SUMMARY OF CRAB INJURY ASSESSMENT AND AERIAL EXPOSURE SAMPLE RESULTS FROM SELECTED 1998/1999 BERING SEA/ALEUTIAN ISLANDS KING AND TANNER CRAB FISHERIES AND THE 1999 PRIBILOF ISLANDS HAIR CRAB FISHERY

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ABSTRACT

Between 1997 and 1999 Alaska Department of Fish and Game observers sampled female and undersized male bycatch crabs, and recorded pot catch sorting times and crab injuries. The relationship between aerial exposure and total catch was examined and injury data results were tested for significant differences between fisheries and individual vessels. Data results show the combined catch rates of retained and non-retained crabs appear to influence aerial exposure rates in some fisheries but not others. Results from three years of sample data indicate that injury types, rates and aerial exposure times of bycatch crabs can be highly variable between fisheries and individual fishing vessels. The data also suggests that factors causing injury or greater time on board vessels include high catch and bycatch rates, timing of fishing seasons, and types of sorting procedures. Vessel crew sorting practices were also documented but differences in aerial exposure times due to variable sorting practices and equipment used were difficult to detect. In all fisheries observed the overwhelming percentage of injuries noted were minor in nature. Major injuries were rare and when observed, most often consisted of severely damaged walking legs.

INTRODUCTION

Large numbers of female and sublegal-sized male crabs captured in some Bering Sea/Aleutian Islands commercial crab fisheries must be discarded to comply with state regulations governing minimum size limits and sex restrictions (ADF&G 1999). Prior to their return to the sea, a percentage of these crabs may be subjected to excessive on-deck aerial exposure and body injuries resulting from on deck handling and discard. Research studies conducted in both controlled and field settings have examined the types and frequency of injuries and potential resultant handling mortality to bycatch crabs in the commercial fisheries. Zhou and Shirley (1995) studied potentially lethal effects of handling on bycatch female and sublegal male red king crabs by simulating on-deck sorting and handling procedures and evaluating injuries and subsequent overall condition of the test subjects. Although body damage increased significantly with increased handling, there were no significant differences among the treatment groups in long term mortality, feeding rates, righting responses, or bacterial infections. Study results indicated the effects of handling on red king crab bycatch may be less detrimental than that reported for other commercially caught crab species.

However, numerous other studies examining handling-induced mortality in shellfish have identified lethal and sublethal effects on several crab species due to stress, cold air temperatures and injuries, including limb loss (Kruse 1993). Handling experiments conducted on red king crabs and Tanner crabs by Stevens and MacIntosh (1993) examined survival rates of male and female crabs inflicted with various injuries suspected to occur in the Bering Sea commercial fisheries. In a review of capture and handling effects Kruse (1993) noted that consequences from handling at-sea during the commercial fisheries may result in reduced fishery yields and significant mortality to declining stocks.

To further document the frequency and nature of injuries and other potentially harmful effects attributable to handling of bycatch crabs, at-sea observers deployed in several Bering Sea/ Aleutian Islands king and Tanner crab fisheries were utilized for a data gathering project initiated in 1997. During this project observers systematically categorized and evaluated injuries to non-retained crabs from daily chosen randomly selected pots. They also recorded on deck aerial exposure times of discarded crabs and described catch sorting operations for each of the observed vessels. The following report summarizes results of the data collected in 1998/99 and examines variables that may influence injury rates and handling effects to bycatch crabs. A report on the 1997/98 injury assessment and aerial exposure data can be found in Tracy and Byersdorfer (2000).

METHODS

Observed Fisheries and Vessels

Handling injuries and crab aerial exposure times were recorded in four fisheries and seven fishing seasons occurring between September 1, 1998 and December 31, 1999. Observer coverage levels varied by fishery, fishing season and by numbers of participating vessels. Areas

fished, the target species and seasons for which injury and aerial exposure data were collected in each fishery were as follows:

Bering Sea Snow Crab Jan. 15 – March 22, 1999; March 29 – May 1999
Aleutian Islands Golden King Crab Sept. 1, 1998-Nov. 7, 1998; Sept. 1, 1999-Oct. 25, 1999
Pribilof Islands Hair Crab Oct. 30, 1999-Dec. 1, 1999
Bristol Bay Red King Crab Oct. 15, 1999-Oct. 20, 1999; Oct. 27, 1999-Nov. 7, 1999

In some fisheries data collections were obtained during both the open-access (competitive) and Community Development Quota (CDQ) seasons. All CDQ vessels carried observers, as did all those fishing Aleutian Islands golden king crabs and Pribilof Islands hair crabs. Observer deployments during the Bristol Bay red king crab open-access season included all catcher-processors and limited numbers of catcher-only vessels, which together comprised just over 4% of the fishing fleet.

Aerial Exposure Time

On deck aerial exposure times were measured for up to six pot catches randomly selected during each fishing day. Exposure times for crabs of the target species were recorded and from this group typically only the exposure times of the non-retained catch, consisting of females and sub-legal or sub-market-sized males. Exposure times were categorized as follows: *minimum exposure* – the recorded time interval beginning when a retrieved pot was lifted from the water and ending when the first non-retained crab was returned to the sea; and *maximum exposure* – the time interval beginning when a retrieved pot was lifted from the water and ending when the last non-retained crab was returned to the sea. Additionally, in each sampled pot crabs of the target species were enumerated and subdivided into total retained and non-retained catch. Due to large numbers of crabs per pot in the snow crab fishery, catch estimates were often made in lieu of actual counts.

Complete sample protocols and example forms used to record aerial exposure times are provided in Appendix A.

Injury Assessment Sampling

Pots selected for crab injury assessment sampling were also randomly chosen, with at least one pot sampled during each fishing day. Crabs assessed for handling-related injuries were all non-retained males and females of the target species that were sorted from retained crabs by the vessel crew. After crabs were removed from the pots they were enumerated and examined. Injury sampling procedures included visual inspection of the carapace, sternum, abdomen, coxa, and each pereiopod. Injuries noted were categorized by anatomical reference and classified as 'major' or 'minor 'in nature. Minor injuries included punctures, cracks, or other shell damage without exposure of integument, muscle, or vital organs. Major injuries were characterized by internal tissues and viscera visible through damaged shells. Leg autotomies, unique from all other types of injuries, were categorized as minor in nature only because of the well documented fact that crabs may voluntarily shed one or more limbs in combat or while fending off predators and self-cauterize the resultant wound. Sampled crabs were also assessed for vitality and

characterized as moribund, if not exhibiting appendage movement when prodded, or dead, if maxilliped movement was also not apparent. Ancillary data recorded for most crabs inspected included measurement of carapace length (carapace width in snow and Tanner crabs) and shell age.

Complete sample protocols and example forms used to record injury assessment data are provided in Appendix B.

Documentation of Vessel Catch Sorting Operations

Methods and equipment utilized by vessel crews to sort pot catches examined for injuries were documented through a survey questionnaire completed by the onboard observer. The multiple choice answers provided in the survey questions described the design and on-deck configuration of sorting equipment and various aspects relating to catch sorting practices, such as the sorting order of retained and non-retained crabs, the means used to release non-retained crabs, and number of crewmembers participating in sorting operations. Tabulated results of completed surveys for each season were used to create a profile of catch handling techniques commonly practiced in the commercial fisheries.

An example questionnaire used for describing individual vessel sorting operations is provided in Appendix C with results in Appendix D.

Data Analysis

To examine the relationship between aerial exposure times and total catches in sample pots, simple linear regression using ordinary least-squares (Neter et al. 1983) was used to fit the linear model,

$$Y_{\text{maximum aerial exposure}} = \beta_o + \beta_1(X_{\text{total crabs per pot}}) + \varepsilon$$

where the error, ε, is assumed normally distributed with a mean 0.

The regression model was applied to exposure times and total catch counts recorded for individual vessels and also to those pooled by fishing season. A coefficient of determination (r^2) computed for each data set quantifies variation in exposure times attributable to an approximate linear relationship to total catch per pot. Interactive effects between vessel data sets were not considered in evaluating model output for each fishing season. Significance of the linear model was evaluated for each of the data sets by testing the null hypothesis:

$$H_0: \beta_1 = 0$$

at level $\alpha = .05$, and where $t_{\alpha/2,n-2}$ = critical value of the *t* distribution at .05 and n-2 degrees of freedom.

RESULTS

Bering Sea Snow Crab

Open-Access Season

More than 6,200 non-retained snow crabs from 159 sampled pots were assessed for injuries during the 66 d open-access snow crab season. Injury rates varied greatly among the nine observed catcher-processors, ranging from 2.6% to 17.6% of crabs sampled (Table 1). Combined samples from all vessels revealed that approximately 10% of the mean 39.3 non-retained crabs per pot received at least one injury prior to release. Crabs with two or more injuries comprised 1.7% of the total.

Injuries considered minor in nature predominated sampled crabs (Figure 1). Autotomized legs were the most prevalent of all injuries, comprising 81% of the minor injury total and 67% of the all injuries (Table 2). Other types of limb damage ranging from mildly bent, cracked and punctured legs, to those severely crushed and torn, were the second most prevalent minor injury and the most commonly observed major injury. Excluding chela injuries (minor in nature and third most common in this category), other injuries combined comprised slightly over 20% of all injuries. Minor and major sternum and minor coxa damage was not observed in any sampled crabs. Fewer than 0.5% of crabs examined for injuries were characterized as moribund or dead.

Observed injury rates varied little among crab shell age groups. New-shell crabs were injured at a rate of 10.3%, and old and very-old shelled crabs were injured at a rate of 11%.

Data was to be collected only on the target species being fished and since the Bristol Bay Tanner crab fishery has been closed since 1997, no injury data was anticipated. A number of observers collected data opportunistically on Tanner crab caught during the Bering Sea snow crab fishery even though it was a non-target species. Injury data for Tanner crab caught during the open access and CDQ Bering Sea snow crab fisheries can be found in Appendix E. The data is presented for information purposes only and is not compared to other fisheries or discussed further in this document.

Aerial exposure times of non-retained crabs were measured from a total of 677 pots on catcher-processors. Mean maximum exposure times of sorted and discarded crabs varied greatly between individual vessels, ranging from 1.3 to 9.1 minutes (Table 3). Overall, mean maximum on deck exposure time was 3.7 minutes. The median of maximum exposure times by vessel and overall is lower than the mean (Table 3), reflecting the influence of a few abnormally large maximum exposure times on the mean. Mean catch of retained and non-retained snow crabs per sampled pot was generally a poor predictor of mean maximum exposure time. Even though a positive linear relationship between maximum aerial exposure and total non-retained crabs per pot was significant for most vessels, meaningful relationships where the r^2 values were ≥ 0.5 existed for only 3 of the 10 observed catcher-processors (Table 3). Scatter plots of data from each vessel with fitted lines from the regression models are illustrated in Figure 2. Analysis of data pooled from all vessels also revealed a significant linear relationship between exposure time and total crabs per pot, although a low r^2 value of 0.02 suggested that little of the variation in

exposure times was explained by the linear model (Figure 3). Total number of crabs, by itself, is a poor predictor of maximum exposure time for most vessels observed in this fishery.

CDQ Season

Only 2,105 crabs from 35 pots were sampled for injuries during the 34 d snow crab CDQ season. However, greater than 18% of the 2,105 crabs examined were injured. Injury rates observed among the nine observed catcher-only vessels were highly variable, ranging from 3.9% to 23.2% (Table 4). Crabs with more than one injury comprised just under 6% of the sample total.

Most injuries were minor in nature (Figure 4). Autotomized legs were again the most common type of minor injury, comprising 39.9% of the sample. Other minor injuries consisted principally of damaged rostrums (Table 5). Of all injuries detected, those characterized as major comprised 35.9% of the total. Severe leg injuries were the most commonly observed injury in this category. Minor sternum and coxa damage was not observed during the CDQ season. Results of vitality assessments were similar to those from the open access season with less than 1.5% of crabs examined moribund and 0.5% dead.

Variability in snow crab injury rates was small between shell age groups. New-shell, old-shell and very old-shell crabs incurred injuries at nearly the same rate: 17, 21, and 23 crabs per 100 sampled, respectively.

Crab aerial exposure times were measured for 406 pots selected daily during the season. Similar to the open-access fishery, mean maximum exposures of sorted and discarded crabs were variable between vessels, with the mean maximum values ranging from 2.1 to 9.6 minutes (Table 6). At 5.1 minutes the overall mean maximum exposure time for CDQ vessels was higher than that for the open access fishery at 3.7 minutes. Median maximum exposure times for individual vessels ranged from 2.0 to 6.9 minutes; overall median was 3.8 minutes. Although the overall mean catch per pot of retained snow crabs was higher in the CDQ fishery (at 156 compared to 143 in the open access fishery) the mean catch rate of non-retained snow crabs in CDQ sample pots was almost twice that of open access sample pots. Mean catch per pot of retained and non-retained snow crabs was highly variable between individual CDQ vessels and did not appear to correspond to maximum mean aerial exposure. A meaningful linear relationship, where the r^2 values were $\geq$0.5, existed between maximum aerial exposure and total catch per pot existed for data recorded on 8 of 20 vessels (Table 6). Scatter plots and fitted regression lines for each data set are provided in Figure 5. A scatter plot of the combined data for all vessels depicted in Figure 6, indicated a high degree of variation in exposure times was not directly attributable to total catch. The r^2 value of 0.015 was similar to the 0.02 calculated for the open-access fishery.

Aleutian Islands Golden King Crab

Assessments of crab injuries and observations of aerial exposure were recorded on all participating vessels during 115 d of the 123 d golden king crab season. Observers examined 431 pots and 12,414 crabs for signs of major or minor body damage. Injury rates were similar to those observed in the snow crab CDQ fishery, ranging between 1.1% and 66.2% by vessel, and 13.5% overall (Table 7). Crabs with multiple injuries comprised just under 3% of the total sample.

Injuries recorded from sampled crabs were most commonly minor injuries with an average of nearly four minor injuries noted for each major injury observed. Variability in this ratio between individual vessels is illustrated by Figure 7. Most minor injuries consisted of broken rostrums, which afflicted 4% of crabs sampled and 31% of crabs with minor injuries (Table 8). Injuries to the mid-section of the carapace were the second-most common injury. Of the 454 crabs with major injuries, 63.2% had severely damaged legs. Sternum injuries were the least common injury observed in either of the two categories. Moribund or dead crabs made up less then 0.02% of the total crabs examined.

Pooled injury assessment samples were nearly evenly comprised of females and sublegal male crabs, and overall injury rates for each sex were very comparable at 13% and 14% of the sample totals. New-shell golden king crabs made up more than 98% of those shell aged and accordingly, 96% of those with injuries. Of the 54 crabs sampled with new-pliable shells, 44% were injured as compared to 13% of new-shell crabs and 21% of old-shell crabs.

Aerial exposure times for non-retained golden king crabs in 1,514 pots randomly selected during the season were markedly lower than those observed in the snow crab fishery. The overall mean maximum exposure time from data combined for all 17 observed vessels was 2.4 minutes (median=1.7 minutes), and mean maximum exposure times varied by more than 7 minutes between individual vessels (Table 9). Overall catch per pot of retained crabs were also relatively low at 9.9 with non-retained crabs almost four times higher at 37.1. Catch rates for individual vessels didn't appear to strongly correspond to observed differences in mean maximum exposure times, although data sets from 5 vessels revealed a substantial linear relationship between maximum exposure time and total crabs per pot. Regression lines fit to each of the data sets are shown in Figure 8. Combined data from all vessels, shows a significant relationship between exposure time and total crabs per pot, but a small r^2 value (0.032) indicates total crabs by itself is a poor predictor of maximum exposure time (Figure 9).

Pribilof Islands Hair Crab

Observers sampled 210 pots during the 37 d hair crab fishery. Injury rates were highly variable between observed vessels, ranging between 0% and 11.8% (Table 10). Crabs with two or more injuries comprised just under 1% of the total. Catch rates of non-retained hair crabs were extremely low by comparison to other observed fisheries, 0.1 crabs per sample pot. However, low numbers of sampled crab on some of the eight vessels participating in the fishery resulted in low precision in estimates of injury rates. Overall injury rates for non-retained hair crabs were just under 4%. Crabs with minor injuries were most prevalent in the non-retained catch, comprising 77% of the total injuries (Table 11). Moribund or dead crabs, relatively rare in comparison to the total sample size, were observed three times.

Although there was a catch ratio of about 3 males for each female hair crab in sample pots, there was a 7 male to 1 female injury ratio. Injury rates by shell age group (from a total of 208 shell-aged crabs), however, were somewhat disparate. While just over 3% of new-shell crabs incurred injuries, 10% of the old-shell crabs were damaged during handling.

Mean maximum crab aerial exposure times for non-retained hair crab catches in 222 pots selected during the season were just 1.0 minute overall, with a low of 27 seconds on one of the

eight observed vessels (Table 12). Catch rates in sample pots of non-retained crabs were extremely low by comparison to other observed fisheries at less than one crab per pot. A useful linear relationship of aerial exposure with total catch per pot was found for one of the eight vessels observed (r^2 = 0.480). In most cases a poor linear relationship was in part likely due to high variability in the sample data (Figure 10). A regression line fitted to exposure times and total catch for pots sampled on all vessels also failed to show a significant relationship between the two variables (Figure 11).

Bristol Bay Red King Crab

Open-Access Season

Collection of handling injury statistics was continued during the 1999 Bristol Bay season, with 109 pot catches sampled and total of 842 crabs examined on nine observed vessels during the 5 d season. Although injury rates on a number of vessels were greater than 30%, the overall rate was approximately 22%, which was almost double that recorded during the 1998 season (Table 13). Numbers of non-retained crabs sampled per pot decreased from 44.9 in the 1998 season to 7.7 crabs in 1999. Crabs with two or more injuries comprised slightly more than 3% of the total. Injuries characterized as minor were most commonly recorded, comprising 85.2% of all injuries. (Table 14). Broken rostrums constituted the most prevalent injury overall; broken rostrums were observed in 133 of the 842 crabs sampled (16%) and accounted for 60% of total injuries. Carapace injuries were the second most common minor injury, followed by damaged legs, which were the most common major injury noted at 78.8%. Other major injuries frequently observed included damage to the mid-carapace section and cracked, punctured or crushed chelipeds. A total of one moribund and no dead crabs were noted in the catch samples. Comparison of injury rates by injury type between individual vessels for sampled catches are provided in Figure 12.

Shell age did not appear to be as significant a factor influencing the probability of injury for non-retained crabs in 1999. From a total 838 shell aged crabs, 21% of those with new-shells were injured compared to 26% of old-shell crabs, 36% of very old-shell crabs and 100% of new pliable shell crabs sampled received injuries.

Crab aerial exposure times were recorded for non-retained catches in 148 pots selected on all nine of the observed vessels. Mean maximum aerial exposure time was 2.2 minutes (Table 15). Mean maximum exposure times for individual vessels varied only by 1.6 minutes. Regression analysis of the data sets showed substantial linear relationships between exposure time and total catch per pot in six of nine catcher processors (Table 15). Regression lines fit to each of the data sets are shown in Figure 13. As illustrated in Figure 14, exposure times plotted against total sample catches from all vessels also demonstrated a significant linear relationship between the two variables (r^2 =0.34; $p<0.0001$). The low r^2 value indicates the variable "total crabs" is a poor predictor of maximum exposure time.

CDQ Season

Few pots were selected for injury assessment sampling from the eight vessels participating in the 11d CDQ season and, as a result, just 380 crabs were examined. Numbers of non-retained crabs per sample pot at 7.9 were similar to the 7.7 in the open-access season (Table 16). Injuries were

recorded from 30.8% of the crabs sampled. Crabs with more than one injury made up 8.4% of the total and occurred in sampled catches on five of the eight observed vessels. The type and number of injuries noted for crabs sampled on individual vessels are shown in Figure 15. Similar to data results from the open-access season, most noted injuries were minor in nature and most minor injuries consisted of broken rostrums (Table 17). Mid and side carapace injuries were the second and third most prevalent minor injuries, each comprising approximately 11.5% of the total in this category. Major injuries, which occurred in 10.7% in all injured crabs, were also predominately damaged legs. Moribund or dead crabs were not observed in any of the sample pot catches.

Of the crabs sampled, 378 were males and 2 were females. Injury rates between shell-age groups were similar with 31% of 353 new-shell crabs incurring injuries compared to 37% old-shell crabs and 20% of very old-shell crabs.

Individual maximum mean aerial exposure times were recorded for non-retained crabs from 91 pots selected on 10 of the observed vessels. Although overall catches per sample pot of retained crabs were almost double those in pots sampled during the open-access season, the overall mean maximum exposure time was the same at 2.2 minutes (Table 18). Mean maximum exposure for individual vessels ranged from 1.4 minutes to 2.9 minutes. Exposure times were linearly related to total crabs per pot with substantial r^2 values in data sets from eight of the 10 vessels sampled (Table 18). Scatter plots and regression lines fitted to each of the data sets are presented in Figure 16. A regression line fitted to exposure times pooled from all 10 vessels, shown in Figure 17, was significant ($r^2 = 0.719$; $p < 0.0001$). In this fishery the total number of crabs per pot accounted for almost 72% of the variability in the maximum exposure time.

Catch Sorting

Pot catch-sorting equipment and procedure questionnaires were completed for a total of 27 different vessels participating in three of the six observed fisheries. While methods and equipment varied for individual vessels and sometimes by fishery, certain items were observed and practices noted more frequently than others. These included: tables, rather than totes, for depositing pre-sorted catches from pots; the use of pivot-legged tables moved under the vessel pot launcher for receiving catches and subsequently rotated back to the catch sorting area (as opposed to hinged or one-piece hydraulic tables, which in some cases result in deposited catches being mechanically "thrown" from one side of the table to the other); moving bycatch crabs by employment of ramp structures or conveyor belts for this purpose; and the placement of discarded catches into vessel scuppers manually or via ramps or conveyors (as opposed to dumping crabs over the vessel's freeboard manually by hand or in totes).

Sorting tables were present on 25 of the 27 observed vessels. While crews of 13 vessels employed ramps or conveyors to move bycatch crabs to the water's edge, the remaining 14 for which questionnaire responses were provided did so by hand carrying or placing them into totes (which were then dragged to the release area). Methods of release of bycatch crabs on nearly all vessels surveyed consisted of placing them in scuppers, although crews on three vessels resorted to hand tossing discards over the side or dumping them from totes (Appendix D).

Survey results of methods for removing crabs from pots, likely a significant potential source of injury in some fisheries, indicated that mechanized equipment was most commonly employed for this part of the process. Retrieved pots were routinely emptied on a majority of vessels by the practice of dumping the contents onto the sorting platform using the hydraulic pot launcher. Crabs dumped from pots fell less than two feet to the sorting platform on 13 vessels and between two and four feet on 14 vessels.

Aspects of sorting procedures relating to exposure times of bycatch crabs included tallies of crewmembers participating in sorting and the order of priority for separating the retained and non-retained catch. At least two of the crew sorted crabs on 11 of the vessels surveyed and three of the crew sorted crabs on 11 of the vessels surveyed. Crews on more than 59 % of vessels retrieved retainable crabs from pot catches before removing and discarding bycatch crabs from the sorting platform. The release of bycatch crabs was prioritized on one vessel, while retained or non-retained crabs appeared to be randomly sorted from the catch on the remaining nine vessels surveyed.

DISCUSSION

Results from three years of sample data (Tables 19 and 20) indicate that injury types, rates and aerial exposure times of bycatch crabs can be highly variable between fisheries and individual fishing vessels. The data suggest that factors causing injury or greater time on board vessels include high catch and bycatch rates, timing of fishing seasons, and types of sorting procedures. Other prevailing circumstances, such as competition between harvesters, and weather may also be important.

Directed catch and bycatch rates of crabs were expected to correlate strongly to maximum aerial exposure based on the logical assumption that as crabs per pot increase, more time will be required for catch sorting by vessel crews. Indeed, regression analysis by Zhou (1996) of aerial exposure versus catch rates recorded on a single vessel fishing Bristol Bay red king crabs produced results corroborative to this assumption. However, as shown in data results from the observed vessels, combined catch rates of retained and non-retained crabs appear to influence aerial exposure times in some fisheries, but not necessarily others. Significant correlation between the two variables was most apparent in the Bristol Bay red king crab CDQ season. There was a relatively strong linear relationship between exposure time and catch rates during the 1998 St. Matthew CDQ blue king crab season. Exposure times were most poorly correlated to catch rates in the Pribilof Islands hair crab fishery and the snow crab open access and CDQ fisheries. The Pribilof Islands hair crab fishery had the lowest overall and least variable individual catch rates of retained and non-retained crabs and the snow crab fisheries had the highest overall and most variable catch rates.

Changes in mean catch rates between fisheries appeared to correspond somewhat to changes in mean maximum exposure times. The highest mean maximum exposure times occurred in the open access and CDQ snow crab seasons, each of which as mentioned previously also produced the highest combined mean catch rates of retained and non-retained crabs. As might be expected, the lowest mean maximum aerial exposure was recorded for the Pribilof Island hair crab fishery.

In 14 of the 16 fisheries and fishing seasons, except the 1999 and 1998 CDQ Bering Sea snow crab, the mean maximum exposure times were less than a 5 minute minimum exposure time threshold used for treatment groups in recent studies of handling mortality, limb loss and righting response of Tanner crabs resulting from aerial exposure and subsequent wind-chill effects (Zhou and Kruse 1998, Shirley 1998). Study results indicated that for crabs subject to subzero wind-chill temperatures for at least 5 minutes, some mortality, limb loss, or reduced vigor could be expected.

Differences in aerial exposure times due to variable sorting practices and equipment used were difficult to detect without further examination of the data. Additionally, association of the two variables would likely be confounded by the observed differences in target species catch rates between fisheries. Other factors also not considered, such as fished gear types, might also influence findings. An illustration of how such factors could complicate sample results can seen in the Pribilof hair crab fishery, where the lowest mean maximum exposure time corresponded to the least mechanized sorting operations. (In contrast to other fisheries, nearly all hair crab vessel crews removed their catches from pots by hand.) However, as noted previously catch rates of hair crabs were also the lowest of all fisheries. In addition, hair crab pots as defined in regulation are smaller and more lightweight than those typically used in other fisheries, and may also be longlined as opposed to being fished singly (ADF&G 1999). Accordingly, hair crab pots are typically retrieved at relatively rapid rates, an operations detail which by itself may explain the reduction in aerial exposure of bycatch crabs. Without additional consideration of these and other potential variables, inferences relating aerial exposure to sorting practices might be overvalued.

A number of generalized statements can be made based on the results of injury assessment sampling regarding the nature, extent, and probable causes of injuries inflicted on crabs during handling in the observed fisheries over three years of the study. In each case the overwhelming percentage of injuries observed were those defined in the study as minor. Major injuries were rare, and when observed often consisted of severely damaged walking legs. Bycatch crabs seldom incurred more than a single injury during handling, as those with multiple injuries comprised less than 4 % of sample sizes in all fisheries and fishing seasons except the 1999 Bristol Bay red king crab CDQ season. Autotomized legs were the most prevalent minor injury inflicted on snow crabs and broken rostrums the most commonly recorded for red and golden king crabs. However, it should also be noted that autotomized legs were one of the three most common injuries in all fisheries and fishing seasons except: the 1998 Pribilof Islands CDQ red king crab; the 1999 Bristol Bay open access and CDQ red king crab; and the Aleutian Islands golden king crab fisheries. New-shelled crabs typically suffered injuries at rates much lower than that of old and very old-shelled shelled crabs, all of which in some fisheries had damage inflicted prior to being released. Differences in injury rates due to variable sorting practices and equipment used are not easily detectable without further data collection and analysis.

The predominance of damaged rostrums in king crabs corresponds to results of laboratory studies conducted by Zhou (1996). Rostrum damage was most prevalent followed by carapace spine damage. Spine damage was not recorded for crabs sampled on observed vessels. Study results of Zhou and Kruse (1998) and Shirley (1998) suggest that the prevalence of leg autotomies in both of the snow crab fisheries may be the result of increased cold air exposure due to the winter timing of the fishing season. Observations of golden king crab handling

injuries, also made during the cold winter months, showed lower leg autonomy rates for this species, which coincided with lower aerial exposure times of crabs in pots selected for sampling.

When looking at the data collected from 1997 through 1999 there doesn't seem to be a real trend between injury rates and fishery type (open access vs CDQ) as previously thought. The 1998 Bering Sea open access snow crab and Bering Sea red king crab fisheries had a higher injury rate that the CDQ fisheries, but just the opposite was apparent in the 1999 fisheries where the CDQ fisheries had the highest injury rate. The reasonable assumption that the absence of competition during CDQ seasons may lead to slower-paced harvesting, which in turn would result in more careful handling of bycatch crabs and fewer injuries, does not hold true for both years. In most cases the lower injury rate corresponded to a higher aerial exposure time. Slower sorting may have resulted in fewer injuries. Further studies are needed to make any further conclusions concerning the injury rates between years, fishing seasons and fisheries.

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Table 1. Observed body injuries of non-retained crabs in pot samples taken on nine catcher-processors during the 1999 Bering Sea snow crab open access season.

		Crabs Sampled		Crabs With Injuries				
Vessel	Pots Sampled	Total	Number per pot	Total	Number per Pot	Percent of Sample	Number with >1 injury	Percent sampled crab with >1 Injury
A	8	323	40.4	33	4.1	10.2	3	0.9
B	24	366	15.2	45	1.9	12.3	13	3.6
C	43	2,188	50.9	216	5.0	9.9	42	1.9
D	20	1,222	61.1	111	5.5	9.1	19	1.6
E	27	845	31.3	149	5.5	17.6	15	1.8
F	13	716	55.1	72	5.5	10.1	10	1.4
G	11	287	26.1	11	1.0	3.8	0	0
H	10	267	26.7	7	0.7	2.6	1	0.4
J	3	31	10.3	5	1.7	16.1	2	6.5
Total	159	6,245	39.3	649	4.1	10.4	105	1.7

Table 2 . Major and minor body injuries of non-retained crabs examined in pots sampled on nine catcher-processors during the 1999 Bering sea snow crab open access season.

VESSEL	A	B	C	D	E	F	G	H	J	Total Injury By Type	Percent Minor Injuries	Percent Total Injuries
% Crabs sampled per pot	100	100	100	95	100	100	96	100	100			
# Pots Observed	9	24	43	20	27	13	11	10	3			
MINOR INJURIES												
Rostrum	1	0	1	0	1	0	3	1	0	7	1.1	0.9
Carapace (middle)	1	0	1	0	0	0	0	0	0	2	0.3	0.3
Carapace (side)	2	3	1	0	0	0	0	0	0	6	0.9	0.8
Leg injury	3	23	8	23	23	0	0	0	1	81	12.4	10.3
Leg-Autotomy	15	0	245	86	113	58	3	0	9	529	80.9	67.3
Left chela	4	0	1	1	3	0	1	0	0	10	1.5	1.3
Right chela	4	1	2	0	1	0	0	0	0	8	1.2	1.0
Chela-Autotomy	0	0	5	1	0	1	1	0	0	8	1.2	1
Abdomen	0	0	1	0	2	0	0	0	0	3	0.5	0.4
Sternum	0	0	0	0	0	0	0	0	0	0	0	0
Coxa	0	0	0	0	0	0	0	0	0	0	0	0
Total Minor Injuries	30	27	265	111	143	59	8	1	10	654		83.2
MAJOR INJURIES												
Carapace (middle)	0	1	1	0	13	0	0	0	0	15	11.4	1.9
Carapace (side)	0	4	0	0	2	1	0	0	0	7	5.3	0.9
Leg injury	7	22	3	9	2	9	3	4	0	59	44.7	7.5
Left chela	1	2	0	3	3	3	0	4	0	16	12.1	2
Right chela	0	7	1	4	3	10	0	0	0	25	18.9	3.2
Abdomen	0	3	0	0	2	0	0	0	0	5	3.8	0.6
Sternum	0	0	0	0	0	0	0	0	0	0	3.8	0
Coxa	0	0	0	5	0	0	0	0	0	5	0	0.6
Total Major Injuries	8	39	5	21	25	23	3	8	0	132		16.8

Table 3. Linear relationship between maximum aerial exposure time and CPUE (crabs per pot) of retained and non-retained crabs combined in pots sampled on 10 catcher-processors during the 1999 Bering Sea snow crab open access season.

VESSEL	Pots Sampled	Mean Crabs per Pot		Maximum Exposure (minutes)		r^2 value	t	p value
		Retained	Non-Retained	Mean	(Median)			
A	78	168.1	32.8	9.1	(4.6)	0.0001	0.1	0.926
B	93	87.9	24.2	3.7	(3.2)	0.179	4.4	<0.001
C[a]	98	201.7	54.5	3.5	(3.3)	0.537	10.6	<0.001
D	78	141.4	88.3	2.1	(1.8)	0.418	7.4	<0.001
E	68	123.7	21.6	2.1	(1.8)	0.034	1.5	0.135
F[a]	42	108.1	64.5	3.5	(3.0)	0.792	12.3	<0.001
G	57	131.5	37.1	4.3	(4.3)	0.235	4.1	<0.001
H	27	172.0	25.6	1.3	(1.1)	0.166	2.2	0.035
I[a]	103	146.9	74.6	2.4	(2.1)	0.579	11.9	<0.001
J	33	127.1	34.1	3.9	(3.5)	0.297	3.6	0.001
TOTALS	677	142.5	48.5	3.7	(2.9)	0.02	3.6	<0.001

[a] Vessels where r^2 values are $\geq$0.5 and showed a significant linear relationship between maximum exposure time and total crabs per pot.

Table 4. Observed body injuries of non-retained crabs in pot samples taken on nine catcher-only vessels during the 1999 Bering Sea snow crab CDQ season.

		Crabs Sampled		Crabs With Injuries				
VESSEL	Pots Sampled	Total	Number per Pot	Total	Number per Pot	Percent of Sample	Number with >1 injury	Percent sampled crab with >1 injury
A	2	220	110.0	49	24.5	22.3	17	7.7
C	4	194	48.5	32	8.0	16.5	13	6.7
D	1	77	77.0	3	3.0	3.9	0	0
G	3	167	55.7	17	5.7	10.2	9	5.4
H	9	556	61.8	129	14.3	23.2	37	6.7
I	1	33	33.0	3	3.0	9.1	0	0
O	6	545	90.8	96	16.0	17.6	22	4.0
P	4	157	39.2	29	7.2	18.5	26	16.6
Q	5	201	40.2	33	6.6	16.4	1	0.5
Totals	35	2,105	60.1	391	11.2	18.6	125	5.9

Table 5. Major and minor body injuries of non-retained crabs examined in pots sampled on nine catcher-only vessels during the 1999 Bering Sea snow crab CDQ season.

VESSEL	A	C	D	G	H	I	O	P	Q			
% Crabs sampled	100	100	100	100	100	100	100	100	100	Total Injury By Type	Percent Minor Injuries	Percent Total Injuries
# Pots Observed per pot	2	4	1	3	9	1	6	4	5			
MINOR INJURIES												
Rostrum	10	1	0	1	49	0	27	11	0	99	29.9	19.2
Carapace (middle)	0	0	0	0	4	0	1	0	0	5	1.5	1.0
Carapace (side)	0	2	0	0	0	0	0	0	0	2	0.6	0.4
Leg injury	1	0	1	0	3	0	1	0	0	6	1.8	1.2
Leg-Autotomy	44	0	0	0	78	1	58	25	0	206	62.2	39.9
Left chela	0	0	0	0	0	0	0	1	0	1	0.3	0.2
Right chela	0	0	1	1	2	0	1	2	0	7	2.1	1.4
Chela-autotomy	2	0	0	0	0	0	2	0	0	4	1.2	0.8
Abdomen	0	0	0	0	1	0	0	0	0	1	0.3	0.2
Sternum	0	0	0	0	0	0	0	0	0	0	0	0
Coxa	0	0	0	0	0	0	0	0	0	0	0	0
Total Minor Injuries	57	3	2	2	137	1	90	39	0	331		64.1
MAJOR INJURIES												
Carapace (middle)	0	0	1	0	3	0	0	0	0	4	2.2	0.8
Carapace (side)	0	0	0	0	1	0	0	0	2	3	1.6	0.6
Leg injury	3	37	0	18	15	2	15	9	28	127	68.6	24.6
Left chela	0	3	0	6	0	0	1	3	2	15	8.1	2.9
Right chela	6	2	0	0	5	0	10	2	2	27	14.6	5.2
Abdomen	0	0	0	0	3	0	2	0	0	5	2.7	1.0
Sternum	0	0	0	0	1	0	0	0	0	1	0.5	0.2
Coxa	0	0	0	0	1	0	0	2	0	3	1.6	0.6
Total Major Injuries	9	42	1	24	29	2	28	16	34	185		35.9

Table 6. Linear relationship between maximum aerial exposure time and CPUE (crabs per pot) of retained and non-retained crabs combined in pots sampled on 20 catcher-only vessels during the 1999 Bering Sea snow crab CDQ season.

Vessel	Pots Sampled	Mean Crabs per Pot		Maximum Exposure (minutes)				
		Retained	Non-retained	Mean	(Median)	r^2 value	t	p value
A	10	245.5	118.0	4.4	(3.6)	0.234	1.6	0.156
B[a]	4	210.0	173.8	4.6	(4.7)	0.995	20.0	0.002
C	42	156.1	130.5	4.2	(3.2)	0.081	1.9	0.068
D	7	150.0	97.1	4.3	(4.1)	0.378	1.7	0.142
E[a]	29	167.1	153.3	3.2	(3.3)	0.747	8.9	<0.001
F[a]	20	123.5	97.3	2.7	(2.6)	0.741	7.2	<0.001
G	18	100.1	78.3	2.1	(2.0)	0.317	2.7	0.015
H	40	166.4	82.8	7.6	(5.7)	0.086	1.9	0.065
I[a]	8	218.8	58.1	6.6	(6.3)	0.540	2.7	0.038
J	15	219.3	67.9	4.9	(5.2)	0.322	2.5	0.027
K	42	170.9	47.5	9.6	(6.7)	0.018	0.9	0.391
L[a]	14	132.1	131.4	3.9	(3.9)	0.835	7.8	<0.001
M[a]	10	158.0	116.0	4.2	(4.2)	0.454	2.6	0.033
N	15	158.3	53.1	7.4	(5.2)	0.248	2.1	0.059
O	39	130.6	104.0	5.6	(4.3)	0.011	-0.6	0.518
P	25	82.1	40.1	4.2	(3.5)	0.014	-0.6	0.567
Q[a]	30	141.3	50.8	2.5	(2.4)	0.674	7.6	<0.001
R[a]	19	193.4	108.7	3.2	(302)	0.637	5.5	<0.001
S	11	155.7	53.8	7.1	(6.9)	0.001	-0.1	0.936
T	8	253.8	87.5	5.2	(5.0)	0.034	0.5	0.661
TOTAL	406	156.4	89.5	5.1	(3.8)	0.015	2.4	0.015

[a] Vessels where r^2 values are ≥ 0.5 and showed a significant linear relationship between maximum exposure time and total crabs per pot.

Table 7. Observed body injuries of non-retained crabs in pot samples taken on 14 catcher-only vessels and one catcher-processor during the 1998/99 Aleutian Islands golden king crab fishery.

		Crabs Sampled		Crabs With Injuries				
Vessel	Pots Sampled	Total	Number per Pot	Total	Number per Pot	Percent of Sample	Number with >1 injury	Percent sampled crab with >1 injury
A	37	402	10.9	46	1.2	11.4	9	2.2
B	23	874	38.0	10	0.4	1.1	1	0.1
C	22	2,740	124.5	134	6.1	4.9	11	0.4
D	37	607	16.4	192	5.2	31.6	52	8.6
E	33	599	18.2	75	2.3	12.5	8	1.3
F	39	727	18.6	50	1.3	6.9	5	0.7
G	25	328	13.1	217	8.9	66.2	88	26.8
H	11	297	27.0	70	6.4	23.6	8	2.7
I	35	905	25.9	239	6.8	26.4	57	6.3
J	30	1,232	41.1	152	5.1	12.3	22	1.8
K	28	433	15.5	13	0.5	3.0	3	0.7
L	41	1,010	24.6	289	7.0	28.6	75	7.4
M	8	66	8.3	25	3.1	37.9	10	15.1
N	31	1,473	47.5	113	3.6	7.7	10	0.7
O	31	721	23.3	53	1.7	7.4	3	0.4
Totals	431	12,414	28.8	1,678	3.9	13.5	341	2.7

Table 8. Major and minor body injuries of non-retained crabs examined in pots sampled on 14 catcher-only vessels and one catcher-processor during the 1998/99 Aleutian Islands golden king crab fishery.

VESSEL	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O			
% Crabs sampled per pot	96	100	90	100	100	100	100	100	100	100	100	100	100	100	93	Total Injury by Type	Percent Minor Injuries	Percent Total Injuries
# Pots Observed	37	23	22	37	33	39	25	11	35	30	28	41	8	31	31			
MINOR INJURIES																		
Rostrum	11	4	27	31	25	28	80	33	74	75	7	53	12	38	24	522	30.7	24.3
Carapace (middle)	12	1	16	109	9	1	94	4	47	47	0	72	4	3	4	423	24.9	19.7
Carapace (side)	12	2	10	10	4	6	92	17	67	22	0	100	13	20	4	379	22.3	17.6
Leg injury	1	0	28	15	3	3	12	2	33	5	1	18	3	2	16	141	8.3	6.5
Leg-Autotomy	2	0	29	9	9	3	1	0	15	5	3	13	0	17	4	110	6.5	5.1
Left chela	0	0	1	1	0	0	0	1	1	0	0	0	0	0	0	4	0.2	0.2
Right chela	0	0	0	3	0	0	0	1	0	0	0	0	0	0	0	4	0.2	0.2
Chela-Autotomy	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	9	0.5	0.4
Abdomen	0	0	0	9	0	0	5	0	5	3	2	5	0	0	0	29	1.7	1.3
Sternum	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0.1	>0.1
Coxa	3	0	0	9	0	0	5	0	8	0	0	54	0	0	0	79	4.6	3.7
Total Minor Injuries	41	7	113	196	50	41	290	58	250	157	13	315	32	80	52	1695		79.2
MAJOR INJURIES																		
Carapace (middle)	2	2	7	18	8	4	27	0	5	5	0	7	0	5	1	91	20.0	4.2
Carapace (side)	0	0	4	2	3	4	10	6	3	0	0	8	0	7	0	47	10.4	2.2
Leg injury	20	2	22	39	20	5	23	15	49	13	2	39	3	32	3	287	63.2	13.3
Left chela	1	1	0	0	1	0	1	1	0	0	0	0	0	0	0	5	1.1	0.2
Right chela	0	1	0	0	0	1	0	2	1	0	0	0	0	0	0	5	1.1	0.2
Abdomen	2	0	0	2	0	0	1	0	0	0	0	1	0	0	0	6	1.3	0.3
Sternum	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0.2	>0.1
Coxa	0	0	0	3	1	0	0	0	0	0	1	7	0	0	0	12	2.7	0.6
Total Major Injuries	25	6	33	64	33	14	62	24	59	18	3	62	3	44	4	454		21.2

Table 9. Linear relationship between maximum aerial exposure time and CPUE (crabs per pot) of retained and non-retained crabs combined in pots sampled on 16 catcher-only vessels and one catcher-processor during the 1998/99 Aleutian Islands golden king crab fishery.

Vessel	Pots Sampled	Mean Crabs per Pot		Maximum Exposure (minutes)		r^2 Value	t	p value
		Retained	Non-retained	Mean	(Median)			
A	112	15.1	19.3	3.4	(2.2)	0.346	7.6	<0.001
B[a]	89	8.9	20.8	1.0	(0.9)	0.495	9.2	<0.001
C	60	5.6	96.3	8.5	(2.2)	0.003	-0.4	0.664
D	106	6.9	17.8	2.0	(1.6)	0.380	8.0	<0.001
E	49	10.6	38.0	2.3	(2.1)	0.059	1.7	0.092
F	104	6.9	29.1	2.0	(2.0)	0.338	7.2	<0.001
G[a]	84	3.4	26.8	2.4	(1.3)	0.448	8.2	<0.001
H	87	11.5	57.9	2.4	(1.9)	0.277	5.7	<0.001
I	211	8.2	15.4	2.1	(1.5)	0.087	4.5	<0.001
J	138	11.3	41.4	2.1	(1.8)	0.271	7.1	<0.001
K[a]	51	3.5	21.4	0.9	(0.7)	0.547	7.7	<0.001
L	115	12.1	33.3	3.0	(2.5)	0.143	4.3	<0.001
M	27	2.6	8.8	1.4	(1.1)	0.381	3.9	<0.001
N[a]	107	17.5	113.2	2.1	(1.9)	0.734	17.0	<0.001
O	112	11.1	21.9	1.7	(1.2)	0.115	3.8	<0.001
P[a]	28	11.6	5.7	1.6	(1.5)	0.468	4.8	<0.001
Q	33	15.8	103.4	3.3	(3.0)	0.279	3.5	0.002
Totals	1,514	9.9	37.1	2.4	(1.7)	0.032	7.0	<0.001

[a] Vessels where r^2 values are $\geq$0.5 and showed a significant linear relationship between maximum exposure time and total crabs per pot.

Table 10. Observed body injuries of non-retained crabs in pot samples taken on eight catcher-only vessels during the 1999 Pribilof Islands hair crab fishery.

		Crabs Sampled		Crabs With Injuries				
Vessel	Pots Sampled	Total	Number per Pot	Total	Number per Pot	Percent of Sample	Number with >1 injury	Percent sampled crab with >1 injury
A	38	67	1.8	2	<0.1	2.9	0	0
B	15	17	1.1	1	<0.1	5.9	1	5.9
C	26	34	1.3	4	0.2	11.8	1	2.9
D	16	4	0.3	0	<0.1	0	0	0
E	43	3	<0.1	0	0	0	0	0
F	28	27	0.9	1	<0.1	3.7	0	0
G	28	39	1.4	0	0	0	0	0
H	16	18	1.1	0	0	0	0	0
Totals	210	209	0.9	8	<0.1	3.8	2	0.9

Table 11. Major and minor body injuries of non-retained crabs examined in pots sampled on eight catcher-only vessels during the 1999 Pribilof Islands hair crab fishery.

VESSEL	A	B	C	D	E	F	G	H			
%Crabs sampled per pot	100	100	100	100	100	100	100	100	Total Injury By Type	Percent Minor Injury	Percent Total Injuries
# Pots Observed	38	15	26	16	43	28	28	16			
MINOR INJURIES											
Rostrum	0	0	1	0	1	1	0	0	3	30	23.1
Carapace (middle)	0	0	1	0	0	1	0	0	2	20	15.4
Carapace (side)	0	0	0	0	0	0	0	0	0	0	0
Leg injury	0	2	0	0	0	1	0	0	3	30	23.1
Leg-Autotomy	0	0	0	0	0	0	0	0	0	0	0
Left chela	1	0	1	0	0	0	0	0	2	20	15.4
Right chela	0	0	0	0	0	0	0	0	0	0	0
Chela-Autotomy	0	0	0	0	0	0	0	0	0	0	0
Abdomen	0	0	0	0	0	0	0	0	0	0	0
Sternum	0	0	0	0	0	0	0	0	0	0	0
Coxa	0	0	0	0	0	0	0	0	0	0	0
Total Minor Injuries	1	2	3	0	1	3	0	0	10		77
MAJOR INJURIES											
Carapace (middle)	0	0	2	0	0	0	0	0	2	66.7	15.4
Carapace (side)	0	0	0	0	0	0	0	0	0	0	0
Leg injury	0	0	0	0	0	0	0	0	0	0	0
Left chela	1	0	0	0	0	0	0	0	1	33.3	7.6
Right chela	0	0	0	0	0	0	0	0	0	0	0
Abdomen	0	0	0	0	0	0	0	0	0	0	0
Sternum	0	0	0	0	0	0	0	0	0	0	0
Coxa	0	0	0	0	0	0	0	0	0	0	0
Total Major Injuries	1	0	2	0	0	0	0	0	3		23

Table 12. Linear relationship between maximum aerial exposure time and CPUE (crabs per pot) of retained and non-retained crabs combined in pots sampled on eight catcher-only vessels during the 1999 Pribilof Islands hair crab fishery.

Vessel	Pots Sampled	Mean Crabs per Pot		Maximum Exposure (minutes)				
		Retained	Non-retained	Mean	(Median)	r^2 Value	t	p value
A	40	2.9	0.2	0.5	(0.3)	0.016	-0.8	0.439
B	24	1.4	0.3	0.6	(0.5)	0.398	3.8	0.001
C[a]	27	2.1	0.4	1.1	(1.0)	0.480	4.8	<0.001
D	24	1.8	2.4	1.0	(1.0)	0.121	1.7	0.095
E	34	2.1	1.3	2.5	(0.9)	0.056	-1.4	0.176
F	27	1.4	1.9	0.4	(0.4)	0.029	0.9	0.399
G	28	1.1	0.4	0.7	(0.5)	0.193	-2.5	0.019
H	18	2.6	0.3	0.6	(0.6)	0.024	0.6	0.542
TOTAL	222	2.0	0.9	1.0	(0.5)	0.001	-0.4	0.695

[a] Vessels where r^2 values are ≥ 0.5 and showed a significant linear relationship between maximum exposure time and total crabs per pot.

Table 13. Observed body injuries of non-retained crabs in pot samples taken on nine catcher-processors during the 1999 Bristol Bay red king crab open access season.

		Crabs Sampled		Crabs with Injuries				
Vessel	Pots Sampled	Total	Number per Pot	Total	Number per pot	Percent of Sample	Number with >1 injury	Percent sampled crab with >1 injury
A	10	42	4.2	4	0.4	9.5	0	0
B	11	102	9.3	31	2.8	30.4	9	8.8
C	7	103	14.7	11	1.6	10.7	0	0
D	10	142	14.2	65	6.5	45.8	8	5.6
E	11	64	5.8	24	2.2	37.5	7	10.9
F	11	89	8.1	10	0.9	11.2	2	2.2
G	10	57	5.7	24	2.4	42.1	1	1.8
H	24	131	5.5	4	0.2	3.1	0	0
I	15	112	7.5	11	0.7	9.8	1	0.9
Total	109	842	7.7	184	1.7	21.9	28	3.3

Table 14. Major and minor body injuries of non-retained crabs examined in pots sampled on nine catcher-processors during the 1999 Bristol Bay red king crab open access season.

VESSEL	A	B	C	D	E	F	G	H	I			
% Crabs sampled per pot	100	100	100	100	100	100	100	100	100	Total Injury By Type	Percent Minor Injuries	Percent Total Injuries
# Pots Observed	10	11	7	10	11	11	10	24	15			
MINOR INJURIES												
Rostrum	3	26	6	55	20	4	13	0	6	133	70.2	59.6
Carapace (middle)	0	5	0	4	8	3	4	0	0	24	12.6	10.8
Carapace (side)	0	3	0	0	8	0	2	0	0	13	6.8	5.8
Leg injury	0	4	1	3	1	0	1	0	0	10	5.3	4.5
Leg-Autotomy	0	0	2	1	0	0	1	0	1	5	2.6	2.2
Left chela	0	0	0	0	0	0	0	0	1	1	0.5	0.45
Right chela	0	0	0	0	0	0	0	0	1	1	0.5	0.45
Chela-Autotomy	0	1	0	0	0	0	0	0	0	1	0.5	0.45
Abdomen	0	0	0	0	0	0	1	0	0	1	0.5	0.45
Sternum	0	0	0	1	0	0	0	0	0	1	0.5	0.45
Coxa	0	0	0	0	0	0	0	0	0	0	0	0
Total Minor Injuries	3	39	9	64	37	7	22	0	9	190		85.2
MAJOR INJURIES												
Carapace (middle)	0	1	1	1	0	0	1	0	0	4	12.1	1.8
Carapace (side)	0	0	0	0	0	0	1	0	0	1	3	0.4
Leg injury	1	0	1	11	1	5	2	3	2	26	78.8	11.7
Left chela	0	0	0	0	0	0	0	0	0	0	0	0
Right chela	0	0	0	0	0	0	0	1	1	2	6.1	0.9
Abdomen	0	0	0	0	0	0	0	0	0	0	0	0
Sternum	0	0	0	0	0	0	0	0	0	0	0	0
Coxa	0	0	0	0	0	0	0	0	0	0	0	0
Total Major Injuries	1	1	2	12	1	5	4	4	3	33		14.8

Table 15. Linear relationship between maximum aerial exposure time and CPUE (crabs per pot) of retained and non-retained crabs combined in pots sampled on nine catcher-processors during the 1999 Bristol Bay red king crab open access season.

Vessel	Pots Sampled	Mean Crabs per Pot		Maximum Exposure (minutes)				
		Retained	Non-retained	Mean	(Median)	r^2 Value	t	p value
A	15	9.0	4.3	2.9	(2.1)	0.078	1.1	0.312
B[a]	15	16.0	11.3	2.7	(2.8)	0.777	6.7	<0.001
C	15	10.1	5.3	1.4	(1.5)	0.145	1.5	0.162
D[a]	17	53.3	8.5	2.3	(1.7)	0.613	4.9	<0.001
E[a]	15	8.3	4.1	1.7	(1.4)	0.719	5.8	<0.001
F[a]	11	25.2	14.8	2.9	(3.1)	0.938	11.7	<0.001
G[a]	15	12.0	6.0	1.3	(1.3)	0.796	7.1	<0.001
H	15	7.6	6.1	2.0	(1.7)	0.364	2.7	0.017
I[a]	30	10.3	10.9	2.6	(2.3)	0.747	9.1	<0.001
Total	148	16.5	8.0	2.2	(1.9)	0.341	8.7	<0.001

[a] Vessels where r^2 values are ≥ 0.5 and showed a significant linear relationship between maximum exposure time and total crabs per pot.

Table 16. Observed body injuries of non-retained crabs in pot samples taken on eight catcher-only vessels during the 1999 Bristol Bay red king crab CDQ season.

		Crabs Sampled		Crabs With Injuries				
Vessel	Pots Sampled	Total	Number per Pot	Total	Number per Pot	Percent of Sample	Number with >1 injury	Percent sampled crab with >1 injury
A	4	25	6.3	5	1.3	20.0	0	0
B	4	18	4.5	11	2.8	61.1	5	27.8
C	6	56	9.3	4	0.7	7.1	0	0
D	2	13	6.5	3	1.5	23.0	1	7.7
E	18	69	3.8	24	1.3	34.8	4	5.8
F	2	17	8.5	2	1.0	11.8	0	0
G	4	100	25.0	30	7.5	30.0	3	3.0
H	8	82	10.3	38	4.8	46.3	19	23.1
Total	48	380	7.9	117	2.4	30.8	32	8.4

Table 17. Major and minor body injuries of non-retained crabs examined in pots sampled on eight catcher-only vessels during the 1999 Bristol Bay red king crab CDQ season.

VESSEL	A	B	C	D	E	F	G	H			
% Crabs sampled per pot	100	100	100	100	100	100	100	100	Total Injury By Type	Percent Minor Injuries	Percent Total Injuries
# Pots Observed	4	4	6	2	18	2	4	8			
MINOR INJURIES											
Rostrum	3	5	2	0	14	0	24	47	95	67.0	59.8
Carapace (middle)	0	0	0	0	6	0	0	10	16	11.3	10.1
Carapace (side)	0	7	0	0	4	0	0	6	17	11.9	10.7
Leg injury	0	3	1	0	0	0	6	0	10	7	6.2
Leg-Autotomy	1	0	0	2	0	0	0	0	3	2.1	1.9
Left chela	0	0	0	0	0	0	0	0	0	0	0
Right chela	0	0	0	0	0	1	0	0	1	0.7	0.6
Chela-Autotomy	0	0	0	0	0	0	0	0	0	0	0
Abdomen	0	0	0	0	0	0	0	0	0	0	0
Sternum	0	0	0	0	0	0	0	0	0	0	0
Coxa	0	0	0	0	0	0	0	0	0	0	0
Total Minor Injuries	4	15	3	2	24	1	30	63	142		89.3
MAJOR INJURIES											
Carapace (middle)	0	0	0	0	0	0	0	1	1	5.9	0.6
Carapace (side)	0	0	0	0	0	0	0	0	0	0	0
Leg injury	1	2	1	2	4	0	4	1	15	88.2	9.5
Left chela	0	0	0	0	0	0	0	0	0	0	0
Right chela	0	0	0	0	0	1	0	0	1	5.9	0.6
Abdomen	0	0	0	0	0	0	0	0	0	0	0
Sternum	0	0	0	0	0	0	0	0	0	0	0
Coxa	0	0	0	0	0	0	0	0	0	0	0
Total Major Injuries	1	2	1	2	4	1	4	2	17		10.7

Table 18. Linear relationship between maximum aerial exposure time and CPUE (crabs per pot) of retained and non-retained crabs combined in pots sampled on 10 catcher-only vessels during the 1999 Bristol Bay red king crab CDQ season.

Vessel	Pots Sampled	Mean Crabs per Pot		Maximum Exposure (minutes)		r^2 Value	t	p value
		Retained	Non-retained	Mean	(Median)			
A[a]	7	37.0	1.7	1.9	(1.6)	0.959	10.8	<0.001
B[a]	8	16.1	4.9	1.6	(1.6)	0.523	2.6	0.043
C[a]	10	40.5	12.9	2.7	(2.3)	0.890	8.1	<0.001
D	11	10.9	2.8	1.7	(1.4)	0.392	2.4	0.039
E[a]	14	21.8	2.4	1.4	(1.2)	0.675	5.0	<0.001
F[a]	6	31.3	5.2	2.0	(2.1)	0.828	4.4	0.012
G[a]	8	36.5	19.3	2.9	(2.6)	0.551	2.7	0.035
H[a]	19	42.9	9.6	2.6	(2.4)	0.798	8.2	<0.001
I[a]	4	40.5	6.3	2.9	(3.1)	0.932	5.2	0.034
J	4	32.0	23.0	2.3	(2.5)	0.005	-0.1	0.929
Total	91	30.8	8.0	2.2	(2.0)	0.719	15.1	<0.001

[a] Vessels where r^2 values are ≥ 0.5 and showed a significant linear relationship between maximum exposure time and total crabs per pot.

Table 19. Percentage of major and minor body injuries of crabs examined in pots sampled by fishery and year (1997-1999).

	% Total Injury Bering Sea Open access Snow crab		% Total Injury Bering Sea CDQ Snow crab		% Total Injury Aleutian Islands Open access Golden king crab		% Total Injury St. Matthew Open access Blue king crab		% Total Injury St. Matthew CDQ Blue king crab		% Total Injury Pribilof Hair crab		%Total Injury Bristol Bay Open access Red king crab			% Total Injury Bristol Bay CDQ Red king crab		% Total Injury Pribilof CDQ Red king crab	
	1998	1999	1998	1999	1997/98	1998/999	1998	1999	1998	1999	1998	1999	1997	1998	1999	1998	1999	1998	1999
Total Crab Sampled	14,399	8,388	29,170	3,260	4,697	12,414	354		166		480	209	1,569	5,305	842	837	380	50	
MINOR INJURIES																			
Rostrum	6.1	4.7	5.5	22.5	23.9	24.3	33.4		23.5		2.6	23.1	41.2	48.7	59.6	33.3	59.8	64.4	
Carapace (middle)	0.6	0.3	1.3	1.2	14.4	19.7	7.4	NO	0	NO	23.1	15.4	5.1	5.8	10.8	4.4	10.1	0	NO
Carapace (side)	0.9	1.2	1.4	0.5	12.9	17.6	3.7	Fishery	0	Fishery	5.1	0	6.6	2.1	5.8	0	10.7	14.3	Fishery
Leg injury	12	11.4	9.0	6.6	12.6	6.5	11.1		17.7		23.1	23.1	8.9	8.8	4.5	11.1	6.2	0	
Leg-Autotomy	59	57.2	71.3	34.6	8.6	5.1	11.1		52.9		9.0	0	8.9	13.3	2.2	17.8	1.9	0	
Left chela	4.3	1.7	1.6	0.3	0.3	0.2	3.7		0		2.6	15.4	3.5	0.7	0.45	2.2	0	0	
Right chela	3.9	1.0	2.2	0.9	0.1	0.2	0		0		3.8	0	5.1	1.4	0.45	0	0.6	7.1	
Chela-Autotomy	0.3	1.1	1.2	1.2	2.2	0.4	0		5.9		1.3	0	0	1.3	0.45	8.9	0	0	
Abdomen	0.2	0.5	0	0.2	0.3	1.3	0		0		2.6	0	0.4	0.4	0.45	0	0	0	
Sternum	0.6	0	0.6	0	0.5	>0.1	0		0		0	0	0.4	0.1	0.45	0	0	0	
Coxa	1.1	0	0.5	0	2.2	3.7	7.4		0		1.3	0	3.1	0.8	0	0	0	0	
% Minor Injuries	89.1	79.1	94.8	68.0	78.0	79.0	77.8		100.0		74.4	77	83.3	83.6	85.2	77.8	89.3	85.8	
MAJOR INJURIES																			
Carapace (middle)	0.8	1.8	0.4	0.6	3.7	4.2	0		0		1.3	15.4	2.3	1.7	1.8	2.2	0.6	7.1	
Carapace (side)	1.4	1.0	0.4	0.6	4.2	2.2	0		0		0.0	0	0.4	0.7	0.4	2.2	0	7.1	
Leg injury	3.8	11.1	2.6	22.0	12.1	13.3	11.1		0		15.4	0	10.5	8.6	11.7	13.3	9.5	0	
Left chela	1.1	2.1	0.8	2.6	0	0.2	3.7		0		1.3	7.6	1.6	1.4	0.0	0	0	0	
Right chela	0.9	3.8	0.6	4.6	0.3	0.2	0.0		0		7.7	0	0.8	1.0	0.9	0	0.6	0	
Abdomen	0.3	0.5	<0.1	0.8	1.0	0.3	3.7		0		0	0	0	1.3	0	2.2	0	0	
Sternum	0.6	0	0.2	0.2	0.3	>0.1	0		0		0	0	0	0.6	0	2.2	0	0	
Coxa	2.0	0.6	0.2	0.6	0.4	0.6	3.7		0		0	0	1.2	1.3	0	0	0	0	
% Major Injuries	10.9	20.9	5.2	32.0	22.0	21.0	22.2		0		25.6	23.0	16.7	16.4	14.8	22.2	10.7	14.2	

Table 20. Linear relationship between maximum aerial exposure time and CPUE (crabs per pot) of retained and non-retained crabs combined in pots sampled on all vessels during 19 fisheries from 1997-1999.

FISHERY	YEAR	Pots Sampled	Mean Crabs per Pot		Mean Maximum Exposure (minutes)	r^2 Value
			Retained	Non-retained		
Bering Sea Snow Crab [a]	1998	1,548	205.6	61.2	4.4	0.03
Bering Sea Snow Crab [a]	1999	677	142.5	48.5	3.7	0.02
Bering Sea Snow Crab [b]	1998	1,014	199.9	134.2	6.1	0.03
Bering Sea Snow Crab [b]	1999	406	156.4	89.5	5.1	0.015
Aleutian Is. Golden King Crab	1997/98	790	7.5	22.7	2.0	0.16
Aleutian Is. Golden King Crab	1998/99	1,514	9.9	37.1	2.4	0.032
St Matthew Blue King Crab[a]	1998	49	4.9	12.6	2.9	0.13
St Matthew Blue King Crab[a]	1999		-NO FISHERY-			
St Matthew Blue King Crab[b]	1998	35	11.4	8.8	1.7	0.41
St Matthew Blue King Crab[b]	1999		-NO FISHERY-			
Pribilof Islands Hair Crab	1998	304	2.0	1.8	1.0	<0.01
Pribilof Islands Hair Crab	1999	221	2.0	0.9	1.0	0.001
Bristol Bay Red King Crab[a]	1997	225	14.2	24.0	2.8	0.29
Bristol Bay Red King Crab[a]	1998	362	18.1	74.5	3.0	0.28
Bristol Bay Red King Crab[a]	1999	148	16.5	8.0	2.2	0.34
Bristol Bay Red King Crab[b]	1998	48	24.6	36.6	3.0	0.12
Bristol Bay Red King Crab[b]	1999	91	30.8	8.0	2.2	0.719
Pribilof Is. Red King Crab[b]	1998	13	0.6	3.0	4.0	0.23
Pribilof Is. Red King Crab[b]	1999		-NO FISHERY-			

[a] Open-access season
[b] CDQ season

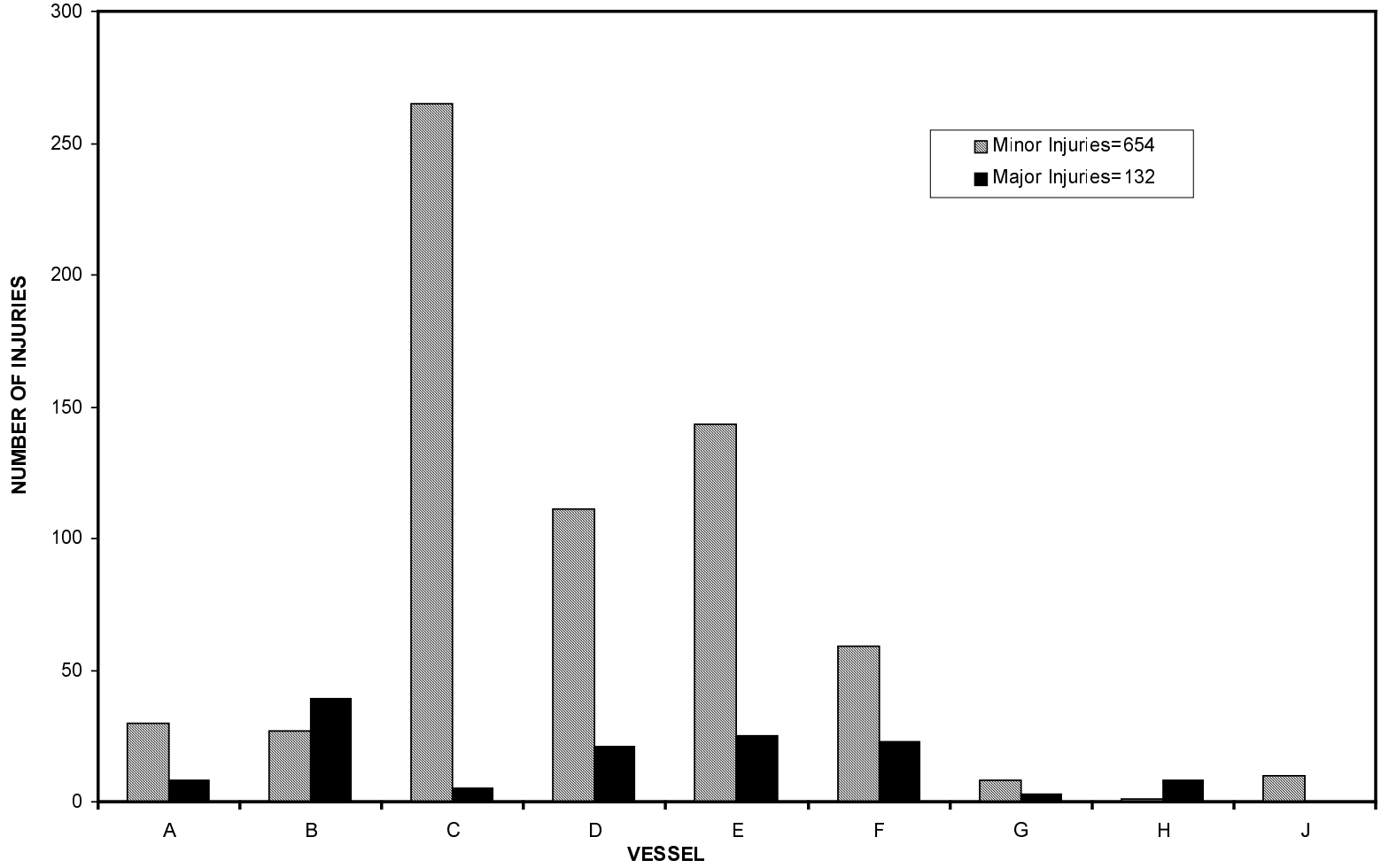

Figure 1. Major and minor body injuries of non-retained crabs examined in pots sampled on nine catcher-only vessels during the 1999 Bering Sea snow crab open access season.

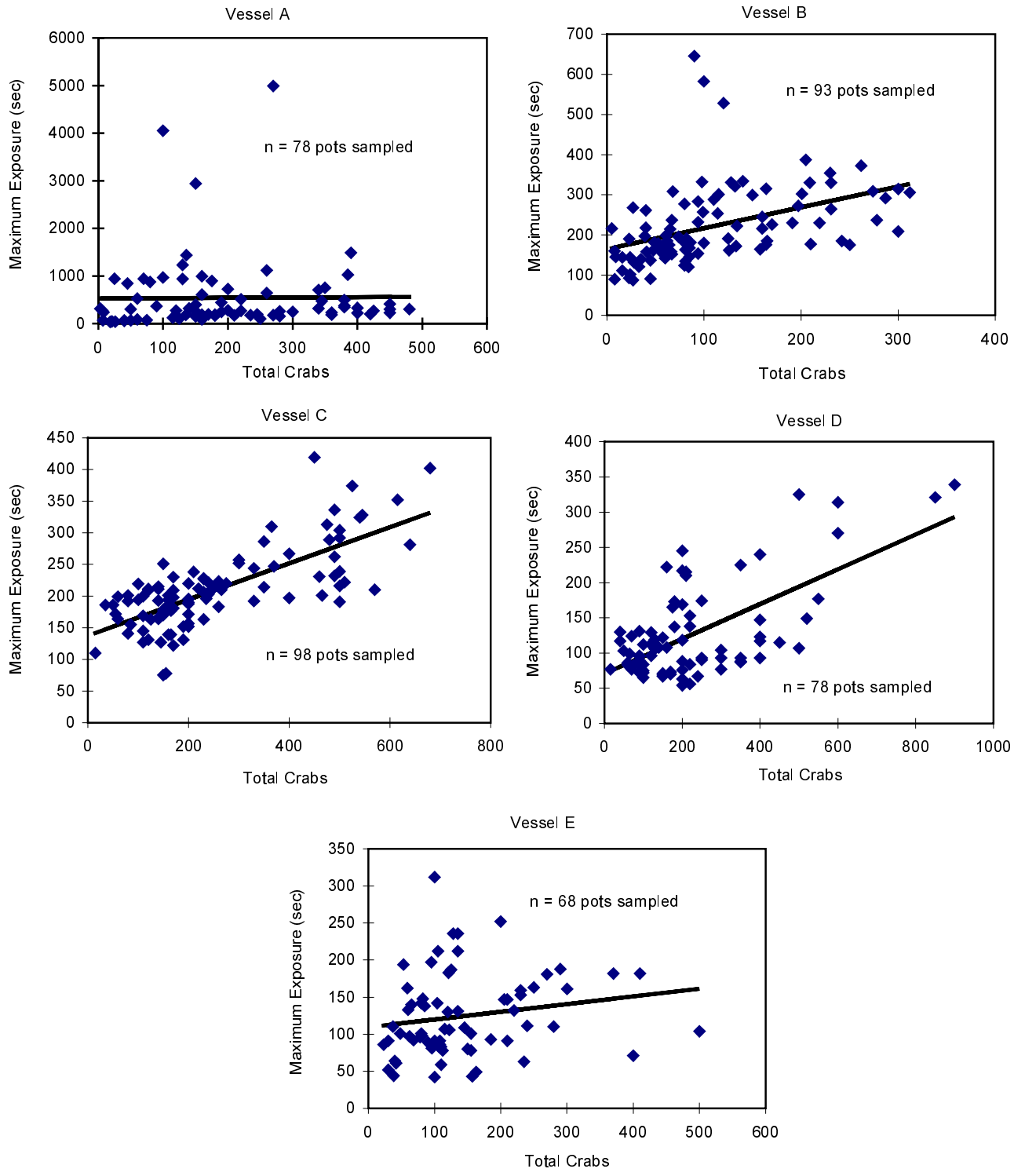

Figure 2. Fitted line plots for maximum aerial exposure times and total crabs per pot from samples taken on 10 catcher-only vessels (A-J) during the 1999 Bering Sea snow crab open access season.

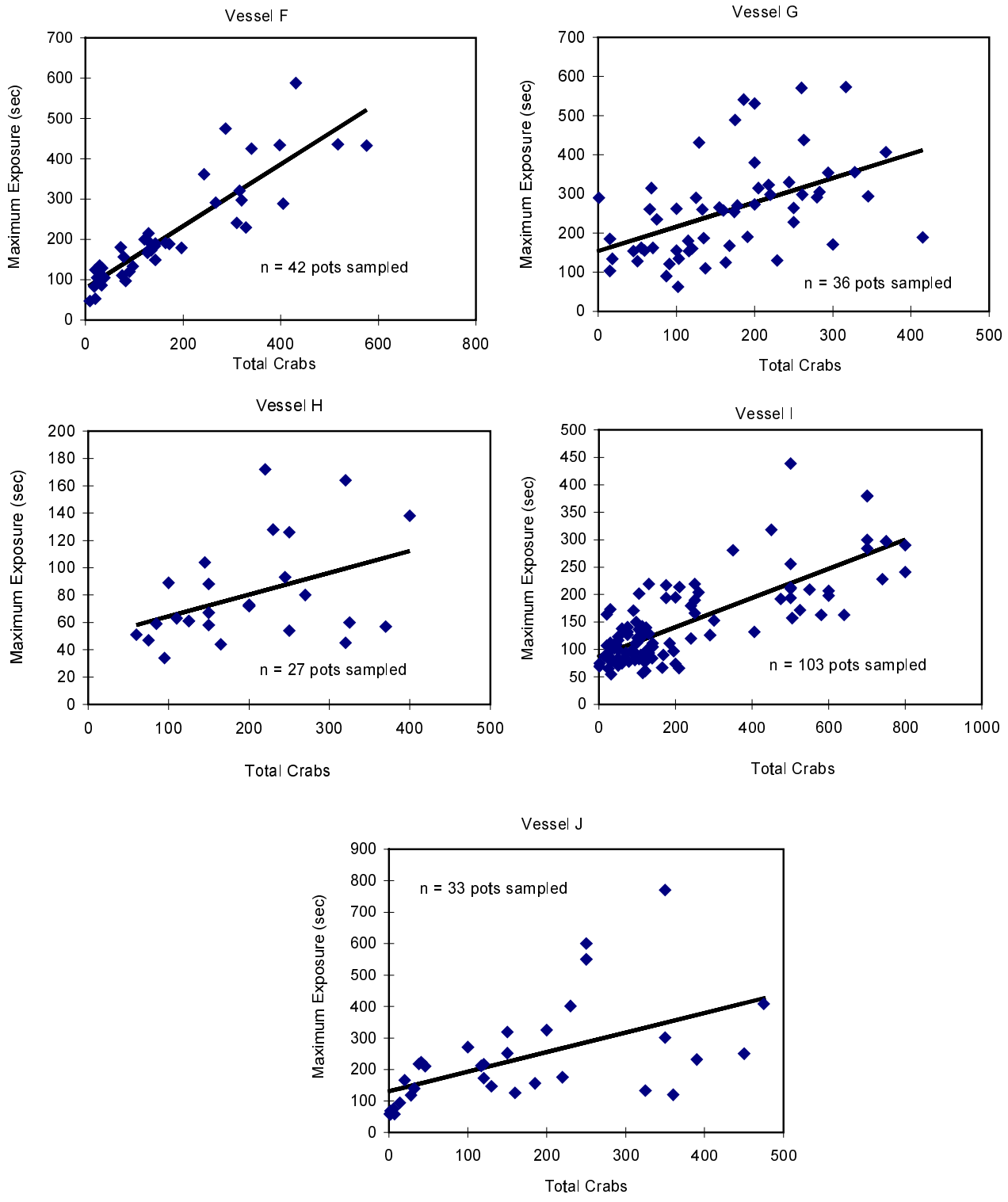

Figure 2. (page 2 of 2)

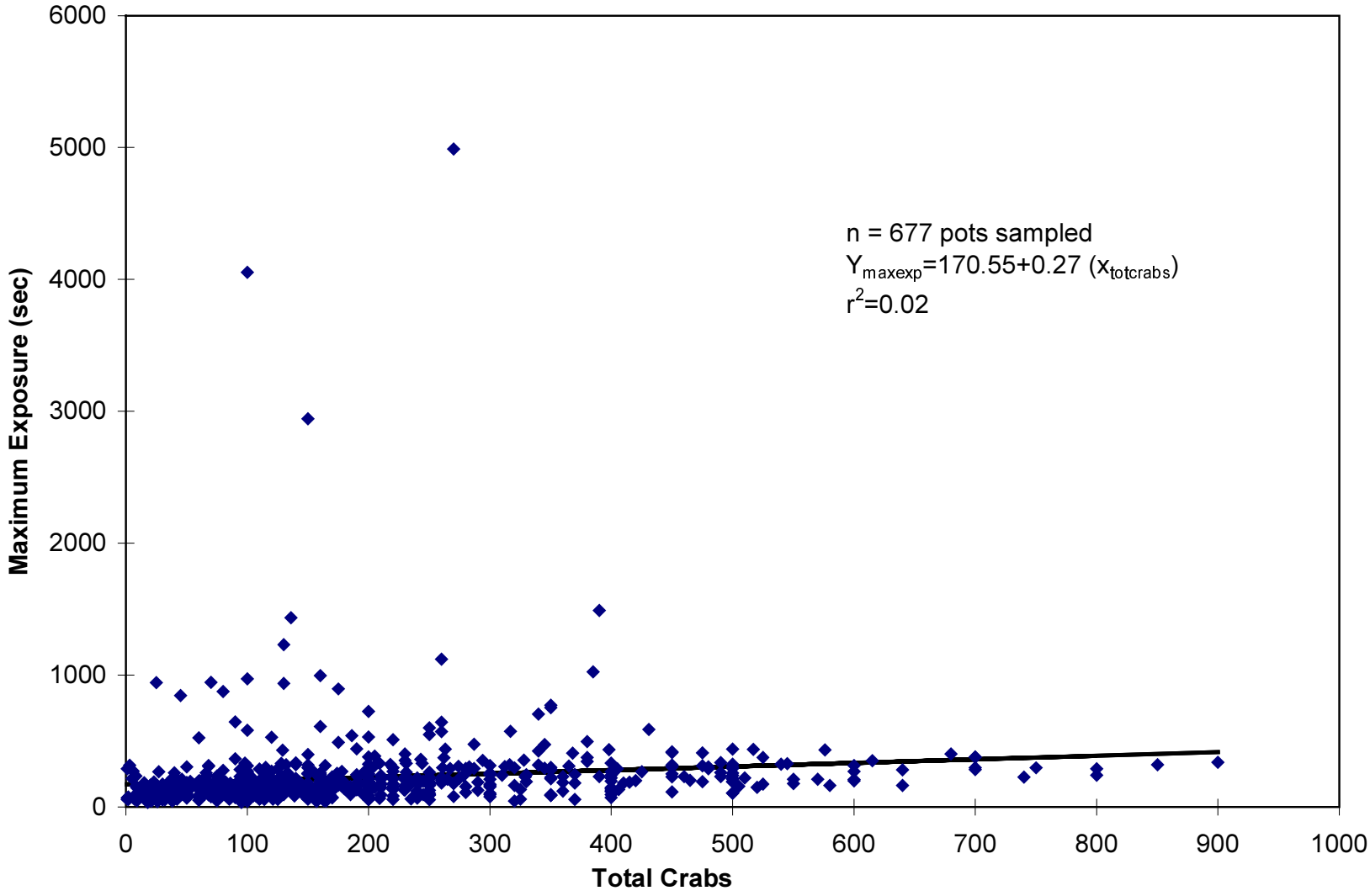

Figure 3. Linear relationship between maximum aerial exposure times and total crabs from combined pot samples taken on 10 catcher-only vessels during the 1999 Bering Sea snow crab open access season.

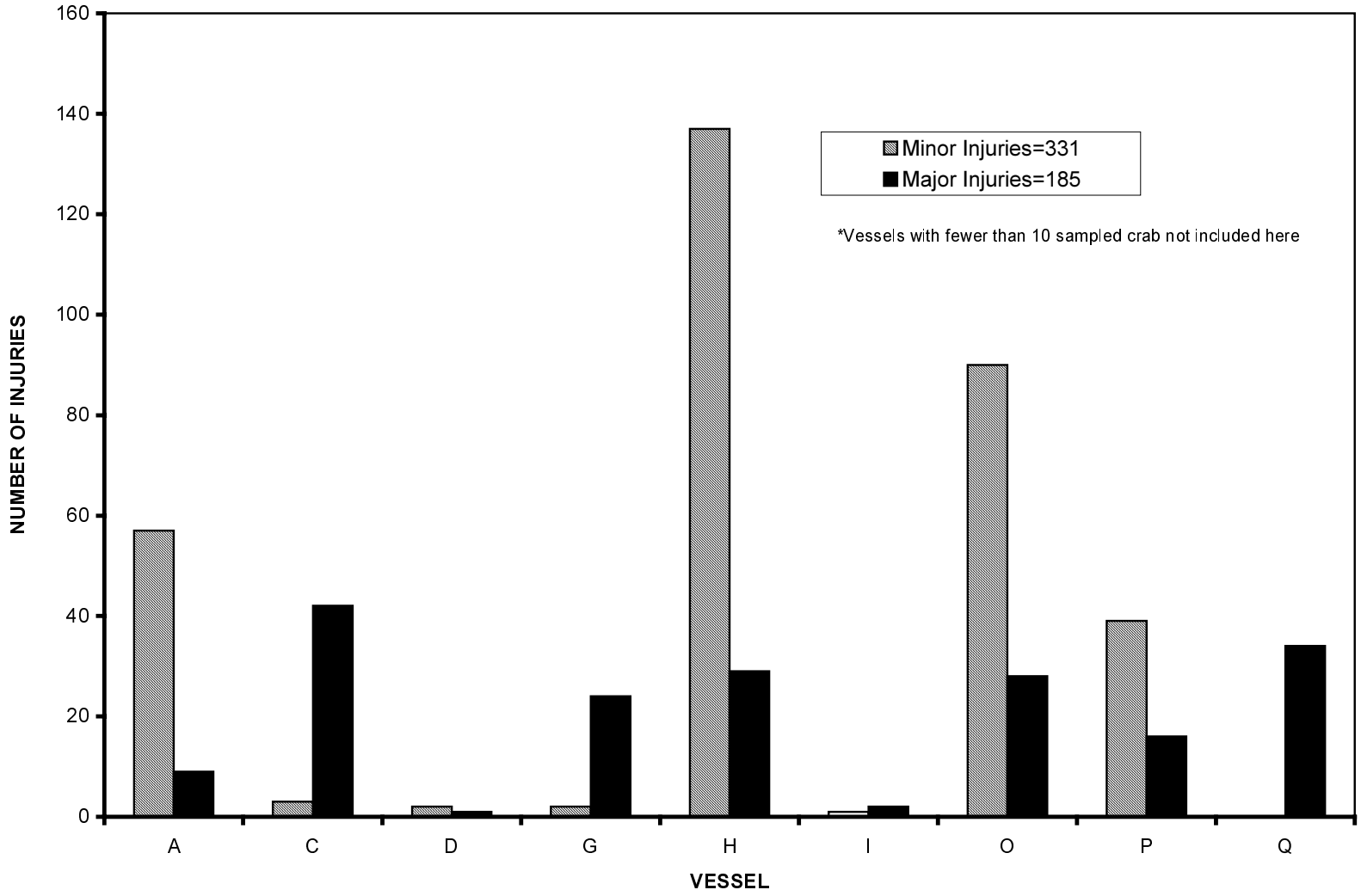

Figure 4. Major and minor body injuries of non-retained crabs examined in pots sampled on nine catcher-only vessels during the 1999 Bering Sea snow crab CDQ season.

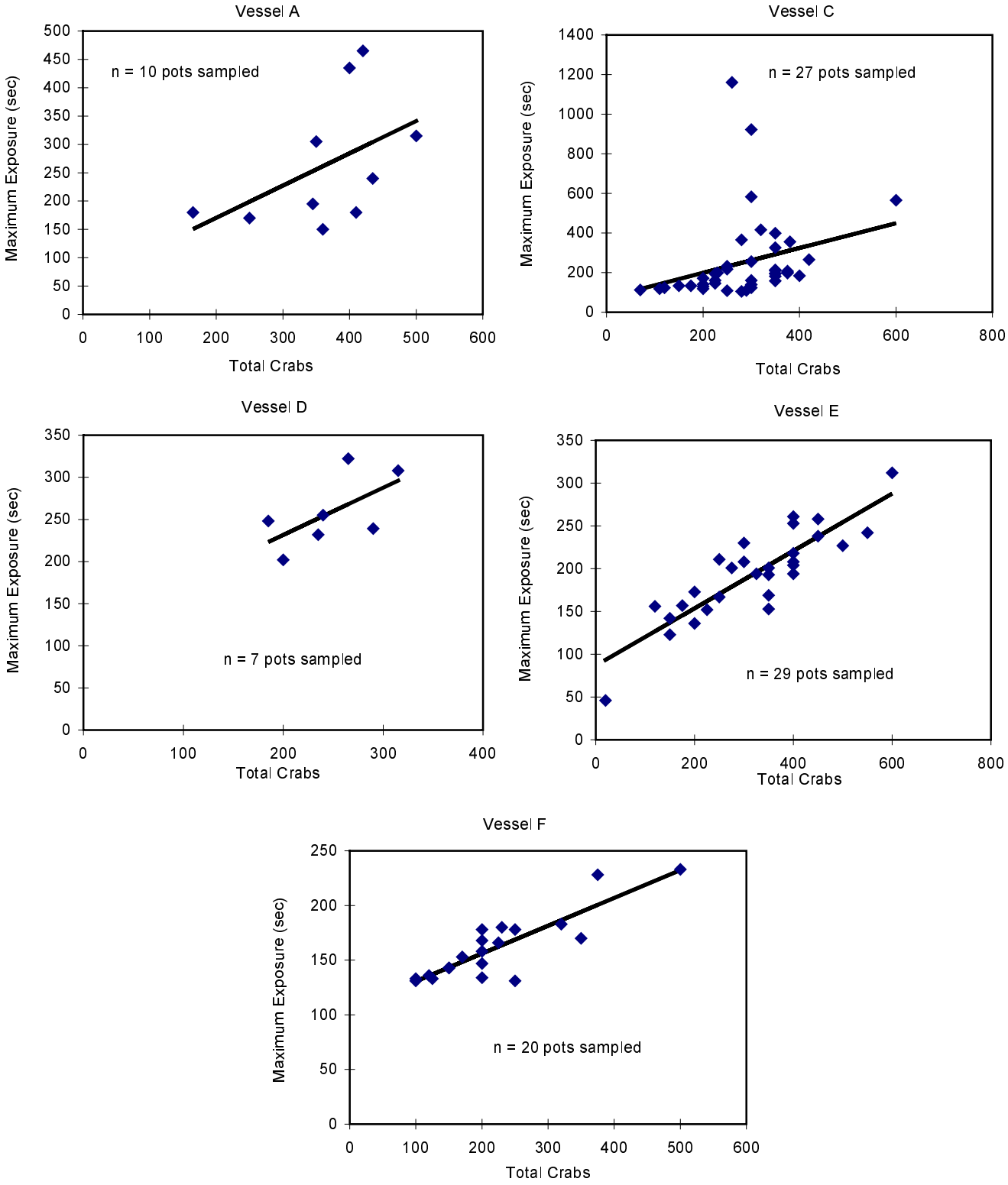

Figure 5. Fitted line plots for maximum aerial exposure times and total crabs per pot from samples taken on 19 catcher-only vessels (A, C-T) vessels during the 1999 Bering Sea snow crab CDQ season.

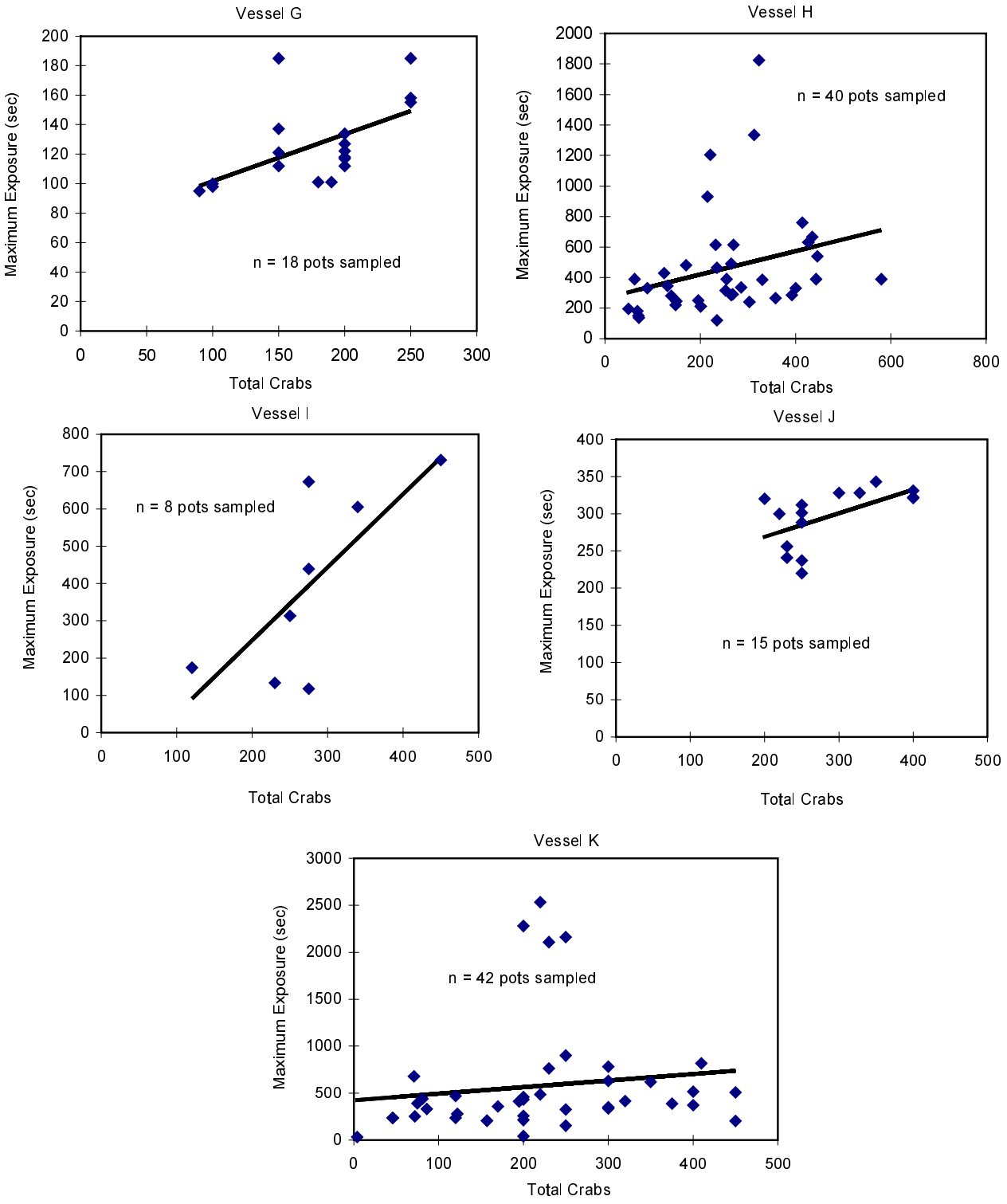

Figure 5. (page 2 of 4)

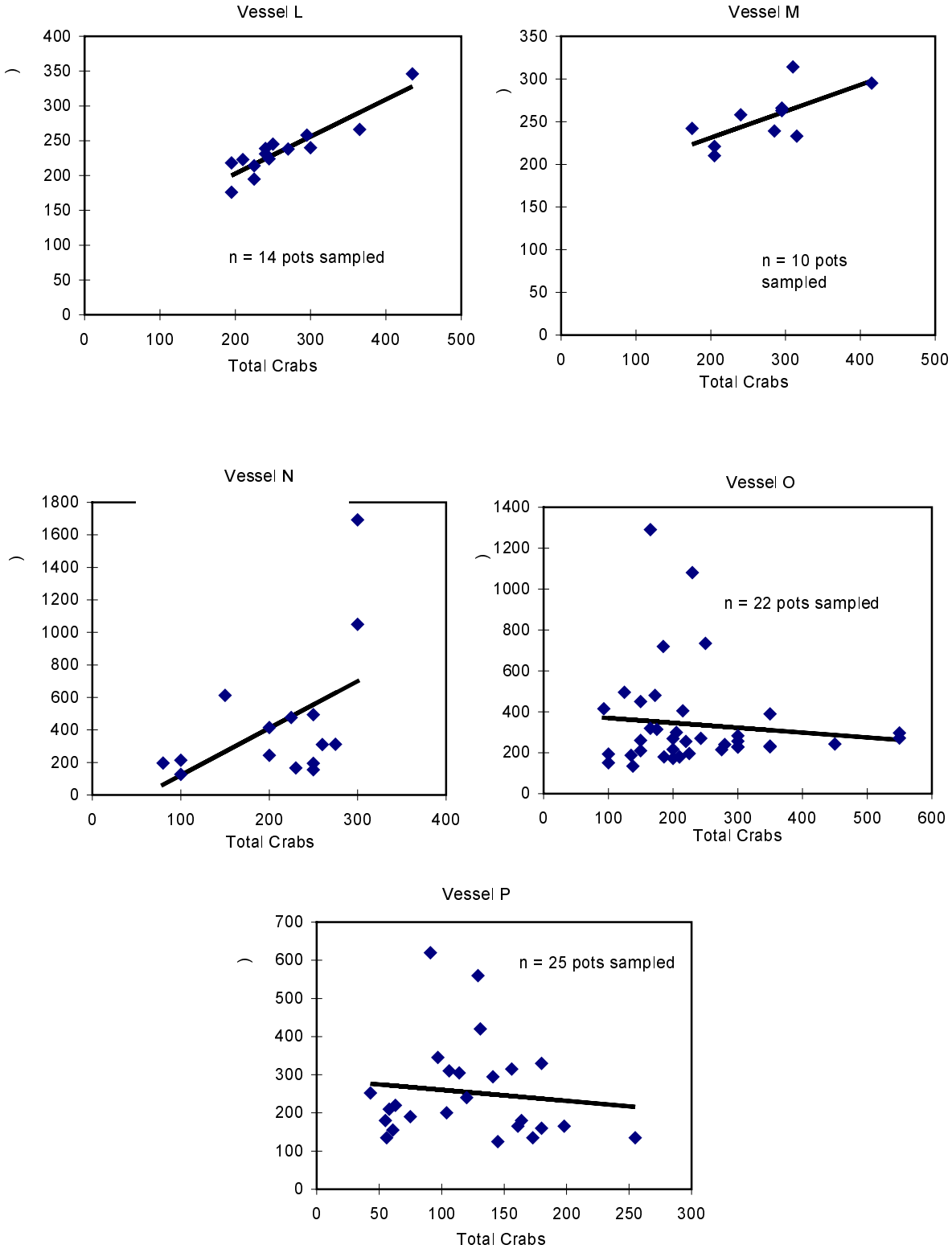

Figure 5. (page 3 of 4)

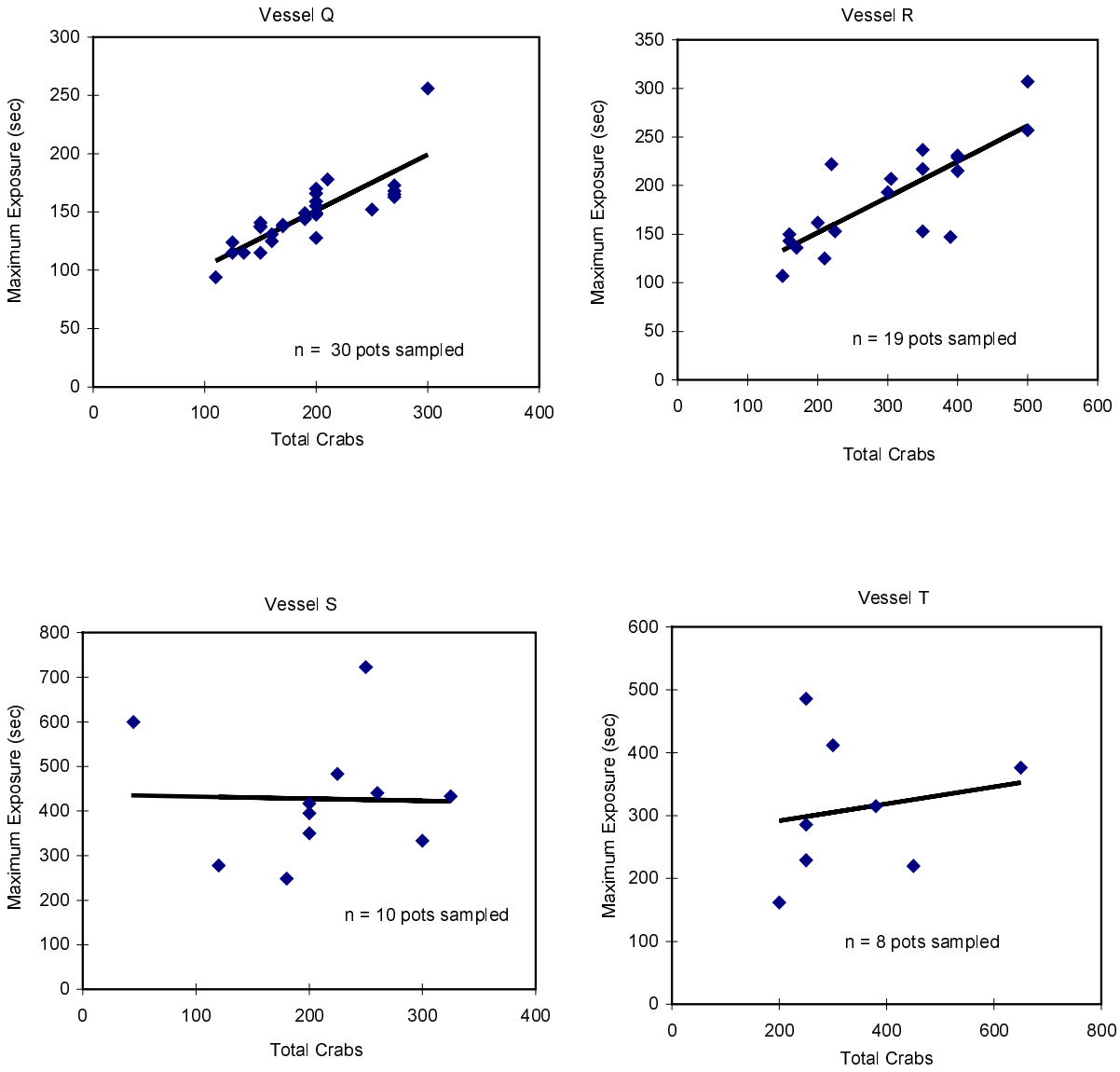

Figure 5. (page 4 of 4)

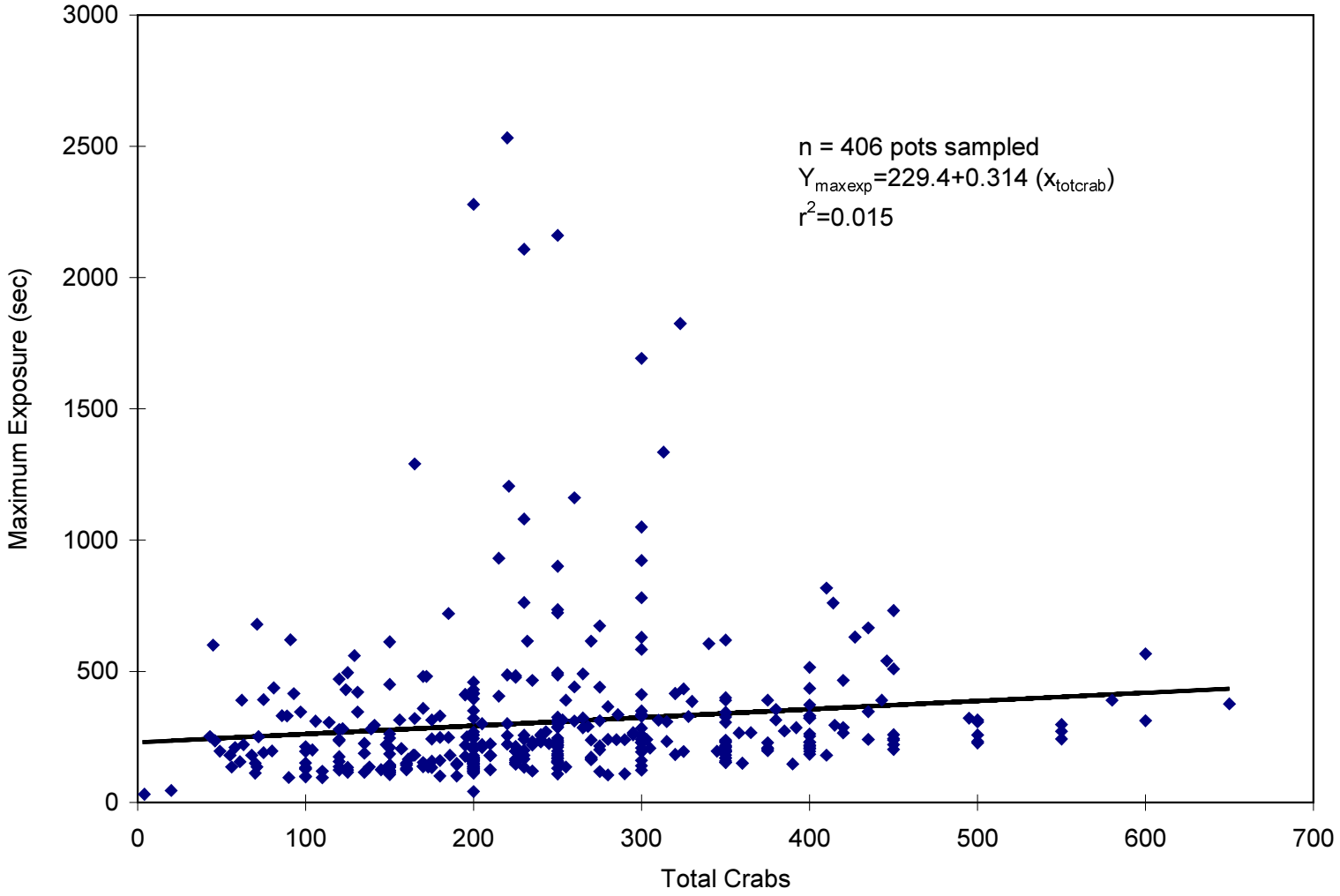

Figure 6. Linear relationship between maximum aerial exposure times and total crabs from combined pot samples taken on 19 catcher-only vessels during the 1999 Bering Sea snow crab CDQ season.

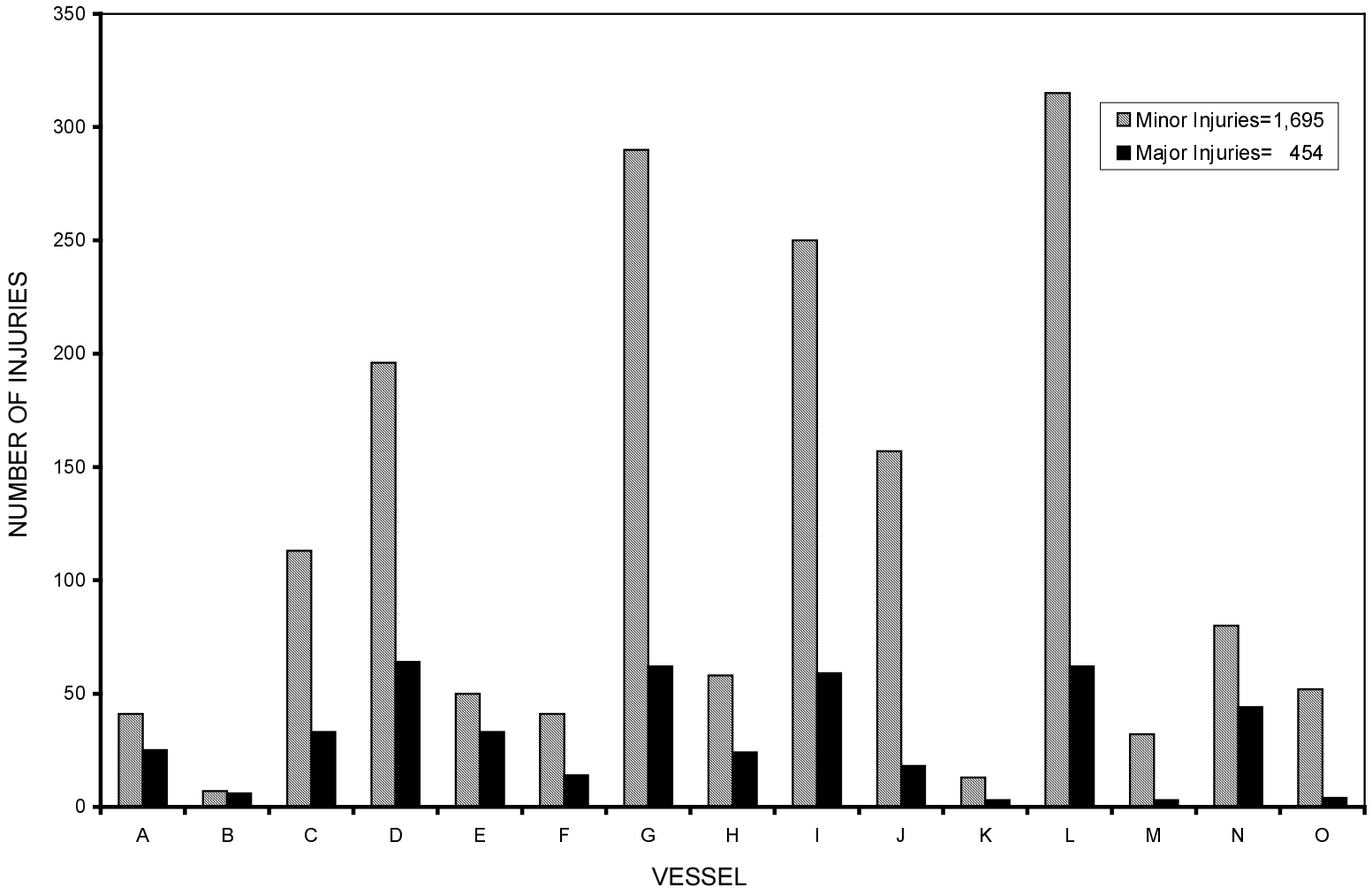

Figure 7. Major and minor body injuries of non-retained crabs examined in pots sampled on 14 catcher-only vessels and one catcher-processor during the 1998/99 Aleutian Islands golden king crab fishery.

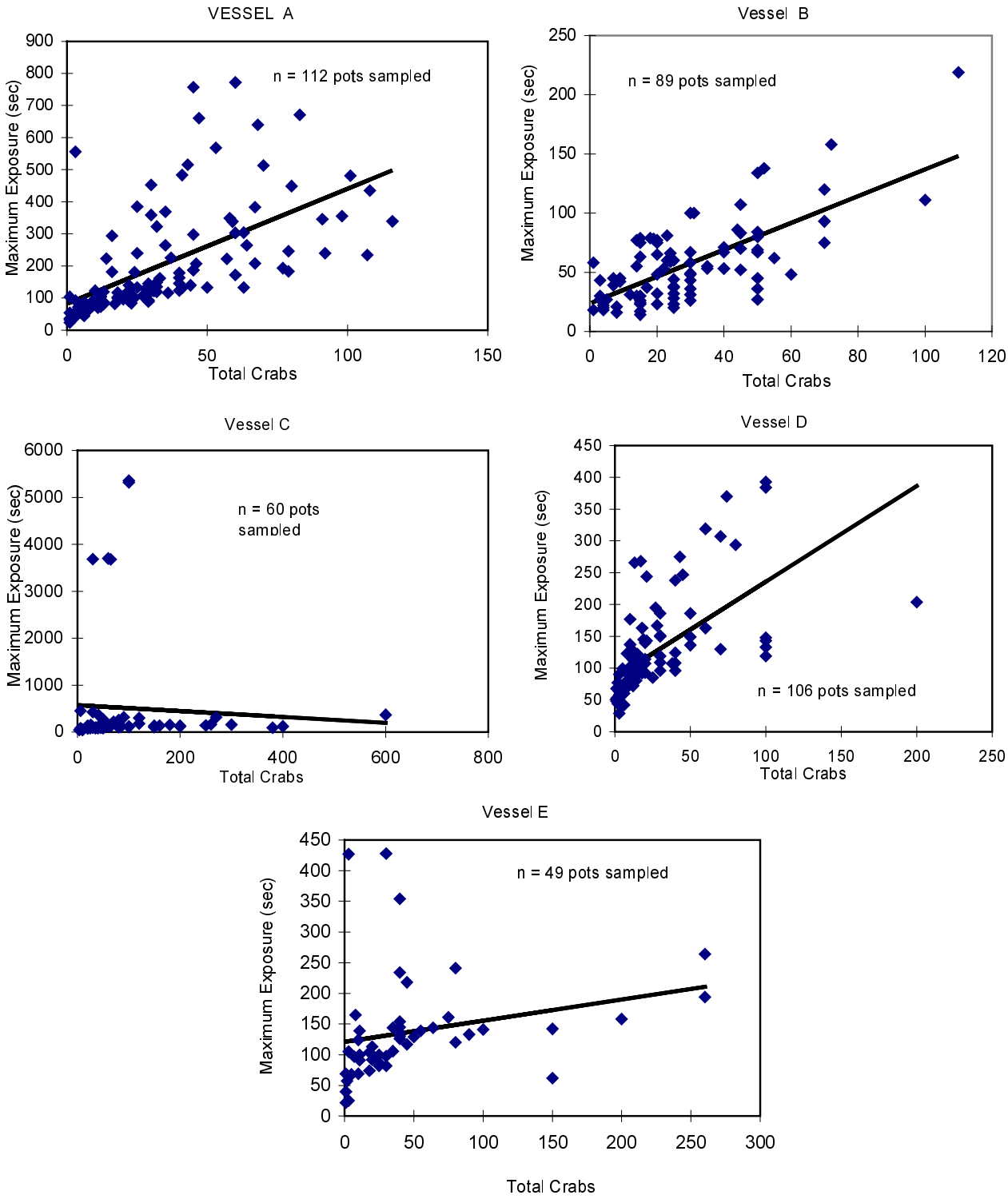

Figure 8. Fitted line plots for maximum aerial exposure times and total crabs per pot from samples taken on 16 catcher-only vessels and one catcher-processor (vessels A-Q) during the 1998/99 Aleutian Islands golden king crab fishery.

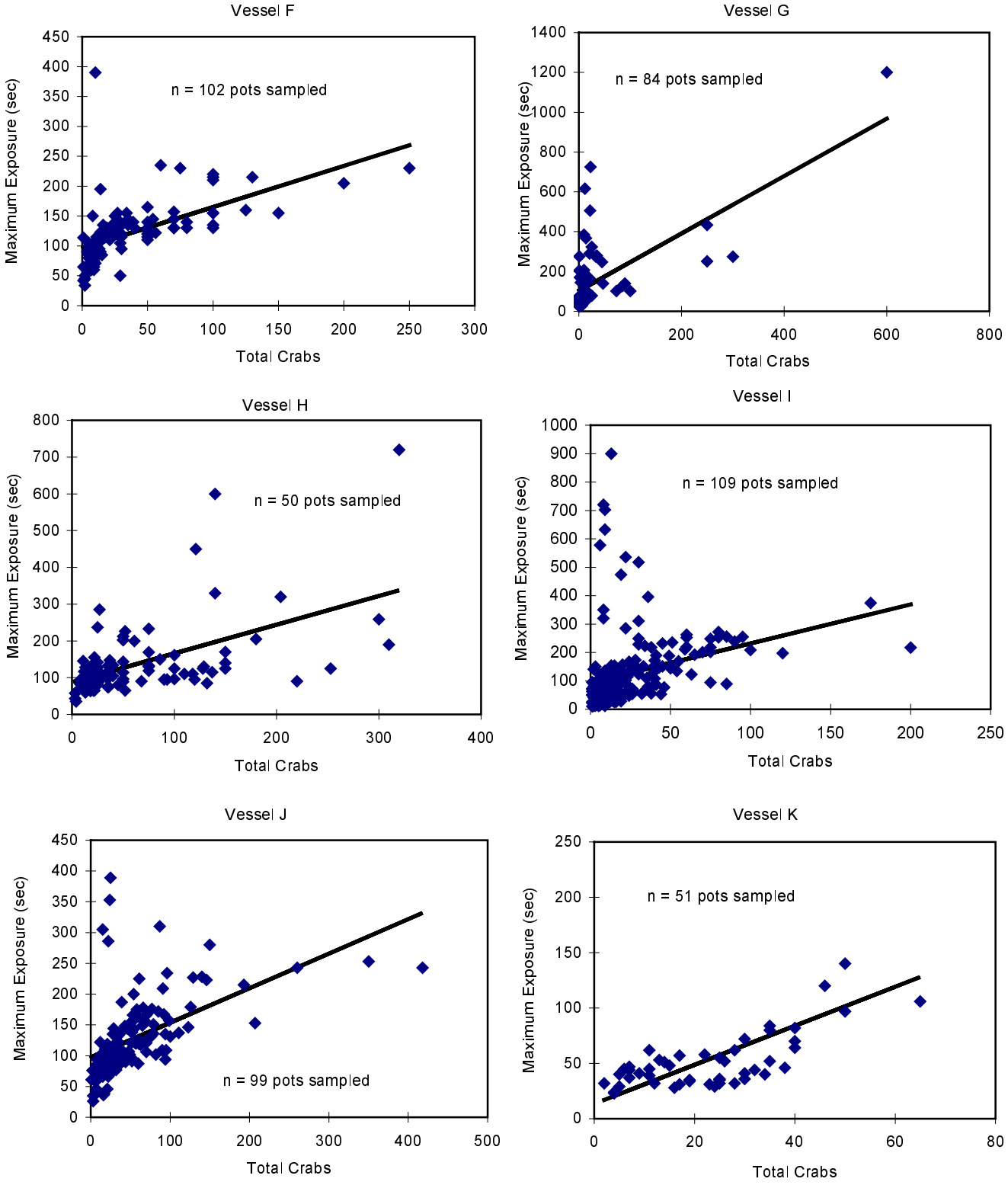

Figure 8. (page 2 of 3)

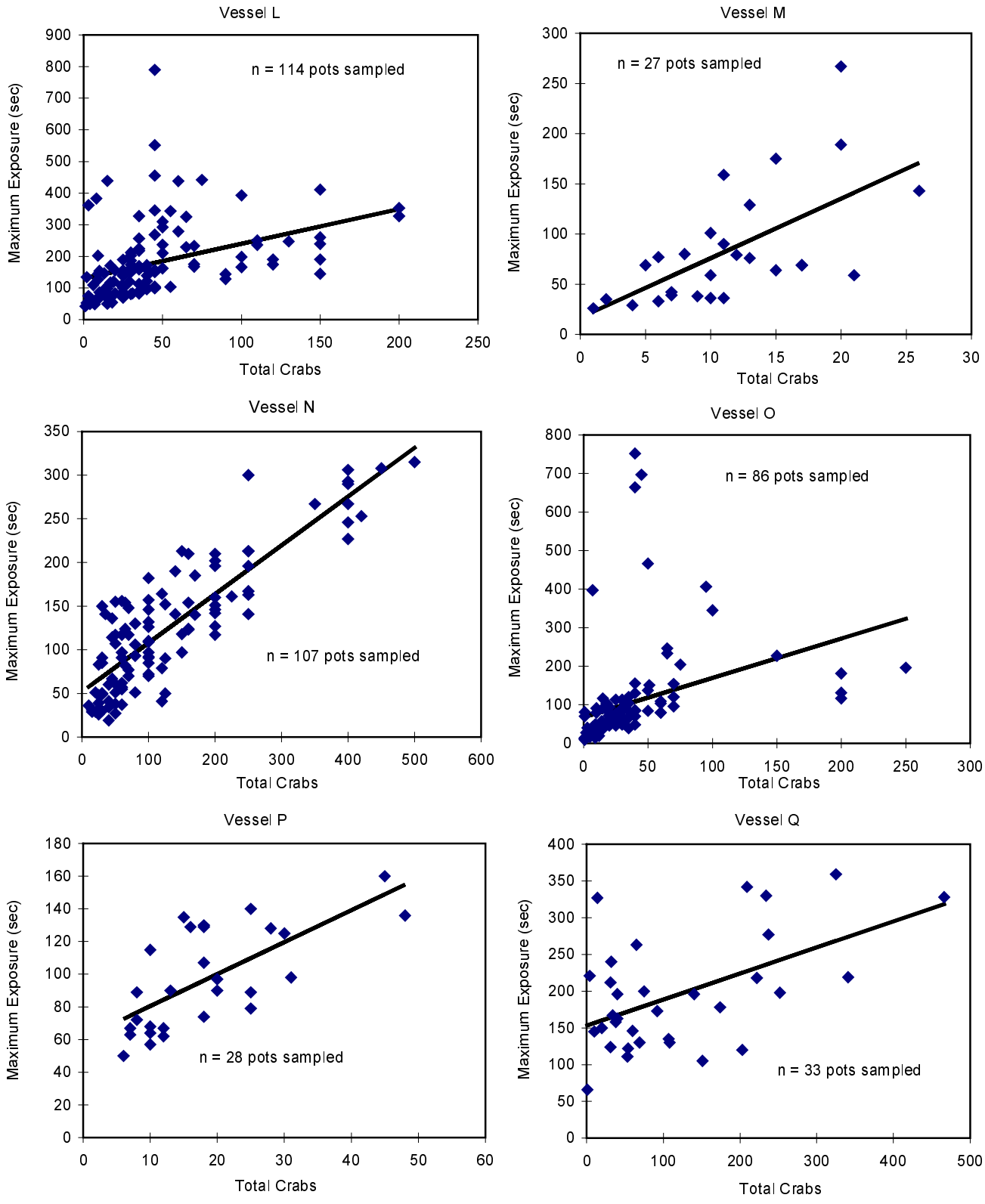

Figure 8. (page 3 of 3)

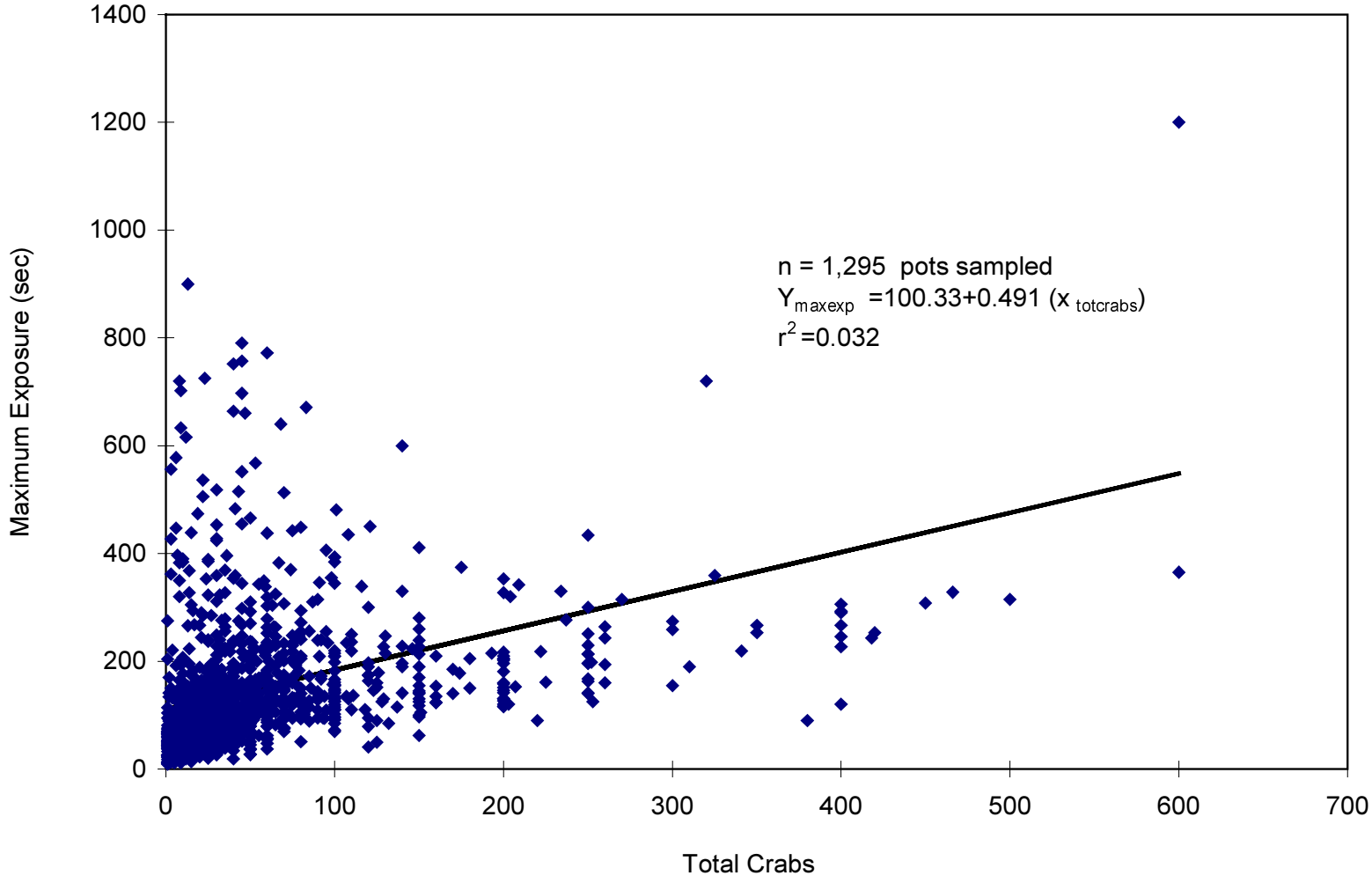

Figure 9. Linear relationship betyween maximum aerial exposure times and total crabs per pot from combined pot samples taken on 16 catcher-only vessels and one catcher-processor during the 1998/99 Aleutian Islands golden king crab fishery.

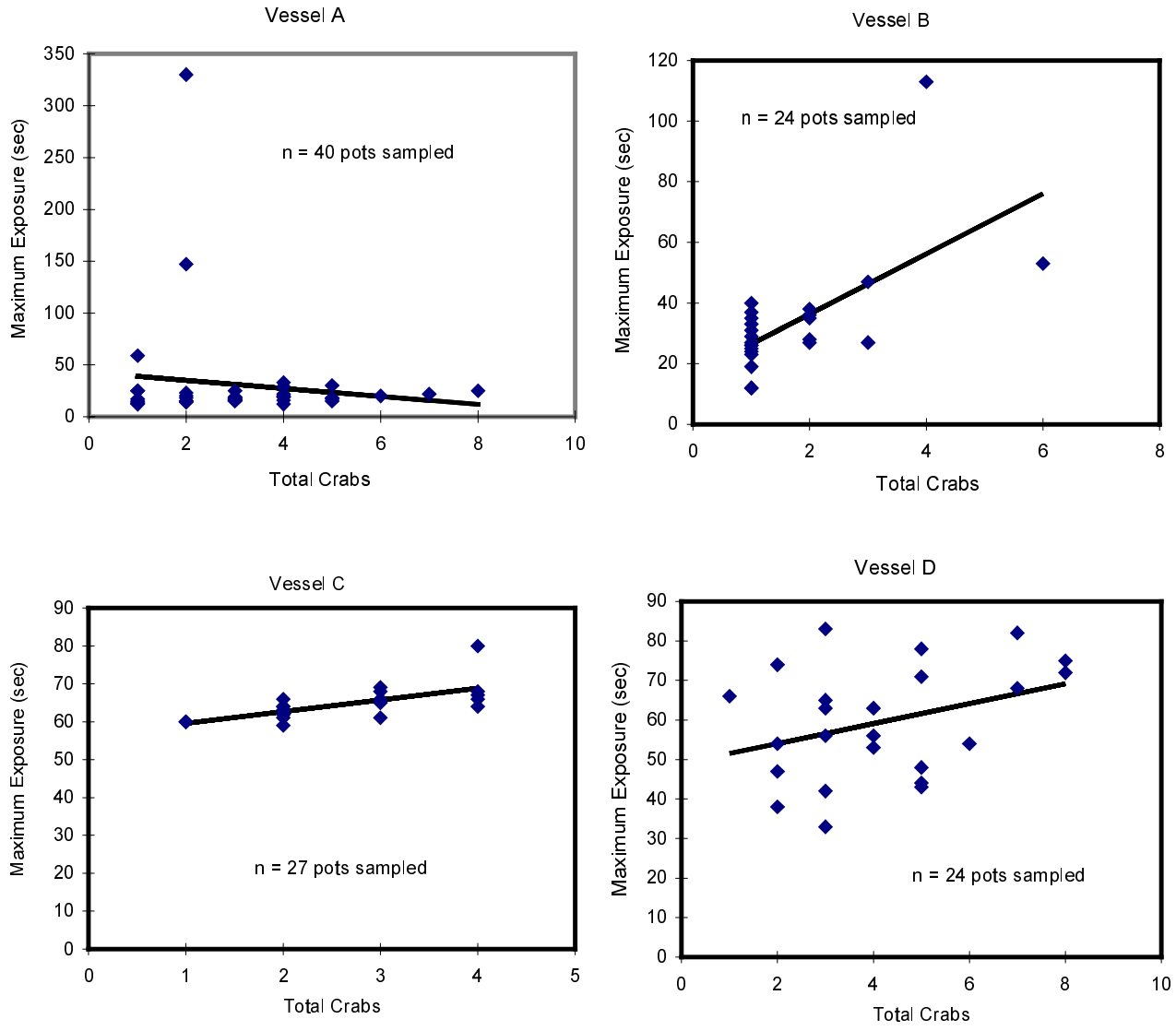

Figure 10. Fitted line plots for maximum aerial exposure times and total crabs per pot from samples taken on eight catcher-only vessels (A-H) during the 1999 Pribilof Islands hair crab fishery.

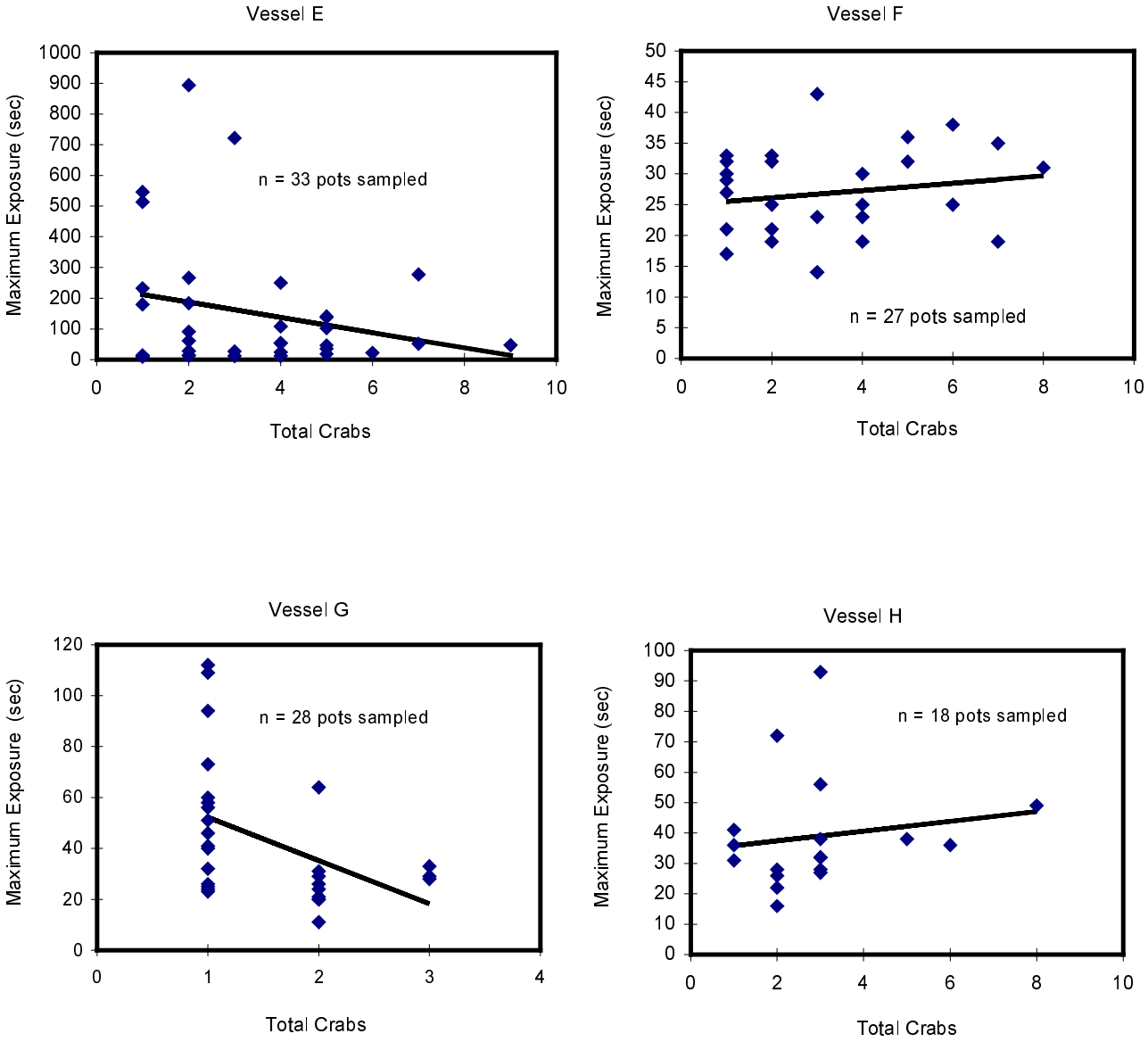

Figure 10. (page 2 of 2)

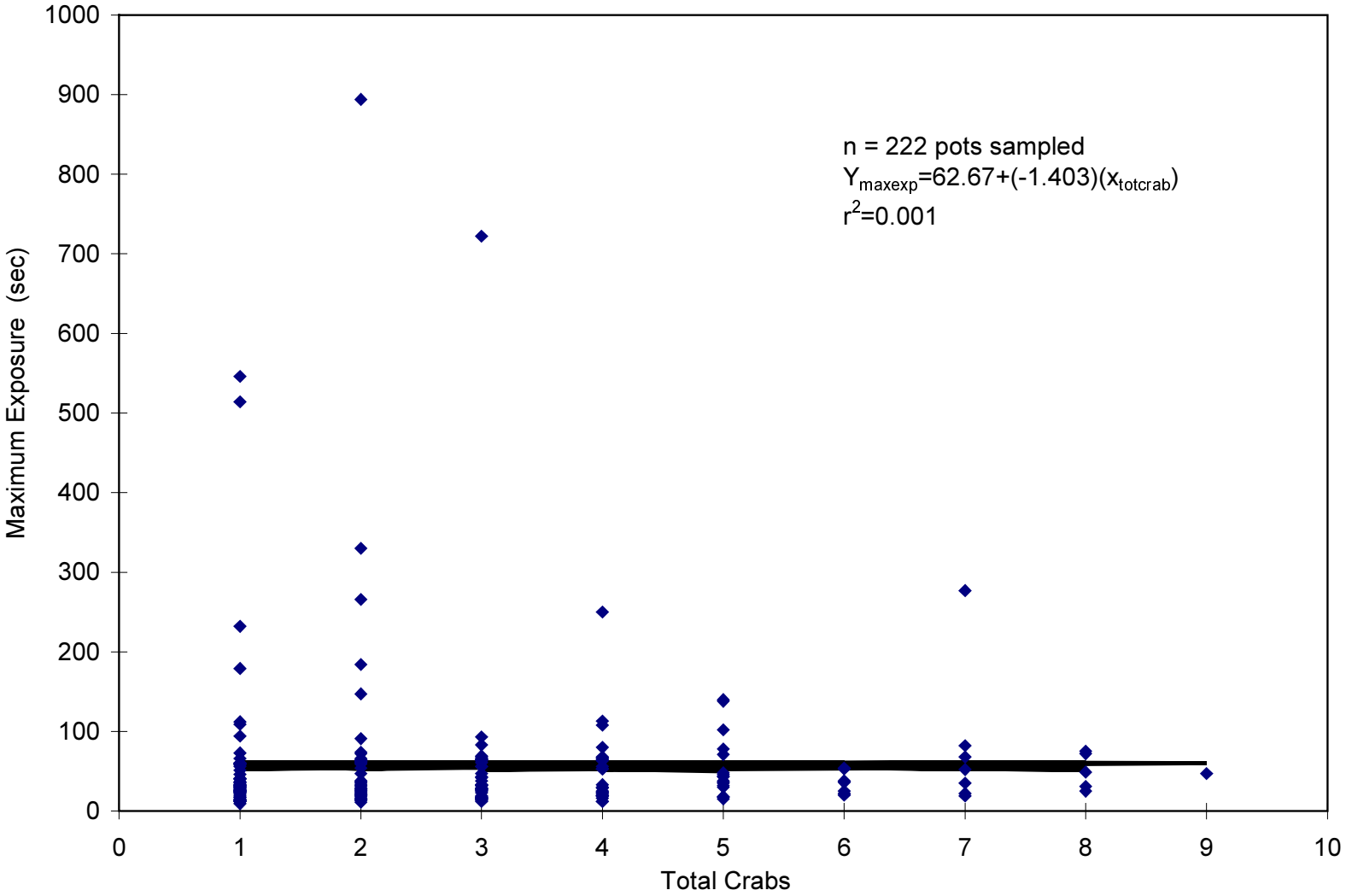

Figure 11. Linear relationship between maximum aerial exposure times and total crabs from combined pot samples taken on ight catcher-only vessels during the 1999 Pribilof Islands hair crab fishery.

e

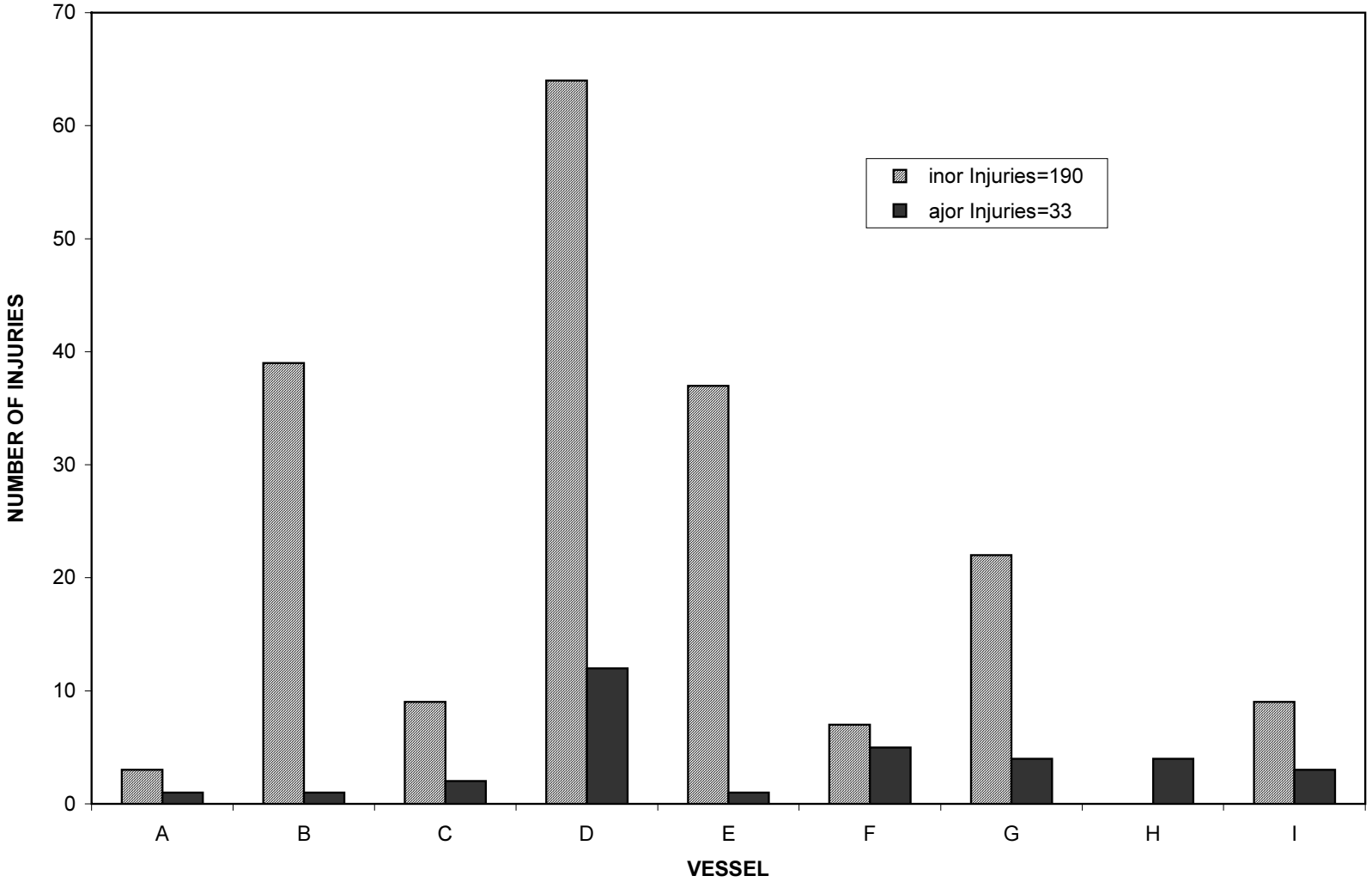

Figure 12. Major and minor body injuries of non-retained crabs examined in pots sampled on one catcher-only vessel and eight catcher-processors during the 1999 Bristol Bay red king crab open access season.

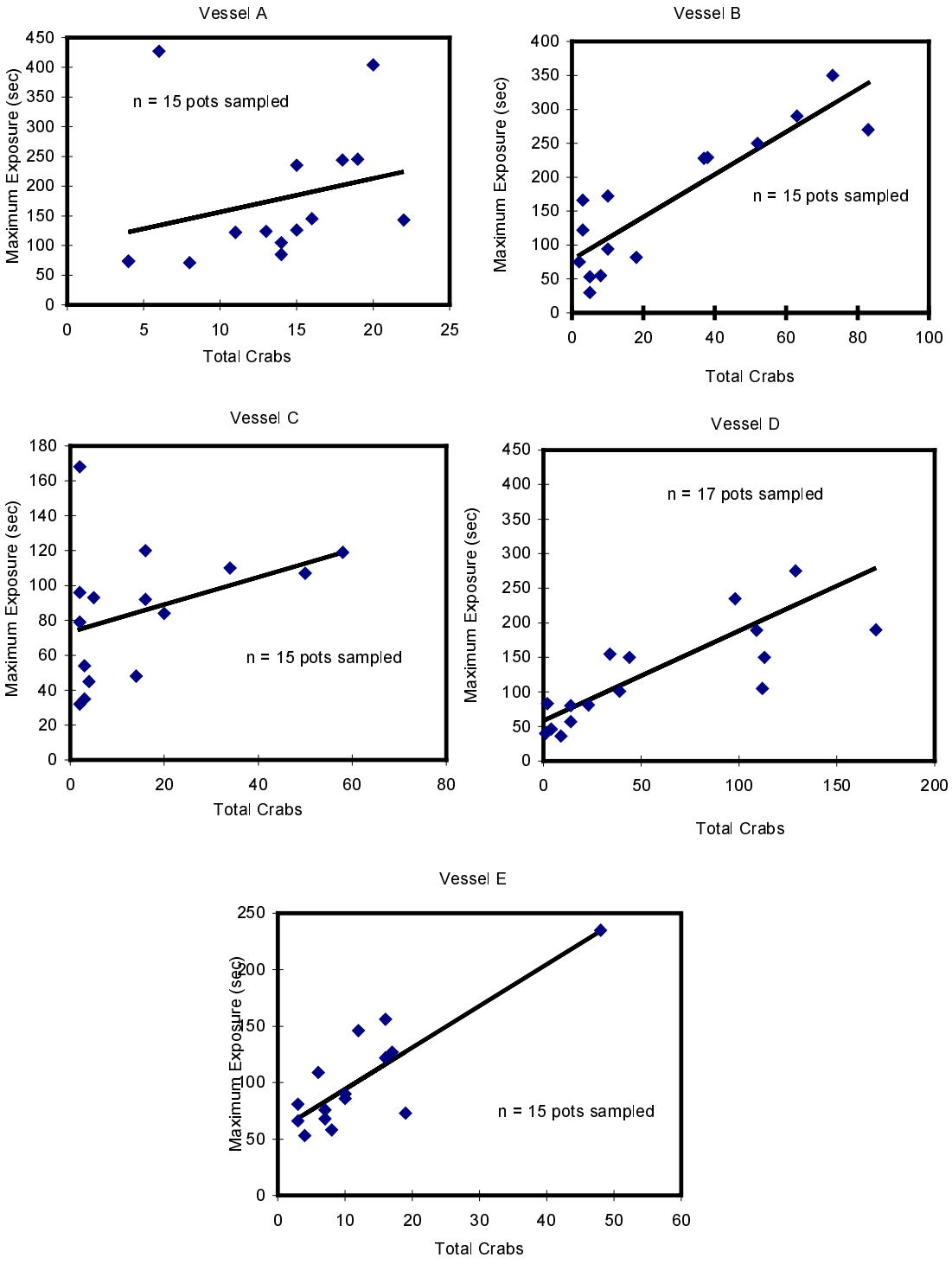

Figure 13. Fitted line plots for maximum aerial exposure times and total crabs per pot from samples taken on one catcher-only vessel and eight catcher-processors (vessels A-I) during the 1999 Bristol Bay red king crab open access season.

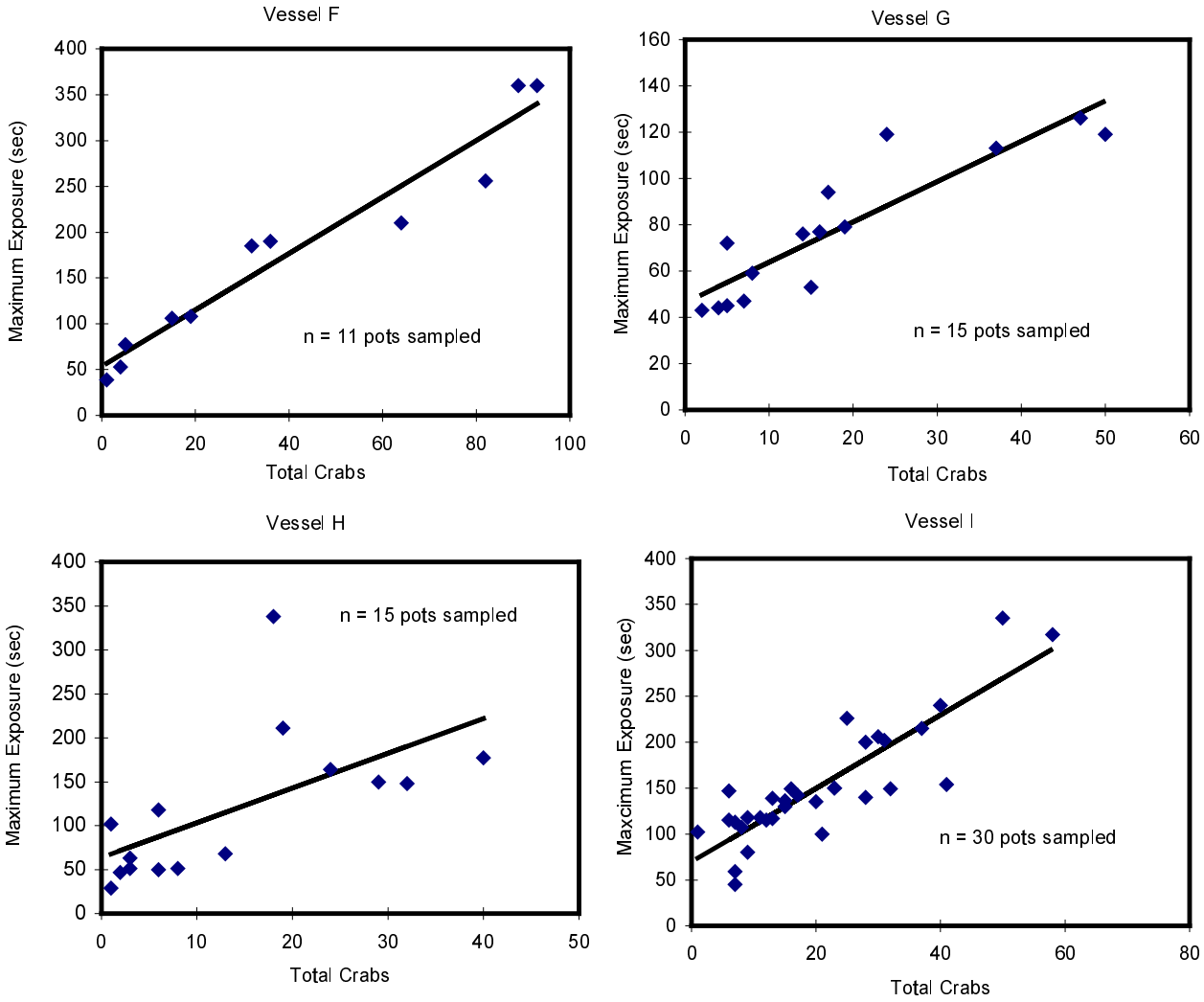

Figure 13. (page 2 of 2)

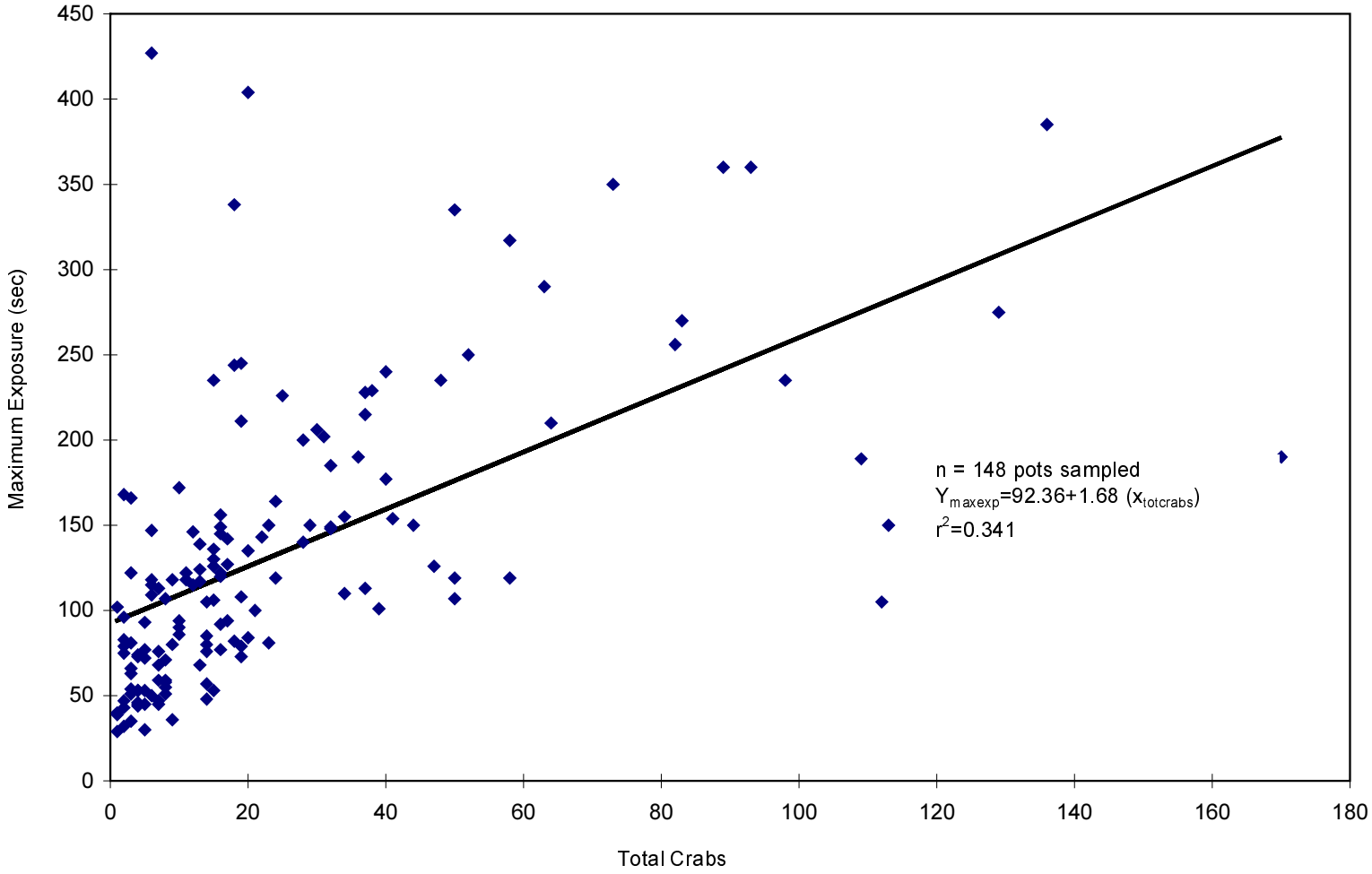

Figure 14. Linear relationship between maximum aerial exposure times and total crabs from combined pot samples taken on one catcher-only vessel and eight catcher-processors during the 1999 Bristol Bay red king crab open access season.

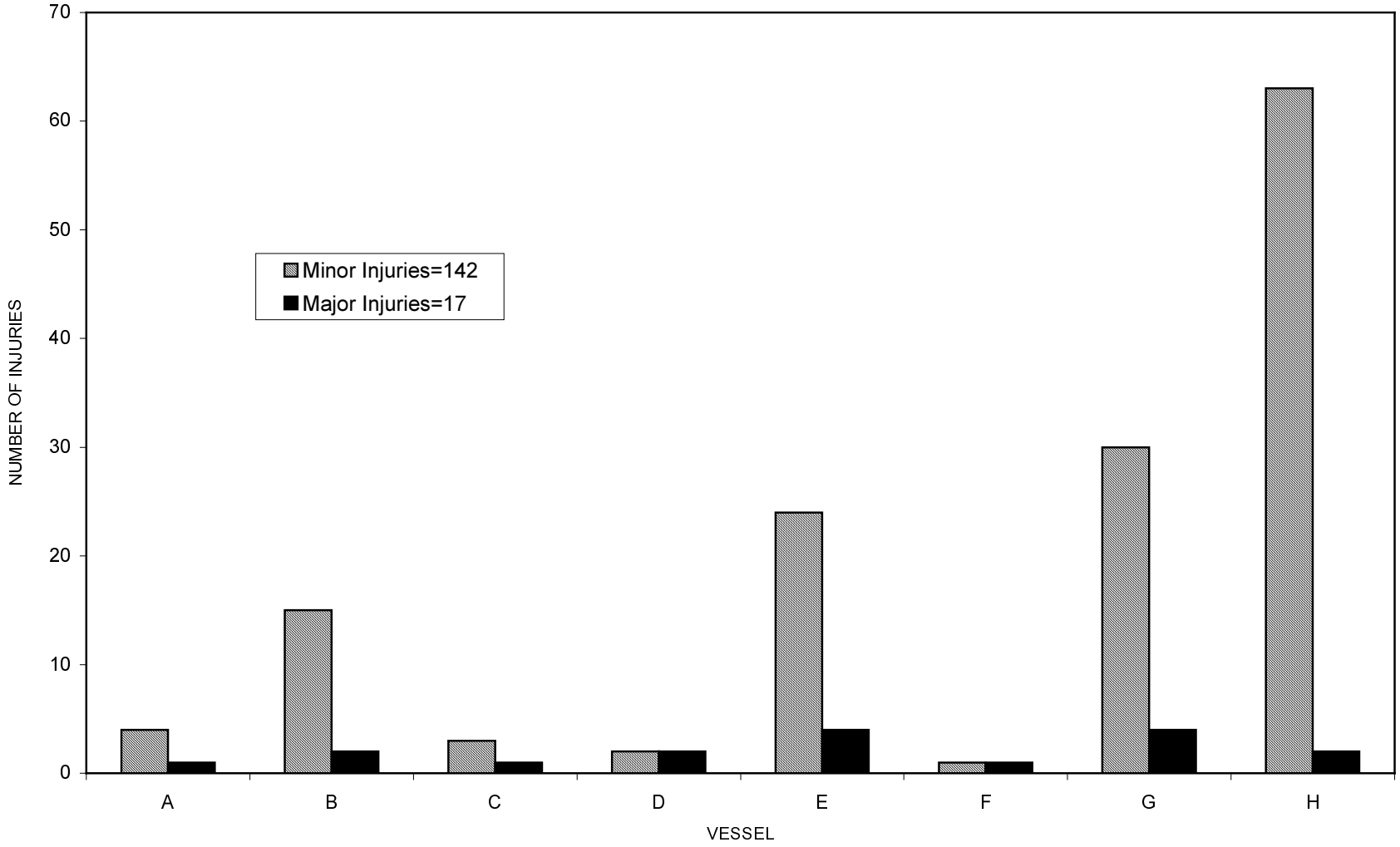

Figure 15. Major and minor injuries of non-retained crabs examined in pots sampled on eight catcher-only vessels during the 1999 Bristol Bay red king Bristol Bay red king crab CDQ season.

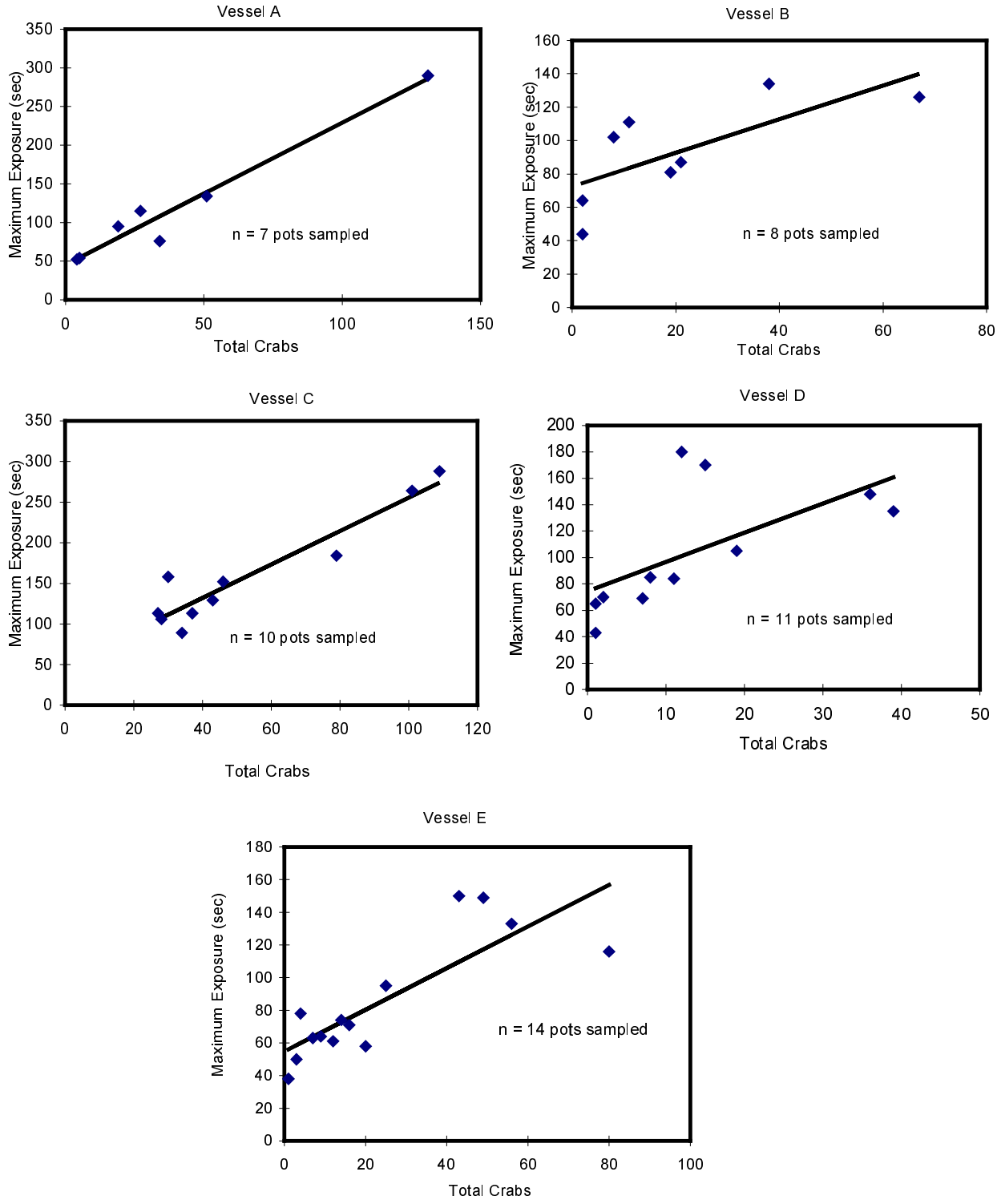

Figure 16. Fitted line plots for maximum aerial exposure times and total crabs per pot from samples taken on 10 catcher-only vessels (A-J) during the 1999 Bristol Bay red king crab CDQ season.

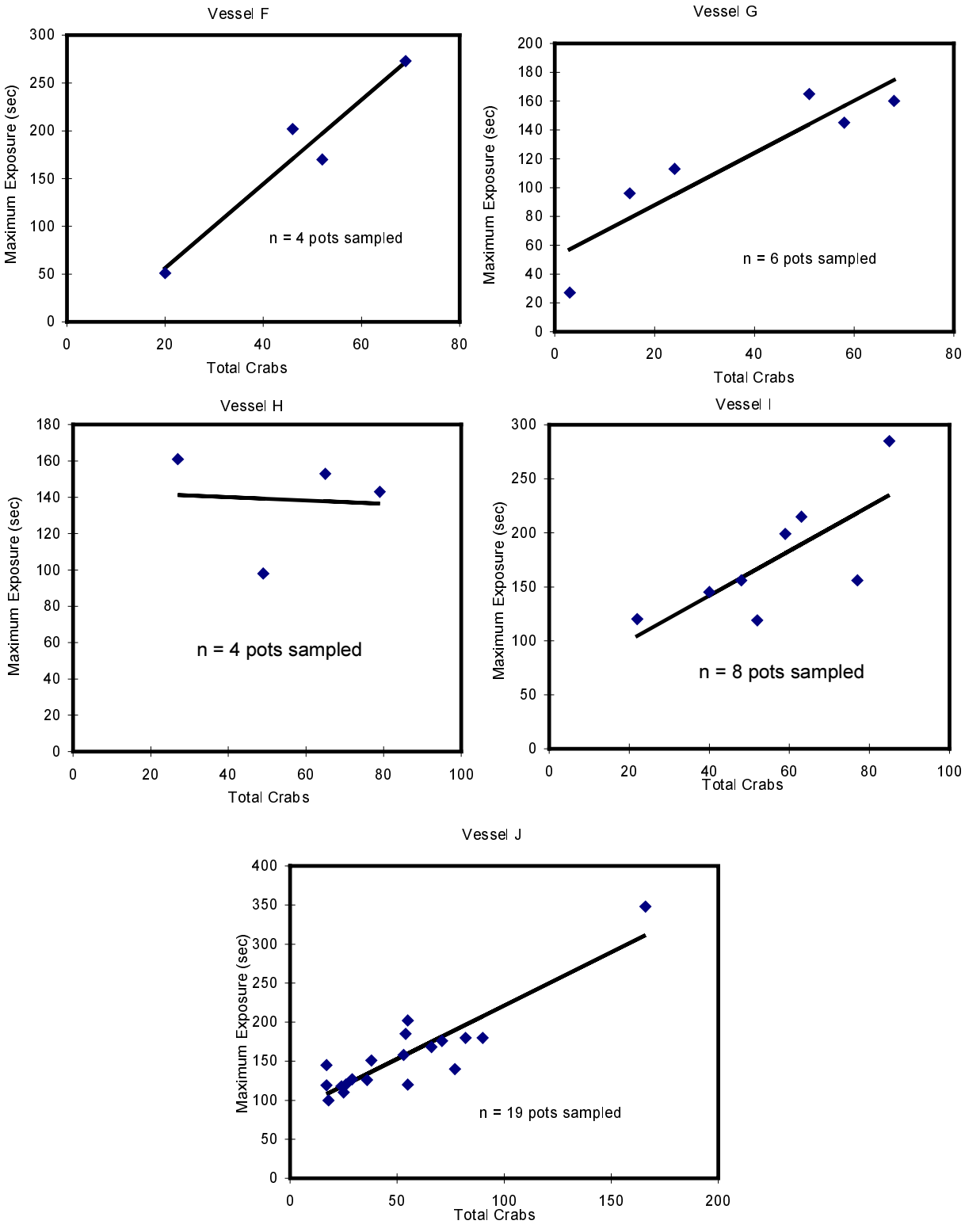

Figure 16. (page 2 of 2)

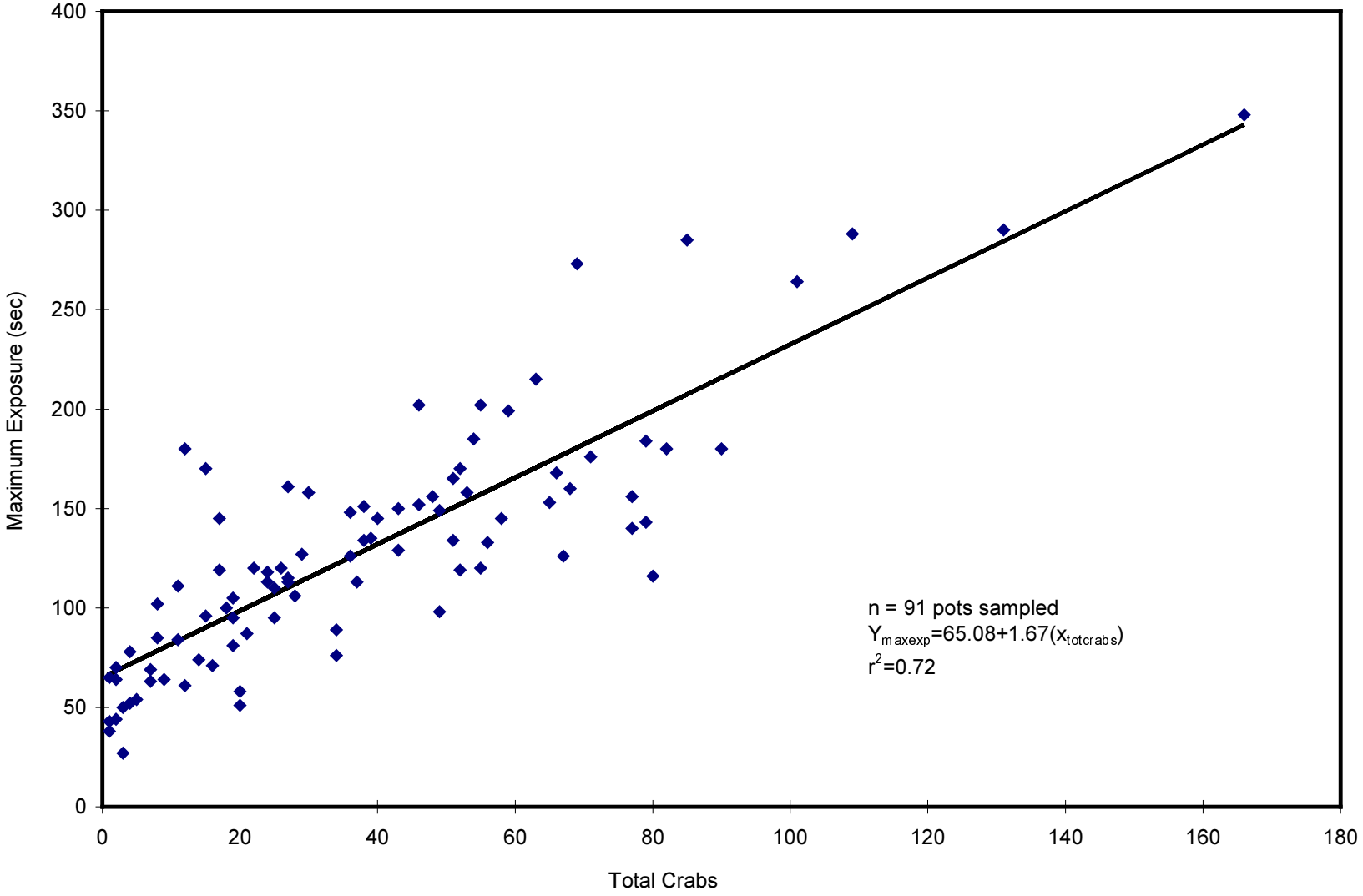

Figure 17. Linear relationship between maximum aerial exposure times and total crabs from combined pot samples taken on 10 catcher-only vessels during the 1999 Bristol Bay red king crab CDQ season.

APPENDIX

Appendix A. Alaska Department of Fish and Game aerial exposure sampling instructions.

Daily or cumulative sampling goals for measuring the aerial exposure times of sample pot catches will be provided during briefings or in shipboard instruction manuals. Pots will be randomly selected for this purpose. **Aerial exposures will only be measured for non-retained crabs of the target species - unless retained (legal-sized) crabs comprise the entire pot contents**. Non-retained crabs are sublegal male and female crabs of the target species; do not include fish, non- target crabs or other invertebrates in the measured exposure time interval. **Sampling will comprise objective observations; under no circumstances will accurately measured exposure times be discounted - especially due to situations which result in a perceived extension in the time "normally" spent on deck by non-retained crabs (e.g. accelerated fishing activity, pot stacking, etc.)**. In order to maintain an objective sampling environment, exposure times should be recorded without the knowledge of the vessel crew whenever possible. Record data for each category as specified below.

Species code: The target species being sampled; refer to the list of species codes provided in the "ADF&G Shellfish Observer Field Manual".

Fishery code: The 4-character alpha/numeric code provided during briefing for the fishery being sampled.

Observer code: Leave this column blank, unless instructed otherwise during briefing.

Vessel ADF&G #: Refer to the vessel registration or the list of vessel numbers provided in the "ADF&G Shellfish Observer Field Manual".

Sequential Pot Number: Unique and distinct from bycatch sample pot numbers **and** injury assessment sample pot numbers. Begin with the number one (1); the last sequential pot number reflects the total number of observations made for the purpose of measuring aerial exposures.

Exposure times: All exposure times will recorded in whole seconds only (do not record minutes and seconds).

Minimum*:* The time interval beginning when a retrieved pot comes out of the water and ending when the **first non-retained crab** is returned to the sea **OR**, if the entire catch contents are retained crabs, when the **first retained crab** is placed in the holding tank.

Maximum*:* The time interval beginning when a retrieved pot comes out of the water and ending when the **last non-retained crab** is returned to the sea **OR**, if the entire catch contents are retained crabs, when the **last retained crab** is placed in the holding tank.

Number of Retained Crabs: The total number of **retained crabs** of the target species in the pot. **Estimates are acceptable, but only when accurate counts are unobtainable**, and must be noted on the data form.

Estimated (Est.): Check the box in this column if the number of retained crabs is estimated. **Leave this box blank if actual counts of retained crabs in the pot are obtained**.

Total Crabs: The total number of crabs **- retained and non-retained -** of the target species in the pot. **Estimates are acceptable, but only when accurate counts are unobtainable**, and must be noted on the data form.

Estimated (Est.): Check the box in this column if the total number of crabs is estimated. **Leave this box blank if actual counts of total crabs in the pot are obtained**.

Appendix B. Alaska Department of Fish and Game injury assessment sampling instructions.

Species code: The 3-digit code provided in the "ADF&G Shellfish Observer Field Manual" for the target crab species being sampled.

Fishery code: The 4-character alpha-numeric code provided during briefing for the fishery being sampled.

Observer code: Leave blank.

Sequential pot #: Unique and distinct from bycatch sample pot number. Begin with the number one (1); the last sequential pot number recorded reflects the total number of pots sampled for injury assessment during the vessel deployment.

No. of crabs sampled/sample total: The number of crabs measured and assessed for injuries vs. the total number of crabs in the pot. **Leave blank if sub-sampling does not occur**.

Carapace length/width (CL/CW): The biological measurement (CL = mid-posterior to right eye orbit; CW = greatest width not including peripheral spines).

Shell age: 0 = soft 9 = new-pliable 1 = new 2 = old 3 = very old

Vitality: Assess all sampled crabs for vitality and record the appropriate code as follows:

blank - Leave field blank if crab is alive and exhibiting movement of appendages either spontaneously or when prodded.

1 - Moribund (alive but inactive, i.e. not exhibiting appendage movement even when prodded, but mouth parts are moving either spontaneously or when flicked at 5-10 second intervals.

2 - Dead (i.e. no movement of appendages even when prodded; no movement of mouth parts, even when prodded. Presence or severity of injuries is not a criterion of whether or not a crab is dead.

Injuries:

Examination of each crab measured will include a visual assessment of the carapace, sternum, abdomen, coxa (or "shoulders"), and each leg (refer to the generic anatomy diagram provided). Record all injuries observed on each sampled crab using the following codes. (**Note:** there can be multiple injuries per individual crab.)

blank - No injuries observed.

minor injuries:

1 - Rostrum - this prominent carapace feature breaks off frequently during handling.

2 - Carapace (middle) - punctures, cracks, or other damage to the middle section of the carapace over vital organs where integument (new skin) or other tissue isn't visible as a result of the injury.

3 - Carapace (side) - punctures, cracks, or other damage to the periphery of the carapace over the gill region where integument or other tissue isn't visible as the result of the injury.

4 - Leg injury - punctures cracks or damage to any of the walking legs where integument or other tissue isn't visible as the result of the injury.

-Continued-

5 - Leg autotomy - an autotomy is a clean break at a walking leg joint where no blood is lost and no ragged flesh is exposed (a smooth concave surface is seen at the autotomized joint).

6 - Left chela - punctures, cracks or any damage to the left chela (claw) where integument or other tissue isn't visible as the result of the injury.

7 - Right chela - punctures, cracks, or any damage to the right chela where integument or other tissue isn't visible as the result of the injury.

8 - Chela autotomy - an autotomy is a clean break at the chela leg joint where no blood is lost and no ragged flesh is exposed (a smooth concave surface is seen at the autotomized joint).

9 - Abdomen - any punctures, cracks or damage to the ventral abdominal flap where integument or other tissue isn't visible as the result of the injury.

10 - Sternum - any punctures, cracks or damage to the ventral surface around the abdomen(not including the any part of the legs) where integument or other tissue isn't visible as the result of the injury.

11 - Coxa ("shoulder") - punctures, cracks or any damage to the first leg segment closest to the body where integument or other tissue isn't visible as the result of the injury.

major injuries:

12 - Carapace (middle) - punctures, cracks, or other damage to the middle section of the carapace over vital organs where integument or other tissue is clearly showing through or protruding from the injury site (i.e., you can see tissue).

13 - Carapace (side) - punctures, cracks, or other damage to the periphery of the carapace over the gill region organs where integument or other tissue is clearly showing through or protruding from the injury site (i.e., you can see tissue).

14 - Leg injury - punctures cracks or damage to any of the walking legs organs where integument or other tissue is clearly showing through or protruding from the injury site (i.e., you can see tissue).

15 - Left chela - punctures, cracks or any damage to the left chela (claw) where integument or other tissue is clearly showing through or protruding from the injury site (i.e., you can see tissue).

16 - Right chela - punctures, cracks, or any damage to the right chela where integument or other tissue is clearly showing through or protruding from the injury site (i.e., you can see tissue).

17 - Abdomen - any punctures, cracks or damage to the ventral abdominal flap where integument or other tissue is clearly showing through or protruding from the injury site (i.e., you can see tissue).

18 - Sternum - any punctures, cracks or damage to the ventral surface around the abdomen(not including the any part of the legs) where integument or other tissue is clearly showing through or protruding from the injury site (i.e., you can see tissue).

19 - Coxa ("shoulder") - punctures, cracks or any damage to the first leg segment closest to the body where integument or other tissue is clearly showing through or protruding from the injury site (i.e., you can see tissue).

Appendix C. Alaska Department of Fish and Game vessel catch sorting equipment and procedures questionnaire.

Observer name ___ _____ Vessel name ___ _____

Fishery Code				Observer Code		Vessel ADF&G No.					Deployment Dates: from Mo.	from Day	from Yr.	to Mo.	to Day	to Yr.

Catch sorting equipment and configuration:

1. Are the contents of fished pots typically placed into totes or onto a sorting table?

a. sorting table	b. totes*

*Skip to Question 5.

2. What is the design of the sorting table?

a. pivot leg	b. hydraulic - one piece	c. hydraulic – hinged/split	d. other*

*Describe in the 'comments' section.

3. Are there slide ramps or conveyers used in conjunction with the sorting table for the purpose of placing sorted crabs overboard and/or in the holding tanks?

a. yes	b. no

4. If the answer to Question 3 is 'yes', indicate which of the above devices are used on your vessel.

a. slide ramp	b. conveyer	c. other*

*Describe in the 'comments' section.

Catch sorting and handling methods:

5. Before placing retrieved pots in the hydraulic launcher (or otherwise bringing each one aboard), does the crew routinely swing them against the outside of the vessel hull in order to knock the catch contents to one end?

a. yes	b. no

6. Is the catch typically "shaken out" of each pot by use of the hydraulic launcher, or does the crew remove the pot contents by hand?

a. catch removed with launcher	b. catch removed by hand

-Continued-

7. If the pot contents are emptied by use of the launcher or other platform, what is the estimated distance crabs fall from the pot onto the sorting table or into totes?

a. less than 2 feet	b. 2 to 4 feet	c. greater than 4 feet

8. If your vessel does not use a sorting table, or does not use slide ramps or conveyors to transport the catch contents off the sorting table, are non-retained crabs typically returned to the sea by being thrown or dropped over the side of the vessel, or does the crew normally place bycatch in the discard chutes (scuppers)?

a. catch over the side	b. catch in discard chutes

9. How many crewmembers usually participate in sorting the catch?

a. one	b. two	c. greater than two

10. Which of the following are usually sorted and removed from the pot contents by the crew first?

a. retained crabs	b. bycatch crabs

Comments:

Fishery code: The 4-character alphanumeric code provided during briefing for the fishery being observed.

Observer code: Leave blank.X

Vessel ADF&G #: Refer to the vessel registration or the list of vessel numbers provided in the "ADF&G Shellfish Observer Field Manual".

Deployment dates: The date of briefing and the date of debriefing for the fishery being observed.

Questions:

Preliminary results from crab injury assessment sampling conducted by observers in 1997 indicate that a great deal of variance in injury rates exists between individual vessels. In order to gain further insight as to the reasons for this variability, the ADF&G research staff is requesting that the equipment and methods used to sort crabs are documented on all observed vessels.

Please circle the most accurate answer for each question to describe the sorting operation on your vessel. If necessary, also include other information or comments in the space provided that may better characterize the method(s) used for handling catches. Reference question numbers where appropriate when providing information supplemental to the choice(s) of answers given.

Appendix D. Summary of crab sorting survey questionnaire results for vessels observed during the 1999 Bering Sea/ Aleutian Islands king and snow crab fisheries and Pribilof Islands hair crab fishery.

Fishing Season	Vessels Surveyed	Sorting Equipment			Sorting Methods					
					Removing Catch From Pots			Catch discarding	# of crew sorting	Sorting priority[d]
		Table/ totes	Table type[a]	Catch discard devices[b]	By hand/ launcher	Shake pot with launcher	Catch drop distance [c]			
Aleutian Islands Golden King Crab	7	table- 5 tote- 1 both-1	pivot- 2 hydraulic 'B'- 4 n/a- 1	conveyor- 1 none- 1 n/a- 5	hand- 1 launcher- 6	n o- 7	<2 ft- 2 2-4 ft- 5	scupper- 2 n/a- 5	two- 4 >two-3	retained- 5 n/a- 2
Bering Sea open access Snow Crab	19	table- 19 both- 1	pivot- 10 hydraulic 'A'- 2 hydraulic 'B'- 6 other- 1	ramp- 10 conveyor- 1 none- 8	launcher- 17 both- 2	no- 11 yes- 8	<2 ft-10 2-4 ft- 9	scupper- 11 over side- 4 n/a- 4	one- 3 two- 6 >two- 8 n/a-2	retained- 10 random- 7 bycatch- 1 n/a- 1
Bristol Bay open access Red King Crab	1	table- 1	pivot- 1	ramp- 1	launcher- 1	no- 1	<2 ft- 1	scupper- 1	one- 1	retained- 1

[a] Table designs: Pivot leg-sorting table rotates across deck to launcher around secured table leg; Hydraulic "A'-sorting table top hinged at or near mid section; Hydraulic 'B'- one piece table top, hydraulically controlled.
[b] Structural or mechanical device to allow the unassisted release of discarded crabs.
[c] Estimated distance crabs fall to sorting platform (i.e., table or totes) from pots emptied by use of launcher.
[d] Order in which crabs are selected from the unsorted catch.

Appendix E. Injury data on *C. bairdi* crabs taken opportunistically in pot samples during the 1999 Bering Sea snow crab open access and CDQ seasons

1999 Bering snow crab open access season

		C. bairdi sampled		***C. bairdi*** With Injuries				
Vessel	Pots Sampled	Total	Number per pot	Total	Number per pot	Percent of sample	Number with >1 injury	Percent sampled crab with >1 injury
A	30	130	4.3	5	0.2	3.8	0	0
B	122	317	2.6	31	0.3	9.8	4	1.3
E	7	69	9.9	4	0.6	5.8	1	1.4
F	22	75	3.4	3	0.4	4.0	3	4.0
G	61	796	13.0	77	1.3	9.7	5	0.6
I	114	280	2.5	19	0.2	6.8	2	0.7
J	30	51	1.7	8	0.3	15.7	2	3.9
Total	386	1,718	4.5	147	0.4	8.6	17	1.0

1999 Bering Sea snow CDQ season

		C. bairdi sampled		C. bairdi With Injuries				
Vessel	Pots Sampled	Total	Number per pot	Total	Number per pot	Percent of sample	Number with >1 injury	Percent sampled crab with >1 injury
B	1	4	4.0	0	0	0	0	0
C	20	57	2.8	1	0.1	1.8	1	1.8
E	24	102	4.2	13	0.5	12.7	0	0
F	20	68	3.4	9	0.4	13.2	0	0
H	23	312	13.6	39	1.7	12.5	12	3.8
J	1	8	8.0	2	2.0	25.0	0	0
K	6	17	2.8	2	0.3	11.8	1	5.9
L	14	92	6.6	4	0.3	4.3	0	0
M	15	61	4.1	5	0.3	8.2	0	0
N	2	4	2.0	0	0	0	0	0
O	17	246	14.5	34	2.0	13.7	2	0.8
Q	3	13	4.3	1	0.3	7.7	0	0
R	17	119	7.0	9	0.5	7.6	0	0
Total	163	1,103	6.8	119	0.7	10.8	16	1.5