Request for an exempted fishing permit (EFP) to collect performance data on a halibut excluder design that Amendment 80 captains feel is likely to achieve the best selectively from among excluders in use in Amendment 80 flatfish fisheries

Date of Application: June 2020

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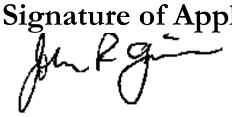

Collaborators:

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Dr. Suresh Sethi, Cornell University

Dr. Stan Kotwicki, Alaska Fisheries Science Center

Dr. Steve Martell, Sea State Incorporated

EFP vessel information sheet

(ii) Name, address, and telephone number of owner and master. NORTH STAR FISHING CO 2320 West Commodore Way Ste 200, Seattle, WA 98199 206-298-1200 Owner representatives: Mr. James Johnson and Mr, Erik Peterson; Vessel Master: Captain Josh Buchanan

(iii) USCG documentation, state license, or registration number: Official#1267875, N/A, IMO#9806122,

(iv) Home port: Seattle, WA

(v) Length of vessel: 233ft

(vi) Net tonnage: 1324 ICTM

(vii) Gross tonnage: 4412 ICTM

(viii) The approximate time(s) and place(s) fishing will take place, and the type, size, and amount of gear to be used: EFP fishing will occur in the normal locations on the Bering Sea shelf where trawling for yellowfin sole and flathead sole occurs. The proposed timing for the EFP is August 2021 so fishing at that time would likely occur outside of Zone 1 in flatfish fishing areas east of the Pribilof Islands. If the EFP is delayed for some reason, fishing will occur in areas where normal flatfish fishing operations occur seasonally. The North

Star will use a non-pelagic otter trawl during the EFP and the rigging of that trawl will be a twin trawl set up (see figure of a twin trawl below).

Motivation:

The flatfish fishery in the Bering Sea is at a critical juncture with existing halibut bycatch regulations and anticipated additional restrictions. The fishery is concerned that its ability to continue to catch its flatfish and other groundfish allowances could be greatly impacted, particularly if fishing conditions encountered during the 2018 and 2019 fishing seasons (low target species catch rates and relatively high encounter rates for halibut) are the new norm due to warming bottom water temperatures.

Flatfish fishing is a significant component of the Bering Sea groundfish fishery, annually producing approximately 200,000 metric tons of sole, founders, and plaice. Prior to a 2008 change in management program, establishing vessel-specific catch and bycatch allowances administered through fishing cooperatives (Amendment 80), halibut bycatch tended to constrain harvest of much of the total allowable flatfish catches. Since 2008, the Amendment 80 sector has been able to make significant improvements to reduce halibut and other bycatch and has increased target fish yields. This has been achieved because the new management program allows fishermen to fish when and where it makes most sense and to make better use of bycatch reduction tools like sharing information to avoid bycatch "hot spots", bycatch avoidance agreements, and gear modifications.

Over the last two decades, Bering Sea flatfish trawlers have been developing and using halibut "excluders", which are modifications to the intermediate section of the trawl intended to allow halibut to escape while retaining sufficient levels of target species for operational efficiency. Because halibut encountered in the Bering Sea were generally larger than targeted flatfish species, early designs were rigid or mesh selection grates were installed perpendicular to the water flow to help discourage halibut from continuing to go back to the codend. Instead, the halibut exited through escapement portals at the top or bottom of the sorting grate (depending on the design and angle of the sorting panel) with the goal of retaining target fish passing through the grate (Rose and Gauvin 2000).

Figure 1: Conceptual diagram of a sorting panel halibut excluder with a metal grate

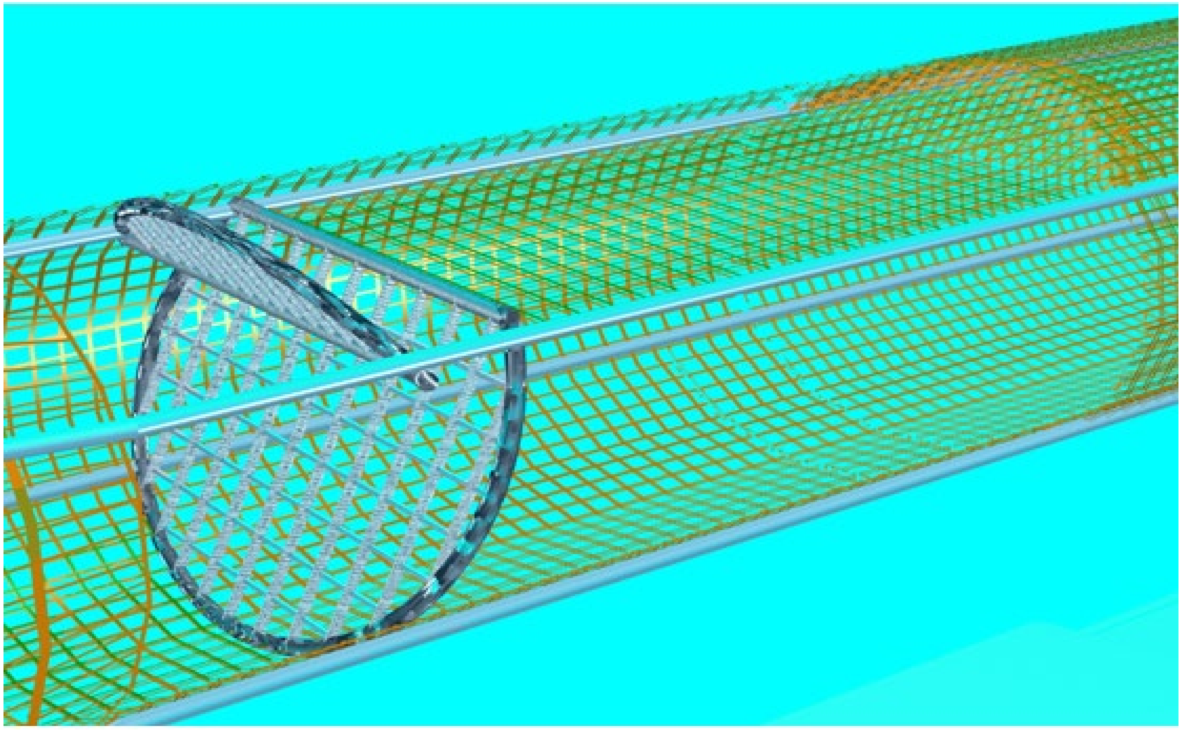


Figure 2: Picture of a semi-rigid ("Pex" grate) salmon excluder

Usage of early designs of halibut excluders was greatly hampered due to the relative fragility and vulnerability to damage of the early devices. The vessel would find a work-around to avoid loading the excluder portion of the net onto its net reel to avoid damaging or modifying its shape. This created considerable inefficiency for dumping codends and resetting nets because the section of netting with the device installed had to be set off to the side, routinely adding up to an additional hour of handling time for each haulback and reset of the nets. This also created safety issues with lifting hooks and shackles needed to secure the excluder section off to the side coming loose and swinging across the deck.

Amendment 80 spurred use of halibut excluders, and this brought forth new designs using flexible grates that could be reeled up onto net reels without damaging the device or significantly slowing down the haulback and setting process. These designs were long mesh hallways parallel to the water flow. The concept of "hallway" excluder is that fish coming back through the net into the intermediate section are routed through an inner hallway constructed from a specialized mesh panel. Separation between the outer netting and the inner hallway is achieved via large water kites installed at the front and aft end of the excluder. The inner hallway narrows as fish move back through it, thereby encouraging the target fish to swim though the meshes of hallway, and mesh size in that section is designed to be large enough for target fish to pass through. Fish that swim through are retained by the outer netting and eventually move back to the codend with the flow of the water. The meshes of the inner hallway are therefore sized to be large enough for target fish to pass through but too small for halibut to swim through. Halibut (and other catches) that do not pass through in the inner hallway exit the net through a portal at the lower aft end of the inner panel of excluder. A conceptual illustration of a hallway excluder is included below.

Hallway excluders can be rolled onto the vessel's net reel with less chance of distorting the shape of the panels or damaging the excluder. The ability to roll the excluder onto the net reel saves considerable time bringing the net on board relative to earlier designs. Hallway excluders also provide considerably more surface area for separating fish and that, in conjunction with the parallel orientation to the water flow, makes hallway excluders less vulnerable to clogging and "gilling" of target fish problems experienced with earlier excluders.

Figure 3: Conceptual depiction of a "hallway" halibut excluder (top view)

Figure 4: Conceptual drawing illustrating a hallway halibut excluder installed in a flatfish net

Formalized testing of some hallway-style versions of excluders developed for the Bering Sea was done fairly recently on smaller, lower-opening U.S. West Coast trawls off the coast of Oregon (Lomeli and Wakefield 2013, 2016, Lomeli et al. 2017). This provided field-based validation of their effectiveness, but differences in trawl design and operational characteristics between the two fisheries likely mean those results are only indirectly applicable to Bering Sea fisheries where use of such excluders is more extensive. This is because Bering Sea flatfish trawlers use of four-seam versus two seam nets and flatfish fishing in the Bering Sea involves faster towing speeds, higher target species catch rates, and differences in size of target fish relative to halibut.

In 2015, following the sector's success under Amendment 80 and in response to a decline in halibut biomass in the Bering Sea, the North Pacific Fishery Management Council (NPFMC) approved a 25% reduction in the sector's halibut bycatch mortality cap. To help prevent a return to leaving a large fraction of its flatfish un-harvested, the Amendment 80 sector worked with National Marine Fisheries Service (NMFS) to change fish handling rules to allow halibut to be rapidly sorted off the deck, while still collecting adequate data to quantify halibut catch and viability. Through this new program, savings in halibut mortality from "deck sorting" have been significant. But over the last two fishing years (possibly due to warming sea temperatures and lack of the "Cold Pool" thermal front that tended to spatially separate flatfish from halibut), encounter rates for halibut by the Amendment 80 fleet have increased, despite overall lower halibut biomass. The result has meant that nearly all of the bycatch mortality savings from deck sorting were needed to maintain flatfish catches at status quo levels in 2019.

With no sign of improvement in Bering Sea halibut stocks, more restrictions on halibut bycatch for the Amendment 80 sector may be imminent, emphasizing a need to advance gear innovation as a means to further reduce bycatch of halibut in flatfish trawl fishing.
Facing this "perfect storm" of potentially higher halibut bycatch encounter rates with warming seas and more impetus to reduce halibut bycatch, the Amendment 80 sector strongly feels that further development of halibut excluders is a logical and potentially productive direction for maintaining fishery yields under increasing constraints associated with halibut bycatch.

Based upon their experiences of using hallway design excluders in recent years, Amendment 80 fishermen have raised observations that motivate a need for improvement. Fishermen indicate escapement rates for target fish are relatively high, estimating up to 20-30% target loss by weight in hauls using excluders relative to fishing without them. Lower target catch rates can lead to more fishing effort and thus may increase halibut bycatch risk. Furthermore, fishermen also report that they are uncertain whether the excluders they are using are the same as others used by fishermen, some of whom report their excluders are achieving better selectivity. Unlike the pollock fishery where design and field testing efforts for salmon excluders have been an open and collaborative process through an EFP, development and field testing of halibut excluders for flatfish fishing has been more *ad hoc* rather than fishery-wide, open-source, and systematic.

During discussions at the Alaska Seafood Cooperative's (AKSC) annual captains' meeting, attendees expressed a strong interest in collaborating on halibut excluder designs and were supportive of rigorous field testing to generate sound data to inform tradeoffs between reduction in halibut bycatch and loss of target catch with different excluders of known design. There was also considerable interest in working on, and testing of, new excluder design(s) that might better address the selectivity issues fishermen are encountering with current fishing conditions. Thus, the goals of the work proposed under this EFP are to enable collaborative study of halibut excluders for the Bering Sea flatfish trawl fishery and to conduct scientifically robust field testing to yield data for objective assessment of excluder fishing performance, particularly focusing our test on the excluder design among the various excluders in use that flatfish fishermen feel is most likely to provide the best and most useful selectivity under today's fishing conditions.

In the following section, we present an exploratory analysis of haul-level data from flatfish fishing in the Bering Sea to examine whether fishermen's observations on halibut excluder performance are consistent with catch data from the fishery. Data used in this analysis are 'opportunistic' insofar as they were not collected under controlled excluder testing trials, yet we believe they provide an objective exploration of best available information for assessment of current performance of hallway-style halibut excluders. Subsequently, we outline our operational objectives, and present detailed methodology and some statistical analysis to support study design making efforts to implement a robust field trial to explore halibut excluder outcomes in terms of target and halibut catch rates. Exemptions to fish handling and data collection regulations needed to collect data in support of this research are outlined in that section. Finally, we conclude with a description of an opportunity to collect additional data during sea trials proposed under this EFP to develop sex ratio data collection methods that could eventually provide important information for halibut bycatch management.

<u>Assessing current performance of halibut excluders using Bering Sea fishing data:</u>
To investigate the effect of excluders on target catch and halibut bycatch we analyzed haul-specific data collected as part of the AKSC's management of deck sorting operations. Our objective was to use best available information to characterize the current state of halibut excluder performance in terms of halibut catch reduction and target-species catch rates; results highlight there is significant room for improvement in halibut excluder design as well as identification of areas of focus for improving data needed for performance evaluation.

While data for a number of vessels targeting flatfish were available, we focused on what we felt best reflected the current usage of excluders and was most suitable for analysis of halibut excluder outcomes. First, we identified vessels which had high proportions of hauls both with- and without halibut excluders deployed during flatfish and other halibut bycatch-constrained fisheries. Second, we limited analysis to operational data in 2018 and 2019 to reflect use of 'contemporary' excluder designs in recent years of warmer water and high halibut encounter rate conditions. Third, we favored vessels that used the same excluder design over the two years (as informed by communication with vessel captains). This was done because we were interested in knowing if a given vessel had different excluder performance in the two years covered by the data because fishing conditions were quite different between 2018 and 2019, and adding the possibility that performance differences were due to use of a different excluder unnecessarily complicated things. Finally, we restricted analysis only to hauls with deck sorting as data collection protocols for these events produced finer-resolution estimates of halibut catch per haul and also included a haul-specific field indicating whether a halibut excluder was used. This led to selection of three vessels' data, and a total of N=3,239 hauls for analysis over 2018 and 2019, noting one of the vessels had low participation in deck sorting operations in 2018 and thus only 2019 data was included for that boat.

To investigate whether we would find differences in catch rates for halibut and groundfish for hauls with and without an excluder we computed haul-specific catch rates for: 1) kilograms of halibut catch (sum of estimated weight of deck sorted and estimated weight of halibut collected in the factory per haul) per duration of the haul; 2) metric tons of groundfish ("OTC" from the vessel's flow scale) per duration of the haul; and 3) kilograms of halibut catch per metric ton of groundfish per haul. We then calculated mean haul-level catch rates across fishing events using excluders versus those not using excluders, presenting results by vessel, and by year. We opted for looking at arithmetic means of haul-level catch rates over comparing global means because the former more closely matches our "paired comparison" approach to excluder testing proposed below. Additionally, the same calculations of difference in catch rates showed no substantive differences in the rate comparisons, if global means are used instead.

Our expectation for all these analyses was that for haul catch rates with the excluder would have a lower mean kg/hour of halibut, some reduction in mean groundfish catch per hour with excluder usage, and that the difference in mean kg/mt of groundfish for hauls with the excluder would tell us something about the relative benefits of excluder usage for that vessel in that year.

Table 1: Vessel and Year Specific Excluder Performance in Halibut kg/hr; Groundfish mt/hr; and Halibut kg/mt Groundfish

Vessel	Year	Tows with Excluder	N	Mean Hal kg/hr	% Reduction	Mean Grndfish mt/hr	% Reduction	Mean Hal kg / Grndfish mt	% Reduction
Vessel A		No	258	106.6		6.9		21.2	
	2018				-53%		-14%		-44%
		Yes	15	49.7		5.9		11.9	
		No	456	82.6		7.8		14.5	
	2019				-31%		-30%		-11%
		Yes	147	56.8		5.5		13.0	
		Tows with Excluder	**N**	**Mean Hal kg/hr**	**% Reduction**	**Mean Grndfish mt/hr**	**% Reduction**	**Mean Hal kg/Grndfish mt**	**% Reduction**
Vessel B		No	505	130.5		9.5		20.0	
	2018				-64%		-48%		-27%
		Yes	368	45.9		4.9		14.7	
		No	661	76.6		6.4		16.3	
	2019				-23%		-15%		-12%
		Yes	148	58.8		5.4		14.3	
		Tows with Excluder	**N**	**Mean Hal kg/hr**	**% Reduction**	**Mean Grndfish mt/hr**	**% Reduction**	**Mean Hal kg/Grndfish mt**	**% Reduction**
Vessel C		No	182	260.8		8.7		31.5	
	2019				-54%		-26%		-24%
		Yes	241	113.7		6.4		24.0	

Results of our analysis are presented in Table 1. From these data, we see that the direction of effects of halibut excluders on catch rates is in the expected direction. Mean rates of reduction in halibut catch per hour for three of the five "vessel/year" comparisons are greater than 50% and the reduction is 23% and 31% for the remaining two vessel/year comparisons. While there is high variability by year and vessel, this still appears to confirm the expectation that excluders work to reduce halibut catch rates appreciably.

One of the main concerns flagged by captains is that rates of escapement of target fish are high, recalling that based on their understanding, it was in the range of 20-30%. Looking at our analysis, in some cases groundfish escapement appears to be below the range reported by captains, but for three of the vessel/year comparisons (comparison of groundfish catch rates with and without excluders) loss rates of groundfish are in the upper part of their range; in one case it is well above it (48%).

Furthermore, while these haul-level excluder analyses indicate current excluder designs, and deployment practices may have resulted in some selectivity advantage against halibut in catches, tradeoffs between avoiding halibut catch and realizing lower target-species catch rates with excluder usage are better in 2018 than 2019, at least using kilograms per metric ton as the criterion. We were not surprised by this result because 2019 was a year when many captains reported very low groundfish catch rates and relatively high halibut encounter rates, especially for small halibut which are particularly problematic for exclusion with the current size-based excluder designs.

Escapement of groundfish may be the most important factor for captains' decisions to use an excluder because it affects the baseline operational margins of fishing and operational costs are relatively high for catcher/processor vessels. Indications of relatively high rates of groundfish escapement in some of the vessel/year performance data (accepting limitations to the data as is discussed below) are particularly concerning because unlike the metrics that are affected by observer sampling variance (also discussed below), total weight of groundfish per hour is determined from the vessels' certified motion-compensated flow scales alone. Accuracy of those scales is required to be validated each day so observer sampling variance is not a factor in evaluating the applicability of these results. That said, the bias associated with the captains' selection of when to use an excluder may affect the degree to which our results actually represent groundfish escapement rates from current excluder designs. For example, fishermen may opt to use their excluder only when they feel that loss rates for target fish will be tolerable. This could mean that groundfish escapement rates are biased downwards or may explain the difference in loss rates between vessel/year in our data.

In the end we are unable to resolve this issue with the available data. Ideally, the most productive approach to understanding the effects of halibut excluders of catches would likely be to compare differences in groundfish and halibut catch rates in similar areas, times, and fishing conditions, but lacking location and other covariate data necessary for that approach we were unable to examine the data in that manner.

Finally, the tradeoffs in catch reductions can be seen in both the difference in kg of halibut catch per metric ton and through the proportional magnitude of the reduction in halibut per hour compared to the reduction in groundfish per hour. These two ways of looking at the effects of the excluder are generally consistent in that based on our analysis, both show positive tradeoffs in terms of greater reduction on halibut than groundfish. Tradeoffs in terms of kg of halibut /mt of groundfish appear to be more positive than what we see from the comparisons of catch rates per hour. For example, for Vessel A in 2019, the reduction in rates of halibut and groundfish catch per hour are nearly identical (31% and 30%, respectively) but the difference in terms of kilograms of halibut per ton of groundfish is 11% lower for hauls using an excluder. The explanation for why these two metrics can be somewhat different likely relates to catch rates being a function of the patchiness of groundfish, not purely a function of towing time.

In summary, this analysis suggests that halibut excluder performance in recent years suffers from the main problem identified by Amendment 80 captains: high loss rates of target fish, and halibut bycatch reduction that is at times not much greater than loss rates of target species. We have the most confidence in our conclusions regarding the rate of loss of groundfish catch per hour, which should not be affected by observer sampling variance. Groundfish loss rates could be affected by captains' choice of when to use the excluder, but the direction of that bias is difficult to predict (do they use the excluder when they feel halibut bycatch will be highest or when they feel groundfish loss rates will still be tolerable for vessel daily production needs?).

If the rates seen in our analysis are representative of actual loss rate for groundfish (e.g. annual mean rate of 26%, 30% and 48% for three of the five vessel/year comparisons) one could conclude that the feasibility of excluder use is low, because the associated target species catch rate reductions increase costs of fuel per day and likely impact the operational profitability of fishing. Furthermore, these high target catch rate losses seen in recent years associated with warm water, represent Bering Sea ocean conditions scientists expect to see more frequently moving forward, potentially defining a 'new normal'. Thus, excluder designs that avoid these high target species catch rate losses, while allowing significant proportions of the halibut bycatch to escape, would be a significant improvement for fishermen, and would likely help foster wider adoption of halibut bycatch reduction devices in the fleet.

Results from this simple analysis provide insight into the current state of halibut excluder performance in the Amendment 80 flatfish trawling fishery; however, we acknowledge a pair of key caveats with these fishing-based data for which we caution against over-interpretation of these results. First, haul-level halibut catch data includes both data from fish sorted on deck and those accounted for in the factory (fish that the crew did not sort out of the catch on deck). With observers using a randomized sampling design to collect data from approximately 20% of the deck sorted fish, the estimated weight of halibut sorted on deck has a relatively high sampling fraction. In contrast, the estimated weight of halibut in the factory is done through observer species composition sampling where sampling is also random, but sample fraction is a far smaller percentage (generally considerably less than 1%) of the weight of groundfish in the vessel's tank from each haul. This is not a criticism of sampling methods, but does indicate potential for high variance in reconstructing total halibut catch from the combination of deck and factory data collections.

Second, we are not able to randomize the hauls with and without excluders. Thus, the analysis may suffer from some form of selection bias, whereby captains choose to deploy excluders preferentially in conditions where they expect high halibut encounter rates or perhaps in conditions where they felt target-species escapement would be 'tolerable'. Ultimately, the magnitude and direction of these potential biases on our exploratory estimates of halibut and target-species catch rate outcomes is unknown. These shortcomings are inherent to the opportunistic approach of utilizing fishing data, and highlight a need for a statistically robust and direct study design to quantify the effect of halibut excluders on bycatch and target-species catch rates (see below).

EFP Objectives:

As highlighted by input from fishermen and the challenges outlined above in analyzing and interpreting fishery-dependent data on the performance of excluders, our objectives in this EFP seek to advance a scientifically robust approach to excluder performance assessment, and to provide sound data to inform captains' decisions on selectivity gains from halibut excluders in their Bering Sea flatfish fisheries where halibut bycatch is constraining. Specific objectives include:

1) Collect escapement rate data on an existing halibut excluder design, selected by Amendment 80 fishermen to be the excluder thought to create the best and most useful selectivity and utility (e.g.

minimizing slowdowns with usage) for current fishing conditions. We would hold a meeting with Amendment 80 captains to discuss and select the device for the EFP tests in August 2021. The device selected for the testing will be one that captains feel reflects the best design for achieving useful selectivity for flatfish fishing under current conditions (e.g. warming seafloor temperatures, commonly encountered differential in size of halibut and target fish).

2) Employ appropriate data collections methods to statistically estimate excluder performance (rates and uncertainty).
3) Conduct the tests in a manner that reflects actual fishing conditions where the excluder device would be used.
4) Conduct testing in two different target flatfish fisheries (yellowfin sole and flathead/mid-shelf flatfish target) to ensure the relevance of the testing to a broader range of relevant fishing conditions than if a single fishery target were used for the testing.
5) Take advantage of the research platform and data collection personnel at sea to collect caudal fin clips from a sample of the halibut encountered in the EFP for a pilot study of sex ratios of bycaught halibut. These are small portions of the tail fin that are not expected to harm the halibut. Sexing of halibut from the directed halibut fishery has been done recently but this is not necessarily representative of the ratio for fish taken as bycatch in the Bering Sea (generally juveniles and fish of a size not landed in the directed fishery). Approximately 100 fins will be randomly selected from halibut encountered on deck and in the vessel's factory to assess methods and practicality for a potentially expanded and more representative future project to evaluate sex ratio of halibut taken as bycatch in Amendment 80 fisheries.
6) Draft EFP reports to effectively communicate key results for excluder testing and the opportunistic data collection (separate reports). Conduct outreach meetings of key results on halibut excluder performance tailored to the information needs of flatfish fishermen and gear manufacturers interested in improvement of halibut excluders.

Plan to Accomplish EFP Objectives:
Acknowledging data limitations and their effects on what we know about utility of today's halibut excluders, the EFP work needs to avoid similar types of bias and needs to control for sources of sampling variance to the extent possible in its data collection methods. Our excluder tests also need to be conducted under conditions that resemble as closely as possible Amendment 80 fishing to ensure the data collected are relevant to the industry's bycatch reduction needs. This includes both ensuring that the test fishing resembles as closely as possible commercial fishing practices in the Amendment 80 sector and that testing encompasses two target flatfish fisheries that are important to the sector. Steps to address these challenges in our plan have been developed in consultation with captains, and based on literature from our previous experience on fishing gear testing. We have also tried to incorporate advice from scientists and analysts with experience in experimental design and field testing.

To better understand the issue of bias with captain's decisions of when to use an excluder, we had discussions with Amendment 80 fishermen wherein it was apparent that the factors affecting their past decision to use excluders were driven by the expectation that halibut bycatch could/would be high and that the expected rate of escapement of target fish would be low for operational efficiencies. Untangling these separate motivations from existing fishery-dependent data is impossible, but it is important to recognize that given the magnitude of flatfish escapement rates seen in our analysis, that specific driver may significantly affect conclusions from our data and may influence our current assessment of the performance of existing halibut excluders.

After dialog regarding bycatch issues with the Amendment 80 fleet captains and stakeholders, fishermen are supportive of robust testing of halibut excluders; if excluders can be successfully tested over a broader set of conditions, then fishermen will have better information on the tradeoffs of using an excluder across realistic fishing scenarios. This could guide their future decisions of when to use the excluder as a stand-alone bycatch reduction tool or in combination with deck sorting and other bycatch reduction tools. Perhaps most importantly, the benefit of unbiased escapement rate data would be to help fishermen avoid using an excluder when it could actually be working against them; i.e. when the loss rate of target fish is comparable to or perhaps greater than halibut escapement.

Minimizing Bias in EFP's Methods to Collect Halibut and Groundfish Catch Rate Data:
Recognizing the importance of controlled comparisons to assess halibut excluder performance under this proposed EFP effort, we propose to conduct testing on a vessel equipped with a twin trawl rig. Our preference for a twin trawl reflects our review of existing literature and field project reports detailing experience in the field of "conservation engineering" including our own projects. A central challenge for comparisons between "treatments" (hauls with the bycatch reduction device) and "controls" (hauls with the unmodified net) is ensuring that conditions are standardized across the treatment and control hauls (i.e. both experience the same operational conditions, sea state, fish encounter rates, inter alia).

In most studies we reviewed involving trawl gear, "experimental pairs" represented the adopted approach wherein the test vessel conducted pairs of hauls with either the same net or two nets that are as identical as possible (assuming test vessels have two net reels). Subsequently, catch rates between deployments with the net rigged with the device against those without it are compared. The testing plan with paired hauls is to arrange for the vessel to make pairs of tows with as similar as possible fishing conditions, thus allowing useful comparisons of catch rates. However, because deployments are from one vessel and one net at a time, this requires trying to standardize location, time of day, and other fishing conditions, etc., which is very difficult in practice.

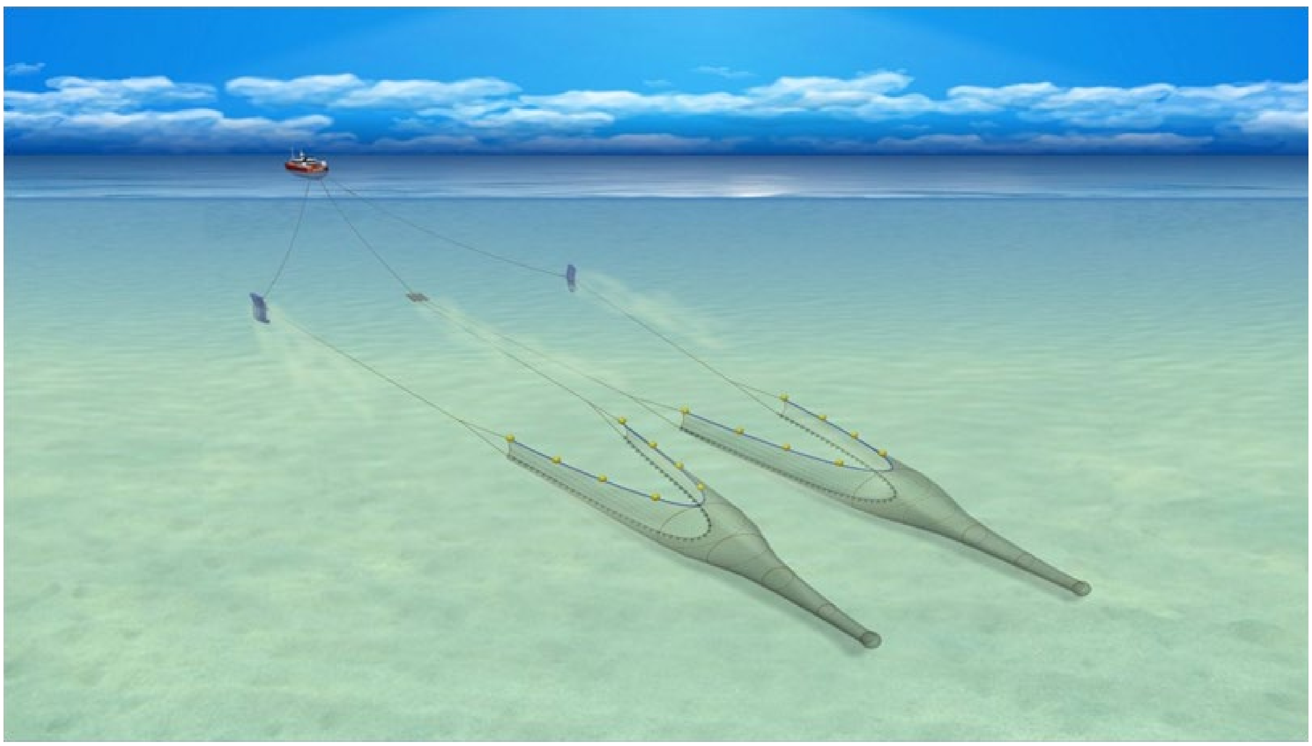
From our experience with halibut excluder testing in the late 1990s, (Rose and Gauvin) this testing method worked to produce credible results, but it is challenging to conduct pairs of tows with similar fishing conditions. Fishing conditions change rapidly and working around factors like time of day and tides can be cumbersome. Furthermore, testing with the experimental pairs approach tends to create operational slowdowns for the test vessel. These challenges are problematic when, as was the case for us, the test vessel is dependent on the revenue from the fishing to cover operational costs.

To avoid the most pressing difficulties in standardizing fishing conditions, direct comparison through a twin-trawl rig that deploys treatment and control hauls simultaneously may better control for conditions across replicates and yield data more robust for objective inference. Some studies have attempted to do this with two separate vessels fishing side-by-side using the same net design but with one using the device and the other an unmodified net. But often even when both vessels are fishing with "identical nets" and similar towing speeds, there are differences in catch rates even absent the use of a bycatch reduction device. These are due to factors that are generally poorly understood that simply make one vessel catch fish differently from the other. Considerable research on herding and how fish react to trawls has been conducted in association with trawl surveys (e.g. Ryer et al., 2010; Ryer & Barnett 2006; Somerton et al., 2017). Suffice it to say that using simultaneous comparisons between two vessels fishing side-by-side can work, but reading through studies where this method has been used, the need to compensate for "vessel effects" can be daunting.

This is where advantages from testing with a true "twin trawl" rig become attractive. A vessel with this system tows two nets side by side that are intended to be "identical". For purposes of gear testing one side is rigged with the excluder and the other not, affording the opportunity to collect data from as close to the same conditions as possible. To make this work for gear testing, the catch handing facilities on the vessel need to allow for separate accounting for the components of catch composition of interest, more on that subject below. To account for any inherent difference in catchability between the two nets used in the twin trawl system, periodically switching the excluder from one side to the other is important. More on tradeoffs of switching the excluder between the nets of the twin trawl (reducing potential bias versus practicality for the test vessel) is explained below.

While twin trawl fishing is uncommon in Alaska, the Amendment 80 sector actually had a vessel using a relatively low-tech version of a twin trawl for several years in the early 2000s. Additionally, the sector has a newly built vessel that uses a modern twin trawl system that started fishing with it in 2019. Another new vessel with a twin trawl (FT Northstar) is also scheduled to come on line in the Amendment 80 sector in early 2021. Fortuitously, the Northstar is being made available for this EFP for a trip in August of 2021.

In some European fisheries, twin trawl systems are common and often preferred because fishermen feel - they have efficiency advantages (e.g. increased catchability for the fish in the pathway of the net). An illustration of a twin trawl is shown below.



From our discussions with the vessel operator for Northstar, the advantage to twin trawling is mostly from being able to sweep a larger area because the rigging allows better door spread etc. Also, twin trawls are thought to create advantages in product quality with two codends allowing for less bruising of flatfish coming on board when the nets are hauled up the stern ramp. All other characteristics of the nets used in twin trawling in terms of herding fish and tow speeds etc. that could affect excluder performance are expected to reflect normal fishing with single rig otter trawls used more commonly in the flatfish fishery.

As part of our plan to reduce controllable sources of variance, we will work with the vessel operator in 2021 prior to the EFP to collect data to help us understand whether one net (one side) on average tends to fish differently from the other in terms of catch rates for halibut and target species. This factor, encountered in various trawl surveys (Kotwicki et al. 2017) would likely affect our assessment of excluder performance and would therefore need to be accounted for. Modern twin trawl systems catching the same amount of fish on both sides on average is highly desirable. To accomplish this, rigging and trawl deployment control systems (auto trawl gear and spread sensors) on both sides are designed to be highly "tune-able" to help standardize spread for the two nets. Sensors also allow for monitoring and adjustment of bottom tending aspects of the sweeps and footropes. In spite of these modern technologies for helping to ensure catch rate differences between the two nets in a twin trawl system are minimized, there still may be differences in catch rates between the sides and the EFP testing methods will need to take steps to help avoid this potential problem as it could introduce unwanted variance to our comparisons of halibut and groundfish catch rates with and without the excluder.

Differences in catch rates between the two nets in the system can be evaluated with reasonable precision for target species prior to the EFP. The operators of twin trawl vessels routinely look at product case counts by size grade of target species to evaluate whether one net catches more per haul or per hour than the other. We plan to work with Northstar to look at this issue prior to and during the EFP. This will be done only for high-valued flatfish species where discards will not affect our assessment of catch rates and for species where discarding is not allowed (cod and pollock). These comparisons are expected to be highly likely to reveal whether catch rates for target species between sides are different.

Unfortunately, we will not have the ability to fully gauge differences in catchability of halibut between the nets of Northstar on fishing trips prior to the EFP. This is because, as will be discussed below, additional data collections will be needed to provide sufficient data for accurately gauging haul-specific halibut catch rates between the two sides (nets). These needed supplemental data collections require exemptions from fish handling rules and hence will not be in place prior to the EFP.

As a work around, we can use existing Amendment 80 data collections to estimate net-specific differences in halibut catch rates between the two sides but these would only be truly useful if all halibut were sorted on deck from each net and this is highly unlikely. Nonetheless, there will be an opportunity to collect data using the EFP methods at the outset of the EFP trip where both sides of the twin trawl would not have an excluder. This will only be for a few hauls and therefore sample size may be limiting but it may show some differences.

The main work around to address potential differences in catch rates to avoid this problem will be to switch <u>the excluder being tested</u> from one side to the other at the half way point for each part of the EFP testing (halfway through the tows in the yellowfin target; same for the tows in the flathead target). This should allow us to perform a separate analysis of excluder performance by side (net it is installed in), which will then help us understand whether differences in inherent catchability for halibut and target species between sides needs to be taken into account in our assessment of performance results.

<u>Minimizing Sampling Variance for Haul-Specific Catch Rates</u>:
The second area of focus for our testing plan is to minimize effects of observer sampling variance This on haul-specific halibut catch rates. Here we are reasonably confident that the relatively high level of sampling occurring on deck with the standard deck sorting data collection methods does an adequate job estimating weight and length distribution of halibut sorted on deck. We base this statement on the considerable work AKSC and collaborators on this EFP has done in conjunction with the Alaska Fisheries Science Center in the development of deck sorting data collection methods. For this reason, we feel the most productive focus for reducing sampling variance is on supplemental data collections in the factory to reduce variance in estimation of haul-specific amounts of halibut that are accounted for there.

To do this, we are seeking an allowance through exemption from applicable regulations governing handling of PSC species to allow crew members to collect all halibut that make it to the factory (are not sorted on deck) for purposes of measuring each of these fish and recoding the length data before discarding them using the same conveyor belt pathway that is normally used. These supplemental collections will occur "downstream" of the observer's sampling station, in a location on the conveyor belts past where the observers collect their catch composition sample in the factory and in a manner that minimizes inconvenience to observers' normal data collection activities. One added dimension to the data collection is that crew will need to account for the "factory halibut" from each net separately; more on separate collections of data for each net in the twin trawl and accounting data on halibut and groundfish catches from each net in the twin trawl is discussed below.

Each halibut collected in the factory during the EFP will be measured on an electronic measurement board and then discarded on the normal belt where PSC is discarded as soon as the supplemental length data has been collected. We are confident this can be done in an orderly manner that does not interfere with observer data collections. This is because measurement of all factory halibut was done by sea samplers for several years of AKSC's deck sorting EFP. And we expect that the electronic measurement board will facilitate crew's data collections relative to what was done when length data were collected from factory halibut during the early years of the deck sorting EFP. Additionally, our experience from the EFP and coordination with NMFS' Fishery Monitoring and Assessment Division (FMA) on crew data collections for halibut in the factory will help us establish procedures for crew that avoid inconveniencing or negatively affecting the observer's duties. The workload of measuring each halibut in the factory will fall only on the crew during the EFP.

In 2018 and again in 2019, AKSC conducted a sea trial of an electronic measurement board developed in conjunction with Archipelago Marine Resources and FMA personnel. From this experience, we feel the board can expeditiously record the supplemental length data from halibut that are sorted from the catch in the factory. The tablet linked to the board communicates data from the board via "Bluetooth" connection. Our board/tablet set ups are already programmed to use standard length to weight conversion from the IPHC to convert the census of lengths to a total estimates weight of factory halibut on haul-specific basis. The tablets also archive the individual length dataset into an Excel database that will allow length distribution for a given net/haul to be tagged to length data already collected on deck under normal deck sorting data collections done by the observer.

An area of interest for the EFP will be the effects of the excluder on length of halibut in the catch. The collection of lengths in the factory plus the standard data collections for length of halibut sorted on deck will allow for sufficient data for comparison between sides (nets) to help us understand the effects of the excluder on length composition of halibut in the catch. Data on size effects of the excluder on major target species is of interest to the industry and important for estimating selectivity ratio tradeoffs on halibut and target species (Kotwicky et al. 2017).

For examination of how the excluder affects size distribution of target species, factory production data (product case counts by grade size) alone will be used. While strictly speaking, factory production data are not the same as scientific data for examination of relative size effects of the excluder on target species. The number of cases of target fish by product grade does, however, evaluate the data in a format that the industry uses to judge production effects of a halibut excluder. An additional advantage of this approach is that it avoids burdening observer data collections because using observer data to look at size effects of the excluder would likely increase the number of fish that the observer would have to measure per haul. Again, the objective here is to do the best we can to collect supplemental data for the EFP without unnecessarily creating additional work for the observers on the EFP trip.

To avoid departures from standard catch accounting methods and problems associated with entering non-conforming data into NMFS' databases to the greatest extent possible for this EFP, the official data from halibut catch accounting during the EFP for purposes of Amendment 80 will be the normal data collected by the observers using procedures that would be in place outside the EFP whenever possible. This means that the estimate of halibut from deck sorting under the current regulations and the estimate of factory halibut from standard observer procedures will be the official data to account for halibut catches (and their mortality) during the EFP.

A relatively small change (but still a departure from normal observer duties) under the EFP is that we will need to account for any halibut that comes up in the observer's sample as part of the haul-specific accounting of halibut catch for the EFP. To do this, observers on the vessel for the EFP will be asked to provide data for any halibut collected in the observer's sample. This could be done by simply making the halibut available to the crew during the crew's census after the observer is done collecting data from those halibut (if doing that does not affect timing of the observers duties) or asking the observer to provide the crew with the number, length, or weight of any halibut (un-extrapolated) from the observer's sample so this can be added to the catch.

Perhaps the most important component in our plan to understand the effects of the excluder involves collecting halibut catch and groundfish total catch data from each side of the twin trawl separately. The vessel's facilities to do this will already be in place, allowing them to bring catch on board from the two nets separately and in conjunction with deck sorting, place the contents of each net into separate tanks. This allows for separate deck sorting and catch sampling/accounting and for calculation of quantity of groundfish and halibut for the EFP and for accounting for species composition.

It is our understanding that NMFS' data collections methods in use for an Amendment 80 vessel already using a twin trawl in Amendment 80 fisheries is currently not collecting data on halibut or target species from catches from each net separately. Given that this is as critical aspect of our testing objectives in this EFP, we will need to work with representatives of the FMA's Observer Program to establish catch handling protocols for the EFP that allows for halibut catch to be estimated and accounted for by each net separately. At the same time the procedures will need to minimize departures for observer catch sampling and accounting procedures, avoid added work or inconvenience to observers during the EFP, and result in data that meets the data quality protocols of the Amendment 80 management and NMFS' catch accounting system.

We recognize that the need for separate accounting of groundfish and halibut catch for the two nets in the twin trawl system for the objectives of the EFP will require some work with the agency to arrange for meeting the standards set out above. Our intent is to work with FMA to figure out the most efficient and least burdensome way to do this for observers and for the NMFS catch accounting system and we plan to work with FMA to figure this out when they have personnel available so that these methods are well understood prior to the EFP trip in August of 2021. Initial feedback from FMA suggested they will need to direct someone from their staff to work with us on this in the latter part of 2020 and FMA has identified that person and communications on this issue have begun. At this point a key issue that has been discussed is where the crew will collect halibut collected in the factory from each net and where that fish for each net will be temporarily stored. A related issue is whether the viability of those halibut can be assessed by the observers proximate to the point of discard. We have forwarded diagrams of the Northstar's factory layout to the FMA person working on this and we believe that the diagrams illustrate that there is sufficient room for the crew to store halibut recovered in the factory for each net without creating obstacles to observer duties in the factory. Likewise, when the observer is ready to assess viabilities for the collected halibut, the crew will carry or slide the baskets or bin containing the collected halibut to the point of discard so that assessments can occur at the point of discard. Additionally, the EFP PI and the FMA person working on this are planning to visit Northstar in Seattle when the factory area is sufficiently set up to visually inspect and do a dry run of the halibut related temporary storage and data collection steps to ensure they will work and avoid obstructing or inconveniencing observer data collection duties. This visit to the vessel is likely to occur in February 2021 and we may be able to do it in conjunction with the vessel's annual inspection for Amendment 80 and deck sorting certifications

Sample Size Considerations:
The amount of test fishing we are requesting the EFP "exemptions" for supplemental data collections etc. to cover for a normal trip on Northstar is expected to involve approximately 60-70 hauls amounting to 60-70 experimental pairs for our analysis. Assuming a small number at the outset would be for examining differences in halibut catch rates using EFP accounting methods but without an excluder, the remainder would be split between yellowfin sole and flathead/mid-shelf flatfish fishing. The reason for splitting the test fishing between these two target fisheries is to ensure the experiment reflects halibut and target flatfish sizes and catch rates that are typical of Amendment 80 fishing trips in summer/fall when the testing will occur. Dividing the test fishing between two fisheries is to better reflect real fishing conditions where the excluder would be used eventually and we are less concerned with being able to report statistically sound assessments of performance by target fishery.

Based on the power analysis done by APU in support of this EFP (Appendix 1), where data from both yellowfin sole and flathead sole target hauls were included, we anticipate this amount of testing will provide a robust sample size for understanding the performance of the excluder selected for the EFP trials. We base this anticipation on the fact that APU's statistical power analysis shows that 60-70 experimental "pairs" was sufficient for understanding at least some of the effects of excluders in use. And this was using data that does not incorporate the supplemental data collection steps and the use of a twin trawl to reduce selection bias.

While the power analysis is suggestive that the proposed amount of excluder testing will deliver statistically robust results for judging performance of the excluder, there is no way to ensure it will. Ideally, we would have some way of knowing the degree to which the data collection and other steps we are proposing for reducing sampling variance and avoiding bias will help to ensure the testing will produce meaningful confidence intervals around escapement rates. That would probably involve doing a trip on the test vessel devoted to testing the EFPs data collection sampling regimes alone (absent an excluder test) and then another trip or trips to collect data on hauls which are experimental pairs with and without the excluder. Unfortunately, we do not have that option because the test vessel is only available for a single trip next year.

This perspective on inherent limitations of the data used for the power analysis does underscore that to some extent this EFP is both designed to be a test to measure the performance of the halibut excluder with reasonable statistical precision (which we strongly feel can be accomplished with a single trip). And if for unforeseen reasons we are not able to measure the performance of the excluder with sufficient statistical confidence, the EFP testing would still provide some important information on precision of testing methods and ambient variability that affect testing.

From the Amendment 80 industry perspective, if excluder performance in the test does reflect the high rate of target catch escapement rates seen in the analysis done of fishery data above, or if selectivity tradeoffs of reduction of halibut bycatch and loss of target catch is confirmed to be along the same lines as what was seen in the available fishery data analyzed above, then we may request a rollover or continuation/extension of the of the EFP in future years to test additional excluder design(s) based on what was learned from this EFP. And if the proposed flume tank design work is not funded or funded but delayed due to travel constraints, an extended testing opportunity with an extension of the EFP may create an opportunity to incorporate a flume tank design step into the process of development of excluders for future excluder tests.

Plan for Supplemental Halibut Data Collection:

We feel it is important to use the opportunity of having exemptions from fish handling regulations and added data collection personnel with the EFP to start to understand what it would take to undertake a larger data collection to understand sex ratios of bycatch halibut in the Amendment 80 sector. This pilot study to start to develop methods and better understand how to work efficiently for this type of data collection only involves collecting 100 caudal fin clips during the EFP. This will nonetheless help us examine methods for a larger project to evaluate sex ratios for halibut taken in Amendment 80 fisheries in the Bering Sea where mostly juvenile Pacific halibut are encountered.

The larger project this pilot study would help inform was highlighted as an important data gap by the International Pacific Halibut Commission (IPHC) at their interim meeting in November 2019. Specific goals of the pilot investigation focus on developing caudal fin collection and data processing methods, and to use the data collected to help us understand the potential utility and workload associated with a possible larger collection of fins in the future that would be sufficient to say something about the sex ratio of halibut taken as bycatch.

Key questions that this pilot collection of 100 clips from fins will help us understand are what sampling rate will avoid slowing down getting the fish back into the water (with deck sorting) and would avoid disturbing the normal sampling deck sorting and observer data collection on deck workflow, and what number of samples can be fit into a standard otolith tray, which at this point we expect is the best way to organize the clips both during sampling and for storage.

As for sampling protocol, we propose that the sampler (field project manager) removes the fin clip with either standard diagonal cutters or tissue biopsy forceps with the former likely being preferred because the fins are quite dense and may be too robust for the biopsy forceps to punch cleanly. The sampler would then place the clip in a well in a standard otolith tray. The alpha numeric organization of the tray would make matching the samples to length measurements relatively easy. If needed, a septum system that promotes oneway access to the well can be rigged. The sampler would fill the entire tray (100 samples), and add high grade ethanol to the samples for storage any time within the ~12-24 hours (e.g. at the very end of their shift). The samples could then be stored at room temperature for analysis.

Proposed methods for sex ratio determination include collection of approximately 1 cm^2 clips from the caudal fins of a random sample of halibut from both the deck and factory. Sex identification will be conducted by analyzing single nucleotide polymorphisms (SNPs) using the same methods employed by the IPHC. This work will be developed in collaboration with APU and IPHC researchers who will assist in determining final sample sizes and methods.

Methods for EFP Data Analysis:

For the halibut catch rate data collected in the EFP we propose to use inferential statistics to compare paired excluder/no-excluder twin trawl catch rates outcomes (e.g. paired tests or ANCOVA type analyses to control for conditions at the time of hauls). Size frequency differences across excluder/no-excluder groups will assess both mean size differences through paired tests, and size frequency differences through Kolmogorov-Smirnov tests. Additionally, we are exploring with AFSC the use of selectivity ratios following what has been done to evaluate NMFS/Industry collaborative survey for crab (Kotwicki et al). More details on rationale for proposed analytical approaches are provided in Appendix 1 below.

Draft EFP Reports:

Draft and final report on excluder testing will specifically focus on these metrics: halibut catch rate reduction per hour; groundfish escapement rate per hour; change in rate of halibut kg/ metric ton of groundfish; how excluder affects size of halibut taken as bycatch. Detailed information on specifics of the device(s) tested and construction/rigging will be included and this report will also provide basic information about the testing methods. All EFP reports will be written to be accessible to flatfish captains and gear manufacturers involved with halibut excluder construction. A separate final report will be drafted for the sex ratio pilot data collection. That report will detail what we learned about the practicality of data collection methods and how this may affect sampling strategies in a potential larger-scale collection aimed at understanding sex ratio of halibut taken as bycatch in the Amendment 80 fisheries.

Table 2: EFP Milestones and Anticipated Timing

	2020				2021				2022	
Tasks	**Jan-Mar**	**Apr-Jun**	**Jul-Sep**	**Oct-Dec**	**Jan-Mar**	**Apr-Jun**	**Jul-Sep**	**Oct-Dec**	**Jan-Mar**	**Apr-Jun**
Drafting EFP and Informal Review	X	X								
Informal consultation with FMA on Data Collection Methods		X	X							
Prioritize Designs for EFP with Captains (BREP or other process)				X						
Finalize Data Collection Methods for Excluder Test			X	X						
Excluder Construction					X	X				
Work on specifics of methods for Sex Ratio Collections			X	X						
Work on specifics of methods for pinger tagging pilot			X	X						
Finalize Application and NMFS Review of EFP			X	X	X	X				
Council Review					X					
Permit Issance						X				
Field Work and preliminary data							X			
Processing of Samples for Sex Ratios							X	X		
Full Data Analyses for Excluder and Other Studies								X	X	
Report Drafting								X	X	X

<u>Expected catches during EFP activities</u>:

Groundfish and PSC catch during all EFP activities will be funded through the annual catch allowances available through Alaska Seafood Cooperatives Amendment 80 allocations and non-allocated catch allowances for BS/AI permitted groundfish vessels. This EFP therefore does not request any catch allowances outside of those normally available to the Alaska Seafood Cooperative members; the only request is for exemptions to regulations and catch accounting rules and procedures necessary to allow EFP catch accounting methods and to support the collection of fin clips from halibut.

For informational purposes, tables below describe the data used to come up with the expected catches during the EFP and a summary table covering the estimated amounts for the main species of interest. Of note for those estimations is that data from recent year(s) catch during the month of August are used in order to reflect expected catches of key groundfish and PSC species (e.g. Pacific cod and Pacific halibut). To estimate catches in the yellowfin sole target fishing portion of the EFP, data for 2017 and 2018 were used because due to market conditions, very little yellowfin sole fishing occurred in August of 2019. For the flathead sole/other flatfish, only data from August 2019 is used because due to market factors, very little target fishing for flathead sole and other mid-shelf flatfish species occurred in 2018.

Table 3: Expected Catches in EFP based on one trip for the F/T Northstar split evenly between YFS and Other Flatfish (separate tables for catch estimation by target)

Yellowfin sole target fishing using 2017 and 2018, leaves out 2019 for lack of August fishing in that target													
Catch	Species (Major)												
Year	Pollock	Pacific Cod	Yellowfin Sole	Rock Sole	Arrowtooth Flounder	Kamchatka Flounder	Flathead Sole	Rex Sole	Alaska Plaice	total gndfish	Pacific Halibut Pre-mortality	Pacific Halibut Mortality	Halibut # on Deck
2017	1,395	1,070	11,998	785	109	37	467	0	1,093	16,955	109	59	3,011
2018	2,585	794	5,340	306	575	32	640	0	704	10,978	122	58	3,651
average 17-18	1,990	932	8,669	546	342	35	553	0	899	13,966	116	59	3,331
% of gf total wt	14%	7%	62%	4%	2%	0%	4%	0%	6%	100%	0.008	0.004	286
Projections: \estimated catch in EFP in YFS target fishing for 1200	171	80	745	47	29	3	48	0	77		10.0	5.0	286

Flathead sole and related mid-shelf species target fishing catches baswed on 2019 fishing only															
Reporting Area		* This includes all Targets EXCLUDING: ATF, KAM, Turbot and YFS													
Catch	Species (Major)														
Year	Pollock	Pacific Cod	Yellowfin Sole	Rock Sole	Greenland Turbot	Arrowtooth Flounder	Kamchatka Flounder	Flathead Sole	Rex Sole	Alaska Plaice	Pacific Ocean Perch	total grndfish	Pacific Halibut Pre-mortality	Pacific Halibut Mortality	Halibut # on Deck
2019	2,469	1,249	1,787	576	120	1,123	284	1,783	81	481	38	9,991	176	65	5,606
% of gf total wt	25%	13%	18%	6%	1%	11%	3%	18%	1%	5%	0%	100%	0.018	0.007	482
Projections: \estimated catch in EFP in flats other than YFS fishing for 1200 mt	297	150	215	69	14	135	34	214	10	58	5		21.2	7.8	482

Table 4: Summary of expected catches for major groundfish and PSC species for the EFP

Expected EFP catches based on 2400 mt groundfish catch divided evenly between YFS and Flathead sole target fishing in August	
Species	Tonnage
Pollock (mt)	439
P cod (mt)	216
YFS (mt)	908
Rocksole (mt)	109
Flathead sole (mt)	245
Arrowtooth flounder (mt)	154
Kamchatka flounder (mt)	35
Greenland turbot (mt)	13
Atka mackerel (mt)	13
sablefish (mt)	6
subtotal	2,139
PSC	PSC Units
Pacific halibut mortality (mt)	12.1
Red King Crab (#)	716
C. opilio (#)	10,895
C. bairdi (3)	3,322

Anticipated effects of EFP activities on marine mammals and endangered species:
The design of this project is that EFP data collections are being added onto fishing that the F/T Northstar would otherwise be doing during 2021 (or 2022 if the EFP gets delayed until 2022). Furthermore, EFP methods are designed to collect performance data from normal fishing operations to ensure that our assessment of excluder performance is relevant to normal Amendment 80 fishing. Nothing in what the vessel will be asked to do for the EFP or the locations where the vessel will fish during the EFP will be different from fishing it would otherwise be doing when the EFP takes place. Data collection from the separate nets of the twin trawl will be the only difference from normal fishing. For these reasons the EFP will not result in any additional effects on marine mammals and endangered species relative to what is already contemplated and allowed for under the existing Marine Mammal Protection Act (MMPA) reporting requirements and Endangered Species Act (ESA) permits and biological opinion for Amendment 80 fisheries.

Exemptions to Regulations Needed for the EFP and Requested Timeframe for the Permitted Activities:
The applicant requests that the NMFS Alaska Region provide the necessary exemptions to PSC handing regulations in support of the proposed EFP activities. Additionally, we request that once the procedures for data collection in support of the EFP research are established with FMA, any necessary exemptions to the Amendment 80 and deck sorting catch handing and observer sampling and data collection procedures and rules be included in the exemptions (as necessary).

The EFP activities are designed to be done in a single trip on the F/T Northstar and the estimated duration of that trip will be three to four weeks. The projected timing for that trip is August 2021. Given uncertainties with a new vessel coming on line (expected start date is January 2021) and fishing with a relatively new twin trawl system and other start-up issues known to occur with new vessels, the applicant requests that the permit issuance allow for flexibility for when the EFP trip would occur. This is needed to accommodate unknowns and to avoid the need to reissue the permit if for some unforeseen reason, the vessel or other factors affect the ability to undertake the EFP activities in August of 2021. We would therefore prefer that the permit allow the EFP research trip to occur anytime from August 1, 2021 to December 31, 2022.

Administration of the EFP: As has been the case for previous EFPs done by the Amendment 80 sector, John Gauvin will serve as principal investigator and the Alaska Seafood Cooperative will be the permitted entity for the EFP. The principal investigator will hold responsibility for ensuring that the field research follows the terms of the permit and the research plan described in the EFP application. Mr. Gauvin and AKSC will provide a field project manager under his direction to oversee the fieldwork on the vessel and the project manager will serve as Mr. Gauvin's designee on the vessel for administration of the permitted EFP fishing while at-sea. F/T Northstar will be the permitted vessel for the EFP. All data collection responsibilities, analyses, draft and final reports, reporting of EFP catches, and other activities and requirements related to the permit will be the responsibility of the PI and his designee in consultation with the EFP collaborators listed above.

Areas where EFP activities would occur: EFP fishing is expected to occur in areas where F/T Northstar would otherwise be allowed to fish for YFS and flathead/other flatfish in the BS/AI management area.

Appendix 1: Power analysis for halibut excluder EFP

Fisheries, Aquatic Science, and Technology (FAST) Lab at Alaska Pacific University

We conducted a power analysis on request of the Alaska Seafood Cooperative in support of their EFP application to evaluate performance of halibut excluders. The goal of the analysis was to determine the number of paired, twin trawl hauls necessary to evaluate tradeoffs associated with halibut excluder devices. The methodology and results of these analyses are presented along with a discussion of some important limitations in the available data which impact our ability to draw strong conclusions.

We were provided halibut and groundfish catch data for three vessels which employed halibut excluders on a portion of their tows in target fisheries where halibut bycatch is common (e.g. flatfish). Data were at the haul level and all hauls employed traditional (single rig) otter trawls. Data from two of the vessels spanned the 2018-2019 fishing seasons; data from the third vessel was limited to 2019 due to not using an excluder in 2018. Analyses were conducted for each of the three vessels individually to control for differing excluder configurations and fishing behavior among the vessels. The key performance metrics we evaluated were halibut catch rate (kg/hour), groundfish catch rate (mt/hr), and the ratio of halibut to groundfish (kg/mt). The halibut:groundfish ratio is intended to help evaluate tradeoffs associated with excluder usage. If this ratio is less on hauls with excluders, we may infer that the reduction in halibut is outpacing the loss of groundfish. However, if we find that the ratio is greater on hauls with excluders, the loss of groundfish may outweigh the reduction in halibut. At the recommendation of the Alaska Seafood Cooperative based on their knowledge of data collection in Amendment 80 fisheries, we limited all analyses to hauls when halibut were deck sorted to reduce the variability and anomalous zeros in the halibut data introduced by Observer sampling extrapolations. When deck sorting was not conducted, zero halibut were estimated on 68% of the hauls compared to 3% in deck sorted hauls, although Observer estimates still contribute to 10% - 23% of the total halibut catch among deck sorted hauls (Table 1).

In the data provided, there is evidence that excluder use affects both halibut and groundfish catch rates. In hauls with excluders, halibut catch rates were down 35.8, 50.4, and 147.1 kg/hour for vessels A, B, and C, respectively, all of which were significant differences ($p < 0.001$ for all vessels; Table 2). Likewise, groundfish catch rates were down on hauls with excluders 1.94, 2.69, and 2.30 mt/hour, for the same vessels, also all significant differences ($p < 0.01$ for all vessels; Table 3). Although the groundfish catch rates decreased alongside the halibut catch rates, these data still suggest there was a positive tradeoff with excluder use as the halibut:groundfish ratios decreased 4.0, 3.34, and 7.6 kg/mt among the three vessels, though these differences were only significant in vessels A and B (Table 4) and our analysis did not extend to other tradeoffs associated with excluder usage (e.g. efficacy and operational cost).

Power analyses were conducted to evaluate how many paired twin trawl hauls would be necessary to detect effect sizes similar to those in the provided data in each of the three performance metrics assuming no ship-based differences in fishing efficiency or escapement rates of either halibut of the flatfish species complex between the trawls on either side of the ship. Power analyses were conducted for both halibut and groundfish catch rates as one-sided t-tests based on the *a priori* expectation that both halibut and groundfish catch rates would be less in trawls equipped with excluders. The power analysis for the halibut:groundfish ratio was run as a two-sided test because the direction of the effect is not as strongly predictable. All power analyses were conducted with 80% power and 95% significant levels as paired t-test because the twin trawl study design will allow for pair-wise comparison of catch rates.

A number of key assumptions were made for use of paired t-tests for evaluation of statistical power in a field test where a twin trawl system would be used. At this time we have no reason to believe fishing events for the proposed EFP efforts (i.e. deployments of the twin trawl rig) would violate the independence assumption among pairs of data (i.e. catches from each side of the twin trawl) within a sampling trip; however, clearly catches across sides of the twin rig within a haul are not independent and thus we are proposing a paired-sample test. Without prior data from twin trawls deployed w/ excluders on only one side, we cannot confirm whether the differences in catches across sides are normally distributed, however, we have no prior reason to expect otherwise and thus our power analysis assuming paired t-test assumptions would not be violated during the course of data collection under the EFP. We do acknowledge the potential shortcomings of sample design analysis without true paired-data in hand, and stress that the EFP is best suited as a pilot experiment to generate data to guide future efforts, more on this approach below.

If normality assumptions appear violated after we have EFP experimental data in hand (unexpected), we could attempt transformations of the data or analyze the data with nonparametric paired test (e.g. Wilcoxon paired test). We included brief language noting this plan for analysis in the main text under 'Methods for EFP Data Analysis' section.

The results from the these power analyses suggest that up to 29 - 75 paired twin trawl tows may be required to detect significant differences in halibut catch rates (Table 2), and 49 - 310 may be needed to detect differences in groundfish catch rates (Table 3). The halibut:groundfish ratio may require 145 – 300 pair tows (Table 4). While the upper bound of these sample size estimates exceeds the likely number of possible paired tows during the study, there are at least two sources of variability and bias inherent in these data that likely contribute to an overestimation in sample sizes:

1) *Observer sampling.* The data provided here combine a census of deck sorted halibut with extrapolations from Observer sampling in the factory to estimate total halibut caught for each tow. The Observer extrapolations are likely adding substantial variability to the data, leading to an increase in the apparent number of twin trawls needed to detect a significant difference. Of note here is that the catch rate data are haul-specific as the use of an excluder applies to specific hauls but Observer sampling methods are designed to track vessel-specific catches at a more aggregated level (e.g. weekly catches).
2) *Captain's decision to use an excluder.* In data provided, the use of halibut excluders was determined on a tow by tow basis by the captain of the vessel. Generally, we can infer that excluders were employed when the captain expected a large number of halibut to be encountered during the tow, and not used when halibut were not expected in large numbers. Thus, halibut catch rates for tows with excluders likely overinflate halibut catch, and vice versa. This would bias the data by reducing the apparent difference between halibut catch rates in excluder/non-excluder tows, again leading to an overestimation of sample size.

We encourage the proposed study design to consider how these sources of variability and bias will be controlled during the twin trawl trials. We do note that while the points raised above are applicable to halibut catch rates, and by extension the halibut:groundfish ratio, they are not as consequential for evaluating groundfish catch rates alone. The groundfish catch provided in this data were collected by approved flow scales that are validated for accuracy on a daily basis by observers and thus are not subject to Observer sampling variability. However, a captain's decision to use an excluder may affect groundfish catch rates, but the effect is not as clear as its effect on halibut catch rates. It may be the case that the effect is too small to realistically be detected by this proposed study design.

In summary, we caution use of the power analysis results provided here without careful consideration of the limitations of the underlying data. Instead, we encourage treating the proposed EFP as a pilot study that will generate data suitable to inform future work.

Table 1. Summary of data

Vessel	Years included	# tows with excluder	# tows without excluder	Percentage of halibut catch from Observer estimates
A	**2018, 2019**	**164**	**714**	**10.2%**
B	**2018, 2019**	**518**	**1167**	**13.1%**
C	**2019**	**242**	**183**	**22.6%**

Table 2. Halibut catch rate t-test and power analysis

Vessel	Excluder kg/hour Mean (sd)	No excluder kg/hour Mean (sd)	Difference (pooled sd)	t-test results[1]	Paired twin trawls needed[2]
A	**55.4 (59.8)**	**91.2 (87.1)**	**-35.8 (74.7)**	**p < 0.001 t = -6.29 df = 342.11**	**29**
B	**49.7 (57.7)**	**100.0 (238.3)**	**-50.4 (173.4)**	**p < 0.001 t = -6.79 df = 1438**	**75**
C	**113.7 (144.4)**	**260.8 (509.9)**	**-147.1 (374.7)**	**p < 0.001 t = -3.79 df = 204.19**	**42**

[1] Two sample one-sided t-test
[2] Based on a paired one-sided t-test

Table 3. Groundfish catch rate t-test and power analysis

Vessel	Excluder mt/hour Mean (sd)	No excluder mt/hour Mean (sd)	Difference (pooled sd)	t-test results[1]	Paired twin trawls needed
A	**5.56 (4.29)**	**7.50 (6.27)**	**-1.94 (5.38)**	**p < 0.001 t = -4.74 df = 343.27**	**49**
B	**5.02 (4.88)**	**7.71 (26.4)**	**-2.69 (19.0)**	**p < 0.001 t = -3.35 df = 1334.4**	**310**
C	**6.36 (5.19)**	**8.66 (9.38)**	**-2.30 (7.58)**	**p = 0.002 t = -2.98 df = 265.47**	**69**

[1] Two sample one-sided t-test
[2] Based on a paired one-sided t-test

Table 4. Halibut:groundfish ratio t-test and power analysis

Vessel	Excluder kg halibut/mt groundfish Mean (sd)	No excluder kg halibut/mt groundfish Mean (sd)	Difference (pooled sd)	t-test results[1]	Paired twin trawls needed
A	**12.9 (13.3)**	**16.9 (20.2)**	**-4.02 (12.1)**	**p = 0.002 t = -3.13 df = 360.49**	**145**
B	**14.6 (19.8)**	**17.9 (21.3)**	**-3.34 (20.5)**	**p = 0.002 t = -3.12 df = 1059.4**	**300**
C	**24.1 (39.3)**	**31.7 (48.4)**	**-7.62 (44.1)**	**p = 0.08 t = -1.74 df = 344.52**	**266**

[1] Two sample two-sided t-test
[2] Based on a paired two-sided t-test

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