Molting Pacific Steller's Eider Survey in Southwest Alaska 2014

By

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August 2016

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Abstract
This report presents the results of the third consecutive year of annual surveys of molting Steller's eiders. In fall 2014, we used fixed-wing aircraft to conduct two photographic surveys of molting Steller's eiders at major lagoons along the Alaska Peninsula from King Salmon to Cold Bay. Replicate surveys were flown one week apart at the Seal Islands, Izembek and Nelson lagoons, to examine temporal differences related to timing of molt of Steller's eiders. The first survey was flown August 26-30th and the second survey was flown September 3-6th. Total numbers of molting Steller's Eiders were similar between the two replicate surveys, but differences varied among areas. We do not know whether differences between replicates were due to missing birds during the first replicate or arrival of new birds during the week between replicates. In 2014, we estimated 70,321 Steller's Eiders were molting at surveyed areas along the Alaska Peninsula with an average of 17,588 birds at Seal Islands, 46,786 birds at Nelson lagoon, 3,857 birds at Izembek lagoon, and 2,090 birds scattered between Port Moller and Port Heiden. These estimates are higher than, 50,404 in 2012 and 30,407 in 2013, but the time series is too short to make inferences on population trajectory and techniques and methodologies for the survey were being developed during the preceding years making inter-annual comparisons difficult. We recommend further investigation into variation due to survey methodology and timing of molt.

Key Words Alaska, Steller's eider, *Polysticta stelleri*, population index, aerial, photographic, survey, molt

Suggested Citation: Anderson, A. J., T. D. Bowman, H. M. Wilson, and A. R. Williams. 2016. Molting Pacific Steller's eider survey in Southwest Alaska 2014. Unpublished report, USFWS, Migratory Bird Management, Anchorage, Alaska.

Introduction
The preponderance of the Pacific population of Steller's eiders (*Polysticta stelleri*) breeds in Russia, but winters, molts, and migrates through Alaskan coastal waters (U.S. Fish and Wildlife Service 2002). The portion of the Pacific population that breeds in Alaska (hereafter, the Alaska breeding population) was listed as Threatened under the Endangered species Act in 1997 due to declines in the population size (U.S. Fish and Wildlife Service 2002). The U.S. Fish and Wildlife Service's (USFWS) Endangered Species Program monitors the population size and nesting success of the Alaska breeding population (Safine 2013), while the Migratory Bird Management Program has conducted abundance surveys of the entire Pacific population of Steller's eiders in Alaska since 1992. From 1992 through 2011, the Migratory Bird Management Program reported annual indices of the Pacific population based on spring aerial surveys along the Yukon-Kuskowkim Delta and Alaska Peninsula (Larned 2012). Because of constraints with this traditional spring survey (weather, timing and high inter-annual variation, and flock estimation bias), the feasibility of monitoring molting Steller's eiders in fall using photographic methods was tested in 2012 (Wilson et al. 2013). Based on these efforts, photographic methods were determined to be an effective to providing an annual index for the Pacific population in its primary molting sites on north side of the Alaska Peninsula. While other molting locations have been documented within the range of Pacific Steller's eiders, the largest concentrations occur along Alaska Peninsula (Martin et al. 2015). There, large numbers of Steller's eiders molt in

August and September in a series of shallow estuaries protected by long, narrow, and partially vegetated barrier islands, or spits (Dau et al. 2000). Primary molt areas in this region include Port Heiden, Seal Islands, Izembek Lagoon, and Nelson Lagoon.

Surveys in 2012 and 2013 demonstrated that a photographic survey of molting Steller's eiders was feasible, although large differences in estimates between 2012 and 2014 suggested the need for within-year replicate surveys that would provide insight into sampling errors and temporal variability associated with timing of molt.

The goal of this survey is to assess the prognosis of recovery of the listed Alaska Steller's eider breeding population using population trend data from the overall Pacific population of Steller's eiders. Our specific objectives were to 1) calculate an annual index of molting Steller's eiders based on photographic counts within bays and estuaries between King Salmon and Cold Bay, Alaska; 2) measure variation between photographic counts within each estuary; and 3) measure variation in total photographic counts between surveys conducted one week apart.

Methods

The 2014 photographic surveys of molting Steller's eiders were flown using a Cessna 206 with amphibious floats. Two surveys were conducted in 2014 at major lagoons along the Alaska Peninsula from King Salmon to Cold Bay, with replicate surveys at the Seal Islands, Izembek and Nelson lagoons. The first survey was flown on August 26-30, and the second was flown September 3-6. The first survey crew consisted of pilot (Anna Anderson), right front observer (Chris Dau), and left rear seat photographer (Tim Bowman). The second survey crew consisted of pilot (Heather Wilson), right front observer (Anna Anderson), and left rear seat photographer (Dennis Marks). (see Appendix 1: Trip itinerary).

Habitats within the lagoons and bays were thoroughly searched based on historical knowledge of abundance and distribution from earlier surveys (Wilson et al. 2013). Before attempting to photograph Nelson Lagoon and Seal Islands, we flew a reconnaissance survey of each area at approximately 1,500 ft above ground level (AGL) to determine the distribution of the birds within the lagoons and to formulate an efficient strategy for photographing the flocks. We learned during previous surveys that molting Steller's eiders rarely dove on our first overflight, but were more likely to dive on successive passes. We strove to photograph all flocks on the first low level overflight, before birds began diving in response to aircraft. During the photographic surveys, we flew with 10° of flaps, at an altitude of between 700-900 feet above ground level (AGL), with groundspeeds that ranged from 80 to 100 knots depending on wind direction and wind speed.

Oblique photographs were taken through the rear passenger window on the pilot side of the aircraft. We used a Canon 5D Mark II SLR® digital still camera (21 megapixel resolution) with an image-stabilizing lens (70-200 mm f4) and standard camera settings (shutter priority, photographing between 1/1000 and 1/1600, ISO 800, auto-focus, and auto-exposure). To minimize image distortion caused by the Plexiglas window, we maneuvered the plane into a slight side slip to allow the photographer to shoot perpendicular through the window. We attempted to photograph long linear flocks with a series of overlapping photographs in a single pass (Wilson et al. 2013). Small, distinct flocks were sampled with a single photograph. We timed flights at Nelson Lagoon to be at or near low tide when eiders were more concentrated in channels. At Izembek Lagoon, photographic flights were timed for high tide and calm winds which, based on previous experience, improved visibility of molting flocks from greater distances. The pilot used a GPS that displayed the aircraft's track to ensure full survey area coverage.

Steller's eiders typically form distinct, dense, single-species flocks; making identification of flocks relatively straightforward. If species identification was in question, we made a low pass after photographing the flock to confirm species type. We periodically encountered mixed-species flocks, containing Pacific common eiders (*S. mollisima v. nigrum*), Steller's eiders, and black scoters (*Melanitta nigra*) (Wilson et al. 2013). The front right-seat observer recorded hand-written notes in coordination with the photographer. These notes included frame numbers, flock location, flock shape, or other information, such as whether or not to count the flock (e.g., photos solely for species identification were not counted). While in the aircraft, the photographer made an initial review of the photos to assess quality, recorded frames shot, and dictated to the right front observer any specific notes about photos, while sampling details were still easy to recall. This helped to ensure photo quality, assisted with future compiling of photos, and ensured that adequate photo coverage was achieved.

Following the survey we created an Excel spreadsheet listing all photos taken and corresponding notes. We marked each photo with a Y or N placed in the column next to the photo number in the spreadsheet, Y symbolizing photos that needed to be counted and N photos that should be skipped because they were redundant or did not include Steller's eiders. We then used Adobe Photoshop CS-6 Extended to draw lines delineating which birds should be counted within each individual photo, considering adjacent photo overlap and image quality. To avoid undercounting or double-counting in overlapping serial images, we simultaneously displayed adjacent images on two computer screens and drew lines on each image, indicating the area to be excluded with an 'X' (Figure 2).

We used the Photoshop Count tool to enumerate Steller's Eiders within 540 photos to analyze in the first survey and 1,637 photos to analyze in the second survey. With this tool, we positioned the cursor over each bird to be counted and clicked the mouse, leaving a marker and an incremental number over each bird in the flock (Wilson et al. 2013). Species other than Steller's eiders were identified based on relative size, plumage, and comparison to reference photos, and were not counted. We entered photo counts of Steller's eiders into an Excel spreadsheet and totaled counts for each major lagoon system. In locations where we had replicate surveys, we used the average number for replicates during that time period. We derived the index for the 2014 Pacific Steller's Eider population by summing averages of each lagoon. Time required for analysis of the two surveys was approximately 500 hours. We believe analysis time can be significantly reduced in future surveys if recommendations listed later in this report are followed.

In an effort to pursue more expedient photo processing options, we explored the use of a geographic information system approach to automate counting of Steller's eiders in photos. We used the Feature Analyst (Overwatch Systems, LTd.) extension in ArcMap (ESRI, Inc.), treating birds as dark features on a lighter landscape to be enumerated. To test the efficacy of this technique, a representative photo was chosen and birds were counted by hand with the Adobe

Photoshop CS-6 Extended count program. Training polygons were then screen digitized around individual birds distributed throughout the photo to establish a digital "signature" for birds. Automated counts varied between the hand-counted photos due to errors of omission (i.e., some birds were missed) and addition (i.e., some dark shadows were incorrectly counted as birds). We experimented with changing the parameters of the Feature Analyst extension to improve bird identification rates, but this resulting in increasing errors of omission. After optimizing program parameters, we processed a batch of photos through the program. Each photo took about 1.5 min. to run using Featured Analyst as compared to 1.5 hours to count a similar photo manually (e.g., a photo with 2200 birds). However, continued errors of omission and addition, post-processing of each photo required varying amounts of additional manual processing time, which could often be significant. The Feature Analyst model also failed to create individual polygons around birds that were spaced closely, creating instead one polygon around multiple birds. The polygon shapefiles were then converted to point shapefiles for final editing and counting. We used ArcMap editing tools to edit each shapefile by deleting points representing dark shadows and finding and adding missed birds. The final count for each photo was indicated by the number of point records in the shapefiles attribute table. The Feature Analyst program in ArcMap required substantial training, and required retraining the program when bird size differed among photos. In the end, after post-editing the numerous photos run through the Feature Analyst program, we found it easier to hand-count birds using the Adobe Photoshop CS-6 Extended count feature. The Feature Analyst program was very time consuming for photo processers who were not proficient in ArcMap. However, a photo-processor who was also an experienced ArcMap user might be able to utilize the system more efficiently.

Results and Discussion

Total flight time for the first survey on August 26-30, 2014 was 19 hours. Approximately 10 hours were needed to search for and photograph flocks. The remaining 9 hours were used to transition the aircraft to and from Anchorage. Total flight time for the second survey on September 3-6, 2014 was 18.8 hours. Approximately 10 hours were needed to search for and photograph flocks. The remaining 8.8 hours were used to transition the aircraft to and from Anchorage.

We estimated 70,321 Steller's eiders for all surveyed areas. The survey indicated that Seal Islands, and Nelson and Izembek lagoons comprised 97% of the molting birds we surveyed along the Alaska Peninsula in fall 2014. Proportionally, 66.5% were in the Nelson Lagoon complex and 25% were at Seal Islands (Table 1). Most of the birds at Nelson Lagoon were along the lagoon side of Walrus Island, and along the inside of the spit at Seal Islands.

Consolidation of birds within flocks was the most important factor for effective photography. Large scattered groups, particularly in open water, made photographic analysis inefficient because the lack of shoreline reference made it difficult to determine what had been photographed and, later, which sections of photos should be counted.

Given the relatively large inter-annual variation in the counts of Steller's eiders during the fall aerial survey of Emperor geese and other water birds in southwestern Alaska (Table 2), this photographic survey should more accurately document population fluctuations of Pacific Steller's eiders. However, the two surveys are not directly comparable, as the fall ocular aerial survey is focused on emperor geese and is conducted a month later than the photographic molt survey.

Despite the many benefits of a molt-based index, variation in fall molt counts could be confounded with variation in production. Molt migration generally involves males, as well as non-breeders or failed breeders (Salomonsen 1968, Hohman et al. 1992). Highest numbers of failed breeders would be expected at molt sites in years of poor breeding success (Reed et al. 2003), thereby adding variation to annual trends. Thus, abundance estimates derived from molt surveys represent a combination of population size and current breeding conditions, and separation of the two can be difficult (Wilson et al. 2013). The 2014 estimates of molting Steller's eiders were higher than previous estimates in 2012 and 2013 (Table 2). We do not know the relative contribution of sampling variation (e.g., missed birds, double-counted birds, or sensitivity in survey timing) versus process variation (true population change) in the overall variability between annual counts.

Crew coordination and communication proved to be a significant factor in effectively photographing large flocks of swimming birds. 2014 was the only year in which separate surveys were flown to try to understand how survey timing may influence estimates of molting birds. However, the surveys were done less than a week apart, and this may have been too short a time frame to estimate variability in counts due to molt chronology.

Clear protocols and assignment of duties is necessary prior to survey flights to ensure the success of the survey. We were reasonably confident we covered all areas where Steller's eiders were molting on the north side of the Alaska Peninsula, and that we had obtained acceptable photographs of all flocks. However, we omitted photographs from analysis if there was significant uncertainty in what should be counted, difficulty in reconciling photos, and/or problems with image quality.

Below is a list of replicate counts from 2014 that we did not use and the reasons why. We present these descriptions here to document potential problems that have arisen during this survey and to help ensure they don't happen during future surveys.

- Photos from Seal Islands on 8-26-14 were not used due to underexposed photos and incorrect camera settings. This emphasizes the need for a photographer who is well trained with the camera and who is able to immediately look at the photos to ensure good quality.

- Photos from Nelson Lagoon on 8-28-14 in the morning were not used due to high winds and white caps on the water that made it hard to see and photograph birds. Survey was abandoned partway through.

- Two back-to-back replicates of Nelson Lagoon were flown on the afternoon of 8-28-14. The first replicate was excellent, but the second was not used because there was a difficulty in reconciling the photos once back in Anchorage. This emphasizes need to analyze images as soon as possible after survey is completed, and also to ensure thorough notes about photos during and after the survey.

- Photos from Nelson Lagoon on 9-5-14 in the evening were not used because it was high tide, birds were dispersed, and we did not photograph the entire lagoon.

- Photos from Nelson Lagoon on 9-6-14 in the morning were not used because we ran out of camera memory card space in the middle of the survey and we did not get complete coverage of the lagoon.

- Photos from Port Heiden on 9-6-14 were not used because the photos were blurry and too distant to accurately count individual birds.

Suggestions and Recommendations for Future Surveys

- We suggest that boundaries are defined for a permanent survey area to help standardize coverage among annual surveys and within-year replicates.

- Boundaries need to be large enough to include the full extent of previously observed distribution, plus a peripheral buffer area to accommodate potential future distribution shifts. The primary survey areas would include Port Heiden, Seal Islands, Port Moller, Nelson Lagoon, and Izembek Lagoon.

- Continued comparisons between Pacific Steller's eider fall molt counts and the fall aerial ocular survey of Emperor geese in southwestern Alaska (Mallek and Dau 2012) should be used to reveal potential shifts in distribution away from the primary molting areas. We also propose an every 5-year expanded search of areas outside of the northern Alaska Peninsula, where molting Steller's eiders have been documented in the past (e.g., Kuskokwim Shoals, Lower Cook Inlet). This would help improve understanding and documentation of the overall distribution of molting Steller's eiders.

- Because we have observed significant differences in counts among years and even between replicates in the same year, we recommend that a minimum of 2 replicate surveys be attempted at each area within each year. We assume variability between replicates during the same time period (same day or subsequent day) is the product of sampling error typically caused by visibility or estimation bias. Because molting birds cannot fly and are essentially a closed population; we assumed there was little immigration or emigration of flightless (pre-molt or post-molt) birds during our sampling periods.

- Consistent should be scheduled and committed to participate in the entire survey in order to ensure comparability among surveys and replicates.

- A checklist should be developed and utilized to ensure all the batteries are charged, memory cards are cleared and camera settings are appropriate for the specific survey conditions.

- The pilot should be responsible for keeping track of which flock was photographed and communicate clearly to the crew if they fly back over an area that was previously covered.

- The photographer needs to be able to immediately review photos and determine if they are acceptable. If this cannot be achieved, then the area with the flock in question should be re-flown and re-photographed with clear notes taken to indicate the frames that should be discounted.

- Steps should be taken to improve situational awareness among all crew members. Because the recorder cannot see the flocks due to being on the opposite side of the aircraft, it is difficult for them to accurately describe photos/flocks in notes unless crew communication is clear. Having previously agreed upon landmarks as reference points will help increase situational awareness and unambiguous notes.

- To help with reconciling the photos after the survey, we recommend that the photographer records notes using a hand held recorder with microphone taped to the camera. This would improve understanding of the photograph sequence and thought process, and avoid misinterpretations that occur when verbally transcribing notes to a second person.

- It is essential to have a photographer that has experience with the camera and in taking aerial photos.

- As opportunities arise, the photographer should train the observer in camera operation so there is an alternate experienced photographer if needed.

- We recommend that all photos be reviewed and documented the day of the survey to ensure adequate photo quality and accurate notes that are easily interpreted for photo processing.

- Before the survey, the crew needs to designate a crew member from the survey that will first go through each photo with the notes. Then, they will put the photos used for counting into designated folders of each area with clear lines on what to count and not count.

Acknowledgements

Funding for this project was provided by the U.S. Fish and Wildlife Service (USFWS), Office of Migratory Bird Management (Region 7) and Fisheries and Ecological Services-Endangered Species Program. Special thanks to Robert Platte for photo analysis. We thank Michael Swaim for creating Figure 1, the Alaska Peninsula-Becharof and Izembek National Wildlife Refuges for providing logistic support in King Salmon and Cold Bay, and Butch Gunderson for being a wonderful host and historian during our stay at the Tides Inn in Nelson Lagoon.

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Table 1. Numbers of molting Steller's eiders at selected locations along the Alaska Peninsula in the fall of 2014, as counted from aerial photographs.

Location	Date(s)	Rep 1	Rep 2	Rep 3	Mean	Proportion of Total
Port Heiden	9/4/14	1,716	2,265		1,991	3%
Seal Islands	8/29/14 9/4/14 9/6/14	17,226	 20,029	 15,508	17,588	25%
Port Moller	9/6/14	99			99	<1%
Nelson Lagoon	8/28/14 9/5/2014	47,286	 46,286		46,786	67%
Izembek Lagoon	8/29/14 9/5/14	3,543 4,469	2,967 4,448		3857	5%
Total					**70,321**	

Table 2. Estimates of molting Steller's eiders along the Alaska Peninsula, 2012-2014 based on Steller's eider photographic survey and fall emperor goose survey.

Survey Name	**Steller's eider photographic survey**				**Fall Emperor goose survey**		
Year	*2012*	*2013*	*2014*		*2012*	*2013*	*2014*
Date **Location**	Aug 27-30	Aug 26-27	Aug 26-30	Sept 3-6	Sept 28-29	Oct 19-20	Sept 29-30
Port Heiden	341	no photos	no photos	1,991	818	270	2,895
Seal Islands	9,764	6,990	17,226	17,769	4,070	8,025	8,105
Nelson Lagoon	36,151	20,832	47,286	46,385	18,925	34,832	24,731
Izembek Lagoon	4,148	2,585	3,255	4,459	5,076	2,446	7,048
TOTAL	**50,404**	**30,407**	**67,767**	**70,604**	**28,988**	**45,573**	**42,779**

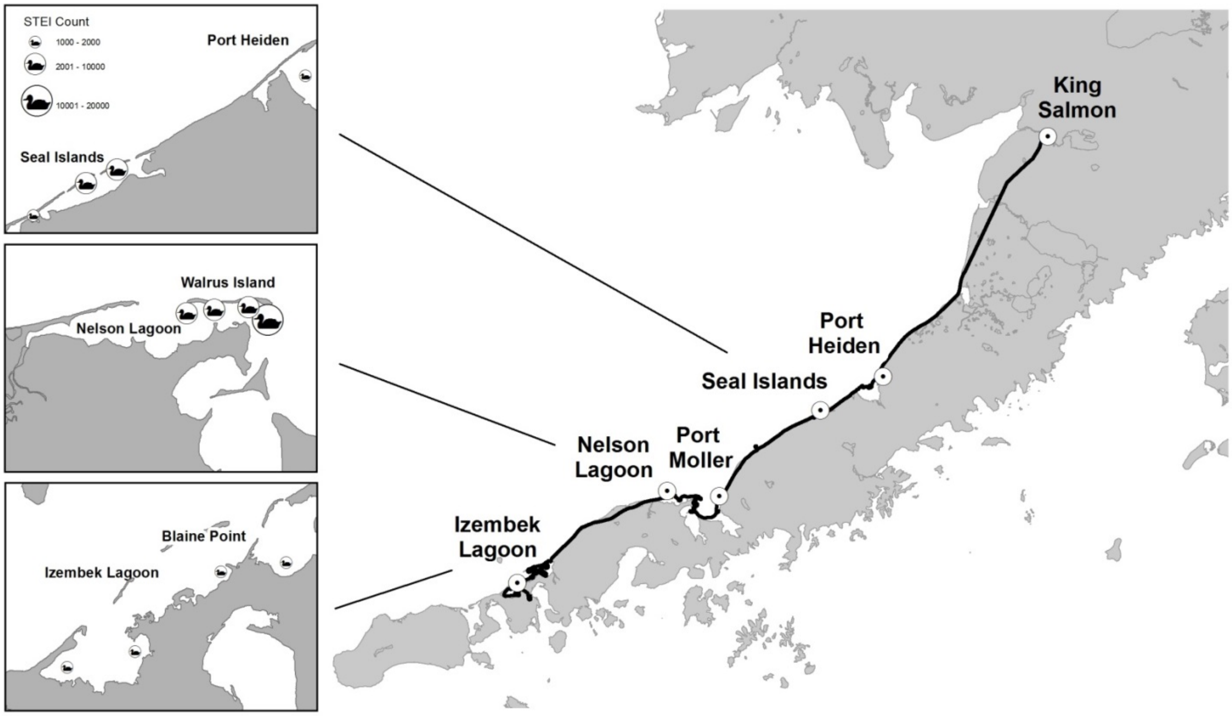

Figure 1**.** The flight track from King Salmon to Cold Bay along the north side of the Alaska Peninsula where molting Steller's eiders were photographed. Inset boxes show relative abundance and location of Steller's eiders within primary molting lagoons.

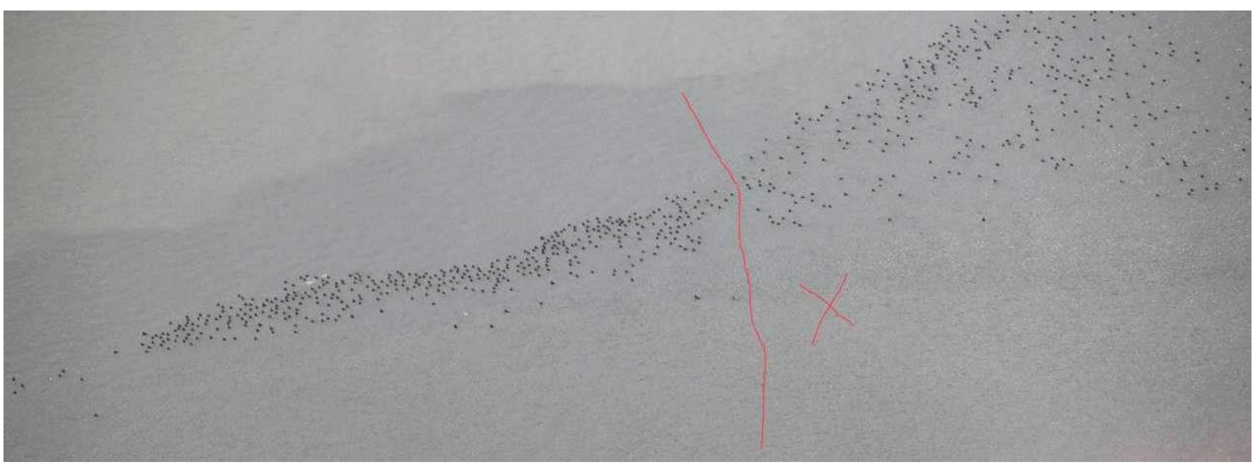

Figure 2. Typical photo from a series used to count a long, linear flock of molting Steller's eiders at Nelson Lagoon. The red line and "X" delineate the portion of the photo that overlapped with the next photo and thus, had already been counted.

Appendix 1. Trip itinerary.

Survey #1

Pilot: Anna Anderson

Photographer: Tim Bowman

Recorder: Chris Dau

8/26/2014: Departed Anchorage for King Salmon. Re-fueled King Salmon. Surveyed from King Salmon to Nelson Lagoon, photographing at Seal Islands. Overnighted in Nelson Lagoon.

8/27/2014: Weather day.

8/28/2014:Surveyed Nelson lagoon, then re-fueled in Nelson Lagoon. Departed in the evening at low tide to do a replicate of Nelson lagoon. Overnighted in Nelson Lagoon.

8/29/2014:Departed Nelson Lagoon for Cold Bay. Surveyed Izembeck Lagoon in the morning and re-fueled in Cold Bay. We departed and did a replicate of Izembek Lagoon and then departed for Nelson lagoon. We refueled in Nelson Lagoon and then surveyed Seal Islands while enroute to King Salmon. Landed King Salmon and overnighted at the Becharof NWR bunkhouse.

8/30/2014:Departed King Salmon for Anchorage. Landed Anchorage, end of survey.

Survey #2

Pilot: Heather Wilson

Photographer: Dennis Marks

Recorder: Anna Anderson

9/3/2014: Departed Anchorage for King Salmon. Re-fuel King Salmon. Surveyed from King Salmon to Port Heiden. Overnighted in Port Heiden.

9/4/2014: Surveyed Port Heiden and Seal Islands. Overnighted in Port Heiden.

9/5/2014: Departed Port Heiden. Surveyed from Port Heiden to Cold Bay, photographing at Seal Islands and Nelson and Izembek lagoons. Re-fueled in Cold Bay. We departed and did a replicate count of Izembek Lagoon and then departed for Nelson lagoon. Overnight in Nelson lagoon.

9/6/2014: Departed Nelson Lagoon and did a replicate count of Nelson Lagoon. Surveyed Nelson Lagoon and Seal Islands while enroute to Port Heiden. We refueled in Port Heiden and then surveyed enroute to King Salmon. Re-fueled King Salmon. Departed King Salmon for Anchorage. Landed Anchorage, end of survey.

Appendix 2. Inclusive dates, flight hours, and personnel, Molting Pacific Steller's Eider Survey in Southwest Alaska.

Year	Date	Hours	Pilot	Photographer	Recorder
2012	8/27-30	16.6	H. Wilson	T. Bowman	W. Larned
2013	8/26-27	15.4	H. Wilson	T. Bowman	W. Larned
2014	8/26-30	19	A. Anderson	T. Bowman	C. Dau
	9/3-6	18.8	H. Wilson	D. Marks	A. Anderson