THE EFFECTS OF WINDCHILL EXPOSURE ON THE SNOW CRAB, *CHIONOECETES OPILIO*

By

Jonathan J. Warrenchuk

Recommended:

Advisory Committee Chair

Director, Fisheries Division

Approved:

Dean, School of Fisheries and Ocean Sciences

Dean of the Graduate School

7-23-01

Date

THE EFFECTS OF WINDCHILL EXPOSURE ON THE SNOW CRAB, *CHIONOECETES OPILIO*

A

THESIS

Presented to the Faculty

of the University of Alaska Fairbanks

in Partial Fulfillment of the Requirements

for the Degree of

MASTER OF SCIENCE

By

Jonathan J. Warrenchuk, B.S.

Juneau, Alaska

August 2001

Thesis Abstract

Millions of snow crabs, Chionoecetes opilio, are aerially exposed during sorting in the annual Bering Sea commercial fishery. A laboratory experiment measured snow crab responses to windchill exposure. Crabs were exposed to 8 to 16 m/s windspeed and air temperatures from –2 to –10 °C for 5 minutes. Mortality, autotomy, and righting response were assessed for seven days post-treatment. Crabs experienced 40% to 100% mortality at windchill from –10 to –16 °C. Reduced exposure time significantly reduced mortality. Autotomy was variable but pronounced below –10 °C windchill. The righting response was impaired after all but the least severe treatment.

Estimates of mortality of discarded snow crab in 1998 were calculated from deadloss of retained crab, a windchill model, and a temperature/windspeed model. No relationship existed between catch deadloss and the windchill conditions when the crabs were caught. Mortality of non-retained snow crab was estimated at 3.6% by the windchill model and 19.6% by the temperature/windspeed model.

Table of Contents

List of Figures

Chapter 1.

Chapter 2.

List of Tables

Chapter 1.

Chapter 2.

Chapter 1.

The effects of windchill exposure on the snow crab, *Chionoecetes opilio.*[1]

Abstract

Tens of millions of snow crabs, Chionoecetes opilio (Fabricus), are sorted and discarded each year during the Alaskan snow crab fishery. The fishery occurs during winter in the Bering Sea and there is a high probability that discarded crabs will be exposed to cold air temperatures and high winds (windchill) during their aerial exposure. A laboratory experiment was conducted to measure responses of snow crab to a range of air temperatures and windspeed to assess the effects of windchill. Male snow crabs of the size typically discarded by the fishery were collected from the Bering Sea. A wind tunnel in a walk in freezer simulated the windy and cold conditions on the deck of a commercial Bering Sea crab boat. Crabs were exposed to windspeeds from 8 to 16 m/s and air temperatures from –2 to –10 °C for 5 minutes. Mortality, autotomy, and reduced activity in the form of a righting response were assessed before, immediately after, one day, and seven days post-treatment. Snow crabs experienced 100% to 40% mortality at windchill values from –16 °C to –10 °C. Reduced exposure time significantly reduced mortality. Autotomy was variable, but pronounced at windchill values below –10 °C. Righting response was impaired after all but the least severe treatment.

(1) Warrenchuk, J. J. and T. C. Shirley. The effects of windchill exposure on the snow crab, *Chionoecetes opilio*. Submitted to Proceedings of Crab 2001 Symposium, University of Alaska Sea Grant College.

Acknowledgments

I thank Lynnette McNutt, UAF and Dr. Adam Moles, NMFS for assistance. My gratitude goes to personnel in Dutch Harbor for support in snow crab collection: Rance Morrison and staff at ADF&G, Larry Boyle and Ryan Burt from the Observer Training Center, and Gordon Blue and the crew of F/V *Zolotoi*. Auke Bay Laboratory, NMFS graciously provided laboratory space and support. Dr. Tom Shirley provided insight and guidance. I also thank Dr. Terrance J. Quinn II and Dr. Sherry Tamone for review of the manuscript. Funded by Alaska Dept. of Fish. & Game under Cooperative Agreement NA97FN0129 from the National Oceanic and Atmospheric Administration (NOAA). The views expressed are those of the author and do not necessarily reflect the views of NOAA or any of its sub-agencies.

Introduction

Objectives

The objectives of this study were to determine the effects of windchill exposure (cold air temperature and wind) on mortality, autotomy, and activity (measured as a change in the righting response) for male snow crabs (Chionoecetes opilio) of the size typically discarded as bycatch.

Background

The snow crab, Chionoecetes opilio (Fabricius, 1788) is a widely distributed and commercially important crustacean. It exists in the northern Pacific, Arctic, and

northwest Atlantic oceans. The range of the snow crab extends from the Sea of Japan east of the Korean Peninsula, the Sea of Okhotsk, the Bering Sea north of the Alaska Peninsula, and in the Beaufort Sea east to Cape Parry (Garth 1958). In the northwest Atlantic, it is found from Greenland to Maine (Garth 1958).

The life history of C. opilio in the Bering Sea is slowly being clarified. Most of the research on snow crab biology has occurred on the Atlantic populations; this research should be applied with caution to the Bering Sea. For a review of snow crab biology see Adams (1979), Garth (1958), Incze et al. (1982), Jademac et al. (1999), Jewett (1982), and Paul (2000).

The eastern Bering Sea snow crab stock supports a valuable fishery. Harvest increased from under 1 million pounds in 1974 to a maximum of 328 million pounds in 1991 and 315 million pounds in 1992; reduced quotas followed thereafter (Fig.1). Population estimates indicate the stock is currently near historical low abundance (Fig.2) (Stevens et al. 2000). The Alaskan snow crab fleet is based out of the Aleutian Islands at Dutch Harbor and the prime crabbing grounds are a one to two day trip away. Many of the vessels are from Washington State. In 1999, 241 vessels participated in the harvest (R. Morrison, ADF&G, pers. comm.). The legal gear for catching snow crab are modified king crab pots, large 600 to 700 pound steel frames covered with nylon-webbing. To avoid bycatch of red king crab, the maximum tunnel opening is 3" diameter. In addition, a minimum of four 3.75" diameter escape rings must be present or, instead of rings, 1/3 of a panel must be 5" diameter stretched mesh to allow escape of sublegal male and female snow crabs (ADF&G regulation 5AAC 35.525). Pots are

baited with chopped herring or squid and allowed to soak for one to two days. The pots are then retrieved from depths of up to 300 meters and lifted onto the deck for sorting. The catch is spilled onto a sorting table with flowing water. Sorting is generally quick and efficient. However, one pot may contain up to 1000 crabs and sorting times vary from a few seconds to several minutes (Tracy and Byersdorfer 2000).

The Bering Sea snow crab stock is managed by the State of Alaska through a federal Bering Sea and Aleutian Islands (BSAI) king and Tanner crab fishery management plan (FMP) from the North Pacific Fishery Management Council (NPFMC 2000). Population estimates are generated from data collected during the annual National Marine Fisheries Service (NMFS) Eastern Bering Sea Crab trawl survey. Guideline harvest levels for the season are determined from population estimates based on survey data from the preceding year. With the decline of the red king crab and Tanner crab fisheries, the Bering Sea snow crab became Alaska's most valuable crustacean fishery. That distinction is now in peril; the stock was declared "overfished" in 1999 and reduced harvest quotas have followed (R. Morrison, Alaska Department of Fish & Game, pers. comm.).

Scope of problem

The snow crab fishery occurs during winter months when conditions in the Bering Sea are the most severe. Sublegal sized males (<78 mm) and all females must be returned to the sea; crabs deemed unmarketable such as very old shell males, injured crabs, and small males (78-101 mm carapace width) are also sorted and discarded. The

discarded snow crabs receive aerial exposure to harsh windchill conditions during pot retrieval and sorting.

Aerial exposure is a stress for any aquatic animal. Exposure to air creates respiration problems; aquatic animals cannot exist out of water for extended periods. Aerial exposure during cold temperatures creates added problems of heat loss for a heterothermic animal. Air movement accelerates heat loss, so the effects of wind must also be considered. The accelerated rate of cooling due to the combination of cold temperatures and wind is referred to as windchill (Court 1948).

Aerial exposure for short periods has minimal effects on snow crab fitness. In an experiment on temperature tolerance of snow crabs, crabs stored in moist air for 4 days at 3 °C or 8 °C had no mortality (McLeese 1968). Time to 50% mortality was 8.5 days at 3 °C and 1.9 days at 13 °C (McLeese 1968), demonstrating that snow crabs can survive aerial exposure to cool moist air for short periods with no mortality. Sublethal effects from aerial exposure are unknown.

Aerial exposure to cold air temperatures affects red king crab and Tanner crab. Short duration exposure to low temperatures caused the same effects as longer exposure at higher temperatures (Carls and O'Clair 1990). Severe exposure (long duration at moderate temperatures or short duration at low temperatures) caused death in Tanner crab and red king crab (Carls and O'Clair 1990, 1995). Moderate exposures caused reduced vigor, autotomy, depressed feeding rates, and decreased juvenile growth in Tanner crab (Carls and O'Clair 1995). Exposure to cold air caused reduced vigor and growth, but did not affect hatching success of ovigerous female red king crab (Carls and O'Clair, 1990).

Studies that simulated capture and release reported that handling alone does not cause significantly higher mortality in red king crabs (Zhou and Shirley 1995) and Tanner crabs (MacIntosh et al. 1996). Snow crabs, having morphology similar to Tanner crabs, would be expected to have similar responses to handling. However, handling in the laboratory is likely to be conservative when compared to handling in the field. During the fishery, snow crabs have the potential to fall from 2 to 4 feet on a hard surface as the pots are tipped (Tracy and Byersdorfer 2000), their extremities can be pinched under the pot, and the mass release of many crabs through small scuppers can cause damage.

The combined effect of exposure to wind and cold air temperature, or windchill, could be the most severe stressor on snow crabs. Red king crab (Shirley 1999) and Tanner crab (Shirley 1998) had dramatic responses to windchill exposure. Laboratory experiments with juvenile, male Tanner crabs demonstrated that exposure to windchill values commonly encountered during the fishery resulted in mortality, autotomy, and decreased activity (Shirley 1998). Five-minute exposures to temperatures of –7 °C and wind speed of 16 m/s resulted in 90% mortality of Tanner crabs within a week.

Extreme heat loss can be fatal for any organism and is especially problematic for heterothermic crabs. Heat can be lost by radiation, conduction, or convection. Radiative heat loss occurs as heat waves are radiated into the surrounding environment. Conductive heat loss occurs from the transfer of heat from one object in contact with another; e.g., a crab could lose heat to a cold sorting table, or to the air itself. Sorting tables on commercial crab boats vary in design; conductive heat loss is mitigated when

flowing water is pumped across the table. Convective heat loss results from the movement of air over a surface. Air movement disturbs the laminar insulating layer of air around an object and serves to draw heat away from that object. Convective air loss is the major avenue of heat loss that results in windchill.

While snow crab bycatch occurs in many fisheries in the Bering Sea, the snow crab fishery itself accounts for most of the bycatch. Between 1994 to 1999, bycatch due to the snow crab fishery ranged from 40 million to 75 million crabs (Table 1). Of lesser importance were groundfish trawls, groundfish fixed gear, scallop dredging, and other crab fisheries. Bycatch of snow crabs is decreasing in the groundfish fisheries (but is not a major component of the total bycatch). The majority of snow crab bycatch consists of small, legal-sized males. The legal size and marketable size of snow crab differ: crabs in the size range between legal size (79 mm carapace width) and marketable size (102 mm CW) are discarded. The legal, sub-marketable crabs constitute the largest bycatch component. Female snow crabs are estimated to account for less than 1% of the snow crab bycatch. Sublegal sized male snow crabs (<79 mm carapace width) are estimated to account for 2% or less of the total bycatch (NPFMC 2000).

The total bycatch declined from a high of 81 million crabs in 1997 to 43 million in 1999. However, bycatch as a percentage of the stock of similar-sized male crabs (<4'' CW) is increasing (Table 1), probably due to increased fishing effort to find crabs when stock abundance is low. The trend had been masked in other reports (Witherall 2000) where bycatch was reported as a percentage of the estimated abundance of both sexes and

all size classes of crabs. Since the majority of bycatch is male snow crab less than 4" CW, percentages should reflect the estimated abundance of crabs of that size.

Mortality of snow crab bycatch from the directed Bering Sea snow crab pot fishery had been estimated at 24%; this estimate was incorporated into the rebuilding plan (NPFMC 2000).

Sublethal effects such as autotomy can occur when snow crabs are caught and discarded. Autotomy occurs naturally in C. opilio; it is the reflexive severance of an appendage and is considered an adaptation to avoid predation (Juanes and Smith 1995). The direct benefit of autotomy (survival of predation situation) is offset if future costs are incurred. Reduction in growth, foraging efficiency, and mating success and increased vulnerability to predation and intraspecific competiton are potential future costs of autotomy. Single limb loss was the most common injury observed in decapod populations (Juanes and Smith 1995).

Snow crabs with regenerated limbs are rarely observed in the catches (R. Morrison, ADF&G, pers.comm). In a laboratory study of limb regeneration, no crabs over 90 mm carapace width were observed to regenerate limbs (Miller and Watson 1976). Crabs formed a scar where a limb had been autotomized; the scar was reformed after molting in the laboratory (Miller and Watson 1976). Smaller crabs do regenerate limbs, but require at least 2 molts to regenerate to 74% if their full length (Miller and Watson 1976). Snow crabs of this size constitute a much smaller proportion of the bycatch (<2%). Since most of the snow crab bycatch consists of males over 90 mm, autotomy can be considered total and irrevocable. A snow crab with lost limbs is not market

desirable. Injury rates in the field were highly variable, but averaged 24% of discarded crabs (Tracey and Byersdorfer 2000).

Snow crabs of the size caught in the fishery may not regenerate limbs because the time and number of molts required are past terminal molt. Chionoecetes bairdi, Paralithodes camtschaticus, and Homarus americanus had a negative correlation between body size and injury (Juanes and Smith 1995). A negative correlation between body size and injury may indicate that injury reduces survival, and fewer crabs with lost limbs survive to grow to a larger size. An alternative hypothesis is that smaller crabs are more susceptible to injury.

This study was the first to use live C. opilio from the Bering Sea in a laboratory experiment. Previous laboratory studies on live snow crab have used specimens from the Atlantic and Gulf of St. Lawrence (Foyle et al. 1989; Hardy et al. 1994; McLeese 1968).

Materials and Methods

Male snow crabs of the size typically discarded by the fishery (79-102 mm CW) were used in the experiment. The experiment was comprised of seven experimental treatments and one control treatment with 15 replicate crabs in each treatment. Crabs were placed in tanks with one tank per treatment. Each treatment contained a sample of crab sizes with minimized variation in size between tanks.

A commercial fishing vessel, the F/V *Zolotoi*, was chartered in April, 2000 prior to opening of the commercial fishery. Snow crabs were captured with commercial square crab pots along an extended track-set across the Bering Sea (Figure 3). The extensive

area covered by the set pots sampled snow crabs that were representative of the population. Short soak times decreased the efficiency of the pots and minimized the antagonistic injuries associated with crowding. The crabs were handled much more gently than would be expected in the fishery.

Snow crabs selected for the experiment were new shell crabs (minimal epibiont growth, an iridescent carapace, sharp spines) with few lost limbs. Several crabs were selected as specimens from each pot haul and were immediately hand-carried to the seawater-circulating live well. Any crabs with bitter crab disease, black mat syndrome, pepper crab, or torch disease (Jadamec et al. 1999) were not retained. Hybridization occurs between Tanner (Chionoecetes bairdi Rathbun 1924) and snow crab, which can make identification of specimens problematic. Hybrids were not used in the experiment and were identified and sorted from the snow crab specimens. Hybrids can be distinguished by a suite of characters that span the range of Tanner and snow crab morphology. Defining characteristics of hybrids have been identified (Jadamec et al. 1999). I attended a workshop at the Interagency Crab Meeting on December 1999 in Anchorage, Alaska and learned how to distinguish hybrids with reasonable confidence.

Care was taken to minimize handling and exposure of the crabs to air through their capture and transport. The snow crabs were packed in large coolers amongst layers of ice packs, burlap bags, and seawater-soaked newspaper for the flight to Juneau. Transport time from the vessel live-well in Dutch Harbor to the seawater tanks in Juneau was approximately 10 hours. Approximately 10% of the crabs died due to the stress of

capture, transport, and acclimation (assumed to include all deaths within the first 2 weeks of observation).

Crabs were maintained in flow-through seawater tanks at the Juneau Center, School of Fisheries and Ocean Sciences and the NMFS Auke Bay Laboratory. The seawater intake for both labs is at –30 m in Auke Bay; temperature and salinity variations were within the range recorded for the waters of the Bering Sea. Seawater discharge from the tanks was passed through a freshwater reservoir before being routed to the seawater return line.

Crabs were observed for two weeks prior to initiation of the experiment to ensure health and uniformity. Size measurements, previous damage (old injuries), shell condition, and hemolymph screening were performed on all specimens. Fixed and stained hemolymph films from each crab were observed under the microscope to determine the presence of bitter crab disease. Bitter crab disease is caused by a parasitic dinoflagellate that can be identified by the vegetative stage that replaces most of the hemocytes in the hemolymph (Meyers et al. 1987). Bitter crab disease was not observed in any of the crabs. Carapace length was measured from the notch between the rostral horns to the posterior of the carapace (mean CL ± 1 SD = 95.7 mm ± 8.7 mm). Carapace width was measured as the greatest distance across the carapace and did not include the spines (mean CW ± 1 SD = 96.3 mm ± 9.0 mm). Crabs were numbered with Floy tags attached with a plastic cable tie to the merus of the fourth or fifth pereopod. Crabs were ranked from largest to smallest in groups of 10 and then randomly placed into treatment

tanks to decrease variance in crab size between treatments. After the completion of the study, the crabs were frozen and disposed at the ADF&G tag lab.

Exposure times reflected actual sorting time measurements from the field. Crabs were exposed to treatments for 5 minutes, similar to the average maximum aerial exposure measured by observers in 1998 (Tracy and Byersdorfer 2000). Total exposure time was reduced to 2.5 minutes for the two most severe treatments.

Wind and cold treatments were selected using the best available weather data reflective of the Bering Sea during the crabbing season. Unfortunately the best weather data are obtained from a National Weather Service buoy that is 300 miles southwest of the fishing grounds. The recorded weather at the buoy and at the fishing grounds is assumed to be similar. Windchill treatments were performed with the following combinations of windspeed and temperature for an exposure time of 5 minutes: -2 °C and 8 m/s, -2 °C and 16 m/s, -6 °C and 8 m/s, -5 °C and 16 m/s, -10 °C and 8 m/s, and a control with no exposure. The two most severe treatments, -5 °C and 16 m/s and –10 °C and 8 m/s, were also performed with an exposure time of 2.5 minutes.

The windchill for each treatment was calculated using the National Weather Service formula (Parker 1987):

$$Temp_{windchill} = Temp_{initial} + 0.045*((5.27*\sqrt{Windspeed}) + 10.45 - (0.28*Windspeed))*(Temp_{air} - Temp_{initial})$$

where $Windspeed$=mean wind speed (km/hr), $Temp_{air}$=ambient temperature (°C), and $Temp_{initial}$=initial temperature of body (°C). The initial temperature of a crab body was assumed to be the same as the water temperature from which it was removed (~6°C).

Windchill treatments were performed in a large walk-in freezer. Temperature was recorded every minute and averaged for the duration of the treatment. A squirrel cage blower was used to generate wind speeds through a wind tunnel (44 x 38 x 239 cm) made of wood and plastic sheeting. An electronic anemometer measured wind speeds within the tunnel. To minimize aerial exposure, crabs were moved to the cold room while immersed in seawater. Crabs were placed inside the wind tunnel while confined within mesh cages (43 x 33 x 23 cm having 2.5 x 3.8 cm mesh) to insure uniformity of exposure aspect. Immediately after exposure, crabs were replaced in seawater and then returned to the lab.

Observations of mortality, limb autotomy, and the righting response were made for each numbered crab immediately after crabs are returned to the wet laboratory, again after 24 hours, and then after seven days. Mortality was determined by detection of movement of the scathognathites (gill bailers), pereopods, mandibles, and maxillae. Functional mortality, where the crab remained moribund for extended periods, was noted. Mortality was assessed daily for 7 days post-treatment and dead crabs were removed from the tanks. The righting response is a complex reflex requiring muscle coordination and balance and can be a sensitive measure of well-being of organisms (Shirley and Stickle 1982). The righting response was determined by placing the crabs on their dorsum and measuring the time in seconds (to a maximum of 300 seconds) required for the crabs to right themselves. Each crab served as its own control, as the righting response of individual crabs was measured prior to and after exposure.

Statistical analysis

Statistical methods were selected as described by Kleinbaum et al. (1998) and Zar (1996). The Statview statistical program was used to perform calculations for statistical tests. Significance was tested at an alpha value of 0.05 unless otherwise noted. A Chi-square test was used to test the significance of mortality differences among treatments and between the 2.5 minute and 5 minute exposure treatments. An unpaired t-test was used to test the significance of the differences between the mean size (measured as carapace width) for the pooled dead and alive crabs. An unpaired t-test was also used to assess the difference between the mean amount of prior damage (scars from prior injuries) for the pooled dead and alive crabs. Logistic regression was performed to develop a model to predict mortality likelihood given exposure for 5 minutes to a certain windchill value. Logistic regression is a technique for modeling dichotomous dependent variables and uses maximum likelihood to estimate model parameters (Kleinbaum et al. 1998). A logistic classification table was used to assess the correctness of the fit of the model to the observed values. The Kruskal-Wallis test was used to test significance of treatments on limb autotomy and righting response time. Dunnett's test was used to test the significance of the exposure treatments against the control treatment.

Results

Post-hoc removal of potentially impaired crabs from the data analysis

The snow crabs in the experiment were captured in the wild before being transported to the laboratory for study. Some crabs may have been injured or slightly impaired during capture and transportation. The speed of the righting response is a measure of well being, therefore crabs that had a slow initial righting response were removed from the data analysis. Any crab that did not right within 300 seconds before treatment was removed from the data analysis. The removal did not detract from the significance and only slightly affected the power of the analysis. The removal created unbalanced samples, but robust statistical analysis was still possible.

Mortality

The percentage of mortality increased with increasing windchill severity (Fig. 4). Mortality was 100% at a windchill of –16 °C (-10 °C and 8 m/s). Mortality was 80% and 40% for the –5 °C and 16 m/s and –6 °C and 8 m/s treatments respectively (Fig. 4). No mortality occurred in the two least severe treatments or the control. Mortality differences among windchill treatments were significant (chi-square test, $p<0.0001$, df=5). Size and prior damage did not affect mortality. There was no difference between the mean size (measured as carapace width) (t-test, $p=0.354$) and the mean amount of prior damage (scars from prior autotomy) (t-test, $p=0.165$) for the dead and alive crabs. Shorter exposure time reduced mortality (Fig. 4). The mortality differences between the

2.5 minute and 5 minute exposure times were significantly different (chi-square $p<0.0001$, df=1).

A logistic regression was performed to develop a model to predict the probability of mortality given exposure for 5 minutes to a certain windchill value (Fig. 5). The resulting prediction equation is:

$$pr(dead = 1) = \frac{1}{1 + \exp[-(-12.161 - 1.182 * windchill)]}$$

For example, the likelihood of death for a snow crab exposed to a windchill of –10 °C for 5 minutes is 0.415. The model predicted the likelihood of a crab being killed by exposure to a particular windchill value and is significant at an alpha value of 0.1. The model predicted whether a crab was alive or dead 83.3% correctly for the observed values.

Autotomy

Only the crabs that survived treatments were used to test significance of autotomy. Crabs that subsequently died were not included in the analysis of autotomy. The percent autotomy for each crab was calculated by dividing the total number of limbs lost after the treatment by the number of limbs the crab had before the treatment. Of the 120 specimens used in this study, none had regenerated limbs, and 56% had previous injuries (limb bud scars). Autotomy was measured as the proportion of limbs dropped. The arcsine transformation is recommended for proportion data (Zar 1996), but in this case the transformation did not generate a normal underlying distribution. Instead, a nonparametric analysis of variance, the Kruskal-Wallis test, was used to test the

hypothesis. The effect of the windchill treatments on autotomy was significant ($p=0.002$). Dunnet's test was used to test significance of the treatments against the control. One crab from the control group autotomized one limb (average autotomy for control group=0.01). The control group and the exposures of –2 x 8 m/s and –2 x 16 m/s were not significantly different from one another (Table 2). A significant difference existed among all other treatments. High variability was associated with autotomy within windchill treatments. For example, a range of 0-80% autotomy was observed at a windchill of –10.5 °C (Table 2).

The rear walking legs were dropped most frequently (Fig. 6). The 3rd and 4th walking legs accounted for 75% of all autotomy. The chelipeds were rarely autotomized.

Righting Response

Each crab's righting response was measured before and after treatment so each crab served as its own control. Only crabs that survived treatments were included in the analysis of righting response. The righting response times followed a modified Pareto distribution, that is, a skewed distribution of positive values with a long right-hand tail (Zar 1996). However, the righting response times were not measured past 300 seconds (assumption of no response past 5 minutes of no activity), which resulted in a bimodal Pareto distribution. The assumption of normality could not be met. Visual inspection of the distribution of residuals also disproved the assumption of homoscedasticity. The lack of homoscedasticity is mainly a function of the response times that are truncated at 5 minutes. Therefore, the severe treatments in which all the crabs did not right themselves

after 5 minutes had lower variances than the control and the less severe treatments. Non-parametric analysis of the change in righting response was necessary.

The Kruskal-Wallis test was used to test the effect of windchill treatment on the righting response time. The change in response times due to treatment was significantly different ($p=0.002$). Dunnett's test (used for specifically comparing controls to other treatments) (Zar 1996) did not show a significant difference between the control and the least severe windchill treatment, but a significant difference did exist between the control and the other three treatments (Table 3). The response times were either significantly slower or non-existent. Response times were also significantly slower after the 2.5 minute exposure treatments. However, there was no significant difference between the response times from the 2.5 minute exposure treatments and the 5 min exposure treatments (Table 3).

Discussion

Mortality

Mortality increased with increasing severity of treatment. The probability of mortality increased after a windchill exposure of −10.3 °C for 5 minutes; no mortality occurred at less severe exposures. Death occurred even when a snow crab was exposed for 2.5 minutes at a windchill of −10.3 °C. The rapid cooling associated with windchill may cause some failure at the cellular level. Ice crystals forming in the cytoplasm will disrupt cell membranes and cell death will occur. As heat loss approaches lethal limits,

neurons are the first cells to fail (Prosser 1991). Critical neuron failure associated with major organ systems is a probable cause of death.

Body parts with high surface area to volume ratio are probably the most susceptible to freezing damage. The appendages, eyestalks, and mouthparts could become irreversibly damaged and would cause impairment to the crab. The filamentous gills are also susceptible; injury to the gills could initiate mortality.

The mortality threshold between the two treatments of –5 x 16 m/s and –6 x 8 m/s may be due to the different windspeeds. High windspeed may increase the rate of water loss and evaporation from the gill chambers thereby increasing the potential for freezing damage to the gills.

The model described by Figure 5 explains 83.3% of the variability in the observed mortality due to windchill. The threshold response could be affected by many factors. The time of water retention in the gill chambers could have varied dependent upon the angle from which the crabs were removed from the water. Although size (measured as carapace width) and prior injuries were found to be insignificant in predicting mortality, a larger sample size controlled for these variables might have determined effects. However, the size range of snow crabs caught and discarded as bycatch is fairly narrow, so stratifying by size may not be a useful endeavor.

Mortality rates decreased when the exposure time was decreased. The length of time a crab is exposed to cold air and wind is a significant factor in predicting the mortality of the crab. The less time a crab is exposed, the less it would cool. The retention of seawater in the gill chambers may also be a factor as more water is retained

over shorter periods. Insulating seawater may lessen freezing damage to the gills. It is possible other physiological responses, e.g., impaired oxygen delivery, cause death from rapid cooling. However, oxygen demand is very low at low temperatures, so a decrease in oxygen delivery will not cause rapid death.

Autotomy

Why does autotomy, a predator escape response, result from a non-specific stressor like windchill? Autotomy of a limb initiates at the cleavage plane between the coxa and merus (Skinner 1985). Three motor neurons are used to control the anterior levator muscle, two produce normal limb movements and one is phasic with a higher activation threshold that initates autotomy (McVean 1974). The third motor neuron fires when the limb is severely damaged (McVean 1974). A cuticular stress detector that responds to distortion of the cuticle may innervate the autotomy neuron (Wales et al. 1971). Windchill exposure that results in freezing of part or the whole of a limb and the resultant cell damage may trigger the autotomy response.

Autotomy occurred at moderate to severe windchill, but was highly variable. No significant difference occurred in the amount of autotomy between the moderate and severe windchill treatments. Severe windchill treatments included death as a final response of the crabs to the treatments. Treatments that stressed a portion of the crabs to death complicated the results, as autotomy is a deliberate response that could be compromised by severe windchill. Severe windchill may damage the nerves associated with the autotomy response such that no further autotomy (or many other behaviors) is

observed. Autotomy is maximized when the windchill exposure is severe enough to trigger the synapse, but not so severe as to damage the nerves.

Autotomy resulting from windchill exposure differs from natural, predator-induced autotomy. Windchill-induced autotomy may be more severe as multiple limbs can be lost following exposure. Windchill exposure is a non-specific stressor whereas predator-induced autotomy is directed towards one or a few limbs. The stress of windchill exposure is analogous to a predator that attacks every limb at the same time. Multiple limb loss in populations of the related C. bairdi is rare (Juanes and Smith 1995). Chionoecetes opilio may not have evolved to cope with multiple autotomy.

The extent that appendage loss might affect an individual varies with the number of damaged limbs. Autotomy does not necessarily preclude survival. A shore crab, Hemigrapsus oregonensis, can survive over a year with no limbs (S. Rice, NMFS, unpublished data). However, there is probably some level of autotomy that may affect survival. Snow crabs have ten limbs: four pairs of walking legs and a pair of chelipeds. The chelipeds are presumably the most important for survival with their functions in feeding, defense, and mating (grasping of females). Chelipeds are the most commonly lost appendage in many crab species; snow crabs react in defense with chelipeds extended (B. St. Marie, pers.comm.). Chelipeds were rarely lost as a result of windchill in my experiments. The rear (4^{th}) walking leg was the most readily autotomized limb, followed by any other walking leg. The smaller diameter limbs may be more susceptible to freezing damage and autotomy. Mathematical models have demonstrated that the

limbs may cool faster and reach a lower temperature than the crab body (P. van Tamelen, ADF&G, pers. comm.).

The loss of one walking leg would be expected to have a minimal effect on crab fitness. However, the additive effects of many lost limbs and the pattern by which they are lost will affect crab fitness. Multiple autotomy occurred in some crabs exposed to windchill; up to 80% of the limbs could be lost due to severe windchill.

The rear walking legs may be important for some crab behaviors. When healthy crabs right themselves after being turned over, the most common technique involves a dorsal to ventral flip from abdomen to stern. Snow crabs with a full number of limbs use both rear (4^{th}) walking legs to first contact the substrate and initiate the flip. The 4^{th} walking legs were the most readily autotomized limbs in the experiment. However, the many different patterns of autotomy that resulted from exposure did not allow for statistical analysis. Crabs that lost more limbs were more likely to have difficulty righting. Crabs that lost only the rear legs also had difficulty righting.

Mating behaviors could be compromised by a reduced number of limbs. Behaviors observed in C. bairdi such as the ability to stand over a female, standing "high-on-legs", kicking, and body lifting (of the female above the male) (Donaldson and Adams 1989) rely on leverage and balance and may be difficult without a full complement of limbs. These behaviors are also common during antagonistic interactions with other males (Donaldson and Adams 1989). Autotomy could affect both mating behavior and competitive ability of male C. opilio. Chela loss in male shore crab Carcinus maenas reduced mating success and the ability to compete for or defend pre-moult females

(Abello et al. 1994). However, snow crabs in the windchill experiment rarely autotomized chelipeds.

Chionoecetes opilio has a behavior observed in the lab that may stem from predator avoidance. Snow crabs flare out their limbs when grasped. A predator that seizes the crab in the same fashion would be presented with a much larger effective prey size. The predator may have difficulty fitting the crab into its mouth with its limbs splayed out. A crab with fewer limbs would be easier to consume.

Autotomy may increase vulnerability in future encounters with predators. The escape speed of blue crab, Callinectes sapidus, was affected by missing limbs (Smith 1995). Furthermore, asymmetrical injuries propelled crabs in the direction of the missing limb (Smith 1995). Chela loss reduced defensive ability and increased predation of juvenile blue crabs (Smith 1995). Snow crabs react defensively when threatened with chelipeds extended (B. St. Marie pers. comm.). However, snow crabs in the windchill experiment rarely lost chelipeds.

Autotomy could reduce growth increments of snow crabs as more limbs are lost. Skinner (1985) noted the "regenerative load" where the size increase at molt was decreased by the extent of regeneration required. Multiple limb loss (4 limbs) in blue crabs, C. sapidus, resulted in significantly reduced growth, but loss of one or two limbs had no effect on growth (Smith 1990). However, snow crabs of the size caught as bycatch do not regenerate limbs. If molting occurs subsequent to autotomy, the crab will regenerate the scar on the limb bud. Autotomy in discarded snow crabs would affect

growth through indirect costs (i.e., feeding efficiency) rather than through direct costs of regeneration.

Injury rates of snow crabs aboard catcher-processors during the 1997/1998 Bering Sea snow crab fishery were assessed from 14,000 non-retained snow crabs from 394 sampled pots (Tracy and Byersdorfer 2000). Injury rates varied among vessels from 7% to 44% of crabs sampled with an average of 24% (Tracy and Byersdorfer 2000). Autotomized legs were the most prevalent injury and comprised 59% of the total injuries. Major damage (cracked carapace, bent/torn limbs, chela damage) comprised 10.9% of the total injuries (Tracy and Byersdorfer 2000). The weather conditions were not noted during the injury assessment samples. Injuries classified as major in the assessment (other than chela loss) could be considered independent of weather conditions and are mostly due to handling, antagonistic interactions, and pot crushing. Field assessment of injuries cannot distinguish between those caused by handling and those due to weather.

Bycatch autotomy in the field is likely to be underestimated. Comparison of experimental autotomy and observed injury rates in the field is difficult. The injury rate from observer data is the rate of instantaneous autotomy that occurs over the few minutes the crabs are held. Instantaneous autotomy in the laboratory study occurred, but snow crabs also autotomized limbs over 7 days of observation.

Handling mortality of red king crab (inferred from tag return rate) was not influenced by two different methods of release (Watson and Pengilly 1994). Tag return rates were not significantly different for crabs dropped off the deck of a moving vessel versus being gently placed back into the water (Watson and Pengilly 1994). However,

non-retained snow crab in the Bering Sea fishery are generally released through the vessel scuppers (Tracy and Byersdorfer 2000).

Annual pot surveys by observers on fishing vessels assess the crab condition (and hence previous injuries). If the occurrence of autotomy in discarded crabs is high, this should be evident in pot samples as these crabs are captured again the following year. However, if injury and autotomy reduce survival, then estimates of bycatch autotomy will be too small.

The snow crabs in this experiment were handled carefully after being exposed to the windchill treatments. Bycatch snow crabs are not handled as gently on a fishing vessel, and any rough handling would exacerbate autotomy.

Righting response

The righting response was impaired in all but the least severe windchill treatments. A threshold exists above a severity of exposure of –2 °C and 16 m/s (~-6 °C windchill) where the righting response is impaired.

A functional righting response depends on the unanimity of the nervous system and the musculature. The nervous system is complex and even slight damage can result in a loss of function. Loss of coordination was evident by increased righting response times after red king crabs and Tanner crabs were exposed to wind and cold (Shirley 1998, 1999). Snow crabs exposed to windchill below –6 °C have an impaired righting response. A snow crab with no righting response, in a state of chill coma, could be considered functionally dead.

The rapid cooling associated with windchill must cause some failure at the cellular level; neurons are the first cell types to fail (Prosser 1991). Critical neuron failure explains the functional death, or chill coma experienced by Tanner crabs and red king crabs at lower windchill exposures (Shirley 1998, 1999). Some red king and Tanner crabs in a state of chill coma recovered seven days post exposure (Shirley 1999). Several snow crabs with no righting response immediately after treatment in the less severe treatments recovered after seven days post exposure, suggesting the potential to recover from mild exposures. Snow crabs that survived severe to moderate windchill exposure were unlikely to recover.

Loss of mobility was evident after windchill exposure. Very little active movement was observed in crabs that survived windchill of less than –10 °C. Only 4 of 8 surviving crabs from the –6 °C and 8 m/s treatment were observed actively moving. Sporadic motion of the limbs with no net movement described the remaining survivors. All crabs in the less severe windchill treatments could actively move, even when no righting response was evident. Crabs that could move did so with jerky, uncoordinated motion of the walking legs. High "standing-on-legs" type travel was not noted. Crab movement could be described as lifting the walking legs, pushing and sliding the body across the substrate.

Impaired mobility could alter foraging efficiency, seasonal migration, and daily movement behaviors. However, little is known about movement patterns of C. opilio in the Bering Sea. A tagging and recapture experiment with C. opilio in the Gulf of St. Lawrence found that snow crabs could move up to 3 km in 48 hr (Brêthes et al. 1985).

Loss of mobility and coordination could make crabs more vulnerable to predation. Cod (Gadus morhua) have been found to prey seasonally on snow crab in the northwest Atlantic and can consume soft shell males of up to 110 mm carapace width (Robichaud et al. 1991). However, cod stomachs contained four times more lyre crab Hyas spp. than snow crab, even when snow crab densities were much higher (Robichaud et al. 1991). While cod use visual and olfactory clues to hunt, there is evidence that cod are not capable of detecting buried prey (Brawn 1969). The difference in predation rates may be explained by behavior. Snow crabs bury in sediment for protection, while lyre crab rely more on camouflage (Arnold 1968). Moreover, stomach samples from skates (which can detect buried prey) collected in the same area contained five times more snow crab than stomach samples of cod (Robichaud et al. 1991). If similar predator/prey relationships occur in the Bering Sea, high predation of discarded snow crab might be expected if discarding occurred during weather severe enough to impair the righting response. Loss of mobility and coordination could make crabs more vulnerable to predation. Heavy predation on C. bairdi and C.opilio occurs in the southeastern Bering Sea by the Alaska and Bering skates, wattled eelpout, Pacific cod, and four sculpin species (Jewett 1982).

Suggestions to mitigate the effect of windchill on bycatch

1. Closure or avoidance of areas with high incidences of bycatch. Commercial crabbers did not fish in areas with the highest abundance of small crabs in 1999. The areas of greatest fishing effort (measured as the number of pot lifts) did not coincide with

areas of greatest abundance of small male C. opilio estimated from the annual trawl survey (Mabry and Armistead 2000). Nonetheless, "hotspots" of bycatch were evident. Four survey stations (survey stations are 400 nm^2) had estimated bycatch rates of C. opilio of 103-250 per pot lift. Twenty-four stations had estimated bycatch rates of 40-103 crabs per pot lift. These areas with high bycatch rates were not particularly high in fishing effort or estimated crab abundance.

Bycatch reduction through closure of the "hotspots" is not an option. The discrepancy between crab abundance estimated from trawl survey data and the observed bycatch in the same region reflects the inability of predicting where high bycatch will occur. The spatial distribution of submarket-sized legal snow crab suggests no area closures that would reduce bycatch without significantly impacting the directed fishery (NPFMC 2000).

2. Fishery closure during lethal windchill temperatures. Closing the fishery during severe weather would decrease bycatch mortality. This already occurs to some degree when crabbers delay fishing when conditions are poor. However, regulated fishery closure due to severe weather would require daily monitoring, management, and enforcement. It is not an easily enforceable regulation and would best be served with a voluntary compliance.

3. Bycatch reduction through gear modifications. Regulations for the Bering Sea snow crab fishery already require escape rings of minimum inside diameter of 3.75

inches and escape meshes 5 inches in length when stretched. Options for future gear modifications could include increased escape ring diameter, increased number of escape rings, and placement within the pot. Escape rings placed near the bottom of the pot may not be as effective as the pot fills with crabs (Byersdorfer et al. 1997). However, crabs hesitate to escape from rings placed higher because their limbs do not touch the substrate (T. Shirley, UAF, pers. comm.). Snow crab pots are large and can contain up to 1000 crabs; small crabs may have difficulty locating the escape rings.

New gear-restriction regulations may decrease the incidence of bycatch in the upcoming 2001 snow crab fishery. The new regulations require that "a pot must have at least four 4-inch (inside diameter) rings within one mesh panel of the bottom of the pot on each of at least two sides of the pot (for a total of at least eight rings per pot) or that the pot must have at least one-half of one vertical surface composed of not less than 5 1/4 inch stretched mesh" (NPFMC 2000). The new restrictions are an improvement over the old in that the escape ring size is increased and the location of rings is specified. Previously, 75% of pots with rings as the escape mechanism had the rings placed mid-height or higher on the vertical panel (Byersdorfer et al. 1997). A minimum 4-inch ring retained male snow crab as large as the industry standard and allowed for the escape of most males below the industry standard (Byersdorfer et al. 1997). Crabbers are scheduled to use the new pot regulations in the 2001 fishery season. The bycatch estimates from the upcoming season will give an opportunity to evaluate the effectiveness of the new gear restrictions. The new gear restrictions may significantly reduce bycatch such that mortality due to windchill will be minimal.

4. Change the timing of the fishing season to coincide with milder weather. The Alaska Board of Fisheries established the winter snow crab season for several reasons. One reason was to minimize bycatch and associated handling mortality of molting and mating crabs (NPFMC 2000). Snow crabs are thought to molt and mate in early to mid summer. The winter timing of the snow crab fishery allows fishermen to work in other fisheries prior to and after the season. Market considerations are also a factor to avoid competition with the eastern Canada snow crab fishery and local crab fisheries. Also, the winter season provides a high meat recovery yield from the crabs. Any change to the timing of the fishery would require the consultation and agreement of many stakeholders.

5. Incorporate the estimated bycatch mortality in guideline harvest levels. Mortality of snow crab bycatch from the directed crab pot fishery had been estimated at 24%; this estimate was incorporated into the rebuilding plan (NPFMC 2000). Mortality rates of discarded snow crab in the field are dependent on the weather conditions at capture. There is no database of weather conditions with which to "groundtruth" the estimated bycatch mortality, the reported deadloss, and the laboratory windchill data. Coast guard buoy #46035, located 300 miles southwest of the fishing grounds, is the most reliable source of continuous weather data. Average temperature, windspeed, and windchill can be calculated over the fishing season. However, fishing effort is not constant over every day of the season. Fishing effort (measured as the number of pot pulls) increased towards the end of the season (Moore et al., 2000). The snow crab fleet

does not deliver crab on the same days, therefore some fishing days will have more effort when more of the fleet is fishing. Weather conditions on those particular days will impact more crabs than other days. If weather conditions are severe, fishing may be postponed or halted. These factors complicate accurate estimates of bycatch mortality. Nevertheless, an estimate of bycatch mortality using these parameters could be possible with more data collection. The upcoming season could be an opportunity for on-board observers to collect data on sorting practices and equipment, and on-deck weather conditions. Bycatch mortality estimates would occur at the conclusion of the fishing season. Estimates from several years would have to be analyzed to observe trends.

However, with bycatch mortality included in harvest limits, there would be no incentive for fishermen to release bycatch with any concern for survival.

6. It is ironic that the snow crab fishery itself, which catches the abundance of snow crab bycatch in the Bering Sea, is not constrained by any bycatch limits. The NPFMC could set limits on the bycatch of C. opilio using similar management as the groundfish fisheries. Other fisheries in the Bering Sea have bycatch caps. The groundfish trawl fisheries are constrained by prohibited species catch (PSC) limits for snow crab. The snow crab PSC cap is set at 0.1133% of the Bering Sea stock abundance based on annual NMFS trawl survey data, with a minimum PSC of 4.5 million crabs and a maximum of 13 million snow crabs (NPFMC 2000). Snow crabs harvested within the large sector of the Bering Sea that encompasses the "C. opilio bycatch limitation zone" are counted towards the PSC for the trawl fisheries. A trawl fishery that attains their

allotted snow crab PSC limit is prohibited from fishing within the zone. Similar bycatch limits are established for the Alaska scallop fisheries (NPFMC 2000).

7. Increased awareness of lethal and sublethal effects of exposure on bycatch through education. Ultimately, the fate of harvested snow crabs lies with the fishermen. They can choose whether or not to fish during extreme cold and severe weather. Deckhands could prioritize returning discarded crabs to the water and do so as quickly as possible. Vessel owners can outfit their boats with slides or chutes to release bycatch as opposed to cramming them into the scuppers.

Conclusions

A relationship existed between cold air and wind or windchill exposure to mortality and sublethal effects on snow crab. A progression of effects was observed from mild to severe windchill: first, a loss of coordination evident from reduced righting response time; then, limb autotomy; and finally, death.

Literature Cited

Abello, P., C.G. Warman, D.G. Reid, and E. Naylor. 1994. Chela loss in the shore crab Carcinus maenus (Crustacea:Brachyura) and its effect on mating success. Mar. Biol. 121: 247-252.

Adams, A.E. 1979. The life history of the snow crab, Chionoecetes opilio: a literature review. Univ. Alaska, Sea Grant Report. 78-13.

Arnold, A.F. 1968. The Sea-Beach At Ebb-Tide: A Guide to the Study of the Seaweeds and the Lower Animal Life Found Between Tide-Marks. Dover Publications, Inc.

Brawn, V.M. 1969. Feeding behavior of cod (Gadus morhua). J. Fish. Res. Board Can. 26: 583-596.

Brêthes, J.C., R. Bouchard, and G. Desrosiers. 1985. Determination of the area prospected by a baited trap from a tagging and recapture experiment with snow crabs (Chionoecetes opilio). J. Northw. Atl. Fish. Sci. 6: 37-42.

Byersdorfer, S.D., D. Pengilly, and D. Tracy. 1997. A survey of escape mechanisms and ring placements on commercial crab pots fished during the 1997 Bering Sea snow crab, Chionoecetes opilio, season. Alaska Department of Fish and Game, Division of Commercial Fisheries, Regional Information Report No. 4k97-45, Kodiak.

Carls, M.G. and C.E. O'Clair. 1990. Influence of cold air exposures on ovigerous red king crabs (Paralithodes camtschatica) and Tanner crabs (Chionoecetes bairdi) and their offspring. Proc. Int. Symp. King and Tanner Crabs, Alaska Sea Grant College Program, AK-SG-90-04. Pp. 329-343.

Carls, M.G. and C.E. O'Clair. 1995. Responses of Tanner crabs, Chionoecetes bairdi, exposed to cold air. Fish. Bull. 93: 44-56.

Court, A. 1948. Windchill. Bull. Amer. Meterology. C. 29: 487-493.

Donaldson, W.E. and A. Adams. 1989. Ethogram of behavior with emphasis on mating for the Tanner crab Chionoecetes bairdi Rathburn. J. Crustacean Biol. 9: 37-53.

Foyle, T.P., R.K. O'Dor, and R.W. Elner. 1989. Energetically defining the thermal limits of the snow crab. J. Exp. Biol. 143: 371-393.

Garth, J.S. 1958. Brachyura of the Pacific Coast of America. Oxyrhyncha. Allan Hancock Pacific Expedition 21 (1&2): 854 pp.

Hardy, D., J. Munro, and J.D. Dutil. 1994. Temperature and salinity tolerance of the soft-shell and hard-shell male snow crab, Chionoecetes opilio. Aquaculture 122: 249-265.

Incze, L.S., D.A. Armstrong, and D.L. Wencker. 1982. Rates of development and growth of larvae of Chionoecetes bairdi and C. opilio in the southeastern Bering Sea. Pp. 191-219 in Proceedings of the International Symposium on the Genus Chionoecetes. University of Alaska, Alaska Sea Grant Report No. 82-10.

Jadamec, L.K., W.E. Donaldson, and P. Cullenberg. 1999. Biological field techniques for Chionoecetes crabs. University of Alaska Sea Grant College Program. AK-SG-99-02.

Jewett, S.C. 1982. Predation on crabs of the genus Chionoecetes: literature review. Pp. 521-539 in Proceedings of the International Symposium on the Genus Chionoecetes. University of Alaska, Alaska Sea Grant Report No. 82-10.

Juanes, F. and L. D. Smith. 1995. The ecological consequences of limb damage and loss in decapod crustaceans: a review and prospectus. J. Exp. Mar. Ecol. 193: 197-223.

Kleinbaum, D.G., L. L. Kupper, and K.E. Muller. 1998. Applied regression analysis and other multivariable methods: 3rd edition. Duxbury Press, Pacific Grove, California. Pg 656-686.

Mabry, K. and C. Armistead. 2000. Stock and bycatch distribution of King and Tanner crab in the Bering Sea, 1999. In: Stock Assessment and Fishery Evaluation Report for the King and Tanner Crab Fisheries of the Bering Sea and Aleutian Islands Regions. North Pacific Fishery Management Council, 605 W. 4th Ave, #306, Anchorage, Ak, 99501.

MacIntosh, R.A., B.G. Stevens, J.A. Haaga, and B.A. Johnson. 1996. Effects of handling and discarding mortality of Tanner crabs (Chionoecetes bairdi). High Latitude Crabs: Biology, Management, and Economics. Alaska Sea College Program, AK-SG-96-02. Pp. 591-611.

McLeese, D.W. 1968. Temperature resistance of the spider crab Chionoecetes opilio. J. Fish. Res. Bd. Canada 25 (8): 1733-1736.

McVean, A. 1973. The nervous control of autotomy in Carcinus maenas. J. Exp. Biol. 60: 423-436.

Meyers, T.R., T. M. Koeneman, C. Botelho, and S. Short. 1987. Bitter crab disease: a fatal dinoflagellate infection and marketing problem for Alaskan Tanner crabs Chionoecetes bairdi. Dis. Aquat. Org. 33: 195-216.

Miller, R. J. and J. Watson. 1976. Growth per molt and limb regeneration in the spider crab, Chionoecetes opilio. J. Fish. Res. Board. Can. 33: 1644-1649.

Moore, H., L.C. Byrne, and D. Connoly. 2000. Alaska Department of Fish and Game summary of the 1998 mandatory shellfish observer program database. Regional Information Report No. 4K00-21. Alaska Department of Fish and Game, Division of Commercial Fisheries, Kodiak, Alaska.

North Pacific Fishery Management Council (NPFMC). 2000. Amendment 14 to the Fishery Management Plan: a rebuilding plan for the Bering Sea C. opilio stock. Sustainable Fisheries Division, Alaska Region, NMFS, P.O. Box 21668, Juneau, AK, 99802.

NPFMC. 1999. Environmental Assessment/Regulatory Impact Review/Initial Regulatory Flexibility analysis for Amendment 11 to the FMP for the Bering Sea and Aleutian Islands King and Tanner crabs. North Pacific Fishery Management Council, 605 W. 4th Ave, #306, Anchorage, Ak, 99501.

Parker, S.P., editor. 1987. Meteorology Source Book. McGraw-Hill, Inc. Pp. 214-227.

Paul, A.J., editor. 2000. Bibiliography of research on snow crab (Chionoecetes opilio). University of Alaska Sea Grant College Program, AK-SG-00-01.

Prosser, C.L. 1991. Environmental and Metabolic Animal Physiology. John Wiley & Sons, Inc. Pp. 115-130.

Robichaud, D.A., R.W. Elner, and R.F.J. Bailey. 1991. Differential selection of crab Chionoecetes opilio and Hyas spp. as prey by sympatric cod Gadus morhua and thorny skate Raja radiata. Fishery Bulletin 89 (4): 669-679.

Shirley, T.C. 1999. Appendix B: Effects of windchill on red king crabs. Eds. G.H. Kruse. King and Tanner Crab Research In Alaska: Annual Report for July 1, 1998 Through June 30, 1999. Regional Information Report No. 5J99-10.

Shirley, T.C. 1998. Appendix D: Crab handling mortality and bycatch reduction. Eds. G.H. Kruse. King and Tanner crab Research in Alaska: Annual Report for July 1, 1997 to June 30, 1998. Regional Information Report No. 5J98-07.

Shirley, T.C., and W.B. Stickle. 1982. Responses of Leptasterias hexactis (Echinodermata: Asteroidea) to low salinity. I. Survival, activity, feeding, growth and absorption efficiency. Mar. Biol. 169: 147-154.

Skinner, D. M. 1985. Molting and regeneration. Pp.43-146 in Biology of Crustacea, vol. 9. Edited by D. E. Bliss & L. H. Mantel, Academic Press, New York.

Smith, L. D. 1995. Effects of limb autotomy and tethering on juvenile blue crab survival from cannibalism. Mar. Ecol. Prog. Ser. 116: 65-74.

Smith, L.D. 1990. Patterns of limb loss in the blue crab, Callinectes sapidus Rathbun, and the effects of autotomy on growth. Bul. Mar. Sci. 46(1): 23-36.

Stevens, B.G., J.A. Haaga, R.A. MacIntosh, R.S. Otto, and L. Rugulo. 2000. Report to industry on the 2000 Eastern Bering Sea Crab Survey. Processed Report 2000-07. Alaska Fisheries Science Center, Kodiak, Alaska.

Tracy, D and S. C. Byersdorfer. 2000. Summary of crab injury assessment and aerial exposure sample results from selected 1997/1998 Bering Sea/Aleutian Islands King and Tanner crab fisheries and the 1998 Pribilof Islands hair crab fishery.

Regional Information Report No. 4K00-52. Alaska Department of Fish and Game, Division of Commercial Fisheries, Kodiak, Alaska.

Wales, W., F. Clarac, and M.S. Laverack. 1971. Stress detection at the autotomy plane in the decapod Crustacea-I. Comparative anatomy of the receptors of the basi-ischiopodite. Z. Vergl. Physiol. 73: 357-382.

Warrenchuk, J.J. 2001. Estimates of mortality and sublethal effects due to windchill of snow crab discarded during the Bering Sea Fishery. M.S. Thesis, University of Alaska Fairbanks.

Watson, L.J., and D. Pengilly. 1994. Effects of release method on recovery rates of tagged red king crabs (Paralithodes camtschaticus) in the 1993 Bristol Bay commercial fishery. Alaska Department of Fish and Game, Commercial Fisheries Management and Development Division, Regional Information Report 4K94-40.

Witherell, D. 2000. BSAI crab bycatch. In: Crab Plan Team. Stock Assessment and Fishery Evaluation Report for the King and Tanner Crab Fisheries of the Bering Sea and Aleutian Islands Regions. North Pacific Fishery Management Council, 605 W. 4th Ave, #306, Anchorage, Ak, 99501.

Zar, J.H. 1996. Biostatistical Analysis. 649 pp. Prentice-Hall, Inc., Upper Saddle River, New Jersey.

Zhou, S. and T.C. Shirley. 1995. Effects of handling on feeding, activity, and survival of red king crabs, Paralithodes camtschaticus (Tilesius, 1815). J. Shellfish Research 14(1): 173-177.

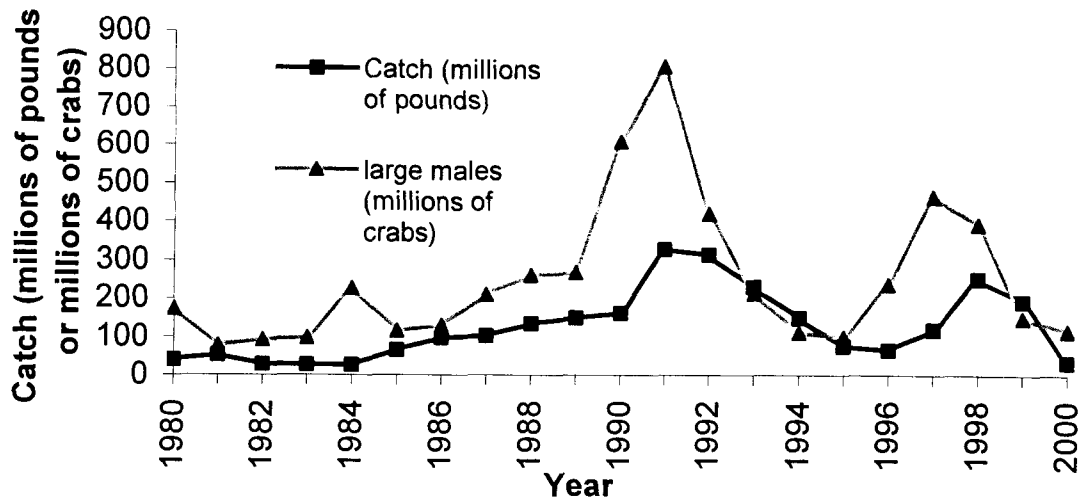


Figure 1. Harvests of Bering Sea snow crab, including deadloss, and estimated exploitable stock of large male crabs 1980-2000.[1]

(1) Modified from Stevens et al., 2000.

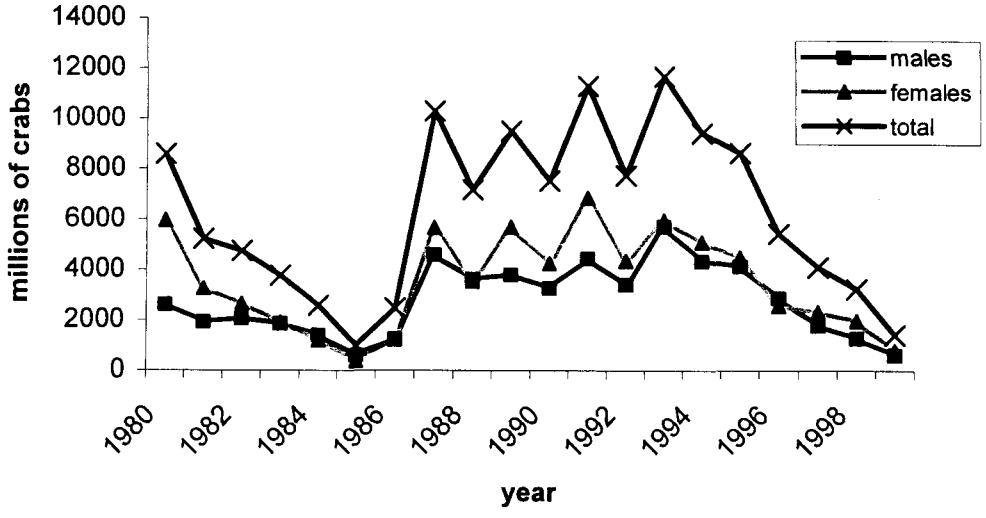


Figure 2. Abundance of Bering Sea snow crabs from NMFS trawl survey, 1980-2000.[1]

(1) Modified from Stevens et al., 2000.

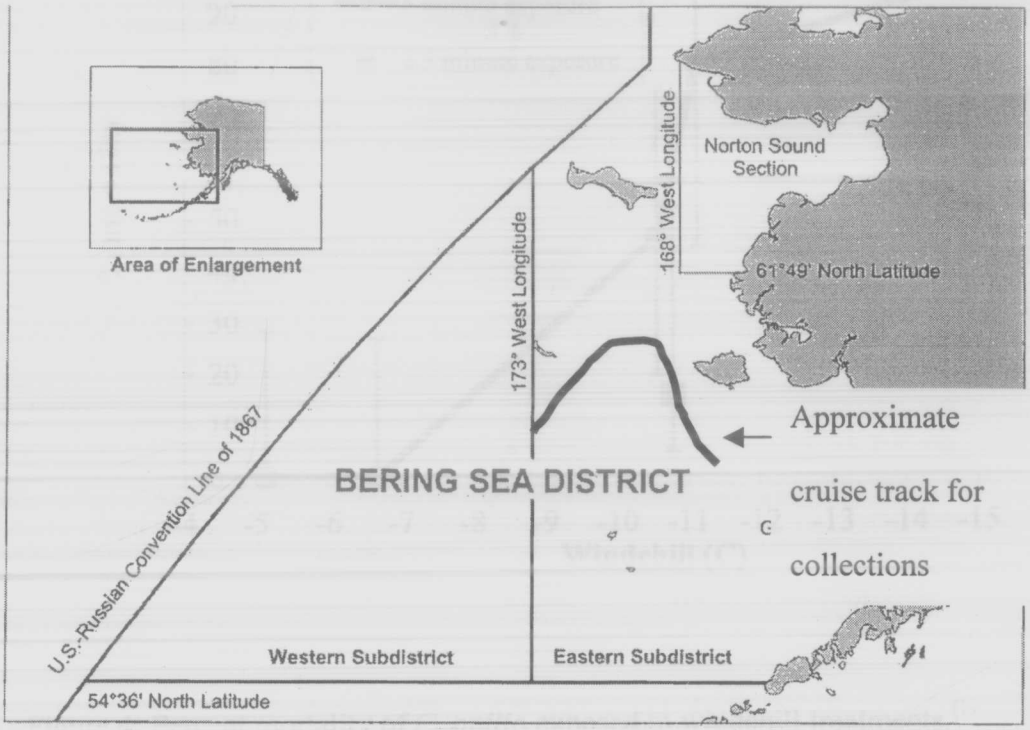


Figure 3: Collection site for snow crab used in the experiment.

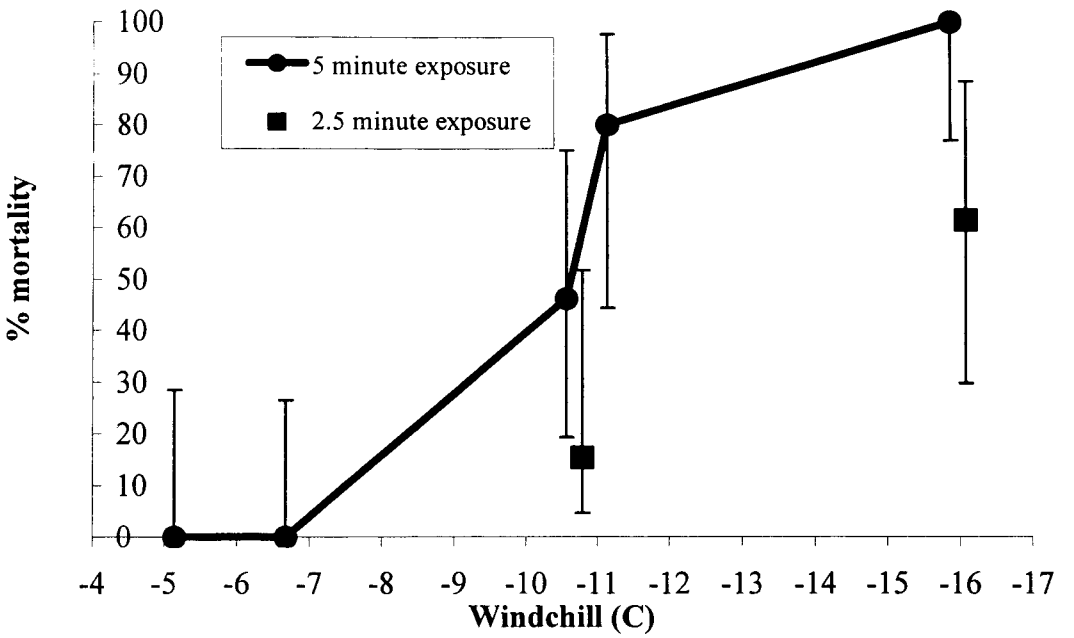


Figure 4: Percent mortality of *C. opilio* exposed to windchill treatments.(1)

(1) Error bars show 95% confidence limits.

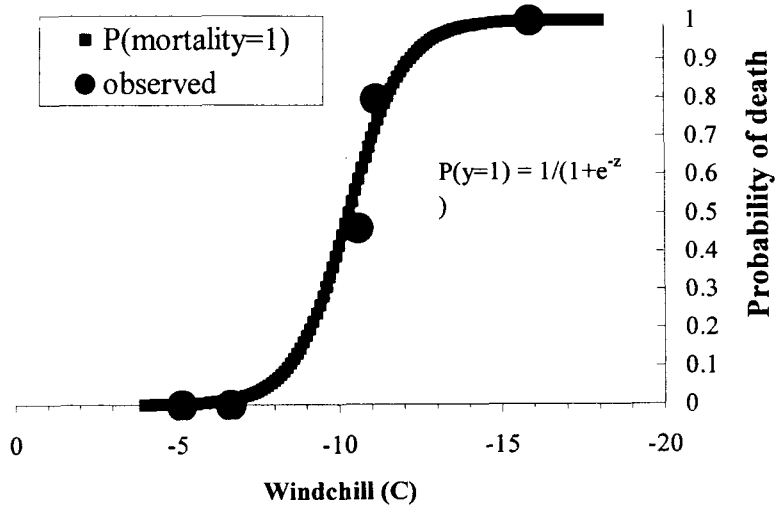
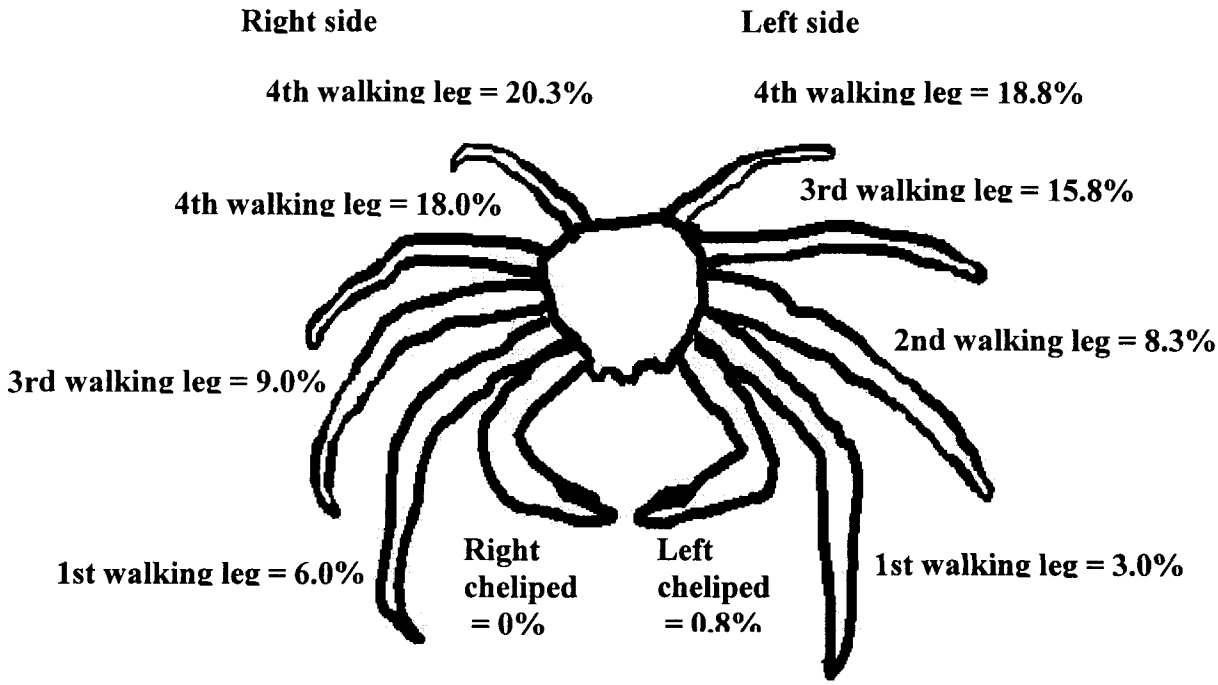


Figure 5: Probability of mortality of *C. opilio* with 5 minute exposure

Figure 6: Frequency of types of limbs lost by C. opilio, all treatments combined.[1]



(1) Results are pooled for all crabs (n=120) with 133 limbs lost in total. Note that not all the crabs had a full complement of limbs prior to initiation of the experiment

Table 1: Bycatch of *C. opilio* in Bering Sea fisheries, 1994-1999 and estimated abundance of small males (thousands of crabs)

Year	Directed crab pot	Groundfish trawl, fixed gear, scallop dredge	Bycatch total	Abundance of small male opilio (<4")	Bycatch as % of small males
1994	53,083	12,517	65,600	4,282,500	1.53
1995	48,734	5,396	54,130	4,086,800	1.33
1996	56,571	4,016	60,587	2,700,100	2.24
1997	75,005	6,026	81,031	1,490,800	5.44
1998	51,591	4,905	56,496	1,014,700	5.57
1999	41,666	1,965	43,631	517,000	8.44

Table 2: Autotomy by *C. opilio* following exposure to windchill treatments

Treatment	Dunnett's Test (% autotomy)			Avg. autotomy (%)	Min autotomy (%)	Max autotomy (%)	n
	Mean diff (1)	Crit diff	Significant autotomy?				
control	0	N/A	no	0.01	0	0.1	10
-2 °C x 8 m/s	-0.028	0.141	no	0	0	0	11
-2 °C x 16 m/s	0.032	0.144	no	0.4	0	5.0	12
-6 °C x 8 m/s	0.634	0.165	yes	38.9	10	89	7
-5 °C x 16 m/s	0.740	0.237	yes	66	50	82	2
-10 °C x 8 m/s	N/A	N/A	N/A	N/A	N/A	N/A	0
-5 °C x 16 m/s (2.5 min)	0.344	0.321	yes	14.6	0	84	13
-10 °C x 8 m/s (2.5 min)	0.359	0.256	yes	24.2	0	50	5

(1) Mean diff is the average difference between the autotomy of crabs in the control treatment and the exposure treatment.

Table 3: Change in righting response of *C. opilio* following exposure to windchill treatments

Windchill (°C)	Treatment	Righting response after 7 days (s) (Dunnett's test)		
		Mean diff.[1] (s)	Critical diff. (s)	Significant?
-5.14	-2 °C x 8 m/s	37.2	110.3	No
-6.67	-2 °C x 16 m/s	184.1	107.8	Yes
-10.5	-6 °C x 8 m/s	279.3	126.2	Yes
-11.2	-5 °C x 16 m/s	291.1	204.5	Yes
-15.8	-10 °C x 8 m/s	N/A, all crabs dead		
-16.1	-10°C x 8 m/s (2.5 min)	263.4	122.3	Yes
-10.8	-5°C x 16 m/s (2.5 min)	124.6	91.1	Yes

(1) Mean diff is the average difference between the righting response times of the crabs in the control treatment and the exposure treatment.

Chapter 2: Estimates of mortality of snow crab, Chionoecetes opilio, discarded during the Bering Sea fishery in 1998.[2]

Abstract

The mortality of discarded bycatch snow crab was estimated for the 1998 Bering Sea snow crab fishery. Estimates of bycatch mortality were calculated from deadloss of retained crab, a windchill model of mortality from laboratory results, and a model that predicted mortality from temperature and wind exposure. The 1998 season was used because it had the most complete set of data. No relationship existed between the deadloss reported in the delivered catch and the windchill conditions when the crabs were caught. Mortality of non-retained snow crab was estimated at 3.6% by the windchill model and 19.6% by the temperature/windspeed model.

(2) Warrenchuk, J. J. and T. C. Shirley. Estimates of mortality of snow crab, Chionoecetes opilio, discarded during the Bering Sea fishery in 1998. Prepared for submission in Alaska Fishery Research Bulletin.

Acknowledgments

I thank Sue Engle and Rance Morrison from the Alaska Department of Fish & Game, Dutch Harbor for supplying the database of catch data. Dr. Tom Shirley provided insight and guidance. I also thank Dr. Terrance J. Quinn II and Dr. Sherry Tamone for review of the manuscript. Funded by Alaska Dept. of Fish. & Game under Cooperative Agreement NA97FN0129 from the National Oceanic and Atmospheric Administration (NOAA). The views expressed are those of the author and do not necessarily reflect the views of NOAA or any of its sub-agencies.

Introduction

The snow crab, Chionoecetes opilio, is the one of the most economically important crustaceans in Alaska. The sustainability of the Bering Sea snow crab fishery has been of recent concern following substantial decreases in the allowable harvest. The fishery was termed "overfished" in 1999 when the stock fell below the minimum stock size threshold (NPFMC 1999). Population estimates indicated the stock was near historical low abundance in 1999 (Stevens et al. 2000).

Tens of millions of snow crabs are sorted and discarded each year during the Alaskan snow crab fishery. Snow crab bycatch includes sublegal males (<78 mm) and all females that are returned to the sea; crabs deemed unmarketable such as very old shell males, injured crabs, and small males (78-101 mm carapace width) are also sorted and discarded.

Other fisheries in the Bering Sea catch snow crabs as bycatch. Groundfish trawl fisheries caught over four million snow crab in 1998 (NPFMC 1999). The long exposure time during sorting, the crushing loads associated with trawl bycatch, and the severity of Bering Sea weather conditions likely result in low survival of snow crab bycatch. Tanner crabs, C. bairdi, captured by Bering Sea sole trawlers in late summer, had overall survival of 22% after two days of shipboard observation in seawater holding tanks (Stevens 1990). Immediate and delayed mortality of snow crab captured incidentally by trawl fisheries was estimated at 80% (NPFMC 1999). The weathervane scallop fishery captured 232 thousand snow crab in 1998; immediate and delayed mortality had been estimated at 40% (NPFMC 1999).

Bycatch of snow crabs also occurs in the St. Matthew blue king crab fishery, the Korean hair crab fishery, the Bristol Bay red king crab fishery, and the BSAI Tanner crab fishery. In 1998, approximately 120 thousand snow crabs were caught as bycatch in these other crab fisheries (NPFMC 1999).

While snow crabs are incidentally caught in many fisheries in the Bering Sea, the snow crab fishery itself accounts for most of the bycatch. Between 1994 to 1999, bycatch due to the snow crab fishery ranged from 40 million to 75 million crabs (NPFMC 1999). The majority of snow crab bycatch are small, legal-sized males. The legal size and marketable size of snow crab differ: crabs in the size range between legal size (79 mm CW) and marketable size (102 mm CW) are discarded. The legal, sub-marketable crabs constitute the largest bycatch component. Female snow crabs are estimated to account for less than 1% of the snow crab bycatch. Sublegal male snow crabs (<79 mm

carapace width) are estimated to account for 2% or less of the total bycatch (NPFMC 2000).

Handling of bycatch crabs in pot fisheries is not a major source of mortality, except under unusual circumstances (Stevens 1996). The typical conditions of the Bering Sea snow crab fishery include severe weather and sea conditions, which are unusual circumstances encountered in other crab fisheries. Snow crabs caught and released during the Bering Sea fishery are potentially exposed to severe windchill conditions that may result in mortality (Chapter 1). The Bering Sea snow crab fishery is unique; no other crab fishery in the world subjects millions of crabs to more extreme windchill conditions.

The objective of this study was to estimate the number of snow crab that may die during the Bering Sea snow crab fishery when discarded as bycatch. Several factors that may contribute to mortality were evaluated. Exposure to cold temperatures and wind could be a significant contributor to mortality. The 1998 season was used because it had the most complete set of data. Bycatch mortality due to exposure had not been previously estimated for Bering Sea snow crab.

Mortality

One possible reason that may contribute to the decline of the population is mortality that is unaccounted for in the guideline harvest levels. A portion of this mortality could be due to the stress experienced as crabs are brought in as part of the bycatch. The Bering Sea fishery occurs during the winter months and very severe weather conditions. Laboratory studies on snow crabs (Chapter 1) and the related Tanner crabs,

Chionoecetes bairdi, (Shirley 1998) have found that exposure to a matrix of cold air and wind (=windchill) causes acute mortality.

Bycatch estimate

How many crabs are discarded as bycatch? The total catch of retained crab is fairly precise measurement as the data are examined by at least two stakeholders involved. The fishermen want to get paid for every crab they bring in to the processors, and the processors will only pay for the exact number of crab delivered. A similar system of checks and balances does not exist for the total bycatch since the crabs are returned to the sea. The total bycatch must be estimated from sample data.

Methods

A database of the catches for each vessel during each fishing trip was obtained from ADF&G in Dutch Harbor. The database contained 100% of the data for catches of the open access fishery. Confidential interviews with vessel captains in 1998 provided information on the total catch of retained crab, the total number of pots pulled and the fishing location. This information is considered more accurate than information obtained from fish tickets (Moore et al. 2000). The actual catch per pot was calculated by dividing the total catch by the total number of pots pulled. The catch per pot is considered the catch per unit effort (CPUE), with one pot set and its retrieval an effort unit of crab fishing.

Tens of millions of snow crabs are estimated as being discarded as bycatch each year. The total bycatch estimate is computed from a catch per pot (CPUE) estimate

derived from pot lifts sampled by observers. Observers on at-sea catcher/processors sample random crab pots and count all crabs caught. In 1998, observers sampled 2,132 pots and enumerated the target and non-target catch from those pots (Moore et al. 2000). The counts included all male crabs retained, legal-sized male crabs discarded, sublegal sized male crabs, female crabs, and non-target crabs of different species. A CPUE was estimated for each type of crab catch. The total number of pots selected for bycatch sampling accounted for less than one percent of the 891,268 pot lifts reported by vessel operators during the 1998 open-access season.

The CPUE for retained male crab estimated from the sample data differs from the actual (observed) CPUE from the vessel interviews. For the past several years, the estimated fishery CPUE has underestimated the actual fishery CPUE (Moore et al. 2000). If the total catch of retained crabs is underestimated, then the catches of non-target crabs may be underestimated as well.

A possible reason for the underestimate is that the estimated catch and CPUE of retained crabs do not include hybrid crabs that were retained. Snow crabs can hybridize with Tanner crabs, Chionoecetes bairdi. The hybrid progeny are characterized by a suite of characters that range between snow crab and Tanner crab morphology. Alaska Department of Fish and Game regulations legally distinguish between hybrids, C. opilio, and C. bairdi.

Regulations state that any crab: "...with both eyes completely red in color and the margin of the upper lip (labrum) notched at two points with angular V-shaped cuts forming an "M" shape is considered to be a C. bairdi Tanner crab' (Alaska

Administrative Code, 5 ACC 35.521(a)) and '..hybrid Tanner crab that does not conform to that description is considered to be a C. opilio (snow) Tanner crab' (Alaska Administrative Code, 5 ACC 35.521(c)). Fishermen can legally retain hybrids but must release C. bairdi Tanner crab during the snow crab fishery. Deckhands must quickly sort the retained crab from the non-retained crab. Hybrid crabs are only cursorily examined and if they fit the legal definition they are retained. The retained hybrids are placed in the hold with all other retained crabs. Processors do not distinguish between pedigreed snow crab and hybrids. Therefore, the observed catch includes all the retained hybrid snow crabs. On the other hand, observers differentiate hybrid snow crab during pot sampling (and may be more skilled at detecting hybrids). The total hybrid crab catch and CPUE is estimated from the sample data.

If the estimated hybrid catch is added to the estimated catch of retained crabs, then the difference from the actual catch is reduced. Nevertheless, the total catch remained underestimated and an underestimation factor was calculated:

$$\hat{\theta}_{uf} = \hat{CPUE}_{(actual\ retained\ catch)} / \left(\hat{CPUE}_{(est.retained)} + \hat{CPUE}_{(est.hybrid)}\right)$$

The CPUE estimate for non-retained legal crab and the estimated CPUE for sublegal crab were added to give an estimated total bycatch CPUE. The bycatch CPUE estimate was then scaled by the underestimation factor:

$$\hat{CPUE}_{(scaled\ bycatch)} = \hat{\theta}_{uf} * \hat{CPUE}_{(est.bycatch)}$$

To preserve the variance of the individual fishing trips, the ratio of the estimated (scaled) CPUE bycatch to the actual CPUE of the total catch was used to estimate the bycatch caught during each trip:

$$\hat{bycatch}_{(trip\ i)} = \left(\hat{CPUE}_{(scaled\ bycatch)} / CPUE_{(actual\ total\ catch)}\right) * catch_{(trip\ i)}$$

Rather than the number of crabs caught per pot being held constant, the ratio of retained/non-retained crabs was held constant. Indeed, the number of crabs caught in each pot haul is not constant; "hotspots" are encountered where catches are high, and poor catches in other areas are just as likely (Mabry and Armistead 2000). The total bycatch estimated for the open-access fishery in 1998 was approximately 57.5 million crabs (± 1 SE of 1.7 million). The data are summarized in Table 1.

Weather conditions and windchill

Weather buoy # 46035 at (56.9 N 177.8 W) in the Bering Sea is the only marine source of continuous weather data 300 miles of the fishing grounds (Fig. 1). The buoy collects hourly measurements of air temperature, sea temperature, and windspeed; the database is available online at the National Buoy Weather Center website (National Buoy Weather Center, http://seaboard.ndbc.noaa.gov).

Unfortunately, weather buoy #46035 in the Bering Sea was partially out of service in 1999 and did not record windspeed for most of the year. In 2000, the buoy underwent repairs and was out of service for most of the season. A complete data set of weather conditions was only available for 1998. The 1998 Bering Sea snow crab open-access season lasted 76 days, from January 11 to March 27, 1998. The weather during

the 1998 season was fairly representative of past years (Table 2). The average windspeed during the 1998 season was close to the long-term average (Table 2). The air temperature and windchill during the 1998 snow crab season were slightly colder when compared to past years (Table 2).

The average daily temperature, windspeed, and sea temperature from the buoy data was calculated directly for each of the 76 days of the fishery. The average daily windspeed and air temperature over the fishing season is shown in Figure 2. The average daily windchill is displayed in Figure 3. However, different days have different intensities of fishing. That is, many boats would be fishing on the same days and the weather during those days of intense fishing would affect more overall crabs. The average weather during each trip may be more reflective of the conditions to which a crab is exposed.

The data from fish tickets included the start date and the delivery date of each fishing trip during the season. The weather conditions for each trip were determined by referencing the buoy weather database and averaging the daily temperature, windspeed, and windchill values over the course of the trip.

Deadloss

The 'deadloss' is recorded for each vessel delivery to the processors and can be retrieved from the database of fish tickets. The deadloss is the number of snow crabs that are delivered dead or close to death. The number of retained crabs that died could potentially reflect the number of discarded crabs that died (Witherell 2000). Retained crabs are subject to the same weather conditions as discarded crab so any relationship

between windchill and mortality would be evident in the deadloss of the catch. However, deadloss is also caused by factors other than windchill. Equipment failure (e.g. failure of seawater pumps and resultant poor circulation) can cause high deadloss (F. Bowers, ADF&G, pers. comm.). The deadloss delivered to processors accounted for 2.3 million crabs or 1.2% of the total catch in 1998. If a relationship between windchill and deadloss existed, then deadloss could serve as a predictor of the equivalent bycatch mortality. If deadloss is assumed to be representative of bycatch mortality, then 1.2% of non-retained crabs (estimated 703 thousand crabs) died in 1998.

Windchill model estimate of mortality

Mortality of snow crab increases with severity of windchill exposure in the lab (Chapter 1). The relationship between windchill and mortality derived in the laboratory was applied to estimates of bycatch caught per trip and the average windchill over that trip. The total number of discarded crabs that died as a result of windchill exposure was then estimated.

The windchill was calculated using the National Weather Service formula (Parker 1987):

$$Temp_{windchill} = Temp_{initial} + 0.045*[(5.27*\sqrt{Windspeed}) + 10.45 - (0.28*Windspeed)]*(Temp_{air} - Temp_{initial})$$

where Windspeed=mean wind speed (km/hr), $Temp_{air}$=ambient temperature (°C), and $Temp_{initial}$=initial temperature of body (°C).

The initial temperature of a crab body was assumed to be the same as the water temperature from which it was removed. Daily sea temperature measurements were used for the initial crab temperature.

A model derived from a laboratory experiment predicted the probability of death given exposure to a certain windchill value (Chapter 1). The following expression is a logistic model of mortality given windchill exposure:

$$pr(death) = \frac{1}{1 + \exp[-(\alpha - \beta * windchill)]}$$

The parameters in the windchill model were derived using maximum likelihood estimators to fit to the experimental data. The estimate of α was –12.161 (± 1 SE of 5.700) and was significantly different from 0 (p=0.033). The estimate of β was 1.182 (± 1 SE of 0.538) and was significantly different from 0 (p=0.028). The variable "windchill" is the windchill in degrees Celsius calculated from the summary function (Parker 1985) of windspeed, air temperature, and initial temperature. The model predicted 83% of the observed mortality in the laboratory experiment and was significant at an alpha of 0.1 (Chapter 1).

Temperature and windspeed model estimate of mortality

The windchill summary function may not be the best descriptor of the cooling effect on snow crabs. The windchill equation was derived from cooling effects on exposed human flesh with baseline conditions of a moderate breeze (Court 1945). Low windspeed values in the windchill equation result in windchill values warmer than the ambient temperature. A comparison model was developed that used the temperature and

windspeed (without summarizing into a windchill equation) as predictors of mortality. Temperature was expressed in degrees Celsius and windspeed in meters per second. A logistic regression was performed to develop a model that predicted mortality likelihood given exposure for 5 minutes to both cold temperatures and wind:

$$pr(death) = \frac{1}{1 + \exp[-(\alpha - \beta * temperature + \delta * windspeed)]}$$

All parameters were derived from maximum likelihood estimators fitted to the experimental data. The estimate of α was -14.672 ($\pm$ 5.663) and was significantly different from 0 ($p=0.091$); the temperature modifying parameter β was estimated to be 1.837 ($\pm$ 0.732) and was significantly different from 0 ($p=0.012$); and the windspeed-modifying parameter δ was estimated at 0.446 ($\pm$ 1 SE of 0.179) and was significantly different from 0 ($p=0.013$). The model that used temperature and windspeed to predict mortality fit the observed mortality better than the windchill model. The parameters for the two variable model are significant at an alpha value of 0.05 level versus alpha of 0.1 for the windchill model (Chapter 1). The temperature and windspeed model also predicted mortality 82% correctly for the observed mortality in the experiment versus 83% correctly for the windchill model. Both models are compared graphically in Figure 4. The temperature/windspeed model has a steeper slope; probability of death increases rapidly (Fig.4). The contribution of windspeed in the windchill model is less, and lower temperatures are necessary before probability of death increases (Fig. 5).

Results

Windchill as predictor of deadloss

No relationship existed between deadloss and the windchill conditions during the trips. The deadloss from every trip (N=1645) was plotted with the average windchill over that trip and there appeared to be no relationship (Fig. 4). The database included a few outliers where the deadloss was as high as 30% of the catch. High deadloss is likely associated with equipment failure (i.e., water pumps, circulation system) in the holding tanks (F. Bowers, ADF&G, pers. comm.). Since a relationship between windchill and deadloss could not be determined, deadloss probably does not reflect equivalent bycatch mortality. The estimate of 1.2% bycatch mortality derived from deadloss is thus circumspect.

Mortality estimate with windchill model

The windchill/mortality model derived from the laboratory data was used to estimate the total mortality of the snow crab bycatch in 1998. The mortality due to windchill in 1998 was estimated at 3.9% of the total bycatch, or 2.26 million crabs (± 0.76 million) (Table 3). The estimated number of crabs that died per trip ranged from 0 to 85 thousand crabs. Most fishing trips (84% of trips) resulted in mortality of less than 1000 discarded crabs. Only 2% of trips had mortality of over 20,000 crabs.

Mortality estimate with temperature/windspeed model

The two-variable temperature/windspeed model derived from the laboratory data was used to estimate the total mortality of snow crab bycatch. In 1998, the number of non-retained snow crabs that died solely as a result of exposure to wind and cold was

estimated to be 11.29 million crabs (± 1.16 million) (Table 3). The dead crabs accounted for 19.6% of the estimated bycatch (Table 3). The estimated number of crabs that died per trip ranged from 0 to 113 thousand crabs. The two-variable model resulted in higher bycatch mortality distributed over a greater range of conditions. The number of fishing trips with mortality of less than 1000 crabs (54% of trips) was lower and more trips had high mortality of more than 20,000 crabs (14% of trips).

Discussion

Deadloss

Retained crab mortality (evidenced by deadloss) is circumspect as a predictor of bycatch mortality. No relationship existed between windchill and deadloss. Since a relationship between windchill and mortality was clearly observed in the lab (Chapter 1), retained crabs may not be subject to the same level of stress as bycatch crabs. Bycatch crabs are exposed longer than retained crabs as most crews prioritize sorting retained crabs (Tracy and Byersdorfer 2000). Retained crabs are dropped only a short distance directly into the holding tanks. Non-retained crabs may be thrown over the side of the vessel or swept along the deck into scuppers (Tracy and Byersdorfer 2000) which may result in rougher and more prolonged handling.

Non-retained crabs are smaller and may lose heat quicker than retained crabs. Smaller crabs have a greater surface area to volume ratio and less thermal mass (Shirley 1999). Smaller, juvenile Tanner crabs were more sensitive to cold aerial exposure than

larger adults (Carls and O'Clair 1995). Adult Tanner crabs were more sensitive to exposure than larger red king crabs (Carls and O'Clair 1990).

Models

The mortality of crabs estimated from the windchill model was 3.6%, but this value may not be pragmatic. A discrepancy may lie with the windchill calculation from the field weather data versus windchill calculated in the lab. The sea temperature (and hence the initial body temperature of the crabs) averaged 2.3 °C over the fishing season. The laboratory windchill calculations assumed initial body temperature of 6 °C, the water temperature the crabs had acclimated to in the flow-through tanks. Hence, the apparent windchill will be different for crabs acclimatized to water at 2.3 °C and 6 °C. The laboratory-derived model predicts mortality based on the apparent windchill experienced by a crab at 6 °C. Perhaps a better model would use temperature and windspeed as separate variables predicting mortality as opposed to the windchill function. The windchill model is limited because similar windchill values can result from different combinations of windspeed and temperature. For example, a high windspeed with a warmer temperature or a low windspeed with a colder temperature could both result in the same windchill value. The physiological responses of crabs exposed to similar windchill values that are calculated from different combinations of windspeed and temperature may be quite different. Greater windspeed could cause increased cooling of limbs with high surface area or increased evaporation of water from the gill chambers. The contribution of windspeed to the mortality probability is low in the windchill model

(Fig. 5). Windspeed has a much greater contribution to the mortality probability in the temperature/windspeed model, particularly at warmer temperatures (Fig. 4).

The two-variable temperature/windspeed model estimated snow crab bycatch mortality to be 19.6%. The estimated bycatch mortality is conservative if compared to actual bycatch mortality in the field. The mortality due to exposure is only one component of the total mortality. Snow crabs are also killed during handling (Tracy and Byersdorfer 2000). However, experiments on Tanner crab, C. bairdi, suggested that handling alone did not cause significant mortality (MacIntosh et al. 1996). Furthermore, multiple handling in the laboratory did not affect survival of red king crab, Paralithodes camtshaticus (Zhou and Shirley 1995). Severe exposure and rough handling are likely synergistic. The windchill mortality estimates derived from the laboratory relationship assume gentle handling of the crabs.

Injury rates of snow crabs aboard catcher-processors during the 1998 Bering Sea snow crab fishery were assessed from 14,000 non-retained snow crabs from 394 sampled pots (Tracy and Byersdorfer 2000). Injury rates varied among vessels from 7% to 44% of crabs sampled with an average of 24% (Tracy and Byersdorfer 2000). Autotomized legs were the most prevalent injury and comprised 59% of the total injuries. Major damage (cracked carapace, bent/torn limbs, chela damage) comprised 10.9% of the total injuries (Tracy and Byersdorfer 2000). The weather conditions were not noted during the injury assessment samples. Injuries classified as major in the assessment (other than chela loss) could be considered independent of weather conditions and are mostly due to handling, antagonistic interactions, and pot crushing. The major injuries could lead to massive

hemolymph loss and likely result in death of the crab. Therefore at least 10.9% of 24% (or 2.6%) of discarded crabs likely die as a result of handling. Unfortunately, standard errors could not be calculated for these estimators.

The total bycatch mortality estimate could include the estimate of mortality due to wind and cold exposure (19.6% of crabs) added to the mortality due to major injuries from handling (2.6% of crabs). The estimate of 22.2% mortality is still conservative, as it does not take into account the synergistic effect of handling with wind and cold exposure.

The mortality estimates only account for the direct mortality resulting from the catch and release process. Sublethal effects, such as autotomy and reduced activity also result after exposure (Chapter 1). The reduced fitness of crabs from the sublethal effects of catch and release may also affect mortality. Reduction in growth, foraging efficiency, movement, mating success and increased vulnerability to predation and intraspecific competition are potential future costs of autotomy and reduced activity.

Utility of bycatch mortality estimate

The bycatch mortality estimates could be used to refine stock-recruitment predictions for Bering Sea snow crab. Unfortunately, stock-recruitment models have not been implemented for management of crab fisheries. While some progress towards length-based recruitment models for Tanner crab (Zheng and Kruse 1998, 2000) and snow crab (Zheng, pers. comm.) have been made, neither have been implemented in management. Guideline harvest limits for snow crab are set every year based on data collected from annual trawl surveys.

The North Pacific Fishery Management Council was responsible for developing a rebuilding plan for the Bering Sea snow crab stock (NPFMC 1999). Mortality estimates were incorporated into rebuilding scenarios under different management strategies (NPFMC 1999). A rebuilding plan that incorporated an assumed 25% bycatch mortality was implemented. New guideline harvest levels based on a sliding scale relative to crab abundance were implemented in 2000.

The estimate of 22.2% bycatch mortality is close to the 25% assumed in the rebuilding plan (NPFMC 1999). It is unlikely that rebuilding would be affected by implementing a 22.2% bycatch mortality estimate instead of the 25% estimate. Nevertheless, this study has validated the bycatch mortality assumption in the rebuilding plan, because the rates are not significantly different.

Literature cited

Alaska Administrative Code. 5 ACC 35.521 (a). Lieutenant Governor's Office, P.O. AA, Juneau, Alaska 99811.

Alaska Administrative Code. 5 ACC 35.521 (c). Lieutenant Governor's Office, P.O. AA, Juneau, Alaska 99811.

Carls, M.G. and C.E. O'Clair. 1990. Influence of cold air exposures on ovigerous red king crabs (Paralithodes camtschatica) and Tanner crabs (Chionoecetes bairdi) and their offspring. Proc. Int. Symp. King and Tanner Crabs, Alaska Sea Grant College Program, AK-SG-90-04. Pp. 329-343.

Carls, M.G. and C.E. O'Clair. 1995. Responses of Tanner crabs, Chionoecetes bairdi, exposed to cold air. Fish. Bull. 93: 44-56.

Court, A. 1948. Windchill. Bull. Amer. Meterology. C. 29: 487-493.

Mabry, K. and C. Armistead. 2000. Stock and bycatch distribution of King and Tanner crab in the Bering Sea, 1999. In: Stock Assessment and Fishery Evaluation Report for the King and Tanner Crab Fisheries of the Bering Sea and Aleutian Islands Regions. North Pacific Fishery Management Council, 605 W. 4th Ave, #306, Anchorage, Ak, 99501.

MacIntosh, R.A., B.G. Stevens, J.A. Haaga, and B.A. Johnson. 1996. Effects of handling and discarding mortality of Tanner crabs (Chionoecetes bairdi). High Latitude Crabs: Biology, Management, and Economics. Alaska Sea College Program, AK-SG-96-02. Pp. 591-611.

Moore, H., L.C. Byrne, and D. Connoly. 2000. Alaska Department of Fish and Game summary of the 1998 mandatory shellfish observer program database. Regional Information Report No. 4K00-21. Alaska Department of Fish and Game, Division of Commercial Fisheries, Kodiak, Alaska.

North Pacific Fishery Management Council (NPFMC). 2000. Amendment 14 to the Fishery Management Plan: a rebuilding plan for the Bering Sea C. opilio stock. Sustainable Fisheries Division, Alaska Region, NMFS, P.O. Box 21668, Juneau, AK, 99802.

North Pacific Fishery Management Council (NPFMC). 1999. Environmental Assessment/Regulatory Impact Review/Initial Regulatory Flexibility analysis for Amendment 11 to the FMP for the Bering Sea and Aleutian Islands King and Tanner crabs. North Pacific Fishery Management Council, 605 W. 4th Ave, #306, Anchorage, Ak, 99501.

Parker, S.P., editor. 1987. Meteorology Source Book. McGraw-Hill, Inc. Pp. 214-227.

Shirley, T.C. 1998. Appendix D: Crab handling mortality and bycatch reduction. Eds. G.H. Kruse. King and Tanner crab Research in Alaska: Annual Report for July 1, 1997 to June 30, 1998. Regional Information Report No. 5J98-07.

Stevens, B.G. 1990. Survival of king and Tanner crabs captured by commercial sole trawls. Fish. Bull. 88(4): 731-744.

Stevens, B.G. 1996. Crab bycatch in pot fisheries: causes and solutions. In: Solving Bycatch: considerations for today and tomorrow. Alaska Sea Grant College Program Report No. 96-03, University of Alaska Fairbanks, pp. 151-158.

Tracy, D and S. C. Byersdorfer. 2000. Summary of crab injury assessment and aerial exposure sample results from selected 1997/1998 Bering Sea/Aleutian Islands King and Tanner crab fisheries and the 1998 Pribilof Islands hair crab fishery. Regional Information Report No. 4K00-52. Alaska Department of Fish and Game, Division of Commercial Fisheries, Kodiak, Alaska.

Warrenchuk, J.J. 2001. The effects of wind and cold air exposure on the snow crab, Chionoecetes opilio. M.S. thesis, University of Alaska Fairbanks.

Witherell, D. 2000. BSAI Crab Bycatch. In: Stock Assessment and Fishery Evaluation Report for the King and Tanner Crab Fisheries of the Bering Sea and Aleutian Islands Regions. North Pacific Fishery Management Council, 605 W. 4th Ave, #306, Anchorage, Ak, 99501.

Zheng, J. and G. H. Kruse. 1998. Stock-recruitment relationships for Bristol Bay Tanner crab. Alaska Fishery Research Bulletin 5(2): 116-130.

Zheng, J. and G. H. Kruse. 2000. Rebuilding probabilities under alternative management strategies for Eastern Bering Sea Tanner crabs. Alaska Fishery Research Bulletin 7: 1-10.

Zhou, S. and T.C. Shirley. 1995. Effects of handling on feeding, activity, and survival of red king crabs, Paralithodes camtschaticus (Tilesius, 1815). J. Shellfish Research 14(1): 173-177.

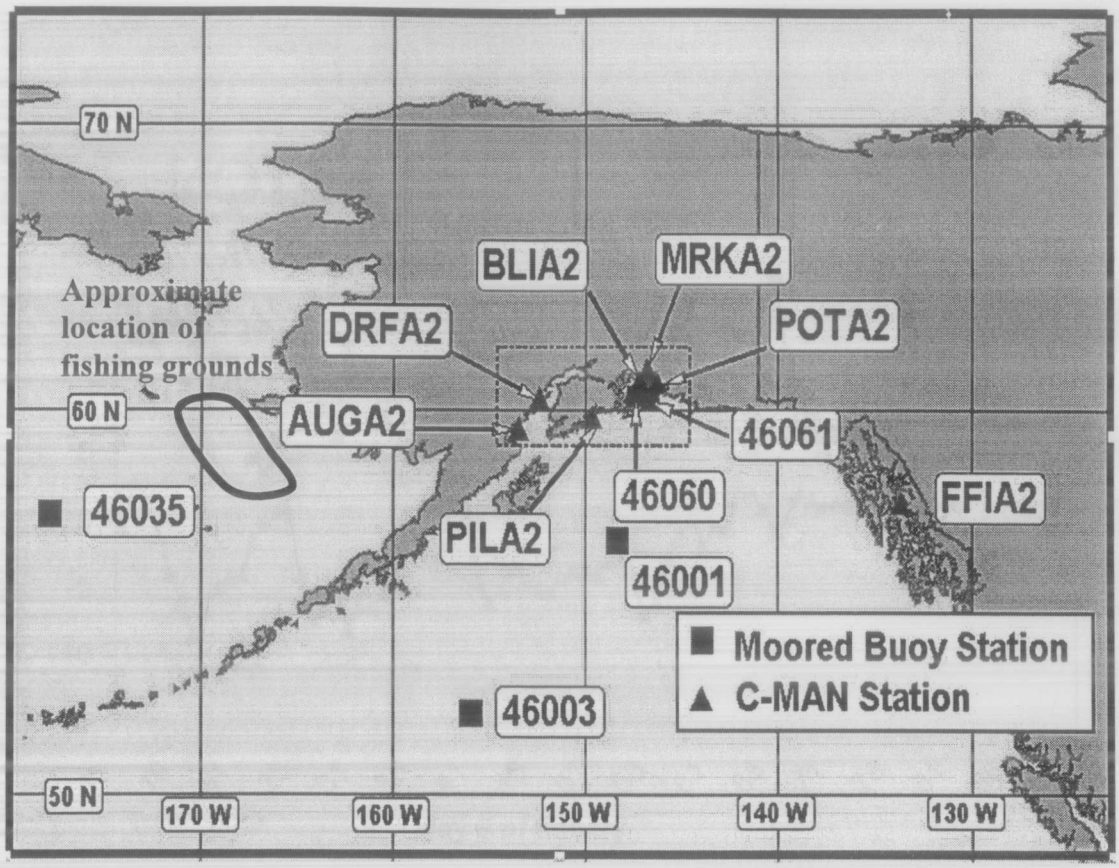


Figure 1: Location of weather buoy #46035, source of weather data during the 1998 Bering Sea snow crab fishery.

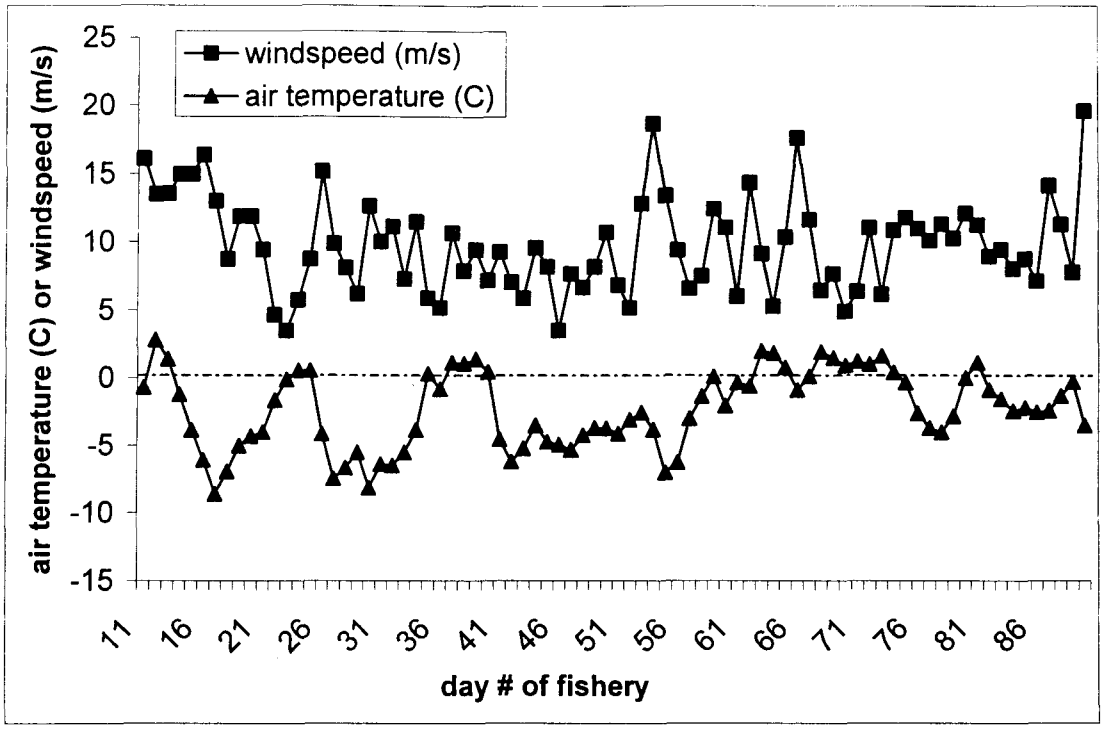


Figure 2: Daily air temperature and windspeed measured by buoy #46035 during the 1998 Bering Sea snow crab fishery. [1]

(1) The open access season lasted from January 11 to March 27.

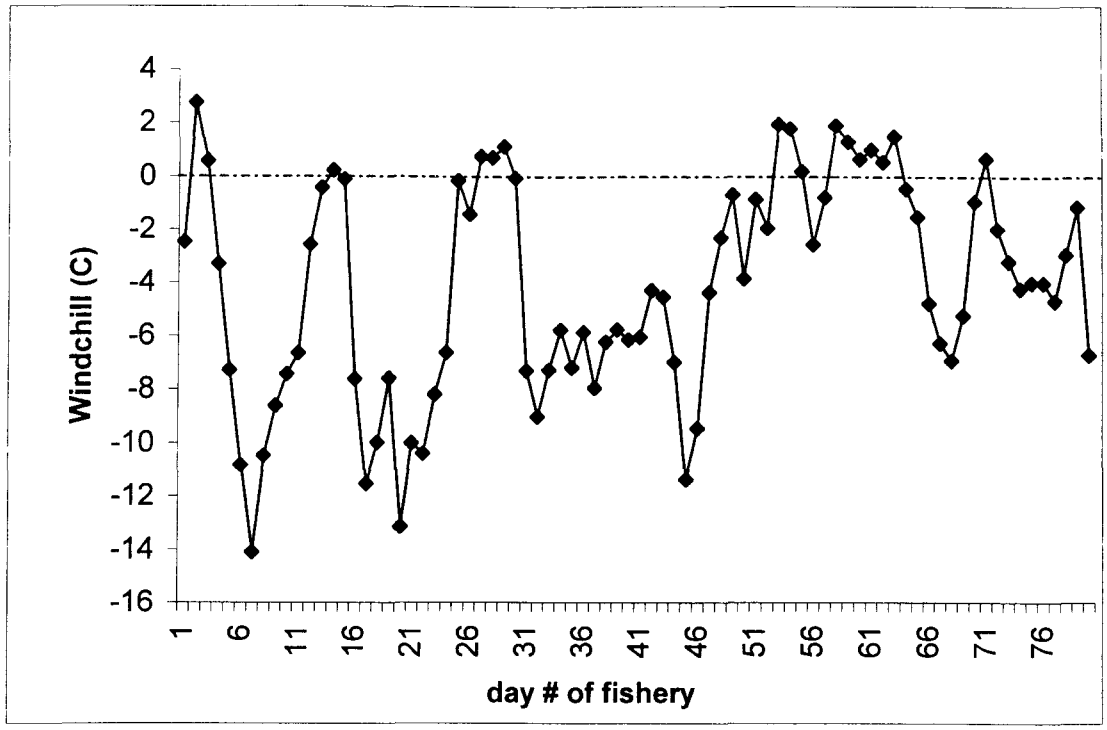


Figure 3: Daily windchill calculated from weather data measured by buoy #46035 during the 1998 Bering Sea snow crab fishery. [1]

(1) The open access season lasted from January 11 to March 27.

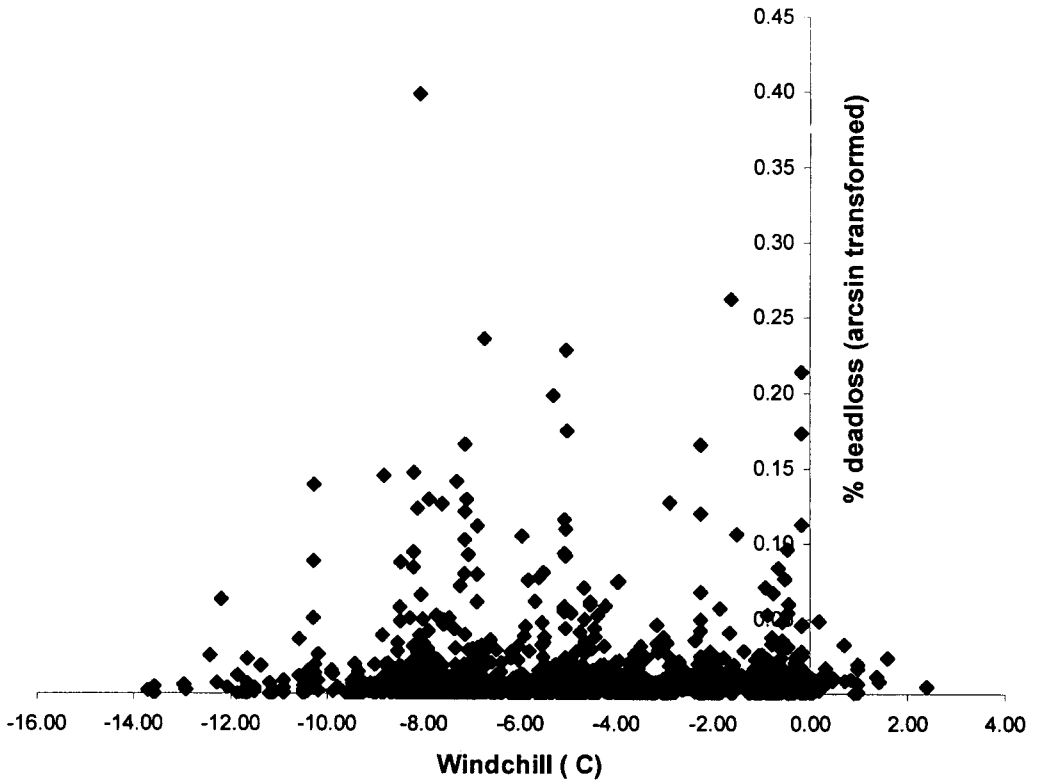


Figure 4: The deadloss of delivered total catch versus the windchill condition during each fishing trip for the Bering Sea snow crab fishery in 1998.

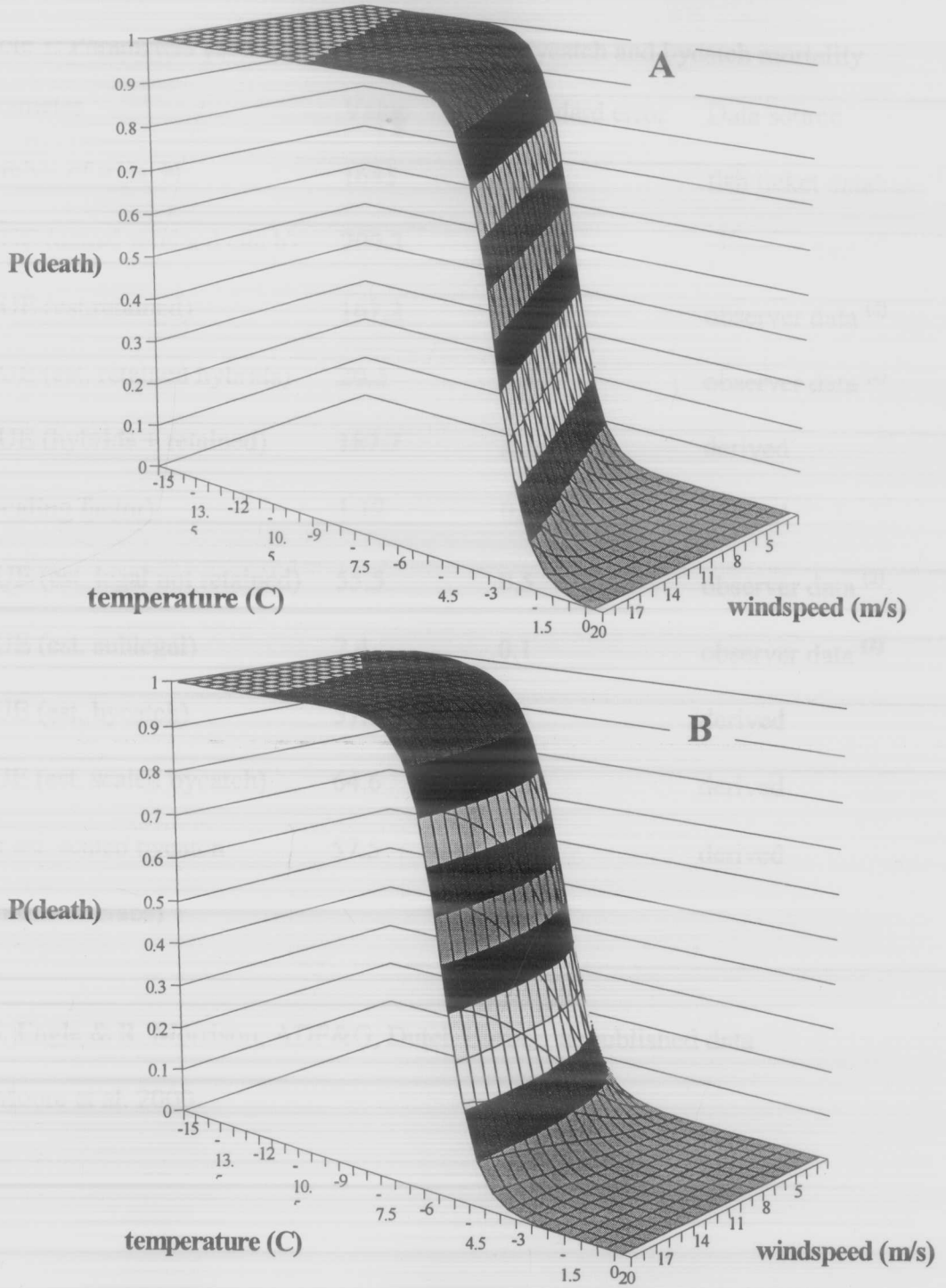


Figure 5: Comparison of the (A) temp/windspeed model and the (B) windchill model at similar combinations of windspeed and temperature for predicting probability of mortality. Shaded bands indicate increments of 0.1 mortality probability.

Table 1: Parameters used in calculations of total bycatch and bycatch mortality

Parameter	Value	Standard error	Data source
Number of trips, N	1645		fish ticket database [1]
CPUE (actual retained catch)	209.3		observer data [2]
CPUE (est.retained)	167.2	2.0	observer data [2]
CPUE (est. retained hybrids)	20.5	0.6	observer data [2]
CPUE (hybrids + retained)	187.7	2.1	derived
θ (scaling factor)	1.12	0.01	derived
CPUE (est. legal not retained)	55.5	0.5	observer data [2]
CPUE (est. sublegal)	2.4	0.1	observer data [2]
CPUE (est. bycatch)	57.9	0.5	derived
CPUE (est. scaled bycatch)	64.6	0.8	derived
total est. scaled bycatch (millions of crabs)	57.5	1.7	derived

(1) S. Engle & R. Morrison, ADF&G, Dutch Harbor, unpublished data

(2) Moore et al. 2000

Table 2: Comparison of the average temperature, windspeed, and windchill for the 1998 season by month to the eight-year average from 1985 to 1993.(1)

	Temperature (°C)		Windspeed (m/s)		Windchill (°C)	
Month	1985-1993	1998	1985-1993	1998	1985-1993	1998
January	-1.3	-3.6	9.7	10.9	-2.9	-6.3
February	-1.2	-3.2	9.5	9.0	-2.7	-5.4
March	-0.9	-0.6	9.3	10.0	-2.2	-1.9

(1) Data from weather buoy #46035 (modified from the National Data Buoy Center, http://seaboard.ndbc.noaa.gov, 2000).

Appendix 1. Crab measurements, exposure treatments, and record of responses

	Size (mm)			Treatment				Righting response (s)			Autotomy (lost limb=1, additive			Mortality (a=alive, d=dead)		
crab#	length	width	claw ht	temp (C)	wspd (m/s)	time (min)	windchill (C)	before	after	7day	pre-dmg	post-dmg	% loss	day 0	day 1	day 7
1709	106.9	108	27.2	control	control	0	control	300.0	82.6	226.1	2.0	0.0	0.0%	a	a	a
1741	108	106	27.8	control	control	0	control	95.4	108.8	1.6	2.0	0.0	0.0%	a	a	a
1743	106.8	105	27.1	control	control	0	control	21.6	51.4	5.7	0.0	0.0	0.0%	a	a	a
1769	103.6	104	26.2	control	control	0	control	300.0	94.9	300.0	1.0	0.0	0.0%	a	a	a
1759	101.5	104	25.3	control	control	0	control	5.7	330.5	4.4	1.0	0.0	0.0%	a	a	a
1704	99.6	101	25	control	control	0	control	9.8	51.6	300.0	0.0	0.0	0.0%	a	a	a
1788	98.2	99.8	24.7	control	control	0	control	6.8	197.7	300.0	2.0	0.0	0.0%	a	a	a
1886	111.5	111	30.4	control	control	0	control	26.1	52.8	28.4	2.0	0.0	0.0%	a	a	a
1778	95.9	98.2	24	control	control	0	control	5.6	129.6	14.8	2.0	1.0	12.5%	a	a	a
1701	97.5	93.2	23	control	control	0	control	26.8	300.0	3.0	1.0	0.0	0.0%	a	a	a
1705	93.2	92	23.7	control	control	0	control	8.0	140.4	2.8	1.0	0.0	0.0%	a	a	a
1742	86.7	88.5	21.2	control	control	0	control	1.6	204.7	17.9	0.0	0.0	0.0%	a	a	a
1702	86.2	86.2	20.8	control	control	0	control	190.9	300.0	93.7	0.5	0.0	0.0%	a	a	a
1779	82.4	82.9	21.2	control	control	0	control	34.5	74.1	1.9	0.0	0.0	0.0%	a	a	a
1858	95.1	94.2	23.7	control	control	0	control	4.1	190.5	5.8	0.0	0.0	0.0%	a	a	a
1837	99.9	101	27	-10.2	8	2.5	-16.4	2.8	300.0	d	1.0	1.0	11.1%	a	d	d
1807	95.3	91.3	23.3	-10.2	8	2.5	-16.4	111.7	300.0	d	2.0	1.0	12.5%	a	d	d
1869	81	82.7	18.7	-10.2	8	2.5	-16.4	21.2	300.0	d	0.0	5.0	50.0%	a	d	d
1875	102.7	110	27.4	-10.1	8	2.5	-16.2	300.0	300.0	300.0	2.0	0.0	0.0%	a	a	a
1898	102.3	102	25.3	-10.1	8	2.5	-16.2	300.0	300.0	d	1.0	1.0	11.1%	a	d	d
1733	90.8	92.2	23.7	-10.1	8	2.5	-16.2	4.9	300.0	300.0	1.0	2.0	22.2%	a	a	a
1865	105.6	104	23.3	-10.1	8	2.5	-16.1	3.9	300.0	d	1.0	2.0	22.2%	a	a	d
1826	91.4	89.6	22.5	-10.1	8	2.5	-16.1	70.8	300.0	d	1.0	1.0	11.1%	a	a	d
1831	81.5	78.2	18.6	-10.1	8	2.5	-16.1	5.9	300.0	300.0	0.0	5.0	50.0%	a	a	a

Appendix 1. (continued)

	Size (mm)			Treatment				Righting response (s)			Autotomy (lost limb=1, additive			Mortality (a=alive, d=dead)		
crab#	length	width	claw ht	temp (C)	wspd (m/s)	time (min)	windchill (C)	before	after	7day	pre-dmg	post-dmg	% loss	day 0	day 1	day 7
1835	99.2	101	20	-2.1	8	5	-5.2	263.5	10.7	6.3	2.0	0.0	0.0%	a	a	a
1818	95	95	21.5	-2.1	8	5	-5.2	5.6	8.4	300.0	0.0	0.0	0.0%	a	a	a
1891	92.7	90.8	23.9	-2.1	8	5	-5.2	7.8	118.1	4.7	2.5	0.0	0.0%	a	a	a
1873	97.2	96.8	25.5	-2.0	8	5	-5.0	7.3	300.0	9.8	1.0	0.0	0.0%	a	a	a
1850	92.5	92.1	22.5	-2.0	8	5	-5.0	300.0	300.0	300.0	0.5	0.0	0.0%	a	a	a
1735	77.9	79.5	19.7	-2.0	8	5	-5.0	300.0	300.0	127.1	1.0	0.0	0.0%	a	a	a
1782	107.3	104	27.9	-2.0	16	5	-6.3	300.0	300.0	299.0	0.0	0.0	0.0%	a	a	a
1827	104	104	29.9	-2.0	16	5	-6.3	6.1	300.0	300.0	0.0	0.0	0.0%	a	a	a
1774	90.3	92.8	23.6	-2.0	16	5	-6.3	92.5	300.0	41.5	0.0	0.0	0.0%	a	a	a
1855	96.7	95.5	24.9	-1.9	8	5	-4.9	48.0	241.6	79.3	1.0	0.0	0.0%	a	a	a
1801	87.4	85.7	21.8	-1.9	8	5	-4.9	300.0	300.0	300.0	0.0	0.0	0.0%	a	a	a
1839	98	98.8	24.9	-1.9	8	5	-4.9	12.5	15.2	124.1	4.0	0.0	0.0%	a	a	a
1748	99.7	98.5	22	-1.8	16	5	-6.1	124.6	300.0	300.0	2.0	0.0	0.0%	a	a	a
1703	97.4	97.8	24.7	-1.8	16	5	-6.1	11.9	300.0	5.1	1.0	0.0	0.0%	a	a	a
1751	97.1	96.3	23.9	-1.8	16	5	-6.1	15.9	300.0	300.0	1.0	0.0	0.0%	a	a	a
1770	108.8	109	29.1	-1.8	16	5	-6.1	5.9	300.0	300.0	0.0	0.0	0.0%	a	a	a
1870	82	83.5	20.1	-1.8	16	5	-6.1	7.9	300.0	276.3	0.0	0.0	0.0%	a	a	a
1841	77	77.1	19.9	-1.8	16	5	-6.1	28.9	300.0	179.0	0.0	0.0	0.0%	a	a	a
1832	101.6	104	27.8	-1.8	8	5	-4.8	300.0	300.0	300.0	1.5	0.0	0.0%	a	a	a
1811	99.4	97.4	24.5	-1.8	8	5	-4.8	9.5	17.1	20.1	1.0	0.0	0.0%	a	a	a
1893	95.9	94.5	24.8	-1.8	8	5	-4.8	44.3	300.0	59.3	0.0	0.0	0.0%	a	a	a
1728	106.5	108	21.4	-1.7	16	5	-5.9	8.9	300.0	17.4	0.0	0.0	0.0%	a	a	a
1739	102.9	104	25.9	-1.7	16	5	-5.9	300.0	300.0	17.4	1.0	0.0	0.0%	a	a	a
1789	99	102	24.3	-1.7	16	5	-5.9	11.8	24.3	300.0	0.0	0.0	0.0%	a	a	a

Appendix 1. (continued)

	Size (mm)			Treatment				Righting response (s)			Autotomy (lost limb=1, additive			Mortality (a=alive, d=dead)		
crab#	length	width	claw ht	temp (C)	wspd (m/s)	time (min)	windchill (C)	before	after	7day	pre-dmg	post-dmg	% loss	day 0	day 1	day 7
1887	96.6	97.7	23.5	-10.0	8	5	-16.1	4.1	300.0	d	0.0	0.0	0.0%	a	a	d
1761	85.1	84.6	21	-10.0	8	5	-16.1	4.1	300.0	d	0.0	0.0	0.0%	a	d	d
1796	71.4	72.2	17.4	-10.0	8	5	-16.1	300.0	300.0	d	3.0	0.0	0.0%	a	d	d
1847	105.2	107	28.4	-9.8	8	5	-15.8	86.3	300.0	d	1.0	4.0	44.4%	a	d	d
1838	104.3	104	27.7	-9.8	8	5	-15.8	74.2	300.0	d	2.0	0.0	0.0%	a	d	d
1896	99.7	98.6	24	-9.8	8	5	-15.8	33.9	300.0	d	2.5	2.0	26.7%	a	d	d
1843	95.2	95	23.3	-9.8	8	5	-15.8	5.0	300.0	d	1.0	1.0	11.1%	a	d	d
1830	89.8	90	22.7	-9.8	8	5	-15.8	74.2	300.0	d	2.0	0.0	0.0%	a	d	d
1889	87.1	88.3	21	-9.8	8	5	-15.8	2.4	300.0	d	0.0	1.0	10.0%	a	d	d
1861	99.2	104	26	-9.5	8	5	-15.4	5.6	300.0	d	0.0	3.0	30.0%	a	d	d
1846	100.7	101	25.6	-9.5	8	5	-15.4	57.1	300.0	d	1.0	3.0	33.3%	a	d	d
1892	94.2	95.5	23.9	-9.5	8	5	-15.4	13.1	300.0	d	0.0	0.0	0.0%	a	d	d
1727	105.8	108	26.7	-6.2	8	5	-10.8	23.9	300.0	d	1.0	0.0	0.0%	a	a	d
1866	88	88.9	20.6	-6.2	8	5	-10.8	300.0	300.0	300.0	3.0	1.0	14.3%	a	a	a
1849	76	76	17.6	-6.2	8	5	-10.8	2.7	300.0	300.0	1.0	7.0	77.8%	a	a	a
1776	100.2	100	26.1	-6.1	8	5	-10.7	2.5	300.0	300.0	0.0	1.0	10.0%	a	a	a
1747	96.4	96.7	21.9	-6.1	8	5	-10.7	2.3	300.0	300.0	0.0	2.0	20.0%	a	a	a
1813	76.7	77.8	18.4	-6.1	8	5	-10.7	44.6	300.0	300.0	1.0	7.0	77.8%	a	a	a
1786	104.6	105	28.5	-6.0	8	5	-10.6	3.0	300.0	d	0.0	2.0	20.0%	a	a	d
1791	102.5	103	26.5	-6.0	8	5	-10.6	300.0	300.0	300.0	0.0	0.0	0.0%	a	a	a
1764	99.8	100	25	-6.0	8	5	-10.6	8.3	300.0	300.0	0.0	2.0	20.0%	a	a	a
1746	98.2	98	24.5	-6.0	8	5	-10.6	26.0	300.0	300.0	1.0	4.0	44.4%	a	a	a
1834	92.4	91.8	22.8	-6.0	8	5	-10.6	6.1	300.0	d	1.0	0.0	0.0%	a	a	d
1859	82.5	83.2	19.1	-6.0	8	5	-10.6	111.0	300.0	d	0.0	1.0	10.0%	a	d	d

Appendix 1. (continued)

	Size (mm)			Treatment				Righting response (s)			Autotomy (lost limb=1, additive			Mortality (a=alive, d=dead)		
crab#	length	width	claw ht	temp (C)	wspd (m/s)	time (min)	windchill (C)	before	after	7day	pre-dmg	post-dmg	% loss	day 0	day 1	day 7
1835	99.2	101	20	-2.1	8	5	-5.2	263.5	10.7	6.3	2.0	0.0	0.0%	a	a	a
1818	95	95	21.5	-2.1	8	5	-5.2	5.6	8.4	300.0	0.0	0.0	0.0%	a	a	a
1891	92.7	90.8	23.9	-2.1	8	5	-5.2	7.8	118.1	4.7	2.5	0.0	0.0%	a	a	a
1873	97.2	96.8	25.5	-2.0	8	5	-5.0	7.3	300.0	9.8	1.0	0.0	0.0%	a	a	a
1850	92.5	92.1	22.5	-2.0	8	5	-5.0	300.0	300.0	300.0	0.5	0.0	0.0%	a	a	a
1735	77.9	79.5	19.7	-2.0	8	5	-5.0	300.0	300.0	127.1	1.0	0.0	0.0%	a	a	a
1782	107.3	104	27.9	-2.0	16	5	-6.3	300.0	300.0	299.0	0.0	0.0	0.0%	a	a	a
1827	104	104	29.9	-2.0	16	5	-6.3	6.1	300.0	300.0	0.0	0.0	0.0%	a	a	a
1774	90.3	92.8	23.6	-2.0	16	5	-6.3	92.5	300.0	41.5	0.0	0.0	0.0%	a	a	a
1855	96.7	95.5	24.9	-1.9	8	5	-4.9	48.0	241.6	79.3	1.0	0.0	0.0%	a	a	a
1801	87.4	85.7	21.8	-1.9	8	5	-4.9	300.0	300.0	300.0	0.0	0.0	0.0%	a	a	a
1839	98	98.8	24.9	-1.9	8	5	-4.9	12.5	15.2	124.1	4.0	0.0	0.0%	a	a	a
1748	99.7	98.5	22	-1.8	16	5	-6.1	124.6	300.0	300.0	2.0	0.0	0.0%	a	a	a
1703	97.4	97.8	24.7	-1.8	16	5	-6.1	11.9	300.0	5.1	1.0	0.0	0.0%	a	a	a
1751	97.1	96.3	23.9	-1.8	16	5	-6.1	15.9	300.0	300.0	1.0	0.0	0.0%	a	a	a
1770	108.8	109	29.1	-1.8	16	5	-6.1	5.9	300.0	300.0	0.0	0.0	0.0%	a	a	a
1870	82	83.5	20.1	-1.8	16	5	-6.1	7.9	300.0	276.3	0.0	0.0	0.0%	a	a	a
1841	77	77.1	19.9	-1.8	16	5	-6.1	28.9	300.0	179.0	0.0	0.0	0.0%	a	a	a
1832	101.6	104	27.8	-1.8	8	5	-4.8	300.0	300.0	300.0	1.5	0.0	0.0%	a	a	a
1811	99.4	97.4	24.5	-1.8	8	5	-4.8	9.5	17.1	20.1	1.0	0.0	0.0%	a	a	a
1893	95.9	94.5	24.8	-1.8	8	5	-4.8	44.3	300.0	59.3	0.0	0.0	0.0%	a	a	a
1728	106.5	108	21.4	-1.7	16	5	-5.9	8.9	300.0	17.4	0.0	0.0	0.0%	a	a	a
1739	102.9	104	25.9	-1.7	16	5	-5.9	300.0	300.0	17.4	1.0	0.0	0.0%	a	a	a
1789	99	102	24.3	-1.7	16	5	-5.9	11.8	24.3	300.0	0.0	0.0	0.0%	a	a	a

Appendix 1. (continued)

	Size (mm)			Treatment				Righting response (s)			Autotomy (lost limb=1, additive			Mortality (a=alive, d=dead)		
crab#	length	width	claw ht	temp (C)	wspd (m/s)	time (min)	windchill (C)	before	after	7day	pre-dmg	post-dmg	% loss	day 0	day 1	day 7
1887	96.6	97.7	23.5	-10.0	8	5	-16.1	4.1	300.0	d	0.0	0.0	0.0%	a	a	d
1761	85.1	84.6	21	-10.0	8	5	-16.1	4.1	300.0	d	0.0	0.0	0.0%	a	d	d
1796	71.4	72.2	17.4	-10.0	8	5	-16.1	300.0	300.0	d	3.0	0.0	0.0%	a	d	d
1847	105.2	107	28.4	-9.8	8	5	-15.8	86.3	300.0	d	1.0	4.0	44.4%	a	d	d
1838	104.3	104	27.7	-9.8	8	5	-15.8	74.2	300.0	d	2.0	0.0	0.0%	a	d	d
1896	99.7	98.6	24	-9.8	8	5	-15.8	33.9	300.0	d	2.5	2.0	26.7%	a	d	d
1843	95.2	95	23.3	-9.8	8	5	-15.8	5.0	300.0	d	1.0	1.0	11.1%	a	d	d
1830	89.8	90	22.7	-9.8	8	5	-15.8	74.2	300.0	d	2.0	0.0	0.0%	a	d	d
1889	87.1	88.3	21	-9.8	8	5	-15.8	2.4	300.0	d	0.0	1.0	10.0%	a	d	d
1861	99.2	104	26	-9.5	8	5	-15.4	5.6	300.0	d	0.0	3.0	30.0%	a	d	d
1846	100.7	101	25.6	-9.5	8	5	-15.4	57.1	300.0	d	1.0	3.0	33.3%	a	d	d
1892	94.2	95.5	23.9	-9.5	8	5	-15.4	13.1	300.0	d	0.0	0.0	0.0%	a	d	d
1727	105.8	108	26.7	-6.2	8	5	-10.8	23.9	300.0	d	1.0	0.0	0.0%	a	a	d
1866	88	88.9	20.6	-6.2	8	5	-10.8	300.0	300.0	300.0	3.0	1.0	14.3%	a	a	a
1849	76	76	17.6	-6.2	8	5	-10.8	2.7	300.0	300.0	1.0	7.0	77.8%	a	a	a
1776	100.2	100	26.1	-6.1	8	5	-10.7	2.5	300.0	300.0	0.0	1.0	10.0%	a	a	a
1747	96.4	96.7	21.9	-6.1	8	5	-10.7	2.3	300.0	300.0	0.0	2.0	20.0%	a	a	a
1813	76.7	77.8	18.4	-6.1	8	5	-10.7	44.6	300.0	300.0	1.0	7.0	77.8%	a	a	a
1786	104.6	105	28.5	-6.0	8	5	-10.6	3.0	300.0	d	0.0	2.0	20.0%	a	a	d
1791	102.5	103	26.5	-6.0	8	5	-10.6	300.0	300.0	300.0	0.0	0.0	0.0%	a	a	a
1764	99.8	100	25	-6.0	8	5	-10.6	8.3	300.0	300.0	0.0	2.0	20.0%	a	a	a
1746	98.2	98	24.5	-6.0	8	5	-10.6	26.0	300.0	300.0	1.0	4.0	44.4%	a	a	a
1834	92.4	91.8	22.8	-6.0	8	5	-10.6	6.1	300.0	d	1.0	0.0	0.0%	a	a	d
1859	82.5	83.2	19.1	-6.0	8	5	-10.6	111.0	300.0	d	0.0	1.0	10.0%	a	d	d

Appendix 2. Catch, trip date and length, average weather, estimated bycatch, and estimated bycatch mortality per trip for the 1998 open-access Bering Sea snow crab

Catch/trip				Day #		Weather by trip			Temp/wind mode		Windchill model	
delivered live crabs	dead loss	total catch	est. bycatch	start	sale	wind chill	temp (C)	wind (m/s)	P(mort)	mortality	P(wc)	bycatch mortality
63631	391	64022	19749	17	20	-10.1	-8.0	11.4	0.994	19623	0.459	9061
115709	586	116295	35874	17	20	-10.1	-8.0	11.4	0.994	35646	0.459	16459
73911	321	74232	22898	18	25	-4.5	-3.9	8.1	0.018	421	0.001	25
120136	620	120756	37250	18	25	-4.5	-3.9	8.1	0.018	685	0.001	40
121123	915	122038	37645	18	25	-4.5	-3.9	8.1	0.018	692	0.001	40
123682	419	124101	38282	19	23	-5.1	-4.0	8.3	0.024	931	0.002	87
113682	476	114158	35214	19	23	-5.1	-4.0	8.3	0.024	856	0.002	80
152761	408	153169	47248	21	30	-5.9	-4.7	8.4	0.082	3862	0.006	274
146285	1069	147354	45454	24	32	-7.5	-5.8	9.7	0.538	24475	0.036	1653
94303	244	94547	29165	26	33	-9.8	-7.2	10.0	0.951	27741	0.353	10283
142677	690	143367	44225	27	35	-8.4	-6.4	9.1	0.750	33163	0.102	4515
134156	3320	137476	42407	28	37	-6.3	-5.1	8.7	0.182	7700	0.009	378
145251	667	145918	45011	31	38	-3.6	-3.5	8.5	0.010	431	0.000	17
141342	805	142147	43848	32	42	-3.7	-3.3	8.4	0.007	292	0.000	18
105296	3500	108796	33560	33	39	-2.0	-1.9	8.2	0.001	17	0.000	2
78214	431	78645	24260	33	39	-2.0	-1.9	8.2	0.001	12	0.000	1
47348	410	47758	14732	34	40	-0.8	-1.2	8.2	0.000	2	0.000	0
185226	916	186142	57419	36	45	-3.5	-3.2	8.0	0.005	264	0.000	20
154866	870	155736	48040	39	46	-5.2	-4.5	7.5	0.044	2116	0.002	114
100211	1127	101338	31260	40	49	-6.2	-5.3	7.3	0.135	4235	0.008	261
172034	1200	173234	53438	41	48	-7.1	-5.7	7.2	0.256	13675	0.022	1177
73980	690	74670	23034	45	52	-6.2	-4.9	7.1	0.069	1578	0.008	179
101216	840	102056	31481	47	54	-6.0	-4.7	9.6	0.136	4271	0.006	195
59711	240	59951	18493	48	51	-6.0	-4.6	8.1	0.063	1168	0.007	121
106182	1360	107542	33174	48	51	-6.0	-4.6	8.1	0.063	2095	0.007	218
107558	714	108272	33399	48	51	-6.0	-4.6	8.1	0.063	2109	0.007	219
54381	1316	55697	17181	48	51	-6.0	-4.6	8.1	0.063	1085	0.007	113
80198	938	81136	25028	50	55	-6.6	-5.0	11.3	0.379	9498	0.012	302
87531	1208	88739	27373	50	55	-6.6	-5.0	11.3	0.379	10388	0.012	331
81084	1538	82622	25486	51	62	-4.7	-4.2	10.3	0.080	2032	0.001	36
68088	476	68564	21150	52	59	-5.5	-5.0	10.7	0.298	6311	0.003	74
133644	1067	134711	41554	53	64	-3.6	-3.4	10.5	0.021	873	0.000	15
98716	515	99231	30610	56	65	-2.0	-2.3	9.2	0.001	46	0.000	2
146850	2692	149542	46129	57	71	-0.6	-1.0	9.2	0.000	7	0.000	0
135896	758	136654	42154	59	68	-0.5	-0.9	10.4	0.000	9	0.000	0
126551	1866	128417	39613	66	75	0.2	-0.1	9.4	0.000	1	0.000	0
108411	269	108680	33525	67	73	0.9	0.4	7.7	0.000	0	0.000	0
53723	500	54223	16726	68	71	1.2	0.5	6.3	0.000	0	0.000	0
126445	2564	129009	39796	68	71	1.2	0.5	6.3	0.000	0	0.000	0
100074	2500	102574	31641	70	79	-2.2	-1.7	9.4	0.001	20	0.000	2
97697	1282	98979	30532	74	83	-3.1	-2.6	10.7	0.005	157	0.000	6
107634	761	108395	33437	76	80	-4.8	-3.7	11.0	0.042	1417	0.002	53
32506	431	32937	10160	76	80	-4.8	-3.7	11.0	0.042	431	0.002	16

Appendix 2. (continued)

Catch/trip				Day #		Weather by trip			Temp/wind mode		Windchill model	
delivered live crabs	dead loss	total catch	est. bycatch	start	sale	wind chill	temp (C)	wind (m/s)	P(mort)	mortality	P(wc)	bycatch mortality
102415	2705	105120	32426	17	20	-10.1	-8.0	11.4	0.994	32220	0.459	14877
181742	764	182506	56298	17	20	-10.1	-8.0	11.4	0.994	55940	0.459	25830
15291	1033	16324	5035	18	19	-9.5	-8.0	10.3	0.989	4982	0.292	1469
111414	1181	112595	34732	18	19	-9.5	-8.0	10.3	0.989	34362	0.292	10132
99125	2033	101158	31204	18	19	-9.5	-8.0	10.3	0.989	30872	0.292	9103
85928	7042	92970	28679	19	24	-4.2	-3.4	7.8	0.007	188	0.001	23
134290	1343	135633	41839	19	24	-4.2	-3.4	7.8	0.007	275	0.001	33
56587	12000	68587	21157	20	24	-3.4	-2.9	7.0	0.002	39	0.000	6
152369		152369	47001	21	23	-3.2	-2.8	5.9	0.001	45	0.000	11
120323	902	121225	37394	21	23	-3.2	-2.8	5.9	0.001	36	0.000	9
149728	694	150422	46401	22	28	-4.6	-3.7	8.0	0.012	556	0.001	54
106917	1230	108147	33360	22	28	-4.6	-3.7	8.0	0.012	400	0.001	39
102514	3000	105514	32548	23	33	-6.9	-5.4	8.8	0.282	9163	0.017	565
76416	462	76878	23715	24	32	-7.5	-5.8	9.7	0.538	12769	0.036	862
75693	709	76402	23568	25	35	-7.5	-5.9	9.6	0.601	14163	0.037	872
41638	517	42155	13004	26	30	-10.0	-7.4	10.4	0.972	12637	0.406	5283
163249	1504	164753	50822	28	34	-9.3	-6.9	9.5	0.899	45682	0.241	12244
111920	1361	113281	34944	30	36	-6.7	-5.4	8.9	0.285	9974	0.013	469
37242	2131	39373	12145	31	41	-3.2	-3.2	8.5	0.006	79	0.000	3
107447		107447	33144	32	40	-2.7	-2.5	8.4	0.002	58	0.000	4
110774	2941	113715	35078	34	37	-1.9	-1.9	8.3	0.001	18	0.000	2
162926	1250	164176	50644	34	37	-1.9	-1.9	8.3	0.001	26	0.000	2
80172		80172	24731	35	40	0.2	-0.6	7.7	0.000	1	0.000	0
126322	1653	127975	39477	35	40	0.2	-0.6	7.7	0.000	1	0.000	0
171218	2756	173974	53666	35	40	0.2	-0.6	7.7	0.000	2	0.000	0
75821	1481	77302	23845	35	40	0.2	-0.6	7.7	0.000	1	0.000	0
103772		103772	32011	36	38	0.0	-0.2	7.9	0.000	1	0.000	0
76658	820	77478	23900	37	37	0.8	0.5	10.7	0.000	0	0.000	0
123930		123930	38229	37	37	0.8	0.5	10.7	0.000	1	0.000	0
108766	3126	111892	34515	38	46	-4.5	-4.0	7.6	0.017	570	0.001	38
74319	440	74759	23061	39	46	-5.2	-4.5	7.5	0.044	1016	0.002	55
127373		127373	39291	40	48	-6.3	-5.3	7.2	0.146	5748	0.009	349
155837		155837	48071	42	50	-6.8	-5.4	7.5	0.171	8201	0.016	769
104787	1587	106374	32813	43	47	-6.8	-5.5	7.0	0.170	5564	0.016	532
5463	813	6276	1936	43	47	-6.8	-5.5	7.0	0.170	328	0.016	31
240166		240166	74084	43	47	-6.8	-5.5	7.0	0.170	12562	0.016	1200
101853		101853	31419	44	49	-6.5	-5.1	7.3	0.109	3409	0.011	338
146772	6667	153439	47331	45	53	-6.0	-4.8	7.7	0.074	3496	0.006	296
60463	391	60854	18772	47	55	-6.6	-5.1	10.0	0.275	5167	0.012	234
63872	2400	66272	20443	49	52	-5.6	-4.3	7.7	0.033	679	0.004	76
80976		80976	24979	49	52	-5.6	-4.3	7.7	0.033	830	0.004	93
57142		57142	17627	50	51	-6.1	-4.4	8.8	0.059	1045	0.007	122
79706	2400	82106	25327	50	51	-6.1	-4.4	8.8	0.059	1502	0.007	176
89157	1550	90707	27980	52	57	-6.8	-5.6	11.0	0.584	16348	0.017	465
61089	2033	63122	19471	52	57	-6.8	-5.6	11.0	0.584	11376	0.017	324

Appendix 2. (continued)

Catch/trip				Day #		Weather by trip			Temp/wind mode		Windchill model	
delivered live crabs	dead loss	total catch	est. bycatch	start	sale	wind chill	temp (C)	wind (m/s)	P(mort)	mortality	P(wc)	bycatch mortality
47173	2479	49652	15316	53	60	-5.4	-5.0	11.5	0.366	5606	0.003	50
115935		115935	35763	53	60	-5.4	-5.0	11.5	0.366	13091	0.003	117
165496	2479	167975	51815	53	60	-5.4	-5.0	11.5	0.366	18967	0.003	169
87307	1681	88988	27450	54	56	-9.3	-7.0	13.8	0.985	27044	0.230	6318
59565	8403	67968	20966	54	56	-9.3	-7.0	13.8	0.985	20656	0.230	4826
148723	4724	153447	47334	55	66	-2.8	-2.7	10.3	0.005	245	0.000	7
99237	6489	105726	32613	55	66	-2.8	-2.7	10.3	0.005	169	0.000	5
75100	437	75537	23301	57	64	-1.3	-2.0	9.0	0.001	19	0.000	1
89233	1181	90414	27890	58	68	-0.7	-1.1	10.2	0.000	7	0.000	0
105900	37651	143551	44281	59	74	0.0	-0.5	9.5	0.000	3	0.000	0
91550	1190	92740	28608	62	68	0.1	-0.1	10.7	0.000	2	0.000	0
85203		85203	26283	63	70	0.5	0.2	9.1	0.000	0	0.000	0
97182	2000	99182	30595	64	68	0.1	0.1	10.3	0.000	1	0.000	0
67125	840	67965	20965	64	68	0.1	0.1	10.3	0.000	1	0.000	0
64006	984	64990	20048	65	72	0.3	0.1	9.5	0.000	0	0.000	0
84772	2564	87336	26941	65	72	0.3	0.1	9.5	0.000	1	0.000	0
35687	2756	38443	11859	66	71	0.2	-0.1	9.1	0.000	0	0.000	0
85920		85920	26504	66	71	0.2	-0.1	9.1	0.000	1	0.000	0
74089	2564	76653	23645	66	71	0.2	-0.1	9.1	0.000	1	0.000	0
94878	2542	97420	30051	66	71	0.2	-0.1	9.1	0.000	1	0.000	0
144050	5085	149135	46004	69	80	-1.8	-1.5	9.5	0.000	21	0.000	2
47076	847	47923	14783	72	76	-0.9	-0.8	10.2	0.000	2	0.000	0
76410	1681	78091	24089	72	76	-0.9	-0.8	10.2	0.000	4	0.000	0
63745	1271	65016	20056	73	78	-3.1	-2.3	10.2	0.002	47	0.000	4
49132	545	49677	15324	73	78	-3.1	-2.3	10.2	0.002	36	0.000	3
80783	870	81653	25188	73	78	-3.1	-2.3	10.2	0.002	59	0.000	5
51205	4159	55364	17078	73	78	-3.1	-2.3	10.2	0.002	40	0.000	3
89044	1567	90611	27951	76	79	-5.8	-4.1	10.7	0.081	2264	0.005	139
65607	1282	66889	20633	78	82	-2.9	-2.6	10.8	0.006	116	0.000	3
362411	758	363169	112027	15	31	-7.4	-5.8	10.1	0.585	65538	0.031	3488
50611	71	50682	15634	16	21	-9.7	-7.5	11.9	0.987	15434	0.327	5116
231290	182	231472	71402	16	21	-9.7	-7.5	11.9	0.987	70488	0.327	23365
135980	234	136214	42018	18	23	-6.0	-5.0	8.3	0.142	5984	0.006	271
161754	85	161839	49923	18	23	-6.0	-5.0	8.3	0.142	7109	0.006	321
213134	200	213334	65807	18	23	-6.0	-5.0	8.3	0.142	9371	0.006	424
59144	93	59237	18273	18	23	-6.0	-5.0	8.3	0.142	2602	0.006	118
224898	741	225639	69603	18	24	-5.1	-4.4	8.0	0.039	2718	0.002	157
131905	338	132243	40793	19	29	-5.7	-4.5	8.6	0.066	2678	0.004	171
74360	655	75015	23140	19	29	-5.7	-4.5	8.6	0.066	1519	0.004	97
78716	446	79162	24419	20	32	-6.4	-5.1	8.9	0.191	4656	0.010	254
80829	134	80963	24975	21	27	-4.1	-3.4	8.2	0.008	193	0.001	17
171795	572	172367	53170	22	32	-6.3	-5.0	8.6	0.156	8294	0.009	480
221853	1133	222986	68785	24	34	-7.5	-5.8	9.6	0.551	37877	0.035	2438
119537	1000	120537	37182	24	34	-7.5	-5.8	9.6	0.551	20475	0.035	1318
91602	189	91791	28315	26	26	-7.6	-6.4	15.2	0.977	27673	0.041	1147

Appendix 2. (continued)

Catch/trip				Day #		Weather by trip			Temp/wind mode		Windchill model	
delivered live crabs	dead loss	total catch	est. bycatch	start	sale	wind chill	temp (C)	wind (m/s)	P(mort)	mortality	P(wc)	bycatch mortality
156548	227	156775	48361	26	26	-7.6	-6.4	15.2	0.977	47264	0.041	1959
212001	1040	213041	65717	26	26	-7.6	-6.4	15.2	0.977	64227	0.041	2662
66785	234	67019	20673	27	35	-8.4	-6.4	9.1	0.750	15503	0.102	2110
79188	166	79354	24478	27	35	-8.4	-6.4	9.1	0.750	18356	0.102	2499
77325	692	78017	24066	28	37	-6.3	-5.1	8.7	0.182	4370	0.009	215
66621	202	66823	20613	29	38	-5.1	-4.4	8.7	0.052	1081	0.002	45
302534	422	302956	93453	29	38	-5.1	-4.4	8.7	0.052	4901	0.002	206
212165	136	212301	65489	31	39	-3.0	-3.0	8.6	0.004	285	0.000	12
175475	286	175761	54217	33	42	-3.0	-2.9	8.1	0.003	156	0.000	10
158122	165	158287	48827	35	41	-0.9	-1.4	7.9	0.000	9	0.000	1
139171	775	139946	43169	36	36	-1.4	-1.5	5.2	0.000	3	0.000	1
95897	395	96292	29703	42	42	-9.0	-6.9	7.1	0.743	22058	0.183	5429
94896		94896	29273	43	43	-7.3	-6.3	5.9	0.362	10596	0.028	815
264079	974	265053	81761	44	44	-5.8	-4.3	9.6	0.070	5730	0.005	395
127693	849	128542	39651	45	45	-7.2	-5.7	8.2	0.344	13657	0.025	988
347482	1124	348606	107535	47	47	-8.0	-5.9	7.7	0.377	40521	0.059	6392
502393	445	502838	155111	48	48	-6.2	-5.0	6.7	0.069	10715	0.008	1266
280251	455	280706	86590	50	50	-6.1	-4.3	10.7	0.110	9544	0.007	642
88658	167	88825	27400	51	51	-6.0	-4.5	6.9	0.031	852	0.006	178
260206	345	260551	80372	52	52	-4.3	-3.9	5.2	0.005	400	0.001	67
292210	959	293223	90451	53	53	-4.6	-3.9	12.8	0.132	11952	0.001	102
127066	515	127581	39355	54	54	-7.0	-5.5	18.6	0.975	38363	0.020	779
314094	1991	316085	97503	55	55	-11.4	-8.1	13.4	0.998	97285	0.782	76223
110313	182	110495	34084	57	57	-4.4	-4.6	6.6	0.033	1126	0.001	31
104546	90	104636	32277	58	58	-2.3	-2.6	7.5	0.001	42	0.000	3
221113	357	221470	68317	59	59	-0.7	-3.8	12.4	0.096	6546	0.000	1
163560	851	164411	50716	60	60	-3.9	-3.8	11.1	0.055	2770	0.001	25
327367	598	327965	101168	62	62	-2.0	-1.5	14.3	0.004	369	0.000	5
136837	278	137115	42296	63	63	1.9	0.1	9.1	0.000	1	0.000	0
247160	326	247486	76342	66	66	-2.6	-1.5	17.6	0.015	1179	0.000	8
202733	496	203229	62690	67	67	-0.8	-0.7	11.6	0.000	16	0.000	1
216000	1379	217379	67055	68	68	1.9	1.2	6.5	0.000	0	0.000	0
153107	635	153742	47425	69	69	1.3	0.8	7.7	0.000	0	0.000	0
266912	189	267101	82393	71	71	1.0	-0.2	6.4	0.000	1	0.000	0
68496		68496	21129	72	72	0.5	0.5	11.1	0.000	0	0.000	0
337387	1212	339744	104801	73	73	1.5	1.2	6.1	0.000	0	0.000	0
160227	588	160815	49607	74	74	-0.5	-0.8	10.9	0.000	11	0.000	0
186764	389	187153	57731	75	75	-1.5	-1.6	11.8	0.001	81	0.000	2
77559	771	79544	24537	78	78	-6.9	-4.6	11.3	0.219	5372	0.018	453
125489	754	126243	38942	79	79	-5.2	-4.1	10.3	0.066	2578	0.003	99
305010	1763	307233	94772	80	80	-0.9	-1.9	12.1	0.003	266	0.000	2
121508	268	121776	37564	81	81	0.7	-0.8	11.3	0.000	10	0.000	0
174710	998	175708	54201	82	82	-2.0	-1.6	8.9	0.000	21	0.000	3
268809	8942	277751	85678	83	83	-3.2	-2.5	9.4	0.003	220	0.000	20
195834	336	196170	60513	85	85	-4.0	-3.1	8.8	0.006	344	0.001	36

Appendix 2. (continued)

Catch/trip				Day #		Weather by trip			Temp/wind mode		Windchill model	
delivered live crabs	dead loss	total catch	est. bycatch	start	sale	wind chill	temp (C)	wind (m/s)	P(mort)	mortality	P(wc)	bycatch mortality
105987	1695	107682	33217	16	28	-6.9	-5.5	9.8	0.409	13570	0.019	615
147253	5600	152853	47151	17	22	-8.3	-6.7	9.9	0.878	41395	0.087	4115
121931	8730	130661	40305	17	22	-8.3	-6.7	9.9	0.878	35385	0.087	3518
80618	1653	82271	25378	17	22	-8.3	-6.7	9.9	0.878	22280	0.087	2215
117055	3205	120439	37152	18	23	-6.0	-5.0	8.3	0.142	5291	0.006	239
21109	286	21395	6600	19	19	-8.6	-5.9	11.9	0.798	5264	0.120	793
105180	1786	106966	32996	22	29	-4.9	-4.1	7.7	0.022	739	0.002	60
131135	1379	132514	40877	22	29	-4.9	-4.1	7.7	0.022	915	0.002	74
214230	7547	221777	68412	23	33	-6.9	-5.4	8.8	0.282	19260	0.017	1188
96841	2016	98857	30495	24	27	-4.8	-3.9	9.9	0.036	1103	0.001	44
91315	2479	93794	28933	25	34	-8.4	-6.4	10.1	0.803	23245	0.092	2660
92666	1382	94048	29011	28	35	-8.0	-6.3	8.9	0.670	19446	0.063	1837
112312	6015	118327	36500	29	37	-5.8	-4.9	8.8	0.135	4921	0.005	190
94707	2049	96756	29846	30	36	-6.7	-5.4	8.9	0.285	8519	0.013	401
59956	1817	61773	19055	30	36	-6.7	-5.4	8.9	0.285	5439	0.013	256
124432	2439	126871	39136	31	42	-3.7	-3.5	8.4	0.011	419	0.000	16
201012	6612	207624	64046	33	41	-2.4	-2.4	8.2	0.001	86	0.000	5
141373	1240	142653	44004	33	41	-2.4	-2.4	8.2	0.001	59	0.000	4
112328	4167	116495	35935	34	39	-0.9	-1.1	8.4	0.000	4	0.000	1
207894	2542	210436	64913	34	39	-0.9	-1.1	8.4	0.000	8	0.000	1
89022	1575	90597	27947	36	44	-3.1	-2.9	8.0	0.003	76	0.000	6
85617	21186	106803	32946	36	44	-3.1	-2.9	8.0	0.003	90	0.000	7
152997	1074	154071	47526	37	47	-4.4	-3.7	7.8	0.012	586	0.001	43
59411	2419	61830	19073	41	45	-7.3	-5.9	8.0	0.411	7847	0.029	552
124964	2420	127384	39294	41	45	-7.3	-5.9	8.0	0.411	16167	0.029	1138
15950	811	16761	5170	42	47	-7.2	-5.7	7.0	0.241	1246	0.025	128
104999	5595	110594	34115	43	56	-6.8	-5.3	9.0	0.279	9508	0.016	529
63448	1513	64961	20039	44	46	-6.3	-5.1	7.1	0.092	1841	0.009	174
130175	3444	133619	41218	44	46	-6.3	-5.1	7.1	0.092	3786	0.009	357
80297	800	82337	25399	48	48	-6.2	-5.0	6.7	0.069	1754	0.008	207
41748	813	42561	13129	48	48	-6.2	-5.0	6.7	0.069	907	0.008	107
158546	3125	161671	49871	48	48	-6.2	-5.0	6.7	0.069	3445	0.008	407
53073	738	53811	16599	49	55	-6.4	-5.0	10.8	0.310	5142	0.011	175
77689	2400	80089	24705	49	55	-6.4	-5.0	10.8	0.310	7652	0.011	261
91505	5042	96547	29782	52	60	-5.3	-4.8	10.8	0.254	7568	0.003	84
77768	12821	90589	27944	53	61	-4.9	-4.5	10.9	0.159	4438	0.002	50
79464	1214	80678	24887	54	54	-7.0	-5.5	18.6	0.975	24260	0.020	493
175284	1678	176962	54588	54	54	-7.0	-5.5	18.6	0.975	53212	0.020	1081
98346	1789	100135	30889	55	61	-4.7	-4.4	9.5	0.083	2577	0.001	42
79930	1695	81704	25203	55	61	-4.7	-4.4	9.5	0.083	2102	0.001	34
119192	17391	136583	42132	58	65	-0.7	-1.3	9.5	0.000	13	0.000	1
94673	1172	95845	29565	58	65	-0.7	-1.3	9.5	0.000	9	0.000	0
68947	793	69740	21513	60	68	-0.5	-0.6	10.2	0.000	2	0.000	0
62463	1017	63480	19582	60	68	-0.5	-0.6	10.2	0.000	2	0.000	0
129301	1189	130716	40322	60	68	-0.5	-0.6	10.2	0.000	4	0.000	0

Appendix 2. (continued)

Catch/trip				Day #		Weather by trip			Temp/wind mode		Windchill model	
delivered live crabs	dead loss	total catch	est. bycatch	start	sale	wind chill	temp (C)	wind (m/s)	P(mort)	mortality	P(wc)	bycatch mortality
161350	2314	163664	50486	64	74	0.5	0.2	8.9	0.000	1	0.000	0
68963	1667	72071	22232	65	70	0.1	0.1	9.8	0.000	1	0.000	0
100837	7273	108110	33349	65	70	0.1	0.1	9.8	0.000	1	0.000	0
58551	1709	60260	18588	65	70	0.1	0.1	9.8	0.000	1	0.000	0
125808	3097	128905	39763	66	73	0.4	0.2	9.0	0.000	1	0.000	0
46328	1719	48047	14821	68	75	0.6	0.1	8.2	0.000	0	0.000	0
69940	1740	71680	22111	68	75	0.6	0.1	8.2	0.000	0	0.000	0
56874	1271	58145	17936	68	75	0.6	0.1	8.2	0.000	0	0.000	0
62976	704	63680	19643	69	77	-0.9	-0.9	8.9	0.000	2	0.000	0
86242	684	88899	27423	70	78	-1.8	-1.5	9.3	0.000	10	0.000	1
66189	1140	67572	20844	71	80	-2.3	-1.9	10.1	0.001	25	0.000	2
73629	901	74530	22990	73	81	-2.7	-2.3	10.5	0.003	63	0.000	3
104366	1092	105458	32531	73	81	-2.7	-2.3	10.5	0.003	89	0.000	4
63040	2500	65540	20217	76	76	-4.8	-3.2	11.0	0.018	368	0.001	30
11420	1653	13073	4033	78	78	-6.9	-4.6	11.3	0.219	883	0.018	74
49930	1429	51359	15843	80	80	-0.9	-1.9	12.1	0.003	44	0.000	0
72742	1130	74073	22849	81	81	0.7	-0.8	11.3	0.000	6	0.000	0
183413	15384	199074	61409	85	85	-4.0	-3.1	8.8	0.006	350	0.001	37
48641		48641	15004	82	82	-2.0	-1.6	8.9	0.000	6	0.000	1
70430	326	70756	21826	17	19	-11.1	-8.8	11.2	0.998	21790	0.712	15545
89960	111	90071	27784	17	19	-11.1	-8.8	11.2	0.998	27738	0.712	19788
129353	121	129474	39939	17	19	-11.1	-8.8	11.2	0.998	39873	0.712	28445
126534	493	127027	39184	17	19	-11.1	-8.8	11.2	0.998	39119	0.712	27907
178071	1163	179234	55288	17	20	-10.1	-8.0	11.4	0.994	54937	0.459	25367
40815		40815	12590	17	21	-9.4	-7.4	11.0	0.977	12305	0.270	3401
144425	492	144917	44703	18	27	-5.5	-4.6	9.0	0.084	3751	0.004	159
141153	1475	142628	43997	19	24	-4.2	-3.4	7.8	0.007	289	0.001	35
156214	685	156899	48399	21	26	-2.9	-2.7	7.9	0.002	84	0.000	7
179934	776	180710	55744	21	26	-2.9	-2.7	7.9	0.002	97	0.000	9
122753	814	123567	38117	22	28	-4.6	-3.7	8.0	0.012	457	0.001	44
125788	400	126188	38925	22	28	-4.6	-3.7	8.0	0.012	467	0.001	45
125795	126	125921	38843	23	25	-0.1	-0.5	6.0	0.000	1	0.000	0
171053	534	171587	52930	23	25	-0.1	-0.5	6.0	0.000	1	0.000	0
147293	2148	149441	46098	24	31	-7.1	-5.6	9.5	0.434	20006	0.023	1045
11952	50	12002	3702	25	26	-3.9	-3.6	12.0	0.056	209	0.001	2
160758	683	161441	49800	26	33	-9.8	-7.2	10.0	0.951	47368	0.353	17558
175727	878	176605	54478	28	36	-7.2	-5.7	8.5	0.384	20937	0.025	1356
122067	991	123058	37960	29	34	-9.2	-6.9	9.7	0.908	34452	0.213	8100
168232	919	169151	52178	29	34	-9.2	-6.9	9.7	0.908	47356	0.213	11134
176480	923	177403	54724	31	38	-3.6	-3.5	8.5	0.010	525	0.000	21
153135	1211	154346	47611	32	39	-3.0	-2.6	8.6	0.002	95	0.000	9
119768	976	120744	37246	34	40	-0.8	-1.2	8.2	0.000	6	0.000	1
172134	952	173086	53392	34	40	-0.8	-1.2	8.2	0.000	8	0.000	1
129854	185	130039	40113	35	43	-2.5	-2.6	7.6	0.001	51	0.000	4
228439	1034	229473	70786	35	43	-2.5	-2.6	7.6	0.001	91	0.000	7

Appendix 2. (continued)

Catch/trip				Day #		Weather by trip			Temp/wind mode		Windchill model	
delivered live crabs	dead loss	total catch	est. bycatch	start	sale	wind chill	temp (C)	wind (m/s)	P(mort)	mortality	P(wc)	bycatch mortality
127126	1187	128313	39581	36	49	-4.4	-3.7	7.6	0.011	429	0.001	37
181016	946	181962	56130	39	46	-5.2	-4.5	7.5	0.044	2472	0.002	133
122980	1426	124406	38376	40	48	-6.3	-5.3	7.2	0.146	5615	0.009	341
139316		139316	42975	41	47	-7.2	-5.8	7.3	0.300	12883	0.025	1089
148065	861	148926	45939	43	51	-6.5	-5.1	7.5	0.111	5096	0.011	499
140518	1264	141782	43736	43	51	-6.5	-5.1	7.5	0.111	4852	0.011	475
127435	472	127907	39456	44	50	-6.4	-5.0	7.8	0.109	4291	0.010	402
180837	600	181437	55968	47	54	-6.0	-4.7	9.6	0.136	7592	0.006	347
38406	195	38601	11907	48	51	-6.0	-4.6	8.1	0.063	752	0.007	78
134249	743	134992	41641	48	51	-6.0	-4.6	8.1	0.063	2630	0.007	273
125054	1088	126142	38911	50	56	-7.0	-5.4	11.0	0.496	19302	0.020	759
120313	1285	121598	37509	50	56	-7.0	-5.4	11.0	0.496	18607	0.020	732
56157	410	56567	17449	51	57	-6.7	-5.4	10.4	0.450	7856	0.015	254
139058	1279	140337	43290	51	57	-6.7	-5.4	10.4	0.450	19491	0.015	630
144859	1101	145960	45024	52	63	-4.1	-3.8	10.5	0.045	2006	0.001	29
162349	1136	163485	50430	53	65	-3.3	-3.1	10.5	0.012	613	0.000	13
6630	89	6719	2073	54	57	-8.0	-6.4	12.0	0.909	1885	0.066	136
124764	478	125242	38634	56	63	-2.7	-3.0	9.6	0.007	280	0.000	5
181898	1203	183101	56481	56	63	-2.7	-3.0	9.6	0.007	409	0.000	7
174525	1618	176143	54335	58	68	-0.7	-1.1	10.2	0.000	14	0.000	1
143190	2207	145397	44851	61	79	-1.1	-1.0	9.6	0.000	7	0.000	1
95323	1531	96854	29877	62	70	0.3	0.0	9.7	0.000	1	0.000	0
143882	629	144511	44577	63	71	0.6	0.2	8.8	0.000	1	0.000	0
138935	1344	140279	43272	63	71	0.6	0.2	8.8	0.000	1	0.000	0
150697	574	151271	46663	63	71	0.6	0.2	8.8	0.000	1	0.000	0
133471	233	133704	41244	64	72	0.4	0.2	9.0	0.000	1	0.000	0
197263	3618	200881	61966	68	80	-1.5	-1.3	9.2	0.000	17	0.000	2
96996	1396	98392	30351	70	82	-1.8	-1.7	9.7	0.001	19	0.000	1
63830	562	64392	19863	71	81	-2.0	-1.8	10.2	0.001	21	0.000	1
57140	319	57459	17724	74	75	-1.0	-1.2	11.3	0.001	10	0.000	0
114018	791	114809	35415	74	75	-1.0	-1.2	11.3	0.001	19	0.000	1
99391	827	100218	30914	74	75	-1.0	-1.2	11.3	0.001	17	0.000	1
12412	34	12446	3839	78	80	-4.4	-3.5	11.2	0.037	141	0.001	4
38357		38357	11832	18	24	-5.1	-4.4	8.0	0.039	462	0.002	27
22006		22006	6788	19	22	-6.3	-4.9	9.5	0.183	1240	0.009	61
72450	77	72527	22372	19	22	-6.3	-4.9	9.5	0.183	4087	0.009	202
69131		69131	21325	20	28	-5.1	-4.1	8.6	0.030	642	0.002	47
28199		28199	8699	20	28	-5.1	-4.1	8.6	0.030	262	0.002	19
40863	74	40937	12628	26	30	-10.0	-7.4	10.4	0.972	12272	0.406	5130
45850		45850	14143	26	30	-10.0	-7.4	10.4	0.972	13744	0.406	5746
32603	9	32612	10060	28	34	-9.3	-6.9	9.5	0.899	9042	0.241	2424
22011		22011	6790	33	38	-2.5	-2.3	8.1	0.001	7	0.000	1
28684		28684	8848	38	38	0.7	0.5	7.9	0.000	0	0.000	0
19072	33	19105	5893	40	44	-5.9	-5.2	7.8	0.155	913	0.006	32
72100	40	72140	22253	48	56	-6.8	-5.2	10.2	0.355	7902	0.015	337

Appendix 2. (continued)

Catch/trip				Day #		Weather by trip			Temp/wind mode		Windchill model	
delivered live crabs	dead loss	total catch	est. bycatch	start	sale	wind chill	temp (C)	wind (m/s)	P(mort)	mortality	P(wc)	bycatch mortality
142458	1201	143659	44315	51	62	-4.7	-4.2	10.3	0.080	3533	0.001	62
127360	589	127949	39469	51	62	-4.7	-4.2	10.3	0.080	3147	0.001	55
16000	253	16253	5014	53	57	-7.3	-5.9	12.2	0.813	4075	0.030	150
139274	305	139579	43056	57	67	-1.2	-1.6	10.2	0.001	29	0.000	1
17230		17230	5315	59	59	-0.7	-3.8	12.4	0.096	509	0.000	0
63770	166	63936	19722	60	60	-3.9	-3.8	11.1	0.055	1077	0.001	10
13688		13688	4222	60	60	-3.9	-3.8	11.1	0.055	231	0.001	2
70809		70809	21843	63	63	1.9	0.1	9.1	0.000	0	0.000	0
96728	422	97150	29968	65	71	0.2	0.0	9.3	0.000	1	0.000	0
137909	840	138749	42800	65	71	0.2	0.0	9.3	0.000	1	0.000	0
98395	408	98803	30478	66	75	0.2	-0.1	9.4	0.000	1	0.000	0
163636	416	164052	50605	67	80	-1.4	-1.3	9.4	0.000	14	0.000	1
93016	351	93367	28801	68	68	1.9	1.2	6.5	0.000	0	0.000	0
51225	44	51269	15815	69	72	0.9	0.3	7.5	0.000	0	0.000	0
154363	525	154888	47778	69	72	0.9	0.3	7.5	0.000	0	0.000	0
84828	404	85232	26292	70	70	0.6	0.0	4.9	0.000	0	0.000	0
79610	375	79985	24673	72	77	-1.8	-1.4	10.1	0.000	12	0.000	1
64890	425	65315	20148	73	73	1.5	1.2	6.1	0.000	0	0.000	0
124398	1953	126351	38976	73	73	1.5	1.2	6.1	0.000	0	0.000	0
95444	757	96201	29675	74	74	-0.5	-0.8	10.9	0.000	6	0.000	0
52746		52746	16271	74	74	-0.5	-0.8	10.9	0.000	3	0.000	0
47000	294	47294	14589	76	78	-6.0	-4.1	10.8	0.087	1263	0.006	91
25174		25174	7765	76	78	-6.0	-4.1	10.8	0.087	672	0.006	48
90582	645	91227	28141	82	82	-2.0	-1.6	8.9	0.000	11	0.000	2
117289	365	117654	36293	17	23	-7.2	-5.8	9.0	0.478	17330	0.025	895
162361	182	162543	50140	17	23	-7.2	-5.8	9.0	0.478	23943	0.025	1237
95341	351	95692	29518	17	23	-7.2	-5.8	9.0	0.478	14095	0.025	728
73699	36	73735	22745	18	22	-7.1	-6.0	9.3	0.584	13282	0.024	541
143470	176	143646	44311	18	22	-7.1	-6.0	9.3	0.584	25876	0.024	1053
95070	129	95199	29366	18	22	-7.1	-6.0	9.3	0.584	17149	0.024	698
129441	342	129783	40034	19	26	-4.1	-3.5	8.9	0.011	454	0.001	28
80376	248	80624	24870	22	28	-4.6	-3.7	8.0	0.012	298	0.001	29
66824	85	66909	20639	22	28	-4.6	-3.7	8.0	0.012	247	0.001	24
98852	81	98933	30518	24	32	-7.5	-5.8	9.7	0.538	16432	0.036	1110
88867	150	89017	27459	25	32	-8.6	-6.5	10.3	0.840	23076	0.122	3360
83054	112	83166	25654	26	33	-9.8	-7.2	10.0	0.951	24402	0.353	9045
150936	676	151612	46768	28	35	-8.0	-6.3	8.9	0.670	31348	0.063	2961
84485	75	84560	26084	29	34	-9.2	-6.9	9.7	0.908	23674	0.213	5566
80262	417	80679	24887	29	34	-9.2	-6.9	9.7	0.908	22587	0.213	5310
110787	263	111050	34256	29	34	-9.2	-6.9	9.7	0.908	31090	0.213	7309
73257	377	73634	22714	31	38	-3.6	-3.5	8.5	0.010	218	0.000	9
83851	833	84684	26123	31	38	-3.6	-3.5	8.5	0.010	250	0.000	10
50114	417	50531	15587	32	42	-3.7	-3.3	8.4	0.007	104	0.000	6
103039	363	103402	31897	33	40	-1.7	-2.0	8.1	0.001	17	0.000	1
61168	333	61501	18971	33	40	-1.7	-2.0	8.1	0.001	10	0.000	1

Appendix 2. (continued)

Catch/trip				Day #		Weather by trip			Temp/wind mode		Windchill model	
delivered live crabs	dead loss	total catch	est. bycatch	start	sale	wind chill	temp (C)	wind (m/s)	P(mort)	mortality	P(wc)	bycatch mortality
70535	420	70955	21888	34	39	-0.9	-1.1	8.4	0.000	3	0.000	0
79245	403	79648	24569	35	42	-1.9	-2.1	7.8	0.001	15	0.000	1
96314	568	96882	29885	35	42	-1.9	-2.1	7.8	0.001	18	0.000	2
170976	540	171516	52908	36	45	-3.5	-3.2	8.0	0.005	243	0.000	18
104888	451	105339	32494	38	47	-4.9	-4.2	7.6	0.023	762	0.002	53
11960	35	11995	3700	39	48	-5.6	-4.7	7.4	0.059	218	0.004	14
70533	301	70834	21850	40	46	-6.1	-5.3	7.2	0.139	3035	0.007	149
69861	657	70518	21753	41	49	-6.9	-5.6	7.3	0.224	4866	0.019	404
104051	537	104588	32262	42	48	-7.0	-5.6	6.9	0.205	6616	0.021	684
84671	328	84999	26220	43	50	-6.5	-5.2	7.5	0.129	3378	0.012	303
42437	42	42479	13104	44	48	-6.6	-5.2	7.1	0.120	1568	0.013	166
21353	118	21471	6623	44	48	-6.6	-5.2	7.1	0.120	793	0.013	84
239238	1009	240247	74109	44	48	-6.6	-5.2	7.1	0.120	8869	0.013	939
87667	615	88282	27232	45	55	-6.6	-5.1	9.3	0.235	6391	0.012	335
85197	403	85600	26405	46	51	-6.3	-4.9	7.3	0.077	2023	0.009	243
90482	551	91033	28081	48	56	-6.8	-5.2	10.2	0.355	9972	0.015	425
69978	159	70137	21635	49	54	-5.6	-4.5	10.4	0.124	2690	0.004	87
50966	132	51098	15762	50	56	-7.0	-5.4	11.0	0.496	7819	0.020	308
66320	313	66633	20554	51	58	-6.2	-5.1	10.0	0.268	5510	0.008	157
161850	798	162648	50172	52	60	-5.3	-4.8	10.8	0.254	12749	0.003	141
14738	417	15155	4675	57	67	-1.2	-1.6	10.2	0.001	3	0.000	0
73867	292	74159	22876	59	67	-0.8	-1.1	10.9	0.000	9	0.000	0
54916	256	55172	17019	60	64	-0.6	-1.0	9.2	0.000	2	0.000	0
53350	585	53935	16637	60	64	-0.6	-1.0	9.2	0.000	2	0.000	0
92195	127	92322	28479	62	65	0.5	0.1	9.8	0.000	1	0.000	0
65988	83	66071	20381	63	67	0.1	-0.1	10.8	0.000	1	0.000	0
81816	345	82161	25344	63	67	0.1	-0.1	10.8	0.000	1	0.000	0
59795	236	60031	18518	63	67	0.1	-0.1	10.8	0.000	1	0.000	0
70022	914	70936	21882	63	67	0.1	-0.1	10.8	0.000	1	0.000	0
75367	579	75946	23427	64	73	0.5	0.3	8.7	0.000	0	0.000	0
96900	333	97233	29994	65	70	0.1	0.1	9.8	0.000	1	0.000	0
85979	369	86348	26636	66	72	0.3	0.0	9.4	0.000	1	0.000	0
66967	129	67096	20697	68	74	0.9	0.4	7.6	0.000	0	0.000	0
63098	1308	64406	19867	68	74	0.9	0.4	7.6	0.000	0	0.000	0
83472	345	83817	25855	69	75	0.4	0.0	8.4	0.000	0	0.000	0
84257	528	84785	26154	70	80	-2.0	-1.8	9.6	0.001	19	0.000	2
90210	275	90485	27912	71	76	-0.6	-0.7	9.5	0.000	3	0.000	0
33757	269	34026	10496	72	74	0.5	0.3	9.4	0.000	0	0.000	0
51365	690	52055	16057	74	81	-3.2	-2.7	11.1	0.008	123	0.000	4
93432	749	94181	29052	74	81	-3.2	-2.7	11.1	0.008	223	0.000	7
52317	78	52395	16162	76	81	-3.9	-3.2	11.0	0.018	297	0.001	9
107905	199	108104	33347	15	24	-6.8	-5.4	10.0	0.403	13433	0.016	539
102650	201	102851	31727	18	21	-8.3	-6.7	10.5	0.898	28480	0.086	2724
187151	1095	188246	58068	18	21	-8.3	-6.7	10.5	0.898	52125	0.086	4985
249494	1389	250883	77390	18	21	-8.3	-6.7	10.5	0.898	69470	0.086	6644

Appendix 2. (continued)

Catch/trip				Day #		Weather by trip			Temp/wind mode		Windchill model	
delivered live crabs	dead loss	total catch	est. bycatch	start	sale	wind chill	temp (C)	wind (m/s)	P(mort)	mortality	P(wc)	bycatch mortality
228300	723	229023	70647	20	23	-4.3	-3.6	7.4	0.007	493	0.001	57
110249	450	110699	34147	20	23	-4.3	-3.6	7.4	0.007	238	0.001	28
84122	1920	86042	26541	23	26	-2.0	-2.0	8.3	0.001	16	0.000	1
140845	648	141493	43646	24	28	-5.8	-4.5	9.5	0.092	4032	0.005	216
193289	2406	195695	60366	24	28	-5.8	-4.5	9.5	0.092	5577	0.005	299
99254	942	100196	30908	24	28	-5.8	-4.5	9.5	0.092	2855	0.005	153
102746	314	103060	31791	27	35	-8.4	-6.4	9.1	0.750	23839	0.102	3245
122652	1449	124101	38282	28	36	-7.2	-5.7	8.5	0.384	14712	0.025	953
106927	1336	108263	33396	28	36	-7.2	-5.7	8.5	0.384	12835	0.025	831
130502	1410	131912	40691	29	39	-4.5	-3.9	8.8	0.024	977	0.001	43
38842	78	38920	12006	30	37	-5.6	-4.6	9.2	0.104	1247	0.004	47
71711	382	72093	22239	32	39	-3.0	-2.6	8.6	0.002	44	0.000	4
121741	2143	123884	38215	33	40	-1.7	-2.0	8.1	0.001	20	0.000	2
144739	1705	146444	45174	34	42	-2.4	-2.4	8.2	0.001	60	0.000	4
153092	1772	154864	47771	34	42	-2.4	-2.4	8.2	0.001	63	0.000	5
168306	1252	169558	52304	36	44	-3.1	-2.9	8.0	0.003	142	0.000	11
101480	764	102244	31539	37	46	-4.0	-3.5	7.9	0.008	265	0.001	19
120823	703	121526	37487	39	45	-5.1	-4.4	8.1	0.048	1784	0.002	79
176899	1727	178626	55101	39	45	-5.1	-4.4	8.1	0.048	2622	0.002	116
124153	1370	125523	38720	41	53	-6.4	-5.1	7.8	0.137	5312	0.010	394
83073	1139	84212	25977	42	48	-7.0	-5.6	6.9	0.205	5327	0.021	550
169815	1290	171105	52781	42	48	-7.0	-5.6	6.9	0.205	10823	0.021	1118
62992	886	63878	19705	42	48	-7.0	-5.6	6.9	0.205	4040	0.021	418
138533	905	139438	43013	44	55	-6.5	-5.1	9.3	0.214	9220	0.011	490
188370	3266	191636	59114	44	55	-6.5	-5.1	9.3	0.214	12671	0.011	674
57424	606	58030	17901	45	50	-6.5	-5.1	7.5	0.117	2090	0.012	207
166472	1705	168177	51878	46	52	-6.0	-4.8	7.0	0.053	2730	0.007	340
93185	444	93629	28882	47	51	-6.4	-4.9	8.0	0.095	2734	0.010	297
143059	2308	145367	44841	47	51	-6.4	-4.9	8.0	0.095	4244	0.010	461
76648	886	77534	23917	48	56	-6.8	-5.2	10.2	0.355	8493	0.015	362
28048	303	28351	8745	48	56	-6.8	-5.2	10.2	0.355	3106	0.015	132
81070	1061	82131	25335	52	60	-5.3	-4.8	10.8	0.254	6438	0.003	71
163835	862	164697	50804	56	61	-3.6	-3.8	8.8	0.022	1097	0.000	18
185733	6109	191842	59178	56	61	-3.6	-3.8	8.8	0.022	1278	0.000	22
90551	800	91351	28179	58	65	-0.7	-1.3	9.5	0.000	9	0.000	0
112725	1384	114109	35199	58	65	-0.7	-1.3	9.5	0.000	11	0.000	0
145840	2388	148228	45724	59	69	-0.3	-0.8	10.2	0.000	7	0.000	0
154008	1504	155512	47971	60	67	-0.8	-0.8	10.7	0.000	10	0.000	1
180239	1521	181760	56068	61	68	0.0	-0.2	10.1	0.000	3	0.000	0
99355	2459	101814	31407	61	68	0.0	-0.2	10.1	0.000	2	0.000	0
112579	976	113555	35028	63	72	0.6	0.2	9.0	0.000	1	0.000	0
94236	1475	95711	29524	65	73	0.4	0.2	9.1	0.000	0	0.000	0
112772	952	113724	35081	66	74	0.3	0.1	9.2	0.000	1	0.000	0
27617	352	27969	8628	67	71	0.8	0.2	7.4	0.000	0	0.000	0
138115	1681	139796	43123	69	75	0.4	0.0	8.4	0.000	1	0.000	0

Appendix 2. (continued)

Catch/trip				Day #		Weather by trip			Temp/wind mode		Windchill model	
delivered live crabs	dead loss	total catch	est. bycatch	start	sale	wind chill	temp (C)	wind (m/s)	P(mort)	mortality	P(wc)	bycatch mortality
85503	394	85897	26497	69	75	0.4	0.0	8.4	0.000	0	0.000	0
74854	1526	76380	23561	69	75	0.4	0.0	8.4	0.000	0	0.000	0
43231	625	43856	13528	71	76	-0.6	-0.7	9.5	0.000	1	0.000	0
60710	1125	61835	19074	72	76	-0.9	-0.8	10.2	0.000	3	0.000	0
95814	1134	96948	29906	73	79	-3.4	-2.5	10.2	0.004	114	0.000	9
55997	645	56642	17472	75	80	-4.3	-3.3	11.1	0.024	424	0.001	14
42084	556	42640	13153	76	80	-4.8	-3.7	11.0	0.042	558	0.002	21
65311	1198	66509	20516	76	80	-4.8	-3.7	11.0	0.042	870	0.002	32
21788	720	22508	6943	77	80	-4.8	-3.8	10.9	0.052	362	0.002	11
33487		33487	10330	17	25	-5.6	-4.6	8.6	0.083	852	0.004	39
268209		268209	82735	18	24	-5.1	-4.4	8.0	0.039	3230	0.002	186
315330		315330	97270	32	38	-3.6	-3.0	8.5	0.004	432	0.000	37
240364		240364	74145	39	50	-5.6	-4.7	7.8	0.063	4643	0.004	298
166106		166106	51239	64	64	1.8	1.2	5.3	0.000	0	0.000	0
304074		304074	93798	79	79	-5.2	-4.1	10.3	0.066	6209	0.003	239
4551		4551	1404	34	37	-1.9	-1.9	8.3	0.001	1	0.000	0
194773	1345	196118	60497	17	23	-7.2	-5.8	9.0	0.478	28888	0.025	1492
288981	1418	290399	89580	18	27	-5.5	-4.6	9.0	0.084	7516	0.004	318
98250	472	98722	30453	19	22	-6.3	-4.9	9.5	0.183	5563	0.009	275
86866	547	87413	26964	19	22	-6.3	-4.9	9.5	0.183	4925	0.009	243
120984	1338	122322	37733	19	22	-6.3	-4.9	9.5	0.183	6892	0.009	341
142272	1938	144210	44485	19	22	-6.3	-4.9	9.5	0.183	8126	0.009	402
127443	803	128246	39560	20	29	-5.4	-4.4	8.3	0.045	1774	0.003	117
188419	2828	191247	58994	22	32	-6.3	-5.0	8.6	0.156	9202	0.009	532
136766	704	137470	42406	23	34	-6.9	-5.4	9.1	0.295	12491	0.017	717
90093	1626	91719	28293	25	35	-7.5	-5.9	9.6	0.601	17002	0.037	1047
108031	1855	109886	33897	29	39	-4.5	-3.9	8.8	0.024	814	0.001	36
111293	1074	112367	34662	30	35	-7.7	-6.0	9.7	0.646	22403	0.045	1553
151474	1489	152963	47185	31	38	-3.6	-3.5	8.5	0.010	452	0.000	18
164171	2713	166884	51479	32	41	-3.2	-2.9	8.5	0.004	187	0.000	11
84227	5263	89490	27605	34	42	-2.4	-2.4	8.2	0.001	36	0.000	3
169982	816	170798	52686	36	44	-3.1	-2.9	8.0	0.003	143	0.000	11
157872	4202	162074	49995	37	37	0.8	0.5	10.7	0.000	1	0.000	0
109998	420	110418	34061	38	43	-3.6	-3.4	7.8	0.007	231	0.000	13
151278	3750	155028	47822	38	43	-3.6	-3.4	7.8	0.007	325	0.000	19
99536	965	100501	31002	39	45	-5.1	-4.4	8.1	0.048	1475	0.002	65
67619	446	68065	20996	41	47	-7.2	-5.8	7.3	0.300	6294	0.025	532
194840	1552	196392	60581	43	51	-6.5	-5.1	7.5	0.111	6721	0.011	657
116992	2252	119244	36783	44	48	-6.6	-5.2	7.1	0.120	4402	0.013	466
67653	313	67966	20966	44	48	-6.6	-5.2	7.1	0.120	2509	0.013	266
98225	877	99102	30570	46	53	-5.9	-4.7	7.7	0.059	1812	0.005	161
52630	397	53027	16357	48	53	-5.5	-4.4	8.4	0.048	780	0.003	57
111572	789	112361	34660	48	53	-5.5	-4.4	8.4	0.048	1652	0.003	121
68469	354	68823	21230	50	58	-6.2	-5.0	10.1	0.245	5204	0.008	162
85398	1230	86628	26722	50	58	-6.2	-5.0	10.1	0.245	6550	0.008	203

Appendix 2. (continued)

Catch/trip				Day #		Weather by trip			Temp/wind mode		Windchill model	
delivered live crabs	dead loss	total catch	est. bycatch	start	sale	wind chill	temp (C)	wind (m/s)	P(mort)	mortality	P(wc)	bycatch mortality
224565	4725	229290	70729	52	55	-6.8	-5.4	12.5	0.656	46379	0.016	1126
13992	331	14323	4418	56	61	-3.6	-3.8	8.8	0.022	95	0.000	2
155761	1610	157371	48544	56	61	-3.6	-3.8	8.8	0.022	1049	0.000	18
85797	678	86475	26675	60	65	-0.5	-0.7	9.4	0.000	3	0.000	0
55594	1120	56714	17495	60	65	-0.5	-0.7	9.4	0.000	2	0.000	0
53126	342	53468	16493	61	61	-0.9	-0.8	6.0	0.000	0	0.000	0
84294	1176	85470	26365	61	61	-0.9	-0.8	6.0	0.000	1	0.000	0
34504	128	34632	10683	62	62	-2.0	-1.5	14.3	0.004	39	0.000	1
47453	409	47862	14764	62	62	-2.0	-1.5	14.3	0.004	54	0.000	1
63101	1176	64277	19828	63	68	0.4	0.1	10.1	0.000	1	0.000	0
60433	698	61131	18857	63	68	0.4	0.1	10.1	0.000	1	0.000	0
179523	1447	180970	55824	64	73	0.5	0.3	8.7	0.000	1	0.000	0
65755	496	66251	20437	64	73	0.5	0.3	8.7	0.000	0	0.000	0
127434	7080	134514	41494	65	70	0.1	0.1	9.8	0.000	1	0.000	0
217268	5909	223177	68844	65	70	0.1	0.1	9.8	0.000	2	0.000	0
105375	504	105879	32661	67	76	-0.1	-0.3	8.8	0.000	1	0.000	0
58594	1695	60289	18597	69	71	1.0	0.2	6.3	0.000	0	0.000	0
82810	870	83680	25813	70	79	-2.2	-1.7	9.4	0.001	16	0.000	2
76573	3017	79590	24551	72	77	-1.8	-1.4	10.1	0.000	12	0.000	1
119072	1802	120874	37286	74	83	-3.1	-2.6	10.7	0.005	191	0.000	7
120624	1754	122378	37750	75	82	-3.4	-2.8	10.8	0.008	313	0.000	11
121378	3509	124887	38524	75	82	-3.4	-2.8	10.8	0.008	320	0.000	11
33770	270	34040	10500	76	81	-3.9	-3.2	11.0	0.018	193	0.001	6
40118	427	40545	12507	76	81	-3.9	-3.2	11.0	0.018	230	0.001	7
31923	180	32103	9903	77	79	-6.1	-4.4	10.6	0.129	1278	0.007	74
19872	342	20214	6235	77	79	-6.1	-4.4	10.6	0.129	805	0.007	46
118000	500	118500	36554	15	20	-9.8	-7.5	12.8	0.991	36243	0.355	12985
139010	556	139566	43052	15	20	-9.8	-7.5	12.8	0.991	42686	0.355	15294
15436	195	15631	4822	16	19	-11.0	-8.6	12.5	0.999	4815	0.699	3369
182900	1481	184381	56876	16	19	-11.0	-8.6	12.5	0.999	56800	0.699	39736
32790	250	33040	10192	17	20	-10.1	-8.0	11.4	0.994	10127	0.459	4676
135700	736	136436	42087	17	20	-10.1	-8.0	11.4	0.994	41819	0.459	19309
119030	504	119534	36873	17	20	-10.1	-8.0	11.4	0.994	36638	0.459	16917
282961	1753	284714	87826	17	20	-10.1	-8.0	11.4	0.994	87268	0.459	40295
176746	958	177704	54817	17	21	-9.4	-7.4	11.0	0.977	53576	0.270	14809
186113	1576	187689	57897	17	23	-7.2	-5.8	9.0	0.478	27647	0.025	1428
129166	596	129762	40028	18	22	-7.1	-6.0	9.3	0.584	23375	0.024	951
56678	318	56996	17582	19	21	-7.6	-5.5	11.1	0.582	10238	0.038	672
106733	406	107139	33049	19	21	-7.6	-5.5	11.1	0.582	19245	0.038	1262
78322	392	78714	24281	20	27	-4.5	-3.7	8.6	0.016	388	0.001	26
84430	415	84845	26172	21	26	-2.9	-2.7	7.9	0.002	45	0.000	4
184340	1502	185842	57327	21	26	-2.9	-2.7	7.9	0.002	100	0.000	9
95205	592	95797	29551	21	26	-2.9	-2.7	7.9	0.002	51	0.000	5
342008	1592	343600	105991	21	26	-2.9	-2.7	7.9	0.002	184	0.000	16
136336	845	137181	42316	22	31	-5.9	-4.8	8.3	0.099	4176	0.005	224

Appendix 2. (continued)

Catch/trip				Day #		Weather by trip			Temp/wind mode		Windchill model	
delivered live crabs	dead loss	total catch	est. bycatch	start	sale	wind chill	temp (C)	wind (m/s)	P(mort)	mortality	P(wc)	bycatch mortality
158000	1115	159115	49082	22	31	-5.9	-4.8	8.3	0.099	4843	0.005	260
64059	669	64728	19967	23	32	-6.7	-5.2	9.0	0.243	4843	0.015	293
125000	1146	126146	38912	25	32	-8.6	-6.5	10.3	0.840	32701	0.122	4761
199456	1134	200590	61876	25	32	-8.6	-6.5	10.3	0.840	51999	0.122	7570
98500	1016	99516	30698	25	32	-8.6	-6.5	10.3	0.840	25798	0.122	3756
285747	2624	288371	88954	25	32	-8.6	-6.5	10.3	0.840	74755	0.122	10883
75333	929	76262	23525	26	36	-7.7	-6.0	9.3	0.591	13897	0.043	1010
130791	772	131563	40583	28	36	-7.2	-5.7	8.5	0.384	15597	0.025	1010
96422	309	96731	29839	29	34	-9.2	-6.9	9.7	0.908	27081	0.213	6367
172346	1074	173420	53495	29	34	-9.2	-6.9	9.7	0.908	48551	0.213	11415
90600	946	91546	28239	31	38	-3.6	-3.5	8.5	0.010	271	0.000	11
307841	1270	309111	95352	31	38	-3.6	-3.5	8.5	0.010	914	0.000	36
124694	668	125362	38671	32	37	-4.3	-3.6	8.6	0.014	525	0.001	34
93468	802	94270	29080	32	37	-4.3	-3.6	8.6	0.014	394	0.001	26
82043	783	82826	25549	32	37	-4.3	-3.6	8.6	0.014	347	0.001	23
157408	1131	158539	48905	32	37	-4.3	-3.6	8.6	0.014	663	0.001	43
185942	1215	187157	57733	33	39	-2.0	-1.9	8.2	0.001	29	0.000	3
67915	358	68273	21060	35	38	0.0	-0.5	7.4	0.000	1	0.000	0
150115	431	150546	46439	35	38	0.0	-0.5	7.4	0.000	1	0.000	0
206025	2058	208083	64188	36	45	-3.5	-3.2	8.0	0.005	295	0.000	22
139076	1067	140143	43230	37	40	0.6	-0.2	8.8	0.000	1	0.000	0
65880	72	65952	20344	37	40	0.6	-0.2	8.8	0.000	1	0.000	0
182239	713	182952	56435	37	40	0.6	-0.2	8.8	0.000	1	0.000	0
126111	542	126653	39069	38	46	-4.5	-4.0	7.6	0.017	645	0.001	43
102725	602	103327	31873	39	43	-4.5	-4.2	7.8	0.028	891	0.001	34
129335	645	129980	40095	39	43	-4.5	-4.2	7.8	0.028	1120	0.001	43
109222	2837	112059	34567	40	45	-6.1	-5.3	7.9	0.179	6198	0.007	245
170778	811	171589	52930	40	45	-6.1	-5.3	7.9	0.179	9491	0.007	375
95387	1455	96842	29873	40	45	-6.1	-5.3	7.9	0.179	5357	0.007	212
76768	653	77421	23882	41	48	-7.1	-5.7	7.2	0.256	6111	0.022	526
92000	704	92704	28596	41	48	-7.1	-5.7	7.2	0.256	7318	0.022	630
125034	565	125599	38744	42	48	-7.0	-5.6	6.9	0.205	7945	0.021	821
46544	396	46940	14480	43	50	-6.5	-5.2	7.5	0.129	1865	0.012	168
265931	1418	267349	82469	43	50	-6.5	-5.2	7.5	0.129	10624	0.012	954
86065	738	86803	26776	43	50	-6.5	-5.2	7.5	0.129	3449	0.012	310
87896	485	88381	27263	45	48	-6.8	-5.5	6.5	0.136	3710	0.016	439
58270	284	58554	18062	45	48	-6.8	-5.5	6.5	0.136	2458	0.016	291
106724	677	107401	33130	45	48	-6.8	-5.5	6.5	0.136	4509	0.016	533
188088	2465	190553	58780	45	48	-6.8	-5.5	6.5	0.136	8000	0.016	946
126007	625	126632	39062	46	52	-6.0	-4.8	7.0	0.053	2056	0.007	256
113015	423	113438	34992	46	52	-6.0	-4.8	7.0	0.053	1842	0.007	229
135000	1137	136137	41994	47	55	-6.6	-5.1	10.0	0.275	11559	0.012	524
290578	2284	292862	90339	47	55	-6.6	-5.1	10.0	0.275	24866	0.012	1128
119460	329	119789	36951	48	54	-5.7	-4.5	9.9	0.115	4235	0.004	165
75688	365	76053	23460	48	54	-5.7	-4.5	9.9	0.115	2689	0.004	105

Appendix 2. (continued)

Catch/trip				Day #		Weather by trip			Temp/wind mode		Windchill model	
delivered live crabs	dead loss	total catch	est. bycatch	start	sale	wind chill	temp (C)	wind (m/s)	P(mort)	mortality	P(wc)	bycatch mortality
66775	595	67370	20782	48	54	-5.7	-4.5	9.9	0.115	2382	0.004	93
155380	1173	156553	48292	49	62	-4.9	-4.2	10.2	0.080	3887	0.002	83
90468	221	90689	27975	50	55	-6.6	-5.0	11.3	0.379	10616	0.012	338
81394	658	82052	25311	50	55	-6.6	-5.0	11.3	0.379	9605	0.012	306
101144	1169	102313	31561	50	55	-6.6	-5.0	11.3	0.379	11976	0.012	381
238134	2509	240643	74231	52	66	-3.3	-3.0	10.6	0.012	865	0.000	19
113652	737	114389	35286	54	59	-5.9	-5.3	11.3	0.514	18142	0.005	188
29156	3569	32725	10095	55	59	-5.6	-5.3	9.9	0.340	3433	0.004	41
25471	486	25957	8007	55	59	-5.6	-5.3	9.9	0.340	2723	0.004	33
259165	15699	274864	84788	55	59	-5.6	-5.3	9.9	0.340	28831	0.004	346
97830	360	98190	30289	58	65	-0.7	-1.3	9.5	0.000	10	0.000	0
104139	1068	105207	32453	58	65	-0.7	-1.3	9.5	0.000	10	0.000	0
92643	1083	93726	28912	59	69	-0.3	-0.8	10.2	0.000	4	0.000	0
133545	1460	135005	41645	60	70	-0.2	-0.4	9.5	0.000	2	0.000	0
53860	756	54616	16847	61	66	-0.2	-0.3	10.5	0.000	1	0.000	0
72525	856	73381	22636	62	71	0.3	0.0	9.4	0.000	1	0.000	0
196345	1928	198273	61161	63	71	0.6	0.2	8.8	0.000	1	0.000	0
129991	1448	131439	40545	63	71	0.6	0.2	8.8	0.000	1	0.000	0
245077	5965	251042	77439	63	71	0.6	0.2	8.8	0.000	1	0.000	0
103363	825	104188	32139	64	70	0.3	0.2	9.1	0.000	0	0.000	0
145000	1908	146908	45317	64	70	0.3	0.2	9.1	0.000	1	0.000	0
196332	2574	198906	61357	65	74	0.3	0.1	9.3	0.000	1	0.000	0
88870	1366	90236	27835	65	74	0.3	0.1	9.3	0.000	1	0.000	0
39094	1450	40544	12507	66	75	0.2	-0.1	9.4	0.000	0	0.000	0
211886	1650	213536	65870	67	73	0.9	0.4	7.7	0.000	0	0.000	0
388005	2581	390586	120484	67	73	0.9	0.4	7.7	0.000	1	0.000	0
200298	2442	202740	62539	68	79	-1.5	-1.3	9.0	0.000	14	0.000	2
1822		1822	562	69	69	1.3	0.8	7.7	0.000	0	0.000	0
82815	306	83121	25640	69	69	1.3	0.8	7.7	0.000	0	0.000	0
86576	625	87201	26899	69	69	1.3	0.8	7.7	0.000	0	0.000	0
131147	1247	132394	40840	70	79	-2.2	-1.7	9.4	0.001	25	0.000	3
22803	510	23313	7191	71	80	-2.3	-1.9	10.1	0.001	9	0.000	1
140000	378	140378	43303	71	80	-2.3	-1.9	10.1	0.001	52	0.000	3
16980	223	17203	5307	72	78	-2.6	-1.9	10.3	0.001	6	0.000	1
135282	2034	137316	42358	73	85	-2.9	-2.4	10.0	0.003	115	0.000	7
78479	737	79216	24436	74	80	-3.7	-3.0	11.1	0.012	304	0.000	11
88386	1082	89468	27598	74	80	-3.7	-3.0	11.1	0.012	344	0.000	12
68000	221	68221	21044	75	81	-3.6	-3.0	11.1	0.013	269	0.000	8
57047		57047	17597	76	78	-6.0	-4.1	10.8	0.087	1524	0.006	109
11600	88	11688	3605	76	78	-6.0	-4.1	10.8	0.087	312	0.006	22
32472	300	32772	10109	78	85	-3.2	-2.8	10.0	0.005	54	0.000	2
151034	690	151724	46802	17	22	-8.3	-6.7	9.9	0.878	41090	0.087	4085
87609	1417	89026	27462	17	22	-8.3	-6.7	9.9	0.878	24110	0.087	2397
128938	1224	130162	40151	17	22	-8.3	-6.7	9.9	0.878	35250	0.087	3504
246230	2819	249049	76824	17	22	-8.3	-6.7	9.9	0.878	67447	0.087	6705

Appendix 2. (continued)

Catch/trip				Day #		Weather by trip			Temp/wind mode		Windchill model	
delivered live crabs	dead loss	total catch	est. bycatch	start	sale	wind chill	temp (C)	wind (m/s)	P(mort)	mortality	P(wc)	bycatch mortality
154518	1092	155610	48001	18	23	-6.0	-5.0	8.3	0.142	6836	0.006	309
107237	2445	109682	33834	18	23	-6.0	-5.0	8.3	0.142	4818	0.006	218
286585	1268	287853	88794	18	23	-6.0	-5.0	8.3	0.142	12645	0.006	572
73957	263	74220	22895	19	22	-6.3	-4.9	9.5	0.183	4182	0.009	207
80410	460	80870	24946	19	22	-6.3	-4.9	9.5	0.183	4557	0.009	225
147844	1067	148911	45935	22	31	-5.9	-4.8	8.3	0.099	4533	0.005	243
154311	1653	155964	48110	24	33	-7.6	-5.9	9.4	0.560	26960	0.040	1903
119221	1186	120407	37142	25	33	-8.6	-6.5	9.9	0.830	30834	0.116	4292
189936	1111	191047	58932	26	34	-9.4	-7.0	10.2	0.932	54922	0.255	15016
146253	3285	149538	46128	27	36	-7.7	-5.9	8.6	0.500	23044	0.043	1993
170978	2721	173699	53581	27	36	-7.7	-5.9	8.6	0.500	26767	0.043	2315
160462	1154	161616	49854	29	37	-5.8	-4.9	8.8	0.135	6722	0.005	259
102995	881	103876	32043	30	38	-4.8	-4.1	9.0	0.036	1168	0.002	49
139040	774	139814	43129	31	41	-3.2	-3.2	8.5	0.006	280	0.000	9
45008	615	45623	14073	34	41	-1.6	-1.9	8.4	0.001	7	0.000	1
131213	1097	132310	40814	34	41	-1.6	-1.9	8.4	0.001	21	0.000	1
125699	1043	126742	39096	36	45	-3.5	-3.2	8.0	0.005	180	0.000	14
111894	800	112694	34763	37	43	-3.0	-2.9	8.2	0.003	101	0.000	6
161532	945	162477	50119	37	43	-3.0	-2.9	8.2	0.003	146	0.000	9
163798	1220	165018	50903	39	47	-5.5	-4.7	7.5	0.058	2941	0.003	173
77522	417	77939	24042	41	48	-7.1	-5.7	7.2	0.256	6152	0.022	530
60923	909	61832	19073	41	48	-7.1	-5.7	7.2	0.256	4881	0.022	420
144568	927	145495	44881	42	52	-6.5	-5.1	7.2	0.110	4948	0.011	507
119066	625	119691	36921	43	49	-6.6	-5.3	7.1	0.132	4862	0.012	455
95802	546	96348	29721	43	49	-6.6	-5.3	7.1	0.132	3914	0.012	366
97501	833	98334	30333	44	54	-6.1	-4.8	8.9	0.122	3707	0.007	206
46219	446	46665	14395	46	52	-6.0	-4.8	7.0	0.053	758	0.007	94
66122	2105	68227	21046	46	52	-6.0	-4.8	7.0	0.053	1108	0.007	138
156226	1151	157377	48546	46	52	-6.0	-4.8	7.0	0.053	2555	0.007	318
55618	508	56126	17313	49	53	-5.4	-4.2	8.7	0.044	766	0.003	51
55854	719	56573	17451	49	53	-5.4	-4.2	8.7	0.044	772	0.003	51
151597	1049	152646	47087	50	62	-4.8	-4.2	10.4	0.082	3850	0.002	75
116320	819	117139	36134	56	66	-2.0	-2.2	10.0	0.002	67	0.000	2
93871	746	94617	29187	56	66	-2.0	-2.2	10.0	0.002	54	0.000	2
100071	480	100551	31017	58	63	-1.3	-2.1	10.1	0.002	48	0.000	1
40932	444	41376	12763	58	63	-1.3	-2.1	10.1	0.002	20	0.000	0
103977	826	104803	32329	59	64	-0.6	-1.4	9.7	0.000	13	0.000	0
330975	2787	333762	102956	59	64	-0.6	-1.4	9.7	0.000	42	0.000	1
85422	650	86072	26551	60	63	-1.2	-1.5	10.1	0.001	15	0.000	1
99633	656	100289	30936	63	68	0.4	0.1	10.1	0.000	1	0.000	0
165966	3620	169586	52312	64	69	0.3	0.3	9.8	0.000	1	0.000	0
169933	2068	172001	53057	64	69	0.3	0.3	9.8	0.000	1	0.000	0
102590	3321	105911	32670	65	73	0.4	0.2	9.1	0.000	1	0.000	0
178798	1678	180476	55672	68	75	0.6	0.1	8.2	0.000	1	0.000	0
115398	1491	116889	36057	68	75	0.6	0.1	8.2	0.000	0	0.000	0

Appendix 2. (continued)

Catch/trip				Day #		Weather by trip			Temp/wind mode		Windchill model	
delivered live crabs	dead loss	total catch	est. bycatch	start	sale	wind chill	temp (C)	wind (m/s)	P(mort)	mortality	P(wc)	bycatch mortality
140246	1913	142159	43852	68	75	0.6	0.1	8.2	0.000	1	0.000	0
96437	840	97277	30007	69	79	-1.8	-1.5	9.2	0.000	11	0.000	1
158318	820	159138	49089	69	79	-1.8	-1.5	9.2	0.000	19	0.000	2
176877	1739	178616	55098	72	84	-2.5	-2.1	10.2	0.002	97	0.000	6
39425	427	39852	12293	73	80	-3.1	-2.5	10.4	0.004	45	0.000	2
175506	3813	179319	55315	73	80	-3.1	-2.5	10.4	0.004	203	0.000	11
62349	840	63189	19492	77	82	-3.5	-2.9	10.7	0.010	191	0.000	6
39284	272	39556	12202	17	22	-8.3	-6.7	9.9	0.878	10712	0.087	1065
16648	17	16665	5141	18	20	-8.8	-7.2	10.8	0.966	4967	0.152	782
116339	351	116690	35995	18	20	-8.8	-7.2	10.8	0.966	34781	0.152	5477
62958	370	63328	19535	18	20	-8.8	-7.2	10.8	0.966	18876	0.152	2972
175770	232	176002	54292	18	20	-8.8	-7.2	10.8	0.966	52460	0.152	8261
80699	210	80909	24958	18	21	-8.3	-6.7	10.5	0.898	22404	0.086	2143
169244	290	169534	52296	19	21	-7.6	-5.5	11.1	0.582	30453	0.038	1998
249208	310	249518	76969	19	21	-7.6	-5.5	11.1	0.582	44820	0.038	2940
109225	250	109475	33770	19	21	-7.6	-5.5	11.1	0.582	19665	0.038	1290
86376	271	86647	26728	20	22	-5.6	-4.6	8.6	0.079	2113	0.004	98
56269	314	56583	17454	20	22	-5.6	-4.6	8.6	0.079	1380	0.004	64
48730	99	48829	15062	20	22	-5.6	-4.6	8.6	0.079	1191	0.004	55
93368	155	93523	28849	21	60	-5.3	-4.5	8.7	0.065	1869	0.003	78
169007	1345	170352	52549	22	31	-5.9	-4.8	8.3	0.099	5185	0.005	278
113909	719	114628	35359	23	31	-6.3	-5.0	8.7	0.160	5656	0.009	303
175295	410	175705	54200	24	33	-7.6	-5.9	9.4	0.560	30372	0.040	2144
81501	234	81735	25213	25	33	-8.6	-6.5	9.9	0.830	20931	0.116	2914
230059	500	230559	71121	27	36	-7.7	-5.9	8.6	0.500	35529	0.043	3073
85508	227	85735	26447	28	34	-9.3	-6.9	9.5	0.899	23772	0.241	6372
213463	579	214042	66026	28	34	-9.3	-6.9	9.5	0.899	59349	0.241	15908
90712	233	90945	28054	30	34	-9.6	-6.9	10.6	0.936	26264	0.303	8512
104645	902	105547	32558	30	34	-9.6	-6.9	10.6	0.936	30481	0.303	9879
124546	2049	126595	39051	30	34	-9.6	-6.9	10.6	0.936	36559	0.303	11849
49210	121	49331	15217	31	39	-3.0	-3.0	8.6	0.004	66	0.000	3
168697	2564	171261	52829	31	39	-3.0	-3.0	8.6	0.004	230	0.000	10
99630	950	100580	31026	32	41	-3.2	-2.9	8.5	0.004	113	0.000	7
90586	160	90746	27993	35	41	-0.9	-1.4	7.9	0.000	5	0.000	0
75570	149	75719	23357	35	41	-0.9	-1.4	7.9	0.000	4	0.000	0
126523	385	126908	39147	35	41	-0.9	-1.4	7.9	0.000	7	0.000	1
194615	547	195162	60202	36	45	-3.5	-3.2	8.0	0.005	277	0.000	21
99541	192	99733	30765	39	45	-5.1	-4.4	8.1	0.048	1464	0.002	65
50468	47	50515	15582	40	43	-5.9	-5.5	7.3	0.186	2903	0.006	89
214475	840	215315	66418	40	43	-5.9	-5.5	7.3	0.186	12373	0.006	377
109866	420	110286	34020	40	43	-5.9	-5.5	7.3	0.186	6338	0.006	193
172117	647	172764	53293	40	43	-5.9	-5.5	7.3	0.186	9928	0.006	303
86787	236	87023	26844	41	45	-7.3	-5.9	8.0	0.411	11045	0.029	778
101940	331	102271	31548	42	50	-6.8	-5.4	7.5	0.171	5382	0.016	504
178670	537	179207	55280	43	49	-6.6	-5.3	7.1	0.132	7279	0.012	681

Appendix 2. (continued)

Catch/trip				Day #		Weather by trip			Temp/wind mode		Windchill model	
delivered live crabs	dead loss	total catch	est. bycatch	start	sale	wind chill	temp (C)	wind (m/s)	P(mort)	mortality	P(wc)	bycatch mortality
53346	163	53509	16506	44	51	-6.4	-4.9	7.7	0.094	1545	0.010	159
134338	680	135018	41649	45	53	-6.0	-4.8	7.7	0.074	3076	0.006	261
99172	385	99557	30710	46	52	-6.0	-4.8	7.0	0.053	1616	0.007	201
56861	188	57049	17598	46	52	-6.0	-4.8	7.0	0.053	926	0.007	115
122284	1167	123451	38081	47	55	-6.6	-5.1	10.0	0.275	10482	0.012	475
69795	270	70065	21613	49	54	-5.6	-4.5	10.4	0.124	2688	0.004	87
90745	407	91152	28118	50	52	-5.5	-4.2	7.6	0.026	742	0.003	96
190427	720	191147	58963	50	52	-5.5	-4.2	7.6	0.026	1555	0.003	202
148973	938	149911	46243	50	52	-5.5	-4.2	7.6	0.026	1220	0.003	159
66153	313	66466	20503	51	56	-7.1	-5.5	11.0	0.582	11926	0.023	469
16130	199	16329	5037	51	56	-7.1	-5.5	11.0	0.582	2930	0.023	115
136527	315	136842	42212	51	56	-7.1	-5.5	11.0	0.582	24554	0.023	966
63916	244	64160	19791	53	57	-7.3	-5.9	12.2	0.813	16085	0.030	592
85850	496	86346	26635	53	57	-7.3	-5.9	12.2	0.813	21647	0.030	797
122889	611	123500	38096	54	63	-4.0	-3.8	10.8	0.049	1875	0.001	22
16492	118	16610	5124	56	58	-5.4	-4.8	7.8	0.084	430	0.003	15
89284	462	89746	27684	57	65	-1.1	-1.7	9.2	0.001	15	0.000	1
54040	203	54243	16732	58	61	-1.9	-2.8	9.2	0.004	63	0.000	1
48752	250	49002	15116	58	61	-1.9	-2.8	9.2	0.004	56	0.000	1
113225	542	113767	35094	58	61	-1.9	-2.8	9.2	0.004	131	0.000	2
77984	853	78837	24319	58	61	-1.9	-2.8	9.2	0.004	91	0.000	1
27166	125	27291	8418	59	62	-1.8	-2.5	11.0	0.005	41	0.000	0
131712	667	132379	40835	59	62	-1.8	-2.5	11.0	0.005	197	0.000	2
127424	833	128257	39564	59	62	-1.8	-2.5	11.0	0.005	191	0.000	2
32770	258	33028	10188	60	66	-0.8	-0.8	10.5	0.000	2	0.000	0
186669	923	187592	57867	60	66	-0.8	-0.8	10.5	0.000	11	0.000	1
100941	315	101256	31235	61	66	-0.2	-0.3	10.5	0.000	2	0.000	0
182689	1230	183919	56734	61	66	-0.2	-0.3	10.5	0.000	4	0.000	0
33021	167	33188	10238	62	64	0.6	-0.1	9.6	0.000	0	0.000	0
43648	24	43672	13472	63	68	0.4	0.1	10.1	0.000	0	0.000	0
44792	41	44833	13830	64	70	0.3	0.2	9.1	0.000	0	0.000	0
97850	496	98346	30337	64	70	0.3	0.2	9.1	0.000	0	0.000	0
74412	414	74826	23082	64	70	0.3	0.2	9.1	0.000	0	0.000	0
187979	968	188947	58285	64	70	0.3	0.2	9.1	0.000	1	0.000	0
111443	820	112263	34630	65	71	0.2	0.0	9.3	0.000	1	0.000	0
119003	7580	126583	39047	67	74	0.7	0.3	8.1	0.000	0	0.000	0
81456	560	82016	25300	68	73	1.1	0.6	7.1	0.000	0	0.000	0
119763	229	119992	37014	68	73	1.1	0.6	7.1	0.000	0	0.000	0
178632	902	179534	55381	69	79	-1.8	-1.5	9.2	0.000	21	0.000	3
164602	960	165562	51071	69	79	-1.8	-1.5	9.2	0.000	19	0.000	2
20331	64	20395	6291	70	72	0.7	0.1	7.4	0.000	0	0.000	0
41184	192	41376	12763	70	72	0.7	0.1	7.4	0.000	0	0.000	0
49538	320	49858	15380	71	76	-0.6	-0.7	9.5	0.000	1	0.000	0
120338	480	120818	37269	71	76	-0.6	-0.7	9.5	0.000	4	0.000	0
21786	122	21908	6758	72	76	-0.9	-0.8	10.2	0.000	1	0.000	0

Appendix 2. (continued)

Catch/trip				Day #		Weather by trip			Temp/wind mode		Windchill model	
delivered live crabs	dead loss	total catch	est. bycatch	start	sale	wind chill	temp (C)	wind (m/s)	P(mort)	mortality	P(wc)	bycatch mortality
113994	522	114516	35325	73	76	-1.3	-1.1	9.9	0.000	9	0.000	1
95664	500	96164	29664	73	76	-1.3	-1.1	9.9	0.000	7	0.000	1
67599	190	67789	20911	73	76	-1.3	-1.1	9.9	0.000	5	0.000	1
98101	696	98797	30476	74	78	-4.0	-3.0	11.0	0.012	363	0.001	18
142285	614	142899	44080	74	78	-4.0	-3.0	11.0	0.012	525	0.001	26
59851	454	60305	18602	75	81	-3.6	-3.0	11.1	0.013	238	0.000	7
17723		17723	5467	77	83	-3.4	-2.9	10.5	0.008	44	0.000	2
85017	744	85761	26455	77	83	-3.4	-2.9	10.5	0.008	214	0.000	8
17843	1575	19418	5990	78	80	-4.4	-3.5	11.2	0.037	221	0.001	5
163188	327	163515	50440	17	22	-8.3	-6.7	9.9	0.878	44283	0.087	4402
182278	923	183201	56512	17	22	-8.3	-6.7	9.9	0.878	49614	0.087	4932
273808	1442	275250	84907	17	22	-8.3	-6.7	9.9	0.878	74543	0.087	7411
133432	647	134079	41359	17	22	-8.3	-6.7	9.9	0.878	36311	0.087	3610
21353	49	21402	6602	19	22	-6.3	-4.9	9.5	0.183	1206	0.009	60
145206	972	146178	45092	22	31	-5.9	-4.8	8.3	0.099	4449	0.005	239
175796	882	176678	54500	24	33	-7.6	-5.9	9.4	0.560	30540	0.040	2156
187920	451	188371	58107	25	25	-0.1	-0.8	8.7	0.000	5	0.000	0
179850	473	180323	55624	25	25	-0.1	-0.8	8.7	0.000	5	0.000	0
277831	1785	279616	86253	28	38	-5.6	-4.6	8.6	0.077	6676	0.004	338
274984	3425	278409	85881	28	38	-5.6	-4.6	8.6	0.077	6648	0.004	336
106833	297	107130	33046	30	30	-13.1	-9.0	12.6	0.999	33026	0.967	31941
110223	142	110365	34044	32	32	-10.4	-7.2	11.1	0.968	32967	0.533	18132
201236	1923	203159	62669	33	45	-3.9	-3.5	8.1	0.008	516	0.001	32
133259	929	134188	41393	35	43	-2.5	-2.6	7.6	0.001	53	0.000	4
10457	340	10797	3331	38	38	0.7	0.5	7.9	0.000	0	0.000	0
154340	357	154697	47720	39	46	-5.2	-4.5	7.5	0.044	2102	0.002	113
240762	1266	242028	74659	39	46	-5.2	-4.5	7.5	0.044	3288	0.002	177
151227	492	151719	46801	42	42	-9.0	-6.9	7.1	0.743	34755	0.183	8553
169660	952	170612	52629	42	42	-9.0	-6.9	7.1	0.743	39083	0.183	9618
11194	203	11397	3516	43	43	-7.3	-6.3	5.9	0.362	1273	0.028	98
183814	321	184135	56800	44	53	-6.0	-4.7	7.9	0.073	4174	0.006	347
205136	1024	206160	63594	45	54	-6.1	-4.9	8.8	0.129	8200	0.007	447
95848	1293	97141	29965	46	52	-6.0	-4.8	7.0	0.053	1577	0.007	196
127933	333	128266	39566	47	47	-8.0	-5.9	7.7	0.377	14909	0.059	2352
64426	591	65017	20056	48	59	-5.7	-4.8	9.9	0.187	3752	0.004	86
98985	365	99350	30647	49	61	-5.1	-4.4	9.9	0.101	3081	0.002	69
166485	214	166699	51422	51	63	-4.2	-3.9	10.3	0.043	2229	0.001	39
193362	729	194091	59871	51	63	-4.2	-3.9	10.3	0.043	2595	0.001	45
168086	1043	169129	52171	55	55	-11.4	-8.1	13.4	0.998	52055	0.782	40785
88409	313	88722	27368	55	55	-11.4	-8.1	13.4	0.998	27307	0.782	21395
88080	609	88689	27358	56	56	-9.4	-7.3	9.4	0.945	25849	0.270	7379
55659	132	55791	17210	58	58	-2.3	-2.6	7.5	0.001	23	0.000	1
68629	233	68862	21242	62	62	-2.0	-1.5	14.3	0.004	77	0.000	1
109692	410	110102	33963	65	65	0.2	0.5	10.4	0.000	1	0.000	0
276893	1217	278110	85789	65	65	0.2	0.5	10.4	0.000	1	0.000	0

Appendix 2. (continued)

Catch/trip				Day #		Weather by trip			Temp/wind mode		Windchill model	
delivered live crabs	dead loss	total catch	est. bycatch	start	sale	wind chill	temp (C)	wind (m/s)	P(mort)	mortality	P(wc)	bycatch mortality
42566	84	42650	13156	67	67	-0.8	-0.7	11.6	0.000	3	0.000	0
88291	721	89012	27458	69	76	-0.2	-0.4	8.7	0.000	1	0.000	0
125575	882	126457	39008	71	71	1.0	-0.2	6.4	0.000	0	0.000	0
297910	2753	300663	92746	71	71	1.0	-0.2	6.4	0.000	1	0.000	0
5643	96	5739	1770	72	72	0.5	0.5	11.1	0.000	0	0.000	0
87531	642	88173	27199	72	72	0.5	0.5	11.1	0.000	1	0.000	0
97732	351	98083	30256	72	72	0.5	0.5	11.1	0.000	1	0.000	0
43548	42	43590	13446	73	73	1.5	1.2	6.1	0.000	0	0.000	0
163395	531	163926	50566	74	74	-0.5	-0.8	10.9	0.000	11	0.000	0
70689	340	71029	21910	76	84	-3.7	-3.0	10.3	0.009	195	0.000	9
5089	7	5096	1572	79	79	-5.2	-4.1	10.3	0.066	104	0.003	4
34662	351	35013	10800	80	80	-0.9	-1.9	12.1	0.003	30	0.000	0
32406	136	32542	10038	82	82	-2.0	-1.6	8.9	0.000	4	0.000	1
23737	177	23914	7377	84	84	-4.2	-3.5	8.1	0.009	64	0.001	6
119518	1067	120585	37197	85	85	-4.0	-3.1	8.8	0.006	212	0.001	22
181467	5691	187158	57733	18	26	-4.9	-4.2	8.9	0.042	2447	0.002	93
87208	968	88176	27200	19	22	-6.3	-4.9	9.5	0.183	4968	0.009	246
85419		85419	26349	19	22	-6.3	-4.9	9.5	0.183	4813	0.009	238
125129	464	125593	38742	20	25	-2.8	-2.6	7.3	0.001	43	0.000	6
95298	736	96034	29624	22	29	-4.9	-4.1	7.7	0.022	663	0.002	54
59839	1602	61441	18953	24	35	-6.8	-5.5	9.3	0.352	6678	0.016	311
117783	489	118272	36483	27	35	-8.4	-6.4	9.1	0.750	27358	0.102	3724
75462	1829	77291	23842	28	33	-9.9	-7.2	9.1	0.929	22141	0.375	8940
100166	429	100595	31031	33	37	-3.1	-2.9	8.1	0.003	91	0.000	7
63251	781	64032	19752	33	37	-3.1	-2.9	8.1	0.003	58	0.000	4
74025	410	74435	22961	34	42	-2.4	-2.4	8.2	0.001	30	0.000	2
88282	930	89212	27519	35	44	-2.8	-2.7	7.8	0.002	53	0.000	4
157819	833	158652	48940	38	46	-4.5	-4.0	7.6	0.017	808	0.001	54
116590	1857	118447	36537	39	56	-6.1	-5.0	8.9	0.155	5672	0.007	263
63143	1957	65100	20081	44	48	-6.6	-5.2	7.1	0.120	2403	0.013	254
32290	90	32380	9988	57	64	-1.3	-2.0	9.0	0.001	8	0.000	0
92287	9836	102123	31502	63	73	0.7	0.3	8.8	0.000	0	0.000	0
108478	909	109387	33743	66	81	-1.4	-1.3	10.0	0.000	12	0.000	1
139982	6780	146762	45272	66	81	-1.4	-1.3	10.0	0.000	16	0.000	1
48890	212	49102	15147	75	81	-3.6	-3.0	11.1	0.013	193	0.000	5
165934	3604	169538	52298	76	84	-3.7	-3.0	10.3	0.009	467	0.000	21
8062	121	8183	2524	78	82	-2.9	-2.6	10.8	0.006	14	0.000	0
142246		142246	43879	16	20	-10.3	-8.0	12.4	0.996	43698	0.499	21905
127152	399	127551	39346	17	21	-9.4	-7.4	11.0	0.977	38456	0.270	10629
172751	551	173302	53459	17	21	-9.4	-7.4	11.0	0.977	52249	0.270	14442
158966	246	159212	49112	17	21	-9.4	-7.4	11.0	0.977	48001	0.270	13268
26543	39	26582	8200	18	19	-9.5	-8.0	10.3	0.989	8112	0.292	2392
175112	308	175420	54112	18	19	-9.5	-8.0	10.3	0.989	53535	0.292	15785
258702	420	259122	79932	18	19	-9.5	-8.0	10.3	0.989	79079	0.292	23317
157057	86	157143	48474	18	19	-9.5	-8.0	10.3	0.989	47957	0.292	14140

Appendix 2. (continued)

Catch/trip				Day #		Weather by trip			Temp/wind mode		Windchill model	
delivered live crabs	dead loss	total catch	est. bycatch	start	sale	wind chill	temp (C)	wind (m/s)	P(mort)	mortality	P(wc)	bycatch mortality
363869	2440	366309	112996	18	21	-8.3	-6.7	10.5	0.898	101431	0.086	9700
159013	1476	160489	49506	18	23	-6.0	-5.0	8.3	0.142	7050	0.006	319
234697	197	234894	72458	19	26	-4.1	-3.5	8.9	0.011	821	0.001	51
159403	760	160163	49406	19	26	-4.1	-3.5	8.9	0.011	560	0.001	35
221736	148	221884	68445	19	26	-4.1	-3.5	8.9	0.011	776	0.001	48
114636	203	114839	35424	20	29	-5.4	-4.4	8.3	0.045	1589	0.003	105
76518	8404	84922	26196	21	27	-4.1	-3.4	8.2	0.008	203	0.001	17
244011	1744	245755	75808	21	27	-4.1	-3.4	8.2	0.008	587	0.001	50
63275	190	63465	19577	22	30	-5.9	-4.6	8.3	0.073	1438	0.005	104
261622	3680	265302	81838	22	30	-5.9	-4.6	8.3	0.073	6013	0.005	433
133254	77	133331	41129	23	28	-4.9	-3.8	8.5	0.018	753	0.002	71
183344	7937	191281	59005	23	28	-4.9	-3.8	8.5	0.018	1080	0.002	102
270403	1722	272125	83943	24	33	-7.6	-5.9	9.4	0.560	47039	0.040	3321
140446	157	140603	43372	24	33	-7.6	-5.9	9.4	0.560	24304	0.040	1716
212920	1888	214808	66262	25	34	-8.4	-6.4	10.1	0.803	53237	0.092	6092
134044	498	134542	41502	25	34	-8.4	-6.4	10.1	0.803	33344	0.092	3816
98922	277	99199	30600	26	30	-10.0	-7.4	10.4	0.972	29737	0.406	12432
150784	2124	152908	47168	26	30	-10.0	-7.4	10.4	0.972	45837	0.406	19163
295818	1292	297110	91650	27	36	-7.7	-5.9	8.6	0.500	45784	0.043	3960
85745	26490	112235	34621	27	36	-7.7	-5.9	8.6	0.500	17295	0.043	1496
112295	325	112620	34740	30	38	-4.8	-4.1	9.0	0.036	1266	0.002	53
249245	636	249881	77081	31	42	-3.7	-3.5	8.4	0.011	824	0.000	32
42525	266	42791	13200	32	36	-5.4	-4.4	8.2	0.049	651	0.003	39
78970	873	79843	24629	32	36	-5.4	-4.4	8.2	0.049	1215	0.003	72
113057	548	113605	35044	32	36	-5.4	-4.4	8.2	0.049	1728	0.003	103
62517		62517	19285	33	37	-3.1	-2.9	8.1	0.003	57	0.000	4
173634	658	174292	53764	33	37	-3.1	-2.9	8.1	0.003	158	0.000	11
287449	992	288441	88976	33	37	-3.1	-2.9	8.1	0.003	261	0.000	19
124646	398	125044	38572	34	39	-0.9	-1.1	8.4	0.000	5	0.000	1
133250	1204	134454	41475	34	39	-0.9	-1.1	8.4	0.000	5	0.000	1
131790	92	131882	40682	34	39	-0.9	-1.1	8.4	0.000	5	0.000	1
79140	153	79293	24460	35	38	0.0	-0.5	7.4	0.000	1	0.000	0
60515	84	60599	18693	36	39	0.3	0.1	8.3	0.000	0	0.000	0
135895	330	136225	42021	36	39	0.3	0.1	8.3	0.000	1	0.000	0
268004	904	268908	82950	37	44	-3.4	-3.1	8.4	0.004	363	0.000	23
180561	1900	182461	56284	38	45	-4.4	-3.8	8.1	0.016	880	0.001	50
130588	821	131409	40536	38	45	-4.4	-3.8	8.1	0.016	634	0.001	36
41987	199	42186	13013	40	43	-5.9	-5.5	7.3	0.186	2424	0.006	74
142119	3061	145180	44784	40	43	-5.9	-5.5	7.3	0.186	8343	0.006	255
142826	782	143608	44299	40	43	-5.9	-5.5	7.3	0.186	8253	0.006	252
136648	447	137095	42290	40	43	-5.9	-5.5	7.3	0.186	7878	0.006	240
90331	159	90490	27914	41	48	-7.1	-5.7	7.2	0.256	7143	0.022	615
129003	719	129722	40015	41	48	-7.1	-5.7	7.2	0.256	10240	0.022	881
111965	2047	114012	35169	41	48	-7.1	-5.7	7.2	0.256	9000	0.022	775
103030	306	103336	31876	42	47	-7.2	-5.7	7.0	0.241	7681	0.025	791

Appendix 2. (continued)

Catch/trip				Day #		Weather by trip			Temp/wind mode		Windchill model	
delivered live crabs	dead loss	total catch	est. bycatch	start	sale	wind chill	temp (C)	wind (m/s)	P(mort)	mortality	P(wc)	bycatch mortality
110888	258	111146	34285	42	47	-7.2	-5.7	7.0	0.241	8262	0.025	850
130163	244	130407	40227	44	51	-6.4	-4.9	7.7	0.094	3765	0.010	388
211113	590	211703	65304	44	51	-6.4	-4.9	7.7	0.094	6112	0.010	629
113555	3258	116813	36033	44	51	-6.4	-4.9	7.7	0.094	3372	0.010	347
266740	1025	267765	82598	45	50	-6.5	-5.1	7.5	0.117	9646	0.012	954
222705	1256	223961	69085	45	50	-6.5	-5.1	7.5	0.117	8068	0.012	798
174421	723	175144	54027	47	55	-6.6	-5.1	10.0	0.275	14871	0.012	675
116366	748	117114	36126	48	56	-6.8	-5.2	10.2	0.355	12829	0.015	547
249525	639	250164	77168	48	56	-6.8	-5.2	10.2	0.355	27404	0.015	1169
105421	999	106420	32827	49	59	-5.6	-4.8	10.2	0.203	6672	0.004	133
97359	607	97966	30220	51	60	-5.4	-4.8	10.4	0.212	6406	0.003	92
113845	75	113920	35141	51	60	-5.4	-4.8	10.4	0.212	7449	0.003	107
27699	56	27755	8562	52	55	-6.8	-5.4	12.5	0.656	5614	0.016	136
138042	636	138678	42778	52	55	-6.8	-5.4	12.5	0.656	28051	0.016	681
295748	3450	299198	92294	53	61	-4.9	-4.5	10.9	0.159	14657	0.002	165
231342	638	231980	71559	53	61	-4.9	-4.5	10.9	0.159	11364	0.002	128
62607	426	63033	19444	54	62	-4.6	-4.2	11.0	0.111	2156	0.001	25
182148	568	182716	56363	54	62	-4.6	-4.2	11.0	0.111	6251	0.001	72
154604	634	155238	47886	54	62	-4.6	-4.2	11.0	0.111	5311	0.001	61
91935	99	92034	28390	56	66	-2.0	-2.2	10.0	0.002	53	0.000	2
18366	40	18406	5678	57	59	-2.5	-3.7	8.8	0.017	94	0.000	1
200320	737	201057	62020	57	59	-2.5	-3.7	8.8	0.017	1025	0.000	6
73027	435	73462	22661	58	58	-2.3	-2.6	7.5	0.001	30	0.000	2
68123	103	68226	21046	58	58	-2.3	-2.6	7.5	0.001	28	0.000	2
87421	84	87505	26993	58	58	-2.3	-2.6	7.5	0.001	35	0.000	2
332032	3435	335467	103482	58	58	-2.3	-2.6	7.5	0.001	135	0.000	8
182771	1067	183838	56709	58	67	-0.9	-1.3	10.5	0.000	26	0.000	1
188558	1878	190436	58744	59	74	0.0	-0.5	9.5	0.000	4	0.000	0
66707	409	67116	20703	60	68	-0.5	-0.6	10.2	0.000	2	0.000	0
129359	572	129931	40080	60	68	-0.5	-0.6	10.2	0.000	4	0.000	0
160564	880	161444	49801	60	68	-0.5	-0.6	10.2	0.000	5	0.000	0
104229	80	104309	32176	61	73	0.4	0.1	9.0	0.000	1	0.000	0
5508		5508	1699	62	63	0.0	-0.7	11.7	0.000	0	0.000	0
64046	79	64125	19781	62	63	0.0	-0.7	11.7	0.000	5	0.000	0
144114	824	144938	44709	62	63	0.0	-0.7	11.7	0.000	12	0.000	0
300898	6466	307364	94813	62	63	0.0	-0.7	11.7	0.000	25	0.000	0
144071	625	144696	44635	65	71	0.2	0.0	9.3	0.000	1	0.000	0
36330	328	36658	11308	65	71	0.2	0.0	9.3	0.000	0	0.000	0
357507	1246	358753	110665	65	71	0.2	0.0	9.3	0.000	3	0.000	0
335044	2685	337729	104180	65	71	0.2	0.0	9.3	0.000	2	0.000	0
110708	645	111353	34349	66	76	-0.3	-0.4	9.6	0.000	2	0.000	0
262104	1016	263120	81165	68	83	-1.5	-1.4	9.3	0.000	26	0.000	2
88723	90	88813	27396	69	80	-1.8	-1.5	9.5	0.000	12	0.000	1
138503	475	138978	42871	69	80	-1.8	-1.5	9.5	0.000	19	0.000	2
158715	577	159292	49137	70	80	-2.0	-1.8	9.6	0.001	35	0.000	3

Appendix 2. (continued)

Catch/trip				Day #		Weather by trip			Temp/wind mode		Windchill model	
delivered live crabs	dead loss	total catch	est. bycatch	start	sale	wind chill	temp (C)	wind (m/s)	P(mort)	mortality	P(wc)	bycatch mortality
71508	276	71784	22143	71	83	-2.1	-1.9	10.0	0.001	23	0.000	1
158653	553	159206	49110	72	80	-2.7	-2.1	10.5	0.002	102	0.000	6
105225	180	105405	32514	73	79	-3.4	-2.5	10.2	0.004	124	0.000	9
128310	266	128576	39662	74	82	-3.1	-2.6	10.8	0.006	220	0.000	8
172430	1513	173943	53656	74	82	-3.1	-2.6	10.8	0.006	297	0.000	10
94634	142	94776	29236	75	81	-3.6	-3.0	11.1	0.013	373	0.000	10
39068	628	39696	12245	75	81	-3.6	-3.0	11.1	0.013	156	0.000	4
86080	149	86229	26599	75	81	-3.6	-3.0	11.1	0.013	340	0.000	10
88947	786	89733	27680	75	81	-3.6	-3.0	11.1	0.013	354	0.000	10
84784	578	85362	26332	76	85	-3.7	-3.0	10.1	0.009	225	0.000	11
12861	99	12960	3998	77	78	-6.6	-4.6	10.7	0.176	705	0.013	50
156574	473	157047	48444	77	78	-6.6	-4.6	10.7	0.176	8548	0.013	612
92667	374	93041	28700	77	78	-6.6	-4.6	10.7	0.176	5064	0.013	362
134107	156	134263	41416	17	21	-9.4	-7.4	11.0	0.977	40479	0.270	11189
234616	1760	236376	72915	17	21	-9.4	-7.4	11.0	0.977	71265	0.270	19698
128839	208	129047	39807	18	21	-8.3	-6.7	10.5	0.898	35733	0.086	3417
219423	396	219819	67808	18	21	-8.3	-6.7	10.5	0.898	60868	0.086	5821
213989	267	214256	66092	18	21	-8.3	-6.7	10.5	0.898	59328	0.086	5674
139829	194	140023	43193	18	21	-8.3	-6.7	10.5	0.898	38772	0.086	3708
321448	968	322416	99456	18	22	-7.1	-6.0	9.3	0.584	58078	0.024	2364
129428	212	129640	39990	19	27	-5.0	-3.9	9.0	0.029	1160	0.002	74
192530	2269	194799	60090	19	27	-5.0	-3.9	9.0	0.029	1744	0.002	111
104184	224	104408	32207	20	26	-3.5	-3.1	8.4	0.005	160	0.000	11
227204	640	227844	70283	21	28	-4.8	-3.9	8.1	0.017	1224	0.002	111
99858	231	100089	30875	22	26	-2.1	-2.2	7.6	0.001	20	0.000	2
70558	368	70926	21879	22	26	-2.1	-2.2	7.6	0.001	14	0.000	1
173759	949	174708	53892	22	26	-2.1	-2.2	7.6	0.001	35	0.000	3
235922	1350	237272	73192	23	29	-5.3	-4.2	8.2	0.035	2561	0.003	198
86036	1504	87540	27004	24	33	-7.6	-5.9	9.4	0.560	15132	0.040	1068
171953	661	172614	53246	25	31	-8.3	-6.3	10.1	0.802	42717	0.089	4762
218950	1489	220439	67999	25	31	-8.3	-6.3	10.1	0.802	54552	0.089	6081
170639	1462	172101	53088	27	37	-6.8	-5.4	8.8	0.272	14419	0.016	871
48091	703	48794	15052	28	33	-9.9	-7.2	9.1	0.929	13977	0.375	5644
119358	698	120056	37034	29	36	-6.8	-5.6	8.5	0.323	11957	0.016	580
184818	1463	186281	57462	30	38	-4.8	-4.1	9.0	0.036	2094	0.002	88
104570	1387	105957	32685	31	38	-3.6	-3.5	8.5	0.010	313	0.000	12
148686	1087	149773	46201	31	38	-3.6	-3.5	8.5	0.010	443	0.000	17
183611	2061	185672	57274	31	38	-3.6	-3.5	8.5	0.010	549	0.000	22
116497	872	117369	36205	32	39	-3.0	-2.6	8.6	0.002	72	0.000	7
236380	2110	238490	73567	32	39	-3.0	-2.6	8.6	0.002	147	0.000	14
112133	614	112747	34779	33	41	-2.4	-2.4	8.2	0.001	46	0.000	3
75583	2109	77692	23966	34	43	-2.9	-2.8	8.0	0.002	58	0.000	4
114503	452	114955	35460	35	41	-0.9	-1.4	7.9	0.000	6	0.000	1
204830	1270	206100	63576	35	41	-0.9	-1.4	7.9	0.000	11	0.000	1
135871	662	136533	42116	36	39	0.3	0.1	8.3	0.000	1	0.000	0

Appendix 2. (continued)

Catch/trip				Day #		Weather by trip			Temp/wind mode		Windchill model	
delivered live crabs	dead loss	total catch	est. bycatch	start	sale	wind chill	temp (C)	wind (m/s)	P(mort)	mortality	P(wc)	bycatch mortality
124020	551	124571	38427	36	39	0.3	0.1	8.3	0.000	1	0.000	0
220321	857	221178	68227	37	46	-4.0	-3.5	7.9	0.008	573	0.001	40
98033	706	98739	30458	38	45	-4.4	-3.8	8.1	0.016	476	0.001	27
96743	417	97160	29971	39	46	-5.2	-4.5	7.5	0.044	1320	0.002	71
142081	1389	143470	44256	39	46	-5.2	-4.5	7.5	0.044	1949	0.002	105
352415	7500	359915	111023	39	46	-5.2	-4.5	7.5	0.044	4890	0.002	263
115733	2059	117792	36335	42	48	-7.0	-5.6	6.9	0.205	7451	0.021	770
168872	1428	170300	52533	42	48	-7.0	-5.6	6.9	0.205	10772	0.021	1113
139654	880	140534	43351	42	48	-7.0	-5.6	6.9	0.205	8889	0.021	919
84307	475	84782	26153	44	51	-6.4	-4.9	7.7	0.094	2448	0.010	252
78882	294	79176	24423	47	51	-6.4	-4.9	8.0	0.095	2312	0.010	251
164462	767	165229	50968	47	51	-6.4	-4.9	8.0	0.095	4824	0.010	523
164391	1216	165607	51085	48	55	-6.4	-5.0	10.3	0.264	13477	0.010	523
118052	745	118797	36645	48	55	-6.4	-5.0	10.3	0.264	9667	0.010	375
120357	916	121273	37409	49	60	-5.5	-4.7	10.2	0.184	6881	0.003	128
143909	2483	146392	45158	50	61	-5.1	-4.4	10.0	0.104	4701	0.002	95
68383	1290	69673	21492	53	58	-6.5	-5.3	11.4	0.529	11374	0.011	243
184345	1293	185638	57264	53	58	-6.5	-5.3	11.4	0.529	30306	0.011	648
148598	1049	149647	46162	56	62	-3.4	-3.5	9.6	0.017	775	0.000	13
80263	675	80938	24967	56	62	-3.4	-3.5	9.6	0.017	419	0.000	7
80845	805	81650	25187	56	62	-3.4	-3.5	9.6	0.017	423	0.000	7
129427	593	130020	40107	57	65	-1.1	-1.7	9.2	0.001	21	0.000	1
81604	507	82111	25329	57	65	-1.1	-1.7	9.2	0.001	13	0.000	1
216011	1190	217201	67000	59	71	-0.2	-0.7	9.5	0.000	6	0.000	0
154763	1466	156229	48192	61	66	-0.2	-0.3	10.5	0.000	4	0.000	0
105771	764	106535	32863	61	66	-0.2	-0.3	10.5	0.000	2	0.000	0
66928	207	67135	20709	61	66	-0.2	-0.3	10.5	0.000	2	0.000	0
132178	1735	133913	41308	62	70	0.3	0.0	9.7	0.000	1	0.000	0
33782	425	34207	10552	63	76	0.0	-0.2	9.3	0.000	0	0.000	0
83882	714	84596	26095	65	72	0.3	0.1	9.5	0.000	1	0.000	0
96047	480	96527	29776	66	72	0.3	0.0	9.4	0.000	1	0.000	0
96543	536	97079	29946	66	72	0.3	0.0	9.4	0.000	1	0.000	0
154043	982	155025	47821	67	73	0.9	0.4	7.7	0.000	0	0.000	0
104451		104451	32220	69	74	0.8	0.3	7.8	0.000	0	0.000	0
181176		181176	55888	69	74	0.8	0.3	7.8	0.000	0	0.000	0
83270	614	83884	25876	69	74	0.8	0.3	7.8	0.000	0	0.000	0
153547	1784	155331	47915	69	74	0.8	0.3	7.8	0.000	0	0.000	0
80997	252	81249	25063	71	75	0.2	-0.2	9.2	0.000	1	0.000	0
99345	3226	102571	31640	72	81	-2.3	-2.0	10.6	0.002	53	0.000	3
79217	588	79805	24618	74	79	-4.2	-3.2	10.9	0.016	392	0.001	18
238674	1852	240526	74195	75	80	-4.3	-3.3	11.1	0.024	1801	0.001	61
47310	215	47525	14660	78	80	-4.4	-3.5	11.2	0.037	540	0.001	13
75117	800	75917	23418	15	21	-9.3	-7.2	12.3	0.980	22945	0.245	5733
132796	1818	134614	41525	17	22	-8.3	-6.7	9.9	0.878	36456	0.087	3624
66746	591	67337	20772	18	21	-8.3	-6.7	10.5	0.898	18646	0.086	1783

Appendix 2. (continued)

Catch/trip				Day #		Weather by trip			Temp/wind mode		Windchill model	
delivered live crabs	dead loss	total catch	est. bycatch	start	sale	wind chill	temp (C)	wind (m/s)	P(mort)	mortality	P(wc)	bycatch mortality
183068	1370	184438	56894	18	21	-8.3	-6.7	10.5	0.898	51071	0.086	4884
105898	3008	108906	33594	18	21	-8.3	-6.7	10.5	0.898	30156	0.086	2884
77985	211	78196	24121	19	23	-5.1	-4.0	8.3	0.024	586	0.002	55
69904	360	70264	21674	22	22	-2.6	-3.1	4.7	0.001	20	0.000	2
81812	769	82581	25474	22	22	-2.6	-3.1	4.7	0.001	23	0.000	3
56107	704	56811	17525	23	30	-6.3	-4.8	8.7	0.122	2131	0.009	150
77896	1056	78952	24354	24	31	-7.1	-5.6	9.5	0.434	10569	0.023	552
65532	1048	66580	20538	25	33	-8.6	-6.5	9.9	0.830	17050	0.116	2374
73362	136	73498	22672	26	34	-9.4	-7.0	10.2	0.932	21129	0.255	5777
65505	1087	66592	20542	28	31	-10.2	-7.3	9.0	0.937	19240	0.484	9933
147634	1290	148924	45939	27	36	-7.7	-5.9	8.6	0.500	22949	0.043	1985
86447	977	87424	26968	29	37	-5.8	-4.9	8.8	0.135	3636	0.005	140
82267	741	83008	25606	31	38	-3.6	-3.5	8.5	0.010	245	0.000	10
68084	725	68809	21226	32	37	-4.3	-3.6	8.6	0.014	288	0.001	19
84595	752	85347	26327	32	37	-4.3	-3.6	8.6	0.014	357	0.001	23
45609	312	45921	14165	34	45	-3.5	-3.2	8.1	0.005	71	0.000	5
78163	231	78394	24182	35	40	0.2	-0.6	7.7	0.000	1	0.000	0
101698	1064	102762	31699	36	42	-2.2	-2.2	8.1	0.001	25	0.000	2
36956	472	37428	11545	38	40	0.6	-0.4	8.2	0.000	0	0.000	0
60201	373	60574	18685	39	42	-3.8	-3.7	8.2	0.013	251	0.000	9
55270	226	55496	17119	39	42	-3.8	-3.7	8.2	0.013	230	0.000	8
105711	299	106010	32701	39	42	-3.8	-3.7	8.2	0.013	440	0.000	16
100344	159	100503	31002	40	44	-5.9	-5.2	7.8	0.155	4803	0.006	171
61549	321	61870	19085	40	44	-5.9	-5.2	7.8	0.155	2957	0.006	105
82440	752	83192	25662	41	46	-7.1	-5.8	7.2	0.288	7387	0.022	563
78592	1515	80107	24711	41	46	-7.1	-5.8	7.2	0.288	7113	0.022	542
53246	1200	54446	16795	43	49	-6.6	-5.3	7.1	0.132	2212	0.012	207
135516	2459	137975	42561	43	49	-6.6	-5.3	7.1	0.132	5605	0.012	525
68230	517	68747	21206	44	50	-6.4	-5.0	7.8	0.109	2306	0.010	216
79602	700	80302	24771	44	50	-6.4	-5.0	7.8	0.109	2694	0.010	253
73814	735	74549	22996	46	51	-6.3	-4.9	7.3	0.077	1762	0.009	212
92841	813	93654	28890	46	51	-6.3	-4.9	7.3	0.077	2213	0.009	266
25068	248	25316	7809	48	49	-6.0	-4.8	7.4	0.067	525	0.006	48
80819	339	81158	25035	48	49	-6.0	-4.8	7.4	0.067	1684	0.006	155
62386	550	62936	19414	48	49	-6.0	-4.8	7.4	0.067	1306	0.006	120
78359	700	79059	24387	49	57	-6.6	-5.2	10.2	0.336	8185	0.012	291
4035	50	4085	1260	50	52	-5.5	-4.2	7.6	0.026	33	0.003	4
182647	5000	187647	57884	52	59	-5.5	-5.0	10.7	0.298	17271	0.003	201
81625	600	82225	25364	53	57	-7.3	-5.9	12.2	0.813	20614	0.030	759
82603	1000	83603	25789	54	61	-5.0	-4.6	10.6	0.162	4189	0.002	49
50072	3306	53378	16466	56	62	-3.4	-3.5	9.6	0.017	276	0.000	5
64483	1200	65683	20261	56	62	-3.4	-3.5	9.6	0.017	340	0.000	6
118263	850	119113	36743	56	62	-3.4	-3.5	9.6	0.017	617	0.000	10
78651	650	79301	24462	57	63	-1.7	-2.4	9.6	0.002	59	0.000	1
62876	500	63376	19550	58	61	-1.9	-2.8	9.2	0.004	73	0.000	1

Appendix 2. (continued)

Catch/trip				Day #		Weather by trip			Temp/wind mode		Windchill model	
delivered live crabs	dead loss	total catch	est. bycatch	start	sale	wind chill	temp (C)	wind (m/s)	P(mort)	mortality	P(wc)	bycatch mortality
77292	1953	79245	24445	58	61	-1.9	-2.8	9.2	0.004	91	0.000	1
104426	1938	106364	32810	60	67	-0.8	-0.8	10.7	0.000	7	0.000	0
88039	800	88839	27404	61	67	-0.3	-0.4	10.6	0.000	2	0.000	0
79862	781	80643	24876	63	66	0.3	0.1	10.6	0.000	1	0.000	0
123673	700	124373	38365	65	71	0.2	0.0	9.3	0.000	1	0.000	0
73850	976	74826	23082	66	72	0.3	0.0	9.4	0.000	1	0.000	0
60619	675	61294	18907	66	72	0.3	0.0	9.4	0.000	0	0.000	0
58419	450	58869	18159	67	69	0.8	0.4	8.6	0.000	0	0.000	0
72132	900	73032	22528	67	69	0.8	0.4	8.6	0.000	0	0.000	0
83146	787	83933	25891	68	73	1.1	0.6	7.1	0.000	0	0.000	0
108477	1900	110377	34048	70	75	0.3	-0.2	8.5	0.000	1	0.000	0
72114	2032	74146	22872	70	75	0.3	-0.2	8.5	0.000	1	0.000	0
111932	800	112732	34775	70	75	0.3	-0.2	8.5	0.000	1	0.000	0
56347	550	56897	17551	72	77	-1.8	-1.4	10.1	0.000	8	0.000	1
37376	410	37786	11656	73	79	-3.4	-2.5	10.2	0.004	44	0.000	3
87133	800	87933	27125	73	79	-3.4	-2.5	10.2	0.004	103	0.000	8
68508	500	69008	21287	74	82	-3.1	-2.6	10.8	0.006	118	0.000	4
67778	500	68278	21062	75	75	-1.5	-1.6	11.8	0.001	29	0.000	1
103848	2632	106480	32846	75	75	-1.5	-1.6	11.8	0.001	46	0.000	1
96979	1316	98295	30321	75	75	-1.5	-1.6	11.8	0.001	42	0.000	1
35858	800	36658	11308	76	83	-3.6	-2.9	10.5	0.009	101	0.000	4
34836	650	35486	10946	77	82	-3.5	-2.9	10.7	0.010	107	0.000	3
3025	22	3047	940	11	17	-4.9	-3.7	14.6	0.188	177	0.002	2
83763	761	84524	26073	18	24	-5.1	-4.4	8.0	0.039	1018	0.002	59
77338	560	77898	24029	25	31	-8.3	-6.3	10.1	0.802	19277	0.089	2149
99126	954	100080	30872	32	38	-3.6	-3.0	8.5	0.004	137	0.000	12
51153	942	52095	16070	39	45	-5.1	-4.4	8.1	0.048	765	0.002	34
25035	270	25305	7806	46	52	-6.0	-4.8	7.0	0.053	411	0.007	51
29043	954	29997	9253	53	59	-5.7	-5.1	11.5	0.445	4119	0.004	39
56273	1461	57734	17809	60	66	-0.8	-0.8	10.5	0.000	3	0.000	0
99911	2564	102475	31611	67	73	0.9	0.4	7.7	0.000	0	0.000	0
72009	3317	75326	23236	74	80	-3.7	-3.0	11.1	0.012	289	0.000	10
160648	350	160998	49663	15	20	-9.8	-7.5	12.8	0.991	49241	0.355	17642
96956	300	97256	30001	15	20	-9.8	-7.5	12.8	0.991	29745	0.355	10657
66355	357	66712	20579	17	20	-10.1	-8.0	11.4	0.994	20448	0.459	9442
137278	592	137870	42529	17	20	-10.1	-8.0	11.4	0.994	42259	0.459	19512
136969	417	137386	42380	18	23	-6.0	-5.0	8.3	0.142	6035	0.006	273
124576	494	125070	38580	18	23	-6.0	-5.0	8.3	0.142	5494	0.006	248
145414	2491	147905	45624	18	23	-6.0	-5.0	8.3	0.142	6497	0.006	294
93663	960	94623	29188	18	23	-6.0	-5.0	8.3	0.142	4157	0.006	188
54931	9324	64255	19821	18	23	-6.0	-5.0	8.3	0.142	2823	0.006	128
148837	14319	163156	50329	18	23	-6.0	-5.0	8.3	0.142	7167	0.006	324
51118	33898	85016	26225	18	23	-6.0	-5.0	8.3	0.142	3735	0.006	169
75207	1298	76505	23600	19	28	-5.5	-4.3	8.9	0.048	1131	0.003	79
88054	141	88195	27206	20	30	-6.1	-4.8	8.7	0.108	2948	0.007	185

Appendix 2. (continued)

Catch/trip				Day #		Weather by trip			Temp/wind mode		Windchill model	
delivered live crabs	dead loss	total catch	est. bycatch	start	sale	wind chill	temp (C)	wind (m/s)	P(mort)	mortality	P(wc)	bycatch mortality
56079	385	56464	17418	23	30	-6.3	-4.8	8.7	0.122	2118	0.009	149
135061	276	135337	41748	24	31	-7.1	-5.6	9.5	0.434	18117	0.023	946
75606	909	76515	23603	25	25	-0.1	-0.8	8.7	0.000	2	0.000	0
89934	2241	92175	28433	25	25	-0.1	-0.8	8.7	0.000	2	0.000	0
89438	2481	91919	28354	26	35	-8.4	-6.4	9.7	0.801	22722	0.092	2621
116034	313	116347	35890	27	27	-11.5	-7.9	9.9	0.985	35335	0.812	29154
99243	341	99584	30719	28	36	-7.2	-5.7	8.5	0.384	11806	0.025	765
103250	163	103413	31900	29	34	-9.2	-6.9	9.7	0.908	28952	0.213	6807
83084	413	83497	25756	29	34	-9.2	-6.9	9.7	0.908	23376	0.213	5496
151988	1563	153551	47366	29	34	-9.2	-6.9	9.7	0.908	42989	0.213	10107
88434	1754	90188	27820	30	37	-5.6	-4.6	9.2	0.104	2891	0.004	108
80587	301	80888	24952	30	37	-5.6	-4.6	9.2	0.104	2592	0.004	97
77608	328	77936	24041	31	37	-4.3	-4.0	8.6	0.028	667	0.001	21
155718	1667	157385	48549	31	37	-4.3	-4.0	8.6	0.028	1348	0.001	43
51581	693	52274	16125	31	37	-4.3	-4.0	8.6	0.028	448	0.001	14
148916	288	149204	46025	32	42	-3.7	-3.3	8.4	0.007	306	0.000	19
106775	231	107006	33008	32	42	-3.7	-3.3	8.4	0.007	220	0.000	14
89597	1571	91168	28123	34	40	-0.8	-1.2	8.2	0.000	4	0.000	0
113548	2803	116351	35891	34	40	-0.8	-1.2	8.2	0.000	5	0.000	0
111005	917	111922	34525	37	44	-3.4	-3.1	8.4	0.004	151	0.000	10
75693	317	76010	23447	37	44	-3.4	-3.1	8.4	0.004	103	0.000	7
151980	6154	158134	48780	37	44	-3.4	-3.1	8.4	0.004	213	0.000	14
78598	413	79011	24373	38	46	-4.5	-4.0	7.6	0.017	402	0.001	27
291277	7258	298535	92089	38	46	-4.5	-4.0	7.6	0.017	1520	0.001	101
74290	660	74950	23120	39	50	-5.6	-4.7	7.8	0.063	1448	0.004	93
199574	6927	206501	63700	41	48	-7.1	-5.7	7.2	0.256	16301	0.022	1403
176073	7212	183285	56538	41	48	-7.1	-5.7	7.2	0.256	14468	0.022	1245
143369	235	143604	44298	43	52	-6.3	-5.0	7.2	0.083	3675	0.008	373
83998	1651	85649	26420	44	49	-6.5	-5.1	7.3	0.109	2867	0.011	284
75646	64	75710	23354	45	49	-6.6	-5.3	6.8	0.118	2759	0.013	294
105011	273	105284	32477	45	49	-6.6	-5.3	6.8	0.118	3837	0.013	409
116834	357	117191	36150	46	56	-6.8	-5.3	9.4	0.296	10709	0.016	566
155156	1802	156958	48417	47	59	-5.9	-4.9	9.7	0.199	9619	0.005	256
83190	305	83495	25756	48	54	-5.7	-4.5	9.9	0.115	2952	0.004	115
131585	322	131907	40689	48	54	-5.7	-4.5	9.9	0.115	4663	0.004	182
100098	236	100334	30950	49	57	-6.6	-5.2	10.2	0.336	10388	0.012	369
102961	292	103253	31851	52	60	-5.3	-4.8	10.8	0.254	8093	0.003	89
118815	621	119436	36843	52	60	-5.3	-4.8	10.8	0.254	9362	0.003	103
66555	323	66878	20630	54	63	-4.0	-3.8	10.8	0.049	1016	0.001	12
180778	459	181237	55906	55	65	-2.8	-2.8	9.6	0.005	262	0.000	8
69552	185	69737	21512	56	61	-3.6	-3.8	8.8	0.022	465	0.000	8
20352	118	20470	6314	56	61	-3.6	-3.8	8.8	0.022	136	0.000	2
57830	133	57963	17880	57	64	-1.3	-2.0	9.0	0.001	15	0.000	0
89394	219	89613	27643	57	64	-1.3	-2.0	9.0	0.001	23	0.000	1
71516	201	71717	22123	57	64	-1.3	-2.0	9.0	0.001	18	0.000	1

Appendix 2. (continued)

Catch/trip				Day #		Weather by trip			Temp/wind mode		Windchill model	
delivered live crabs	dead loss	total catch	est. bycatch	start	sale	wind chill	temp (C)	wind (m/s)	P(mort)	mortality	P(wc)	bycatch mortality
30070	220	30290	9344	58	66	-0.9	-1.4	10.4	0.000	5	0.000	0
88123	354	88477	27293	59	59	-0.7	-3.8	12.4	0.096	2615	0.000	0
89225	310	89535	27619	63	69	0.5	0.2	9.7	0.000	1	0.000	0
114308	10474	124782	38492	63	69	0.5	0.2	9.7	0.000	1	0.000	0
176404	242	176646	54490	63	69	0.5	0.2	9.7	0.000	1	0.000	0
171179	281	171460	52890	64	75	0.3	0.1	9.2	0.000	1	0.000	0
39915	315	40230	12410	66	76	-0.3	-0.4	9.6	0.000	1	0.000	0
109089	164	109253	33701	67	70	0.8	0.3	7.7	0.000	0	0.000	0
147089	314	147403	45470	68	73	1.1	0.6	7.1	0.000	0	0.000	0
40765	248	41013	12651	69	74	0.8	0.3	7.8	0.000	0	0.000	0
84321	813	85134	26261	69	74	0.8	0.3	7.8	0.000	0	0.000	0
40745	3386	44131	13613	70	74	0.6	0.1	7.9	0.000	0	0.000	0
92445	152	92597	28563	72	77	-1.8	-1.4	10.1	0.000	14	0.000	1
42549	407	42956	13251	72	77	-1.8	-1.4	10.1	0.000	6	0.000	1
36212	246	36458	11246	73	76	-1.3	-1.1	9.9	0.000	3	0.000	0
25017	625	25642	7910	74	80	-3.7	-3.0	11.1	0.012	99	0.000	3
20637	61	20698	6385	76	79	-5.8	-4.1	10.7	0.081	517	0.005	32
42468	64	42532	13120	76	79	-5.8	-4.1	10.7	0.081	1063	0.005	65
74738	4516	79254	24448	81	81	0.7	-0.8	11.3	0.000	6	0.000	0
125978	216	126194	38927	82	82	-2.0	-1.6	8.9	0.000	15	0.000	2
282286	976	283262	87378	84	84	-4.2	-3.5	8.1	0.009	759	0.001	68
45351	242	45593	14064	17	21	-9.4	-7.4	11.0	0.977	13746	0.270	3799
88295	586	88881	27417	18	22	-7.1	-6.0	9.3	0.584	16011	0.024	652
148067	984	149051	45978	18	22	-7.1	-6.0	9.3	0.584	26849	0.024	1093
82482	388	82870	25563	18	22	-7.1	-6.0	9.3	0.584	14928	0.024	608
38374	229	38603	11908	18	22	-7.1	-6.0	9.3	0.584	6954	0.024	283
79662	320	79982	24672	18	22	-7.1	-6.0	9.3	0.584	14408	0.024	586
104733	488	105221	32458	19	23	-5.1	-4.0	8.3	0.024	789	0.002	73
194419	1247	195666	60357	19	23	-5.1	-4.0	8.3	0.024	1467	0.002	136
82885	524	83409	25729	21	32	-6.3	-5.0	8.6	0.160	4111	0.009	240
162728	1273	164001	50590	22	27	-3.7	-3.2	7.9	0.004	220	0.000	20
79960	500	80460	24820	22	27	-3.7	-3.2	7.9	0.004	108	0.000	10
91236	543	91779	28311	23	29	-5.3	-4.2	8.2	0.035	991	0.003	77
154258	583	154841	47764	23	29	-5.3	-4.2	8.2	0.035	1671	0.003	129
106521	738	107259	33086	24	26	-2.5	-2.5	9.9	0.003	104	0.000	3
79275	812	80087	24705	24	26	-2.5	-2.5	9.9	0.003	77	0.000	2
81738	625	82363	25407	25	28	-7.3	-5.5	10.5	0.514	13061	0.029	729
102977	645	103622	31964	26	30	-10.0	-7.4	10.4	0.972	31063	0.406	12986
101000	2033	103033	31783	26	30	-10.0	-7.4	10.4	0.972	30886	0.406	12912
85402	615	86017	26534	27	34	-9.6	-7.1	9.5	0.919	24395	0.316	8372
111332	492	111824	34494	28	34	-9.3	-6.9	9.5	0.899	31006	0.241	8311
135510	806	136316	42050	28	34	-9.3	-6.9	9.5	0.899	37797	0.241	10131
183411	1008	184419	56888	29	37	-5.8	-4.9	8.8	0.135	7670	0.005	296
173415	653	174068	53695	30	41	-4.1	-3.7	8.9	0.018	985	0.001	34
82176	569	82745	25524	32	39	-3.0	-2.6	8.6	0.002	51	0.000	5

Appendix 2. (continued)

Catch/trip				Day #		Weather by trip			Temp/wind mode		Windchill model	
delivered live crabs	dead loss	total catch	est. bycatch	start	sale	wind chill	temp (C)	wind (m/s)	P(mort)	mortality	P(wc)	bycatch mortality
87340	696	88036	27157	32	39	-3.0	-2.6	8.6	0.002	54	0.000	5
90013	984	90997	28070	34	40	-0.8	-1.2	8.2	0.000	4	0.000	0
161103	1387	162490	50123	34	40	-0.8	-1.2	8.2	0.000	7	0.000	1
108230	880	109110	33657	35	42	-1.9	-2.1	7.8	0.001	20	0.000	2
97275	702	97977	30223	36	43	-2.8	-2.7	7.8	0.002	54	0.000	4
107410	738	108148	33361	38	44	-3.9	-3.6	8.0	0.010	318	0.001	19
268024	2493	270517	83447	39	47	-5.5	-4.7	7.5	0.058	4822	0.003	284
83987	820	84807	26160	39	47	-5.5	-4.7	7.5	0.058	1512	0.003	89
91763	766	92529	28543	40	45	-6.1	-5.3	7.9	0.179	5118	0.007	202
120027	4223	124250	38328	42	50	-6.8	-5.4	7.5	0.171	6539	0.016	613
101829	4496	106325	32798	43	49	-6.6	-5.3	7.1	0.132	4319	0.012	404
57941	1271	59212	18265	43	49	-6.6	-5.3	7.1	0.132	2405	0.012	225
175950	5968	181918	56116	45	51	-6.5	-5.0	7.4	0.097	5470	0.011	597
103808	2327	106135	32740	47	52	-6.1	-4.7	7.5	0.059	1940	0.007	222
85527	1971	87498	26991	48	57	-6.5	-5.2	9.8	0.294	7943	0.011	310
81362	12096	93458	28829	48	57	-6.5	-5.2	9.8	0.294	8484	0.011	331
101170	491	101661	31359	49	53	-5.4	-4.2	8.7	0.044	1387	0.003	92
120167	775	120942	37307	49	53	-5.4	-4.2	8.7	0.044	1650	0.003	109
106330	410	106740	32926	50	53	-5.3	-4.2	8.9	0.040	1318	0.003	86
75887	484	76371	23558	50	53	-5.3	-4.2	8.9	0.040	943	0.003	61
62496	484	62980	19428	51	53	-5.0	-4.1	8.3	0.028	548	0.002	36
15587	259	15846	4888	51	53	-5.0	-4.1	8.3	0.028	138	0.002	9
144728	1487	146215	45103	51	53	-5.0	-4.1	8.3	0.028	1272	0.002	83
55070	697	55767	17203	53	58	-6.5	-5.3	11.4	0.529	9104	0.011	195
101260	508	101768	31392	54	58	-6.9	-5.6	11.1	0.626	19665	0.018	560
95354	840	96194	29673	55	62	-4.4	-4.1	10.1	0.057	1703	0.001	27
63781	720	64501	19897	56	61	-3.6	-3.8	8.8	0.022	430	0.000	7
57891	744	58635	18087	56	61	-3.6	-3.8	8.8	0.022	391	0.000	7
67158	560	67718	20889	58	60	-2.3	-3.4	10.3	0.020	410	0.000	2
57831	605	58436	18026	58	60	-2.3	-3.4	10.3	0.020	354	0.000	1
56611	750	57361	17694	58	60	-2.3	-3.4	10.3	0.020	347	0.000	1
103552	656	104208	32145	59	62	-1.8	-2.5	11.0	0.005	155	0.000	1
72522	2193	74715	23047	59	62	-1.8	-2.5	11.0	0.005	111	0.000	1
163117	6907	170024	52447	60	66	-0.8	-0.8	10.5	0.000	10	0.000	1
78925	820	79745	24599	60	66	-0.8	-0.8	10.5	0.000	5	0.000	0
71443	476	71919	22185	60	66	-0.8	-0.8	10.5	0.000	4	0.000	0
92771	726	93497	28841	61	65	0.2	-0.1	9.0	0.000	1	0.000	0
134574	1067	135641	41841	61	65	0.2	-0.1	9.0	0.000	1	0.000	0
46264	431	46695	14404	62	69	0.2	0.0	10.3	0.000	1	0.000	0
55723	455	56178	17329	64	68	0.1	0.1	10.3	0.000	1	0.000	0
21606	244	21850	6740	64	68	0.1	0.1	10.3	0.000	0	0.000	0
80881	547	81428	25118	64	68	0.1	0.1	10.3	0.000	1	0.000	0
86928	587	87515	26996	64	68	0.1	0.1	10.3	0.000	1	0.000	0
55840	744	56584	17455	65	69	0.0	0.1	10.7	0.000	1	0.000	0
43661	604	44265	13654	65	69	0.0	0.1	10.7	0.000	1	0.000	0

Appendix 2. (continued)

Catch/trip				Day #		Weather by trip			Temp/wind mode		Windchill model	
delivered live crabs	dead loss	total catch	est. bycatch	start	sale	wind chill	temp (C)	wind (m/s)	P(mort)	mortality	P(wc)	bycatch mortality
97624	684	98308	30325	65	69	0.0	0.1	10.7	0.000	1	0.000	0
46311	669	46980	14492	66	71	0.2	-0.1	9.1	0.000	0	0.000	0
57923	2285	60208	18572	66	71	0.2	-0.1	9.1	0.000	0	0.000	0
78841	775	79616	24559	67	74	0.7	0.3	8.1	0.000	0	0.000	0
78085	820	78905	24340	67	74	0.7	0.3	8.1	0.000	0	0.000	0
296940	1344	298284	92012	67	74	0.7	0.3	8.1	0.000	1	0.000	0
220800	1503	222303	68574	70	76	-0.4	-0.6	8.9	0.000	4	0.000	1
17307	234	17541	5411	71	77	-1.4	-1.2	9.6	0.000	1	0.000	0
97508	798	98306	30325	71	77	-1.4	-1.2	9.6	0.000	8	0.000	1
37678	756	38434	11856	74	77	-3.3	-2.6	10.9	0.005	65	0.000	3
25197	496	25693	7926	74	77	-3.3	-2.6	10.9	0.005	43	0.000	2
28128	645	28773	8876	75	78	-4.9	-3.5	11.0	0.032	284	0.002	15
42817	661	43478	13412	75	78	-4.9	-3.5	11.0	0.032	429	0.002	22
36361	490	36851	11367	76	79	-5.8	-4.1	10.7	0.081	921	0.005	57
58446	504	58950	18184	76	79	-5.8	-4.1	10.7	0.081	1473	0.005	91
51739	531	52270	16124	76	79	-5.8	-4.1	10.7	0.081	1306	0.005	80
32725	575	33300	10272	77	81	-3.7	-3.2	11.0	0.018	189	0.000	4
54432	690	55122	17004	77	81	-3.7	-3.2	11.0	0.018	314	0.000	7
5786	27	5813	1793	33	34	-7.4	-6.0	9.4	0.608	1090	0.032	57
7893	197	8090	2496	37	38	0.7	0.5	9.3	0.000	0	0.000	0
1774		1774	547	19	27	-5.0	-3.9	9.0	0.029	16	0.002	1
4944		4944	1525	20	28	-5.1	-4.1	8.6	0.030	46	0.002	3
905		905	279	23	29	-5.3	-4.2	8.2	0.035	10	0.003	1
16793		16793	5180	25	32	-8.6	-6.5	10.3	0.840	4353	0.122	634
4937		4937	1523	27	32	-10.5	-7.4	9.6	0.957	1457	0.569	867
6750		6750	2082	28	28	-10.0	-7.0	8.1	0.847	1763	0.410	855
11683		11683	3604	29	29	-7.6	-6.9	6.2	0.662	2386	0.039	141
6362	23	6385	1970	30	37	-5.6	-4.6	9.2	0.104	205	0.004	8
1963	7	1970	608	30	37	-5.6	-4.6	9.2	0.104	63	0.004	2
15844		15844	4887	35	35	-0.2	-1.5	5.9	0.000	0	0.000	0
9350	976	10326	3185	35	35	-0.2	-1.5	5.9	0.000	0	0.000	0
6858	59	6917	2134	37	41	-1.0	-1.4	8.9	0.000	1	0.000	0
4831	77	4908	1514	42	42	-9.0	-6.9	7.1	0.743	1124	0.183	277
9193		9193	2836	43	43	-7.3	-6.3	5.9	0.362	1026	0.028	79
9730		9730	3001	44	44	-5.8	-4.3	9.6	0.070	210	0.005	14
4916		4916	1516	45	45	-7.2	-5.7	8.2	0.344	522	0.025	38
5537		5537	1708	48	56	-6.8	-5.2	10.2	0.355	607	0.015	26
17834		17834	5501	50	50	-6.1	-4.3	10.7	0.110	606	0.007	41
9000		9000	2776	52	52	-4.3	-3.9	5.2	0.005	14	0.001	2
6000		6000	1851	55	55	-11.4	-8.1	13.4	0.998	1847	0.782	1447
12915		12915	3984	56	60	-4.1	-4.4	9.4	0.079	315	0.001	3
7558		7558	2331	65	73	0.4	0.2	9.1	0.000	0	0.000	0
9993		9993	3083	67	67	-0.8	-0.7	11.6	0.000	1	0.000	0
1300		1300	401	70	70	0.6	0.0	4.9	0.000	0	0.000	0
10921		10921	3369	72	72	0.5	0.5	11.1	0.000	0	0.000	0

Appendix 2. (continued)

Catch/trip				Day #		Weather by trip			Temp/wind mode		Windchill model	
delivered live crabs	dead loss	total catch	est. bycatch	start	sale	wind chill	temp (C)	wind (m/s)	P(mort)	mortality	P(wc)	bycatch mortality
9795		9795	3021	78	78	-6.9	-4.6	11.3	0.219	661	0.018	56
3141		3141	969	80	82	-0.8	-1.4	10.8	0.001	1	0.000	0
17520	1719	19239	5935	16	17	-12.5	-9.2	14.7	1.000	5934	0.929	5512
169122	15651	184773	56997	18	24	-5.1	-4.4	8.0	0.039	2225	0.002	128
107967	13148	121115	37360	25	31	-8.3	-6.3	10.1	0.802	29972	0.089	3341
114874	6885	121759	37559	32	38	-3.6	-3.0	8.5	0.004	167	0.000	14
153515	10820	164335	50693	40	45	-6.1	-5.3	7.9	0.179	9090	0.007	359
111566	9693	121259	37405	46	52	-6.0	-4.8	7.0	0.053	1969	0.007	245
19449	1899	21348	6585	53	58	-6.5	-5.3	11.4	0.529	3485	0.011	74
43837	1932	45769	14118	60	66	-0.8	-0.8	10.5	0.000	3	0.000	0
215927	10334	226261	69795	67	73	0.9	0.4	7.7	0.000	0	0.000	0
150981	5142	156123	48159	74	79	-4.2	-3.2	10.9	0.016	767	0.001	36
41839		41839	12906	17	19	-11.1	-8.8	11.2	0.998	12885	0.712	9192
134124		134124	41373	17	19	-11.1	-8.8	11.2	0.998	41305	0.712	29466
158502		158502	48893	17	19	-11.1	-8.8	11.2	0.998	48812	0.712	34822
173975		173975	53666	17	19	-11.1	-8.8	11.2	0.998	53577	0.712	38221
94621		94621	29188	17	19	-11.1	-8.8	11.2	0.998	29139	0.712	20788
123249	782	124031	38260	17	19	-11.1	-8.8	11.2	0.998	38197	0.712	27249
104227		104227	32151	18	20	-8.8	-7.2	10.8	0.966	31066	0.152	4892
108635		108635	33511	18	20	-8.8	-7.2	10.8	0.966	32380	0.152	5099
223197		223197	68850	18	20	-8.8	-7.2	10.8	0.966	66527	0.152	10476
166652		166652	51407	18	20	-8.8	-7.2	10.8	0.966	49673	0.152	7822
101059		101059	31174	18	20	-8.8	-7.2	10.8	0.966	30122	0.152	4744
78566		78566	24235	19	23	-5.1	-4.0	8.3	0.024	589	0.002	55
98142		98142	30274	19	23	-5.1	-4.0	8.3	0.024	736	0.002	68
74419		74419	22956	19	23	-5.1	-4.0	8.3	0.024	558	0.002	52
122839		122839	37892	19	23	-5.1	-4.0	8.3	0.024	921	0.002	86
159779	2101	161880	49935	19	23	-5.1	-4.0	8.3	0.024	1214	0.002	113
200802		200802	61942	19	23	-5.1	-4.0	8.3	0.024	1506	0.002	140
86171		86171	26581	20	26	-3.5	-3.1	8.4	0.005	132	0.000	9
249093	650	249743	77038	21	31	-5.9	-4.8	8.4	0.106	8170	0.006	447
187835		187835	57942	22	28	-4.6	-3.7	8.0	0.012	695	0.001	67
144038		144038	44432	22	28	-4.6	-3.7	8.0	0.012	533	0.001	52
91465		91465	28214	23	28	-4.9	-3.8	8.5	0.018	517	0.002	49
282742		282742	87218	23	28	-4.9	-3.8	8.5	0.018	1597	0.002	150
63349		63349	19541	23	28	-4.9	-3.8	8.5	0.018	358	0.002	34
76668		76668	23650	24	30	-7.1	-5.5	9.5	0.383	9047	0.023	536
78128		78128	24100	25	35	-7.5	-5.9	9.6	0.601	14483	0.037	892
100775		100775	31086	26	31	-10.0	-7.3	10.4	0.962	29893	0.406	12630
238436		238436	73551	26	31	-10.0	-7.3	10.4	0.962	70728	0.406	29882
182890		182890	56416	26	31	-10.0	-7.3	10.4	0.962	54251	0.406	22920
94381		94381	29114	27	34	-9.6	-7.1	9.5	0.919	26767	0.316	9187
139558		139558	43050	27	34	-9.6	-7.1	9.5	0.919	39580	0.316	13584
109363	1681	111044	34254	27	34	-9.6	-7.1	9.5	0.919	31493	0.316	10808
275058	5755	280813	86623	27	34	-9.6	-7.1	9.5	0.919	79641	0.316	27333

Appendix 2. (continued)

Catch/trip				Day #		Weather by trip			Temp/wind mode		Windchill model	
delivered live crabs	dead loss	total catch	est. bycatch	start	sale	wind chill	temp (C)	wind (m/s)	P(mort)	mortality	P(wc)	bycatch mortality
142645		142645	44002	28	37	-6.3	-5.1	8.7	0.182	7990	0.009	392
99242		99242	30613	29	35	-7.7	-6.1	9.1	0.640	19597	0.044	1341
141791		141791	43738	29	35	-7.7	-6.1	9.1	0.640	27998	0.044	1917
195109		195109	60185	30	35	-7.7	-6.0	9.7	0.646	38899	0.045	2697
175365		175365	54095	30	35	-7.7	-6.0	9.7	0.646	34963	0.045	2424
265819		265819	81997	31	41	-3.2	-3.2	8.5	0.006	533	0.000	18
155049	648	155697	48028	32	39	-3.0	-2.6	8.6	0.002	96	0.000	9
164224		164224	50658	32	39	-3.0	-2.6	8.6	0.002	101	0.000	9
96006		96006	29615	32	39	-3.0	-2.6	8.6	0.002	59	0.000	6
105106		105106	32422	33	39	-2.0	-1.9	8.2	0.001	16	0.000	2
198939		198939	61367	33	39	-2.0	-1.9	8.2	0.001	31	0.000	3
67550		67550	20837	34	41	-1.6	-1.9	8.4	0.001	11	0.000	1
67645		67645	20867	34	41	-1.6	-1.9	8.4	0.001	11	0.000	1
165530		165530	51061	35	42	-1.9	-2.1	7.8	0.001	31	0.000	3
181709		181709	56052	36	42	-2.2	-2.2	8.1	0.001	44	0.000	4
208680	9875	218555	67418	36	42	-2.2	-2.2	8.1	0.001	53	0.000	5
100208		100208	30911	37	43	-3.0	-2.9	8.2	0.003	90	0.000	6
259081		259081	79919	37	43	-3.0	-2.9	8.2	0.003	233	0.000	15
140086		140086	43212	37	43	-3.0	-2.9	8.2	0.003	126	0.000	8
173865		173865	53632	38	45	-4.4	-3.8	8.1	0.016	838	0.001	48
234533		234533	72347	39	45	-5.1	-4.4	8.1	0.048	3442	0.002	152
99253		99253	30617	39	45	-5.1	-4.4	8.1	0.048	1457	0.002	64
94350		94350	29104	40	47	-6.3	-5.4	7.3	0.160	4653	0.009	261
160255		160255	49434	40	47	-6.3	-5.4	7.3	0.160	7903	0.009	444
92302		92302	28472	40	47	-6.3	-5.4	7.3	0.160	4552	0.009	255
146607		146607	45224	41	45	-7.3	-5.9	8.0	0.411	18607	0.029	1310
224368	945	225313	69503	42	46	-7.0	-5.7	6.8	0.218	15165	0.021	1443
285467		285467	88058	42	46	-7.0	-5.7	6.8	0.218	19214	0.021	1828
265684		265684	81956	42	46	-7.0	-5.7	6.8	0.218	17883	0.021	1702
196703		196703	60677	43	51	-6.5	-5.1	7.5	0.111	6731	0.011	659
140991		140991	43492	44	51	-6.4	-4.9	7.7	0.094	4071	0.010	419
65664		65664	20255	44	51	-6.4	-4.9	7.7	0.094	1896	0.010	195
77236		77236	23825	45	50	-6.5	-5.1	7.5	0.117	2782	0.012	275
176695		176695	54505	45	50	-6.5	-5.1	7.5	0.117	6365	0.012	629
182850		182850	56404	45	50	-6.5	-5.1	7.5	0.117	6587	0.012	651
77940		77940	24042	47	52	-6.1	-4.7	7.5	0.059	1425	0.007	163
64529		64529	19905	47	52	-6.1	-4.7	7.5	0.059	1180	0.007	135
199763		199763	61621	47	52	-6.1	-4.7	7.5	0.059	3652	0.007	417
100887		100887	31121	47	52	-6.1	-4.7	7.5	0.059	1844	0.007	211
152365		152365	47000	48	54	-5.7	-4.5	9.9	0.115	5386	0.004	210
123926		123926	38228	48	54	-5.7	-4.5	9.9	0.115	4381	0.004	171
87730		87730	27062	49	53	-5.4	-4.2	8.7	0.044	1197	0.003	79
84064		84064	25931	49	53	-5.4	-4.2	8.7	0.044	1147	0.003	76
88291		88291	27235	49	53	-5.4	-4.2	8.7	0.044	1204	0.003	80
90290		90290	27852	50	57	-6.6	-5.3	10.4	0.393	10939	0.013	373

Appendix 2. (continued)

Catch/trip				Day #		Weather by trip			Temp/wind mode		Windchill model	
delivered live crabs	dead loss	total catch	est. bycatch	start	sale	wind chill	temp (C)	wind (m/s)	P(mort)	mortality	P(wc)	bycatch mortality
199574		199574	61563	50	57	-6.6	-5.3	10.4	0.393	24178	0.013	823
88366		88366	27258	50	57	-6.6	-5.3	10.4	0.393	10705	0.013	365
62610		62610	19313	51	57	-6.7	-5.4	10.4	0.450	8696	0.015	281
224697		224697	69313	51	57	-6.7	-5.4	10.4	0.450	31207	0.015	1008
174013		174013	53678	51	57	-6.7	-5.4	10.4	0.450	24168	0.015	781
172644		172644	53256	52	59	-5.5	-5.0	10.7	0.298	15890	0.003	185
64950		64950	20035	53	59	-5.7	-5.1	11.5	0.445	8918	0.004	85
58245		58245	17967	53	59	-5.7	-5.1	11.5	0.445	7998	0.004	77
80941		80941	24968	53	59	-5.7	-5.1	11.5	0.445	11114	0.004	106
102575		102575	31641	54	64	-3.5	-3.3	10.3	0.018	558	0.000	10
172655		172655	53259	55	70	-1.9	-1.9	9.6	0.001	52	0.000	3
70642		70642	21791	56	61	-3.6	-3.8	8.8	0.022	471	0.000	8
174061		174061	53693	56	61	-3.6	-3.8	8.8	0.022	1160	0.000	20
106944		106944	32989	57	62	-2.3	-2.9	9.7	0.005	177	0.000	3
180217	222	180439	55660	57	62	-2.3	-2.9	9.7	0.005	299	0.000	5
119191		119191	36767	57	62	-2.3	-2.9	9.7	0.005	197	0.000	3
324492		324492	100096	57	62	-2.3	-2.9	9.7	0.005	537	0.000	8
58024	3670	61694	19031	58	62	-1.9	-2.5	10.3	0.004	71	0.000	1
163462		163462	50423	58	62	-1.9	-2.5	10.3	0.004	187	0.000	3
68348		68348	21083	58	62	-1.9	-2.5	10.3	0.004	78	0.000	1
161316		161316	49761	58	62	-1.9	-2.5	10.3	0.004	185	0.000	3
30750	121	30871	9523	58	63	-1.3	-2.1	10.1	0.002	15	0.000	0
152113		152113	46922	58	64	-0.8	-1.6	9.4	0.000	23	0.000	1
110412		110412	34059	60	67	-0.8	-0.8	10.7	0.000	7	0.000	0
202308		202308	62406	60	67	-0.8	-0.8	10.7	0.000	13	0.000	1
119949		119949	37001	62	64	0.6	-0.1	9.6	0.000	1	0.000	0
138081		138081	42594	62	64	0.6	-0.1	9.6	0.000	1	0.000	0
155901		155901	48091	62	64	0.6	-0.1	9.6	0.000	2	0.000	0
231270		231270	71340	63	77	-0.4	-0.5	9.4	0.000	4	0.000	1
312331		312331	96345	64	71	0.4	0.2	8.8	0.000	1	0.000	0
207662		207662	64058	65	72	0.3	0.1	9.5	0.000	2	0.000	0
241668		241668	74548	66	74	0.3	0.1	9.2	0.000	2	0.000	0
46730		46730	14415	67	72	0.8	0.3	8.0	0.000	0	0.000	0
192451		192451	59366	67	72	0.8	0.3	8.0	0.000	1	0.000	0
75421		75421	23265	68	74	0.9	0.4	7.6	0.000	0	0.000	0
29306		29306	9040	69	70	1.0	0.4	6.3	0.000	0	0.000	0
58492		58492	18043	69	70	1.0	0.4	6.3	0.000	0	0.000	0
61518		61518	18977	69	70	1.0	0.4	6.3	0.000	0	0.000	0
82825		82825	25549	70	79	-2.2	-1.7	9.4	0.001	16	0.000	2
110523		111499	34394	71	80	-2.3	-1.9	10.1	0.001	42	0.000	3
89845	552	90397	27885	72	77	-1.8	-1.4	10.1	0.000	13	0.000	1
157615		157615	48620	72	77	-1.8	-1.4	10.1	0.000	24	0.000	2
146308		146308	45132	72	77	-1.8	-1.4	10.1	0.000	22	0.000	2
110595		110595	34115	72	77	-1.8	-1.4	10.1	0.000	17	0.000	2
67509	1062	68571	21152	73	83	-2.7	-2.2	10.3	0.002	48	0.000	3

Appendix 2. (continued)

Catch/trip				Day #		Weather by trip			Temp/wind mode		Windchill model	
delivered live crabs	dead loss	total catch	est. bycatch	start	sale	wind chill	temp (C)	wind (m/s)	P(mort)	mortality	P(wc)	bycatch mortality
78260		78260	24141	73	83	-2.7	-2.2	10.3	0.002	55	0.000	3
37944		37944	11705	74	77	-3.3	-2.6	10.9	0.005	64	0.000	3
84072	850	84922	26196	74	77	-3.3	-2.6	10.9	0.005	143	0.000	6
61486		61486	18967	74	77	-3.3	-2.6	10.9	0.005	104	0.000	5
138994	259	139253	42956	74	77	-3.3	-2.6	10.9	0.005	234	0.000	11
13887		15278	4713	75	77	-4.2	-3.1	10.9	0.016	75	0.001	4
104511		104511	32239	75	77	-4.2	-3.1	10.9	0.016	514	0.001	24
80419		80419	24807	75	77	-4.2	-3.1	10.9	0.016	395	0.001	18
52868		52868	16308	77	78	-6.6	-4.6	10.7	0.176	2878	0.013	206
24658		25158	7761	77	78	-6.6	-4.6	10.7	0.176	1369	0.013	98
41373		41373	12762	78	78	-6.9	-4.6	11.3	0.219	2794	0.018	236
61012	456	61468	18961	82	82	-2.0	-1.6	8.9	0.000	8	0.000	1
113040	833	113873	35127	84	84	-4.2	-3.5	8.1	0.009	305	0.001	27
78307	1271	79578	24548	85	85	-4.0	-3.1	8.8	0.006	140	0.001	15
2320		2320	716	17	18	-12.3	####	10.9	1.000	716	0.913	654
3257		3257	1005	22	22	-2.6	-3.1	4.7	0.001	1	0.000	0
3284	49	3333	1028	22	22	-2.6	-3.1	4.7	0.001	1	0.000	0
2956		2956	912	26	26	-7.6	-6.4	15.2	0.977	891	0.041	37
3778	10	3788	1168	31	32	-10.4	-6.8	11.1	0.936	1094	0.533	622
5082	13	5095	1572	31	32	-10.4	-6.8	11.1	0.936	1471	0.533	837
3204		3204	988	34	34	-6.6	-5.1	11.5	0.430	425	0.013	13
2200		2200	679	35	35	-0.2	-1.5	5.9	0.000	0	0.000	0
9000		9000	2776	37	37	0.8	0.5	10.7	0.000	0	0.000	0
3296		3296	1017	41	41	-7.3	-6.3	9.3	0.720	732	0.029	29
7223		7223	2228	42	42	-9.0	-6.9	7.1	0.743	1655	0.183	407
4153		4153	1281	51	52	-5.2	-4.2	6.0	0.013	16	0.002	3
4907		4907	1514	52	54	-5.3	-4.4	12.2	0.236	357	0.003	4
10778		10778	3325	72	73	1.0	0.9	8.6	0.000	0	0.000	0
6969		6969	2150	72	73	1.0	0.9	8.6	0.000	0	0.000	0
6454		6454	1991	80	80	-0.9	-1.9	12.1	0.003	6	0.000	0
27134	602	27736	8556	16	17	-12.5	-9.2	14.7	1.000	8554	0.929	7947
232418	1001	233419	72003	18	24	-5.1	-4.4	8.0	0.039	2811	0.002	162
67654	501	68155	21024	29	31	-10.4	-7.4	9.4	0.956	20106	0.521	10945
203611	750	204361	63039	32	38	-3.6	-3.0	8.5	0.004	280	0.000	24
193006	900	193906	59814	39	45	-5.1	-4.4	8.1	0.048	2846	0.002	126
81154	300	81454	25126	46	52	-6.0	-4.8	7.0	0.053	1322	0.007	165
62750	300	63050	19449	53	59	-5.7	-5.1	11.5	0.445	8657	0.004	83
88710	2000	90710	27981	60	66	-0.8	-0.8	10.5	0.000	5	0.000	0
114676	2455	117131	36132	67	73	0.9	0.4	7.7	0.000	0	0.000	0
81583	5000	86583	26708	74	79	-4.2	-3.2	10.9	0.016	426	0.001	20
13183	400	13583	4190	17	26	-5.8	-4.8	9.3	0.143	599	0.005	20
228704	2333	231037	71268	24	26	-2.5	-2.5	9.9	0.003	223	0.000	7
172357	3413	175770	54220	25	36	-7.0	-5.6	9.2	0.390	21128	0.020	1060
142814	2349	145163	44779	32	36	-5.4	-4.4	8.2	0.049	2208	0.003	131
35566	872	36438	11240	38	46	-4.5	-4.0	7.6	0.017	186	0.001	12

Appendix 2. (continued)

Catch/trip				Day #		Weather by trip			Temp/wind model		Windchill model	
delivered live crabs	dead loss	total catch	est. bycatch	start	sale	wind chill	temp (C)	wind (m/s)	P(mort)	mortality	P(wc)	bycatch mortality
245730	3332	249062	76828	39	47	-5.5	-4.7	7.5	0.058	4439	0.003	261
17240	900	18140	5596	11	17	-4.9	-3.7	14.6	0.188	1053	0.002	10
198783	20378	219161	67605	18	24	-5.1	-4.4	8.0	0.039	2640	0.002	152
93919	15195	109114	33659	25	31	-8.3	-6.3	10.1	0.802	27002	0.089	3010
134685	17754	152439	47023	32	38	-3.6	-3.0	8.5	0.004	209	0.000	18
129897	16389	146286	45125	39	45	-5.1	-4.4	8.1	0.048	2147	0.002	95
103392	20593	123985	38246	46	52	-6.0	-4.8	7.0	0.053	2013	0.007	251
164251	5000	169251	52209	18	24	-5.1	-4.4	8.0	0.039	2039	0.002	118
92765	9001	101766	31392	25	31	-8.3	-6.3	10.1	0.802	25184	0.089	2808
140037	14499	154536	47670	32	38	-3.6	-3.0	8.5	0.004	212	0.000	18
123763	10709	134472	41481	39	45	-5.1	-4.4	8.1	0.048	1974	0.002	87
51511	5901	57412	17710	46	52	-6.0	-4.8	7.0	0.053	932	0.007	116
182831	16859	199690	61599	53	59	-5.7	-5.1	11.5	0.445	27420	0.004	263
140035	19120	159155	49095	60	66	-0.8	-0.8	10.5	0.000	10	0.000	1
121137	15409	136546	42120	67	73	0.9	0.4	7.7	0.000	0	0.000	0
148911	18355	167266	51597	74	80	-3.7	-3.0	11.1	0.012	643	0.000	22
62775	467	63242	19508	17	21	-9.4	-7.4	11.0	0.977	19067	0.270	5270
63892	365	64257	19821	18	21	-8.3	-6.7	10.5	0.898	17793	0.086	1702
109555	674	110229	34002	18	21	-8.3	-6.7	10.5	0.898	30522	0.086	2919
96041	123	96164	29664	18	21	-8.3	-6.7	10.5	0.898	26628	0.086	2546
137915	630	138545	42737	18	21	-8.3	-6.7	10.5	0.898	38363	0.086	3669
138303	271	138574	42746	18	22	-7.1	-6.0	9.3	0.584	24962	0.024	1016
189751	442	190193	58669	19	25	-3.7	-3.0	8.0	0.004	207	0.000	23
133501	269	133770	41264	19	25	-3.7	-3.0	8.0	0.004	145	0.000	16
246438	1250	247688	76405	19	25	-3.7	-3.0	8.0	0.004	269	0.000	30
152812	359	153171	47249	21	29	-5.1	-4.2	7.9	0.029	1372	0.002	107
110122	1754	111876	34510	23	32	-6.7	-5.2	9.0	0.243	8370	0.015	506
100727	698	101425	31287	24	31	-7.1	-5.6	9.5	0.434	13578	0.023	709
151701	571	152272	46971	24	31	-7.1	-5.6	9.5	0.434	20384	0.023	1065
139643	733	140376	43302	25	33	-8.6	-6.5	9.9	0.830	35948	0.116	5004
218782	2177	220959	68159	26	34	-9.4	-7.0	10.2	0.932	63521	0.255	17367
165153	369	165522	51059	27	27	-11.5	-7.9	9.9	0.985	50269	0.812	41476
145525	320	145845	44989	27	27	-11.5	-7.9	9.9	0.985	44294	0.812	36545
157832	318	158150	48785	27	27	-11.5	-7.9	9.9	0.985	48031	0.812	39629
127659	597	128256	39563	28	37	-6.3	-5.1	8.7	0.182	7184	0.009	353
160632	263	160895	49631	29	38	-5.1	-4.4	8.7	0.052	2603	0.002	109
111381	472	111853	34503	31	41	-3.2	-3.2	8.5	0.006	224	0.000	8
201775	266	202041	62324	33	40	-1.7	-2.0	8.1	0.001	32	0.000	3
112263	442	112705	34766	33	40	-1.7	-2.0	8.1	0.001	18	0.000	1
144197	513	144710	44639	34	44	-3.2	-3.0	8.1	0.003	148	0.000	10
155067	593	155660	48017	36	44	-3.1	-2.9	8.0	0.003	131	0.000	10
164844	1220	166064	51226	37	45	-3.8	-3.3	8.3	0.007	380	0.000	23
129424	787	130211	40166	38	48	-5.0	-4.2	7.5	0.026	1041	0.002	76
154476	459	154935	47793	39	46	-5.2	-4.5	7.5	0.044	2105	0.002	113
105672	315	105987	32694	41	48	-7.1	-5.7	7.2	0.256	8366	0.022	720

Appendix 2. (continued)

Catch/trip				Day #		Weather by trip			Temp/wind mode		Windchill model	
delivered live crabs	dead loss	total catch	est. bycatch	start	sale	wind chill	temp (C)	wind (m/s)	P(mort)	mortality	P(wc)	bycatch mortality
215029	776	215805	66570	41	48	-7.1	-5.7	7.2	0.256	17035	0.022	1466
160883	2222	163105	50313	42	42	-9.0	-6.9	7.1	0.743	37364	0.183	9195
34916	195	35111	10831	42	42	-9.0	-6.9	7.1	0.743	8043	0.183	1979
98775	407	99182	30595	44	49	-6.5	-5.1	7.3	0.109	3320	0.011	329
169293	1653	170946	52732	44	49	-6.5	-5.1	7.3	0.109	5722	0.011	567
81633	569	82202	25357	45	49	-6.6	-5.3	6.8	0.118	2996	0.013	320
125940	806	126746	39097	45	49	-6.6	-5.3	6.8	0.118	4619	0.013	493
162919	766	163685	50492	46	54	-6.0	-4.8	8.9	0.114	5753	0.006	308
167143	651	167794	51760	46	54	-6.0	-4.8	8.9	0.114	5898	0.006	316
101025	714	101739	31384	47	53	-5.9	-4.6	8.3	0.067	2093	0.005	165
36612	74	36686	11317	48	48	-6.2	-5.0	6.7	0.069	782	0.008	92
132822	1600	134422	41465	49	61	-5.1	-4.4	9.9	0.101	4168	0.002	93
83391	1475	84866	26179	50	55	-6.6	-5.0	11.3	0.379	9934	0.012	316
86837	317	87154	26884	50	55	-6.6	-5.0	11.3	0.379	10202	0.012	325
142730	1864	144594	44603	52	58	-6.2	-5.1	10.5	0.342	15233	0.008	348
92000	164	92164	28430	54	57	-8.0	-6.4	12.0	0.909	25852	0.066	1871
158900	1172	160072	49378	54	57	-8.0	-6.4	12.0	0.909	44900	0.066	3250
130128	640	130768	40338	55	62	-4.4	-4.1	10.1	0.057	2315	0.001	36
109997	909	110906	34211	56	63	-2.7	-3.0	9.6	0.007	248	0.000	4
105798	351	106149	32744	57	63	-1.7	-2.4	9.6	0.002	79	0.000	1
152851	800	153651	47397	57	63	-1.7	-2.4	9.6	0.002	114	0.000	2
76252	703	76955	23738	58	66	-0.9	-1.4	10.4	0.000	12	0.000	0
58351	976	59327	18301	59	59	-0.7	-3.8	12.4	0.096	1753	0.000	0
49652	331	49983	15418	60	64	-0.6	-1.0	9.2	0.000	2	0.000	0
163977	950	164927	50875	60	64	-0.6	-1.0	9.2	0.000	7	0.000	1
51874	317	52191	16099	61	61	-0.9	-0.8	6.0	0.000	0	0.000	0
122978	1382	124360	38361	61	61	-0.9	-0.8	6.0	0.000	1	0.000	1
99625	1374	100999	31155	62	70	0.3	0.0	9.7	0.000	1	0.000	0
98177	1129	99306	30633	63	66	0.3	0.1	10.6	0.000	1	0.000	0
78307	373	78680	24270	63	66	0.3	0.1	10.6	0.000	1	0.000	0
68588	756	69344	21391	64	68	0.1	0.1	10.3	0.000	1	0.000	0
213675	2308	215983	66624	64	68	0.1	0.1	10.3	0.000	2	0.000	0
162491	1250	163741	50509	65	71	0.2	0.0	9.3	0.000	1	0.000	0
228596	192	228788	70574	65	71	0.2	0.0	9.3	0.000	2	0.000	0
167098	605	167703	51732	65	71	0.2	0.0	9.3	0.000	1	0.000	0
80559	924	81483	25135	66	69	0.0	-0.1	10.8	0.000	1	0.000	0
58540	744	59284	18287	68	70	1.3	0.7	6.3	0.000	0	0.000	0
59735	1403	61138	18859	68	70	1.3	0.7	6.3	0.000	0	0.000	0
84454	2177	86631	26723	68	70	1.3	0.7	6.3	0.000	0	0.000	0
48950	694	49644	15314	69	74	0.8	0.3	7.8	0.000	0	0.000	0
83824	468	84292	26002	70	77	-1.2	-1.1	9.0	0.000	4	0.000	1
81428	785	82213	25360	71	74	0.6	0.2	8.6	0.000	0	0.000	0
170806	1215	172021	53063	71	74	0.6	0.2	8.6	0.000	1	0.000	0
73673	2016	75689	23348	72	82	-2.3	-2.0	10.4	0.001	34	0.000	2
218506	1169	219675	67763	73	83	-2.7	-2.2	10.3	0.002	154	0.000	8

Appendix 2. (continued)

Catch/trip				Day #		Weather by trip			Temp/wind mode		Windchill model	
delivered live crabs	dead loss	total catch	est. bycatch	start	sale	wind chill	temp (C)	wind (m/s)	P(mort)	mortality	P(wc)	bycatch mortality
90284	1653	91937	28360	74	78	-4.0	-3.0	11.0	0.012	338	0.001	17
107116	313	107429	33139	74	78	-4.0	-3.0	11.0	0.012	395	0.001	19
94941	769	95710	29524	74	78	-4.0	-3.0	11.0	0.012	352	0.001	17
49588	2282	51870	16000	75	76	-3.2	-2.4	11.4	0.005	81	0.000	3
65667	2333	68000	20976	75	76	-3.2	-2.4	11.4	0.005	106	0.000	5
24786	1074	25860	7977	75	76	-3.2	-2.4	11.4	0.005	40	0.000	2
43141	438	43579	13443	76	87	-3.8	-3.1	10.2	0.011	153	0.000	6
40217	492	40709	12558	78	78	-6.9	-4.6	11.3	0.219	2749	0.018	232
7094		7094	2188	18	23	-6.0	-5.0	8.3	0.142	312	0.006	14
5790		5790	1786	18	23	-6.0	-5.0	8.3	0.142	254	0.006	12
5900		5900	1820	22	22	-2.6	-3.1	4.7	0.001	2	0.000	0
5950		5950	1835	26	26	-7.6	-6.4	15.2	0.977	1794	0.041	74
32216	1563	33779	10420	11	17	-4.9	-3.7	14.6	0.188	1962	0.002	19
210827	1369	212196	65456	24	24	0.2	-0.3	5.7	0.000	1	0.000	0
148704	1360	150064	46290	31	31	-10.0	-6.4	10.0	0.811	37529	0.416	19237
113536	3125	116661	35987	38	38	0.7	0.5	7.9	0.000	0	0.000	0
95853	1650	97503	30077	45	45	-7.2	-5.7	8.2	0.344	10359	0.025	749
104228	1527	105755	32622	52	52	-4.3	-3.9	5.2	0.005	162	0.001	27
130604	3018	133622	41219	53	59	-5.7	-5.1	11.5	0.445	18348	0.004	176
122316	1230	123546	38110	60	66	-0.8	-0.8	10.5	0.000	7	0.000	0
198306	2191	200497	61848	66	73	0.4	0.2	9.0	0.000	1	0.000	0
115948	1793	117741	36320	73	80	-3.1	-2.5	10.4	0.004	133	0.000	7
144059	4202	148261	45734	47	66	-4.1	-3.5	10.0	0.020	912	0.001	29
77509	4800	82309	25390	54	66	-3.1	-2.9	10.9	0.010	260	0.000	5
41853	5001	46854	14453	61	66	-0.2	-0.3	10.5	0.000	1	0.000	0
123363	6000	129363	39905	68	74	0.9	0.4	7.6	0.000	0	0.000	0
97019	5085	102104	31496	74	81	-3.2	-2.7	11.1	0.008	242	0.000	7
85510	14774	100284	30935	53	59	-5.7	-5.1	11.5	0.445	13770	0.004	132
110440	21934	132374	40834	60	66	-0.8	-0.8	10.5	0.000	8	0.000	1
214119	44957	259076	79917	67	73	0.9	0.4	7.7	0.000	0	0.000	0
116319	34433	150752	46503	74	80	-3.7	-3.0	11.1	0.012	579	0.000	20
16085	162	16247	5012	16	17	-12.5	-9.2	14.7	1.000	5011	0.929	4655
150565	2000	152565	47062	18	24	-5.1	-4.4	8.0	0.039	1838	0.002	106
103443	13167	116610	35971	25	31	-8.3	-6.3	10.1	0.802	28858	0.089	3217
67906	1257	69163	21335	38	38	0.7	0.5	7.9	0.000	0	0.000	0
117038	2341	119379	36825	45	45	-7.2	-5.7	8.2	0.344	12684	0.025	918
63903	1278	65181	20106	52	52	-4.3	-3.9	5.2	0.005	100	0.001	17
17065	341	17406	5369	59	59	-0.7	-3.8	12.4	0.096	514	0.000	0
14221	284	14505	4474	66	66	-2.6	-1.5	17.6	0.015	69	0.000	0
125180	2505	127685	39387	73	73	1.5	1.2	6.1	0.000	0	0.000	0
93010	2706	95716	29526	80	80	-0.9	-1.9	12.1	0.003	83	0.000	0
23239		23239	7169	16	18	-11.8	-9.5	12.7	1.000	7167	0.856	6138
135972	1000	136972	42252	18	25	-4.5	-3.9	8.1	0.018	777	0.001	45
1779		1779	549	26	30	-10.0	-7.4	10.4	0.972	533	0.406	223
11579	245	11824	3647	31	31	-10.0	-6.4	10.0	0.811	2957	0.416	1516

Appendix 2. (continued)

Catch/trip				Day #		Weather by trip			Temp/wind mode		Windchill model	
delivered live crabs	dead loss	total catch	est. bycatch	start	sale	wind chill	temp (C)	wind (m/s)	P(mort)	mortality	P(wc)	bycatch mortality
153952	3074	157026	48438	32	38	-3.6	-3.0	8.5	0.004	215	0.000	18
137824	4352	142176	43857	39	45	-5.1	-4.4	8.1	0.048	2087	0.002	92
88203	1754	89957	27749	46	52	-6.0	-4.8	7.0	0.053	1460	0.007	182
42751	889	43640	13462	54	55	-9.2	-6.8	16.0	0.992	13360	0.212	2853
64058	3328	67386	20787	60	66	-0.8	-0.8	10.5	0.000	4	0.000	0
121648	6208	127856	39440	68	73	1.1	0.6	7.1	0.000	0	0.000	0
108713	5436	114149	35212	74	79	-4.2	-3.2	10.9	0.016	561	0.001	26
99447	4912	104359	32192	18	23	-6.0	-5.0	8.3	0.142	4584	0.006	207
83146	4421	87567	27012	25	31	-8.3	-6.3	10.1	0.802	21670	0.089	2416
109927	4994	114921	35450	32	38	-3.6	-3.0	8.5	0.004	157	0.000	13
76483	3641	80124	24716	39	45	-5.1	-4.4	8.1	0.048	1176	0.002	52
45332		45332	13984	46	52	-6.0	-4.8	7.0	0.053	736	0.007	92
55909	2716	58625	18084	53	59	-5.7	-5.1	11.5	0.445	8050	0.004	77
57989	2883	60872	18777	60	66	-0.8	-0.8	10.5	0.000	4	0.000	0
61313	3046	64359	19853	67	79	-1.5	-1.2	9.2	0.000	5	0.000	1
42520	2399	44919	13856	74	79	-4.2	-3.2	10.9	0.016	221	0.001	10
9161	600	9761	3011	11	17	-4.9	-3.7	14.6	0.188	567	0.002	5
102419	2001	104420	32211	18	24	-5.1	-4.4	8.0	0.039	1258	0.002	73
112286	5999	118285	36487	25	31	-8.3	-6.3	10.1	0.802	29272	0.089	3263
100400	5857	106257	32777	32	38	-3.6	-3.0	8.5	0.004	146	0.000	12
46091	2999	49090	15143	39	45	-5.1	-4.4	8.1	0.048	721	0.002	32
99844	13822	113666	35063	46	52	-6.0	-4.8	7.0	0.053	1845	0.007	230
68671	7177	75848	23397	53	59	-5.7	-5.1	11.5	0.445	10415	0.004	100
121890	6310	128200	39546	60	66	-0.8	-0.8	10.5	0.000	8	0.000	1
53366	14521	67887	20941	67	73	0.9	0.4	7.7	0.000	0	0.000	0
70505	7149	77654	23954	74	80	-3.7	-3.0	11.1	0.012	298	0.000	10