Sea Duck Joint Venture
Annual Project Summary
FY22 (October 1, 2021 – September 30, 2022)

Project Title *(including SDJV Project #)*: Improving US Sea Duck Harvest Estimates through Improved Sampling Design and Model Development – SDJV project #163

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Project Description *(issue being addressed, location, general methodology):*

Our proposal directly addresses the following SDJV priority science need: to improve harvest estimates for North American sea ducks by increasing the amount and quality of information from hunters and applying analytical techniques to reliably estimate the size and composition of harvests. The level and composition of the harvest, derivation and distribution of the harvest and an assessment of the values and concerns of stakeholders are all necessary elements of effective harvest strategies and regulatory framework that ensure sustainable harvests. Estimating harvest of American Common Eiders is a top priority.

Project Objectives:

This project involves three primary objectives:

1. Develop Bayesian hierarchical models to estimate species' harvests by integrating data from the Waterfowl Harvest Survey and the PCS.

2. Evaluate model structures to identify critical factors affecting harvest estimation and determine streamlined design elements that capture main sources of uncertainty for performance. Model components to evaluate include: (1) the general model structure, including likelihood and prior distributions (e.g., including total harvest data only vs. also the number of hunters, hunting days, etc.), (2) incorporating underlying trends or auto-regressive structure, and (3) individuals as repeated measures or random effects to evaluate bias on resulting estimates.

3. Based on the above results and new survey methodology, design a sampling scheme that most accurately estimates sea duck harvest on an annual basis. Provide BMDM recommendations for future survey/sampling modifications based on results from the study (e.g., updated sample size targets and/or sampling frames for stratification based on model variances, guidelines for repeat sampling of the same individuals).

Preliminary Results *(include maps, photos, figures/tables as appropriate):*

We developed three Bayesian hierarchical model structures to integrate data from the Waterfowl Harvest Survey and the PCS. The most simple model is the "independence model" where we integrate the Harvest Survey and PCS data for each year-species one at a time. This model requires the fewest assumptions, but does not share any information across space (states) or time (years). The second model of intermediate complexity is one where we assume that the change between years in both the total harvest and harvest composition follows a random walk, such that proportional changes in harvest and harvest composition for a focal state-year are correlated with the proportional changes in the previous state-year. This model allows information about total harvest and harvest composition to be shared across years within each state. The third, most complex model we developed is one where we assumed that the change between years in both total harvest and harvest composition follows a spatially-correlated random walk across time (years). This model shares information across both space and time.

We fit these three models to the Waterfowl Harvest Survey and PCS data from 2003-2019 and compared the estimates of species-specific harvest across models. For the independence model, we found that the priors were difficult to set such that the MCMC sampling was adequate without inducing much positive bias for states where species were truly not harvested. As a result, we believe the independence model may overestimate the harvest in state-years for species with 0 or very few samples in the PCS sample. In these cases, the time model estimated lower species-specific harvest by pooling information across years within each state. For the space-time model, the total harvest estimates were similar to the time model and both fit the data similarly well. However, we were unable to get the space-time model to converge reliably for the PCS harvest composition data due to sparse neighbor information in combination with many species with 0 PCS samples in many state-years. Ultimately, we believe there is little information to be gained by sharing information across states over sharing information within states across time with time series as long as are available in these data sources.

The state and species-specific harvest estimates from the time model were generally more precise, particularly for state-species with no or very few PCS samples. However, estimates for state-species with more abundant PCS samples are also more precise and the point estimates are likely to be more accurate because they consider the temporal correlation in estimates across time. Here, we show the total harvest estimates for Common Eiders for two states, one with low harvest and another with a higher harvest. Figure 1 depicts the point and 95% interval estimates for from 2003 to 2019 in the state of Deleware. We see the time model provides consistently lower and more precise estimates than the independence model. Next, Figure 2 shows the estimates for Massachusetts. Here, we see less difference in the point and interval estimates, but the time estimates are more precise on average and more similar to the estimates of neighboring years.

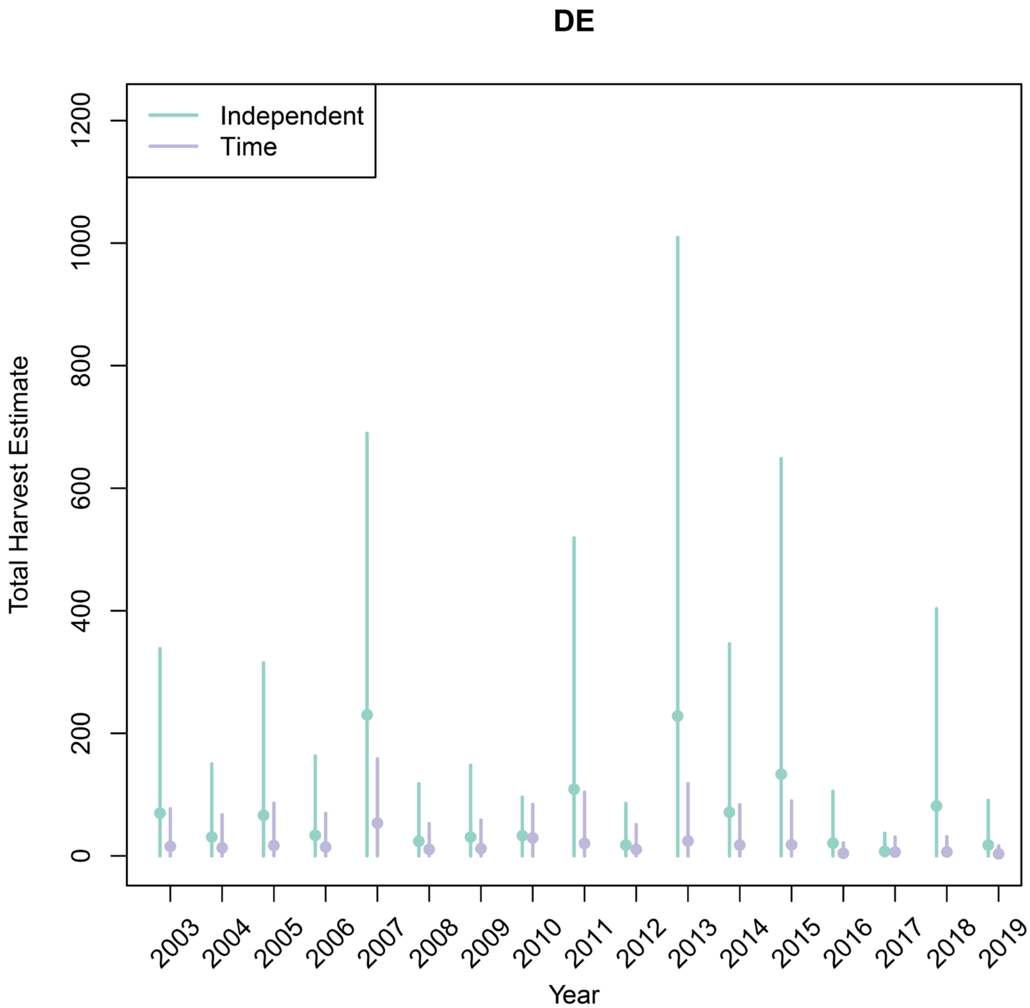

Figure 1. Total harvest point and 95% interval estimates for Common Eider in Deleware from the Independence and Time Models.

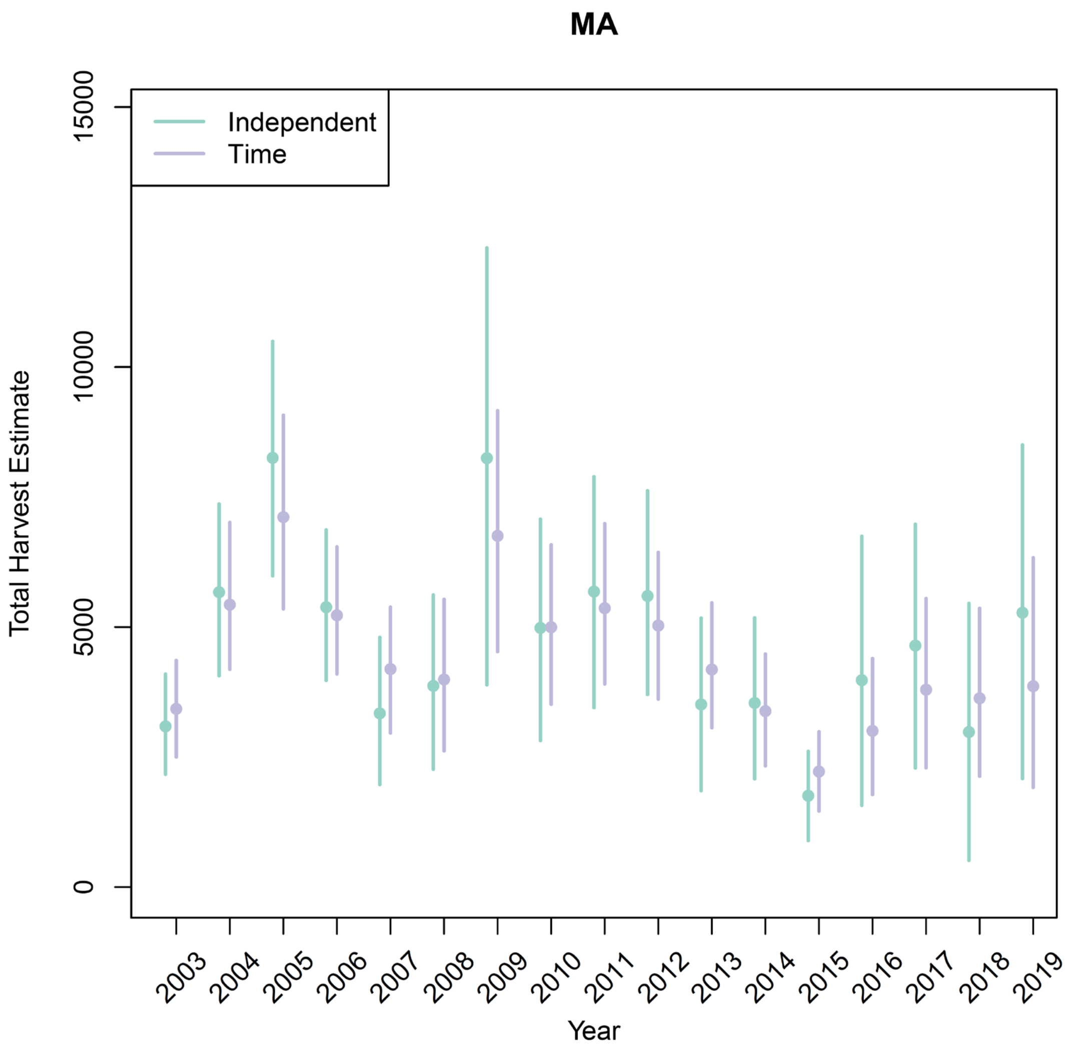

Figure 1. Total harvest point and 95% interval estimates for Common Eider in Massachusetts from the Independence and Time Models.

Project Status *(e.g., did you accomplish objectives, encounter any obstacles, what are your future plans):*

We have achieved Objectives 1 and 2, with Objective 3 left to be completed. We developed models to integrate the Waterfowl Harvest Survey and PCS data to produce appropriate uncertainty intervals for state-level species-specific harvest, which can be aggregated to higher spatial orders, such as the flyway or entire United States. For Objective 2, we plan on discussing alternative approaches to share information across time; however, we believe there is little spatial information to capitalize on after sharing information across time within each state. Therefore, we believe Objective 3 will be the focus during Fiscal Year 23.

Project Funding Sources (US$). Complete only if funded by SDJV in FY22. This is used to document: 1) how SDJV-appropriated funds are matched, and 2) how much partner resources are going into sea duck work. You may include approximate dollar value of in-kind contributions in costs. Add rows as needed for additional partners.

SDJV (USFWS) Contribution	Other U.S. federal contributions	U.S. non-federal contributions	Canadian federal contributions	Canadian non-federal contributions	Source of funding (name of agency or organization)

Total Expenditures by Category (SDJV plus all partner contributions; US$). Complete only if project was funded by SDJV in FY22; total dollar amounts should match those in previous table.

ACTIVITY	BREEDING	MOLTING	MIGRATION	WINTERING	TOTAL
Banding (include only if this was a major element of study)					
Surveys (include only if this was a major element of study)					
Research					