

Abstract—The relative abundance of Bristol Bay red king crab (*Paralithodes camtschaticus*) is estimated each year for stock assessment by using catch-per-swept-area data collected on the Alaska Fisheries Science Center's annual eastern Bering Sea bottom trawl survey. To estimate survey trawl capture efficiency for red king crab, an experiment was conducted with an auxiliary net (fitted with its own heavy chain-link footrope) that was attached beneath the trawl to capture crabs escaping under the survey trawl footrope. Capture probability was then estimated by fitting a model to the proportion of crabs captured and crab size data. For males, mean capture probability was 72% at 95 mm (carapace length), the size at which full vulnerability to the survey trawl is assigned in the current management model; 84.1% at 135 mm, the legal size for the fishery; and 93% at 184 mm, the maximum size observed in this study. For females, mean capture probability was 70% at 90 mm, the size at which full vulnerability to the survey trawl is assigned in the current management model, and 77% at 162 mm, the maximum size observed in this study. The precision of our estimates for each sex decreased for juveniles under 60 mm and for the largest crab because of small sample sizes.

In situ data collected from trawl-mounted video cameras were used to determine the importance of various factors associated with the capture of individual crabs. Capture probability was significantly higher when a crab was standing when struck by the footrope, rather than crouching, and higher when a crab was hit along its body axis, rather than from the side. Capture probability also increased as a function of increasing crab size but decreased with increasing footrope distance from the bottom and when artificial light was provided for the video camera.

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Capture probability of a survey trawl for red king crab (*Paralithodes camtschaticus*)

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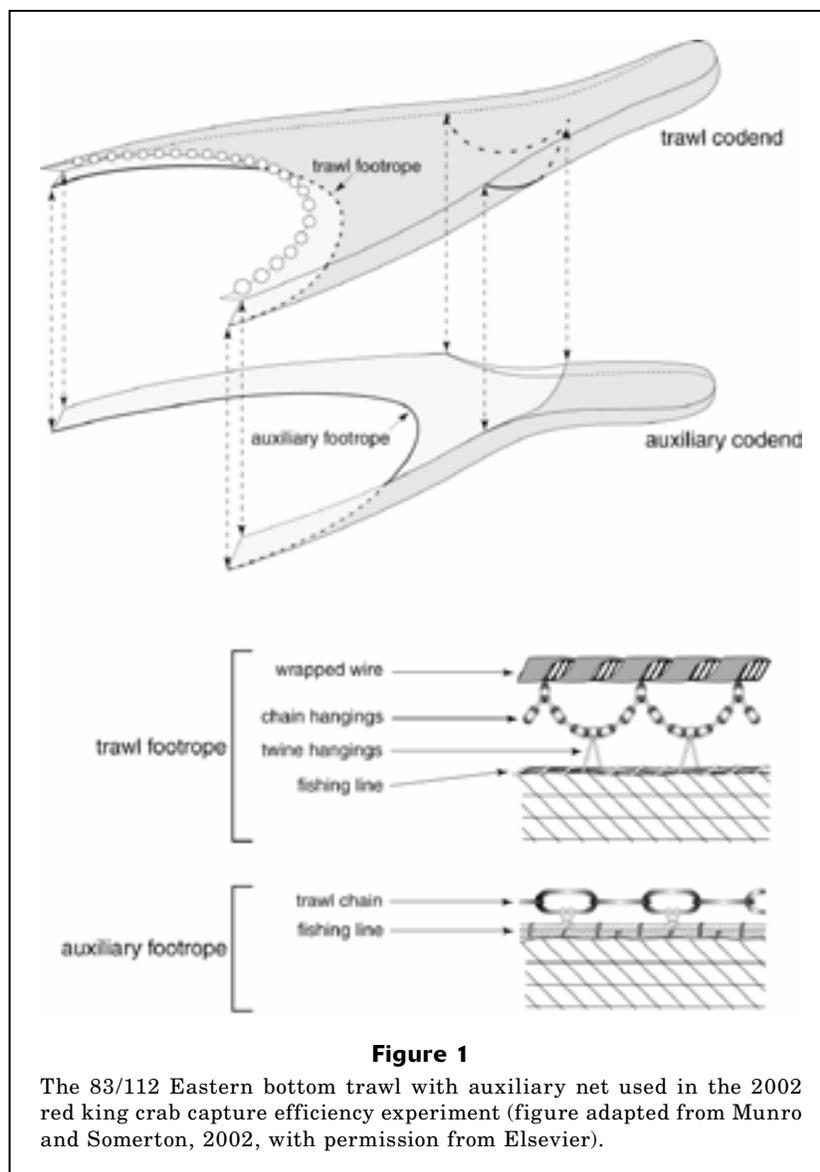
Regulations limit the annual harvest of Bristol Bay red king crab (RKC; *Paralithodes camtschaticus*) to males ≥ 135 mm in carapace length¹ (6.5 inches carapace width), and the size of the harvest is dependent upon the estimated biomasses of mature males and females. For stock assessments of RKC, area-swept abundance estimates are determined from the data from annual eastern Bering Sea (EBS) bottom trawl surveys conducted by the National Marine Fisheries Service, Alaska Fisheries Science Center (AFSC), and these estimates are used as input into a length-based assessment model (Zheng et al., 1995) to compute the total allowable catch for each annual fishing season.

It is assumed with the current assessment model that all male RKC ≥ 95 mm and all female RKC ≥ 90 mm within the path of the survey trawl (wingtip to wingtip) are captured. This assumption seems reasonable because the survey trawl uses a small diameter footrope designed to stay close to the bottom and red king crab are quite large. However, video photography taken following the 2000 EBS survey revealed that a considerable number of large (≥ 90 mm) RKC

pass under the footrope of the survey trawl.

To assess the potential impact of escaping crab on the calculation of crab biomass, we conducted an experiment to estimate the size-related capture efficiency of the standard survey bottom trawl for Bristol Bay RKC. In this experiment, crab passing beneath the survey trawl were subsequently captured with an auxiliary net that was attached underneath and behind the footrope of the survey trawl (Engås and Godø, 1989; Walsh, 1992). Experimental nets like the one used for this study have been used previously in trawl efficiency studies for flatfish (Munro and Somerton, 2002), as well as for snow (*Chionoecetes opilio*) and Tanner (*C. bairdi*) crabs (Somerton and Otto, 1999). Trawl catch data alone, however, tell little about the details involved with escapement. Therefore, we deployed a video camera on the trawl to observe crab behavior and analyzed a combination of trawl-per-

¹ All references to measured crab lengths are carapace length.



formance and crab-behavioral variables to help us understand the escapement process.

Materials and methods

Description of trawl gear

The 83/112 Eastern bottom trawl has been used by the AFSC in annual surveys to assess EBS crab and shelf groundfish stocks since 1982 (Armistead and Nichol, 1993). For the present experiment, an auxiliary net with an independent footrope constructed of heavy chain-link and a separate codend were attached to the bottom of the survey trawl to capture epibenthic animals passing beneath the trawl footrope (Fig. 1). Briefly, the 83/112 Eastern is a low-rise trawl that has a 25.3-m long hea-

drope strung with 48 floats giving it approximately 102 kg of lift and a 34.1 m long, 5.2-cm diameter footrope constructed of 1.6-cm stranded wire rope protected with a single wrap of polypropylene line and split rubber hose. The net is constructed with nylon twine: 10.1-cm stretch mesh throughout the wing and throat sections; 8.9-cm stretch mesh in the intermediate section; a double layer of 8.9-cm stretch mesh in the codend; and a 3.1-cm stretch mesh liner in the codend. It is fished with a pair of 1.8×2.7-m steel V-doors weighing approximately 816 kg apiece.

The auxiliary net attaches to the wingtips and to the bottom of the survey trawl so that the bottom panel of the trawl serves as the top panel of the auxiliary net up to the beginning of the intermediate section. At this point, the two nets part and the auxiliary net then has a top panel of 8.9-cm stretch mesh and a double layer

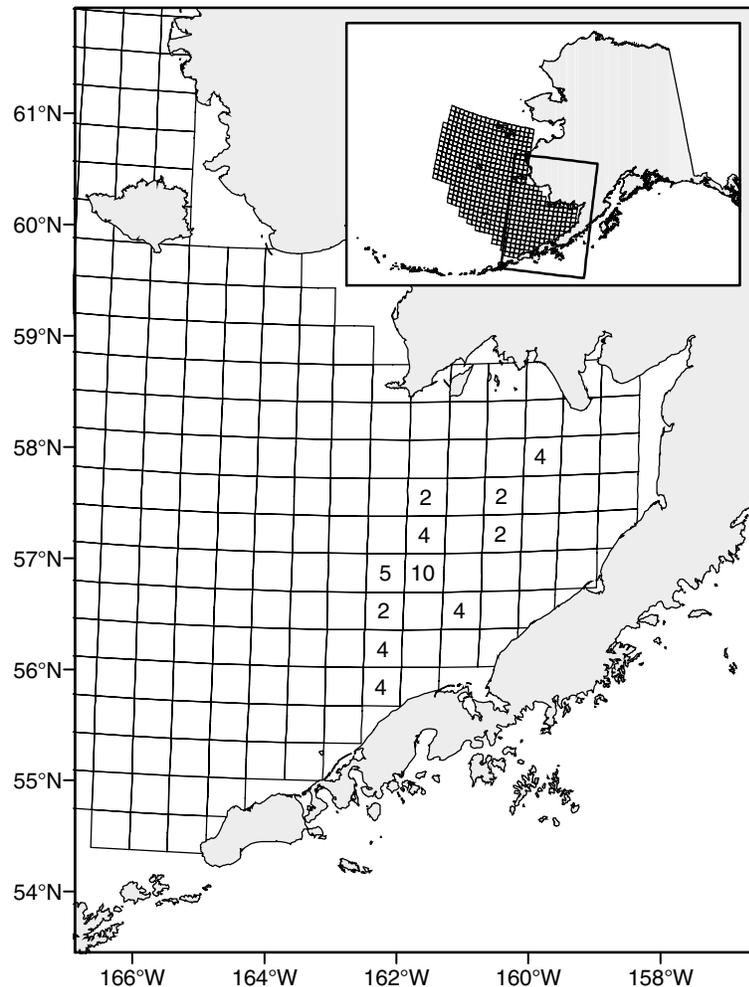


Figure 2

The annual eastern Bering Sea survey station grid showing the number of successful tows per station block made during the 2002 red king crab capture efficiency study. Each block represents a 400-nmi² area.

codend with a 3.1-cm stretch mesh liner. The 38.2 m long auxiliary footrope constructed of heavy 16-mm-long link trawl chain was designed to drag through soft bottom and presumably captures all escaping crabs. Munro and Somerton (2002) provided detailed construction plans of this experimental gear in their appendices.

Experimental design

Operations were conducted from 21 to 29 July 2002, aboard the FV *Arcturus*, one of two commercial stern trawlers chartered by the AFSC since 1993 to carry out annual Bering Sea groundfish surveys. Trawling took place in Bristol Bay (Fig. 2) at depths from 41 to 77 m and followed standardized survey protocols that included towing during daylight hours at a 1.5 m/sec (3 knots) vessel speed and using locked winches and standardized lengths of trawl warp (scope) at each towing depth. Acoustic net mensuration equipment was used

to measure wing spread for each tow. Bottom contact sensors were used on the centers of both the trawl and auxiliary footropes to measure the distance (in centimeters) between the footropes and the bottom (Somerton and Weinberg, 2001). A silicon-intensified tube (SIT) camera, which uses ambient light, was attached to the center of the trawl to view RKC interaction with the footrope. On some of our trial tows, however, a 30-W quartz halogen light was also used to increase contrast between ambient light and the sea floor.

Two departures from standardized survey protocol were necessary for this experiment. First, 27.5-m long bridles were used instead of the survey standard 55-m long bridles to help offset the loss of wing spread caused by the added drag of the auxiliary net (Munro and Somerton, 2002). Second, tow length was shortened from the survey standard of 30 min to 20 min to minimize the decrease of path width over time due to increased drag from large catches in the auxiliary net.

Towing sites were selected according to catch rates and carapace lengths obtained from the recently completed 2002 EBS survey (Stevens²). Tows were made in pairs, one in a northerly direction, the other in a southerly direction and were offset to the east or west by a minimum of 0.1 nmi; the initial direction was chosen randomly in order to mitigate any bias that the current flow might have on footrope contact with the bottom (Weinberg, 2003). Increased effort was given to sites producing favorable numbers and crab lengths by adding additional towing pairs. For each tow the total catch of all species from each net was first weighed before all RKC were removed from the catch, weighed, coded by sex, and measured to the nearest millimeter.

Data analysis

Trawl geometry Trawl geometry for standard survey nets and experimental nets was measured to confirm that the two gear types fished similarly. Average wing spreads and footrope heights off-bottom for experimental tows were compared to those from 33 standard survey gear tows taken at the same or nearby sampling locations. Because the depth of sampling varied, wing spread and footrope height were linearly regressed on scope, a factor variable indicating gear type (i.e., survey or experimental), and their interaction. Two-tailed *t*-tests were used to test for the difference in the slopes and the intercepts between gear types. Significance of the interaction term indicated that slopes differed between gear types. For nonsignificant interaction, significance of the intercepts indicated that wing spread or footrope height differed between gear types by a constant amount.

Capture probability Capture probability for the experimental gear was estimated from catch data of the trawl and the auxiliary net as a function of carapace length (*L*) for both male and female crab. Based on the assumption that the auxiliary net allows no escapement, the probability of capture at the footrope was modeled as a logistic function (Munro and Somerton, 2002) by using SPLUS software (version 6.1, Insightful Corporation, Seattle, WA). Two models were considered: the first, a two-parameter model which reaches an asymptotic maximum of 1 (unity):

$$P(L) = \frac{1}{1 + e^{-(\alpha + \beta L)}}; \quad (1)$$

and the second, a three-parameter model which reaches an asymptotic maximum less than 1:

$$P(L) = \frac{\gamma}{1 + e^{-(\alpha + \beta L)}}. \quad (2)$$

² Stevens, B. G., R. A. Macintosh, J. A. Haaga, C. E. Armistead, and R. S. Otto. 2002. Report to industry on the 2002 eastern Bering Sea crab survey. AFSC Proc. Rep. 2002-5, 59 p. Alaska Fish. Sci. Cent., Natl. Mar. Fish. Serv., NOAA, Kodiak Fishery Research Center, 301 Research Court, Kodiak AK 99615.

Because crab capture at the footrope is a binomial process (i.e., crabs are either captured or they escape), the models were fitted to the capture and length data by using maximum likelihood (Millar, 1992; Munro and Somerton, 2001) and the data were pooled across tows. For each sex, both models were fitted to the data, and the best of the competing models was selected according to the lowest obtained value of the Akaike information criterion (AIC; Burnham and Anderson, 1998), defined as

$$AIC = -2(\log \text{likelihood}) + 2(\text{number of parameters}).$$

After choosing a model for each sex, we examined whether the capture probability curves differed between sexes by fitting a model to the data for both sexes combined, and then comparing the value of AIC for this model to the sum of the AIC values for the models fitted to each sex, again using the minimum AIC value to objectively select the better of the two models.

Bootstrapped confidence intervals were constructed for the mean capture probability for each 1-mm length category, between the smallest and the largest individuals (Efron and Tibshirani, 1993) by resampling the catch-at-size data from individual hauls 1000 times. Empirical 95% confidence intervals were then determined as the range between the 25th highest and the 25th lowest of the bootstrap capture probability estimates.

Video data analyses

To understand the factors associated with crab escapement under the footrope, a video camera was mounted on the trawl to observe RKC interaction with the center of the trawl footrope. These *in situ* video observations included tows made in 2000 on the standard trawl and in 2002 on the experimental trawl. Artificial light was provided for all of the 2000 tows, and for some of the 2002 trial tows made before the capture efficiency experiment began. All the 2002 experimental tows were made under natural light conditions. RKC encounters observed on the videotapes were counted from the time the footrope settled to the bottom until the time the footrope was lifted off-bottom at the end of the tow. The probability of capture was predicted as a function of several explanatory variables. Variables observed and codes (in parentheses) for each individual included the following:

- 1 the capture event—the crab escaped beneath the footrope (0) or was captured (1);
- 2 use of artificial light—the tow was made with (0) or without artificial light (1);
- 3 estimated mean footrope height above the sea floor over the course of the entire tow was based on the bottom contact sensor and was expressed in centimeters (0–5);
- 4 body height—the crab was observed to be crouching with its legs either tucked beneath the carapace or stretched out so that the carapace was very close to the bottom (0) or standing upright on its dactyls (1);

Table 1

Regression coefficients of wing spread (width) and footrope distance from the bottom (footrope) as a function of scope and gear type based on tows from the capture efficiency experiment and tows using standard survey gear. Also provided are the results of two-tailed *t*-tests testing for the difference in intercept between gear types.

	Slope	Intercept		<i>P</i> intercept
		Experimental gear (<i>n</i> =43)	Standard gear (<i>n</i> =33)	
Width (m)	0.0038	15.3206	16.0713	<0.0000
Footrope (cm)	0.0087	-1.2582	-0.4241	0.0023

- 5 body orientation at the point of contact with the footrope—footrope contact occurred along the body axis (1) or from the side (2);
- 6 crab size—small (0), medium (1), or large (2), where size is expressed as an approximation based on visual comparison of carapace length to the dimensions of trawl parts, such as mesh or chain links. Corresponding length intervals were approximately ≤ 90 mm, 90–135 mm, and ≥ 135 mm.

As a general rule, crabs could be seen in the videos 1–2 seconds prior to contact with the footrope. Assignment of codes was typically straightforward. However, in some instances, several reviews of the encounter were necessary in order to determine a crab's position or orientation in relation to the footrope.

The probability of capture was estimated by using stepwise generalized linear modeling (GLM; Venables and Ripley, 1994) to fit a logistic model describing the probability of capture as a function of crab size, where body height, body orientation, average footrope distance from the bottom during the tow, the use of artificial light, and all possible first order interactions were considered as additional potential terms. The model fitting procedure (with data from crabs for which all variables were observed) entailed a stepwise backward model selection process. The process began with fitting the model to all interaction terms less one, and then calculating and comparing the resulting AIC values. The interaction producing the largest decrease in AIC was subsequently eliminated. Next, the procedure was repeated with the remaining terms until no interaction term could be eliminated without increasing the AIC. Then, the above process was repeated for the main effects. For the main effects having an interaction term, both the main effects and the interaction term were eliminated together as a unit. The final model chosen contained those terms that produced the minimum AIC value.

Results

Effect of the auxiliary net on trawl geometry

Regressions of wing spread and footrope height on scope, gear type, and their interaction were compared

to determine how closely the two gear types fished. The interaction term was not significant for wing spread ($P=0.08$) nor for footrope height ($P=0.82$), indicating that the slopes did not differ between gear types. However, tests of the intercepts were significant for both wing spread and footrope height and indicated that trawl geometry differed between survey and experimental trawls (Table 1). Predicted standard survey wing spreads for the minimum (137 m), median (229 m), and maximum (320 m) scopes used were 16.6, 16.9, and 17.3 m—approximately 0.8 m more than the experimental gear at the same scopes. Predicted footrope distances off the bottom were 0.8, 1.6, and 2.4 cm, at the above three scope values—approximately 0.8 cm greater than the experimental gear. Although we detected statistical differences in the trawl geometry between the two gear types, the actual difference in physical measurements was small and presumably had only a nominal effect on the results of the capture efficiency experiment.

Our assumption that the auxiliary net caught all escaping crabs was reinforced by two observations: 1) the data from the bottom contact sensor on the chain footrope indicated consistent contact with the sea floor; and 2) the auxiliary net consistently had large catches of benthic organisms other than crab, such as starfish and shells, and produced enough drag on the system to reduce wing spread. The effectiveness of the auxiliary footrope at capturing escaping crab is in part due to its weight and small diameter that enable it to sweep beneath the crabs and in part due to the suspension of benthic organisms initiated by the turbulence created by the passing of the first footrope.

Length-based capture probability

Capture probability was estimated from length measurements ($n=3233$) collected from 43 successful experimental tows (21 north, 22 south) made within 11 standard EBS survey station blocks (Fig. 2). Male samples ($n=1667$) ranged in size from 23 to 184 mm (Fig. 3). Female samples ($n=1566$) ranged in size from 51 to 162 mm.

The two-parameter model (model 1) of capture probability was selected over the three-parameter model (model 2) because it had a lower AIC value for both male and female RKC (Table 2). For the comparison of

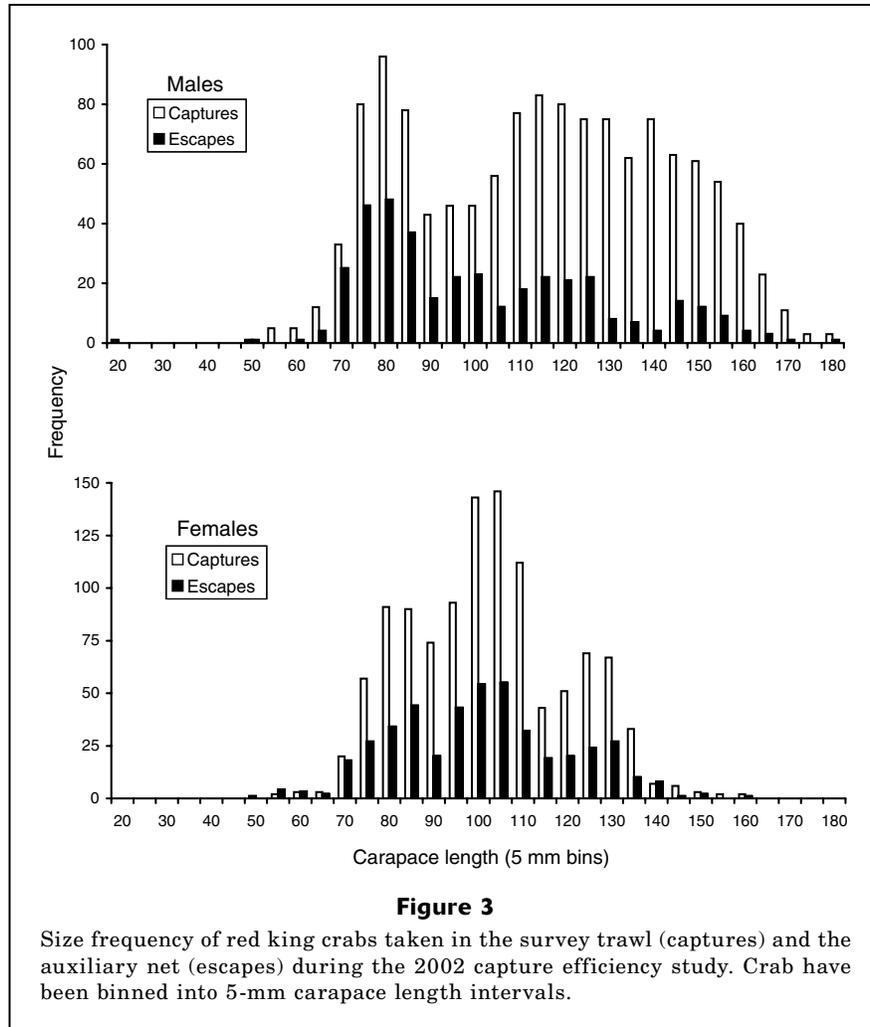


Table 2

Estimated parameter and Akaike's information criterion (AIC) values for the maximum likelihood fit of the 2-parameter and the 3-parameter logistic models for males, females, and for sexes combined. Parameter variance estimates based on bootstrapping 1000 replicates are provided for the final model used to estimate red king crab capture probability for the 83/112 Eastern survey bottom trawl.

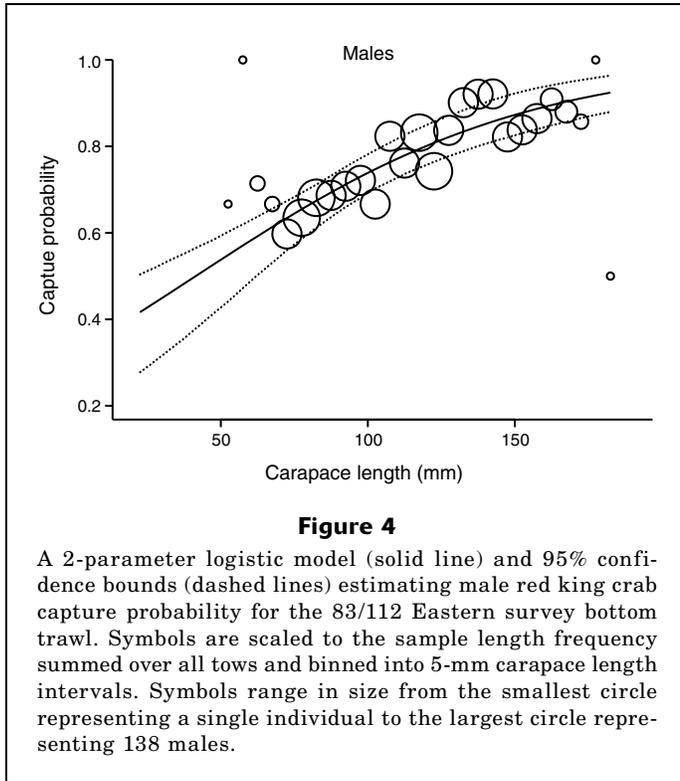
Sex	Model	α	β	γ	AIC	Var α	Var β	Covariance $\alpha\beta$
Male	$1 / (1 + e^{-(\alpha + \beta v)})$	-0.7366	0.0178	—	1725.3	0.113	1.28×10^{-5}	-1.14×10^{-3}
	$\gamma / (1 + e^{-(\alpha + \beta v)})$	-0.8826	0.0209	0.9622	1727.1	—	—	—
Female	$1 / (1 + e^{-(\alpha + \beta v)})$	0.3540	0.0054	—	1875.7	0.279	2.58×10^{-5}	-2.63×10^{-3}
	$\gamma / (1 + e^{-(\alpha + \beta v)})$	0.3540	0.0054	0.9999	1877.7	—	—	—
Combined sexes	$1 / (1 + e^{-(\alpha + \beta v)})$	-0.4569	0.0143	—	3612.7	—	—	—

selectivity curves for males and females with model 1, we found the summed AIC for separate curves to be lower than the AIC for sexes combined. Consequently, separate selectivity curves were estimated for males and females (Table 2).

The fitted model predicted male capture probability to be 41.9% at 23 mm (size of the smallest male observed); 72.2% at 95 mm (size at which full vulnerability to the survey trawl is assigned in the current management model); 80.2% at 120 mm (size assigned

in the current management model for male maturity); 84.1% at 135 mm (legal size for males); and 92.7% at 184 mm (size of the largest male crab encountered in

our experiment [Fig. 4]). The fitted model predicted female capture probability to be 65.2% at 51 mm (size of the smallest female observed); 69.8% at 90 mm (size at which both full vulnerability to the survey trawl and 50% female maturity are assigned in the current management model); 74.7% at 135 mm (same size at which males enter the fishery); and 77.4% at 162 mm (size of the largest female crab encountered in our experiment [Fig. 5]). Estimated capture probability for both male and female crab was equal at 88 mm (69.9%). Model variability, as indicated by the 95% confidence bounds, was greatest at the extremes of our size ranges because of low sample frequency. This was especially true for small crabs, and the uncertainty was so large that extrapolation of the capture probability functions to either males or females below <60 mm is not recommended.



Factors influencing escapement

Modeling the effect of various factors on capture probability was based on observations of RKC ($n=248$) from videotapes collected during 28 EBS tows. Approximately two-thirds of the counted crabs were captured. The influence of artificial lighting, body height, footrope distance from the bottom, crab size, body orientation, and the interaction of body height and body orientation were significant (Table 3). Capture probability decreased when lights were used and when the distance between the footrope and the bottom increased. Capture probability increased when crabs were standing up on their legs, with increased body size, and when the footrope contact was made along the body axis rather than from the side of the crab.

Capture probability, based on direct observation, was predicted by the fitted logistic models to illustrate how the various explanatory variables affect the capture outcome. We present two examples. In the first case, capture probability in natural light

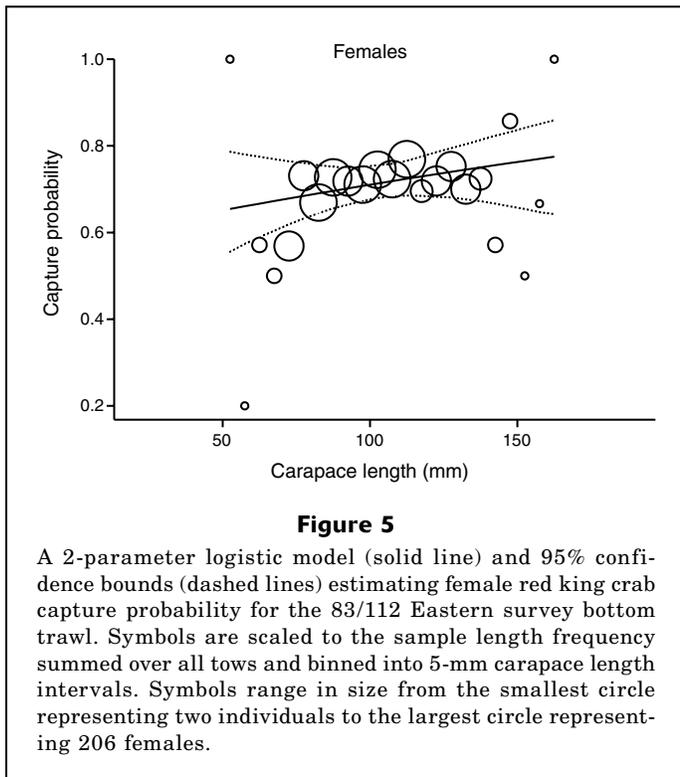


Table 3

Model coefficients for predicting red king crab capture probability from counts obtained with a trawl-mounted video camera.

	Value	Standard error
Intercept	-2.014	0.676
Light variable	-0.959	0.526
Body height variable	3.789	0.624
Body orientation variable	0.207	0.613
Crab size variable	1.506	0.315
Footrope height variable	-0.286	0.197
Body height and orientation interaction	-1.436	0.785

conditions and when crab are oriented sideways to the oncoming footrope, was predicted as a function of footrope distance off the bottom for each size class, and for both standing and crouching crab (Fig. 6). For all size groups, capture probability decreased with increasing footrope height from the bottom. The importance of whether a crab was standing or crouching diminishes with decreasing crab size because the footrope is more likely to pass completely over smaller crab. In contrast, the importance of standing was higher for large crab because they were more likely to be undercut by the footrope and captured, whereas crouching crab were more susceptible to having their legs first pinned down by the footrope, which exerted a downward pressure on their carapace and allowed the footrope to pass over the crab. Capture probability of medium-size individuals, which included a large proportion of egg-bearing females, was more dependent upon the body height of the crab. Footrope contact below the carapace typically resulted in capture; however contact above the legs often forced the crab's carapace down, causing the crab to roll forward and pass beneath the footrope.

In the second case, capture probability was predicted for natural light conditions when the footrope is 1 cm off-bottom, as a function of crab size, by body orientation to the footrope, and for standing and crouching individuals (Fig. 7). Under these conditions, capture probability was greater for crab contacted along their body axis than for crab hit from the side. In addition, capture probability increased with crab size for both standing and crouching crab, regardless of whether the footrope first contacted the crab along their body axis or from the side. When the footrope was 1 cm off bottom, the difference in the body-orientation effect on capture probability for standing crab was greater for smaller crab than for medium and larger individuals, but relatively equal for crouching crab of all sizes.

Discussion

Our observations confirmed that adult Bristol Bay red king crab can escape beneath the footrope of the AFSC's 83/112 Eastern survey bottom trawl under normal towing conditions. Capture probability increased with size but did not reach 100% for the largest crab caught. For the current management model used for RKC stock assessments, 100% capture probability is assumed for adult crabs and should be revised. A recruitment ogive is used in the calculation of the total spawning biomass for defining overfishing under the Magnuson-Stevens Fishery Conservation and Management Act (Stevens²). Revised computations of vulnerability will be required for this purpose as well. Survey trawl selectivity, although similar between the two sexes at prerecruit

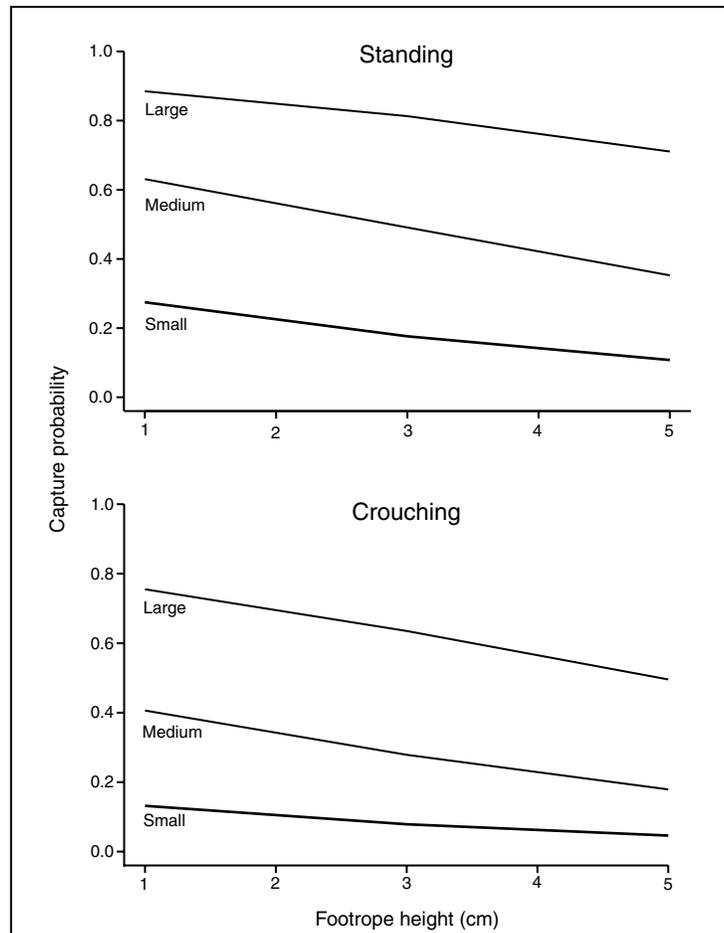


Figure 6

Estimated red king crab capture probability (based on direct observations) by size class as a function of footrope height above the bottom for standing and crouching individuals. For this model, it was assumed that no artificial light was used for the camera and that crab were oriented sideways to the footrope upon initial contact.

sizes, was generally 15% higher for legal-size males than for equal-size females. This between-sex difference in capture probability may be explained by behavioral differences (for instance, egg-bearing females stand differently from large males). Unfortunately, crab, when viewed from above, mask their gender; thus sex was excluded from our modeling exercise of video data.

Survey catch statistics for RKC are routinely included in the management modeling procedure to estimate the abundance of legal-size males (≥ 135 mm), male prerecruits (95–134 mm), the effective spawning biomass of males (≥ 120 mm), and the spawning biomass of females (≥ 90 mm, as determined from size at 50% maturity). We estimated capture probability for legal-size males (up to 184 mm) to range from 84% to 93%, for prerecruit males from 73% to 84%, and for the mature portion of the male spawning population (up to 184 mm) from

80% to 93% Our estimated capture probability for the survey trawl on the female portion of the spawning RKC population ranged from 70% to 77% for crab up to 162 mm. A review of the AFSC database for EBS crab surveys showed that the largest male and female crabs taken were 200 mm and 172 mm. Corresponding capture probabilities estimated by the model for these size crabs were 94% and 78%, respectively.

Two main factors affect the overall capture efficiency of epibenthic species by a bottom trawl: 1) horizontal herding, defined as movement into the path of the trawl between the wingtips in response to stimuli produced by the doors or bridles; and 2) escapement, defined as the avoidance of capture once the crab is within the path of the trawl. We believe herding is negligible because our observations of crab movement, which were consistent with those reported by Rose (1999), indicated that RKC are slow-moving animals that can travel only slight distances before being overtaken by a trawl approaching

at 1.5 m/sec. Our video observations of the trawl bridle revealed that RKC consistently passed over the top of the bare cable, with one exception—where a few crabs were seen sliding along the bridle, legs entangled, to the wingtip before being cast outside the path of the trawl. Escapement is likely restricted to footrope escapement because mesh escapement is impeded by the spiny surface and long legs of the crab and could only occur for the smallest individuals, which we encountered in low numbers and which could not be predicted reliably by our model.

We recognize from the analysis of our *in situ* data that capture probability is influenced not only by trawl performance but also by crab behavior. For instance, crabs standing upright, such as moving or migrating individuals, are more susceptible to capture than those with their bodies resting on the substrate. Crab density could also affect capture probability as seen for some species of fish (Godø et al., 1999). The crabs we observed

with our video cameras were fairly dispersed and the maximum number of crabs seen in any single video frame was two (twice observed). Crabs in relatively low abundance are likely to react directly to the gear, but in areas of high abundance, crabs may react to each other in response to the stimuli from the approaching gear, causing them to crouch or conversely move away from perceived danger. Both of these responses would result in a different capture probability.

Our estimates of capture probability apply to the conditions in which the EBS survey is conducted; that is, relatively disperse offshore populations encountered during daylight hours on sandy bottom during the summer months. There are other behavioral factors or environmental conditions that we did not consider in the present study but which could affect the efficiency of the survey trawl. These include, but are not limited to, the following: trawling where the substrate is substantially different; crabs that are either aggregated into pods or are buried (Dew³); and temperatures or tidal currents that would affect the migratory or feeding behavior, and therefore the body height of crab (Dew, 1990). Our estimates of capture probability are also based on the assumption that the auxiliary net is 100% efficient at capturing crab escaping beneath the footrope of the survey trawl. We have no direct evidence to believe otherwise. However, if crabs also escaped the auxiliary net, then our estimates of capture probability would be too large.

In conclusion, we wish to clarify to users of our findings that, although these experimentally determined selectivity models indicate an upward correction in spawning biomass of red king crab may be in order, we find no reason

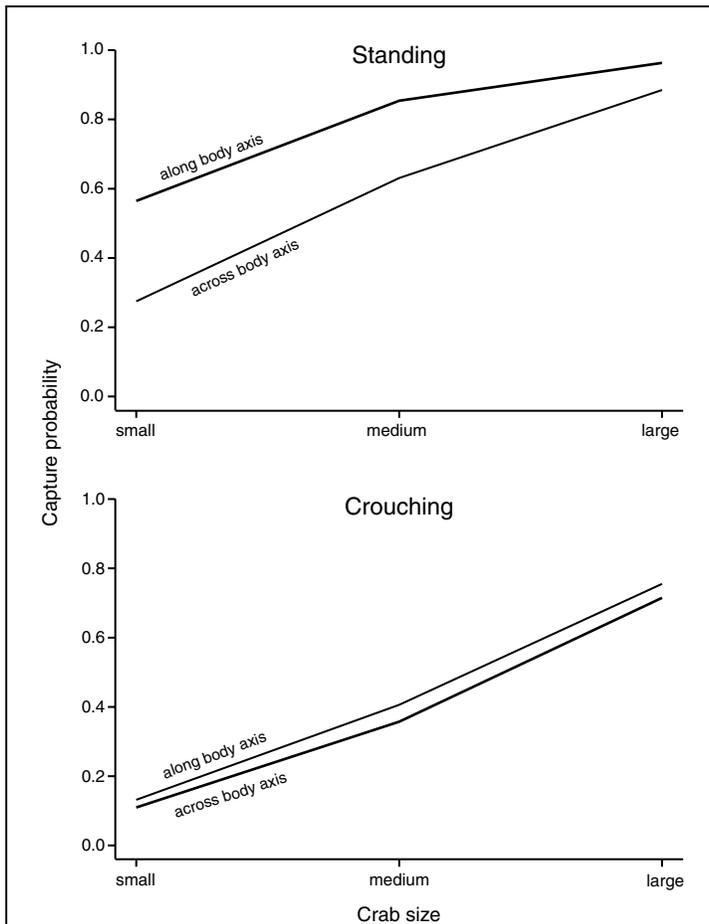


Figure 7

Estimated red king crab capture probability (based on direct observations) by body orientation at the time of footrope contact as a function of crab size for standing and crouching individuals. For this model, it was assumed that no artificial light was used for the camera and that the footrope was 1 cm off bottom.

³ Dew, C. B. 2003. Personal commun. Alaska Fisheries Science Center, 7600 Sand Point Way NE, Seattle, WA 98115.

to claim that the stock is in any better condition than the condition that was determined by the most recent assessment. The foremost utility of the AFSC annual EBS surveys is to monitor distribution and abundance trends through time. The survey accomplishes this by maintaining strict protocols and consistency in trawling methods, in computation of area-swept abundance, and in nonenvironmentally affected trawl efficiency. The survey time series is designed to detect changes in abundance, signaling advances in the population's rebuilding processes, regardless of whether crab are 100% or 80% vulnerable to the survey trawl. We advocate that careful consideration be given to the other factors that drive the management model, along with the results of our capture efficiency experiment, to ensure that the stock rebuilding process remains uninterrupted.

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