Request for an exempted fishing permit (EFP) allowing up to five Amendment 80 vessels to whole-haul census red king crab in the Bering Sea yellowfin sole and rock sole fisheries.

Date of Application: September 2018

Requested dates for permit to be in effect: January 20th, 2019 through April 15th, 2019

EFP Applicant Information:

Cory Lescher (M.S. candidate) and Dr. Bradley Harris
Fisheries, Aquatic Science, and Technology (FAST) Laboratory
Alaska Pacific University
4101 University Dr
Anchorage, AK 99503
(541) 951-3590
clescher@alaskapacific.edu

Collaborators:
Mr. John Gauvin, Alaska Seafood Cooperative
Dr. Noëlle Yochum, RACE Division, Alaska Fisheries Science Center, NOAA

Introduction/Motivation

United States fisheries policy requires managers to account for mortality of all fished species, including target catch, bycatch and prohibited species catch (PSC). Bycatch of PSC in the North Pacific groundfish trawl fisheries is managed under bycatch caps that can trigger closures of management areas or target fisheries. Catches are estimated by sub-sampling catch from individual hauls by fishery observers. Observer samples are then extrapolated to the haul level. These haul-level estimates are aggregated to produce vessel-specific and sector-level bycatch and PSC estimates in a fishery. Currently the methods used by the NOAA Fisheries Observer Program to estimate PSC assume no haul-level variability.

Most non-pollock fisheries are managed under fishing cooperatives where estimates from observer sampling are used to account for bycatch against bycatch caps by number (e.g. crab species or by weight for other PSC). Cooperatives track each vessel's catches against vessel-specific limits that the cooperatives administer. Cooperatives are ultimately responsible for ensuring that the bycatch allowances they administer are not exceeded. Individual accountability is enforced at the vessel and company level through legal contracts and bycatch agreements among members. In this context, understanding the degree to which current sub-sampling practices provide accurate data for accounting of actual quantities of incidentally-caught individuals in a fishing haul or trip is important for conservation and fishery management objectives overall as well as improvement of cooperative management.

In its review of a previous EFP proposal where examination of haul-specific variability was one of the objectives, the North Pacific Fishery Management Council's Scientific and Statistical Committee (SSC) noted (Dec 2015 SSC Minutes) that existing observer data could be used to examine the degree to which high catch-per-unit-effort (CPUE) groundfish fishing impacted red king crab (RKC; *Paralithodes camtschaticus*) PSC rates. The SSC noted that to do this, first, a comparison between whole-haul and observer (haul-specific) samples would be needed to support the estimation of variances of these observer data-derived PSC rates. To better understand the ability of current PSC rate estimation to support haul-level analyses and to help industry collaborators understand and improve vessel-specific bycatch performance tracking, we will compare red king crab PSC rates generated using current Observer Program sub-sampling protocols to whole-haul censuses in the Amendment 80 Bering Sea yellowfin sole and rock sole fisheries. We expect our study to be most informative where PSC species represent a small proportion of the total catch (rare species), where the distribution of PSC in the environment is very patchy, or where the design of vessel stern tanks may stratify distribution of the PSC in the tank.

Additionally, 80% of red king crab PSC in the groundfish fishery is assumed to die after being discarded (Siddeek, 2003; BBRKC Discussion Paper 2017). Field studies with other crab and fish species suggest that discard mortality rates vary under a suite of capture and on-deck conditions (e.g., total catch weight, air temperatures and exposure time) and that current viability assessment methods for predicting discard survival may be applicable to RKC. For example, estimated Tanner crab (*Chionoecetes bairdi*) discard mortality associated with catcher vessels averaged 37% to 52% depending on factors including the target species (NPFMC, 2010) suggesting that post-discard survival may be higher than assumed. However, further study is needed to support inferences to catcher-processing (CP) vessels which differ from catcher vessels in fishing practices and below-deck catch handling conditions. In addition, since discard mortality rates were estimated for RKC in the Bering Sea flatfish fishery, fishing practices have changed. For example, fishing practices in the Amendment 80 sector and others in non-pollock trawl fisheries are changing in response to incentives to improve catch quality for target species and fishermen now focus on smaller codend size to minimize bruising of fish when codends are brought on board. In addition, deck sorting of halibut is in place for most of the non-pollock CP fishing which has also changed fishing practices to emphasize shorter tows for increased halibut survival. For these reasons, this EFP includes an at-sea crab vitality pilot study to examine the feasibility of using vitality assessment metrics to predict delayed discard survival and to better understand the variables that may influence crab discard mortality.

Ultimately, we expect that whole-haul accounting of red king crab will reveal important dynamics in the relationship between trawl-caught target and PSC species leading to more informed use of data generated via observer sampling along with potential improvements in PSC rate estimation for NMFS and industry management for crabs and other species for this fishery. We also expect that the vitality pilot study will enhance our understanding of the variables that influence discard mortality and determine metrics that can be used to evaluate discard survival, leading to better field and laboratory studies in the future.

Exemptions requested

National Standard 9 - Bycatch (50 CFR 600.350 (d) and 50 CFR 679.21(a)(2)(ii))

Federal regulations for prohibited species state that "The operator of each vessel must return all prohibited species, or parts thereof, to the sea immediately with a minimum of injury, regardless of its condition."

Exemption for comparison of whole-haul and subsampling:

The requested exemption is to delay discard of red king crab for a longer period than under normal discarding operations to conduct the whole-haul assessment and gather individual crab-specific biological data. The estimated additional per crab handling time is 1 – 2 minutes. Hauls with large numbers of crab (e.g. >200) may require additional time to complete data collection. The exemption will apply to up to five Amendment 80 vessels performing their standard fishing practices between January and April 2019 in the Bering Sea yellowfin sole and rock sole fisheries. Selected vessels will participate in the EFP for up to four trips each resulting in up to 40 fishing days per vessel, providing a total expected sample size of up to 200 hauls. Data collection and analysis details are provided below.

Exemption for at-sea crab vitality pilot study:

The requested exemption is to hold red king crab on board for a longer period than under normal discarding operations in order to assess their survival. The estimated additional per crab holding time is 72 hours (in circulating sea water). The exemption will apply to two Amendment 80 vessels for up to two fishing trips each between January and April 2019. Given the on-deck tank capacity and the aim of a 72-hour holding period up to 96 crabs for each vessel per trip or 384 crabs total will be held in on-deck tanks for observation. At the end of each crab's 72-hour holding, the crab will be returned to the sea. Data collection and analysis details are provided below.

No additional crab PSC or change to observer sampling:

The EFP does not require any additional crab PSC quota, and data will be collected under normal fishing conditions. The two regular NMFS-trained fishery observers on board each vessel during the EFP will sample normally. All RKC sampled in the vitality pilot study on deck will be handled by the EFP project manager (Cory Lescher) and the haul-specific pre-sorted catch data (RKC count and weight) will be provided to the on-board observers to be included with their data.

Purpose

The overall goal of this project is to enhance our understanding of RKC catch rates and vitality metrics in the groundfish trawl fishery. Primary objectives of the project are:

1. Collect basic biological data from bycaught RKC to examine key characteristics of interest to the industry and managers (sex, size, shell condition, clutch assessment for females).
2. Use whole-haul census of RKC to make empirical estimates of haul-level sampling variance from sub-sample estimates.
3. Examine how RKC PSC rates are influenced by haul characteristics and environmental variables.
4. Examine potential vitality metrics and/or environmental and biological variables that can be used to predict delayed discard mortality.

Methods/Plan to Achieve Objectives

Study time, area and platforms (vessel selection)

EFP fishing will encompass up to five factory trawl vessels within the Bering Sea groundfish trawl fishery (Amendment 80 sector) from January 20th through April 15th, 2019. Target fishery will be flatfish (yellowfin sole and northern rock sole) in the Eastern Bering Sea. Vessels participating in this EFP will follow all National Marine Fisheries Service (NMFS) regulations, save for the exemptions requested; this EFP does not request any exemptions to trawl in fishing closures. We will work cooperatively with the Alaska Seafood Cooperative (AKSC) to select vessels for this EFP. Prior to the 2019 fishing season the AKSC will canvass its members to determine which vessels are able to participate. From those able to participate, the selection process will focus on including a representative range of factors expected to affect sampling including vessel sizes, differences in catch amounts per haul, vessel stern tank and conveyor belt configurations. To encompass this range of factors, up to five vessels may be selected. A list of participating vessels and copies of the vessel's USCG documentation and the names of the owner and master will be provided prior to the permit issuance. Similarly, each participating vessel will provide a factory diagram detailing flow of fish, observer sampling station, and point of discard for all bycatch and PSC.

Normal Observer Sampling Operations

Under normal groundfish factory trawler operations catch is held in stern (live) tanks where fish are released to a conveyor belt and flow over a motion-compensated flow scale at a regulated speed (~200 kg per minute). After crossing the flow scale, the catch is subject to the observer's systematic-random sampling. Downstream of the observer, the vessel crew sorts the catch removing all bycatch and PSC from the line. All non-subsampled crabs are removed from the catch and placed on a discard belt running out a scupper and off the vessel back into the sea. Once the observer is finished sampling and data collection, the sampled catch is returned to the belt to be sorted and discarded as described above. Depending on the vessel, target fishery and size of catch, the processing of an entire haul can take anywhere from one to ten hours.

EFP Sampling

Data for this EFP will be collected by a trained sea sampler working on each vessel participating in the EFP or by the project manager (Cory Lescher). The project manager will plan, manage and oversee all EFP operations with help from Dr. Noelle Yochum (Alaska Fisheries Science Center, Resource Assessment and Conservation Engineering division) and Mr. John Gauvin (Alaska Seafood Cooperative). The project manager will communicate directly with all sea samplers and EFP vessels involved to ensure procedures are followed correctly to stay within the bounds of the EFP and ensure data collection meets the needs of the EFP. The sea samplers will be hired through the vessel's observer provider company and have the same qualifications as NMFS groundfish observers in Alaska. Additionally, sea samplers participating in this project will be provided additional training to supplement the portion of their groundfish observer training pertaining to crab. Sea sampler data collection duties will be separate from those duties of the vessel's two NMFS observers and their work will not interfere with or constrain the work of the observers.

Objective 1: Collect basic biological data from bycaught RKC to examine key characteristics of interest to the industry and managers (sex, size, shell condition, vitality, and clutch assessment for females).

All red king crab will be assessed for sex, size, shell condition, vitality metrics and clutch assessment for females. This objective is included to help resolve data gaps identified in a previous EFP project proposed (not approved) for sampling variance and other issues associated with RKC encountered in the yellowfin sole and rock sole fisheries in the first part of the year. The biological data collections described below follow the methods given by Donaldson and Byersdorfer (2005). The abdominal flap will be used to determine the sex of crab. If very small RKC are encountered, sexing will be carried out using a magnifying glass to detect presence of gonopores on the ventral surface of the coxa of the second pair of walking legs (for females, absent in males). Each crab will be measured for carapace length to the nearest millimeter. Carapace length is measured as the straight-line distance across the carapace from the posterior margin of the right eye orbit to the medial-posterior margin of the carapace. Shell condition for RKC will be classified as soft-shell, new-shell pliable, new-shell, old-shell or very old-shell. Clutch assessment for female RKC will be broken down into two parts: clutch fullness and egg condition. Clutch fullness will be recorded as no eggs, trace, ¼ full, ½ full, ¾ full or full. Egg condition categories will be: no eggs present, uneyed eggs present, eyed eggs present, hatching eggs or matted setae. Vitality metrics for RKC will be scored based on the presence and absence of pre-determined injuries, and reflex and behavior responses (e.g., reflexes established for Tanner crab by Stoner et al. 2008: leg flare, leg retraction, chela closure, eye retraction and mouth closure). In addition to the above biological data collected, all RKC will be evaluated for externally visible physical injuries such as fresh autotomized (lost) legs or chela and cracked or crushed carapace.

To meet this objective the composition of the sex, size, shell condition, egg stages for females, and vitality for each haul will be characterized with summary statistics and the data will be made available for further studies.

<u>Objective 2: Make empirical estimates of haul-level sampling variance from sub-sample estimates (abundance, sex and size composition, and shell condition).</u>

Sea samplers will conduct a species-specific whole-haul count for RKC within every haul. To do this, the sea sampler will instruct designated personnel on each participating EFP vessel to remove all crab from the sorting belt. Downstream of the observer sampling station the designated crew will remove crab from the sorting belt and place them in a designated tote that will be labeled with the vessel haul number for that tow. This will keep all haul-specific crab together and will not interfere with the observer's sampling duties or vessel operations. The sea sampler will sort the crab from the tote returning all non-RKC immediately to the discard belt and will assess and record crab-specific biological data from each RKC as described above and return it immediately to the discard belt.

RKC distribution in the catch as it is available for sampling will be determined using the video footage captured by the vessel's camera monitoring the flowscale in the factory. These cameras/ video recording systems are mandatory on all Amendment 80 factory vessels. All vessels use Fusion Marine Technology camera systems with a designated camera observing the flowscale. Vessels selected for the EFP will be required to record flowscale footage at 30 frames per second. After each trip the video footage will be transferred to external hard drives and later reviewed by image analysts at the Fisheries, Aquatic Science & Technology Laboratory at Alaska Pacific University. The event time of each crab crossing the flow scale will be recorded during video playback with all belt stoppages removed. These data will be used to analyze the distribution of RKC on the belt for each haul.

Under this EFP, NMFS-trained observers will sample per standard procedures for species composition and will not be affected by the work of the sea sampler. Numbers of RKC within each of the observer's samples for every haul will be used to compare to the sea sampler's RKC whole-haul. Discard methods for observer's sub-sampled bycatch and PSC may vary on different vessels, in which case all observers will be asked to return all crab to the sorting belt where crew can remove crab to ensure sub-sampled RKC are included in the whole-haul count by sea samplers. Because whole-haul censusing deals with RKC numbers and not weights, crab parts (i.e., broken legs, chela) will not be added to the whole-haul count. All partial and/ or crushed RKC will be documented in the haul notes including the number of coxa present. Partial and/ or crushed RKC with five or more coxa will be treated as complete crab in the whole-haul accounting analysis. The number of partial and/ or crushed RKC in each haul will be summarized and sensitivity analyses will be conducted to determine the impacts of broken crab on whole-haul crab counts compared to sub-sample estimates. If the observer's sample for species composition contains any crab that cannot be returned to the sorting line with the catch of their haul of origin the observer will retain the crab in a basket provided by the vessel and notify the sea sampler to ensure species identification and inclusion in the haul-specific whole-haul count and immediate discard after biological data has been collected. The sea sampler on board each vessel will coordinate with the on-duty observer as needed on a haul by haul basis.

To meet the second objective we will assess haul-level sampling variation and/ or bias of sub-sample RKC estimates using collected whole haul data as empirical validation. We will compare any measured bias and sampling variability against expected values of each. Sampling bias is expected to be zero and sampling variability expected to be a function of total target species catch size, sample size, total RKC in the haul, and the distribution of crab on the conveyor belt. Estimates of expected sampling variability will be generated using simulations based on 10,000 iterations with realistic distributions of these variables (Figure 1). If we detect bias or variance inflation (or constriction) in the EFP data, we will use regression modeling to evaluate what haul characteristics and/or environmental variables (objective 3) contribute to differences in expected and empirical measures of sampling bias and/ or variability.

Objective 3: Examine how RKC PSC rates are influenced by haul characteristics and environmental variables.

Fishing effort information and environmental conditions will be recorded on a trip data sheet for all hauls under this EFP. The vessel haul number, haul set and retrieval time and location will be recorded, giving us total towing time of each haul. Fishing depth will be recorded in fathoms. Seafloor water temperature will be recorded in Celsius. Vessel's towing speed can fluctuate from tow to tow, whether it be ocean/ tidal currents, wind, etc. We will record the average tow speed for every haul and record it on the trip sheet. The fishing vessel's target catch will be recorded per haul. Final catch weight for each haul will be derived from the flowscale and will be recorded and will be used to calculate CPUE (total catch weight/towing time). Ambient air temperature will also be recorded at this time. Haul level distribution of RKC on the belt will be derived from the flow scale video review as described above.

To meet the third objective, we will use the whole haul RKC counts to examine what variables may affect RKC PSC at the haul-level. Regression analyses will be used to examine the influence of haul characteristics and environmental variables on RKC PSC whole-haul count. We will also conduct stratified analyses by crab characteristics (objective 2) to examine if there is an interaction between haul level characteristics and RKC strata that affect the RKC PSC whole-haul count. Taking the outcomes from first three objectives together, we will provide recommendations on how subsample estimates of RKC may be used in future analyses of haul-level RKC PSC.

Objective 4: Examine the potential to use vitality metrics to predict discard mortality (vitality pilot study)

This EFP includes an exemption allowing for an examination of factors affecting RKC survival and the ability to predict discard survival using vitality metrics (e.g., reflex responsiveness). To do this, we are requesting an allowance to hold up to 384 RKC (up to 32 at a time based on on-board tank capacity) in on-deck flow-thru seawater tanks for 72 hours of observations. The aim is to assess the feasibility of collecting data on vitality metrics (e.g., injury, reflex impairment, and behavioral indices of viability), towards predicting post-discard mortality. The sampling of these individual crab will coincide with halibut deck sorting to allow the assessment of crab collected both from the deck and the point of discard in the factory without impeding fishing operations. The on-deck collections will be conducted independent of and will not impact halibut deck sorting activities or observer data collections under the halibut deck sorting EFP. The collection of crab in the factory will be at the standard point of discard, downstream of the observer sampling station.

Under halibut deck sorting operations, the crew dumps the catch directly from the codend on to the deck to allow the pre-sorting and removal of halibut prior to the catch entering the vessel's stern tank where it awaits processing in the factory. The halibut deck sorting procedures provide ample time and opportunity to collect RKC on deck without delaying the transfer of catch to the stern tank for more than the 35 minutes allotted as per the rules of the existing halibut deck sorting EFP.

RKC collected for this pilot study will be held in flow-thru seawater tanks assembled on the back deck of the vessel selected to do this component of the EFP. The tanks will be plumbed with fresh circulating seawater using the vessels deck pump. We expect that due to the winter/ spring timing of this work there will be minimal differences between the bottom water temperatures and the temperature of the near-surface water pumped through the holding tanks. Previous holding studies have concluded that holding crab in warmer surface water did not contribute to mortality (Stoner et al., 2008). Each tank will be divided into four separate sections that will hold two crab each (8 crab per tank). These partitions will be constructed out of material similar to vessel's factory grating to allow unobstructed water flow and circulation throughout. These holding tanks will all be equipped with removable lids that can be secured tightly when crab are not being observed or examined. This is to minimize external stressors (e.g., sun exposure, deck lights, noise, air temperature) to the extent feasible. Water temperature and dissolved oxygen will be recorded from each of the seawater tanks daily using a YSI temperature and oxygen sensor. The crabs collected on deck for the vitality study will be assessed following the same methods from objective 1. Initial vitality metrics will be taken for each crab at the time of their collection. The continued monitoring of vitality during holding will be recorded on deck sheets. The crab collected on deck will be removed from the catch prior to observer sampling. Because this pilot study requires pre-sorting of RKC from selected hauls, the project manager (Cory Lescher) will take RKC counts and weights to be provided to the vessel's observer to include in the final flowscale weight of each haul. Weights will be obtained using a Marel motion compensated scale and recorded to the nearest tenth of a kilogram. Cory will collect data to the same level of accuracy as required by the observer program. In the factory, crab collected for holding will be removed from the conveyor belt downstream of the observer sampling station following the protocols described under Objective 2 above, and will be transferred immediately to the seawater tanks on deck.

Red king crab holding for the vitality study will commence at the beginning of the fishing trip, but will not occur on every haul due to the limited holding capacity of 32 crab at a time. During a predetermined haul, up to 32 RKC will be selected from the deck or the factory until the holding tanks are full. A vitality test will be used to select only live crab, and in particular, crab with a range of initial impairments and levels of vitality for the holding trials. Each crab will be labeled with a uniquely numbered tag attached to its forward walking leg via removable twine. Carapace length and sex will be recorded for each crab along with shell condition and vitality (i.e., the same assessment data collected for the census component of this study described above in "Objective 1"). Assessments will take place at the time of deck collection (or factory collection at point of discard) and will last approximately one 1-2 minutes per crab, after which they will be placed in the seawater tanks on deck.

Subsequent to the initial assessment on deck or in the factory, crab will be monitored following methods described by Yochum et al. (2015). Each crab will be placed directly in one of the four seawater tanks where they will be re-assessed for vitality metrics every 2, 4, 6, 12, 24, 48 and 72 hours. These additional vitality assessments will allow us to look at a rate of vitality change. The purpose of this is to observe for post release (delayed) mortality, and to record if and when mortality happens for each crab with corresponding covariates. During these additional assessments, observations will be made to see if any crab have died and dead crab will be removed and discarded.

Additional hauls will be sampled following the procedures described above until all partitions in the four seawater tanks are filled with two crab each. These crab will also be monitored for up to 72 hours and then released (dead crab will be released near time of death). Before being released, live crab will be assessed once more for condition and vitality metrics. Once a tank is emptied of the crab (i.e., returned to the Bering Sea), the tank will be flushed with seawater and refilled with eight new crab from a subsequent tow. Due to space limitations on deck the 72-hour time period for releasing the crab will provide a short window to observe for discard mortality, yet will allow for a larger sample size than if we were to hold crab longer. In addition, by doing multiple assessments for vitality metrics and delayed mortality we are able to measure a rate of decline.

For hauls that crab are removed from the catch on deck, census counts will continue in the factory but data will be analyzed separately due to possible bias of pre-sorting crab from catch prior to the factory. This at-sea crab vitality pilot study will be co-led by Dr. Noelle Yochum, RACE Division, Alaska Fisheries Science Center, NOAA.

To meet the fourth objective, we will examine the metrics that may be used to predict RKC mortality. To evaluate the influence of fishing and sampling related variables, fishing effort information (e.g., length of tow, tow depth, bottom temperature, total catch size) will be recorded for all hauls where deck sampling is taking place, along with crab specific time out of water, measured as the total time between when the codend comes up the stern ramp and the crab is assessed and placed in the sea water tank. We will use a binomial logistic regression modeling and AIC values to test which variables are significant predictors of mortality. Descriptive statistics will also be used to help in the determination of the most common indicators of vitality impairment. The change in vitality will be examined using ordinal regression and AIC values to test which variables are significant predictors of change in vitality.

Timeline

- Vessel selection, notification to NMFS: December 2018
    - We will select vessels for the EFP by fall of 2018, in which we will provide a copy of the vessels' USCG documentation, state license or registration and the names of the owner and master of each participating vessel.
- Training of sea samplers: December 2018
    - We will coordinate with NMFS observer training staff to arrange a group training for the project manager and sea samplers, December 2018.
- Field work: January-April 2019
    - Field work for this EFP will take place during the A season groundfish fishery in the Bering Sea between January 20th through April 15th, of 2019.
- Summary write up: September 2019
    - A post EFP summary write up will be provided September 2019, after the completion of the field season. This will be a preliminary report commenting on the EFP itself. The data write up and final report will be presented Spring of 2020.
- Report to Council, AMSS, AKSC captains meeting: December 2018-January 2019
    - The research objectives and methods for this study will be presented at an industry workshop in 2019. Data summary and conclusion of findings will be presented via oral presentation at AMSS and an industry workshop in 2019. The final report will be submitted by the end of 2019, with a goal of submitting for publishing in a peer reviewed journal.

References

(BBRKC discussion paper, 2017) http://npfmc.legistar.com/gateway.aspx?M=F&ID=0630e0bd-bc82-45bf-9c82-1a0d1aae3778.pdf

Donaldson, William E. and Byersdorfer, Susan C., 2005. Biological Field Techniques for Lithodid Crabs Fairbanks, Alaska: Alaska Sea Grant College Program, University of Alaska.

NPFMC, 2010. Mortality Rates - Bycatch mortality in trawl gear *in* Area Closures for *Chinoecetes bairdi* Crab Protection in Gulf of Alaska Groundfish Fisheries, North Pacific Fisheries Management Council, EA/RIR/IRFA October 2010. Section 3.3.2, pages. 25-26. https://www.npfmc.org/wp-content/PDFdocuments/bycatch/GOAcrab.pdf

Siddeek, M. S. M., 2003. Determination of biological reference points for Bristol Bay red king crab. Fish. Res. 65:427-451.

Stoner, A. W., Rose, Craig S., Munk, Eric J., Hammond, Carwyn F., Davis, Michael W. 2008. An assessment of discard mortality for two Alaskan crab species, Tanner crab (*Chionoecetes bairdi*) and snow crab (*C. opilio*), based on reflex impairment. Fish. Bull. 111, 42-53.

(SSC minutes, December, 2015.) http://npfmc.legistar.com/gateway.aspx?M=F&ID=a1197c8b-f06e-4087-b847-bee7494ca2b7.pdf

Yochum, Noelle. Rose, Craig S. Hammond, Carwyn F. 2015. Evaluating the flexibility of a reflex action mortality predictor to determine bycatch mortality rates: A case study of Tanner crab (*Chionoecetes bairdi*) bycaught in Alaska bottom trawls. Fisheries Research, volume 161, pages 226-234.

Figures

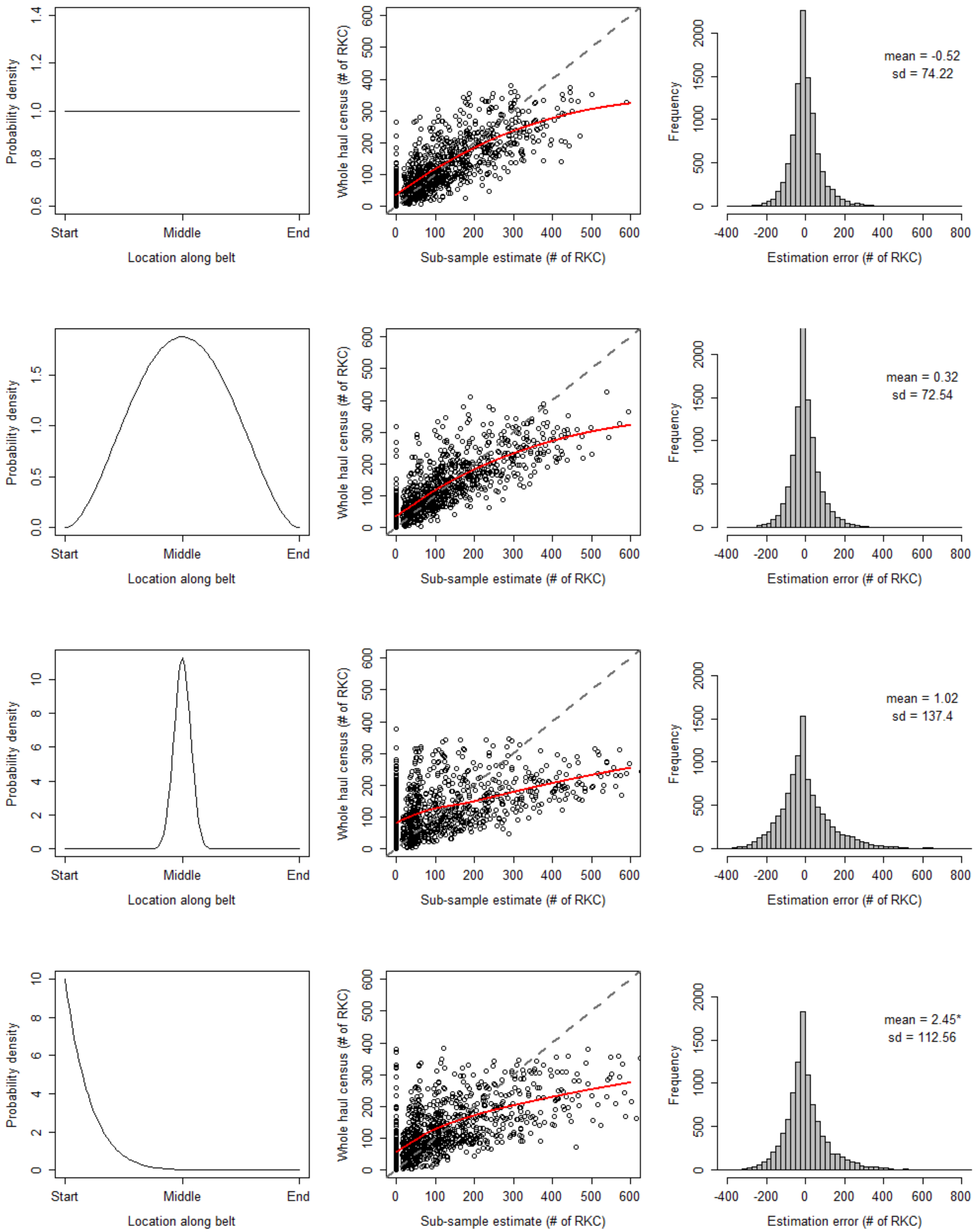
Probability density
Start
Middle
End
Location along belt
Whole haul census (# of RKC)
Sub-sample estimate (# of RKC)
Frequency
Estimation error (# of RKC)
mean = -0.52
sd = 74.22
mean = 0.32
sd = 72.54
mean = 1.02
sd = 137.4
mean = 2.45*
sd = 112.56

Figure 1. Simulation of sub-sample estimations from whole haul counts. The left column shows the distribution of RKC as they come across the belt used for each simulation. The middle column shows the results of the simulations representing the expected relationship between sub-sample estimates of and whole-haul census of RKC count per haul. Each point represents one outcome from 1,000 simulations of sampling variability. The dashed line shows the 1:1 relationship and would be the expected sub-sample estimation if there is no bias. The red lines show a loess smoother for each set of data. Where the red line is above the dashed line, there is a bias toward more RKC in the haul than estimated, and where the red line is below the dashed line, there tends to be bias toward less RKC in the haul. The right column shows the distribution of sampling errors (error = RKC census – RKC estimate). The asterisk indicates a mean error significantly different from zero suggesting and overall sampling bias. The rows from top to bottom represent simulations with uniform, mild aggregation, severe aggregation, and front loaded RKC distributions as they come across the belt. All simulations varied total haul weights between 10 – 40 mt and crab densities from 0 – 0.01 RKC/kg (0 – 10 RKC/mt). Sampling effort was set at 5 samples of 125 kg per haul for each relationship.

Recoverable Signature

X 

Cory Lescher

EFP Applicant

Signed by: a3304ebb-820a-4854-ad77-e48fc0ec6b46