Public Testimony Sign-Up Sheet
Agenda Item D-2 Groundfish Specs

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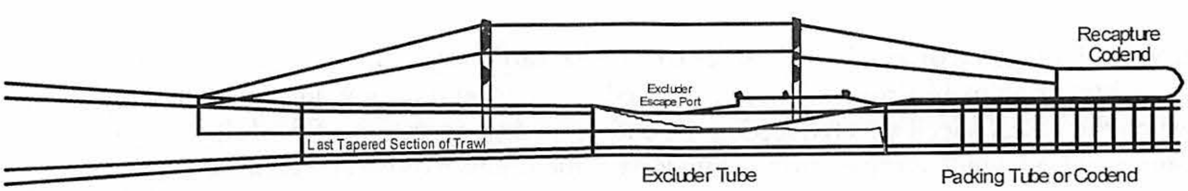
D2 John Gauvin

Final Report for EFP 08-02 to explore the potential for flapper-style salmon excluders for the Bering Sea pollock fishery



Co-investigators: John Gauvin, Gauvin and Associates LLC on behalf of the North Pacific Fisheries Research Foundation; John Gruver, United Catcher Boats Association, Craig Rose, Alaska Fisheries Science Center

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The objective of EFP 08-02 was to evaluate a new salmon excluder design called the "flapper" excluder. In its initial concept, the "flapper" was simply a panel of webbing that trails back with the water flow at towing speed to prevent access to the escapement hole located above the panel. Access to the escapement hole would be achieved only when the vessel reduced its speed to approximately one-half its normal towing speed. Weight placed on the flapper panel was designed to allow the panel to drop down during the slowdown and salmon to escape. Depending on the amount of weight and towing direction relative to the tide, it might take as little as a few minutes to almost 10 minutes for the panel to descend when speed is reduced to one-half of normal towing speed. For effective salmon escapement, slowdowns to allow salmon to escape would have to be done periodically during a tow. The weight was placed on the aft part of the flapper panel such that it would create a sort of ramp for salmon swimming forward in the net during a slowdown to swim out of the escapement hole at the top of the trawl.

The flapper excluder in its initial concept was quite different from earlier excluders because it was designed to allow salmon escapement only during periodic slowdowns. This meant that conducting periodic slowdowns at approximately one-half towing speed was necessary to achieve salmon escapement. The impetus for this alternative approach was that observations in earlier field work with tunnel and funnel excluder designs showed that salmon were capable of swimming ahead of the codend as it filled with pollock. Some of these salmon were observed moving forward when the vessel speed was reduced at the time when the net sounder (third wire) device was being removed from the headrope.

From video footage recorded during earlier trials with earlier excluder designs, salmon escapements (principally Chinook) were observed to occur both during normal towing operations and when the vessel speed was reduced at the end of towing operations. So while it was known that some salmon would escape during slowdowns, the fraction of escapements attributable to slowdowns versus immediate escapes at normal towing speeds was not known. This is because testing methods with a recapture net were not designed to specifically account for escapements in one manner versus the other and there was no way to redesign a recapture net or use video to allow for separate accounting of escapement paths.

The motivation to explore flapper-style excluders as an alternative to earlier designs was due to problems encountered with the earlier excluders, particularly for higher horsepower vessels. Earlier designs such as the funnel and tunnel excluders showed significant promise for Chinook escapement with performance in the range of 25-42%. The basic concept behind those earlier excluders was the use of a tapered square mesh panel to reduce the effective diameter of the last section of tapered intermediate. Several different locations for the square mesh funnel or tunnel excluders were evaluated. These were in the 4 inch and sometimes 6 inch mesh sections just ahead of the straight section or "stuffing tube" used on most nets. This is approximately 100 meshes in front of the cod end.

The concept for the earlier excluders was that the aft end of the tapered square mesh panel created an area of slower water flow above the funnel or tunnel panel. This area was also out of the flow of the catch as fish exited the reduced diameter tapered square mesh section inside the intermediate. The principle was that salmon, being stronger swimmers, could make use of this slower water outside the main flow of fish to rest and eventually move up so they could access the escapement hole (in some excluder versions multiple escapement holes were used). So escapement in the earlier excluder designs was expected to occur during normal towing operations instead of during periodic slowdowns as was the case for our initial focus on flapper excluders later on.

While escapement rates for Chinook were consistently attractive in our EFP trials of funnel and tunnel excluders, restricting the flow of water through the trawl with a square mesh tunnel or funnels unfortunately created a strongly negative outcome. The main problem was that the trawl intermediate sometimes bulged as fish became pinned against the entrance to the funnel or tunnel. This was thought to occur because there was insufficient room for a large quantity of pollock to move through the rigid excluder section of the trawl when pollock catch rates were high.

Unlike diamond mesh, square mesh will not provide any flexibility or "give" in terms of being able to accommodate additional catch. Square mesh was, however, essential for creating the proper shape of the tapered section that reduced the diameter of the trawl. The rigidity created by the square mesh section had the downside of creating a place where fish moving through the net could become pinned. Once pinned against the webbing just in front of the excluder, a collection point was created for more fish as the shape of the intermediate changed. In the extreme, the webbing at the entrance to the excluder turned against the direction of water flow down the net. When this occurred, trawl door spread was reduced and in extreme cases, the net became damaged, particularly with higher horsepower vessels.

When damage to the net did occur, this was mostly associated with high-horsepower vessels fishing in dense schools of pollock or when jellyfish became pinned at the leading edge of the excluder. For the former situation, the potential remedy of advising fishermen to avoid dense schools of pollock was inherently unappealing. The latter part of EFP 05-02 in 2006 attempted to evaluate buffer strips and slower tapers to address "bulge" problems. But when these approaches created as many problems as they addressed, the need to explore other approaches to excluding salmon became evident.

As an alternative approach to mitigating these problems, several fishermen attending a salmon excluder workshop during the winter of 2006 suggested an alternative that became the first design of the flapper excluder. This alternative design was simply to have a sheet of weighted webbing that would fully close off access to escapement hole under normal towing speeds via water flow at normal towing speeds. This "trap door" or "flapper" concept would necessitate periodic slowdowns to allow salmon to escape. But because the flow of water through the trawl was not reduced appreciably by the flapper sheet, bulging of the net with fish becoming pinned would not be likely to occur. Although requiring slowdowns, the workings of the flapper excluder (Figures 1 and 2 below) were viewed by many in the fleet as the best way to achieve salmon escapement without impairing the ability of pollock nets to fish on a day to day basis.

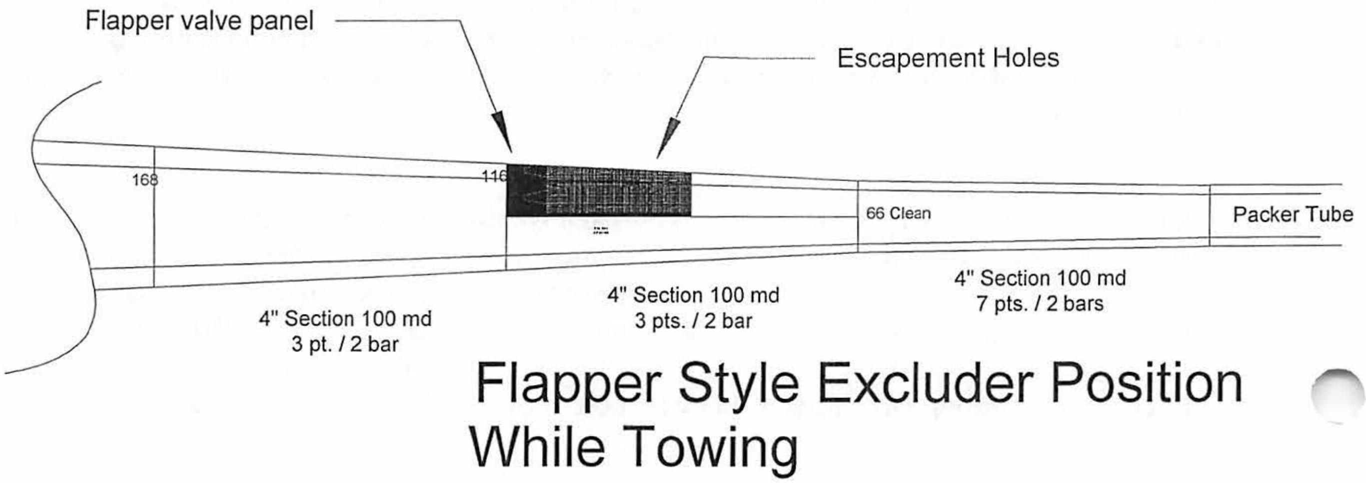
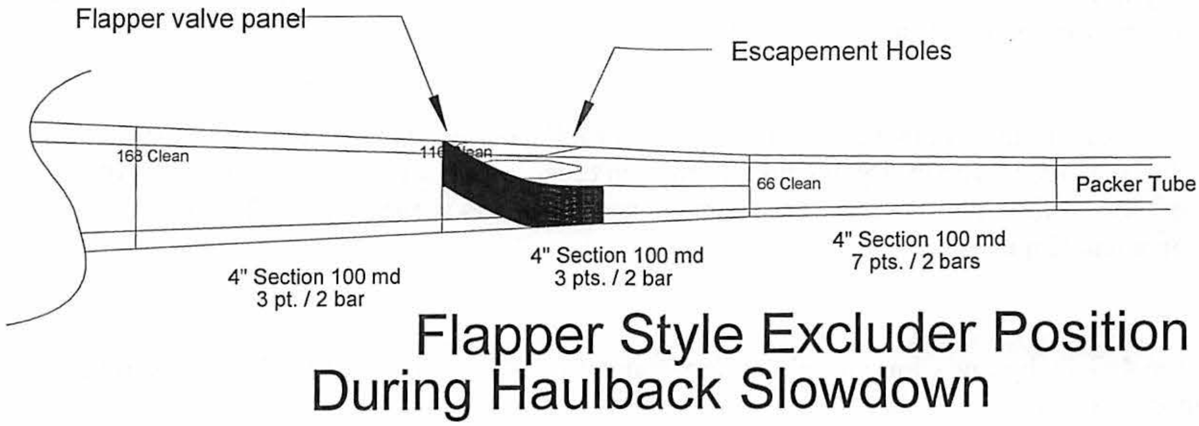


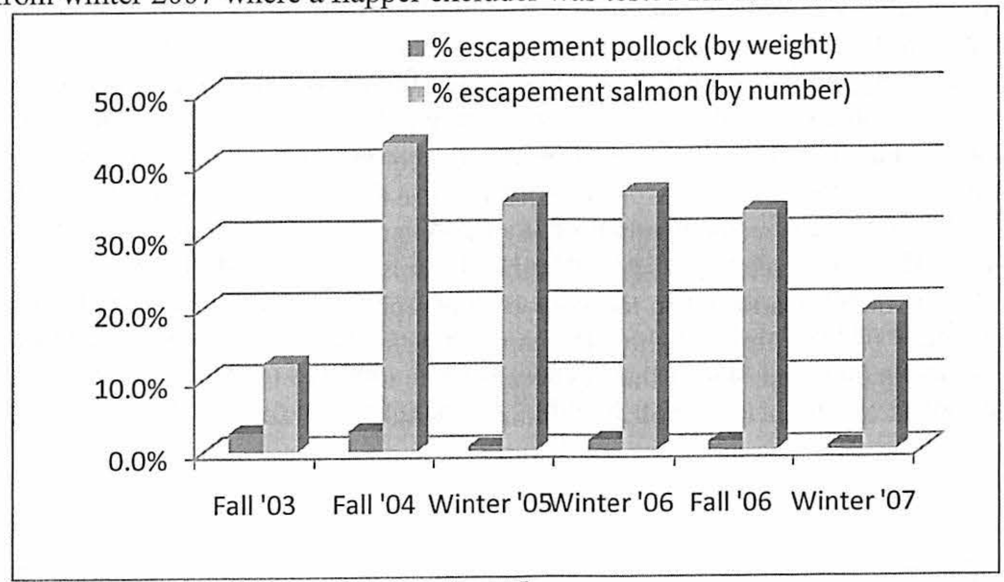
Figure 1: 2008 version of flapper excluder while at normal towing speed

Figure 2: 2008 version of a flapper excluder with vessel speed reduced to one-half of towing speed



As the concept of a flapper excluder began to take shape, the impetus to examine how it would work and how escapement rates might differ from those attained from funnel and tunnel excluders increased. To that end, an early version of a flapper excluder was tested by the *Pacific Prince* during the last stage of fieldwork on EFP 05-02 in winter of 2007. Overall, those tests showed some promise. An average escapement rate of 19% for Chinook salmon was achieved in the test. Additionally, the winter 2007 results showed Chinook escapement rates on some tows (nominal escapement rates) in the neighborhood of the rates attained in tests of later versions of funnel and tunnel devices (approximately 30 to 42% escapement for Chinook salmon, in earlier EFPs, as seen in Figure 3).

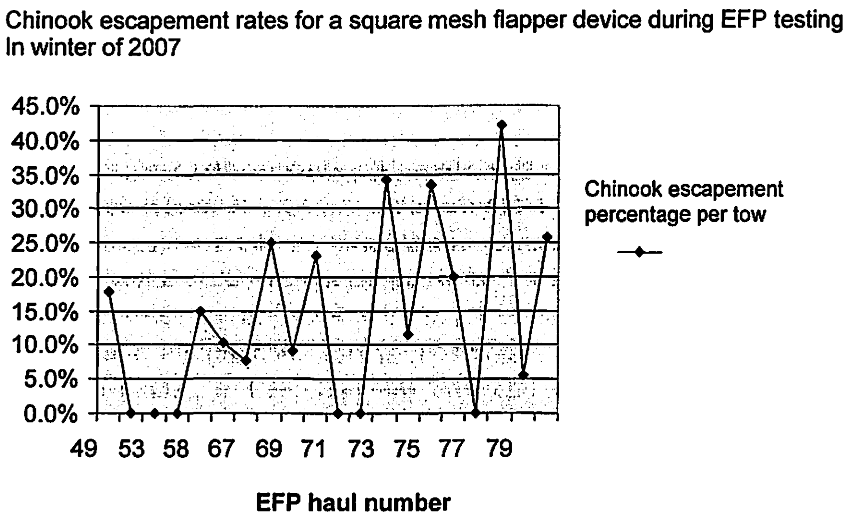
Figure 3: Contrasting average salmon and pollock escapement rates in earlier EFP testing to the results from winter 2007 where a flapper excluder was tested for the first time



Even more promising in terms of practicality for the fishery, was that the early tests of the flapper showed that the bulge problems were eliminated. This was significant because the testing during winter of 2007 encountered high catch rate conditions for pollock such that bulge problems with earlier designs would likely have occurred.

Of particular note from those winter 2007 tests of a flapper excluder on the *Pacific Prince* was the high degree of variability in Chinook salmon escapement rates. Effectively, many of the tows showed little or no Chinook escapement and the others in the range of 20-40 percent escapement (Figure 4).

Figure 4: Tow by tow Chinook salmon escapement rates from March 2007 EFP tests of the flapper excluder



The tow to tow variability raised the important question of why the flapper excluder seemed to have performed as well as earlier excluders in terms of Chinook escapement on some tows and so poorly on others. Hypotheses considered included: the flapper panel failed to drop down to allow escapement on some tows; towing direction relative to the direction of the tide/current affected the ability of the panel to drop; tow duration or catch rate for pollock affected salmon escapement; timing of salmon capture. Unfortunately, the test at the end of work on EFP 05-02 was not designed to provide reliable information on separate factors (covariates) affecting overall escapement rates. Also, the relatively small number of tows in the first test of the flapper excluder left little room for attempting to develop even preliminary inferences about factors. Our application for EFP 08-02 noted that there appeared to be sufficient impetus to take a more complete look at the potential for the flapper design since it appeared to show potential for significant Chinook escapement as well as avoiding the bulge problems that plagued earlier excluder use.

Step by step evaluation of flapper excluders in EFP 08-02

Fall 2009: During the review phase of our application for EFP 08-02, the Science and Statistical Committee (SSC) of the North Pacific Fishery Management Council recommended the first part of the new EFP research be dedicated to repeating the flapper experiment done at the last stage of fieldwork on the 2005-2007 EFP. The SSC was particularly interested in seeing the degree to which results would be consistent. This was important to the panel because repetition of the same gear configuration in a test had never been done in our previous EFP tests. So this left open questions of repeatability. Additionally, the highly variable results from the first flapper test in winter 2007 clearly begged the question of whether additional testing would stabilize the results to some degree.

While the SSC's suggestion made good sense from a scientific perspective, the increasing problem of salmon bycatch for the pollock fishery also created a growing interest in the speedy development of an effective excluder. Many pollock fishermen were convinced that further work on a flapper excluder, a simpler and easier to use design, was the way to go. For this reason, some fishery participants urged that all effort should be devoted to testing different ideas for improving the flapper excluder instead of looking retrospectively at how variable our results would be with a repeat test. The advice of the SSC was heeded, however, and we revamped our testing schedule to start with a repeat of the winter 2007 test. The earliest opportunity to do this was the fall of 2008.

Fall of 2008: Given that potential for a "vessel effect" on excluder performance was great, it was decided that the repeat experiment should utilize the same vessel, same net, and same excluder as the one used in the winter 2007 test. The reasoning behind the assumption of a vessel effect came from fishermen who had noted over time that different vessels fishing the same area often had rather different salmon bycatch rates. This was thought to be due to differences in the way different vessels towed their nets or how fish reacted to the herding effects of different nets. Given that EFP 08-02 provided limited seasonal allocations of pollock and salmon to cover testing from fall 2008 to winter 2010, it was hoped that the repeat experiment could be accomplished in the fall of 2008 and then the work could turn to improvements in flapper excluder designs.

Potential for a successful test on Chinook salmon (normally mostly encountered as bycatch in winter pollock fishing) existed because in some years Chinook bycatch rates increase in the fall as conditions start to turn into those occurring in winter towards the end of the pollock "B" season. Also, the availability of sufficiently high Chinook bycatch conditions for a repeat test in the fall season appeared to be likely given that Chinook bycatch rates had been relatively high in winter of 2007 and relatively high at times in the 2008 B season even as early as August 2008. Thus the plan was to attempt to get the repeat test done in September and October of 2008 so that other approaches to flapper devices could be tested as early as winter 2009.

Unfortunately, fishing conditions in the fall of 2008 did not match expectations. Specifically, the only fishing grounds that had sufficient Chinook salmon bycatch conditions resembling those needed for our testing methods offered poor pollock catch rates in mid-September 2008. This was the time window we had pre-arranged with the owners of the *Pacific Prince* to conduct the repeat test. Even in that location, Chinook bycatch rates were highly variable with reports from vessels fishing in the "Horseshoe" area near Dutch Harbor showing some promise but it was clearly an "on again, off again" situation for the smaller boats working there.

In spite of this the *Pacific Prince* endeavored to find conditions resembling those of the 2007 winter season (relatively high catch rates for pollock and Chinook) but finding those conditions proved to be largely unattainable. Because the vessel in all our EFP tests needs to cover its costs of operation from the sale of catches during the EFP, this created a dilemma. After approximately two weeks of searching for the elusive medium to high pollock catch rates and high Chinook conditions needed to repeat the winter 2007 EFP test, the EFP vessel had landed less than 200 tons of pollock and only 24 Chinook. This is considerably less pollock than was needed to cover the fuel cost of operating the vessel for the experiment.

Therefore, attempts to repeat the flapper test at the end of EFP 05-02 were rescheduled for the winter of 2009. The plan for that next test included the additional goal of examining diamond mesh flapper panel that offered the attributes that many in the pollock industry thought were better than the square mesh flapper panel.

Winter 2009: With the plan for phase one of the winter 2009 testing being a second attempt to repeat the winter 2007 square mesh flapper experiment, the *Pacific Prince* was once again tasked with finding the necessary conditions for the repeat test. The period of testing on the *Pacific Prince* during the winter of 2009 spanned from January 23 to March 1 and the repeat of the winter 2009 test occupied roughly the first half of this time period. Results for the re-do were quite similar to the winter 2007 test in terms of highly variable Chinook escapement on a tow by tow basis. On the repeat test, the average escapement rate for Chinook was 11% by number and pollock escapement was approximately 3% by weight (see result for winter 2009 "P1" (phase 1) in Table 1 below)

Table 1: Overall salmon escapement results from EFP 08-02

Test /date	Vessel	Codend salmon #	Recap salmon #	Salmon escape %
Winter 2009 P1	Pac Prince	726	91	11.1%
Winter 2009 P2	Pac Prince	1079	209	16.2%
Winter 2009	Starbound	720	70	8.9%
Fall 2009 P1 (chum)	Starbound	196	5	2.5%
Fall 2009 P2 (chum)	Starbound	643	34	5.0%
Winter 2010 P1	Pac Prince	122	62	33.7%
Winter 2010 P2	Pac Prince	37	25	40.3%
Winter 2010 P1	Starbound	150	49	24.6%
Winter 2010 P2	Starbound	38	21	35.6%

In addition to obtaining an effective salmon escapement rate, minimizing groundfish escapement is also important. Groundfish escapement rates have remained under three percent for all salmon excluders EFPs and escapement at this level is generally not seen as problematic for pollock fishermen as long as salmon escapement is proportionally much higher. Table 2 reports groundfish escapement rates for the winter 2009 repeat test of the flapper excluder (see the result for "winter 2009 P1") and other testing done under EFP 08-02. Overall, the 4% groundfish escapement rate was not troubling by itself. But with only 11% Chinook escapement the selectivity of the flapper excluder in the repeat test was admittedly disappointing.

Table 2: groundfish escapement rates in EFP 08-02

	Test /date	Vessel	Codend groundfish	Recap groundfish	Groundfish %
	Winter 2009 P1	Pac Prince	445	18.6	4.0%
	Winter 2009 P2	Pac Prince	806	27.9	3.3%
	Winter 2009	Starbound	1482	7.1	0.5%
	Fall 2009 P1 (chum)	Starbound	814	22.6	2.7%

Fall 2009 P2 (chum)	Starbound	574	14.1	2.4%
Winter 2010 P1	Pac Prince	849	14.2	1.6%
Winter 2010 P2	Pac Prince	396	6.8	1.7%
Winter 2010 P1	Starbound	689	2.8	0.4%
Winter 2010 P2	Starbound	433	2.1	0.5%

One major distinction between the winter 2009 test and the earlier test was that two vendor companies that provide sonar systems to fishermen built monitoring devices for the flapper to help answer one of the most pressing issues of flapper excluder performance. These vendors made demo units of their monitoring prototype devices available to the EFP test in winter 2009. With this, the position of the flapper could be monitored on a real time basis during the EFP testing and the capability to know if the flapper panel actually descended to allow escapement on all tows was finally at hand. The devices differed in specific technique but both had the same purpose of allowing real time flapper position monitoring on the test vessel. One device was designed to monitor the distance between the sending unit and the receiver. The other was an "eco-sounder" designed to show the position of the flapper panel as it reflected the sound transmissions from the sender unit placed on the bottom of the trawl intermediate just under the flapper panel.

Another motivation for having flapper monitoring devices was to help answer the persistent question of whether towing direction relative to the tide and relative speed was affecting the ability of the flapper panel to descend to allow salmon escapement. Of interest also was monitoring in real time how long a vessel would need to slowdown in order for the flapper panel to descend to allow escapement. While lighted video could have been used to help address these questions, lights would be expected to affect fish behavior so they could not be used in the EFP testing.

The flapper monitoring devices described above helped to elucidate some of the factors affecting the variability in escapement rates during the winter 2009 tests. In addition to showing that the flapper position during slowdowns was in fact affected by direction of towing relative to the tide and currents, it was also clear that the time needed for the flapper to descend varied greatly depending on the time needed for the vessel to slow to 2.5 knots. For example, on some tows the flapper panel only descended to approximately one-fourth of the distance of the diameter of the intermediate during the 10 minutes. On other tows the panel extended all the way down in a matter of minutes.

Even more interesting in terms of learning about flapper panels used with periodic slowdowns was the observation by the captain of the *Pacific Prince* during the EFP test that salmon bycatch overall might be increased by doing periodic slowdowns. Comparing notes with other captains fishing in proximity to his vessel during the EFP, the *Pacific Prince*'s captain seemed to be catching more salmon than the other vessels that were not engaged in the test. In other words, while fishing with the flapper excluder may have been reducing the EFP vessel's salmon bycatch rate by the proportion seen in the test (fraction in recapture net compared to overall number), slowdowns associated with using the flapper might actually be increasing the number of salmon that the test vessel was catching.

The reason slowdowns could increase overall salmon catches despite escapement via the excluder is uncertain but fishermen reasoned it could occur in the following manner. Slowdowns involve hauling the net up slowly during the duration of the slowdown to prevent the back end of the net from sinking to the seafloor. Because hauling the net lifts the net higher into the water column during the slowdown, potential for this to increase the time the net spent in a zone with potentially higher abundance of salmon could be the mechanism for increasing salmon bycatch relative to not doing slowdowns.

While data to confirm the possibility that slowdowns were increasing salmon catch rates was not available (boats outside the test did not have the sorting facilities to count salmon on each haul), the captain of the *Pacific Prince* became deeply concerned about this issue. As this matter was discussed among pollock captains during the EFP and at meetings following the test, more and more captains agreed that slowdowns could increase salmon catch rates overall. This simply seemed to make intuitive sense and as a result the fleet's interest in a flapper excluder that required periodic slowdowns diminished considerably and the feeling of "back to the drawing board" once again prevailed.

The next direction for development of a salmon excluder starting in fall of 2009 was how to make a flapper excluder that would remain partially in the "down" (open to escapement) position at normal towing speeds. This could allow some of the salmon passing through the net to escape on their way back rather than relying on escapement during slowdowns. Using the flapper in this manner would obviate the need for slowdowns.

Meetings between the PIs and the pollock industry prior to the winter 2009 testing focused on how to add additional weight to the flapper panel so that it would remain open while towing. The concept was that even with the flapper panel hanging down one-third to one-half of the way during towing operations, bulging of the net would not be created because dense schools of pollock moving through the net would simply push the flapper up as the fish passed through the excluder section of the net. The absence of a rigid tapered square mesh funnel or tunnel used in the earlier excluder designs would, therefore, avoid the bulge problem even at high catch rates of pollock.

Accordingly, the next phase of testing was devoted to evaluating how much weight was necessary and where it should be placed to allow salmon to access the escapement hole during regular towing. Another aspect of this was to see if salmon escapement rates would be higher with this partially open flapper design than those in the tests of flappers that were completely closed to escapement during towing. Related to this was whether pollock escapement rates would be high with these heavily weighted flappers relative to escapement rates with funnel and tunnel excluders.

Placing weight on a panel of webbing creates potential challenges because the panel is made of relatively soft material. So exactly how the weight is placed on the panel affects the shape of the panel during towing. This means that the expectation that the weight will achieve a desired shape such as a gradually downward sloping ramp to allow salmon to follow it to the escapement hole is not at all a guarantee. In fact, we soon learned that every adjustment to the heavily-weighted flapper excluders designed to allow escapement while towing in the pre-test tows on each EFP vessel raised new questions and challenges. For instance, placing nearly all the weight at the aft edge of the flapper panel might sink the back edge of the flapper panel during towing but the middle portion of the flapper panel might tend to billow up and close off access to the escapement portal.

On CP *Starbound*, the additional towing force of a large horsepower factory trawler presented even bigger challenges. One challenge was simply getting the panel to stay down at all during towing. Pre-test tows with incremental increases in weighting showed that more than 700 lbs of lead-core line (leadline) was needed before the flapper would stay down at all during normal towing speeds. Even then, the panel would be open only about one-fourth of the diameter of the intermediate and this varied to nil at times depending on the towing direction relative to the tide. In the extreme, a set of strong elastic lines were used during pre-test tows to pull the flapper panel down. Unfortunately, this achieved small gains in terms of opening access to the escapement hole during towing but it served to distort the shape of the panel. Once again billowing of the panel was noted at points where the rubber cords were not actually pulling the panel down.

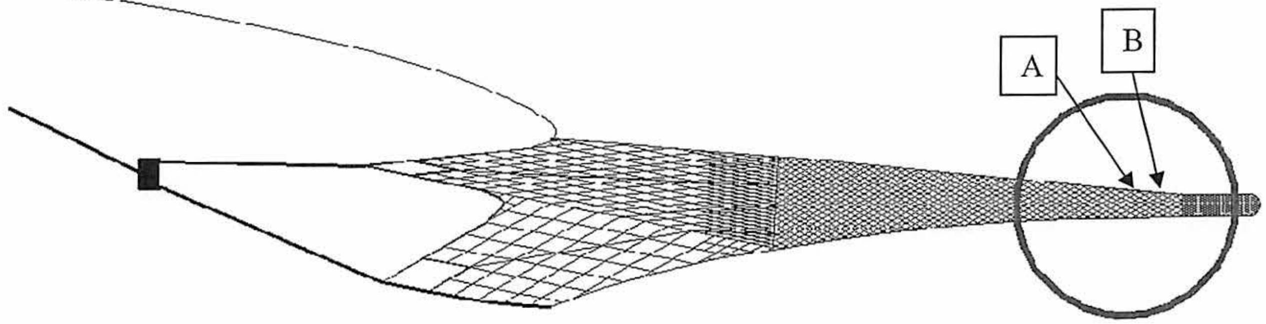
After the pre-test tows for the phase two tests in the winter of 2009 where adjustments were made to achieve some meaningful escapement opening for salmon at normal towing speeds, the EFP test was conducted to measure the escapement performance for salmon and groundfish with the "highly weighted" flapper panels on the two EFP vessels. Results from the phase two tests on *Pacific Prince* showed minimal improvement in escapement of Chinook and practically the same result in terms of loss of pollock relative to the first phase of the winter 2009 work (Tables 1 and 2). For *Starbound*, a rate of less than 10% salmon escapement occurred although pollock escapement was small (Tables 1 and 2). The video obtained during the testing on *Starbound* showed that even with some opening to allow escapement during towing, fish struggled to move forward in the strong flow of water aft of the flapper panel. This suggested that challenges for highly weighted flapper panels on factory trawlers might be even greater.

<u>Fall 2009:</u> The plan for fall 2009 shifted somewhat in response to information brought forward by one of the pollock trawl manufacturers that had been working with some of the catcher processor vessels on similar flapper excluders. The information presented at the excluder workshop held for the pollock industry suggested that some of the challenges with the high degree of water flow could be addressed by moving the location of the excluder closer to the codend. For the video shown at the workshop, the flapper panel was equipped with weight of approximately 120 pounds (similar to what we had evaluated for flapper excluders requiring slowdowns to achieve escapement) but the panel appeared to provide a useful pathway for salmon to reach the escapement hole even at regular towing speeds. The difference was that this

excluder was located in the straight tube section just ahead of the codend. Water flow in this section was expected to be slower in that straight section of the end.

What was also clear from the video footage reviewed at that workshop was that flapper panel located in the straight section just ahead of the codend suffered from some billowing and inconsistent opening space but did appear to create some opportunities for escapement during towing. Placement in the straight tube therefore could be advantageous in terms of opportunity for salmon escapement relative to where the excluder had been placed in earlier tests at the aft tapered section of the intermediate (Figure 5). But achieving reasonable access to the escapement hole was not necessarily going to be easy. Based on this, the EFP test for fall 2009 would look at an approach similar to what was seen in the video but with some additional weight to create increased opportunities for escapement.

Figure 5: Stylized depiction of potential flapper excluder placement locations comparing the aft section of the tapered intermediate (A) or in the straight tube section just ahead of the codend or stuffing tube (B)

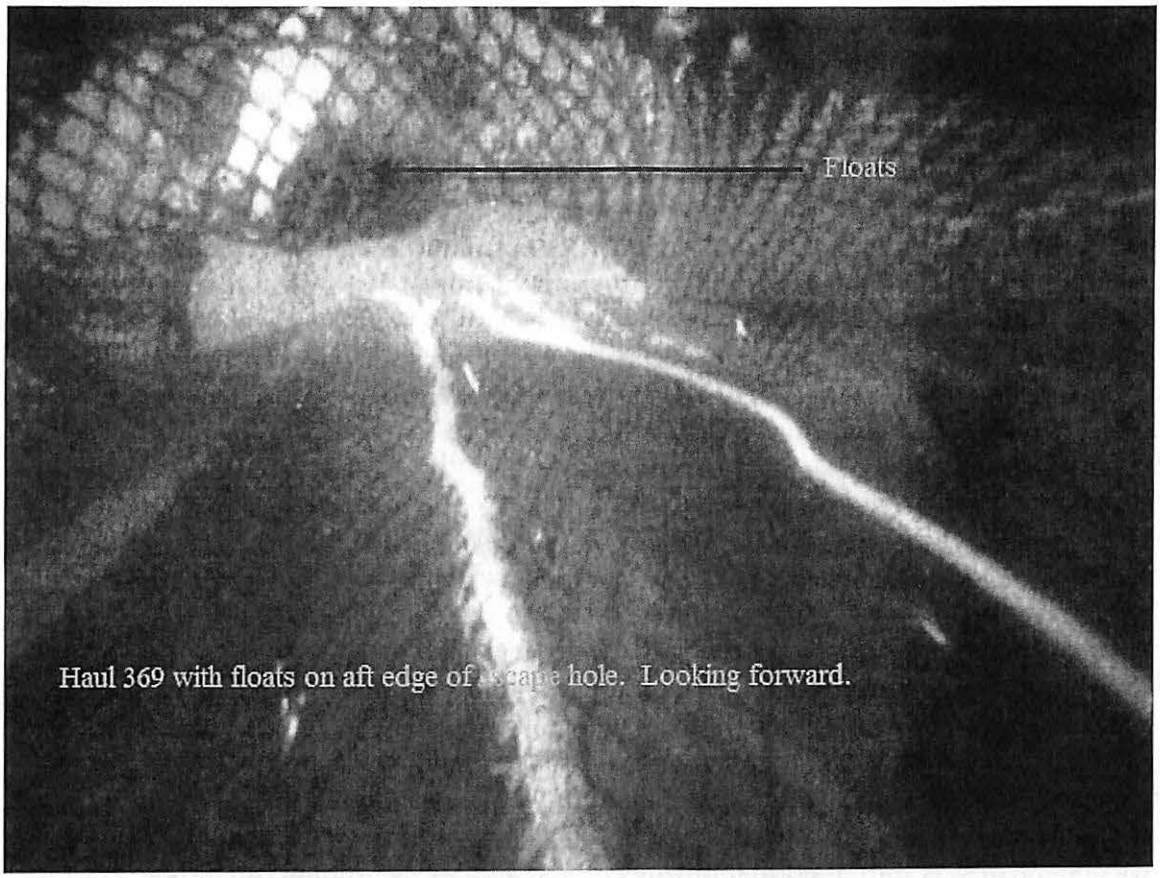


The vessel selected for the fall 2009 test was once again the CP *Starbound.* As part of their application to conduct the EFP test, *Starbound* agreed to install a flapper excluder in the straight section of their net just in front of the cod end prior to the EFP test. Additionally, *Starbound* agreed to use one of the underwater video systems that many pollock industry companies had purchased in 2009 to get some video images of the excluder position at towing speed. This would allow the test to focus on measuring the escapement performance of the excluder instead of spending a lot of effort "tuning" the weighting to get the excluder to remain open during fishing.

With the work *Starbound* did prior to the EFP, useful information was available for our review before starting the EFP test in September 2009. In taking a close look at the video, it was noted that the panel remained partially open at the aft end of the panel but once again billowing of the panel created a somewhat imperfect escapement pathway for salmon. The question was whether salmon would swim the required distance of approximately four meters from the aft edge of the excluder panel all the way to the escapement hole in a fairly narrow pathway where webbing appeared to be billowing up with the flow of water (see underwater camera shot of pathway in Figure 6 below). Our best estimate looking at the video was that the aft edge of the flapper panel was down approximately one-fourth of the diameter of the intermediate although the billowing panel materials reduced this amount at times. Additionally, the video showed that billowing of the flapper panel near the escapement hole potentially created insufficient room for salmon to access the escapement hole. To remedy this, a set of eight inch trawl floats were added to the aft edge of the escapement hole in an attempt to create some lift and potentially increase the space available between the flapper panel and the top of the escapement panel (Figure 6).

Results from the fall 2009 tests were unfortunately somewhat discouraging (Tables 1 and 2). Salmon escapement rates (mostly chum salmon) were quite low (about 2.5% and 5%). Areas with sufficient numbers of Chinook salmon bycatch were not located during the fall 2009 test. What was perhaps more discouraging was that pollock escapement rates were in the range of 2.5% for both tests. While not necessarily problematic when compared to previous groundfish escapement rates in earlier tests, the basic issue was that salmon and pollock escapement was nearly the same so the device appeared to be almost random escapement. The lack of selectivity was unfortunately not unlike simply just cutting a hole in the net.

Figure 6: Underwater camera view of pathway for salmon escapement with flapper located in straight section of pollock trawl



Flume Tank work and the plan for our final testing in winter 2010: Following the disheartening but still informative test results from the fall of 2009, the EFP investigators met to consider everything that had been learned from our testing, and reports from other industry efforts regarding flapper excluders, and particularly flapper excluders designed to allow escapement while towing. The objective was to come up with a set of changes that would make the flapper work because the advantages of the flapper in terms of avoiding bulging problems made it the industry's best hope for an effective excluder.

The focus of discussion was whether or not to work in the tapered section where faster water flow made it easier to achieve the desired flapper shape although necessitating heavier weights. The alternative was to place the excluder in the straight tube section where slower water may allow easier escapement but billowing of the flapper might be problematic. The discussion led to a plan for addressing these questions prior to settling on a design for the final stage of testing under our EFP which would occur in the winter of 2010 pollock "A" season. The plan was to go to a test tank (flume tank) facility at Memorial University in St. Johns Newfoundland with a set of scale models to answer as many questions as we could and come up with a design for the upcoming tests in January 2010.

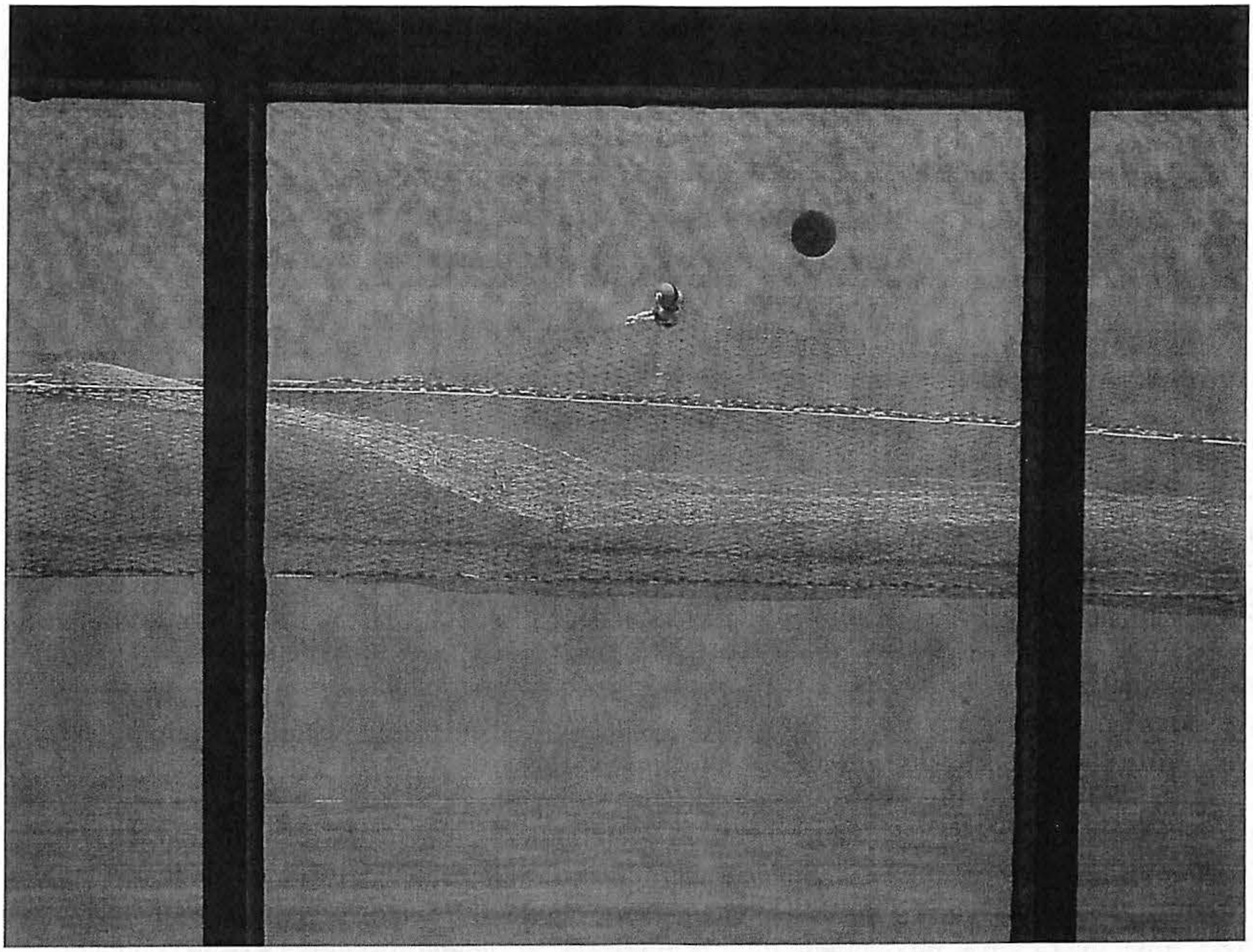
The trip to Newfoundland was made in early November of 2009. A group of pollock captains and crewmen who had been most involved with the recent flapper development and testing as well as several interested pollock net manufacturers joined the investigators for the trip. Several other researchers and pollock industry leaders also joined the delegation going to Newfoundland given the exceedingly high importance of coming up with a workable excluder for Chinook to help the industry cope with new restrictions to protect Chinook salmon that had recently been approved and are scheduled to come into effect in 2011.

Prior to our departure, we constructed three flume tank models that were the most basic versions of flapper excluders placed in tapered and straight sections of model net intermediates. From our past experience, use of the flume tank facility at Memorial University is ideal for resolving basic water flow and shape issues. The Newfoundland facility is sufficiently large to provide adequate space and water flow capacity to test models constructed of full scale materials. Our models included only the intermediate and codend sections of the net and a towing "hoop" was used to open the meshes to the proper degree. Additionally, our models were scaled down by reducing the number of meshes for each section. In most flume tank work models include all components of the trawl and model doors are rarely used to open the net. For our purposes, this would have meant that the intermediate section of the net was considerably smaller and therefore made it more difficult to visualize the effects of water flow on the weighted section of the flapper.

The flume tank trip work led to some important breakthroughs in flapper excluder design. One was that weighting could be placed at the front part of the flapper panel. In this manner, the portion of the panel aft of where the weight was applied would stream nearly straight back. Secondly, the effects of flow seen in our earlier field work on the tapered section versus straight tube were confirmed in the flume tank. The straight tube section clearly allowed for more practical amounts of weight (120 to 200 lbs when scaled up to full scale) to keep the flapper panel down about half way during normal towing speeds. Finally, additional room for escapement of salmon could be achieved by "gusseting" the aft edge of the escapement hole and attaching a few small trawl floats to the gusset. The "hood" that this created was designed to provide additional salmon escapement opportunity because even if the flapper panel was not one-half way down (open) because flow of target catch through the excluder section lifted up the flapper panel, there could still be sufficient room for salmon passing back at the same time to get out of the flow of pollock and eventually move forward and up to escape.

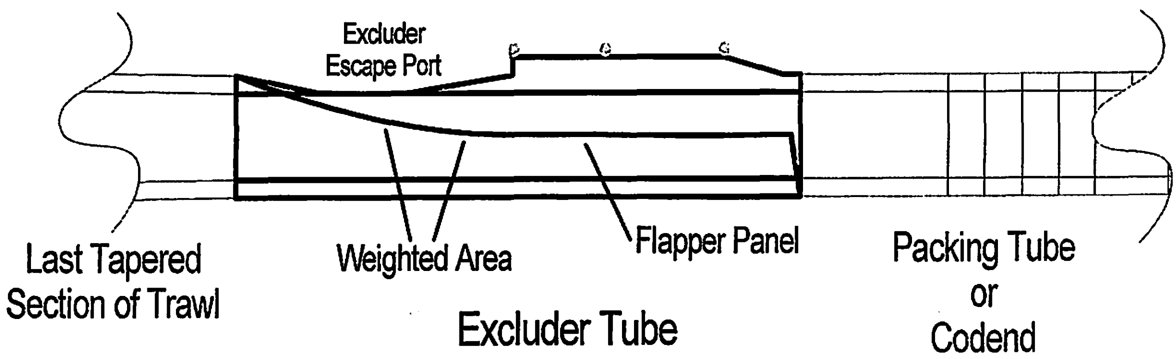
The picture below taken of one of our flume tank models illustrates the combined design features of the flapper excluder developed at the final stages of fall 2009 work on the flapper excluder at Memorial University's flume tank (Figure 7).

Figure 7: Final design product for an improved flapper excluder from fall 2009 flume tank work



Note in the photo the weight (here simple chain instead of leadline that would be used in an actual excluder) is applied in the forward portion of the flapper panel and that the remaining portion of the panel trails back fairly straight from where the weight is applied. Additionally, small trawl floats applied to the gusseted aft edge of the escapement hole create a great deal of lift to increase the space available for a salmon attempting to swim forward to escape the flow of pollock passing through the excluder section. Figure 8 below is a stylized depiction of these design changes as they were developed from the flume tank work.

Figure 8: Design changes to the flapper excluder in preparation for winter 2010 EFP testing



<u>Results from winter 2010 testing of the flapper design reflecting October 2009 flume tank work:</u> The two vessels that had been involved with recent flapper testing were once again selected for these important final tests of flapper excluders under EFP 08-02. The reasoning for using these vessels once more was that the crews had demonstrated a willingness and ability to work under the constraints of the testing protocol and most importantly the *Pacific Prince* and *Starbound* provided a range of horsepower differences needed for the evaluation without adding any new unknowns in terms of towing speeds and fishing practices.

As with the fall 2009 tests, each vessel was asked to use some of its 2010 AFA groundfish quota to pre-test the weighting on the excluder panel. This would mean that when the EFP tests started, we would be confident that the shape parameters from the flume tank work would already be in place when the EFP test was started. In these pre-tests, *Starbound* was also asked to conduct some tows under the same experimental protocol that would be used for the EFP testing to the extent possible given partial haul rather than a full census of salmon catch on each tow is the norm for observer sampling on AFA factory trawlers. Additionally, it was known from the outset that *Starbound* would not be able to conduct the pre-testing in areas of high Chinook bycatch because AFA vessels were subject to the industry's regular "rolling hotspot" bycatch avoidance program.

Winter 2010 tests went relatively well and both vessels encountered sufficient pollock and Chinook to achieve the desired sample size for evaluation of the performance of the excluder for each test. For the first phase of the testing ("P1" results in Tables 1 and 2 above), F/T *Starbound* achieved an average Chinook escapement rate of 25% and *Pacific Prince* achieved 35%. Groundfish escapement in this same test was lower for *Starbound* (less than half a percent by weight) than for *Pacific Prince* (about 1.5%).

The difference in the excluder configuration between vessels was that *Starbound* had applied 160 lbs of leadline on the flapper panel according to the design parameters of the flume tank work (as had *Pacific Prince*) but this may have been relatively lightly weighted compared to *Pacific Prince* given the greater towing force of the factory trawler *Starbound.*

Of note from the *Starbound*'s video during pre-testing was that the flapper panel remained nearly one-half down (open) during regular towing operations but tended to lift up and stay up longer than the flapper on the *Pacific Prince*. Having noted this, however, it is important to point out that there are multiple factors that complicate such a comparison. In any case, the lower escapement rate for both Chinook salmon and pollock makes intuitive sense in the context of the possible difference in effective weighting. Escapement rates for both Chinook and pollock were promising compared to past results with flapper excluders. Further, no negative effects on fishing from bulging or other practical aspects of fishing with the excluder (e.g. setting the net) were detected.

Once a sufficient number of Chinook were encountered during the tests to achieve the statistical significance and practicality assessment objectives of the EFP test, the EFP collaborators came up with a plan for adjustments to the excluder for Phase II testing with the remaining groundfish and Chinook salmon allowances. This was done in consultation with the EFP captains and crews. With a 35% Chinook escapement rate from the first test, the captain of the *Pacific Prince* thought that no changes to the weighting of the flapper panel should be done. Instead, he was curious to see if artificial lighting placed in the recapture net above the escapement hole would entice salmon to swim up and therefore increase the escapement rate. His rationale for this was that his own testing outside the EFP seemed to suggest that salmon at fishing depths were attracted to the lighting for the camera he had used.

For EFP testing, we have been careful in all previous tests to avoid potentially influencing salmon behavior with light. Thus, only extremely light-sensitive cameras have been used without artificial light. In this case, however, everything else could be held constant and the light in the recapture net was essentially a treatment variable of interest for the phase two test. When this was done, the escapement did nominally increase to approximately 40% for *Pacific Prince's* phase two testing (P2 in Table 1). But because the remaining groundfish allowance was not sufficient to achieve the minimum number of salmon for the statistical power goals of the test, this P2 result is far less certain than the P1 result. What was clear from this result, however, was that additional testing of the effects of adding light positioned to increase escapement of salmon may be useful in future EFPs because potential for this to increase escapement performance of flapper excluders is worth examining.

For the second phase of testing on *Starbound*, the adjustment to the excluder flowed naturally out of the questions surrounding why *Starbound*'s salmon escapement rate was lower than that of *Pacific Prince*. The only difference was the relative amount of weight on the flapper (compared to towing force). So for the second test on *Starbound*, 40 lbs of leadline was added to the top of the flapper panel in the same position of the earlier weight placements. The phase two results for *Starbound* did in fact show a nominal increase in Chinook escapement to 35% but once again this test fell slightly short of the desired Chinook sample size as well. Additionally, overall tow to tow escapement rates for both phases of testing on *Starbound* (Figure 9) seemed more variable than for *Pacific Prince* (Figure 10). So the certainty that the weighting differences between phase one and phase two were responsible for the salmon escapement performance difference is likely quite limited.

Figure 9: Per tow escapement rates of Chinook for phase one and phase two of winter 2010 EFP testing

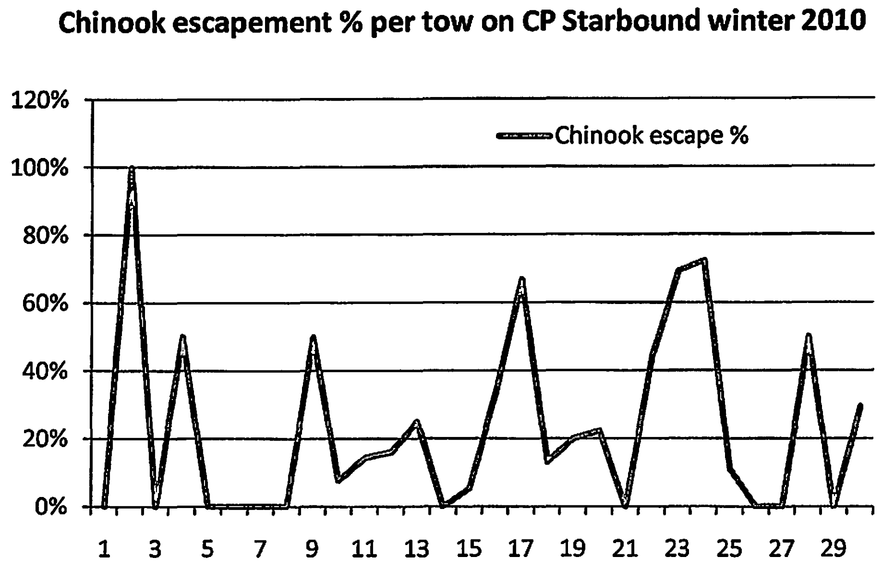
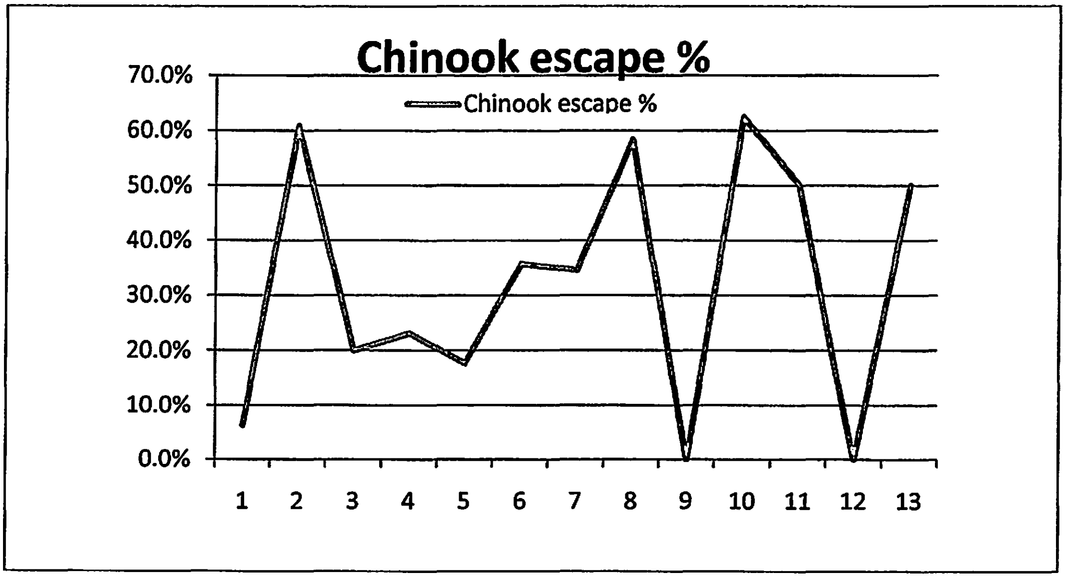


Figure 10: Tow by tow escapement rates for *Pacific Prince* in winter 2010 EFP testing phase 1:



Summary of findings and direction for future research on flapper excluders:

EFP 08-02 successfully conducted an extensive assessment of the potential for flapper excluders to reduce salmon bycatch rates and avoid the problems encountered with earlier excluder designs. With the highly suggestive first stage results on a prototype flapper used in the final stage of testing during the 05-02 EFP, the flapper excluder appeared from the outset to be a viable excluder design for reducing Chinook salmon bycatch rates. As testing of the first flapper design was being conducted with periodic slowdowns, a more realistic assessment of escapement potential became clear. At the same time, the potential for slowdowns to allow escapement but potentially increase salmon bycatch catch overall (with the increased time of the net in the water column above pollock schools) became a significant issue for pollock fishermen. While never demonstrated concretely, the intuitive reasoning that slowdowns might increase salmon bycatch even if some manage to escape and the anecdotal evidence from vessels fishing near the EFP with markedly lower salmon bycatch rates were enough to persuade EFP investigators and interested industry to abandon the flapper concept that was designed around vessel slowdowns.

Once the direction away from slowdowns was agreed upon by everyone, EFP 08-02 used its remaining effort and groundfish and salmon allowances for testing flapper excluders designed to allow escapement during towing. Water flow differences between tapered versus straight tube sections of the net and tradeoffs with excluder shape and salmon escapement performance potential were the focus of the remainder of the EFP work. In this regard, the design arrived at iteratively represents what we feel is a workable excluder that may contribute significantly to the pollock industry's ability to control its salmon bycatch rates.

This final design is based on installing the flapper in the straight tube section just ahead of the packing tube (where applicable) or codend. Weight is placed on the forward part of the flapper panel and floatation on the aft section of the escapement hole is used to achieve lift and additional room for escapement. Configured in this manner, the flapper excluder achieved between 25% and 35% Chinook escapement by number with pollock (groundfish) escapement in the range of one-half to one and one-half percent by weight. This is a significant accomplishment given the inherent difficulty of developing a bycatch reduction device that works solely on differences in swimming ability and other behavioral aspects that differ between salmon and pollock. As was noted in the final tests on *Pacific Prince*, adding artificial light above or around the escapement hole may increase the Chinook escapement rate as well but additional testing would be needed to help confirm this possibility.

The final version of a flapper excluder arrived at through EFP 08-02 appears to avoid problems occurring with earlier designs of excluders such as bulges in the net. Additionally, no operational problems or detrimental effects on fishing occurred in the winter 2010 testing. So presumptively this excluder avoids the once seemingly insurmountable problem affecting earlier excluder designs. But this conclusion (as well as all results from the EFP) is strictly applicable to the limited set of conditions under which testing occurred in the EFP. Further, the results are most applicable to the types of vessels selected for the EFP. It should be noted that even though we specifically selected these vessels to be applicable to the Bering Sea pollock fishery, our focus was mostly on higher horsepower boats relative to smaller catcher vessels because it was on the higher horsepower vessels where problems with the bulging in the net appeared to occur most frequently with the early funnel and tunnel excluder designs.

Finally, achievement of these promising Chinook escapement rates in the EFP was done under relatively high catch rate conditions and overall fishing conditions under which testing occurred as described above. Our testing specifically focused on areas with high Chinook catch rates and medium to high pollock catch rates. Further, testing was not done in areas with high density of jellyfish or other factors that appeared to be problematic for earlier excluder designs. The flapper design seems to us to be less vulnerable to jellyfish problems but this inference is based on design elements and not from testing results.

Likewise, all testing in the latter part of the EFP was done following considerable pre-testing by the EFP vessel to "tune" the excluder weighting such that it achieved the desired shape prior to the start of the test. We therefore advise pollock fishermen interested in using the concepts and designs described in this report to make use of cameras to verify that the flapper excluder they are installing is actually achieving the design parameters described herein. These are: shape of the excluder panel and intermediate as described above; flapper panel that remains 50% open during towing; and sufficient weight on the flapper panel to allow recovery of the flapper panel to 50% open following being lifted up by a mass of pollock passing under the panel. All three EFP investigators are available for consultation on these design and performance issues relevant to the work done in this EFP.

From here a few directions for further research in this regard are apparent. First and foremost, additional proofing of the current flapper excluder by interested pollock fishermen is needed. This would allow the excluder to be evaluated under a wider array of fishing conditions than occurred in the limited EFP testing. This expanded testing will likely raise interesting and important questions and issues regarding the general effectiveness of the excluder under an expanded set of fishing conditions.

The pathway to excluder improvements for bycatch reduction performance for Chinook salmon will undoubtedly be a combination of additional informal testing by pollock fishermen and further systematic testing through EFPs. At this point, for iincreasing Chinook salmon escapement rates, the leading direction would be, based on our initial efforts, whether adding artificial light (e.g. glow sticks) would improve salmon escapement rates. To adequately address this issue, some systematic testing would be preferred to ad hoc testing efforts with no scientific controls.

In a bigger context for the future of salmon excluder development, a clear priority for salmon excluder development would be to focus on chum salmon. To date and for unknown reasons, chum salmon have not responded measurably to all the excluder designs that have been developed thus far. An obvious priority for future research would be to do a systematic test of the current flapper design to see if it is at all effective for chum salmon. Depending on that result, the next step may be to explore alternative design modifications to the current excluder including escapement holes that are not on the top of the trawl intermediate.

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