January 28, 2022

Pot Gear Modifications – BREP Project Update for NPFMC February 2022

"Testing pot gear modifications to reduce crab bycatch in cod and halibut fisheries"

Executive Summary

Current Bering Sea fixed gear groundfish target fisheries encounter crab bycatch that warrants further research to provide options to reduce impacts on crab stocks. This crab bycatch reduction project was initiated to investigate tractable options for current pot (cod) and new pot (halibut) gear modifications that would lead to reduced crab bycatch in these two Bering Sea fixed gear sectors. The project addresses immediacy of three elements: 1) the current depressed status of primary commercial shelf stocks of crab in the Bering Sea, 2) the importance of focusing updated research to reduce bycatch impacts on crab, and 3) working collaboratively with other gear/target sectors and stakeholders toward solutions. The most recent Bristol Bay red king crab (BBRKC) directed pot fishery was closed, and the current Bering Sea snow crab (BSS) pot fishery is open at its lowest historical level, and was recently declared overfished. Both BBRKC and BSS stocks are typically observed as pot bycatch with some instances of high encounters that help to focus the relevance of this gear modification work to reduce overall bycatch rates when possible. Pot gear stakeholders share some interests in target cod, halibut and crab fisheries so collaboration on bycatch reduction is a shared goal. During a period of conservation concern for Bering Sea crab stocks, this project and associated research are both timely and important.

The project has proceeded through several lab and field stages and this report is intended to provide an update on some preliminary results, building on our report to the Council in February 2021. Our approach has been to collaborate on current gear design to ensure modification options are feasible, that the gear components are tested in a controlled laboratory setting, and that field trials are conducted in a manner that have controls in place, but reflects typical fishing. Lab work has required the project to obtain State of Alaska permits to transport live crab back to Kodiak for live-holding crab during experiments in tanks. To date we have completed lab work that tested the efficacy of BBRKC and BSS crabs' ability to pass through pot entrance test panels to access bait. These lab tests were completed in Kodiak NMFS and ADFG saltwater tanks in a controlled setting with crab samples. Lab tests followed prescriptive methods for documenting crab sex and size, general crab health, feeding, bait use, test replicates, and pass or fail test results. Generally, our test gear designs represent current fishing gear elements and variants that are part of pot entrance tunnels and ramp designs. Lab methods

required test gear tunnels and ramps to be configured to compartmentalize the saltwater holding tanks. Lab results so far reflect that gear designs which were known and expected to reduce successful crab passage (entry into a pot) were realized. Of all gear variants tested in the lab, the "sock" tunnel design and sock-variants are showing the lowest rates of passage (lower inferred bycatch) based on preliminary results.

Our field trials have been conducted during regular seasonal fishing but have been impacted by COVID-19 and variable crab catches. Currently, we have completed three of five planned field trials and our emphasis for this progress report update is to provide some further information from our September 2021 field work during pot cod fishing in Bristol Bay. As noted in the results below, field work from last September pot cod fishery was the first of our trials where test gear components were used in the field during fishing that were in proximity to relatively high abundance of target species (cod) and bycatch species (RKC). Results show the vessels using our test gear elements encountered relatively high counts of RKC as bycatch, but generally, the summary of bycatch rates is supportive of lab results with the exception of one test boat that had high RKC catch rates across all gear variants.

This research will be complete in October 2022, with final laboratory work commencing this spring (opilio gear tests), and final field work being conducted this summer for halibut and this fall for pot cod.

Background

Two NOAA Bycatch Reduction Engineering Program (BREP) grants were awarded to principals from Natural Resources Consultants, Inc. (NRC), Alaska Bering Sea Crabbers (ABSC), and the Bering Sea Fisheries Research Foundation (BSFRF). Principal investigators for this project are Kyle Antonelis (NRC), Jamie Goen (ABSC), and Scott Goodman (BSFRF). Lead collaborators are Dr. Christopher Long (NOAA, Kodiak) and Dr. Ben Daly (ADFG, Kodiak), with logistical support from other NMFS and ADFG staff in Seattle, Kodiak, and Dutch Harbor. Primary industry collaborators include gear manufacturers, pot cod and halibut vessel owners and captains.

There are four primary project objectives which include: 1) host an industry gear committee meeting and determine gear modifications to be tested, 2) conduct laboratory experiments to determine bycatch reduction effectiveness of pot modifications, 3) field testing of modifications on fishing grounds, and 4) disseminate information. Several sub-objectives include options for feedback as this project is about gear design and is trial-based, both for the lab and field work. An unofficial but informative behavioral objective we have included in our project was to record video of crabs interacting with test gear and fishing gear in both the lab and the field. The summary of data and statistical analyses are being completed by our federal and state partners, and preliminary summaries may differ from conclusions after final review and analyses are complete.

Methods & Preliminary Results

A summary of our gear test methods includes several details about accounting for how individual crab interacted with gear test variants for lab work, and how total counts of crab in field pots were tabulated. Lab work included documenting the size and sex of crabs, tagging (numbering) crab, and then attending

to both individuals and groups of crab to control which had undergone tests. Pot cod gear variants focused on six main pot entrance types, three of which are presently used to an extent in current fishing gear and include: Hilty triggers, Neptune triggers, socks, 'slick ramps, vertical barriers, and horizontal barriers ('false tunnel'). A representation of scale and general pot entrance design of these four elements is shown in the photos in Figure 1.

Figure 1. (a) Neptune trigger with slick ramp during RKC trials in Kodiak Lab. (b) Control pot (no tunnel insert) during RKC trial. (c) Dr. Chris Long (NOAA - Kodiak) and Scott Goodman (BSFRF) at NOAA Kodiak Lab with sock tunnel (left), Hilty trigger (center), and Neptune trigger (right). (d) RKC interacting with vertical barrier. (e) RKC interacting with horizontal barrier ('false tunnel').

Pot halibut gear variants are more experimental as this fishery is in development. However, halibut pot entrance variants, which were used in the first halibut lab and field trials, were generally similar to cod pots in scale and design, with the exception of differing entrance dimensions (wider openings). We are also aware of some newer approaches to halibut pots that are very unique and differ substantially from more traditional pots. Two we are aware of and have considered are a 'coffin' nesting-style pot (longer length dimension), and a 'slinky' style pot (coiled, spiral spine within a cylindrical mesh containment), and we are currently working with gear manufacturers to test these gears in 2022.

Vessels used for field work were selected on an opportunistic basis, with an effort to balance robust sampling without altering normal fishing. Field trials were intended to focus on seasons and fishing activity that would occur to show directed catch and bycatch that would be typical and representative for the fleet in that season. Field summaries were based on vessel-recorded catches of fish and crab per test pot after skippers and crews received information and training for data recording during the project. Field results are based on CPUE of cod and crab, and comparisons of CPUE across pots, gear variants, and boats. Further methods details will be included in subsequent updates and final project reporting.

For this update, we are providing a blended description of current progress through laboratory and field methods, progress on the project, and preliminary results. The project has generally followed lab methods with one adjustment when protocols to meet safety requirements changed and NMFS Kodiak staff agreed to complete final holding/testing due to COVID, (March-April 2020). Field work has proceeded but adjusted to fishing schedules, travel logistics, and safety requirements. Four field periods were planned but we have added a fifth. Our field work focus for this update is the most recent testing from September 2021 during directed pot cod fishing because there were high enough crab encounters to differentiate bycatch rates between gear variants.

Table 1. BREP project progress through laboratory and field work to date with overview of completed RKC and opilio laboratory holding, pot cod and pot halibut fishing, and scheduled final lab and field work.

BREP LAB & FIELD WORK		Target Species	
		COD	HALIBUT
Bycatch Species	RKC	Lab 1 NOV 2019 Lab 3 NOV 2020 Field 1 JAN 2021 Field 2 SEP 2021 Field 5 SEP 2022	Not part of this BREP Project
	OPILIO	Not part of this BREP Project	Lab 2 MAR 2020 Lab 4 MAR 2022 Field 3 SEP 2021 Field 4 MAR-SEP '22

Notes: upcoming project work in red

Lab 1	RKC delivered to Kodiak from the fishery
Lab 2	Opilio delivered to Kodiak from the fishery - COVID altered
Lab 3	RKC delivered to Kodiak from the fishery
Lab 4	Opilio delivered to Kodiak from the fishery
Field 1	2 boats, Bering Sea grounds, very few crab
Field 2	4 boats, Bristol Bay, high crab encounters, field 5 planned
Field 3	1 boat, Bering Sea halibut, no crab encounters
Field 4	scheduled for halibut (# boats TBD)
Field 5	scheduled for 4 boats, Bristol Bay

For RKC lab testing (Labs 1 & 3), a total of 78 and 80 crab were used for the first and second rounds, respectively. In each round, crabs were split into three groups with each group containing similar numbers of males and females, with sizes ranging from 85 to 148 mm carapace length. Three male and three female RKC (six total) were chosen randomly, were tested in each tank during each trial. Each trial included four tanks, each equipped with one of the test panel variants. Each gear test panel variant

underwent six trials, therefore the bycatch reduction effectiveness for each modification combination was tested on a total of 36 RKC (18 male and 18 female). Trial times were held constant for all lab work at 18 hours (as a proxy for 'soak time' in lab setting).

Lab results for RKC from both rounds of testing are shown below in Figure 2. In the first preliminary summaries (round 1) sock variants reflected 25%-75% reductions in successful passage of a test panel, implying a bycatch reduction of the same scale. In the second round of similar testing, socks (variants) again supported low rates of successful test panel passage that approached 80%-85% reductions compared to other test variants. Both the vertical and horizontal barriers along, without the sock trigger, were successful in reducing RKC passage by 53% and 70%, respectively, compared to the control (Figure 2 bottom).

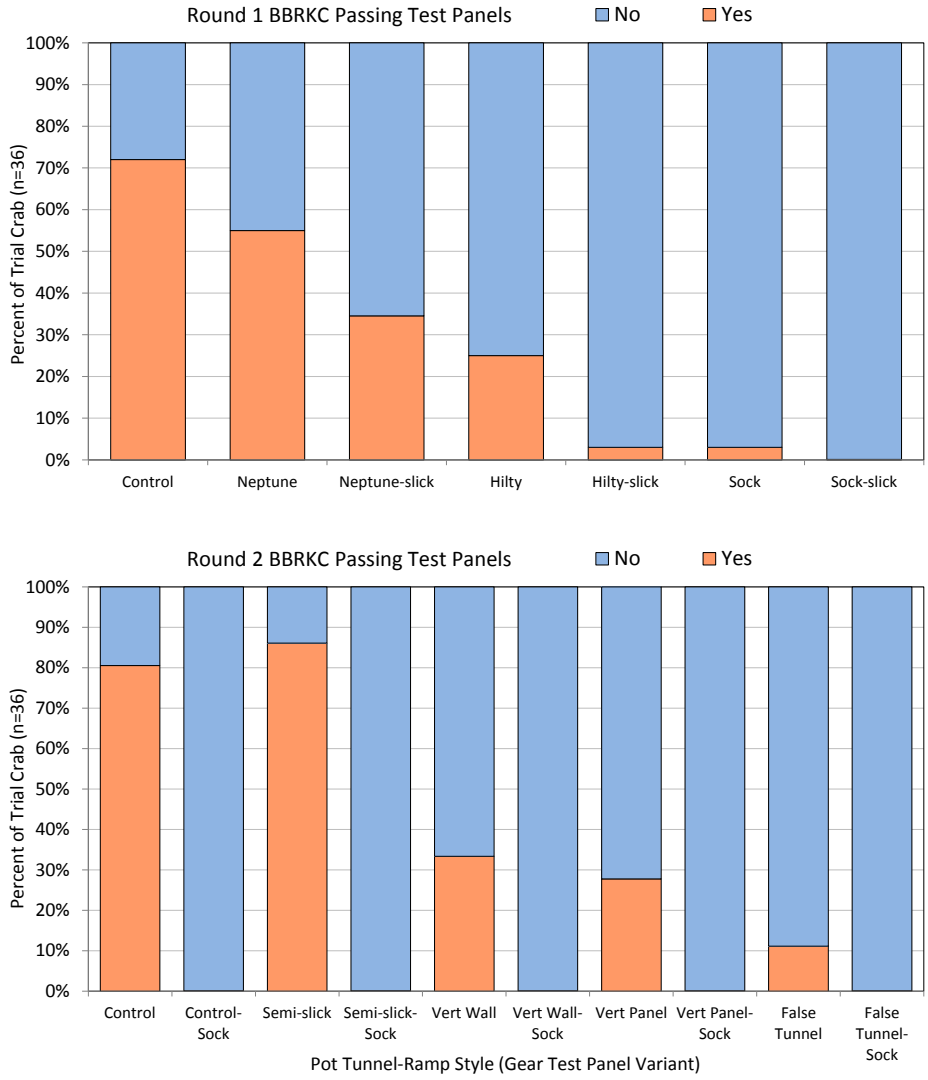

Figure 2. Preliminary lab results for RKC passage of test panels from rounds 1 (top panel) and 2 (bottom panel) in Kodiak lab tanks, 2019-2020. Red bars represent successful passage through the test panel, blue represents no passage.

For opilio lab testing (Labs 2 & 4), a total of 73 male and 24 female crab were used for the first round. The scientific design was similar to that of the RKC trials with six total animals being tested per tank per trial. However, after assessment of animal behavior during initial trials, only males (6 in each tank per trial) were used, due to excessive male grasping of females which appeared to distract the crab from attempting to pass through the panel to reach the bait. Each daily trial included 4 tanks (different gear variants) which applied to 24 randomly chosen crabs per daily trial. Each gear test panel variant (pot tunnel and ramp style) received 36 total crab for testing trials for each lab. Trial times were held constant for all lab work at 18 hours (as a proxy for 'soak time' in lab setting).

The effectiveness of gear variants for opilio bycatch reduction (test panel passage) was not as convincing as for RKC. While preliminary results were somewhat promising, further analysis showed that the 'slick ramp' gear presence alone was not as effective by itself at preventing opilio entry into pots. The tunnel triggers proved to be more of a predictor of opilio bycatch reduction effectiveness than the slick ramps with the black sock tunnel insert as most effective, followed by the Hilty trigger, then the Neptune trigger, and finally the Dyneema tunnel (Figure 3). Lab results for opilio from round one testing are shown below in Figure 4. Observations of opilio behavior made by project personnel during lab trials suggested that the opilio were not as interested at crossing the panels into the baited sided of the tank as the RKC were in the earlier testing. This was supported by the fact that only 58% of opilio crossed through the unobstructed tunnel of the control pot. Fortunately, this can be addressed through adjustments to the scientific plan in the lab during the second round of lab tests that will occur in early 2022.

Figure 3. Photos from Kodiak lab trials showing additional opilio test panel variants with the Dyneema sock (right) and 'black sock' (left) tunnel inserts, each with opilio crab approaching passage. Dyneema is a newer, high strength, synthetic fiber material used in some fishing gears.

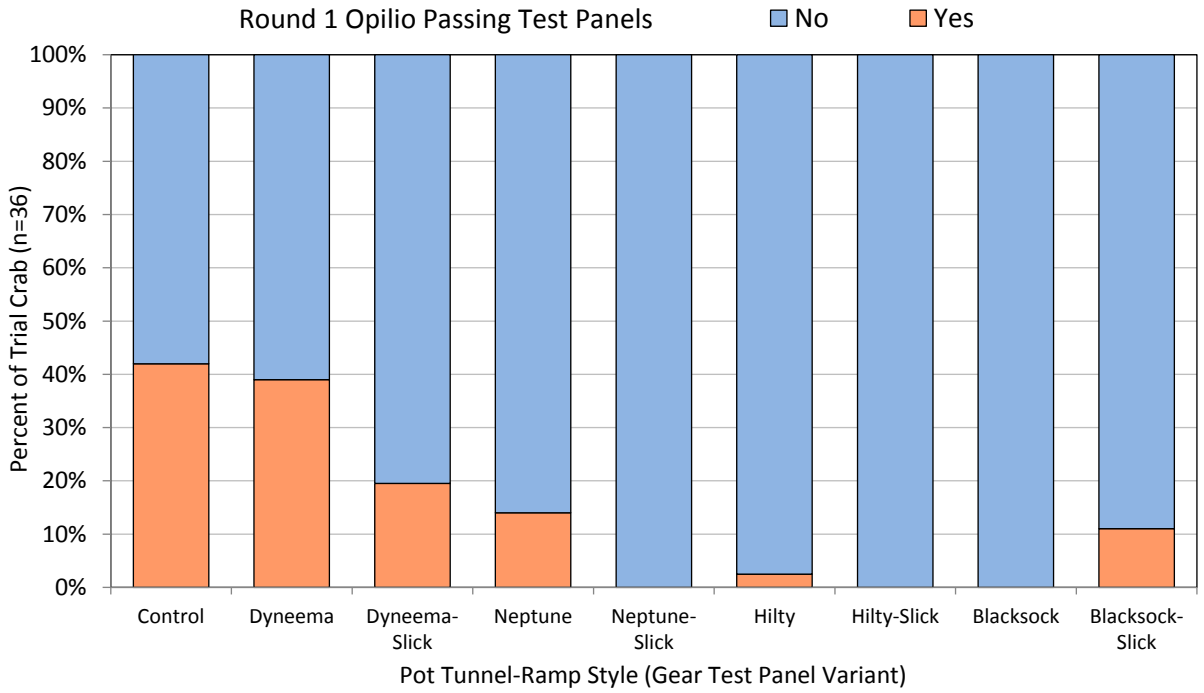

Figure 4. Preliminary lab results for opilio passage of test panels from round 1 in Kodiak lab tanks, 2020. Red bars represent successful passage through the test panel, blue represents no passage.

The first field testing of gear variants for RKC bycatch reduction during pot cod fishing occurred in January 2021 with two vessels, one of which caught no crab and the other vessel had very few crab. This was not unexpected as this fishery in January tends to have lower RKC bycatch. The second field trials occurred during the September 2021 pot cod fishery in Bristol Bay with high encounters of RKC. Accordingly, project schedules were adjusted and a fifth field testing is scheduled to cover September 2022 pot cod fishing. The third field testing focused on halibut gear onboard one boat that encountered no crab. Final testing for halibut field work will occur later this year.

During the second field testing in Bristol Bay (Sep 2022), four boats agreed to participate during the pot cod fishery and test gear results are generally consistent with the lab work trials with RKC. Gear variants were split up across the four boats (A, B, C, and D) and catches of cod and crab per pot were documented. For preliminary reporting, the following provides the general scale and magnitude of the test gear within the total pots fished by these four boats during this field work. Vessel A fished 12 test pots with socks and sock variants and had approximately 135 total pots fishing. Vessel B fished 16 test pots with socks and other variants and had approximately 180 total pots fishing. Vessel C fished 15 test pots split evenly between three main variants and had approximately 155 total pots fishing. Vessel D fished 10 test pots with socks and sock variants and had approximately 150 total pots fishing.

During this field work conducted during the 2-3 week fishery in Bristol Bay, 272 test pot lifts were completed with recorded cod and RKC catches of 5,021 and 1,663, respectively to compute CPUE in cod or crab per pot lift (Figure 5). Cod CPUE for test pots by vessel-variant ranged from about 10-30 cod per pot lift, averaging 18.46. RKC CPUE for test pots by vessel-variant ranged from about 1-36 crabs per pot

lift, averaging 6.11. Across all boats and all gears, sock variants had consistently low bycatch CPUE of RKC. CPUE of RKC across major test gears (grouped) ranged from about 4 to 11 crabs per pot lift. Individual gear variants ranged from about 1 (sock w/ vertical panel) to 16 (Hilty w/ false tunnel) RKC per pot lift (Figure 6). Preliminary results for one vessel differ from the other three using some similar test gear panels. Vessel B crab CPUE reflects the highest RKC per pot lift for each of its gear variants including socks. This vessel caught 58% of the test pot observed RKC (965 crabs) in 20% of test pot effort (54 pot lifts). One gear type (Hilty) on this vessel caught 30% of the total RKC (503) and of those crab from 14 total pot lifts, 400 came from three pots and the other 11 pot lifts' RKC catches ranged from 0-20 crab. In contrast to vessel B, the highest catch in a pot of RKC for vessels A, C, and D were 19, 17, and 16, respectively. Further, observed test pots from this vessel also had the lowest cod CPUE at about 13 cod per pot lift which was about 30% below the 4-vessel average. Regardless, crab CPUE from modified test pots on this boat were significantly lower than those in the un-modified control pots, supporting the efficacy of the gear modifications to reduce BBRKC bycatch.

Video from pots was recorded opportunistically from vessels A and D (Figure 7). Two cameras from NOAA Seattle were placed on top of pots to view activity as fish and crab entered to access the pot and its bait. Preliminary review of footage shows very few RKC evident, many cod, flatfish, and sculpin at times in the pots. The information from the videos is high resolution and very clearly shows bait that draws fish/crab into the pots. Further review of existing and new video will be ongoing to help with any behavioral project elements that would otherwise be unobservable.

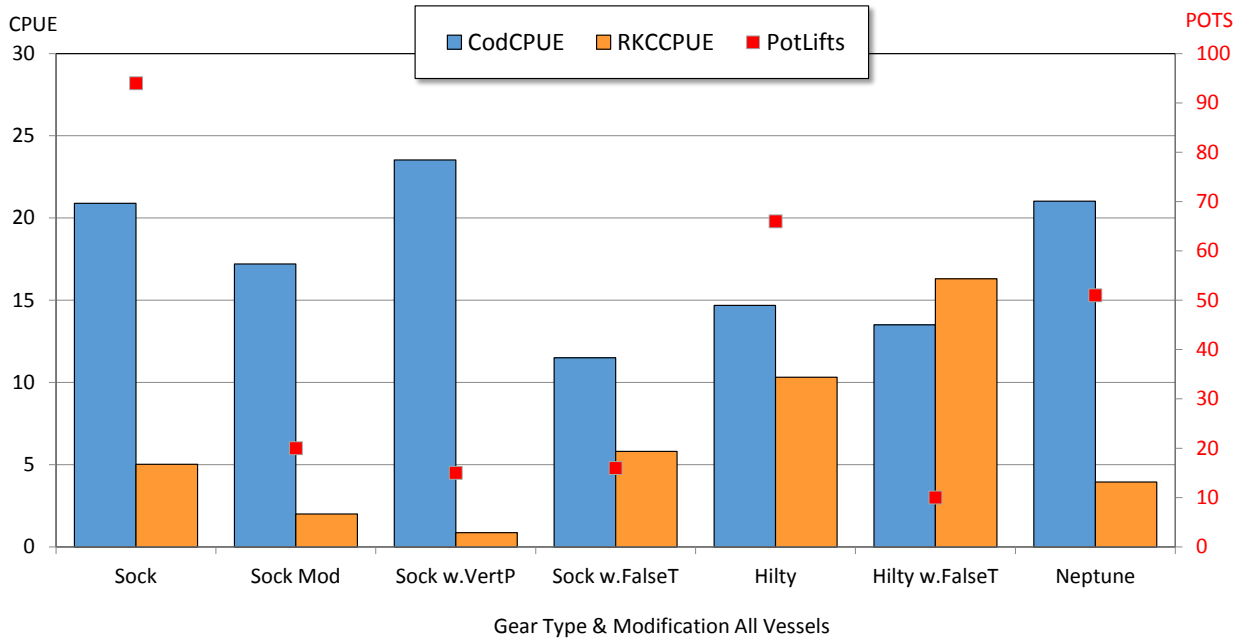

Figure 5. Pot lifts and CPUE (catch per pot lifts) for cod and RKC for test gear variants across all boats from September 2021 pot cod field testing.

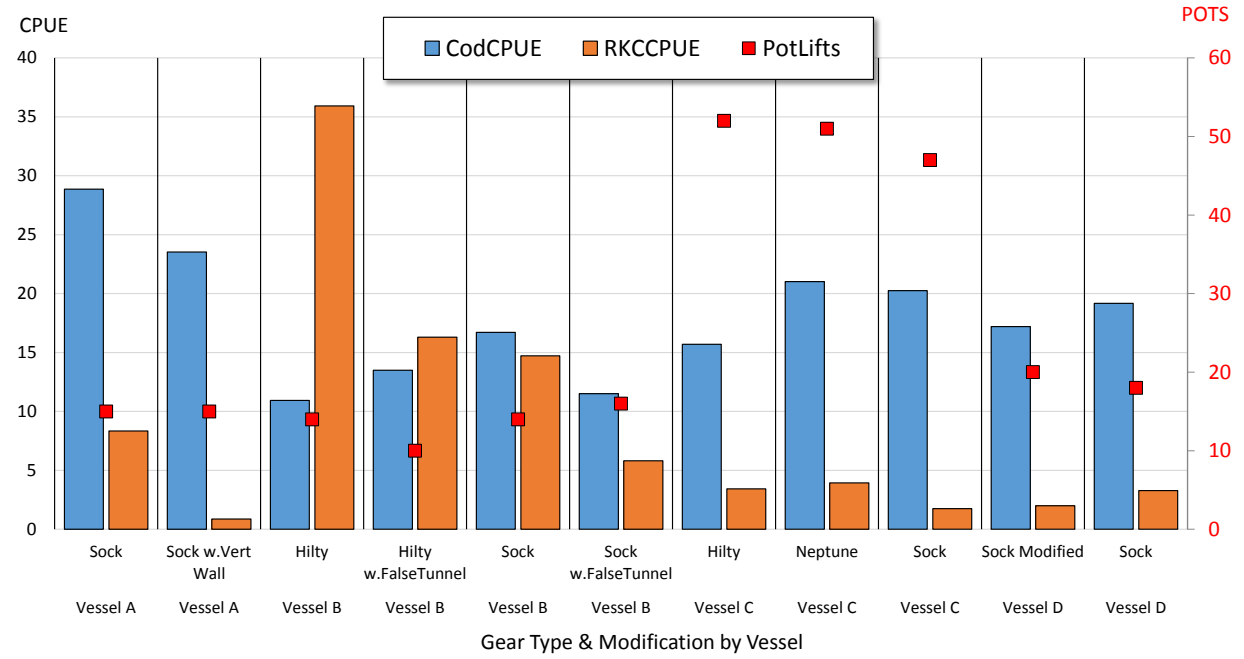

Figure 6. Pot lifts and CPUE (catch per pot lifts) for cod and RKC for test gear variants by boat (vessels A, B, C, and D) from September 2021 pot cod field testing.

Figure 7. Photo of video equipment and screenshots from underwater pot footage from September 2021 pot cod field testing.

Discussion

Our efforts to date have not included final lab testing with opilio or adequate field time for halibut gear, so our comments focus on pot cod project results. Some high recent BBRKC bycatch events have brought attention to the importance of this project and for further clarity on why this project was pursued. High observed bycatch of RKC in pot cod fishing in the fall of 2018 was part of the initiative to pursue this BREP research. The fall 2021 cod fishery was a second recent high incidence of RKC bycatch. Pot fishermen have already been exploring gear designs in an attempt to keep crab out of the pots altogether while allowing access to productive fishing grounds as an ideal solution to balancing fishery interests, as they are keenly aware that occasional high bycatch events are known to occur in the pot cod fishery in Bristol Bay. A general goal of this project was to provide documented and quantified information from gear variants that are presently used by some boats in the fishery and are believed to reduce crab bycatch. This project connects the valuable work that the fishermen are already doing and puts it together with a study that documents those efforts.

The lab and field results for RKC and pot cod trials so far support the concept that pot tunnel, ramp, and entry elements can change the way that cod and RKC are able to pass through gear panels and enter a pot. A specific goal is to find and test gear variants which offer a balance between high target CPUE and low bycatch CPUE. Further specific goals are to get feedback from the fishermen to determine if gear options are effective, robust, and generally easy to deal with. There were two gear variants that were expected to reduce crab bycatch, the 'sock' and the 'slick ramp' and both showed reduced passage for crab in lab results. However, there was evidence of lower cod CPUE and logistical challenges with the 'slick ramp' in field trials. The 'slick ramps' caught less cod in contrast to control pots and were not resilient on deck (tearing with use) so we omitted further consideration after field trial reporting. Preliminary project results to date reflect lab and field summaries that support the use of 'socks' or 'sock variants' as the best likely method for reducing crab bycatch.

Preliminary results from September 2021 pot cod trials at the vessel-gear level reveal a likely vessel-effect with results from vessel B, which had higher RKC catches across all gear variants. Project data from vessel trials provides positional information from test fishing (project data sheets) and from total fishing effort (logbooks). We are investigating spatial fishing patterns from available information from the four boats that volunteered for this project. The few observed crab in video footage from the other test fishing shows RKC that appear to be smaller individuals which may, in part, explain higher encounters observed in vessel B RKC catches. Our video footage was not taken from vessel B however, so information to further understand higher crab catches is uncertain at this time.

Finally, for these two fishery gear sectors (halibut and cod), given the spatial and temporal distributions of crab, lab and field work have focused on BBRKC bycatch and BSS bycatch, respectively. There could potentially be other crab stocks that overlap with either pot cod or pot halibut fishing, especially as some level of environmental change occurs, but this was not tested. We have conducted some preliminary statistics that support the information presented in this update and final reporting after September 2022 will thoroughly evaluate outcomes.

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Attachments

Photos of gear variants in the lab

Photos of setting up gear in Dutch Harbor

SOCK TUNNEL

NEPTUNE TRIGGER

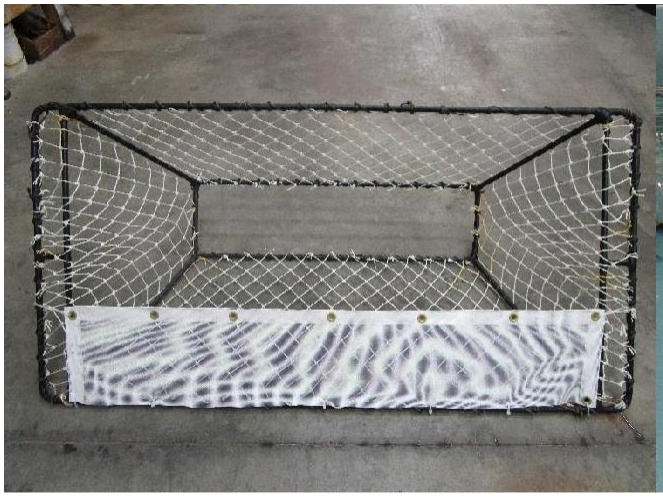
Example lab set-up with Hilty trigger and slick track

HILTY TRIGGER

SOCK TUNNEL

SEMI-SLICK RAMP

VERTICAL WALL BARRIER



VERTICAL PANEL


FALSE TUNNEL


DUTCH HARBOR GEAR SETUP

DUTCH HARBOR GEAR SETUP