Overview: effects of crab injury on the survival rate for BBRKC

Benjamin Daly
ADF&G, Commercial Fisheries Division
Alaska Bycatch Advisory Council Meeting
September 23, 2025

Why is handling mortality important?

- Discarding (target species) and bycatch (non-target species) occurs in BSAI crab fisheries
- Once returned to the ocean, a portion of those crab die
- Catch accounting: Estimates of discard/bycatch mortality is needed to estimate total fishery mortality
- “Overfishing” occurs when total fishery mortality exceeds the OFL
- Assumptions about what portions of discards/bycatch die affect estimates of total fishery mortality
- NOTE: Retained catch: deadloss rate very low ~<2%

Sources of handling mortality

- Injuries: physical trauma of dumping and sorting on deck
- On-deck anoxia
- Temperature stress (freezing)

Short-term mortality

- Can be studied and estimated relatively easily

Long-term effects

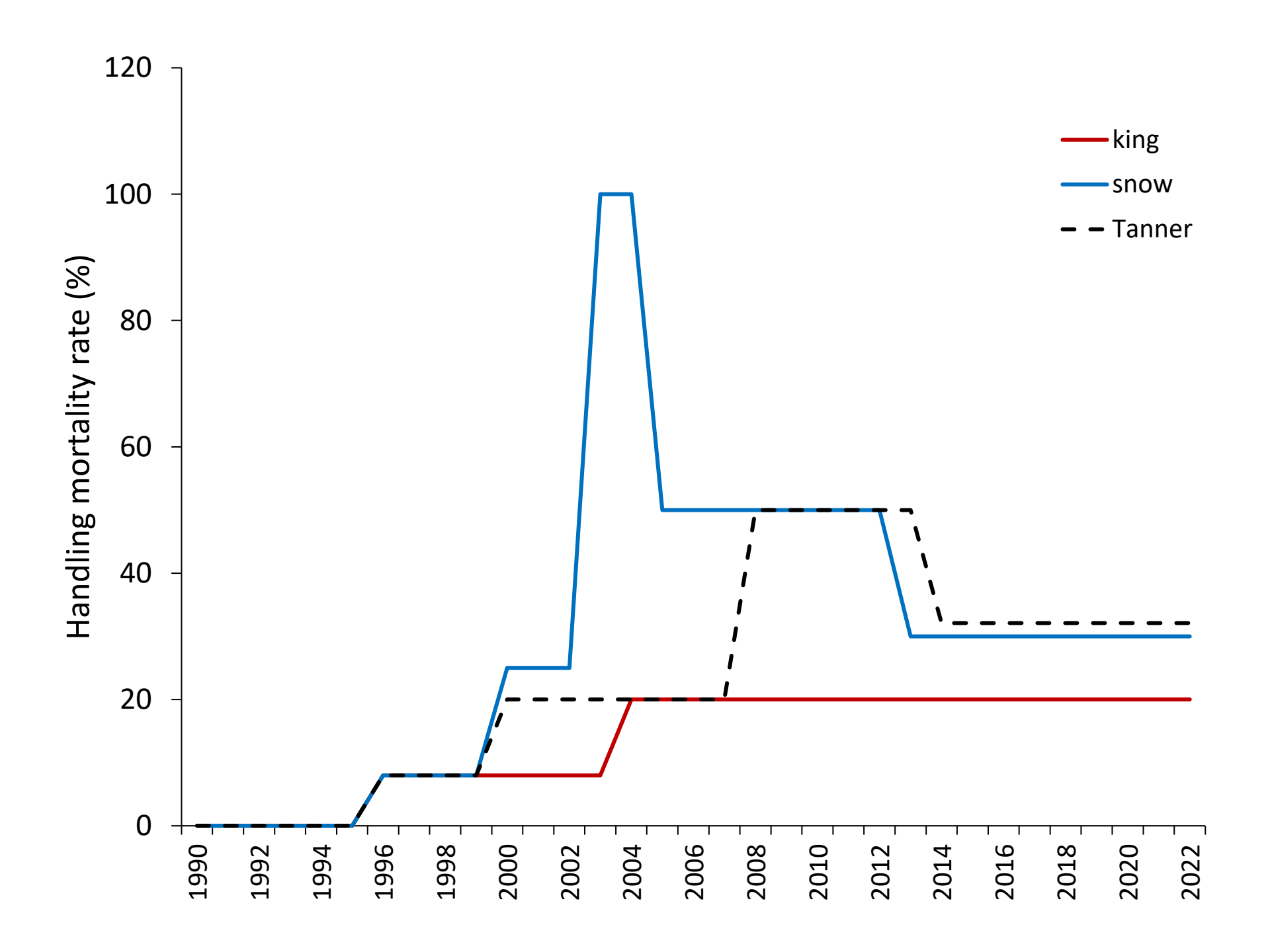
- "*Individuals that incur damage to sensory structures during handling may survive well in captivity but in the wild may be eaten or may fail to obtain enough food, leading to delayed mortality*." (van Tamelen 2005)
  - Increased predation
  - Decreased ability to feed or mate
  - Increased mortality during molting
    - Some evidence of this for Tanner crab (eyestalk freezing)
  - Cumulative effects of repeated capture?
- **More difficult to estimate**

Current handling mortality rates

BBRKC

- Directed fishery: 20%
- Tanner fishery: 25%

- Snow
  - Directed fishery: 30%
  - Tanner fishery: 30%
- Tanner
  - Directed fishery: 32.1%
  - snow fishery: 32.1%
  - BBRKC fishery: 32.1%
- AIGKC
  - Directed: 20%


120
100
80
60
40
20
0
Handling mortality rate (%)
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014
2016
2018
2020
2022
king
snow
Tanner

Stoner et al., 2008; Stoner 2009

RAMP: Reflex action mortality predictor

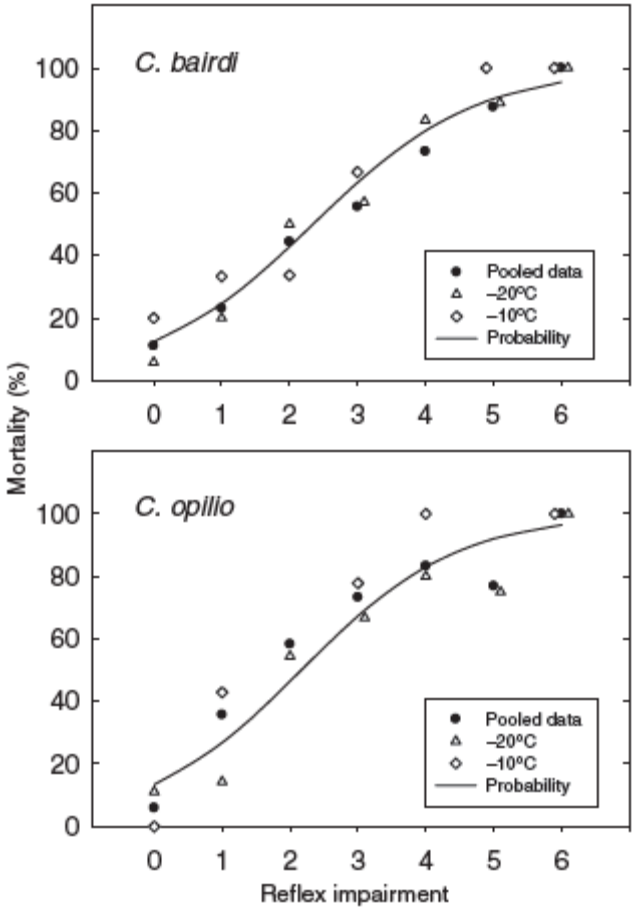
Table 1

Reflexes identified as useful for assessing stress in *Chionoecetes* spp. "Test" is the manipulation required to elicit a stereotypic positive response. No response was recorded when no motion was detected in response to repeated testing (modified from Stoner et al., 2008)

Reflex	Test	Positive response	Lost response
Leg flare	Lift crab by the carapace, dorsum up	Legs spread wide and to near horizontal orientation in strong crabs	Legs droop below horizontal, with no attempt to raise them
Leg retraction	While holding crab as above, draw the forward-most walking legs in the anterior direction	Legs retract in the posterior direction, or present resistance to the motion in weakened crabs	No resistance to the manipulation occurs
Chela closure	Observe for motion or hold the chelae in the fingers	Chelae open and close with or without manipulation. In weakened crabs the chelae may close slowly, or show low resistance to manual opening	No motion is detected in the chelae under manipulation
Eye retraction	Touch the eye stalk with a blunt probe, or lift the eye stalk from its retracted position	Eye stalk retracts in the lateral direction below the carapace hood, or shows resistance to lifting	No motion or resistance to manipulation occurs in the eye stalk
Mouth closure	If closed, attempt to open (extend) the 3rd maxillipeds with a sharp dissecting probe. If open, draw the maxillipeds downward	3rd maxillipeds retract to cover the smaller mouth parts. The maxillipeds droop open or move in an agitated manner in weakened crabs	No motion in the maxillipeds occurs
Kick	With the crab in ventrum-up position, use a sharp dissecting probe to lift the abdominal flap away from the body	One or more legs or chelipeds move quickly in the ventral direction, particularly in males. Motion in the hind most legs is retained in weakened crabs	No motion in the legs or chelipeds occurs

RAMP: Stoner et al., 2008; Stoner 2009

- Means to estimate short-term (<2 weeks) mortality by scoring 6 reflex responses of captured crab prior to being discarded
- Applied to snow + Tanner crab
- 80% accurate in predicting mortality



Dan Urban Research

- Applied RAMP during 2010-2012 **snow** crab fisheries
  - Over 19,000 crab evaluated
  - Estimated discard mortality was 4.5%
  - Strongly correlated to air temperature
- Applied relationship to historical 1991-2011 temps and historical handling mortality rate estimated at 4.8%

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Discard mortality rates in the Bering Sea snow crab, *Chionoecetes opilio*, fishery

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Urban, J. D. Discard mortality rates in the Bering Sea snow crab, *Chionoecetes opilio*, fishery. – ICES Journal of Marine Science, doi: 10.1093/icesjms/fsv004.
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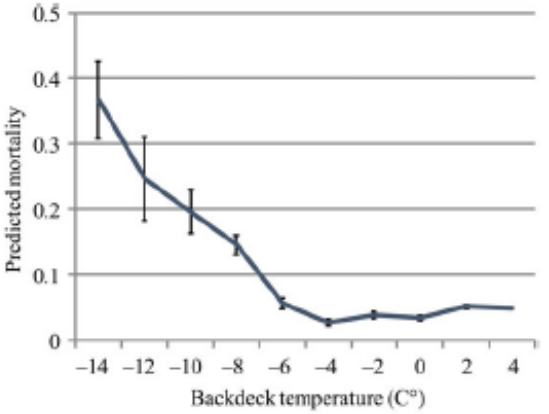
Fish and invertebrates that are unintentionally captured during commercial fishing operations and then released back into the ocean suffer mortality at unknown rates, introducing uncertainty into the fishery management process. Attempts have been made to quantify discard mortality rates using reflex action mortality predictors or RAMP which use the presence or absence of a suite of reflexes to predict discard mortality. This method was applied to snow crab, *Chionoecetes opilio*, during the 2010 – 2012 fisheries in the Bering Sea. Discard mortality in the fishery is currently assumed to be 50% in stock assessment models, but that rate is not based on empirical data and is widely recognized to be in need of refinement. Over 19 000 crab were evaluated using the RAMP method. The estimated discard mortality rate was 4.5% (s.d. = 0.812), significantly below the rate used in stock assessment models. Predicted discard mortality rates from the 2010 to 2012 study were strongly correlated with the air temperature at the St Paul Island airport in the Pribilof Islands. Using this relationship, the discard mortality rate from 1991 to 2011 was estimated at 4.8% (s.d. = 1.08).

Keywords: Alaska, Bering Sea, *Chionoecetes opilio*, discard mortality, RAMP, reflex action mortality predictor, snow crab.



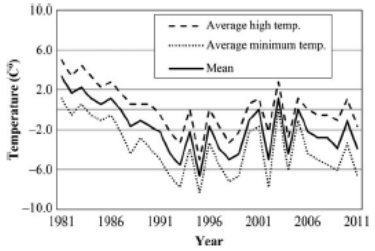


Figure 2. The average daily temperature at the St Paul airport in the Pribilof Islands from 1981 to 2011 for the days when the Bering Sea snow crab fishery was occurring.

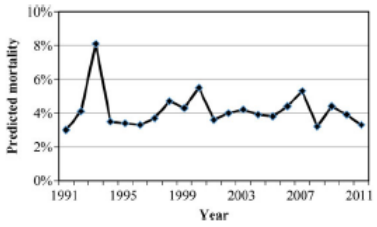


Figure 3. Estimates of historical snow crab discard mortality rates based on the relationship between predicted discard mortality and the temperature at the St Paul airport in the Pribilof Islands when the discards were occurring.

Snow crab: Dan Urban research, May **2013** CPT Meeting

- Acknowledgement by CPT about difficulty in determining true handling mortality (unknown long-term effects)
- At the time, snow crab assessment assumed 50% handling mortality in directed fishery
- RAMP study provided evidence to suggest 50% too high: CPT agreed
  - CPT considered range of options: 20%, 25%, 30%
  - **Settled on 30%**: derived by summing the highest estimate due to freezing (0.08) with the highest estimate of injury rates (0.12) to capture the short-term mortality and multiplying that sum by 1.5 to provide an estimate that includes long-term mortality. Since there is no information on long-term mortality, the CPT agreed that the best first-order estimate of the long-term mortality is 50% of the short-term mortality.
- At the time, CPT recommended 30% handling mortality not be applied to Tanner crab
  - No Tanner data
  - Stoners work suggested that Tanner crab may have higher handling mortality

King crab

Some evidence vitality metrics can capture impairment, initial recovery, and short-term mortality

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Selecting species specific vitality metrics to predict red king crab (*Paralithodes camtschaticus*) discard survival

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ARTICLE INFO

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ABSTRACT

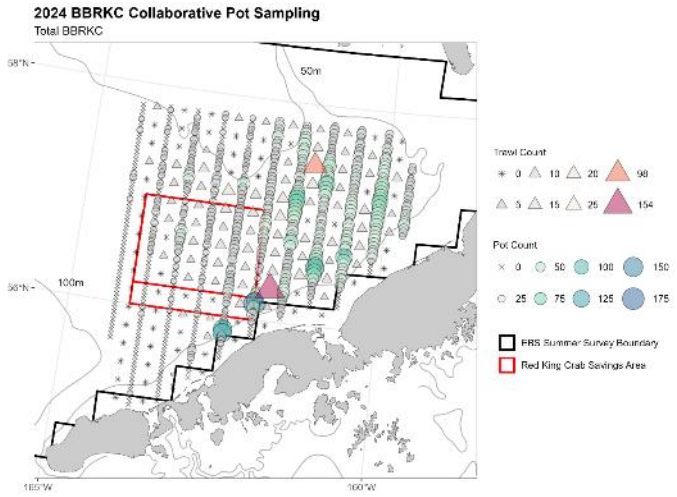
Quantifiable behavior and reflex responses, termed "vitality assessment metrics", have successfully linked impact from the commercial fishery capture and handling process with post-discard survival. These metrics have been effectively applied to commercially important crab species, including Tanner (*Chionoecetes bairdi*) and snow crab (*C. opilio*) bycaught in the Eastern Bering Sea groundfish bottom trawl fishery. When applied to red king crab (RKC; *Paralithodes camtschaticus*) in the same fishery, those metrics had limited success. We examined a suite of candidate RKC-specific metrics based on prior studies as well as several recommended by commercial fishermen. Provisional testing in a laboratory setting was used to narrow the list of metrics for field testing to include only those to which RKC showed consistent and definitive responses. Ultimately, seven vitality metrics were advanced for at-sea testing on RKC caught during commercial groundfish bottom trawl fishing. A total of 55 RKC were collected, 37 on deck as the codend was emptied and 18 from the below-deck factory at the regulatory point of discard. An initial assessment testing for the presence of the seven metrics was conducted immediately upon collection, generating a vitality score based on the number of absences. Crabs were tagged for individual tracking and held for 72 -hs in seawater tanks for re-assessment at 2, 4, 6, 12, 24, 48 and 72 -hs. Crab collected from the factory had higher initial impairment scores based on the vitality metrics than crab collected from the deck. In total, 6 crab, with higher impairment scores, died and the remaining 49, with lower impairment scores, showed evidence of strong to moderate recovery and were discarded alive after 72 -hs. Results from this study indicate that our species-specific vitality metrics successfully captured impairment, initial recovery and short-term mortality. This work elucidated the relationship between RKC impairment and delayed discard mortality, providing a mechanism to generate quantitative post-discard mortality rates in future studies.

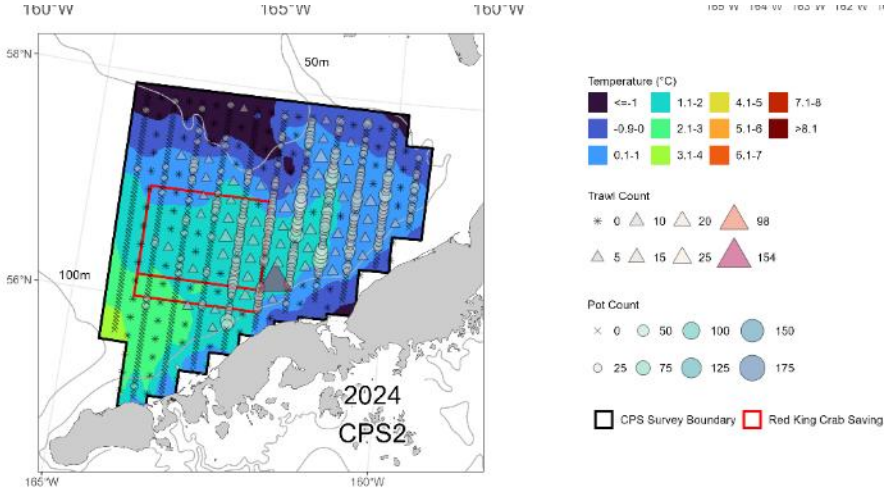
"We recommend that future studies applying our RKC-specific vitality metrics target larger sample sizes collected under a broader range of fishing and environmental conditions, including collecting sufficient samples of size-stratified male and female crab to ascertain if mortality rates are size and sex-specific."

NOAA Technical Memorandum NMFS-AFSC-483

2023 Early Spring Collaborative Pot Sampling (CPS1) for Bristol Bay District Red King Crab (*Paralithodes camtschaticus*)

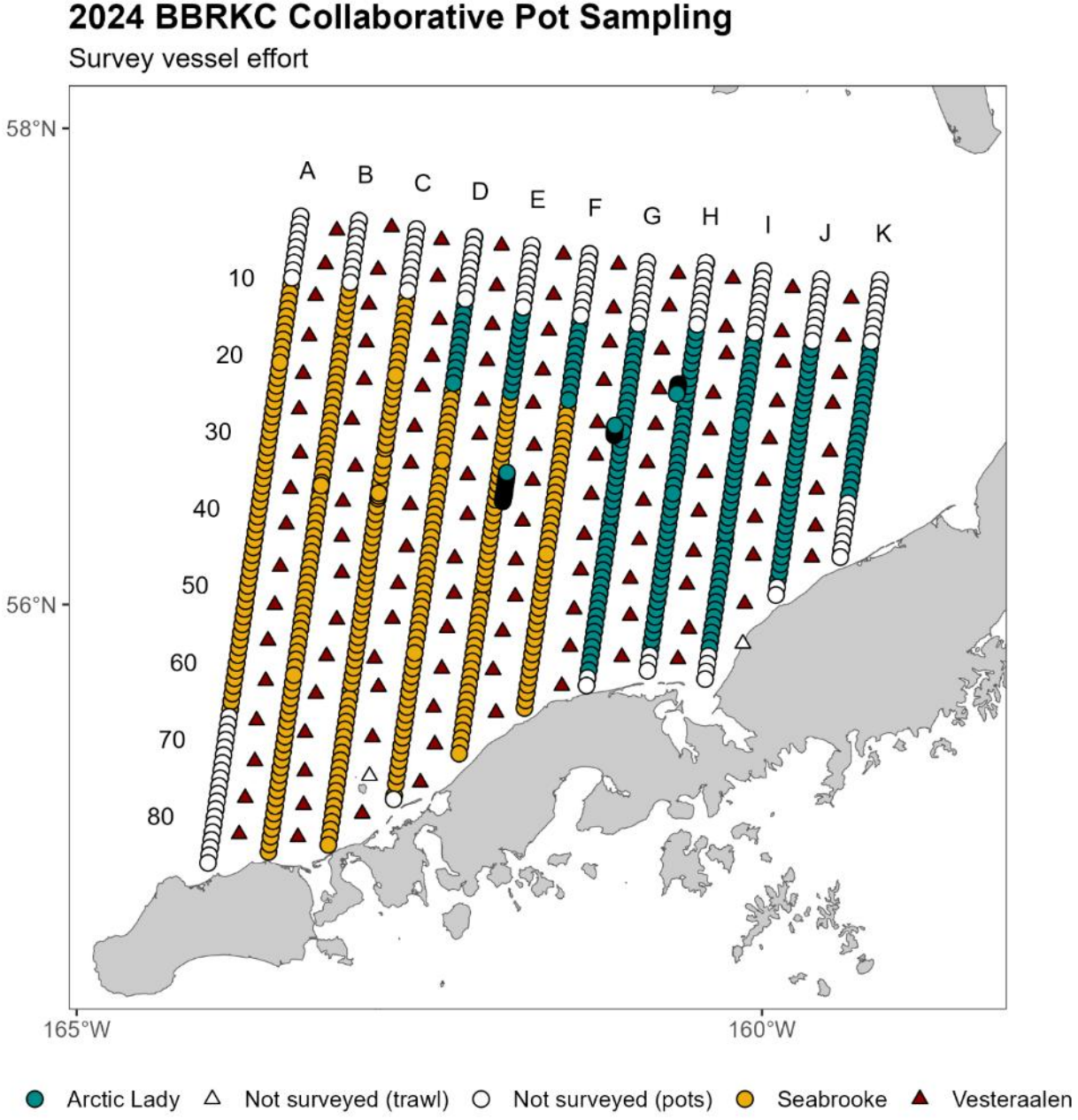
T. Loher, B. Daly, S. E. Goodman, M. A. Litzow, A. Nault, E. R. Ryznar, and L. S. Zacher





April 2024

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Alaska Fisheries Science Center


2024 BBRKC Collaborative Pot Sampling
Survey vessel effort
58°N
56°N
165°W
160°W
A
B
C
D
E
F
G
H
I
J
K
10
20
30
40
50
60
70
80
Arctic Lady
Not surveyed (trawl)
Not surveyed (pots)
Seabrooke
Vesteraalen

Pilot study: RKC injury assessments and mortality evaluation

- Very small is scope
- Goal: To obtain additional information on direct relationships between crab injuries and short-term mortality
- RKC that were injured during CPS2 were held and monitored for seven days (i.e., 168 hours) post-capture.
- Individuals were categorized into one of eight distinct injury levels based on injuries that were deemed to have occurred during capture and handling during the current survey (i.e., injuries that were determined to have occurred during prior capture events were not considered), as follows:

1. no new injury;
2. rostrum broken at the tip;
3. rostrum entirely parted from the carapace, at the base of the rostrum;
4. one autotomized leg or chela (cleanly separated at a joint);
5. one leg broken (dangling or mangled), but still attached;
6. one leg with a crack >3 cm in length, but leg not broken into separate sections;
7. carapace crushed, with internal organs visible;
8. carapace cracked, internal organs not visible.

Pilot study: RKC injury assessments and mortality evaluation

- Crab were monitored regularly (i.e., no less than once per day) to identify live versus dead individuals.
- Crab that had died were removed from the holding tank as soon as mortality was observed; surviving crab were removed and returned to the sea at the end of their 7-day observation period.

Pilot study: RKC injury assessments and mortality evaluation

	Pot		Trawl		
Injury type	male	female	male	female	Total
1	5	0	1	6	12
2	0	0	4	4	8
3	5	0	2	0	7
4	2	1	3	2	8
5	8	1	8	5	22
6	2	0	1	0	3
7	4	3	0	0	7
8	3	1	0	0	4
Total	29	6	19	17	71

Photo credit: Cory Lescher

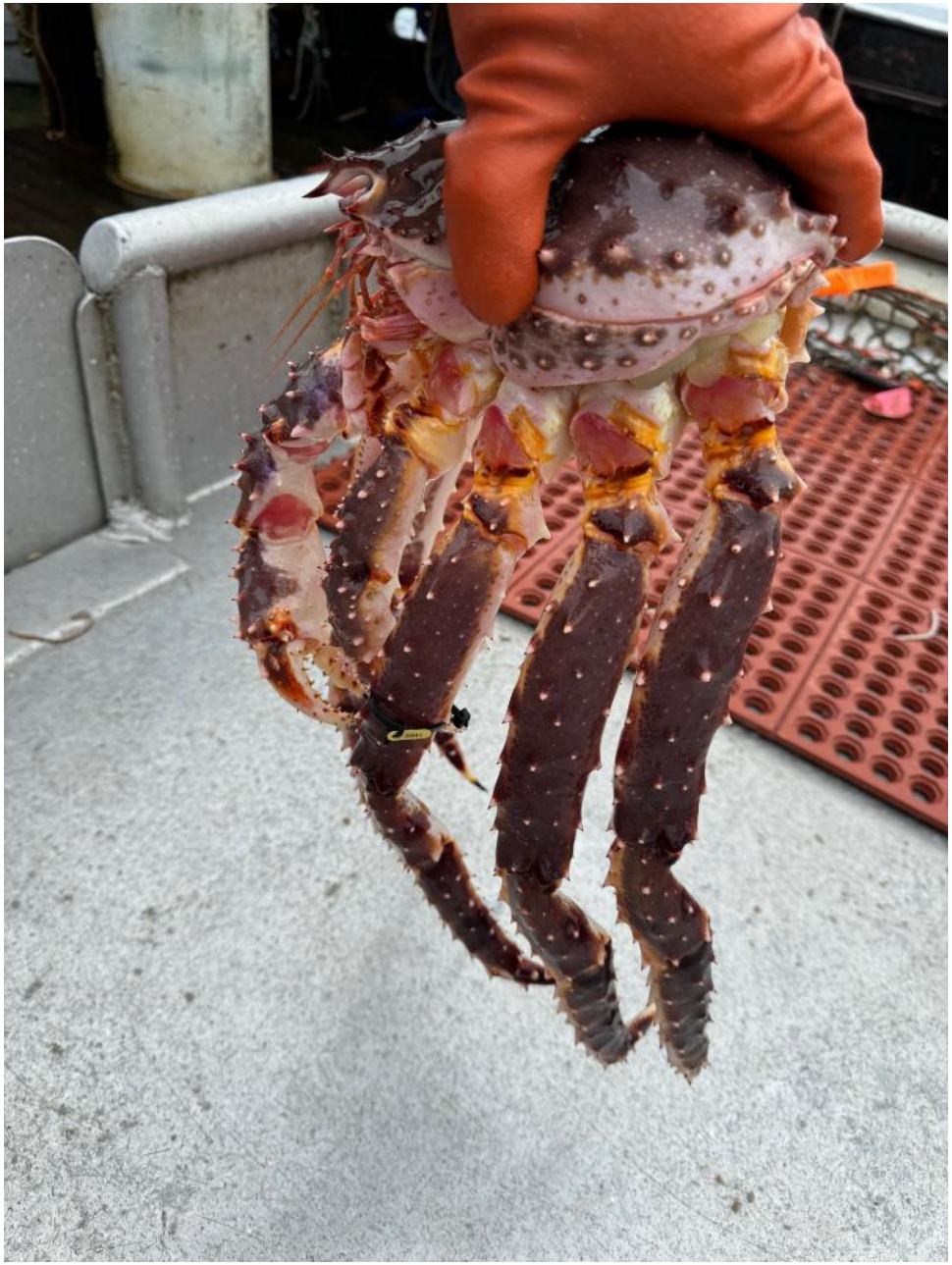


Photo credit: Cory Lescher

Photo credit: Cory Lescher

Photo credit: Cory Lescher

Results and analysis

- In progress

Crab Disaster Projects

2025 CRAB 5067

Summary Page
Proposal No: 5067
Project Period: Start Date: Jul 2025, End Date: Jul 2027
Proposal Title: Understanding Lost Crab Pot Degradation and Impacts on the Bristol Bay Red King Crab Stock
Investigators: • Scott Goodman **(Lead),** sgoodman@nrccorp.com, Bering Sea Fisheries Research Foundation • Cory Lescher , cory@alaskacrabbers.org, Bering Sea Fisheries Research Foundation • Mr. Kyle Antonelis , kantonelis@nrccorp.com, Natural Resources Consultants, Inc.
Cycle Priorities: Bering Sea Crab Disaster Funds

Crab Disaster Projects

"Understanding lost crab pot degradation and impacts on the Bristol Bay red king crab stock"

Abstract:

The Bristol Bay red king crab (*Paralithodes camtschaticus*, BBRKC) stock supports an iconic and economically important fishery in Alaska (Garber-Yonts *et al.*, 2023). Over the last decade, biomass trends have reflected a persistent decline, leading to the closure of two recent seasons (Palof, 2024). The current stock status reflects the ongoing crises for several Alaska crab stocks, and federal disaster relief programs are in place to provide economic support to stakeholders (ADFG, 2024a). Importantly, disaster relief has also specified funds to support research that is prioritized by the North Pacific Fishery Management Council (NPFMC, 2024a). Current management approaches to protect and rebuild the BBRKC stock are focused primarily on existing harvest guidelines and spatiotemporal area closures (NPFMC, 2022). Recent research has focused on seasonal distribution, tagging, and movement of BBRKC, as part of the strategy for ongoing disaster relief research (Loher et al., 2024). Impacts from unobserved fishing mortality (UFM) have been identified as a high-priority crab research topic, but there is a lack of focused UFM research to date (NPFMC, 2024b). This proposed research is part of a cross-sector strategy to understand mobile and fixed gear impacts on crab. Our proposed research narrows the focus to fixed gear with a simulation of 'lost' pots from the BBRKC fishery. 'Lost' pots would be placed initially as typical crab pots (baited, placed during open season) and left on the grounds for monitoring for one year. The simulation objectives are to document the timing of escape mechanism engagement (biotwine release) and time-lapse photo encounters of BBRKC in the pots. Biotwine release timing is intended to be tested using pop-up satellite tags. Photos from crab encounters will be recorded from remote marine cameras in pots. This proposed work uniquely focuses on data collection in the Bering Sea under actual crab fishing conditions.

Crab Disaster Projects

“Understanding lost crab pot degradation and impacts on the Bristol Bay red king crab stock”

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