Review of Preferred Methods to Project Charter Yields Under Alternative Management Measures

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1.0 Purpose

In December of 2011, the Alaska Department of Fish and Game (ADF&G) presented charter harvest projections for 2012 under three alternative management measures to the North Pacific Fishery Management Council. Projections were presented for a range of minimum size limits, reverse slot limits, and closures of days of the week. These were the management measures selected by the Council's Charter Implementation Committee for analysis. The Council recommended a reverse slot limit that allowed charter harvest of halibut less than or equal to 45 inches and greater than or equal to 68 inches in length (U45O68). This recommendation was adopted by the International Pacific Halibut Commission (IPHC) and implemented as a regulation under the IPHC's annual management measures for the 2012 season.

For development of the proposed Catch Sharing Plan (CSP), the Council also asked ADF&G to analyze additional management measures, including an annual limit on the number of fish retained that are exempt from a size limit, restricting captain and crew harvest, limits on the number of charter trips per day, and maximum size limits applied to both fish under a one-fish bag limit. Analysis of these measures was included in a discussion paper that was presented to the Council in April 2012 (King et al. 2012).

The Council has requested that the Charter Implementation Committee again recommend specific management measures for analysis for the 2013 season. Charter yield will be projected under these measures to enable the Council to recommend specific measures to constrain the charter harvest within the Guideline Harvest Levels (GHLs) for Areas 2C and 3A. These recommendations will be made to the IPHC and, with their concurrence, will be implemented as part of the annual management measures for 2013. In addition, the Council's preliminary preferred alternative for the proposed CSP recommends a similar procedure that will be used on an annual basis to identify and evaluate alternative measures, and then recommend specific measures to keep the Area 2C and 3A charter sectors within their allocation for the coming year.

This paper, therefore, presents the procedures that ADF&G will use to project charter yields under alternative management measures that the Council is likely to consider for review by the Scientific and Statistical Committee. Further reviews will be requested only as needed as these methods evolve.

2.0 Background

The charter halibut Guideline Harvest Level (GHL) and catch limits established under the proposed catch sharing plan are in units of weight. Therefore, ADF&G calculates charter halibut yield for each IPHC area as the product of the estimates of the numbers of fish harvested and average net weight (headed and gutted).

The number of halibut harvested is currently estimated through the ADF&G Statewide Harvest Survey (SWHS). This is a mail survey based on stratified random sampling of resident and nonresident households containing at least one licensed angler. Survey respondents report for the entire household the number of anglers, the number of guided and unguided trips made in each location, and the numbers of each species caught and kept on guided and unguided trips. Estimates are produced for seven subareas in Area 2C and seven subareas in Area 3A. The subareas match SWHS reporting areas or ADF&G

management areas, and each subarea contains at least one sampled port (Table 1). Response data from three mailings are used to adjust estimates for nonresponse bias.

Average net weight of the charter harvest is estimated from halibut length data collected at sampled ports in each subarea. Net weights (w) are estimated from length (l) using the IPHC length-weight relationship (Clark 1992):

$$\hat{w}(lb) = 6.921 \times 10^{-6}\ l(cm)^{3.24} \quad (1)$$

Estimates of average weight for subareas with two sampled ports are stratified using logbook data as stratum weights when possible. If not, the data from both ports are pooled for estimation.

Harvest trends and estimates of average weight vary by area (Figure 1). Therefore, estimates of charter yield Y are calculated by subarea s and summed:

$$\hat{Y} = \sum_{s} \hat{H}_s \hat{\bar{w}}_s \quad (2)$$

Where

$\hat{H}_s =$ the estimated charter halibut harvest in subarea s (in numbers of fish), and

$\hat{\bar{w}}_s =$ the estimated average weight of halibut harvested by charter anglers in subarea s.

Projections of charter yield under alternative management measures follow the same basic approach, replacing estimates of harvest and average weight with forecasts.

Alternative management measures are assumed to have an effect on either the number of fish harvested (e.g., bag limit) or the average weight (e.g., size limit). There is potential for almost any management measure to affect both number and weight. For example, under a reduced bag limit, an angler may be motivated to retain larger fish. The history of bag limit or size limit changes in the charter fishery is short, so data are insufficient to model any more than the direct effects of management alternatives.

3.0 Projection Methods

3.1 Status Quo Projections

Methods:

Forecasts of charter halibut harvest (in number of fish) or average weight under status quo are required to see if a change in management measure is necessary for the upcoming season. In many cases, a harvest forecast (number of fish) is needed in combination with projections of average weight from proposed management measures that are assumed to have no effect on the number of fish harvested.

Charter harvest forecasts will be made using simple time series methods, at least until better models are developed. Time series methods were used to forecast charter harvest in 20l2 and unguided harvest in recent years. Typically forecasts from several methods have been compared, including the naïve forecast (previous year's value), moving averages, linear trends based on 3-6 years, and single and double exponential models. Forecast methods are compared using mean squared deviations. Single exponential or moving average models have generally been best for stationary time series (lacking trend), while the linear or double exponential models have generally been best for trended data.

There was a large decrease in the harvest in Area 2C in 2009, probably because of the change from a 2-fish to a 1-fish daily bag limit combined with the recent decline in demand for charter trips (Figure 1). There was also a large drop in harvest in Area 3A in 2008 and 2009, presumably due to similar economic factors. Because exponentially weighted models give more weight to recent years, these models do not provide accurate forecasts for highly variable time series or time series perturbed by a major regulation change. However, if the time series experiences a perturbation and then stabilizes at a new level, it may only take a few years for the model to begin providing reliable forecasts. In the case of recent large perturbations that are due to either changes in harvest or recent size regulations, the prior year's value (naïve forecast), or a simple average or weighted average of recent years may be the best status quo forecast for the coming year.

Alternative simple forecasting models will be run retrospectively on data from each subarea. The naïve forecast will always be included. The model with the lowest mean squared deviations from retrospective forecasts will be chosen for each subarea, and the forecasts for the coming year will be summed to obtain the overall IPHC area forecast.

Example:

Three simple models were run retrospectively on the time series of available SWHS charter estimates for each of six subareas in Area 2C: naïve, single exponential, and double exponential (Figure 2). The naïve forecasts performed best in all subareas except Juneau/Haines/Skagway, where the single exponential forecast was better. Looking only at data before the big decrease in harvest in 2009, the naïve forecast still outperformed the other methods in every subarea except Prince of Wales and Glacier Bay. The double exponential model performed best in these areas, probably because they had strong trends with relatively less variation than other areas. It is clear that all models performed poorly in 2009 and 2010, but forecasts from each were relatively close to the estimated harvest for 2011.

3.2 Prohibition of Crew Harvest (Area 3A only)

Harvest of halibut by skippers and crew is currently prohibited in Area 2C under NMFS regulations. In Area 3A, however, skippers and crew are currently allowed to retain halibut, and these fish count toward the charter GHL. Therefore, prohibition of skipper and crew harvest to further restrict harvest is a viable IPHC annual management measure for Area 3A only. The State of Alaska issued Emergency Orders (EOs) to restrict harvest of all species by guides and crew while guiding clients for portions of the 2007, 2008, and 2009 seasons. The state EO necessarily applied to all species because the state lacks authority specifically for the halibut fishery. Under federal regulations, however, the prohibition on crew retention could be applied specifically to halibut. The advantage of a prohibition on crew harvest is that it preserves harvest opportunity for clients.

Method:

The effect of prohibiting crew harvest would be estimated using logbook data on client and crew harvest. Specifically, the harvest forecasts would be reduced by the proportion of fish taken by crew, using data from the most recent year or an average of recent years, depending on trends in the data. The underlying assumption is that crew would have about the same propensity to harvest halibut in the coming year as in recent years. Because there are no size data specific to crew-caught fish, the overall charter mean weight is assumed for crew fish.

Example:

Crew harvest accounted for 10.4% of Area 3A charter harvest in 2006, less than 1% under the restrictions in place in 2007-2009, and about 6% in 2010-2011 (Table 2). These data represent all of Area 3A, but in practice, ADF&G would apply crew harvest percentages by subarea. Specifically, the percentage reduction due to crew harvest will be applied to the harvest forecast for each subarea, and this adjusted forecast will then be a multiplied by the forecast of average weight to obtain a yield projection for the coming year.

3.3 Maximum Size Limit Under One-Fish or Two-Fish Bag Limit

Method:

Maximum size limits have been used in Area 2C to control average weight and keep charter yield within the GHL. Projections of charter average weight under maximum size limits will initially be analyzed using the "hybrid method" described in a paper presented to the Council in June 2011 (Meyer 2011a). At that meeting, the Council approved a motion to recommend to the National Marine Fisheries Service that this method be used to set maximum size limits under the CSP. This method can be used to project average weight when a size limit is applied under a one-fish bag limit or two-fish bag limit.

The hybrid method relies on length data from charter harvest in a previous year in which the fishery was not constrained by a size limit, or from a year in which a less constraining (higher) maximum size limit was in place (the reference year). This method assumes that, under a size limit in the coming year, (a) the proportion of the halibut harvest that will be smaller than the size limit will equal the proportion that were under that length in the reference year, (b) the average weight of fish smaller than the size limit will remain unchanged from the reference year, and (c) the fish from the reference year's harvest that were larger than the prospective maximum size limit will be exactly equal to the size limit in length in the coming year.

Average weight is projected for each subarea $\overline{w}_s$ as follows:

$$\widehat{\overline{w}}_s = (\hat{p}_{UL}\widehat{\overline{w}}_{UL}) + (\hat{p}_{OL}\widehat{\overline{w}}_L) \qquad (3)$$

Where

$\hat{p}_{UL} =$ the estimated proportion of halibut in the previous year's creel survey sample from subarea *s* that were less than or equal in length to the prospective length limit L,

$\widehat{\overline{w}}_{UL} =$ the estimated average weight of halibut in the previous year's sample from subarea *s* that were less than or equal in length to the length limit L,

$\hat{p}_{OL} =$ the estimated proportion of halibut in the previous year's creel survey sample from subarea *s* that were greater in length to the length limit *L* ($p_{UL}+p_{OL} = 1$), and

$\widehat{\overline{w}}_L =$ the average weight of a halibut of length equal to the length limit L, predicted from the IPHC length-weight relationship (equation 2).

These average weight projections are combined with forecasts of the number of fish that will be harvested using equation 1 to project charter yield over a range of prospective maximum size limits. Intuitively, a smaller maximum size limit would have to be applied under a two-fish bag limit than under a one-fish bag limit to achieve the same projected yield.

As stated earlier, this method utilizes length-frequency data from a recent year for which there was either no size limit or a higher size limit. If the forecast involves raising the maximum size limit, there may be no year for which there are data to estimate the proportion of fish above the prospective length limit. In those cases, the analyst may have to use data from the most recent year without a size limit. In some cases, the lag to the reference year could be several years.

It is unlikely that all fish over the prospective size limit will be replaced in the harvest with fish exactly equal to the size limit. Therefore, this method is likely to be conservative in that it may tend to overestimate the average weight. Support for this comes from the 2011 season in which a 37-inch maximum size limit was in place for the Area 2C charter fishery. Using length-frequency data from 2010, the hybrid method would have predicted an average net weight of 13.2 lb for the Area 2C harvest in 2011;

the final estimate of average weight was 9.4 lb. The length-frequency distribution of harvest in 2011 was similar to the distribution of 2010 harvest below 37 inches, instead of the distribution with a strong mode right at 37 inches predicted by the hybrid method (Figure 3). If it appears after several years of implementation that the hybrid method is overly conservative, alternate projection methods may be developed.

For now, this method is not assumed to have any effect on angler demand (effort) or the number of fish that will be harvested. It is conceivable that restrictive maximum size limits would discourage effort or encourage anglers to harvest more fish. When the Area 2C charter fishery was regulated under a 37-inch maximum size limit in 2011, there was a slight decrease in effort and a slight increase in harvest. Bottomfish effort decreased 6.7% and halibut harvest increased 0.03% from the previous year. Charter anglers harvested 0.64 halibut per bottomfish angler-day in 2011, up only slightly from 0.60 fish per angler-day under no size limit in 2010.

While these results do not indicate a significant change in effort or harvest, they are not conclusive because effort and harvest may have been even higher or lower in 2011 if the maximum size limit were not in place. It may also be that there was not a substantial drop in effort because it takes time for demand effects to manifest in the fishery. The charter industry has suggested that effort did not drop much as expected under the 37-inch size limit in 2011 because many Area 2C charter anglers were effectively held "hostage" by their reservation deposits. It may be that the effects of size limits on demand, if any, are delayed.

Example:

The hybrid method was used to project average weight for Area 2C in 2012 over a range of maximum size limits. The projections used length-frequency data from 2010. Data from 2011 could not be used because projections were required for maximum size limits larger than the 37-inch size limit in place in 2011. The predicted average weights were combined with two alternative harvest forecasts (number of fish) to present a table of projected yields. The table showed that the highest maximum size limit that would keep the harvest below the 931,000 lb GHL would be 55 inches under the lower harvest projection and 49 inches under the higher harvest projection (Table 3).

3.4 Maximum Size Applied to One Fish Under Two-Fish Bag Limit (Area 3A)

Method:

A maximum size limit could also be applied to only one fish under a two-fish bag limit in Area 3A. This type of regulation is likely to have an effect that is intermediate between a two-fish bag limit and one-fish bag limit. A maximum size limit on one fish was applied to the Area 2C charter fishery in 2007 and most of 2008. In that case, the bag limit was two fish per day, no more than one of which could be larger than 32 inches in length. Under an annual review procedure, a range of other maximum size limits could be considered.

A number of catch scenarios are possible. For example, an angler's first fish may be over or under the maximum size limit. If the first fish is over the maximum size limit, then if a second fish is harvested, it must be under the maximum size limit. If the first fish is under the maximum size limit, then the angler's second fish can be of any size (under or over the size limit). In this case, it is likely that some anglers would keep fishing until they caught a second fish that was over the maximum size limit. The likelihood that they would be successful cannot be predicted. Size data are not available for fish caught by individual anglers, and no size limit of this type has ever been enacted in the Area 3A fishery. Therefore, the various catch scenarios cannot be modeled with probabilities based on actual data.

Given the lack of information, a simple method will be employed. Charter logbooks provide data on the numbers of fish caught by each individual angler. The number of "first fish" and "second fish" in the harvest are calculated from these data. For example, if an angler harvested two halibut, then one "first fish" and one "second fish" are tallied. The maximum size limit on the second fish will be assumed to have no effect on the total number of fish harvested. Average weight would again be estimated using length-frequency data from the most current year for which there was either no size limit or a higher size limit. If the forecast involves raising the maximum size limit, the reference year may be the most recent year without a size limit.

Average weight for each prospective size limit will then be projected for each subarea as follows:

$$\hat{\hat{w}}_s = (\hat{p}_1 \hat{\hat{w}}) + (\hat{p}_2 \hat{\hat{w}}_L) \qquad (4)$$

Where

$\hat{p}_1 =$ the estimated proportion of halibut harvest made up of "first fish,"

$\hat{\hat{w}} =$ the estimated overall average weight of halibut in the previous year's sample from subarea s,

$\hat{p}_2 =$ the estimated proportion of halibut harvest made up of "second fish," and

$\hat{\hat{w}}_L =$ the average weight of a halibut of length equal to the prospective length limit L, predicted from the IPHC length-weight relationship (equation 2).

It would also be possible to use the hybrid method to estimate the average weight of the "second fish" (replace $\hat{\hat{w}}_L$ with $\hat{\hat{w}}_s$ from equation 3). The result would be a lower average weight for the "second fish" and a slightly lower average weight overall. Given that "first fish" could have an average weight greater than the previous year's overall average weight due to highgrading, the method outlined in equation 4 is more conservative.

Example:

This example uses average weight data from 2011, approximate forecasts of the number of fish harvested, and approximate proportions of "first" and "second" fish from logbook data (not final values). Average weight and yield are projected for maximum size limits of 30, 32, and 34 inches on the "second fish" (Table 4). The projected average weights for Area 3A range from 12.2 to 14.2 lb, and projected yields range from 2.25 to 2.62 M lb. The projected yield without a size limit is 2.79 M lb.

This method is inherently conservative because it assumes all "second fish" will be equal to the maximum size limit. Therefore, projected average weights under higher prospective size limits may sometimes exceed the average weight without a size limit.

3.5 Reverse Slot Limit

Reverse slot limits have previously been considered by the Council as a means to control the average weight of the charter harvest to manage the Area 2C and 3A fisheries within their respective GHLs. The two options considered for both areas were allowing harvest of fish under 32 inches and over 45 inches (U32O45) and fish under 32 inches and over 50 inches (U32O50). Both of these reverse slot limits were intended to apply to only one fish under a two-fish bag limit (NPFMC 2007, NPFMC 2008).

A reverse slot of U45O68 was implemented for the Area 2C charter halibut fishery in 2012 under a one-fish bag limit. This was one of the alternatives considered to replace the 37-inch maximum size limit that was in place in 2011 (Meyer 2011b). The U45O68 reverse slot limit not only increased the lower (maximum) size limit from 37 to 45 inches, but also provided the opportunity to harvest an exceptionally large fish (over 68 inches). The charter industry suggested the reverse slot limit in order to market charter trips and lodge stays to anglers motivated to catch large fish.

Method:

A reverse slot is likely to be considered when the fishery is managed under a one fish bag limit, primarily as an alternative to a maximum size limit. Similar to Meyer (2011b), calculation of the projected average weight requires length data from the most recent year for which the fishery was not constrained by a size limit (the reference year). Therefore, this approach assumes that the length distribution from the reference year is representative of what the length distribution in the year of the projection would have been in the absence of a size limit.

This approach assumes that reverse slot limits do not affect angler demand. It assumes that all fish caught between the upper and lower size limits will be released and replaced in the harvest by fish above or below the size limits. In the simplest case, the resulting harvest will be distributed below the lower limit and above the upper limit in the same relative proportions as were present in the reference year without any size limit.

Because size composition varies among subareas of each IPHC area, the average weight associated with each prospective length limit is calculated for each subarea as:

$$\hat{\bar{w}} = \left(\frac{\hat{p}_L}{\hat{p}_L + \hat{p}_U}\right)\hat{\bar{w}}_L + \left(\frac{\hat{p}_U}{\hat{p}_L + \hat{p}_U}\right)\hat{\bar{w}}_U, \quad (5)$$

where

$\hat{p}_L$ = proportion of harvest (in numbers) ≤ the lower maximum length limit,

$\hat{\bar{w}}_L$ = the estimated average weight of fish ≤ the lower maximum length limit,

$\hat{p}_U$ = proportion of harvest (in numbers) ≥ the upper minimum length limit, and

$\hat{\bar{w}}_U$ = the estimated average weight of fish ≥ the upper minimum length limit.

This is essentially a weighted average of the average weights in the tails above and below the upper and lower size limits from the reference year. Once average weights are obtained for each size limit and subarea, the projected yield under each prospective size limit (Y_i) is obtained using equation 1.

Equation 5 is simpler and improved from the version used to estimate average weights under reverse slot limits for the Council's consideration of management measures for Area 2C for 2012 (Meyer 2011b). The original form of the equation incorporated a highgrading multiplier that effectively increased the proportion of harvest above the upper limit. For example, a highgrading multiplier of 1.1 would make the proportion of harvest in the upper tail 10% larger than the estimated proportion from the reference year.

The highgrading multiplier was removed because the concept of additional highgrading was purely theoretical without any evidence from the fishery. The simple version of the equation is probably sufficiently conservative so that accounting for additional highgrading is unnecessary. Equation 5 is felt to be inherently conservative because the reverse slot is not assumed to affect the number of fish harvested, and because the relative proportion of harvest above the upper limit is assumed to be the same as in the reference year. Under the first assumption, non-legal size fish that are caught must be released and replaced in the harvest by fish of a legal size. Depending on the limits of the slot, this can represent a large proportion of harvest and a large number of fish. Under the second assumption, the number of fish that are "redistributed" above the upper limit can be unrealistically high, and the harvest of those fish is not likely to be realized because they are relatively rare in the population. Therefore, these assumptions will likely contribute to overestimation of the number of fish that will be harvested above the upper size limit. The example that follows provides support for this idea.

Example:

Charter yield was calculated for Area 2C using the reference year of 2010 and an assumed harvest of 45,338 fish. The harvest was distributed among subareas using the average proportions from 2009-2011. Yield was calculated for combinations of lower limits ranging from 35 to 45 inches (U35-U45) and upper limits ranging from 50 to 76 inches (O50-O76). The full range of size limits considered was therefore U35O50 to U45O76 (Table 5). Projected charter yield ranged from 0.654 to 1.362 M lb over the range of size limits examined. It is evident in the example that a given yield projection can be obtained under a variety of reverse slot limits. For example, a yield of about 1 M lb can be obtained under limits of about U35O64, U36O62, U37O62, etc.

In the range of limits considered, changes in the upper length limit have a larger effect per inch on yield than changes in the lower limit. For example, with an upper limit of 66 inches, the maximum difference in yield over the 10-inch range of lower limits from 35 to 45 inches is 126,000 lb. On the other hand, with a lower limit of 35 inches, raising the upper limit 10 inches from 56 inches to 66 inches decreases the yield by 315,000 lb. This is because weight increases approximately as the cube of the length. A 35-inch halibut weighs about 19 lb round weight, but a 70-inch halibut weighs about 179 lb. The gain or loss in big fish that results from different limits has a larger effect on average weight, and therefore on yield, than the gain or loss of small fish.

It is also evident that, for a given upper limit, projected yield can decrease as the lower limit is increased. For example, under an upper limit of 50 inches, projected yield declines from 1.362 M lb with a lower limit of 35 inches to 1.170 M lb with a lower limit of 44 inches (Table 5). This may be counterintuitive, but it results from the assumption that there is no decrease in the number of fish harvested, and fish in the prohibited slot are redistributed in proportion to the legal size fish below the lower limit and above the upper limit. As the lower limit is increased, relatively fewer fish are redistributed above the upper limit. The relative reduction in large fish causes a reduction in the average weight because the large fish are disproportionately heavier than small fish.

There is some evidence from the 2012 season that this method is inherently conservative. The proportions of harvest over 68 inches in length and the average weight of charter harvest of all sizes were projected for each port using Equation 5 and compared to data from the fishery through July 29. For ports where large fish are typically uncommon, there was good agreement between the projected and observed proportions of O68 fish and average weight (Figure 4). For Elfin Cove and Gustavus, however, the observed proportions of O68 fish and average weights were below the projected values.

Despite the inherent conservatism in the projections, much uncertainty remains. Because the method requires length data from a recent year in which there was no size limit, projection could be problematic in situations where different size limits have been in place in recent years. Because fish above the upper limit are worth so much more in terms of weight than fish below the lower limit, small departures from the assumptions of proportional distribution could have a large effect on the average weight. Uncertainty in the projection also arises from the potential for errors in the projection of harvest by subarea, because the length distribution of the harvest varies by subarea. In the future, it may be possible to develop theoretical predictions of the length distribution of the charter harvest based on an independent measure of the sizes of fish in the population, such as the IPHC longline survey. Until those methods are developed and verified, the empirical approach described above will be used.

4.0 Other Measures Considered but Not Selected

4.1 Bag Limit Reduction

The charter halibut bag limit is currently one fish per day in Area 2C and two fish per day in Area 3A. Because the Area 2C bag limit is specified in 50 CFR 300.65, the daily bag limit in Area 2C could not be increased to two fish without initiation of a full rulemaking process by the Council. The bag limit for Area 3A, however, is specified only in IPHC regulations and could be changed under the Halibut Act for conservation reasons with sufficient justification. Presumably, the IPHC would not recommend a decrease in the Area 3A bag limit without a recommendation from the Council, and the Council would not make such a recommendation until less stringent measures that still achieved the harvest objective had been considered.

If the Council were to recommend a reduced bag limit in Area 3A, the effect would be based on the recent proportions of harvest made up of the second fish in the charter harvest (about 48% in Area 3A). For example, logbook data would be used to calculate the proportion of second fish in the harvest in each subarea, and these proportional reductions would be applied to the status quo (2-fish limit) harvest forecasts by subarea. The resulting adjusted forecasts would be multiplied by the projected average weights to obtain the yield projections by subarea.

4.2 Close Selected Days of the Week

ADF&G was asked by the Council to analyze the effect of closures of selected days of the week as a management measure for the Area 2C charter fishery for 2012 (Meyer 2011b). The average proportion of the harvest (numbers of fish) was calculated for each day of the week using logbook data from 2008-2010, and these proportions were added to estimate the harvest reductions associated with various combinations of two or three days closed per week. On the suggestion of Charter Implementation Committee members, the combinations of closed days were chosen to be non-consecutive to minimize rescheduling of charter trips to avoid the harvest restriction. The analysis concluded that the predicted harvest reductions were best-case scenarios because of the potential for charter operators and anglers to book around the closures. The degree to which businesses would be able to circumvent the daily closures could not be determined, leaving the effectiveness of the measure in doubt.

4.3 Trip Limits

The Council has previously considered limits on the number of charter vessel trips per day to control charter harvest in Areas 2C and 3A (NPFMC 2006, 2007, 2008). The Council was again presented with an analysis of the effect of trip limits in April 2012. About 20-30 percent of charter businesses in Area 2C and 28-39 percent of businesses in Area 3A reported making multiple trips per vessel at least once during the years 2007-2010. For most businesses, however, multiple trips per day were infrequent. Only 5 or 6 businesses made multiple trips on more than 20 days per year in Area 2C and only 7-15 businesses made multiple trips on more than 20 days per year in Area 3A (King et al. 2012, page 28). Therefore, the effect of limiting charter vessels to one trip per day would be focused on the small proportion of businesses that regularly engage in the multiple-trip business model.

Just as the number of trips after the first trip made up a small fraction of the total trips, harvest associated with trips after the first trip of the day was relatively small. For example, limiting charter boats to one trip per day would have reduced the number of fish harvested by a maximum of 2.0-3.1 percent in Area 2C and 6.0-7.1 percent in Area 3A during the years 2007-2010 (King et al. 2012, page 28). These percentages represent the expected reductions in the <u>number</u> of charter halibut harvested associated with a limit of one trip per day. Assuming no systematic difference in the sizes of fish harvested on different trips each day, these percentages also represent the potential harvest savings in pounds. Data are not available to estimate average weight on each trip, but the charter fleet suggested anecdotally that halibut caught on half-day trips might be smaller on average than halibut from full day trips. Reasons included that boats may not travel as far to the best fishing grounds, or that the emphasis is on filling bag limits in a shorter period.

The effect of trip limits on charter harvest may be overestimated for several reasons. First, some apparent instances of multiple trips may be caused by misreporting of dates. Second, the impacts of trip limits may be mitigated by excess capacity in the charter fleets in Areas 2C and 3A. A trip limit will reduce the number of seat-days available to be booked, but there will be no reduction in the number of fish harvested if charter anglers can still book a trip on another vessel. In addition, businesses that currently operate vessels below capacity on partial-day trips may choose to operate at capacity if limited to one trip per day. Finally, if the average weight of halibut harvested on half-day trips is in fact lower than halibut harvested on full-day trips, then limiting vessels to one trip per day could slightly increase the average weight of the harvest, which would moderate the savings in yield associated with the trip limit.

This method is not pursued in this document because previous analyses have concluded that projected harvest reductions from this measure are minor, may be overstated, and may disproportionately affect a small number of businesses that utilize this type of business model.

4.4. Annual Exemption to Size Limit

In December 2011, the Council requested analysis of the potential use of a measure that would allow an annual limit of at least one halibut that was exempt from an existing size limit. This measure would preserve the charter industry’s ability to market the opportunity for clients to retain a fish that is larger than a maximum size limit. This exemption would presumably be implemented in addition to a maximum size limit. It may not be needed if a reverse slot limit were in place because the reverse slot limit allows the opportunity to harvest exceptionally large fish. However, if implemented with a reverse slot limit, it would allow retention of fish of intermediate size that may be preferred by some anglers.

This measure is not considered for several reasons. First, no reliable method could be devised to provide a reliable analysis of the impacts. This measure involves an annual cap on harvest of fish by individual anglers. Although fish size data are available on a vessel-trip basis, they are not linked to individual anglers. The size distributions of fish kept or released by individual anglers are unknown. In short, there are no data that could be used to estimate the proportion of anglers that would take advantage of the exemption, the sizes of fish they would be likely to catch, or the sizes of fish they would be likely to retain. The opportunity to harvest a large fish afforded by this measure would likely also change the frequency distribution of annual harvests, making harvest projections even more uncertain. Finally, there is currently no reporting mechanism that can be implemented to record lengths and annual limits for purposes of enforcement.

4.5 Annual Limit

The Council considered annual limits in conjunction with other measures for management of the Area 2C and 3A charter fisheries under the GHL in 2006 (NPFMC 2006). In June 2006, NOAA Fisheries presented a letter to the Council reporting that current federal and state laws do not allow the use of state reporting documents by Federal enforcement personnel. NOAA determined that the proposed annual limit would require federal reporting mechanisms that would be prohibitively costly and redundant to state reporting requirements (NPFMC June 2006 Newsletter). However, the Council again considered annual limits for management of the Area 2C charter fishery in 2007 and the Area 3A fishery in 2008. The Area 3A analysis (NPFMC 2008) listed a number of reporting and recordkeeping requirements that might need to be put in place in order to implement and enforce annual limits. The Council has not seriously pursued annual limits since 2008 and it is unclear which, if any, of the recordkeeping, data sharing, and enforcement requirements would be possible or practical. It is unlikely that these mechanisms could be put into place for the 2013 season.

5.0 Considerations for Release Mortality

Release mortality in sport fisheries coastwide is not yet accounted for in the IPHC stock assessment. The IPHC is interested in accounting for release mortality in all fishery removals, and in 2012 sent letters asking agencies coastwide to initiate procedures to estimate release mortality in sport fisheries. Estimates of the number of fish released are available for Areas 2C and 3A from the logbook and SWHS, but there are no size data for released fish. ADF&G is still in the process of developing and improving methods to estimate release mortality in the sport fishery. Without size data on released fish, the method will rely on strong assumptions regarding the mortality rate and average weight of released fish.

In making management recommendations for the 2012 season, the Council and the IPHC were interested in the expected release mortality associated with various alternatives. Relatively speaking, without a change in bag limit, maximum size limits are expected to have the highest release mortality because these limits require the release of all fish larger than the limit. The next highest release mortality would be expected from reverse slot limits that allow retention of some large fish. The expected effect of a reduction in the bag limit is less clear – anglers may release more halibut in their attempt to harvest a larger fish, or they may release fewer fish because they will spend less time halibut fishing under a lower limit. The only experience that can be brought to bear is that the number of released fish in Area 2C declined from 2008 to 2009 when the Area 2C bag limit was reduced from two fish to one.

Although ADF&G is still developing methods to estimate release mortality, we will at least attempt to characterize the relative amounts of release mortality for alternatives under consideration. For example, maximum size limits and reverse slot limits were considered for Area 2C for the 2012 season. Assuming a length-frequency distribution similar to 2010, a harvest of 45,338 fish, and a 6% mortality rate, the number and average weight of fish that were required to be released by various size limits were compared. These estimates did not include fish that anglers would release voluntarily because they were too small, but these were expected to be comparable among alternative size limits. The recommended reverse slot limit of U45O68 was estimated to produce about 48,000 lb of release mortality, compared with 51,000 lb from a 47-inch maximum size limit and 101,000 lb from a 37-inch size limit (Figure 5). As stated above, these estimates apply only to fish required to be released under the size limits, but do provide at least a relative measure of release mortality associated with the alternatives.

6.0 Dealing with Uncertainty

There is a considerable amount of uncertainty associated with several of the projection methods described in this paper. Confidence intervals can be provided for single and double exponential harvest forecasts, but probably not for projections of average weight under various size limit alternatives give all the assumptions involved. It may become increasingly difficult to quantify the uncertainty in future projections if the management measures change annually.

The Council has not provided any specific guidance on how to frame yield projections for various management alternatives. Last year, I provided the Council with two harvest forecasts; one being the naïve forecast, the other the recent three-year average. I also provided projections of yield associated with maximum and reverse slot size limits for Area 2C in 2012 over a range of limits that encompassed the GHL. This allowed the Council to select a management measure that included a buffer between the projected yield and the GHL. This approach would be used in 2013 unless an alternate approach is recommended by the SSC.

7.0 Summary

For the 2013 season, ADF&G will make charter harvest projections for a limited number of management options identified by the Charter Implementation Committee. The Council will review this analysis in December, and based upon preliminary IPHC estimates of allowable removals and thus GHLs, recommend management measures that constrain the Area 2C and Area 3A charter fleets within their GHLs for 2013.

Projections will be done by subarea to account for differences in harvest trends and size composition, and then summed to provide projections for each IPHC regulatory area. Management measures are assumed to affect either the number of fish harvested, or the average weight, but not both. Therefore, if a measure is assumed to affect average weight, it will be combined with a time series forecast of harvest to obtain the projected yield. Likewise, if a measure is assumed to affect the number of fish harvested, it will be combined with a time series forecast of average weight to obtain yield.

Candidate management measures included restriction of crew harvest, a maximum size limit in conjunction with a one- or two-fish bag limit, a maximum size limit on only one fish under a two-fish bag limit, and reverse slot size limit. Projection methods for size limits are dependent on size distributions from prior years, which will be directly affected by the choice of management measure. Frequent changes in management measures will make harvest projections more uncertain.

A number of measures were described that have been considered or analyzed in the past and are either not possible to project, or are not likely to be implemented for 2013.

To the extent possible ADF&G will attempt to project release mortality associated with alternative management measures under consideration.

ADF&G will attempt to provide reasonable alternative harvest forecasts and bracket harvest projections for size limits in order to allow the Council to implement buffers for uncertainty in their choice of management measures.

8.0 References

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King, Jonathan, Jane DiCosimo, Mark Fina, and Scott Meyer. 2012. Pacific halibut catch sharing plan for the charter and commercial fisheries in Area 2C and Area 3A. Discussion Paper for the North Pacific Fishery Management Council, March 16, 2012.

Meyer, S. 2011a. Methods for establishing maximum size limits for the charter fishery under the halibut Catch Sharing Plan: Report to the North Pacific Fishery Management Council, June 2011. Alaska Department of Fish and Game, Anchorage.

Meyer, S. 2011b. Analysis of management options for the Area 2C charter halibut fishery for 2012: Report to the North Pacific Fishery Management Council, December 2011. Alaska Department of Fish and Game, Anchorage.

NPFMC 2006. Environmental assessment/regulatory impact review/initial regulatory flexibility analysis for a regulatory amendment to implement guideline harvest level measures in the halibut charter fisheries in IPHC Regulatory Areas 2C and 3A. Public Review Draft, March 13, 2006.

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NPFMC 2008. Environmental assessment/regulatory impact review/initial regulatory flexibility analysis for a regulatory amendment to implement guideline harvest level measures in the halibut charter fisheries in IPHC Regulatory Area 3A. Draft for Public Review, August 28, 2008.

Table 1. List of subareas and sampled ports used in estimation of charter halibut yield in IPHC areas 2C and 3A.

IPHC Area	Subarea	Sampled Port(s)
2C	Ketchikan	Ketchikan
	Prince of Wales Island	Craig, Klawock
	Petersburg/Wrangell	Petersburg, Wrangell
	Sitka	Sitka
	Juneau	Juneau
	Haines/Skagway	None
	Glacier Bay	Elfin Cove, Gustavus
3A	Glacier Bay	Elfin Cove, Gustavus
	Yakutat	Yakutat
	Eastern Prince William Sound	Valdez
	Western Prince William Sound	Whittier
	North Gulf	Seward
	Central Cook Inlet	Anchor Point, Deep Creek
	Lower Cook Inlet	Homer
	Kodiak	Kodiak

Table 2. Charter halibut skipper and crew harvest in Area 3A, 2006-2011 (ADF&G logbook data).

Year	Crew Harvest Regulation	Crew	Resident, Nonresident, and Unknown Clients	Total	Crew Harvest Percent
2006	No prohibition	27,704	238,189	265,893	10.4%
2007	State EO prohibited crew harvest 5/01-12/31	228	258,196	258,424	0.1%
2008	State EO prohibited crew harvest 5/24-9/01	1,269	231,363	232,632	0.5%
2009	State EO prohibited crew harvest 5/23-9/01	1,260	190,750	192,010	0.7%
2010	No prohibition	12,339	204,081	216,420	5.7%
2011	No prohibition	13,638	206,183	219,821	6.2%

Table 3. Projected Area 2C charter halibut yields under maximum size limits of 37-58 inches and two alternative harvest projections.

Maximum Size Limit (in)	Yield (M lb) when Harvest is: 41,209 fish	Yield (M lb) when Harvest is: 45,338 fish
37	0.530	0.586
38	0.557	0.616
39	0.583	0.645
40	0.609	0.675
41	0.634	0.703
42	0.660	0.731
43	0.684	0.759
44	0.709	0.787
45	0.732	0.813
46	0.755	0.838
47	0.777	0.863
48	0.798	0.887
49	0.818	0.910
50	0.838	0.932
51	0.857	0.953
52	0.875	0.972
53	0.891	0.991
54	0.907	1.008
55	0.921	1.025
56	0.935	1.040
57	0.947	1.054
58	0.959	1.067

Table 4. Example calculation of projected average weight and charter yield for Area 3A under maximum size limits on one fish under a two fish bag limit. Calculations are shown for maximum size limits of 30, 32, and 34 inches, and a projected harvest of 184,300 halibut. See Equation 4 in the text for symbol explanations.

Subarea	$\hat{p}_1$	$\hat{\bar{w}}$	$\hat{p}_2$	$\hat{\bar{w}}_L$ (30″)	$\hat{\bar{w}}_L$ (32″)	$\hat{\bar{w}}_L$ (34″)	Projected Harvest (no. fish)	Projected Yield (M lb) Under Max Size Limit on Second Fish of: 30″	32″	34″
GlacBay	0.687	35.919	0.313	8.664	10.679	12.996	600	0.02	0.02	0.02
Yakutat	0.650	35.041	0.350	8.664	10.679	12.996	3,600	0.09	0.10	0.10
EPWS	0.570	19.611	0.430	8.664	10.679	12.996	5,100	0.08	0.08	0.09
WPWS	0.624	16.148	0.376	8.664	10.679	12.996	2,700	0.04	0.04	0.04
N Gulf	0.540	13.930	0.460	8.664	10.679	12.996	39,300	0.45	0.49	0.53
CCI	0.513	14.588	0.487	8.664	10.679	12.996	45,500	0.53	0.58	0.63
LCI	0.522	14.797	0.478	8.664	10.679	12.996	74,500	0.88	0.96	1.04
Kodiak	0.596	14.524	0.404	8.664	10.679	12.996	13,000	0.16	0.17	0.18
						Total:	184,300	2.25	2.42	2.62
							Overall average weight (lb) =	12.2	13.1	14.2

Table 5. Example of projected charter halibut yield (M lb net weight) in Area 2C under various reverse slot limits, assuming a harvest of 45,338 halibut distributed among subareas using the 2009-2011 average harvest. Estimates are based on length-frequency data from 2010.

Upper Size Limit (in)	Lower Size Limit (in)										
	35	36	37	38	39	40	41	42	43	44	45
50	1.362	1.311	1.283	1.250	1.234	1.212	1.195	1.182	1.173	1.170	1.171
52	1.352	1.295	1.263	1.226	1.209	1.185	1.166	1.152	1.143	1.140	1.142
54	1.327	1.266	1.233	1.194	1.177	1.152	1.133	1.119	1.111	1.109	1.112
56	1.282	1.219	1.187	1.147	1.131	1.106	1.088	1.075	1.069	1.068	1.072
58	1.242	1.178	1.144	1.104	1.089	1.065	1.049	1.037	1.031	1.032	1.038
60	1.199	1.134	1.100	1.060	1.046	1.024	1.009	0.998	0.994	0.997	1.003
62	1.130	1.068	1.035	0.998	0.986	0.967	0.953	0.945	0.942	0.947	0.956
64	1.028	0.974	0.944	0.914	0.906	0.892	0.883	0.878	0.879	0.887	0.898
66	0.967	0.919	0.892	0.866	0.861	0.851	0.844	0.841	0.844	0.853	0.867
68	0.888	0.853	0.831	0.811	0.811	0.806	0.803	0.803	0.809	0.820	0.835
70	0.818	0.792	0.774	0.761	0.763	0.762	0.763	0.766	0.773	0.786	0.803
72	0.769	0.752	0.738	0.729	0.734	0.735	0.739	0.742	0.751	0.766	0.783
74	0.697	0.694	0.685	0.683	0.692	0.698	0.704	0.711	0.722	0.738	0.757
76	0.660	0.661	0.654	0.655	0.666	0.674	0.682	0.690	0.702	0.719	0.738

Figure 1. Time series of charter halibut harvest (upper graphs) and average weight (lower graphs) by subarea in IPHC Regulatory Areas 2C and 3A.

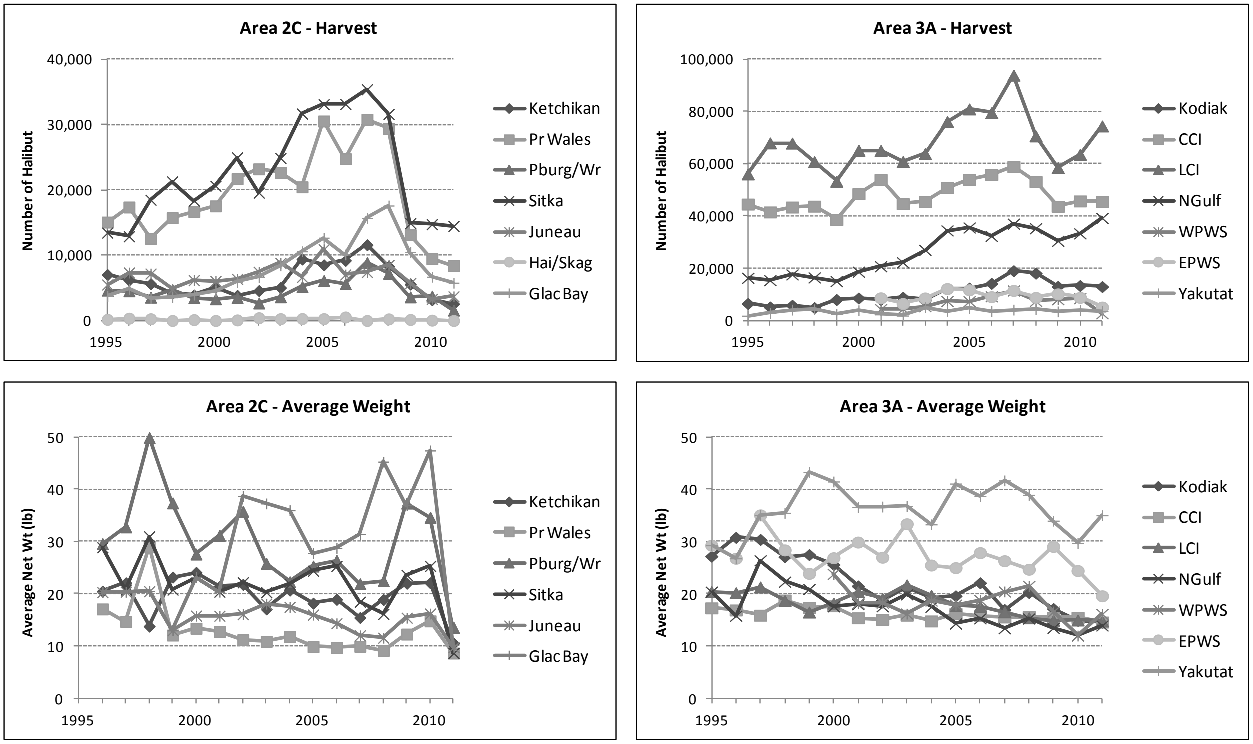


Figure 2. Retrospective fits of naïve (previous year), single exponential, and double exponential time series models to ADF&G SWHS estimates of the number of halibut harvested by charter anglers in subareas of IPHC Area 2C.

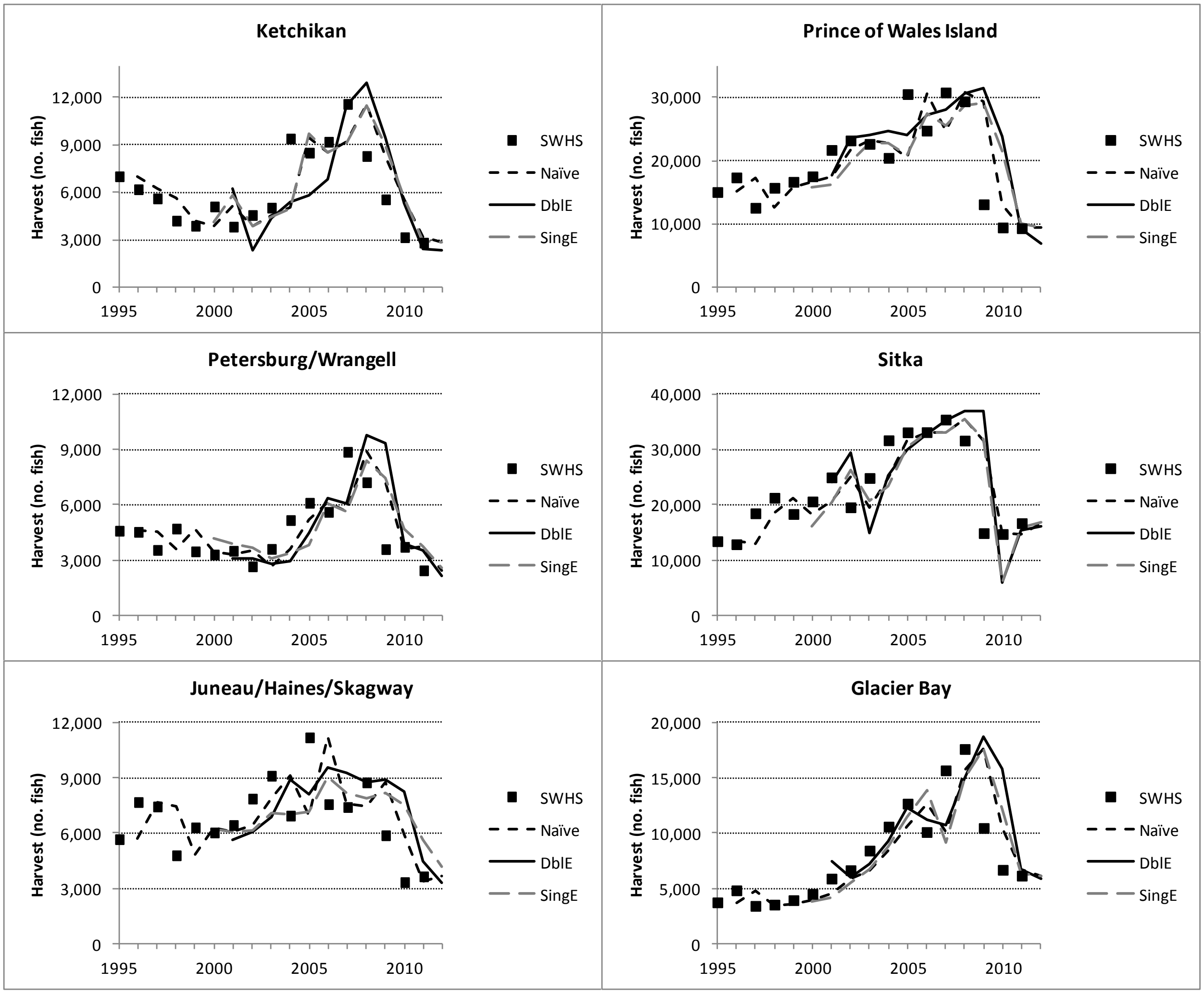


Figure 3. Comparison of the Area 2C charter halibut harvest length-frequency distribution for 2010, the projected length-frequency distribution for 2011 using the hybrid method applied to 2010 data, and the observed distribution of 2011 charter harvest.

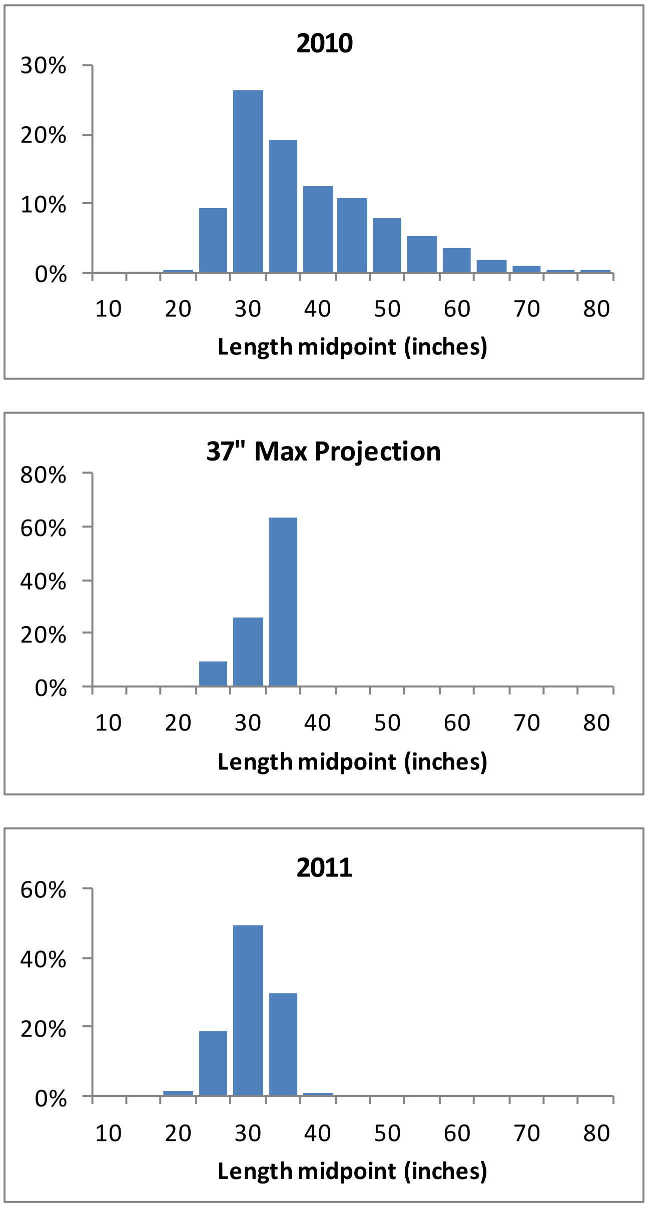
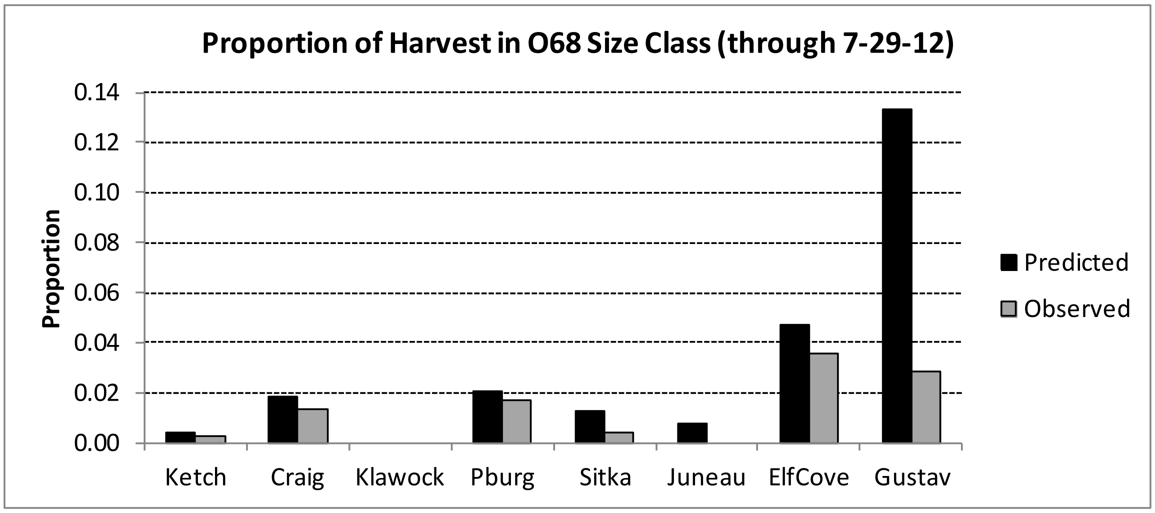


Figure 4. Comparison of the predicted and observed (a) proportions of 2012 Area 2C charter harvest that were over 68 inches in length (upper plot), and (b) average weights (data through July 29).



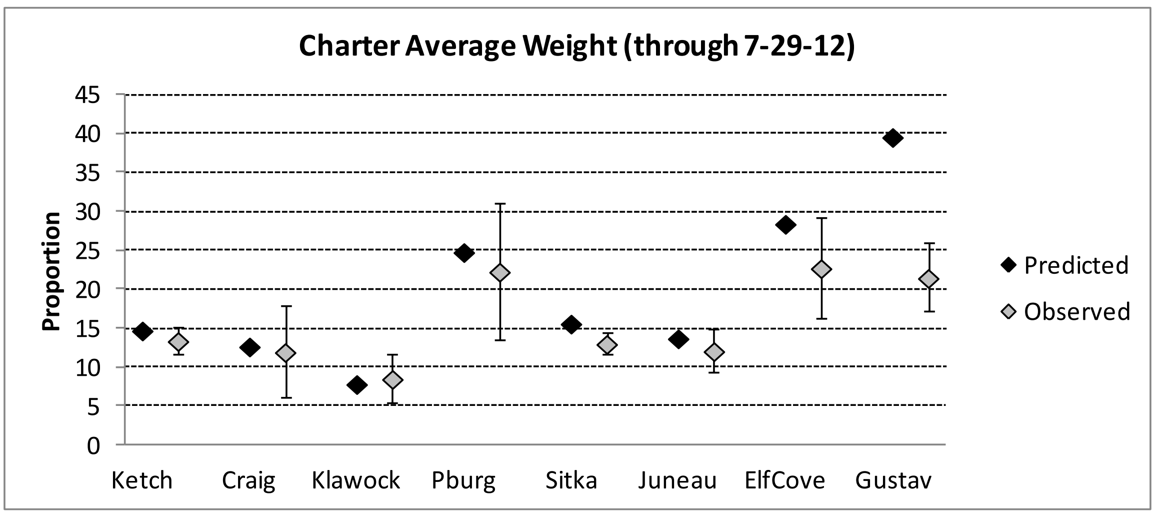
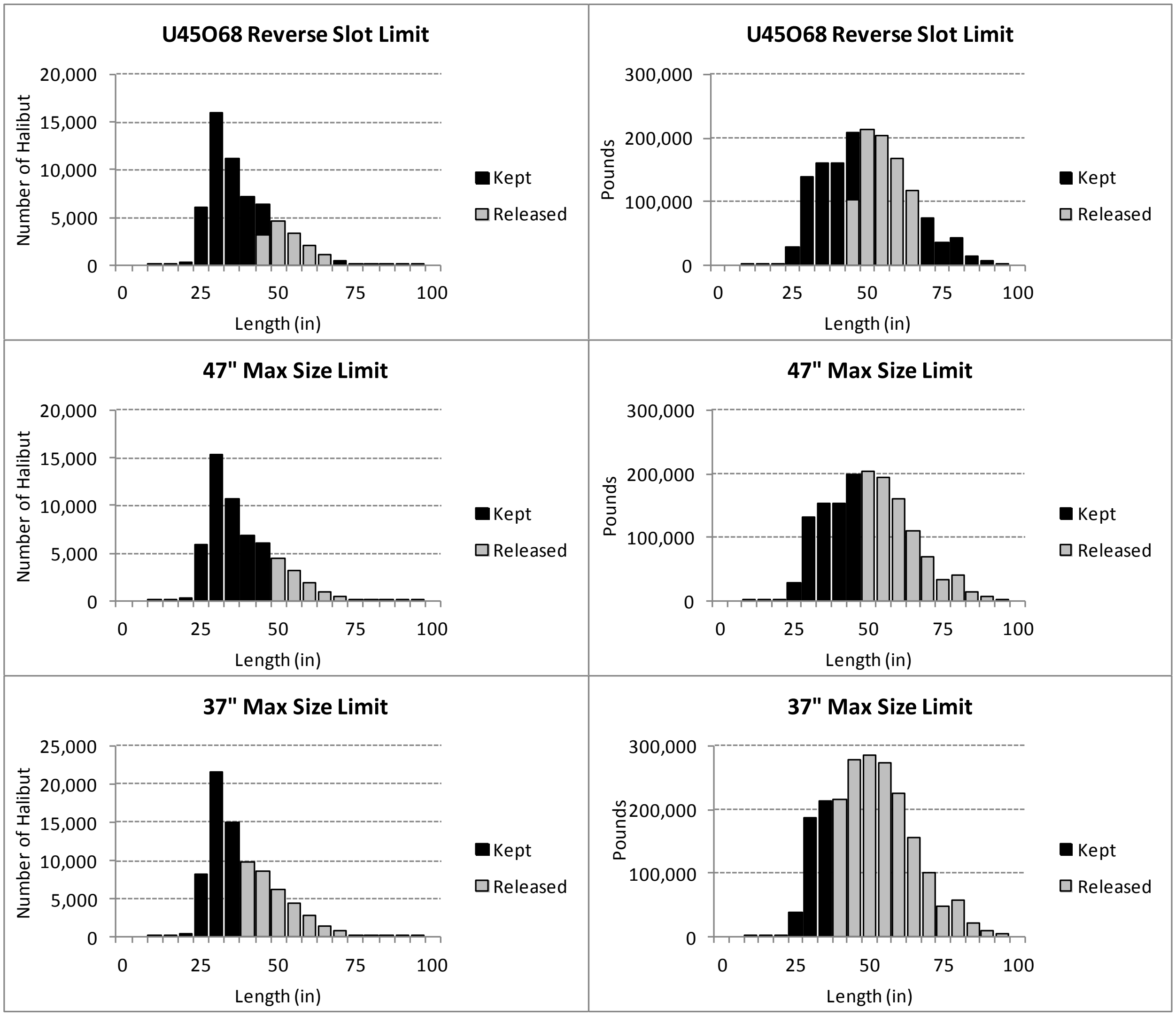


Figure 5. Projected frequency distributions of 2012 Area 2C harvest and release by length class, under the U45O68 reverse slot limit, 47-inch maximum size limit, and 37-inch maximum size limit. Black bars represent the length-frequency (left side) and biomass (right side) associated with retained fish, while gray bars represent that portion of the catch that would be required to be released under each limit.



Estimate	U45O68 RevSlot	47" max	37" max
Number of fish released	14,360	11,659	34,811
Number of dead fish (6% mortality)	862	700	2,089
Avg. wt. of released fish (lb)	56.0	72.2	48.2
Release mortality (lb)	48,286	50,518	100,657