Potential Take Level Analyses and a Decision Support Tool for Canvasbacks

Greg Balkcom (GA DNR), Steve Cordts (MN DNR), Pam Garrettson (USFWS), Jeff Knetter (ID Fish and Game), Erik Osnas (USFWS), Mike Szymanski (ND Game and Fish)

Technical assistance by Fred Johnson, U.S. Geological Survey

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EXECUTIVE SUMMARY

Beginning with the 2016-17 hunting seasons, a new federal regulatory cycle was implemented for setting migratory bird hunting regulations, which precludes use of the canvasback harvest management strategy that had been in use since 1994. At the October 2015 Service Regulatory Committee (SRC) meeting, the SRC requested that a group be convened to develop a decision support tool (DST) to deliver canvasback framework recommendations for the 2017-18 hunting seasons. A group of US Fish and Wildlife Service biologists and state biologists, represented by the Flyways' diving duck committee chairs, was formed to develop the DST. At the November 2015 Harvest Management Working Group meeting, this group established criteria for developing the DST, which consisted of the following: (1) it needed to be biologically based, (2) must use data that is currently available, (3) must be simple (i.e., could not require lengthy, intensive analyses), and (4) would be used as a short-term approach for developing harvest recommendations, preferably only for the next 1-2 hunting seasons. The group agreed that a "potential take level" analysis that used fixed values for demographic variables estimated for canvasbacks would likely be sufficient to use as the framework for the DST. Results from the analysis recommend canvasback seasons open, with a 1-bird daily bag, provided the most recent breeding population estimate is above 460,000. Moreover, the daily bag limit can increase to 2-birds per day when the most recent population estimate is above 480,000. The committee recognizes that this analysis used maximum sustained yield as a harvest objective and thus may not be fully reflective of the long-term canvasback population and harvest objectives of the flyways. Given the short-term use of the tool and that the flyways will be addressing long-term canvasback objectives as part of the process of revisiting overall duck harvest objectives, the committee was comfortable moving forward with the DST.

INTRODUCTION

Canvasbacks are large diving ducks that breed mostly in north-central North America, and winter in all four flyways. Relative to many ducks that share the same habitats, they are relatively long-lived, have low reproduction rates, and are among the least abundant of North American ducks. In modern times, they have been managed conservatively. Prior to 1994, canvasback harvest regulations were fairly complex, with variable bag limits and season lengths, and some area), and canvasbacks were monitored as eastern and western populations. In 1993, following a request from the flyways, USFWS personnel reviewed and analyzed available monitoring data, namely breeding population and Canadian pond estimates, harvest survey data, age-ratios, and banding and recovery data.

Based on that work, from 1994--2014, canvasbacks were managed as a single continental population, using a simple population model to predict the size of the breeding population the following spring based on the current year's BPOP, the number of Canadian ponds, and the harvest expected under each of 5 regulatory alternatives. The model incorporated cohort-specific average annual survival rates and the relationship between Canadian ponds and fall age ratios. A regulatory alternative could be chosen if the predicted BPOP was greater than 500,000. In 2007, canvasback BPOP data were reviewed, and expected harvest rates were updated with the most recent available data. At that time a liberal season with a 2-bird canvasback bag (L2) was added to the closed, restrictive, moderate and liberal 1-bird (L1) bag alternatives, but the predicted BPOP required for an L2 season was set at 725,000.

In 2015, the migratory game bird regulations-setting schedule was changed, as prescribed under SEIS 2013 (US DOI 2013), so that harvest regulations are set nearly a year in advance, and so must be informed by monitoring data from the prior rather than the current year. In August 2015, DMBM recommended an L1 bag for the 2016--17 season, based on a risk assessment and simulations that predicted the 2017 BPOP using 1994--2014 canvasback model and data. In October 2015, the flyways recommended an L2 bag for the 2016-17 season, citing the relatively low predictive power of the 1994—2014 model and the fact that no additional biological data were available between the setting of the 2015-16 season (an L2) and the decision for the 2016-17 season. The Service approved an L2 bag limit for the 2016-17 season, and DMBM and the flyways agreed to work together toward a biologically-based process for setting canvasback harvest regulations for 2017-18 and beyond.

A small committee consisting of at least one representative from each Flyway and FWS personnel formed to develop a set of priorities and objectives for canvasback harvest management. In December 2015 the Harvest Management Working Group discussed these objectives and possible options for assessing canvasback status and setting regulations.

All participants expressed a desire for stable, simple canvasback regulations. Participants also noted that the mid-continent mallard AHM double-looping process and the exploration of multiple-stock management could mean that the overall regulations framework within which canvasbacks are managed could look very different in a few years. Thus, they desired a biologically sound but simple method that could be employed in a timely manner in the interim. The group agreed to explore Potential Take Level (PTL) analyses of currently available canvasback data. With the help of USGS scientist Fred Johnson, some preliminary analyses were run, and this report summarizes those efforts, follow-up work, and the decision support tool that was developed as a result.

The process we have outlined represents one method for assessing the overall harvest potential of canvasbacks. As such, it meets the stated objectives of (1) developing a biologically-based decision tool that can be implemented for the short-term while the mid-continent mallard and Atlantic Flyway double-looping processes proceed, (2) developing a model that includes thresholds for L1, L2 and closed seasons, and (3) providing an assessment that didn't require much time or technical complexity.

These analyses may not adequately represent stakeholder objectives for long-term canvasback management (e.g., minimizing closed seasons, stable regulations). Rather, given the short time available we assessed the expected frequency of closed seasons over the long-term under an objective of maximizing cumulative harvest. A full assessment of alternative approaches, including a thorough discussion and agreement on objectives for management, acceptable harvest-management alternatives, and the biological data and models used to inform management would require additional time.

METHODS AND RESULTS

Potential take level analyses were originally developed to assess the effects of take on marine mammals (Wade 1998, Slade et al. 1998), but their use has been extended to other taxa including black vultures (Runge et al 2009), wood ducks (Garrettson 2007), sea ducks (Koneff et al. 2015), and take of passerines for the pet trade (Johnson et al. 2012). These methods all require estimates of the theoretical maximum annual growth rate (r_{max}) but differ with respect to the type of demographic information needed for its calculation. Most generally, r_{max} is calculated using an estimate of survival in the absence of harvest and an estimate of reproduction under ideal conditions (typically, low population densities).

We estimated r_{max} for the continental population of canvasbacks, using the demographic invariants method (Niel and Lebreton 2005, Madsen et al. 2015). We used this estimate of r_{max} in a discrete logistic model based on historic canvasback harvest and BPOP data. We used stochastic dynamic programming (Fackler 2011), to calculate optimal canvasback harvest rates over plausible range of canvasback BPOPs, using an objective of maximizing cumulative harvest. We converted optimal harvest rates to expected harvests and set the population thresholds for closed, L1 and L2 seasons accordingly. We calculated the expected harvest rates of adults under this policy as derived.

Estimating r_{max}: Demographic Invariants Method

We used the demographic invariants method (Niel and Lebreton 2005) to estimate r_{max}. This method requires only age at first breeding (α) and adult annual survival probability (s).

$$r_{max} = \left[\frac{(s\alpha - s + \alpha + 1)\sqrt{(s - s\alpha - \alpha - 1)^2 - 4s\alpha^2}}{2\alpha}\right] - 1$$

This equation is not solvable in closed form so we used the R package 'rootSolve' (Soetaert 2015) for our calculations. To estimate adult survival in the absence of harvest, we used an equation that expresses the allometric relationship between body mass (adult male) and adult annual survival (Johnson et al. 2012):

$$s = p^{\frac{1}{(exp(3.22+0.24log(M)+e)-\alpha)}}$$

where M = body mass (kg), p is the estimated proportion of the population that remains alive at maximum lifespan, and

$p \sim Beta(3.34{,}101.24)$,

so that $p_{mean} = 0.03(sd = 0.017)$, and $\epsilon \sim Normal(0, \sigma^2 = 0.087)$. We assumed an age at first breeding (α) of 1.67 (i.e., only 50% of 1-year olds breed). We drew replicates (n=10,000) from the distributions of body mass and the proportion alive at maximum longevity to generate replicates of adult survival. We used these replicates to generate 95% credible intervals on adult survival, and combined with the age at first breeding, on r_{max}.

The estimate of adult survival (s) for canvasbacks based on allometric relationships was 0.87 (0.78-0.93, 95% CI). Applying the demographic invariants method produced an estimate of r_{max} of 0.23 (0.18-0.28).

Deriving an Optimal Harvest Policy

We used the estimate of r_{max} along with other demographic information to derive an optimal harvest strategy for canvasbacks. We simulated population dynamics using the logistic growth equation, with carrying capacity (K) estimated as

$$K = \frac{N_{eq}}{1 - \frac{h}{r}}$$

where N_{eq} = equilibrium breeding population size, *r* = our estimate *of* r_{max} (0.23) and *h* = the average harvest rate of adults.

We used the average (2006–2015) canvasback breeding population (mean = 697,294, SD =106,050) as an estimate of N_{eq}. The banding data for canvasbacks are too sparse to calculate precise estimates of annual harvest rate, but estimates of the absolute number harvested (*H*) are available via the Harvest Information Program and Parts Collection Survey, and the Canadian National Harvest survey. All harvest data and age ratios include Canadian data. To obtain the harvest rate (*h*) for adults, we first calculated an average (1994–2014, excluding 2008, when the season was closed) harvest age ratio of 1.39 juveniles/adult. We converted this to the average proportion of adults in the harvest:

$$Prop_{Ad} = 1 - \left({}^{1.39}/_{(1+1.39)}\right) = 0.42$$

We multiplied the total canvasback harvest expected under an L1 season (106,000) by the average proportion of adults in the harvest to obtain an estimate of adult harvest (*H*). We divided this by mean canvasback population size to estimate an average adult harvest rate (*h*).

$$\bar{h}_{adult} = \frac{(106{,}000 \times 0.42)}{697{,}000} = 0.06$$

Inserting this into the logistic growth equation gives us an estimate of carrying capacity (*K*):

$$K = \frac{697{,}000}{1 - \left(\frac{0.06}{0.23}\right)} = 966{,}000$$

Optimization

We used stochastic dynamic programming (Lebow 1995, Fackler 2011) to derive optimal harvest rates over the range of canvasback BPOPs, under an objective to maximize long-term cumulative harvest. The program MDPSOLVE (Fackler 2011) was used for the optimization. We used our estimates of r_{max} and K in a discrete-time logistic model:

$$N_{t+1} = N_t + N_t r_{max} \left[1 - \left(\frac{N_t}{K} \right)^{\theta} \right] - h_t N_t$$

and applied a CV of 10% to N to account for uncontrolled environmental variation and process error. We simulated population dynamics under a range of harvest rates (h_t) from 0 to 0.2 in increments of 0.01 to derive optimal adult harvest rates. We converted optimal adult *h* to an optimal adult harvest (*H*) using $H = h\ x\ N$. We compared optimal adult *H* with those expected under closed (C), liberal 1-bird daily bag limit (L1) and liberal 2-bird daily bag limit (L2) seasons, and set the BPOP thresholds for these seasons accordingly.

Based on our estimates of optimal adult harvest under an objective of maximizing cumulative harvest and expected total canvasback harvest under closed (11,100), L1 (105,800), and L2 (150,900) seasons, the resulting policy calls for an L2 season at canvasback BPOPs >480,000, a closed season at BPOPs less than 460,000, and an L1 season between 460,000--479,999 (Figure 1).

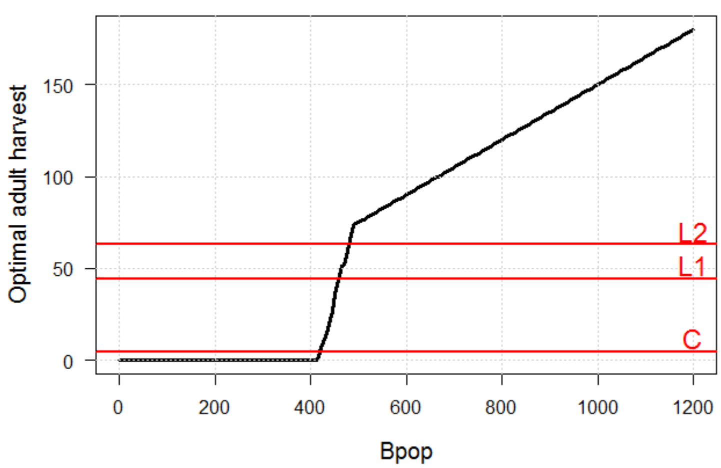

Figure 1. Canvasback breeding population size and optimal adult harvest levels corresponding to 3 regulatory alternatives: C = closed; L1 = liberal season, 1-bird bag; L2 = liberal season, 2-bird bag (F. Johnson).

Canvasback harvest rates expected under regulatory alternatives

The derivation of an optimal policy under an objective of maximizing cumulative harvest was useful for examining overall population dynamics, but may not represent the desire for stable, simple regulations expressed by the HM working group

We calculated the expected distribution of the harvest rate expected under each regulatory alternative two ways. Recall that we don't have harvest rates from banding data, and that canvasback management has therefore been based on estimates of absolute harvest. We began by converting historical estimates of canvasback absolute harvest and BPOP into adult harvest rates, and fitting a linear model of adult harvest rate as a function of season selection (1994-2014), to obtain means and variances of historical adult harvest rates under closed, restrictive, ML (liberal and moderate combined) and L2 seasons.

Table 1. Canvasback adult harvest rates (1994-2014) as a function of hunting season selection.

Season	Estimate	SE
intercept(closed)	0.015	0.016
L2	0.079	0.028
ML	0.080	0.024
R	0.046	0.026

However, we realized that historical harvest rates would not adequately capture the range of possible harvest rates under the optimal harvest policy based on maximizing cumulative harvest. In particular, an L2 season is prescribed under the proposed optimal policy over the entire range of CANV BPOP experienced from 1994–2014, yet under the 1994–2014 policy, adult harvest rates could range from about 7% at higher BPOPs (similar to historic rates) to as high as 13% at the lower edge of the policy space. Thus we calculated a harvest rate distribution for L2 seasons based on 1994--2014 BPOPs, the average proportion of adults in the population (0.42), and the total absolute harvest (H = 150,900) expected under an L2 season (mean = 0.099, se = 0.028), which is likely a more realistic estimate of the distribution of harvest rates that would be expected during L2 seasons under the proposed new policy.

DISCUSSION:

We have presented a simple technical framework can be used to inform canvasback harvest management over a short time-frame. The demographic invariants method gave estimates of adult survival and r_{max} that seem biologically reasonable. It produced an optimal policy under an objective of maximizing cumulative harvest that allows an L2 season over the entire range of BPOPs observed over the past 20 years. Under this policy, we estimate that the long-term average harvest rate of adults would increase by approximately 0.02, relative to 1994–2014 rates.

We recognize that this analysis used maximum sustained yield as a harvest objective and that this may not fully reflect the long-term canvasback population and harvest objectives of the flyways. Given the short-term use of the tool and that the flyways will be addressing long-term canvasback objectives as part of the process of revisiting overall duck harvest objectives, we feel comfortable recommending the use of this technical framework as a canvasback harvest management decision support tool in the meantime.

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LITERATURE CITED:

Fackler, P. L. 2011. MDPSOLVE: A MATLAB Toolbox for Solving Markov Decision Problems with Dynamic Programming. User's Guide. Raleigh, NC. 64pp. https://sites.google.com/site/mdpsolve/user-s-guide

Johnson, F. A., Walters, M. A. H. and Boomer, G. S. 2012. Allowable levels of take for the trade in Nearctic songbirds. Ecological Applications 22: 1114-1130.

Madsen, J., Guillemain, M., Nagy, S., Defos du Rau, P., Mondain-Monval, J-Y., Griffin, C., Williams, J.H., Bunnefeld, N., Czajkowski, A., Hearn, R., Graur, A., Alhainen, M., and Middleton, A. 2015. Towards sustainable management of huntable migratory waterbirds in Europe: A report by the Waterbird Harvest Specialist Group of Wetlands International. Wetlands International, the Netherlands.

Niel, C. and Lebreton, J. 2005. Using demographic invariants to detect overharvested bird populations from incomplete data. Conservation Biology 19: 826-835.

Runge, M. C., Kendall, W. L. and Nichols, J. D. 2004. Exploitation. Pages 303-328 in W. J. Sutherland, I. Newton, and R. E. Green, editors. Bird Ecology and Conservation: A Handbook of Techniques. Oxford University Press, Oxford, U.K.

Runge, M. C., Sauer, J. R., Avery, M. L., Bradley, F. B. and Koneff, M. D. 2009. Assessing allowable take of migratory birds. Journal of Wildlife Management 73: 556-565.

Slade, N. A., Gomulkiewicz, R. and Alexander, H. M. 1998. Alternatives to Robinson and Redford's method of assessing overharvest from incomplete demographic data. Conservation Biology 12: 148-155.

Soetaert , K. 2015. rootSolve: Nonlinear Root Finding, Equilibrium and Steady-State Analysis of Ordinary Differential Equations. https://cran.r-project.org/web/packages/rootSolve/index.html

U.S. Department of the Interior. 2013. Final Supplemental Environmental Impact Statement: Issuance of Annual Regulations Permitting the Hunting of Migratory Birds (EIS 20130139). U.S. Fish and Wildlife Service, Washington, D.C., USA. 418pp. http://www.fws.gov/migratorybirds/pdf/policies-and-regulations/FSEISIssuanceofAnnualRegulations.pdf

Wade, P. R. 1998. Calculating limits to the allowable human-caused mortality of cetaceans and pinnipeds. Marine Mammal Science 14: 1-37.