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# Estimated Mortality of Snow Crabs *Chionoecetes opilio* Discarded During the Bering Sea Fishery in 1998

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ABSTRACT: The mortality of discarded snow crabs *Chionoecetes opilio* was estimated for the 1998 fishery for snow crabs in the Bering Sea. Estimates of discard mortality were calculated from deadloss of retained crabs, a windchill model of mortality was developed from the results of a laboratory study, and a model that predicts mortality from temperature and windspeed was developed. The 1998 season was used because it had the most complete set of data. No relationship existed between the deadloss reported in the catch delivered to processors and the windchill conditions when the crabs were caught. Mortality of discarded snow crabs was estimated at 3.9% by the windchill model and 19.6% by the temperature and windspeed model.

## INTRODUCTION

The snow crab *Chionoecetes opilio* is 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).

A possible contributor 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 by crabs that are discarded as bycatch. The Bering Sea fishery occurs during the winter months and severe weather conditions. Laboratory studies on snow crabs (Warrenchuk and Shirley 2002) and the congeneric Tanner crabs *C. bairdi* (Shirley 1998) found that exposure to cold air and wind (windchill) caused acute mortality.

Tens of millions of snow crabs are sorted and discarded each year during the Bering Sea snow crab fishery. Snow crab bycatch includes sublegal males (<78 mm carapace width, CW) and all females. Crabs deemed unmarketable such as very old shell males, injured crabs, and small males (78-101 mm CW) are also sorted and discarded. The number of discarded crabs varies with vessel and year.

Many fisheries in the Bering Sea catch snow crabs as bycatch. Groundfish trawl fisheries caught over 4 million snow crabs in 1998 (NPFMC 1999). The long exposure time during sorting, the crushing loads within trawls, and the severity of Bering Sea weather conditions likely result in low survival of snow crab bycatch. Tanner crabs captured by Bering Sea sole trawlers in late summer had an overall survival rate of 22% after 2 days of shipboard observation in seawater holding tanks (Stevens 1990). Total mortality of snow crabs captured incidentally by trawl fisheries was estimated at 80% (NPFMC 1999). The weathervane scallop *Patinopecten caurinus* fishery captured 232,000 snow crabs in 1998; total mortality of the snow crab bycatch was estimated at 40% (NPFMC 1999).

Bycatch of snow crabs also occurs in the St. Matthew Island blue king crab *Paralithodes platypus* fishery, the hair crab *Erimacrus isenbeckii* fishery, the Bristol Bay red king crab *P. camtschaticus* fishery, and the Bering Sea Aleutian Islands Tanner crab fishery. In 1998 approximately 120,000 snow crabs were caught as bycatch in these other crab fisheries (NPFMC 1999).

Although snow crabs are caught incidentally in many fisheries in the Bering Sea, the snow crab fish-

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ery itself accounts for most of the bycatch. Between 1994 and 1999 estimated bycatch of snow crabs in the snow crab fishery was 40 million to 75 million crabs (NPFMC 1999). The majority of incidentally captured snow crabs are small males (78-101 mm CW). The legal retention size (≥78 mm) and marketable size (≥102 mm) of snow crab differ: crabs in the size range between legal size (78 mm CW) and marketable size (102 mm CW) are usually discarded. Female snow crabs are estimated to account for less than 1% of the snow crab bycatch. Male snow crabs <78 mm CW are estimated to account for 2% or less of the total bycatch (NPFMC 2000).

Handling of bycatch crabs in fisheries that use pot gear 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 in other crab fisheries (e.g., Atlantic coast blue crab *callinectes sapidus* fishery, Pacific coast Dungeness crab *cancer magister* fishery). Snow crabs caught and released during the Bering Sea fishery are potentially exposed to severe windchill conditions that may result in mortality. 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 crabs that might have died during the 1998 Bering Sea snow crab fishery when discarded as bycatch. 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 observer and weather data. Bycatch mortality due to exposure had not been previously estimated for Bering Sea snow crab.

The catch per unit effort (CPUE) for retained male crabs estimated from the sample data can differ from the observed CPUE from the vessel interviews conducted by the observer program. For the past several years, the estimated fishery CPUE has underestimated the observed fishery CPUE (Moore et al. 2000). If the total catch of retained crabs is underestimated, then the incidental catch 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. The hybrid progeny are characterized by a suite of morphological characters that range between snow crabs and Tanner crabs (D. Urban, Alaska Department of Fish and Game, Kodiak, personal communication). Fishermen can retain hybrids but must release *C. bairdi* Tanner crabs during the snow crab fishery. Processors do not distinguish between pedigreed snow crabs and hybrids. Therefore, the observed catch includes all of the retained hybrid snow crabs.

## METHODS

A database of the catches for each vessel during each fishing trip was obtained from the Alaska Department of Fish and Game in Dutch Harbor. The database contained all the data for catches during the fishery and included the total number of retained snow crabs, the total number of pots pulled, and the dates and length of the fishing trip. 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 the unit effort of crab fishing equal to one pot retrieved.

The total bycatch estimate is computed from a CPUE estimate derived from catches sampled by observers (Moore et al. 2000; Table 1). Observers on at-

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

| Parameter | Value | Standard Error | Data Source |
|---|---|---|---|
| Number of trips | 1,645 | | fish ticket database[a] |
| CPUE (actual retained catch) | 209.3 | | observer data[b] |
| CPUE (est. retained) | 167.2 | 2.0 | observer data[b] |
| CPUE (est. retained hybrids) | 20.5 | 0.6 | observer data[b] |
| CPUE (hybrids + retained) | 187.7 | 2.1 | derived |
| $q$ (scaling factor) | 1.12 | 0.01 | derived |
| CPUE (est. legal not retained) | 55.5 | 0.5 | observer data[b] |
| CPUE (est. sublegal) | 2.4 | 0.1 | observer data[b] |
| 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 |

[a] S. Engle and R. Morrison, ADF&G, Dutch Harbor, unpublished data
[b] Moore et al. 2000

sea catcher/processors randomly sample crab pots and count all crabs caught.

## Weather conditions and windchill

Weather buoy # 46035 at lat 56.9 °N, long 177.8° W in the Bering Sea is the only marine source of continuous weather data within 450 km of the fishing grounds. 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). The average daily temperature, windspeed, and sea temperature from the buoy data was calculated for each day of the fishery.

A database obtained from the Alaska Department of Fish and Game in Dutch Harbor 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 the number of snow crabs that are delivered to the processors dead or near death. The number of retained crabs that died could potentially reflect the number of discarded crabs that died (Witherell 2001). Retained crabs should be subjected to the same weather conditions as discarded crab so any relationship between windchill and mortality would be evident in the deadloss of the catch.

## Windchill model estimate of mortality

Mortality of snow crabs increased with severity of windchill exposure in the lab (Warrenchuk and Shirley 2002). The relationship between windchill and mortality derived in the laboratory was applied to estimates of bycatch 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 following National Weather Service formula (Parker 1987):

$$Temp_{windchill} = Temp_{initial} + 0.045 \times \left[\left(5.27 \times \sqrt{Windspeed}\right) + 10.45 - \left(0.28 \times Windspeed\right)\right] \times \left(Temp_{air} - Temp_{initial}\right) \quad (1)$$

where Windspeed is mean wind speed (km/h), $Temp_{air}$ is ambient temperature (°C), and $Temp_{initial}$ is the initial body temperature (°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 surface temperatures were used for the initial crab temperature.

A model derived from a laboratory experiment was used to predict the probability of death given exposure to certain windchill values (Warrenchuk and Shirley 2002). The following expression is a logistic model of mortality given windchill exposure:

$$pr(death) = \frac{1}{1 + \exp\left[-\left(a - b \times windchill\right)\right]}. \quad (2)$$

The parameters in the windchill model were derived using maximum likelihood estimators to fit to the experimental data. The estimate of $a$ was –12.161 (standard error, SE=5.700) and was significantly different from zero ($P$=0.033). The estimate of $b$ was 1.182 (SE=0.538) and was significantly different from zero ($P$=0.028). The variable windchill is the windchill in °C calculated from the summary function (Parker 1987) of windspeed, air temperature, and initial temperature. The model predicted 83% of the observed mortality in the laboratory experiment and was significant at $a$ = 0.1 (Warrenchuk and Shirley 2002).

## Temperature and windspeed model estimate of mortality

We developed a comparison model that used the temperature and windspeed (without summarizing into a windchill equation) as predictors of mortality. Temperature was expressed in °C and windspeed in m/s. A logistic regression was used to develop a model to predict mortality likelihood given exposure for 5 min to both cold temperatures and wind:

$$pr(death) = \frac{1}{1 + \exp\left[-\left(a - b \times temperature + d \times windspeed\right)\right]}. \quad (3)$$

All parameters were derived from maximum likelihood estimators fitted to the experimental data. The estimate of $a$ was –14.672 (SE=5.663) and was significantly different from zero ($P$=0.009); the temperature modifying parameter $b$ was estimated to be 1.837 (SE=0.732) and was significantly different from zero ($P$=0.012); and the windspeed-modifying parameter $d$

Table 2. Comparison of the average temperature, windspeed, and windchill for the 1998 season by month to the 8-year average from 1985 to 1993. Data from weather buoy #46035 (modified from the National Data Buoy Center, http://seaboard.ndbc.noaa.gov, 2000).

| | Average Temperature (°C) | | Average Windspeed (m/s) | | Average 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 |

was estimated at 0.446 (SE=0.179) and was significantly different from zero (*P*=0.013).

## RESULTS

Because the weather buoy was partially out of service and did not record windspeed for 1999 and most of 2000, a complete data set of weather conditions was only available for 1998. The 1998 season for snow crabs in the Bering Sea lasted 76 days, from January 11 to March 27, 1998. The average daily air temperature and windspeed over the fishing season is shown in Figure 1. The average daily windchill is shown in Figure 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 colder when compared to past years (Table 2).

In 1998 observers sampled 2,132 pots and enumerated all 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 incidental catch of crabs of different species. A CPUE was estimated for each type of crab catch (Table 1). The total number of pots selected for bycatch sampling accounted for less than 1% of the 891,268 pot lifts reported by vessel operators during the 1998 season.

The total hybrid crab catch and CPUE is estimated from the sample data. The estimated hybrid catch was added to the estimated catch of retained crabs and the difference from the actual catch is reduced. Nevertheless, the total catch remained underestimated and an underestimation factor was calculated:

$$\hat{q}_{uf} = \frac{C\hat{P}UE_{(actual\ retained\ catch)}}{C\hat{P}UE_{(est.\ retained)} + C\hat{P}UE_{(est.\ hybrid)}}. \qquad (4)$$

The resulting underestimation factor increased the bycatch estimates by 12% (Table 1). The CPUE estimate for non-retained legal-sized crabs and the estimated CPUE for sublegal-sized crabs were added to

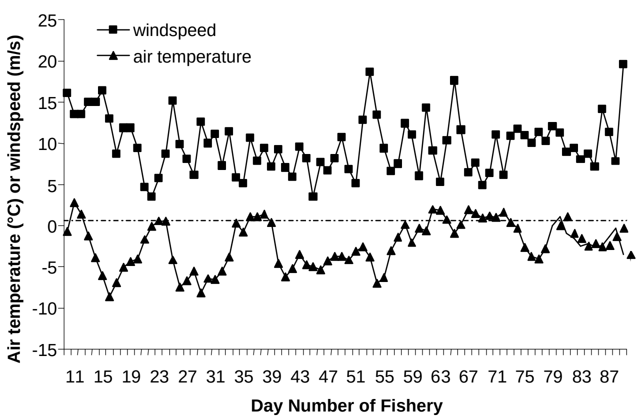


Figure 1. Average daily air temperature and windspeed measured by buoy #46035 during the 1998 Bering Sea snow crab fishery; the season lasted from January 11 to March 27, 1998.

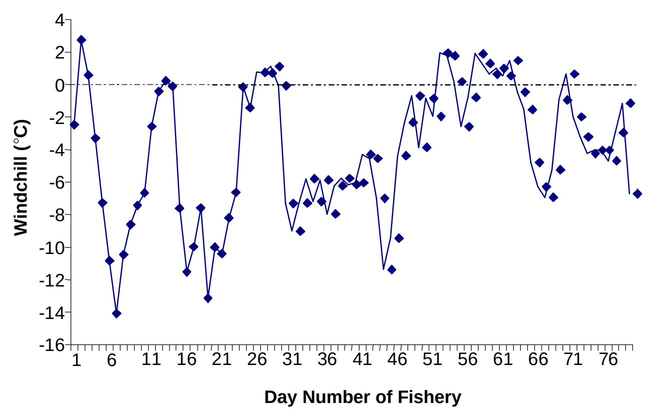


Figure 2. Average daily windchill calculated from weather data measured by buoy #46035 during the 1998 Bering Sea snow crab fishery; the season lasted from January 11 to March 27, 1998.

give an estimated total bycatch CPUE. The bycatch CPUE estimate was then scaled by the underestimation factor:

$$C\hat{P}UE_{(scaled\ bycatch)} = \hat{q}_{uf}\left(CPUE_{(est.\ bycatch)}\right). \quad (5)$$

To preserve the variation among 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 during each trip:

$$byc\hat{a}tch_{(trip\ i)} = \frac{C\hat{P}UE_{(scaled\ bycatch)}}{CPUE_{(actual\ total\ catch)}}\left(catch_{(trip\ i)}\right). \quad (6)$$

Rather than holding the number of crabs caught per pot 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 sum of the bycatch of each trip equals the total estimated bycatch:

$$total\ bycatch = \sum_{i=1}^{N} byc\hat{a}tch_{(trip\ i)}. \quad (7)$$

The total bycatch estimated for the fishery in 1998 was approximately 57.5 million crabs (SE=1.7 million). The data are summarized in Table 1.

## Windchill as a predictor of deadloss

The deadloss delivered to processors was 2.28 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. The deadloss from every trip ($n$=1,645) was plotted with the average windchill over that trip, and no relationship existed (Figure 3). The database included a few outliers where the deadloss was as high as 40% of the catch.

## Mortality estimate with windchill model

The mortality due to windchill in 1998 was estimated at 3.9% of the total bycatch, or 2.26 million crabs (SE= 0.76 million) (Table 3). The estimated number of crabs that died per trip ranged from 0 to 85,000 crabs. Most fishing trips (84% of trips) resulted in mortality of less than 1,000 discarded crabs. Only 2% of trips had mortalities over 20,000 crabs.

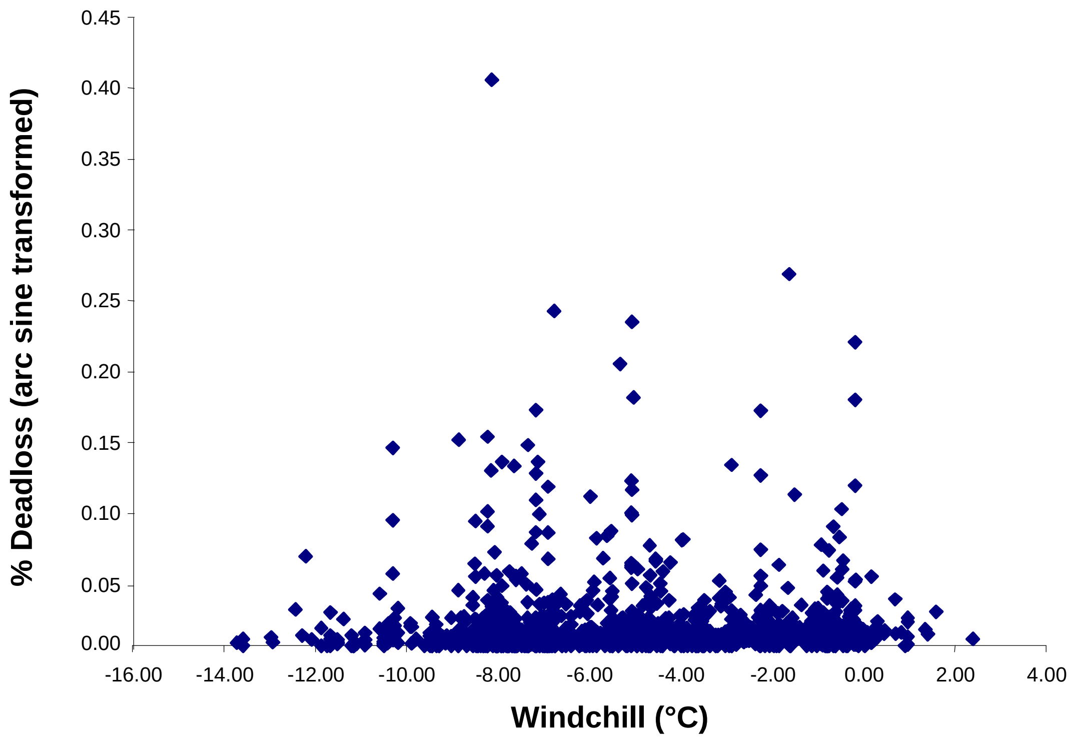


Figure 3. The deadloss of the total catch delivered to the processors plotted against the windchill condition during each fishing trip for the Bering Sea snow crab fishery in 1998.

Table 3. Estimates of mortality of discarded snow crabs during the 1998 Bering Sea snow crab fishery.

| Method of Estimation | Dead Crabs (millions) | Mortality of Bycatch (%) |
|---|---|---|
| Deadloss of retained crabs | 2.28 | 1.2 |
| Windchill model | 2.26 (SE=0.76) | 3.9 |
| Temperature and windspeed model | 11.29 (SE=1.16) | 19.6 |
| Handling mortality due to major injuries | 1.65 | 2.6 |
| Temperature and windspeed model + handling mortality | 14.22 | 22.2 |

## Mortality estimate with temperature and windspeed model

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 (SE=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 113,000 crabs. The two-variable model resulted in higher bycatch mortality distributed over a greater range of conditions than estimated with the windchill model. The number of fishing trips with mortality of less than 1,000 crabs (54% of trips) was lower and more trips had high mortality of more than 20,000 crabs (14% of trips).

## Model comparison

The model that used temperature and windspeed to predict mortality fit the observed mortality in the laboratory (Warrenchuk and Shirley 2002) better than the windchill model. The parameters for the 2-variable model are significant at $a = 0.05$ versus $a = 0.1$ for the windchill model (Warrenchuk and Shirley 2002). The temperature and windspeed model also predicted mortality 82% correctly for the observed mortality in the experiment versus 83% correctly for the windchill model. The two models are compared graphically in Figure 4. The temperature and windspeed model has a steeper slope and the probability of death increases rapidly (Figure 4). The contribution of windspeed in the windchill model is less, and lower temperatures are necessary before the probability of death increases (Figure 4).

# DISCUSSION

## Deadloss

Retained crab mortality (as evidenced by deadloss) is not a predictor of bycatch mortality. High deadloss is probably associated with equipment failure (e.g., water pumps, circulation system) in the holding tanks (F. Bowers, Alaska Department of Fish and Game, Dutch Harbor, personal communication). 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 (Table 3) is thus suspect. Because a relationship between windchill and mortality was clearly observed in the lab (Warrenchuk and Shirley 2002), retained crabs may not be subject to the same levels of stress as bycatch crabs. Bycatch crabs are exposed longer than retained crabs because most crews sort retained crabs first (Tracy and Byersdorfer 2000). Retained crabs are dropped only a short distance directly into the holding tanks. Discarded 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.

Discarded crabs are smaller and may lose heat more quickly than retained crabs. Smaller crabs have a greater surface area-to-volume ratio and less thermal mass (Shirley 1998). 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 realistic. The windchill summary function may not be the best descriptor of the cooling effect on snow crabs. The windchill equation, Eq. (1), was derived from cooling effects on exposed human flesh with baseline conditions of a moderate breeze (Court 1948). Low windspeed values in Eq. (1) result in windchill values warmer than the ambient temperature. A discrepancy may exist between the windchill calculation from the 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 an initial body temperature of 6°C, the water tempera-

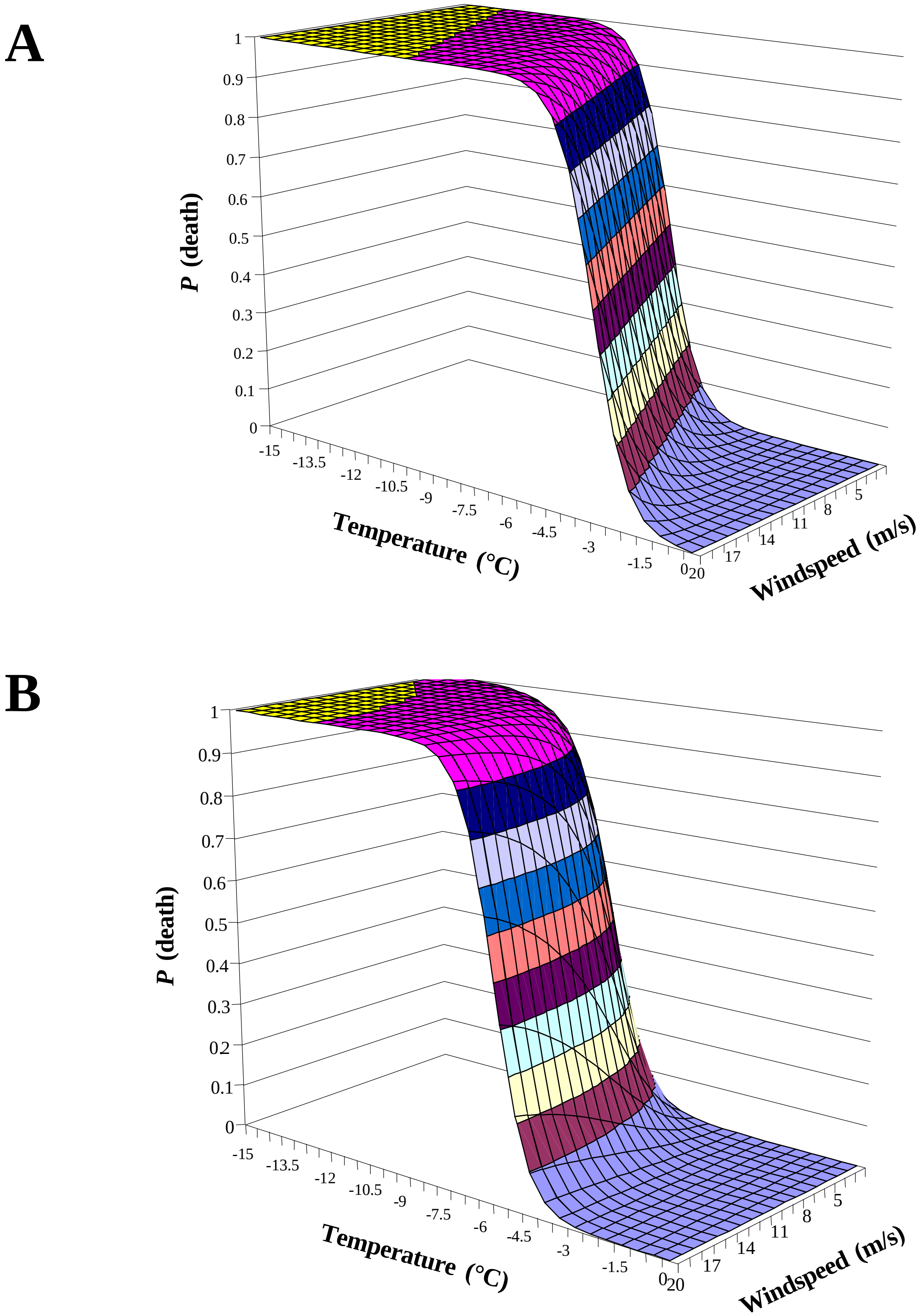


Figure 4. Comparison of the (A) temperature and windspeed model and the (B) windchill model at similar combinations of windspeed and temperature for predicting probability of mortality. Shaded bands indicate increments of 0.1 mortality probability.

ture 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 those acclimatized at 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 (Figure 4). Windspeed has a much greater contribution to the mortality probability in the temperature and windspeed model, particularly at warmer temperatures (Figure 4).

Actual temperatures and windspeeds may be different aboard a fishing vessel than those recorded by the weather buoy. Windspeed may be significantly reduced depending on the orientation of the vessel and shelter from blocking objects. If actual conditions were different than those assumed for the mortality estimates, then the estimates would change accordingly.

The 2-variable temperature and windspeed model estimated snow crab bycatch mortality to be 19.6%. The estimated bycatch mortality may be 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 with Tanner crabs suggested that handling alone did not cause significant mortality (MacIntosh et al. 1996). Furthermore, multiple handling in the laboratory did not reduce survival of red king crab (Zhou and Shirley 1995). Severe exposure and rough handling are probably 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 discarded snow crabs from 394 sampled pots (Tracy and Byersdorfer 2000). Injury rates of crabs sampled varied from 7% to 44% among vessels and averaged 24% (Tracy and Byersdorfer 2000). Autotomized legs were the most prevalent injury and comprised 59% of the total injuries. Major damage (e.g., cracked carapace, bent or torn limbs, chela damage) comprised 10.9% of the total injuries (Tracy and Byersdorfer 2000). 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 among crabs, and crushing of crabs within pots. 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 may die as a result of handling (Table 3). This estimate was derived from information contained within Tracy and Byersdorfer (2000) but data was insufficient to calculate standard errors.

The total bycatch mortality estimate could include an 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 because it does not take into account the synergistic effect of handling and exposure to wind and cold (Table 3).

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 (Warrenchuk and Shirley 2002). 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 the bycatch mortality estimate

The bycatch mortality estimates could be used to refine stock-recruitment predictions for Bering Sea snow crabs. Stock-recruitment models have not been implemented for management of this crab fishery. Although some progress has been made towards length-based recruitment models for Tanner crabs (Zheng and Kruse 1998, 2000) and snow crabs (J. Zheng, Alaska Department of Fish and Game, Juneau, personal communication), neither model has been implemented in management. Instead, guideline harvest limits for snow crabs 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 estimated 22.2% bycatch mortality is similar to the 25% assumed in the rebuilding plan (NPFMC 1999). Rebuilding scenarios would be probably not be affected by implementing a 22.2% bycatch mortality estimate instead of the 25% estimate. Nevertheless, this study is in agreement with the bycatch mortality assumption in the rebuilding plan.

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