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

Project Title: Evaluating stable hydrogen isotopes for identifying breeding areas of harvested sea ducks (F21AC00061-00)

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Partners: None beyond SDJV.

Project Description: This project represents a pilot study aimed at assessing the ability of feather stable hydrogen isotope (δ^2H) data to delineate the most probable breeding locations of juvenile long-tailed ducks and surf scoters harvested in North America. To accomplish our objectives, SDJV provided us with feathers from 120 harvested individuals in the SDJV's feather archive (n= 60 juvenile long-tailed ducks and n = 60 juvenile surf scoters) spread across the Atlantic, Mississippi, and Pacific flyways. For 90% (n=108) of these individuals we performed δ^2H analysis on a single feather, whereas for 10% of them (n=12) we assessed intra-feather and intra-individual variation in isotope values by measuring subsamples from the proximal, middle and distal ends of 3 feathers per individual. Following an initial evaluation of the δ^2H data that we obtained from these feathers (see Preliminary Results below), we suspected that some individuals may have been provisioned with marine resources that would make them unsuitable for geolocation purposes using δ^2H data. Therefore, to identify such individuals we performed carbon and nitrogen isotope ($\delta^{13}C$ and $\delta^{15}N$) analyses of the same feather samples.

Project Objectives: (1) Quantify intra-feather and intra-individual variation in feather δ^2H values, (2) Use δ^2H values to create a likelihood-of-origin maps for each individual, (3) Use likelihood-of-origin maps to identify regions where juveniles fledged and grew their feathers, (4) Evaluate the need to improve geo-location through isotopic analysis of feathers from reference individuals with known breeding locations, and (5) If results indicate that δ^2H values are useful for estimating breeding locations, then provide a preliminary evaluation of hypotheses about variation in the location of breeding grounds of these species between flyways.

Preliminary Results: For the 12 birds for which we sampled from multiple feathers and from multiple locations within feathers, intra- and inter-feather in δ^2H, $\delta^{13}C$, and $\delta^{15}N$ values was small relative to the among-bird variation. The mean (range) standard deviation of multiple analyses per feather was 6.6 ‰ (2.1-17.5 ‰), 0.9 ‰ (0.1-3.5 ‰), and 0.5 ‰ (0.1-1.2 ‰), respectively, across all 12 birds, indicating that intra-variation in δ^2H, $\delta^{13}C$, and $\delta^{15}N$ values was relatively small. The mean standard deviation across all 12 birds of all feathers from each bird was 7.3, 0.9, and 0.5 ‰ for δ^2H, $\delta^{13}C$, and $\delta^{15}N$, respectively, indicating that, for a given bird, inter-feather isotopic variation was similar in magnitude to intra-feather isotopic variation. These patterns are consistent with our expectation that intra- and inter-feather isotopic variation be relatively small since juvenile sea ducks are believed to form all of their feathers in one general location within a relatively short period of time. Therefore, isotopic data from one feather of a juvenile should be representative of isotopic values of that individual.

The results from these 12 birds also revealed a much larger range of variation in δ^2H values than would be expected for individuals that grew their feathers in the northern high latitudes where these species are born and grow their feathers (Fig. 1). Specifically, the highly positive δ^2H values of some individuals would suggest that they fledged far south of their expected range, assuming they were feeding in terrestrial and/or freshwater food webs when their feathers were formed. However, an alternative possibility is that these individuals may have been eating from coastal/marine food webs during the period of feather growth. To assess this possibility, we measured $\delta^{13}C$ and $\delta^{15}N$ values for these 12 individuals (at no cost to the project), since prior studies indicate that $\delta^{13}C$ and $\delta^{15}N$ values tend to be greater than approximately -20 and 11 ‰, respectively, for birds eating from coastal/marine food webs relative to those eating from terrestrial and/or freshwater food webs (Chamberlain et al. 2005, Yerkes et al. 2008, Newsome et al. 2010). Four individuals (two of each species) had $\delta^{13}C$ and $\delta^{15}N$ values suggestive of marine inputs (data not shown), and thus the δ^2H values of these birds are likely ill-suited for geolocation purposes.

We also performed $\delta^{13}C$ and $\delta^{15}N$ analyses of the single feathers from each of the 108 other birds that were part of our study. Overall, 8/60 long-tailed ducks (4/30 from the Atlantic flyway and 4/30 from the Mississippi flyway) and 12/60 surf scoters (10/19 from Pacific flyway, 0/11 from the Mississippi flyway, and 2/30 from the Atlantic flyway) had $\delta^{13}C$ and $\delta^{15}N$ values suggestive of a marine influence in their diets (Fig. 2). Therefore, most individuals of each species appear to have hatched and fledged in terrestrial/freshwater habitat. The existence of some juveniles with possible coastal/marine diets is generally contrary to the current understanding that these species (especially surf scoters) are hatched and raised in terrestrial and/or freshwater environments. One explanation may be that the age of those hunter-killed birds was misidentified at wing bees (i.e., instead of being hatch-year individuals, they were older birds). Alternatively, the apparent marine signatures may be related to nutrient input from anadromous Pacific salmon, which migrate from the ocean hundreds of miles inland, mainly in Alaska and northwestern Canada, and die, thereby delivering marine-derived nutrients to potential sea duck breeding areas (Schindler et al. 2003, Reisinger et al. 2013). This would help explain why there was a higher proportion of apparent marine signatures in some Pacific surf scoters. To help distinguish among these possibilities, in spring 2022 the SDJV Continental Technical Team provided us with additional feathers from lived-captured long-tailed ducks (n=44 from Atlantic flyway) and surf scoters (n=30 from Pacific flyway and n=30 from Atlantic flyway) whose age (i.e., hatch year) was definitively known; those analyses are in progress.

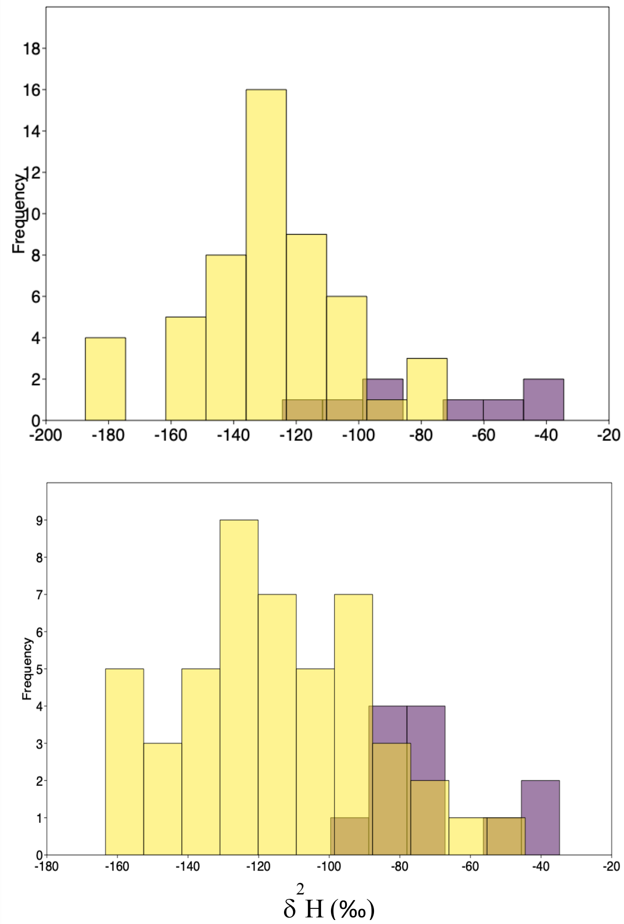

Figure 1. Feather δ^2H values for 60 long-tailed ducks (top) and 60 surf scoters (bottom). Individuals in pink were those identified as having likely been provisioned on coastal/marine food webs, as discussed in the text.

Several lines of evidence indicate that δ^2H values are a promising approach for delineating the breeding locations of juvenile long-tailed ducks and surf scoters harvested in North America. First, δ^2H values for the hatch-year long-tailed ducks and surf scoters eating on freshwater/terrestrial food webs (n=52 and n=48, respectively) fall within the ranges expected for individuals from throughout their geographic ranges (Fig. 1). Second, the surf scoters tended to have more positive δ^2H values (mean = -

116‰) than long-tailed ducks (mean = -131‰), consistent with surf scoters having a relatively more southern breeding distribution (Fig. 1). Third, the location at which each bird was killed was south of its δ^2H-inferred geographic origin of each that individual (data not shown), as expected. Fourth, the δ^2H values allowed us to identify the 20% of the species range (on average) from which each individual originated, which illustrates the precision at which we can infer fledgling locations using this approach. These results, along with low intra- and inter-feather isotopic variation, indicate that δ^2H values are useful for constraining the breeding locations of juvenile long-tailed ducks and surf scoters harvested in North America, even without feathers from individuals of these species with known breeding locations.

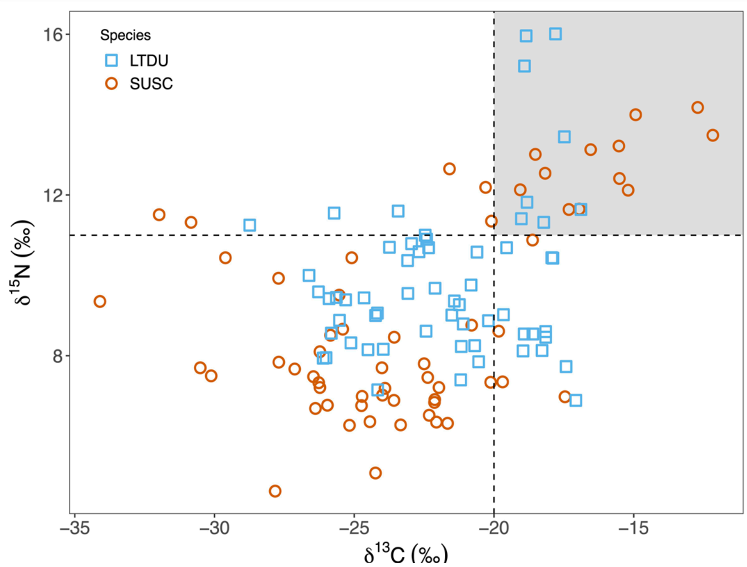

Figure 2. Feather δ^{13}C and δ^{15}N values for 60 long-tailed ducks (LTDU) and 60 surf scoters (SUSC). Individuals in the grey shaded region are potentially provisioned on coastal/marine food webs, as discussed in the text.

Our results indicate that juvenile long-tailed ducks likely provisioned from terrestrial/freshwater food webs had a large range of δ^2H values (Fig. 1), indicating origins spanning from northern Quebec to Nunavut (Fig. 3). Mean δ^2H values from the Atlantic and Mississippi flyways were similar (-131 ‰; data not shown), which suggests that individuals killed in these flyways have overlapping geographic origins. This result stands in contrast to the expectation from telemetry data that individuals from the Mississippi flyway would breed to the south and west of those from the Atlantic flyway (https://seaduckjv.org/wp-content/uploads/2014/1 2/AGLSDMS-Progress-Report-June2015_web.pdf). However, in our existing long-tailed duck dataset sample sizes are relatively low and there are no samples from birds killed in the Pacific flyway, including Alaska and British Columbia.

For juvenile surf scoters, our results indicate that individuals provisioned from terrestrial/freshwater food webs also had a large range of δ^2H values (Fig. 1), indicating origins spanning from central Quebec to northern western Canada and Alaska (Fig. 3). Individuals from the Atlantic flyway tended to have higher δ^2H values (mean = -109 ‰) than those from the Mississippi (mean = -133 ‰) and Pacific (mean = -125 ‰) flyways (data not shown), which suggests a more southerly geographic origins in eastern Canada for individuals shot in the Atlantic flyway than for individuals from the latter two flyways that likely originate from northwestern Canada and Alaska. However, in the existing dataset sample sizes are relatively low and there are no hunter-killed samples in the Pacific flyway from areas north of Washington state, which suggests that the existing samples from the Pacific flyway are likely not representative of that flyway.

Project Status: We completed project objectives, as well as additional δ^{13}C and δ^{15}N analyses, with the exception of analyses of live-captured birds (which are ongoing). We believe that sulfur isotopes (δ^{34}S) may provide additional help for discriminating power between sea ducks provisioned in terrestrial/freshwater and coastal/marine ecosystems. We are currently preparing a proposal to SDJV to expand these existing results to assess (1) variation in the location of breeding habitat across flyways and (2) the potential of coastal/marine habitat as fledgling areas.

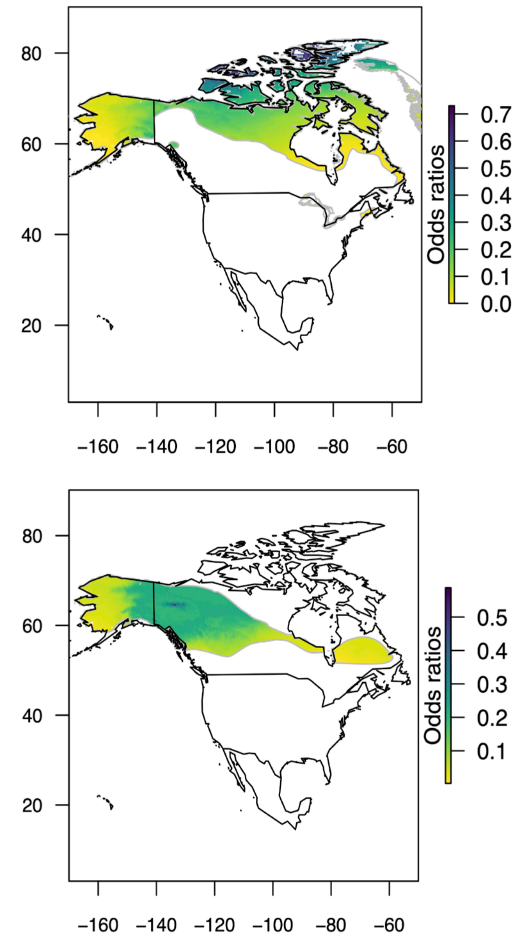

Figure 3. Composite likelihood-of-origin maps for 60 long-tailed ducks (top) and 60 surf scoters (bottom). Dark blue/purple colors indicate areas where more individuals have shared geographic origin than the lighter green/yellow colors.

References

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