AGENDA B-4
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GROUNDFISH FORUM'S EXPERIMENTAL FISHING PERMIT TO TEST THE EFFECTIVENESS OF A HALIBUT EXCLUDER.

(EFP #98-01)

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Introduction

Every year, many flatfish fisheries in the North Pacific are closed before their target quotas have been taken because fishermen catch the allowed quantity of halibut bycatch first. Flatfish fishermen have long been interested in developing halibut excluders to place in trawl nets to release halibut to increase fishing time and harvests in the fishery. Some trawl vessel captains have developed their own designs for halibut excluders but as of last summer, these industry-developed excluders had not been tested in any type of scientifically valid manner. In early 1998, the Groundfish Forum applied to NMFS and the North Pacific Council for approval of an experimental fishing permit to work with NMFS scientist Craig Rose (RACE Division) to systematically test industry devices that exclude halibut from flatfish trawls.

The purpose of the experiment was to test whether the selected halibut excluder device would reduce halibut bycatch rates without significantly reducing catch rates for target species. Additional objectives of the field work were to estimate the effects of the device on species and size compositions of the target catch and to test whether deck sorting halibut can lower the mortality rate of halibut taken as bycatch. If the device proved useful, the data from the experiment could be used to demonstrate to all participants in the fishery that reductions in halibut bycatch rates can be beneficial to the fleet because more target flatfish overall can be harvested.

Experimental Fishing Permit

Groundfish Forum's permit was approved by the Council in June and final NMFS approval came in August last year. Materials explaining the intent of the experiment were circulated in July and August. The entire Alaskan trawl industry was invited to submit designs of halibut excluders with any supporting information available regarding the design's effectiveness. Four completed applications were received and these were reviewed in late August by a panel of experts appointed by NMFS. Vessels participating in this fishery were selected based on the following information:

1. Diagrams of the vessel's fishing gear, including both experimental and control nets, if two trawls were to be used.

2. Description of a halibut excluder concept that would be installed in the vessel's trawl,

3. A description of the vessel itself, with emphasis on facilities and configuration to allow extended observer sampling of the catch, and

4. Written and signed agreement to abide by experimental protocols and other permit requirements.

The design chosen for the experiment was submitted by the F/T Legacy. F/V Alliance was picked at random from the remaining applications to participate in the field trial because the experiment required testing by two vessels. Both vessels were catcher processors which fish in the Gulf of Alaska for deepwater flatfish species and both used low-opening commercial bottom trawls. The 108 foot Alliance, being one of the smallest Gulf catcher processors, provided a test of whether this grate system could be fished effectively from a vessel with very limited deck space.

The field test was conducted in the Gulf of Alaska deep water flatfish fishery because halibut and deep water flatfish species are concentrated in the same areas and exclusion of halibut could dramatically increase yield of target species. Also, halibut in the Gulf of Alaska tend to be larger than target flatfish and this presents opportunities for excluders to reduce halibut bycatch significantly. Participants in the test were allowed to keep legally retainable groundfish caught in the experiment (subject to additional limitations established in the permit) to help defray the costs of fishing and gear development.

Requirements under the EFP

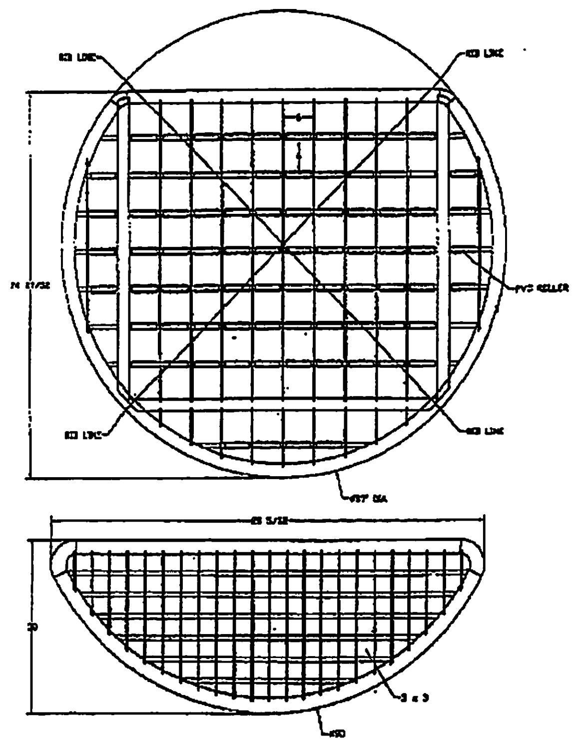
Each vessel participating in the experiment was required to carry two NMFS-certified observers to cover the additional sampling necessary for the experiment. In addition, vessels had to accommodate and facilitate the work of additional personnel for the experiment including a NMFS gear researcher, a University of Alaska School of Fisheries graduate student, and representatives of Groundfish Forum. The graduate student was invited to participate in the experiment because her research focuses on flatfish and their habitat.

In accordance with the experimental design, each vessel made a series of paired tows - during one tow the excluder was used, during the other it was not. The captain first selected an area for fishing after which the NMFS observer randomly selected whether or not the excluder would be used in the first tow of the pair. This was done to prevent potential operator bias. Tows within pairs had standardized towing speeds, depths, area, and duration. The differences in catch of halibut and other groundfish species between the tows were the variables used to determine how well the excluder performed.

Each tow was sampled for species composition and amount of halibut. To ensure accuracy, all halibut were counted, measured, and returned to the sea from the deck. Deck sorting halibut is a departure from the normal procedure where basket sampling methods are used to determine the quantity of halibut and other species below deck. Participants were required to deck sort halibut under a controlled set of procedures to get a more accurate estimate of the amount of halibut per tow and to minimize the mortality of halibut bycatch. One reason for including deck sorting was to gain additional information and experience with methods to reduce halibut mortality that were developed in Groundfish Forum's 1997 EFP.

Effects of the halibut excluder on catch of halibut and target deep water species - Methods

The halibut excluder proposed in the Legacy's application, and used in the experiment, consisted of a circular, rigid grate with 6 inch square openings over its entire surface (Figure 1). The grate was mounted in the trawl intermediate by tying it to the four riblines and lacing the sides and bottom to the mesh. The attachment point on the top ribline was 28 inches (5 meshes) aft of that on the lower riblines, creating a top - backward slope of about 28 degrees. The top 15 inches of the circular grate was left off to allow fish that passed over the grate to continue aft. An auxiliary grate, called the "deflector", was installed ahead of the opening above the main grate to prevent fish from swimming directly aft. The deflector was constructed with 3 inch square openings and installed in a top forward orientation. The spacing between the deflector and the grate at the lower edge of the deflector was 9 inches. A panel of 5.5 inch double mesh was attached to the top edge of the grate and the top riblines, extending aft for 4 meters. This panel and the top panel of the intermediate formed a low tunnel which escaping fish passed along before exiting through a slit in the top panel.



Drawing provided by: Coastline Equipment, Inc. Bellingham, WA

Figure 1

The panel and deflector were constructed of welded aluminum and sufficient flotation was installed to make the section positively buoyant. PVC rollers were installed over each of the horizontal rods on the grate. Because these rollers protruded above the vertical bars, objects sliding along the grate were aided by their rolling action.

To improve statistical measurements of the halibut excluder's effects on target and bycatch catch rates, vessels alternated experimental and control gears to create pairs of tows (blocks) conducted under similar conditions. Blocking of the data helped to eliminate variations in catch between areas, days, times of day, and between vessels from the analysis. The gear used for the first tow of each block was randomly determined and the vessel captain was not informed of the selection until after the decision of where and when to tow had been made. The second tow of each block was made as close in time and space as practical to the first, matching speed and other towing parameters. Tow duration was allowed to vary within blocks with the goal that similar catch sizes were obtained from experimental and control tows.

The Legacy used two trawls of identical construction for the test. The excluder was installed on one while the other was used for control tows. Every 5 pairs of tows, the excluder was switched to the other net to avoid a bias due to any net differences. The Alliance used the same trawl throughout the tests, alternating an intermediate section with the excluder installed with an unmodified section for control tows.

An underwater video system was installed on the Legacy's excluder during some tows to observe grate configuration and fish behavior. Miniature sensor / datalogger systems were installed on the trawl throughout the study. These recorded depth, temperature and light level at 30-second intervals during fishing.

So that the experiment would be representative of commercial fishing efforts, vessels were allowed to fish at any location that would be open for the October 1998 deepwater flatfish season, which was to open after the experiment, and were required to follow the directed fishing standards and several additional restrictions for the EFP fishery. Each vessel was allocated a portion of the fisheries quotas of target species and of important bycatch species, particularly halibut. These limits were monitored throughout the fishery to assure that the vessel captains could adjust their tactics in such a way that their parts of the experiment would be completed without exceeding the catch and bycatch limits set by the exempted fishing permit.

A sample power analysis was conducted using observer data from four vessels that fished in the second quarter of the 1997 deepwater flatfish fisheries. This indicated that a sample size of 60 pairs would be sufficient to have an 90 % chance of detecting catch differences of 35 % for halibut and close to a 100% chance of detecting a 25% decrease in rex sole catch. To accomplish this, each vessel was assigned a goal of 30 complete blocks (pairs of one control and one experimental tow) to achieve during the experiment. A small number of short test tows were used to allow a vessel moving into a new area to determine if the catch composition warranted a pair of full tows. If the initial tow of a pair was unsuccessful (i.e. gear damage) or the catch composition made further towing at that site inadvisable (i.e. excessive halibut bycatch) vessels were allowed to abandon an incomplete block in a limited number of cases. These test tows and incomplete blocks were not included in the experimental analysis, though they were accounted for in tracking the target and bycatch limits for each vessel and for the experiment as a whole.

Catch sampling followed NMFS fisheries observer protocols for North Pacific "head and gut" trawlers with a few modifications. Each vessel contracted two NMFS certified observers who alternated 12 hour shifts to assure that all catches were sampled. On the Legacy, catch volumes were estimated by determining the shape of the filled codends and taking necessary codend measurements. On the Alliance, the catch was dumped into an on-deck bin from which fullness measurements were made. Catch weight was estimated using a conversion factor for deepwater flatfish of 0.95MT per cubic meter, which was recommended by the NMFS Observer Program.

To assure a reliable tracking of each vessel's use of their halibut bycatch cap and to improve survival of discarded halibut, as many halibut as possible were sorted out of the catch on deck as the catch was dumped into the live tank. The observer worked with the deck crew to achieve a census of these halibut and to measure them before they were returned to the sea. To assure that the rest of the catch was available for sampling, no fish were moved out of the bin into the factory until the deck sampling was completed and the observer went down to the factory. While this procedure cannot currently be used on sampled tows in the trawl fisheries, due to the constraints of sampling for the vessel incentive program (VIP), a specific exemption from these requirements was made for this project

Samples of the catch to determine species composition were taken by filling baskets from conveyor belts as the catch passed from the holding tank to the factory. Basket samples were taken at several points throughout the emptying of the bin. The procedures of the NMFS observer manual were followed, except that larger sample sizes were encouraged to improve catch estimates, with a goal of at least 300 kg from each catch. Any remaining halibut coming out of the live tanks were taken from the conveyor and measured.

Subsamples of target species were selected to determine their size composition. These included rex sole, Dover sole and arrowtooth flounder. Where possible, the same species was measured from both tows of a block.

Bridge personnel recorded the position and time of the start and end of each tow. They also recorded the depth, towing speed and whether the experimental or control net was used.

The goal of this experiment was to measure the proportion by which the excluder changed the catch rates of target and bycatch species, particularly rex sole, Dover sole, arrowtooth flounder, flathead sole and Pacific halibut. To adjust for varying tow durations, all analyses were done on catch per unit of distance rates, not raw catches. Tow length was the distance traveled between when the trawl depth stabilized at the beginning of the tow until the winches were started during retrieval.

To allow tests for proportional differences with additive models, a (natural) logarithmic transformation was applied to all catch rates. This also improved the normality of the catch rate distributions. The parameter which was used as a measure of the effect of the excluder was the difference between the transformed catch rate from each tow with the excluder (subscript e) and the comparable rate from the control tow (subscript c) in the same block (pair).

This parameter was calculated for each block for each major species in the catch. Means and confidence intervals of LnCPE's were untransformed, using the exponential function, to provide estimates of the proportion retained when the excluder was used. The LnCPE values for were analyzed with t-tests to determine whether the excluder significantly changed catch rates. In addition to the significance tests, estimates and confidence intervals for each significant effect were generated.

Any effect of the excluder on the size selectivity of the trawl was of interest because of significant price differentials between large and small flatfish. To test whether the effect of the excluder varied for different sizes of the same species, catch rates by size class were generated and analyzed in the same manner as the species catch rates. Size classes were based on individual fish weights because that is the standard generally used in the industry. For each block where a species was sampled from both tows, the number of sole in the length subsample from each of these classes was expanded by both the length subsample fraction and the basket sampling fraction to provide estimates of the number of sole in each size class in the entire catch. The number in each class was then multiplied by the average weight of an individual of that length (using length - weight curves from the Gulf of Alaska groundfish survey (Martin and Clausen 1995) to give a weight of each size class in the catch. LnCPE values were calculated with these catch weights for each size group. These analyses were carried out for arrowtooth flounder, rex sole, Dover sole and Pacific halibut. Tests for differences in retention between size classes were done with a single factor analysis of variance (ANOVA).

Effects of the halibut excluder on catch of halibut and target deep water species - Results

The exempted fishery experiment to test the excluder was conducted from September 18 to 28, 1998. The Legacy completed 31 blocks and the Alliance completed 30. Staying well within the constraints set by the exempted fishing permit, 614.2 tons of groundfish and 23.7 tons of halibut mortality were taken.

The crews of both vessels developed effective and efficient procedures for setting, retrieving, changing and storing the selection grate. There was some concern that the Alliance would not be able to follow the procedures because this rigid grate system had not been used before on a vessel with such a restricted deck or an aft net reel. The fact that both vessels completed their 30 blocks on the same day demonstrates how well the Alliance crew was able overcome these problems. The most time consuming procedures were actually associated with the experimental requirement to change from control to experimental gear between tows.

Both vessels started towing west of Kayak Island in the Central Gulf of Alaska. After completing five blocks, the Legacy moved to the northern and western edges of Portlock Bank, where they completed the rest of their tows. The Alliance remained near Kayak Island for the duration of the experiment. Most tows were made between 200 and 250 m depth with a few blocks by both vessels in the 100 - 200 m range and a few by the Legacy between 250 and 325 m. Average water temperature was 5.9 degrees with shallow tow temperatures as high as 6.5 and those from deep tows as low as 5.2. Light levels were nearly all below 3 X 10^{-6} microEinsteins meter^{-2} sec^{-1} (average 6 X 10^{-7}), with only a few (7) daytime, shallow tows with readings as high as 4 X 10^{-3}.

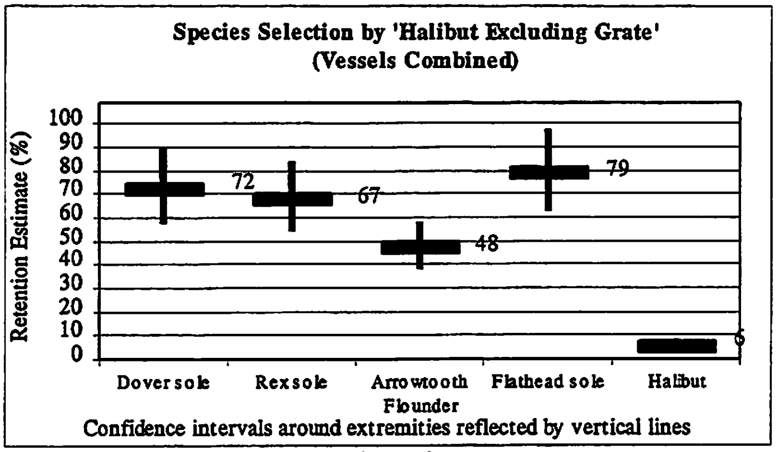


Figure 2

Flathead sole made up less than 1% of the catches on Portlock Bank; so those blocks were excluded from the estimations for that species. In addition, there were two blocks where both Dover sole and rex sole made up less than 1% of the species composition sample in both control and experimental tows. These tows were likewise excluded for those species.

With the data from both vessels combined, the excluder retained only 6 % of the halibut, while keeping 62% of the aggregated deepwater flatfish species (Figure 2). The retention rates for the individual deepwater flatfish species varied from 48% for arrowtooth flounder to 79% for flathead sole. Dover and rex sole were retained at 72% and 67% respectively. All of these values, except that for flathead sole, were significantly different from the null hypothesis of no effect.

The retention rates were significantly different between the vessels for only rex sole and halibut (Figure 3). For both species, the Legacy allowed more fish to escape while the Alliance retained more. This was also the direction of the non-significant

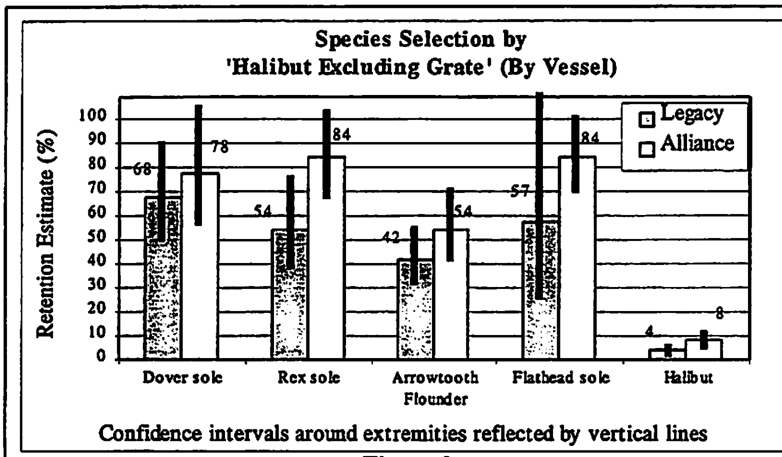


Figure 3

differences for the other species.

Because the length of every halibut was measured, the size composition and selectivity data was very complete for that species. Fish in the 5 - 10 kg (75 - 93 cm lengths) class made up 45% of the weight of halibut caught in the control net. The grate excluded all but 2 % of the halibut weight in this and larger size classes. The only halibut passing through the grate in large proportions were those less that 3 kg (64 cm), of which 46% of the weight was retained. The retention difference between size classes was statistically significant ($p<0.0001$).

Size composition collections for target species were relatively light, being given lower priority than catch weight, halibut measurement and condition, as well as species composition sampling. None were made aboard the Alliance, which had a smaller crew and more physical constraints on sampling. Aboard the Legacy, paired size composition samples were acquired for arrowtooth flounder from 14 blocks. Twelve blocks were sampled for Dover sole and 6 blocks for rex sole.

Arrowtooth flounder in the 1200 - 1600 g (52 - 56 cm) size class made up 33% of the flounder catch in the control tows. When the grate was used, only 44% of this weight class was retained. While there appeared to be a pattern of lower retention rates at larger size classes, an ANOVA detected no significant differences in retention between the size classes ($p=0.25$).

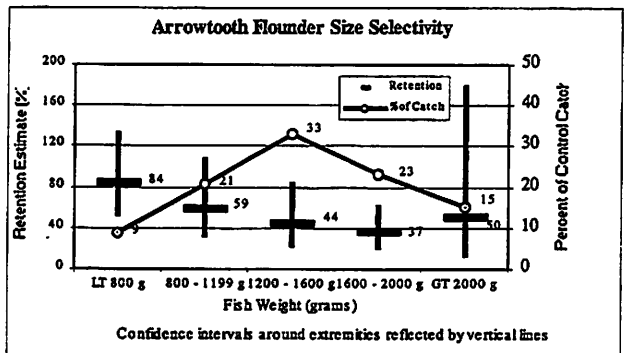


Figure 4

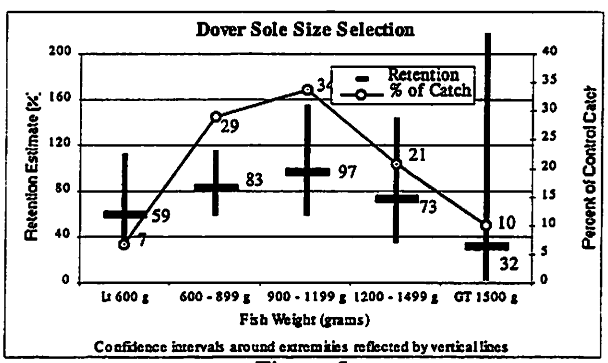


Figure 5

Thirty- four percent of the Dover sole catch was in the 900 - 1200 g (45 - 49 cm) size class with nearly as many (29%) in the 600 - 899 g (40 - 44 cm) class. Again, no significant differences in retention rates were detected ($p = 0.62$).

The most abundant size class for rex sole was fish between 400 and 599 g (39 - 43 cm). While one size class (240 - 399 g, 34 - 38 cm) had nearly double the average retention of the others, this difference was still not statistically significant ($p= 0.20$).

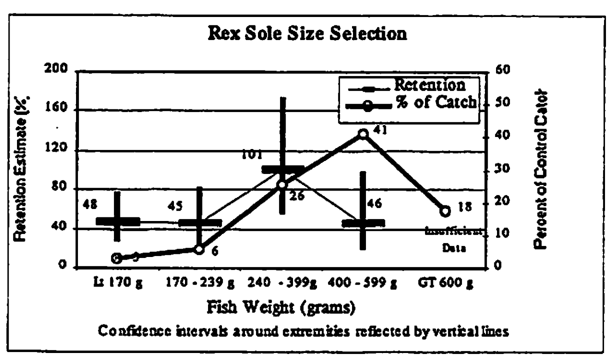


Figure 6

One of the first problems encountered was that some debris and fish would remain ahead of the grate when the trawl was retrieved. This was particularly true of large skates. To allow some assessment of whether an accumulation in front of the grate was affecting its sorting ability, the weight of fish ahead of the grate was estimated for each Legacy experimental tow. This weight varied from 0 to 0.9 MT with an average of 0.3 MT. Linear regressions of each species @ retention percentage with this weight showed no useful relationship for any species. The best correlation was for rex sole where the regression explained only 10% of the variation.

Underwater video observations were made on the grate system during several tows. While descending to the seafloor and being retrieved, the grate was shown to fish consistently in the expected configuration. Unfortunately, continuous sediment clouds obscured observation while the trawl was on the bottom.

Effectiveness of halibut deck sorting procedures used in the EFP

Although the primary objective of the experiment was to reduce halibut bycatch rates, a secondary but important objective of the experiment was to test whether deck sorting halibut can lower the mortality rate of halibut taken as bycatch. In 1998, the deep water flatfish fishery in the Gulf of Alaska was assigned a halibut mortality rate of 62%. This rate is based on NMFS' observers' assessments of the condition of released halibut under current practices where halibut are sampled below deck in basket samples. The condition of each sampled halibut is assessed as Excellent, Poor or Dead. Each of these factors is assigned a probability of mortality, based on International Pacific Halibut Commission research. For the deep water flatfish fishery, these are 20% for Excellent, 55% for poor and 90% for Dead. To test the efficacy of deck sorting for reducing mortality on tows with and without the experimental excluder, the experiment employed a procedure to rapidly count and make condition 57 assessments before returning the halibut to the sea.

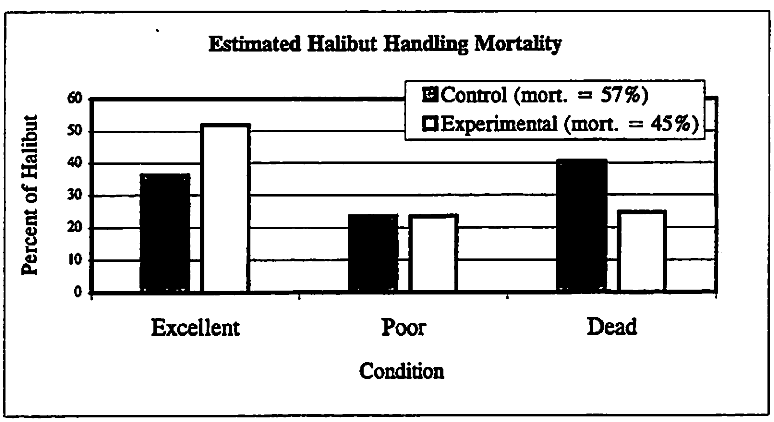


Figure 7

On the Legacy, each catch was sorted as it was dumped into the fish tank to remove and measure as many halibut as possible and to return them to the sea quickly. During the control tows, 75% of the halibut were kept out of the factory in this manner. The reduction of halibut in the experimental tows allowed even more complete sorting, with 88% removed on deck. Condition assessments were made on the vast majority of the released fish.

To estimate mortality rates, the proportion of halibut in each condition category was multiplied by that category's mortality estimate. These values were summed to produce a combined mortality estimate. On tows without the excluder, the average estimated halibut mortality rate was 57% and on tows with the excluder, a rate of 45% was achieved (Figure 74). The probable explanation for a lower mortality rate for tows with the excluder was that the smaller number of halibut in the catch allowed deck sorting to occur more rapidly and halibut to be handled more carefully. Another difference was the inclusion of halibut that were recovered in the factory, of which the control tows had a higher proportion. These fish were all put into the "dead" category because they had to be held for later measurement by the observer.

Effective presorting was not feasible on the Alliance, because the necessary deck space was needed for changing the grate in and out and other gear handling. Because there was a significant delay in getting to the halibut because the experiment required switching trawl intermediates, most of these were assessed in the "dead" category.

Linear extrapolations to assess the potential for expanded use of the halibut excluder

To help interpret the potential value of the halibut excluder to the fishing industry (in its current state of development), an attempt was made to extrapolate the performance of the excluder to the actual deep water flatfish fishery that occurs in the spring each year in the Central Gulf of Alaska. The intent was to generalize the results through extrapolations to evaluate the magnitude of changes in the regular fishery when performance from the two vessels in the experiment was applied to the entire fleet. These extrapolations were theoretical and involved assumptions that, as discussed below, were not necessarily an accurate reflection of reality. The extrapolations, however, are thought to be useful for evaluation of tradeoffs between reductions in target catch and extended fishing time from lower halibut catch rates.

To understand the limitations of the extrapolations, it is important to remember that the model is simplistic and completely linear. For example, total catch divided by the number of fishing days is catch per day used for the model. Similarly, catch per vessel per day is total catch per day divided by the number of vessels. The model did not allow for adjustment in the gear or fishing strategy to increase or maximize economic performance in the face of constraints.

The extrapolations were based on daily catch rates of the 1998 deep water flatfish fishery, reduced by the loss rate of target catch from the experiment. Halibut bycatch was extrapolated by multiplying these deep water flatfish catches by the weight of halibut per ton of deep water flatfish catch from the experiment's tows with the excluder. Because of differences between halibut catch rates with the control net and those during the fisheries, it was recognized that selecting a best value for halibut catches could be difficult. The control net achieved a halibut bycatch rate of 11% which was considerably higher than what actually occurred in the regular April fishery in 1998 (4%) and earlier years. This difference between the regular fishery and the control net rate may be attributable to the use of excluders by some participants in the fishery already. Several members of the flatfish industry report using excluders and several of these devices were described in applications for participation in this EFP. Use of the fishery halibut catch rate and the halibut reduction from the experiment would underestimate halibut catch if this were the cause of the difference. Other factors such as the season during which the experiment was conducted compared to the regular fishery, different fishing areas, etc. could partially explain the difference in bycatch rates as well.

The prevailing assumption for the extrapolations are that every vessel uses the excluder in the April deep water fishery (except for the third extrapolation), and that the excluder performs for each vessel as it did in the experiment last fall. This is, of course, in some respects a large leap of faith, particularly since the data from the experiment represent a different season. Species and size composition of catch data from the experiment indicate a different species mix and smaller rex sole than have usually been caught in the April deep water fishery. In fact, very few rex sole over 44 cm were captured during the experiment, while fish of this size are the principle target of the April deep water fishery.

The original intent of the extrapolations was to estimate revenue and possibly net revenue performance in the fishery with the excluder compared to not fishing with it. However, the size composition of the catch is an important determinant of price (unit price premiums as large as 160% are paid for rex sole in the "large" to "extra large" category. Since the paucity of large target fish in the experimental catches prevented good estimates of their rate of exclusion by the grate (Figures 4,5,6), it was not feasible to estimate the revenue effects of using the excluder. Lacking this important component, the focus of the extrapolations was limited to catch and bycatch differences under three different scenarios. Admittedly, the economic component would have greatly increased the utility of the extrapolations, but the extrapolated catch and bycatch tradeoffs illustrated in the three scenarios are informative nonetheless.

EXTRAPOLATION 1: ESTIMATED DURATION AND CATCH OF THE DEEP WATER FISHERY IF EVERY VESSEL USED THE HALIBUT EXCLUDER

To attempt to illustrate what the fishery would catch if every vessel used the excluder, baseline catch and bycatch rates were used from the April 1998 deep water flatfish fishery and the experiment. The amount of target catch taken during the 1998 April deep water flatfish opening was determined from NMFS bulletin board data. In 1998, the April deep water flatfish season ran from April 1st to the 21st. Catch taken in the season was determined by subtracting the total catch for target species posted on the NMFS' electronic bulletin board reports on 3/28 from that posted on 5/16. Additional weekly reports were included in the data set to allow for lagged catch reports, which can occur in the NMFS data system. The total catch was divided by 21 days to estimate the average catch per day.

Next, the daily catch rates were adjusted to project what the rates would have been if every boat used the halibut excluder tested in the fishing permit. These catch rates were multiplied by the retention rates estimated in the experimental fishery (Figure 2) for each deep water species. To determine the daily catch of halibut, the rate of halibut per metric ton of deep-water flatfish for the experimental tows using the excluder was applied to the projected amount flatfish caught per day in the extrapolated fishery. Halibut catch rates per ton of deep water flatfish were converted to halibut mortality per ton of by applying the official NMFS/IPHC mortality rate of 62% assigned for the deepwater flatfish fishery in 1998 to catch rates.

The "simulated" fishery with all vessels using the excluder was modeled using the new catch rates for target species and halibut as per the results of the experiment. Constraints for the model were the annual TACs and PSC caps for the 1998 fishery in the Central Gulf statistical reporting area. For every day of the fishery (model periods are days), catch was accumulated for each species. Daily model runs are included in an appendix to illustrate the accumulation of daily catch and bycatch under the catch constraints. The linear program model was allowed to run for each extrapolated day of fishing until the model converged on one of the TAC or PSC constraints.

Table Ex1	Arrowtooth Flounder	Dover Sole	Flathead sole	Rex sole	Total Deep Water Flatfish	Black Cod (Sablefish)	Thornyhead	Halibut
Catch in April 1998								
Total catch for April 1-21 1998	3,496	1,868	358	1,190	6,912	255	219	270
Catch/ day (Total/ 21 days)	166.48	88.95	17.05	56.67	329	12.14	10.43	12.86
Projected target catch with excluder								
Estimated retention rate with excluder[1]	0.48	0.72	0.79	0.67		0.58	0.78	
Estimated catch/day with excluder	79.91	64.05	13.47	37.97	195	7.04	8.13	
Projected Halibut catch with excluder								
Catch/day[2]								2.20
Estimated halibut mortality/day[3]								1.36
Deep water flatfish TAC or Cap[4]	25,000	3,690	5,000	5,490	39,180	1,264	710	270
# of days to reach any TAC or Cap	57	57	57	57	57	57	57	57
Groundfish left in TAC/ Cap	19,166	26	3,871	2,738	25,802	852	236	115
Total catch when TAC is reached	4,555	3,651	768	2,164	11,137	401	464	
Halibut Mortality when TAC is reached								78
Difference in catch from April 98 fishery	**1,058.8**	**1,782.6**	**409.7**	**974.1**	**4,225**	**146.4**	**244.7**	**(192.3)**

[1] See Figure 2
[2] Estimated from experimental tows, .01 MT halibut/ MT deep water flatfish
[3] Assumes mortality rate of 62%
[4] Uses 1998 Final Specifications
= Model convergence

The results of the first extrapolation point out that additional fishing time is achieved (at least in theory) with the lower halibut bycatch rates (summary of extrapolation needs a name such as Table Ex1) . The normal fishery lasted 21 days in 1998 and caught 329 metric tons of deepwater flatfish per day on average for a total catch of 6,912 metric tons. Assuming all vessels in the fishery used the excluder, and assuming that performance of the excluder in the September field trial would be achieved in the regular April deep water flatfish fishery, the estimated duration of the fishery with all vessels using the excluder is 57 days. Accounting for the percentage loss of target catch and the extended duration of the fishery, the estimated total catch of deep water flatfish over the 57 days is 11,137 metric tons, which amounts to a 4,225 MT gain in catch compared to what occurred in 1998. Note that the projected duration of the fishery more than doubles but total catch is not increased to the same proportion.

Under the scenario described in this extrapolation, the fishery attains its total allowable catch limit of Dover sole (one of the deep water flatfish species), instead of closing due to attainment of the halibut cap. Reduction in halibut bycatch estimated from the use of the excluder by the fleet results in an estimated savings of 192 metric tons of halibut (the fishery used 270 metric tons in 1998). With the lower halibut catch rates, halibut bycatch is no longer a binding constraint for the deep water flatfish fishery. This is an important result given that the fishery has closed for halibut cap attainment every year since the halibut caps were set.

These results were not sensitive to the use of the halibut bycatch rate from the experimental tows in the extrapolations. Had the approach that was originally envisioned been used (a 94% reduction in bycatch rate been applied to the rate occurring with the control net), halibut bycatch would have been even less of a binding constraint for the fishery. Under the original approach, the same result of the model's attainment of a TAC constraint before hitting the halibut constraint would have been occurred so this adjustment in approach effectively had no effect on the results and was done simply to attempt to make the model's depiction of the fishery using the excluder more accurate.

Given the uncertain effects of the excluder on the size composition of target catch (where premiums for large fish are significant), the revenue tradeoff involved with using the fishery can not be estimated accurately. Underlying this, however, is the more fundamental question of whether the reduction in revenue per day would allow vessels to operate in the fishery at a break even level or above. It is important to understand that additional fishing time is not necessarily beneficial if the vessel is not producing enough catch to justify operation costs in the fishery. What the extrapolation does illustrate, however, is that the excluder does differentially exclude a greater proportion of halibut than target fish. This creates the possibility of improvements in catch of target species and reductions in halibut bycatch.

The industry has stressed that the deep water fishery is currently very dependent on current catch rates to justify fishing costs. Therefore, it seems that the feasibility of using the halibut grate may depend heavily on adjustments to reduce loss of target catch and to avoid the loss of larger, more valuable fish. With additional experimentation and adjustment, the industry may be able to reduce the loss of target species catch without increasing halibut bycatch rates considerably.

EXTRAPOLATION TWO: AVOIDING UNINTENDED CONSEQUENCES BY SETTING RESERVES

Table Ex2	Arrowtooth Flounder	Dover Sole	Flathead sole	Rex sole	Total Deep Water Flatfish	Black Cod (Sablefish)	Thornyhead	Halibut
Catch in April 1998								
Total catch for April 1-21 1998	3,496	1,868	358	1,190	6,912	255	219	270
Catch/ day (Total/ 21 days)	166.48	88.95	17.05	56.67	329	12.14	10.43	12.86
Projected target catch with excluder								
Estimated retention rate with excluder[1]	0.48	0.72	0.79	0.67		0.58	0.78	
Estimated catch/day with excluder	79.91	64.05	13.47	37.97	195	7.04	8.13	
Projected Halibut catch with excluder								
Catch/day[2]								2.20
Estimated halibut mortality/day[3]								1.36
Deep water flatfish TAC or Cap[4]	25,000	3,690	5,000	5,490	39,180	1,264	710	270
# of days to reach any TAC or Cap	49	49	49	49	49	49	49	49
Amount needed for July fishery	3,376	391	356	362	4,485	848	294	
Groundfish left in TAC/ Cap[5]	16,429	148	3,623	2,680	22,880	60	7	126
Total catch when TAC is reached	3,916	3,138	660	1,860	9,574	345	399	
Halibut Mortality when TAC is reached								67
Difference in catch from April 98 fishery	419.5	1,270.2	301.9	670.4	2,662	90.1	179.6	(203.2)

[1] See Figure 2
[2] Estimated from experimental tows, .01 MT halibut/ MT deep water flatfish
[3] Assumes mortality rate of 62%
[4] Uses 1998 Final Specifications
[5] With amount needed for the July fishery deducted from the TAC.
_ = Model convergence

The second extrapolation illustrates the potential for unintended consequences with the potential for catching more of target TACs via lower halibut catch rates. In the first scenario, the model converged on the Dover sole TAC constraint. Had the TAC for Dover sole been slightly higher, the next constraint to be triggered would have been the TAC for Thornyhead rockfish. This is an important result because the July Pacific Ocean Perch (POP) fishery is of larger economic importance than deep water flatfish and it catches significant amounts of

Thornyheads. The remaining balance of Thornyhead TAC when fishing closed in the first scenario was 236 MT. The quantity of Thornyhead rockfish taken in the July 1998 Pacific Ocean Perch fishery was 294 MT. This indicates that the remaining balance would be insufficient to "fund" the full extent of the July POP fishery and thus POP fishing would close earlier than otherwise would have occurred. To accommodate the potential effects of a longer April deep water fishery, the second extrapolation evaluates the effects of setting reserves so that the July POP fishery is not affected by the extended April deep water fishery.

The second extrapolation added a constraint to account for the objective of not impacting the July POP fishery in the Central Gulf of Alaska. The mechanics of the second extrapolation effectively reserve the quantity of flatfish, Thornyhead rockfish, and sablefish needed for the July POP fishery (at 1998 levels of catch) so the July fishery remains unhindered. When this constraint was added, Thornyhead rockfish becomes the binding constraint on the April deep water flatfish fishery and the model convergence occurs when deep water flatfish fishing closes after 49 days instead of 57 days that occurred in the first extrapolation. Catch of deepwater flatfish is reduced by approximately 15% by the shorter duration of the fishery compared to the first extrapolation, but the overall result of a significantly longer deep water fishery with increased catch compared to what actually occurred in April of 1998 remains the same.

EXTRAPOLATION 3: AN ILLUSTRATION OF INCENTIVES FOR INDIVIDUAL GAINS FROM NON-COMPLIANCE

Table Ex3	Arrowtooth Flounder	Dover Sole	Flathead sole	Rex sole	Total Deep Water Flatfish	Black Cod (Sablefish)	Thornyhead	Halibut
Catch in April 1998								
Total catch for April 1-21 1998	3,496	1,868	358	1,190	6,912	255	219	270
Catch/ day (Total/ 21 days)	166.48	88.95	17.05	56.67	329	12.14	10.43	12.86
Estimated daily catch per boat[1]	8.32	4.45	0.85	2.83	16	0.61	0.52	0.64
Projected target catch with excluder								
Estimated retention rate with excluder[2]	0.48	0.72	0.79	0.67		0.58	0.78	
Estimated catch/day with excluder	79.91	64.05	13.47	37.97	195	7.04	8.13	
Estimated daily catch per boat	4.00	3.20	0.67	1.90	10	0.35	0.41	
Projected Halibut catch with excluder								
Catch/day[3]								2.20
Estimated halibut mortality/day[4]								1.36
Estimated daily catch per boat								0.07
Catch/day for fleet								
19 boats using excluder	75.91	60.84	12.79	36.07	186	6.69	7.73	1.30
1 boat w/o excluder	8.32	4.45	0.85	2.83	16	0.61	0.52	0.64
Projected catch/day for whole fleet	84.24	65.29	13.65	38.90	202	7.30	8.25	1.94
Deep water flatfish TAC or Cap[5]	25,000	3,690	5,000	5,490	39,180	1,264	710	270
# of days to reach any TAC or Cap	49	49	49	49	49	49	49	49
Amount needed for July fishery	3,376	391	356	362	4,485	848	294	
Groundfish left in TAC/ Cap[6]	16,217	87	3,614	2,634	22,552	47	2	98
Total catch when TAC is reached	4,128	3,199	669	1,906	9,902	358	404	
Halibut Mortality when TAC is reached								95
Total Catch/boat with excluder	195.8	156.9	33.0	93.0	479	17.3	19.9	3.3
Total Catch/boat without excluder	407.9	217.9	41.8	138.8	806	29.8	25.6	31.5
Difference	212.1	61.0	8.8	45.8	327.7	12.5	5.6	28.2

[1] Assumes a fleet of 20 boats in the fishery
[2] See Figure 2
[3] Estimated from experimental tows, .01 MT halibut/ MT deep water flatfish
[4] Assumes mortality rate of 62%
[5] Uses 1998 Final Specifications
[6] With amount needed for the July fishery deducted from the TAC.
.. = Model convergence

The final extrapolation evaluates the obvious "tragedy of the commons" problem resulting from incentives for individual gain versus collective gain. The projection in this scenario evaluates the catch on a per boat basis for all boats fishing with the excluder except for one. The incentives to not use the excluder, surreptitiously or otherwise, to avoid the loss of target catch are clear. If other trawlers were using the device, the additional fishing time would still be large. Therefore, the vessel not using the excluder would not only avoid losing target catch, but would benefit from the extended fishing time from the reduced halibut catch from vessels using the excluder.

To illustrate the magnitude of individual gains and per vessel catch comparisons, the average catch per day was broken down to the average daily catch per boat based on an arbitrary number of vessels in the fleet (20). The average daily catches for the April 1998 and projected fisheries were divided by 20. The daily halibut usage for the boat that did not use the excluder was determined from the NMFS' weekly bulletin board statistics for the April 98 fishery. The daily catch for a fleet of 20 boats was determined by assuming that all boats but one used the halibut excluder. The daily catch per boat using the excluder was multiplied by 19 and the daily catch for the single boat that fished without the excluder was added to determine the daily catch for the fleet (Table Ex2). Groundfish needed for the July fishery was deducted from the TAC's in the manner used for the second extrapolation.

The final model run illustrates the magnitude of incentives that could exist for individual gains over collective gains. The duration of the resulting fishery was still 49 days according to the model and the model converged again due to attainment of the Thornyhead catch constraint. The average total catch for a vessel that uses the excluder was compared to the vessel that did not use the excluder to illustrate the additional target catch and halibut accruing to the vessel that did not use the excluder. The model simulated this by dividing the total catch of all vessels using the excluder by 19 vessels (Table Ex 3) and, in effect, not applying the reductions in catch of target species and halibut to the vessel not using the excluder). The model illustrates that the boat without an excluder caught nearly twice the quantity of deep water flatfish (Table Q below). Even more striking is the near ten-fold increase in halibut mortality from the boat that was not using the excluder over the duration of the fishery (31.5 MT of halibut compared to 3.3 MT).

Table Q Total catch per boat for Extrapolation III

	Boat with excluder	Boat without excluder	Difference
Arrowtooth	195.8	407.9	212.1
Dover Sole	156.9	217.9	61.0
Flathead	33.0	41.8	8.8
Rex sole	93.0	138.8	45.8
Total deep water flatfish	**479**	**806**	**327.7**
Black Cod	17.3	29.8	12.5
Thornyhead	19.9	25.6	5.6
Halibut	3.3	31.5	28.2

Summary and Conclusions

This experiment has demonstrated that the halibut excluder grate dramatically reduced the catch of halibut with only moderate reductions in catches of rex sole, Dover sole, flathead sole and arrowtooth flounder. The halibut exclusion was size selective, with 46% of the halibut weighing less than 3 kg retained, while nearly all of the halibut larger than 5 kg escaped. The size sampling of the target species was insufficient to detect selectivity differences by size groups, leaving unresolved concerns of whether the largest, most valuable, target species would be excluded at a higher rate.

Both vessels developed procedures for handling their nets, with the excluder installed, in ways that did not significantly impede normal fishing operations. This was particularly important on the Alliance, which had restricted deck space and only a single aft net reel, demonstrating that a rigid grate can be used on smaller vessels.

Deck sorting procedures were effective in improving the condition of halibut removed from the catch for release. The smaller number of halibut in the experimental tows expedited this process, resulting in even lower estimated mortalities.

The experimental fishing permit again proved its effectiveness as a vehicle for achieving useful tests of gear modifications for bycatch reduction. The use of vessels from the fishery operating under commercial conditions, without the competitive pressures of the open fishery, allowed the collection of relevant and statistically defendable data in a controlled experiment.

Extrapolations of catches which would result if the grate were used by all vessels in the Spring deep water fishery in the Gulf of Alaska demonstrated that:

1. halibut bycatch would no longer be a constraint for the fishery but the tradeoff in terms of increased fishing time versus forfeited revenue per day remains unresolved,
2. limitations on the catch of other species (thornyheads) might be needed to prevent unintended impacts on other fisheries, and
3. there would be a very strong financial incentive to be the only vessel not using a grate, or using an ineffective grate, in such a fishery.

<u>Assessment of the overall utility of the halibut excluder based on the results from the experiment</u>

The deep water flatfish fishery has not been able to catch a large proportion of its allowable harvest levels in the past because the halibut bycatch limits for the fishery have lead to premature closures every year since the halibut caps have been in place. So the reduction in halibut bycatch rates via the excluder offers potential for avoiding early closure of the deep water flatfish fishery and harvesting a greater percentage of the target flatfish quotas. At the same time, the fairly significant loss of target catch from using the excluder may affect the economic viability of the fishery because fishermen may not be able to justify the operating costs of fishing on a day to day basis if revenue per day is too low due to the reduction of target catch rates. Additional effects of loss of revenue from forfeiting larger, more valuable, rex sole would also affect the bottom line significantly. Modifications to the excluder will have to be attempted so that loss of target catch can be reduced before the halibut excluder can be considered an unqualified success.

An additional finding from the experiment is that deck sorting halibut can significantly reduce the mortality of halibut caught in flatfish trawls. The handling procedures used in the experiment, in conjunction with the low numbers of halibut taken with the excluder create an excellent opportunity to dramatically lower the mortality of halibut that are not released by the excluder. Results showed that halibut mortality can be reduced to 45% which is a reduction of approximately one-third of the current rate, without hamstringing fishermen and observers with excessive workload on deck.

The third extrapolation raises an important aspect of voluntary or mandatory bycatch reduction programs. In other Council jurisdiction regions, gear regulations have often failed to deliver the expected results when incentives for individual gain exist for not using the gear at all or using it in a way that defeats its purpose. Problems experienced with mesh regulations in New England and turtle excluder devices in the Gulf of Mexico are illustrations of this. In the opinion of Groundfish Forum, the basic problem with gear regulations or voluntary gear programs is that fishermen are the most knowledgeable parties on how to make gear work and how to disable its effectiveness. This is why Groundfish Forum believes that the key element to a successful fleet-wide adoption of gear modifications for halibut bycatch reduction is to create economic incentives for fishermen to want to use the modified gear by allowing them to realize some benefit from their actions.

Because of the large incentives for individual gain at the expense of the overall benefit, the key issues for successful fleet-wide or sub-sector implementation of a halibut excluder device program would be to allow for refinement of the device so that loss of target catch can be reduced, and most importantly, allow those individuals willing to use the device to realize benefits for their sacrificed catch and additional labor for deck crew etc. For such a program to work, we also believe participating vessels would be responsible for providing sufficient means to prove they are actually using the excluder. One possible solution for ensuring those who make the effort benefit from their actions might be to sub-divide the halibut allocation into two portions, one for those vessels using excluders (and willing to take steps to make this enforceable) and those who wish prefer to remain in the fishery as it is currently prosecuted.

Further Development of the excluder

While the grate excluder proved very effective, some avenues are open for further improvement. A means to prevent the accumulation of large fish, particularly skates, and debris ahead of the grate would definitely improve the utility and likely improve the effectiveness of the device. Means should be sought to improve the retention of target species, especially larger individuals. Even if this causes some additional retention of halibut, it would provide a greater range of choices with which to achieve management and fishery goals. Even though the Alliance was able to efficiently use the rigid grate, some testing should be done on excluders that are more easily handled by smaller vessels. Several vessels have tried mesh excluders for halibut selection and though they were not selected for this study, further testing and development are warranted.

REFERENCES

Martin, M.H., and Clausen, D.M. 1995. "Data Report: 1993 Gulf of Alaska bottom trawl survey." U.S. Department of Commerce, NOAA. *NOAA Technical Memorandum NMFS-AFSC-59.* 217 pp.

APPENDIX 1

Extrapolation 1
Total Catch for each day in fishery

	Arrowtooth Flounder	Dover sole	Flathead sole	Rex sole	Total deep water flatfish	Black Cod (Sablefish)	Thornyhead	Halibut
1	79.9	64.1	13.5	38.0	195.4	7.0	8.1	1.4
2	159.8	128.1	26.9	75.9	390.8	14.1	16.3	2.7
3	239.7	192.2	40.4	113.9	586.2	21.1	24.4	4.1
4	319.6	256.2	53.9	151.9	781.6	28.2	32.5	5.4
5	399.6	320.3	67.4	189.9	977.0	35.2	40.7	6.8
6	479.5	384.3	80.8	227.8	1,172.4	42.2	48.8	8.2
7	559.4	448.4	94.3	265.8	1,367.8	49.3	56.9	9.5
8	639.3	512.4	107.8	303.8	1,563.2	56.3	65.0	10.9
9	719.2	576.5	121.2	341.7	1,758.6	63.4	73.2	12.2
10	799.1	640.5	134.7	379.7	1,954.0	70.4	81.3	13.6
11	879.0	704.6	148.2	417.7	2,149.4	77.4	89.4	15.0
12	958.9	768.6	161.6	455.6	2,344.8	84.5	97.6	16.3
13	1,038.8	832.7	175.1	493.6	2,540.2	91.5	105.7	17.7
14	1,118.7	896.7	188.6	531.6	2,735.6	98.6	113.8	19.0
15	1,198.7	960.8	202.1	569.6	2,931.0	105.6	122.0	20.4
16	1,278.6	1,024.8	215.5	607.5	3,126.4	112.6	130.1	21.8
17	1,358.5	1,088.9	229.0	645.5	3,321.8	119.7	138.2	23.1
18	1,438.4	1,152.9	242.5	683.5	3,517.2	126.7	146.3	24.5
19	1,518.3	1,217.0	255.9	721.4	3,712.6	133.8	154.5	25.8
20	1,598.2	1,281.0	269.4	759.4	3,908.0	140.8	162.6	27.2
21	1,678.1	1,345.1	282.9	797.4	4,103.4	147.8	170.7	28.6
22	1,758.0	1,409.1	296.3	835.3	4,298.8	154.9	178.9	29.9
23	1,837.9	1,473.2	309.8	873.3	4,494.2	161.9	187.0	31.3
24	1,917.8	1,537.2	323.3	911.3	4,689.6	169.0	195.1	32.6
25	1,997.8	1,601.3	336.8	949.3	4,885.0	176.0	203.3	34.0
26	2,077.7	1,665.3	350.2	987.2	5,080.4	183.0	211.4	35.4
27	2,157.6	1,729.4	363.7	1,025.2	5,275.8	190.1	219.5	36.7
28	2,237.5	1,793.4	377.2	1,063.2	5,471.2	197.1	227.6	38.1
29	2,317.4	1,857.5	390.6	1,101.1	5,666.6	204.2	235.8	39.4
30	2,397.3	1,921.5	404.1	1,139.1	5,862.0	211.2	243.9	40.8
31	2,477.2	1,985.6	417.6	1,177.1	6,057.4	218.2	252.0	42.2
32	2,557.1	2,049.6	431.0	1,215.0	6,252.8	225.3	260.2	43.5
33	2,637.0	2,113.7	444.5	1,253.0	6,448.2	232.3	268.3	44.9
34	2,716.9	2,177.7	458.0	1,291.0	6,643.6	239.4	276.4	46.2
35	2,796.9	2,241.8	471.5	1,329.0	6,839.0	246.4	284.6	47.6
36	2,876.8	2,305.8	484.9	1,366.9	7,034.4	253.4	292.7	49.0
37	2,956.7	2,369.9	498.4	1,404.9	7,229.8	260.5	300.8	50.3
38	3,036.6	2,433.9	511.9	1,442.9	7,425.2	267.5	308.9	51.7
39	3,116.5	2,498.0	525.3	1,480.8	7,620.6	274.6	317.1	53.0
40	3,196.4	2,562.0	538.8	1,518.8	7,816.0	281.6	325.2	54.4
41	3,276.3	2,626.1	552.3	1,556.8	8,011.4	288.6	333.3	55.8
42	3,356.2	2,690.1	565.7	1,594.7	8,206.8	295.7	341.5	57.1
43	3,436.1	2,754.2	579.2	1,632.7	8,402.2	302.7	349.6	58.5
44	3,516.0	2,818.2	592.7	1,670.7	8,597.6	309.8	357.7	59.8
45	3,596.0	2,882.3	606.2	1,708.7	8,793.0	316.8	365.9	61.2
46	3,675.9	2,946.3	619.6	1,746.6	8,988.4	323.8	374.0	62.6
47	3,755.8	3,010.4	633.1	1,784.6	9,183.8	330.9	382.1	63.9
48	3,835.7	3,074.4	646.6	1,822.6	9,379.2	337.9	390.2	65.3
49	3,915.6	3,138.5	660.0	1,860.5	9,574.6	345.0	398.4	66.6
50	3,995.5	3,202.5	673.5	1,898.5	9,770.0	352.0	406.5	68.0
51	4,075.4	3,266.6	687.0	1,936.5	9,965.4	359.0	414.6	69.4
52	4,155.3	3,330.6	700.4	1,974.4	10,160.8	366.1	422.8	70.7
53	4,235.2	3,394.7	713.9	2,012.4	10,356.2	373.1	430.9	72.1
54	4,315.1	3,458.7	727.4	2,050.4	10,551.6	380.2	439.0	73.4
55	4,395.1	3,522.8	740.9	2,088.4	10,747.0	387.2	447.2	74.8
56	4,475.0	3,586.8	754.3	2,126.3	10,942.4	394.2	455.3	76.2
57	4,554.9	3,650.9	767.8	2,164.3	11,137.8	401.3	463.4	77.5

Extrapolation 2
Total Catch for each day in fishery

	Arrowtooth Flounder	Dover Sole	Flathead sole	Rex sole	Black Cod (Sablefish)	Thornyhead	Halibut
1	79.9	64.1	13.5	38.0	7.0	8.1	1.4
2	159.8	128.1	26.9	75.9	14.1	16.3	2.7
3	239.7	192.2	40.4	113.9	21.1	24.4	4.1
4	319.6	256.2	53.9	151.9	28.2	32.5	5.4
5	399.6	320.3	67.4	189.9	35.2	40.7	6.8
6	479.5	384.3	80.8	227.8	42.2	48.8	8.2
7	559.4	448.4	94.3	265.8	49.3	56.9	9.5
8	639.3	512.4	107.8	303.8	56.3	65.0	10.9
9	719.2	576.5	121.2	341.7	63.4	73.2	12.2
10	799.1	640.5	134.7	379.7	70.4	81.3	13.6
11	879.0	704.6	148.2	417.7	77.4	89.4	15.0
12	958.9	768.6	161.6	455.6	84.5	97.6	16.3
13	1,038.8	832.7	175.1	493.6	91.5	105.7	17.7
14	1,118.7	896.7	188.6	531.6	98.6	113.8	19.0
15	1,198.7	960.8	202.1	569.6	105.6	122.0	20.4
16	1,278.6	1,024.8	215.5	607.5	112.6	130.1	21.8
17	1,358.5	1,088.9	229.0	645.5	119.7	138.2	23.1
18	1,438.4	1,152.9	242.5	683.5	126.7	146.3	24.5
19	1,518.3	1,217.0	255.9	721.4	133.8	154.5	25.8
20	1,598.2	1,281.0	269.4	759.4	140.8	162.6	27.2
21	1,678.1	1,345.1	282.9	797.4	147.8	170.7	28.6
22	1,758.0	1,409.1	296.3	835.3	154.9	178.9	29.9
23	1,837.9	1,473.2	309.8	873.3	161.9	187.0	31.3
24	1,917.8	1,537.2	323.3	911.3	169.0	195.1	32.6
25	1,997.8	1,601.3	336.8	949.3	176.0	203.3	34.0
26	2,077.7	1,665.3	350.2	987.2	183.0	211.4	35.4
27	2,157.6	1,729.4	363.7	1,025.2	190.1	219.5	36.7
28	2,237.5	1,793.4	377.2	1,063.2	197.1	227.6	38.1
29	2,317.4	1,857.5	390.6	1,101.1	204.2	235.8	39.4
30	2,397.3	1,921.5	404.1	1,139.1	211.2	243.9	40.8
31	2,477.2	1,985.6	417.6	1,177.1	218.2	252.0	42.2
32	2,557.1	2,049.6	431.0	1,215.0	225.3	260.2	43.5
33	2,637.0	2,113.7	444.5	1,253.0	232.3	268.3	44.9
34	2,716.9	2,177.7	458.0	1,291.0	239.4	276.4	46.2
35	2,796.9	2,241.8	471.5	1,329.0	246.4	284.6	47.6
36	2,876.8	2,305.8	484.9	1,366.9	253.4	292.7	49.0
37	2,956.7	2,369.9	498.4	1,404.9	260.5	300.8	50.3
38	3,036.6	2,433.9	511.9	1,442.9	267.5	308.9	51.7
39	3,116.5	2,498.0	525.3	1,480.8	274.6	317.1	53.0
40	3,196.4	2,562.0	538.8	1,518.8	281.6	325.2	54.4
41	3,276.3	2,626.1	552.3	1,556.8	288.6	333.3	55.8
42	3,356.2	2,690.1	565.7	1,594.7	295.7	341.5	57.1
43	3,436.1	2,754.2	579.2	1,632.7	302.7	349.6	58.5
44	3,516.0	2,818.2	592.7	1,670.7	309.8	357.7	59.8
45	3,596.0	2,882.3	606.2	1,708.7	316.8	365.9	61.2
46	3,675.9	2,946.3	619.6	1,746.6	323.8	374.0	62.6
47	3,755.8	3,010.4	633.1	1,784.6	330.9	382.1	63.9
48	3,835.7	3,074.4	646.6	1,822.6	337.9	390.2	65.3
49	3,915.6	3,138.5	660.0	1,860.5	345.0	398.4	66.6

Extrapolation 3

Total Catch for each day in fishery

	Arrowtooth			Dover Sole			Flathead			Rex sole			Black Cod			Thornyhead			Halibut		
	w/ HED	Ave.	w/o HED	w/ HED	Ave.	w/o HED	w/ HED	Ave.	w/o HED	w/ HED	Ave.	w/o HED	w/ HED	Ave.	w/o HED	w/ HED	Ave.	w/o HED	w/ HED	Ave.	w/o HED
1	75.9	4.0	8.3	60.8	3.2	4.5	12.8	0.7	0.9	36.1	1.9	2.8	6.7	0.4	0.6	7.7	0.4	0.5	1.3	0.1	0.6
2	151.8	8.0	16.6	121.7	6.4	8.9	25.6	1.3	1.7	72.1	3.8	5.7	13.4	0.7	1.2	15.5	0.8	1.0	2.6	0.1	1.3
3	227.7	12.0	25.0	182.5	9.6	13.4	38.4	2.0	2.6	108.2	5.7	8.5	20.1	1.1	1.8	23.2	1.2	1.6	3.9	0.2	1.9
4	303.6	16.0	33.3	243.4	12.8	17.8	51.2	2.7	3.4	144.3	7.6	11.3	26.8	1.4	2.4	30.9	1.6	2.1	5.2	0.3	2.6
5	379.6	20.0	41.6	304.2	16.0	22.3	64.0	3.4	4.3	180.3	9.5	14.2	33.5	1.8	3.1	38.6	2.0	2.6	6.5	0.3	3.2
6	455.5	24.0	49.9	365.0	19.2	26.7	76.7	4.0	5.1	216.4	11.4	17.0	40.1	2.1	3.7	46.4	2.4	3.1	7.8	0.4	3.8
7	531.4	28.0	58.2	425.9	22.4	31.2	89.5	4.7	6.0	252.5	13.3	19.8	46.8	2.5	4.3	54.1	2.8	3.6	9.1	0.5	4.5
8	607.3	32.0	66.6	486.7	25.6	35.6	102.3	5.4	6.8	288.6	15.2	22.6	53.5	2.8	4.9	61.8	3.3	4.2	10.4	0.5	5.1
9	683.2	36.0	74.9	547.6	28.8	40.1	115.1	6.1	7.7	324.6	17.1	25.5	60.2	3.2	5.5	69.6	3.7	4.7	11.7	0.6	5.8
10	759.1	40.0	83.2	608.4	32.0	44.5	127.9	6.7	8.5	360.7	19.0	28.3	66.9	3.5	6.1	77.3	4.1	5.2	13.0	0.7	6.4
11	835.0	43.9	91.5	669.2	35.2	49.0	140.7	7.4	9.4	396.8	20.9	31.1	73.6	3.9	6.7	85.0	4.5	5.7	14.3	0.8	7.0
12	910.9	47.9	99.8	730.1	38.4	53.4	153.5	8.1	10.2	432.8	22.8	34.0	80.3	4.2	7.3	92.8	4.9	6.2	15.6	0.8	7.7
13	986.8	51.9	108.2	790.9	41.6	57.9	166.3	8.8	11.1	468.9	24.7	36.8	87.0	4.6	7.9	100.5	5.3	6.8	16.9	0.9	8.3
14	1,062.7	55.9	116.5	851.8	44.8	62.3	179.1	9.4	11.9	505.0	26.6	39.6	93.7	4.9	8.5	108.2	5.7	7.3	18.2	1.0	9.0
15	1,138.7	59.9	124.8	912.6	48.0	66.8	191.9	10.1	12.8	541.0	28.5	42.5	100.4	5.3	9.2	115.9	6.1	7.8	19.5	1.0	9.6
16	1,214.6	63.9	133.1	973.4	51.2	71.2	204.6	10.8	13.6	577.1	30.4	45.3	107.0	5.6	9.8	123.7	6.5	8.3	20.8	1.1	10.2
17	1,290.5	67.9	141.4	1,034.3	54.4	75.7	217.4	11.4	14.5	613.2	32.3	48.1	113.7	6.0	10.4	131.4	6.9	8.8	22.1	1.2	10.9
18	1,366.4	71.9	149.8	1,095.1	57.6	80.1	230.2	12.1	15.3	649.3	34.2	50.9	120.4	6.3	11.0	139.1	7.3	9.4	23.4	1.2	11.5
19	1,442.3	75.9	158.1	1,156.0	60.8	84.6	243.0	12.8	16.2	685.3	36.1	53.8	127.1	6.7	11.6	146.9	7.7	9.9	24.7	1.3	12.2
20	1,518.2	79.9	166.4	1,216.8	64.0	89.0	255.8	13.5	17.0	721.4	38.0	56.6	133.8	7.0	12.2	154.6	8.1	10.4	26.0	1.4	12.8
21	1,594.1	83.9	174.7	1,277.6	67.2	93.5	268.6	14.1	17.9	757.5	39.9	59.4	140.5	7.4	12.8	162.3	8.5	10.9	27.3	1.4	13.4
22	1,670.0	87.9	183.0	1,338.5	70.4	97.9	281.4	14.8	18.7	793.5	41.8	62.3	147.2	7.7	13.4	170.1	9.0	11.4	28.6	1.5	14.1
23	1,745.9	91.9	191.4	1,399.3	73.6	102.4	294.2	15.5	19.6	829.6	43.7	65.1	153.9	8.1	14.0	177.8	9.4	12.0	29.9	1.6	14.7
24	1,821.8	95.9	199.7	1,460.2	76.9	106.8	307.0	16.2	20.4	865.7	45.6	67.9	160.6	8.5	14.6	185.5	9.8	12.5	31.2	1.6	15.4
25	1,897.8	99.9	208.0	1,521.0	80.1	111.3	319.8	16.8	21.3	901.7	47.5	70.8	167.3	8.8	15.3	193.2	10.2	13.0	32.5	1.7	16.0
26	1,973.7	103.9	216.3	1,581.8	83.3	115.7	332.5	17.5	22.1	937.8	49.4	73.6	173.9	9.2	15.9	201.0	10.6	13.5	33.8	1.8	16.6
27	2,049.6	107.9	224.6	1,642.7	86.5	120.2	345.3	18.2	23.0	973.9	51.3	76.4	180.6	9.5	16.5	208.7	11.0	14.0	35.1	1.8	17.3
28	2,125.5	111.9	233.0	1,703.5	89.7	124.6	358.1	18.8	23.8	1,010.0	53.2	79.2	187.3	9.9	17.1	216.4	11.4	14.6	36.4	1.9	17.9
29	2,201.4	115.9	241.3	1,764.4	92.9	129.1	370.9	19.5	24.7	1,046.0	55.1	82.1	194.0	10.2	17.7	224.2	11.8	15.1	37.7	2.0	18.6
30	2,277.3	119.9	249.6	1,825.2	96.1	133.5	383.7	20.2	25.5	1,082.1	57.0	84.9	200.7	10.6	18.3	231.9	12.2	15.6	39.0	2.1	19.2
31	2,353.2	123.9	257.9	1,886.0	99.3	138.0	396.5	20.9	26.4	1,118.2	58.9	87.7	207.4	10.9	18.9	239.6	12.6	16.1	40.3	2.1	19.8
32	2,429.1	127.8	266.2	1,946.9	102.5	142.4	409.3	21.5	27.2	1,154.2	60.7	90.6	214.1	11.3	19.5	247.4	13.0	16.6	41.6	2.2	20.5
33	2,505.0	131.8	274.6	2,007.7	105.7	146.9	422.1	22.2	28.1	1,190.3	62.6	93.4	220.8	11.6	20.1	255.1	13.4	17.2	42.9	2.3	21.1
34	2,580.9	135.8	282.9	2,068.6	108.9	151.3	434.9	22.9	28.9	1,226.4	64.5	96.2	227.5	12.0	20.7	262.8	13.8	17.7	44.2	2.3	21.8
35	2,656.9	139.8	291.2	2,129.4	112.1	155.8	447.7	23.6	29.8	1,262.4	66.4	99.1	234.2	12.3	21.4	270.5	14.2	18.2	45.5	2.4	22.4
36	2,732.8	143.8	299.5	2,190.2	115.3	160.2	460.4	24.2	30.6	1,298.5	68.3	101.9	240.8	12.7	22.0	278.3	14.6	18.7	46.8	2.5	23.0
37	2,808.7	147.8	307.8	2,251.1	118.5	164.7	473.2	24.9	31.5	1,334.6	70.2	104.7	247.5	13.0	22.6	286.0	15.1	19.2	48.1	2.5	23.7
38	2,884.6	151.8	316.2	2,311.9	121.7	169.1	486.0	25.6	32.3	1,370.7	72.1	107.5	254.2	13.4	23.2	293.7	15.5	19.8	49.4	2.6	24.3
39	2,960.5	155.8	324.5	2,372.8	124.9	173.6	498.8	26.3	33.2	1,406.7	74.0	110.4	260.9	13.7	23.8	301.5	15.9	20.3	50.7	2.7	25.0
40	3,036.4	159.8	332.8	2,433.6	128.1	178.0	511.6	26.9	34.0	1,442.8	75.9	113.2	267.6	14.1	24.4	309.2	16.3	20.8	52.0	2.7	25.6
41	3,112.3	163.8	341.1	2,494.4	131.3	182.5	524.4	27.6	34.9	1,478.9	77.8	116.0	274.3	14.4	25.0	316.9	16.7	21.3	53.3	2.8	26.2
42	3,188.2	167.8	349.4	2,555.3	134.5	186.9	537.2	28.3	35.7	1,514.9	79.7	118.9	281.0	14.8	25.6	324.7	17.1	21.8	54.6	2.9	26.9
43	3,264.1	171.8	357.8	2,616.1	137.7	191.4	550.0	28.9	36.6	1,551.0	81.6	121.7	287.7	15.1	26.2	332.4	17.5	22.4	55.9	2.9	27.5
44	3,340.0	175.8	366.1	2,677.0	140.9	195.8	562.8	29.6	37.4	1,587.1	83.5	124.5	294.4	15.5	26.8	340.1	17.9	22.9	57.2	3.0	28.2
45	3,416.0	179.8	374.4	2,737.8	144.1	200.3	575.6	30.3	38.3	1,623.1	85.4	127.4	301.1	15.8	27.5	347.8	18.3	23.4	58.5	3.1	28.8
46	3,491.9	183.8	382.7	2,798.6	147.3	204.7	588.3	31.0	39.1	1,659.2	87.3	130.2	307.7	16.2	28.1	355.6	18.7	23.9	59.8	3.1	29.4
47	3,567.8	187.8	391.0	2,859.5	150.5	209.2	601.1	31.6	40.0	1,695.3	89.2	133.0	314.4	16.5	28.7	363.3	19.1	24.4	61.1	3.2	30.1
48	3,643.7	191.8	399.4	2,920.3	153.7	213.6	613.9	32.3	40.8	1,731.4	91.1	135.8	321.1	16.9	29.3	371.0	19.5	25.0	62.4	3.3	30.7
49	3,719.6	195.8	407.7	2,981.2	156.9	218.1	626.7	33.0	41.7	1,767.4	93.0	138.7	327.8	17.3	29.9	378.8	19.9	25.5	63.7	3.4	31.4