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Project title: Technical support for adaptive harvest management for American black ducks

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Duration: Starting date --- End Date 31 December 2009. Year 2 of 3.

Partners: US Fish and Wildlife Service, USGS, CWS, Black duck joint venture

Project description:

Issue

Scientific management for American black ducks (*Anas rubripes*) has been hampered by a lack of understanding regarding factors affecting the dynamics of black duck populations. This has resulted in a lack of agreement among stakeholders as to the potential for arresting the decline of black duck stocks through management intervention, especially through harvest regulations.

This work builds on previous work contracted to the Principal Investigator, entitled "Development of an Integrated, Adaptive Management Protocol for American Black Ducks". The final report for this project is available at
http://coopunit.forestry.uga.edu/blackduck/final_report/public/final_report.pdf
In that work the Principal Investigator developed and evaluated several single- and multiple-population adaptive harvest management (AHM) models. Initially, a single-population model was developed based on the monograph by Conroy et al. (2002), in which abundance of black ducks and mallards (*Anas platyrhynchos*) were parameterized by midwinter surveys. The AHM project extended these models to breeding surveys implemented by CWS starting in 1990, and developed both spatially-stratified and non-stratified models.

FWS and CWS have now agreed to move forward with implementation of AHM for black ducks. Additional technical work is needed to support this implementation, and to address technical issues not completely resolved by the recently completed work order. Specific tasks to be addressed in the proposed project are:

Objectives

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1. Incorporate new integrated fixed-wing/ helicopter BPOP estimates into Python models of black duck dynamics.
2. Incorporate historical, longer-term data from MWS surveys and US harvest surveys via Bayesian analyses, in which the latter would be used to build priors distributions.
3. Update analyses to include data from recent integrated BPOP surveys.
4. Incorporate estimates based on MWS surveys, BPOP, or a combination of both into optimization models in order to produce stat-specific optimal harvest strategies.

Hypotheses

Conroy et al. (2002) summarized previous studies of American black ducks into four alternative hypotheses (models), representing combinations of assumptions about the influence of mallards on black duck reproduction rates (competition vs. no competition) and the impact of harvest on survival (additive vs. compensatory). These alternative hypotheses are directly incorporated into statistical models used to estimate parameters from survey data, and optimization models used to derive optimal harvest strategies.

Study area

The study area is the continental range of American black ducks, with focus on 1) traditional breeding areas in Canada, Ontario eastward, 2) harvest areas in Canada, and 3) harvest and wintering areas in the U.S. (Mississippi and Atlantic Flyways).

Methods

<u>Sources of data</u>

Population states-- Previous work (Conroy et al. 2002) has been based on the use of midwinter surveys (MWS) as the measure of abundance states for black ducks and mallards. However, current thinking regarding black duck AHM is based on spring abundance as estimated by integrated breeding population surveys in eastern Canada (BPOP), which were initiated in 1990. To provide an adequate time series for analysis of density dependence, competition, and other factors, we conducted an initial analysis used MWS figures for black ducks in the Atlantic (AF) and Mississippi Flyways (MF), and for mallards in the AF and states in the MF deriving >75% of their direct band recoveries from within the black duck breeding range; all date from 1961-2007 were used. We conducted a second analysis using BPOP from the core black range for 1990 to 2007 (the last year available at the time the analyses were initiated).

Productivity measures- We used estimates of harvest age ratios derived from the USFWS and CWS parts collection surveys, adjusted by direct band recoveries for differential vulnerability, to estimate fall age ratio. For MWS-based modeling we used only USFWS harvest data corrected by US direct recoveries; this allowed us to construct models starting in 1961 (before corresponding harvest data from Canada were available). For BPOP-based modeling we used both USFWS and CWS harvest data, respectively adjusted by direct recoveries in the US and Canada, to estimate a common fall age ratio. Because the last year of band recovery and harvest data available to us at the initiation of analyses was 2006, productivity measures were available for 1961-2006 for MWS modeling, and 1990-2006 for BPOP modeling.

Harvest rates- We used direct recoveries of adult and juvenile male and female black ducks banded in Canada, 1961- 2006 to estimate age-and sex-specific harvest rates, corrected for band reporting rates associated with different band types (MBMO, unpubl. Data). We used a standard (but likely conservative) assumption of 20% crippling loss to convert harvest estimates into estimates of harvest kill.

Annual survival rates- We used direct and indirect recoveries of adult and juvenile male and female black ducks banded in Canada, 1961- 2006 to estimate age and sex-specific annual harvest rates.

<u>State-space model</u>

Our basic approach uses state-space modeling (SSM) to construct (1) a model of the underlying (but not necessarily observable) population process, and (2) models relating sample data (above) to the process model. The basic form of the state-space model for the black duck population is:

$$\tilde{N}_{t+1} = N_t(S_t + f_t S_t')$$

$$N_{t+1} \sim \text{LogNormal}(\mu_{t+1}, \tau)$$

$$\mu_{t+1} = \ln(\tilde{N}_{t+1})$$

where N_t is abundance of black ducks in year *t* (of the winter or spring population, depending on model), $\tilde{N}_{t+1}$ is the model-based prediction of abundance in year *t*+1, and $\tau = 1/\sigma^2$ where σ^2 is a measure of process variation. The parameters f_t, S_t, and S_t' represent annual recruitment and adult and juvenile, sex-specific survival rates. These parameters, in turn, are derived under specific assumptions about density and mallard influences on f_t (under 2 alternative models: presence or absence of mallard competition) and harvest influence on S_t and S_t' (under additive or compensatory assumptions).

The mallard SSM is similar in essence, but involves only a basic random walk assumption about mallard dynamics. That is,

$$M_{t+1} \sim \text{LogNormal}(\upsilon_{t+1}, \tau_m)$$

$$\upsilon_{t+1} = \ln(M_{t+1})$$

where M_t is abundance of mallards in year *t* (of the winter or spring population, depending on model), $\tau_m = 1/\sigma_m^{\;2}$ where $\sigma_n^{\;2}$ is a measure of process variation for mallards.

The corresponding statistical models specify sampling distributions relating each of the observable statistics (survey estimates, band recoveries, etc.) to a parameter in the SSM. For the abundance states the sampling models are specified via normal distributions

$$X_t \sim \text{Normal}(S_t, \tau_{obs,t})$$

where S_t is the population state (N_t or M_t) and $\tau_{obs,t}$ is sampling precision specified by an assumed CV=0.20 (for the MWS data) and directly estimated from the survey data (for the BPOP data).

Details of the modeling are beyond this short report, but will be elaborated in November at the BDAHM meetings, and in the Final Report.

<u>Bayesian estimation</u>

We used PyMC v2.0 (http://code.google.com/p/pymc/) to obtain Markov chain Monte Carlo (MCMC) samples from the posterior distributions of model parameters. We performed 3 analyses: (1) MWS-based models, (2) BPOP-based models, (3) BPOP-based models using prior distributions on parameters from the MWS models. Key parameters for which posterior distributions were obtained were: S_0. sex- and age- specific survival in the absence of harvest (under additive or compensatory assumptions), P_0 (initial proportion males, necessary to initialize the SSM), τ and τ_m, and c_0, c_1, c_2, c_3 the coefficients for predicting fall age ratios :

$$\tilde{A}_t = \exp(c_0 + c_1 N_t + c_2 M_t + c_3 t)$$

where c_2 is zero under the hypothesis of no mallard competition, and c_3 represents a linear decline in productivity since 1961 (presumable related to loss of habitat; Conroy et al. 2002).

Results

We have obtained preliminary estimates of model parameters and evaluation of model weights using Bayesian information criteria. Space precludes presentation of detailed results here. In addition, our initial analyses revealed evidence of lack of convergence of several parameter distributions. We are therefore in the process of conducting a revised analysis that separates the analysis of band recovery data from the productivity/ integrated SSM; estimates from the survival analysis are then used to produce prior distributions for the productivity/ integrated SSM. Results of the revised analyses are encouraging, with much better convergence properties.

Project status:

We are on track to complete parameter estimation for the SSM well in advance of the November BDAHM meetings. At that time, we will be in a good position to begin running optimization models in ASDP and produce tables of optimal state-specific harvest strategies. However, before proceeding with detailed optimization studies, we wish to confirm the consensus regarding objectives under BDAHM, and will do so at the November meeting.

Project funding sources (US$). Provide information about previous year's expenditures.

BDJV Contribution	Other US federal contributions	US non-federal contributions	Canadian federal contributions	Canadian non-federal contributions	Other
$52,781,28 (08) $54,456 (07)					

Total cost: $157, 734 (through FY 09)

Total BDJV funds: $157, 734

Conroy, MJ, Conroy, MW Miller and JE Hines. 2002. Identification and synthetic modeling of factors affecting American black duck populations. Wildl. Monogr. 150: 1-64.

Conroy, MJ, CJ Fonnesbeck and NL Zimpfer. 2005. Modeling regional waterfowl harvest rates using Markov chain Monte Carlo. J. Wildl. Manage. 69: 77-90.