Central Gulf of Alaska Salmon Excluder EFP 13-01 Final Report

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ABSTRACT

The “flapper” and “over/under” (O/U) salmon excluder designs were tested on two Central Gulf of Alaska pollock catcher vessels in the spring and fall of 2013 and 2014. The field trials were done under an exempted fishing permit (EFP) that employed a systematic testing protocol and careful review of escapement and catch data. The performance of the flapper excluder was disappointing but the over/under design exceeded expectations with selectivity outpacing all previous salmon excluders. While both vessels had good results for all tests of the O/U design, the F/V Caravelle in the fall 2014 achieved a salmon escapement rate of 54%, pollock escapement of less than 2%, and consistent escapement results on a haul to haul basis.

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Abstract

Following nearly a decade of developmental work on salmon excluders in the Bering Sea pollock fishery, the Principal Investigators (PI's) working under the auspices of the North Pacific Fisheries Research Foundation (NPFRF) shifted their focus to the Central Gulf of Alaska (CGOA) pollock fishery for this EFP. The opportunity to delve into the CGOA emerged when the focus in the Bering Sea shifted from field testing to outreach to fishermen to inform them of the best performing excluder designs for Bering Sea boats. The PIs and the NPFRF welcomed the chance to work with CGOA fishermen because it included the opportunity to conduct testing on smaller, lower horse power vessels that had not been the focus in the Bering Sea. Additionally, there were many compelling reasons to focus on the CGOA. One was that concurrent with the approval of our salmon excluder EFP application for the CGOA, Amendment 93 was implemented in the GOA, establishing annual Chinook salmon prohibited species catch (PSC) limits in the directed Gulf of Alaska pollock fisheries (18,316 Chinook salmon in the Central GOA and 6,684 Chinook salmon in the Western GOA). The hard cap limits presented a "perfect storm" scenario wherein the caps were based on recent historical salmon bycatch levels and the pollock biomass in the Gulf of Alaska expanded greatly, resulting in large increases in GOA pollock quotas.

Under these circumstances, EFP 13-01 tested modified "flapper" and "over/under" salmon excluder styles previously tested to different degrees in the Bering Sea. Testing occurred on two Central Gulf of Alaska pollock catcher vessels (the 98 foot F/V Alaska Beauty at 850 hp and the 86 foot F/V Caravelle at 1,200 hp) during the spring and fall of 2013 and 2014 (four separate seasonal testing phases). The work started with the most proven Bering Sea design, the "flapper" where testing was done with "recapture nets" to quantify salmon and pollock escapes, just as had occurred in the Bering Sea. Those tests resulted in less promising results with Chinook salmon escape rates of 0-33% and pollock escape rates of .3-.9%. The most likely explanation for the generally lower and highly variable salmon escapement performance of the flapper excluder in the CGOA was the much lower force of water through the nets on these less powerful vessels.

The results of the over/under (O/U) design (with two, top and bottom, escape avenues) were much more encouraging. These tests used underwater video cameras to measure escapements due to the inability to rig a recapture net to recover escapement from the bottom escapement portion of the O/U excluder. Chinook salmon escapement with the O/U ranged from 34-54% with pollock escapement rates of 1.2-9.8%. The results from the fall 2014 trial on the Caravelle, with the O/U excluder placed in the aft end of the net's tapered section, were notable for their consistent, haul-by-haul high performance under conditions with relatively high salmon numbers on each EFP haul. Perhaps most encouraging was the fact that these high salmon escapement rates occurred over a wide range of pollock fishing conditions. The high degree of selectivity– 54% salmon escapement, 1.2% pollock escapement –were especially notable in light of the fact that previous trials in the Bering Sea and with the flapper excluder in the CGOA produced generally lower salmon escapement rates and typically less consistent performance on a haul-by-haul basis.

Introduction

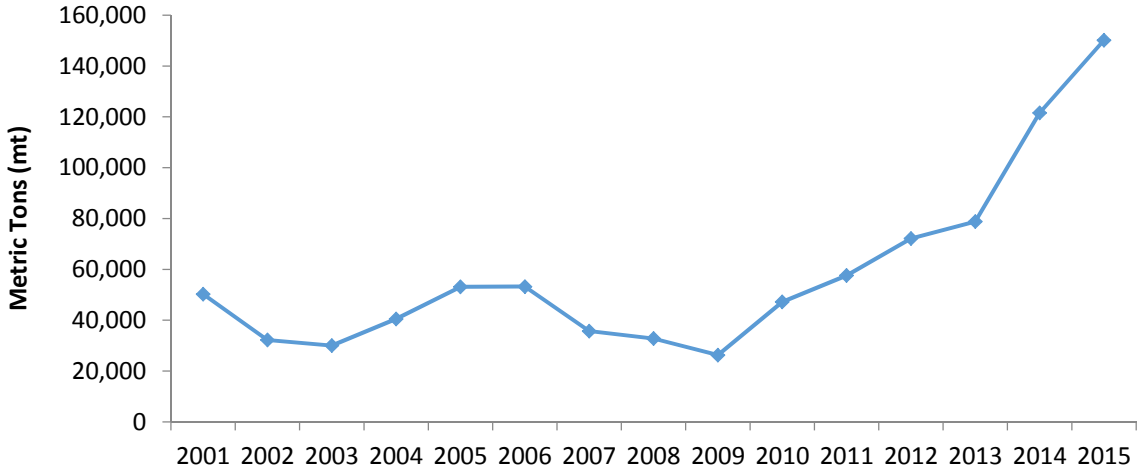
Since 2003, the ever-evolving salmon excluder devices have been tested extensively in the Bering Sea pollock fishery through the use of exempted fishing permits (EFPs). Testing with these "exempted" permits allows for dedicated studies of performance outside the regular fishery where pressures to maximize economic value generally preclude systematic testing. The more recent versions of the Bering

Sea pollock fishery excluder design have been shown to reduce Chinook bycatch by between 25-34% with less than one-percent pollock escapement (previous EFP reports can be found at http://alaskafisheries.noaa.gov/ram/efp.htm). In reference to expectations for use of the same excluder devices for the CGOA pollock fishery, it is noteworthy that all of these EFP trials were on relatively large, high horsepower Bering Sea pollock vessels (2,400 to 3,000 hp catcher vessels and catcher-processors with 3,000 to 12,000 hp). The CGOA salmon excluder EFP therefore afforded the opportunity to test performance on the smaller, less powerful pollock vessels in the Gulf of Alaska (GOA) including the opportunity to evaluate salmon behavior inside the net with slower towing speed and water flow. Experience with salmon excluder development in the Bering Sea has shown that horsepower, towing speed, pollock catch rates, and differences in net design/size are factors that affect excluder shape and performance.

The primary objective of this exempted fishing permit (EFP 13-01) research was to modify the design of the existing BSAI excluders for use in the Central Gulf of Alaska pollock trawl fishery. Additional tools are needed to reduce the number of salmon taken by the Gulf of Alaska pollock trawl fishermen since the implementation of Amendment 93 in 2012 which established annual (fixed) Chinook salmon prohibited species catch (PSC) limits in the directed Gulf of Alaska pollock fisheries (18,316 Chinook salmon in the Central GOA and 6,684 Chinook salmon in the Western GOA). The need for a "better mouse trap" was intensified by the large increase in GOA pollock quotas (Figure 1) (the 2015 ABC is 191,309 mt, the highest since 1985 when the ABC was 305,000 mt. The average CGOA ABC over the years selected for the CGOA Chinook hard cap was about 40,000 mt). Additionally, Amendment 97, implemented in 2015, established annual PSC Chinook salmon caps in the GOA non-pollock fisheries (7,500 Chinook salmon).

This report details the methods and results of the tests performed in 2013/2014 under EFP 13-01 with the objective of modifying the most recent and promising BSAI salmon excluder designs ("flapper" and "over/under" styles) for use in the Central GOA. The research design incorporated four field testing seasons over two years using two different vessel size classes (<= 900 hp and >900 hp) in each season. Two catcher vessels participated in this EFP: the F/V Alaska Beauty (98 feet, 800 hp, using a Swan net) and the F/V Caravelle (86 feet, 1200 hp, using a Dantrawl net), selected through an application review process conducted for the PIs by the RACE Division at the Alaska Fisheries Science Center. The intent behind conducting testing on two different vessel horsepower categories was to make sure the study would be applicable to the prevalent types of pollock vessels in the CGOA. Both vessels used similarly sized nets with mouth openings of about 18 x 42 fathoms.

Figure 1. Central Gulf of Alaska (CGOA) pollock quotas, 2001-2015



Field Methods: Certified NMFS observers acting as "sea samplers" for the project were responsible for (1) sampling and monitoring of the catch to ensure accurate haul by haul accounting of groundfish and salmon (from both the main and recapture nets during trials when recapture nets were utilized) to allow measurement of excluder performance and to stay within the seasonal EFP groundfish and salmon limits (Table 1); (2) collecting tissue samples, biological data and coded wire tags (CWT's) from salmon for stock of origin analysis. All landed Chinook salmon were examined with a "wand" tag detector device for the absence/presence of CWT. Tissue samples (PAP's) were also collected from all Chinook in hauls with more than 50 landed Chinook only; (3) collecting length frequencies from all encountered salmon as well as from a sample of pollock from every haul.

All landed salmon (cleaned and iced at sea) were donated to Sea Share and distributed to food banks in Kodiak and other regions in Alaska. All groundfish were retained except large sharks, halibut and other species on PSC status (big skates, POP) – at sea discard amounts were recorded in the vessel logbooks with final trip groundfish harvest values obtained from ADFG fish tickets.

Whereas the Bering Sea vessels were equipped with highly accurate motion compensated flow scales to estimate haul weights at sea, the smaller GOA vessels were not so equipped. Instead, the fish were passed over the deck level conveyor belt from the trawl alley and sea samplers, with crew assistance, sorted out salmon (for census) and PSC species from the haul as the fish flowed over the belt into a ~1 mt capacity bin from which the fish were dumped into the fish holds (Figure 2). On the Caravelle, a brailer scale was attached to the bin, allowing for actual scale weights of each bin "dump" (not motion compensated). On the Alaska Beauty, no brailer scale was attached to their bin – instead, the bin was filled to the same approximate height and "dumps" tallied to estimate haul weights (tests at the dock established appropriate weight to use for the volume). The EFP vessels were already accustomed to using these dump boxes during the regular fishing season to stay within the allowed maximum retainable allowances (MRAs). Whereas species composition sampling was conducted on the Caravelle to estimate the weight of pollock in each haul (as opposed to total groundfish), no species composition sampling occurred on the Alaska Beauty since it had no brailer scale to facilitate sampling. Methods to measure performance of the excluder, recapture nets and underwater video cameras, are detailed in the relevant sections.

Table 1. EFP 13-01 groundfish, Chinook salmon and Halibut PSC limits by year

EFP 13-01 limits	2013	2014	Total
Groundfish* (mt)	2,400	2,400	4,800
Chinook (no.)	2,400	2,400	4,800
Halibut PSC (mt)	4		

*Groundfish includes allocated species only

Figure 2. Deck of F/V Caravelle with fish flowing from the trawl alley, across the conveyor belt and into the "weigh" box from which, once full, a door is lifted and the fish are dumped into the hold below. The sea sampler is in the red jacket.

Spring 2013/Fall 2013: "flapper" design using recapture nets to measure escapement rates

Both the Alaska Beauty and the Caravelle used the "flapper" excluder design (previously tested in the Bering Sea) in the spring of 2013, modified by the net manufacturers based on the directions provided by John Gruver, the NPFRF's net designer, to fit their respective nets. The panel was weighted to remain half-way down at towing speed with a floated "hood" to increase the space available for escapement (Figure 3). Whereas the most recent flapper excluders used in the Bering Sea needed about 160 lbs of weight to achieve the desired shape when used in the same approximate location in the net, the Alaska Beauty and Caravelle, needed only about 15 lbs to achieve the correct position for the flapper panel while towing. This was due to the much lower force of water through the GOA nets. As in previous EFP's, a "recapture" net was used to collect all escaping fish to allow for the calculation of salmon and pollock escapement rates.

The flapper excluder was again tested on the Alaska Beauty in the fall of 2013, also using the recapture net to collect escaped fish. The schematics of this excluder with recapture net are shown in Figure 4, Figure 5 and Figure 6. After poor performance on the Caravelle for the first four hauls in the spring 2013 test, the excluder was relocated from the straight tube section forward of the codend to the aft end of last tapered section of the net, resulting in two phases of the experiment on the Caravelle during this leg of the EFP. For the Alaska Beauty, the excluder was moved from a straight section aft of the last tapered section (spring 2013) to approximately 50 meshes from the end of the last tapered section (fall 2013). The idea behind moving the flapper further forward (ahead of the codend) was to place the excluder in a section of higher water flow to increase the probability of it retaining its shape due to its placement in an area of higher relative water flow.

Problems with the shape and performance of recapture nets became evident in the GOA salmon excluder trials. Poor clearance of the recapture net above the main net (likely due, again, to the much lower force of water while fishing) led to the suspicion that salmon may at times have been re-entering the main bag after "escaping" and that this was occurring to a much greater degree than was evidenced in the Bering Sea trials. To examine the degree that recapture net performance was affecting the test results, the recapture net was removed for the final Alaska Beauty trip in the Spring (four hauls) as well as in the Fall (three hauls) and video cameras were placed near the escape portal to monitor fish escapes (this method of monitoring escapes is explained later in the report). Whereas no lights were used for the EFP data hauls when the recapture nets were deployed, lighting was obviously essential for these last trips to observe escapes via video.

Figure 3. Flapper hanging about half-way down, Alaska Beauty fall 2013. View is looking forward from aft end of excluder in the last tapered section of the Swan net. The elevated hood is seen at the forward end of the excluder's panel.

Figure 4. Side view of the salmon excluder flapper design (in the straight section of the net) used in the spring of 2013 on the Caravelle and the Alaska Beauty and in the Fall of 2013 on the Alaska Beauty. Note: the excluder was initially placed in the straight section on the Caravelle but moved to the aft end of last tapered section after four initial hauls. The location for the Alaska Beauty was also initially in the straight section then later moved forward in the fall of 2013. The Caravelle switched to the over/under design starting Fall 2013.

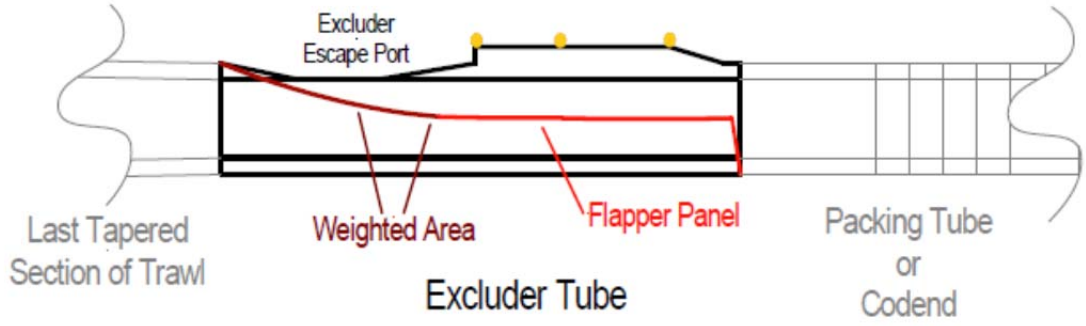


Figure 5. Functional schematic of the flapper style salmon excluder

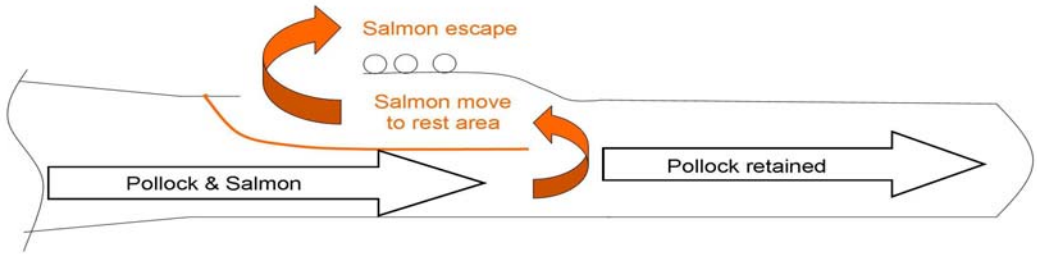
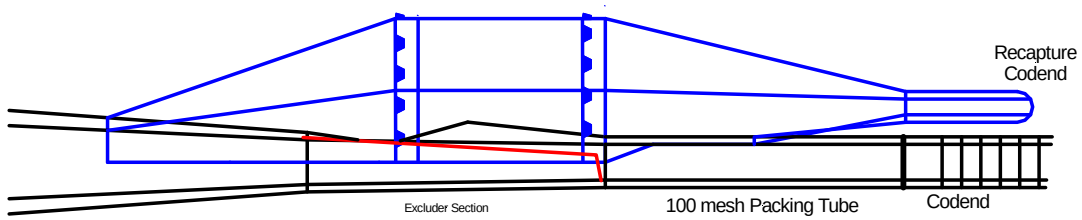


Figure 6. Net diagram showing excluder and recapture net. The excluder was located in the last tapered section of a Swan 700 MW Trawl (Fall/Spring 2013 Alaska Beauty)



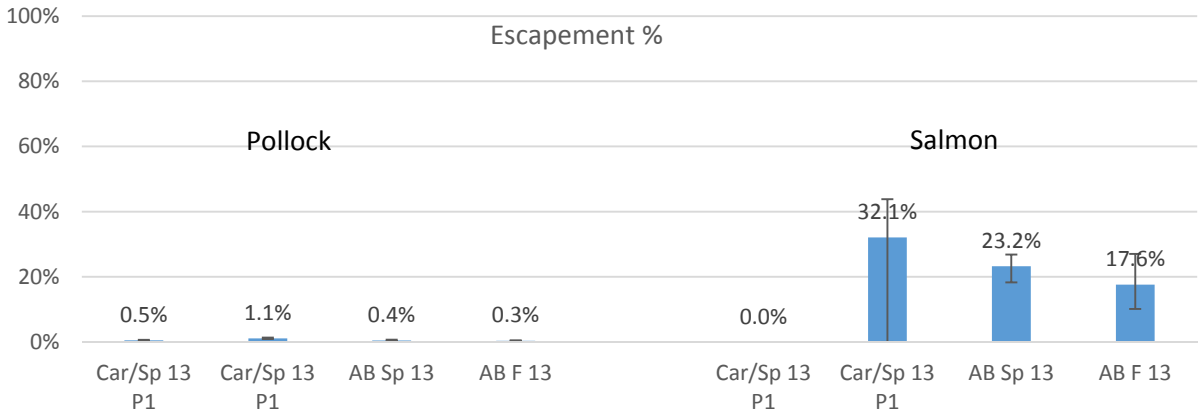
Observations from previous flapper excluder tests in the Bering Sea revealed that it was difficult to tune the weighting to achieve the desired panel position during towing (half way down) – accurate tuning required extensive vessel-specific video observations and adjustments due to differences in vessel horsepower, net design/size and towing variables. Chinook escapement rates in the Bering Sea trials were decent (25-34%) but additional modifications made to attempt to increase the rates did not show any improvement (e.g. using artificial light, modifying the length of the panel).

For the flapper trials on the Caravelle (spring 2013) and Alaska Beauty (spring/fall of 2013), the salmon escapement results were poor to average and the recapture nets did not perform as well on these smaller, less powerful vessels – the desired lift was not always achieved and although not observed on video during the test tows when the use of light was permitted, there was the suspicion that salmon were restricted to some degree in their escapement opportunities. Table 2 details the salmon and pollock escapement results for each flapper excluder trial by vessel: pollock escapement was negligible (.3-.9% of the pollock catch); Chinook salmon escapement rates ranged from 0 – 32.7% (Figure 7). While the almost 33% escapement rate achieved with the flapper excluder on the Caravelle in the spring of 2013 appears to be evidence of good selectivity from the gear, it is important to note that statistical confidence (P alpha=.05) around the mean escapement rate ranged from approximately zero to 43% (Figure 7).

Table 2. EFP results by vessel and season, flapper style excluder using recapture net to estimate escape rates (P1 = phase I, P2 = Phase II). Test tows and abnormal hauls (ripped nets, haulback difficulties) were excluded.

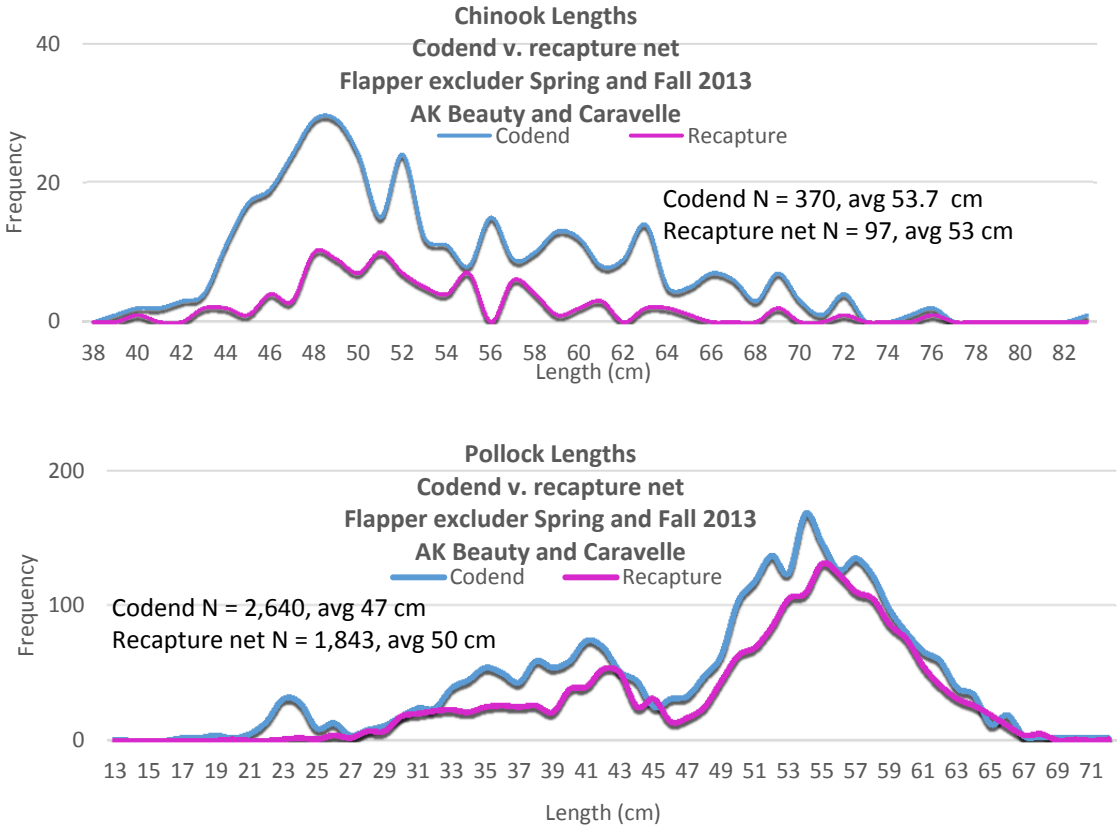
Vessel/EFP Leg (Flapper excluder)		No. EFP Hauls	No. Salmon in Codend	No. Salmon Escapes	Salmon escape rate	Poll Escape %
Caravelle/Spring 2013 P1	Flapper straight section	4	28	0	0.0%	0.5%
Caravelle/Spring 2013 P2	Flapper tapered section	9	103	50	32.7%	0.9%
AK Beauty/Spring 2013	Flapper straight section	16	136	41	23.2%	0.4%
AK Beauty/Fall 2013	Flapper tapered section	17	80	17	17.5%	0.3%

Figure 7. Salmon and pollock escape rates using the flapper style salmon excluder: by EFP leg with 95% CI boundaries. P1 = Phase I, P2 = Phase II. Data set resampled 5000x.



In learning of the escapement rates for salmon excluder tests, fishermen often inquire as to whether larger fish escape at a higher rate. This makes intuitive sense because escapement requires swimming forward against the flow (especially escapement at normal towing speeds as opposed to turning the vessel or when the vessel is slowed to remove the net sounder device). To inform this issue, all Chinook and a random sample of pollock from both the main codend and the recapture nets were measured during each trial. The results are plotted in Figure 8. As noted in previous EFP reports where recapture nets allowed for size comparisons of retained and escaped fish, there was no apparent size difference for either Chinook or pollock. The underlying reason that a size difference is not evident is unknown but one plausible explanation is that escapement sometimes occurs during turns and haulback and this is a time when the vessel is moving more slowly than towing speed (some vessels make turns in a manner that nearly stops forward progress and speed of the vessel during haulbacks is approximately one-half of normal towing speed). The intermittent periods of slower speed may allow smaller fish to escape even if escapement of smaller fish is less likely at normal towing speeds.

Figure 8. Length frequencies, flapper excluder trials with recapture net: Chinook salmon (top) and pollock (bottom). Main codend vs. recapture net (escapes)



Fall 2013 "Over/Under" (O/U) design using video cameras to measure escapement rates: F/V Caravelle

Given the lackluster results of the flapper excluder in the spring of 2013, there was considerable interest by CGOA fishermen in testing the O/U excluder as part of the Gulf of Alaska trials. This was based on excitement amongst designers and fishermen when the O/U excluder was first considered as a scale model in a flume tank in Newfoundland in fall of 2011. An O/U excluder trial was also done briefly via an EFP during the fall of 2012 on the Bering Sea pollock catcher vessels Pacific Prince and Destination (EFP 11-01 final report can be found at http://alaskafisheries.noaa.gov/ram/efp.htm). That preliminary test in the Bering Sea spurred interest in the O/U due to the relative ease that the device took the desired shape. In reality, however, the testing was done late in the year at a time when fishing conditions were quite poor and catch rates for pollock were not very representative. Despite the unknowns, the captain of the Caravelle was interested in skipping a second trial of the flapper excluder given how poorly the first test had gone on his vessel. The plan was therefore adjusted to include a test of a modified over/under design during the fall of 2013. The Alaska Beauty would do the second trial of the flapper, relocated in the tapered section, during this second EFP leg. Moving the flapper forward was intended to place the device in an area of higher water flow, hopefully addressing some of the shaping issues described above. The O/U design first tested on the Caravelle was adapted from the initial design first tested in the Bering Sea (version one or v.1), but instead of having an "overlap" 20 meshes, there was zero overlap on the GOA version. The concept of adding overlap creates separation from where fish pass through the excluder to the escapement portals. Hence, by eliminating overlap the idea was to make

salmon escapement more probable even if pollock escapement might also increase. To understand the concept of overlap, please see Figure 9 and Figure 10. Without overlap, the result would be less distance to cover for fish swimming forward in the net from behind the excluder to escape out the escape portals.

Figure 9. Conceptual schematic of the Over and Under (O/U) excluder (version one). Cross section below.

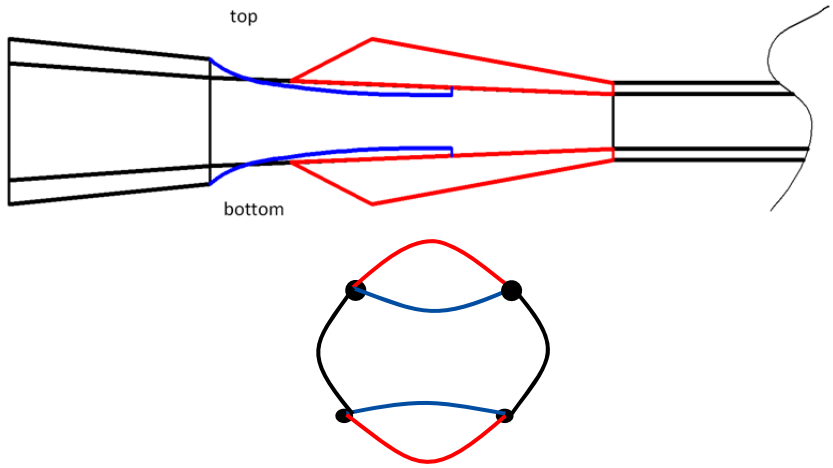
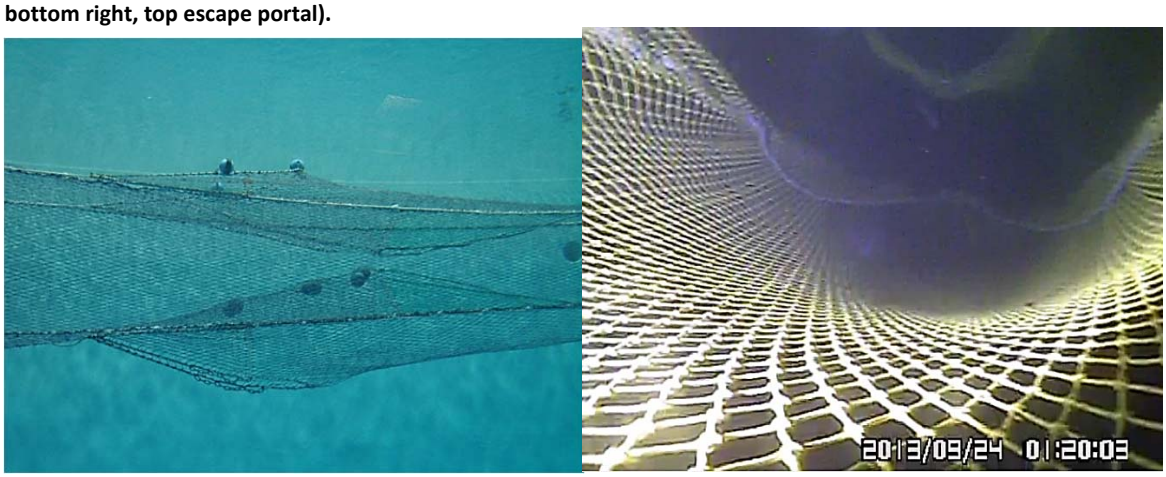
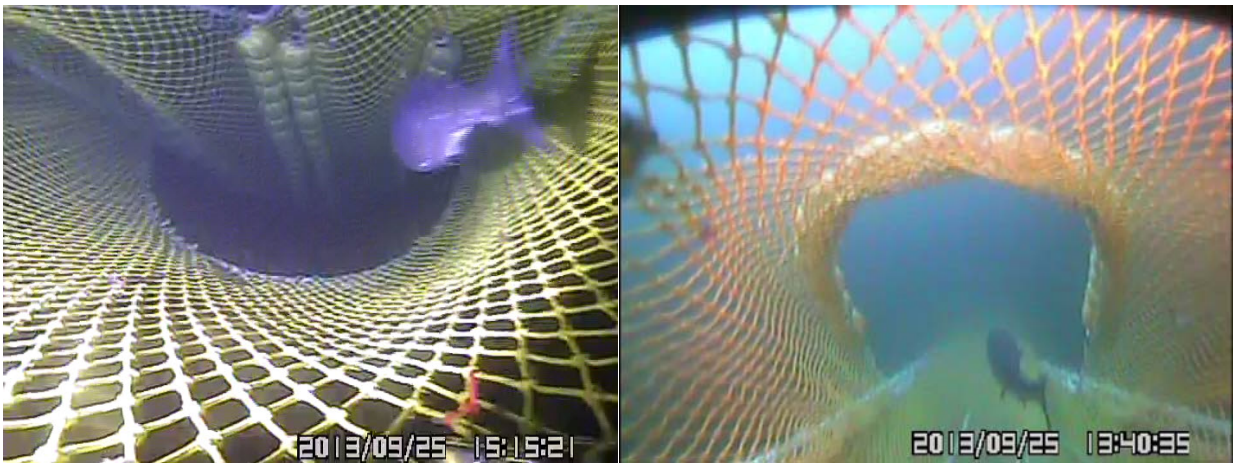


Figure 10. V.1 Over/Under (O/U) excluder model tested in the flume tank in October 2011 (top left) and on the Caravelle during the Fall 2013 EFP leg (top right, view of both bottom and top escape tunnels; bottom left, bottom escape hole; bottom right, top escape portal).





The concept for the over and under excluder, as seen in the figures above, is to have two avenues of escape opportunity – from the top and from the bottom. To achieve this, the top panel is weighted with lead line and secured to the rib lines to achieve the desired position (about half way down while towing). At the same time, the bottom panel is floated from below using float rope. The panels are highly flexible because they come together from floatation and weighting alone. This allows for large amounts of pollock to pass through by pushing through the two panels without creating a restriction in the net as was experienced with previous designs (funnel and tunnels). The top hood is floated with float rope or small trawl floats while the bottom hood is weighted with lead line. "Hoods" are designed, as noted in previous EFP reports, to increase the area from which salmon can get out of the flow of pollock and eventually escape the net.

Recapture nets were not a feasible option for quantifying escapes so underwater video cameras were used to monitor escapes, with one camera placed to view the entire escape hole at the top, another at the bottom. These camera systems (Figure 11), manufactured by Mac Marine Instruments and purchased in 2012 by the North Pacific Fisheries Research Foundation, are depth rated for 1,000 meters and come with digital video recorder, battery, light, and camera lens. All components are integrated into single, acrylic tube pressure housing that makes the system waterproof to approximately 1,000 meters. The internal chassis holds all components and is removable for battery charging and downloading of video data – it can be rotated and the wide-angle lens reversed to obtain the desired view when mounted on fishing gear. Battery capacity allows for about 6 hours of continuous video recording with light, depending on the intensity of the light which can be adjusted. Overall, these camera systems are light weight, simple to operate and have proven to be very reliable. Issues that did arise were batteries expending their charge before haulback, fussy DVR's, and occasional moisture in the tubes (condensation). This resulted in some loss of video time. EFP hauls with incomplete video were excluded from the analyses since it could not be certain that all escapes were accounted for.

Although it is commonly believed by fish behavior experts (scientists and many fishermen) that light affects fish behavior, there was clearly no option but to use light to observe fish behavior via video in order for the video reviewers to count escapes. Specifically, many believe that light attracts fish, particularly salmon, but effects of light on behavior are actually unknown based on our observations of the reactions of fish to the lighting used with our camera deployments. Although the light was mostly directed outward towards and out of the escape holes, the areas were clearly well lit. One possibility for future trials is to experiment with red spectrum lights, not detectable by fish. Admittedly, our approach with the use of lights assumes that escapement results from our testing are still representative of what

fishermen would achieve without adding artificial light when excluder devices are used in normal fishing operations.

At the outset it was hoped that salmon viewed on the video footage could be identified to species but this proved not to be possible (with certainty, anyway). Therefore, all salmon data for O/U tests in this EFP were aggregated to include both Chinook and non-Chinook species. It should be noted that the vast majority of landed salmon (salmon recovered in the test vessels' codends), all of which were identified to species, were Chinook (886 out of 954). Only 68 non-Chinook (Chum) salmon were landed over all trials, 59 of which (89%) were taken during the fall of 2014. From this we have inferred that escapement was predominately comprised of Chinook, but this cannot be known definitively. Generally speaking, it is safer to expect that testing during winter encountered only Chinook salmon. In fall, however, a greater fraction of chum salmon can be expected although salmon bycatch in the GOA pollock fishery is still primarily Chinook, even in the fall. The fish collected in the codends during the O/U trials and those collected in the codends and recapture nets during the flapper excluder tests certainly followed this pattern.

Pollock escapement by weight was calculated by applying the average weight for the haul to the tallied number of pollock seen escaping on the available video footage.

Figure 11. Acrylic tube underwater video camera placed in the net to monitor fish escapes. One was placed near the top portal, one at the bottom escape portal

The results from the first GOA O/U trial (Caravelle fall 2013) were encouraging (Table 3 shows results from all 20 hauls and from the 16 hauls with complete video which is what was used to calculate our escapement rates). Of the 16 EFP hauls with 100% complete video, there were 103 landed salmon (one of which was Chum) and 77 escapes noted in the video (42.8% escapement). Pollock escapement averaged 2.9% but ranged from 1%-8% (higher than observed during the Bering Sea trials).

The majority of salmon escapements were out the top excluder (62%) whereas the majority of the pollock escapes were out the bottom excluder (75%). Table 3 also summarizes salmon escapes by portal (top or bottom) and by time (while towing at depth, during turnarounds when the doors are brought up to the surface, or during haulback). More than half of the escapes occurred during turnarounds or at haulback (57% of all escapes) but still a meaningful percentage did occur while towing (43%). Broken down this way, most escapes occurred through the top excluder while towing (32 of the 77 observed escapes or 41.6%).

Table 3. Fall 2013 Caravelle O/U results (All EFP hauls and EFP hauls with complete video*).*

Salmon escapes		Total
54	35	**89**
60.7%	39.3%	**39.6%**
from top	from btm	

Pollock escapes (mt)		Total
3.92	13.23	**17.15**
22.9%	77.1%	**2.8%**
from top	from btm	

All Hauls included (1-20)

Salmon escapes		Total
48	29	**77**
62.3%	37.7%	**42.8%**
from top	from btm	

Pollock escapes (mt)		Total
3.49	10.49	**13.98**
25.0%	75.0%	**2.9%**
from top	from btm	

Hauls 1, 18-20 excluded (missing video)

	Escapes while towing		Escapes at turnaround		Escapes at haulback		Total
	Top	Bottom	Top	Bottom	Top	Bottom	Escapes
No. Escapes	32	1	11	6	5	22	77
% of Total	41.6%	1.3%	14.3%	7.8%	6.5%	28.6%	100.0%
% of Total	42.9%		22.1%		35.1%		100.0%
% of Total	42.9%		57.1%				100.0%

Spring/Fall 2014: "Over/Under" (O/U) design (version 2) using video cameras to measure escapement rates: F/V Caravelle, F/V Alaska Beauty

Both EFP vessels tested a second version of the O/U design in the spring and fall of 2014, the second year of the EFP. Based on additional flume tank work with models and feedback from the second trip to the flume tank in November 2013, the design was modified to further increase the space available for the salmon to escape by creating bigger "scoops" of the top and bottom panels. Figure 12 shows the version 2 model tested at the flume tank, Figure 13**Figure *13*** and Figure 14 show the schematics and underwater snapshots of the excluders used on both vessels in the spring and fall of 2014. In addition to greater scoops, the float rope (which proved to be less durable than was expected) was replaced with more durable 5" fishing floats. There were no changes between the spring and fall 2014 – both vessels tested the same excluder during both seasons.

Spring 2014: The excluder was placed at the aft end of the last tapered section in the Caravelle net, at the forward end of the last tapered section in the Alaska Beauty net (both with zero overlap, see Figure 13). Both vessels initially used 100 mesh long packing tubes forward of the codend but the Caravelle switched to a 200 mesh long tube after 7 hauls due to high pollock escapement (discussed below).

Figure 12. Over/Under Excluder v.2, Flume tank model, Memorial University, St. Johns, Newfoundland Fall 2013. Zero overlap.

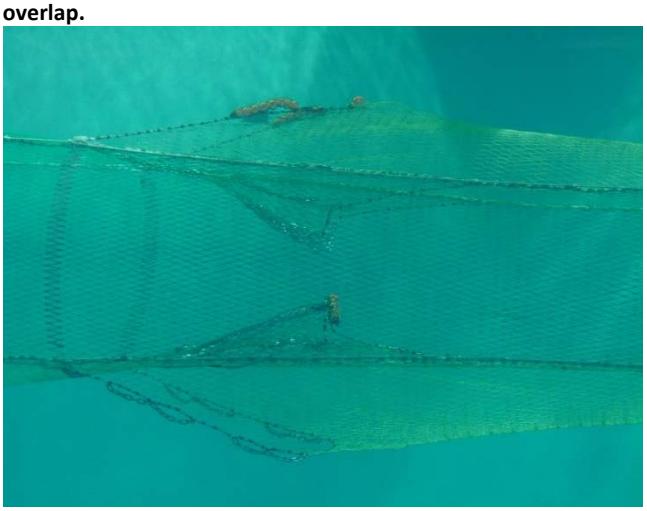


Figure 13. V.2 Over/Under Excluder designs for the Caravelle and Alaska Beauty used during the spring and Fall 2014 EFP trials. The excluder was placed at the aft end of the last tapered section in the Caravelle net, at the forward end of the last tapered section in the AK Beauty net (zero overlap). Cross section is below, showing the larger "scoops" in this design with the goal of increasing the area available for escapement. Video cameras were used to monitor and quantify salmon and pollock escapes.

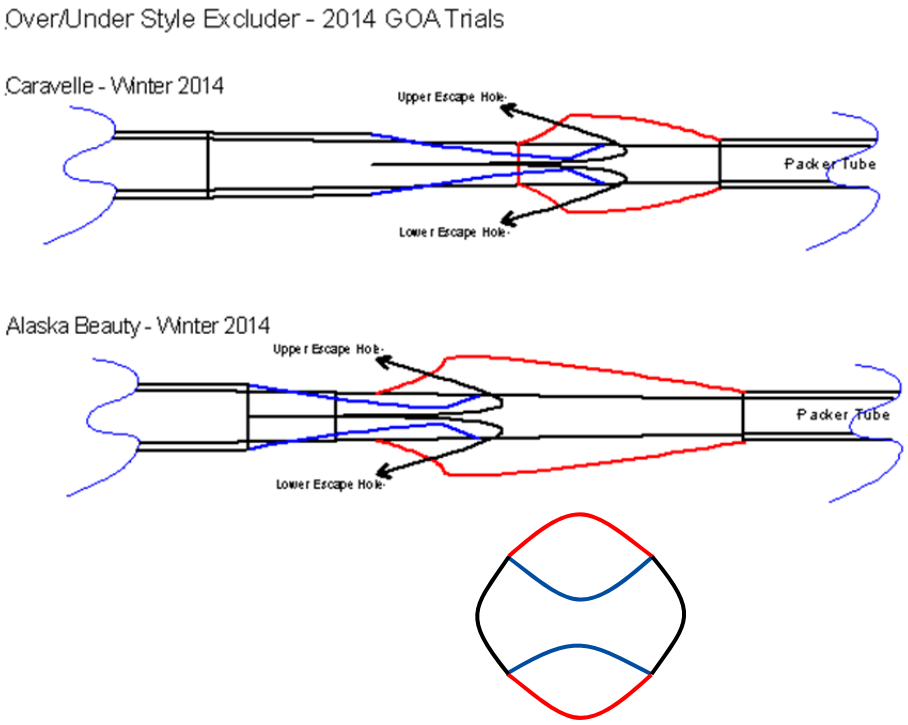


Figure 14. 2014 v 2 O/U excluders: Caravelle (left), Alaska Beauty (right). View is looking forward in the net from the aft end of the excluder.

Caravelle Spring 2014: Of the 15 EFP hauls on the Caravelle, about 2 hours of video (one from top camera, one from the bottom) were lost due to battery failures on one haul. Since the fraction of time when video was not working was minimal, this haul was still included in the analysis. A total of 132 hours of video footage was reviewed for salmon and pollock escapes on the Caravelle - pollock escapement by weight was calculated by applying the average weight of adults to the number of adult pollock observed escaping. Juvenile pollock escapement was not tallied because most of this was escapement through the net's meshes and probably unrelated to the excluder itself. There were two phases to this leg of the EFP on the Caravelle: Phase I (hauls 1-7) had a 100 long mesh packing tube forward of the codend. For Phase II (hauls 8-15), the 100 mesh tube was replaced with a 200 long mesh tube in an attempt to reduce pollock escapement.

The overall salmon escapement rate was about 38% for both phases (38.5% phase I, 37.5% phase II). Pollock escapement averaged 9.8% for Phase I but tow to tow rates ranged from 4.3%-18%. Pollock escapement dropped significantly during phase II (2.2%, range .9%-5%) when the 100-mesh tube was switched out for a 200-mesh tube (Table 4). Relatively low salmon numbers were an issue in the spring of 2014: only 55 salmon were seen in the 15 EFP hauls (34 in the codends – all Chinook, 21 video escapes). 39 salmon were observed in phase I, only 16 in phase II. That the EFP testing encountered low abundance of salmon was not surprising given salmon bycatch was also low during the open access Central GOA pollock season immediately preceding the EFP. Keeping in mind the low number of salmon encountered during this EFP leg, the majority of salmon escapements for phase I were out the top excluder (73%); the majority of pollock escapement was also out the top (65.5%). For Phase II, the majority of salmon and pollock escapes were out the bottom excluder (66.7% and 72.5% respectively). This pattern of lower/upper escapement portal and pollock/salmon escapement rates followed what occurred in the first O/U trail exactly. The issue of low salmon numbers was especially prevalent during Phase II: only 6 escapes were seen during this phase (10 salmon in the landed codends). Table 4 also summarizes salmon escapement by portal (top or bottom) and by time of escapement (while towing at depth, during turnarounds when the doors are brought up to the surface, or during haulback). The majority of escapes occurred while towing at depth (71% of all escapes) and of these, most escaped out the top portal. Broken down this way, most escapes occurred through the top excluder while towing, similar to the results from fall 2013 (12 of the 21 observed escapes or 57%).

Table 4. Spring 2014 Caravelle summarized escapement results for P1 and P2. The third table summarizes escapes by portal and time of tow.

Caravelle Phase I, Spring 2014 (100 mesh packing tube)

Salmon escapes		Total
11	4	**15**
73.3%	26.7%	**38.5%**
from top	from btm	

Pollock escapes (mt)		Total
15.52	8.17	**23.69**
65.5%	34.5%	**9.8%**
from top	from btm	

Caravelle Phase II, Spring 2014 (200 mesh packing tube)

Salmon escapes		Total
2	4	**6**
33.3%	66.7%	**37.5%**
from top	from btm	

Pollock escapes (mt)		Total
1.42	3.74	**5.16**
27.5%	72.5%	**2.2%**
from top	from btm	

	Escapes while towing		Escapes at turnaround		Escapes at haulback		Total
	Top	**Bottom**	**Top**	**Bottom**	**Top**	**Bottom**	**Escapes**
No. Escapes	12	3	0	3	1	2	21
% of Total	57.1%	14.3%	0.0%	14.3%	4.8%	9.5%	100.0%
% of Total	71.4%		14.3%		14.3%		100.0%
% of Total	71.4%		28.57%				100.0%

<u>Alaska Beauty Spring 2014</u>: Of the 17 EFP hauls on the Alaska Beauty, 5 were removed from the analysis due to incomplete video. This left 132 hours of video footage to review for salmon and pollock escapes. Low salmon numbers were also an issue for the Alaska Beauty - only 70 salmon were observed over the 17 hauls (48 in the codends – all Chinook except one, 22 video escapes). As already noted, salmon bycatch was also low during the open access Central GOA pollock season immediately preceding the EFP. Table 5 summarizes the Alaska Beauty spring 2014 results. In brief, salmon escapement averaged 36%, pollock escapement 1.8%. The majority of escapes occurred while towing at depth (62% of all escapes) and of these, all escaped out the top portal.

Table 5. Spring 2014 Alaska Beauty summarized escapement results (all hauls and only those with complete video).

Salmon escapes		Total
17	5	**22**
77.3%	22.7%	**37.9%**
from top	from btm	

All Hauls included (1-17)

Pollock escapes (mt)		Total
2.81	7.35	**10.16**
27.7%	72.3%	**1.5%**
from top	from btm	

Salmon escapes		Total
16	5	**21**
76.2%	23.8%	**36.2%**
from top	from btm	

Excluding 5 hauls with incomplete video

Pollock escapes (mt)		Total
1.31	5.43	**6.74**
19.4%	80.6%	**1.8%**
from top	from btm	

	Escapes while towing		Escapes at turnaround		Escapes at haulback		Total
	Top	**Bottom**	**Top**	**Bottom**	**Top**	**Bottom**	**Escapes**
No. Escapes	13	0	2	2	1	3	21
% of Total	61.9%	0.0%	9.5%	9.5%	4.8%	14.3%	100.0%
% of Total	61.9%		19.0%		19.0%		100.0%
% of Total	61.9%		38.1%				100.0%

Caravelle fall 2014: For the fall testing, the Caravelle continued using the 200-mesh packing tube it had used in the spring still placed at the aft end of the last tapered section in the net, and there were no other changes to the O/U excluder. Of the 21 EFP hauls, 23 hours of video (12% of the total) were lost – data from these six hauls were left out of the analysis. A total of 169 hours of video footage were reviewed for salmon and pollock escapes. The salmon encounter rate was much higher compared to previous trials: 441 Salmon (landed and escapes) during this leg compared to 55 in the spring. Of the 202 landed salmon (two were landed at the plant – missed during sorting on deck - and not attributed to any haul), 153 (76%) were Chinook, 49 were chum. Interestingly, the fall of 2014 saw the most Chum salmon of any of the EFP legs. In summary, the overall salmon escapement rate was about 54% (95% CI 46-59%), pollock escapement about 1.2%. (95% CI 1-1.4%) This was a notable increase in escapement compared to 38% and 2.2% respectively observed during the trials on the Caravelle during the spring of 2014. Again, the majority of salmon escapements were out the top excluder (69% compared to 62% in the spring). Pollock escapement was about even between the top and bottom portals (Table 6). Contrary to the spring when the majority of escapes occurred while towing at depth (71% of all escapes compared to this trial with 34%), most escapes during this trial occurred during haulbacks or turnarounds (66% of all escapes with escapement at haulbacks about twice that at turnarounds) and most of those were out the top (59%). Overall, the Caravelle fall 2014 trials were remarkable for consistently moderate to high salmon numbers and very high and relatively consistent salmon escapement rates over all the 21 hauls. These hauls occurred over six trips, three in Uyak Bay, Shelikof Strait, three on the east side of Kodiak in an area referred to as the sandbox. With these different fishing areas and the duration over which the testing occurred, these are impressive escapement results that occurred over a variety of fishing conditions, pollock catch rates, and fishing areas (Table 7). Overall, the fall 2014 Caravelle results are the best salmon excluder performance obtained since the project started in 2003, particularly with the consistency in salmon escapement rates over all of the EFP tows and hence tight confidence interval around the mean escapement rate.

Table 6. Fall 2014 Caravelle summarized escapement results – all hauls and only those with complete video.

All Hauls

Salmon escapes		Total
173	66	**239**
72.4%	27.6%	**54.4%**
from top	from btm	

Pollock escapes (mt)		Total
3.57	4.16	**7.73**
46.2%	53.8%	**1.1%**
from top	from btm	

Hauls w/ 100% complete video

Salmon escapes		Total
143	63	**206**
69.4%	30.6%	**54.4%**
from top	from btm	

Pollock escapes (mt)		Total
2.81	3.13	**5.94**
47.3%	52.7%	**1.2%**
from top	from btm	

	Escapes while towing		Escapes at turnaround		Escapes at haulback		Total
	Top	**Bottom**	**Top**	**Bottom**	**Top**	**Bottom**	**Escapes**
No. Escapes	63	7	24	19	56	37	206
% of Total	30.6%	3.4%	11.7%	9.2%	27.2%	18.0%	100.0%
% of Total	34.0%		20.9%		45.1%		100.0%
% of Total	34.0%		66.02%				100.0%

Table 7. Haul by haul escapement data, Caravelle Fall 2014 EFP trials

	Salmon No.			Escape Rate	Pollock (mt)		Escape Rate	CPUE
Haul	**Codend**	**Escapes**	**Total**	**Salmon %**	**Codend**	**Escapes**	**Pollock %**	**(mt/hr)**
1	2	1	3	33.3%	44.1	0.33	0.8%	11.1
2	27	33	60	55.0%	22.9	0.19	0.8%	6.5
3	9	13	22	59.1%	41.7	0.43	1.0%	10.0
4	13	6	19	31.6%	20.6	0.12	0.6%	7.5
5	1	1	2	50.0%	40.1	0.13	0.3%	6.1
6	33	44	77	57.1%	16.0	0.18	1.1%	4.4
7	5	3	8	37.5%	24.2	0.07	0.3%	5.3
8	14	7	21	33.3%	19.4	0.10	0.5%	10.5
9	12	16	28	57.1%	37.7	0.31	0.8%	9.7
10	8	21	29	72.4%	20.6	0.15	0.7%	5.4
11	32	54	86	62.8%	4.2	0.03	0.8%	2.3
12	4	12	16	75.0%	42.9	0.65	1.5%	9.1
13	1	3	4	75.0%	34.7	0.55	1.6%	6.1
14	4	3	7	42.9%	15.4	0.20	1.3%	3.9
15	4	4	8	50.0%	61.4	0.83	1.3%	18.1
16	0	1	1	100.0%	30.7	0.89	2.8%	5.4
17	0	0	0	-	18.0	0.47	2.5%	5.9
18	18	13	31	41.9%	56.3	0.43	0.8%	11.3
19	0	1	1	100.0%	55.7	0.53	0.9%	11.4
20	4	2	6	33.3%	48.5	0.58	1.2%	23.4
21	9	1	10	10.0%	27.9	0.55	1.9%	22.34
Total	**200**	**239**	**439**	**54.4%**	**682.79**	**7.73**	**1.1%**	**7.58**

** Shaded cells denote missing video*

Alaska Beauty Fall 2014: There were no changes to the O/U excluder, still placed at the forward end of the last tapered section in the net. Of the 19 EFP tows, six were removed from the analysis due to incomplete video or net malfunction. A total of 140 hours of video were reviewed for salmon and pollock escapes. This EFP trial had surprisingly lower salmon numbers compared to F/V Caravelle: only 60 salmon (44 in the codend and 16 video escapes), were encountered. Of the 44 salmon collected from the codend, 34 (77%) were Chinook, 10 were Chum. Overall, salmon escapement was 34% and pollock escapement was 1.2%. This compares with escapement rates during the Spring EFP trials of 36% and 1.9% respectively. As on the Caravelle, the majority of salmon escapes (73%) occurred through the top escapement portal; most pollock escaped out the bottom portal (72%). Also similar to the Caravelle results, most salmon escapes took place either at the turnarounds or at haulback (67%). See Table 8. Haul by haul data for Alaska Beauty's fall 2014 EFP tests is detailed in Table 9.

Table 10 and Figure 15 summarize the data from all O/U EFP trial legs by vessel and season. Figure 16 plots the length frequencies for all the landed Chinook and random samples of pollock over all O/U trials.

Table 8. Fall 2014 Alaska Beauty summarized escapement results (hauls with incomplete video excluded*).*

Salmon escapes		Total
11	4	**15**
73%	27%	**34.1%**
from top	from btm	

Pollock escapes (mt)		Total
1.79	4.49	**6.28**
28.5%	71.5%	**1.2%**
from top	from btm	

	Escapes while towing		Escapes at turnaround		Escapes at haulback		Total
	Top	Bottom	Top	Bottom	Top	Bottom	
No. Escapes	5	0	5	1	1	3	**15**
% of Total	33.3%	0.0%	33.3%	6.7%	6.7%	20.0%	**100.0%**
% of Total	33.3%		40.0%		26.7%		**100.0%**
% of Total	33.3%		66.7%				**100.0%**

Note: Only 1 additional salmon escape was observed in the 6 hauls with incomplete data - this occurred through the bottom portal on haulback.

Table 9. Haul by haul escapement data, Alaska Beauty Fall 2014 EFP trials

	Salmon No.			Escape Rate	Pollock (mt)		Escape Rate	Catch Rate
Haul	**Codend**	**Escapes**	**Total**	**Salmon %**	**Codend**	**Escapes**	**Pollock %**	**mt/hr**
1	4	0	4	0.0%	5.4	0.00	0.0%	11.17
2	2	1	3	33.3%	34.2	0.16	0.5%	12.75
3	2	6	8	75.0%	36.6	0.10	0.3%	10.36
4	1	0	1	0.0%	43.6	0.34	0.8%	9.69
5	1	0	1	0.0%	14.6	0.16	1.1%	62.57
6	2	1	3	33.3%	101.0	0.72	0.7%	26.93
7	0	0	0	-	85.6	1.14	1.3%	35.42
8	0	0	0	-	18.7	0.30	1.6%	22.44
9	7	4	11	36.4%	45.9	0.40	0.9%	14.27
10	5	1	6	16.7%	34.7	1.00	2.8%	6.94
11	5	0	5	0.0%	26.4	0.66	2.4%	5.14
12	1	0	1	0.0%	78.0	0.93	1.2%	16.25
13	5	0	5	0.0%	11.2	0.26	2.2%	1.79
14	2	0	2	0.0%	22.4	0.21	0.9%	12.00
15	1	1	2	50.0%	31.4	1.26	3.9%	8.37
16	1	0	1	0.0%	16.8	0.67	3.8%	5.93
17	1	0	1	0.0%	9.2	0.22	2.4%	1.83
18	3	2	5	40.0%	56.8	0.42	0.7%	16.62
19	1	0	1	0.0%	29.7	0.06	0.2%	17.13
Total	**44**	**16**	**60**	**26.7%**	**702.2**	**9.22**	**1.3%**	**11.43**

** Shaded cells denote missing video or net malfunction*

Table 10. O/U excluder test results by vessel and EFP leg.

Vessel/Season (Over/Under excluder)		No. EFP Hauls*	No. Salmon in Codend	No. Salmon Escapes	Salmon Escape Rate	Poll Escape Rate
Caravelle/Fall 2013	v.1	16	103	77	42.8%	2.9%
Caravelle/Spring 2014 P1	v.2	7	24	15	38.5%	9.8%
Caravelle/Spring 2014 P2	v.2	8	10	6	37.5%	2.2%
Caravelle/Fall 2014	v.2	15	173	206	54.4%	1.2%
AK Beauty/Spring 2014	v.2	12	37	21	36.2%	1.8%
AK Beauty/Fall 2014	v.2	13	29	15	34.1%	1.2%

*Hauls with incomplete video excluded

Figure 15. Salmon and pollock escape rates using the over/under style salmon excluder: by EFP leg/vessel with 95% CI boundaries. P1 = Phase I, P2 = Phase II. Data set resampled 5000x.

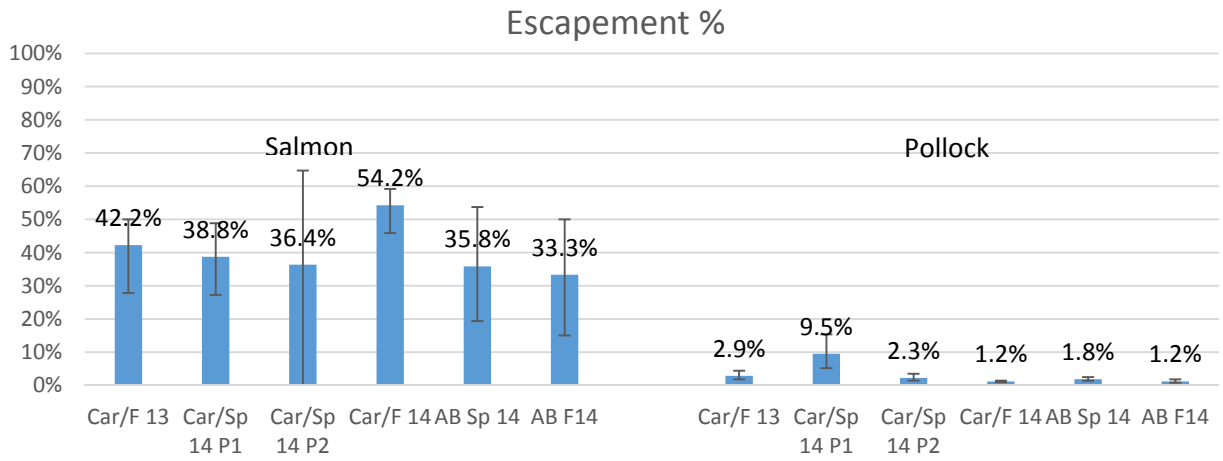
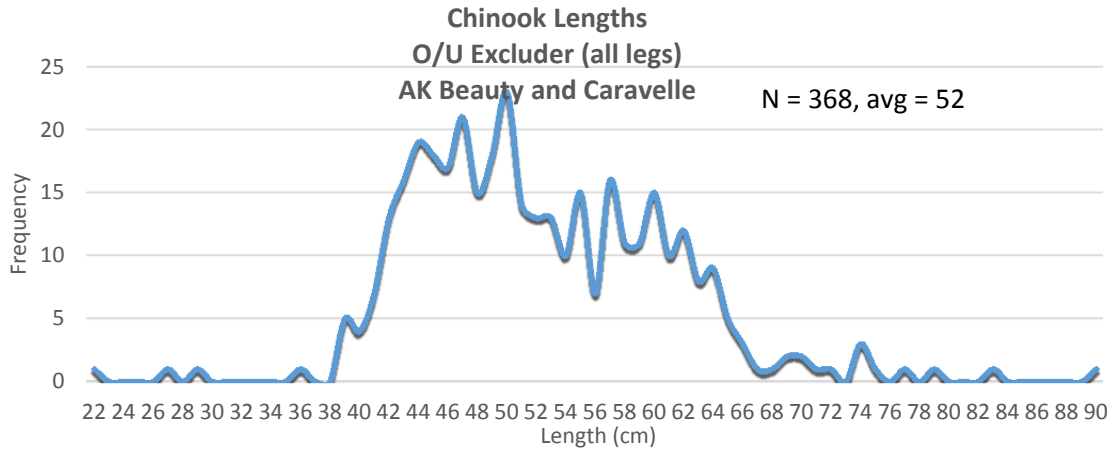
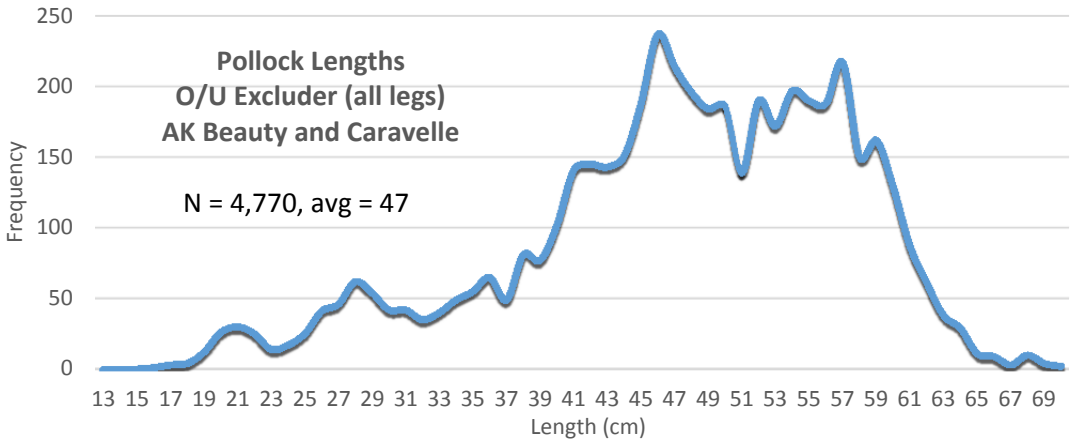


Figure 16. Length frequencies, O/U excluder trials: Chinook salmon (top) and pollock (bottom). Landed fish only.





Salmon and pollock escape rates versus CPUE (catch per unit effort): To examine whether or not salmon or pollock escapement varied with pollock catch rates, CPUE was plotted against the escape rates over all O/U hauls that had salmon (61 tows) – see Figure 17 and Figure 18 (note different y-axis scales). There was no easily detectable relationship between the two variables, although the escape rates appear to decrease slightly with higher CPUE. For pollock escapement, the expectation would be that greater rates of escapement would occur when pollock catch per hour was greater. In fact, that is not seen in the data. The reason for this not evident but it suggests that pollock escapement in not necessarily related to factors fishermen expected such as crowding as the fish pass through the net or slowing down of the flow through the net with the filling or over-filling of the codend.

Figure 17. Salmon escape rate vs. CPUE for all O/U EFP hauls combined (excluding hauls with zero salmon and incomplete video). N=61.

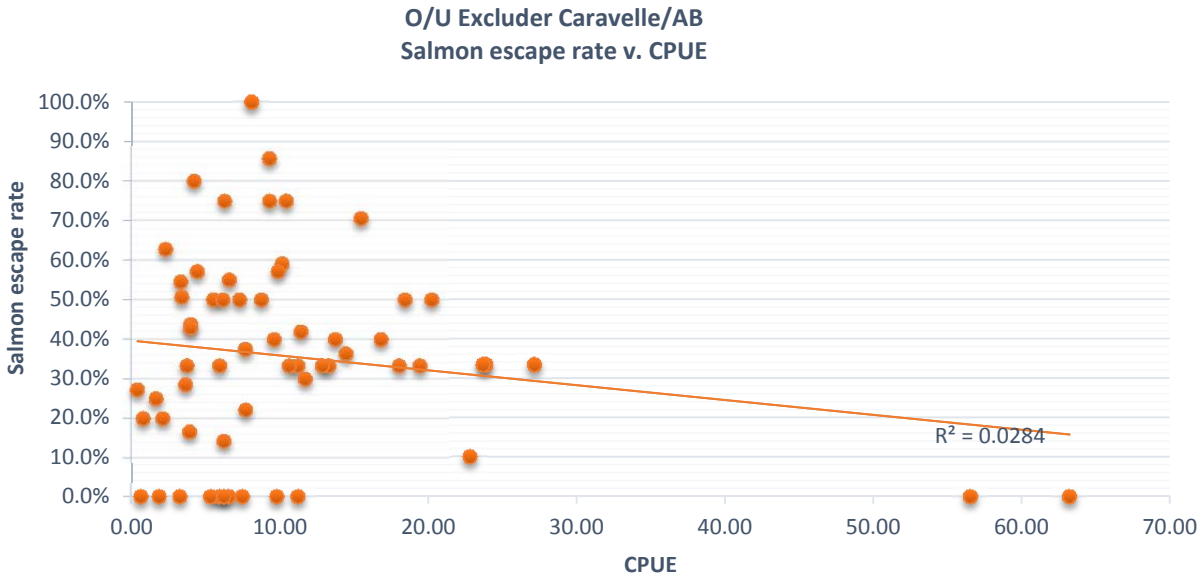
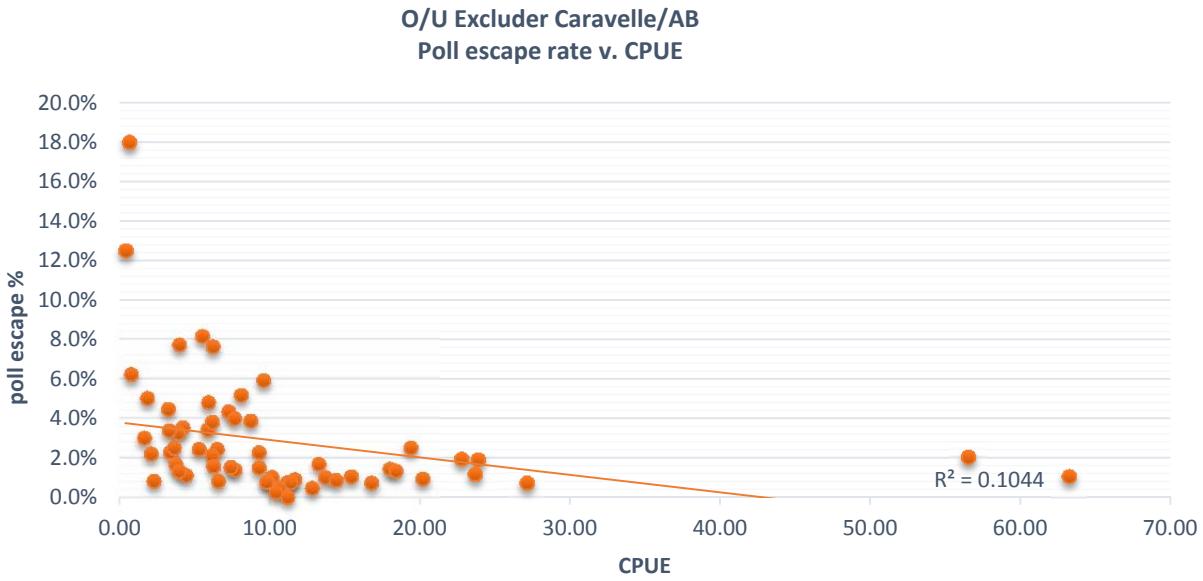


Figure 18. Pollock escape rate vs. CPUE for all O/U EFP hauls combined (excluding hauls with zero salmon and incomplete video). N=61.



Chinook Genetics: Of the total 878 Chinook scanned for presence/absence of coded wire tags across all trips, 73 were positive for CWT (8.3%) and the snouts collected and sent to the NMFS Auke Bay genetics lab for processing. See Table 11. 139 Chinook (15.8%) has an adipose fin clip. Tissue samples (PAP's) were collected only once during the EFP – on the Caravelle during the spring of 2013 (Uyak Bay). One haul had >50 Chinook and from this haul 105 PAP's were collected and sent to Auke Bay Lab for DNA analysis: the stock composition results showed that the majority of those Chinook salmon originated from West Coast U.S. (79%), British Columbia (17%), and Coastal Southeast Alaska (2%) stocks (see: Guyon et al, 2015).

Table 11. Summary of CWT and DNA sampling for genetic stock of origin analysis, by EFP vessel/leg

EFP Leg	Excluder Design	Total # Chinook in Hauls (landed)*	No. Chinook genetic samples	Total # Chinook Scanned	Total # Chinook Positive Signal	Total # Chinook missing adipose fin	Total # snouts Collected
Caravelle Sp 13	Flapper	208	105	208	32	47	32
AB Sp 13	Flapper	170	0	170	16	17	16
AB Fall 13	Flapper	95	0	95	3	9	3
Caravelle Fall 13	O/U	138	0	138	3	18	3
Caravelle Sp 14	O/U	35	0	35	3	6	3
AB Sp 14	O/U	47	0	47	1	5	1
Caravelle Fall 4	O/U	151	0	151	15	32	15
AB Fall 14	O/U	34	0	34	0	5	0
Totals		**878**	**105**	**878**	**73**	**139**	**73**
*does not include some salmon missed at sea and landed at the plant (8 Chinook across all trips)						15.8%	8.3%

EFP Harvests and catch accounting: Table 12 and Table 13 detail the harvests of groundfish and Chinook salmon by vessel and season. 886 Chinook were landed (video escapes not included) over all four legs of the project, 18% of the 4,800 salmon EFP limit. 4,733 mt of groundfish were harvested of the 4,800 mt limit (2,326 mt in 2013, 2,407 mt in 2014; the 2014 limit of 2,400 mt was exceeded by 7 mt which was deducted from the limited access pollock TAC). Groundfish totals do not include weights of salmon, halibut, herring (PSC species) or non-allocated species such as eulachon and lumpsuckers. At-sea discards were included: big skates which went on PSC status in the GOA on May 8 in 2013 and on February 5 in 2014 and were required to be discarded at sea; and large sharks which were discarded at sea due to the difficulty of putting them in an RSW tank and bringing them back to port. Similarly, POP went on PSC status in the CGOA on August 19 in 2014 and was therefore required to be discarded at sea during the fall 2014 trials. There were a total of 68 non-Chinook (Chum) salmon landed over all trials, 59 of which (89%) were taken during the fall of 2014. Note: Over all trials, 11 Chinook and one Chum salmon were missed during sorting at sea (landed and accounted for at the plant). Because the hauls were mixed in the tanks, these salmon could not be attributed to a specific haul and were therefore not included in the data for analysis of escapement rates.

Table 12. EFP 13-01 limits and harvests by vessel, season, year*. Minor differences due to rounding.

		Harvests				
	Limit	Car Sp 13	AB Sp 13	Car Fall 13	AB Fall 13	**2013 Totals**
Groundfish (mt)	2,400	498	577	663	588	**2,326**
Pollock (mt)	n/a	491	572	646	576	**2,285**
Chinook (no. landed)	2,400	210	170	141	95	**616**
Halibut PSC (mt)	4	0	0.004	0.009	0.000	**0.013**
	Limit	Car Sp 14	AB Sp 14	Car Fall 14	AB Fall 14	**2014 Totals**
Groundfish (mt)	2,400	472	521	745	669	**2,407**
Pollock (mt)	n/a	471	520	734	663	**2,388**
Chinook (no. landed)	2,400	36	47	153	34	**270**
Halibut PSC (mt)	4	0	0.000	0.019	0.000	**0.019**

	Limit	Caravelle	AK Beauty	**EFP Totals**
Groundfish (mt)	4,800	2,378	2,356	**4,733**
Pollock (mt)	n/a	2,341	2,332	**4,673**
Chinook (no. landed)	4,800	540	346	**886**
Halibut PSC (mt)	4	0.028	0.004	**0.032**

* Halibut PSC cap is over all seasons, not annual. Groundfish weight does not include non-allocated species (including eulachon, capelin, smelt) or PSC

Table 13. EFP harvests (lbs) by species, 2013 and 2014 (landed and discarded at sea). Allocated species do not include forage fish or PSC species. Source: elandings

Species	2013	2014	Total	% of Total
Pollock	5,036,043	5,264,462	10,300,505	98.3%
Cod	5,835	18,331	24,166	0.2%
Arrowtooth	18,773	11,009	29,782	0.3%
POP	8,390	4,208	12,598	0.1%
Dusky rockfish	44	70	114	0.0%
Flathead sole	837	401	1,238	0.0%
Rex sole	291	756	1,047	0.0%
Rock sole	34	0	34	0.0%
Rougheye rockfish	2	10	12	0.0%

Sculpin	32	0	32	0.0%
Skate	18	0	18	0.0%
Big skate	0	128	128	0.0%
Longnose skate	189	626	815	0.0%
Octopus	0	47	47	0.0%
Squid	47,712	1,579	49,291	0.5%
Shark	500	0	500	0.0%
Sleeper shark	1,600	2,625	4,225	0.0%
Salmon shark	4,900	1,420	6,320	0.1%
Spiny dogfish	350	194	544	0.0%
Lumpsucker	2,256	230	2,486	0.0%
Grenadier	0	50	50	0.0%
Capelin	2,947	8,599	11,546	0.1%
Eulachon	25,542	3,284	28,826	0.3%
Herring	0	23	23	0.0%
Total (lbs)	**5,156,295**	**5,318,052**	**10,474,347**	**100.0%**
Allocated (lbs):	**5,125,550**	**5,305,866**	**10,431,416**	
Allocated (mt):	**2,325**	**2,407**	**4,732**	

Discussion:

Degree to which methods employed for data collection were successful

In terms of assessing the methods used in this EFP, those used to account for the effect of the excluder on catch rates worked well overall. Reasonably accurate hauls weight estimates were necessary in order to estimate pollock escapement rates (pollock escapement rate = total weight of escapes divided by total weight of pollock in the haul plus weight of pollock escapes). Initially there was some doubt that acceptable haul weight estimates could be arrived at given that these smaller GOA pollock vessels did not have motion compensated flow scales as were available Bering Sea catcher vessels and catcher processors selected in the past by NMFS for the EFP. Although the haul weight estimates on the Caravelle and Alaska Beauty were not as precise as those on the Bering Sea vessels, the volumetric and weight estimation methods used (dump box weight using a brailer scale - used on salmon boats and tested at the plant - or volumetric estimates) proved to function sufficiently well. This is encouraging for our collective ability to do excluder testing on smaller catcher vessels as we are now launching into the next phase of salmon excluder work in the Bering Sea and will be using these same methods on the Bering Sea pollock vessels selected for the testing that are not equipped with flow scales. Use of these less expensive and more accessible methods will greatly expand the pool of vessels that can apply for future salmon excluder EFP's.

Without haul weight estimates from another source to compare, we cannot measure the accuracy of the at-sea haul weight estimates, but trip by trip comparisons with fish tickets showed trip totals matched within an approximated range of 3-7%. Because the Alaska Beauty was not able to estimate the weight of pollock in each haul through species composition sampling, the pollock escapement rates may be slightly underestimated (since total groundfish, not just pollock, in the haul was compared to the weight of pollock escapes), although pollock accounted for 98.3% of the total catch (Table 13).

There were pros and cons to using underwater video to quantify escapement in the O/U trials versus the previous method of recapture nets. The biggest obstacle was losing data (video) due to battery or camera failure. This was less of an issue in the Bering Sea fall 2012 trials (the first time the video method was employed in these EFP's) because there were two cameras monitoring each portal (four cameras per haul). The second camera in the Bering Sea trials provided a backup in case one of the cameras failed since each camera had a complete view of the escape hole. Although the design and reliability of the cameras used for this EFP are much improved over previous systems, battery capacity, DVR performance and operator error (given the complexity of operating the systems) are still issues that need to be considered. The battery issue is probably the most limiting– even when fully charged (according to the indicator on the charger), capacity varied depending on the battery and camera used, intensity of light level and length of haul. Temperature was also a factor for battery life and it was therefore very difficult to predict how long any one battery would last for any particular tow. Even when the lights were turned down to the lowest level and operators confined their tow times to 5-6 hours, there were still times when the cameras came back to the boat with dead batteries. Table 14 details the number of hauls excluded from the data sets due to missing video: about 24% of the hauls were excluded, a rate that could be much reduced with a backup camera in each portal.

Table 14. O/U EFP hauls with complete and incomplete video to monitor escapes. Except for Caravelle Spring 2014 trial (one haul missing about 1 hour from each camera at haulback), EFP hauls with missing video were excluded from data analysis since total escapes could not be determined.

O/U EFP Leg	Hauls w/ complete video	Hauls w/missing video	Total EFP Hauls	% of Hauls lost
Caravelle/Fall 2013	16	4	20	20.0%
Caravelle/Spring 2014 P1	6	1	7	14.3%
Caravelle/Spring 2014 P2	8	0	8	0.0%
Caravelle/Fall 2014	15	6	21	28.6%
AK Beauty/Spring 2014	12	5	17	29.4%
AK Beauty/Fall 2014	13	6	19	31.6%
Total	**70**	**22**	**92**	**23.9%**

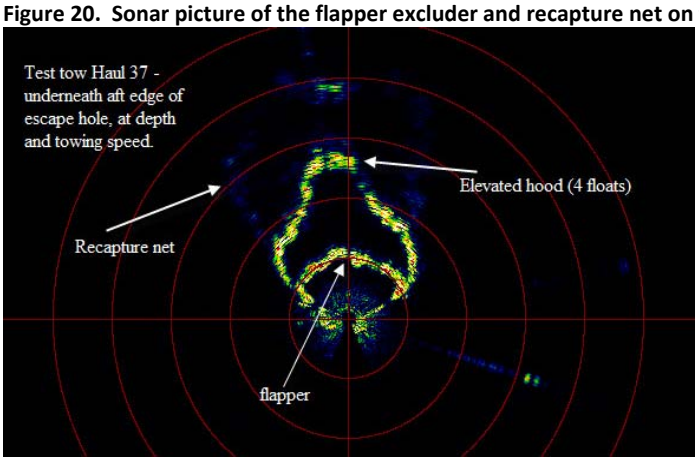
Discussion of performance of salmon excluders tested in this EFP for the CGOA pollock fishery**:**

One clear lesson from this EFP is that for the lower horsepower vessels of the CGOA pollock fishery, the flapper excluder is unlikely to be the best option for reducing salmon bycatch rates as it has been shown to do in the Bering Sea. Even where it has proven to be a workable excluder in the Bering Sea, achieving the proper weighting and shape of the flapper excluder requires extensive underwater observations and modifications of the weight on the panel (lead line amount and positioning). Whereas the flapper excluder might require as much as 160 lbs in the Bering Sea on a catcher processor (F/T Starbound, 2011/12) to achieve the desired shape, the Caravelle and Alaska Beauty excluders eventually ended up with only 15 lbs total on their panels to get lift off the bottom. Clearly this was because the force of the water flow in the net was much lower on these less powerful boats with smaller nets. Even when the proper positioning was arrived at once the weight was reduced to 15 lbs, the flapper panel positioning was highly variable ranging from the desired amount of room for escapement to little to no room for fish passage out of the net. This is likely inevitable for CGOA boats because the lower water flow results

in low but variable flow instead of the higher degree of consistency in position for Bering Sea boats with steadier water flow and large amount of weighing that achieves a more consistent opening. The low flow on CGOA vessels probably explains the high degree of uncertainty around the results of the flapper excluder tests on the Caravelle and Alaska Beauty (Table 2 and Figure 7). The use of a recapture net with low flow and highly variable degree of access to the escapement portal likely also contributed to the uncertainty around escapement results. The clearance seen with recapture net usage in the Bering Sea trials was certainly not achieved on the GOA vessels. Figure 19 shows the recapture net on the Starbound, a medium sized Bering Sea catcher processor, and on the Caravelle during the spring of 2013. A sonar snapshot of the excluder and recapture net on the Starbound is shown in Figure 20. The lift of the recapture net was low on the GOA vessels which may have restricted escapement as well as allowed for re-entry (salmon or pollock, having escaped from the main net into the recapture net, may have re-entered the main net during towing, turnarounds or haulback). With the low salmon escapement seen in the flapper tests in the CGOA fishery the first (and second on the Alaska Beauty) seasons, the decision was made to move to the over/under design which many CGOA pollock captains were interested in trying based on their own assessment of what would work on their nets.

Figure 19. Flapper excluder. Left: view of recapture net and escape hole on the Starbound (BS CP, fall 2011) and (right) on the Caravelle, spring 2013. The clearance (lift) was much greater on the larger Bering Sea vessels. The view is looking aft from the top of the main net just forward of the escape holes.

Figure 20. Sonar picture of the flapper excluder and recapture net on the Starbound.



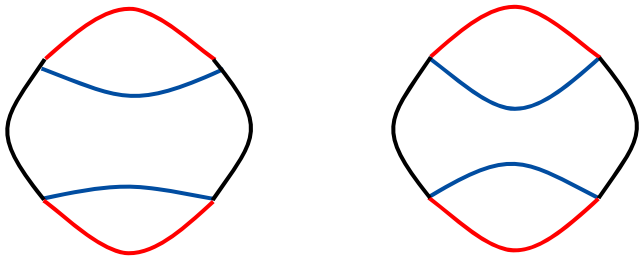
The over/under design tested on the Caravelle in the fall of 2013 reflected what was learned from the flume tank work in Newfoundland in 2011 and subsequent (limited) testing on the Bering catcher vessels during the fall of 2012 under EFP 11-01. The original objective of the O/U was to improve

escapement of chum salmon by adding an escapement opportunity on the bottom of the net. This originated from salmon fishermen commenting that chum salmon seem to move down in a seine net whereas Chinook go up. The fear by some pollock fishermen that adding a bottom escape hole would increase pollock escapement was put to rest in the Fall 2012 trials which saw negligible pollock escapes on both vessels (<.5%) with the caveat that pollock catch rates during those fall 2012 trials were abnormally low. Even though most of the salmon in the fall 2012 trial still escaped out the top portal (81-89%), assuming the majority of salmon caught during these trials were chum salmon, the escapement rates of 19-24% were still about twice the rates for chum salmon seen in previous EFP trials using other excluder designs (funnel, tunnel, flapper). One theory is that the two panels used in combination and/or the hood on the top and the scoop on the bottom used in combination may affect water flow and escapement behavior.

Similar to the fall 2012 EFP results, most salmon on the Caravelle fall 2013 trial escaped through the top portion of the excluder (62%). Pollock escapement was considerably higher than seen in the Bering Sea (2.9%, 95% CI 1.8-4.4%). One significant difference between the two excluders was that the Bering Sea O/U excluders had 20 meshes of "overlap" whereas there was zero overlap on the GOA O/U excluders. Another factor, of course, is the much lower horsepower and smaller nets on the GOA boats. It is not possible to fully explain the differences in pollock escapement rates given all the differences in excluders and testing conditions.

Flume tank testing in November 2013 revealed that the escape areas could be expanded even further by increasing the area of the top and bottom "scoops" through the use of floatation, weighting and panel construction and installation (Figure 21). The objective of doing so was, in conjunction with the elimination of overlap in the design of the excluder panels, to increase escapement rates for salmon. Both ideas came from the escapement rate data in the limited testing done with the O/U in the Bering Sea in 2012 and particularly review of the video where many of the salmon moved close to the escapement portals but were not actually able to escape.

Figure 21. O/U excluder cross sections showing increased area for escapement (top and bottom) in the 2014 version: Fall 2012/2013 (left), 2014 (right)



The results from the fall 2014 GOA trials, testing version two of the O/U excluder reflecting the design aspects discussed above, are the most promising to date. This is especially true for the Caravelle where the escapement rates were the highest seen thus far with any excluder design and the variability around the escapement rate were low in testing that included consistently high salmon sample numbers. At the same time, pollock escapement was relatively high compared to the Bering Sea trials (about 3% compared to <0.5%) – but still at levels that do not appear to reduce economic efficiencies and therefore should be acceptable to fishermen.

One of the most encouraging aspects of the O/U excluders tested in 2014 was the relatively low need for tuning to get them to take the intended shape at normal towing speeds. Using the data from the 2012 O/U trials in the Bering Sea and the subsequent flume tank work in 2013, the initial amounts of weight and floatation put on the O/U excluders used in the GOA hit very close to the mark in term of the intended shape parameters. Effectively, the O/U excluders were nearly ready to go, out of the box, with little modifications needed. Only a small amount of video observation was needed to confirm that they took the proper, intended shape. This is extremely encouraging given the high degree of tuning with weight and floatation that has been needed in the Bering Sea to ensure flapper excluders are taking the correct shape at normal towing speeds. Likewise, our experience with trials of the flapper excluder in the CGOA in 2013 also detected similar problems with tuning and challenges with scaling the weight needed for the flapper panel to be positioned correctly on a consistent basis.

In coming to the conclusion that the O/U excluder is a very promising excluder for the GOA pollock fishery, it is still imperative for fishermen to use cameras to confirm that their newly fabricated or purchased excluder is taking the proper shape and appears to be performing as intended. From our experience, net manufacturers sometimes construct excluders, particularly the O/U design, to their own specifications. These differences, in conjunction with inherent differences nets made by different net manufacturers and even different net models made by the same companies make the need to confirm that the excluder is taking the intended shape even more paramount. Fishermen should want to do this anyway given they are motivated by the bycatch avoidance incentive plans in place and they will also want to confirm that unacceptably large amounts of pollock are not escaping.

To make confirmation of excluder shape and function possible, several of the user-friendly acrylic tube video systems used in this EFP are now available for use by Kodiak-based fishermen from the Alaska Groundfish Data Bank office in Kodiak. NMFS also has loaner systems in Dutch Harbor.

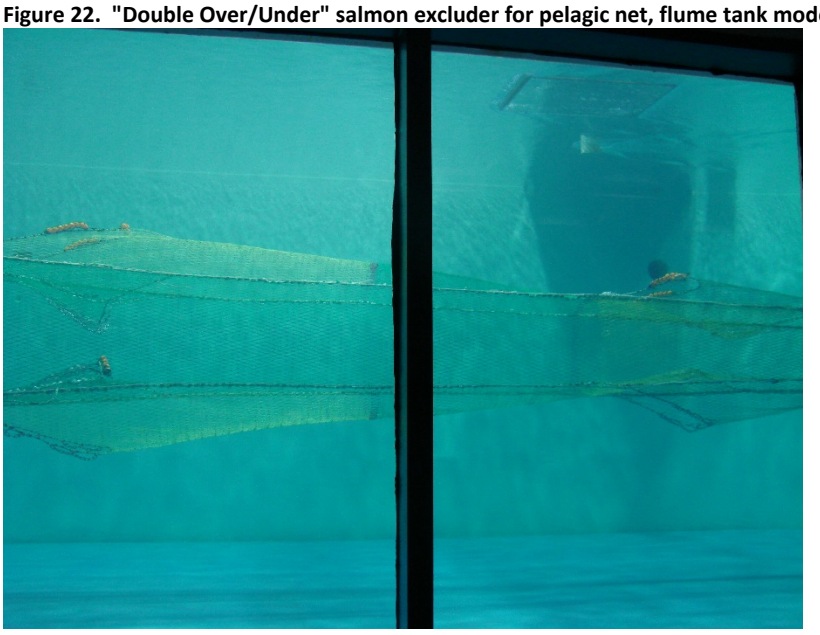
Another encouraging aspect of the O/U excluder for the CGOA pollock industry is the relatively low cost of acquiring or making the excluder. For fishermen interested in making their own by cutting into their existing net, the materials needed are trawl floats, lead line, and a relatively small amount of extra netting for the lower and upper hood/scoop. The cost of having a net manufacturer install the excluder as part of an existing CGOA pollock net is probably in the range of $3,000 to $5,000 based on what fishermen have reported. Finally, having a excluder fabricated as part of a separate tapered section and cutting riblines and fabricating attachment points for the O/U excluder as an add-on section is likely to be in the $10,000 to $15,000 range based on the cost incurred for this EFP where this was the approach.

Outreach and Future Steps: These experiments proved informative and valuable to many involved in the Central Gulf of Alaska fishery and the lessons learned will have value for the wider North Pacific fishing industry. At this point additional outreach will be important to inform CGOA stakeholders of performance and design aspects of what was learned in the EFP over the two year period. John Gruver, the designer of the salmon excluders tested in our EFP's since 2003, travelled to Kodiak In June 2014 on behalf of the North Pacific Fisheries Research Foundation (NPFRF). The purpose of his visit was to present O/U excluder diagrams and plans to anyone interested at a stakeholder forum where fishermen were able to ask questions about construction, installation, and performance. As principal investigator and permit holder, John Gauvin travelled to Kodiak in January 2015 to hold another forum to present the updated EFP results, show video footage of the excluder in action and to answer questions from inquiring fishermen who are always searching for effective, moderately priced gear modification devices

to reduce their bycatch. Both of these outreach meetings were well attended and they appear to have spurred many fishermen to construct and begin using the O/U excluder. Additional outreach will be needed and the authors of this report are available to answer additional questions and concerns from fishermen who are interested in what was learned from this effort. Additionally, the Nature Conservancy recently sponsored the production of a video to document the salmon bycatch issue in the North Pacific pollock fisheries and the development and testing of salmon excluders. A videographer travelled with the crew and project staff aboard the Caravelle on one EFP trip in April 2014 to film the operations and interview crew. This video, *Reducing Salmon Bycatch in the Pollock Fishery,* is available through the NPFRF website, http://www.npfrf.org/videos.html .

EFP 15-01, approved in 2014 for the Bering Sea fishery, will initially test the same over/under design used on the Caravelle during the 2014 trials in the A and B seasons of 2015 and in the A season of 2016 on three size classes of Bering Sea pollock vessels: (1) 1,200 to 1,700 HP catcher vessels; (2) 1,700 to 3,000 HP catcher vessels; and (3) catcher processor (CP). The vessels selected by RACE personnel at the AFSC are the Northern Jaeger (CP), Destination (1,700-3,000 hp) and the Commodore (1,200-1,700 hp). Testing commenced in February 2015. Assuming that the design improvements in the CGOA fishery are confirmed to be effective for the Bering Sea pollock fishery where vessel horsepower and towing speed are quite different from that of the CGOA, the O/U excluder may prove to be a "better mouse trap" for the Bering Sea as well. From there, future possibilities for improving escapement might include such things as a "double over/under" excluder, something that was looked at in the fume tank in 2013 (Figure 22). At this point, however, the basic shape parameters and performance parameters need to be evaluated in the Bering Sea fishery where water flow dynamics are quite different from that of the CGOA fishery given the huge differences in horsepower and scale of nets. The first step for the upcoming Bering Sea trials is therefore to see if the version 2 O/U that worked quite well in the CGOA trials can be made to acquire the same shape as it did in the this Gulf of Alaska EFP and whether salmon can make use of the escapement opportunity to a similar degree as was seen in in this test.

Figure 22. "Double Over/Under" salmon excluder for pelagic net, flume tank model November 2013.



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http://www.afsc.noaa.gov/Publications/AFSC-TM/NOAA-TM-AFSC-289.pdf

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