POPULATIONS AND REPRODUCTIVE SUCCESS OF SEABIRDS ON THE PACIFIC COAST OF BECHAROF NATIONAL WILDLIFE REFUGE, ALASKA PENINSULA, ALASKA

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ABSTRACT

Seabirds were monitored along the Pacific coast of the Becharof National Wildlife Refuge (NWR) to estimate population size, breeding phenology, and reproductive success during the 2003 breeding season. The study focused on common (*Uria aalge*) and thick-billed (*U. lomvia*) murres. A small number of glaucous-winged gulls (*Larus glaucescens*) were also observed. The objectives of the monitoring program are to detect changes in population size and reproductive performance of these ledge-nesting seabirds over time and for comparison with other colonies in Alaska. This baseline information can be used to detect problems in marine bird populations and to provide a basis for directing management actions and assessing the effects of management. In this report we focus on comparisons between data collected in 1992, 2001, 2002, and 2003 within the Becharof NWR.

Three land-based censuses were collected for the Puale Bay colony (Beringia Colony Catalog #35-13) within the 2-week interval around mean hatch date for each target species. The mean population count was 1,442 ±103 murres. This was 185 birds less than 2002's mean and the difference was statistically significant. However, the population counts for 2003 were still significantly greater than the counts in 1992. We monitored 470 common murres sites on 17 plots and 24 thick-billed murre sites on five plots for reproductive success measures. We documented a hatching success of 0.77 ± 0.04, a fledging success of 0.84 ± 0.02, and a reproductive success of 0.65 ±0.04 which were statistically lower than values for 2002 ($p < 0.01$ for all values) and 2001 ($p < 0.08$, $p < 0.01$, $p < 0.02$ respectively). When 2003 was compared to 1992, hatching success was not significantly different, but fledging success and reproductive success were different and higher ($p = 0.028$ and $p = 0.09$, respectively). Similar declines in hatching success and reproductive success from 2001 and 2002 were noted for the thick-billed murre sites monitored, however with the small sample sizes, no conclusion on the differences can be made. This year's set of common murre sites included for reproductive phenology (383 sites on 17 plots) resulted in a mean hatch date of 16 August ± 4.4 days which was significantly later than the mean hatch date of 6 August ± 1.6 days in 2002 ($p = 0.001$). The 2003 mean hatch date was still significantly earlier

than that of 1992 (18 August, $p = 0.043$). Similar results were observed for thick-billed murres. We believe that early and intensive common raven (*Corvus corax*) egg depredation upon the murres was largely responsible for this year's phenological delay.

We monitored 31 glaucous-winged gull nests with phenological data for 16 nests. The mean hatch date was 11 July ± 11.8 days with productivity of 1.19 ± 1.14 chicks fledged per nest attempt. The cliff sites used by red-faced cormorants (*Phalacrocorax urile*) in 2001 and 2002 were not occupied this year. No cormorants were monitored.

In addition to monitoring seabird population and productivity, camp staff also conducted disturbance monitoring, beach watches and small mammal trapping, and recorded daily weather, incidental bird and mammal sightings, bear encounters, and plant phenology.

INTRODUCTION

The Alaska Peninsula / Becharof National Wildlife Refuge continued seabird monitoring on the Pacific coast in 2003. This report summarizes results of surveys at Puale Bay (Beringian seabird colony 35-13) from 12 June to 15 September 2003. We compared these data with those collected at the same colony in 1992, 2001 and 2002. These data will also be used to assess long-term trends of seabirds in the Gulf of Alaska and for comparisons with similar colonies elsewhere in Alaska. We focused on populations, reproductive parameters, and reproductive phenology of the following three seabird species: glaucous-winged gulls, common murres, and thick-billed murres. In addition to seabird colony monitoring, we also continued collecting information for several ongoing projects at the Puale Bay Research Station. This year's projects included colony disturbance monitoring, beach watch surveys, small mammal trapping, vegetation phenology, weather data collection, incidental bird and mammal observations, and brown bear / human interaction observations.

STUDY AREA

The study was conducted along the Pacific – Gulf of Alaska coast of the Alaska Peninsula at Puale Bay. The colony is within the Becharof National Wildlife Refuge and Becharof Wilderness at 57°41'N, 155°29'W (Figure 1). Katmai National Park lies 30 km north and Kodiak Island lies 90 km east across Shelikof Strait from Puale Bay. Dewhurst et al. (1990) selected the study areas and established population and reproductive success plots after the *T/V Exxon Valdez* oil spill in 1989. Plots used from 1989-1992 and again in 2001-2002 were replicated in this study.

Where the Shelikof Strait meets the Aleutian Range, a rugged coastline dominated by eroded mountainsides forms cliff habitat ideal for ledge-nesting seabird colonies. Colony heights range from 170-300 m. The cliffs are punctuated by tidally influenced beaches of various substrates. The summer climate is primarily foggy, windy, and rainy with infrequent sunny days. Generally the area is free from snow at sea level from early May to late September.

METHODS

Staffing and Logistics

The refuge staffed a field camp near Teresa Creek from 12 June – 15 September 2003 with one biological technician and three interns. Equipment, resupplies and personnel transportation from King Salmon to Puale Bay were provided by the refuge Cessna 206 on wheels, and a contracted Cessna 185 and deHavilland Beaver. Camp facilities and equipment included: two weatherports (one for living and one for sleeping) enclosed within an electric fence for bear safety, solar panels and storage batteries, an outhouse, a burn barrel, radio equipment, field computer (Gateway Solo Laptop), two Questar telescopes, two to four Kowa TSN 82 mm fluorite spotting scopes with 20-60X lens, four Bogen tripods, 10 x 40 Zeiss and 10 x 42 Leica binoculars, Sony digital video camera (DCR-TRV30), and safety equipment for stream crossing. The technician voluntarily used his personal digital camera (Canon PowerShot S400, 3X optical zoom, 4 megapixel) to take still photos. Special brown bear safety equipment included four 12 ga. shotguns, shotgun slugs, bear hazing supplies (cracker shells, rubber slugs, air horns),

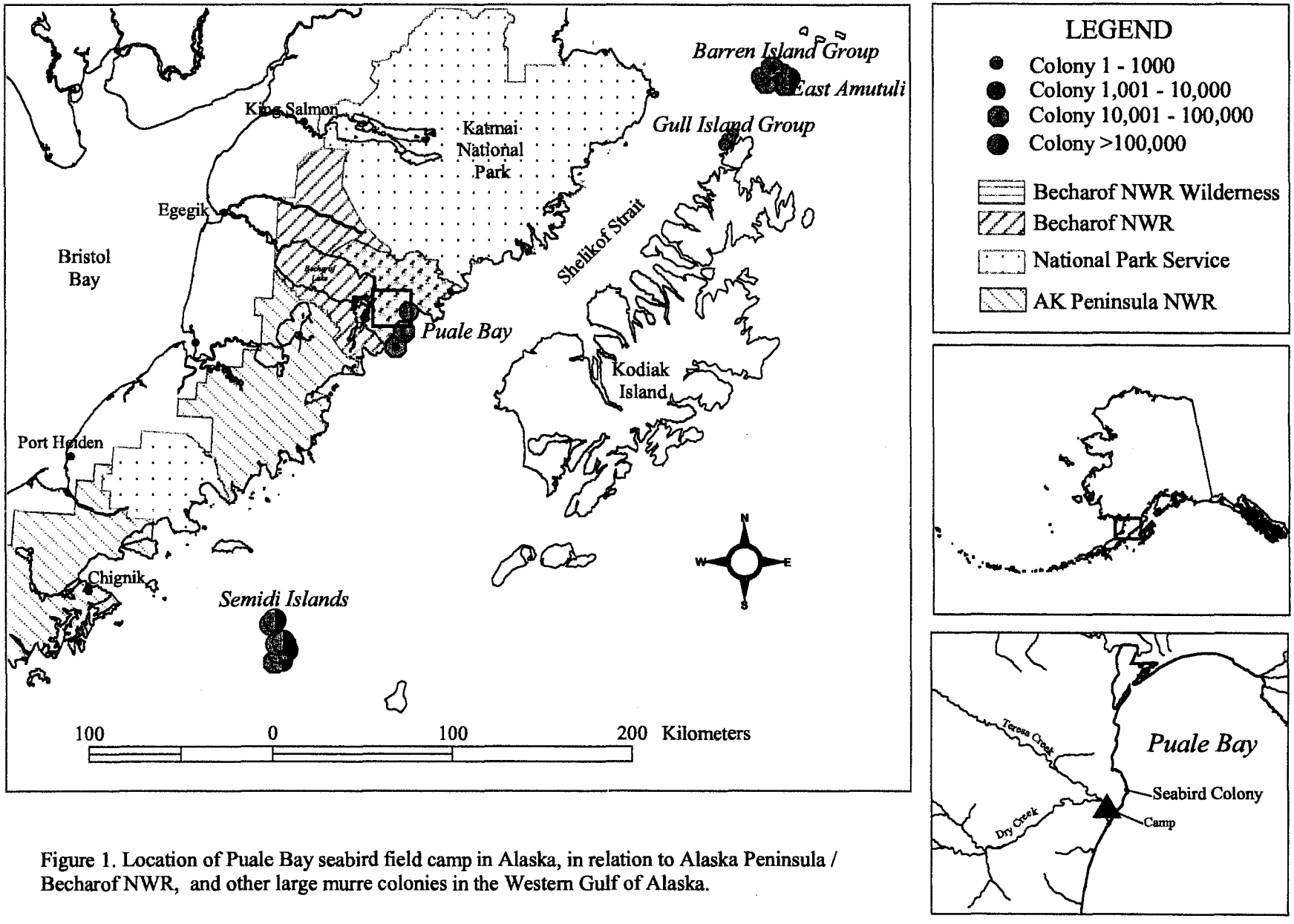

Figure 1. Location of Puale Bay seabird field camp in Alaska, in relation to Alaska Peninsula / Becharof NWR, and other large murre colonies in the Western Gulf of Alaska.

and bear-proof food storage drums. Safety equipment for observing the seabirds included a system of climbing ropes, carabiners, and anchors at each of the overlooks and a rescue pulley system.

Population Surveys (Adult birds)

The land-based survey methods are outlined in the Draft Wildlife Inventory Plan (WIP) *Seabird Colony Census* (USFWS 2001a), WIP *Seabird Reproductive Productivity* (USFWS 2001b), and *Standard Operating Procedure (SOP) for Monitoring Populations and Productivity, Ledge-Nesting Seabirds* (USFWS 2000). Murre land-based surveys were conducted for a sub-sample of the colony corresponding to productivity / phenology plots. Both species of murres were counted together to expedite the census. Population counts were attempted every three days, except during a period from July 25 to August 25 (near mean hatch date) when they were attempted every other day. Inclement weather outside the protocol parameters often precluded scheduled counts. Some counts were taken when wind exceeded the 20-knot (23 mph) limitation suggested in protocol. Although presented in the Appendices, these data are not used in calculating means or to calculate t-tests between years. Data for counts were recorded in all-weather notebooks. Counts within 5% of each other were transcribed into a computer spreadsheet.

Data Analysis: To summarize population data for each species, we averaged replicate counts for each plot on each day and totaled the averages for all plots. In 2003, we accomplished four counts of murres during the period from one week prior, to one week post, mean hatch date, however the last was excluded because wind conditions exceeded what was allowed in protocol. Statistical comparisons were made between 2001 (five replicate counts), 2002 (seven replicate counts), and 2003 using one-tailed t-tests and 0.1 level of significance (calculated p values reported). The data were also compared to 1992 using a smaller set of plots shared between years (some plots were combined and some excluded). We also conducted three replicate counts during the two-week span centered around mean hatch date of glaucous-winged gulls and compared this to five replicate counts corresponding to the same phenological period in 2002.

NOTE: Throughout this paper, summary statistics are presented in tables and plot specific information is presented in appendices where appropriate. Data from 2001 have

been revisited to ensure statistics were calculated in the same way as in 2002 and 2003. However, decision criteria on phenology and productivity developed in 2002 were not reapplied to 2001.

Phenology

Phenology followed procedures outlined in the WIP – *Seabird Reproductive Productivity* (USFWS 2001b) and *Ledge-Nesting Seabirds SOP* (USFWS 2000). Phenology and productivity information was obtained from the same observations for each site. Photographs and drawings were used to aid in identifying individually numbered nest sites. We conducted observations of murres approximately every three days and of gulls every five days. Data were recorded in all-weather notebooks and transcribed to computer spreadsheets daily. Rules to evaluate data quality and inclusion for each site are found in Appendix 1 of Kaler et al. 2003. Because weather delayed mapping and ravens disturbed the colony during egg-laying more so than in 2001 and 2002, many lay dates were not easily determined by previous rules. Back-dating, forward-dating and adjusting lay dates was used to a greater extent in 2003. Additional guidance for determining phenological dates was developed in 2003 and is given in Appendix I.

Note: In 2001, staff attempted to record data for all visible sites on each plot while in 2002 and 2003 staff was directed to limit sampling to 30 – 50 sites per plot.

Data Analysis: Parameters reported for both murre species and glaucous-winged gulls include first, last, and mean date for egg laid, chick hatched, chick fledged, incubation period, and fledging period (15 parameters). In the text portion of this report, all means are presented along with standard deviation. Dates presented for common murres are based on means of 17 plots. When testing for significant differences between years was desired, a paired one-tailed t-test was used. To compare with 1992, some plots were combined and some excluded so plots were still paired. Dates were considered different at the 0.1 level of significance; however the calculated p value was reported. Due to low numbers of thick-billed murres and glaucous-winged gulls, means were based on all sites and no statistical tests were attempted. A mean fledge period for murres that

was significantly shorter in 2003 versus 2002 prompted us to ask if chicks that hatched late fledged at a younger age. To test this, a linear regression was conducted.

Productivity

These surveys followed the protocol established in the Draft WIP – *Seabird Reproductive Productivity* (USFWS 2001b) and Ledge-Nesting Seabirds SOP (USFWS 2000): Level 4-intensive method. Data for productivity were collected simultaneously and from the same sites mapped as above, for phenology. Criteria for inclusion were generally more exclusive for phenology, so the sample size available to be used for productivity calculations was larger. Rules to evaluate data quality and inclusion for each site are found in Appendix II of Kaler et al. 2003.

Data Analysis: Because murres only have one egg per site (nest) and glaucous-winged gulls often have more, different measures of productivity are reported for each species. Nesting success is given as nests with fledglings per nests starts (gulls). Hatching success is defined as chicks hatched per site with eggs (murres). Fledging success was measured as number of chicks fledged per nests with chicks (gulls) or number of fledges per hatched chicks (murres). Productivity was measured as number of chicks fledged per nest start (gulls), and reproductive success reports number of fledges per sites with eggs (murres).

We estimated reproductive success in common murres by using plots as sample units and letting the means of each of the reproductive parameters for a plot be the sample observations. We report the total ratio, standard deviation and the 90% confidence interval for each reproductive parameter, as generated by the ratio estimation procedures of Ackerman and Garton (1987). This approach was employed rather than using an individual nest site as a sample unit because nests located close together may share a common fate and site data are therefore not independent (Birkhead 1977, Byrd 1989). Several assumptions were made due to the limitations on sampling imposed by the physical structure of the cliff and murre colony. The plots that were viewed from the top of the colony were concentrated and therefore we assumed that this portion of the colony represented the entire colony. When testing for significant differences between years was desired, a paired one-tailed t-test was used. To compare with 1992, some plots

were combined and some excluded so plots were still paired. Dates were considered different at the 0.1 level of significance (calculated p values reported). Glaucous-winged gulls and thick-billed murre reproductive statistics were based on sites rather than plots because of the low number of sites per plot. In addition, most gull nests were well dispersed even though they were located on the same "plot" as defined by another species.

Disturbance Monitoring

Disturbance monitoring continued in 2003 and followed guidelines developed for the 2001 season and finalized in the 2002 field season (Kaler et al. 2003, Appendix III). During all population and productivity monitoring, all potential disturbance events were documented. Disturbance events were defined as any event from humans or other animals that might have an influence on the nesting birds' behavior, whether a reaction was observed or not. When events occurred, the actions of the birds on the colony were recorded. Records were used to evaluate the patterns and extent of disturbance to the murre colony.

Data Analysis: Observations were collected and later separated into four time periods based on breeding phenology dates. 'Pre-nesting' is defined as the time leading up to the mean lay date (19 June – 14 July; 26 days in length). 'Incubation' begins on the mean lay date and extends to the day before mean hatch day (15 July – 15 Aug; 32 days). The 'brooding' period is from mean hatch date through the mean fledging period (16 Aug – 5 September; 21 days). 'Post brooding' is the time period remaining until we left the field (6 Sept – 15 Sept; 10 days). For this report, flushing of birds off the colony and predatory events will be the only disturbances that will be reported, although many lesser levels of disturbance (threat displays, erect posture, head-bobbing, alarm-calling, looking direction) were observed and recorded. Occasionally multiple species caused a disturbance together (i.e., peregrine falcon chasing common raven). In those instances, the distubance event was tallied in both *Raptor* and *Raven* categories. The alarm call of glaucous-winged gulls often caused disturbances, but only when the source of their agitation was unknown was the gull's call recorded as the description of the event.

Beachwatch Survey

Staff continued to survey beaches to add to the baseline information collected from previous study years at Puale Bay. We followed guidelines established for 2001 in *USFWS-Forms – Beached Bird Surveys* (USFWS 2001c). As in 2001 and 2002 there was no boat in camp so only four of the six sections set up in 1989 (Dewhurst 1991) were accessible by foot. Modifications to the guidelines were made prior to the 2001 field season to create a more consistent survey protocol for our work schedule and time constraints. Segments 1 and 2, directly south of Teresa Creek and camp, were given priority over Segments 3 and 4 north of the creek, which were only accessible on a negative tide. We planned to complete Segment 1 once every two weeks and Segment 2 once a month. Four to five observers spread out across the beach from water's edge to wrack line to survey, all moving in one direction. Protocol states two observers should start two hours before low tide. With the additional observers surveying the whole beach at once, we began segment walks one hour before low tide. Information for each walk was recorded on a beached bird survey form. Separate marine mammal stranding report forms were available for any marine mammals found.

Weather

Weather data were collected by a Davis Vantage Pro weather station and transferred daily to laptop via Davis' Weatherlink 5.2 software. While many variables were recorded and stored in the database, we used only the following daily measures in our analysis: mean temperature, low / high temperatures, average wind speed, maximum high wind speed, dominant wind direction, and total rainfall. The station was setup on June 15th and was taken down on September 15th. Data were not complete for those dates and were not included in the weather summary. Other variables recorded and archived were: dew point, direction of strongest wind gusts, barometric pressure, rain rate, and heating and cooling degree-days. The wind data should be interpreted with caution when prevailing wind directions were westerly as a dune situated just west of camp diminished wind speeds and influenced recorded wind direction. Other variables recorded manually between 0700 and 0800 were: percent cloud cover, ceiling height, and visibility. We also

recorded whether weather conditions allowed colony monitoring at that time. At the end of the day we noted whether we were able to monitor the colony for at least two hours. Protocol guidelines state that colony censusing (population counts) should not be conducted in winds exceeding 20-knots (23 mph). Monitoring was also dependent on visibility and rainfall.

Avian and Mammalian Sightings

We recorded all avian and mammal sightings daily throughout the 2003 field season. Avian records were taken following the Draft WIP Forms – *Neotropical Avian / Incidental Avian Observational Instructions* (USFWS 2001d). Guidelines for taking and reporting mammal observations were drawn from consistent collecting procedures followed at Mother Goose Lake and presented in Leppold and Savage (2001). Date, time, location, number, age/sex of animals, and behavior were noted for all mammals except brown bears (see next).

Brown Bear/Human Interactions

Following guidelines established in the late 1980's at the refuge (Dewhurst, et al. 1996), we continued to document bear / human encounters. In 2001, we updated the procedure (Draft *WIP Forms – Bears / Bear Record Protocol,* USFWS 2001e). Records were kept on two separate forms. Bear observations that did not result in the bear being aware of, or reacting to, the observer were recorded on a *Bear Sighting* form. Any interaction resulting in a response of the bear to humans required a more detailed write-up on a *Bear Incident Report.* For this report, incidents were categorized in three levels of increasing response by humans: passive human behavior, active noise-making (including air horns this year), and use of guns with cracker shells or rubber slugs. Raw data from earlier years were re-categorized in 2002 as best as possible to match the new criteria. Objectives in collecting these data were to quantify bear / human encounters and their impact on each species. This information is especially desired for areas where a remote camp is established in an area of high bear density such as Puale Bay.

Small Mammal Trapping

We conducted small mammal trapping concurrent with the seabird-monitoring project using procedures outlined in Draft WIP – *Small Mammal Inventory and Trend Monitoring* protocols (USFWS 2001f). Details of this project are available in the small mammal report (Menard and Savage 2003).

Plant Phenology

As in 2002, we collected information about the developmental stage (vegetative, budding, flowering, fruit developing, fruit ripened, plant withering) of approximately 40 species of plants on a weekly basis. These data will be reproduced here and archived for comparison with future years and other areas of the Alaska Peninsula where similar data have been collected.

RESULTS AND DISCUSSION

Glaucous-winged Gulls

Glaucous-winged gull monitoring is an off-shoot of other species monitoring. Because red-faced cormorants did not nest in the area used in 2001 and 2002, these plots were also not monitored for gulls. Gull data in 2003 were from the main murre colony and a plot just north of the main colony.

Population – Population counts of adult gulls were not consistently taken during all years. Often plots Q or X were not counted. Gull counts of the main murre ledge (plots A – G3) and murre plot Y were compared between 2002 and 2003. Only counts taken around gull mean hatch date were used. The 2003 counts were significantly greater than those in 2002 ($p=0.001$). In 2003 the mean was 38.8 ± 6.8 ($n=3$) compared to 15.9 ± 5.2 ($n=5$) in 2002 (Appendix II). Because we did not monitor the red-faced cormorant ledges, we don't know if the increase in number of gulls on the murre ledges was due to movement from the cormorant area, or overall increase on the colony.

Phenology – Although fewer gull plots were observed, the number of nesting sites monitored was similar between all years. More gull nests were found on the main murre colony in 2003 (Appendix III, 20 in 2003 compared to nine in 2001 and 10 in 2002).

This is consistent with the population increase on this part of the colony as noted above. The majority of egg-laying occurred before we arrived at the field station. This was the case in other years as well. In 2003, we observed a mean hatch date of 11 July ± 11.8 days compared to 4 July ± 7.2 days in 2002 and 7 July ± 8.5 days in 2001 (Table 1). Hatching was first detected on 29 June (similar to other years) and last seen on 10 August (substantially later). These late hatching dates (19 and 17 days later than in 2002 and 2001, respectively) were restricted to nests on the North Main plot; Main's hatching parameters were more similar to previous years (Appendix VI). In 2003 large unwitnessed disturbance events between 21 July and 28 July destroyed six of the 11 nests on North Main. It is possible that similar disturbances on North Main may have occurred prior to our monitoring activities, and that these late nests were actually relays, thereby retarding overall phenological dates. The length of the fledging period also increased from 2001 to 2003. In general, glaucous-winged gull phenology has been more variable than that of other species nesting on the colony.

Productivity – If only Main and North Main areas are compared, nesting success, fledging success, and productivity were all lower in 2003 than in 2002 (Appendix III). Nesting success was 0.61 in 2003, 0.76 in 2001 and 0.75 in 2002. In 2003, the fledging success was 1.61; slightly above the 1.44 ratio of 2001, but still considerably below the 2.46 ratio of 2002. Chicks fledged per nest with eggs (productivity) was similar in 2003 and 2001 (1.19 vs. 1.24 respectively), but well below 2002 (2.00). It should be noted, however, that nesting success and productivity in 2002 over the entire colony was much lower than the subtotal used here for North Main and Main plots alone (Table 2). Also note that although our calculations of the parameter nesting success are comparable between years, they may be overestimated compared to other colonies in Alaska. Since we did not observe all nests from initiation, nest starts that did not have eggs or losses of early nests were probably not detected during our observations.

Murres

Population – Our land-based population counts for the two-week period around hatch date in 2003 were similar to 2001 (Appendices Va, Vb). Appendix Va shows totals from all 17 comparable plots used from 2001 to 2003 with means of 1,455 ± 69, 1,627 ±

Table 1. Phenology of glaucous-winged gulls, Puale Bay, Becharof NWR, Alaska, 2001-2003.

	2001		2002		2003	
Laying						
	First lay	--	First lay	--	First lay	--
	Last lay	--	Last lay	7-Jul	Last lay	7-Jul
	Mean laying	--	Mean laying	27-Jun	Mean laying	1-Jul
	n	--	n	3	n	2
	SD	--	SD	8.7	SD	8.5
Hatching						
	First hatch	29-Jun	First hatch	27-Jun	First hatch	29-Jun
	Last hatch	29-Jul	Last hatch	21-Jul	Last hatch	10-Aug
	Mean hatch	7-Jul	Mean hatch	4-Jul	Mean hatch	11-Jul
	n	18	n	21	n	16
	SD	8.5	SD	7.2	SD	11.8
Fledging						
	First fledge	26-Jul	First fledge	10-Aug	First fledge	29-Jul
	Last fledge	7-Sep	Last fledge	7-Sep	Last fledge	14-Sep
	Mean fledge	16-Aug	Mean fledge	18-Aug	Mean fledge	29-Aug
	n	23	n	16	n	16
	SD	9.1	SD	6.4	SD	11.1
Incubation period						
	Mean	30	Mean	30	Mean	33
	n	2	n	1	n	2
	SD	2.8	SD	--	SD	1.4
Fledging period						
	Mean	39.8	Mean	48.3	Mean	52.1
	n	16	n	15	n	14
	SD	4.8	SD	3.9	SD	5.9

Statistical abbreviations: n = sample size, SD = standard deviation, CI = confidence interval

Dash represents insufficient data.

Table 2. Productivity of glaucous-winged gulls, Puale Bay, Becharof NWR, Alaska, 2001-2003.

		2001	2002	2003
		Total	Total	Total
No. of nest with ≥ 1 egg (A)		34	34	31
No. of nest with ≥ 1 chicks (B)		28	21	23
No. of nest with ≥ 1 chicks fledged (C)		26	15	19
Total chicks fledged (D)		45	39	37
Nesting success (C/A)	n	34	34	31
	ratio	0.76	0.44	0.61
	SD	0.43	0.50	0.50
Fledging success (D/B)	n	28	21	23
	ratio	1.61	1.86	1.61
	SD	0.83	1.28	1.03
Productivity (D/A)	n	34	34	31
	ratio	1.32	1.15	1.19
	SD	0.98	1.35	1.14

Statistical abbreviations: n = sample size, SD = standard deviation, CI = confidence interval

Nesting success = total number of nests with fledglings/total nests.

Fledging success = total number of chicks fledged/nest with chicks.

Productivity = number of chicks fledged/nests.

NOTE: In 2003 only Main and North Main plots were observed.

90 and 1,442 ± 103, respectively. T-tests of population counts between year pairs indicated that 2003 was not significantly different from 2001, but was different from 2002 ($p = 0.02$). Population data for the same common plots used back to 1990 are presented in Appendix Vb. T-tests of population counts between year pairs on this smaller set of plots show similar results as above when 2003 is compared to 2001 and 2002. When the 2003 counts are compared to 1992, they are found to be significantly greater ($p = 0.07$). Counts increased steadily from 1990 through 2002 and decreased slightly in 2003 (Figure 2). Refuge monitoring protocol schedules sea-based population counts every five years at the Population Trend Index Level. These were completed for the Puale Bay colony in 2001 (Doster and Savage, 2002), so were not conducted this year.

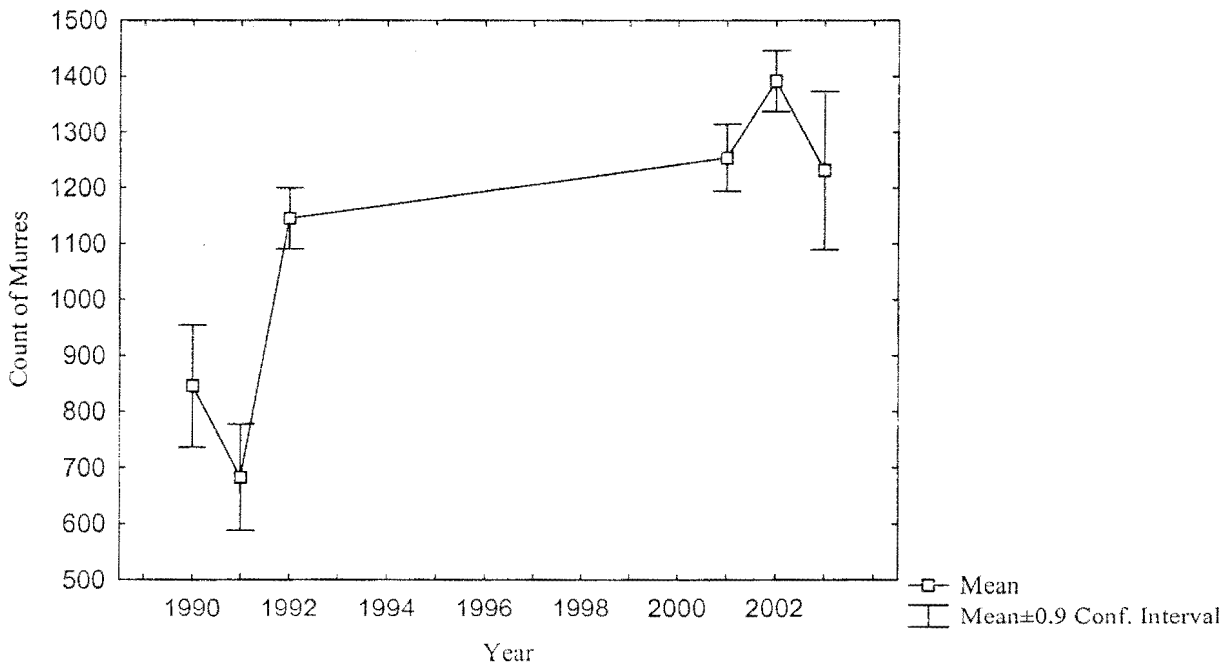

Figure 2 Land-based murre population counts of common plots from 1990 - 2003.

Phenology – Although common murre phenology appeared to change little between 2001 and 2002, some parameters showed significant statistical differences (Kaler et al. 2003). This year's phenology differed substantially among all parameters except Incubation Period (Table 3, Appendix VI), and for common murres were statistically different ($p \leq 0.005$) from 2001 and 2002. We believe this was a direct result

Table 3. Phenology of common and thick-billed murres, Puale Bay, Becharof NWR, Alaska, 1992, 2001-2003. Common murres based on plots; thick-billed murres based on sites.

	Common murres					Thick-billed murres			
Laying	1992*	2001	2002	2003	**Laying**	1992*	2001	2002	2003
First Date	30-Jun	29-Jun	29-Jun	28-Jun	First Date	6-Jul	29-Jun	3-Jul	27-Jun
Last Date	16-Aug	24-Jul	29-Jul	10-Aug	Last Date	7-Aug	17-Jul	13-Jul	29-Jul
Mean Date	15-Jul	6-Jul	6-Jul	15-Jul	Mean Date	16-Jul	6-Jul	5-Jul	13-Jul
SD	3.5	2.7	1.4	3.9	SD	8.6	4.9	2.4	8.9
n	9	17	17	17	n	23	24	29	20
Hatching					**Hatching**				
First Date	5-Aug	31-Jul	29-Jul	30-Jul	First Date	10-Aug	2-Aug	4-Aug	9-Aug
Last Date	8-Sep	28-Aug	1-Sep	11-Sep	Last Date	26-Aug	11-Aug	14-Aug	28-Aug
Mean Date	17-Aug	8-Aug	6-Aug	16-Aug	Mean Date	17-Aug	7-Aug	6-Aug	17-Aug
SD	3.4	1.6	1.6	4.4	SD	5.1	3.1	2.8	6.0
n	9	17	17	17	n	16	21	26	10
Fledging					**Fledging**				
First Date	24-Aug	20-Aug	17-Aug	22-Aug	First Date	2-Sep	20-Aug	19-Aug	30-Aug
Last Date	19-Sep†	10-Sep	13-Sep	14-Sep	Last Date	11-Sep	7-Sep	4-Sep	12-Sep
Mean Date	6-Sep	30-Aug	29-Aug	5-Sep	Mean Date	6-Sep	29-Aug	27-Aug	4-Sep
SD	2.3	1.1	2.2	3.8	SD	3.4	4.3	4.0	4.4
n	9	17	17	17	n	13	21	24	8
Incubation Period					**Incubation Period**				
Mean		33.4	32.0	32.1	Mean		32.4	31.6	33.5
SD		1.6	1.4	1.1	SD		3.9	2.1	3.7
n		17	17	17	n		18	26	10
Fledge Period					**Fledge Period**				
Mean		22.4	22.8	20.7	Mean		21.5	20.9	19.9
SD		1.1	1.9	1.6	SD		3.3	3.2	3.3
n		17	17	17	n		21	24	8

Statistical abbreviations: n = sample size, SD = standard deviation, CI = confidence interval

* Original data from 1992 was reviewed and some backdated sites were eliminated, data from calculation tables 2001

†Last date observations were made, camp closed

of frequent disturbance by common ravens and murre egg depredation (see *Disturbance* section). Also one depredation of an adult murre by a bald eagle (*Haliaeetus leucocephalus*) resulted in the abandonment of at least 62 eggs. The 2003 mean hatch date was still significantly earlier than that of 1992 (18 August, $p = 0.043$).

The minimum dates for egg-laying and hatching of 2003 were very similar to those of the past two years which suggests the colony was on target to have a comparable year phenologically. Ravens were witnessed many times systematically removing every egg from sections of the colony as early as 25 June when we observed them carrying six eggs away. While these eggs were not from monitored sites, that date is four days earlier than the date on which eggs were first seen in both of the past two years (29 June). It is possible that this year would have been phenologically advanced compared to other years had ravens not taken advantage of this resource. Even though eggs were seen at such an early date in 2003, the mean lay date of 15 July ± 3.9 days was nine days later than the mean of 2001 and 2002 (6 Jul ± 2.7 and ± 1.4 days, respectively). The increased standard deviation and maximum (latest) lay date of 10 August also illustrate the negative effect ravens had upon the synchronization of egg-laying. Hatching was similarly delayed with a mean of 16 August ± 4.4 days compared to means of 6 August ± 1.6 days in 2002 and 8 August ± 1.6 days in 2001. Mean fledge date was also later (5 September ± 4.1 days) in 2003.

Incubation period was not statistically different from 2002 at (32.1 ± 1.1 days in 2003, 32.0 ± 1.4 days in 2002), but fledge period was significantly shorter than 2002 (20.7 ± 3.2 days in 2003, 22.8 ± 1.9 days in 2002). A regression between hatch date and fledge period was significant ($r = -0.45$, $n = 246$) indicating that later hatching chicks do fledge at a younger age. Shorter fledge period could be caused by late nesting murres urging their chicks to fledge at a younger age, either to increase fledging synchronization or to avoid late fledging and stormy weather which is more common as the fall progresses. Shorter fledge dates could also reflect reduced detection of new chicks at hatch date by observers. In 2003 there were heavy rains around the mean hatch date reducing monitoring time and also increasing protection by adults. Adult murres sit tighter on younger chicks than on older ones and are especially protective in inclement

weather. Recorded hatch dates may have been inaccurately late and thus, compressed the fledge period.

Parameters of reproductive phenology for thick-billed murres were similar in 2001 and 2002, but like common murres, were delayed eight to eleven days in 2003 (Table 3, Appendix VII). Mean lay date in 2003 was 13 July ± 8.9 days compared to 5 July ± 2.4 in 2002 and 6 July ± 4.9 in 2001. Mean hatch date in 2003 was 17 Aug ± 6.0 days versus 6 August ± 2.8 in 2002 and 7 August ± 3.1 in 2001. Mean fledge date in 2003 was 4 September ± 4.4 days compared to 27 August ± 4.0 in 2002 and 29 August ± 4.3 in 2001. Incubation period for thick-billed murre was slightly longer in 2003 than in previous years at 33.5 ± 3.7 days while fledge period was slightly less at 19.9 ± 3.3 days.

Much of the early egg depredation occurred before monitoring sites were completely mapped. Therefore, it is likely that some sites selected for monitoring and included in phenological analysis were relays (this violates the general rule that relays are not used in phenology calculations). This would bias all phenological dates toward later dates. There was also much more inclement weather in June 2003 than in 2001 or 2002 reducing monitoring time and affecting observer confidence in detecting incubation posture. Because of this, after the field season 30 lay-dates were "modified" using back-dating and 31 lay-dates were "adjusted" (Appendix I). Back-dating will bias incubation period toward the dictated 32 days, however "adjusting" allows using any incubation period of 25 to 40 days. Two hatch dates were modified using forward-dating and three hatch dates were modified using judgment calls on chick age. Although a few instances of back or forward dating may have been used in 2001 and 2002, this was the first year this many modified dates were used in phenological calculations. If modified dates are removed from calculations, mean lay, mean hatch, and mean fledge dates increase by ½ to 1 day while mean incubation period and mean fledge period don't change. Standard deviations of the non-adjusted parameters are similar or less, however sample size drops below five sites for some plots (especially B and Y) on some parameters. We feel the modified dates more accurately reflect the reality of the colony's phenology. In our communications with Dragoo (P.C. via e-mail 8 October 2002, Wildlife Biologist at Alaska Maritime National Wildlife Refuge), backdating is allowed and the judgment of the observer can be taken into consideration.

Reproductive success - All measures of productivity for common murres were lower in 2003 than in 2001 or 2002 (Table 4, Appendix VIII) and statistically different (one-tailed, paired t-test) at the 90% level. In 2003, hatching success (chicks hatched per sites with eggs) was 0.77 ± 0.04 versus 0.90 ± 0.02 in 2002 ($p = 0.002$) and 0.82 ± 0.03 in 2001 ($p = 0.076$). Fledging success (chicks fledged per chicks hatched) was 0.84 ± 0.02, compared to 0.97 ± 0.01 in 2002 ($p < 0.001$) and 0.92 ± 0.02 in 2001 ($p = 0.008$). Reproductive success (chicks fledged per sites with eggs) was 0.65 ± 0.04, well below other years which were 0.88 ± 0.02 in 2002 ($p < 0.001$) and 0.76 ± 0.03 in 2001 ($p = 0.014$). Adjusting phenological dates per above also allowed some sites to be used for reproductive success that would have been deleted had stricter criteria been used. This was the case for nine sites where hatch date or fledge age was adjusted by chick age. Observers felt they were unable to detect a chick soon after hatching due to difficult viewing angles. In addition, as per protocol, relay sites (26 in 2003) were used for productivity calculations, but are not used for phenology. When 2003 was compared to 1992, hatching success was not significantly different, but fledging success and reproductive success were different and higher ($p = 0.028$ and $p = 0.09$, respectively).

Thick-billed murre hatching success and reproductive success were lower in 2003 and fledging success was similar between all years (Table 4, Appendix IX). In 2003 hatching success was 0.63 ± 0.49 compared to 0.90 ± 0.31 in 2002, and 0.81 ± 0.40 in 2001. Fledging success was 0.93 ± 0.26 this year, similar to 0.93 ± 0.27 in 2002, and 1.00 ± 0.0 in 2001. Reproductive success was 0.58 ± 0.5 this year versus 0.83 ± 0.38 in 2002, and 0.81 ± 0.40 in 2001.

Egg Replacement - Since 2001, this year was the first year any major egg loss was detected. Common raven depredation was responsible for the majority of egg loss, although when a bald eagle landed on the colony and killed an adult murre, the whole colony flushed and we counted 62 abandoned eggs. Many eggs rolled from their original site during the panic; some eggs fell, some broke, and the majority were scavenged by glaucous-winged gulls. Much of the common raven activity happened during the plot mapping phase of our project and, as mentioned above, some relays may have been missed. Ravens usually worked in pairs, jumping with wings spread, at any incubating murres that remained to protect eggs. This was generally sufficient to flush the murres.

Table 4. Productivity of common and thick-billed murres, Puale Bay, Becharof NWR, Alaska, 1992, 2001-2003. Common murre based on plots; thick-billed murre based on sites.

	Common murre					Thick-billed murre				
	Statistics	1992	2001	2002	2003	Statistics	1992	2001	2002	2003
Total sites w/ eggs (A)		296	701	616	470		28	26	30	24
Total chicks (B)		243	577	557	363		20	21	27	15
Total fledged (C)		192	530	541	306		14	21	25	14
Hatching success (B/A)	n	9	17	17	17	n	28	26	30	24
	mean	0.82	0.82	0.90	0.77	mean	0.71	0.81	0.90	0.63
	SD	0.06	0.03	0.02	0.04	SD	0.46	0.40	0.31	0.49
	90% c.i.	0.72-0.92	0.78-0.87	0.87-0.94	0.70-0.84					
Fledging success (C/B)	n	9	17	17	17	n	20	21	27	15
	mean	0.79	0.92	0.97	0.84	mean	0.7	1.00	0.93	0.93
	SD	0.05	0.02	0.01	0.02	SD	0.47	0.00	0.27	0.26
	90% c.i.	0.70-0.88	0.88-0.95	0.96-0.98	0.81-0.87					
Reproductive success (C/A)	n	9	17	17	17	n	28	26	30	24
	mean	0.65	0.76	0.88	0.65	mean	0.48	0.81	0.83	0.58
	SD	0.06	0.03	0.02	0.04	SD	0.51	0.40	0.38	0.50
	90% c.i.	0.53-0.77	0.70-0.82	0.84-0.92	0.59-0.72					

Statistical abbreviations: n = sample size, SD = standard deviation, CI = confidence interval

Hatching success = chicks hatched / sites with eggs

Fledging success = chicks fledged/ chicks hatched

Reproductive success = chicks fledged / sites with eggs

The first author witnessed one instance where a raven ultimately jumped on a murre after circling it for over a minute, but such tenacity by a murre was rare. Gulls were seen on occasion to forcibly pull incubating murres off of their sites to take their eggs, but most attempts were successfully repelled. A few gulls were remarkably persistent and seemed to become bolder as the season progressed, especially on plot Q where this behavior was often recorded. For common murres, we noted 26 relay sites and three relays sites for thick-billed murres. Twenty-two reasonable egg-laying intervals could be calculated for these relayed eggs ranging from 9 to 23 days and averaging 13 $\pm$ 3.9 days.

In 2003 there were 164 breeding failures. Sites were considered fledged if the chick was at least 15 days old on the calculated fledge date. By that criterion, 107 (65%) breeding failures occurred in the egg stage (79% in 2002, 73% in 2001) and 57 (35%) occurred after hatching (21% in 2002, 27% in 2001). For the 107 eggs lost, we detected 26 (24%) relays, resulting in 21 chicks and 16 fledges (relay reproductive success = 0.62). In 2002 we had 59 eggs lost, with 15 (25%) replacement eggs resulting in 12 chicks and 7 fledges (relay reproductive success = 0.47). In 2001 we detected 12 relays of which eight hatched and two fledged (relay reproductive success = 0.17) (Figure 3).

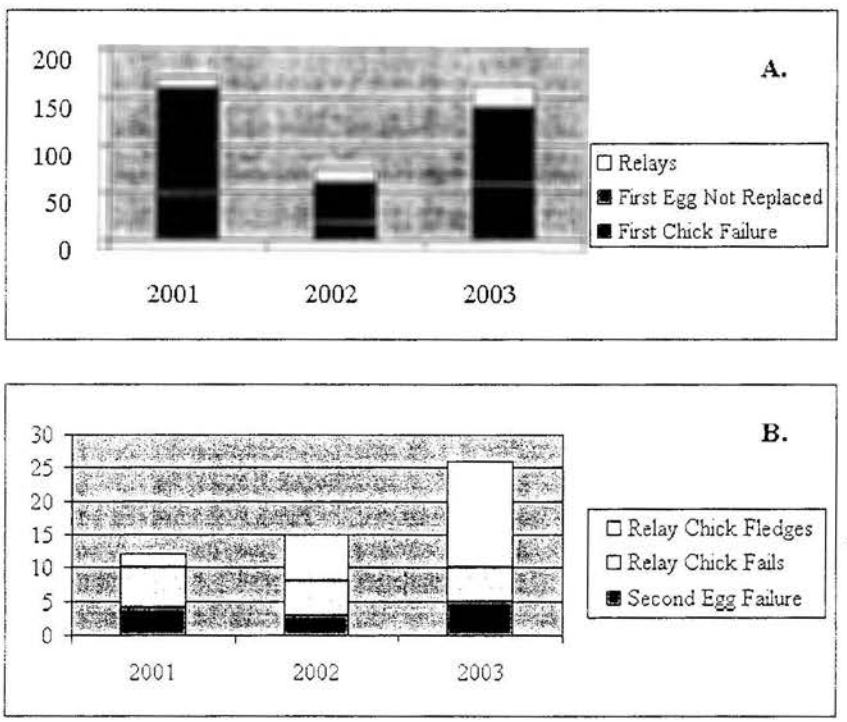

Figure 3A. Chart showing stage of first failed effort; if egg failure - number of relays. **Figure 3B.** Chart showing fate of relayed eggs: egg failure, chick failure or chick fledge for 2001 - 2003 common and thick-billed murres.

Miscellaneous observations – Other observations of note were two common / thick-billed murre pairs and observations of many evening fledgings. The interbreeding observations occurred on plots A and E' which have historically had breeding sites of both species. On both sites, adult murres of each species were observed exchanging brooding duties. On one site a common murre was feeding a chick being brooded by a thick-billed murre. Also observed this year was an adult murre that had field marks which were intermediate between a common and a thick-billed murre. The bill shape was that of a common murre, but possessed the distinct tomium stripe of a thick-billed (seen on both sides) and had reduced (but not entirely absent) flank markings (Figure 4).

Figure 4 Photo of possible hybrid common / thick-billed murre, Puale Bay, Alaska, 2003.

Between 30 August and 9 September staff observed many fledgings. They generally occurred in the evening and continued past the point where light levels permitted us to watch. On 30 August, six chicks fledged between 1530 and 1710. One possible explanation of this early fledging is that high tide was at 1651 and it was a spring tide that day. On 6 September we observed 26 chicks jump; the fledging rate did

not wane as the light faded. During this part of the season, from camp we could hear murres calling, whereas they were never heard before chicks were fledging.

Disturbance Monitoring

Potential disturbance events were recorded during all population and productivity monitoring for the murre colony. During 67 days and 287.8 hours of monitoring (Table 5) disturbance events were detected on 47 days. We documented 242 events that potentially could have disturbed the colony; of these 68 (28%) caused flushing. This year potential causes included humans (1% - one boat, one airplane and visitors throwing rocks), raptors (18%), gulls (38%), ravens (22%), and unknown (21%). Raptors and gulls were the most likely stimulus causing flushing in 2002. In 2003 total disturbance events increased because of increased raven, gull and unknown stimuli. Raptors and unknown sources caused disproportionately more flushing events than the actual number of events in those categories.

Disturbances likely cause different impacts depending on the nesting stage. We postulated that birds are more likely to flush from the colony ledges during a disturbance event early in the breeding cycle when there has been no investment in eggs. Disturbances that do not cause flushing may still have an impact on breeding birds, but detecting the impact on reproductive success is beyond the scope of this project. Although we recorded 113 events during pre-nesting, 56 (50%) resulted in flushing while only 9 (16%) of 55 events did so during incubation and 3 (7%) of 45 did so during brooding. This supports our theory.

In 2003, 43 predatory events were observed while none were observed in 2002. All predatory events consisted of loss of egg(s) with the exception of bald eagles killing three adult murres (one failed attempt as well) and ravens taking one murre chick (all separate events). Most of the predatory events (33 of 43) were initiated by one or more ravens; most occurred during the murre pre-nesting period and involved stealing eggs. On 1 July, an immature bald eagle stooped and killed an adult murre, flushed the colony and left 62 eggs unattended (many falling and rolling about). We could not determine how many of these eggs were later attended to. We speculated that the majority were not reclaimed and were scavenged by glaucous-winged gulls. Peregrine falcons were seen on

Table 5. Disturbance monitoring results from the murre colony, Puale Bay Colony, Becharof NWR, Alaska, 2002-03.

2002

Category	Pre-nest Event	Pre-nest FL	Incubation Event	Incubation FL	Brooding Event	Brooding FL	Post-brooding Event	Post-brooding FL	Total Disturbances Event	Total Disturbances FL	% Distubances Total %	% Distubances FL %
Human	0	0	1	0	1	1	1	0	3	1	2.1%	3.7%
Raptor	29	9	17	3	6	0	2	0	54	12	38.0%	44.4%
Gulls	2	1	24	5	25	4	7	1	58	11	40.8%	40.7%
Ravens	3	0	5	0	3	0	3	0	14	0	9.9%	0.0%
Mammals	3	0	0	0	1	0	0	0	4	0	2.8%	0.0%
Unknown	3	3	0	0	5	0	1	0	9	3	6.3%	11.1%
Total	40	13	47	8	41	5	14	1	142	27	100.0%	100.0%
Days w/Disturb.	6		14		7		11		38			
Days Observed	16		24		18		12		70			
% Days w/Disturb.	38%		58%		39%		92%		54%			
Hours Observed	82.6		119.5		79.0		32.7		313.8			

2003

Category	Pre-nest Event	Pre-nest FL	Pre-nest PE*	Incubation Event	Incubation FL	Incubation PE	Brooding Event	Brooding FL	Brooding PE	Post-brooding Event	Post-brooding FL	Post-brooding PE	Total Disturbances Event	Total Disturbances FL	Total Disturbances PE	% Distubances Total%	% Distubances FL %	% Distubances PE %
Human	1	1	0	2	0	0	0	0	0	0	0	0	3	1	0	1.2%	1.5%	0.0%
Raptor	18	15	5	8	3	0	8	0	0	9	0	0	43	18	5	17.8%	26.5%	11.6%
Gulls	34	17	5	30	5	0	17	0	0	11	0	0	92	22	5	38.0%	32.4%	11.6%
Ravens	32 (24)†	9	30 (24)	4	0	1(1)	12	1	0	5 (2)	0	2 (2)	53 (27)	10	33 (27)	21.9%	14.7%	76.7%
Mammals	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0%	0.0%	0.0%
Unknown	28	14	0	11	1	0	8	2	0	4	0	0	51	17	0	21.1%	25.0%	0.0%
Total	113	56	40	55	9	1	45	3	0	29	0	2	242	68	43	100.0%	100.0%	100.0%
Days w/Disturb.	13			16			12			6			47					
Days Observed	17			26			14			10			67					
% Days observed w/disturl	76%			62%			86%			60%			70%					
Hours Observed	82.3			108.0			68.7			28.8			287.8					

FL = causes a flush of murres

PE = Predatory Event (none occurred 2002)

If two species were involved in the disturbance the event, flush or predatory event is recorded for both.

* Most predatory events also triggered flushing and are recorded in both categories.

† Numbers in parenthesis indicate events not directly witnessed as was often the case with ravens flying by with eggs taken from unmonitored or unviewable sections of the colony. Multiple trips back and forth to cache eggs by ravens are considered one event if they were utilizing (or appeared to be) the same source area. These events are used in totals.

several occasions to take fledging chicks just before they reached the water. There was an active eyrie nearby this year and four immature falcons were frequently seen flying by the colony. This was not reflected in the disturbance data because these observations occurred during incidental monitoring.

Beachwatch Survey

Beach Segment 1 was surveyed six times this summer and Segment 2 was surveyed three times (Table 6). No beach walks were completed this year for Segments 3 and 4. In contrast to the two previous years, we found two tar balls in Segment 1. One measured 30x20x15 cm and one measured 30x15x2 cm. They were collected and samples were sent in to Catherine Berg (Anchorage Fish and Wildlife Field Office, US Fish and Wildlife Service). One adult bald eagle carcass and one common murre carcass were discovered during the 30 July survey. There was no evidence of oiling on either bird. The eagle was in an advanced stage of decomposition (thus was not colleted for the National Eagle Repository) and the murre's breast and viscera had been removed.

Table 6. Summary of beach watch surveys conducted at Puale Bay, Becharof NWR, Alaska, June-September 2003.

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Date	Time Start	Time End	Section	# of Observ	Species Found	Oil/Tar Balls	Weather
20-Jun	13:04	14:06	1	5	None	None	Overcast, Drizzle & Rain, Wind
20-Jun	14:15	15:25	2	5	None	None	Overcast, Drizzle & Rain, Wind
2-Jul	22:42	23:48	1	4	None	None	Overcast, Drizzle
15-Jul	8:48	10:18	1	5	None	1	Partly cloudy, Drizzle, Fog, Wind
15-Jul	10:27	11:59	2	5	None	None	Partly cloudy, Wind
30-Jul	20:51	22:05	1	4	None	None	Partly cloudy, Wind
14-Aug	9:55	10:59	1	4	BAEA, COMU	1	Overcast, Drizzle
14-Aug	11:12	12:07	2	4	None	None	Overcast, Drizzle
31-Aug	11:04	12:03	1	4	None	None	Partly cloudy

Weather

The new weather station reliably monitored all variables for 91 days during the 2003 field season. The mean high temperature for the season was 15.6° C and the mean low was 9.4°C; these were similar to 2002 but more temperate (Table 7). A total of 387.9 mm of rain fell this year compared to 207.8 mm in 2002 and 272.0 mm in 2001. More rain was measured in August 2003 alone than in all of 2002! Precipitation fell on a similar number of days in all years (2001: 56%; 2002: 61%; 2003: 59%).

Conducive conditions for monitoring / censusing include days with little or no rain, minimal fog with clear visibility for viewing the colony, and winds less than 20 knots. It should also be noted that wind speeds presented were recorded in camp where it is often 10 mph less than on top of the colony. Westerly winds were also noted to be under recorded due to a dune just west of the weather station anemometer when compared with a handheld anemometer on top of that dune (winds 5-15 mph higher). However, with 74% and 71% of days in July and September, respectively, having wind gusts over 20 knots, it was necessary to breach protocol and monitor on some of these days. June had the lowest percentage of days we were able to monitor at 55% and August followed at 65%. The season average was lower this year at 71%, compared to 76% in 2002 and 79% in 2001.

Incidental Avian Sightings

During the 2003 season, we documented 77 species of birds. Three new species were sighted this year, bringing the total species count for Puale Bay to 126 (Appendix X). The new species included black-tailed gull (*Larus crassirostris*), glaucous gull (*Larus hyperboreus*), and belted kingfisher (*Ceryle alcyon*). This was the first year that Pacific golden-plover (*Pluvialis fulva*) was confirmed as opposed to lesser golden plover (last seen in 1992). Species seen for the first time last year and resighted again this year included sharp-shinned hawk (*Accipiter striatus*), and black-capped chickadee (*Poecile atricapilla*). Fifteen species were confirmed as breeders, another ten identified as probable breeders, and two identified as possible breeders. Although a pair of bald eagles resided on the south end of the colony all summer they were not nesting successfully. A

Table 7. Summary of weather data collected at Puale Bay, Becharof NWR, Alaska, June-September 2003.

	Temp (°C)			Rain (mm)			Wind (mph)			
	Mean Daily Mean	Mean Low	Mean High	Total Rain	Days of Rain >0.02mm	% Days w/Rainfall	Avg Wind Speed	Avg Daily Max Gust	Dominant Direction*	% Days able to monitor
June 16-30	10.9	8.6	13.2	56.8	12	80.0%	10.1	26.4	SE	55%
July	13.3	10.0	16.7	96.3	14	45.2%	10.7	29.8	WNW	77%
August	12.8	10.0	15.7	222.8	20	64.5%	9.6	27.6	WNW	65%
September 1-14	11.4	7.4	15.5	12.0	7	50.0%	8.7	27.7	W	87%
Season Average/Total		9.4	15.6	387.9	53	58.2%				71%

*Partial days June 15th and Sept 15th not used because data is incomplete and inaccurate due to station setup and rain test

*West winds falsely low due to dune just west of anemometer. This also influenced wind direction recorded.

pair of peregrine falcons successfully nested on the cliff about one hundred meters below where the eagle nest had been in past years.

Incidental Mammal Sightings

This was the third year in which incidental mammal observations were taken. Data for 2001-2003 are summarized in Appendix XI. Fourteen species and two genera (not including brown bears) have been observed over the past three years. Observations for 12 species and one genus were recorded this year. High number of days observed counts for some species [arctic ground squirrels (*Spermophilus parryii*) and red fox (*Vulpes vulpes*)] resulted from individuals residing near camp and being seen on a regular basis. Red foxes, as in 2001 and 2002, had a den near camp with at least three pups. One new mammal was added in 2003: short-tailed weasel (*Mustela erminea*). This year was the first in which a positive identification of a vole was made (excluding small mammal trapping), when a northern red-backed vole was seen amongst driftwood on the beach.

Brown Bear/Human Interactions

Field crews recorded more bear encounters in 1992 and 2001-2003, than in the early years of the Puale Bay camp (Table 8). Undoubtedly, other activities in the early post-oil spill years directed attention away from this project. Methods for recording these data were not well established until 1991. In 2003, we documented 140 encounters, 87% were sightings where humans did not affect bear behavior. Similar percentages were recorded in 2001 and 2002. More encounters were documented in 2001 than either 2002 or 2003. The decision of when to haze and what level to use is somewhat subjective, often depending on the experience or comfort level of humans. In addition, because of different criteria used on the record sheet, scoring may be somewhat different from 1990-1992 to 2001–2003. However, a marked decrease in the necessity of hazing and the level of hazing is still noteworthy for recent years. No bears were hazed with cracker shells or rubber bullets this year. Waving and shouting were generally used to alert a bear to human presence when it was approaching us unaware of our presence. The new US Fish and Wildlife Service, Region 7 bear policy called for carrying two non-lethal deterrents, one of which was not fire-arm deployed. We were equipped with rechargeable air horns

which were used once. Factors contributing to this lowered need for hazing include several camp management actions (see Kaler et al. 2003).

Table 8. Summary of bear encounters for Puale Bay, Becharof NWR, Alaska, 1990-92, 2001-03.

	1990	1991	1992	2001	2002	2003
Sightings	82	86	153	248	117	122 (178†)
Passive Human Behavior affecting Bear*	17		10	8	23	11
Waving / Shouting / Other noise	10	10	19	18	4	7
Cracker / Rubber Shell	16	2	12	6	1	0
Total	125	98	194	280	145	140

* includes talking calmly
† total bears sighted

Plant Phenology

Plant phenology records are presented in Appendix XII. This record can be used in future years as a basis of comparing plant life cycles which are dependent on weather and climatic cycles. These in turn may assist in better understanding marine and terrestrial biological cycles.

Conclusions and Recommendations

The absence / relocation of nesting red-faced cormorants prevented us from monitoring that species. We noted about 15 nests when we walked below the colony, and individuals were seen daily. Although glaucous-winged gull population counts on part of the colony increased, nesting success and timing varied over the colony making comparisons to previous years problematic. Very distinct reductions in murre productivity and delays in phenology were noted this year from 2001 and 2002. This year was unique in the amount of interspecific avian interaction and disturbance that was observed.

Puale Bay offers an excellent opportunity to collect baseline data that helps to direct management actions. The seabird colonies at and near Puale Bay, although small by Alaska standards, provide an important indicator for the health of the marine

ecosystem. We recommend that monitoring studies at Puale Bay be continued as outlined in the refuge Wildlife Inventory Plan and in Kaler et al. 2003.

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Appendix 1: Additional Guidance for Murre Phenological Data

This information pertains to calculations of Lay date (LD), Hatch date (HD), and Fledge date (FD). It refers to raw data from the field data books such as B/E (bird over egg), IP (incubating posture) etc. Information is stored in specific fields in an Excel spreadsheet. The purpose is to modify lay date or hatch date so data meet inclusion criteria (see Appendix I and II Kaler et al. 2003) and improves sample size.

Back-Dating

When backdating remove LD highlighting because there will be no Jul. 1st IP used. Also remove numbers from "Jul 1st IP" and "LD Interval" columns. Enter the new LD (32 days subtracted from the Calc HD). "Incubation Period" column should be 32. Put a "B" in "Alternate Phenology" column. *Do not go back before a B/0 when backdating.*

Adjusting

This is similar to backdating, but looking for site evidence not just assigning 32 day period. Try to go back to an obvious point in the data string (i.e., another group of IP's) but if necessary it is okay to go back to a B. *Do not go back before a B/0 when adjusting.* Highlight new day of observation used for Jul. 1st IP. If there is no obvious point, try backdating instead if HD observations are solid (i.e., B/E then B/C or B/E then BP on next observation). Put an "A" in "Alternate Phenology" column.

Forward-dating

Used to improve HD and only when lay-date data are more solid than HD info. Put "F" in "Alternate Phenology" column.

Using Chick Age To Adjust Hatch Date

If field notes indicate the chick was older than what would be calculated from the dictated HD, put a "C" in "Alternate Pheno" column. Hatch date may be adjusted by a few days 1) if observer believe chick fledged but currently have <15 days as a Fledge Period, and 2) data around HD were not definitive (did not have B/E on last observation before chick), or HD interval is >3 but $\leq$ 7.

Relays

Do not need to highlight because relays are not used in phenology analysis (mark N in Use for Pheno? Column). Highlight site number (should be column C) in pink and put an "R" in the "Alternate Phenology" column. Later, we may try to determine relay period with this information.

Fledge Column

Use U for Unknown if season ended before chick was 15 days old. Mark N in Use for Productivity? Column

If Fledge Period Is <15 Days

Write 0 in "Fledge?" column if Fldg Period is <15 days and clear contents of "Fledge Period", "Calculated FD" and "FD Interval".

Additional Note

Delete "0"s in Inc Period and Fledge Period columns as well as any large or negative numbers resulting from chicks not hatching. ***Do*** leave all "0"s in the Egg, Chick, and Fledge columns.

Appendix II. Land-based population counts of glaucous-winged gulls, Puale Bay, Becharof NWR, Alaska, 2002-2003. Data include any count within 1 week of mean hatch date for the main ledge of the murre colony (including plot Y).

Plots Main and Y Combined

start	end	count 1	count 2	count 3	count 4	count 5
27-Jun-02	11-Jul-02	19	16	9	22.5	13
4-Jul-03	18-Jul-03	42	43.5	31		

year	mean	SD	st error	90% CI	Lower	Upper
2002	15.9	5.2	2.3	5.0	11	21
2003	38.8	6.8	3.9	11.5	27	50

Statistical abbreviations: n = sample size, SD = standard deviation, CI = confidence interval

Appendix III. Productivity of glaucous-winged gulls, Puale Bay, Becharof NWR, Alaska, 2001-2003

	2001					2002					2003				
	Nests			Chicks		Nests			Chicks		Nests			Chicks	
Plot	≥1 egg	≥1 chick	≥1 fledge	Min #	Fledged	≥1 egg	≥1 chick	≥1 fledge	Min #	Fledged	≥1 egg	≥1 chick	≥1 fledge	Min #	Fledged
N. Main	12	10	9	18	14	6	5	4	12	10	11	4	3	8	5
Main	9	8	7	18	12	10	8	8	22	22	20	19	16	41	32
RFCO 1	0	0	0	0	0	1	1	1	3	3	–	–	–	–	–
RFCO 2	6	4	4	8	7	10	4	2	10	4	–	–	–	–	–
RFCO 3	7	6	6	14	12	7	3	0	5	0	–	–	–	–	–
Total	34	28	26	55	45	34	21	15	52	39	31	23	19	49	37

	Success - 2001			Success - 2002			Success - 2003		
Plot	Nesting	Fledging	Productivity	Nesting	Fledging	Productivity	Nesting	Fledging	Productivity
N. Main	0.75	1.40	1.17	0.67	2.00	1.67	0.27	1.25	0.45
Main	0.78	1.50	1.33	0.80	2.75	2.20	0.80	1.68	1.60
Subtotal	0.76	1.44	1.24	0.75	2.46	2.00	0.61	1.61	1.19
Total	0.76	1.61	1.32	0.44	1.86	1.15	0.61	1.61	1.19

Nesting success = total number of nests with fledglings / total nest starts
Fledging success = number of chicks fledged / nest with chicks
Productivity = number of chicks fledged / nests with eggs
Min # = total number hatched chicks

Appendix IV. Phenology of glaucous-winged gulls by plot, Pualc Bay, Becharof NWR, Alaska, 2001-2003.

	2001					2002					2003				
Plot	Mean	SD	n	First	Last	Mean	SD	n	First	Last	Mean	SD	n	First	Last
Laying															
North Main	—	—	—	—	—	23-Jun	0.0	1	23-Jun	—	1-Jul	8.5	2	25-Jun	7-Jul
Main	—	—	—	—	—	29-Jun	11.3	2	21-Jun	7-Jul	—	—	—	—	—
RFCO1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
RFCO2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
RFCO3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
All Sites	—	—	—	—	—	27-Jun	8.7	3	21-Jun	7-Jul	1-Jul	8.5	2	25-Jun	7-Jul
Hatching															
North Main	10-Jul	10.6	8	3-Jul	29-Jul	1-Jul	2.2	5	29-Jun	3-Jul	25-Jul	12.5	4	13-Jul	10-Aug
Main	5-Jul	6.6	8	29-Jun	19-Jul	2-Jul	8.1	8	27-Jun	21-Jul	7-Jul	7.8	12	29-Jun	26-Jul
RFCO1	—	—	—	—	—	—	—	1	29-Jun	—	—	—	—	—	—
RFCO2	4-Jul	2.8	2	2-Jul	6-Jul	7-Jul	5.0	4	3-Jul	14-Jul	—	—	—	—	—
RFCO3	—	—	—	—	—	12-Jul	8.2	3	3-Jul	19-Jul	—	—	—	—	—
All Sites	7-Jul	8.5	18	29-Jun	29-Jul	4-Jul	7.2	21	27-Jun	21-Jul	11-Jul	11.8	16	29-Jun	10-Aug
Fledging															
North Main	21-Aug	10.6	7	14-Aug	7-Sep	15-Aug	1.5	4	13-Aug	16-Aug	8-Sep	6.7	4	30-Aug	13-Sep
Main	12-Aug	10.1	7	26-Jul	26-Aug	21-Aug	8.3	8	10-Aug	7-Sep	26-Aug	10.6	12	29-Jul	14-Sep
RFCO1	—	—	—	—	—	—	—	1	20-Aug	—	—	—	—		
RFCO2	13-Aug	4.5	4	7-Aug	18-Aug	16-Aug	3.5	3	14-Aug	20-Aug	—	—	—	—	—
RFCO3	17-Aug	6.5	5	8-Aug	22-Aug	—	—	—	—	—	—	—	—	—	—
All Sites	16-Aug	9.1	23	26-Jul	7-Sep	18-Aug	6.4	16	10-Aug	7-Sep	29-Aug	11.1	16	29-Jul	14-Sep

Statistical abbreviations: n = sample size, SD = standard deviation, CI = confidence interval

Appendix IV, continued. Phenology of glaucous-winged gulls.

Incubation Period

	2001			2002			2003		
Plot	Mean	SD	n	Mean	SD	n	Mean	SD	n
North Main	30.0	2.8	2	—	—	—	33.0	1.41	2
Main	—	—	—	30	—	1	—	—	—
RFCO1	—	—	—	—	—	—	—	—	—
RFCO2	—	—	—	—	—	—	—	—	—
RFCO3	—	—	—	—	—	—	—	—	—
All Sites	30.0	2.8	2	30	—	1	33.0	1.41	2

Fledge Period

	2001			2002			2003		
Plot	Mean	SD	n	Mean	SD	n	Mean	SD	n
North Main	40.7	3.59	7	46.3	2.06	4	51.3	9.45	3
Main	38.1	6.18	7	49.8	3.77	8	52.2	5.22	11
RFCO1	—	—	—	52.0	—	1	—	—	—
RFCO2	42.5	0.71	2	44.5	4.95	2	—	—	—
RFCO3	—	—	—	—	—	—	—	—	—
All Sites	39.8	4.81	16	48.3	3.90	15	52.0	5.90	14

Statistical abbreviations: n = sample size, SD = standard deviation, CI = confidence interval

Appendix Va. Land-based population counts of murres (common, thick-billed), Puale Bay, Becharof NWR, Alaska, 2001-2003. Data include any count within 1 week of mean hatch date for all "common" plots (A,B,C,D,E,F,G,Q,X,Y).

Start	End	count 1	count 2	count 3	count 4	count 5	count 6	count 7	count 8
8/1/2001	8/15/2001	1406	1374	1446	1512	1537			
7/30/2002	8/13/2002	1289*	1555	1577	1520	1711	1701	1578	1747
8/9/2003	8/23/2003	1338	1544	1444	1616*				

Year	Mean	SD	st error	90% CI	Lower	Upper
2001	1454.6	69.1	30.9	65.88225	1389	1520
2002	1626.8	89.9	31.8	60.22493	1567	1687
2003	1441.7	103.0	59.5	173.6773	1268	1615

* count 1 for 2002 and count 4 for 2003 are excluded because winds were much above the 20 knot limit affecting the presence of the

Statistical abbreviations: n = sample size, SD = standard deviation, CI = confidence interval

Appendix Vb. Land-based population counts of murres (common, thick-billed), Puale Bay, Becharof NWR, Alaska, 1990-92, 2001-03. Data include any count within 1 week of mean hatch date for all "common" plots (A,B,C,D,E,F,G,Y).

Start	End	count 1	count 2	count 3	count 4	count 5	count 6	count 7	count 8
8/26/1990	9/10/1990	906	974	994	726	801	675		
8/29/1991	9/12/1991	802	879	658	695	541	686	523	
8/12/1992	8/25/1992	1148	1141	1119	1020	1225	1245	1123	
8/1/2001	8/15/2001	1225	1173	1240	1311	1325			
7/30/2002	8/13/2002	1091*	1336	1345	1311	1460	1450	1347	1497
8/9/2003	8/23/2003	1143	1310	1243	1380*				

Year	Mean	SD	st error	90% CI	Lower	Upper
1990	846.0	132.3	54.0	108.9	737.1	954.9
1991	683.4	128.5	48.6	94.4	589.0	777.8
1992	1145.9	74.4	28.1	54.6	1091.2	1200.5
2001	1254.8	63.0	28.2	60.1	1194.7	1314.9
2002	1392.3	74.1	28.0	53.1	1339.2	1445.4
2003	1232.0	84.0	48.5	141.7	1090.3	1373.7

* count 1 for 2002 and count 4 for 2003 are excluded because winds were much above the 20 knot limit affecting the presence of the birds and / or the ability of the staff to count

Statistical abbreviations: n = sample size, SD = standard deviation, CI = confidence interval

Appendix VI. Common murre phenology by plot, Puale Bay, Becharof NWR, Alaska, 2001-2003.

Lay Date

	2001					2002					2003				
Plot	Mean	SD	n	Min	Max	Mean	SD	n	Min	Max	Mean	SD	n	Min	Max
A	8-Jul	4.3	30	3-Jul	19-Jul	7-Jul	2.9	28	2-Jul	11-Jul	16-Jul	7.0	18	7-Jul	26-Jul
B	10-Jul	2.4	8	8-Jul	15-Jul	4-Jul	2.1	21	2-Jul	9-Jul	9-Jul	6.7	21	28-Jun	20-Jul
C	2-Jul	5.9	33	30-Jun	24-Jul	4-Jul	3.6	39	29-Jun	21-Jul	12-Jul	5.5	19	2-Jul	26-Jul
D	6-Jul	3.9	45	29-Jun	15-Jul	6-Jul	3.0	47	2-Jul	12-Jul	19-Jul	5.8	29	29-Jun	25-Jul
D'	4-Jul	5.7	25	30-Jun	22-Jul	8-Jul	4.6	37	4-Jul	29-Jul	19-Jul	6.4	29	1-Jul	2-Aug
D2	5-Jul	2.9	32	1-Jul	13-Jul	4-Jul	2.3	24	2-Jul	11-Jul	18-Jul	5.4	17	7-Jul	2-Aug
E'	8-Jul	4.2	17	5-Jul	22-Jul	4-Jul	4.8	13	29-Jun	19-Jul	16-Jul	5.6	16	7-Jul	26-Jul
Efar	4-Jul	2.8	53	29-Jun	11-Jul	6-Jul	2.9	44	2-Jul	15-Jul	13-Jul	7.1	26	29-Jun	4-Aug
Enear	5-Jul	2.7	48	29-Jun	11-Jul	6-Jul	3.4	36	2-Jul	13-Jul	20-Jul	9.9	32	29-Jun	8-Aug
Ffar	6-Jul	3.9	62	30-Jun	19-Jul	6-Jul	4.3	40	2-Jul	20-Jul	10-Jul	6.5	31	28-Jun	23-Jul
Fnear	4-Jul	2.9	55	29-Jun	15-Jul	4-Jul	3.4	40	29-Jun	16-Jul	8-Jul	8.8	26	28-Jun	25-Jul
G	10-Jul	3.8	26	7-Jul	19-Jul	7-Jul	2.7	42	2-Jul	11-Jul	18-Jul	8.1	21	5-Jul	10-Aug
G1/G3	6-Jul	3.5	23	1-Jul	17-Jul	7-Jul	3.7	34	3-Jul	21-Jul	19-Jul	5.4	23	7-Jul	28-Jul
G2	6-Jul	0.5	28	6-Jul	8-Jul	7-Jul	4.2	24	2-Jul	17-Jul	19-Jul	4.5	9	13-Jul	26-Jul
Q	13-Jul	4.7	16	10-Jul	24-Jul	3-Jul	2.9	39	29-Jun	12-Jul	17-Jul	8.0	26	29-Jun	31-Jul
X	5-Jul	2.2	44	3-Jul	8-Jul	6-Jul	4.7	37	29-Jun	21-Jul	13-Jul	5.3	32	28-Jun	25-Jul
Y	7-Jul	5.8	20	30-Jun	24-Jul	6-Jul	2.7	19	2-Jul	11-Jul	15-Jul	7.7	8	2-Jul	25-Jul
Mean Site	6-Jul	4.3	322	29-Jun	24-Jul	6-Jul	3.7	564	29-Jun	29-Jul	15-Jul	7.9	383	28-Jun	10-Aug
Mean Plot	6-Jul	2.7	17			6-Jul	1.4	17			15-Jul	3.9	17		

Statistical abbreviations: n = sample size, SD = standard deviation, CI = confidence interval

Appendix VI, continued. Common murre phenology by plot, Puale Bay, Becharof NWR, Alaska, 2001-2003.

Hatch Date

	2001					2002					2003				
Plot	Mean	SD	n	Min	Max	Mean	SD	n	Min	Max	Mean	SD	n	Min	Max
A	10-Aug	4.7	28	3-Aug	24-Aug	4-Aug	1.3	29	2-Aug	8-Aug	16-Aug	5.5	17	6-Aug	24-Aug
B	7-Aug	4.0	16	3-Aug	16-Aug	5-Aug	3.3	17	29-Jul	8-Aug	7-Aug	5.9	14	30-Jul	18-Aug
C	8-Aug	4.9	34	4-Aug	28-Aug	5-Aug	3.1	38	31-Jul	10-Aug	13-Aug	5.2	10	3-Aug	18-Aug
D	9-Aug	3.0	35	6-Aug	16-Aug	6-Aug	2.4	48	31-Jul	10-Aug	19-Aug	3.7	27	10-Aug	28-Aug
D'	8-Aug	2.8	25	6-Aug	20-Aug	9-Aug	5.3	35	4-Aug	1-Sep	19-Aug	4.9	23	12-Aug	31-Aug
D2	8-Aug	2.0	27	3-Aug	11-Aug	7-Aug	2.9	19	2-Aug	14-Aug	21-Aug	4.1	16	16-Aug	2-Sep
E'	8-Aug	4.4	9	2-Aug	16-Aug	6-Aug	4.6	14	2-Aug	18-Aug	18-Aug	4.6	9	10-Aug	28-Aug
Efar	6-Aug	2.3	47	31-Jul	12-Aug	7-Aug	3.3	38	2-Aug	15-Aug	14-Aug	8.4	23	31-Jul	5-Sep
Enear	8-Aug	3.6	40	4-Aug	20-Aug	4-Aug	2.5	41	31-Jul	11-Aug	18-Aug	6.2	23	4-Aug	31-Aug
Ffar	7-Aug	2.9	46	31-Jul	16-Aug	6-Aug	3.8	38	2-Aug	22-Aug	12-Aug	5.3	25	2-Aug	22-Aug
Fnear	6-Aug	3.2	45	4-Aug	16-Aug	6-Aug	3.3	41	1-Aug	18-Aug	9-Aug	7.1	23	2-Aug	24-Aug
G	11-Aug	4.5	27	4-Aug	24-Aug	6-Aug	2.8	48	31-Jul	13-Aug	17-Aug	8.6	19	6-Aug	11-Sep
G1/G3	9-Aug	3.8	23	2-Aug	20-Aug	8-Aug	5.0	30	31-Jul	22-Aug	18-Aug	3.7	5	14-Aug	22-Aug
G2	11-Aug	1.2	28	6-Aug	11-Aug	10-Aug	3.6	23	4-Aug	18-Aug	22-Aug	5.4	7	15-Aug	30-Aug
Q	8-Aug	3.4	33	2-Aug	20-Aug	6-Aug	3.7	38	1-Aug	19-Aug	18-Aug	7.7	14	2-Aug	28-Aug
X	6-Aug	3.1	38	31-Jul	11-Aug	8-Aug	4.7	27	2-Aug	22-Aug	13-Aug	5.0	26	5-Aug	26-Aug
Y	10-Aug	4.6	20	6-Aug	20-Aug	7-Aug	3.3	12	4-Aug	13-Aug	23-Aug	5.0	3	18-Aug	28-Aug
Mean Site	8-Aug	3.7	521	31-Jul	28-Aug	6-Aug	3.8	536	29-Jul	1-Sep	16-Aug	7.1	284	30-Jul	11-Sep
Mean Plot	8-Aug	1.6	17			6-Aug	1.6	17			16-Aug	4.4			

Statistical abbreviations: n = sample size, SD = standard deviation, CI = confidence interval

Appendix VI, continued. Common murre phenology by plot, Puale Bay, Becharof NWR, Alaska, 2001-2003.

Fledge Date

	2001					2002					2003				
Plot	Mean	SD	n	Min	Max	Mean	SD	n	Min	Max	Mean	SD	n	Min	Max
A	1-Sep	4.4	28	26-Aug	8-Sep	1-Sep	4.9	29	22-Aug	13-Sep	5-Sep	3.7	17	30-Aug	12-Sep
B	28-Aug	2.0	15	26-Aug	4-Sep	25-Aug	3.4	16	17-Aug	28-Aug	27-Aug	3.9	11	22-Aug	4-Sep
C	29-Aug	2.3	31	26-Aug	6-Sep	27-Aug	3.1	37	22-Aug	5-Sep	4-Sep	4.2	10	26-Aug	8-Sep
D	31-Aug	3.0	34	26-Aug	6-Sep	29-Aug	3.9	46	22-Aug	5-Sep	9-Sep	3.3	24	31-Aug	14-Sep
D'	31-Aug	3.0	24	28-Aug	6-Sep	31-Aug	3.8	34	25-Aug	5-Sep	7-Sep	4.2	18	29-Aug	12-Sep
D2	29-Aug	2.5	27	24-Aug	6-Sep	28-Aug	3.3	20	23-Aug	4-Sep	10-Sep	2.5	14	5-Sep	12-Sep
E'	29-Aug	4.8	9	20-Aug	5-Sep	29-Aug	4.2	14	22-Aug	4-Sep	8-Sep	3.8	7	4-Sep	14-Sep
Efar	29-Aug	3.1	45	21-Aug	5-Sep	29-Aug	4.6	35	20-Aug	7-Sep	2-Sep	5.6	21	23-Aug	9-Sep
Enear	30-Aug	4.1	32	20-Aug	8-Sep	29-Aug	4.3	41	19-Aug	7-Sep	6-Sep	5.7	21	23-Aug	13-Sep
Ffar	30-Aug	3.1	41	25-Aug	6-Sep	29-Aug	4.9	40	22-Aug	11-Sep	4-Sep	5.1	24	24-Aug	12-Sep
Fnear	29-Aug	2.6	45	24-Aug	5-Sep	28-Aug	3.9	41	22-Aug	7-Sep	28-Aug	4.8	20	23-Aug	5-Sep
G	1-Sep	3.3	23	26-Aug	5-Sep	2-Sep	3.0	48	26-Aug	7-Sep	3-Sep	4.9	13	24-Aug	9-Sep
G1/G3	31-Aug	3.4	23	26-Aug	10-Sep	30-Aug	4.6	29	22-Aug	8-Sep	6-Sep	1.6	5	4-Sep	8-Sep
G2	1-Sep	3.3	28	28-Aug	8-Sep	2-Sep	3.9	23	25-Aug	11-Sep	9-Sep	3.3	6	6-Sep	14-Sep
Q	30-Aug	3.3	27	26-Aug	5-Sep	27-Aug	3.6	37	22-Aug	5-Sep	5-Sep	5.0	12	28-Aug	11-Sep
X	31-Aug	2.9	38	24-Aug	8-Sep	30-Aug	4.1	29	22-Aug	8-Sep	7-Sep	3.7	24	31-Aug	14-Sep
Y	1-Sep	4.4	20	24-Aug	8-Sep	28-Aug	5.2	12	20-Aug	3-Sep	5-Sep	-	1	5-Sep	5-Sep
Mean Site	30-Aug	3.3	490	20-Aug	10-Sep	29-Aug	4.5	531	17-Aug	13-Sep	5-Sep	5.7	248	22-Aug	14-Sep
Mean Plot	30-Aug	1.1	17			29-Aug	2.2	17			5-Sep	3.8			

Statistical abbreviations: n = sample size, SD = standard deviation, CI = confidence interval

Appendix VI, continued. Common murre phenology by plot, Puale Bay, Becharof NWR, Alaska, 2001-2003.

Incubation Period

2001				2002				2003			
Plot	Mean	SD	n	Plot	Mean	SD	n	Plot	Mean	SD	n
A	33	3.6	28	A	29	3.0	23	A/A'	32	3.9	17
B	32	4.5	5	B	32	2.9	17	B	32	1.9	14
C	37	2.4	30	C	33	2.3	37	C	32	3.3	10
D	35	3.6	35	D	31	3.4	45	D	31	2.7	27
D'	36	4.0	25	D'	32	2.2	35	D'	32	4.7	23
D2	34	2.3	24	D2	34	2.0	19	D2	34	3.9	16
E'	32	4.3	9	E'	32	2.6	12	E'	34	1.9	9
Efar	33	3.1	47	Efar	33	2.2	38	Efar	32	4.7	23
Enear	34	3.7	34	Enear	29	2.8	33	Enear	31	3.8	23
Ffar	33	3.6	42	Ffar	32	3.1	36	Ffar	32	4.7	25
Fnear	34	3.0	45	Fnear	33	2.5	39	Fnear	32	3.7	23
G	32	4.1	21	G	31	3.3	40	G	30	3.4	19
G1/G3	33	3.2	21	G1/G3	32	2.7	30	G1/G3	33	3.3	5
G2	35	1.3	28	G2	33	2.8	23	G2	34	4.0	7
Q	30	3.4	11	Q	33	2.3	36	Q	32	3.1	14
X	32	3.6	38	X	33	3.3	27	X	31	3.6	26
Y	33	3.3	18	Y	33	2.6	11	Y	32	4.0	3
Mean Site	33.7	3.6	461	Mean Site	31.9	3.0	501	Mean Site	31.8	3.8	284
Mean Plot	33.4	1.6	17	Mean Plot	32.0	1.4	17	Mean Plot	32.1	1.1	

Statistical abbreviations: n = sample size, SD = standard deviation, CI = confidence interval

Appendix VI, continued. Common murre phenology by plot, Puale Bay, Becharof NWR, Alaska, 2001-2003.

Fledge Period

2001				2002				2003			
Plot	Mean	SD	n	Plot	Mean	SD	n	Plot	Mean	SD	n
A	22	3.8	28	A	27	5.0	29	A/A'	20	4.1	17
B	22	1.9	15	B	20	1.5	16	B	22	1.7	11
C	23	2.9	31	C	21	2.5	37	C	22	1.7	10
D	22	2.9	34	D	24	3.8	46	D	21	3.5	24
D'	23	3.1	24	D'	23	3.0	33	D'	20	3.3	18
D2	22	2.8	27	D2	21	2.7	19	D2	21	2.3	14
E'	21	5.0	9	E'	24	3.6	14	E'	21	4.5	7
Efar	23	3.0	45	Efar	22	3.0	35	Efar	20	2.5	20
Enear	23	3.6	32	Enear	25	4.1	41	Enear	20	2.8	21
Ffar	22	3.3	41	Ffar	23	3.6	38	Ffar	23	4.1	24
Fnear	23	3.4	45	Fnear	22	3.6	40	Fnear	21	3.4	20
G	22	3.3	23	G	26	3.9	48	G	21	3.2	13
G1/G3	22	2.8	23	G1/G3	23	2.3	28	G1/G3	19	2.6	5
G2	21	3.2	28	G2	24	3.6	23	G2	19	2.8	5
Q	22	3.3	27	Q	21	2.3	37	Q	20	3.5	12
X	26	4.2	38	X	22	3.6	27	X	25	4.7	24
Y	22	3.6	20	Y	21	3.4	12	Y	18	-	1
Mean Site	22.6	3.4	490	Mean Site	23.0	3.9	523	Mean Site	21.2	3.7	246
Mean Plot	22.4	1.1	17	Mean Plot	22.8	1.9	17	Mean Plot	20.7	1.6	

Statistical abbreviations: n = sample size, SD = standard deviation, CI = confidence interval

Appendix VII. Thick-billed murre phenology by plot, Puale Bay, Becharof NWR, Alaska, 2001-2003.

Lay Date

	2001					2002					2003				
Plot	Mean	SD	n	Min	Max	Mean	SD	n	Min	Max	Mean	SD	n	Min	Max
A	6-Jul	5.6	5	30-Jun	15-Jul	5-Jul	2.4	7	4-Jul	9-Jul	19-Jul	9.2	3	11-Jul	29-Jul
A'	7-Jul	6.6	4	29-Jun	15-Jul	4-Jul	0.5	6	3-Jul	4-Jul	7-Jul	10.6	2	29-Jun	14-Jul
E'	9-Jul	5.0	5	5-Jul	17-Jul	8-Jul	3.9	5	5-Jul	13-Jul	13-Jul	7.9	4	3-Jul	22-Jul
X	7-Jul	3.9	5	3-Jul	13-Jul	4-Jul	1.5	4	3-Jul	6-Jul	16-Jul	1.7	3	14-Jul	17-Jul
Y	3-Jul	2.1	5	30-Jun	5-Jul	5-Jul	0.8	7	5-Jul	7-Jul	11-Jul	10.6	8	27-Jun	23-Jul
All sites	6-Jul	4.9	24	29-Jun	17-Jul	5-Jul	2.4	29	3-Jul	13-Jul	13-Jul	8.9	20	27-Jun	29-Jul

Hatch Date

	2001					2002					2003				
Plot	Mean	SD	n	Min	Max	Mean	SD	n	Min	Max	Mean	SD	n	Min	Max
A	7-Aug	3.0	5	4-Aug	11-Aug	6-Aug	2.2	6	4-Aug	8-Aug	21-Aug	8.1	3	12-Aug	28-Aug
A'	8-Aug	2.8	2	6-Aug	10-Aug	4-Aug	0.0	6	4-Aug	4-Aug	14-Aug	-	1	14-Aug	14-Aug
E'	8-Aug	5.2	3	2-Aug	11-Aug	9-Aug	4.6	5	4-Aug	14-Aug	15-Aug	4.6	3	10-Aug	18-Aug
X	7-Aug	1.2	4	6-Aug	8-Aug	7-Aug	2.3	3	6-Aug	10-Aug	22-Aug	-	1	22-Aug	22-Aug
Y	6-Aug	3.6	7	3-Aug	11-Aug	5-Aug	1.6	6	4-Aug	8-Aug	12-Aug	3.5	2	9-Aug	14-Aug
All sites	7-Aug	3.1	21	2-Aug	11-Aug	6-Aug	2.8	26	4-Aug	14-Aug	17-Aug	6.0	10	9-Aug	28-Aug

Fledge Date

	2001					2002					2003				
Plot	Mean	SD	n	Min	Max	Mean	SD	n	Min	Max	Mean	SD	n	Min	Max
A	30-Aug	4.6	5	27-Aug	7-Sep	28-Aug	2.9	5	23-Aug	30-Aug	8-Sep	5.7	2	4-Sep	12-Sep
A'	30-Aug	0.0	2	30-Aug	30-Aug	28-Aug	0.0	5	28-Aug	28-Aug	2-Sep	-	1	2-Sep	2-Sep
E'	28-Aug	6.8	3	20-Aug	2-Sep	30-Aug	6.6	5	19-Aug	4-Sep	3-Sep	1.4	2	2-Sep	4-Sep
X	29-Aug	6.2	4	24-Aug	7-Sep	28-Aug	1.7	3	26-Aug	29-Aug	9-Sep	-	1	9-Sep	9-Sep
Y	27-Aug	2.5	7	24-Aug	30-Aug	23-Aug	2.1	6	22-Aug	26-Aug	31-Aug	0.7	2	30-Aug	31-Aug
All sites	29-Aug	4.3	21	20-Aug	7-Sep	27-Aug	4.0	24	19-Aug	4-Sep	4-Sep	4.4	8	30-Aug	12-Sep

Statistical abbreviations: n = sample size, SD = standard deviation, CI = confidence interval

Appendix VII, continued. Thick-billed murre phenology by plot, Puale Bay, Becharof NWR, Alaska, 2001-2003.

Incubation Period

2001				2002				2003			
Plot	Mean	SD	n	Plot	Mean	SD	n	Plot	Mean	SD	n
A	31.8	2.9	5	A	31.3	3.4	6	A	32.7	3.1	3
A'	36.5	2.1	2	A'	31.3	0.5	6	A'	31.0		1
E'	31.0	6.0	3	E'	31.8	1.1	5	E'	33.3	5.7	3
X	30.8	4.3	4	X	33.7	3.8	3	X	36.0		1
Y	34.0	3.5	4	Y	31.0	1.1	6	Y	35.0	4.2	2
All sites	32.4	3.9	18	All sites	31.6	2.1	26	All sites	33.5	3.7	10

Fledge Period

2001				2002				2003			
Plot	Mean	SD	n	Plot	Mean	SD	n	Plot	Mean	SD	n
A	23.0	3.5	5	A	21.4	4.2	5	A	22.0	1.4	2
A'	22.0	2.8	2	A'	24.0	0.0	5	A'	19.0		1
E'	19.7	2.1	3	E'	21.0	3.7	5	E'	20.0	7.1	2
X	22.0	5.4	4	X	20.7	2.1	3	X	18.0		1
Y	20.7	2.4	7	Y	18.0	1.3	6	Y	19.0	2.8	2
All sites	21.5	3.3	21	All sites	20.9	3.2	24	All sites	19.9	3.3	8

Statistical abbreviations: n = sample size, SD = standard deviation, CI = confidence interval

Appendix VIII. Common Murre productivity by plot, Puale Bay, Becharof NWR, Alaska 2001-2003. Note in 2001 staff attempted all sites on a plot while in 2002&2003 staff was directed to limit sampling to 50 sites.

2001			
Plot	Egg	Chick	Fledge
A	35	32	30
B	25	19	17
C	38	35	32
D	54	42	36
D'	31	31	28
D2	37	27	27
E'	19	10	10
Efar	62	56	54
Enear	54	44	34
Ffar	75	50	45
Fnear	57	47	47
G	33	28	23
G1/G3	27	25	25
G2	28	28	28
Q	52	38	30
X	48	41	41
Y	26	24	23
Total	701	577	530

2002			
Plot	Egg	Chick	Fledge
A	35	29	29
B	23	19	17
C	40	38	37
D	50	48	46
D'	37	36	34
D2	24	20	20
E'	15	14	14
Efar	47	38	35
Enear	44	41	41
Ffar	43	41	40
Fnear	42	42	41
G	52	50	50
G1/G3	34	31	29
G2	24	23	23
Q	41	38	37
X	38	30	30
Y	27	19	18
Total	616	557	541

2003			
Plot	Egg	Chick	Fledge
A/A'	25	21	18
B	22	15	12
C	23	14	14
D	42	40	35
D'	34	28	20
D2	17	16	14
E'	16	9	7
Efar	28	24	21
Enear	40	31	26
Ffar	36	30	28
Fnear	31	27	23
G	29	27	21
G1/G3	26	8	7
G2	22	20	16
Q	38	23	19
X	33	27	24
Y	8	3	1
Total	470	363	306

Appendix IX. Thick-billed Murre productivity by plot, Puale Bay, Becharof NWR, Alaska 2001-2003.

2001			
Plot	Egg	Chick	Fledge
A'	4	2	2
A	5	5	5
E'	5	3	3
X	5	4	4
Y	7	7	7
Total	26	21	21

2002			
Plot	Egg	Chick	Fledge
A'	6	6	5
A	7	6	6
E'	5	5	5
X	5	4	3
Y	7	6	6
Total	30	27	25

2003			
Plot	Egg	Chick	Fledge
A	4	4	4
A'	2	2	2
E'	4	3	2
X	5	3	3
Y	9	3	3
Total	24	15	14

Appendix X. Avian observations at Puale Bay, Becharof NWR, Alaska, June - September 2003, including presence or absence 1990-92 and 2001-02.

Species	2003 Date First Observed	2003 Date Last Observed	2003 No. Days Observed	2003 Peak Count / Dates	2003 Breeding Status	1990 Observed Y/N	1991 Observed Y/N	1992 Observed Y/N	2001 Observed Y/N	2002 Observed Y/N
Red-throated Loon						N	Y	Y	N	N
Pacific Loon	2-Sep		1	1 on 2-Sep	O	Y	Y	N	Y	Y
Common Loon	27-Jul	12-Sep	6	4 on 14-Aug	O	Y	Y	Y	Y	Y
Horned Grebe	26-Aug	12-Sep	3	2 on 26-Aug & 12-Sep	O	Y	N	Y	N	Y
Red-necked Grebe	20-Aug	15-Sep	16	Common on multiple dates	O	Y	Y	Y	Y	Y
Northern Fulmar						N	Y	Y	N	N
Sooty Shearwater						N	Y	Y	Y	N
Double-crested Cormorant	14-Jun	15-Sep	79	Common on multiple dates	CN	Y	Y	Y	Y	Y
Red-faced Cormorant	14-Jun	15-Sep	69	Abundant on multiple dates	CR	Y	Y	Y	Y	Y
Pelagic Cormorant	23-Aug	12-Sep	5	1 on all dates	O	Y	Y	Y	Y	Y
Greater White-fronted Goose						N	N	Y	N	N
Emperor Goose						N	Y	N	N	N
Canada Goose "Lesser"						N	N	N	N	N
Black Brant						Y	Y	Y	N	N
Tundra Swan	24-Aug	7-Sep	3	5 on 28-Aug	O	Y	Y	Y	N	Y
Gadwall						Y	N	N	N	N
American Wigeon						Y	N	N	N	N
Mallard	18-Jun		1	2 on 18-Jun	O	N	Y	N	N	Y
Blue-winged Teal						Y	Y	N	N	N
Northern Shoveler	14-Jul		1	1 on 14-Jul	O	N	Y	N	N	Y
Northern Pintail	2-Sep		1	4 on 2-Sep	O	Y	Y	Y	N	Y
American Green-winged Teal	12-Jun		1	1 on 12-Jun	O	Y	Y	Y	Y	Y
Greater Scaup	16-Jun	15-Jul	2	3 on 16-Jun	O	Y	Y	Y	N	Y
Common Eider						N	N	Y	N	N
Harlequin Duck	14-Jun	14-Sep	39	Abundant on multiple dates	O	Y	Y	Y	Y	Y
Surf Scoter	16-Jun	2-Sep	6	Common on multiple dates	O	N	Y	Y	Y	Y
White-winged Scoter	16-Jun	15-Sep	51	Abundant on multiple dates	O	Y	Y	Y	Y	Y
Black Scoter	20-Jun	24-Aug	5	Abundant on 24-Jul	O	Y	Y	Y	Y	Y
Long-tailed Duck						N	Y	Y	N	N
Barrow's Goldeneye						N	Y	N	N	N
Common Merganser	20-Jun	28-Aug	3	Common on 28-Aug	O	N	Y	N	N	Y
Red-breasted Merganser	18-Jun	12-Aug	6	Abundant on 20-Jun	O	Y	Y	Y	Y	Y
Bald Eagle	12-Jun	15-Sep	73	5 on 20-Jun & 12-Sep	PA	Y	Y	Y	Y	Y
Northern Harrier	21-Aug	14-Sep	15	3 on 14-Sep	O	Y	Y	Y	Y	Y
Sharp-shinned Hawk	1-Sep		1	1 on 1-Sep	O	N	N	N	N	Y
Red-tailed Hawk						N	N	N	Y	N
Rough-legged Hawk	2-Sep		1	1 on 2-Sep	O	Y	Y	Y	N	Y
Golden Eagle	12-Jun	28-Aug	2	1 on both dates	O	N	Y	N	N	Y
Merlin	17-Jun	15-Sep	5	1 on all dates	O	N	N	Y	N	Y

Appendix X, continued. Avian observations at Puale Bay, Becharof NWR, Alaska, June - September 2003, including presence or absence 1990-92 and 2001-02.

Species	2003 Date First Observed	2003 Date Last Observed	2003 No. Days Observed	2003 Peak Count / Dates	2003 Breeding Status	1990 Observed Y/N	1991 Observed Y/N	1992 Observed Y/N	2001 Observed Y/N	2002 Observed Y/N
Gryfalcon	16-Jun	14-Sep	14	2 on 30-Aug	O	Y	Y	Y	Y	Y
Peregrine Falcon	12-Jun	15-Sep	75	5 on 28-Jul & 6-Aug	CR	Y	Y	Y	Y	Y
Willow Ptarmigan						N	Y	Y	Y	N
Rock Ptarmigan						Y	Y	Y	N	N
Sandhill Cranes						Y	N	N	N	N
Black-bellied Plover						Y	Y	N	N	N
Lesser Golden Plover						N	N	Y	N	N
Pacific Golden Plover	29-Aug		1	7 on 29-Aug	O	Not differentiated from lesser golden-plover				
Semipalmated Plover	12-Jun	6-Sep	46	Common on multiple dates	CI	Y	Y	Y	Y	Y
Black Oystercatcher	20-Jun	2-Jul	2	4 on 2-Jul	O	Y	Y	Y	Y	Y
Greater Yellowlegs	30-Jun	15-Sep	9	1 on all dates	X	Y	N	N	N	Y
Wandering Tattler	14-Aug		1	1 on 14-Aug	O	N	Y	Y	Y	Y
Spotted Sandpiper	14-Aug		1	1 on 13-Aug	O	N	Y	Y	N	Y
Whimbrel	1-Aug	14-Aug	3	8 on 1-Aug	O	Y	Y	N	Y	Y
Bar-tailed Godwit						N	Y	N	N	N
Black Turnstone						Y	N	N	N	N
Surfbird	30-Jul	4-Aug	2	2 on both dates	O	Y	Y	Y	N	Y
Sanderling	30-Jul	31-Aug	2	1 on both dates	O	N	Y	Y	Y	Y
Semipalmated Sandpiper						N	N	N	N	N
Western Sandpiper	14-Jul	30-Jul	3	Common on multiple dates	O	N	Y	Y	Y	Y
Least Sandpiper	12-Jun	7-Sep	36	Common on 15-Jul	O	Y	Y	Y	Y	Y
Baird's Sandpiper						N	N	Y	N	N
Pectoral Sandpiper						Y	N	N	N	N
Rock Sandpiper	30-Jul	3-Sep	2	2 on 30-Jul	O	N	Y	Y	N	Y
Dunlin						N	Y	Y	Y	N
Short-billed Dowitcher						N	Y	N	N	N
Red-necked Phalarope						N	Y	Y	N	N
Pomarine Jaeger						Y	N	Y	Y	N
Parasitic Jaeger	18-Jun	8-Aug	2	2 on 18-Jun	O	N	Y	Y	Y	Y
Long-tailed Jaeger	28-Aug		1	1 on 28-Aug	O	N	N	Y	N	Y
Bonaparte's Gull	18-Jul		1	1 on 18-Jul	O	N	Y	Y	Y	Y
Black-tailed Gull	24-Jul		1	1 on 24-Jul	O	N	N	N	N	N
Mew Gull	28-Aug	12-Sep	3	5 on 8-Sep	O	N	Y	Y	Y	Y
Herring Gull	27-Aug	12-Sep	5	3 on 2-Sep	O	N	N	N	Y	Y
Slaty-backed Gull	30-Jul	5-Sep	5	1 on all dates	O	N	N	Y	Y	Y
Glaucous-winged Gull	12-Jun	15-Sep	94	Abundant on multiple dates	CY	Y	Y	Y	Y	Y
Glaucous Gull	16-Jun	20-Jun	2	1 on both dates	O	N	N	N	N	N
Black-legged Kittiwake	14-Jun	12-Sep	27	Abundant on multiple dates	O	Y	Y	Y	Y	Y
Arctic Tern						Y	Y	Y	Y	N

Appendix X, continued. Avian observations at Puale Bay, Becharof NWR, Alaska, June - September 2003, including presence or absence 1990-92 and 2001-02.

Species	2003 Date First Observed	2003 Date Last Observed	2003 No. Days Observed	2003 Peak Count / Dates	2003 Breeding Status	1990 Observed Y/N	1991 Observed Y/N	1992 Observed Y/N	2001 Observed Y/N	2002 Observed Y/N
Common Murre	14-Jun	16-Sep	87	ant on multiple dates due to observed	CI	Y	Y	Y	Y	Y
Thick-billed Murre	14-Jun	15-Sep	87	on on multiple dates due to observed	CI	Y	Y	Y	Y	Y
Pigeon Guillemot	20-Jun	14-Sep	8	3 on 27-Jun & 8-Sep	O	Y	Y	Y	Y	Y
Marbled Murrelet	12-Sep		1	1 on 12-Sep	O	Y	Y	Y	N	Y
Kittlitz's Murrelet						Y	Y	Y	N	N
Ancient Murrelet						N	Y	N	N	N
Parakeet Auklet						N	Y	N	N	N
Horned Puffin	14-Jun	14-Sep	74	Common on multiple dates	CN	Y	Y	Y	Y	Y
Tufted Puffin	14-Jun	14-Sep	69	Common on multiple dates	CF	Y	Y	Y	Y	Y
Short-eared Owl						Y	N	N	N	N
Belted Kingfisher	30-Aug		1	1 on 30-Aug	O	N	N	N	N	N
Alder Flycatcher						N	N	N	Y	N
Northern Shrike						N	N	Y	N	N
Black-billed Magpie	30-Jun	12-Sep	5	1 on all dates	O	N	Y	Y	Y	Y
Northwestern Crow						Y	N	Y	N	N
Common Raven	12-Jun	15-Sep	88	Common on multiple dates	PC	Y	Y	Y	Y	Y
Horned Lark	2-Aug	23-Aug	3	8 on 7-Aug	O	Y	Y	Y	N	Y
Tree Swallow						N	Y	N	Y	N
Violet-Green Swallow						N	N	N	Y	N
Bank Swallow	12-Jun	22-Aug	20	Common on multiple days	O	Y	Y	N	Y	Y
Cliff Swallow						Y	N	N	N	N
Barn Swallow						N	N	Y	N	N
Black-capped Chickadee	28-Aug	13-Sep	11	3 on multiple dates	X	N	N	N	N	Y
Boreal Chickadee						N	N	N	Y	N
Winter Wren						N	N	Y	N	N
American Dipper						Y	Y	N	N	N
Gray-cheeked Thrush	14-Jun	30-Jul	8	1 on all dates	PC	N	Y	N	Y	Y
Swainsons Thrush						Y	N	N	N	N
Hermit Thrush	17-Jun	31-Aug	21	3 on multiple dates	PC	N	N	Y	Y	Y
American Robin	23-Aug	28-Aug	2	4 on 28-Aug	O	N	Y	N	Y	Y
Yellow Wagtail						Y	N	N	N	N
American Pipit	12-Jun	14-Sep	86	Abundant on 14-Aug	CI	Y	Y	Y	Y	Y
Orange-crowned Warbler	17-Jun	25-Jun	2	2 on 25-Jun	PC	N	N	N	Y	Y
Yellow Warbler	17-Jun	17-Jul	13	3 on 17-Jun	PC	Y	N	Y	Y	Y
Yellow-rumped Warbler						N	N	N	N	N
Wilson's Warbler	17-Jun	7-Aug	5	1 on all dates	PC	Y	Y	Y	Y	Y
American Tree Sparrow	28-Aug		1	6 on 28-Aug	O	N	Y	N	N	Y
Savannah Sparrow	12-Jun	14-Sep	87	Common on multiple dates	CI	Y	Y	Y	Y	Y
Fox Sparrow	17-Jun	28-Aug	7	3 on 17-Jun	PC	Y	Y	Y	Y	Y

Appendix X, continued. Avian observations at Puale Bay, Becharof NWR, Alaska, June - September 2003, including presence or absence 1990-92 and 2001-02.

Species	2003 Date First Observed	2003 Date Last Observed	2003 No. Days Observed	2003 Peak Count / Dates	2003 Breeding Status	1990 Observed Y/N	1991 Observed Y/N	1992 Observed Y/N	2001 Observed Y/N	2002 Observed Y/N
Song Sparrow	20-Jun	12-Sep	7	6 on 14-Aug	PC	N	N	Y	Y	Y
Gamble's White-crowned						N	Y	N	N	N
Golden-crowned Sparrow	12-Jun	2-Sep	48	Common on multiple dates	CF	Y	Y	Y	Y	Y
Dark-eyed Junco						N	N	Y	N	N
Lapland Longspur	12-Jun	14-Sep	39	Common on 18-Jun	CR	Y	Y	Y	Y	Y
Snow Bunting	12-Jun	13-Sep	54	Common on 21-Jun	CF	Y	Y	Y	Y	Y
Rusty Blackbird						N	N	Y	N	N
Gray-crowned Rosy Finch	14-Jun	15-Sep	75	Common on 22-Jun	CI	Y	Y	Y	Y	Y
Common Redpoll	12-Jun	14-Sep	57	Common on multiple dates	PC	N	Y	Y	Y	Y

First Puale Bay record (2003)

* Key to Breeding Status:

O= Observed/non-breeding
X= Observed in breeding Habitat
PO= Pair Observed
PC= Courtship
PA= Agitated Behavior
PT= Permanent Territory

PN= Nest-site Visitation
CN= Carrying Nesting Mate
CE= Nest w/ eggs
CF= Carrying Food
CY= Nest with young
CG= Precocial Young

CI= Feeding Recently Fledged Young
CO= Occupied Nest
CR= Recently Fledged Young
C= Confirmed

Appendix XI. Summary of incidental mammal sightings at Puale Bay, Becharof NWR, Alaska, 2001-2003.

		2001			2002			2003		
Common Name	Scientific Name	No. Days Observed	Highest Count	Age/ Reproductive Code	No. Days Observed	Highest Count	Age/ Reproductive Code	No. Days Observed	Highest Count	Age/ Reproductive Code
Shrew species	*Sorex sp.*				5	1	O	5	1	O
Gray Wolf	*Canis lupus*	4	1	O	5	5+[a]	AY	4	1	O
Red Fox	*Vulpes vulpes*	42	5	AY	56	3	AY	69	5	AY
Short-tailed Weasel	*Mustela erminea*							4	2	O
Least Weasel	*Mustela nivalis*				1	1	O	1	1	O
River Otter	*Lontra canadensis*	2	6	AY				6	5	O
Sea Otter	*Enhydra lutris*	9	100	O	8	4	O	14	5	O
Steller Sea Lion	*Eumetopias jubatus*	9	6	O	6	1	O	3	1	O
Harbor Seal	*Phoca vitulina*	19	2	O	34	5	O	20	4	O
Whale sp.		1	3	U						
Harbor Porpoise	*Phocoena phocoena*	1	1	U						
Caribou	*Rangifer tarandus*	33	5	AY	50	12	AY	25	15	AY
Hoary Marmot	*Marmota caligata*	32	6	AY	46	4	AY	73	10	AY
Arctic Ground Squirrel	*Spermophilus parryii*	85	Abundant on multiple dates	AY	94	Common on multiple dates	AY	89	Common on multiple dates	AY
Vole sp.					4	2	O			
Northern Red-backed Vole	*Clethrionomys rutilus*							1	1	O
Meadow Jumping Mouse	*Zapus hudsonius*	1	2	U	3	1	O			

Age/Reproductive Codes: AY= adult and young, O= adult observed, U= unknown

[a] pack heard howling

Appendix XII. Plant phenology data collected at Puale Bay, Becharof NWR, Alaska, 2003. Phenology codes are: V = vegetative stage, B =bud stage, F = flowering, D = fruit developing, R = fruit ripened, W = withering. Plant form: W = woody, H = herbaceous, G = grass / sedge.

Latin Name/ Common Name	17-Jun	23-Jun	30-Jun	7-Jul	13-Jul	21-Jul	28-Jul	2-Aug	11-Aug	18-Aug	25-Aug	1-Sep	8-Sep	Notes
Angelica lucida/ wild celery: H	B	B,F	B,F,D	B,F,D	F,D	F,D	V,F,D,R	D,R,W	D	V,F,D,R	D,W,R	V,D,R, W	V,W	
Heracleum lanatum/ cow parsnip: H		V,B,F	B,F	F,D	F,D	D,R	D,R,W	R,W	W	W	W	W	W	
Ligusticum scoticum/ beach lovage: H	B	B,F	B,F,D	F,D	B,F,D	B,F,D	B,F,D	D,R	D	V,W,D	V,W	V,D,R	V,D,R, W	
Alnus crispa/ American green OR Sitka alder: W	D	F,D	D	D	D	D	D	D	D	D	D	D,W	D,W	
Mertensia maritima maritima/ Oysterleaf: H	B,F	B,F	B,F,D	B,F,D	B,F,D	B,F,D	B,F,D,W	D	F,D	B,F,D,W	V,B,F,D ,	B,F,D	D,R,W,	
Myositis alpestris asiatica/ forget-me-not: H	B,F	B,F	F,D	F	F,D	F,D,R	D,R	F,D	W	V,R,W			W	8/25,9/1 cannot find
Barbarea orthoceras/ winter cress: H	F,D,	B,F,D	F,B	F,D	D	D	D	D,R,W	D,R,W	V,D, R, W	D,R,W	R,W	R,W	
Campanula lasiocarpa/ mountain harebell: H				F	F,D	F,B	B,F,D	B,F.D	B,F	B,F,D	B,F,R	B,F,D	F	
Honkenya peploides/ sea-beach sandwort: H	B,F	B,F,D	F,D	B,F,D	F,D	F,D	V,F.D	F,D	D,R,W	V,F.D, W	V,D,W	D,R,W	D,R,W	
Cerastium beeringianum/ Bering chickweed: H	F	F		F,D	F,D	B,F	B,F,D	F,D		B,F	B,F	F,D	B,F,D	
Silene acaulis/ moss campion: H	F,D,	F,D	B,F,D	D,R	D	F,D	D,R	D	F,D,R,W	V,R,W	V,F,R,W	V	V,R,W	
Aster sibiricus/ Siberian aster: H			B,F	F	F,D	F,D	F,D	B,F,D	F,D	F,D	F,D	F,D	F,D,R,W	
Senecio pseudo-arnica/ beach fleabane: H	V,B	V,B	V,B,F	B,F	B,F	F,D	V,B,F,D	F,D,R	F,D	V,D,R	V,D,R	D,R	R,W	
Artemisia tilesii/ common wormwood: H					V,B	D	B,F	F	F	V,D	D,R,W	V,D,R	Y,R,W	
Solidago decumbens var.*oreophilia*/ elegant goldenrod: H			B,F	B,F	F,B	B,F	F	F,D	F,D	B,F,D	F,D	F,D,R	F,D,R,W	
Sedum rosea integrifolium/ roseroot: H	B,F	F,D	F,D	D	D	D	D,R,W	D	R,W	V,D,R	D,R,W	R,W	D,R,W	
Eriophorum russeolm/ Alaska cotton: G	F,D,	V,D	D	D,R	D,R	D	R,W	D,R	R	R	R,W	W	W	
Empetrum nigrum/ crowberry: W	D	D	D,R	D,R	D,R	R,D	D,R	D,R	R	V,R,W	V,W	V,R	V,R,W	
Rhododendron c. camtschaticum/ kamchatka rhododendron: W	B,F	B,F	F,D	F,D	F,D	F,D	D	D	D	D,R	V,D,R, W	R	D,R,W	

Appendix XII, continued. Plant phenology data collected at Puale Bay, Becharof NWR, Alaska, 2003. Phenology codes are: V = vegetative stage, B =bud stage, F = flowering, D = fruit developing, R = fruit ripened, W = withering. Plant form: W = woody, H = herbaceous, G = grass / sedge.

Latin Name/ Common Name	17-Jun	23-Jun	30-Jun	7-Jul	13-Jul	21-Jul	28-Jul	2-Aug	11-Aug	18-Aug	25-Aug	1-Sep	8-Sep	Notes
Vaccinium uliginosum microphyllum/ bog blueberry: W	B,F,D	B,F	F,D	D	V,D	R,D	V,D,R	D,R	D,R,W	V,R	V,R	V,R	R,W	
Swertia perennis/ star gentian: H		V			B,F	F,B	B,F,D	F,D	B,F	F,D				8/25,9/01,9/08 cannot find
Geranium erianthum/ wild geranium: H	B,F,D	B,F,D	B,F,D	B,F,D	F,D	F,D	F,D	D	F,D,R	V,F,D,R	V	R,W	R,W	
Lathyrus maritimus/ beach pea: H	B,F,D	F	B,F,D	B,F,D	F,D	D,F	V,F,D, W	F,D,R	F,D,W	B,F,D, R,W	B,F,R,W	V,F,R	F,D,R,W	
Iris setosa/ wild iris: H	V	V	D,F,D	B,F,D	B,F,D	D	D,R,W	D	D	V,D	D,R	D,R	D,R,W	
Fritillaria camschatcensis/ chocolate lily: H	F	F	D	W	W									
Epilobium angustifolium/ tall fireweed: H	V		V,B	V,B	V,B	F,B,V	B,F	B,F	B,F	V,B,F	B,F,D	V,B,R, W	D,R,W	
Elymus arenarius mollis/ beach rye: G	B,F	B,F	F,D	D	D	D,R	D	D,R	D,R,W	V,D	D,R,W	R	V,R,W	
Polemonium pulcherrimum/ beautiful Jacob's ladder: H	B,F	F,D	F,D	D	F,D	D,F	D,F,D,R	F,D,R	B,F,D,R	V,R	F,D	V,R	W	
Rumex arcticus/ arctic dock: H	B,F	F	D	D	F	D	D	F,R,W	D,R,W	V,R	W	V,R	W	
Claytonia sarmentosa/ spring beauty: H	B,F		B,F,D	F	F,D	F,D	B,F	V,B,F	F,D	V,D	V,W	V	F,D	
Trientalis europaea arctica/ star flower: H	B,F	B,F	V,F,D	F	V,F,D									7/28-9/08 cannot find
Aconitum d. delphinifolium/ monkshood: H				F	B,F	F,B	B,F,D	F,D	F,D	F,D	F,D	F,D,R,W	F,D	
Dryas octopetala: W	F,D	F,D	F,D,R	D,R	F,D,R	D,R,F	V,F,R,W	B,F,R	F,D,R,W	V,D,R	V,R,W	V,R	W	
Rubus arcticus stellatus/ Nagoonberry: W	B,F,D	F,D	F,D	V,F,D	V,F,D	V,D,F	D	D	R	V,R	V,W	W	V,W	
Galium boreale/ Northern bedstraw: H														did not find
Salix pulchra/diamond leaf willow: W														did not I.D.
Salix arctica/ arctic willow: W														did not I.D.
Parnassia palustris/ small grass-of-parnasis: H					B	B	B,F	B,F	B,F	B,F,D	B,F,D	B,F,D,R	F,D	
Saxifraga bronchialis cherlerioides/ yellow-spotted saxifrage: H	B,F	B,F	F,D	F,D	F,D	F,D	F,D	F,D	F,D	V,R	R,W	V	V,W	

Appendix XII, continued. Plant phenology data collected at Puale Bay, Becharof NWR, Alaska, 2003. Phenology codes are: V = vegetative stage, B =bud stage, F = flowering, D = fruit developing, R = fruit ripened, W = withering. Plant form: W = woody, H = herbaceous, G = grass / sedge.

Latin Name/ Common Name	17-Jun	23-Jun	30-Jun	7-Jul	13-Jul	21-Jul	28-Jul	2-Aug	11-Aug	18-Aug	25-Aug	1-Sep	8-Sep	Notes
Saxifraga oppositifolia/ purple mountain Saxifrage: H	D?	D	D,R	D,R	D	R	R	R	D,W	V,R	R,W	W	V,W	
Pedicularis kanei/ wooly lousewort: H		B	V,F	F	B,F	D,F	F,D	F,D	D	D,R,W	W			cannot find 9/1
Rhinanthus minor borealis/ rattlebox: H					B,F	B,F	B,F,D	F,D	F,D	B,F,D,R	F,D	D,R	DRW	
Valeriana capitata/ capitate valerian: H	B,F	B,F	B,F	B,F	F,D	D	F,D,W		W					As of 18-Aug can no longer find
Artemisia arctica, arctica														
Pinguicula vulgaris	B,F	B,F	B,F,D	F,D										