Sea Duck Joint Venture
Annual Project Summary
FY23 (October 1, 2022 – September 30, 2023)

Project Title: Identifying the diets and breeding areas of harvested juvenile sea ducks: a continued stable isotope investigation (SDJV Project #171)

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Partners: None beyond SDJV.

Project Description: In 2020 the Sea Duck Joint Venture (SDJV) funded a pilot study to evaluate the ability of feather stable hydrogen isotope (δ^2H) data to delineate the most probable fledgling locations of juvenile long-tailed ducks and surf scoters harvested in North America. That study indicated that stable isotopes show promise for identifying the fledging locations of juvenile long-tailed ducks and surf scoters harvested in North America. However, that study had relatively small samples sizes and it also raised additional questions related to the potential of coastal/marine habitat as fledging areas and variation in the location of breeding habitats among flyways for birds provisioned in terrestrial/freshwater habitats. The present project aims to address these issues by describing the broad-scale dispersal patterns of juvenile sea ducks and delineating the breeding grounds of long-tailed ducks and surf scoters.

Project Objectives: (1) Increase sample sizes and fill geographic gaps in the locations of hunter-harvested juvenile long-tailed ducks and surf scoters for feather isotopic analysis. (2) Use δ^{13}C, δ^{15}N, and δ^{34}S values to identify birds provisioned from terrestrial/freshwater vs. coastal marine environments during feather growth. (3) Use δ^2H values to create a likelihood-of-origin map for individuals provisioned from terrestrial/freshwater environments to identify geographic areas of juvenile fledging. (4) Evaluate hypotheses about variation in the location of fledgling grounds of these species between flyways.

Preliminary Results: For the 243 birds for which we currently have δ^{13}C, δ^{15}N, and δ^{34}S data, 5% (surf scoter: n = 8; long-tailed duck: n = 4) had δ^{13}C, δ^{15}N, and δ^{34}S values suggestive of marine inputs (Table 1, Figs. 1-2). When using two or more isotope values to assess marine influence instead of three, the amount of sea ducks identified as provisioned from coastal marine environments during feather growth increased more than twofold to 12% (surf scoter: n = 13; long-tailed duck: n = 17; Figs. 1-2). If only using one isotope value to indicate a marine influence, the number of sea ducks identified as provisioned from coastal marine environments during feather growth substantially grows to 70% (surf scoter: n = 68; long-tailed duck: n = 102; Fig. 1; Fig. 2).

In deciding if we should be strict (i.e., requiring a bird to have three isotope values suggestive of a marine influence) or lenient (i.e., only requiring one isotope value suggestive of a marine influence) when identifying a bird as provisioned from coastal marine environments during feather growth, the δ^2H results suggest that strict criteria is the most appropriate choice. For example, the 8 surf scoters and 4 long-tailed ducks which have δ^{13}C, δ^{15}N, and δ^{34}S values suggestive of marine inputs have an average δ^2H value of -67 and -73 ‰, respectively, which are unusually positive values given their expected range and other δ^2H results (Figs. 3-4). In contrast, the surf scoters and long-tailed ducks with only two or one stable isotope values suggestive of marine inputs based had more negative δ^2H values (-99 and -106 ‰, respectively, for two or more stable isotope values; -89 and -112 ‰, respectively, for only one isotope value) given their expected range and other δ^2H results (Figs. 3-4). Therefore, the δ^2H data support that flagging a marine influence using three isotope values is likely the best strategy for identifying the birds eating off of a coastal marine environment during feather growth.

Since only 5% of birds for which we currently have data have $\delta^{13}C$, $\delta^{15}N$, and $\delta^{34}S$ values suggestive of a marine influence, most individuals of each species appear to have hatched and fledged in terrestrial/freshwater habitat. In our previous pilot study, hypotheses were suggested concerning why some marine signatures are appearing in species which are generally understood to be hatched and raised in terrestrial and/or freshwater environments: 1) hunter-killed birds were misidentified at wing bees (i.e., instead of being juveniles, they were older birds), or 2) 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, is playing a role in the stable isotope values. Our surf scoter data might support the second hypothesis, as the vast majority (88%) of surf scoters with stable isotope values suggestive of a marine influence were harvested in the Pacific flyway. Long-tailed ducks, however, do not show the same pattern as none of the samples suggestive of a marine influence were gathered from the Pacific flyway. Moreover, little support can be lent to the first hypothesis as a few of the live captured long-tailed ducks (n = 3) had $\delta^{13}C$, $\delta^{15}N$, and $\delta^{34}S$ values suggestive of marine inputs.

Our δ^2H results indicate that juvenile surf scoters and long-tailed ducks provisioned from terrestrial/freshwater food webs had a large range of δ^2H values (Fig. 3-4), indicating geographic origins from as south as Ontario to as north as Nunavut. Most δ^2H values suggested origins in Quebec and Ontario (surf scoter mean δ^2H = -126 ‰, Fig. 3; long-tailed duck mean δ^2H = -127 ‰, Fig. 4). Though mean δ^2H values are similar between both species, relatively more long-tailed ducks have more negative δ^2H values (i.e., more northward origins; Table 2). Not all samples with δ^2H values have received $\delta^{13}C$, $\delta^{15}N$, and $\delta^{34}S$ isotope analysis yet, which likely explains why several δ^2H values are highly positive (i.e., some of these samples may be ill-suited for geolocation purposes; Table 2).

Table 1. Stable isotope values which indicate a marine influence.

Stable isotope	**Value**
$\delta^{13}C$	> - 20 ‰
$\delta^{15}N$	> 11 ‰
$\delta^{34}S$	> 11 ‰

Table 2. Sample quantiles of juvenile surf scoter and long-tailed duck δ^2H values provisioned from terrestrial/freshwater food webs.

Probability	**Surf scoter δ^2H value**	**Long-tailed duck δ^2H value**
0%	-191.6 ‰	-188.7 ‰
25%	-143.4 ‰	-143.1 ‰
50%	-125.2 ‰	-128.2 ‰

75%	-107.9 ‰	-115.2 ‰
100%	-21.1 ‰	-30.1 ‰

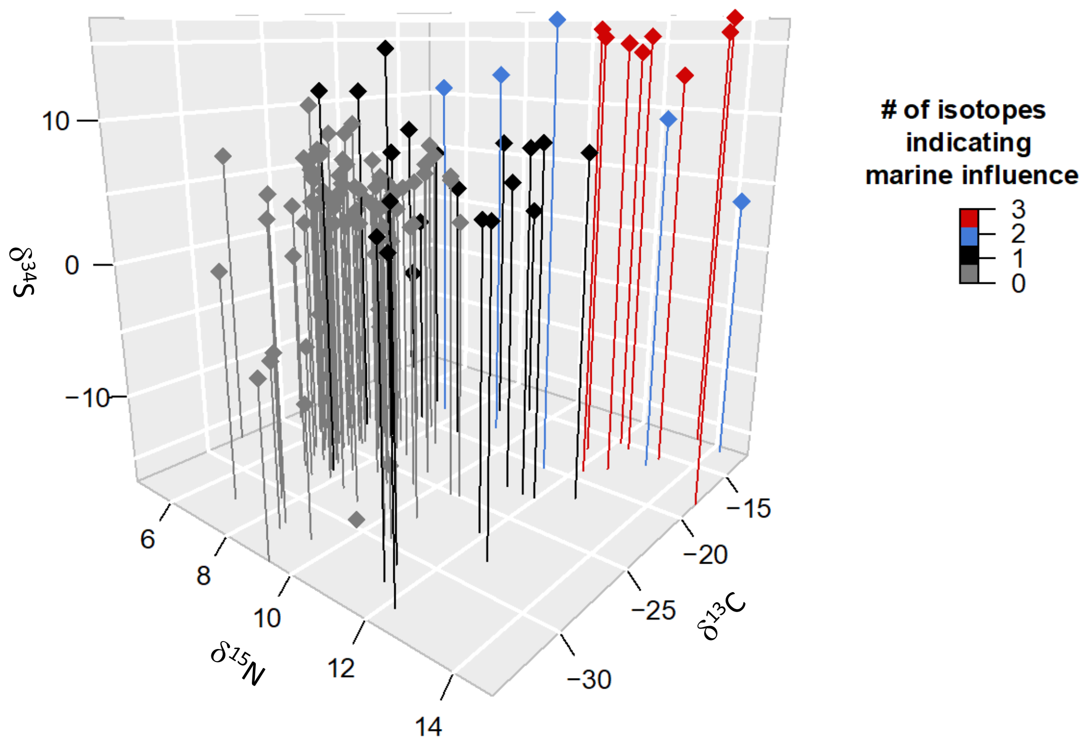

Figure 1. 3-dimensional plot of surf scoter $\delta^{13}C$, $\delta^{15}N$, and $\delta^{34}S$ values (n = 112), color coded by number of isotopes used to identify individuals as provisioned from coastal marine environments during feather growth. The area indicating the most support of a marine influence is located in the top right corner where $\delta^{13}C > -20$ ‰, $\delta^{15}N > 11$ ‰, and $\delta^{34}S > 11$ ‰.

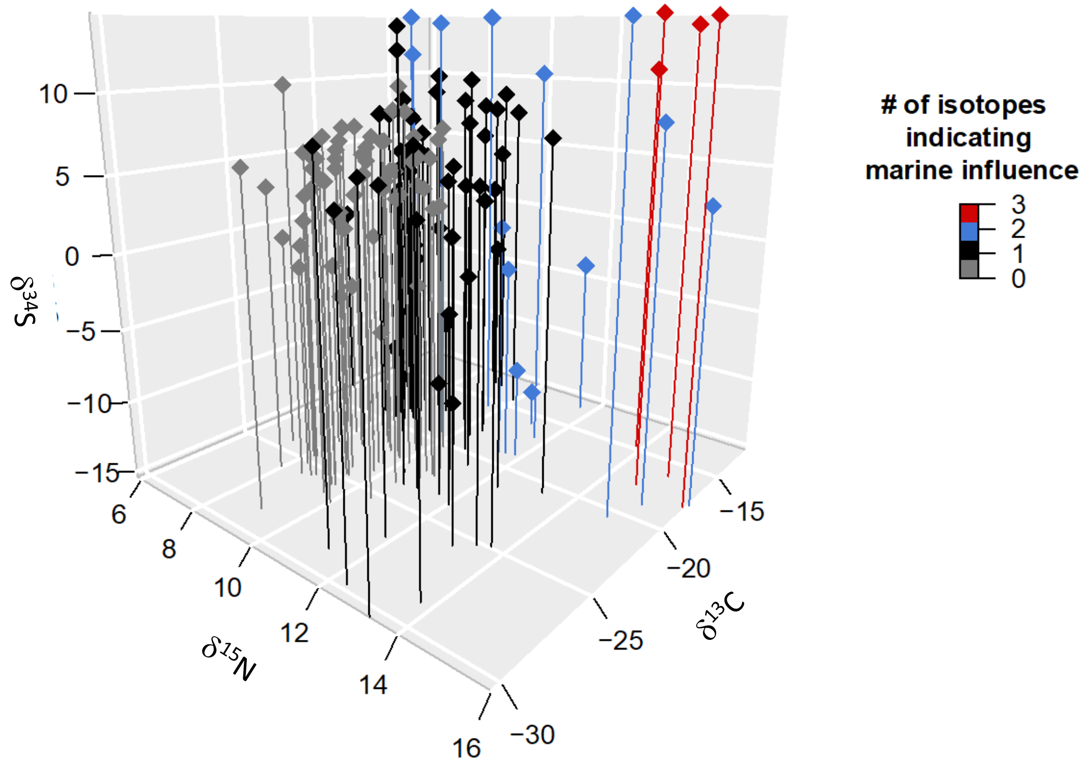

Figure 2. 3-dimensional plot of long-tailed duck $\delta^{13}C$, $\delta^{15}N$, and $\delta^{34}S$ isotope delta values (n = 131), color coded by number of isotopes used to identify individuals as provisioned from coastal marine environments during feather growth. The area indicating the most support of a marine influence is located in the top right corner where $\delta^{13}C$ > - 20 ‰, $\delta^{15}N$ > 11 ‰, and $\delta^{34}S$ > 11 ‰.

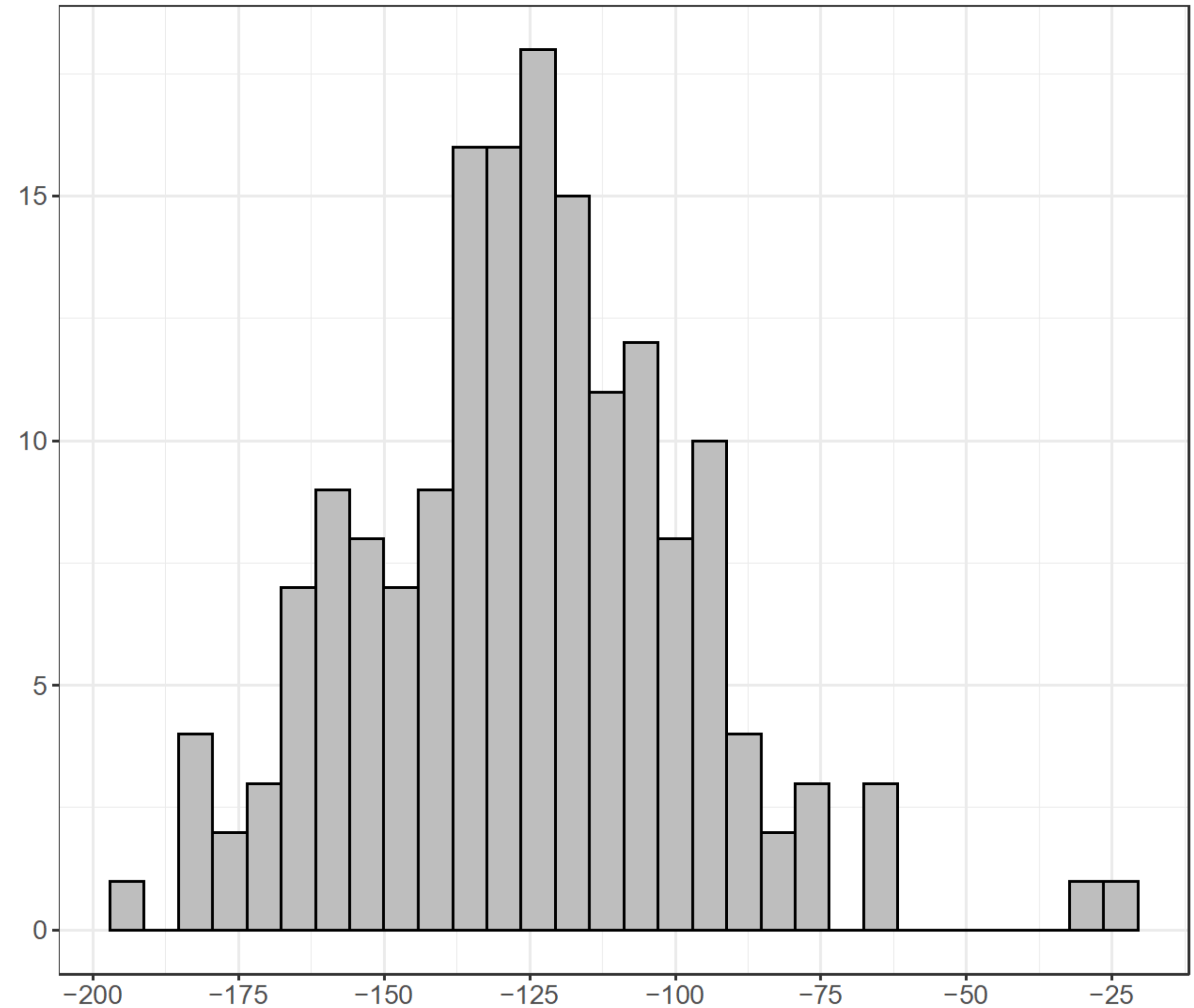

Figure 3. Histogram of surf scoter δ^2H values (n = 170), with δ^2H values on the X-axis and frequency on the Y-axis. Individuals identified as provisioned from coastal marine environments during feather growth based on 3 isotope values ($\delta^{13}C$ > - 20 ‰, $\delta^{15}N$ > 11‰, and $\delta^{34}S$ > 11 ‰) were excluded from the histogram.

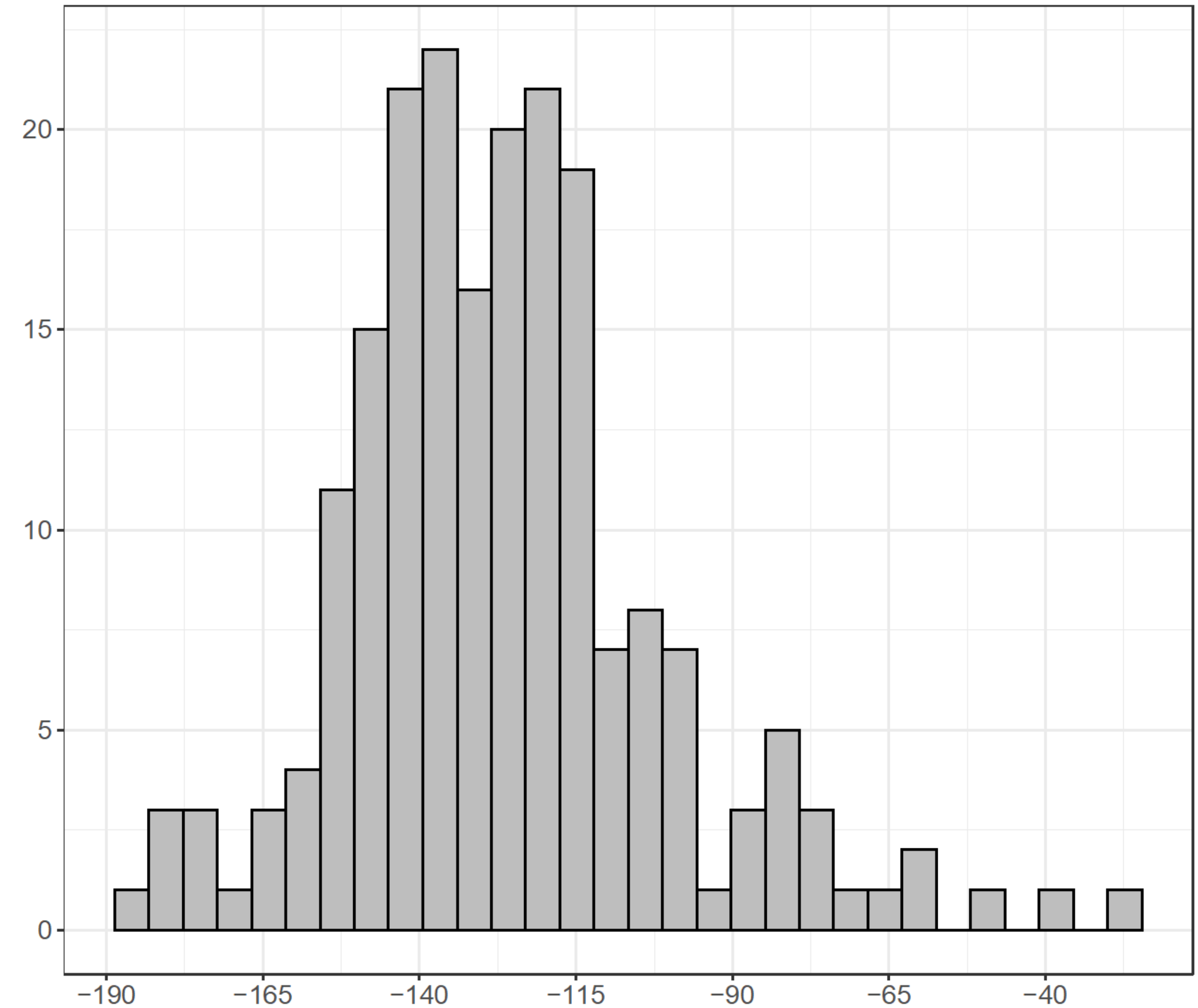

Figure 4. Histogram of long-tailed duck δ^2H values (n = 201), with δ^2H values on the X-axis and frequency on the Y-axis. Individuals identified as provisioned from coastal marine environments during feather growth based on 3 isotope values ($\delta^{13}C$ > - 20, ‰ $\delta^{15}N$ > 11 ‰, and $\delta^{34}S$ > 11 ‰) were excluded from the histogram.

Project Status: Objective 1 has been accomplished; 428 samples were added to the project to fill geographic gaps for feather isotopic analysis. Moreover, 30 long-tailed duck feathers and 14 surf scoter feathers of known origin have been acquired from museums. $\delta^{13}C$, $\delta^{15}N$, and $\delta^{34}S$ analysis to identify birds provisioned from terrestrial/freshwater vs. coastal marine environments during feather growth (objective 2) is ongoing. Out of the total 686 samples provided in both the pilot study and the present project, 302 (44%) have received $\delta^{34}S$ analysis and 258 (38%) have received $\delta^{13}C$ and $\delta^{15}N$ analysis to-date. Accordingly, 384 subsamples remain for $\delta^{34}S$ analysis and 428 subsamples remain for $\delta^{13}C$ and $\delta^{15}N$ analysis. δ^2H analysis for creating a likelihood-of-origin map (objective 3) is ongoing as well. All samples from the pilot study have received δ^2H analysis. Of the 428 new samples provided in the present project, 241 (56%) subsamples have received δ^2H analysis thus leaving 187 left for δ^2H analysis. Future plans consist of completing stable isotope analysis on the remaining subsamples and tackling the final objective to evaluate hypotheses about variation in the location of fledgling grounds of surf scoters and long-tailed ducks between flyways.

Project Funding Sources (US$)

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)
$83,461					

Total Expenditures by Category (SDJV plus all partner contributions; US$)

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			$83,461		$83,461