Summary of Results from NPFRF's Salmon Excluder EFP #18-03

EFF 18-03 Final Report
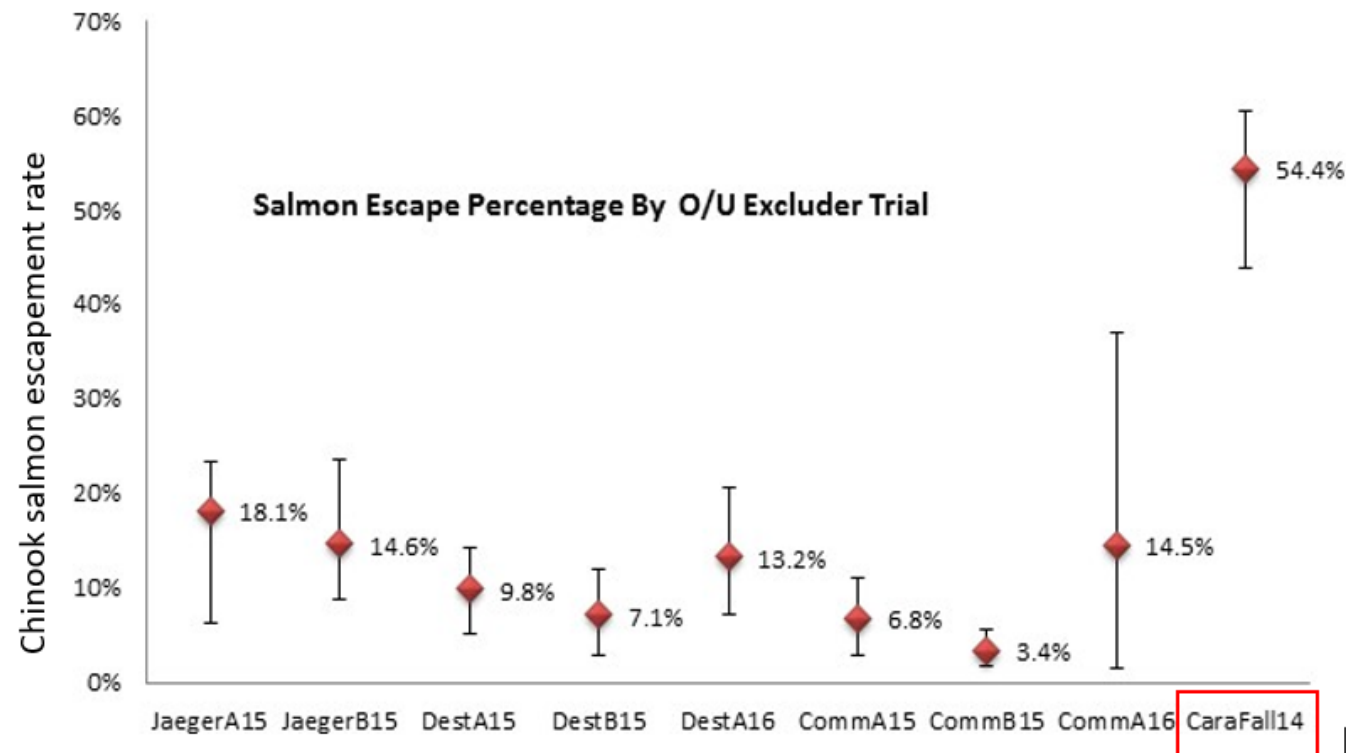## (please see full report for all the details)

2021

EFP 18-03 Final Report

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Motivation for salmon excluder development in the Bering Sea leading to NPFRF's application for EFP 18-01 (Figure 3)

Salmon Escape Percentage By O/U Excluder Trial

Other motivations for EFP 18-03

Increasing Chinook bycatch rates (based on 2013-2017 rates, figure 4 page 12)

Pollock fleet's interest in more comprehensive information on what excluders were in use, performance of those, opportunities for improvement? (NPFRF workshops in 2016 and 2017)

Perception that bycatch limits could be triggered; fishermen encountering Chinook salmon more frequently in years leading to 2018

Interest in examining whether adding lights to increase escapement actually increased escapement

Objectives of Salmon Excluder EFP 18-03

<u>Objective 1</u>: Work with BS pollock vessels (3HP categories) to improve excluder performance by making adjustments iteratively after reviewing results from prior season (start with excluder design each sector felt was most effective)

<u>Objective 2</u>: Collect time-stamped data on factors affecting excluder performance (e.g. light, water flow, amount of pollock moving through the net) and analyze to see how data correspond to escapements (aka covariate data analysis)

<u>Note:</u> Singular focus on Chinook bycatch reduction; all testing done during A season

EFP 18-03 tested advanced versions of flapper and over and under (O/U) salmon excluders

Note: Detailed drawings and construction plans for excluder designs available from John Gruver (jgruver@ucba.org)/Swan Nets.
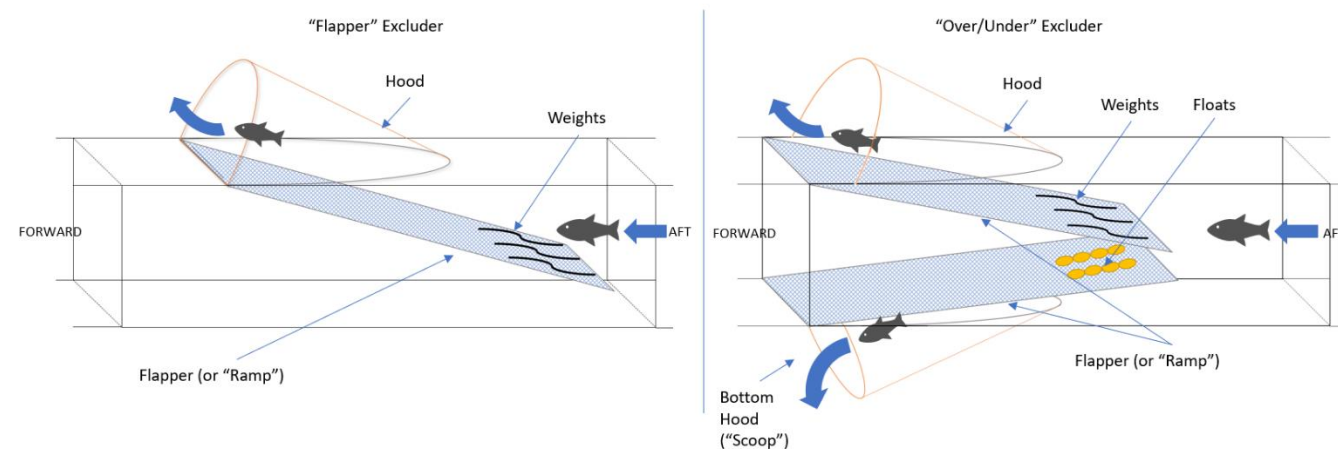

Figure 2: Conceptual diagrams of excluder designs tested during this EFP: the "flapper" (left) and the "over/under" ("O/U", right). The flapper design has one portal (or "escapement hole") through the top hood, and the O/U has two portals (one through the hood, the other through the "scoop").

Vessels selected by NMFS for EFP 18-03 were: F/V Storm Petrel (< 1,800 HP category); F/V Destination (>1,800 HP category); C/P Starbound

EFP Objective 1:

Improve Bering Sea excluder performance through a series of tests. Start in 2018 with the excluder each vessel category felt was most promising. 2019 and 2020 would test modifications to 2018 excluders based on performance results from Year 1. Changes to excluders to be based on input from captains, John Gruver, Swan Nets.

How was excluder performance determined?
Accounting for salmon and pollock escapement with camera deployments on each haul and NPFRF's full review to count salmon and pollock escapements

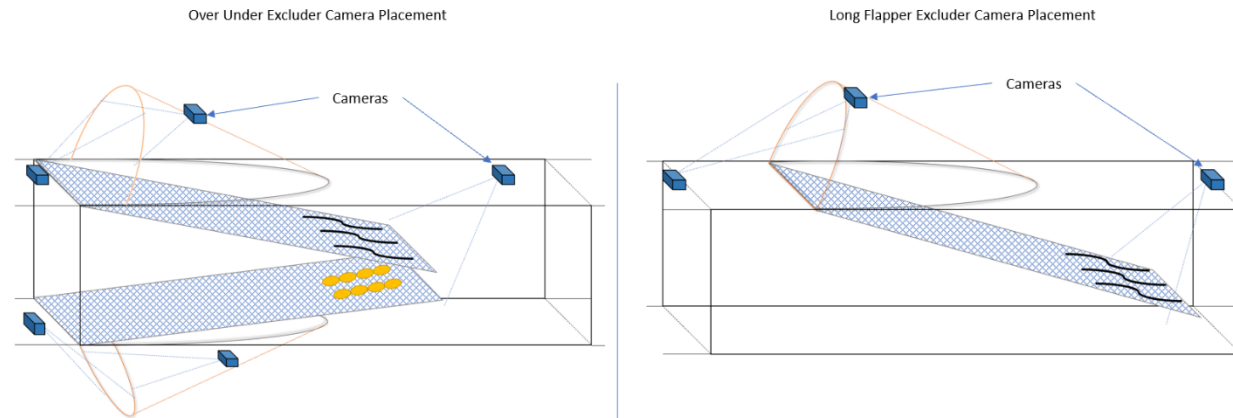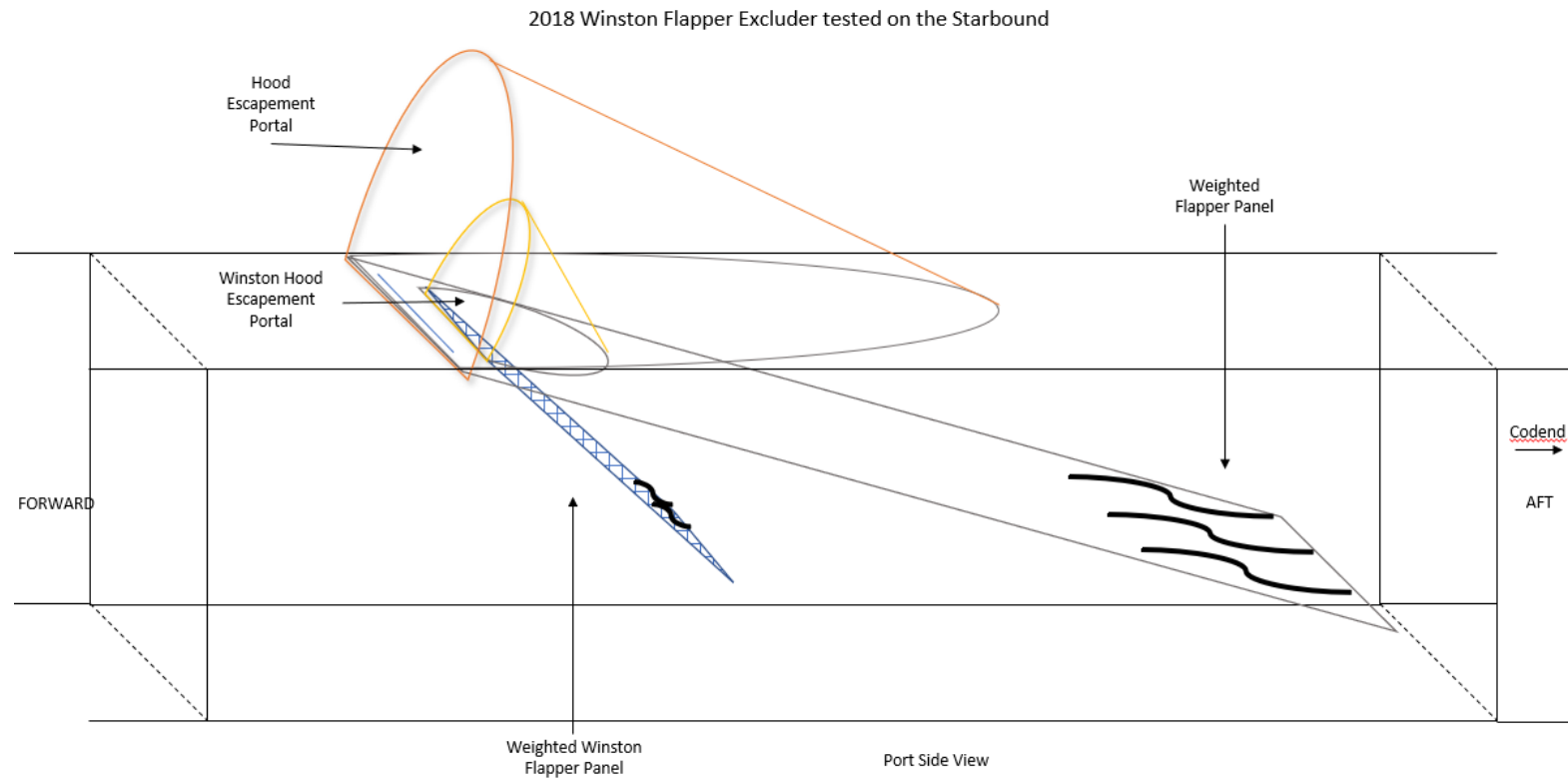Examples of camera positions for different excluders

Over Under Excluder Camera Placement

Long Flapper Excluder Camera Placement

Cameras

Cameras

Figure 6: General camera placements for the O/U and Flapper excluder designs.

Tests on Starbound 2018, 2019, 2020

Starbound's starting point was an Winston flapper excluder with the additional escapement pathway at the forward edge of the regular flapper panel

2018 Winston Flapper Excluder tested on the Starbound

Hood
Escapement
Portal

Winston Hood
Escapement
Portal

Weighted
Flapper Panel

Codend

FORWARD

AFT

Weighted Winston
Flapper Panel

Port Side View

Year 2 for Starbound tested a Winston flapper with a different taper to the hood to create less vertical extension forward.
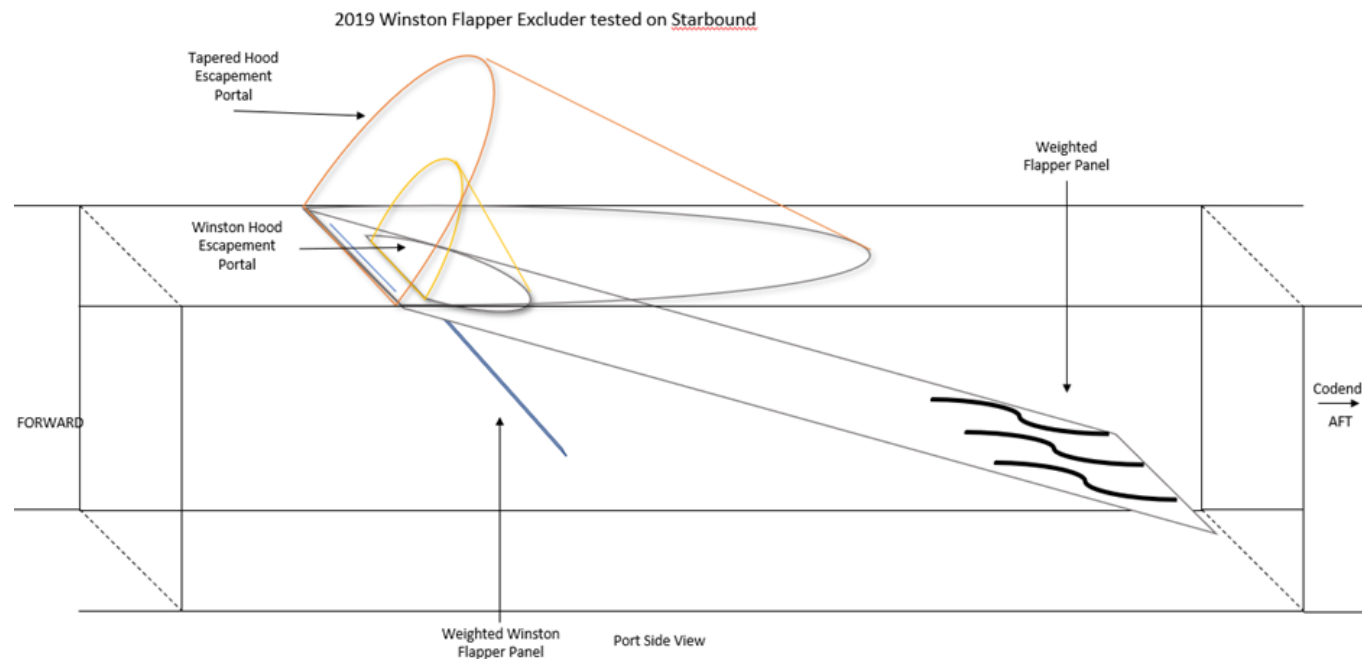

Figure 1: A modified Winston Flapper excluder tested on the Starbound in 2019. The main modification made is that the hood was tapered back to minimize the distance that salmon needed to swim in order to escape.

The motivation for the change in taper to reduce the forward extension of the hood was based on video showing many Chinook lingering under the hood instead of swimming forward and out of the net.

Year 3 (2020) Diamond shaped cut outs were added to the port and starboard sides of Starbound's flapper excluder. Additionally, the additional (Winston) flapper and hood were removed

2020 Flapper Excluder with Diamond Cutouts tested on Starbound

Tapered Hood
Escapement
Portal

Weighted
Flapper Panel

Diamond Cutout
(mirrored on starboard
side of hood)
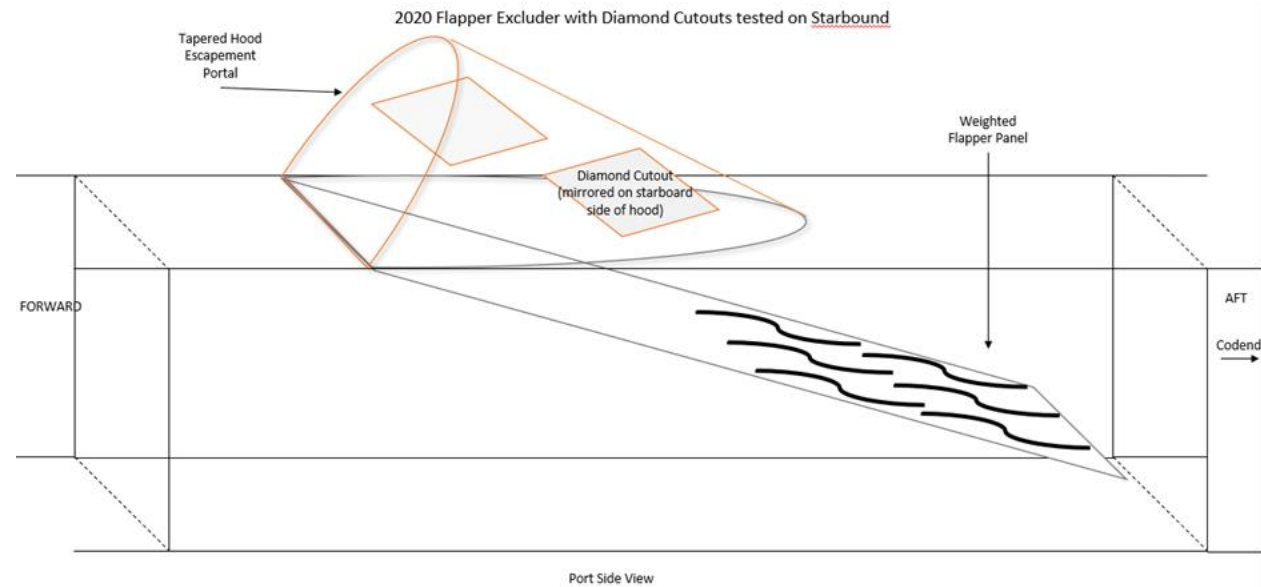
FORWARD

AFT

Codend

Port Side View

Figure 1: The Winston Flapper design with two diamond-shaped cut-outs tested on the Starbound in 2020.

To encourage more Chinook lingering in the hood to escape, diamond escapement portals were added in 2020. Additionally, the Winston excluder was removed because very few Chinook used this pathway in the first two years of the test

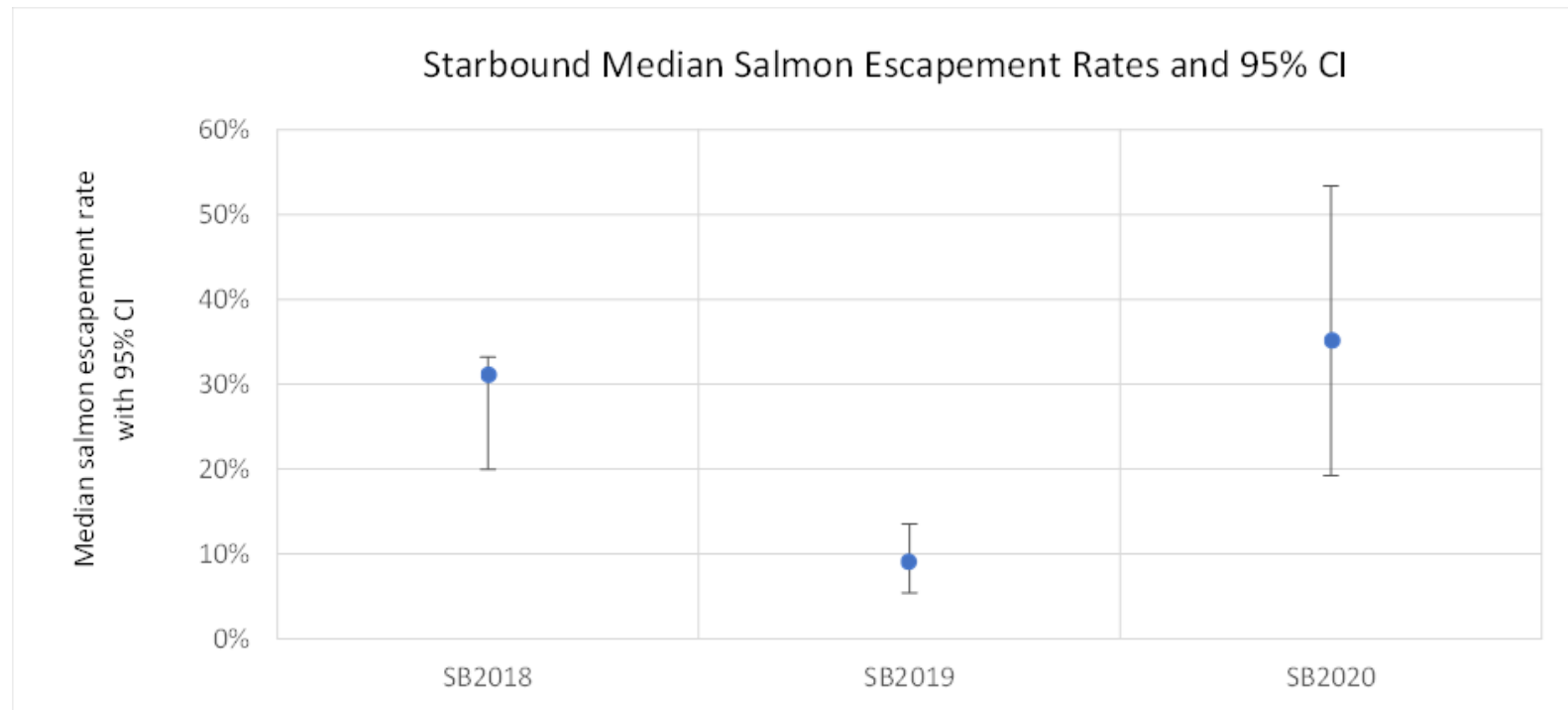# Chinook escapement rates for Starbound

Figure 1: Starbound median salmon escapement rates with 95% confidence intervals for all 3 years of the EFP.

Starbound Results (number of salmon and pollock catches with escapement results). Note that each year's result includes testing over a full trip (pooled EFP and non-EFP catches)

Figure 20: Starbound median salmon escapement rates with 95% confidence intervals for all 3 years of the EFP.

VESSEL	YEAR	SALMON			POLLOCK			
		Cod-end	Escapes	Total Escape %	Cod-end	Escapes	Total Loss %	# Tows Tested
STARBOUND	2018A	620	281	31.19%	2735.05	5.4	0.25%	30
	2019A	188	19	9.18%	2791.7	26.2	0.93%	27
	2020A	27	15	35.71%	2969.6	39.4	1.63%	26

Discussion of Starbound results

Results in 2018 and 2020 have generally overlapping confidence intervals indicating Chinook escapement in the 31%-36% range.
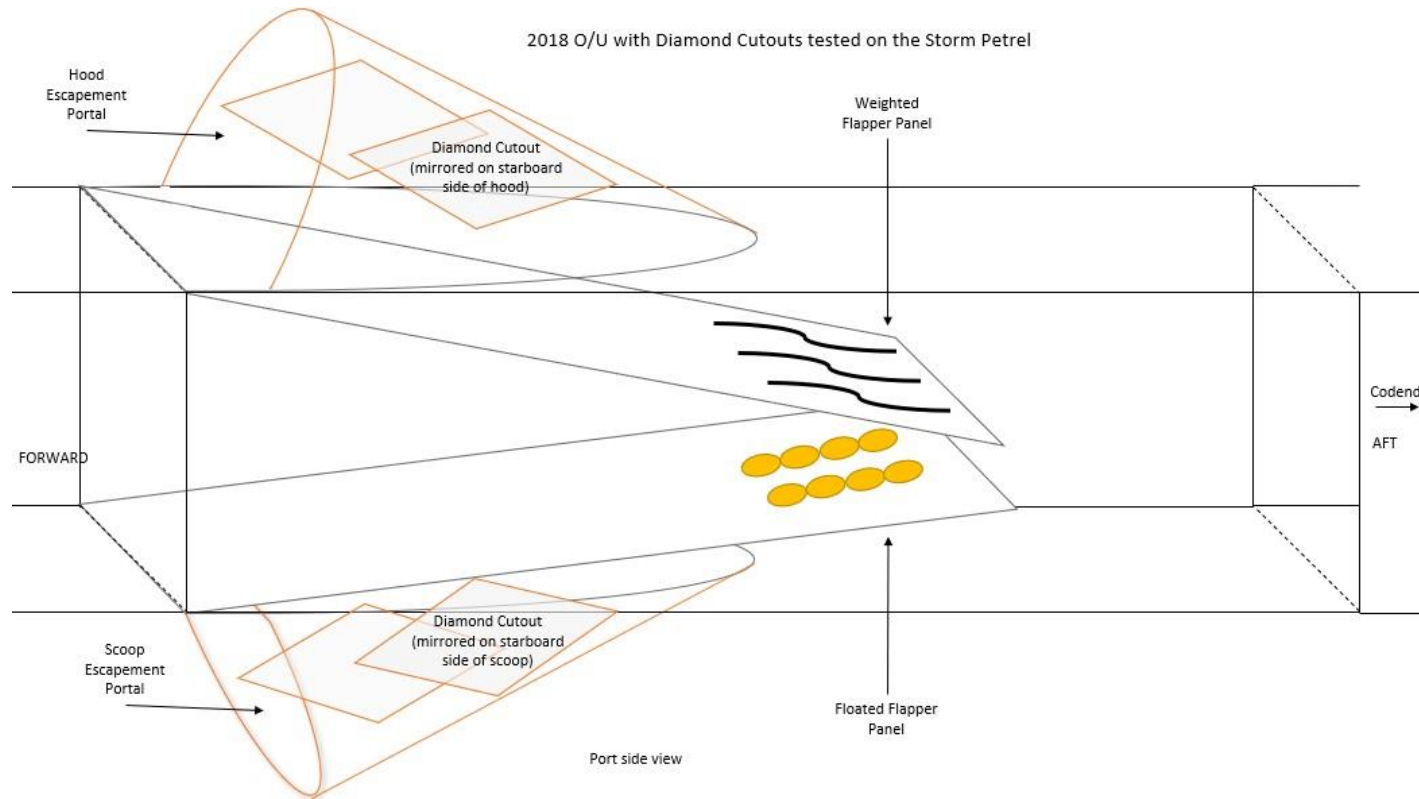
2019 Chinook escapement was only ~9%. This result is significantly lower than other EFP years for Starbound.

Side escapement portals in the hood in 2020 resulted in slightly higher Chinook escapement. The wide confidence intervals, however, indicate we cannot be certain this result is different from the 2018 excluder (w/o side escapement portals)
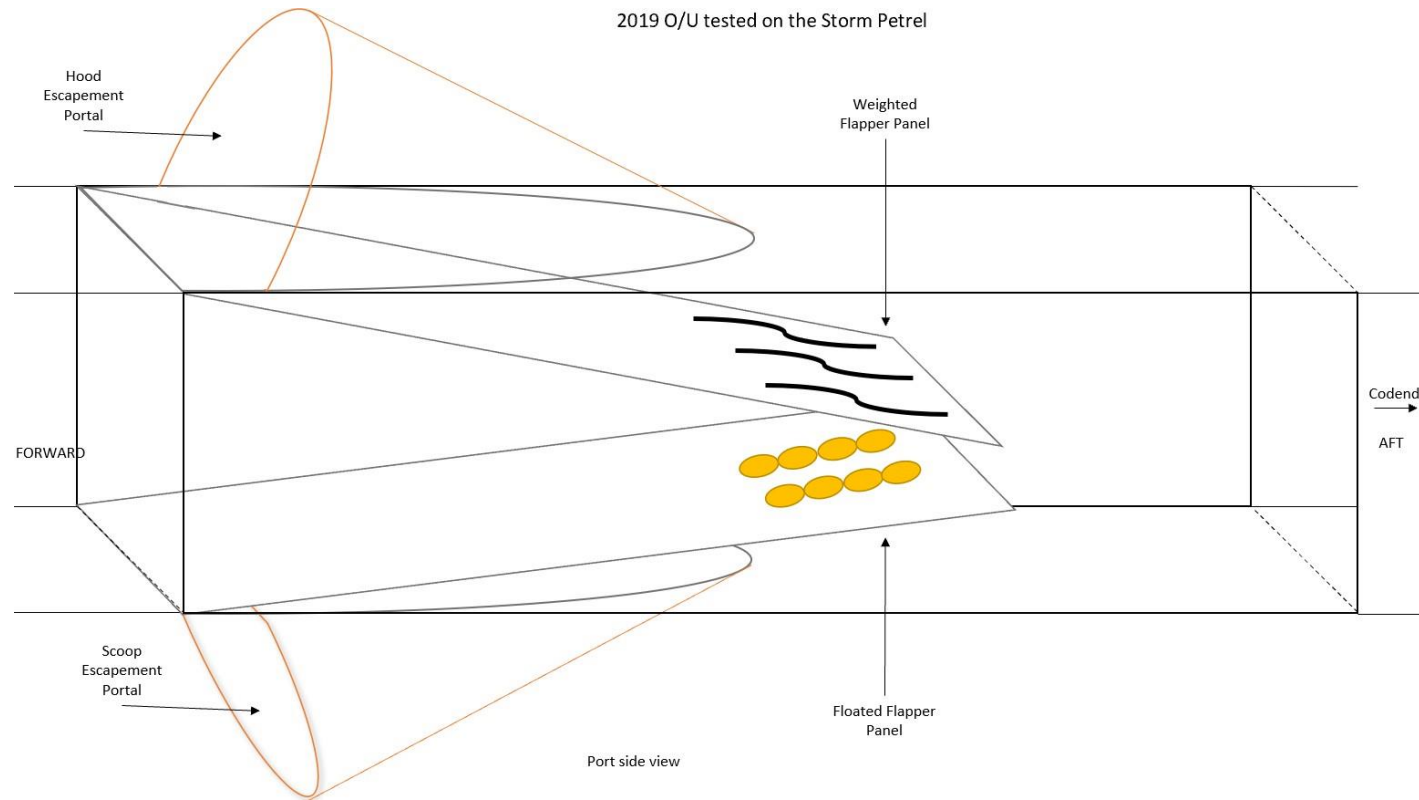
Tests on Storm Petrel 2018, 2019, 2021

Storm Petrel's 2018 starting point was an O/U excluder with additional diamond cut outs on sides of scoop (bottom) and hood (top)
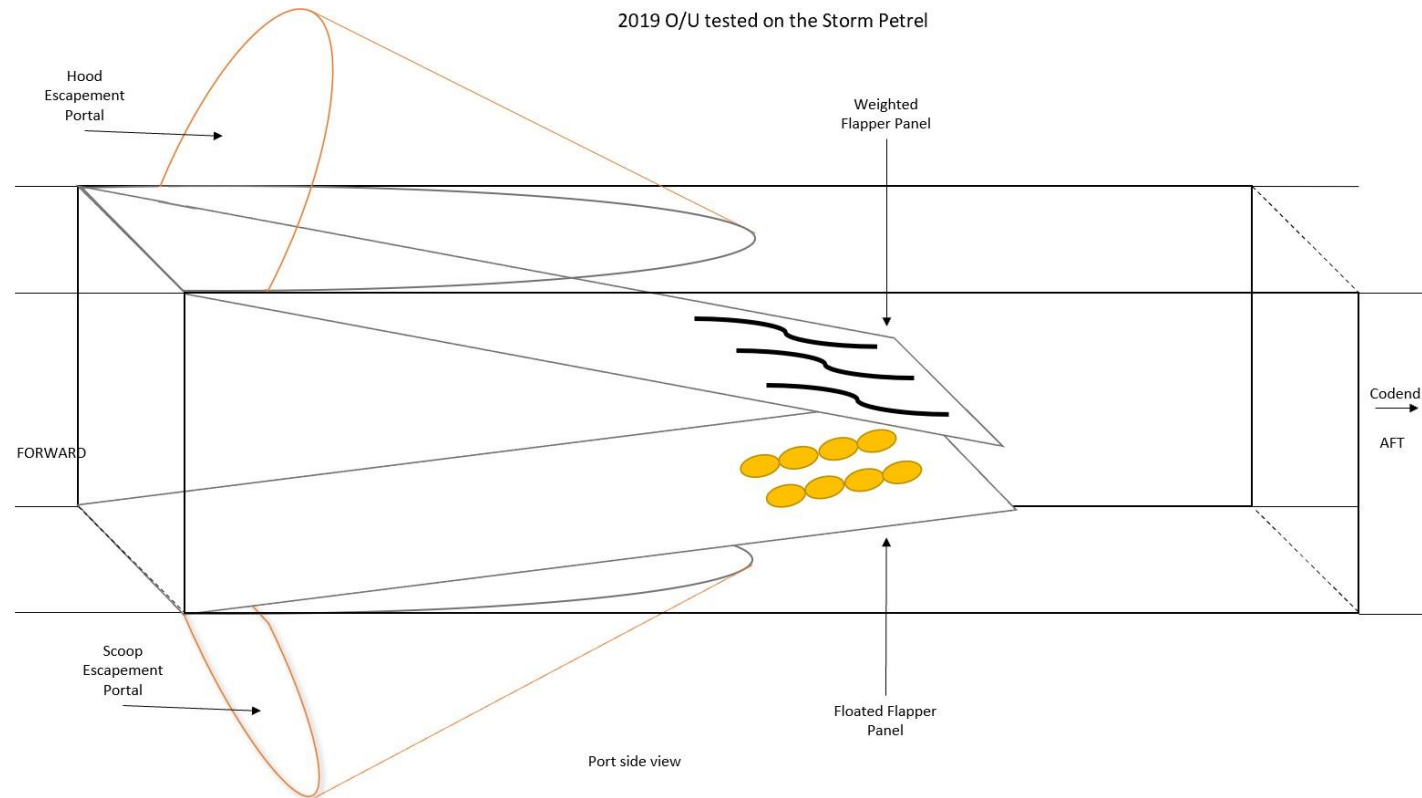

2018 O/U with Diamond Cutouts tested on the Storm Petrel

Hood Escapement Portal

Diamond Cutout (mirrored on starboard side of hood)

Weighted Flapper Panel

Codend

AFT

FORWARD

Scoop Escapement Portal

Diamond Cutout (mirrored on starboard side of scoop)

Floated Flapper Panel

Port side view

Year 2 (2019) tested nearly same excluder but webbing was replaced in sides to close the holes and improve stability

2019 O/U tested on the Storm Petrel

Hood Escapement Portal

Weighted Flapper Panel

FORWARD

Codend

AFT

Scoop Escapement Portal

Floated Flapper Panel

Port side view

Hood and scoop too unstable with cutouts, problems with camera stability for tracking escapements and keeping escapement pathway stable

Year 3 (2021) excluder for Storm Petrel was same as 2019. Instead of changing the excluder, SP added 5 minute slow downs at the end of each tow to increase chances of Chinook escapement

2019 O/U tested on the Storm Petrel

Hood Escapement Portal

Weighted Flapper Panel

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FORWARD

Scoop Escapement Portal

Floated Flapper Panel

Port side view

At end of each haul, vessel slowed speed and hauled wire slowly during 5 minute period to create lower water flow while maintaining shape of net in excluder section

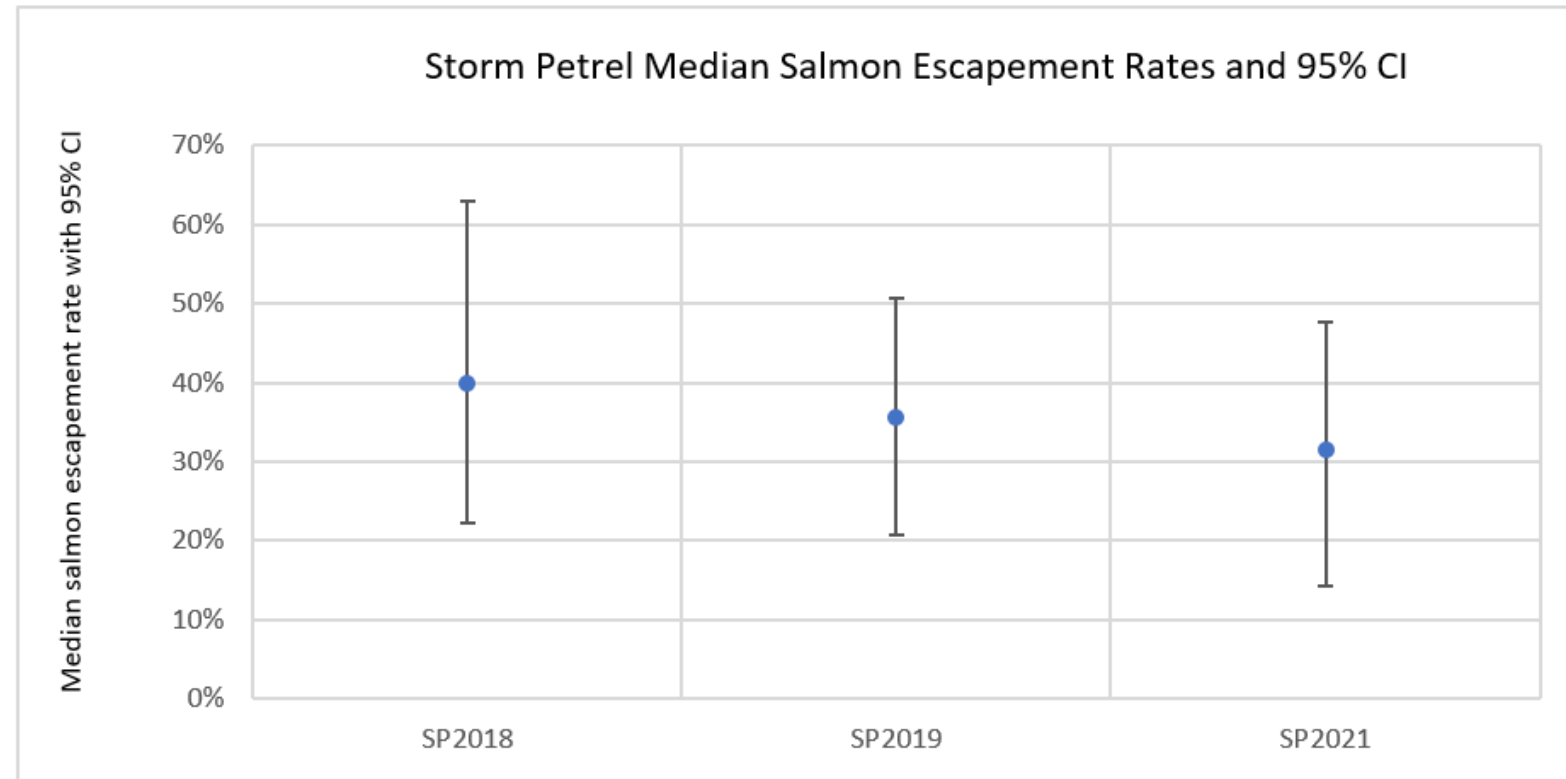# Chinook escapement rates for Storm Petrel

Figure 10: Median salmon escapement rates and 95% confidence intervals for data observed on the Storm Petrel for the 3 years that that EFP testing was conducted.

Storm Petrel's Detailed Results (number of salmon and pollock catches with escapement results)

Table 2: Salmon and pollock captures in the cod-end, escapes, and escapement rates for each of the testing seasons for this EFP.

VESSEL	YEAR	SALMON			POLLOCK			
		Cod-end (Number)	Escapes (Number)	Total Escape %	Cod-end (MT)	Escapes (MT)	Total Loss %	# Tows Tested
STORM PETREL	2018A	140	93	39.91%	331.8	6.1	1.81%	8
	2019A	65	36	35.64%	687.4	4	0.58%	11
	2021A	26	12	31.58%	697.0	1.0	0.15%	12

Discussion of Storm Petrel's Results

Chinook escapement did not improve with sequential adjustments made to excluder (2019) and slowdowns attempting to increase escapement (2021)

Although 2019 and 2021 had slightly lower "average" Chinook escapement rates, statistical confidence intervals essentially overlap. Our conclusion is that Chinook escapement was 30%-40%; pollock loss was 0%-2%. Each test faced quite different fishing conditions and in particular 2019 had very high pollock CPUE.

5 minute slowdowns in 2021 didn't increase salmon or pollock escapement rates. This was surprising and pollock escapement was lowest in 2021. Slowdowns didn't have the desired effect, why?

Results for Destination in 2018, 2019, and 2021

2018 Starting point was a "Winston flapper" excluder with two escapement pathways

Rationale was that Destination was closer to factory trawler in horsepower and heavily-weighted Winston flappers was reportedly getting good results for chum escapement anyway
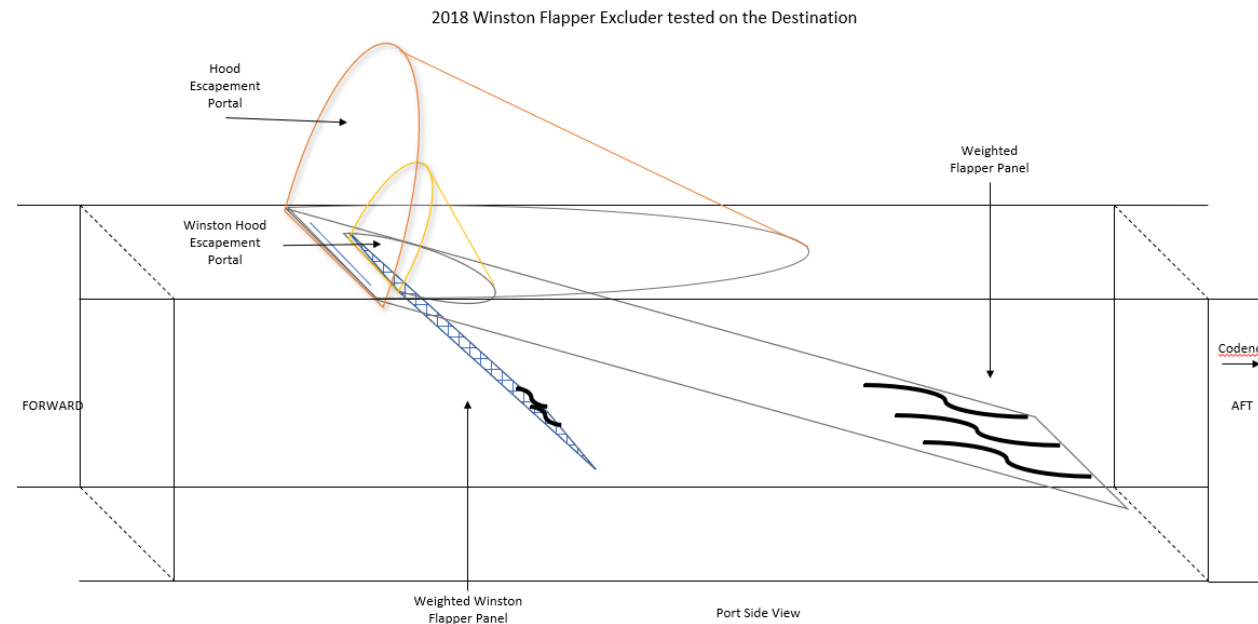

Figure 14: The Winston Flapper excluder design tested on the Destination in 2018.

Destination switched to an O/U for 2019 based on the captain's thoughts and better results seen on Storm Petrel

O/U had reduced overlap. This meant back edge of panels was closer to escapement pathway than most of O/U excluders. This reduced distance salmon need to swim forward relative to Strom Petrel.
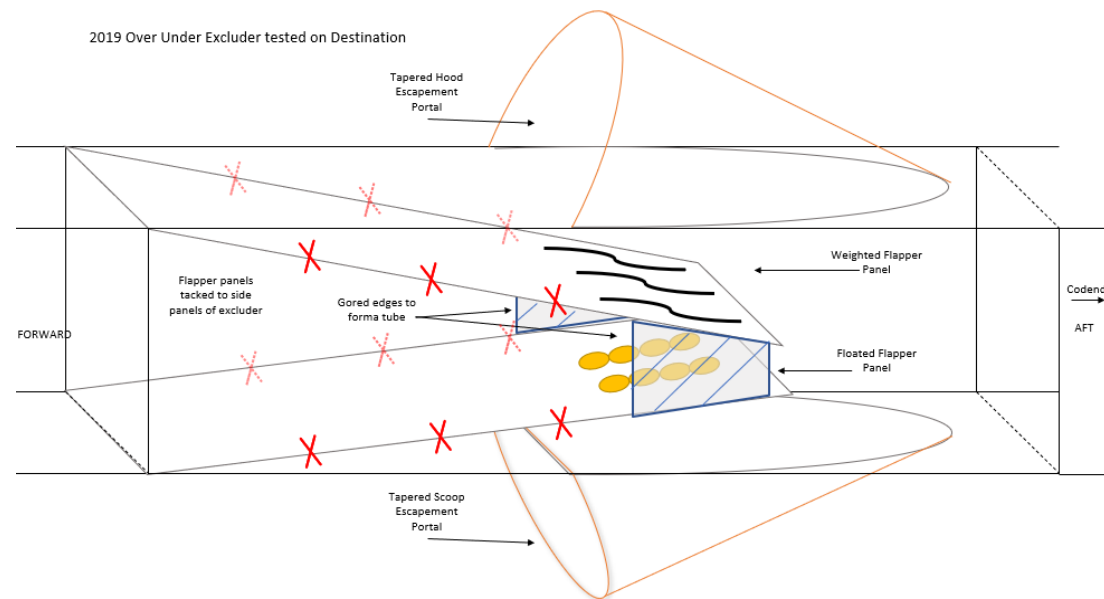

Figure 17: The O/U design tested on the Destination in 2019. This design, while similar in concept to the O/U used on the Storm Petrel, had a lower amount of overlap between the hood/scoop and flappers, providing a large escapement area and short swimming distance for salmon to reach the escapement area. The angle of the hood and scoop openings was also tapered back.

For 2021 Destination used "Zero Overlap" O/U called a "Double Bridge" design

Note: Back edge of panels directly adjacent to escapement pathway. This was intended to allow salmon to escape without having to swim forward at all.
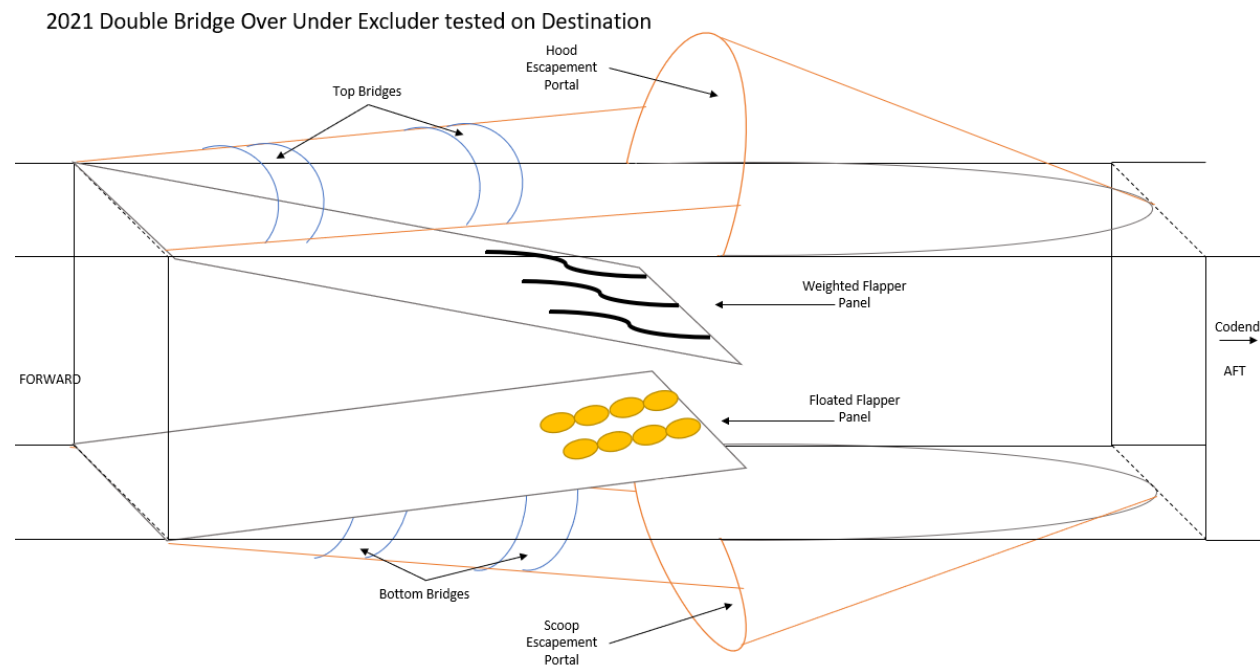

Figure 18: The double-bridge O/U excluder model tested in 2021 on the Destination.

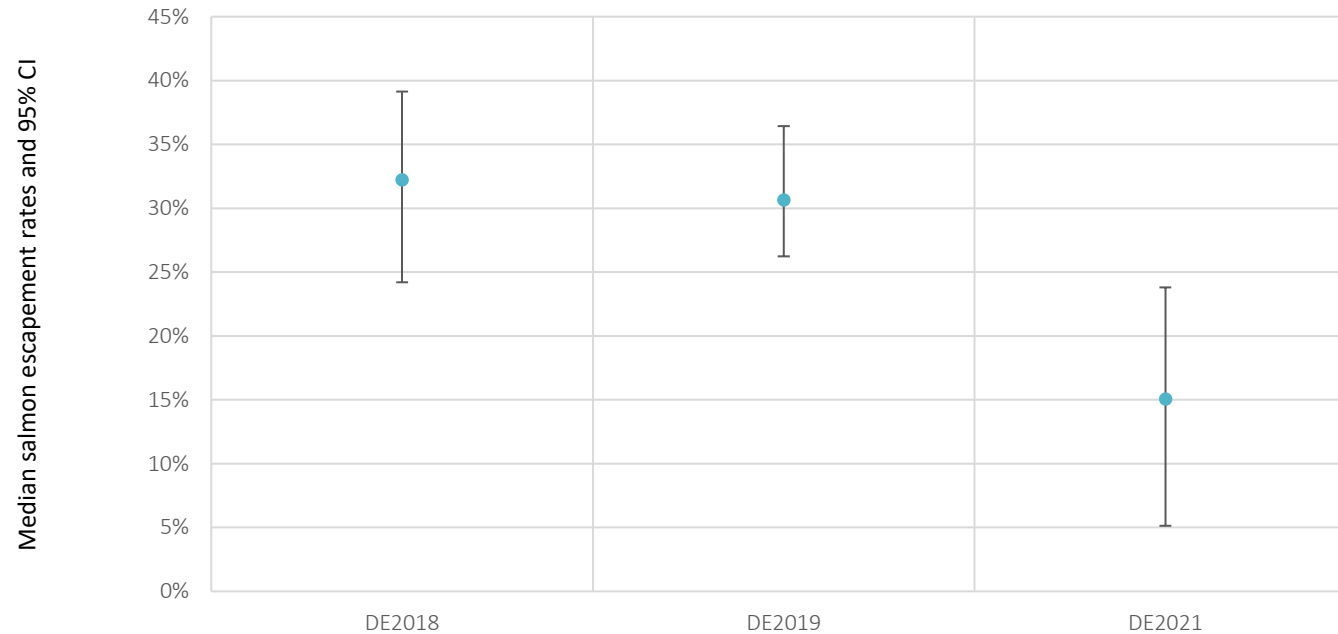# Chinook escapement rates for Destination

Figure 15: Median salmon escapement rates across all three years of the EFP observed on the Destination.

Destination's Detailed Results (number of salmon and pollock catches with escapement results)

Table 3: Salmon and pollock captures in the cod-end, escapes, and escapement rates for each of the testing seasons for this EFP.

| VESSEL	YEAR	SALMON			POLLOCK			
		Cod-end (Number)	Escapes (Number)	Total Escape %	Cod-end (MT)	Escapes MT)	Total Loss %	# Tows Tested
DESTINATION	2018A	80	38	32.20%	889.5	11.6	1.29%	11
	2019A	90	40	30.77%	877.2	6.6	0.74%	12
	2021A	78	14	15.22%	808.9	9.3	1.14%	11

Discussion of Destination's results

The 2018 (Winston flapper) and 2019 (O/U with moderate overlap) reduced Chinook catches nearly identically (~30% reduction, confidence intervals overlap)

The 2021 O/U excluder was designed to be a much more "aggressive" approach to reducing Chinook catches. But this "zero overlap" excluder actually resulted in significantly lower Chinook escapement (~15%). Confidence intervals demonstrate the lower performance.

Pollock escapement was low (~1%) for all excluder designs tested on Destination.

2021's lower Chinook escapement is quite puzzling given our collective understanding of what should facilitate salmon escapement

EFP 18-03 Chinook escapement results for all three EFP vessels

Median Salmon Escapement Rates and 95% CI
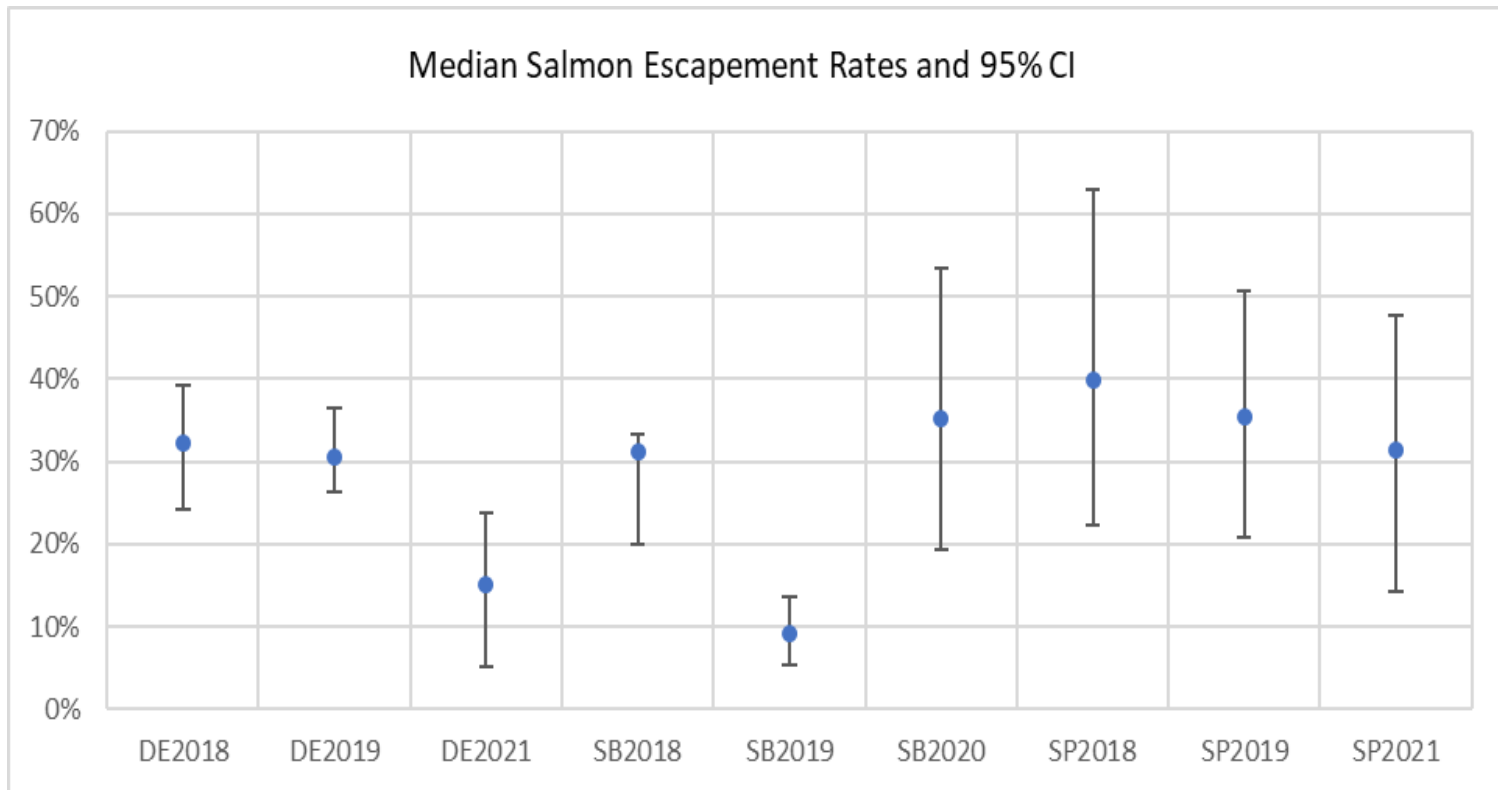
Pollock loss results for all three EFP vessels

Median Pollock Loss Rates and 95% CI
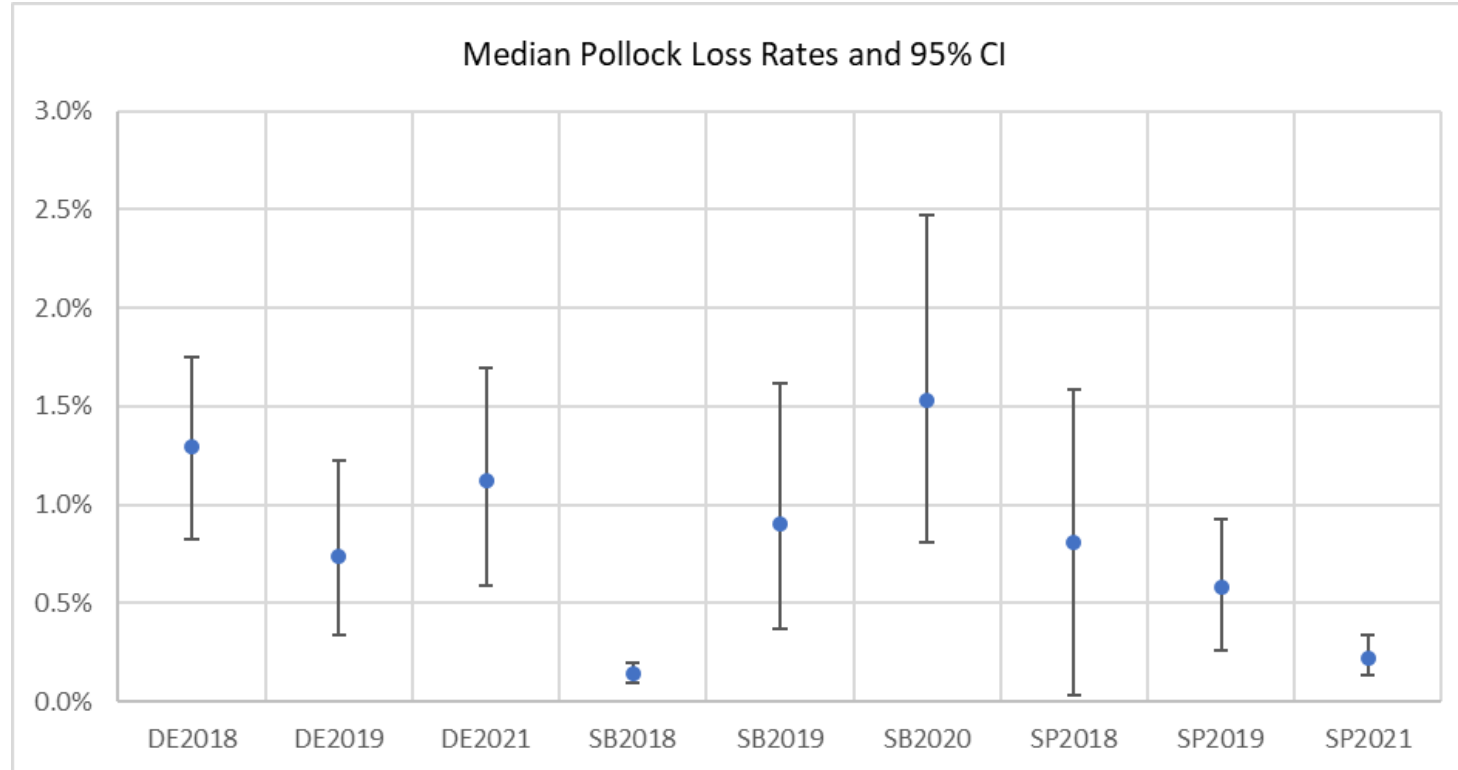
NPFRF's assessment of salmon excluder performance for designs tested in this EFP (all variations of excluders in use)

7 of the 9 excluders achieved Chinook escapement rates over 30%

All excluders tested had pollock loss rates ranging from near zero to 1.5%

Our results strongly suggest performance tradeoffs with excluders are positive

Our study didn't show a logical way forward to improve to improve selectivity

Fishermen's ideas for modifications to improve performance (e.g. ideas for getting salmon to swim out when they are hesitating at escapement portal) didn't result in higher performance

Need to better understand what is actually driving performance (aka covariates)

EFP Objective 2: Evaluate factors that affect escapement (covariates) to allow improvement and eventual optimization of salmon excluders

Factors studied were:

1) Water flow

2) Amount of light (light sensors)

3) Amount of pollock in excluder section when escapements occurred (cameras)

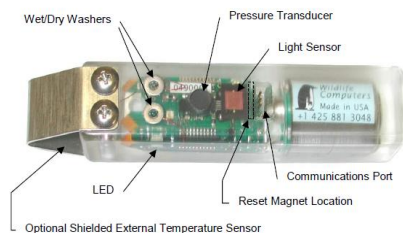4) Vessel activity (towing, turning, hauling back recorded with time stamps)

Figure 29: Wildlife Computer MK9 archival tag.

Figure 28: Example clips from the time-stamped video collected by the pollock flow camera.

Example of covariate data collection and analysis. This figure shows how factors were related to when escapements occurred on one specific haul (see full report)
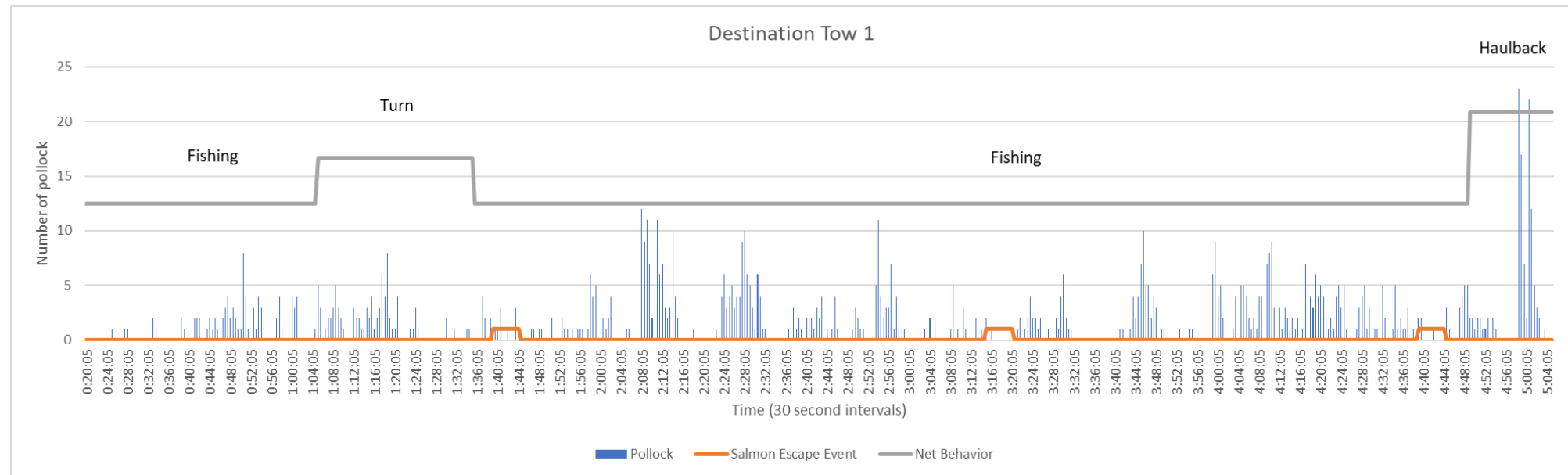
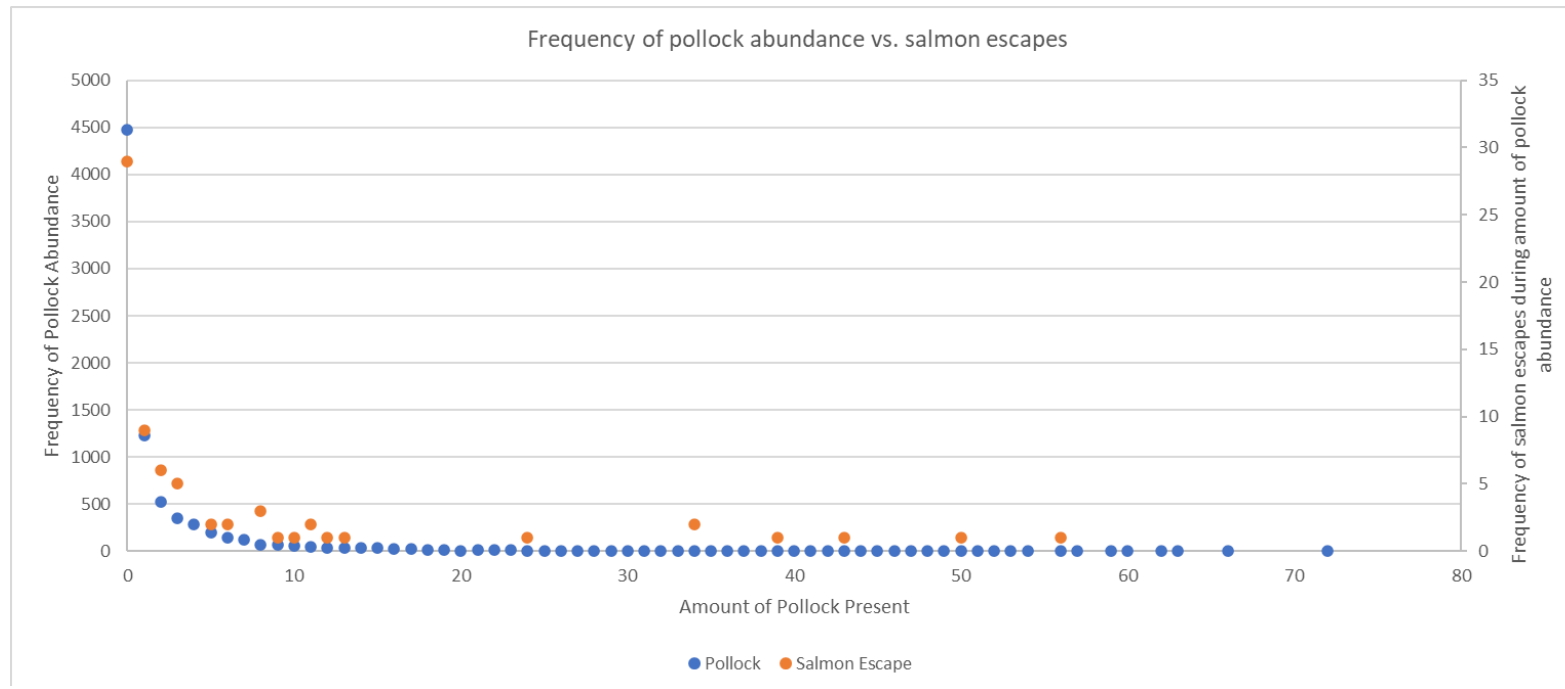# Overall relationship between pollock abundance in excluder section and Chinook escapement

Figure 32: Frequency of pollock abudace verses salmon escapes.

Results for our study of factors affecting escapement with salmon excluders

Water flow: The commercially available flow meter device recommended by marine scientists in Canada to gauge water flow inside the excluder section was deemed to be too unreliable based on further assessment in Canada prior to our tests.

Relative amount of pollock in excluder section: EFP methods for characterizing the relative amount of pollock during each haul worked reasonably well. But because Chinook escapements were not instantaneous (they often lingered at escapement portals before exiting), direct comparisons to simultaneous pollock amounts were not straightforward.

Vessel activity and light: Our analysis found escapements occurred nearly equally across turns, towing, and haulbacks although results differ somewhat by vessel. Artificial lights from our cameras were the dominant light source and therefore there was little measurable differences in light during each haul.

Overall Conclusions from EFP 18-03

Sequential changes to excluders for each vessel HP category were undoubtedly logical steps to increase Chinook escapement from the perspective of captains/others with experience in development and testing of salmon excluders

Why didn't we see sequential improvements? Conditions affecting performance could have masked the effects of modifications to excluders. But given that each change to an excluder in each vessel category created more room therefore should have increased access to escapement, it seems unlikely that more challenging escapement conditions would have masked effects of changes to excluders as uniformly as our results suggest.

We cannot therefore reject the possibility that factors affecting Chinook escapement are not well understood. It is actually possible that what people with experience in fishing and using excluders think should work is not actually that relevant to what affects Chinook behavior.

The study of factors (covariates) for Objective 2 was a reasonable start in terms of increasing understanding. Improved methods (e.g. allowing tracking of factors in real time inside the excluder to the Chinook's behavior to start the escapement process) are needed. Also, a mechanical device that can reliably gauge water flow inside the excluder may be essential to progress in the future.