Sea Duck Joint Venture
Annual Project Summary
FY25 (October 1, 2024 – September 30, 2025)

Project Title: Identifying the diets and breeding areas of harvested juvenile sea ducks: a continued stable isotope investigation (F23AS00018)

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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 $\delta^{13}C$, $\delta^{15}N$, and $\delta^{34}S$ 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:
Objective 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

Throughout the project duration, the SDJV provided feather samples from a total of 670 individuals (Surf Scoters: n=307; Long-tailed Ducks: n=363) for stable isotope analysis. However, 106 of these individuals did not have associated spatial data on harvest location and were therefore not included in analysis. The resulting project sample size thus consists of 564 individuals (Surf Scoters: n=255; Long-tailed Ducks: n=309) from all four North American Flyways (Table 1).

In addition to individuals of unknown origin provided by the SDJV, we have acquired 11 Surf Scoter and 29 Long-tailed Duck feathers of known origin from museums. These samples were used to create transfer functions to calibrate the likelihood-of-origin maps (Figure 1).

Objective 2: Use $\delta^{13}C$, $\delta^{15}N$, and $\delta^{34}S$ values to identify birds provisioned from terrestrial/freshwater vs. coastal marine environments during feather growth.

The majority (95%) of sea ducks were identified as provisioned from terrestrial/freshwater environments during feather growth. Only 18 Surf Scoters and 10 Long-tailed Ducks have $\delta^{13}C$, $\delta^{15}N$, and $\delta^{34}S$ values suggestive of marine inputs (Table 2). As such, the sample size for the likelihood-of-origin maps is 536 individuals (Surf Scoters: n=237; Long-tailed Ducks: n=299) across all North American flyways (Table 3). Hypothesis a from this project postulated that, "***known-age juvenile Long-tailed Ducks and Surf Scoters are not provisioned from coastal/marine environments and therefore hunter-killed juveniles that appear to have fledged in coastal/marine environments are likely to have been mis-aged at wing bees. Alternatively, perhaps some individuals (particularly for Long-tailed Ducks) do fledge in coastal areas.***" The majority (86%; n=24) of individuals identified as having a marine influence in their diet were not live-captured, which supports the hypothesis that hunter-killed juveniles that appear to have fledged in coastal/marine environments are likely to have been mis-aged at wing bees. However, we did find minimal evidence that some individuals (in particular Long-tailed Ducks) do fledge in coastal areas, as 3 Long-tailed Ducks and 1 Surf Scoter were live captured and unlikely to have been mis-aged.

Objective 3: Use $\delta^{2}H$ values to create a likelihood-of-origin map for individuals provisioned from terrestrial/freshwater environments to identify geographic areas of juvenile fledging.

Despite $\delta^{13}C$, $\delta^{15}N$, and $\delta^{34}S$ analysis, 28 individuals (Surf Scoters: n=7; Long-tailed Ducks: n=21) were still unable to be adequately assigned to the breeding grounds due to unusually high $\delta^{2}H$ values that resulted in geographic assignments that were well south of the breeding ranges of these species. The likelihood-of-origin maps for the remaining individuals represent the areas of likely origin for both Long-tailed Ducks (Figures 2-5) and Surf Scoters (Figures 6-8) from each flyway, with variation in the number of individuals coming from the different clusters. After helpful insight from the 2024 SDJV annual project summary meeting, we changed the range maps to reflect the results from Pearce et al. (2019). This change resulted in much more refined assignments to origin (e.g., Figure 3B, Figure 8B). However, given that some of the high likelihood-of-origin regions still span a large longitudinal gradient (e.g. Figure 2D, Figure 6B), we are currently working on refining the likelihood-of-origin maps to better assess hypotheses about variation in the location of fledgling grounds of these species between flyways. To do so, we are incorporating analyses from Sarah's SDJV fellowship (S008).

Objective 4: Evaluate hypotheses about variation in the location of fledgling grounds of these species between flyways.

To evaluate variation in the location of fledgling grounds of these species between flyways, we are conducting a formal analysis of migratory connectivity (see Cohen et al. 2018) that is still underway. Informally, we can use the likelihood-of-origin maps (Figures 2-8) to evaluate hypotheses about variation in the location of fledgling grounds of these species between flyways:

Hypothesis b: Juvenile long-tailed ducks that are provisioned from terrestrial/freshwater habitat and killed in the Atlantic, Mississippi (i.e., Great Lakes region), and Pacific flyways have different origins.

The likelihood-of-origin maps which display more precise predictions do not lend support to hypothesis b. For example, Long-tailed Ducks harvested in Mississippi and Pacific flyways show similar breeding sites (Figure 3B; Figure 5C). As another example, Long-tailed Ducks harvested in the Atlantic and Mississippi flyways show similar breeding sites (Figure 2C; Figure 3E). However, we are currently working on refining the maps which display less precise predictions to better assess hypothesis b.

Hypothesis c: Juvenile surf scoters that are provisioned from terrestrial/freshwater habitat and killed in the Atlantic flyway fledge predominantly in eastern Canada, those killed in the Mississippi flyway fledge predominantly in northcentral Canada, and those killed in the Pacific flyway fledge predominantly in western Canada and Alaska.

The likelihood-of-origin maps reveal some support for hypothesis c. For example, some Surf Scoters harvested in the Atlantic, Mississippi, and Pacific flyways show likely origins in eastern Canada (Figure 6A; Figure 6F), northcentral Canada (Figure 7A; Figure 7B), and western Canada (Figure 8B), respectively. However, the likelihood-of-origin maps also show evidence of origins outside these hypothesized areas. For example, some Surf Scoters harvested in the Atlantic flyway also had likely origins in central Canada (Figure 6D; Figure 6E). As another example, several Surf Scoters harvested in the Mississippi and Pacific flyways had likely origins in southeastern Canada (Figure 7C; Figure 8E).

Table 1. Sample sizes of juvenile Surf Scoter and Long-tailed Duck by flyway.

Flyway	**Sample size**		
	Surf Scoter	*Long-tailed Duck*	*Total*
Atlantic	160	193	353
Mississippi	12	107	119
Central	1	1	2
Pacific	82	8	90

Table 2. Stable isotope values which indicate a marine influence.

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

Table 3. Sample sizes of juvenile Surf Scoter and Long-tailed Duck by flyway for likelihood-of-origin maps

Flyway	**Sample size**		
	Surf Scoter	*Long-tailed Duck*	*Total*
Atlantic	152	186	338
Mississippi	12	104	116
Central	1	1	2
Pacific	72	8	80

Figure 1. Transfer functions for Surf Scoter (Adj. $R^2 = 0.91$; $p < 0.0001$), Long-tailed Duck (Adj. $R^2 = 0.06$; $p > 0.1$), and both species combined (Adj. $R^2 = 0.55$; $p < 0.000001$).

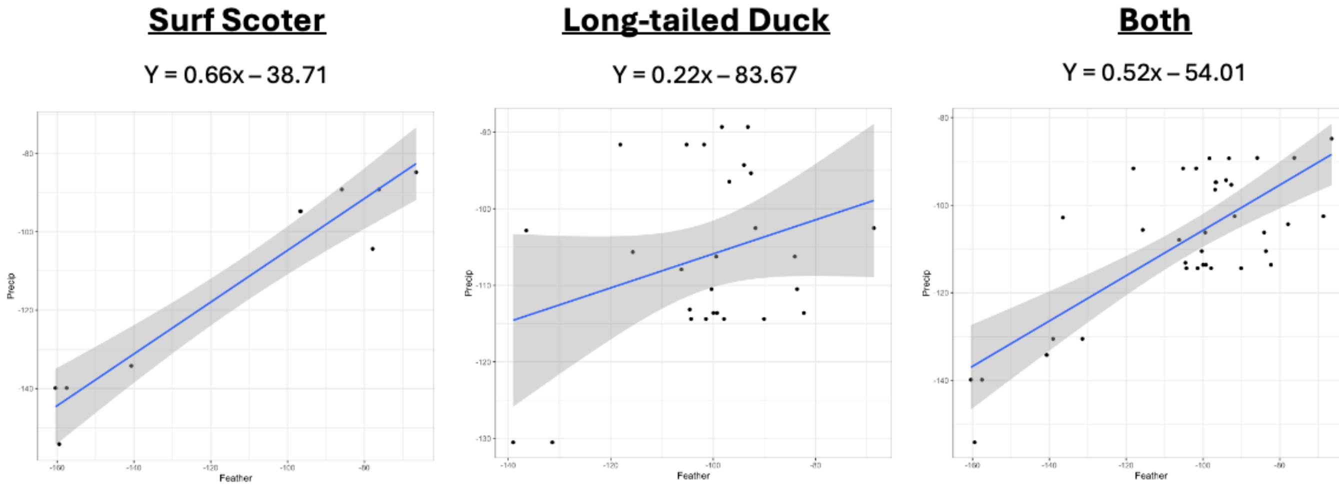


Figure 2. Likelihood-of-origin maps cropped to the breeding range for Long-tailed Ducks harvested in the Atlantic Flyway. Letters reflect clusters of assignments (Cluster A: n=59; Cluster B: n=44; Cluster C: n=14; Cluster D: n=48) and arrows are used to highlight smaller areas of origin.

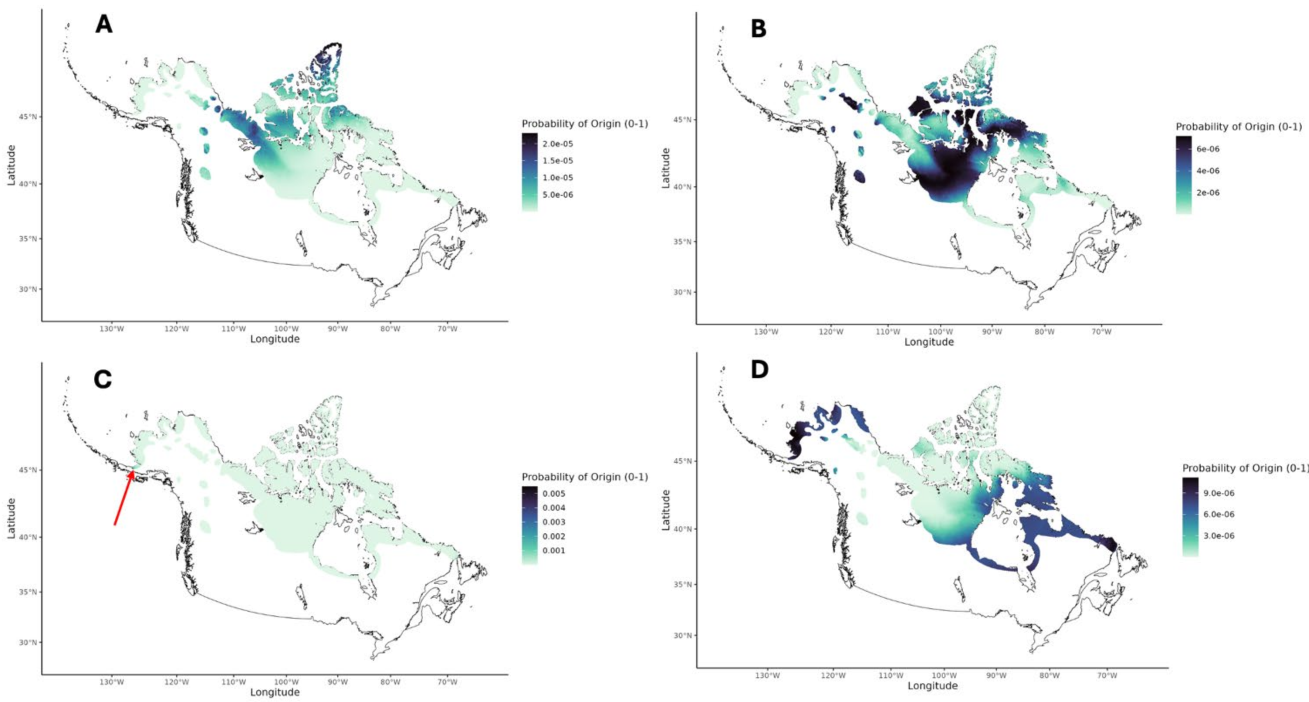


Figure 3. Likelihood-of-origin maps cropped to the breeding range for Long-tailed Ducks harvested in the Mississippi Flyway. Letters reflect clusters of assignments (Cluster A: n=16; Cluster B: n=41; Cluster C: n=21; Cluster D: n=21; Cluster E: n=5) and arrows are used to highlight smaller areas of origin.

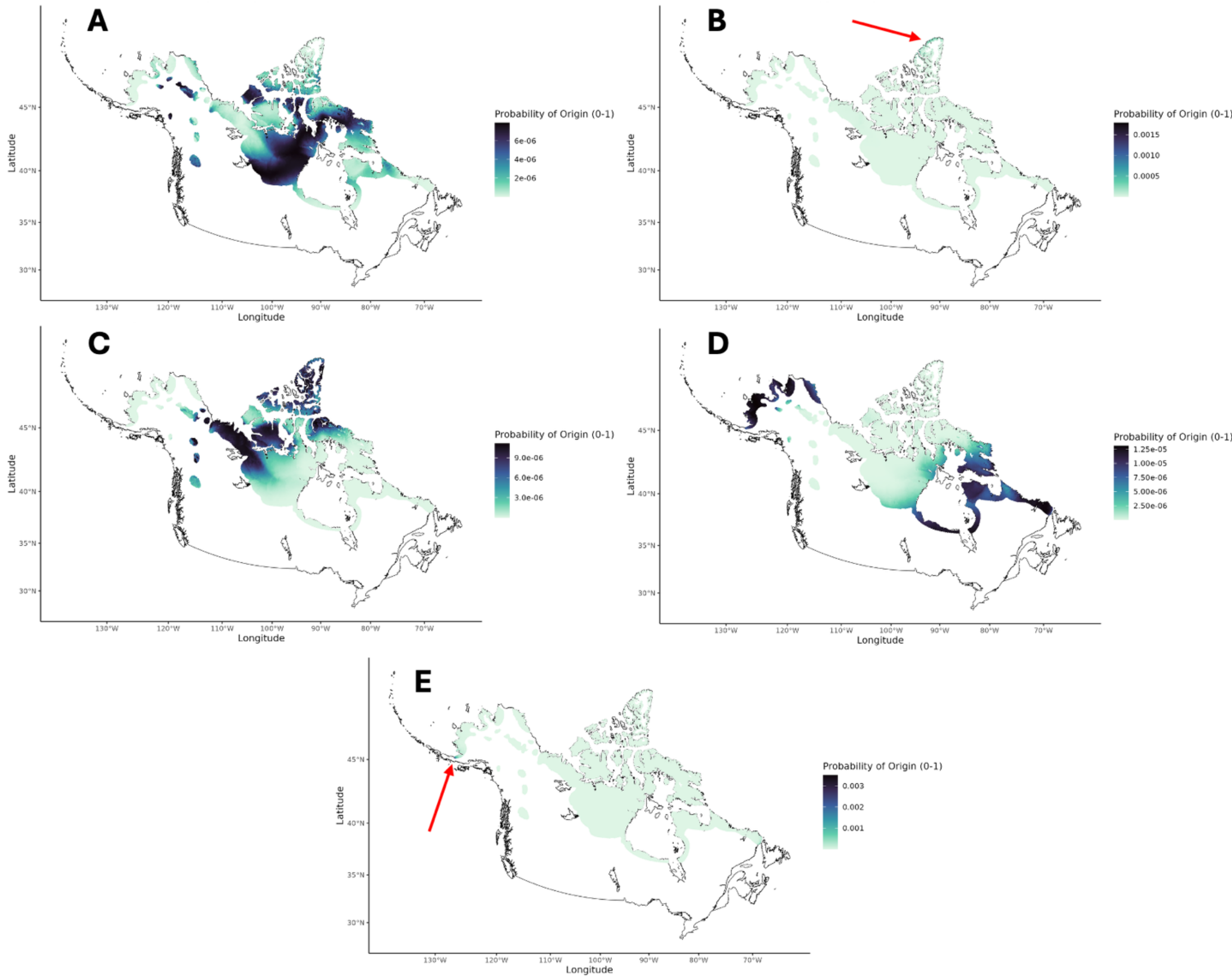


Figure 4. Likelihood-of-origin map cropped to the breeding range for the one Long-tailed Duck harvested in the Central Flyway.

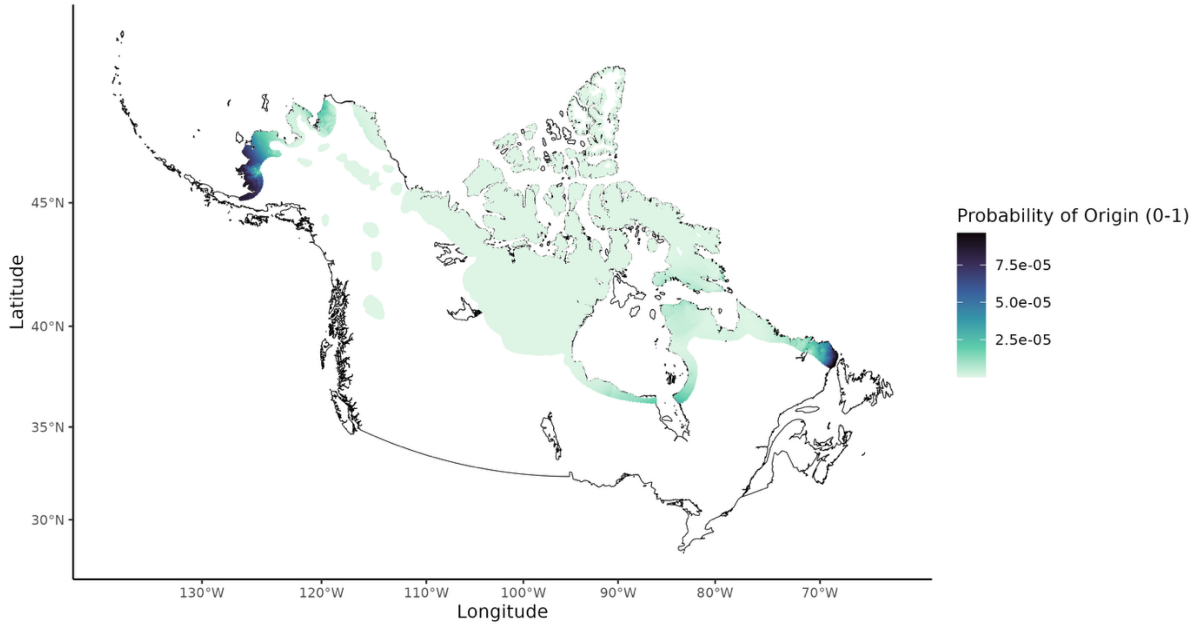


Figure 5. Likelihood-of-origin maps cropped to the breeding range for Long-tailed Ducks harvested in the Pacific Flyway. Letters reflect clusters of assignments (Cluster A: n=4; Cluster B: n=1; Cluster C: n=2; Cluster D: n=1).

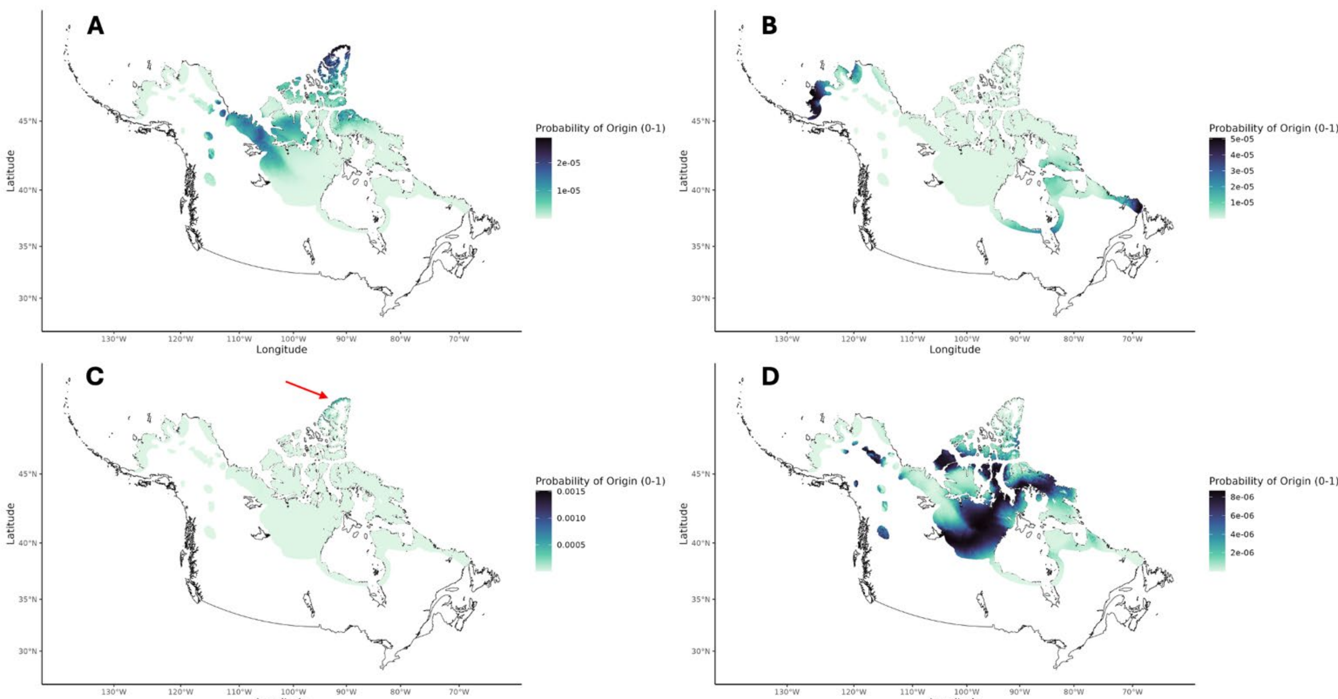


Figure 6. Likelihood-of-origin maps cropped to the breeding range for Surf Scoters harvested in the Atlantic Flyway. Letters reflect clusters of assignments (Cluster A: n=28; Cluster B: n=41; Cluster C: n=30; Cluster D: n=34; Cluster E: n=13; Cluster F: n=4).

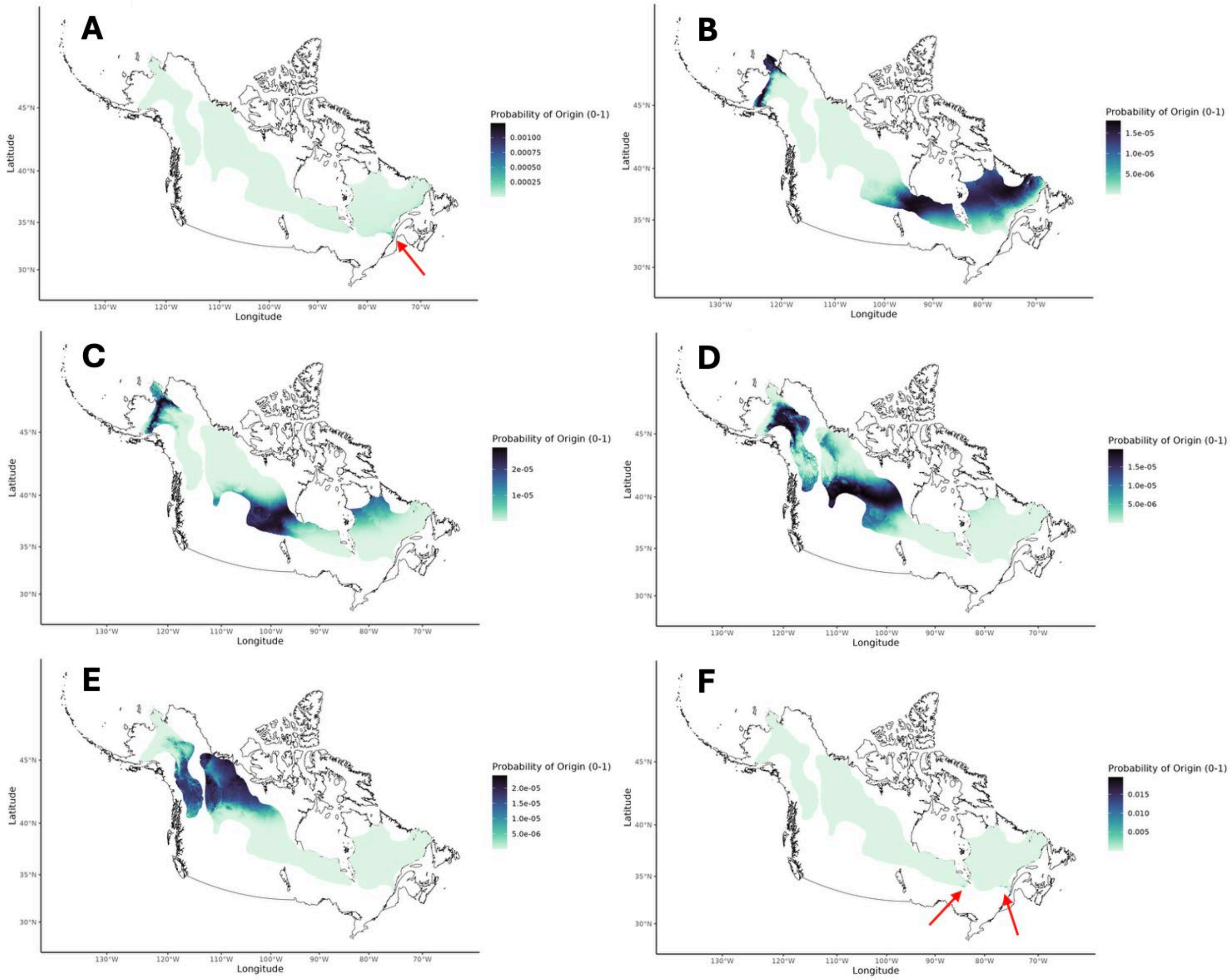


Figure 7. Likelihood-of-origin maps cropped to the breeding range for Surf Scoters harvested in the Mississippi Flyway. Letters reflect clusters of assignments (Cluster A: n=2; Cluster B: n=5; Cluster C: n=3; Cluster D: n=2).

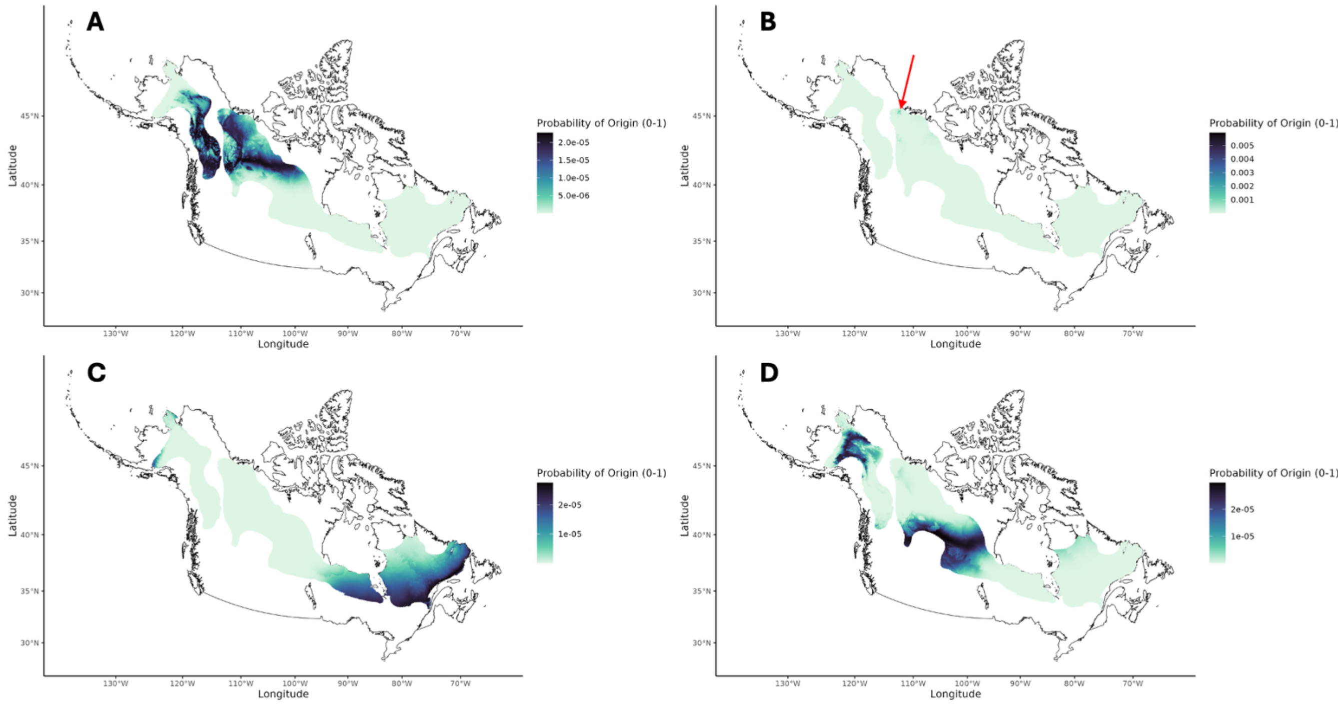
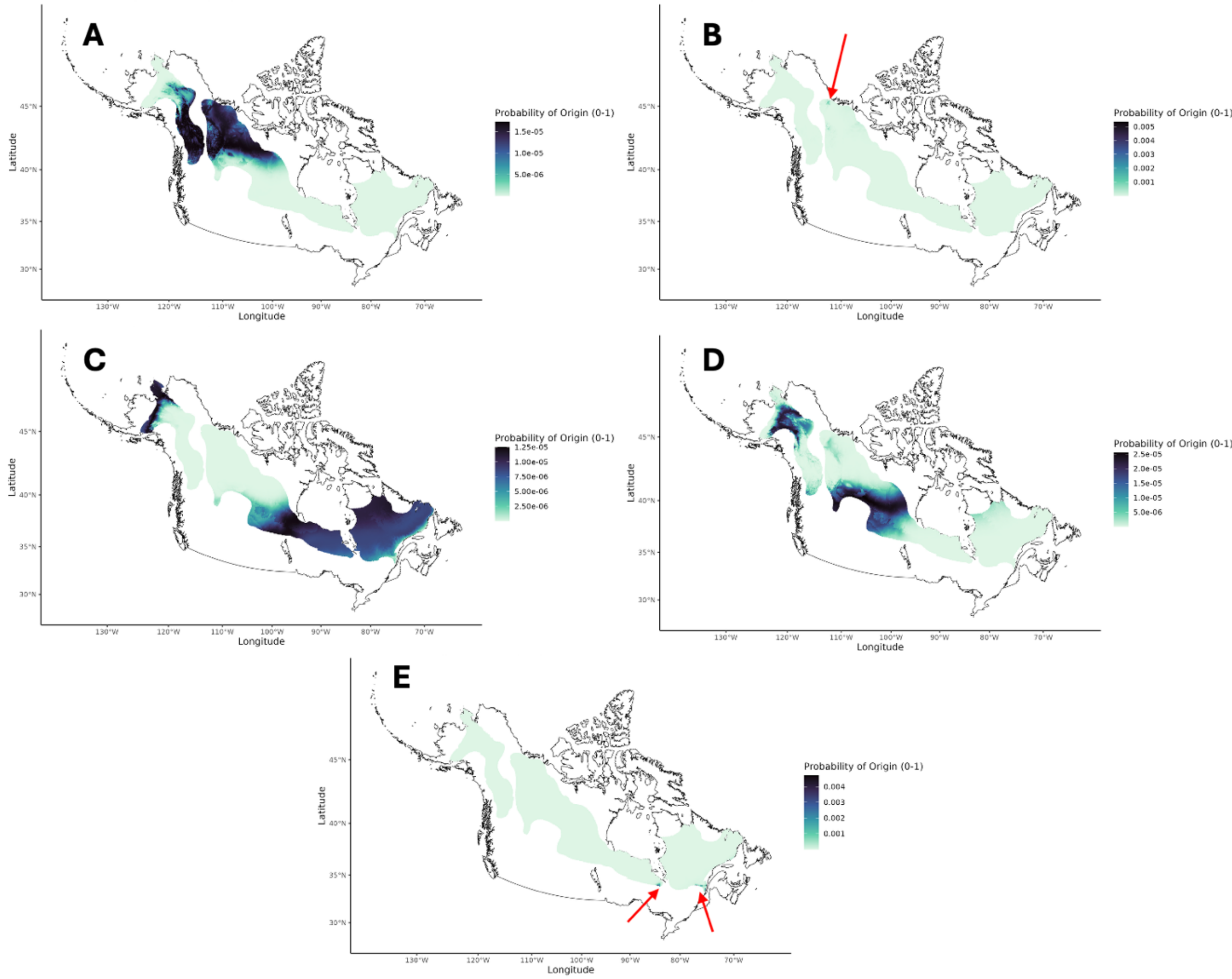


Figure 8. Likelihood-of-origin maps cropped to the breeding range for Surf Scoters harvested in the Pacific Flyway. Letters reflect clusters of assignments (Cluster A: n=15; Cluster B: n=28; Cluster C: n=5; Cluster D: n=11; Cluster E: n=2).



Project Status: Stable isotope analysis has been completed and objectives 1, 2, and 3 have been accomplished. To finish out the project, we will work on evaluating 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