-Scoping Document-
A Process To Determine Scaup Regulatory Alternatives

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1 October 2007

The purpose of this document is to provide some additional information regarding the crafting of regulatory alternatives for scaup harvest management. These regulatory alternatives were requested from the Flyways as an essential part of the proposed scaup decision-making framework for implementation in the 2008-2009 regulatory cycle. The material in this document is not intended to preclude or circumvent continued Flyway input and debate; we are open to negotiation on any of the specific points. However, when we began to think in more detail about how the proposed framework would be implemented it seemed to us that without additional guidance it would be difficult for the Flyways to develop regulatory alternatives. Therefore, we have prepared this communication in the hope that it will make the task of crafting the regulatory alternatives a more tractable problem for the Flyways.

We are proposing a method to establish a set of packages that specify Closed, Restrictive, Moderate, or Liberal regulations for all Flyways. We are asking the Flyways to develop regulatory alternative (e.g., season lengths and bag limits) to achieve a specific threshold harvest level associated with each package. These harvest thresholds were derived from the distribution of expected allowable harvest taken from a simulation of the optimal policy that was derived under an objective to achieve 95% of the long term cumulative harvest. As the Flyways select combinations of season lengths and bag limits, we intend to use Flyway specific harvest models to predict the expected harvest associated with each regulatory package. For demonstration purposes, we provide updated harvest prediction models and results for the Flyways to consider as they develop regulatory options for each package. We anticipate that each Flyway may be developing alternative models to predict scaup harvest and we fully intend to use these models if they demonstrate improved predictability.

We intend to use the total harvest predictions associated with each regulatory package as the decision variable in the optimization procedure we use to derive the scaup harvest policy. As a result, the resulting harvest policy will now prescribe a package (i.e., Closed, Restrictive, Moderate, or Liberal) for a range of breeding population sizes as opposed to specifying an optimal harvest level. A comparison of the management performance of a scaup harvest policy based on the proposed packages is similar to the expected performance of the scaup harvest policy generated with a range of possible optimal harvest values.

We recognize that many of the details presented in this document represent policy decisions, which will require further discussion with the Flyways to reach a consensus. We again want to make clear that the proposed framework is subject to revision based on performance over the next few years. We look forward to continued work with the Flyways as we move forward in developing a decision-making protocol to inform scaup harvest management.

Rationale
The proposed scaup harvest strategy is based on the premise that the annually derived allowable harvest level can be achieved through some set of Flyway-specific regulatory alternatives conditional on an agreed-upon harvest management objective. The Service has proposed a scenario where the continental allowable harvest is allocated to each Flyway according to historical harvest distributions after accounting for kill in Canada and Alaska. Each Flyway has been asked to recommend regulations to achieve their allowable harvest levels. In addition, the Service has provided some preliminary, modeling results that enable Flyway-specific harvest predictions as a function of combinations of bag limits and season lengths to serve as a guide in developing regulatory packages. Although these models provide a useful tool in evaluating regulatory alternatives to achieve specific harvest levels, preliminary feedback from several Flyways has made it clear that more guidance in crafting regulatory options would be useful.

Specification of Regulatory Packages
The Service requests that each Flyway develop three regulatory packages representing a Restrictive, Moderate, and Liberal scaup harvest season. In what follows, we propose a method of determining the level of harvest that the Restrictive, Moderate, and Liberal packages in each Flyway should target. Although the conditions for season closure have not been fully discussed, we propose that an optimal, total allowable harvest less than 50,000 would result in a closed season in all 4 Flyways with the exception of Alaska. At the National level we suggest that a predetermined range of allowable harvests be defined to specify when the package selection would be Restrictive, Moderate, or Liberal in all 4 Flyways. We propose that these ranges be derived from the distribution of expected harvest levels taken from a simulation of the optimal policy derived under an objective of 95% MSY (Figure 1). This simulation was based on an updated policy resulting from an assessment with the most recent summary of scaup harvest data (Ken Richkus Pers. Comm). Cut points on this distribution which define the allowable harvest ranges associated with the 3 regulatory alternatives would correspond to the 20% and 80% quantiles of the distribution. The 20% and 80% quantiles represent 60% of the probability mass centered on the median of the expected harvest distribution. The midpoint between the 20% and 80% quantiles would then represent the continental harvest level that the Moderate package should target. Correspondingly, the 10% quantile would be the target harvest level under a Restrictive package, while the 90% quantile would be the target harvest level under a Liberal package (Table 1).

The National target harvest levels corresponding to the Restrictive, Moderate, and Liberal packages will then be allocated to each Flyway. Each Flyway then will be asked to recommend a specific combination of season length and bag limit to achieve a harvest level less than or equal to the specified target harvest level under each of the 3 packages. For example, the continental target harvest level under the Moderate range (see Figure 1) is approximately 350,000 (i.e., the median). Expected harvest in Alaska and Canada (0.04 million) will be subtracted from this figure, and the resulting allowable harvest in the conterminous U.S. will be allocated to each Flyway. Each Flyway will then be asked to develop regulations to achieve their allowable harvest under the Moderate package. We continue to support Flyway-level flexibility in determining bag and season length combinations that would be predicted to achieve harvests targeting the mid-points of the Restrictive, Moderate, and Liberal harvest ranges with the understanding that independent season lengths for scaup would be constrained by the overall

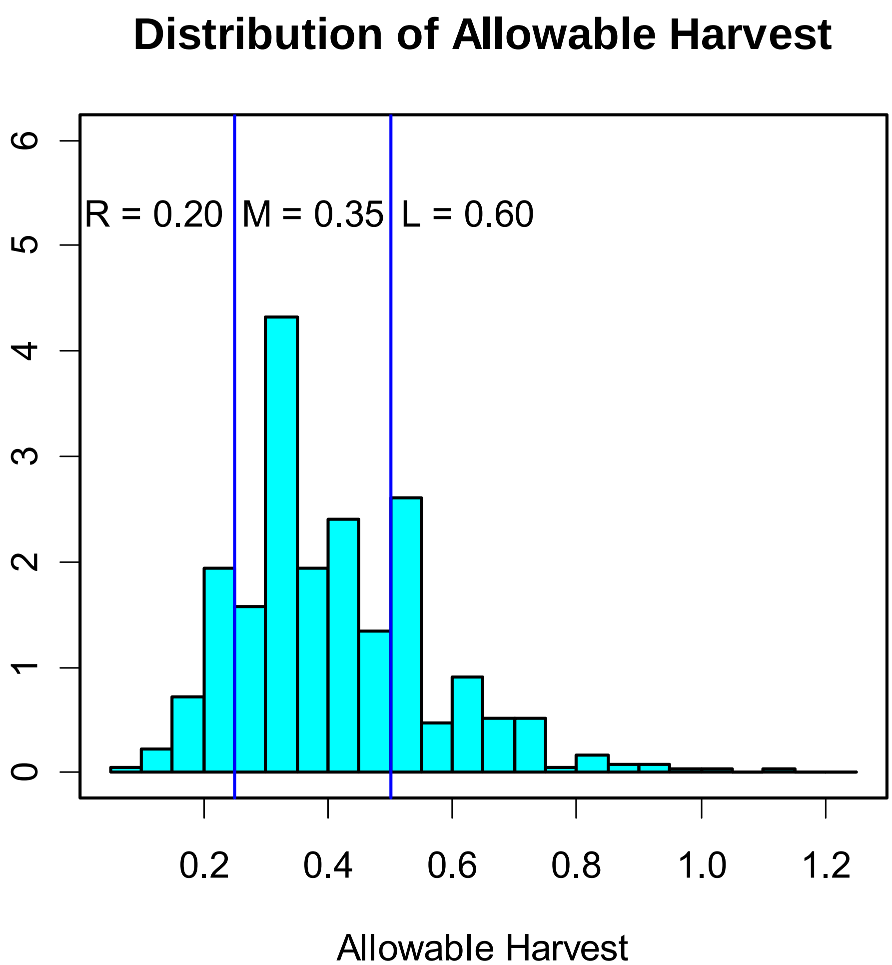

Figure 1. The distribution of allowable harvests (in millions) resulting from a simulation (t = 5000) of an optimal policy derived under an objective to achieve 95% of the maximum long term cumulative harvest. The vertical bands represent the total allowable harvest thresholds in the U. S. that would be targeted under Restrictive (R), Moderate (M), and Liberal (L) Flyway-specific packages. These thresholds were chosen to specify that 60% of the probability mass (i.e., the 20% and 80% quantiles) would be centered under a Moderate package (median = 0.35).

Table 1. Quantiles of the distribution of optimal harvest levels (in millions) based on a simulation of a harvest policy derived under an objective to achieve 95% of the long term cumulative harvest. The harvest level value represents the threshold below which you will find the corresponding percentage of harvest values from the simulation. For example, 10% of the harvest values from the simulation were found to be below 0.2 million.

Quantile	10%	20%	50%	80%	90%
Harvest Level	0.2	0.25	0.35	0.5	0.6

Adaptive Harvest Management framework. We propose that the expected total harvest associated with each package be used to specify a random decision variable in the optimization. By establishing these packages as the decision variable, a policy can be updated each year without the need for the Flyways to have to reconsider a set of regulations required to achieve a new target harvest value. In addition, the use of a package-based decision variable would allow us to explicitly represent prediction uncertainty during the optimization.

Expected Performance of Each Package

We have updated each Flyway's allocation percentages and the set of predictive harvest models with revised harvest data including information from the 2006 hunting season (Table 2; Appendix 1). We then used these models to develop a set of possible regulations to achieve the target harvest levels under each package under the assumption of a liberal AHM season framework. For each policy, we specified two regulatory options characterized by the choice of either a full season, or a restricted season with the largest possible bag. For situations where the full season option was not possible, we assumed each Flyway would select the longest possible season with the largest bag limit. We then characterized the prediction uncertainty associated with the set of regulatory packages by pooling over the intervals for the expected harvest from each Flyway- specific prediction. We pooled the standard deviations from each prediction for each policy to represent variation in the total harvest predictions resulting from each Flyway-specific harvest model while assuming a coefficient of variation of 15% for the harvest expected from Alaska and Canada. We then used the maximum total harvest predictions of each option and the associated variances to specify a distribution for the total harvest expected from each package.

We were concerned about the implications and the expected performance of managing scaup with a set of packages that focused on a specific target harvest level. To explore these ramifications, we derived a harvest policy with an objective of achieving 95% of the long term cumulative harvest, assuming that the control variable in the optimization was now specified by the target harvest levels associated with each package. We used the distributions from the predictions of the maximum, total harvest for each package to define a random decision variable and represent the prediction uncertainty during the optimization. We then compared the resulting policy and the simulated management performance metrics with the original policy that used a range of harvest values as the decision variable.

For each regulatory package, the pooled prediction intervals based on the Flyway-specific harvest models overlapped the target harvest level (see Table 2). Given the large amount of uncertainty associated with the predictability of these harvest models, we believe that the cut points used to specify the three packages and the corresponding target harvest levels provide an appropriate range of harvest opportunity. Moreover, the distributions of the harvest predictions associated with each package are sufficiently different to enable discrimination between the effects of each regulatory package on the total scaup harvest (Figure 2). The resulting harvest policy based on an optimization that included the target harvest levels associated with each package was very similar to the original harvest policy derived using a range of total harvest levels in 0.05 million increments (Table 3). The management performance of this policy was also very similar to the expected performance of the original simulation (Figure 3 and Table 4).

Table 2. Possible regulations to achieve Flyway-specific target harvest levels for each Flyway. The totals represent the pooled 80% prediction intervals under the assumption that the overall AHM framework is liberal.

Restrictive Policy

	AF Target		**0.030**	Lower	Upper	**MF Target**		**0.083**	Lower	Upper	**CF Target**		**0.028**	Lower	Upper	**PF Target**		**0.020**	Lower	Upper
	SL	Bag	Harvest	Interval	Interval	SL	Bag	Harvest	Interval	Interval	SL	Bag	Harvest	Interval	Interval	SL	Bag	Harvest	Interval	Interval
Opt 1	30	3	0.0232	-0.005	0.0514	60	1	0.0498	-0.0125	0.1121	39	3	0.0239	-0.0002	0.048	38	2	0.018	0.0057	0.0303
Opt 2	30	3	0.0232	-0.005	0.0514	45	2	0.0715	0.014	0.129	39	3	0.0239	-0.0002	0.048	38	2	0.018	0.0057	0.0303
Max			0.0232	-0.005	0.0514			0.0715	0.014	0.129			0.0239	-0.0002	0.048			0.018	0.0057	0.0303
	Totals					**Allowable**														
	Opt 1		0.1149	-0.0119	0.2418	**0.16**														
	Opt 2		0.1366	0.0146	0.2586															
	Max		0.1366	0.0146	0.2586															

Moderate Policy

	AF Target		**0.058**	Lower	Upper	**MF Target**		**0.160**	Lower	Upper	**CF Target**		**0.054**	Lower	Upper	**PF Target**		**0.038**	Lower	Upper
	SL	Bag	Harvest	Interval	Interval	SL	Bag	Harvest	Interval	Interval	SL	Bag	Harvest	Interval	Interval	SL	Bag	Harvest	Interval	Interval
Opt 1	45	3	0.0489	0.0219	0.0758	60	2	0.1101	0.0517	0.1686	74	1	0.0482	0.0219	0.0744	107	1	0.0377	0.0264	0.0489
Opt 2	45	3	0.0489	0.0219	0.0758	45	3	0.1318	0.076	0.1876	60	3	0.0501	0.0271	0.0731	86	2	0.035	0.0249	0.0452
Max			0.0489	0.0219	0.0758			0.1318	0.076	0.1876			0.0501	0.0271	0.0731			0.0377	0.0264	0.0489
	Totals					**Allowable**														
	Opt 1		0.2448	0.1219	0.3677	**0.31**														
	Opt 2		0.2658	0.1499	0.3817															
	Max		0.2684	0.1514	0.3855															

Liberal Policy

	AF Target		**0.104**	Lower	Upper	**MF Target**		**0.290**	Lower	Upper	**CF Target**		**0.098**	Lower	Upper	**PF Target**		**0.069**	Lower	Upper
	SL	Bag	Harvest	Interval	Interval	SL	Bag	Harvest	Interval	Interval	SL	Bag	Harvest	Interval	Interval	SL	Bag	Harvest	Interval	Interval
Opt 1	60	6	0.0745	0.0474	0.1017	60	4	0.2308	0.1743	0.2873	74	6	0.0967	0.052	0.1065	107	6	0.0616	0.0508	0.0723
Opt 2	60	6	0.0745	0.0474	0.1017	60	4	0.2308	0.1743	0.2873	74	6	0.0967	0.052	0.1065	107	6	0.0616	0.0508	0.0723
Max			0.0745	0.0474	0.1017			0.2308	0.1743	0.2873			0.0967	0.052	0.1065			0.0616	0.0508	0.0723
	Totals					**Allowable**														
	Opt 1		0.4636	0.3244	0.5679	**0.56**														
	Opt 2		0.4636	0.3244	0.5679															
	Max		0.4636	0.3244	0.5679															

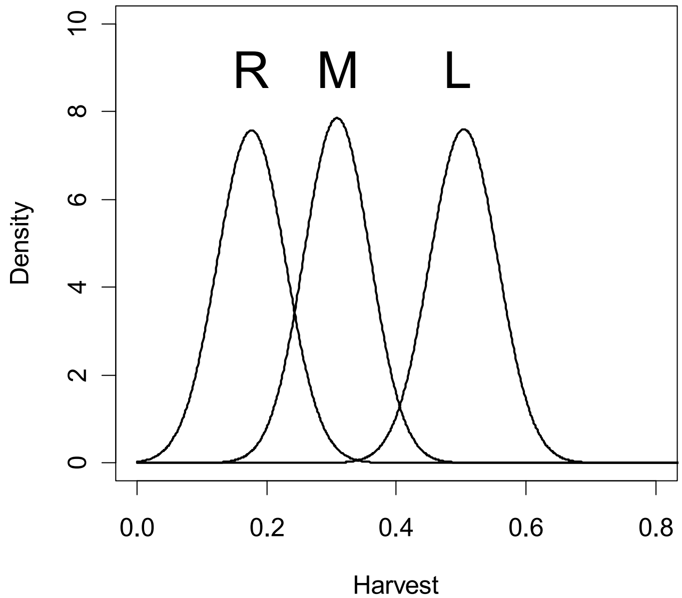

Figure 2. The distribution of the total harvest predicted from each package (Restrictive, Moderate, and Liberal). These distributions were specified as Normal with the mean equal to the maximum, total predicted harvest expected from each package with the variance equal to the corresponding pooled prediction variance.

Table 3. Optimal scaup harvest levels (observed scale in millions) and corresponding breeding population sizes (in millions) derived under different objectives and decision variables.

Decision Variable:	H in 0.05 Increments	Target H
Breeding Population	Optimal Harvest	Optimal Harvest
1.0	0	C
1.25	0	C
1.5	0	C
1.75	0	C
2.0	0.05	C
2.25	0.05	C
2.5	0.10	C
2.75	0.10	R
3.0	0.15	R
3.25	0.20	R
3.5	0.20	R
3.75	0.25	M
4.0	0.30	M
4.25	0.30	M
4.5	0.40	M
4.75	0.40	L
5.0	0.50	L

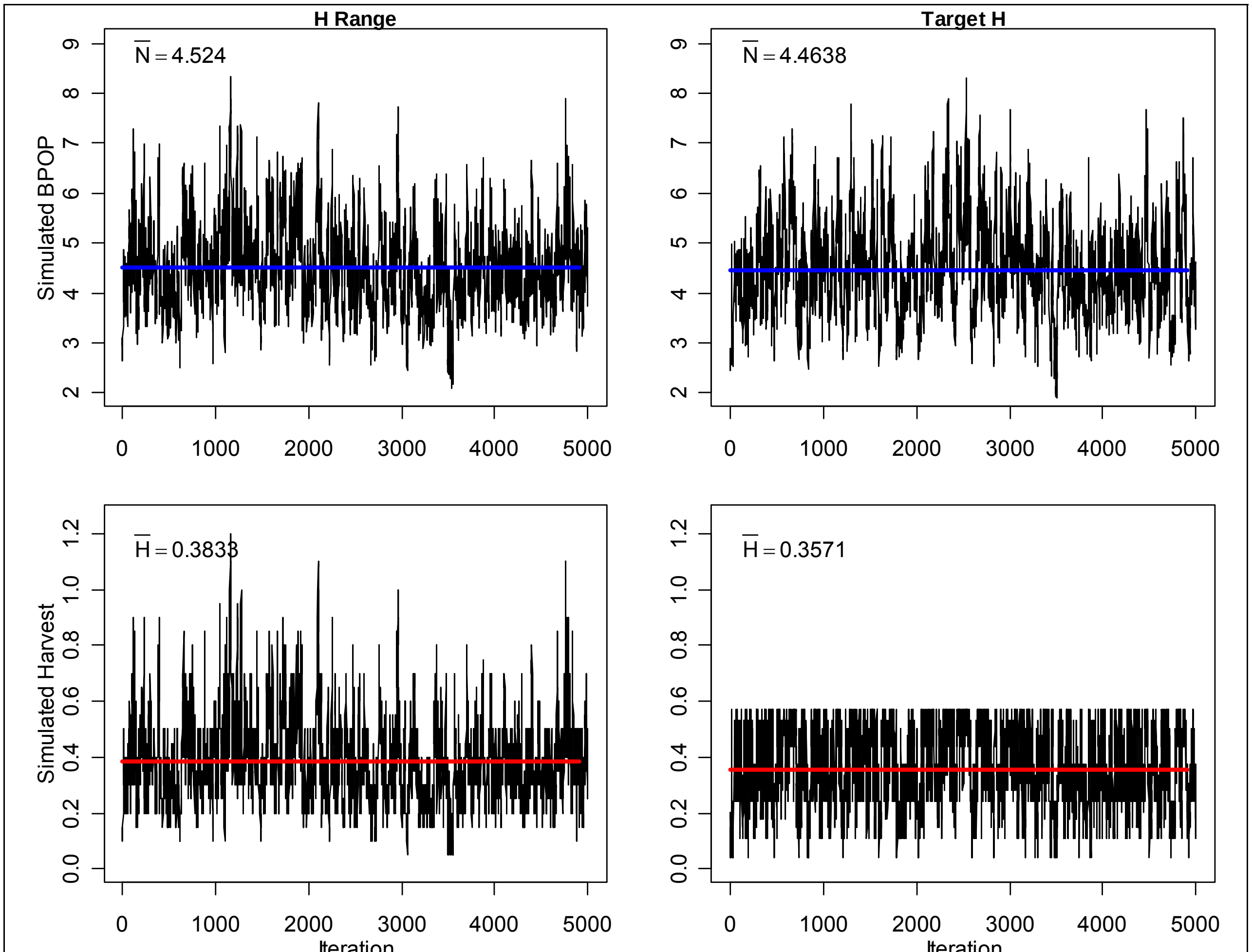

Figure 3. Simulated harvest policies derived under an objective to achieve 95% of MSY using two different decision variables. The figures on the left panel are based on a policy derived using a range of potential harvest values (in 0.05 million increments) as the decision variable, while the figures on the right panel are based on a policy that used the target harvest levels based on the predicted harvests expected from the set of proposed regulatory alternatives associated with each of the three regulatory packages.

Table 4. Summary statistics of simulated harvest strategies derived under an objective to achieve 95% of MSY using two different decision variables. The average of the simulated population and harvest levels are displayed along with the frequency of prescribed optimal harvest levels (in millions) and the frequency of the proposed packages.

Decision	Average		Expected frequency of harvest levels			
Variable	N	H	H < 0.05	0.05 ≤ H < 0.25	0.25 ≤ H ≤ 0. 5	H >0. 5
H (range)	4.524	0.383	0.00	0.15	0.58	0.27
			Closed	Restrictive	Moderate	Liberal
Target H	4.464	0.357	0.01	0.19	0.40	0.40

Outstanding Policy Issues

Ultimately, the details of this proposed framework identify specific issues that must be resolved through policy discussions. We present this scenario as a "straw man" to provide a context for further discussion about the specific, outstanding issues regarding the selection of appropriate regulatory alternatives from which to derive a scaup harvest strategy. In addition, we believe that the proposed scenario imparts a level of consistency regarding the specific regulatory alternatives that would be used to manage scaup harvest opportunity. Reaching a consensus on the selection of these packages would preclude the need for annual changes being made to the set of regulatory alternatives. There are several policy issues associated with the proposed methodology that will require further discussion and coordination with the Flyways:

- For the purposes, of this report, we used an illustrative example of a harvest policy derived under a harvest management objective to achieve 95% of the long term cumulative harvest. We acknowledge that the specification of this objective function is a policy decision. However, we maintain that this is an appropriate level because it results in a policy that is less sensitive to small changes in population size compared to a policy based on achieving100% of the long term harvest and because it allows for some harvest opportunity at relatively lower breeding population sizes.

- We recognize that the Flyways may be interested in developing alternative models to predict Flyway-specific harvest levels. We fully support this development and would consider using these models if they result in better harvest predictions. The review of these models will have to be closely coordinated because the results of these analyses will be used to specify the total harvest predictions that will be use to derive the annual scaup harvest policy.

- The conditions for season closure have not been fully discussed. Similar to other species-specific harvest strategies, we recognize that there may be population sizes for which season closure may not be acceptable. The specification of this threshold represents a critical policy decision that will ultimately define the derived harvest policy.

- The methods and results outlined in this report are conditional on a liberal AHM framework. The relationship between the proposed scaup decision-making framework and the annual AHM process has not been discussed. In particular, we have not fully worked out the details of how the scaup harvest packages would interact with the frameworks specified by AHM season frameworks. This relationship is complicated by the potential of having different AHM frameworks (e.g., a moderate Midcontinent AHM framework and a Liberal Eastern AHM framework). The resolution of this issue represents an additional policy decision that will have to be addressed as we work to establish a set of scaup harvest packages.

It is important to note, that all aspects of the proposed harvest strategy, including regulatory alternatives, will undergo periodic review and adjustment as we gain additional regulatory experience or information. We look forward to Flyway feedback on this proposed framework for developing regulatory alternatives for scaup harvest management.

Appendix 1. Harvest Model Development

An evaluation of historical scaup harvest regulations is complicated by the annual variation in individual state selections of scaup regulatory options from the late 1960s through the late 1980's. Over this time period, individual states had a range of regulatory alternatives to manage scaup harvest opportunity, including bonus bag limits, bonus seasons, or a range of point values under the Point System. Because individual state selections of these regulatory alternatives were not consistent over time or across Flyways, the development of models that predict scaup harvest at the Flyway scale is problematic. As a result, harvest data observed under these regulatory options were not considered during model development. The availability of scaup bonus bag limits or bonus season lengths was suspended during the regulations cycle in 1988. Therefore, harvest information from 1988 through 2006 formed the basis for the development of scaup harvest models as a function of Flyway-specific, historical scaup harvest regulations. Scaup harvest from each Flyway was modeled as a function of season length and bag limit information. Indicator variables were used to distinguish harvest data collected under the Mail Questionnaire Survey (MQS) and the Harvest Information Program (HIP).

Atlantic Flyway

The addition of bag limit information in a model that already included season length was not significant. As a result, scaup harvest in the Atlantic Flyway was modeled as a linear function of season length (Table 1.1). This model explains 57% of the variation in historical scaup harvests. The resulting model to predict scaup harvest (H) in the Atlantic Flyway is:

$$H \;\; -0.0281419 + 0.0017113\,Days \qquad (1.1)$$

where Days is the season length. Predictions with this model based on a range of season lengths are depicted in Figure 1.1.

Table 1.1. The results from fitting a linear model that predicts the scaup harvest in the Atlantic Flyway as a function of season length (Days).

Atlantic Flyway: Harvest ~ Days

```
lm(formula = Harvest ~ Days, data = af)
Residuals:
      Min        1Q    Median        3Q       Max
-0.029353 -0.012533 -0.002399  0.007428  0.045209
Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept) -0.0281419  0.0166125  -1.694    0.106
Days         0.0017113  0.0003213   5.325 3.27e-05 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Residual standard error: 0.01981 on 20 degrees of freedom
Multiple R-Squared: 0.5864,     Adjusted R-squared: 0.5658
F-statistic: 28.36 on 1 and 20 DF,  p-value: 3.268e-05 Analysis of Variance

Analysis of Variance Table
Response: Harvest
          Df    Sum Sq   Mean Sq F value    Pr(>F)
Days       1 0.0111280 0.0111280  28.361 3.268e-05 ***
Residuals 20 0.0078474 0.0003924
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
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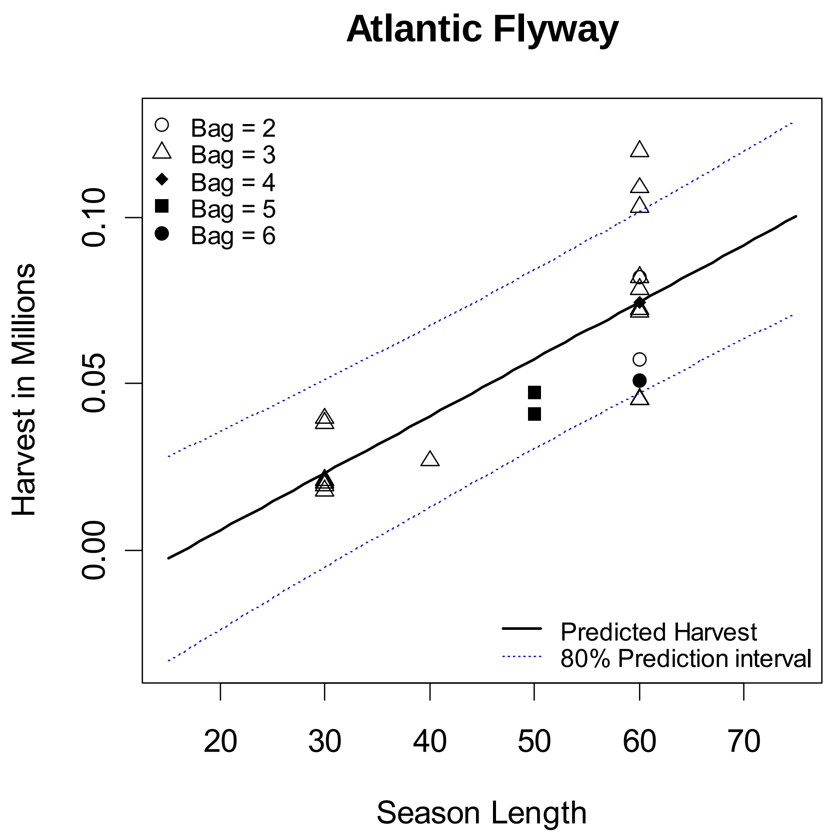


Figure 1.1. Observed Atlantic Flyway scaup harvest (1988-2006) and predicted harvest calculated as a function of season length.

Mississippi Flyway

A plot of Mississippi harvest data as a function of historical regulations suggests a direct relationship between large harvests with longer season lengths and higher bag limits (Figure 1.2). The full model that included an interaction term between season length and bag limit was not significant. As a result, the model used to predict Mississippi harvest included a linear effect of season length and bag limit information. This model explains 78% of the variation in scaup harvest (Table 1.2). The resulting model to predict scaup harvest in the Mississippi Flyway is:

$$H = -0.165098 + 0.002576\ Days + 0.060325\ Bag \qquad (1.2)$$

where Days is the season length and Bag is the bag limit. Predictions calculated with this model evaluated over a range of season lengths and bag limits are shown in Figure 1.2.

Table 1.2. The results from fitting a linear model that predicts the scaup harvest in the Mississippi Flyway as a function of season length (Days) and bag limit (Bag).

Mississippi Flyway: Harvest ~ Days + Bag

```
lm(formula = Harvest ~ Days + Bag, data = mf)
Residuals:
      Min        1Q    Median        3Q       Max 
-0.080501 -0.017743  0.003679  0.030987  0.052163 
Coefficients:
              Estimate Std. Error t value Pr(>|t|)    
(Intercept) -0.1650982  0.0414862  -3.980 0.000803 ***
Days         0.0025763  0.0006689   3.852 0.001075 ** 
Bag          0.0603248  0.0082313   7.329 6.01e-07 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1 
Residual standard error: 0.04088 on 19 degrees of freedom
Multiple R-Squared: 0.8024,     Adjusted R-squared: 0.7816 
F-statistic: 38.58 on 2 and 19 DF,  p-value: 2.042e-07

Analysis of Variance Table
Response: Harvest
          Df   Sum Sq  Mean Sq F value    Pr(>F)    
Days       1 0.039188 0.039188  23.445 0.0001133 ***
Bag        1 0.089776 0.089776  53.709 6.006e-07 ***
Residuals 19 0.031759 0.001672                      
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

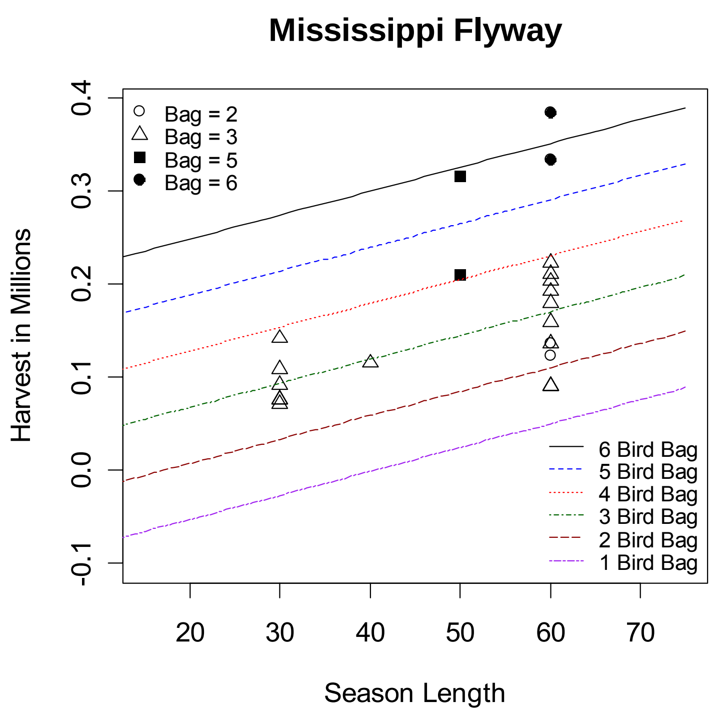


Figure 1.2. Observed Mississippi scaup harvest (1988-2006) and predictions calculated as a function of season length and bag limit based on the Mississippi harvest model.

Central Flyway

A plot of Central Flyway harvest data and historical regulations also suggests a direct relationship between increases in harvest levels with longer season lengths and higher bag limits (Figure 1.3). The full model that included an interaction term between season length and bag limit was not significant (Table 1.3). An evaluation of regression diagnostics strongly suggested that the data point from 1998 was an outlier (Table 1.4). The Cook's distance value was very close to 1 (D = 0.97). As a result, we chose to remove this data point and modeled the Central Flyway harvest with a linear effect of season length and bag limit information. This model explains 62% of the variation in scaup harvest (Table 1.5). The resulting model to predict scaup harvest in the Central Flyway is:

$$H = -0.053902 + 0.001248\ Days + 0.009711\ Bag \qquad (1.3)$$

where Days is the season length and Bag is the bag limit. Predictions based on this model evaluated over a range of season lengths and bag limits are shown in Figure 1.3.

Table 1.3. The results from fitting a linear model that predicts the scaup harvest in the Central Flyway as a function of season length (Days) and bag limit (Bag).

Central Flyway: Harvest ~ Days + Bag

```
lm(formula = Harvest ~ Days + Bag, data = cf)

Residuals:
      Min        1Q    Median        3Q       Max
-0.038238 -0.005265  0.001837  0.010871  0.038648

Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept) -0.0767508  0.0208439  -3.682 0.001583 **
Days         0.0013356  0.0002742   4.872 0.000106 ***
Bag          0.0156716  0.0039556   3.962 0.000836 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.01969 on 19 degrees of freedom
Multiple R-Squared: 0.6993,     Adjusted R-squared: 0.6676
F-statistic: 22.09 on 2 and 19 DF,  p-value: 1.102e-05
Analysis of Variance Table

Response: Harvest
          Df    Sum Sq   Mean Sq F value    Pr(>F)
Days       1 0.0110504 0.0110504  28.488 3.762e-05 ***
Bag        1 0.0060885 0.0060885  15.696  0.000836 ***
Residuals 19 0.0073699 0.0003879
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Table 1.4. Regression diagnostics for the Central Flyway harvest model that includes Days and Bag. The Cook's distance (cook.d) value for 1998 is very close to 1, suggesting that this data point is an outlier.

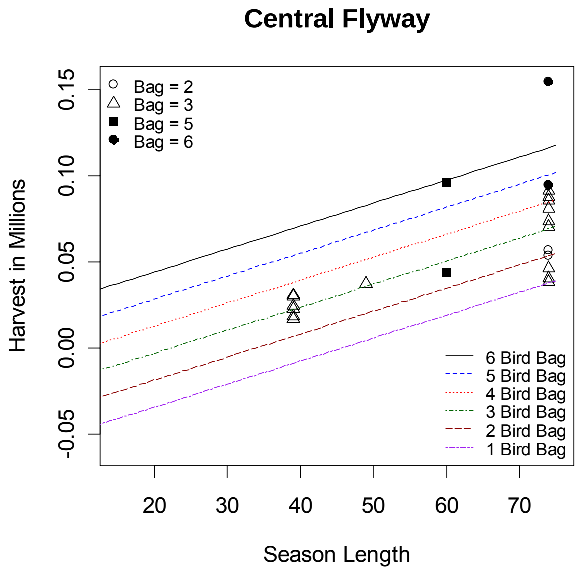
```
Influence measures of lm(formula = Harvest ~ Days + Bag, data = cf) :
      dfb.1_ dfb.Days   dfb.Bag    dffit cov.r   cook.d    hat inf
28  0.139919 -0.13574 -0.016450  0.16727 1.345 9.76e-03 0.1486
29  0.038559 -0.03741 -0.004533  0.04610 1.379 7.47e-04 0.1486
30 -0.075178  0.07293  0.008839 -0.08987 1.371 2.83e-03 0.1486
31  0.004024 -0.00390 -0.000473  0.00481 1.381 8.14e-06 0.1486
32  0.157844 -0.15313 -0.018558  0.18869 1.335 1.24e-02 0.1486
33 -0.106631  0.10345  0.012537 -0.12747 1.360 5.69e-03 0.1486
34  0.018977 -0.01507 -0.004615  0.02469 1.278 2.14e-04 0.0809
35  0.297678  0.16509 -0.849733 -1.01265 0.624 2.76e-01 0.1563
36 -0.099223 -0.05503  0.283236  0.33754 1.260 3.88e-02 0.1563
37  0.622608 -0.18154 -0.855912 -0.96781 1.314 2.99e-01 0.3342
38 -1.279279  0.37300  1.758651  1.98857 0.595 9.68e-01 0.3342   *
39  0.073285 -0.31070  0.162564 -0.50745 0.816 7.80e-02 0.0811
40 -0.042379  0.17967 -0.094007  0.29345 1.093 2.87e-02 0.0811
41 -0.026151  0.11087 -0.058010  0.18108 1.204 1.13e-02 0.0811
42  0.067362 -0.28559  0.149425 -0.46644 0.871 6.73e-02 0.0811
43 -0.037680  0.15975 -0.083583  0.26091 1.129 2.30e-02 0.0811
44 -0.010234  0.04339 -0.022701  0.07086 1.268 1.76e-03 0.0811
45 -0.050707  0.21498 -0.112481  0.35111 1.023 4.03e-02 0.0811
46  0.052593 -0.22297  0.116663 -0.36417 1.006 4.31e-02 0.0811
47 -0.003021  0.01281 -0.006702  0.02092 1.279 1.54e-04 0.0811
48  0.014340  0.04075 -0.060599  0.08250 1.389 2.39e-03 0.1581
49  0.000798  0.00227 -0.003373  0.00459 1.397 7.42e-06 0.1581
```

Table 1.5. The results from fitting a linear model that predicts the scaup harvest in the Central Flyway as a function of season length (Days) and bag limit (Bag) while holding out the 1998 data.

Central Flyway: Harvest ~ Days + Bag

```
Call:lm(formula = Harvest ~ Days + Bag, data = cf, subset = c(1:10,12:22))
Residuals:
       Min         1Q     Median         3Q        Max
-0.0292074 -0.0055602  0.0005111  0.0068380  0.0265448
Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) -0.053902   0.019629  -2.746   0.0133 *
Days         0.001248   0.000237   5.266 5.24e-05 ***
Bag          0.009711   0.004000   2.428   0.0259 *
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Residual standard error: 0.01688 on 18 degrees of freedom
Multiple R-Squared: 0.6552,     Adjusted R-squared: 0.6169
F-statistic:  17.1 on 2 and 18 DF,  p-value: 6.888e-05

Analysis of Variance Table
Response: Harvest
          Df    Sum Sq   Mean Sq F value    Pr(>F)
Days       1 0.0080628 0.0080628 28.3101 4.662e-05 ***
Bag        1 0.0016786 0.0016786  5.8938   0.02591 *
Residuals 18 0.0051265 0.0002848
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```



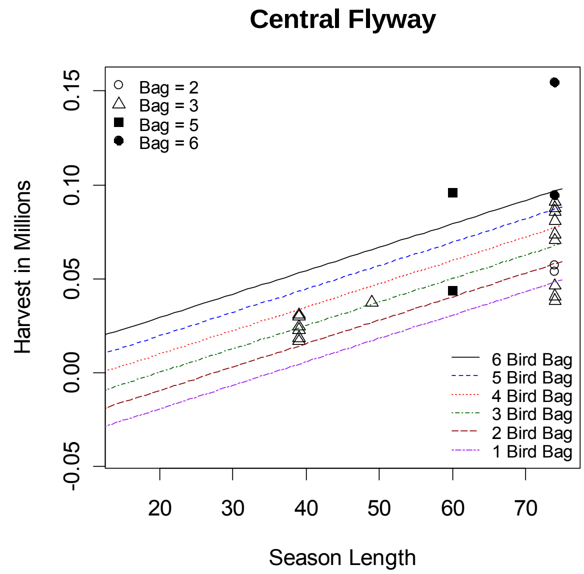


Figure 1.3. Observed Central Flyway scaup harvest (1988-2006) and predictions calculated as a function of season length and bag limit based on the Central Flyway harvest model. The left figure includes predictions based on a model that includes data from 1998, while the right hand figure displays predictions from a model estimated from data that does not include the 1998 observation.

Pacific Flyway

The results from an initial model that included season length, bag limit, a HIP effect, and the interaction between season length and bag limit was significant. However, this model was not considered because predictions calculated with high bag limits showed a decreasing trend in the harvest as the season lengths increased. As a result, a reduced model was used to predict Pacific Flyway harvest as a function of season length, bag limit, and a HIP effect. This model explains 81% of the variation in scaup harvest (Table 1.6). The resulting model to predict scaup harvest in the Pacific Flyway is:

$$H = -0.0216758 + 0.0003541\ Days + 0.0047870\ \mathrm{Bag} + 0.0166583\ HIP \quad (1.4)$$

where Days is the season length, Bag is the bag limit, and HIP is an indicator variable (0 or 1) used to model the HIP effect. Predictions based on this model evaluated over a range of season lengths and bag limits are shown in Figure 1.4.

Table 1.6. The results from fitting a linear model that predicts the scaup harvest in the Pacific Flyway as a function of season length (Days), bag limit (Bag) and a HIP effect.

Pacific Flyway: Harvest ~ Days + Bag + HIP

```
Call: lm(formula = Harvest ~ Days + Bag + HIP, data = pf)
Residuals:
       Min         1Q     Median         3Q        Max
-0.0075197 -0.0041609 -0.0008563  0.0018093  0.0215911
Coefficients:
              Estimate Std. Error t value Pr(>|t|)
(Intercept) -2.168e-02  7.917e-03  -2.738  0.01352 *
Days         3.541e-04  9.714e-05   3.645  0.00185 **
Bag          4.787e-03  1.629e-03   2.939  0.00878 **
HIP          1.666e-02  4.718e-03   3.531  0.00239 **
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Residual standard error: 0.006795 on 18 degrees of freedom
Multiple R-Squared: 0.8369,     Adjusted R-squared: 0.8098
F-statistic:  30.8 on 3 and 18 DF,  p-value: 2.653e-07
Analysis of Variance Table
Response: Harvest
          Df    Sum Sq   Mean Sq F value    Pr(>F)
Days       1 0.0036501 0.0036501 79.0624 5.272e-08 ***
Bag        1 0.0000395 0.0000395  0.8565  0.366964
HIP        1 0.0005755 0.0005755 12.4665  0.002388 **
Residuals 18 0.0008310 0.0000462
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

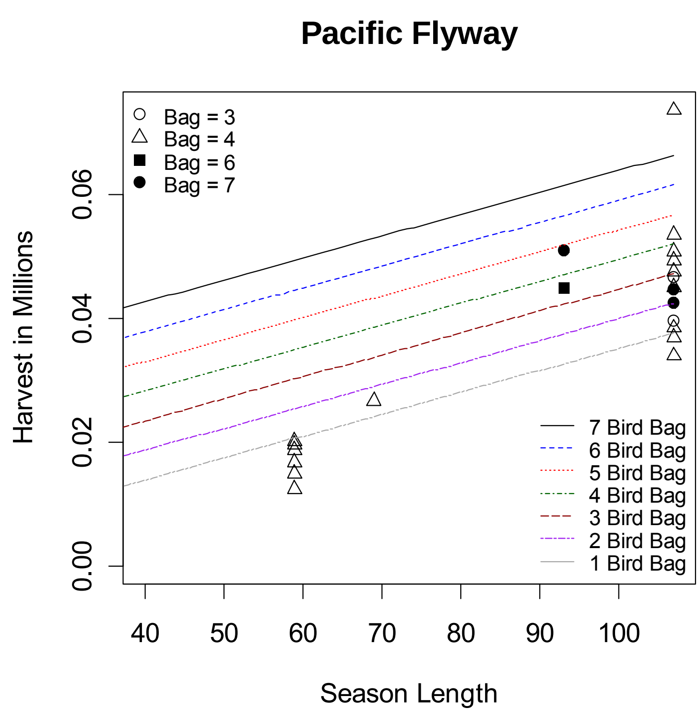


Figure 1.4. Observed Pacific Flyway scaup harvest (1988-2006) and predictions calculated as a function of season length, bag limit, and a HIP effect (i.e., HIP = 1) based on the Pacific Flyway harvest model.

Appendix 2. Harvest data and regulation information used to develop Flyway-specific scaup harvest models.

Atlantic Flyway

Table 2.1 Total scaup harvest, season information, and population data[1] collected in the Atlantic Flyway from 1988 to 2006.

Year	Harvest	HIP	Days	Bag	BPOP
1988	0.038263	0	30	3	4.671351
1989	0.039628	0	30	3	4.34205
1990	0.020442	0	30	3	4.293141
1991	0.017867	0	30	3	5.254899
1992	0.019536	0	30	3	4.639232
1993	0.021152	0	30	3	4.080145
1994	0.026921	0	40	3	4.529044
1995	0.041026	0	50	5	4.446443
1996	0.047453	0	50	5	4.217405
1997	0.051004	0	60	6	4.112349
1998	0.074242	0	60	4	3.471916
1999	0.08197	0	60	3	4.411724
2000	0.045234	0	60	3	4.026323
2001	0.108851	0	60	3	3.69401
1999	0.072568	1	60	3	4.411724
2000	0.04518	1	60	3	4.026323
2001	0.119742	1	60	3	3.69401
2002	0.103096	1	60	3	3.524142
2003	0.078283	1	60	3	3.734444
2004	0.071727	1	60	3	3.807192
2005	0.081936	1	60	2	3.386893
2006	0.057142	1	60	2	3.246663

[1] Harvest data in millions; HIP = data collected under the HIP program, BPOP is the May breeding population from the traditional survey strata in millions.

Mississippi Flyway

Table 2.2 Total scaup harvest, season information, and population data[1] collected in the Mississippi Flyway from 1988 to 2006.

Year	Harvest	HIP	Days	Bag	BPOP
1988	0.091553	0	30	3	4.671351
1989	0.075748	0	30	3	4.34205
1990	0.071045	0	30	3	4.293141
1991	0.108141	0	30	3	5.254899
1992	0.141492	0	30	3	4.639232
1993	0.075314	0	30	3	4.080145
1994	0.115083	0	40	3	4.529044
1995	0.209867	0	50	5	4.446443
1996	0.315621	0	50	5	4.217405
1997	0.384663	0	60	6	4.112349
1998	0.334523	0	60	6	3.471916
1999	0.089956	0	60	3	4.411724
2000	0.222619	0	60	3	4.026323
2001	0.192185	0	60	3	3.69401
1999	0.09008	1	60	3	4.411724
2000	0.203093	1	60	3	4.026323
2001	0.179427	1	60	3	3.69401
2002	0.21136	1	60	3	3.524142
2003	0.158639	1	60	3	3.734444
2004	0.13659	1	60	3	3.807192
2005	0.136169	1	60	2	3.386893
2006	0.122673	1	60	2	3.246663

[1] Harvest data in millions; HIP = data collected under the HIP program, BPOP is the May breeding population from the traditional survey strata in millions.

Central Flyway

Table 2.3 Total scaup harvest, season information, and population data[1] collected in the Central Flyway from 1988 to 2006.

Year	Harvest	HIP	Days	Bag	BPOP
1988	0.029797	0	39	3	4.671351
1989	0.024413	0	39	3	4.34205
1990	0.018342	0	39	3	4.293141
1991	0.022569	0	39	3	5.254899
1992	0.03074	0	39	3	4.639232
1993	0.016671	0	39	3	4.080145
1994	0.037325	0	49	3	4.529044
1995	0.043507	0	60	5	4.446443
1996	0.096076	0	60	5	4.217405
1997	0.094648	0	74	6	4.112349
1998	0.154763	0	74	6	3.471916
1999	0.038375	0	74	3	4.411724
2000	0.087755	0	74	3	4.026323
2001	0.0808	0	74	3	3.69401
1999	0.040548	1	74	3	4.411724
2000	0.085777	1	74	3	4.026323
2001	0.073719	1	74	3	3.69401
2002	0.091178	1	74	3	3.524142
2003	0.046265	1	74	3	3.734444
2004	0.070466	1	74	3	3.807192
2005	0.05696	1	74	2	3.386893
2006	0.053626	1	74	2	3.246663

[1] Harvest data in millions; HIP = data collected under the HIP program, BPOP is the May breeding population from the traditional survey strata in millions.

Pacific Flyway

Table 2.4 Total scaup harvest, season information, and population data[1] collected in the Pacific Flyway from 1988 to 2006.

Year	Harvest	HIP	Days	Bag	BPOP
1988	0.015044	0	59	4	4.671351
1989	0.01248	0	59	4	4.34205
1990	0.018835	0	59	4	4.293141
1991	0.020253	0	59	4	5.254899
1992	0.016848	0	59	4	4.639232
1993	0.01969	0	59	4	4.080145
1994	0.026689	0	69	4	4.529044
1995	0.04483	0	93	6	4.446443
1996	0.051047	0	93	7	4.217405
1997	0.044705	0	107	7	4.112349
1998	0.042552	0	107	7	3.471916
1999	0.033986	0	107	4	4.411724
2000	0.036894	0	107	4	4.026323
2001	0.038505	0	107	4	3.69401
1999	0.047578	1	107	4	4.411724
2000	0.049427	1	107	4	4.026323
2001	0.045124	1	107	4	3.69401
2002	0.050791	1	107	4	3.524142
2003	0.053588	1	107	4	3.734444
2004	0.07361	1	107	4	3.807192
2005	0.039712	1	107	3	3.386893
2006	0.046748	1	107	3	3.246663

[1] Harvest data in millions; HIP = data collected under the HIP program, BPOP is the May breeding population from the traditional survey strata in millions.

Appendix 3. Flyway-specific harvest prediction intervals and corresponding target harvest levels under Restrictive, Moderate, and a Liberal policy, assuming the Adaptive Harvest Management framework is liberal.

Restrictive Policy																			
AF Target		**0.030**	Lower	Upper	**MF Target**		**0.083**	Lower	Upper	**CF Target**		**0.028**	Lower	Upper	**PF Target**		**0.020**	Lower	Upper
SL	Bag	Harvest	Interval	Interval	SL	Bag	Harvest	Interval	Interval	SL	Bag	Harvest	Interval	Interval	SL	Bag	Harvest	Interval	Interval
60	3	0.0745	0.0474	0.1017	60	3	0.1679	0.1116	0.2242	74	3	0.0676	0.0442	0.0909	107	3	0.0472	0.0375	0.0570
60	2	0.0745	0.0474	0.1017	60	2	0.1101	0.0517	0.1686	74	2	0.0579	0.0336	0.0821	107	2	0.0424	0.0321	0.0528
60	1	0.0745	0.0474	0.1017	60	1	0.0498	-0.0125	0.1121	74	1	0.0482	0.0219	0.0744	107	1	0.0377	0.0264	0.0489
45	3	0.0489	0.0219	0.0758	45	3	0.1318	0.0760	0.1876	60	3	0.0501	0.0271	0.0731	86	3	0.0398	0.0299	0.0497
45	2	0.0489	0.0219	0.0758	45	2	0.0715	0.0140	0.1290	60	2	0.0404	0.0165	0.0643	86	2	0.0350	0.0249	0.0452
45	1	0.0489	0.0219	0.0758	45	1	0.0112	-0.0500	0.0723	60	1	0.0307	0.0048	0.0566	86	1	0.0302	0.0194	0.0411
30	3	0.0232	-0.0050	0.0514	30	3	0.0932	0.0349	0.1514	39	3	0.0239	-0.0002	0.0480	60	3	0.0306	0.0196	0.0416
30	2	0.0232	-0.0050	0.0514	30	2	0.0328	-0.0267	0.0924	39	2	0.0142	-0.0107	0.0391	60	2	0.0258	0.0149	0.0367
30	1	0.0232	-0.0050	0.0514	30	1	-0.0275	-0.0903	0.0353	39	1	0.0045	-0.0223	0.0312	60	1	0.0210	0.0098	0.0323
20	3	0.0061	-0.0236	0.0358	20	3	0.0674	0.0059	0.1289	25	3	0.0064	-0.0193	0.0321	38	3	0.0228	0.0102	0.0354
20	2	0.0061	-0.0236	0.0358	20	2	0.0071	-0.0554	0.0696	25	2	-0.0033	-0.0297	0.0232	38	2	0.0180	0.0057	0.0303
20	1	0.0061	-0.0236	0.0358	20	1	-0.0532	-0.1187	0.0122	25	1	-0.0130	-0.0412	0.0152	38	1	0.0132	0.0009	0.0255
Moderate Policy																			
AF Target		**0.058**	Lower	Upper	**MF Target**		**0.160**	Lower	Upper	**CF Target**		**0.054**	Lower	Upper	**PF Target**		**0.038**	Lower	Upper
SL	Bag	Harvest	Interval	Interval	SL	Bag	Harvest	Interval	Interval	SL	Bag	Harvest	Interval	Interval	SL	Bag	Harvest	Interval	Interval
60	3	0.0745	0.0474	0.1017	60	3	0.1679	0.1116	0.2242	74	3	0.0676	0.0442	0.0909	107	3	0.0472	0.0375	0.0570
60	2	0.0745	0.0474	0.1017	60	2	0.1101	0.0517	0.1686	74	2	0.0579	0.0336	0.0821	107	2	0.0424	0.0321	0.0528
60	1	0.0745	0.0474	0.1017	60	1	0.0498	-0.0125	0.1121	74	1	0.0482	0.0219	0.0744	107	1	0.0377	0.0264	0.0489
45	3	0.0489	0.0219	0.0758	45	3	0.1318	0.0760	0.1876	60	3	0.0501	0.0271	0.0731	86	3	0.0398	0.0299	0.0497
45	2	0.0489	0.0219	0.0758	45	2	0.0715	0.0140	0.1290	60	2	0.0404	0.0165	0.0643	86	2	0.0350	0.0249	0.0452
45	1	0.0489	0.0219	0.0758	45	1	0.0112	-0.0500	0.0723	60	1	0.0307	0.0048	0.0566	86	1	0.0302	0.0194	0.0411
30	3	0.0232	-0.0050	0.0514	30	3	0.0932	0.0349	0.1514	39	3	0.0239	-0.0002	0.0480	60	3	0.0306	0.0196	0.0416
30	2	0.0232	-0.0050	0.0514	30	2	0.0328	-0.0267	0.0924	39	2	0.0142	-0.0107	0.0391	60	2	0.0258	0.0149	0.0367
30	1	0.0232	-0.0050	0.0514	30	1	-0.0275	-0.0903	0.0353	39	1	0.0045	-0.0223	0.0312	60	1	0.0210	0.0098	0.0323
Liberal Policy																			
AF Target		**0.104**	Lower	Upper	**MF Target**		**0.290**	Lower	Upper	**CF Target**		**0.098**	Lower	Upper	**PF Target**		**0.069**	Lower	Upper
SL	Bag	Harvest	Interval	Interval	SL	Bag	Harvest	Interval	Interval	SL	Bag	Harvest	Interval	Interval	SL	Bag	Harvest	Interval	Interval
60	6	0.0745	0.0474	0.1017	60	6	0.3514	0.2888	0.4141	74	6	0.0967	0.052	0.1065	107	6	0.0616	0.0508	0.0723
60	5	0.0745	0.0474	0.1017	60	5	0.2911	0.2325	0.3497	74	5	0.087	0.0619	0.1121	107	5	0.0568	0.0468	0.0668
60	4	0.0745	0.0474	0.1017	60	4	0.2308	0.1743	0.2873	74	4	0.0773	0.0536	0.1009	107	4	0.052	0.0424	0.0616
60	3	0.0745	0.0474	0.1017	60	3	0.1679	0.1116	0.2242	74	3	0.0676	0.0442	0.0909	107	3	0.0472	0.0375	0.057
60	2	0.0745	0.0474	0.1017	60	2	0.1101	0.0517	0.1686	74	2	0.0579	0.0336	0.0821	107	2	0.0424	0.0321	0.0528
60	1	0.0745	0.0474	0.1017	60	1	0.0498	-0.0125	0.1121	74	1	0.0482	0.0219	0.0744	107	1	0.0377	0.0264	0.0489
45	3	0.0489	0.0219	0.0758	45	3	0.1318	0.076	0.1876	60	3	0.0501	0.0271	0.0731	86	3	0.0398	0.0299	0.0497
45	2	0.0489	0.0219	0.0758	45	2	0.0715	0.014	0.129	60	2	0.0404	0.0165	0.0643	86	2	0.035	0.0249	0.0452
45	1	0.0489	0.0219	0.0758	45	1	0.0112	-0.05	0.0723	60	1	0.0307	0.0048	0.0566	86	1	0.0302	0.0194	0.0411