U.S. Fish & Wildlife Service

Adaptive Harvest Management

Adjustments for SEIS 2013

PREFACE

This report provides a summary of revised methods and assessment results based on updated adaptive harvest management (AHM) protocols developed in response to the preferred alternative specified in the Final Supplemental Environmental Impact Statement on the Issuance of Annual Regulations Permitting the Hunting of Migratory Birds (SEIS; U.S. Department of the Interior 2013). We describe necessary changes to optimization procedures and decision processes for the implementation of AHM for midcontinent, eastern and western mallards (*Anas platyrhynchos*), northern pintails (*Anas acuta*), and scaup (*Aythya affinis, A. marila*) decision frameworks. We present this final report for communication purposes, and acknowledge that any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

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1 Background

The preferred alternative of the Final SEIS on the Issuance of Annual Regulations Permitting the Hunting of Migratory Birds (SEIS; U.S. Department of the Interior 2013) describes several recommendations to adjust the annual decision-making process for establishing migratory bird hunting regulations. Under Alternative 2 (preferred), the Final SEIS specifies a modified annual regulatory process and schedule (see appended meeting schedule) that includes the following considerations:

- early and late season regulatory actions are combined into a single process;
- regulatory proposals would be developed based on data from the previous year, model predictions, or current-year information;
- the status of ducks and geese would be made available to the public in August;
- Flyway and Council meetings would be held in the early Fall with proposals for the next year's hunting season considered by the Service Regulations Committee (SRC) in late October;
- SRC recommendations for the next year's hunting season would be forwarded to the Service Director and Assistant Secretary with proposed frameworks published in the Federal Register in December;
- the Final rule would then be published in late February and States would make selections by late April.

From a decision-making perspective, the primary consequence of the proposed process under Alternative 2 is the scheduling of a single regulatory meeting in the fall of year t to inform regulations for the next year's upcoming hunting season in year $t + 1$. As a result, regulatory decisions for the upcoming hunting season would be made in advance of observing the status of waterfowl breeding populations (BPOP) and habitat conditions during the spring prior to the upcoming hunting season (Table 1). Effectively, the changes in decision timing associated with the SEIS introduces a lag in the adaptive harvest management (AHM) process where model weight updating and state-dependent decision making are now governed by the previous year's monitoring information. Given that current AHM protocols were developed based on the availability of the most recent monitoring information, we developed technical adjustments in response to these changes in decision timing and investigated the implications of these adjustments to expected performance of operational AHM decision-making frameworks.

Table 1 – The timing of key events depicted in annual decision making under the current AHM protocol compared to the decision-making process considered in the 2013 Final SEIS. Under SEIS 2013, decisions for the hunting season in year $t + 1$ would be made in October of year t based on observations of BPOP and ponds and the regulation selected in year t.

Month	AHM (pre-SEIS 2013)	SEIS 2013 (Alternative 2)
Oct(t-1)		Inform regulatory decision for year t based on observations and regulations from year t-1
May(t)	Observe BPOP, ponds, harvest rates	Observe BPOP, ponds, harvest rates
July(t)	Update model weights and harvest rate distributions	Update model weights and harvest rate distributions
	Derive policy for hunting season in year t	
Aug(t)	Inform regulatory decision for year t based on observations from year t	Derive policy for hunting season in year t+1
Oct(t)		Inform Regulatory Decision for year t+1 based on observations and regulations from year t

2 Problem Description

The setting of annual waterfowl harvest regulations follows a sequential decision process that includes monitoring, biological assessments, regulatory meetings, and rule-making (Blohm 1989). Since 1995, the USFWS and Flyway Councils have applied the principles of adaptive management to inform harvest management decisions in the face of uncertainty while trying to learn about system responses to harvest regulations and environmental changes (Williams and Johnson 1995, Johnson et al. 1997, U.S. Fish and Wildlife Service 2014). Prior to SEIS 2013, the annual AHM process began with the observation of the system state each spring followed by an updating of model weights and the derivation of an optimal harvest policy that was then used to make a state-dependent decision (i.e., BPOP estimates were used with the policy matrix to inform harvest regulatory decisions; Figure 1). The system state then evolves over time in response to the decision and natural variation in population dynamics. The following spring, the monitoring programs observe the state of the system and the iterative decision-making process continues forward in time. With the changes in decision timing specified by the SEIS, the post-survey AHM process will not be possible because monitoring information describing the system state will not be available at the time the decision must be made. As a result, the optimization framework used to derive harvest policy can no longer calculate current and future harvest values as a function of current system and model states. To address this issue, we chose to revise the optimization procedure to evaluate harvest utility values U by conditioning on what is known at the time of the decision. We modified the utility function to calculate average harvest utilities U based on weights q for each model i with

$$U(a_t|x_{t-1}, a_{t-1}, q_{t-1}) = \sum_i q_{t-1}(i) U_i(a_t|x_{t-1}, a_{t-1}),$$

which now specifies that the calculation of utility values is conditioned on the previous year's (t-1) observation of the system state (x), regulatory decision (a), and updated model weights (q_i). This new calculation then formed the basis to develop optimization code to calculate current and future harvest utilities with a new value function V^* according to

$$V^*(x_{t-1}, a_{t-1}, q_{t-1}) = \max_{a_t}\left\{U(a_t|x_{t-1}, a_{t-1}, q_{t-1}) + \sum_{x_t, a_t} p_i(x_t|x_{t-1}, a_{t-1}, q_{t-1}) V^*(x_t, a_t, q_{t-1})\right\}.$$

Based on this formulation, the previous year's regulatory decision (a_{t-1}) now informs the current regulatory decision (see Figure 1 B.). Our prediction of future system states and harvest values must now account for the additional uncertainty about resource status at the time of the decision. As a result, we had to modify the optimization code used for all AHM decision frameworks so we can continue to use stochastic dynamic programming (Williams et al. 2002) while accounting for the new value function formulation (V^*). These modifications were further complicated by the fact that the optimization software ASDP (Lubow 1995) we typically use to derive harvest policies has not been maintained and was not amenable for developing the necessary changes in optimization procedures. We developed updated optimization code with new software implemented with the Matlab toolbox (MDPSOLVE©) under the guidance of the software developer Paul Fackler.

3 Adjustments to AHM Frameworks

In developing technical adjustments for the implementation of AHM under the SEIS 2013 recommendations we wanted to first establish a set of post-survey optimization results with the new software MDPSOLVE that were consistent with the results expected from the current software ASDP. For each AHM decision framework, we compared optimization results resulting from current, post-survey AHM protocols calculated with ASDP to optimal harvest policies derived with MDPSOLVE. We then adjusted the optimization procedures and

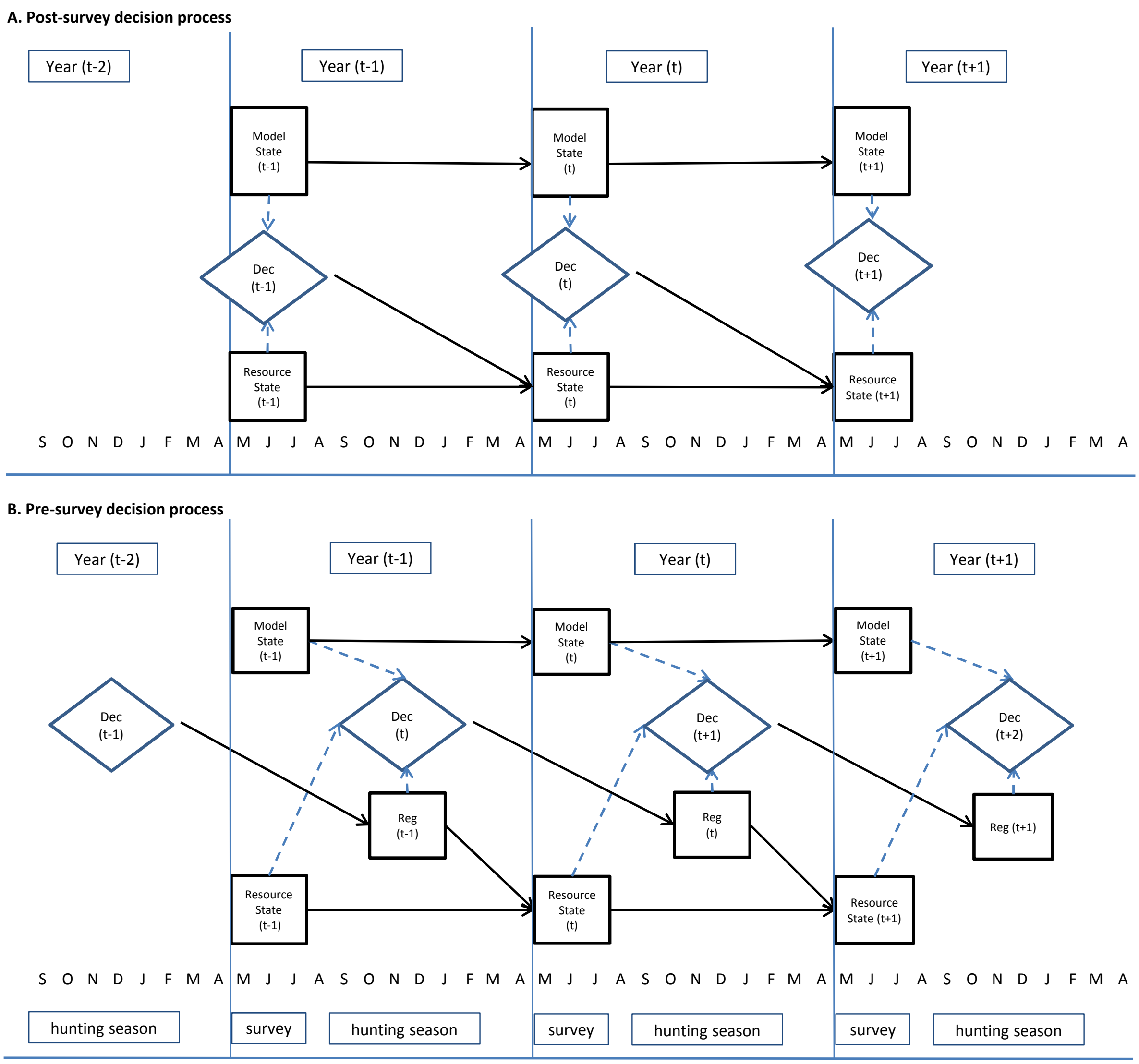

Figure 1 – A. Post-survey decision process based on annual observations of system state and updated model state; each decision in year t is based on system and model states observed in year t. B. Pre-survey decision process where annual monitoring information is not available at the time the decision is made for year t. For any given year t, annual regulatory decisions are made the previous year t-1 based on available observations of system state, updated model state, and knowledge of the previous year's regulation.

model code to evaluate the new value function (V^*) under the pre-survey AHM protocols with MDPSOLVE. We then simulated the state dynamics under the assumption that decision making would adhere to the resulting policies and calculated summary statistics describing harvest management performance. For each AHM decision-making framework, we compared harvest policies and simulation results from pre-survey and post-survey optimizations to characterize differences in the expected management performance under each protocol.

3.1 Midcontinent Mallards

The USFWS implemented a formal AHM process for informing harvest management regulations in the Mississippi and Central Flyways based solely on the status of midcontinent mallards in 1995. Midcontinent mallards are defined as those breeding in Waterfowl Breeding and Habitat Survey (WBPHS; strata 13–18, 20–50, and 75–77), and the lake States in the Great Lakes region (Michigan, Minnesota, and Wisconsin; Figure 2). The harvest management objective for midcontinent mallards is to maximize cumulative harvest over the long-term subject to a constraint to limit regulations that would be expected to result in breeding population sizes below the North American Waterfowl Management Plan (NAWMP) goal. The current objective for mid-continent mallards uses a population goal of 8.5 million birds, which consists of 7.9 million mallards from the WBPHS (strata 13–18, 20–50, and 75–77) corresponding to the mallard population goal in the 1998 update of the NAWMP (less the portion of the mallard goal comprised of birds breeding in Alaska) and a goal of 0.6 million for the combined States of Michigan, Minnesota, and Wisconsin. In addition to the NAWMP constraint, the midcontinent mallard AHM protocol includes a closed season constraint that excludes the consideration of closed seasons when the estimated BPOP is greater than 4.75 million birds. The midcontinent mallard AHM framework specifies four possible regulatory alternatives: closed, restrictive, moderate, and liberal seasons. Expected harvest rates for each alternative are updated each year from band-recovery data (Table 2).

The midcontinent mallard AHM framework includes models to represent the dynamics of the mallard breeding population along with expected changes in the number of Canadian ponds observed in the WBPHS. Details describing the set of population models for midcontinent mallards can be found in the most recent AHM report (U.S. Fish and Wildlife Service 2014). The model set consists of four alternatives, formed by the combination of two survival hypotheses (additive vs. compensatory hunting mortality) and two reproductive hypotheses (strongly vs. weakly density-dependent).

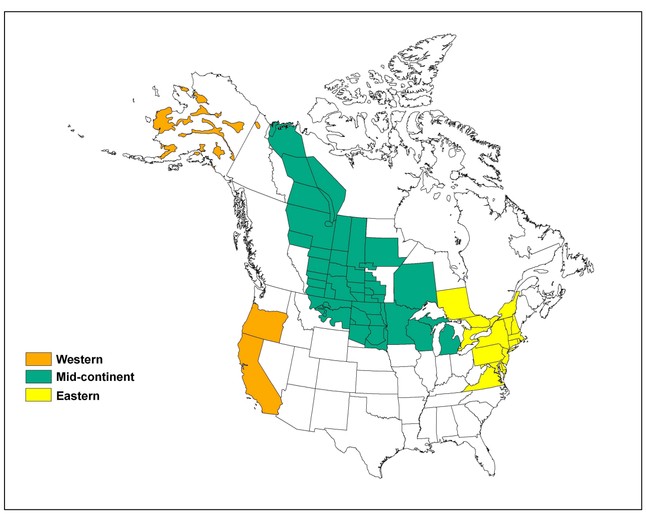

Figure 2 – Survey areas currently assigned to the midcontinent, eastern, and western stocks of mallards for the purposes of AHM.

Table 2 – Predictions of harvest rates of adult, male, midcontinent, eastern, and western mallards expected with application of the 2014 regulatory alternatives in the Mississippi and Central, Atlantic, and Pacific Flyways.

	Midcontinent		Eastern		Western	
Regulatory Alternative	Mean	SD	Mean	SD	Mean	SD
Closed (U.S.)	0.0088	0.0019	0.0797	0.0231	0.0081	0.0181
Restrictive	0.0553	0.0129	0.1064	0.0393	0.0612	0.0173
Moderate	0.0987	0.0215	0.1294	0.0472	0.1020	0.0288
Liberal	0.1146	0.0184	0.1415	0.0368	0.1203	0.0290

We had to make some small changes to the settings of the optimization used to derive harvest policies for midcontinent mallard AHM to account for the change in decision timing and the evaluation of the updated value function (V^*). In particular, we needed to translate a set of optimization constraints (e.g., the closed season constraint or the utility function for devaluing harvest values when subsequent populations are less than the NAWMP goal) into new quantitative expressions that fit within the timing of the new decision context and the availability of updated information. Unfortunately, there were no straightforward solutions to developing these constraints under the SEIS protocol because of the inherent differences in the timing sequences between the two decision frameworks. As a result, we specified the closed season constraint based on the last observed BPOP rather than the current BPOP because this value would be unobservable at the time the decision is made. In addition, we specified the harvest devaluation associated with the NAWMP constraint based on our belief about the BPOP at the time the decision is made which requires calculating the expected population size conditional on the last decision. In specifying these optimization settings, we endeavored to be consistent with the original purposes of the constraints, but we stress that further investigation is warranted to determine whether the new implementation of these constraints produces the intended consequences.

Post-survey harvest policies calculated with 2014 model weights and MDPSOLVE were similar to results derived with the ASDP software (Figure 3). Because pre-survey harvest policies must now be conditioned on all possible regulatory decisions that could have been made the previous year, the optimal policy now includes the optimal regulatory choice for each combination of BPOP, Canadian ponds, and the regulatory alternatives considered the previous year (Figure 4). The pre-survey policies had a much smaller band of the state space specifying moderate regulations compared to the post-survey policies. In general, pre-survey policies were more liberal when the previous year's decision was more conservative. Simulations of the post- and pre-survey policies indicated that we would expect similar long-term harvest management performance of these AHM protocols with the exception of fewer moderate regulatory decisions based on the pre-survey harvest policies (Table 3).

3.2 Eastern Mallards

In 2000, the USFWS implemented a formal AHM process for informing harvest management regulations in the Atlantic Flyway (AF) based solely on eastern mallards. Eastern mallards are defined as mallards breeding in the AF States from Virginia north to New Hampshire, in southeastern Ontario (USFWS strata 51-54), and southwestern Quebec (USFWS strata 56). The breeding population of these mallards has been surveyed since 1990 from fixed-wing aircraft in the Canadian portion of the range (Zimmerman et al. 2012) and ground plot surveys in the US portion (Sauer et al. 2014).

The objective for eastern mallard AHM is to maximize long-term cumulative harvest. The framework considers four regulatory alternatives: closed, restrictive, moderate, and liberal seasons. The most recent (2014) update of expected harvest rates under each of these four alternatives indicates that they are higher than the expected rates for the other two stocks, particularly for a closed season when birds can still be harvested in eastern Canada (see Table 2). Models used in eastern mallard AHM are based on a single state

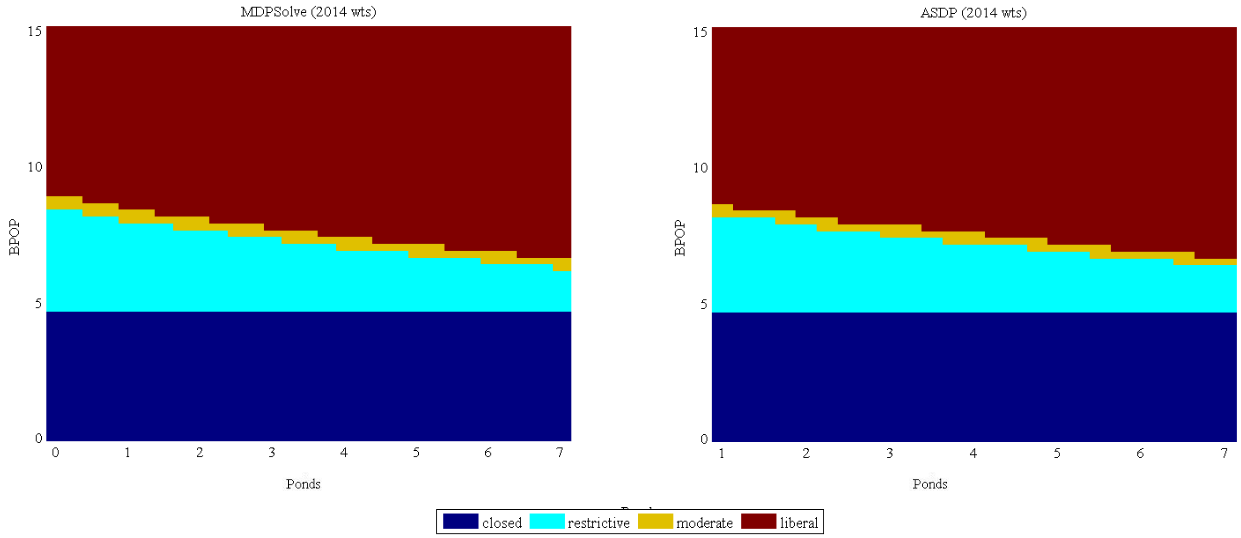

Figure 3 – Comparison of midcontinent mallard harvest policies calculated with ASDP and MDPSOLVE based on post-survey AHM protocols and 2014 model weights. BPOP and Canadian ponds are measured in millions.

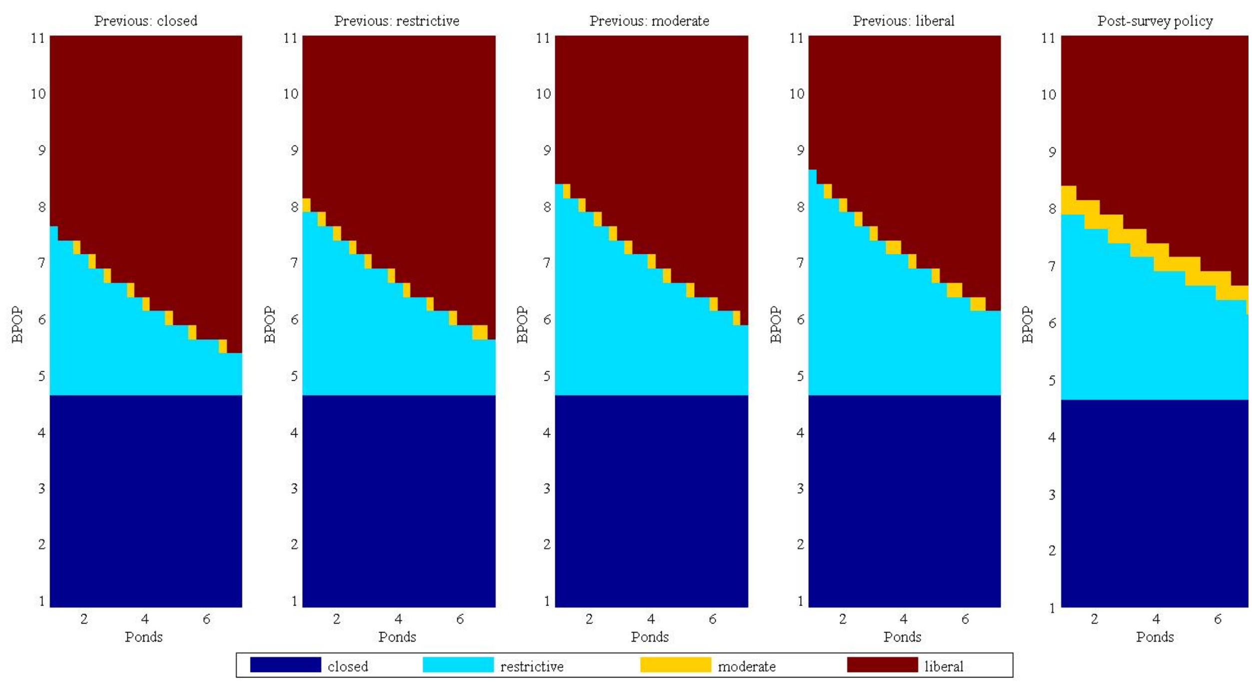

Figure 4 – Midcontinent mallard pre-survey harvest policies derived with updated optimization methods that account for changes in decision timing associated with AHM protocols specified under the SEIS. Harvest policies were calculated with the 2014 midcontinent mallard model weights. Based on updated AHM protocols, harvest decisions for year t will now be made before breeding survey information for year t is available. As a result, current and future harvest values are calculated based on the decision and observations made the previous year. For comparative purposes, the post-survey harvest policy calculated with 2014 AHM protocols is included.

Table 3 – Summary statistics resulting from simulations of pre- and post-survey midcontinent mallard AHM protocols. For each protocol, midcontinent mallard population dynamics were simulated for 50,000 iterations; harvest policies were derived based on 2014 model weights.

Summary statistic	Post-survey	Pre-survey
Mean BPOP[a]	6.76	6.70
% Closed	0.1755	0.1794
% Restrictive	0.3940	0.3992
% Moderate	0.0846	0.0208
% Liberal	0.3460	0.4006
$\Delta Reg^{\dagger}$	0.3195	0.2813

[a] Average breeding population size (in millions) over all iterations of the simulation.
† The percent of years when regulatory decisions were different than the previous year.

variable (BPOP) and represent 4 alternative hypotheses describing different combinations of the relationship between harvest mortality and annual survival (i.e., additive vs compensatory models) and density-dependent effects on recruitment (i.e., strong vs weak).

Comparison of the post-survey policies derived with ASDP and MDPSOLVE indicate a small difference in optimal regulations at 0.300 million mallards (Table 4). The pre-survey policy followed an intuitive pattern in that the policy was more liberal if the prior seasons were closed or restrictive compared to when the prior seasons were moderate and liberal. Comparison of the post-survey policy to the pre-survey policy indicated that the pre-survey policy would be slightly more liberal than the post-survey policy. Simulated post- and pre-survey policies suggest that we would expect similar long-term harvest management performance of these polices (Table 5).

Table 4 – Eastern mallard pre-survey harvest policies derived with updated optimization methods that account for changes in decision timing associated with AHM protocols specified under the SEIS. Harvest policies were calculated with the 2014 eastern mallard model weights. Based on updated AHM protocols, harvest decisions for year t will now be made before breeding survey information for year t is available. As a result, current and future harvest values are calculated based on the decision and observations made the previous year. For comparative purposes, the post-survey harvest policies calculated with ASDP and MDPSOLVE based on 2014 AHM protocols are included.

	Post-survey AHM†		Pre-survey AHM† (Previous regulation)			
BPOP[a]	ASDP	MDPSOLVE	Liberal	Moderate	Restrictive	Closed
0.175	C	C	C	C	C	C
0.2	C	C	C	C	R	R
0.225	C	C	R	L	L	L
0.25	C	C	L	L	L	L
0.275	C	C	L	L	L	L
0.3	L	R	L	L	L	L
0.325	L	L	L	L	L	L
0.35	L	L	L	L	L	L

[a] Breeding population in millions.
† C = closed, R = restrictive, M = moderate, and L = liberal regulatory alternative.

Table 5 – Summary statistics resulting from simulations of pre- and post-survey eastern mallard AHM protocols. For each protocol, eastern mallard population dynamics were simulated for 50,000 iterations; harvest policies were derived based on 2014 model weights.

Variable	Post Survey	Pre Survey
Mean BPOP[a]	1.2889	1.2797
% Closed	0.1726	0.1693
% Restrictive	0.0308	0.0257
% Moderate	0	0
% Liberal	0.7966	0.805

[a] Average breeding population size (in millions) over all iterations of the simulation.

3.3 Western Mallards

In 2008, the USFWS implemented a formal AHM process for informing harvest regulations in the Pacific Flyway based solely on western mallards. Western mallards are defined as those breeding in California, Oregon, Alaska and a small portion of the Yukon Territory (USFWS strata 1-12). Western mallards are surveyed from fixed-wing aircraft during State-funded surveys in California and Oregon. Alaska mallards are also surveyed from fixed-wing aircraft, but are monitored during the WBPHS.

The objective for western mallard AHM is to maximize long-term cumulative harvest subject to a constraint intended to avoid extreme changes in regulations with relatively small changes in population size. The dynamics of the Alaska population and the California-Oregon population are modeled independently but share a common regulatory alternative with correlated harvest rates. A complete description of the models used to predict Alaska and California-Oregon population change can be found in the most recent AHM report (U.S. Fish and Wildlife Service 2014). Similar to the other mallard stocks, western mallard AHM considers closed, restrictive, moderate, and liberal alternatives (see Table 2). Although the season lengths and bag limits are larger than the other mallard protocols, the expected harvest rates under the restrictive, moderate, and liberal seasons are less than those for eastern mallards and similar to those for midcontinent mallards.

Adjustments to the western mallard optimization for a pre-survey decision policy required changes to how the constraint in the western mallard objective function was parameterized. Unfortunately, the methods used in the software ASDP were not transferable to the updated optimization procedures developed with MDPSOLVE. In anticipation of the 2016-17 regulatory decision, we removed the constraint for implementation of pre-survey AHM protocols with the expectation that the FWS will continue working with the Pacific Flyway to develop an updated objective function that fully captures their harvest management objectives. Overall, post-survey western mallard harvest policies calculated with MDPSOLVE without the constraint were similar to policies calculated with ASDP (Figure 5) with the exception of the MDPSOLVE optimization that resulted in a slightly less knife-edged policy that included more state combinations specifying the restrictive package. The pre-survey policies suggest an intuitive pattern in that the more liberal the decision the previous year, the resulting strategy becomes more conservative (Figure 6). Overall, these policies were similar to the post-survey policy. Simulations of the post- and pre-survey policies suggest that we would expect similar long-term harvest management performance of these AHM protocols (Table 6).

3.4 Northern Pintails

In 2010, the Flyway Councils and the USFWS established an adaptive framework to inform northern pintail harvest management decisions. The harvest-management objective for northern pintail AHM is to maximize long-term cumulative harvest subject to a constraint that provides for an open hunting season when the observed breeding population is above 1.75 million birds. The pintail AHM protocol considers a range of

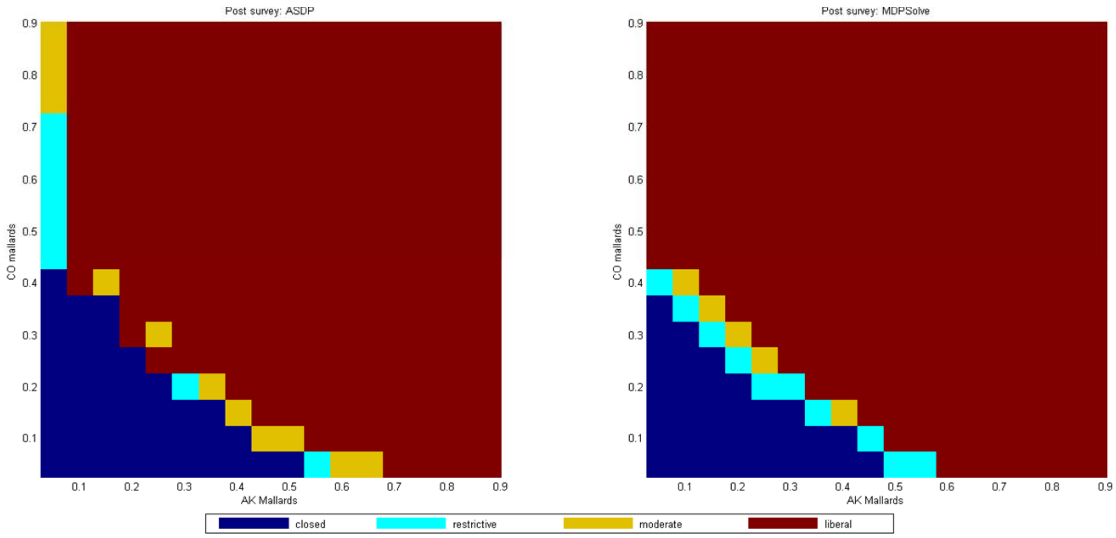

Figure 5 – Comparison of western mallard harvest policies calculated with ASDP and MDPSOLVE based on post-survey AHM protocols and 2014 population parameter updates and model weights. California-Oregon (CO) and Alaska (AK) mallards are measured in millions.

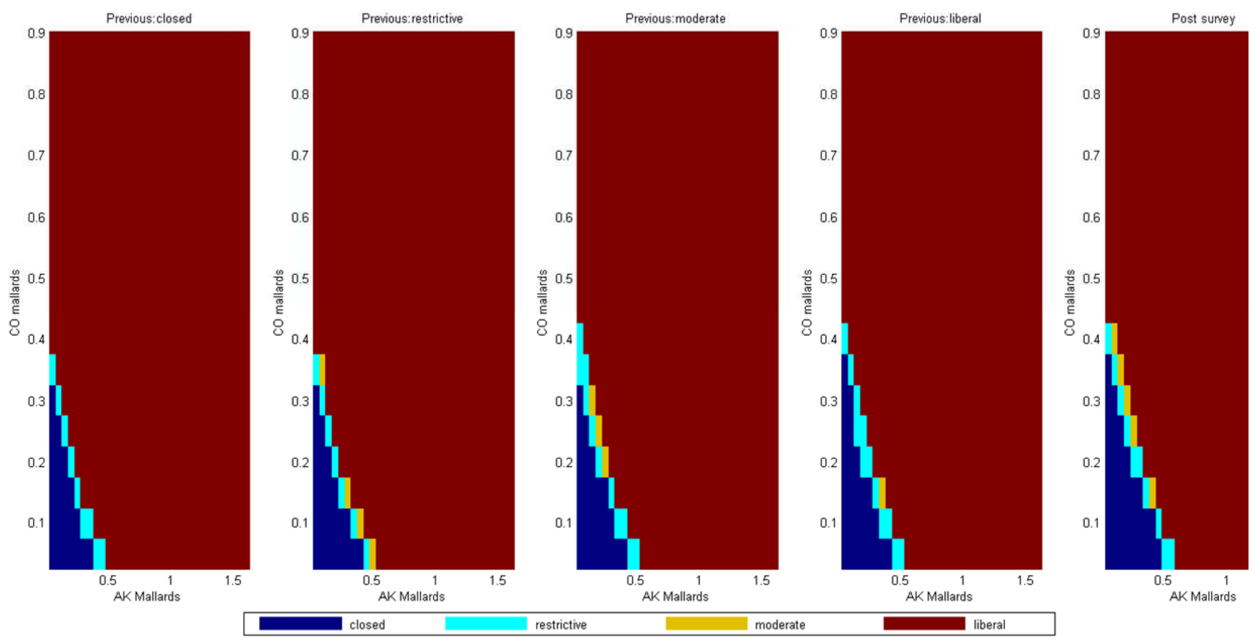

Figure 6 – Western mallard pre-survey harvest policies derived with updated optimization methods that account for changes in decision timing associated with AHM protocols specified under the SEIS. Harvest policies were calculated with the 2014 updated population parameters and model weights. Based on updated AHM protocols, harvest decisions for year t will now be made before breeding survey information for year t is available. As a result, current and future harvest values are calculated based on the decision and observations made the previous year. For comparative purposes, the post-survey harvest policy calculated with 2014 AHM protocols is included.

Table 6 – Summary statistics resulting from simulations of pre- and post-survey western mallard AHM protocols. For each protocol, western mallard population dynamics were simulated for 50,000 iterations; harvest policies were derived based on 2014 updated population parameters and model weights.

Summary statistic	Post-survey	Pre-survey
Mean AK BPOP[a]	0.5781	0.5720
Mean CA-OR BPOP[a]	0.4402	0.4385
% Closed	0	0
% Restrictive	0	0
% Moderate	0	0
% Liberal	1	1

[a] Average breeding population size (in millions) over all iterations of the simulation.

regulatory alternatives that includes a closed season, 1-bird daily bag limit, or 2-bird daily bag limit. The maximum pintail season length depends on the general duck season framework (characterized as liberal, moderate, or restrictive and varying by Flyway) specified by mallard AHM. An optimal pintail regulation is calculated under the assumption of a liberal mallard season length in all Flyways. However, if the season length of the general duck season determined by mallard AHM is less than liberal in any of the Flyways, then an appropriate pintail daily bag limit would be substituted for that Flyway. Thus, a shorter season length dictated by mallard AHM would result in an equivalent season length for pintails, but with increased bag limit if the expected harvest remained within allowable limits.

The current AHM protocol for pintails considers two state variables (BPOP and the mean latitude of the BPOP distribution) to represent pintail population and harvest dynamics. The model set specifies alternative hypotheses about the effect of harvest on population dynamics: one in which harvest is additive to natural mortality, and another in which harvest is compensatory to natural mortality. The compensatory model assumes that the mechanism for compensation is density-dependent post-harvest (winter) survival. The models differ only in how they incorporate the winter survival rate. In the additive model, winter survival rate is a constant, whereas winter survival is density-dependent in the compensatory model. A complete description of the model set used to predict pintail population change can be found in the most recent AHM report (U.S. Fish and Wildlife Service 2014).

We made necessary adjustments to the the pintail optimization to derive a pre-survey harvest policy. Similar to the mallard protocols, we also had to specify the closed season constraint based on the last observed BPOP rather than the current BPOP, because this value would be unobservable at the time the decision is made. Overall, post-survey pintail harvest policies calculated with MDPSOLVE were similar to policies calculated with ASDP (Table 7). Similar to the results for mallards under the pre-survey protocols, the pintail policy becomes more restrictive (more Liberal 1 cells) the more liberal the decision was the previous year (Figure 7). In addition, the higher the latitude observed in the previous year results in a policy with more Liberal 1 cells. Simulations of the post- and pre-survey pintail harvest policies, under the assumption of a liberal season framework, suggest that we would expect similar long-term harvest management performance of these AHM protocols (Table 8).

3.5 Scaup

In 2008, the USFWS and Flyway Councils first implemented an AHM framework to inform scaup harvest regulations (Boomer and Johnson 2007) based on an objective to achieve 95% of the long-term cumulative harvest (MSY). The current scaup AHM protocol first derives optimal harvest levels which are then used to determine the recommended regulatory package. Each year, an optimization is performed to identify the optimal harvest level based on updated scaup population parameters. The harvest regulation is then determined by comparing the optimal harvest level to the harvest thresholds corresponding to restrictive,

Table 7 – Comparison of pintail harvest policies calculated with ASDP and MDPSOLVE based on post-survey AHM protocols and 2014 model weights.

ASDP†	Latitude														
BPOP[a]	52	52.5	53	53.5	54	54.5	55	55.5	56	56.5	57	57.5	58	58.5	59
≤1.6	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
1.8	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1
2	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1
2.2	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1
2.4	L2	L2	L2	L2	L2	L1	L1	L2	L2	L2	L2	L2	L2	L2	L2
2.6	L2	L2	L2	L2	L2	L2	L2	L2	L2	L2	L2	L2	L2	L2	L2
2.8	L2	L2	L2	L2	L2	L2	L2	L2	L2	L2	L2	L2	L2	L2	L2
≥3	L2	L2	L2	L2	L2	L2	L2	L2	L2	L2	L2	L2	L2	L2	L2
MDPSOLVE†															
BPOP[a]															
≤1.6	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
1.8	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1
2	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1
2.2	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1	L1
2.4	L2	L2	L2	L2	L2	L2	L2	L2	L2	L2	L2	L2	L2	L2	L2
2.6	L2	L2	L2	L2	L2	L2	L2	L2	L2	L2	L2	L2	L2	L2	L2
2.8	L2	L2	L2	L2	L2	L2	L2	L2	L2	L2	L2	L2	L2	L2	L2
≥3	L2	L2	L2	L2	L2	L2	L2	L2	L2	L2	L2	L2	L2	L2	L2

[a] Breeding population in millions.

† C = closed, L1 = liberal season length and 1 bird bag limit, L2 = liberal season length and 2 bird bag limit.

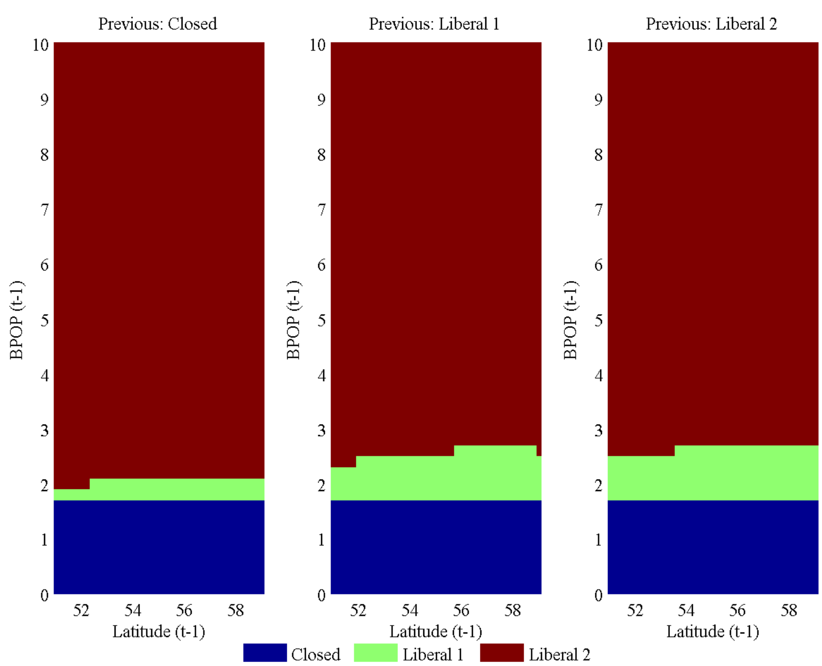

Figure 7 – Northern pintail pre-survey harvest policies derived with updated optimization methods that account for changes in decision timing associated with AHM protocols specified under the SEIS. Harvest policies were calculated with the 2014 pintail model weights. Based on updated AHM protocols, harvest decisions for year t will now be made before breeding survey information for year t is available. As a result, current and future harvest values are calculated based on the decision and observations made the previous year.

Table 8 – Summary statistics resulting from simulations of pre- and post-survey northern pintail AHM protocols. For each protocol, northern pintail population dynamics were simulated for 10,000 iterations; harvest policies were derived based on 2014 model weights.

Summary statistics	Post-survey	Pre-survey
Mean BPOP[a]	2.2	2.2
% Closed	0.293	0.316
% Liberal 1	0.274	0.316
% Liberal 2	0.433	0.368

[a] Average breeding population size (in millions) over all iterations of the simulation.

moderate, and liberal packages (see Boomer et al. 2007). Due to the changes in decision timing associated with the SEIS, these procedures will not be possible because decision makers would have to condition their regulatory decision on the harvest levels observed in the previous year and this information will not be available at the time of the decision. As a result, the decision variable (harvest) in the scaup optimization will have to be changed from harvest levels to a set of packages. Scaup harvest levels associated with each regulatory package will need to be specified as the decision variable in the updated optimization methods. We used the thresholds identified in Boomer et al. (2007) to specify expected harvest levels for each package (Table 9). To account for partial controllability of the scaup harvest, we assumed that the harvest under each package could be represented with a normal distribution with the mean set to the expected harvest level, assuming a coefficient of variation equal to 20%.

The scaup AHM framework is based on a discrete-time, stochastic, logistic-growth population model to represent changes in the continental scaup population, while explicitly accounting for scaling issues associated with the monitoring data. Details describing the modeling and assessment framework that has been developed for scaup can be found in the most recent AHM report (U.S. Fish and Wildlife Service 2014). We made necessary adjustments to the the scaup optimization to derive a pre-survey harvest policy. Overall, post-survey scaup harvest policies calculated with MDPSOLVE were similar to policies calculated with ASDP (Table 10). Similar to the results for mallards under the pre-survey protocols, the scaup policy becomes more restrictive the more liberal the decision was the previous year. Simulations of the post- and pre-survey scaup harvest policies, under the assumption of liberal season frameworks, indicated that we would expect similar long-term harvest management performance of these AHM protocols (Table 11).

Table 9 – Regulatory alternatives and total expected harvest levels corresponding to the restrictive, moderate, and liberal packages considered in the scaup AHM decision framework.

Package[a]	Atlantic	Mississippi	Central	Pacific	Expected Total Harvest[c]
Closed					0.04
Restrictive	20(2)/40(1)[b]	45(2)/15(1)[b]	39(2)/35(1)[b]	86(2)	0.20
Moderate	60(2)	60(3)	74(3)	86(3)	0.35
Liberal	60(4)	60(4)	74(6)	107(7)	0.60

[a] Season length in days (bag limit); these alternatives assume an overall liberal AHM framework as determined by the status of mallards.
[b] Multiple day and bag limit combinations refer to hybrid seasons which allow for different bag limits over a continuous season length.
[c] Total harvest in millions (Canada and U.S. combined).

Table 10 – Optimal scaup, post-survey and pre-survey harvest policies calculated with the 2014 scaup population parameter updates and model weights. The pre-survey policies were derived with updated optimization methods that account for changes in decision timing associated with AHM protocols specified under the SEIS. Based on updated AHM protocols, harvest decisions for year t will now be made before breeding survey information for year t is available. As a result, current and future harvest values are calculated based on the decision and observations made the previous year. For comparative purposes, the post-survey optimal harvest levels (calculated with ASDP and MDPSOLVE) and optimal harvest policy (calculated with MDPSOLVE) based on 2014 AHM protocols are included.

	Post-survey AHM			Pre-survey AHM[p]			
				Previous regulation			
BPOP[a]	ASDP[h]	MDPSOLVE[h]	MDPSOLVE[p]	Closed	Restrictive	Moderate	Liberal
0.2	0	0	C	C	C	C	C
0.4	0	0	C	C	C	C	C
0.6	0	0	C	C	C	C	C
0.8	0	0	C	C	C	C	C
1	0	0	C	C	C	C	C
1.2	0	0	C	C	C	C	C
1.4	0	0	C	C	C	C	C
1.6	0	0	C	C	C	C	C
1.8	0	0	C	C	C	C	C
2	0.05	0.05	C	C	C	C	C
2.2	0.05	0.05	C	C	C	C	C
2.4	0.1	0.1	C	C	C	C	C
2.6	0.1	0.1	C	R	R	C	C
2.8	0.15	0.15	R	R	R	R	C
3	0.15	0.15	R	R	R	R	R
3.2	0.2	0.2	R	R	R	R	R
3.4	0.2	0.2	R	R	R	R	R
3.6	0.25	0.25	R	M	R	R	R
3.8	0.25	0.3	M	M	M	M	R
4	0.3	0.3	M	M	M	M	M
4.2	0.35	0.35	M	M	M	M	M
4.4	0.4	0.35	M	M	M	M	M
4.6	0.4	0.4	M	M	M	M	M
4.8	0.45	0.45	M	L	L	M	M
5	0.5	0.5	L	L	L	L	M
5.2	0.5	0.5	L	L	L	L	L

[a] Scaup breeding population in millions.
[h] Decision variable in the optimization was a range of harvest levels (in millions).
[p] Decision variable in the optimization was the set of regulatory packages (C = closed, R = restrictive, M = moderate, L=liberal).

Table 11 – Summary statistics resulting from simulations of pre- and post-survey scaup AHM protocols. For each protocol, scaup population dynamics were simulated for 10,000 iterations; harvest policies were derived based on 2014 updated population parameters and model weights..

Summary statistics	Post-survey	Pre-survey
Mean BPOP[a]	4.65	4.62
% Closed	0.0	0.0
% Restrictive	0.05	0.03
% Moderate	0.61	0.67
% Liberal	0.34	0.30

[a] Average breeding population size (in millions) over all iterations of the simulation.

4 Summary

The necessary adjustments to the optimization procedures and AHM protocols to account for changes in decision timing are not expected to result in major changes to expected management performance from mallard, pintail, and scaup AHM. In general, pre-survey harvest policies were similar to harvest policies based on post-survey AHM protocols. We found some subtle differences in the degree of knife-edge in the pre-survey policies with a reduction in the number of cells indicating moderate regulations. In addition, pre-survey policies became more liberal when conditioning on previous decisions that were more conservative. These patterns were consistent for each AHM decision-making framework. Overall, a comparison of simulation results of the pre- and post-survey protocols did not suggest substantive changes in the frequency of regulations or in the expected average population size. These results suggest that the additional form of uncertainty that the change in decision timing introduces is not expected to limit our expected harvest management performance with the adoption of the pre-survey AHM protocols.

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Appendix 2016-2017 Regulatory Schedule

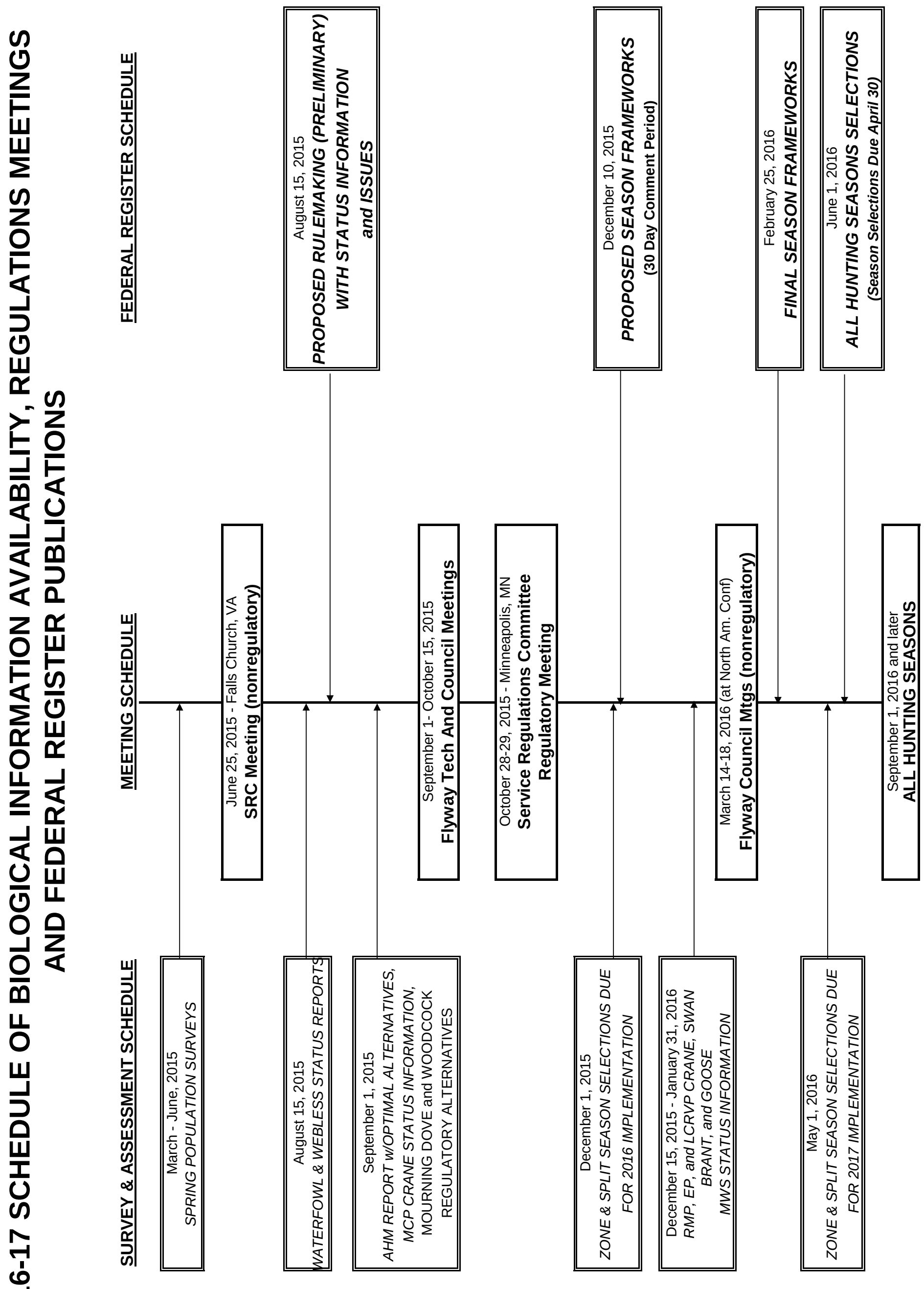

Figure A.1 – Schedule of biological information availability, regulation meetings, and Federal Register publications for the 2016–2017 regulations cycle with updated AHM protocols associated with the implementation of SEIS 2013.

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