Projecting Sport Charter Halibut Harvests Under the NPFMC Catch Sharing Plan

Discussion Paper for the North Pacific Fishery Management Council, Scientific and Statistical Committee

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Introduction

The Council's Catch Sharing Plan (CSP), approved in October 2008, will allocate halibut between the commercial and sport charter sectors, establish bag and size limits annually, and provide for additional harvest opportunity for the sport charter fleet through use of commercial IFQ. The CSP was crafted at the October meeting using some of the concepts included in the EA/RIR/IRFA analysis, but incorporated several new aspects that had not previously been analyzed. This purpose of this paper is to present some initial analysis of the feasibility of projecting charter harvest under the approved CSP, and asks for guidance from the SSC on methods and the practicality of implementing the CSP.

The CSP is a fundamentally different way of accounting for charter removals than is currently used, and will require changes in the timing, number, and methods for ADF&G harvest projections. Under current management, charter and other noncommercial removals, along with bycatch and waste of sublegal size fish, are deducted from the total allowable removals before setting a catch limit for the commercial fishery. The IPHC typically deducts the previous year's estimates (year *i*) of these miscellaneous removals when setting the commercial catch limit for the upcoming year (year *i+1*). Under the CSP, charter harvest would not be deducted, but would instead be part of the combined catch limit to be allocated under the plan. Charter harvest (and private harvest) would still need to be estimated (likely a projection) for the most recent year (year *i*) for purposes of stock assessment.

King (2009) describes how the CSP is envisioned to be implemented. To put that explanation in a more general setting, the likely process with respect to harvest projections would be as follows:

1. October (year *i*): ADF&G provides charter and private sport harvest projections for year *i* to the International Pacific Halibut Commission (IPHC) so they can incorporate sport fishery removals into the stock assessment.
2. January (year *i+1*): The IPHC will approve a charter and commercial combined catch limit. Allocation percentages specified in the CSP will be applied to the combined catch limits for IPHC Areas 2C and Area 3A to derive the commercial fishery catch limits.

   (a) The combined catch limit will determine the default regulations for the charter fishery in each area (bag limits and size limits, if necessary) (tables 1 and 2 of King 2009). Charter harvest will be projected (in weight units) for year *i+1* under these default bag and size limit to determine whether it will fall within the specified allocation range.

   (b) If the projected charter harvest exceeds the allocation range maximum, either a size limit will be implemented to bring charter harvest to the desired allocation or the regulations will revert to the next more restrictive level.

   (c) If the projected charter harvest falls below the allocation range minimum, the regulations will be liberalized, but only if projected harvest for year *i+1* under the more liberal regulations falls within the desired charter allocation range.

Therefore, at least two, and sometimes three charter harvest projections may be required for each area each year: (1) harvest for year *i* for stock assessment, (2) harvest for year *i+1* under default regulations determined by the level of the combined catch limit (scenario 3a above) and in some cases, (3) harvest for year *i+1* to evaluate allocation under more liberal or more restrictive regulations (scenario 3b).

This paper overlaps with and builds upon questions and concepts posed in King (2009). While King focused on choosing the appropriate maximum size limit when one would be needed to stay within the acceptable charter allocation range, this paper discusses the challenges involved with the more general task of routinely projecting charter harvests under alternative scenarios presented by the catch sharing plan.

Specifically, this paper attempts to outline potential problems with making harvest projections under the CSP, and is looking for input from SSC members on the following:

1. What forecasting approaches are recommended when the forecast period will be under different bag or size limits than the time series that is the basis for the forecast?
2. What forecasting approaches are recommended when the time series basis is composed of years with several different underlying regulations, such that the effect of changes in effort, catchability, and regulations are confounded?
3. What approaches are recommended to incorporate all sources of uncertainty into confidence intervals for the harvest projections? These sources will include uncertainty in predicting the number of fish harvested, the mean weight, and the effect of changes in bag and possession limits.

Background on Past Projection Methods

The Council currently bases management and allocation decisions on harvest estimates derived from the ADF&G statewide harvest survey (SWHS). These estimates are not available until the fall of the following year. Therefore, each fall ADF&G provides preliminary estimates of total sport harvest in pounds net weight for the current year (year *i*). These preliminary estimates are often projections based on past harvest trends, multiplied by average weight estimated from onsite length measurements from the current year. Harvest is usually projected by ADF&G statewide harvest survey (SWHS) area and summed to provide total harvest for each IPHC regulatory areas (2C and 3A).

In October 2007, ADF&G presented the SSC with an overview of the methods used in recent years to estimate recreational halibut harvest (including charter sector harvest). To recap, a variety of harvest projection methods have been used since 1995. Until recently, harvest projections for Area 2C were based on expansion of the current year's creel survey estimates for major ports, or raw harvest numbers from interviews for other ports, using the ratio between those data and SWHS estimates. Because there were no creel surveys in Area 3A, harvest for that area was projected from the most recent 5- to 8-year linear trend in numbers of fish harvested in each subarea. Five-year linear projections were used in both areas in 2006.

In 2007, the projection method for each area was chosen by evaluating the mean squared deviations and average absolute percent error of retrospective projections, or hindcasts, using a variety of methods. Methods evaluated in 2007 included:

(1) using the previous year's harvest,
(2) linear trend projections based on the previous 2-6 years, and
(3) single and double exponential projections by SWHS area and by IPHC regulatory area.

For Area 2C, we also looked at projecting the trend in the SWHS/creel survey ratios, regressions of SWHS estimates on creel survey estimates, and simple 2- to 5-year moving averages. The best method for Area 2C was a double exponential forecast using Area 2C-wide harvest data. This was combined with a mean weight estimated from 2007 sampling data (weighted by the previous three-year mean harvest

proportions in each subarea of Area 2C). The best method for Area 3A was linear projections of the previous six years' harvest in each subarea combined with respective mean weight data from the current year, summed across all subareas. The estimates for each area also had to be adjusted downward to account for imposition of a prohibition on retention of fish by charter crew in 2007.

Projection of Area 2C harvest for 2008 was challenging because the imposition of a maximum length limit on one fish in Area 2C in 2007, and brief implementation of a one-fish bag limit in 2008, likely affected angler effort and or behavior (with regard to halibut retention) in unknown ways. Likewise, in Area 3A the past time series now contained two years with a prohibition on retention of fish by charter crews. In addition, observations by staff suggested a substantial drop in effort from 2007, which was not yet captured by the SWHS time series because of the one-year lag. It was felt that data from the current year of the fishery would better predict harvest than projections of past trends with adjustments that could not be substantiated. The only data from the current year were limited numbers of charter interviews from creel survey and port sampling programs, and logbook data. In earlier years, we found poor correlation between harvest indices from onsite sampling interviews and harvest estimates, probably due to insufficient sample sizes as well as varying levels of sampling efficiency among samplers, among ports, and among years. Since logbooks are mandatory and supposedly represent a complete census, charter harvest in 2008 was projected by applying the relative change in logbook harvest from 2007 to 2008 to the 2007 SWHS estimate. At the time, only data for trips made through July 31 was entered, but subsequent analyses indicated that these proportions held for the year.

CSP Forecasting Issues

Time Series Forecasts Under Regulation Changes

Harvest projections are in weight units, and therefore entail forecasting average weight with or without size limits, as well as forecasting the numbers of fish harvested. Given the regulatory options identified in the CSP (Table 1 of King 2009), ten basic types of regulation changes are possible in any given year (Table 1). For example, if the current bag limit is one fish without a maximum size limit, possible changes include retaining the same regulations (Scenario 3), implementing a maximum size limit (Scenario 4), or liberalizing the bag limit (Scenario 5).

A main issue is how to forecast harvest when the underlying fishery regulations are changing. This problem could manifest itself simply, such as forecasting harvest under a two fish bag limit when the regulations have been a one-fish bag limit for a number of years. Or it could be more complex, such as forecasting harvest from a time series with changes in regulations every one or two years. Table 1 only provides the possible types of changes from one year to the next. Once the CSP is in effect for a number of years, the time series will be composed of harvest estimates based on different regulations. In this case, it will likely be difficult to distinguish between the normal year-to-year variability in harvest due to changes in effort or catchability, and the variability induced by the regulation changes. This is true even when the regulation changes are explicitly designed to achieve a specified reduction or level of harvest.

In the first case, forecasts might be a simple matter of forecasting off the time series under consistent regulations and then adjusting the forecast for the anticipated effect of the regulation change. They would still be subject to process error. For example, charter skippers and crew were prohibited from retaining fish for the first time in Area 3A in 2007. Halibut harvest in 2008 was forecast from the 2002-2007 time series and then adjusted downward by the percentage of harvest retained by skippers and crew in the previous year. The same approach might be taken to forecast harvest under a reduction in the bag limit. For example, harvest in the coming year (under a one-fish bag limit) would be forecast from a time series based on a 2-fish bag limit, then the forecast would be adjusted downward by the proportion of harvest represented by the second fish in the bag limit (estimated from individual angler data from a recent year).

It is not clear, however, how we would forecast harvest from a time series of varying regulations such as bag or size limits that have a direct effect on harvest. For example, what forecasting approach could be

used to project harvest from a time series that is a mixture of two-fish and one-fish bag limits with size limits in some years?

It may also be easier to forecast harvest under reductions in bag limits than under increases. For example, if the bag limit is reduced, the forecast can be adjusted downward by the proportion of second fish in the harvest. On the other hand, suppose the bag limit remained at one fish for many years, but was suddenly liberalized to two fish due to a drop in effort or increase in abundance. On what basis would the analyst estimate how many more additional fish will be harvested?

Uncertainty in Projections

As noted earlier, a variety of methods have been used to project charter harvest in the past. The errors associated with these projections have sometimes been substantial. One-year projections have ranged from 77-118% of the final estimates in Area 2C and 85-108% of the final estimates in Area 3A since 2000. Therefore the relative errors in these projections have ranged from -23% to +18% in Area 2C and -15% to +8% in Area 3A (Table 2). The projections have tended to be low in both regulatory areas, with average errors of -6.3% in Area 2C and -5.2% in Area 3A. Retrospective projections made in 2007 using the preferred methods for each area fared similarly, with projection errors of -13% to +10% in Area 2C and -16% to +8% in Area 3A. The retrospective projections for 2001-2007 also tended to be below the final estimates, with average errors of -7% in Area 2C and -6% in Area 3A.

The consistent underprojection is probably due to the upward curve in the harvest trajectories of both areas. It may be safe to say that over the long term, the accuracy of time series projections is limited by the inherent variability in the time series. For example, if harvest is highly variable from year to year but the time series is stationary, projections should be relatively unbiased around the average level of harvest. If the time series contains a stable trend, the projections will likely also be unbiased. Projections from time series with unstable levels and trends are likely to be biased. This appears to be the case with the charter harvest data – most trajectories contain abrupt changes in level and trend (Figure 1).

Projection errors are likely to be considerably larger under the CSP. Because the SWHS estimates lag the fishery by one year, the preliminary estimates ADF&G now provides for the current year are based on one-year forecasts of numbers of fish harvested. These are multiplied by average weights for the current year to project harvest biomass. Similar projections will continue to be needed by the IPHC for stock assessment. Under the CSP, however, charter harvest projections will be needed for the upcoming year to evaluate allocation under default or alternate fishery regulations. If these projections are based on SWHS data, they will be based on two-year forecasts of numbers of fish and one-year forecasts of average weight. Naturally, uncertainty increases with the length of the forecast. As an example, I generated double exponential forecasts of harvest (numbers of fish) in two subareas of Area 2C that are representative of high and low variation in the data. The confidence intervals for two-year forecasts for the Ketchikan area were nearly double the intervals for one-year forecasts (Figure 2).

The CSP specifies an “acceptable” allocation range for the charter fishery of ±3.5 percentage points. This range is meant to absorb some of the difference in harvest under each management regime, but would also absorb some of the projection error. It is doubtful, yet uncertain whether this range will absorb all of the projection error. Under the CSP, analysts will be asked to determine whether the projected harvest is within a specified allocation range. Applying the retrospective projections made in 2007 using the best method for each area, I calculated the errors in determining the charter allocation, i.e., the difference between the charter allocations calculated using projected and final harvests. The errors ranged from -3.1% to +2.7% for Area 2C and from -2.3 to +1.1% for Area 3A (Table 3). To reiterate, these are the ranges of errors observed in one-year retrospective projections. Under the CSP, there will be additional error due to forecasting harvest two years ahead and forecasting mean weight (rather than using observed values), as well as errors associated with predicting the effects of bag limit and size limit changes. In some years, these errors may be offsetting, but the projections are likely to fall outside of this 3.5 percentage point buffer at least occasionally.

In October 2007 the SSC suggested that ADF&G provide confidence intervals for projections. A variety of methods have been used to project harvest, including adjustments to projections such as those to account for prohibition on crew harvest or changes in mean weight. The methodology for establishing confidence intervals has not always been clear. Analysts are looking to the SSC for guidance as to how to incorporate all sources of uncertainty into confidence intervals for these projections. This should be challenging, especially given the potential errors associated with quantifying the effect of changes in bag and size limits.

Consequences of Projection Error

As pointed out by King (2009), if harvest is overprojected, regulations may be more restrictive than necessary and the cost will be borne by the charter fishery. If harvest is underprojected, charter harvest may exceed the combined fishery catch limit and the cost will be borne by the halibut stock (and indirectly, all user groups). It is also possible, however, for errors to be cumulative. For example, suppose harvest under the default regulations was underprojected for the coming year due to an unanticipated increase in effort, catch rate, or average weight. Suppose also that the underprojection dictated liberalization of regulations. The result could be a large overage of the charter allocation range due to liberalization of the charter regulations when harvest was already underprojected.

Potential Use of Logbook Data

ADF&G collected halibut data as part of mandatory logbooks for all charter boats from 1998 through 2001, and then stopped collecting halibut data following Council adoption of a motion to incorporate the charter fleet into the existing IFQ program. The Council motion would have based initial issuance of quota shares on 1998-1999 logbooks, and would have implemented a new catch reporting system. At the time, ADF&G was concerned over discrepancies between SWHS halibut harvest estimates and harvest reported in logbooks. These discrepancies (in numbers of fish) ranged from 14-66% in Area 2C and 8-56% in Area 3A (Figure 3).

ADF&G resumed halibut data collection in 2006 following rescission of the IFQ motion. Logbooks were implemented with several changes, including reporting of catch by individual anglers, and increased monitoring and feedback from data entry staff. The 2006 and 2007 data were more complete than previous data, and logbook-reported harvest was closer than before. In Area 2C, logbooks were 23% higher than the SWHS in 2006 and 10% higher in 2007. In Area 3A, logbooks were 30% higher in 2006 and 9% higher in 2007 (Figure 3). There were no changes to SWHS methodology that would account for this convergence.

The department is planning to present results of the 2006-2008 logbook evaluation to the SSC in the fall of 2009. Adoption of charter logbook data (combined with average weight from sampling) as the standard for managing charter harvest would greatly improve the timeliness of projections and eliminate some of the problems associated with time series projections. With respect to timeliness, logbook data for a major portion of the season should be available by the fall each year. With respect to projections for the current year, we should be able to predict year-end logbook harvest numbers with considerable accuracy because the temporal distribution of harvest has been relatively stable from year to year, and there is relatively little harvest after August. There will be no need to adjust projections for year *i* to account for management changes.

The use of logbooks, however, will not solve issues related to projections of harvest in the coming year. These projections will still have to take into account the effect of regulation changes on effort, and will have to incorporate some projection of mean weight.

Projection of Private (Unguided) Harvest

Under current management, guided and unguided sport harvest projections for the current year, along with preliminary estimates of subsistence harvest, legal-sized waste, and bycatch mortality, are deducted

from the total CEY for the upcoming year to derive the fishery CEY. This represents a starting point for staff recommended catch limits for the commercial fishery for the upcoming year.

The CSP has no provisions for restricting the unguided sport harvest. For the time being, unless better methods are found or suggested by the Council or IPHC, ADF&G plans to continue projecting unguided harvest for the current year (one-year-ahead forecast) using time series methods with the best retrospective performance. Single and double exponential methods have performed best in recent retrospective analyses. Retrospective performance is typically reassessed annually.

References

King, J. 2009. Issues in selecting a maximum length limit to manage charter halibut harvest in times of low abundance. Unpublished discussion paper for North Pacific Fishery Management Council, Scientific and Statistical Committee February 2009 meeting. January 20, 2009.

Table 1. Possible sport charter harvest projection scenarios under the NPFMC catch-sharing plan.

	Current Regulations		Projected Regulations	
Scenario	Bag Limit	Maximum Size Limit	Bag Limit	Maximum Size Limit
1	1 fish	Max	1 fish	None
2	1 fish	Max	1 fish	Max-Raise or Lower
3	1 fish	None	1 fish	None
4	1 fish	None	1 fish	Max
5	1 fish	None	2 fish	1 under 32"
6	2 fish	1 under 32"	2 fish	1 under 32"
7	2 fish	1 under 32"	1 fish	None
8	2 fish	1 under 32"	2 fish	None
9	2 fish	None	2 fish	None
10	2 fish	None	2 fish	1 under 32"

Table 2. Comparison of charter harvest projections and final harvest estimates (M lb) for IPHC Area 2C and 3A, 2000-2007.

	Area 2C				Area 3A			
Year	Projection	Final	Projection Error	Relative Error (%)	Projection	Final	Projection Error	Relative Error (%)
2000	1.050	1.132	-0.082	-7.3%	2.756	3.140	-0.384	-12.2%
2001	0.930	1.202	-0.272	-22.6%	2.946	3.133	-0.187	-6.0%
2002	1.501	1.275	0.226	17.7%	2.943	2.723	0.220	8.1%
2003	1.333	1.412	-0.079	-5.6%	3.279	3.382	-0.103	-3.0%
2004	1.437	1.750	-0.313	-17.9%	3.161	3.668	-0.507	-13.8%
2005	1.639	1.952	-0.313	-16.1%	3.414	3.689	-0.275	-7.5%
2006	2.028	1.804	0.224	12.4%	3.947	3.664	0.283	7.7%
2007	1.701	1.918	-0.217	-11.3%	3.404	4.002	-0.598	-14.9%
			Average	-6.3%			Average	-5.2%
			Min	-22.6%			Min	-14.9%
			Max	17.7%			Max	8.1%

Table3. Error in estimating charter allocation associated with one-year retrospective projections of charter harvest, 2000-2007. Retrospective projections were made using the methods used to project charter harvest in each area in 2007.

	Area 2C						**Area 3A**					
Year	Projected	Final	Comm Catch Limit	Projected Alloc	Final Alloc	Alloc Error	Projected	Final	Comm Catch Limit	Projected Alloc	Final Alloc	Alloc Error
2000	1.05	1.13	8.40	12.5%	13.5%	-1.0%	2.76	3.14	18.31	15.1%	17.1%	-2.1%
2001	0.93	1.20	8.78	10.6%	13.7%	-3.1%	2.95	3.13	21.89	13.5%	14.3%	-0.9%
2002	1.50	1.28	8.50	17.7%	15.0%	2.7%	2.94	2.72	22.63	13.0%	12.0%	1.0%
2003	1.33	1.41	8.50	15.7%	16.6%	-0.9%	3.28	3.38	22.63	14.5%	14.9%	-0.5%
2004	1.44	1.75	10.50	13.7%	16.7%	-3.0%	3.16	3.67	25.06	12.6%	14.6%	-2.0%
2005	1.64	1.95	10.93	15.0%	17.9%	-2.9%	3.41	3.69	25.47	13.4%	14.5%	-1.1%
2006	2.03	1.80	10.63	19.1%	17.0%	2.1%	3.95	3.66	25.20	15.7%	14.5%	1.1%
2007	1.70	1.92	8.51	20.0%	22.5%	-2.5%	3.40	4.00	26.20	13.0%	15.3%	-2.3%

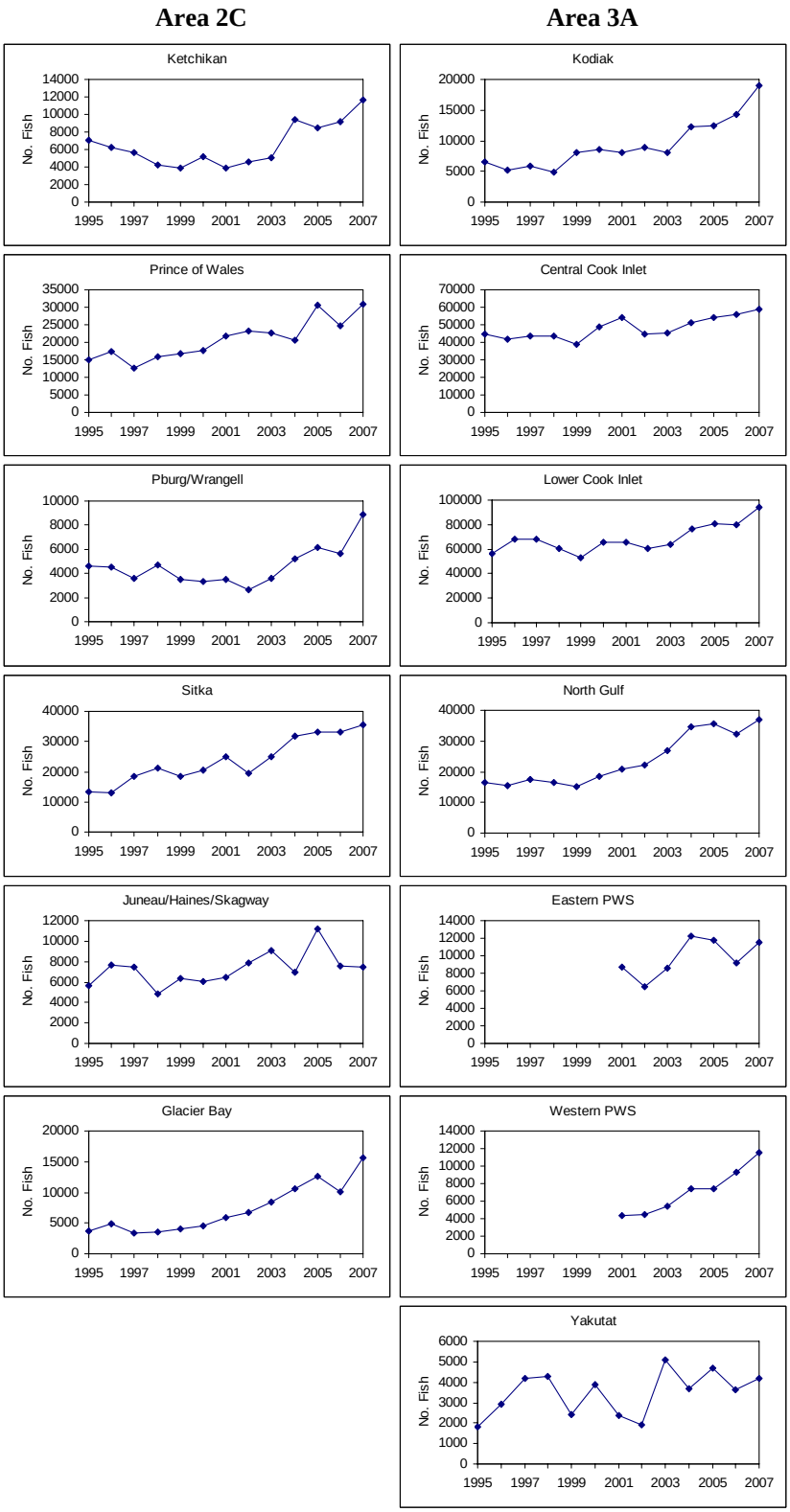

Figure 1. Time series of harvest (numbers of fish) by subarea within IPHC Regulatory Areas 2C and 3A, 1995-2007.

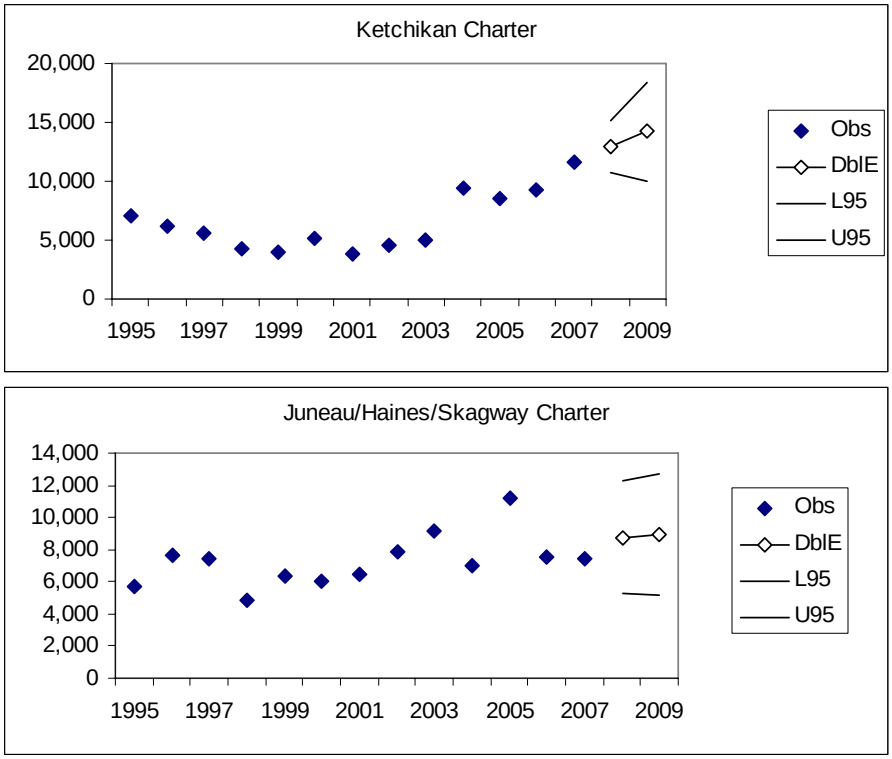

Figure 2. Confidence intervals (95%) of one-year and two-year double exponential forecasts of charter harvest. Forecasts are shown for time series with relatively low and high annual variation. Forecasts were generated using Minitab®.

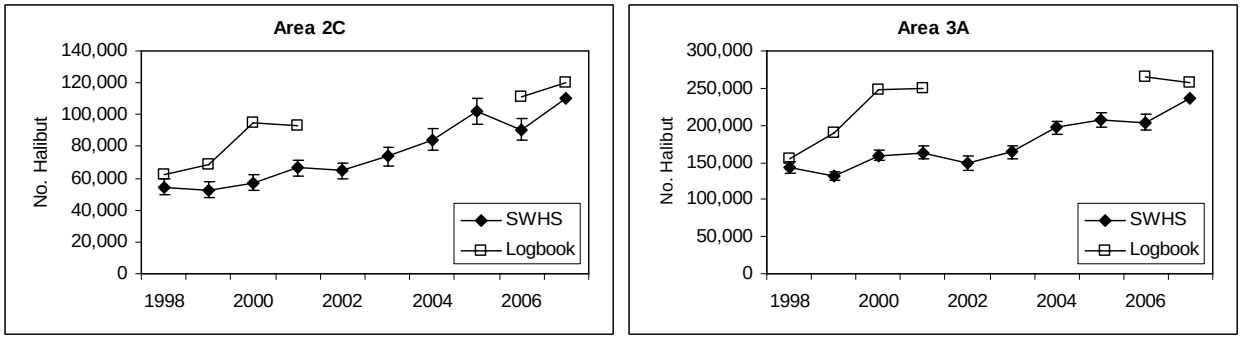

Figure 3. Comparison of Statewide Harvest Survey (SWHS) charter harvest estimates and logbook-reported client and crew harvest, 1998-2007. No halibut data were collected in logbooks during the years 2002-2005.