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

Project Title: Characterization of the migratory patterns, connectivity, philopatry and timing of the western North American Harlequin duck (*Histrionicus histrionicus)* population throughout the annual cycle. SDJV project #168.

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Project Description: The Harlequin duck was recently added to the Sea Duck Joint Venture's (SDJV) list of species of management concern and is included in the FY2022 SDJV Notice of Funding Opportunity as a high priority species because of "historical or current declines and concerns about harvest potential or habitat limitations." Contributing to and further refining our understanding of population delineation, migratory connectivity, and habitat utilization of priority sea duck species is considered by the SDJV to be among its priority scientific needs. The ways in which the different breeding and non-breeding portions of the North American Harlequin duck population are geographically connected throughout the various stages of their annual migratory cycle are poorly understood for the western portion of the species' range. The primary objective of this study is to enhance our collective understanding of Harlequin duck migratory ecology among the western North American population.

Beginning in 2014, representatives from the Washington Department of Fish and Wildlife, the National Park Service, Montana Fish, Wildlife, and Parks, the Biodiversity Research Institute, Environment and Climate Change Canada, Bighorn Wildlife Technologies, and the Wyoming Game and Fish Department initiated a collaborative Harlequin duck tagging effort. Researchers from Environment and Climate Change Canada conducted marine captures off the coast of

British Columbia in 2014 and 2015; capture areas included White Rock, Hornby Island, and Kitimat. In addition, spring captures were conducted on breeding streams each year between 2016 and 2019 on the McLeod River in Alberta, in Glacier National Park and elsewhere throughout Northwest Montana, throughout the Cascade and Olympic Mountains of Washington, and in Grand Teton and Yellowstone National Parks, Wyoming. A small subset of historical telemetry data collected by the Alaska Department of Fish and Game from birds captured in Prince William Sound in 2001 and 2002 was also incorporated. In all, 113 male and 20 female Harlequin ducks were captured and implanted with PTT tags. Birds were tracked for varying degrees of time ranging from several weeks to just under 2 years. The intention of this project is to complete a spatial analysis of this telemetry dataset and compose a report which will be submitted for publication and be used to satisfy the requirements for my Master of Science degree.

Project Objectives:

1. Characterize and quantify the degree of migratory connectivity among individuals throughout the various stages of the annual cycle.
2. Map migration routes and geographic regions of significance that serve as important breeding, over-wintering, stop over, and moulting habitat.
3. Quantify the degree of philopatry associated with the aforementioned regions of significance.
4. Chronicle the temporal sequence of the annual migration.
5. Compare locational data among paired birds in an effort to ascertain timing and location of pair reunion prior to/during the breeding season and length of time spent together on breeding grounds.

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

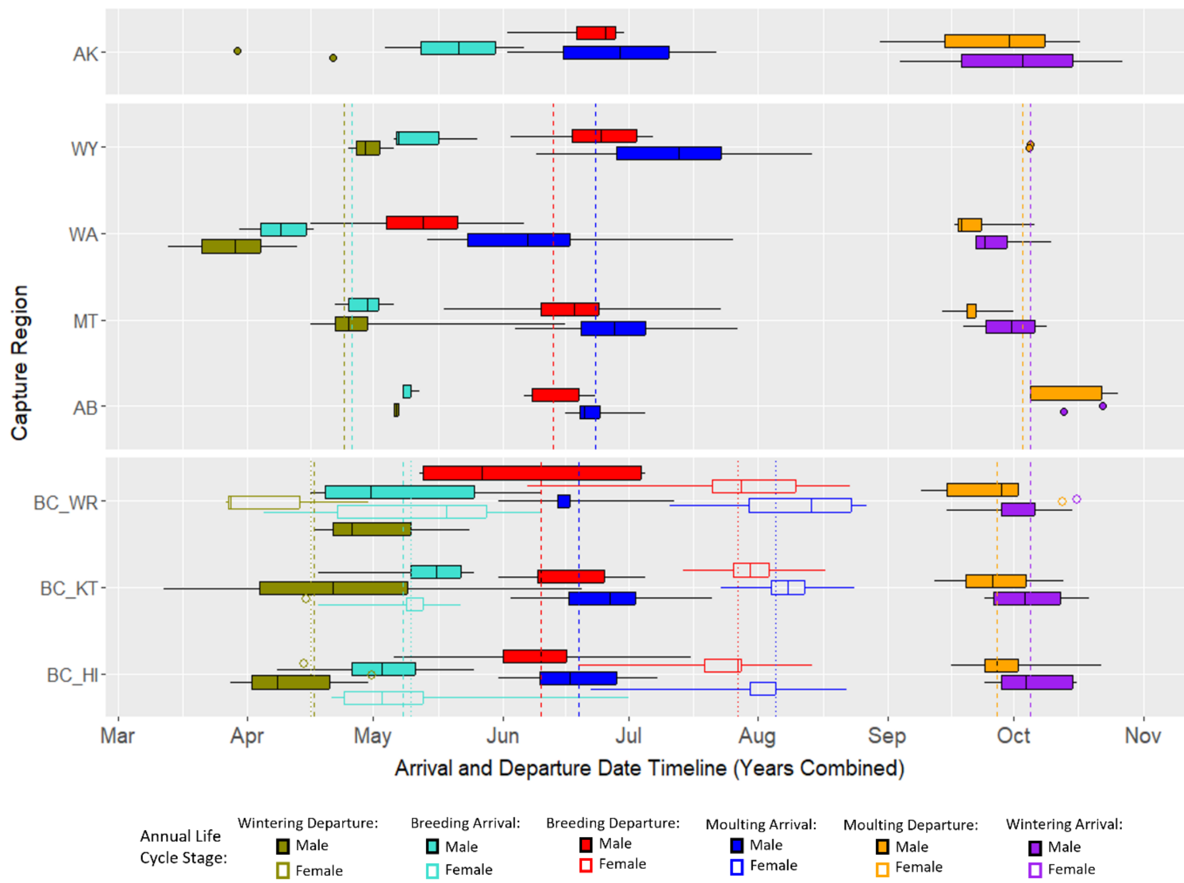

Figure 1: Range of arrival and departure dates for the various stages of the annual life cycle. Dashed lines represent the group median dates for the males for each respective annual life cycle stage and dotted lines represent the group median dates for females for each respective annual life cycle stage (only the BC dataset contains both males and females). The three datasets span multiple years (2001, 2002, 2003, 2014, 2015, 2016, 2017, 2018, and 2019). Arrival dates represent the latest possible arrival date and departure dates represent the earliest possible departure date.

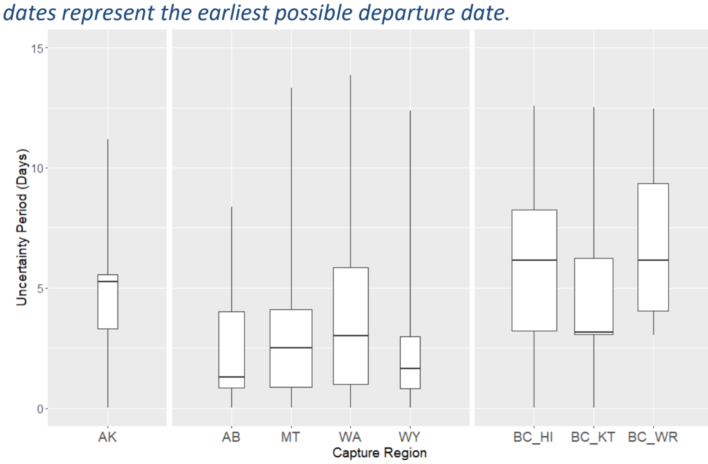

Figure 2: Range of uncertainty periods across all annual life cycle stages. Uncertainty periods were calculated as the duration between the last Argos location recorded outside of the respective annual life cycle stage point cluster and the first point recorded within it (for arrival dates) or the last Argos location recorded inside of the respective annual life cycle stage point cluster and the first point recorded outside of it (for departure dates). Only records with an uncertainty period of 14 days or less were included in the analysis of arrival and departure dates.

Capture Region	Sex	Annual Life Cycle Stage	n	min	max	median	q1	q3	Record Year(s)
AK	m	Breeding Arrival	4	04-May	06-Jun	21-May	12-May	30-May	2002, 2003
AB, MT, WA, WY	m	Breeding Arrival	23	30-Mar	26-May	26-Apr	15-Apr	06-May	2017, 2018, 2019
BC	m	Breeding Arrival	32	08-Apr	10-Jun	08-May	25-Apr	13-May	2014, 2015, 2016
BC	f	Breeding Arrival	22	05-Apr	01-Jul	10-May	24-Apr	20-May	2014, 2015, 2016
AK	m	Breeding Departure	4	02-Jun	30-Jun	25-Jun	18-Jun	27-Jun	2002, 2003
AB, MT, WA, WY	m	Breeding Departure	63	16-Apr	23-Jul	13-Jun	27-May	22-Jun	2016, 2017, 2018, 2019
BC	m	Breeding Departure	31	06-May	16-Jul	10-Jun	31-May	20-Jun	2014, 2015, 2016
BC	f	Breeding Departure	16	07-Jun	23-Aug	27-Jul	19-Jul	01-Aug	2014, 2015, 2016
AK	m	Moulting Arrival	3	02-Jun	22-Jul	29-Jun	-	-	2002
AB, MT, WA, WY	m	Moulting Arrival	58	14-May	14-Aug	23-Jun	15-Jun	04-Jul	2016, 2017, 2018, 2019
BC	m	Moulting Arrival	41	31-May	21-Jul	19-Jun	13-Jun	29-Jun	2014, 2015, 2016
BC	f	Moulting Arrival	14	22-Jun	27-Aug	05-Aug	30-Jul	18-Aug	2014, 2015, 2016
AK	m	Moulting Departure	3	30-Aug	17-Oct	30-Sep	-	-	2001, 2002
AB, MT, WA, WY	m	Moulting Departure	18	14-Sep	12-Nov	03-Oct	19-Sep	05-Oct	2016, 2017, 2018
BC	m	Moulting Departure	25	09-Sep	22-Oct	27-Sep	24-Sep	02-Oct	2014, 2015, 2016
AK	m	Wintering Arrival	3	04-Sep	27-Oct	03-Oct	-	-	2001, 2002
AB, MT, WA, WY	m	Wintering Arrival	12	19-Sep	16-Nov	05-Oct	25-Sep	09-Oct	2016, 2017, 2018
BC	m	Wintering Arrival	18	15-Sep	19-Oct	05-Oct	27-Sep	13-Oct	2014, 2015
AK	m	Wintering Departure	2	07-Apr	29-Apr	-	-	-	2003
AB, MT, WA, WY	m	Wintering Departure	27	13-Mar	16-Jun	24-Apr	06-Apr	01-May	2017, 2018, 2019
BC	m	Wintering Departure	20	12-Mar	20-Jun	17-Apr	02-Apr	01-May	2015, 2016
BC	f	Wintering Departure	6	27-Mar	30-Apr	16-Apr	01-Apr	26-Apr	2015, 2016

Figure 2: Annual life cycle stage arrival and departure date summary statistics (number of records, minimum date, maximum date, median date, quartile 1 date, quartile 3 date, and the year(s) represented in the records). The median dates from this table were used to create the group median lines in the previous figure.

Capture Region	Sex	Annual Life Cycle Stage	n	min	max	median	q1	q3	Record Year(s)
AK	m	Breeding	4	23.47	42.43	28.05	26.28	32.27	2002, 2003
AB_MT_WA_WY	m	Breeding	14	1.08	61.26	37.93	17.59	42.44	2017, 2018, 2019
BC	m	Breeding	24	9.47	53.69	34.4	27.36	40.8	2014, 2015, 2016
BC	f	Breeding	11	50.03	96.88	81.29	67.23	89.12	2014, 2015, 2016
AK	m	Moulting	2	86.64	89.03	-	-	-	2002
AB_MT_WA_WY	m	Moulting	16	49.46	182.17	96.42	84.18	106.62	2016, 2017, 2018
BC	m	Moulting	21	82.58	131.3	100.11	90.7	107.33	2014, 2015, 2016
AK	m	Wintering	1	214.72	-	-	-	-	2002-2003
AB_MT_WA_WY	m	Wintering	8	185.02	214.27	193.19	187.7	208.19	2016-2017, 2017-2018, 2018-2019
BC	m	Wintering	10	168.78	240.7	197.54	186.18	211.81	2014-2015, 2015-2016
AK	m	Moulting/Wintering	1	304	-	-	-	-	2002-2003
AB_MT_WA_WY	m	Moulting/Wintering	12	292.14	325.48	312.6	303.9	319.52	2016-2017, 2018-2019
BC	m	Moulting/Wintering	6	265.66	312.54	302.61	278.94	306.06	2014-2015, 2015-2016
BC	f	Moulting/Wintering	3	265.67	268.74	268.19	-	-	2014-2015, 2015-2016

Figure 4: Annual life cycle stage occupancy duration summary statistics (number of records, minimum date, maximum date, median date, quartile 1 date, quartile 3 date, and the year(s) represented in the records). Expressed in days.

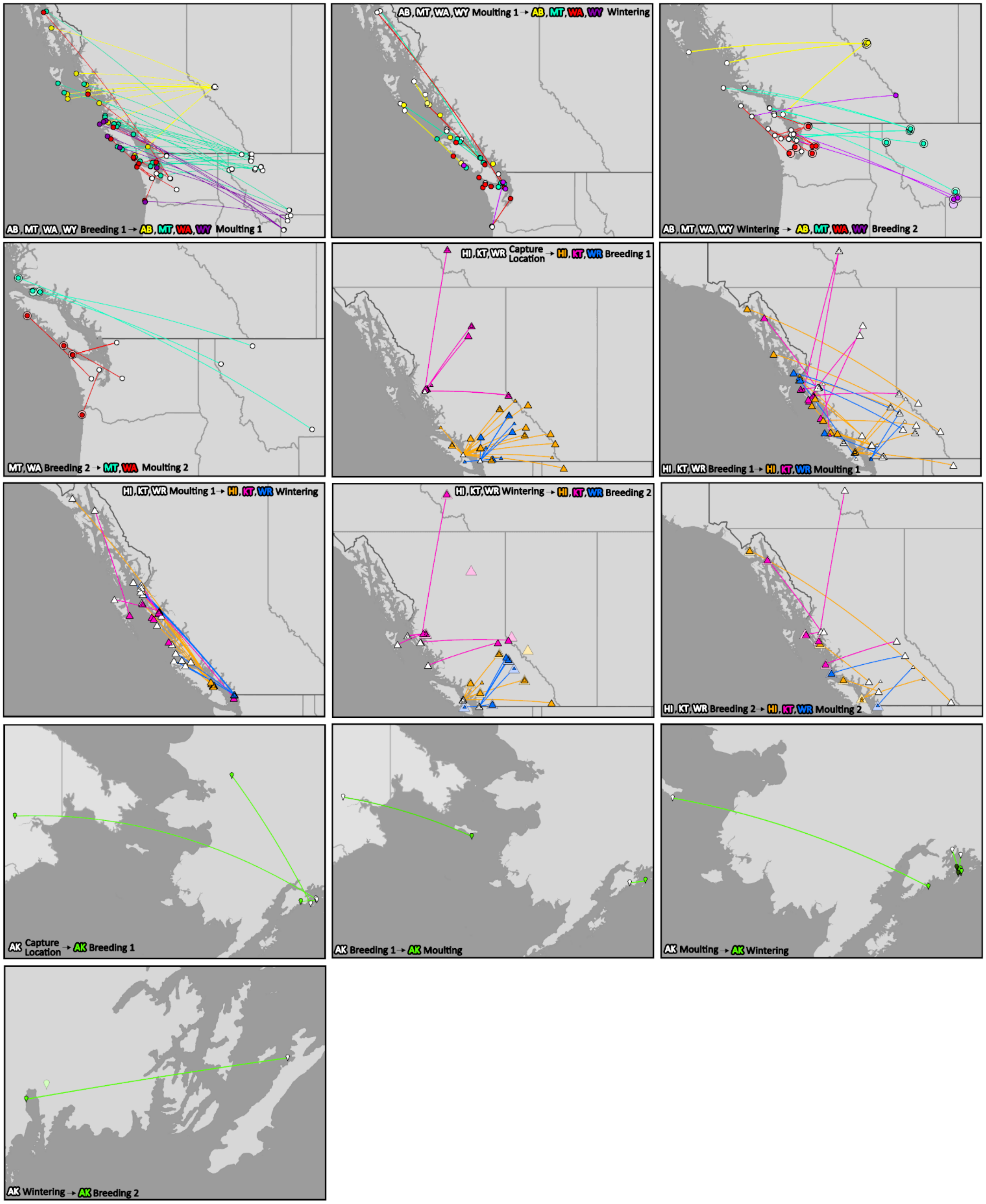

Figure 5: Breeding, moulting, and wintering site maps. The larger, translucent icons depicted in the Breeding 2 and Moulting 2 maps represent the previous seasons use area. For the BC maps (HI, KT, WR), large triangles represent males and small triangles represent females.

Paired Birds (M_F)	Designated Separation Day 1	Designated Reunion Day	Duration Spent Apart (Days)	Designated Separation Day 2	Duration Spent Together Days	Comments
HI15_144781_HI15_135732	2015-06-21 14:26	2015-10-19 05:30	119.6272454	2016-06-14 12:21	239.2859838	Male moulted in a different area than where it wintered (moulted off the coast of Dundas Island, on the BC/Alaska border). Male first arrived on wintering grounds sometime between 10-11 and 10-15. Male and female reunited almost immediately upon the males return to their wintering area. The Argos location dates for these two birds were out of sync, which made it a bit difficult to match up their movements.
HI15_144763_HI15_135734	2015-06-13 10:28	2015-08-05 12:15	53.07418981	2016-06-10 10:50:00*	309.94130787037*	Male moulted and wintered in the same area. Female first arrived on moulting/wintering grounds sometime between 08-01 and 08-05. Male and female reunited immediately upon the females arrival on their moulting/wintering grounds. The Argos location dates for these two birds were out of sync, which made it a bit difficult to match up their movements. *The male stopped transmitting data while on their breeding grounds. The calculated duration spent together is incomplete.
KT14_135664_KT14_135648	2014-05-22 11:40	2014-09-30 15:01	131.1399769	2015-03-30 23:51:00*	181.367951388889*	Male moulted and wintered in the same area. The male and female did not immediately reunite on their moulting/wintering grounds. Male arrived on moulting/wintering grounds sometime between 07-08 and 07-11 and the female arrived sometime between 08-05 and 08-08. The locational data shows them inhabiting different areas within their moulting/wintering range between 08-08 and 9/30. The male inhabited the southeast coast of Fin Island and the female inhabited the northern tip of Gil Island. *The female stopped transmitting data while on their moulting/wintering grounds. The calculated duration spent together is incomplete.
WR15_144768_WR15_144764	2015-07-04 00:17	2015-10-23 10:52	111.4406713	2016-07-05 04:59	255.754838	Male moulted in a different area than where it wintered (moulted off the coast of Duke Island, on the BC/Alaska border). Male first arrived on wintering grounds sometime between 10-11 and 10-15. Male and female reunited almost immediately upon the males return to their wintering area.
KT14_135661_KT14_135645	2014-06-07 02:33	2014-09-27 13:39	112.4625	2015-06-10 20:52	256.3002894	Male moulted and wintered in the same area. The male and female did not immediately reunite on their moulting/wintering grounds. Male arrived on moulting/wintering grounds sometime between 06-10 and 06-13 and the female arrived sometime between 07/14 and 07/23. The locational data shows them inhabiting different areas within their moulting/wintering range between 07/23 and 09/27. The male mostly inhabited the west coast of Porcher Island and the female inhabited the west coast of Goschen Island. The female experienced an equipment falure on the very last day the male was recorded on their breeding grounds.

Figure 6: Summary of the timing and movement of breeding pairs.

Capture Region	Number of Birds	Number of Birds with Detected Site Revisits	Number of Birds with Detected Revisits to a Single Site	Number of Birds with Detected Revisits to Two Different Sites	Number of Birds with Detected Revisits to Three Different Sites	Number of Birds with Detected Revisits to Four Different Sites	Number of Sites with a Single Detected Revisit	Number of Sites with Two Detected Revisits	Number of Sites with Three Detected Revisits	Total Number of Pairwise Distances Between Revisited Site Centroids	min	max	median	q1	q3
AK	13	6	4	2	-	-	7	1	-	10	0.35	11.68	1.62	1.18	7.05
AB_MT_WA_WY	55	29	8	10	10	1	49	10	3	97	0.21	19.69	2.23	0.96	6.4
BC	50	40	14	17	4	5	54	21	5	145	0.1	19.84	2.52	1.16	4.92

Figure 7: Site fidelity summary. Pairwise distances were calculated between revisited site centroids. Sites that were located within 20 km of an area previously occupied were considered revisits. Pairwise distance summary statistics are presented in the far-right end of the table. Distances expressed in km. Site revisits were detected for each annual life cycle stage (breeding, moulting, and wintering) as well as for stopover sites. Some revisited sites were used for different purposes during different times of the year. For example, some sites that served as wintering or moulting sites may have also served as migratory stopovers. Some revisited stopover sites served as such for different annual life cycle stage migrations (i.e. a site may have served as a stopover for both the breeding to moulting migration and for the moulting to wintering migration). Revisits were documented both within years and between years.

Project Status: Project objectives 2-5, as listed above, have been mostly completed at this point. I am currently in the process of conducting the migratory connectivity analysis. For this analysis, I am following the methodology described in Cohen et al. 2018 (Quantifying the Strength of Migratory Connectivity), which utilizes the MigConnectivity package in R. Preliminary results are awaiting review before they can be presented. Once the migratory connectivity analysis has been completed, I was planning to run a series of generalized linear models to assess the relationship between the timing (arrival date, departure date, and duration) of the various annual life cycle stages and a suite of attributes associated with the various use areas, including latitude, longitude, distance traveled, and elevation (this variable will only be used for the breeding areas). I was also planning to include a few climate-related predictor variables, namely the Pacific North American Pattern, the Arctic Oscillation, and the El Niño Southern Oscillation (this was based on a suggestion from Dave Douglas). Upon the completion of these two analyses, I can begin writing the final report.

Project Funding Sources (US$). Complete only if funded by SDJV in FY23. 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.

(NOTE: The matching amounts below were reported in the FY22 US Accomplishment report).

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)
$60,000			Environment and Climate Change Canada: $12,000		Western Washington University: $9000

Total Expenditures by Category (SDJV plus all partner contributions; US$). Complete only if project was funded by SDJV in FY23; 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					**$81,000**