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Fall Izembek Brant Aerial Survey, Alaska, 2018

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SUMMARY

This report presents results from the annual Fall Izembek Brant Survey, conducted in the Izembek Complex of southwest Alaska (1976-2018). The 2018 Fall Izembek Brant population index was 155,724 (95% CI: 148,742-160,879) birds; calculated as the average of five repeated surveys of the Izembek Complex flown on 6, 7, and 9 October (140,165, 155,734, 137,165, 167,859, 177,699; CV: 11%). Two surveys per day (morning and afternoon) were conducted on 7 and 9 October. Double-observer data was collected on surveys 2-5. Annual indices for Canada geese, emperor geese, and Steller's eiders were 33,122 (CV: 9%), 2,552 (CV: 26%), and 4,517 (CV: 20%), respectively. Fall population growth rates for Pacific brant indicated a slight long-term increase (1976-2018; 1.005, 95% CI: 1.002-1.009), while long-term trends for other species indicated decline (e.g., Canada geese: 0.992, 95% CI: 0.985-0.999, emperor geese: 0.968, 95% CI: 0.959-0.978, and Steller's eiders: 0.948, 95% CI: 0.938-0.958). The most recent 10-year growth rate for brant (2009-2018) was 1.013 (95% CI: 0.986-1.039). Cursory double-observer data indicated no significant differences between the ratio of brant observed in the front vs. the rear (right) seat positions, nor between individual right-seat observers, among survey segments.

Key words: aerial survey, Pacific brant, waterbirds, southwest Alaska.

INTRODUCTION

Between September and November each year, nearly the entire world population of Pacific brant (*Branta bernicla*) stages at Izembek Lagoon and surrounding estuaries (hereafter: Izembek Complex; Reed et al. 1998, Ward et al. 2005). The Izembek Complex is a unique area of protected brackish waters, supporting one of the world's largest eelgrass beds and a diverse array of wildlife. Fall-staging brant have been counted in the Izembek Complex since 1975 (USFWS, unpubl. data), with more standardized surveying beginning in 1976.

The primary objective of the Fall Izembek Brant Survey is to provide an annual index of abundance for the entire post-breeding Pacific brant population, while secondarily, providing annual fall population indices for Canada geese (*Branta hutchinsii taverneri* and *B.h. minima*), emperor geese (*Anser canagicus*), and Steller's eiders (*Polysticta stelleri*). Ancillary counts of other waterbird species observed during the survey are also reported each year to provide presence/absence and relative abundance information. Abundance and distribution of each species at Izembek varies seasonally, as well as locally; with birds shifting daily within, and among, Izembek Complex lagoon segments, due to tides, winds, predators, and hunting pressure. To help account for sampling error among these surveys of dense, multi-species aggregations within the Izembek Complex, a minimum of 2 replicate fall surveys (long-term average [1976-2018] = 4 surveys, range: 1-7 surveys; Appendices 1-2) are conducted each year, and the average of survey counts is used as the annual population index for each of the primary species in the survey (i.e., brant, Canada, and emperor geese, as well as Steller's eiders). The coefficient of variation among repeated surveys is provided as a minimum estimate of variance among counts.

Given virtually all of the Pacific brant population stages within the Izembek Complex between late September and early November each year (Reed et al. 1989, Ward et al. 2005), the Fall Izembek Brant Survey (Wilson 2017a) is believed to provide a comparative overall population measure to the Pacific Flyway - Winter Brant Survey (Stehn et al. 2010, Olson 2018). The Pacific Flyway - Winter Brant Survey combines mid-winter counts from Baja Mexico (Palacios and Ávila 2019), California, Oregon, Washington, British Columbia, and Alaska (Wilson 2019) to create a composite 'total' population index (Pacific Flyway Council 2018, Olson 2018). Together, the Fall Izembek Brant Survey and Pacific Flyway - Winter Brant Survey represent the highest-ranked priorities for population assessment of Pacific Brant by the Pacific Flyway Council (2018; see also Stehn et al. 2010).

METHODS

Field Methods

The 2018 Fall Izembek Brant Survey was flown using a USFWS Cessna 206 (N721NR) aircraft equipped with amphibious floats, at a ground speed of 167-200 km/hr (90-110 kts) and an altitude of 45 m (150 ft) above ground level (as measured with a radar altimeter in the aircraft). The survey included the traditional Izembek Complex segments 60-68, 80-81, and 84-85 (Fig. 1), which correspond to Izembek Lagoon, Bechevin and Morzhovi Bays, and northern Cold Bay [including Kinzarof Lagoon]. These segments were surveyed in their entirety, by following a historical survey route and monitoring real-time aircraft tracks to ensure repeated coverage of the survey area. All flights were conducted with <20 knots of wind. The left-seat pilot-observer and right-seat observer each counted birds on their respective side of the aircraft, and input voice-recorded observations of birds (species and flock sizes) into independent portable computers. Geographic coordinates of bird locations were automatically recorded and linked to the position of the aircraft track and individual aerial observations using global positioning systems (GPS) and a custom computer program (RECORD; Jack Hodges, USFWS-MBM, Juneau). Although Pacific brant, Canada geese, emperor geese, and Steller's eiders were the primary species of

interest, counts of other waterbirds species were also recorded during the survey (Appendix 3).

Double-observer Data

In 2018 (as in 2017), a three person crew participated in all surveys. This three person crew consisted of a left-front seat pilot/observer, a right-front seat observer, and a right-rear seat observer. Only data from the front-seat positions (left and right) were used for population indices. The rear-seat observer was present to collect double-observer data behind the right-front observer. We treated our first survey as a training survey, where our less experienced observer sat in the right-rear seat position, and listened to the front-seat observer, with the ability to ask questions, but without collecting data. On the second and third surveys, the less experienced observer collected independent double observer data in the right-rear seat position. The two right-side observers could neither hear nor see one-another's observations being recorded. On the final two surveys (Surveys 4 and 5), we transitioned the less experienced observer (with four years training experience on the survey) to the right-front seat position for operational data collection. For these surveys, we continued to collect double observer data, by having the more experienced observer occupy the right-rear seat position. The primary objectives were to: 1) assess the counts of brant between right-side observers, and 2) to examine any potential effects of seat-position (front versus rear) on counts.

History of the Survey

Aerial counts of fall brant at Izembek National Wildlife Refuge (IZNWR) have been conducted from 1976 to the present (Appendices 1-2). The survey effort was initiated by IZNWR, and was conducted almost exclusively by the refuge in the 1970's and early 1980's. By the mid-1980's, responsibility for the counts became a joint effort between IZNWR and Migratory Bird Management - Alaska (MBM). In 1984 and 1992, two special survey 'workshops', led by MBM – Alaska were conducted. These workshops encompassed 8-30 within-year repeated surveys and were flown by a variety of crews and aircraft, with the goal of better understanding variation in counts among crews (Conant et al. 1984, 1992). Key recommendations from these workshops included incorporating aerial photography into the survey, continuing with repeated within-year counts, and providing additional observer training to help standardize effort. By the early 1990's, MBM – Alaska had taken the lead on the fall aerial Izembek brant counts, typically completing them at the culmination of the Fall Emperor Goose Survey (1981-2015; Wilson 2017b), which terminated in Izembek each year. In 2016, the Fall Emperor Goose Survey was discontinued, and the ocular Fall Izembek Brant Survey (Wilson 2017a) became a stand-alone effort. In 2017, increased observer training, a commitment to five repeated ocular surveys per year, and an exploratory photographic Fall Brant Aerial Survey (Fischer and Flint 2017), were added to the survey effort.

Historical Data

In compiling historical Izembek brant counts, I included only surveys that were flown between 23 September and 31 October (a period that encompassed >90% of the brant counts during the September – November 'fall' window). I also limited surveys to those flown with two observers. I included all within-year survey counts that met these criteria, regardless of any previous

designation as outliers, which occasionally resulted in different annual averages than had previously been reported. No fall Izembek Survey was flown in 1978, and only one complete survey was flown in 1976 and 1981 (Appendix 1), so averages could not be presented for those years. For years with 2+ surveys, I used the average of within-year survey counts as the annual population index for each of the primary species in the survey (i.e., brant, Canada, and emperor geese, and Steller's eiders) and provided coefficient of variation among repeated surveys as a minimum estimate of variance among counts. In 11 years of the survey (1977, 1982, 1984, 1986, 1992, 1996, 2006-2007, 2011, and 2013-2014), there were missing segment data for one or more of the repeated within-year surveys; typically in areas outside the primary Izembek Lagoon staging area (i.e. Bechevin and Morzhovoi Bays, Segments 66-71, 78-81, and/or 82-86). To account for these intermittent missing segments in Izembek Complex totals, I imputed missing segment totals based on the average of the other within-year repeated surveys of those segments (e.g., in 1977, the average of segments 66-86 from the 10/4 & 24 surveys [8,625] was added to the missing segments 66-86 on the 9/23 survey). Further details related to imputed data are provided in Appendix 2. Imputation methods applied to brant data were also applied to the three other primary species of interest; Canada geese, emperor geese, and Steller's eiders.

Analyses

Annual population indices and associated 95% confidence intervals for the four primary species of interest were calculated as the average of within-year repeated surveys. Deterministic log-linear population growth rate estimates were calculated as approximate measures of population trend. I recognize that these do not incorporate within-year sampling error (i.e., variation among within-year replicate counts), into estimates of variance, and thus, likely underestimate the variance in growth rate. As of 2019, a broad-scale data standardization and archiving effort in the R environment (R Core Team 2013) was in development for all MBM-Alaska surveys. Upon completion of this process, I expect annual estimates and population trends to differ slightly from those presented here.

In addition to population index information, I examined double-observer data collected by right-side observers in 2018 for differences between observers (e.g., WWL vs. TKZ) and seats (right-front vs. right-rear). Because double-observer data was not collected in all segments, across all surveys (i.e., 7 segments were missed by the rear-seat observer, due to computer issues), I examined the data at the segment level. Herein, I treated ($n = 34$) complete survey segments (60-65, 67-68, 80, 85, repeated over 4 surveys) as individual sample units, and calculated the index ratio of brant seen by each observer (e.g., WWL and TKZ; more vs. less experienced on the survey) and seat position (e.g., right-front vs. right-rear seat), in each of the 34 segments. Using these numbers, I calculated the weighted mean ratio and its variance, by weighting each segment's ratio by the proportion of birds seen on that segment versus the grand total for all segments. Under the expectation of no difference between observers or seats, I expected the average ratio to be 1.0. I did not attempt to match flock observations and calculate a 'sight-right' detection rate between right-seat observers, but instead examined the overall effect of observer and seat on the total count of geese, across segments. Finally, I tested for a relationship between ratios of birds seen (i.e., by the rear observer and less-experienced observer) and total brant count in segments using simple, linear regression.

RESULTS AND DISCUSSION

My crew and I completed a total of five surveys of the Izembek Complex in 2018 (6 October, and 7 and 9 October [mornings and afternoons] Table 1). Survey conditions for all surveys were moderate to excellent, with broken ceilings of 1,500 feet or greater and west/southwest winds between 5 and 20 kts (typically 10 kts). Glare was a factor on the two surveys conducted on 7 October. Tide stage varied among surveys, but most surveys were conducted at low to mid-tide stages. The only exception was 7 October (morning), which was flown at high tide in Izembek Lagoon (Appendix 3).

Double-Observer Data

Double-observer data was collected on surveys 2-5. On surveys 2 and 3, the more-experienced right-seat observer was in the front seat, and on surveys 4 and 5 the less-experienced observer was in the front seat. 95% confidence intervals around the weighted mean ratio of brant observed by seat (i.e., the front right vs. the rear right-seat position) and by observer (i.e., more- vs. less-experienced) both overlapped 1.0; indicating no significant difference between counts by seats or observers. The average weighted ratio seen by the rear-seat compared to front-seat was 0.928 (95% CI: 0.83-1.03), and the ratio seen by the less-experienced, compared to more experienced, observer was 1.10 (CI: 0.98-1.20); suggesting our newer observer's counts were on par with those of our more experienced observer. No relationship was found between segment ratios and abundance of birds (seat: $R^2 < 0.01$, $p = 0.94$, observer: $R^2 = 0.02$, $p = 0.43$).

Table 1. Summary of 2018 Fall Izembek Complex survey data for four primary species of interest. Observers: Left front; Heather Wilson (HMW), and right-front; Bill Larned (WWL), and Tamara Zeller (TKZ).

SURVEYS	OBSERVERS	SPECIES			
		Pacific Brant	Canada Goose	Emperor Goose	Steller's Eider
1: Oct 6	HMW / WWL	140,165	33,197	3,638	5,260
2: Oct 7 (a.m.)	HMW / WWL	155,734	35,310	2,672	3,930
3: Oct 7 (p.m.)	HMW / WWL	137,165	28,644	2,435	3,767
4: Oct 9 (a.m.)	HMW / TKZ	167,859	31,826	1,930	3,910
5: Oct 9 (p.m.)	HMW / TKZ	177,699	36,634	2,085	5,716
Average		155,724	33,122	2,552	4,517
CV		11%	9%	26%	20%

Pacific Brant

The 2018 index for Pacific brant was 155,724 (Tables 1 and 2, Appendices 1 and 2). Total counts showed a moderate degree of variation between replicate surveys (CV: 11%), and

distributions among segments varied (Appendix 3). Some of the variation in distributions was likely due to brant response to tide; whereby eelgrass beds in the center of the lagoon become inaccessible to grazing at higher tides, as well as variable wind conditions among the 5 surveys. The long-term (1976-2018; Table 3), deterministic log-linear fall population annual growth rate of Pacific brant indicated a very slight increasing trend (1.005, 95% CI: 1.002-1.009, R^2 : 0.19 [Fig. 2]), while the most recent 10-year (2009-2018) growth rate showed no significant population change (1.013, 95% CI: 0.986-1.039, R^2 : 0.10).

Canada Goose

The 2018 Canada goose index was 33,122 (Tables 1-2, Appendix 3). The long-term (1976-2018; Table 2, Fig. 3) fall population growth rate of Canada geese (0.992, 95% CI: 0.985-0.999, R^2 : 0.10) indicated a declining trend, but the most recent 10-year (2009-2018) growth rate (1.014, 95% CI: 0.945-1.081, R^2 : 0.02), showed no significant trend.

Emperor Goose

The 2018 emperor goose index was 2,552 (Tables 1-2, Appendix 3). The long-term log-linear (1976-2018; Table 2, Fig. 3) fall population growth rate of emperor geese at Izembek Complex indicated significant decline (0.968, 95% CI: 0.959-0.978, R^2 : 0.53), despite no significant trend over the most recent 10-years (2009-2018; annual growth rate 0.977, 95% CI: 0.857-1.096, R^2 : 0.02). However, Izembek Complex typically represents only 3% of the total fall emperor geese staging on the Alaska Peninsula, with the largest aggregations of emperor geese occurring northeast of Izembek, in the estuaries of Cinder River (20%), Port Heiden (15%), Seal Islands (20%), and Nelson Lagoon/Port Moller (20%; Wilson 2017b).

Steller's Eider

The 2018 index for Steller's eiders was 4,517 (Tables 1-2, Appendix 3). The long-term (1976-2018; Table 2, Fig. 3) fall population growth rate of Steller's eiders at Izembek Complex indicated a decreasing trend (rate: 0.948, 95% CI: 0.938-0.958, R^2 : 0.73), while the most recent 10-year growth rate indicated no significant trend (2009-2018; 0.956, 95% CI: 0.888-1.024, R^2 : 0.17). Over the long-term (1979-2015; MBM data) Izembek Complex has represented ~20-34% of the total fall Steller's eiders staging on the Alaska Peninsula, with the largest aggregation of Steller's eiders typically occurring at Nelson Lagoon/Port Moller (53%), followed by Port Heiden (12%), and the Seal Islands (14%). As such, changes in the numbers of Steller's Eiders at Izembek may represent changes in distribution, as opposed to real changes in overall population size.

The findings and conclusions in this report are those of the author(s) and do not necessarily represent the views of the U.S. Fish and Wildlife Service.

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I thank Bill Larned for serving as right-front observer on Oct. 6 and 7 surveys and rear-seat double-observer on the Oct. 9 (morning) survey, and for providing continued mentorship and training for new right-front observers in 2018. I thank Tamara Zeller for serving as right-front observer on the Oct. 9 surveys. I gratefully acknowledge Izembek NWR for their continued support of the survey, including lodging, vehicles, hangar space, and other logistics, as well as Alaska Peninsula/Becharof NWR for their assistance in King Salmon. I thank Michael Swaim for creating survey preparation materials (e.g., navigation and hazard maps, as well as help in creating report map figures, and David Safine and Paul Flint for helpful reviews of the report.



The 2018 Fall Izembek Brant Survey Crew, from left to right: Heather Wilson (left-front pilot-observer), Bill Larned (right-front observer, and right-rear double observer), Tamara Zeller (new right-front observer, and right-rear double observer) in Cessna 206 N721NR.

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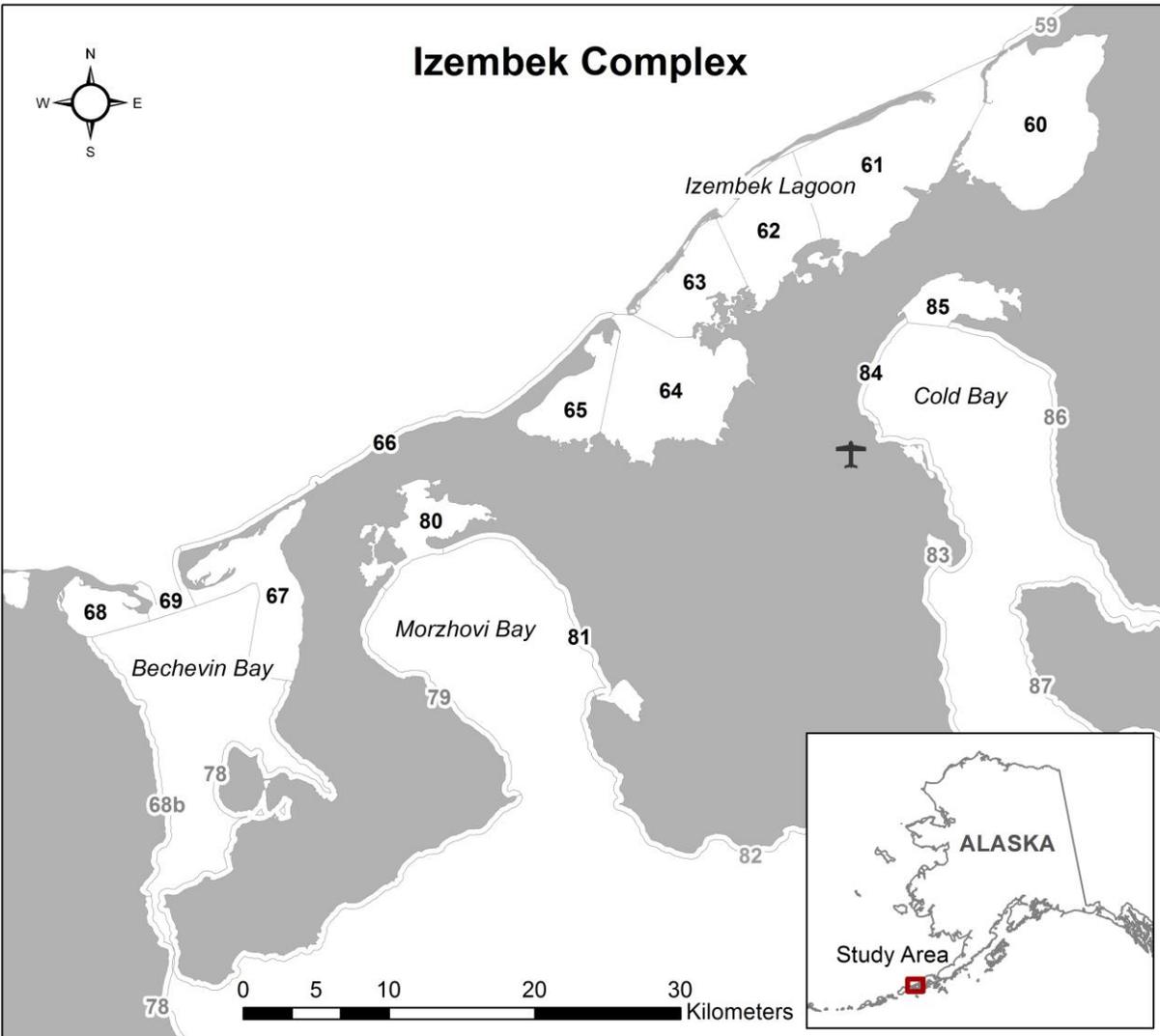


Figure 1. Map of the Fall Izembek Brant Survey area in southwest Alaska, encompassing segments 60-85 of the historical fall survey of the Alaska Peninsula. Bold-font segments indicate those consistently included in the Fall Izembek Brant Survey (1976-2018). The airplane symbol denotes the survey base of operations, Cold Bay, Alaska.

Fall Izembek Brant Survey Segments

Izembek Lagoon (60-65):

- 60:** Moffet Bay
- 61:** Strawberry Point to Round Is. (incl. Neuman Is.)
- 62:** Round Is. to Tern Is.
- 63:** Tern Is. to Banding Islands west of Grant Point
- 64:** Applegate Cove
- 65:** Norma Bay
- 66:** Outer coast shoreline Izembek to Bechevin

Bechevin Bay (67-69):

- 67:** Hook Bay
- 68:** Catherine's Cove

- 69:** Bechevin Channel

Morzhovoi Bay (79-81):

- 79 (not included in survey),
- 80:** Big, Middle, and Little Lagoons,
- 81:** NE Morzhovoi coast to Little John Lagoon

Cold Bay (82-85):

- 84:** Cold Bay Dock to Kinzarof
- 85:** Kinzarof Lagoon
- 82-83 and 86-87 (not included in survey).

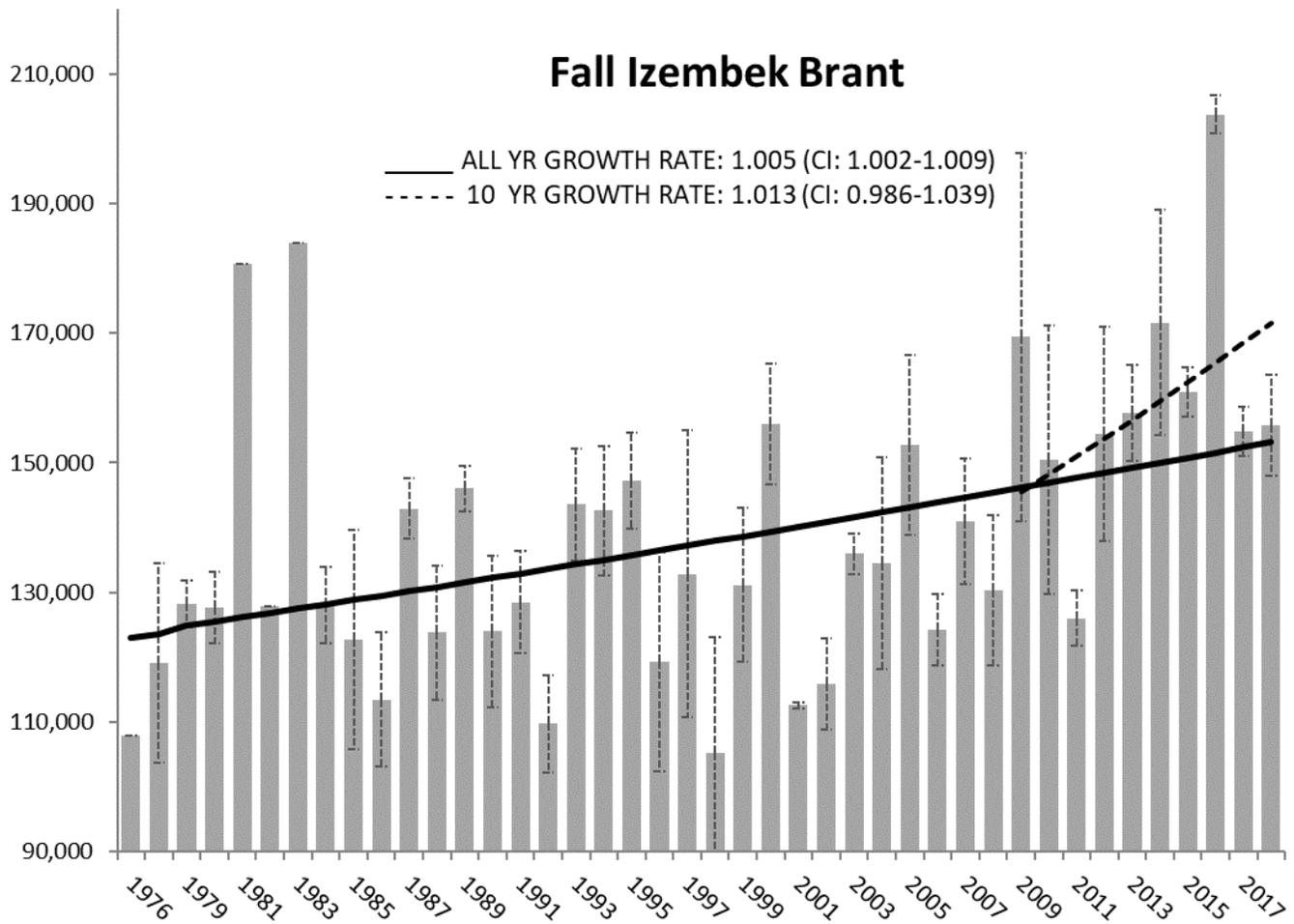


Figure 2. Observed Pacific brant annual indices (\pm 95% confidence intervals from variation among within-year repeated surveys) and log-linear growth rates (All-yr and 10-yr), from the Fall Izembek Brant Survey, Alaska, 1976-2018.

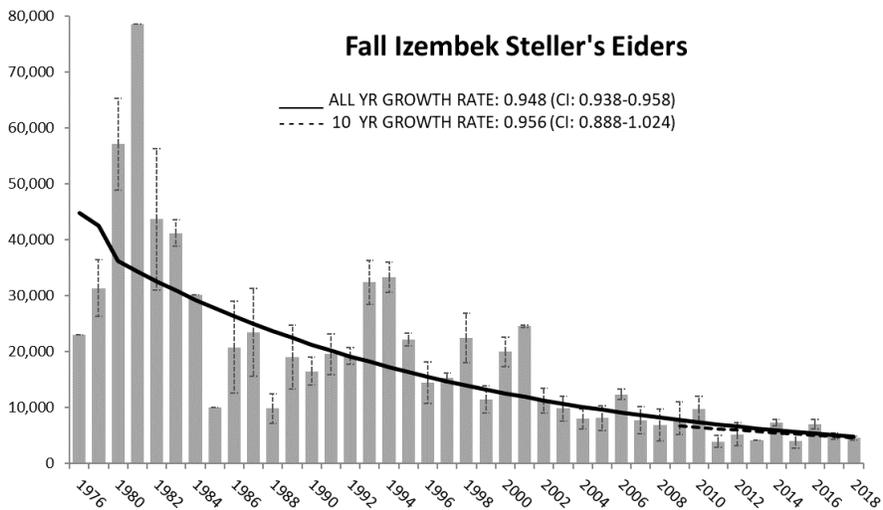
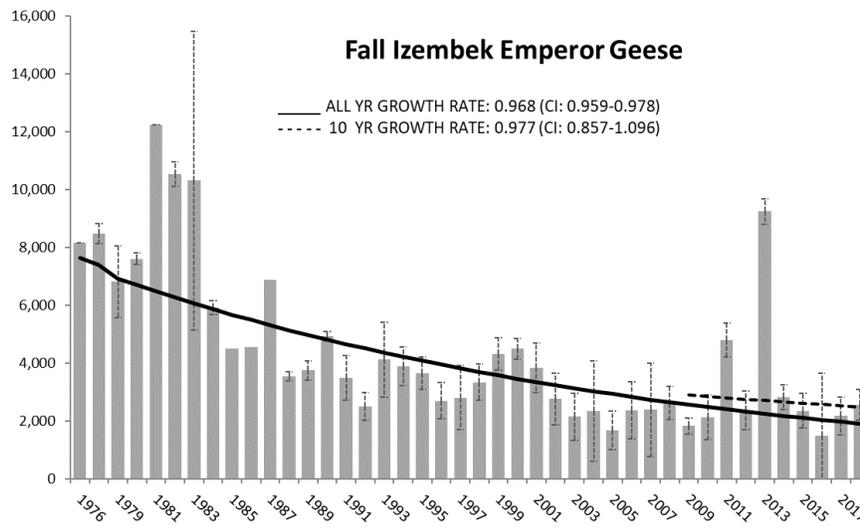
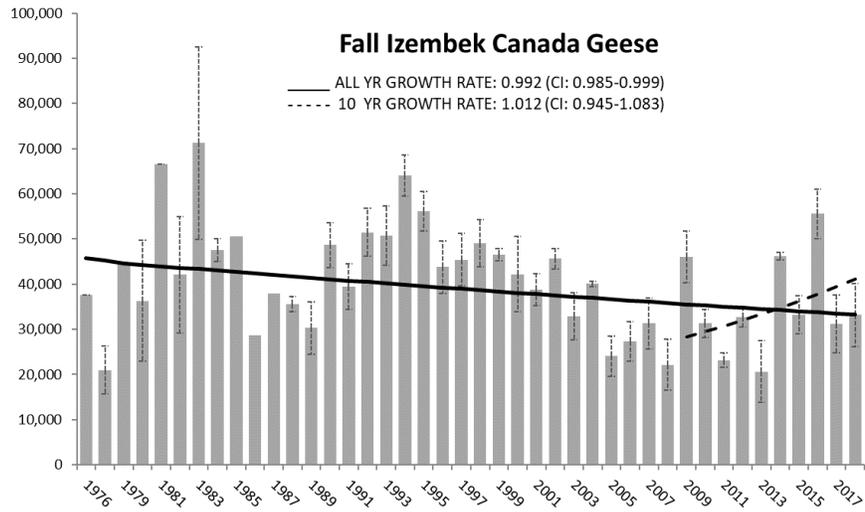


Figure 3. Canada goose, emperor goose, and Steller’s eider annual indices (\pm SE among replicate surveys) and log-linear growth rates, from the Fall Izembek Brant Survey, Alaska, 1976-2018.

Table 2. Annual population indices for Pacific brant, Canada geese, emperor geese, and Steller’s eiders, on the Fall Izembek Brant Survey, Alaska, 1976-2018. This table has been updated from Wilson (2017a), with annual, species-specific indices that are the average of *all* within-year replicate surveys from 23 Sept. – 31 Oct. each year, for *all* species (see Appendices 1- 2 for details of within year replicate surveys). Historically, annual indices of species other than brant reflected only a single Izembek Complex total from the Fall Emperor Goose Survey.

YEAR	PACIFIC BRANT		CANADA GOOSE		EMPEROR GOOSE		STELLERS EIDER	
1976	107,784		37,558		8,155		23,024	
1977	119,173		20,972		8,469		31,366	
1979	128,204		44,825		6,809		NOT COUNTED	
1980	127,667		36,253		7,602		57,114	
1981	180,734		66,591		12,222		78,645	
1982	127,760		42,068		10,524		43,711	
1983	184,022		71,223		10,308		41,225	
1984	127,995		47,506		5,916		30,196	
1985	122,673		50,568		4,506		10,022	
1986	113,487		28,707		4,558		20,771	
1987	142,930		37,849		6,875		23,469	
1988	123,813		35,568		3,545		9,805	
1989	146,038		30,258		3,753		19,000	
1990	123,977		48,668		4,931		16,482	
1991	128,457		39,413		3,487		19,543	
1992	109,719		51,470		2,509		19,172	
1993	143,539		50,690		4,120		32,383	
1994	142,591		64,020		3,891		33,270	
1995	147,193		56,170		3,655		22,188	
1996	119,263		43,749		2,697		14,437	
1997	132,830		45,414		2,803		15,250	
1998	105,185		49,106		3,340		22,467	
1999	131,134		46,474		4,318		11,472	
2000	156,011		42,159		4,492		19,958	
2001	112,554		38,739		3,838		24,550	
2002	115,839		45,625		2,756		11,233	
2003	135,944		32,886		2,145		9,815	
2004	134,474		40,051		2,337		7,974	
2005	152,712		24,025		1,674		8,122	
2006	124,170		27,322		2,364		12,337	
2007	140,897		31,289		2,387		7,721	
2008	130,294		22,147		2,614		6,875	
2009	169,429		45,975		1,827		8,056	
2010	150,510		31,273		2,130		9,742	
2011	126,028		23,165		4,794		3,892	
2012	154,481		32,651		2,371		5,170	
2013	157,781		20,628		9,241		4,147	
2014	171,635		46,118		2,816		7,300	
2015	160,984		33,170		2,347		4,044	
2016	203,735		55,530		1,497		6,953	
2017	154,811		31,190		2,171		4,845	
2018	155,724		33,122		2,552		4,517	
SUMMARY	EST.	SE	EST.	SE	EST.	SE	EST.	SE
ALL YR AVE	139,147	3,399	40,528	1,912	4,413	423	18,592	2,249
10-YR AVE (2009-2018)	160,512	6,200	35,282	3,419	3,175	730	5,866	637
LOG-LINEAR TREND 10-YRS (2009-2018)	1.013	0.013	1.014	0.035	0.977	0.061	0.956	0.035
LOG-LINEAR TREND ALL YRS (1976-2018)	1.005	0.002	0.992	0.004	0.968	0.005	0.948	0.005

Appendix 1. Fall Izembek Brant Survey 1976-2018: annual dates of all surveys, crews, and aircraft from 23 September - 31 October each year.

YEAR	REPS	DATES	PILOT OBSERVER	OTHER OBSERVER(S)	AIRCRAFT
1976	1	10/16-17	Sarvis, Arneson	Arneson/Kurhajec	PA-18
1977	3	9/23, 10/4, 10/24	Sarvis	Vivion	PA-18
1978	2	NO SURVEY			
1979	0	10/3, 10/23	Sarvis/Conant	Petersen/Gill/Dean	PA-18
1980	2	9/30, 10/29	Sarvis	Nunn	PA-18
1981	1	10/8	Sarvis	Nunn	PA-18
1982	2	9/23, 10/8	Sarvis/King	Dau/Bollinger	PA-18, C-185
1983	2	9/22, 10/3	Sarvis	Dau	PA-18
1984	30	10/6-11, 10/14-16	Sarvis/King/Hodges/Conant	Dau/Lensik/J.King/Rothe/Dirksen/ Hansen/Butler/Blenden/Timm/Nunn	PA-18, C-185, Turbine Beaver
1985	2	10/3, 10/11	Sarvis/King	Dau/Eldridge	PA-18, C-185
1986	3	10/3, 10/7, 10/20	Sarvis/King	Eldridge/Dau	C-185, PA-18
1987	4	9/25, 10/3, 10/9, 10/28	Sarvis/Butler/King	Blenden/Dau/Eldridge	PA-18, C-185, C-206
1988	4	9/26, 10/4, 10/11, 10/18	Dau/King	Ward/Eldridge/West	PA-18, C-185
1989	4	9/29, 10/4, 10/11, 10/25	Dau/Butler/King	West/Chase/Ward/Denlinger	PA-18, C-185
1990	5	9/28, 10/15, 10/18, 10/22, 10/25	Dau/King	West/Chase/Ward/Brackney/Chase	PA-18, C-185
1991	5	10/3, 10/6, 10/9, 10/18, 10/23	Dau/King	Chase/Krechmar/Ward/Brackney	PA-18, C-185
1992	10	9/23, 10/4-5, 10/7, 10/9-11, 10/13 (x2), 10/14	Dau/Butler/King/Hodges	Chase/Petersen/Larned/Ward/ Brackney/Dau	PA-18, C-185, C-206, Turbine Beaver
1993	6	9/23, 10/1, 10/15, 10/23, 10/26,	Dau/King	Gill/Ward/Chase/Dewhurst/Mason	PA-18, C-185
1994	5	10/4, 10/11, 10/19, 10/20, 10/27	Dau/Larned/King	Petersen/Balogh/Flint/Laing/ Schulmeister/Zeilemaker	PA-18, C-185, C-206
1995	7	9/26, 9/27, 10/3, 10/11, 10/17, 10/20, 10/26	Dau/King	Petersen/Flint/Gill/Laing/Schulmeister	PA-18, C-185
1996	6	9/25-26, 9/28, 10/9, 10/14, 10/22	Dau/Larned/King	Petersen/Tiplady/Flint/Eldridge/Ward	PA-18, C-185, C-206
1997	3	10/1, 10/4, 10/17	Dau/Larned/King	Petersen/Tiplady/Dau/Ward	PA-18, C-185, C-206
1998	6	9/25, 10/1, 10/2, 10/8, 10/13-14	Larned/Roy/King/Dau	Tiplady/Schafer/Mallek/Ward/Dochet	PA-18, C-185, C-206
1999	5	9/27, 10/1-4	Roy/Larned/Dau	Ziamba/Tiplady/Mallek	PA-18, C-206
2000	5	9/26, 9/28, 9/30, 10/16 (x2)	Larned/Dau	Anderson/Mallek/Ward	C-206
2001	2	9/28, 10/5	Dau	Mallek/Ward	C-206
2002	5	10/1, 10/2, 10/5, 10/8 (x2)	Mallek/Larned	Dau/Anderson	C-206
2003	5	9/26, 9/30, 10/8, 10/9 (x2)	Larned/Mallek	Anderson/Dau/Bollinger	C-206
2004	3	10/2, 10/7 (x2)	Mallek/Larned	Dau/Anderson	C-206
2005	5	10/3, 10/5, 10/7, 10/26, 10/31	Larned/Mallek/Richardson	Anderson/Dau/Sowl	C-206
2006	5	9/27 (x2), 10/2-3, 10/30	Mallek/Bollinger/Richardson	Dau/Sowl	C-206, PA-18
2007	3	9/29, 10/2-3	Mallek/Larned	Dau/Anderson	Turbine Beaver, C-206
2008	4	9/28-30, 10/1	Larned/Mallek	Anderson/Dau	C-206
2009	3	10/1, 10/4-5	Mallek/Larned	Dau/Bollinger	Turbine Beaver, C-206
2010	4	9/28, 10/4, 10/5 (x2)	Larned/Mallek	Wilson/Dau	C-206, Kodiak
2011	2	9/30, 10/1	Mallek	Dau	Kodiak
2012	3	9/29 (x2), 9/30	Larned/Mallek	Wilson/Dau	Kodiak
2013	2	10/19-20	Wilson	Dau	C-206
2014	3	9/30, 10/1, 10/5	Wilson	Larned	C-206
2015	4	10/4, 10/5, 10/6 (x2)	Wilson	Larned/Dau	C-206
2016	2	10/3 (x2)	Wilson	Larned	C-206
2017	5	10/2-3, 10/9 (x2), 10/10	Wilson	Larned/Zeller	C-206
2018	5	10/6, 10/7 (x2), 10/9 (x2)	Wilson	Larned/Zeller	C-206

Appendix 2. Annual and within-year survey information for Pacific Brant on all years of the Fall Izembek Brant Survey, 1976-2018. Annual indices represent the average, coefficient of variation (CV) and standard error (SE) of all within-year replicate surveys. Shaded cells indicate imputed survey totals (see footnotes).

Year	Index	CV	SE	WITHIN-YEAR REPEATED SURVEYS ¹⁻⁵											
				Reps	> 22 September	October									
1976	107,784	-	-	1		107,784									
1977	119,173	22%	15,393	3		100,688	107,094	149,737							
1979	128,204	4%	3,594	2			131,797	124,610							
1980	127,667	6%	5,522	2	122,145		133,189								
1981	180,734	-	-	1			180,734								
1982	127,760	21%	-	2	108,574		146,945								
1983	184,022	28%	-	2	147,933		220,110								
1984	127,995	24%	5,855	30			158,467	156,124	140,684	93,379	162,735	108,134	100,999	136,664	120,164
							92,830	112,534	152,014	207,424	124,514	175,834	190,454	132,284	149,384
							122,024	108,824	141,074	79,082	80,249	146,514	107,637	120,794	118,554
							77,619	113,234	109,624						
1985	122,673	19%	16,887	2			105,786	139,560							
1986	113,487	16%	10,326	3			99,198	133,544	107,718						
1987	142,930	7%	4,721	4	149,290		129,878	150,415	142,138						
1988	123,813	17%	10,370	4	106,221		106,397	147,013	135,620						
1989	146,038	5%	3,491	4	135,966		151,943	147,329	148,915						
1990	123,977	21%	11,714	5	107,386		120,691	169,934	109,178	112,697					
1991	128,457	14%	7,855	5	125,585		152,944	120,434	106,342	136,978					
1992	109,719	21%	7,485	10	127,204		140,071	107,010	94,172	74,422	98,494	92,082	151,074	97,656	115,001
1993	143,539	15%	8,648	6	159,833		131,311	106,035	157,263	148,946	157,844				
1994	142,591	16%	9,905	5			131,572	153,629	168,906	147,860	110,990				
1995	147,193	13%	7,407	7	118,948		171,709	152,345	166,210	146,234	150,232	124,672			
1996	119,263	35%	16,891	6	142,809	92,044	189,062	99,724	117,474	74,463					
1997	132,830	29%	22,164	3			175,205	100,371	122,913						
1998	105,185	42%	17,967	6	48,547		93,272	92,406	179,741	125,738	91,404				
1999	131,134	20%	11,839	5	129,566		118,265	99,179	170,731	137,928					
2000	156,011	13%	9,275	5	131,503	137,396	179,495	169,649	162,012						
2001	112,554	1%	533	2	113,086		112,021								
2002	115,839	14%	7,056	5			98,268	102,171	121,720	120,027	137,009				
2003	135,944	5%	3,162	5	144,184	138,841		139,571	127,669	129,455					
2004	134,474	21%	16,364	3			135,140	105,804	162,479						
2005	152,712	20%	13,840	5			149,133	126,302	127,133	159,021	201,969				
2006	124,170	10%	5,532	5	103,782	127,990		127,724	124,172	137,180					
2007	140,897	12%	9,677	3	154,219		122,079	146,394							
2008	130,294	18%	11,546	4	164,779	115,836		119,644	120,915						
2009	169,429	29%	28,439	3			120,592	219,098	168,596						
2010	150,510	28%	20,697	4	211,768		139,236	127,901	123,135						
2011	126,028	5%	4,207	2	121,821		130,234								
2012	154,481	18%	16,466	3	177,954	122,740	162,750								
2013	157,781	7%	7,426	2			165,207	150,355							
2014	171,635	18%	17,405	3	160,776		148,422	205,706							
2015	160,984	5%	3,781	4			168,642	155,544	153,518	166,232					
2016	203,735	2%	2,934	2			206,668	200,801							
2017	154,811	5%	3,768	5			146,525	158,397	163,647	160,353	145,134				
2018	155,724	11%	7,800	5			140,165	155,734	137,165	167,859	177,699				

Average
(1976-
2018)

139,147 16% 4

¹ Pilot/observer crews and replicate survey counts are presented in chronological order, corresponding to dates of replicate surveys. "(x2)" in the 'Dates' column indicates two surveys flown in the same day. ² No survey was flown in 1978. ³ All 1979 surveys are of Izembek Lagoon only. No Bechevin/Morzhovi Bay counts were conducted. ⁴ In 1984, many surveys of Izembek were flown as part of a survey workshop (Conant et al. 1984). ⁵ Shaded cells indicate imputed totals (i.e., where one or more segments within a survey were not completed and averages from other within-year surveys were used). Typically these missing segments were from areas outside Izembek Lagoon (Segments 60-65), such as Bechevin and Morzhovi Bays (Segments 66-71, 78-81, and 82-26). Details of imputed replicates are as follows: (1976-1992): In 1977, the average of segments 66-86 from the 10/4 & 24 surveys (8,625) was added to the 9/23 survey. In 1981, the counts from segments 66-81 of the 10/8 survey (5,165) was added to the 9/23 survey. In 1984, the average of segments 66-86 (8,486) from surveys on 10/6 and 10/9 were added to all other Izembek-only (Seg 60-65) surveys flown as part of the 1984 Izembek Survey Workshop (Conant et al. 1984). In 1985, the average of segments 66-86 (5,714) from surveys on 10/7 and 10/20 were added to the Izembek only (Seg 60-65) 10/3 survey. In 1986, the average of segments 66-86 (5,714) from surveys on 10/7 and 10/20 were added to the Izembek only (Seg 60-65) 10/3 survey. In 1992, surveys 5-7, and 10 include the average of Seg. 66-71 (4,812), and Seg. 78-81 (3,805) from surveys 1-4, and 8-9. (1993-2017): In 1996, the average of Seg. 66-81 (6,062) flown on 9/25-26 was added to 9/28 (3rd) survey. In 2006, average counts from Seg. 66-81 and 78-81 from 9/27, 10/2 & 10/3 (total = 9,773) was added-in for missing segments on 10/30. In 2007, the average count from Segments 61-81 (8,776) on 9/29 and 10/2, was added to the 10/3 survey. In 2011, the 6,653 birds observed in Bechevin/Morzhovi on 9/30 were added to the 10/1 survey missing those segments. The 2014 replicates each include 10,941 birds observed on a single count of Bechevin/Morzhovi Bays from the 9/30 survey (Wilson 2017a).

Appendix 3. Waterbird and mammal observations by segment for each of five replicate surveys of the 2018 Fall Izembek Brant Survey. Primary species are highlighted in grey.

SURVEY 1

SPECIES	Date: 6 October, Obs: HMW/WWL, Tide: Low													TOTAL
	60	61	62	63	64	65	67	68	69	80	81	84	85	
American Wigeon		20												20
Arctic Tern														
Bald Eagle	5		1							2	1	2		11
Black Scoter							12	9	2		6			29
Black-legged Kittiwake											1			1
Brant	6,310	27,568	27,815	17,921	33,100	19,838	320	275		6,564			454	140,165
Canada Goose	5,991	5,130	1,975	2,550	8,095	1,632		3,884		3,940				33,197
Common Eider														
Common Loon											1			1
Common Merganser														
Common Raven											1			1
D-c Cormorant														
Emperor Goose	689	64	179	46		26		598		973	281	685	97	3,638
Goldeneye													6	6
Greater Scaup	2,501											60		2,561
Gull spp.	738	642	532	234	180	39	417	794	22	1,388	369		250	5,605
Harlequin Duck														
Long-tailed Duck														
Mallard	85			10	260		40			27				422
Northern Pintail	743	1,200	50	220	511	270	205	480		120				3,799
Northern Shoveler														
Pacific Loon								1						1
Pelagic Cormorant											1			1
R-b Merganser							3	2		13				18
Red Necked Grebe								2	1		6			9
Sea Otter	98	215		17	7	52	50	7	1	2	3			452
Shorebird spp.	460	400	1,300	340						420				2,920
Sooty Shearwater														
Steller's Eider	2,150	2,072	382	20		635							1	5,260
Surf Scoter									2					2
Tundra Swan							98							98
Unknown Loon														
W-w. Scoter								3			11	4		18
Mammals:														
Brown Bear	2													2
Harbor Seal		344	160	180			32	1					30	747
Red Fox														
Steller's Seal Lion														
Walrus				210										210

Appendix 3 (continued). Waterbird and mammal observations by segment for each replicate survey of the 2018 Fall Izembek Brant Survey. Primary species are highlighted in grey. *Gulls and shorebirds were not counted by both observers on Survey 4 and 5, thus were not tallied for those surveys.

SURVEY 4

SPECIES	Date: 9 October - Morning, Obs: HMW/TKZ, Tide: Low													TOTAL
	60	61	62	63	64	65	67	68	69	80	81	84	85	
American Wigeon														
Arctic Tern														
Bald Eagle					1	2				3	2			8
Black Scoter							22	4	8		1	5	10	50
Black-legged Kittiwake														
Brant	9,723	37,538	22,895	17,747	46,212	25,446	189	14	7,645				450	167,859
Canada Goose	18,041	130	3,280		3,575	3,500		1,935	1,365					31,826
Common Eider														
Common Loon											2			2
Common Merganser														
Common Raven				1									1	2
D-c Cormorant							10					1		11
Emperor Goose	505	6	355	86	118			531	96	42	187	4		1,930
Goldeneye														
Greater Scaup	956													956
Gull spp.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Harlequin Duck							5							5
Long-tailed Duck														
Mallard	221			3	5		22	45	105				30	431
Northern Pintail	1,100	1,252		57	147	500	403	282	150				40	3,931
Northern Shoveler									20					20
Pacific Loon					1									1
Pelagic Cormorant														
R-b Merganser								140						140
Red Necked Grebe										7				7
Sea Otter	43	142	66	3	20	36	92	5			6	1		414
Shorebird spp.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sooty Shearwater														
Steller's Eider	356	2,614	690			250								3,910
Surf Scoter														
Tundra Swan					3		24			2			12	41
Unknown Loon								1			2			3
W-w. Scoter														
Mammals:														
Brown Bear	3						2			1				6
Harbor Seal		75			5		30	2	70				120	302
Red Fox									1					1
Steller's Seal Lion														
Walrus					303									303

SURVEY 5

SPECIES	Date: 9 October - Afternoon: HMW/TKZ, Tide: Low - Rising													TOTAL
	60	61	62	63	64	65	67	68	69	80	81	84	85	
American Wigeon														
Arctic Tern														
Bald Eagle						1	1					1	3	6
Black Scoter							3	15				22	24	64
Black-legged Kittiwake												1		1
Brant	4,213	51,558	26,450	10,457	49,091	29,496	894	31	5,069				440	177,699
Canada Goose	12,177	5,413	2,895	1,300	7,341	3,896	30	1,320	2,262					36,634
Common Eider														
Common Loon												3		3
Common Merganser														
Common Raven											1			1
D-c Cormorant												2		2
Emperor Goose	169	89	24	100	8		5	759	185	389	155	202		2,085
Goldeneye														
Greater Scaup	2,100				30									2,130
Gull spp.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Harlequin Duck							5					25	13	74
Long-tailed Duck														
Mallard	68				80	20	80	32	80					360
Northern Pintail	360	5,012	535		450	2,210		110	200					8,877
Northern Shoveler									10					10
Pacific Loon									1					1
Pelagic Cormorant												2		2
R-b Merganser														
Red Necked Grebe										2		2		4
Sea Otter	70	332	1	16		61	87	12	2		11	5		597
Shorebird spp.*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Sooty Shearwater														
Steller's Eider	1,602	2,950	1,110		3	51								5,716
Surf Scoter														
Tundra Swan					5	2		1		12				20
Unknown Loon									2			2		4
W-w. Scoter											6	14		20
Mammals:														
Brown Bear	7	1												8
Harbor Seal		100	500	52	160	70	20						40	942
Red Fox														
Steller's Seal Lion												5		5
Walrus						462								462