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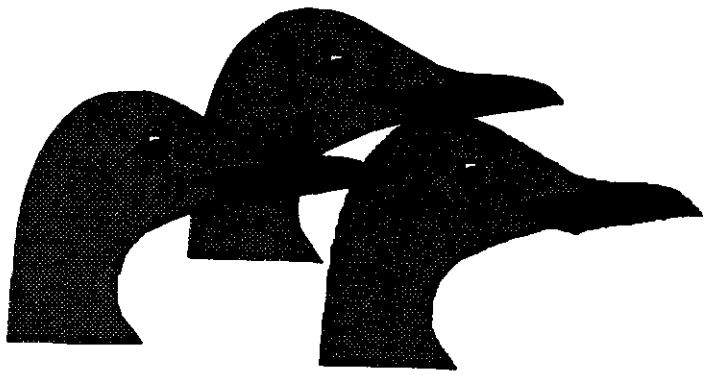
POPULATIONS AND PRODUCTIVITY OF SEABIRDS ON THE PACIFIC COAST OF BECHAROF NATIONAL WILDLIFE REFUGE, ALASKA PENINSULA, ALASKA, 1992



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ABSTRACT

During the summers of 1989-1992, colonial seabirds (murres, kittiwakes, and cormorants) were monitored along the Pacific Coast of Becharof National Wildlife Refuge to determine population size, reproductive success, and the timing of nesting events. Primary species monitored were: common (*Uria aalge*) and thick-billed (*U. lomvia*) murres, black-legged kittiwakes (*Rissa tridactyla*), and red-faced (*Phalacrocorax urile*), pelagic (*P. pelagis*) and double-crested (*P. auritis*) cormorants. This study was one part of a wildlife damage assessment study related to the 1989 *Exxon Valdez* oil spill.

Population counts of murres and kittiwakes conducted in 1992 paralleled those conducted since 1989. Counts of common and thick-billed murres continued to show a decrease of 50-60 percent from historical counts and estimates, while kittiwakes remained stable. Murre breeding phenology was the earliest observed during the 4 year study, however, it continued to remain 15-31 days later than for comparable colonies (Semidi Islands, Cape Peirce), with chick fledging in late August to early September. Productivity for both common and thick-billed murres increased (0.66 and 0.52 respectively) due to less fly-offs of the adults caused by avian predators and the earlier phenology. This increase in productivity was the second (1991 and 1992) year of good reproductive success seen for murres in the oil spill zone. The mean age of fledging also increased significantly ($p<0.025$), from 16.2 ± 3.2 days in 1989 to 22.6 ± 3.8 days in 1992, paralleling the increases in fledging success and productivity. The percentage of breeding murres on the productivity plots decreased significantly ($p<0.001$) from 1990 due to more non-breeders present in 1992, possibly representing pre-spill young (fledged in 1988) returning to the ledges as 4-yr-olds.

Cormorant population counts were low overall in the Puale Bay area in 1992 with nesting only at Colony 013. Eighty-three cormorant nests were counted with red-faced making up 47% and pelagic and double-crested making up 26% each. This was the lowest red-faced count since the study began in 1989. Pelagic and double-crested cormorant nest numbers remained stable. Cormorant reproductive phenology was 4-5 weeks later than similar colonies at Cape Peirce, Middleton Island and the Pribilofs, with no sign of renesting. At Puale Bay, red-faced cormorants fledged young for the first time since the study's initiation, with a mean 1.6 fledglings/nest. Pelagic cormorants fledged 1.9 young/nest, while double-crested showed the best reproductive success with 2.8 chicks fledged/total nests. Brooding periods for red-faced and pelagic cormorants during 1992 were almost half that previously documented at comparable colonies and typical literature values.

INTRODUCTION

The 24 March 1989 grounding of the M/V *Exxon Valdez* on Bligh Reef in Prince William Sound, Alaska, resulted in approximately 11 million gallons of Prudhoe Bay crude oil spilled into the Sound and subsequently spread southwest to the Pacific Coast of the Alaska Peninsula. With the heaviest oiling occurring in Prince William Sound, currents also spread shoreline impacts to the western Gulf of Alaska, southern Kenai Peninsula, lower Cook Inlet, Kodiak Archipelago, Shelikof Strait, Barren Islands, and ultimately the Alaska Peninsula.

Approximately 320 seabird colonies, excluding the Semidi Islands, occur within the area affected by the oil spill. Due to the susceptibility of seabirds to oil, the U. S. Fish and Wildlife Service (FWS) initiated a study to assess damage to local populations. The spill area has been estimated to contain about 1,121,500 breeding seabirds of which 319,130 were murres of both species (FWS, Catalog of Alaskan Seabird Colonies--Computer Archives 1986). Diving seabirds, such as murres, have been documented to be easily impacted by oil spills (King and Sanger 1979). In addition, these species are long-lived with low reproductive rates, making any adult mortality a critical factor in their ability to recover from loss.

Focus of this report is on the Pacific Coast of the Becharof National Wildlife Refuge on the Alaska Peninsula. Approximately 156,580 murres have been reported to breed along the Alaska Peninsula, with most of these birds (74,500 to 92,800) concentrated in colonies around Puale Bay (FWS Computer Archives 1986). In June 1989, two field camps were set up at Oil Creek and Puale Bay (Fig. 1) to monitor breeding seabird numbers in colonies from Cape Unalishagvak to Puale Bay (Dewhurst 1991). From 1990 to 1992, only the Puale Bay field camp was maintained, but the same study area was still monitored (Dewhurst and Moore 1992). Population and productivity surveys were initiated to monitor breeding colonies of common (*Uria aalge*) and thick-billed (*U. lomvia*) murres, black-legged kittiwakes (*Rissa tridactyla*), red-faced (*Phalacrocorax urile*), pelagic (*P. pelagicus*) and double-crested (*P. auritus*) cormorants, with the primary emphasis on murres. Incidental counts of glaucous-winged gulls (*Larus glaucescens*), tufted (*Fratercula cirrhuta*) and horned (*F. corniculata*) puffins were also documented (Appendix I). Survey objectives included:

A. Determine if the numbers of breeding murres, cormorants, and kittiwakes of the Puale Bay area colonies have decreased compared to numbers previously censused.

B. Document reproductive chronology and productivity of murres, cormorants, and kittiwakes of the Puale Bay area colonies for use in a comparison with other colony sites within and outside the oiled area.

METHODS AND STUDY AREA

Study Area

Although shoreline impacts have been documented along the entire 1170 km (725 mi) coast of the Alaska Peninsula/Becharof Refuge Complex (Dewhurst et al. 1990), only seabird colonies along the 161 km (100 mi) Becharof Refuge portion were selected for study. The study area from Cape Kubugakli to Cape Unalishagvak, is bounded to the north by Katmai National Park and Preserve and by Island Bay to the south, and is within a designated National Wilderness Area. The Becharof coast contains 13 previously identified seabird colonies, but only the 3 primary murre colonies were included in this study. These colonies were located at Jute Peak (005), Cape Aklek (008) and Puale Bay (013) (Fig. 1), all within a designated National Wilderness Area. Colony numbers correspond to those designated in the Catalog of Alaskan Seabird Colonies (Sowls et al. 1978), map 35, Karluk.

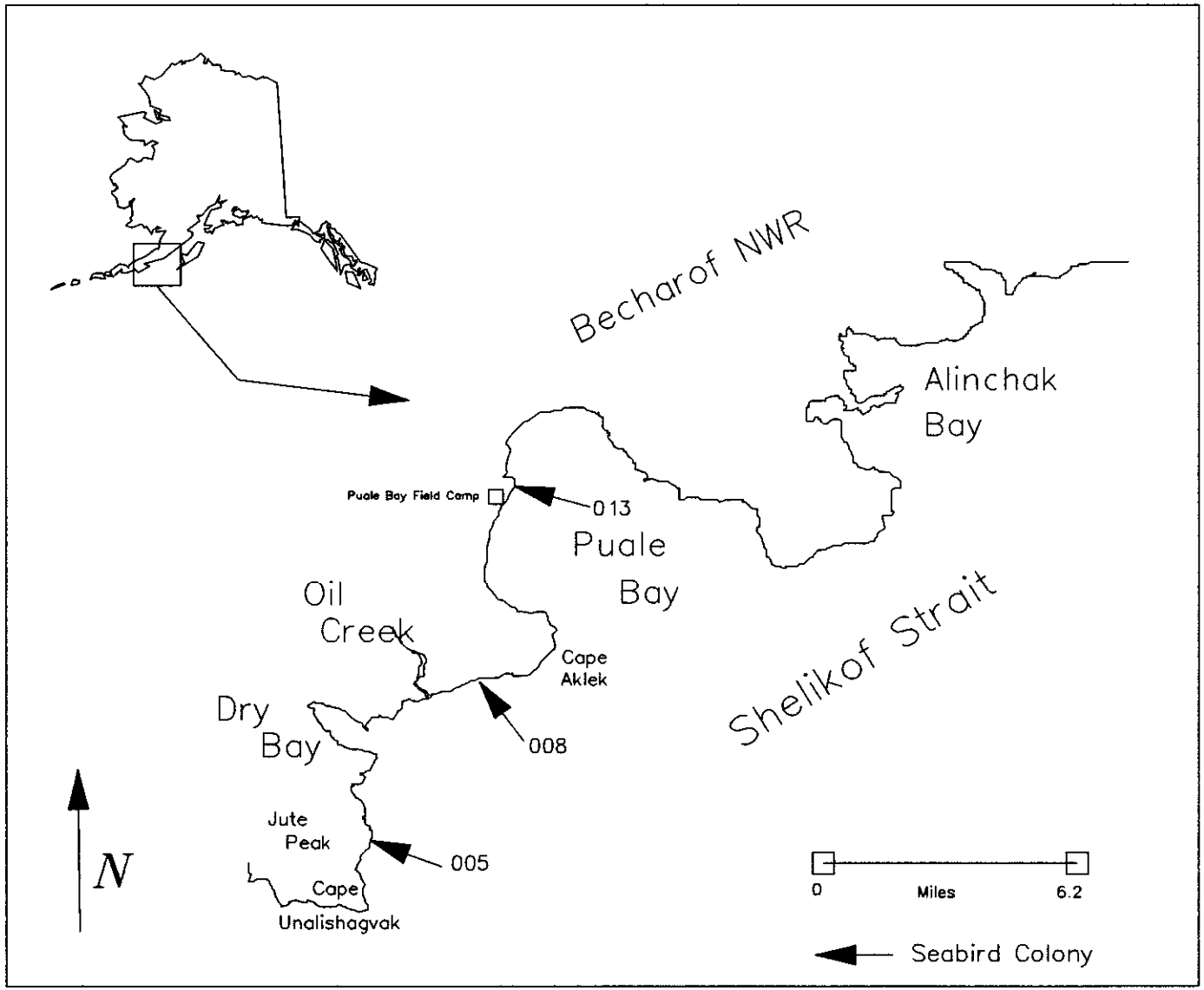

Fig. 1. Map of the Puale Bay study area, highlighting the field camp site and locations of seabird colonies, Becharof National Wildlife Refuge, Alaska Peninsula, Alaska.

The meeting of Shelikof Strait and the Aleutian Range provides a very rugged coastline dominated by eroded mountain-sides forming cliff habitat ideal for ledge-nesting seabird colonies. Colony cliff heights range from 170-300 m (560-1000 ft). The summer climate is primarily foggy, windy and rainy, with infrequent sunny days and generally free from snow at sea level from early May to late September.

Survey Staffing and Logistics

In 1992, the Puale Bay field camp was maintained from 13 June - 23 September. The field camp was staffed by one biological technician and three volunteers. Equipment for the field camp was transported from King Salmon to Puale Bay using a de Havilland DHC3 Otter, Grumman G21 Goose, Cessna 185 and a Bell 206 JetRanger helicopter. Resupplies and personnel transportation were provided using a Cessna 185. Camp facilities and equipment included: 3 weatherports, an outhouse, 2 inflatable boats (Zodiac Mark II and Mark III) with Johnson outboard motors (30 and 9.9 hp) and associated safety equipment, a 4-wheeler ATC with utility trailer, a single-side-band radio, and a portable generator. Special brown bear safety equipment included: 12 ga. riot shotguns, 375 H&H magnum rifles, bear-proof steel barrels for food storage, barrel incinerator for trash burning, miscellaneous hazing supplies (cracker shells, flares, rubber slugs), and an electric fence which surrounded the boats and 4-wheeler. Survival barrels for boating safety were placed in the dunes near Oil Creek and Helen Creek. Survival barrels contained a tent, sleeping bags, blankets, camp stove, freeze-dried food and other emergency equipment.

Population Surveys

Population plots were originally established in July and August 1989 for Colonies 005 - Jute Peak, 008 - Cape Aklek, and 013 - Puale Bay following unpublished regional FWS guidelines (Mendenhall 1989). Problems with interior boundary delineation made it necessary to redefine plots for the Puale Bay (013) colony in June 1990. In 1992, an additional plot (21) was created for Colony 013 as nesting seabirds expanded to the ledges north of the existing plots (Appendix IV). Plots were documented by color photography (slides and prints on file at the Alaska Peninsula/Becharof Refuge Complex office in King Salmon, Alaska) and illustrations drawn from photos (Dewhurst 1991). Plots consist of areas on vertical cliff faces readily identified by physical features and permanently recorded on photographs and drawings on file.

The 21-m (65-ft) M/V *Surfbird* was used in 1989-1991, but was unavailable this year to aid in the surveys of the colonies, so all boat-based population surveys were conducted using inflatables. Survey distances ranged from 30 to 100 m (90-300 ft.). Partial counts of the Jute Peak (005), one full count of the Cape Aklek (008) and 3 complete counts of the Puale Bay colony were completed using the inflatable boats. Boat censuses were restricted to when seas were <1 m (3 ft) and rain of not more than a light drizzle. The overall sea conditions and weather outlook also was taken into account before the inflatable boats were taken into Shelikof Strait to count the Jute Peak (005) and Cape Aklek (008) colonies.

Land-based counts were conducted for sub-samples of the overall colonies. In Puale Bay (013), land-based counts were conducted from "Lookout Point"

(Appendix IV). Murres in the productivity plots, established within population Plots 14-18, (Dewhurst 1991) were censused daily during productivity monitoring.

All population surveys, both land and boat-based, were conducted by a minimum of two observers using spotting scopes or binoculars and tally-whackers for recording. Bausch and Lomb 15-60X spotting scopes and Questar mirror scopes (12-32mm, 1.5-2X) were the optics used for land-based counts and productivity work. Boat-based counts used 10X40 binoculars.

Observers simultaneously counted each plot within a colony. Replicate counts were performed until individual totals were within 5% between the observers. All counts were recorded, but only the final replicate of each plot was used to calculate an average, which was recorded as the daily total for that plot. In some cases, plots were further sub-divided for ease of counting. Color photographic prints and diagrams were used in the field for plot boundary references.

With the exception of those land-based surveys conducted incidentally to the productivity monitoring, murre population censusing was conducted during the period of least fluctuations, when most of the birds were either incubating or rearing chicks (Hatch and Hatch 1989). Survey times were restricted to between 1000 and 1600 hours, Alaska Daylight Time, to minimize count variability due to feeding activity.

Productivity Surveys

Murre productivity plots in the Puale Bay (013) colony were established in June 1989 for land-based monitoring from Lookout Point. Nine plots (A, B, C, D, E, F, G, Y, Z) were selected to monitor, following unpublished regional FWS guidelines (Mendenhall 1989), with color plot photographs on file at the Alaska Peninsula/Becharof Refuge Complex Office in King Salmon. In 1990, two of the original plots (D and G) were further subdivided for ease of data recording, and the monitoring of plot Z was eliminated for safety considerations. In 1991, the previously established subdivisions for Plots D and G were not used (Dewhurst and Moore 1992). In 1992, the established plots were used with the following changes; plot Y' was added to plot Y, plot G was subdivided (G, G1, G2, G3) and Plots X and Q were added to the 8 plots used in 1991 (Appendix IV).

Productivity plots were monitored daily, weather permitting, with observers documenting adult attendance and behavior, and presence or absence of eggs and chicks. Established regional FWS guidelines for monitoring procedures (Mendenhall 1989b) provided a standard methodology. Because it was frequently not possible to view murre breeding site contents (egg or chick), observers used adult behavior postures to indicate incubating or chick brooding (O'Daniel 1988, Baggot et al. 1989, Byrd 1989). To avoid misinterpretation of murre behavior, we followed the convention that a site had to have a bird in "incubating posture" on at least three consecutive days to consider the site as having an egg (Byrd 1989). Also by convention, only one sighting of wing mantling was enough to consider the site as having a chick or to qualify as a "brooding posture." Data was recorded on standardized forms (Byrd et al. 1985, O'Daniel 1988) using conventional coding.

Land-based cormorant productivity plots were established in June 1989 for colonies at Cape Aklek and Puale Bay (Dewhurst 1991). The Cape Aklek plots were not occupied in 1992. At the Puale Bay colony (013) in 1992, new plots were established and observed, along with the previously established plots. Nests were numbered and observed for activity (incubating or brooding adults, eggs, chicks) with data recorded on the same forms used for murre monitoring. At the Puale Bay colony, observation points were above the nesting cormorants, approximately 2-25 m (7-83 ft) away, providing an excellent vantage point to observe the nests. Chicks were recorded as fledging when initially observed flying from the nest. At the time of the last observation date of the season, any cormorant chicks remaining that appeared capable of fledging (as old or older than successful fledglings), but not yet observed flying, assumed to be successful for productivity calculations. These chicks were not used to calculate age of fledging or fledging dates.

Only the Jute Peak colony had breeding kittiwakes present, but lack of land-based viewing opportunities prevented intensive productivity monitoring. Determining reproductive attempts were based on general presence or absence of nests with fresh nesting materials or chicks.

Data Analysis

Analysis of this study's data followed the standard procedures and assumptions used by FWS on colonies in the Alaska Maritime National Wildlife Refuge (Garton 1988, Byrd 1989, Nysewander and Dippel 1990, Schulmeister 1991).

To analyze murre productivity data, standardized conventions adopted by the Alaska Maritime National Wildlife Refuge (Dewhurst 1991) were followed. Murre reproductive phenology was determined using the dates of known events, ie. first egg seen, first chick seen, with data from relaid eggs excluded. Estimates of reproductive success were made using plots as sample units and letting the averages for a plot be the sample observations. Individual nest sites were not used as sample units since nests located physically close together may share a common fate and therefore data would not be independent (Byrd 1989). Ratio estimation procedures were used to estimate overall means and variances (Byrd 1989). The increase in murre productivity and brooding periods from 1989 to 1992 was analyzed using linear regression.

Determining cormorant reproductive phenologies was more difficult than for murres. Cormorants tend to sit "tighter" on their nests than which makes documenting when eggs were laid more difficult. Most lay dates had to be back-calculated from hatch dates for the 3 cormorant species' using the known incubation times of 31 days for red-faced (Hunt et al. 1979), 28-32 days (30 average) for pelagic (Dick 1975) and 28 days for double-crested (Van Tets 1959) cormorants. Hatching dates were easier to document because the adults would often move and stand more often once chicks were hatched making it easier to view the contents of the nest. The hatching and fledging dates were observed and not calculated. The brooding times were compared to the known brooding times of 59 days (Hunt et al. 1979) for red-faced, 42-58 days (50 average) (Dick 1975) for pelagic and 35-42 days (39 average) (Drent et al. 1964) for double-crested cormorants using a one-tailed t-test.

RESULTS AND DISCUSSION

Murres (Common and thick-billed)

Colony Populations.-- The Puale Bay area murre colonies (005, 008, 013 - Fig. 1) did not have a history of replicate census prior to the Exxon Valdez oil spill. Single counts were conducted in 1976 (Sowls et al. 1978) and 1981 (Bailey and Faust 1984) with estimated totals of 97,500 and 74,500 (Table 1) respectively. No information was available to determine whether these counts represented a decline or just natural variation due to seasonal differences of colony attendance (Nysewander and Dippel 1990, 1991).

Replicate counts were initiated for the Puale Bay colonies in 1989, with the establishment of population plots. Counts have been consistently conducted in late July or early August for all years of this study. This corresponded with the time between the peak of egg laying and the peak of chick hatching. Initial counts made in 1989 resulted in a total of 36,433 murres (Table 1, Appendix I), suggesting a significant decline of 50-60% from pre-oil spill estimates (Nysewander and Dippel 1990). Four-year trends varied among the 3 colonies (005, 008, 013) monitored. The Jute Peak colony (005) remained around 14,000 birds from 1989-1991, and when the counts of Plots 1-8 and 21 are compared from 1992 with the previous 3 years, the population still seemed stable (Table 1). The Cape Aklek colony (008) has fluctuated between 20,000 and 17,000 birds over the 4 years (Appendix I). At the same time, the Puale Bay colony (013) increased steadily from 1,976 murrres in 1989 to 2,980 murres in 1991. The 1992 count of Colony 013 showed a drop in population to 2,425. (Appendix I, Table 1). The net result was that these yearly fluctuations did not appear significant relative to the overall difference from pre-oil spill estimates, but lack of a complete count of Colony 005 in 1992 prevented actual statistical testing.

A comparison of boat-based and land-based murre population counts revealed problems in accuracy of the boat-based counts. The land-based productivity plots corresponded to boat-based population Plots 14-17 (Appendix IV). On 1 August 1992, we compared a boat-based population count of Plots 14-17 which yielded a count of 500 murres, with a land-based count of the same ledges that yielded 1,218 murres, inferring that the boat-based count only censused 41% of the birds present. A similar comparison was done on 13 August 1992 yielding a boat-based accuracy of 42%. Boat-based population surveys did not appear to reflect actual counts of murres on the colony cliffs. The depth of some ledges and distance of upper ledges from boat-based observers tended to make the counts lower than what was actually present. The object of the boat-based population counts was not to give accurate population counts but to give a consistent, precise index which can be compared to similar counts in other years or at other times of the year. Hence, boat-based population surveys do provide good indices over time, but should not be interpreted as accurate population estimates.

Population Trends in Murre Productivity Plots.-- Attendance patterns, as recorded for the 1992 Puale Bay productivity plots, paralleled 1990 and 1991 patterns and that described for the murres in the Semidi Islands (Hatch and Hatch 1989). Attendance was cyclic prior to egg laying, settling during the production period until gradual colony abandonment in mid-September (Fig. 2).

Table 1. Comparison of murre (common and thick-billed) and black-legged kittiwake counts conducted at the Puale Bay area colonies, Becharof National Wildlife Refuge, Alaska, 1976 - 1992 (Sowls et al. 1978, Bailey and Faust 1984, Nysewander and Dippel 1990, 1991, Dewhurst 1991, Dewhurst and Moore 1992).

Common and thick-billed murres

Colony Name	Year of Survey 1976	1981	1989	1990	1991	1992
Cape Aklek (008)	73,000	30,000	20,400	16,970	19,088	20,271
Puale Bay (013)	8,000	6,500	1,976	2,804	2,980	2,425
Totals	81,000	36,500	22,376	19,774	22,068	22,696
Jute Peak (005)						
Total Count	16,500	38,000	14,057	14,496	14,374	--[a]
Plots 1-8,21	--[b]	--	5,362	5,659	5,150	5,582

Black-legged kittiwakes

Colony Name	Year of survey 1976	1981	1989	1990	1991	1992
Jute Peak (005)						
Total Count	1,000	1,200	898	1,288	1,326	--[a]
Plot 21	--[b]	--	898	1,156	1,194	1,078

[a] Complete colony census was not conducted in 1992.

[b] Population plots were not established until 1989.

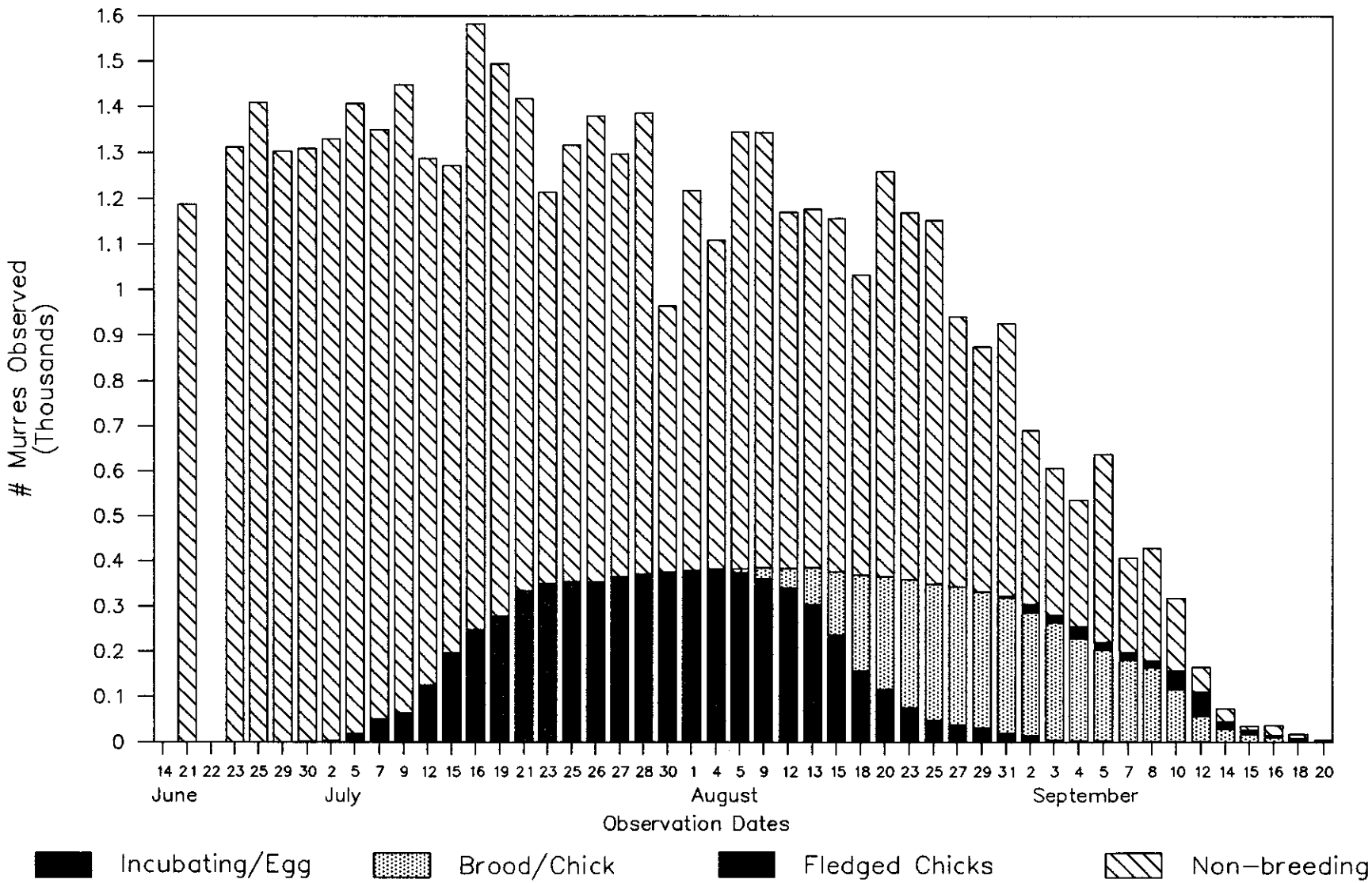

Fig. 2. Composition of murre populations (common and thick-billed combined) observed June-September 1992 in the productivity plots, Colony 013, Becharof National Wildlife Refuge, Alaska Peninsula, Alaska. The stacked bars are additive with the top representing total counts per date.

Figure 2 dramatically illustrates the steady decline in total counts after the peak of chick hatching (25 September). In 1992, Monitored birds involved in reproduction consisted of a mean 28.8% of the population in the plots, which was a significant decrease from 36.9% in 1990 ($p<0.001$) (Fig. 3). The number of murres involved in reproduction on the plots did not change dramatically from 1990; however, the number of non-breeding birds did increase, creating this difference in the percentages. This increase in non-breeding birds may have been tied to local increases in food availability (Gaston and Nettleship 1982), but we were not able to test this theory with a food habits analysis. Additionally, new birds (prospectors) likely came from waters outside the Puale Bay area. Murres have been documented to first visit breeding ledges at 3 years old (Birkhead and Hudson 1977), so these new birds must have hatched during 1989 or before. Complete colony reproductive failures were recorded for the Puale Bay area in 1989 and 1990, necessitating that these new birds were more likely hatched before the oil spill, spending 1989 out at sea, away from the affected area of the spill. A similar occurrence was demonstrated by Birkhead and Hudson (1977) in South Wales, where young birds out at sea avoided a massive nearshore die-off (Irish seabird wreck of 1969).

The Puale Bay productivity plots could be divided into 3 general ledge systems. The larger, central ledge system consisted of Plots B, C, D+D'(D), E+E'(E), F, G+G1 (G), and X while Plots A, G2+G3 (G2/3), Q, and Y+Y'(Y) were on smaller ledges along the periphery. The less abundant thick-billed murres were most prominent on the peripheral ledges, but were also present in the large, central plot E. Only slight differences in attendance patterns were observed between the ledge systems, with all plots stabilizing around 23 June. Plot G2/3 was the only plot to have fly-offs observed. Unlike previous years, predators such as bald eagles (*Haliaeetus leucocephalus*) and peregrine falcons (*Falco peregrinus*) could not flush entire ledge systems as they flew past. Hence the first eggs laid were not exposed to the heavy predation that occurred in previous years. Common ravens (*Corvus corax*) and glaucous-winged gulls (*Larus glaucescens*) which predated heavily on eggs during fly-offs in previous years were not witnessed taking any eggs this year. In fact for the first time at this site, glaucous-winged gulls had 4 active nests on the same ledges as incubating murres, with gull chicks interacting with adult murres.

Phenology.-- The 1992 murre breeding schedule for Puale Bay was the earliest recorded during the 4-year study (Table 2) with a mean laying date 11-19 days earlier for common murres and 6-16 days earlier for thick-billed murres (Fig. 4). This 1-2 week shift may have resulted from 3 possible factors: higher densities on the ledges, older age structure of breeders and/or improved food availability. Direct mortality from oil likely reduced the numbers of birds present on the cliffs in the first years following the oil spill (Piatt et al. 1990, Nysewander et al. 1992), but a significant increase was recorded in 1992 for both breeders and non-breeders. Increased densities may have improved the social stimulation important in determining the timing of egg laying, prompting an earlier start (Tuck 1960, Birkhead 1985). The higher densities were observed to result in less avian predator prompted fly-offs early in the egg laying period.

It has been speculated that the oil spill caused differential mortality, resulting in a higher percentage of younger, more inexperienced birds surviving to breed in 1989 (Bourne 1982, Nysewander et al. 1992). Younger

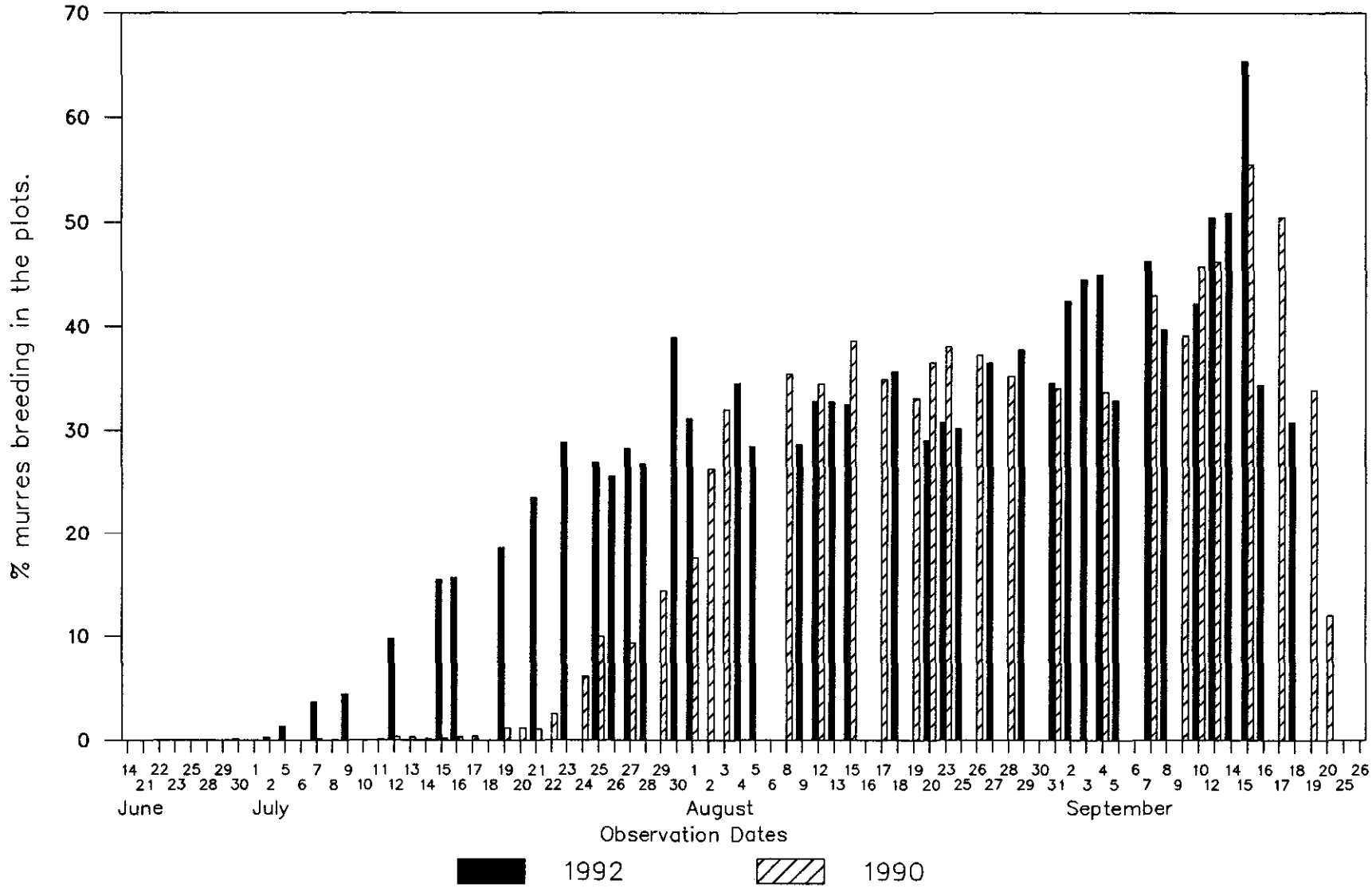

Fig 3. Percentage of breeding murres (common and thick-billed combined) in the productivity plots, Colony 013, Puale Bay, Becharof National Wildlife Refuge, Alaska Peninsula, Alaska, 1990 and 1992.

Table 2. Phenology of common and thick-billed murres, Colony 013, Becharof National Wildlife Refuge, Puale Bay, Alaska Peninsula, Alaska, 1989-1992.

	Year			
	1989	1990	1991	1992
Common murres				
Laying				
First laying date	7/15	7/06	7/20	6/30
Mean date	8/06 (0.9)	8/01 (0.8)	8/01 (3.5)	7/16 (2.7)[a]
Last laying date	8/25	8/18	8/21	8/3
Sample size	266	388	109	415
Hatching				
First hatching date	8/28	8/23	8/20	8/3
Mean date	9/09 (0.9)	9/04 (0.4)	9/05 (3.9)	8/18 (2.6)
Last hatching date	9/25	9/17	9/20	9/8
Sample size	133	289	64	369
Fledging				
First fledging date	9/13	9/9	9/15	8/28
Extrapolated date[b]	10/02	9/27	9/28	9/10
Actual Mean date	9/20 (2.9)	9/17 (3.0)	9/22+	9/7 (2.2)
Last fledging date	9/24	9/20	9/27+[c]	9/19
Sample Size	20	39	41	274
Thick-billed murres				
Laying				
First laying date	7/21	7/06	7/19	7/6
Mean date	7/31 (2.6)	7/26 (3.0)	7/30 (3.5)	7/15 (3.0)
Last laying date	8/15	8/21	8/10	8/8
Sample size	20	43	21	29
Hatching				
First hatching date	8/30	8/23	8/19	8/10
Mean date	9/06 (8.0)	8/29 (2.0)	8/30 (4.1)	8/18 (2.4)
Last hatching date	9/13	9/06	9/09	9/3
Sample size	4	15	15	21
Fledging				
First fledging date	9/15	9/11	9/11	9/1
Extrapolated date[b]	9/29	9/21	9/22	9/10
Actual Mean date	9/15	9/14	9/18+	9/5 (1.9)
Last fledging date	9/15	9/16	9/27+	9/11
Sample size	1	2	10	15

[a] Numbers in parentheses represent 90% Confidence Bounds in # days

[b] Fledging dates were extrapolated from the hatching dates using the mean time of chick departure for common and thick-billed murres, 23 days [Gaston and Nettleship 1981, Hatch and Hatch (in press (a))].

[c] Camp was pulled before last chicks were seen fledging.

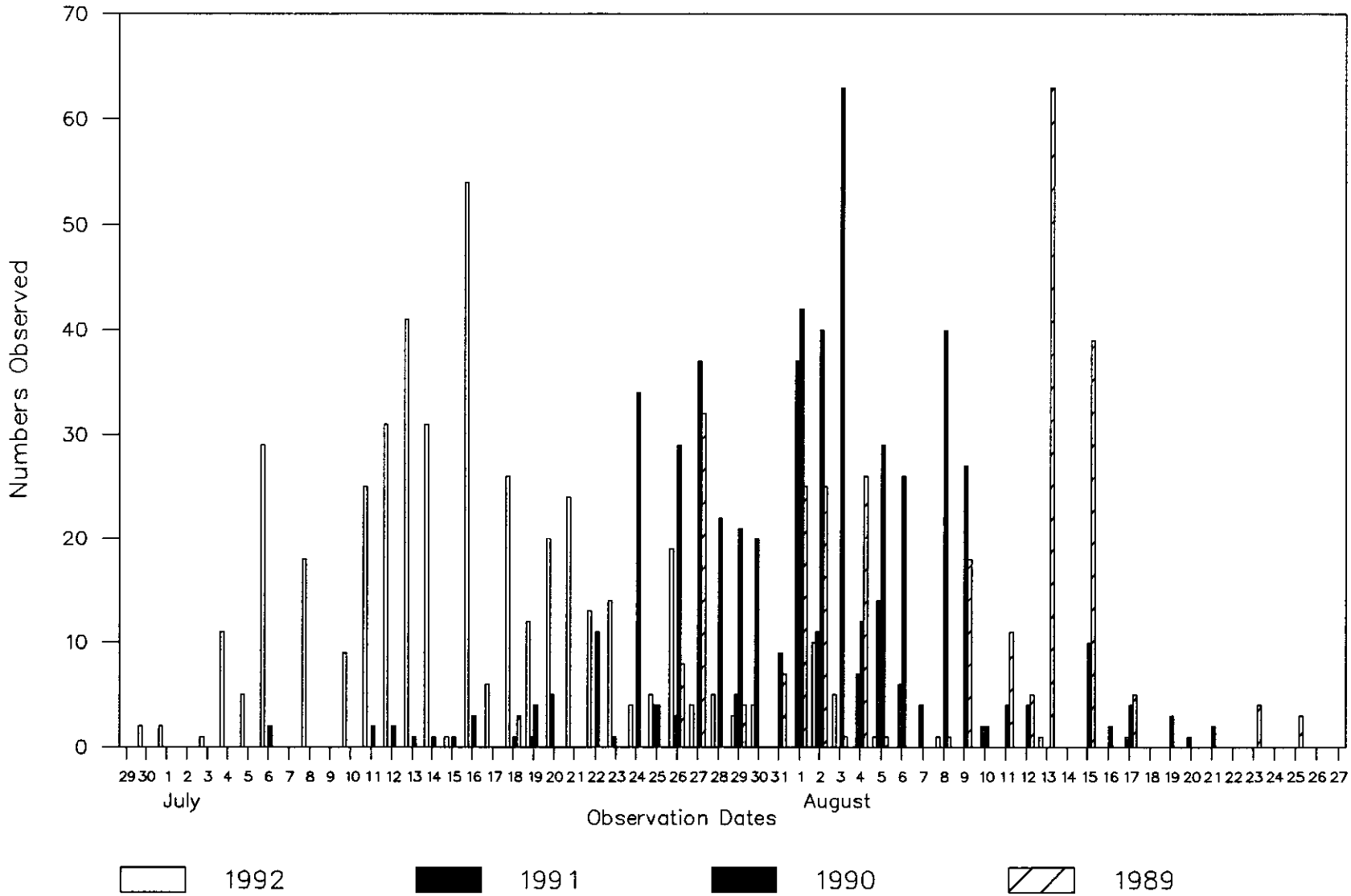

Fig 4. Comparison of murre (common and thick-billed combined) egg-laying phenology from productivity plots, Colony 013, Puale Bay, Becharof National Wildlife Refuge, Alaska Peninsula, Alaska, 1989-1992.

birds have been demonstrated to lay later than older birds, due to being less experienced in catching food, causing delayed reproduction and often lower productivity (Perrins 1970, Birkhead and Nettleship 1981, Wanless and Harris 1988). It has not been determined at what age murres become experienced enough to lay earlier in the season. Perhaps maturation and learning may have occurred for the younger breeders at Puale Bay between 1989 and 1992, resulting in the shift in phenology. This year's increase in numbers of non-breeding birds visiting Puale Bay's ledges suggested a local increase in food availability, which may also have contributed to stimulating earlier egg laying (Perrins 1970, Hatch and Hatch 1990).

Despite the earlier breeding season in 1992, the Puale Bay murre phenology was still 21-31 days later than that reported for the Semidi Islands (Dragoo and Bain 1990) and 15-23 days later than Cape Peirce (Haggblom 1991, Mendenhall 1991).

Lack of synchronization was still apparent but improving in the breeding schedule observed at Puale Bay. Breeding schedules for the peripheral ledges closely paralleled that of the central ledges (Fig. 5 and 6), as did reproductive success. Plots peaked around 27 August with the exception of Plot G2/3 which peaked later, likely due to fly-offs. Plot Y also deviated from the general phenology, but produced no chicks surviving to fledging. Eggs were being laid over a 35-day span (Fig. 7), however, very few fly-offs were recorded (2 in total and they only included Plot G2/3) which minimized egg predation, resulting in good hatching success (Table 3).

Chick rearing/fledging success.-- The earlier phenology in 1992 combined with increased fledging success permitted more observations of murre fledging dates. In 1991, the field camp departed at the point when the few remaining chicks were 15 days old, with the assumption that these chicks would successfully fledge. This year, with a sample size of 274 common murre fledglings, the actual mean fledging date was 3 days earlier than the extrapolated date (Table 2). The average age of successful fledging increased from 16.2 $\pm$ 3.2 days in 1989 to 22.6 $\pm$ 3.8 days in 1992 showing a significant increase in chick age at fledging ($p<0.025$), paralleling increased fledging success and productivity (Fig. 8). Since 1989, the breeding phenology has shifted 1-2 weeks earlier corresponding with the increase in time spent chick rearing to create a negative correlation such as described in Gaston and Nettleship (1981).

As an anecdotal note, the evening of 10 September was a clear, calm night with a full moon and the field crew could hear adult murres calling. That night corresponded to an estimated 50 chicks fledging (Fig. 2).

Given the lateness of the chick rearing period (mid- to late September), we speculate that climate and not food supply has been the limiting factor determining the brooding period at Puale Bay. Gaston and Nettleship (1981) have demonstrated in Newfoundland that climate, especially in the arctic, can dictate the amount of time spent chick rearing. Along the Alaska Peninsula, winter storms with gale force winds and rough, high seas generally start to occur in late September. With chicks hatching in early to mid-September (Table 2), the potential existed for survival conflicts between the interests of the parents and offspring (Trivers 1974), such as occurred in 1990

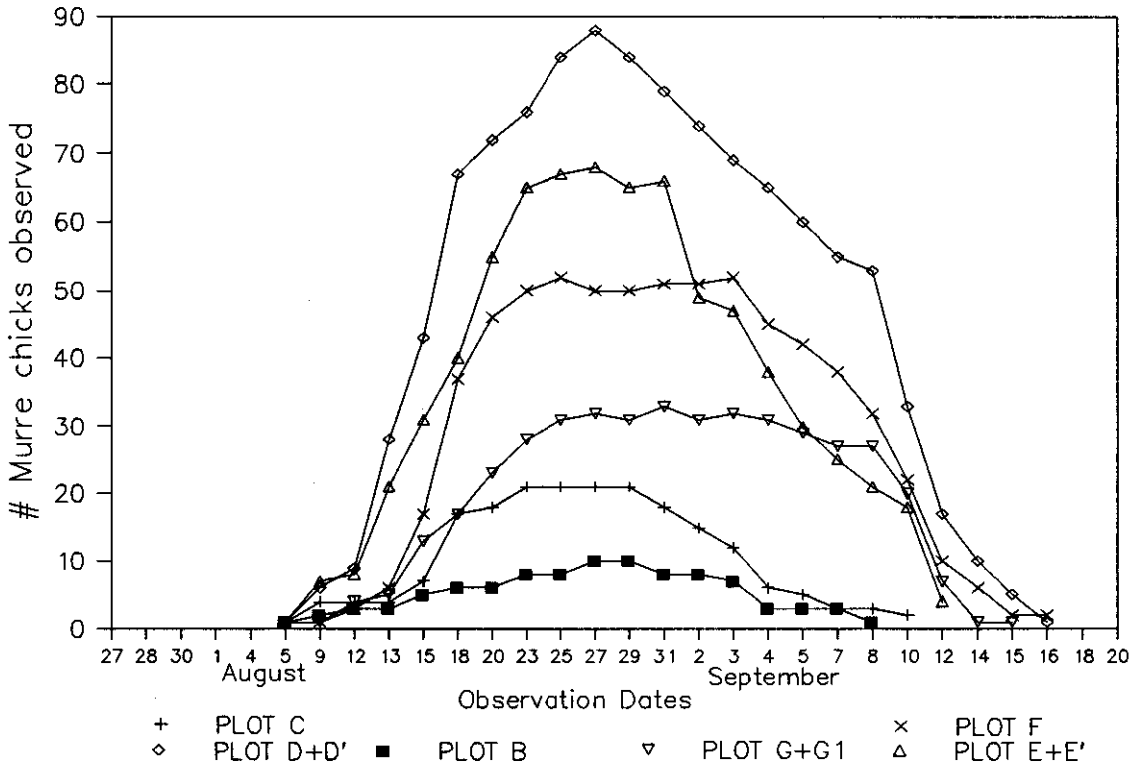

Fig 5. Comparison of 1992 chick hatching phenologies among the main ledge productivity plots, Colony 013, Puale Bay, Becharof National Wildlife Refuge, Alaska Peninsula, Alaska.

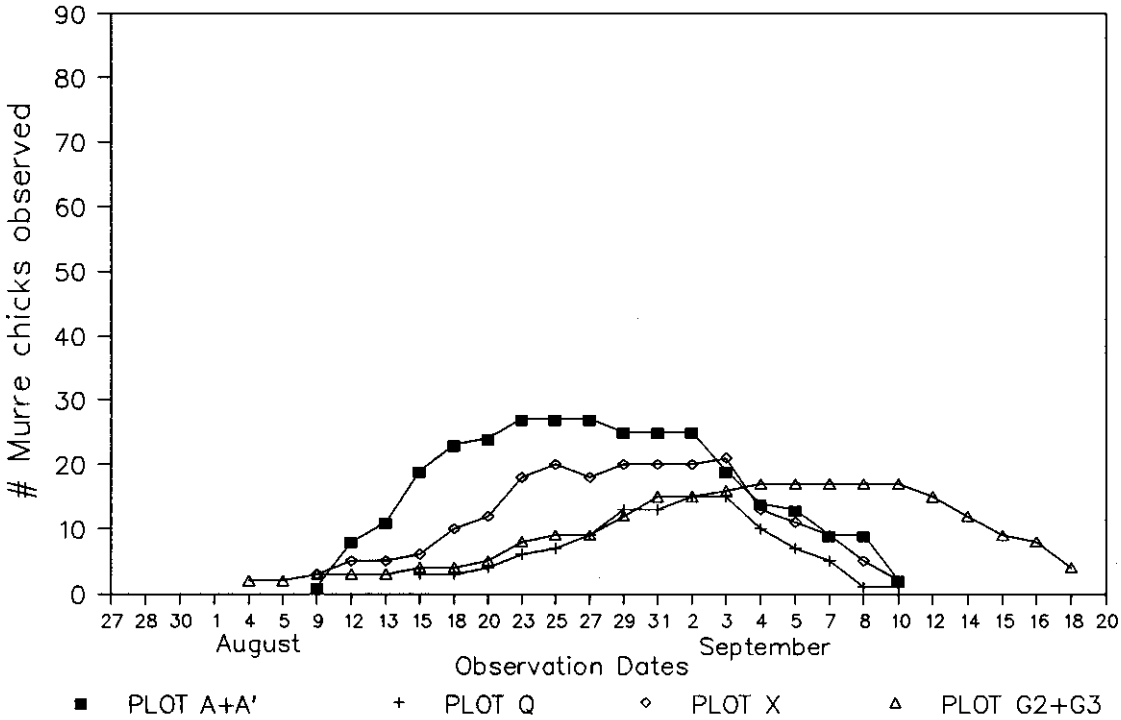

Fig 6. Comparison of 1992 chick hatching phenologies among the peripheral ledge productivity plots, Colony 013, Puale Bay, Becharof National Wildlife Refuge, Alaska Peninsula, Alaska.

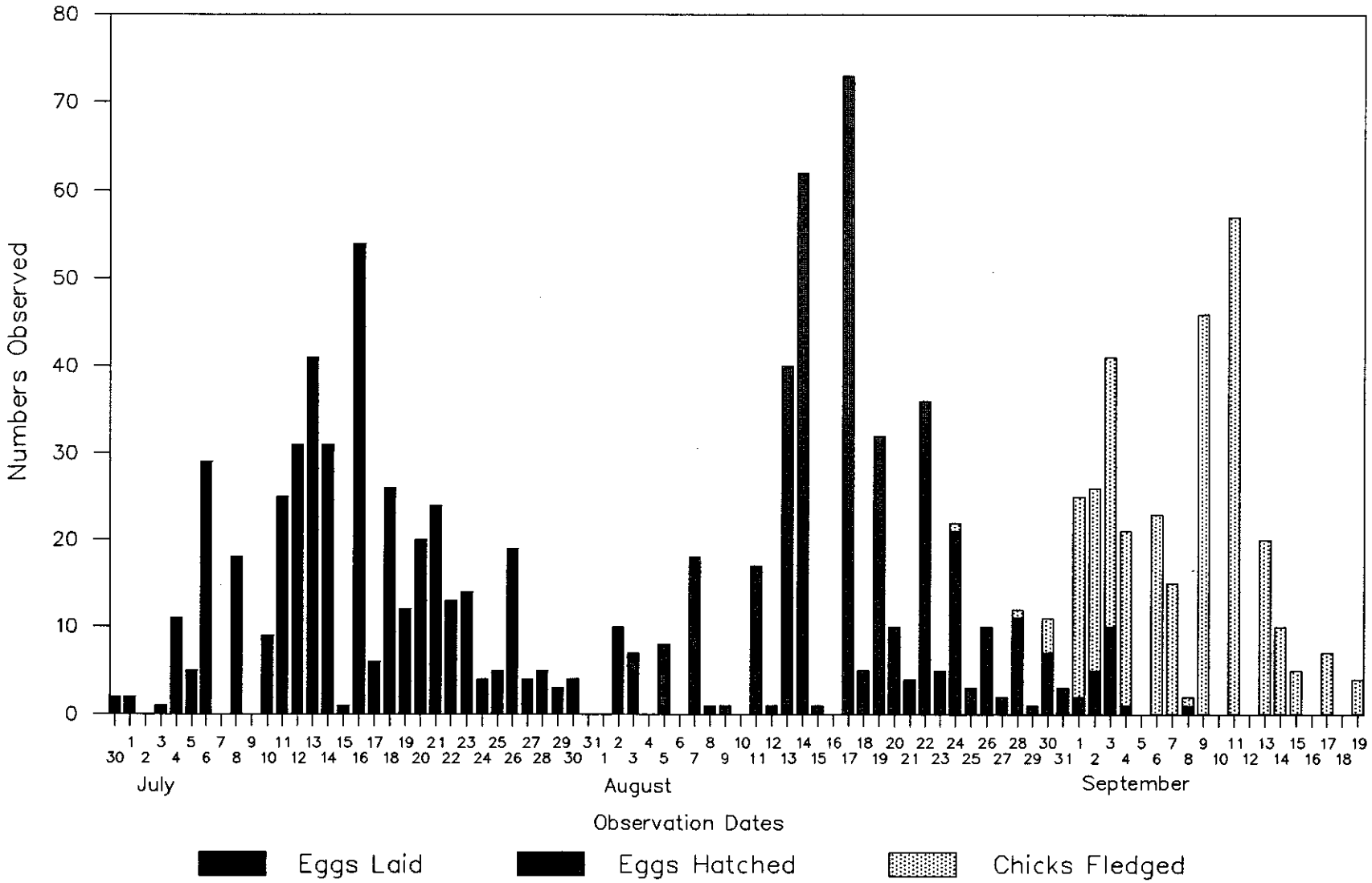

Fig 7. Phenology of murre reproductive events, Colony 013, Puale Bay, Becharof National Wildlife Refuge, Alaska Peninsula, Alaska, 1992.

Table 3. Reproductive success of common and thick-billed murres, Colony 013, Becharof National Wildlife Refuge, Puale Bay, Alaska Peninsula, Alaska, 1989-1992.

	Year			
	1989	1990	1991	1992
Common murres				
Total eggs laid[a]	266	388	109	415
Total chicks[b]	133	289	64	369
Total chicks fledged[c]	20	39	41	274
Hatching success[d]	0.50 ±0.15	0.74 ±0.08	0.59 ±0.07	0.89±0.06[g]
Fledging success[e]	0.15 ±0.15	0.13 ±0.04	0.64 ±0.13	0.74±0.09
Productivity[f]	0.07 ±0.08	0.10 ±0.04	0.38 ±0.09	0.66±0.1
Thick-billed murres				
Total eggs laid	20	43	21	29
Total chicks	4	15	15	21
Total chicks fledged	1	2	10	15
Hatching success	0.20 ±0.54	0.42 ±2.12	0.71 ±0.40	0.72±0.6
Fledging success	0.25 ±2.58	0.13 ±1.03	0.67 ±0.56	0.71±0.5
Productivity	0.05 ±0.42	0.06 ±0.54	0.48 ±0.65	0.52±0.8

[a] Three sequential incubating postures was considered equal to one egg, as per 1990 Conventions (Appendix II)

[b] One brooding posture observed was considered equivalent to one chick, as per 1990 Conventions (Appendix II)

[c] Chicks were presumed to have successfully fledged if observed a minimum of 15 days prior to disappearance, as per 1990 Conventions (Appendix II)

[d] Chicks observed/eggs laid

[e] Chicks fledged/chicks hatched

[f] Chicks fledged/eggs laid

[g] Data expressed as means ± 90% confidence bounds

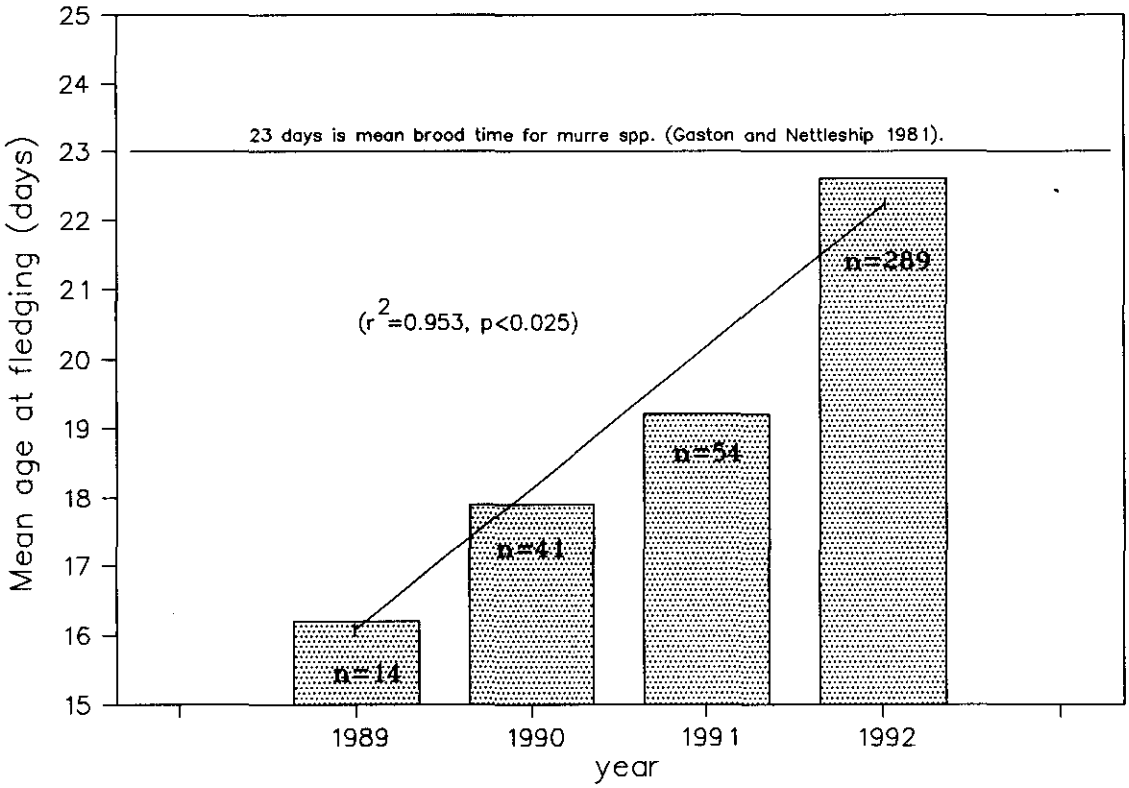

Fig 8. Mean age of fledged murre chicks (common and thick-billed combined), Colony 013, Puale Bay, Becharof National Wildlife Refuge, Alaska Peninsula, Alaska, 1989-1992.

(Dewhurst 1991) with the formation of murre chick creches. Recent studies (Harris et al. 1992) have also demonstrated that a delay in reproductive timing of only 3 weeks could create a significant decline in chick post-fledging survival. Thus, the late phenology, shorter brood times, and possible decreased post-fledging survival validates calling the low reproductive efforts negligible at Puale Bay during 1989 and 1990 (Table 3). This also emphasizes the significance of the 1-2 week shift earlier in breeding phenologies during 1992, yielding higher production levels and higher potential recruitment into the population (Table 3).

Productivity.-- Reproductive performance was monitored on 10 mixed species (common and thick-billed murres) plots at Puale Bay. Hatching success, fledging success and productivity increased from 1991 to 1992 (Table 3). Productivity at Puale Bay was for the second time in this study (1991 and 1992), comparable to that previously reported in the Semidi Islands and the Alaska average for murres - 50% (Dragoo and Bain 1990, Byrd et al. In Press). The increase in productivity from 1989 to 1992 was found to be significant for both common (Fig. 9) ($p<0.025$) and thick-billed (Fig. 10) ($p<0.05$) murres. This increasing trend would likely be expected to level off in the near future.

Black-legged Kittiwakes

Colony Populations.-- Prior to the oil spill, the kittiwake colony at Jute Peak (005) was censused in 1976 (Sowls et al. 1978) and in 1981 (Bailey and Faust 1984). In 1992, replicative surveys were conducted on 29 July and again on 26 August, concurrent with the murre counts. Kittiwake nesting areas were delineated by their relation to the murre productivity plots. The population had a mean of 883 in 1992 demonstrating a slight decrease in adult birds from 1991 (Table 1). However, no significant difference was found to exist between pre- and post-oil spill counts of adult kittiwakes at this colony (Nysewander and Dippel 1991). In 1989, the kittiwakes nested only on Plot 21, in 1990, they expanded to Plots 21, 11, and 10, and in 1991, they shifted slightly to Plots 21, 11 and 12 (Appendix I). Only those kittiwakes in Plot 21 were counted in 1992 due to weather and maneuvering limitations involved with conducting counts from a small inflatable boat. This likely accounts for the slightly lower number of kittiwakes counted this year.

Productivity.-- Productivity monitoring over the breeding season was not possible for the Jute Peak kittiwake colony due to the lack of land-based access. Nests and chicks were present during the population count conducted on 29 July, but conditions did not allow for an accurate census.

Cormorants (Red-faced, Pelagic, and Double-crested)

Colony Populations.-- In 1992, the only nesting cormorants were found in Puale Bay (013) with all 3 species present. Cormorants were seen throughout the colony during boat-based population counts with the majority found in population Plots 3, 6, 4, 9, 10, above Plot 15, and the new Plot 21 (Appendix IV). Eighty-three cormorant nests were recorded from boat-based surveys, while only 34 nests were visible from land-based observation points. Of the 34 nests where productivity was monitored, species composition included 47% red-faced, 26.5% pelagic and 26.5% double-crested. No apparent pattern was

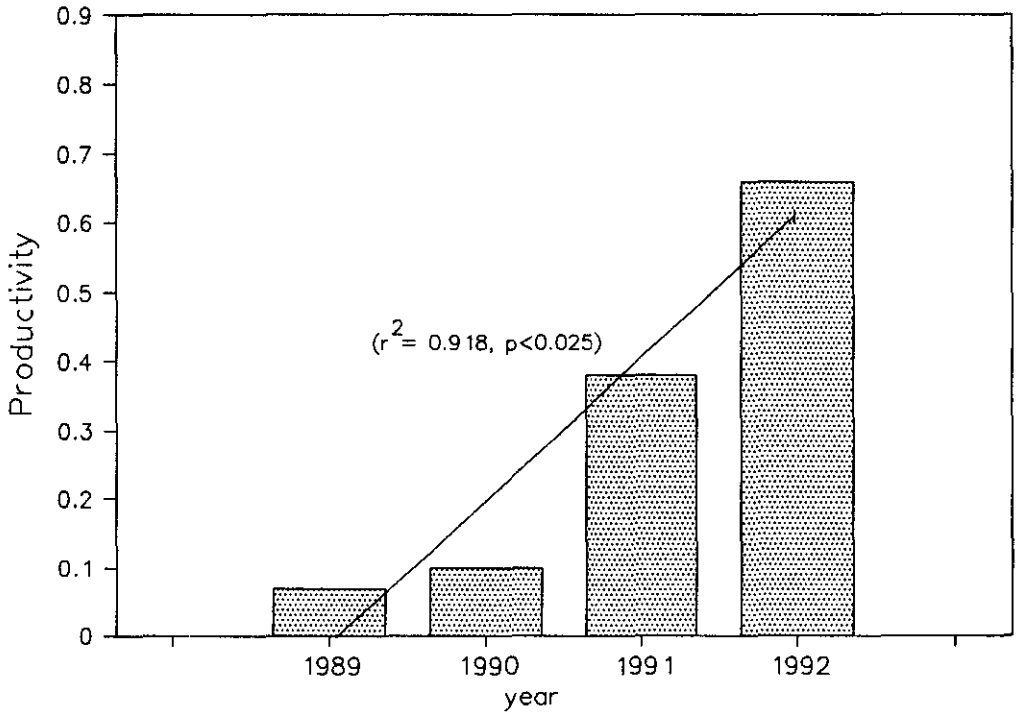

Fig 9. Common murre productivity, Colony 013, Puale Bay, Becharof National Wildlife Refuge, Alaska Peninsula, Alaska, 1989–1992.

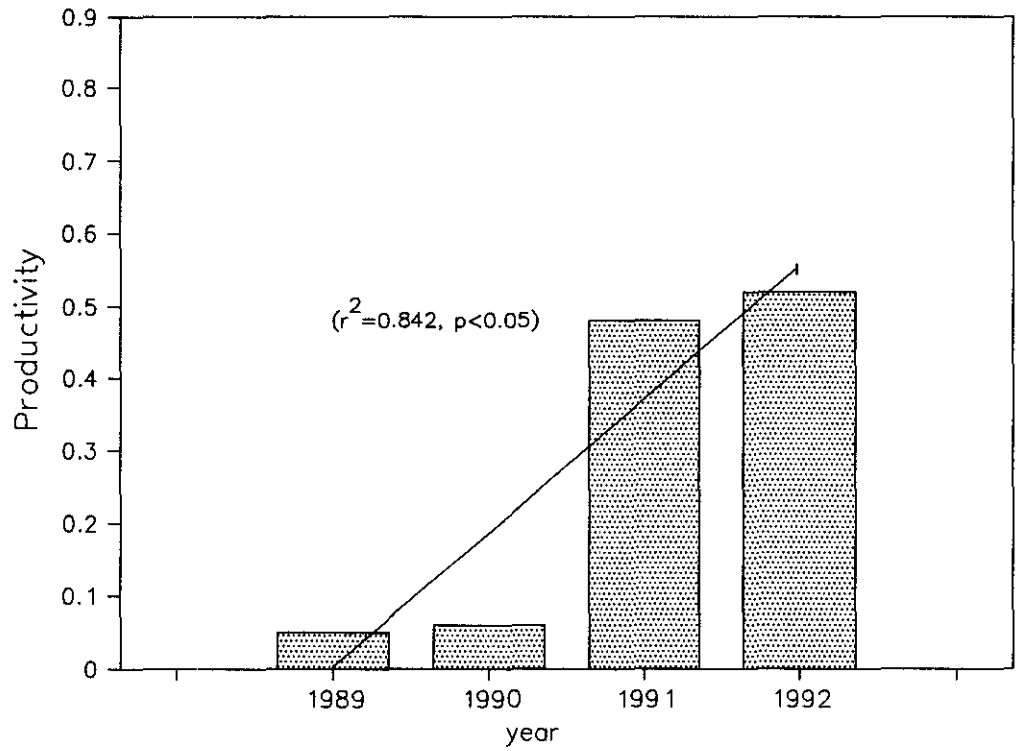

Fig 10. Thick–billed murre productivity, Colony 013, Puale Bay, Becharof National Wildlife Refuge, Alaska Peninsula, Alaska, 1989–1992.

observed for species distribution among the colony groups. No sign of current activity was noted for the large red-faced cormorant colony north of the murre cliff face, which was abandoned in 1991. The nests monitored for productivity this year were on the same face of the colony as the murre productivity plots (Appendix IV).

Phenology.-- Cormorant productivity plots were initially established on 7 July, with new plots discovered on 5 August after most of the cormorants had built nests. Four plots consisting of groups of nests were established this year. Cormorant fledging was documented for the first time in this 4-year study, providing the only complete look at local reproductive phenologies. However, sample sizes were small for calculations of brooding times and fledging dates (Table 4).

Nest contents of cormorants were very difficult to observe during the incubation period. Cormorants usually remained standing until eggs were laid and then sat tightly down over the nest. This change in behavior may be one way to estimate lay dates, when eggs are not directly observed (L. Haggblom, Togiak National Wildlife Refuge, Dillingham, pers. commun.). Puale Bay nests were below and to the side of observers and 0.9-38 m (3-125 ft.) away which allowed excellent observation, but unfortunately several of the nests were not discovered until after eggs were laid. In these cases, lay dates were back-calculated from known hatch dates using the given averages of 31 days for red-faced (Hunt et al. 1980), 28-32 days for pelagic (Dick 1975), and 28 days for double-crested (Van Tets 1959) cormorants.

Hatch dates were more easily distinguished. Incubating adults would act very agitated once the chicks hatched. Brooding behaviors noted included wing mantling, shifting body positions on the nest frequently (approximately every 1-2 minutes), and repeatedly putting their head under their body or wing. Chicks appeared very active and frequently would be seen moving as the parent shifted positions. Initial observation of chicks usually did not allow determination of how many chicks were present because of their constant motion and small size. Also, parents were very quick to tuck the chicks back under their wings. Chick feeding by regurgitation was easy to observe but often did not help determine the number of chicks in the nests. On several occasions one chick was observed to be fed several times before the adult fed others.

Fledge dates were observed for all 3 species. Calculations of fledge dates using mean brood time from the literature (Drent et al. 1964, Dick 1975) were not done because of the differences found between literature brood times and those recorded at Puale Bay.

Red-faced cormorants.--Sixteen nests were observed at Colony 013 which was the lowest land-based nest count of the four years; however, this is the first year that red-faced cormorants did not abandon this colony (Table 4). Red-faced cormorants have initiated nests in mid- to late June every year in the Puale Bay area since the oil spill, but were only successful at Cape Aklek (Colony 008) in 1989 and this year at Colony 013 (Table 5). In 1987, the first chicks were observed on 27 July, and assumed to be 1-2 weeks old at the time of observation (Dewhurst 1991). This would put the 1992 Puale birds 2-3 weeks later in chick hatching than in 1989. However, in either case the reproductive phenology of red-faced cormorants in the Puale area was still

Table 4. Phenology of red-faced, pelagic, and double-crested cormorants, Colony 013, Puale Bay, Alaska Peninsula, Alaska, 1992.

	Red-Faced	Pelagic	Double-Crested
Laying			
First laying date	7/5	7/5	6/27
Mean date[a]	7/15 (6.0)	7/12 (6.9)	7/8 (6.4)[b]
Last laying date	8/5	7/20	8/1
Sample size[c]	21	10	27
Hatching[d]			
First hatching date	8/5	8/5	7/27
Mean date	8/18 (4.9)	8/12 (4.6)	8/12 (5.1)
Last hatching date	9/5	8/19	8/19
Sample size	21	10	18
Mean Incubation time[f]	27(4.1,n=5)	29(0,n=1)	29(0,n=1)
Fledging[e]			
First fledge date	9/9	9/5	9/5
Mean date	9/14 (3.2)	9/13 (4.1)	9/15 (3.6)
Sample size	11	8	11
Mean Brood time[g]	28(5.0,n=5)	34(5.1,n=3)	45(5.8,n=11)

[a] When not known, lay dates were back-calculated from hatch dates using the conventions of incubation time; RFCO 31 days (Hunt 1979), PECO 28-32 days (Haggblom pers. comm.), DCCO 28 days (Van Tets 1959).

[b] Numbers in parentheses represent 90% Confidence Bounds in # days

[c] Sum of observed eggs seen and those inferred from observed chicks.

[d] Only eggs with known hatch dates used.

[e] Only actual fledge dates were used. Average brood times given in literature for each species were not used to calculate fledge dates due to the differences seen in observed brood times and these averages.

[f] Mean incubation time (days) is calculated only from eggs with known lay and hatch dates. The values in parentheses are the 90% confidence interval followed by the number of eggs with known lay and hatch dates.

[g] Mean brood time (days) is calculated only from chicks with known hatch and fledge dates. The values in parentheses are the 90% confidence interval followed by the number of chicks with known hatch and fledge dates.

Table 5. Reproductive success of red-faced, pelagic, and double-crested cormorants, Colony 008, Cape Aklek, Alaska Peninsula, Alaska, 1989-1992.

Cape Aklek (008)

	Red-Faced				Pelagic				Double-Crested			
	1989	1990	1991	1992	1989	1990	1991	1992	1989	1990	1991	1992
Total Nests	327	271	0	0	11	3	0	0	0	0	0	0
Abandoned Nests	220	271	0	0	7	3	0	0	0	0	0	0
Eggs Observed	27	0	0	0	0	0	0	0	0	0	0	0
Chicks- Downy	147	0	0	0	8	0	0	0	0	0	0	0
Chicks- Feathered	106	0	0	0	6	0	0	0	0	0	0	0
Nesting Success[a]	0.4±0.23	0	0	0	0.4±0.30	0	0	0	0	0	0	0
Fledging Success[b]	1.1±0.77	0	0	0	1.5±2.01	0	0	0	0	0	0	0
Productivity[c]	0.4±0.36	0	0	0	0.6±0.44	0	0	0	0	0	0	0

[a] Nests with fledgings/total nests, with data expressed as means ± 90% confidence intervals (CI).

[b] Mean number of fledgings/nest with chicks ± 90% CI.

[c] Mean number of fledglings/total nests ± 90% CI.

1.5-2 months later than reported for St. Paul Island in the Pribilofs (Byrd 1986). Despite occurring later, the incubation periods (23-31 days) remained similar to that of the Pribilofs (31 days) (Hunt et al. 1980). Incubation periods were calculated using only those eggs with known lay and hatch dates so the sample size was small (n=5) (Table 4).

The unusually short brooding period (28 days - Table 4) recorded for red-faced cormorants in Puale Bay this year, created difficulties in comparing the overall 1992 reproductive phenology to that recorded in 1989. In 1989, chicks were produced in mid- to late July, yet were not observed fledging by the study's end on 21 August (Dewhurst 1991). While in 1992, chicks were produced in mid-August and fledging by mid-September (Table 4), suggesting a later but shorter chick rearing period. Typical brooding times for red-faced cormorants in British Columbia were 2 times longer (59 days - Drent et al. 1964), further suggesting that this year's shorter brooding period was non-typical. However, the observed sample size was very low (n=5), representing <25% of the feathered chicks. Since only chicks actually documented flying from the nests by 20 September were used, the 28 day mean likely represents only the beginning of fledging. Therefore, the estimated overall brood period would be longer than 28 days, by some additional unknown amount. As a side note, first time fledglings were observed to circle for approximately 5 to 7 minutes and then land back at the nest. The adults were usually absent from the nest when fledging was observed.

Pelagic cormorants.-- Pelagic cormorants only nested at Colony 013 this year with a total of 9 nests observed. Pelagics were also seen at Puale Bay in 1989 and 1991, but were only previously successful in 1989 (Table 6). In 1992, the timing of reproductive events for pelagic cormorants closely paralleled that of 1989, with chick hatching in early August. Because of a change in red-faced cormorant timing, the pelagics were 2 weeks later than red-faced in 1989, but almost synchronous in 1992. Throughout the study, the pelagics at Puale Bay consistently reared young 4-6 weeks later than documented on Middleton Island and Cape Peirce, where chick hatching was generally concluded by mid-July (Hatch et al. 1979, Mendenhall 1991).

The mean incubation period was calculated to be 29 days. This was calculated from only one egg with a known lay and hatch date (Table 4). This was comparable to the known incubation period of 28-32 days (Dick 1975).

Like with the red-faced cormorants, brood period calculations were based on small sample sizes representing only the earliest contingent of the pelagic cormorant fledglings at Puale Bay. Only 3 chicks with known hatch and fledge dates, each from different nests, were used to calculate the brooding period. This early brooding period of 29-39 days was still substantially shorter than the 42-58 days documented at Cape Peirce (Dick 1975) (Table 4). By fledging at a younger age, the Puale pelagic chicks fledged only 34 days earlier than Cape Peirce, shortening the gap between the timing. As a side note, the possibility of chicks walking between nests rather than fledging was ruled out since all the nests were isolated on individual ledges. Although first fledging was not directly observed, periodic absences from the nest could only be explained by the chicks flying and returning.

Table 6. Reproductive success of red-faced, pelagic, and double-crested cormorants, Colony 013, Puale Bay, Alaska Peninsula, Alaska, 1989-1992.

Puale Bay (013)[a]

	Red-Faced				Pelagic				Double-Crested			
	1989	1990	1991	1992	1989	1990	1991	1992	1989	1990	1991	1992
Total Nests	47	196[b]	85	16	6	0	2	9	4[g]	14	0	9
Abandoned Nests	47	196	85	2	4	0	2	2	0	10	0	0
Eggs Observed	44	0	0	4	4	0	0	6	0	11	0	5
Chicks- Downy	0	0	0	22	6	0	0	9	13	7	0	16
Chicks- Feathered	0	0	0	28	4	0	0	17	10[c]	6	0	29[c]
Nesting Success[d]	0	0	0	0.7±0.2	0.3	0	0	0.8±0.3	1.0	0.3	0	0.9±0.2
Fledging Success[e]	0	0	0	1.8±1.8	2.0	0	0	2.4±1.9	2.5	1.5	0	2.8±2.0
Productivity[f]	0	0	0	1.6±1.9	0.7	0	0	1.9±2.2	2.5	0.4	0	2.8±2.0

[a] All counts presented in this table represent only those nests and birds that could be observed from land-based observation points, and do not necessarily reflect the colony totals.

[b] Number represents the count of individual birds observed, not nests. The cormorants did appear to be actively nesting with fresh nesting material deposited.

[c] One nest of 3 chicks was last observed in late September with small downy young... fledging potential was unknown, hence success at fledging was not assumed. Chicks were not included in this total.

[d] Nests with fledgings/total nests, with data expressed as means ± 90% confidence interval (CI).

[e] Mean number of fledglings/nest with chicks ± 90% CI.

[f] Mean number of fledglings/total nests ± 90% CI.

[g] Nests were not discovered until 13 August and already possessed chicks, so the actual number of nests initiated was unknown.

Double-crested cormorants.-- After missing last year, the double-crested cormorants returned to Puale Bay (Colony 013) to nest in 1992 with a total of 9 nests observed. The reproductive phenology beginning in early July (Table 4) paralleled that recorded for 1989, but was 2 weeks earlier than in 1990 likely due to renesting that year. The 1992 incubation period of 29 days (Table 4) was very comparable to the documented average of 28 days recorded in British Columbia (Van Tets 1959). The mean brooding period of 39-50 days (n=11) was also comparable to known averages of 35-42 days (Drent et al. 1964) (Table 4). Brood periods were also calculated using only those chicks with known hatch and fledge dates, causing the small sample size.

Productivity Comparison.-- Productivity of all 3 species was the highest ever seen at Puale Bay, although with such few nests, eggs, and chicks observed, the 90% confidence limits associated with reproductive success were very large (Table 6).

Double-crested cormorants showed the highest productivity with 2.8 fledglings/nest. Productivity from other colonies could not be found for comparison, although if we compare the fledging success (chicks fledged/nests with eggs) of Puale Bay with the average fledging success of 0.82 chicks fledged/nests with eggs from 1982 to 1985 found at Lake Louis and Skilak Lake (Trapp et al. 1986), Puale Bay's fledging success was higher.

Pelagic cormorants had 1.9 fledglings/nest which was higher than the average productivity of 0.90 found at Middleton Island from 1982 to 1991 (Scott Hatch, Alaska Fish and Wildlife Research Center, pers. commun.). This year's productivity was also higher than that found for pelagic cormorants which produced successful fledglings at Puale Bay in 1989 (Table 6).

Red-faced cormorants had 1.6 fledglings/nest which was higher than the average productivity of 0.27 found for red-faced cormorants found on Agattu Island (Byrd et al. 1989b). This was the first year in the 4 years of monitoring at Puale Bay that red-faced cormorants successfully fledged chicks.

Strong conclusions about cormorant productivity were not possible this year because of the low number of nests, eggs, and chicks observed. These low numbers translated into large confidence intervals for nesting success, fledging success and productivity.

CONCLUSIONS AND MANAGEMENT RECOMMENDATIONS

At the present time, no funding was approved to continue the Puale Bay seabird study in 1993. Some oil spill restoration funds may be available to conduct some smaller scale surveys in 1994, and after that...? Murres appear to be on the road to recovery in the Puale Bay area colonies. Productivity has steadily increased since 1989, with an earlier reproductive phenology and longer chick brooding prior to fledging. However, timing of murre reproduction was still weeks later than similar colonies in Alaska. Cormorant colony attendance was too variable over the study period to determine any population trends, but good productivity was recorded in 1992. The black-legged kittiwake population at Jute Peak (Colony 005) has remained relatively

constant and has expanded into new sections of the colony cliffs. Yet no work was ever accomplished on kittiwake productivity. Continuing population and productivity monitoring will be essential to evaluate the long term effects of the oil spill to these populations. Given the declining budget situation, recommended priorities for future studies should include:

1. Population counts (murres, kittiwakes, cormorants) of the entire colonies (005, 008, 013) conducted on an annual basis as frequently as possible, and

2. Murre productivity monitoring (June-September) of the established plots in Colony 013 (Puale Bay) should be on a 5-year cycle, with monitoring conducted during the first 2 consecutive summers of each cycle. Monitoring years would be: 1991, 1992, 1996, 1997, 2001, 2002... Monitoring over 2 consecutive summers is recommended to test annual fluctuations against long term trends.

Long term agreements should be pursued to conduct the colony population surveys cooperatively using existing Service motor vessels for logistical support to prevent the high cost of chartering vessels. Current Service vessels include: M/V *Ursa Major II* - Kodiak Refuge, Kodiak; M/V *Tiglax* - Alaska Maritime Refuge, Homer; M/V *Surfbird* - Raptor Management Office, Juneau; and M/V *Curlew* - Ecological Services, Juneau.

Cost reductions would be difficult to propose for future murre productivity monitoring at Puale Bay, without compromising safety or building a cabin. The camp's location in an area of high brown bear densities and frequent adverse weather (fog, high winds, sideways rain) dictates use of specialized safety equipment such as weatherports, electric fence, bear barrels, burn barrel and firearms. If Puale Bay monitoring is planned long term for the future, a cost analysis should be explored on the feasibility of constructing an administrative cabin on the current camp site. Being in a designated National Wilderness Area would create restrictions on cabin construction, but not eliminate its possibility. Current construction costs for a Panabode-type cabin run around $85,000. The annual budget for the Puale Bay Field Camp was $60-70,000 for 4 years (1989 - 1992), totaling $260,000. With a cabin in place, costs for personnel, food, supplies, and travel per field season would reduce to $20,000. In the long run, cabin construction would pay for itself in less than 2 field seasons.

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APPENDICES

Appendix I. Seabird estimates and actual counts for Colony 013a, Becharof National Wildlife Refuge, Puale Bay, Alaska Peninsula, Alaska, 1989-1992.

Date	Total Estimate					Method[b]	Observers
	COMU[a]	UNCO	HOPU	TUPU	GWGU		
7/08/89	1297	157	0	22	100	C/I	Marzicola/Bassett
7/21/89	1585	168	3	31	131	C/I	Marzicola/Cassily
7/25/89	1955	138	9	37	127	C/I	Marzicola/Cassily
7/25/89	2000	150	-	-	150	E/F	Dewhurst
8/14/89	1187	113	10	7	147	C/I	Bassett/Howard/Mumma
1989 av	1604	145	5	24	131		
7/15/90	1878	63	17	38	127	C/I	Thomson/Schwartz
7/25/90	2811	55	1	34	202	C/I	Thomson/Stahl
8/02/90	1532	-	7	5	109	C/V	Dewhurst/Schwartz/ Dippel/Simoniello
9/01/90	1877	38	12	21	69	C/I	Thomson/Simoniello
1990 av	2024	52	9	24	126		
8/08/91	2739	123	3	69	-	C/V	Dewhurst/Dippel/ Nysewander/Burke/ Snetsinger/McCarthy
8/19/91	2422	116	-	-	-	C/I	Burke/Snetsinger
9/04/91	2284	-	-	-	-	C/I	McCarthy/Moore/Burke
1991 av	2482	120	3	69	-		
8/01/92	1835	-	8	7	74	C/I	McCarthy/Dewhurst/ Boden
8/13/92	2166	83	26	11	120	C/I	McCarthy/Benjamin
1992 av	2000	83	17	9	97		

[a] COMU - common and thick-billed murres
UNCO - unknown cormorants (pelagic, red-faced, double-crested)
HOPU - horned puffins
TUPU - tufted Puffins
GWGU - glacous-winged gulls

[b] Survey Methods:
C - actual count using plots
E - estimate
I - via inflatable boat
V - via motor vessel
F - via fixed-wing aircraft
H - via helicopter

Appendix I (Continued). Seabird estimates and actual counts for Colony 013b, Becharof National Wildlife Refuge, Puale Bay, Alaska Peninsula, Alaska, 1989-1992.

Date	Total Estimate					Method[b]	Observers
	COMU[a]	UNCO	HOPU	TUPU	GWGU		
7/25/89	400	-	-	-	-	E/F	Dewhurst
8/02/90	780[c]	-	0	-	0	C/V	Dewhurst/Schwartz/ Dippel/Simoniello
8/08/91	498	-	-	-	-	C/V	Dewhurst/Dippel/ Nysewander/Burke/ Snetsinger/McCarthy
8/01/92	460	-	4	2	15	C/I	McCarthy/Dewhurst/ Boden
8/13/92	390	-	-	-	-	C/I	McCarthy/Benjamin
1992 av	425	-	4	2	15		

[a] COMU - common and thick-billed murres
UNCO - unknown cormorants (pelagic, red-faced, double-crested)
HOPU - horned puffins
TUPU - tufted Puffins
GWGU - glacous-winged gulls

[b] Survey Methods:
C - actual count using plots
E - estimate
I - via inflatable boat
V - via motor vessel
F - via fixed-wing aircraft
H - via helicopter

[c] Murres were not consistently on the cliffs and were speculated to be non-breeders.

Appendix I (Continued). Murre counts for Colony 005, Jute Peak, Becharof National Wildlife Refuge, Alaska Peninsula, Alaska, 1989-1992.

Dates :	7/21/89[b]	8/18/89[a]	8/03/90[a]	8/18/90[b]	8/12/91[a]	7/29/92[b]	8/26/92[b]
Plot #	# Murres						
1	454	18	17	25	20	23	13
2	538	389	260	628	466	510	362
3	299	926	370	712	660	330	446
4	542	786	1435	905	909	1335	697
5	1193	974	910	1693	716	1095	920
6	343	419	333	310	217	490	132
7	546	638	244	252		805	186
8	551	393	730	1203	1036	605	875
9		990	850	920	606		
10		540	1095	1043	759		
11		737	390	375	419		
12		1094	740	1670			
13		793	1375	885	2395		
14		430	395		566		
15		715	479		770		
16		248	154		158		
17		734	385		1083		
18		405	500				
19		512	990		1263		
20		1458	1484		1473		
21		1047	1360		858	1205	1135
Total	4466[c]	14246	14496	10621[c]	14374	6398[c]	4766[c]

[a] Counts were conducted from the M/V Surfbird by the following observers:
8/18/89 - D. Dewhurst, D. Rudis, D. Williamson, D.Bassett
8/03/90 - D. Dewhurst, C. Dippel, C. Simoniello, L. Schwartz
8/12/91 - D. Dewhurst, D. Nysewander, C. Dippel, J. McCarthy, T. Burke, C. Snetsinger

[b] Counts were conducted from an inflatable boat by the following observers:
7/21/89 - G. Thomson, Z. Peters, H. Sexauer
8/18/90 - G. Thomson, B. Stahl
7/29/92 - J. McCarthy, D. Dewhurst, N. Benjamin
8/26/92 - J. McCarthy, K. Boden, N. Benjamin

[c] Only partial counts of the colony.

Appendix I (Continued). Kittiwake counts for Colony 005, Jute Peak, Becharof National Wildlife Refuge, Alaska Peninsula, Alaska, 1989-1992.

	8/18/89[a]	8/03/90[a]	8/12/91[c]	7/29/92[b]	8/26/92[b c]
Plot	Adult/Nests	Adult/Nests	Adult/Nests	Adult/Nests	Adult/Nests
1	0/0	0/0	0/0	0/0	0/0
2	0/0	0/0	0/0	0/0	0/0
3	0/0	0/0	0/0	0/0	0/0
4	0/0	0/0	0/0	0/0	0/0
5	0/0	0/0	0/0	0/0	0/0
6	0/0	0/0	0/0	0/0	0/0
7	0/0	0/0	0/0	0/0	0/0
8	0/0	0/0	0/0	0/0	0/0
9	0/0	0/0	0/0	-	-
10	0/0	0/0	0/0	-	-
11	0/0	53/19	50/0	-	-
12	0/0	79/19	82/0	-	-
13	0/0	0/0	0/0	-	-
14	0/0	0/0	0/0	-	-
15	0/0	0/0	0/0	-	-
16	0/0	0/0	0/0	-	-
17	0/0	0/0	0/0	-	-
18	0/0	0/0	0/0	-	-
19	0/0	0/0	0/0	-	-
20	0/0	0/0	0/0	-	-
21a	39/0	68/17	85/0	-	-
21b	859/0	1088/414	1109/0	1078/334	688/-
Total	898/0	1288[d]/469[e]	1326/0	1078/334	688/-

[a] Counts were conducted from the M/V Surfbird by the following observers:
8/18/89 - D. Dewhurst, D. Rudis, D. Williamson, D. Bassett
8/03/90 - D. Dewhurst, C. Dippel, C. Simoniello, L. Schwartz
8/12/91 - D. Dewhurst, C. Dippel, D. Nysewander, J. McCarthy, T. Burke, C. Snetsinger

[b] Counts were conducted from Inflatable boat by the following observers:
7/29/92 - J. McCarthy, D. Dewhurst, N. Benjamin
8/26/92 - J. McCarthy, K. Boden, N. Benjamin

[c] Nests were not counted. Only plots 1-8 and plot 21 were surveyed.

[d] No active nests were visible, only the washed remains of old (1989?) nests.

[e] No chicks were observed.

Appendix I (Continued). Murre counts for Colony 008, Cape Aklek, Becharof National Wildlife Refuge, Alaska Peninsula, Alaska, 1989-1992.

Dates:	8/20/89[a]	8/02/90[a]	8/04/90[a]	8/10/91[a]	7/30/92[b]
Plot #			# Murres		
1	1915	1970	1925	2496	2025
2	1087	670	1015	1086	1995
3	317	31	224	170	175
4	914	770	505	560	390
5	543	340	345	317	400
6	620	670	535	2102	1415
7	600	1363	870	387	2080
8	740	510	500	2133	510
9	405	385	420	310	255
10	220	430	570	307	720
11	640	1230	1305		2255
12	2720	1670	1845	2096	1805
13	1605	303	375	354	845
14	1740	1670	1660	1600	560
15	2037	1743	1810	2005	2070
16	1610	1635	1505	1647	1073
17	2102	930	1030	1135	1173
18	385	280	320	204	250
19	230	305	276	179	275
Total	20430	16905	17035	19088	20271

[a] Counts were conducted from the M/V Surfbird by the following observers:
8/20/89 - D. Dewhurst, D. Rudis, D. Williamson
8/02/90 - D. Dewhurst, C. Dippel, C. Simoniello, L. Schwartz
8/04/90 - D. Dewhurst, C. Dippel, C. Simoniello, L. Schwartz
8/10/91 - D. Dewhurst, C. Dippel, D. Nysewander, T. Burke, J. McCarthy, C. Snetsinger

[b] Counts were conducted from inflatable boat by the following observers:
7/30/92 - J. McCarthy, D. Dewhurst

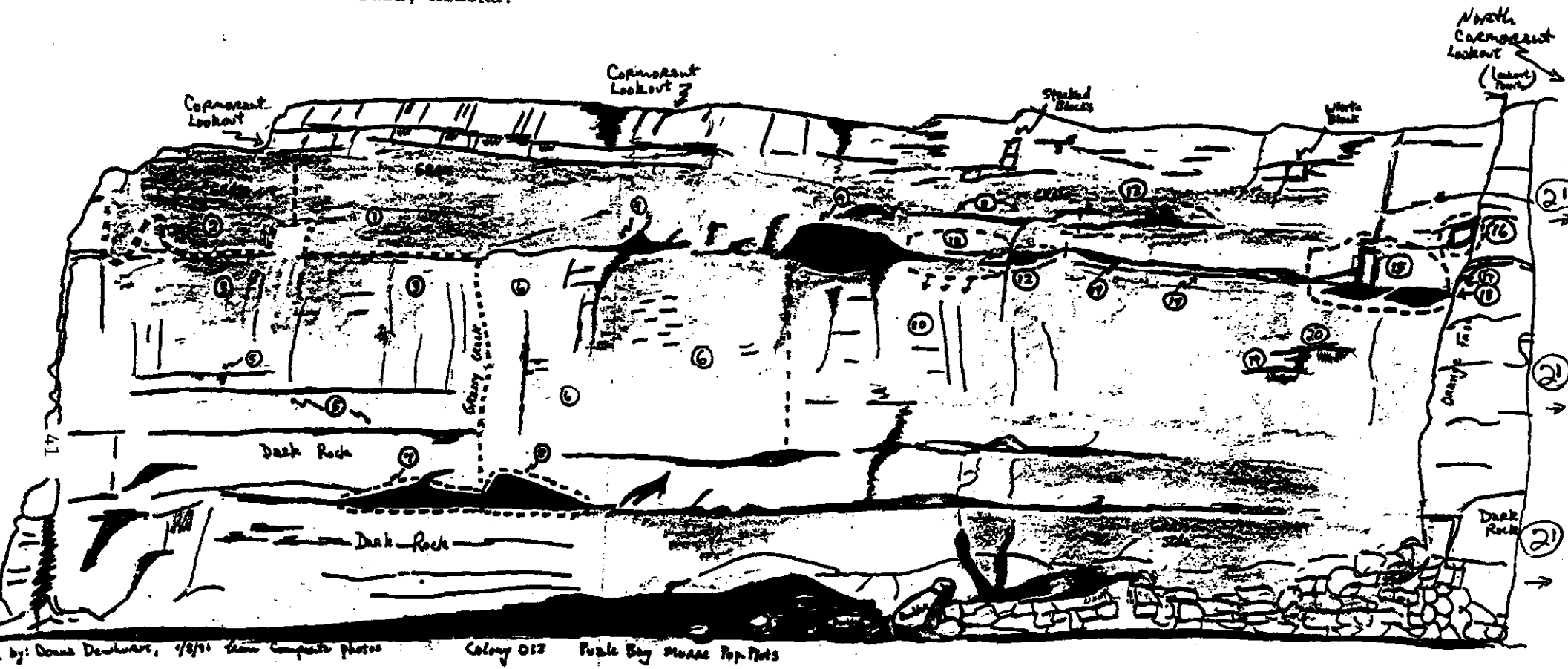
Appendix II. Comparison of 1992 plot names with those names used for the same plots in previous years (1989-1991) at Colony 013, Puale Bay, Becharof National Wildlife Refuge, Alaska Peninsula, Alaska, 1989-1992.

Year			
1989	1990	1991	1992
A+A'	A+A'	A+A'	A+A'
B	B	B	B
C	C	C	C
D1,D2,D3,D4,D5	D1,D2,D3,D4,D5	D	D
lower D1	lower D1	D'	D'
E1,E2,E3	E1,E2,E3	E	E
E4	E4	E'	E'
F1,F2	F1,F2	F	F
G1	G1	G	G+G1
G2	G2	G	G2
G3	G3	G	G3
Y up,Y low	Y up, Y low	Y	Y
-	-	-	Y'[a]
-	-	-	X[a]
-	-	-	Q[a]
Z[b]	-	-	-

[a] New productivity plots established in 1992.

[b] Ledge system holding plot Z collapsed during the winter of 1989-90.

Appendix III. Identifiable stages of murre chick development (Biderman et al. 1978).

Age (days)	
1-8	1. Uniformly leaden color with speckles of white on the head and neck, chick does not raise its head.
	2. Salt and pepper appearance, chick raises its head and stands up.
9-18	3. White chin, "cheeks" still "salt and pepper".
	4. White chin, half-moon white cheeks, stands beside parent, peeps frequently when fed.
	5. Gives ringing double note associated with jumping.

Appendix IV. Population plots for Colony 013, Puale Bay, Becharof National Wildlife Refuge, Alaska Peninsula, Alaska.