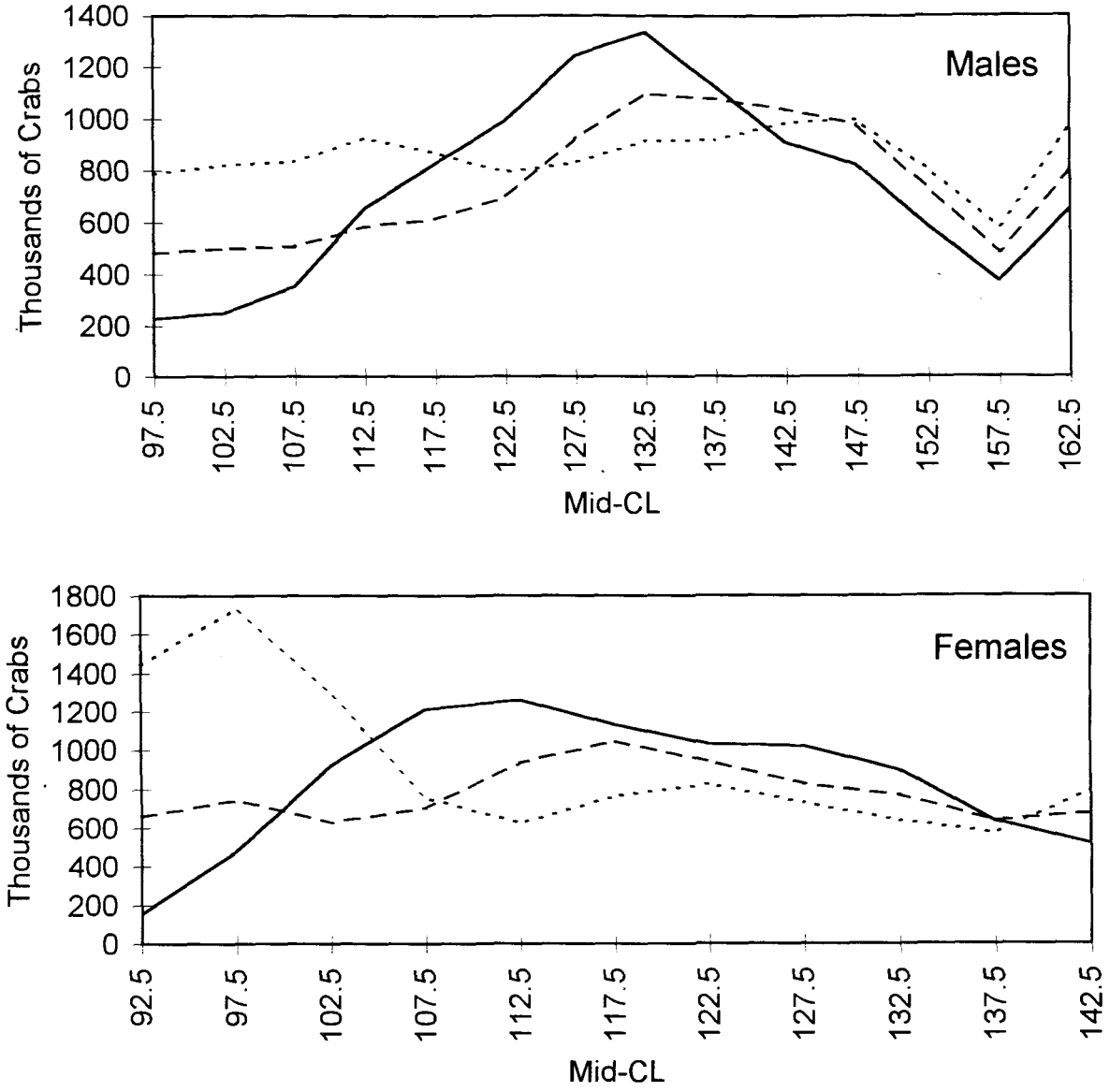

Figure 2. Size-frequency distributions of male (top panel) and female (bottom panel) red king crabs in Bristol Bay as estimated by length-based analysis for 1994 (solid line), 1995 (dashed line), and 1996 (dotted line).

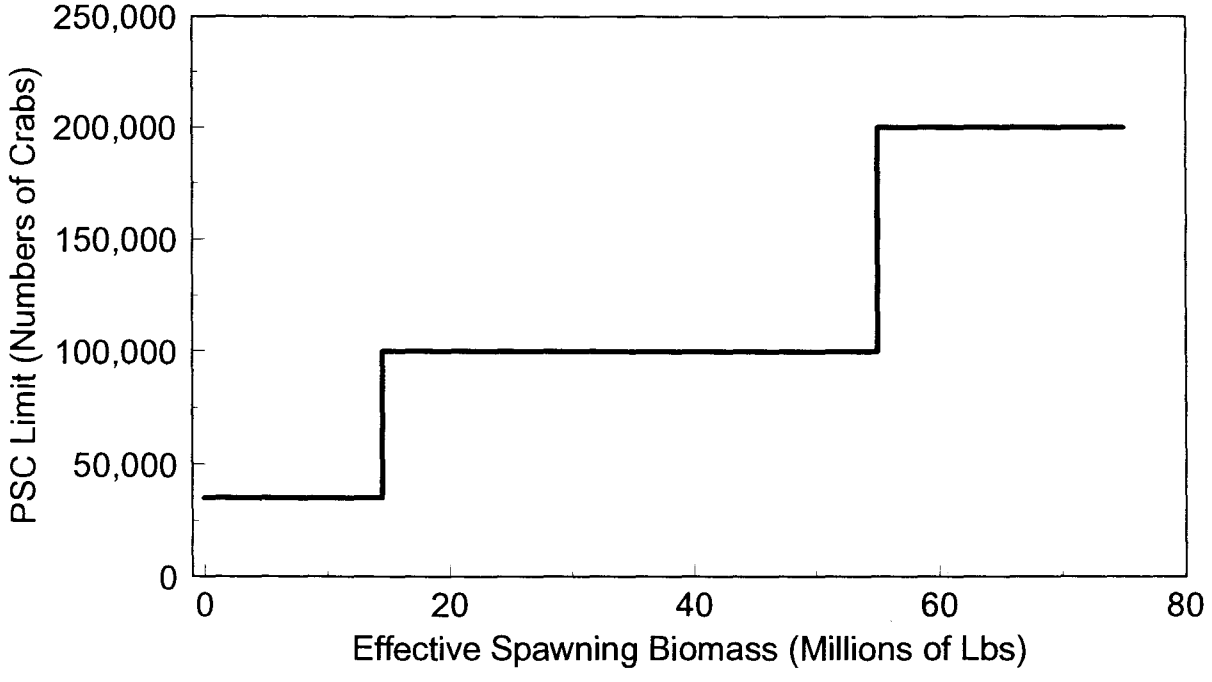

Figure 3. PSC limit of red king crabs in groundfish trawl fisheries in Zone 1 in the eastern Bering Sea in any year as a function of estimated effective spawning biomass (ESB) of Bristol Bay red king crabs in the prior year. PSC = 35,000 crabs if ESB ≤ 14.5 M pounds or if mature females ≤ 8.4 million crabs (not shown); PSC = 100,000 crabs if 14.5 < ESB ≤ 55 M pounds and if mature females > 8.4 million crabs; and PSC = 200,000 if ESB > 55 M pounds.

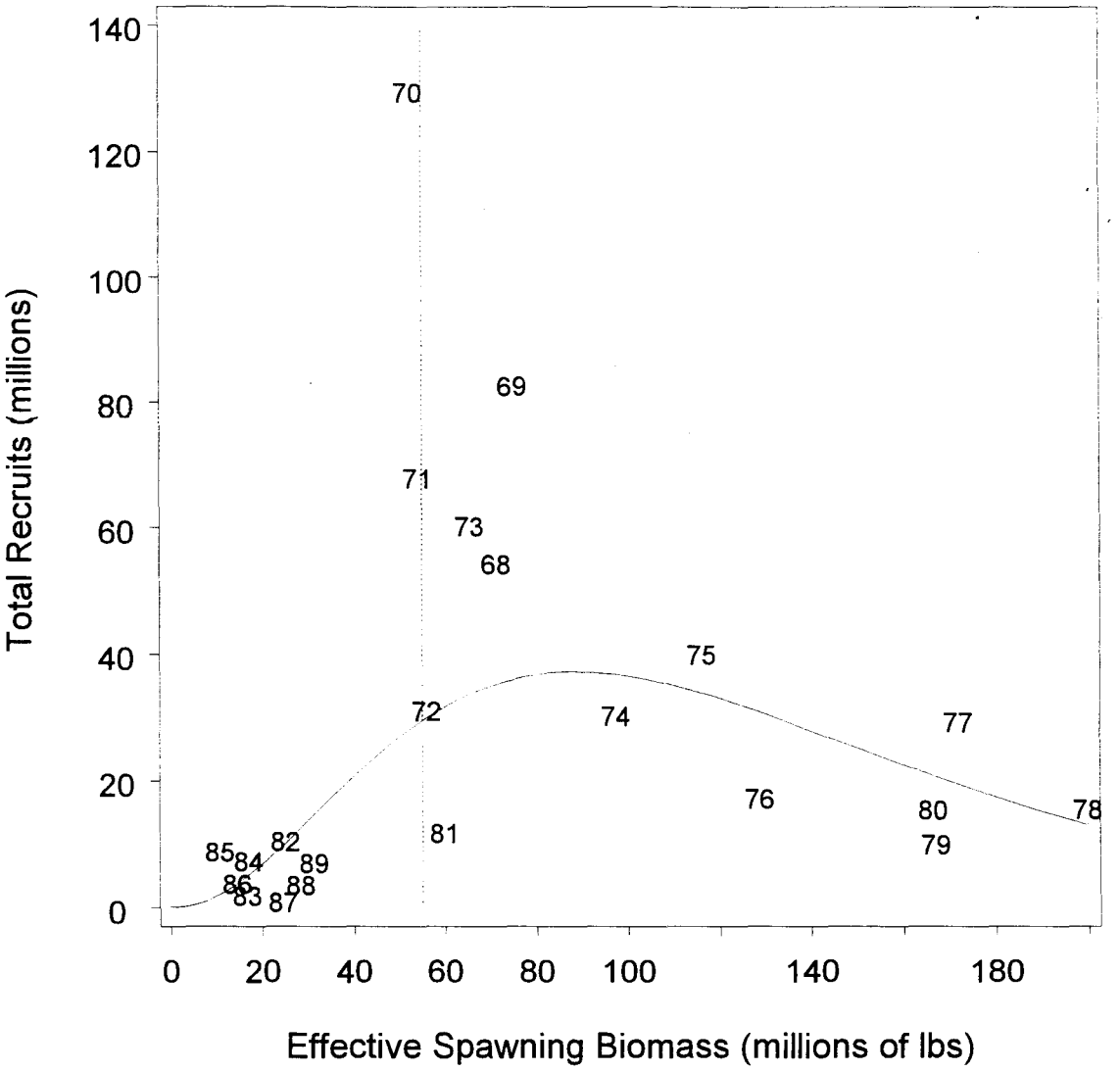

Figure 4. Stock-recruit relationship for Bristol Bay red king crabs. Recruits are age 6.2 from date of hatching corresponding to a 7-year lag from spawning to recruitment. Numbers refer to brood year (year of spawning). Effective spawning biomass is defined in the text. The vertical dotted line indicates the target rebuilding level of 55 million pounds of effective spawning biomass.

The Alaska Department of Fish and Game administers all programs and activities free from discrimination on the basis of sex, color, race, religion, national origin, age, marital status, pregnancy, parenthood, or disability. For information on alternative formats available for this and other department publications, contact the department ADA Coordinator at (voice) 907-465-4120, or (TDD) 907-465-3646. Any person who believes s/he has been discriminated against should write to: ADF&G, PO Box 25526, Juneau, AK 99802-5526; or O.E.O., U.S Department of the Interior, Washington, DC 20240.