Sea Duck Joint Venture
Annual Project Summary
FY2021 (October 1, 2020 – September 30, 2021)

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 (Figure 1). To accomplish our objectives, in winter 2020/2021 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 (δ^{13}C and δ^{15}N) analysis of the same feather samples.

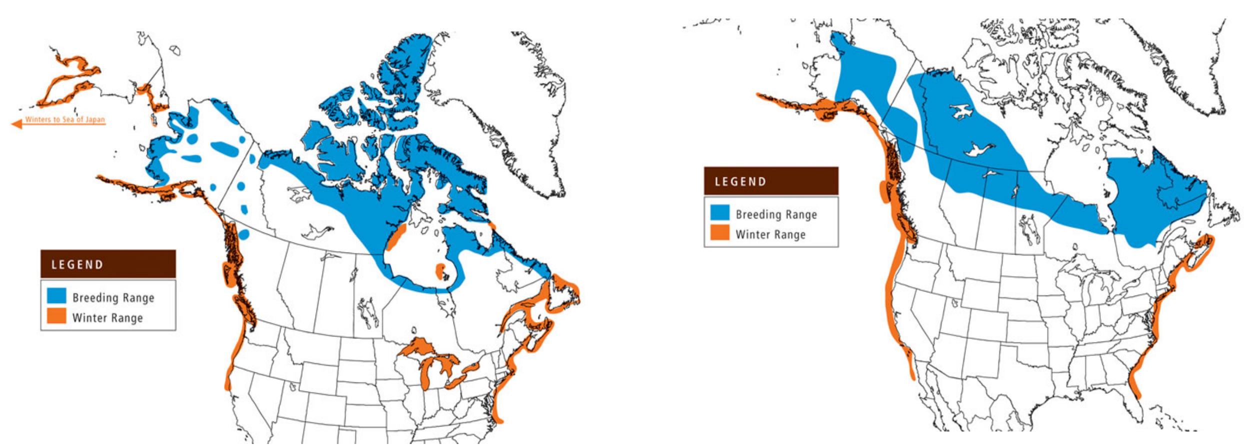

Figure 1. Distribution (from http://seaduckjv.org/) of the breeding and winter ranges of long-tailed duck (left) and surf scoter (right).

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, δ^{13}C, and δ^{15}N values was small relative to the among-bird variation (Figure 2, below). 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, δ^{13}C, and δ^{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, δ^{13}C, and δ^{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 analysis of a single sample from a single feather of a juvenile sea duck should be representative of isotopic values of that individual, and that is the strategy we used for analysis of the remaining individuals in this project.

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. 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 marine food webs during the period of feather growth (e.g., perhaps because their nests were located near marine environments or perhaps because they moved as ducklings from their nest in a terrestrial/freshwater environment to a marine environment before their flight feathers were fully formed). To assess this possibility, we measured δ^{13}C and δ^{15}N values of all of the feather samples from these 12 individuals because δ^{13}C and δ^{15}N values tend to be greater than approximately -20 and 11 ‰, respectively, for birds eating from 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). We found four individuals (two of each species) with δ^{13}C and δ^{15}N values indicative of marine inputs to diet, and those four individuals were also those with the most positive δ^2H values among these 12 individuals (Figure 3). Therefore, these individuals were most likely eating from marine food webs, which results in δ^2H values that are ill-suited for use for geolocation purposes. (This is because the δ^2H value of ocean water is around 0 ‰ and relatively invariant). Based on these results, we decided to also perform δ^{13}C and δ^{15}N analyses of the single feathers from each of the 108 other birds that were part of our study to identify potential marine influences in their diets.

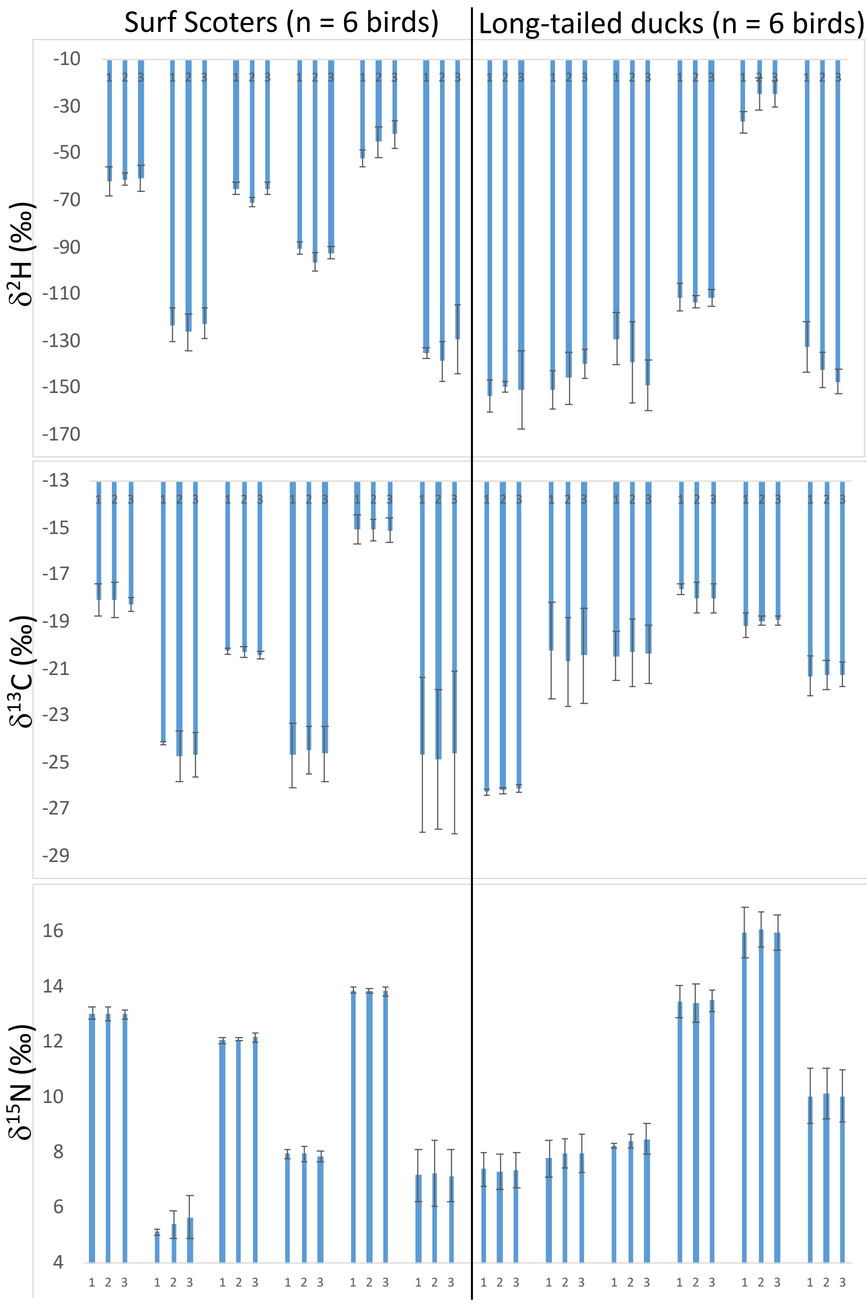

Figure 2. Stable hydrogen (top panel), carbon (middle panel), and nitrogen (bottom panel) isotope data for 12 immature sea ducks for assessment of intra- and inter-feather isotopic variation. For each bird, three samples (from the proximal, middle and distal ends of each feather) were analyzed from three different feathers, with the numbers 1, 2, and 3 on the figure indicating the different feathers. Each cluster of data on the bar plot represents a different individual, with 6 surf scoters on left side of each panel and 6 long-tailed ducks on right side of each panel.

A total of 12/60 (20%) surf scoters and 8/60 (13%) long-tailed ducks had potential marine influence in their diet based on $\delta^{13}C$ and $\delta^{15}N$ values (Figure 3). Therefore, most individuals of each species appear to have hatched and fledged from terrestrial/freshwater habitat. Of the surf scoters, 2/30 from the Atlantic flyway, 10/19 from the Pacific flyway, and 0/11 from the Mississippi flyway had potential marine inputs. Potential areas where surf scoters with marine influence in their diet may have originated include regions along the coast of Newfoundland/Labrador (for the Atlantic flyway) and far NW Northwest territories of Canada or along the coast in Alaska (for the Pacific flyway). Of the long-tailed ducks, 4/30 from the Atlantic flyway and 4/30 from the Mississippi flyway had potential marine inputs, as defined by $\delta^{13}C$ and $\delta^{15}N$ values. Potential areas where long-tailed ducks with marine influence in their diet may have originated include along coast along coast in northern Quebec and/or Newfoundland/Labrador (for the Atlantic flyway) and along coast of Hudson Bay and/or Nunavut (for the Mississippi flyway).

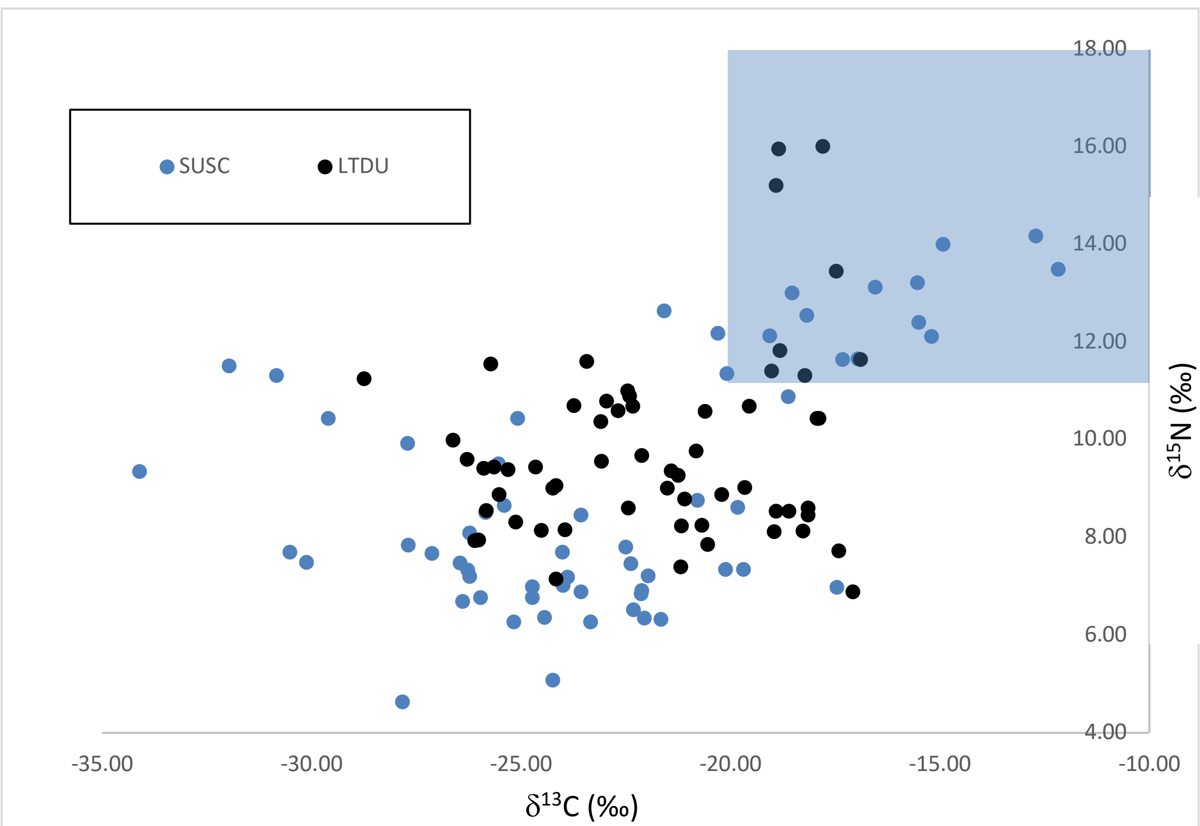

Figure 3. Biplot of stable carbon (x-axis) and nitrogen (y-axis) isotope data for one feather/bird for 60 surf scoters (blue) and 60 long-tailed ducks black). The shaded area represents the area of the figure with $\delta^{13}C$ and $\delta^{15}N$ values greater than -20 and 11 ‰, respectively, which likely represents individuals eating from marine food webs.

As expected, individuals with the more positive δ^2H values are typically those with marine inputs to diets (Figure 4). The wide range (> 100 ‰) of variation in δ^2H values for the remaining individuals (in yellow) suggests a wide range of geographic origins of these individuals.

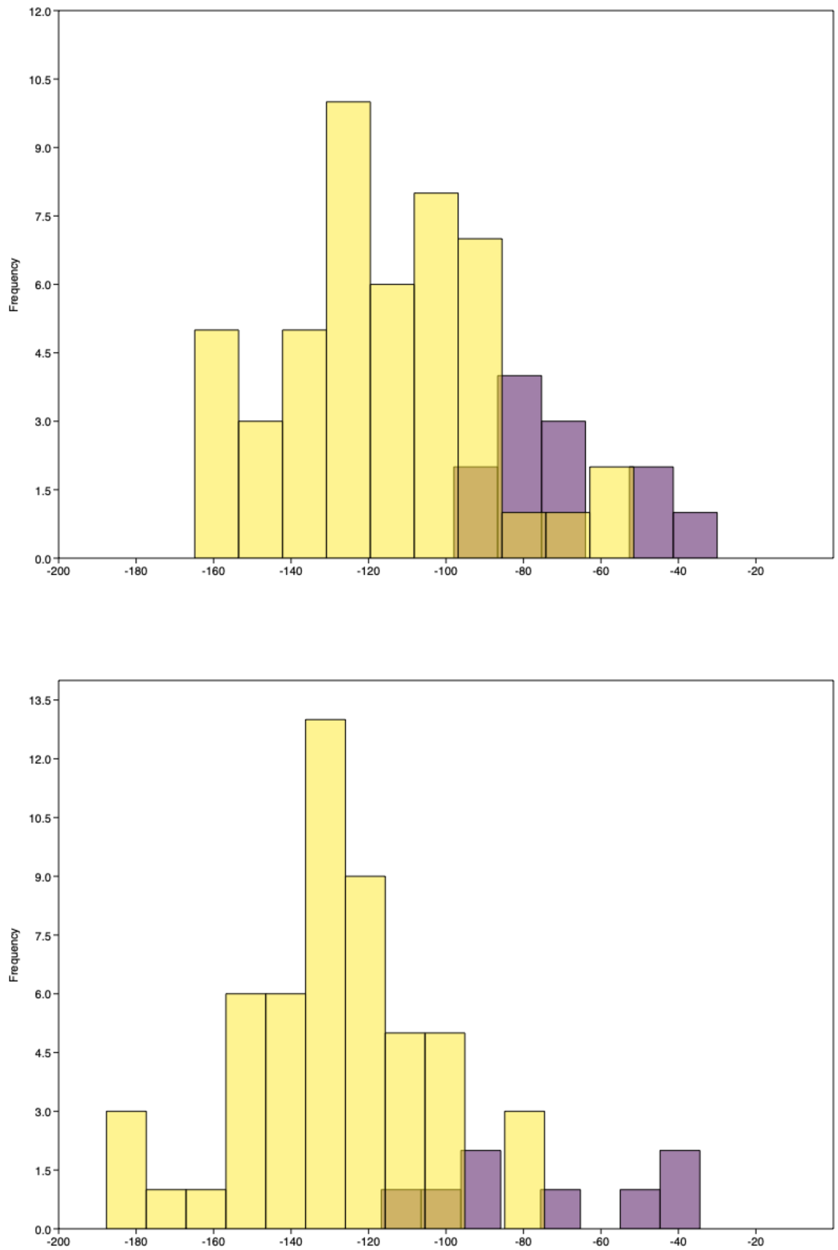

Figure 4. Histograms of δ^2H values for juvenile surf scoters (top panel) and long-tailed ducks (bottom panel). Yellow indicates individuals with terrestrial/freshwater diets (based on $\delta^{13}C$ and $\delta^{15}N$ data), whereas purple indicates individuals with marine inputs to diet. The brown color represents purple bars behind yellow bars.

Juvenile surf scoters eating from terrestrial/freshwater food webs tended to have more positive δ^2H values (mean = -116 ‰) than long-tailed ducks (mean = -131 ‰; Figure 5). This is consistent with surf scoters having a generally more southern range than long-tailed ducks.

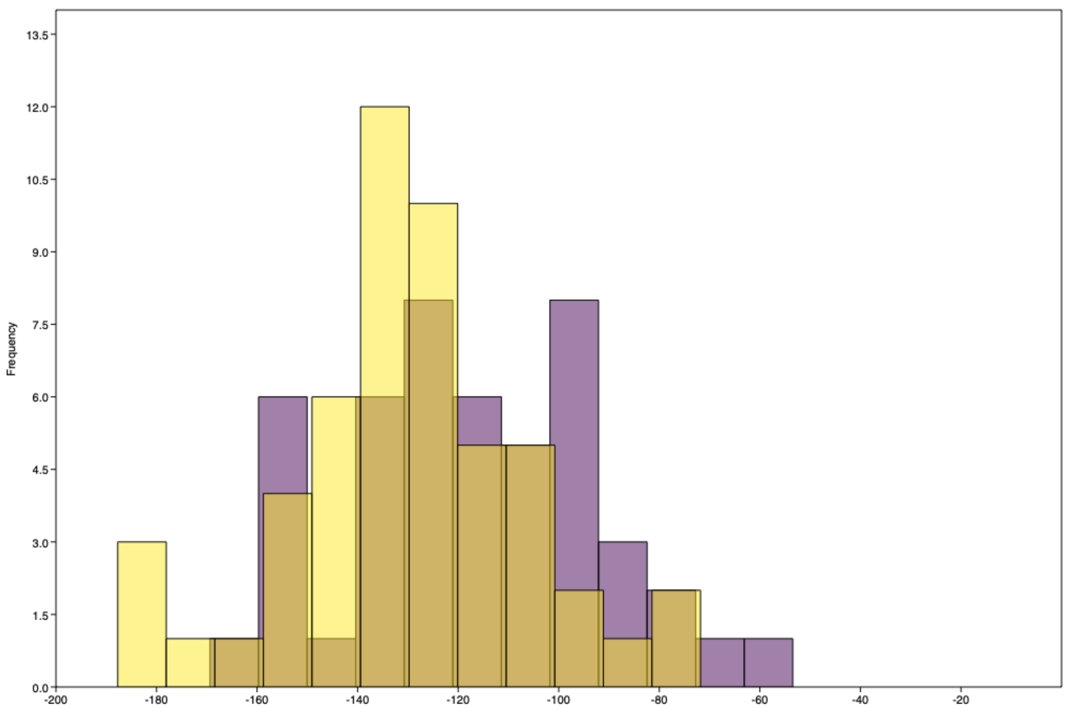

Figure 5. Histogram of δ^2H values for juvenile surf scoters (purple) and long-tailed ducks (yellow) for individuals with terrestrial/freshwater diets (based on $\delta^{13}C$ and $\delta^{15}N$ data).

Juvenile long-tailed ducks eating from terrestrial/freshwater food webs from the Atlantic (purple) and Mississippi flyways had similar δ^2H values (both means = -131 ‰; Figure 6). This suggests that they have similar geographic origins, in contrast to our hypothesis that individuals from the Mississippi flyway would breed to the south and west of those from the Atlantic flyway.

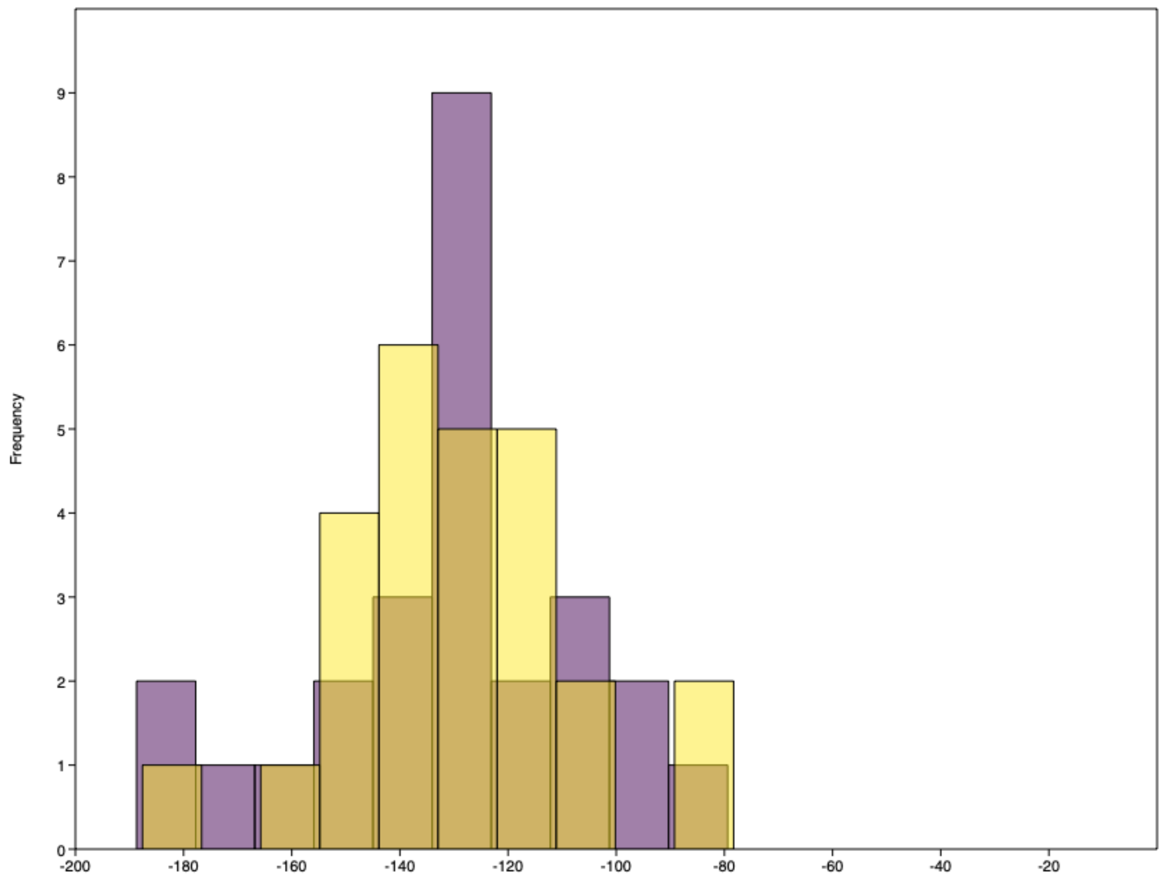

Figure 6. Histogram of δ^2H values for juvenile long-tailed ducks from the Atlantic (yellow) and Mississippi (purple) flyways for individuals with terrestrial/freshwater diets (based on $\delta^{13}C$ and $\delta^{15}N$ data).

Juvenile surf scoters eating from terrestrial/freshwater food webs from the Atlantic flyway had higher δ^2H values (mean = -109 ‰) than those from the Mississippi (mean = -133 ‰) and Pacific (mean = -125 ‰) flyways (Figure 7). This suggests individuals from the Atlantic flyway have more southerly geographic origins in eastern Canada than individuals from the latter two flyways which likely originate from western Canada and Alaska.

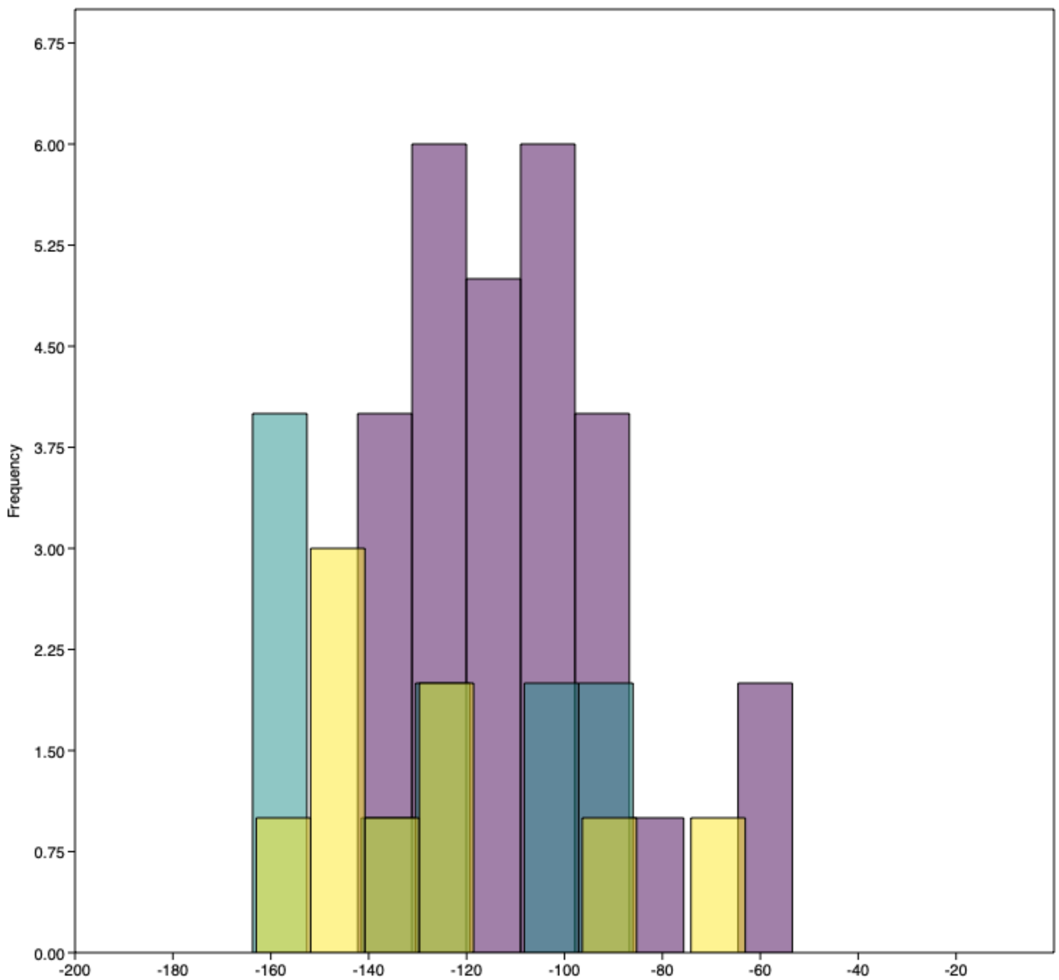

Figure 7. Histogram of δ^2H values for surf scoters from the Atlantic (purple), Mississippi (yellow), and Pacific (green) flyways for individuals with terrestrial/freshwater diets (based on $\delta^{13}C$ and $\delta^{15}N$ data).

Project Status: We completed 216 δ^2H analyses for the project in spring 2021 and have completed objective 1 and have partly completed objective 5. We also performed 216 $\delta^{13}C$ and $\delta^{15}N$ analyses as no cost to the project to assess potential marine inputs to diets that would compromise the use of δ^2H values for identifying the geographic origins of these birds. Our next steps are to create likelihood of origin maps, identify likely hatching sites, and evaluate the suitability of isotopic analysis for geolocation in this system (i.e., complete objectives 2-4) and more rigorously evaluate hypotheses about origins of these ducks (i.e., objective 5).

References

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