Nesting Ecology and Survival of the Pacific Common Eider (*Somateria mollissima v-nigra*) in Central Arctic Canada.

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Technical Report Series Number 471
Date of publication 2007

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Catalogue number CW69-5/471E
ISBN 0-662-44683-5

PCSP/ÉPCP #040-06

This report may be cited as:

Hoover, A. K., and D. L. Dickson. 2007. Nesting Ecology and Annual Survival of Pacific Common Eiders (*Somateria mollissima v-nigra*) in Central Arctic Canada. Technical Report Series 471, Canadian Wildlife Service, Edmonton, Alberta.

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ABSTRACT

We studied annual adult survival rate and nesting ecology of Pacific Common Eiders in a core breeding area within the Kitikmeot Region of Nunavut from 2001-2005. Population monitoring efforts indicated a dramatic decline in the Canadian breeding population of Pacific Common Eiders by more than 50% between 1976 and 1996. Reasons for the decline are largely unknown, primarily due to our lack of knowledge of this subspecies. We captured and banded 562 eiders (253 females and 309 males) over the five year period in mid to late June at a location on Nauyak Lake where eiders move between a nesting colony on the lake and a feeding location at an adjacent marine habitat during the pre and early nesting period. Annual adult female survival based on rate of recapture and resighting bands from a nesting island on Nauyak Lake averaged 73% over a four year period (0.78 ±0.07, 2001; 0.75 ±0.06, 2002; 0.72 ±0.05, 2003; and 0.71 ±0.07, 2004). We conducted nest searches in all years from late June to mid August at both the nesting colony at Nauyak Lake, and 23 islands in the adjacent marine environment. The number of females that attempted to nest in the study area each year ranged from about 1000 to 1300 eiders, with the greatest number of females attempting to nest in 2003 and 2005. For all years combined, mean clutch size for marine nesting areas was 3.58 ±0.04 (n=1741) and for Nauyak Lake nesting area was 4.46 ±0.06 (n=1628). Mayfield nest success estimates ranged from 48.8-69.0% at the freshwater colony, and 13.9-43.3% at the marine nesting colonies. Nest success was greater at the freshwater colony in all years, and nest success increased similarly between the freshwater and marine colonies from 2001-2005. Median nest initiation dates were fairly constant among years (26 June-1 July, freshwater colony; 2-9 July, marine colonies), and in all years the majority of nests were initiated prior to ocean ice break-up (generally in mid July). Earliest nest initiation dates occurred in 2005, the year with the warmest June temperatures. We used body size measurements and weight of captured eiders to assess spring body condition, and found no difference in early nesting body condition among years for either females or males. We investigated factors influencing nest success and found predation to be the overwhelming cause of nest failure at both nesting areas. Mammalian predators caused more complete clutch loss and complete destruction of all nests on an island than avian predators. Our results contribute valuable, and to date, unmeasured rates of fundamental parameters of population dynamics.

RÉSUMÉ

Nous avons étudié le taux de survie annuelle des adultes et l'écologie de nidification de l'Eider à duvet du Pacifique dans une aire de reproduction principale située dans la région Kitikmeot (Nunavut), de 2001 à 2005. Le suivi des populations indique un sérieux déclin (plus de 50 p. 100) de la population reproductrice d'Eider à duvet du Pacifique entre 1976 et 1996. Les raisons de ce déclin sont très peu connues, principalement en raison de notre manque de connaissances en ce qui concerne cette sous-espèce. Entre 2001 et 2005, nous avons capturé et bagué 562 eiders (253 femelles et 309 mâles) pendant les deux dernières semaines de juin à un emplacement du lac Nauyak où les eiders se déplacent entre une colonie de nidification sur le lac et un lieu d'alimentation situé dans un habitat marin adjacent avant et au début de la période de nidification. La survie annuelle des femelles adultes, selon un taux de recapture et d'observation avec relevé de bagues de l'île de nidification sur le lac Nauyak, était en moyenne de 73 p. 100 sur une période de quatre ans (0,78 ±0,07, 2001; 0,75 ±0,06, 2002; 0,72 ±0,05, 2003 et 0,71 ±0,07, 2004). Nous avons recherché des nids chaque année, de la fin juin à la mi-août dans la colonie de nidification du lac Nauyak et sur les 23 îles du milieu marin environnant. Chaque année, le nombre de femelles qui ont tenté de nicher dans l'aire d'étude variait entre 1000 et 1300 eiders, le plus grand nombre ayant été observé en 2003 et en 2005. Pour l'ensemble de ces années, la taille de ponte (nombre d'œufs) moyenne pour les aires de nidification marines était de 3,58 ±0,04 (n=1741) et de 4,46 ±0,06 (n=1628) pour l'aire de nidification du lac Nauyak. Les estimations du succès de la nidification selon la méthode Mayfield variaient entre 48,8 p. 100 et 69,0 p. 100 dans la colonie d'eau douce et entre 13,9 p. 100 et 43,3 p. 100 dans les colonies de nidification marines. Le succès de la nidification était plus important pour la colonie d'eau douce lors de toutes les années, et il a augmenté de façon semblable pour les colonies d'eau douce et marines entre 2001 et 2005. Les dates médianes d'amorce de nidification étaient plutôt constantes d'une année à l'autre (du 26 juin au 1er juillet pour la colonie en eau douce et du 2 au 9 juillet pour les colonies marines), et pour toutes les années, la majorité des nids étaient commencés avant la débâche de l'océan (généralement à la mi-juillet). Les dates d'amorce de nidification les plus précoces sont survenues en 2005, année où l'on a connu le mois de juin le plus chaud. Nous avons utilisé des mesures de la taille corporelle et du poids des eiders capturés pour évaluer l'état corporel au printemps et n'avons remarqué, d'une année à l'autre, aucune différence sur le plan de l'état corporel des femelles et des mâles au début de la nidification. Nous avons examiné les facteurs qui influencent le succès de la nidification et avons constaté que la prédation est la principale cause d'échec dans les deux aires de nidification. Les prédateurs mammaliens ont causé une perte d'œufs plus complète et une destruction plus complète de tous les nids sur une île que les prédateurs aviaires. Nos résultats offrent des taux utiles et jusqu'à ce jour non mesurés des paramètres fondamentaux de la dynamique de cette population.

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ACKNOWLEDGMENTS

We thank the Nunavut Wildlife Management Board, Polar Continental Shelf Project, and Canadian Wildlife Service for financial support for this project. We particularly thank Kevin Dufour, Canadian Wildlife Service, for conducting analyses on our recapture data, and Garnet Raven, Canadian Wildlife Service, for extra help during the latter parts of the project and for providing comments on this report. Additionally, over the past five years, we have had numerous individuals help with the project so we would like to thank J. Aitaok, S. Aitaok, D. Analok, B. Angohiatok, M. Angohiatok , A. Barnes, T. Bowman, N. Clements, J. Dober, R. Ekpakohak, D. Epilon, J. Ficht, S. Hanlan, S. Haszard, A. Holcroft-Weerstra, J. Illaszewicz , K. Jacobsen, A. Kaotalok, S. Lawson, E. Loos, J. Mills, T. Ohokak, M. Schmoll, H. Trefry, and S. Trefry. Ron Goodson, Environment Canada, provided access to satellite imagery of sea ice. Indian and Northern Affairs Canada, Water Resources Branch, provided weather data from a nearby automated weather station.

INTRODUCTION

Over half of Pacific Common Eiders (*Somateria mollissima v-nigra;* hereafter Pacific Eiders or eiders) that nest in Canada likely nest in the central arctic, particularly the Kitikmeot Region of Nunavut (based on observations during spring migration at both Point Barrow Alaska (Suydam et al. 2000) and in Dolphin and Union Strait (Allen 1982, Alexander et al. 1997)). Population monitoring efforts indicated a dramatic decline in the Canadian breeding population of Pacific Eiders of more than 50% between 1976 and 1996 (Suydam et al. 1997, 2000). Reasons for the decline are largely unknown, primarily due to our lack of knowledge of this subspecies (Barry 1986, Cornish and Dickson 1997). Potential causes for the decline are numerous and widespread throughout the Pacific Eiders' range, and include but are not limited to: over-harvest, chronic oil pollution, heavy metal contamination, and changing oceanographic conditions resulting in altered food supply or degraded habitats (Goudie et al. 2000). In recent years, arctic areas and habitats have experienced accelerated exploration and development of natural resources, such as mining and offshore oil and gas extraction. These activities have occurred in areas that may have potential importance to eiders during breeding or migration, and the impacts of these activities on eider population stability are unclear. Additionally, research in Greenland reported Common Eider populations are highly vulnerable to over-harvest (Merkel 2004). Harvest levels of Pacific Eiders are presently relatively unknown, particularly in Russia. All factors combined suggest an urgent need to understand fundamental parameters of population structure and dynamics of Pacific Eiders.

At a basic population dynamics level, population size is a function of both survival and recruitment of individuals into that population. Therefore, for Pacific Eiders, either decreased annual survival, decreased recruitment, or a combination of those factors are responsible for the dramatic decrease apparent in population numbers. Although other subspecies of Common Eider are relatively well studied (Goudie et al. 2000), and some information on survival (Flint et al. 1998) and recruitment (Flint et al. 2003, Quinlan and Lehnhausen 1982, Schamel 1977) is available for Pacific Eiders, little to no information on survival or recruitment existed for the population nesting in Canada.

We addressed a portion of that data gap with this study, by examining factors that may be influencing productivity and survival over a five year period in a key breeding area. Our primary objectives were to determine annual survival of adult females, nesting propensity, and nest success of Pacific Eiders in the Kitikmeot Region of Nunavut. We examined several factors potentially limiting productivity during the nesting season: spring body condition, abundance of predators and rates of predation, the extent of ice present at the nesting colonies, and quality of nest site habitats. Results should lead to a better understanding of factors constraining the size of the Pacific Eider population. In turn, this understanding should help managers address the potential impacts of resource development on eiders, and develop conservation initiatives needed to protect the Pacific Eider.

METHODS AND MATERIALS

Study site

The study area was located approximately 150 km southwest of Cambridge Bay, Nunavut in the Kitikmeot Region of the central Canadian arctic (Fig. 1). Within the study area, we selected 30 islands used by nesting Pacific Eiders: seven in Nauyak Lake (68° 20.76' N; 107° 40.92' W), plus 23 in Parry Bay, west Melville Sound, and east Bathurst Inlet (exact locations of islands in Appendix 5). The marine islands ranged in size from less than 0.2 ha to 12 ha, and generally consisted of bedrock material, boulders, rocks, and pebbles. Most islands were poorly vegetated, and contained only patches of rye grass (*Elymus* spp). Islands in Nauyak Lake were small (6<0.5 ha; 1=2 ha), low-lying and covered in low tundra vegetation with clumps of willows up to 1m high. The area surrounding Nauyak Lake was characterized by rolling, well-vegetated tundra with rock outcrops and cliffs.

Field Methods

Pacific Eiders were captured and banded in the last half of June (2001-2005) prior to nest initiation at Nauyak Lake (Fig. 1). We captured eiders with a large mist net 6m tall and 90m long, extended across a narrow opening in cliffs at the south end of Nauyak Lake where a creek entered the ocean. We experimented with nets of varying weights (gauge sizes of 16, 19, and 23), and found the greatest capture success with the 23 gauge net and mesh size of 5 1/8 to ¼ inches. We erected two 6m-tall poles, one on either side of the creek and about 100m apart. We then strung the net onto a cable between the two poles using metal curtain hooks place approximately 50 cm apart. The cable was raised and lowered using a winch. We closed the net at the end of each capture period by pulling the entire length of the net to one pole and securing with rope. We experimented in 2001 with optimal time of capture of eiders, and determined the best period to be from 22:00 to 08:00 hours. At that time of day, the sun dipped below nearby cliffs making the net less visible. In addition, the wind speed tended to drop during those hours minimizing movement of the net, thus further reducing its visibility. We closed the net if wind speeds surpassed 15kph to avoid bird injury.

We banded eiders with a United States Fish and Wildlife Service/Canadian Wildlife Service stainless steel band (size 7A for females and 7B for males) and two alphanumeric coloured Darvic bands (white letter and number combination on an orange band - Banding permit 10703). The coloured leg bands provided a unique identifier for resighting individuals from a blind at the nesting colony on Nauyak Lake. We used the bands resighted from the blind to contribute to the mark recapture data set for evaluating annual adult survival. Starting in 2002, we used 2 coloured bands, one on each leg, to enable correction of data set in case of losses of coloured bands.

We measured the following morphometric characteristics on each individual eider captured: weight (±5 g), head length (±0.1 mm), total bill length (±0.1 mm), culmen midline (±0.1 mm), nostril-extension; ±0.1 mm), inner tarsus (tarsus bone length; ±0.1 mm), and flattened wing cord length (±0.1 mm) (Fig 2; Mendall 1986, Dzubin and Cooch 1992). In 2002-2005, we also measured the length of the tarsus including the joint (total tarsus; ±0.1 mm).

Each year we conducted nest searches on all islands on Nauyak Lake at 8 to 12 day intervals commencing at the beginning of July, excluding an area on Island 4 (Fig. 1) where we conducted daily surveys from a blind. We also conducted nest searches on 23 islands in Parry Bay, west Melville Sound, and eastern Bathurst Inlet twice in 2001, but four to six times generally at 10 -12 day intervals from 2002 to 2005, commencing searches in late June (Table 1). Islands on Nauyak Lake were accessed by canoe. In 2002, 2003, and 2005, we accessed marine islands in June and July by helicopter, and then used a boat in August when the ocean was ice free. In 2004, ice in adjacent ocean areas prevented the use of a boat in August; therefore, one final survey was conducted by helicopter in late August. Nest searches were conducted on foot by two to four observers. At each nest we recorded date, number of eggs, stage of incubation (determined by candling eggs (Weller 1956), except in 2001 when most eggs were floated (Hay and LeCroy 1971)), status of each egg and status of nest (see version of nest card used in Appendix 1). For nests where incubation had begun, warmth of eggs was used to assess female presence. We assessed nest site habitat type as one or more of the following: rye grass, pebbles/shale, seaweed, boulders, rocks, bedrock, willow, turf, or other. We marked and uniquely numbered each nest with two markers; a 3cm diameter blue aluminum tag placed under the down in the nest bowl, and a tongue depressor put into the ground about 30cm from the rim of the nest. We labeled each egg in the nest using the system of "nest number-egg number". For the marine islands, nest locations were marked on maps that had been created from photos taken from a helicopter to facilitate finding the nests on subsequent visits. Nests were revisited until eggs had hatched, been abandoned by the female, or destroyed by predators. At each visit to every island, we also recorded the number and clutch size of Glaucous Gull (*Larus hyperboreus*) nests, and any evidence of predator activity (such as scat, tracks or physical presence on island).

Island 4 at Nauyak Lake had a particularly high density of nests (over 400 nests each year), so we modified our nest searches somewhat from the methods described previously to reduce observer disturbance as much as possible. We sampled a portion of the island (generally 40 to 60 nests each year) to obtain a Mayfield nest success estimate. We sampled an additional portion of the island to obtain apparent nest success and clutch size, and in another area of the island we monitored nesting from a blind. Finally, at the remaining part of island not covered by the blind plot, Mayfield nest success surveys, or apparent nest success surveys, we assessed number of nests initiated that year from a nest count conducted towards the end of hatch in late July.

The blind we used on Island 4 in Nauyak Lake was set up in mid June each year prior to arrival of Pacific Eiders. Purpose of the blind was primarily to minimize observer disturbance while determining nest success in an area of high density nesting, and to evaluate predator activity on eider eggs and ducklings. To the extent possible, observations on both nesting and predator activity were conducted daily for approximately 8 hours from about 20 June to the end of July. Observers in the blind also had the opportunity to view and record coloured leg bands, thus creating the recapture (or individual resight) data used to estimate annual survival. For each nest within the observation area, we determined the date of onset of full-time incubation and date of hatch based on the presence of an incubating female during a daily 1-hour observation period. Mid way through incubation (approximately 12-15 July), we surveyed a random sample of nests to determine clutch size. Additionally, every 1.5 hours, we recorded predator activity for a half hour period, totaling 2.5 hours per day. Data collected during predator watches consisted of species and number of predators observed, predator effort (time predators spent on the island actively foraging or pursuing prey), predation events, and outcome of attacks (i.e. whether an egg or hatched young was taken).

We determined the period when male eiders were present at the nesting colony on Nauyak Lake by conducting twice daily counts from an observation post on shore each year from mid June to date of departure of males from the nesting area (generally gone by mid July). We selected as our observation post a ridge on the northwest side of the lake that overlooked the nesting colony, and counted males, females, and pairs observed on the ice, open water, and islands in the bay.

Twice daily, we recorded temperature (maximum and minimum), average and maximum wind speed, precipitation over previous 12 hours, percent cloud cover, percent snow cover, and percent ice cover on Nauyak Lake. We also obtained records of daily mean, maximum, and minimum temperatures from an established weather station at Walker Bay, 8km southwest of the nesting areas. The weather station was maintained by and data provided courtesy of the Department of Indian and Northern Affairs Canada, Water Resources Branch, Yellowknife, NT. The extent of open water in Parry Bay and near Cape Croker was checked approximately every ten days between 11 June and 25 July in all years to determine timing of ice break-up.

We also recorded daily sightings of lemmings (either *Lemmus sibiricus*, or *Dicrostonyx torquatus*), Snowy Owls (*Nyctea scandiaca)*, Short-eared Owls (*Asio flammeus*), and jaegers (*Stercorarius* spp) to use as an indication of alternative prey abundance.

Statistical Methods

All analyses were conducted using SAS statistical software (SAS Institute Inc. 1999) unless otherwise stated.

Annual Survival

We estimated rates of annual survival and recapture using extensions of the Cormack-Jolly-Seber model for open populations, as implemented in Program MARK (White and Burnham 1999). We focused exclusively on females because earlier analyses and information from satellite telemetry (Dickson et al. 2005) suggested that survival rates of males would almost certainly represent a confounded admixture of true survival and permanent emigration from the study site. To reduce biasing estimates low due to females settling or nesting away from our sampling area, we produced estimates that were based solely on individuals resighted from the blind on the nesting colony. In other words, the capture period served as the opportunity to mark birds, but individuals only entered the analysis at the first time the banded bird was observed on the nesting colony. However for completeness of results, we also produced estimates based on all marked individuals, including birds recaptured in the net. Additionally, resighting efforts were expanded in 2005 to include more nesting islands at Nauyak Lake, and to account for this difference, the candidate model sets included a model that allowed for detection probabilities to differ from years 2001-2004 and 2005. Individuals with satellite transmitters were not included in survival analyses.

Nesting Ecology

Annual nesting effort

We estimated annual nesting effort in two ways: by comparing total nest count (different than the sample used for nest success estimates) and by comparing clutch size among years. To compare clutch sizes among years, we evaluated mean clutch sizes (and standard errors) each year for marine and freshwater nesting areas separately. We recognized that clutch size count was confounded to some extent by both partial predation events prior to our first nest visit and intraspecific nest parasitism (one female laying eggs in another female's nest). Both factors were not measured in this study; however we adhered to a set of conditions that minimized biasing clutch size estimates low due to partial predation or incomplete laying of clutch, and we estimated to the extent possible, the rate of intraspecific nest parasitism. We used clutch size count from the first visit if the female had commenced incubation (indicated by warm eggs and detection of embryonic development when candled). If incubation had not commenced, we used clutch size count from the second visit. Nests were not included if there was any indication of a partial predation event prior to our first nest visit. To compare the rate of occurrence of intraspecific nest parasitism each year, we assumed that any nest with clutch size greater than four had eggs laid by two females (Robertson 1995a).

Annual nesting success

We used the Mayfield method (Mayfield 1961, 1975) modified by Johnson (1979) to estimate daily survival rates (DSR) and Mayfield nest success estimates for the freshwater nesting area (Nauyak Lake) and the marine nesting areas separately. We excluded from analysis nests already hatched, destroyed or abandoned when first discovered. We also excluded nests if an egg was damaged as a result of our presence, since this could have affected nest fate. Due to a reduced sampling frame in 2001, we used only data from two similarly timed surveys (end of first week of July and mid to late July) from 2002-2005 to compare nest success for the marine environment among all five years. Only estimates for apparent nest success (number of successful nests divided by total number of nests with known fates) were available for freshwater nest surveys in 2001, therefore comparisons among all five years at Nauyak Lake were based on apparent nest success. To evaluate nest success more concisely in the marine environment, we also separated the marine area into island groups based on spatial location within the study area; a distribution of nesting islands we believe might represent nesting colonies (Fig. 1).

For nests monitored from the blind on Island 4 at Nauyak Lake, a nest was considered successful if attended by an incubating female for a minimum of 23 days or if ducklings were seen. We also considered other evidence such as predation events, and the presence of membranes or egg shell chips in the nest after hatch.

We evaluated causes of nest failure for both the freshwater and marine nesting areas each year. We also determined the percentage of nests containing only inviable eggs from all nests initiated each year.

Timing of nest initiation and hatch

For nests surveyed in the marine and freshwater nesting areas, we estimated nest initiation dates by subtracting incubation stage plus the clutch size from the date of first visit. We adjusted initiation dates by one day to account for females commencing incubation prior to date of clutch completion (Robertson et al. 1992, G. Gilchrist personal communication).

We estimated nest initiation differently for nests observed from the blind. Instead of candling eggs to determine stage of incubation, we observed each nest daily for an hour from time of egg-laying to hatch. We considered hatch to be the date ducklings were first observed at the nest or the date the nesting female was last observed at the nest prior to her complete absence. We considered incubation onset to be the first day the nesting female was observed attending her nest for the full hour of observation. Therefore, initiation date was estimated either by backdating the clutch size from incubation onset date (if incubation onset date was known) or by backdating the clutch size plus a 25-day incubation period from a known hatch date (if onset date unknown). In both situations, if clutch size was unknown, we used an average clutch size of four. We presented data from nest surveys and blind observations separately due to differences in methodologies.

We evaluated incubation period from a sample of nests observed from the blind in years 2001 to 2004. We defined and calculated incubation period as the time from the onset of full time incubation to hatch date (hatch date minus incubation onset).

Factors Influencing Nesting Effort and Success

Spring body condition

We used principal components analysis (PROC PRINCOMP) of three morphological measurements, wing chord, inner tarsus, and culmen midline, to score a first principal component (PC1) for structural size of each individual eider (Alisauskas and Ankney 1987, Anteau and Afton 2004, Richkus et al. 2005). We regressed (PROC GLM) body mass on PC1 controlling for date of capture and created a size adjusted measure of condition. We used an analysis of covariance (ANCOVA) to examine effects of year on size adjusted body mass (Richkus et al. 2005).

Abundance of predators and alternate prey

To examine avian predator activity on an eider nesting colony, we used observations from the blind. We separated the nesting period into three distinct segments; laying, incubation, and hatch. The laying period ended when 75% of females began incubation, and the hatch period began when 25% of nests hatched. We modeled number of predation events (combining all predator species) as a function of timing during the nesting period (laying, incubating, and hatch), predation effort (time spent actively foraging on colony for all species of predators combined), and years, combining both predator effort and number of predation events for all predator species at Nauyak Lake. We used an analysis of variance with a log link function to handle count data that assumes a poisson distribution (PROC MIXED, GLIMMIX Macro, SAS Institute Inc., 1999). We used Least Squares Means (LSMEANS) with a Tukey-Kramer adjustment to generate means of main effects, back transforming the log transformed values for ease of interpretation. Due to disproportionate missed days of sampling during laying and incubation in 2001 and 2005, analyses were conducted on 2002-2004 data only. Lastly, to examine predation pressure by species over the nesting period, we presented data as the number of predation events by species by date for all years.

Weather

To evaluate any differences in timing of spring thaw on nest initiation, we calculated thawing degree days, an indicator of temperature change over time, by summing the total of positive values of all daily mean temperatures from 1 June to 15 July. We used data from Walker Bay weather station because we were not present at Nauyak Lake to record temperatures during the pre nesting period in the first half of June.

Nest site habitat

To evaluate the influence of nest site habitat type on nest success, we established a nest success estimate for two categories of habitat: either exposed or concealed sites. Exposed nest sites were those surrounded by boulders, seaweed, turf, bedrock, rock, or other habitat types, whereas concealed sites consisted of rye grass or willow. We only used data from 2002-2005 when nest surveys were conducted at similar times and frequencies.

RESULTS

Annual Survival

A summary of the number of male and female eiders captured, recaptured, and resighted from the blind are presented in Appendix 2a and 2b. Model averaged annual survival for female eiders was 0.78 ±0.07, 0.75 ±0.06, 0.72 ±0.05, and 0.71 ±0.07 for individuals captured and released (based solely on individuals resighted from the blind to reduce biasing estimates low) from 2001/02 to 2004/05 respectively (Fig 3). Detection probabilities are also presented in Figure 3. Additional results of summary output from competing capture-recapture models developed for female Common Eiders are in Appendix 3, and a table of model-averaged survival and detection rate estimates for female eiders are in Appendix 4.

We found no evidence of any losses of the wide coloured Darvic bands over the five years of observations. We did find evidence of two losses of the smaller narrower coloured Darvic band. Both narrow bands were lost in a 10 day period between banding the individual and subsequently resighting the individual on the nesting islands. However, we consider these band losses inconsequential, because there was no loss of the stainless steel or wider coloured band.

Nesting Ecology

Annual nesting effort

The number of nests initiated in the study area each year ranged from about 1000 to 1300 eiders (Table 2, Appendix 5), with the greatest number of females attempting to nest in 2003 and 2005. For all years combined, mean clutch size for marine nesting areas was

3.58 ±0.04 (n=1741) and for Nauyak Lake nesting area was 4.46 ±0.06 (n=1628). Mean annual clutch sizes and range of values for marine and freshwater colonies are presented in Table 2. Nests for which intraspecific nest parasitism is suspected to have occurred (i.e. nests with greater than four eggs) were more prevalent at the larger freshwater colony (28 to 45%; Table 2). Maximum number of eggs found in a nest was 19. Figures displaying the relative frequencies of clutch sizes per number of nests sampled each year for marine nesting islands and freshwater nesting islands are in Appendices 6a and 6b.

Annual nesting success

Daily Survival Rate (DSR) and Mayfield nest success estimates for the freshwater and marine nesting areas are presented in Table 3. Nest success estimates are graphically presented in Figure 4, for years 2002-2005 only (years when data collected by identical methodologies for ease of comparison). By comparison, nest success in both the freshwater and marine nesting areas was higher in 2005 than all other years, and differences were most pronounced in the marine area. Additionally, nest success increased each year from 2002 to 2005 similarly for both the freshwater and marine areas. In 2001, nest success was likely similar to 2002 based on evaluation of DSR's for marine colonies and apparent nest success for freshwater colonies. Nest success estimates for the marine nesting area, separated into clusters of islands representing colonies are presented in Table 4 (see Fig. 1 for location of separate areas). Nest success was consistently higher at islands in Parry Bay than either Cape Croker or Hurd Islands. For additional information on nest success, Appendix 7 provides apparent nest success for each island each year. There was considerable variation in nest success both among areas and among years.

The overwhelming cause of nest failure for both the freshwater and marine nesting areas in all years was predation, although the impacts of predation were more prevalent at the marine nesting areas (Table 5). Other causes of nest failure rarely observed in comparison were: nest washed away or flooded due to storm tides (observed once in 2002 and once in 2005); nest crushed due to ice pushed up on shore (observed in study area in 1996 (Dickson unpublished data)); incubating hen died due to disease or injury (observed twice in 2002, once in 2004, and once in 2005); or nest abandoned due to several females competing to lay eggs and incubate in the same nest bowl. The latter occurrence was observed from the blind every year.

Timing of nest initiation and hatch

Timing of peak nest initiations at the marine nesting area occurred during the first ten days of July, whereas at Nauyak Lake, peak nest initiations occurred approximately one week earlier during the last week of June (Table 3, Fig. 5, and Appendix 8 for timing of nest initiations for each nesting island). Figure 5 shows 95% confidence intervals about the mean initiation dates. These intervals indicate that nests at the marine colonies were initiated earlier in 2005 than all other years, and later in 2002. At the nesting area at Nauyak Lake, nest initiations were earlier in 2005 than 2001, 2003, and 2004, but not earlier than 2002. Nests at Nauyak Lake were initiated latest in 2001. Based on observations at the blind plot on Nauyak Lake, incubation period did not vary among years and was 25 days in duration (n=302; Appendix 9).

In all years, counts of male eiders at the nesting colony were highest four to six days prior to median nest initiation, and nearly all males had departed the nesting colony 10 to 12 days post peak initiation (Fig. 6).

Factors Influencing Nesting Effort and Success

Spring body condition

Mean body masses were 2703.5 (± 13.5) g for 286 females and 2431.1 (± 11.2) g for 317 males for all years combined. A summary of mean body size measurements is presented in Appendix 10. PC1 (i.e. structural size based on length of wing cord, inner tarsus, and culmen midline) explained 42% of the overall variation among the morphological measurements for females and 46% for males. All factor loadings were positive and ranged from 0.53 – 0.65 for females and 0.45 - 0.64 for males. The regression of body mass on PC1 scores showed a significant positive relationship for females (β = 41.31, SE = 12.08, $P = 0.0007$, $r^2 = 0.06$) and males (β = 36.68, SE = 10.06, $P = 0.0003$, $r^2 = 0.05$). We found no differences among years in size adjusted body mass for either females (P=0.23) or males (P=0.13) (Fig. 7).

Ice conditions on spring staging area

Based on satellite imagery of ice conditions, there was open water present on the spring staging area in the southeastern Beaufort Sea by time of arrival of eiders in mid May in all five years of the study (Fig. 8). Due to pixel size of the images, any open water lead visible in the photo must be over half a kilometer in width (R. Goodson, personal communication), and a 500m lead of open water located in the staging area would be ample size for eiders to rest and feed. The area used most intensively each year is the shorefast ice edge off Cape Bathurst and off Tuktoyaktuk Peninsula (Alexander et al. 1997; Dickson et al. 2005), and in all five years, open water was visible on the images at those locations. We conclude that eiders had access to feeding areas during spring migration throughout the study period.

Ice conditions near nesting colonies

The extent of open water at Cape Croker when eiders arrived in mid to late June was not available for 2001, but estimations from 2002 to 2005 varied from 10 to 40 km^2 (37, 10, 33 and 40 km^2 for 2002, 2003, 2004 and 2005 respectively).

Figure 9 displays timing of nest initiations in relation to timing of ice break-up at a sample of nesting islands in Cape Croker, Parry Bay and 97-29. Ice break-up in the marine area varied by only a few days among years, and generally occurred during the third week of July. Similarly, break-up at Nauyak Lake ranged by five days over the five years (from 13-18 July). With few exceptions, the majority of eiders commenced nesting prior to ice break-up.

At Nauyak Lake, most of the colony nested on a chain of five islands extending out from shore (Fig. 1; Islands 1-5). The ice progressively melted from shore out into the bay over a period of about four weeks each year (Appendix 11). Likewise, nest initiations were earliest on the island closest to shore and became gradually later for islands farther into the bay (Appendix 11). Although the difference in timing of ice break-up was about four weeks, the difference in timing of nest initiation among islands was only about two weeks. At the two islands closest to shore, the majority of nests were initiated after the ice had melted, whereas at the two islands farthest from shore, the majority of hens initiated nesting prior to ice break-up in most years.

Abundance of predators and alternate prey

Figures 10a, 10b, and 10c show the number of predation events by species by date each year as observed from the blind. Main avian predator of eider eggs at Nauyak Lake was Glaucous Gull in all years; Thayer's Gull (*Larus thayeri*), Common Raven (*Corvus corax*), and Sandhill Crane (*Grus canadensis*) were also important predators, but only in certain years. Observations from the blind indicated predator effort ($F_{1,94} = 30.74$, $P < 0.0001$) and the interaction between nesting period and year ($F_{4,94} = 2.79$, $P = 0.031$) affected the number of predation events by all avian predator species combined. In other words, predation events throughout the nesting period varied with specific years. There were significantly more predation events during the laying period in 2002 than incubating period in 2003 (LSMEANS $P = 0.017$), during the laying period in 2003 than incubating period in 2003 (LSMEANS $P = 0.026$), and during hatch period in 2003 than the incubating period in 2003 (LSMEANS $P = 0.0037$). However, observations from the blind indicated most predation events during the hatch period, particularly by Glaucous Gulls, were of unhatched eggs in nests where females had already departed with ducklings (i.e. scavenging). Therefore it is important to note that during the period when nests were active, results showed more predation during laying than during incubating. Also not captured in the data set was Peregrine Falcon (*Falco peregrinus*), and Glaucous Gull predation of ducklings occurring for several days around peak hatch, typically taking ducklings on the water as broods left the island.

Data on predator activity and predation pressure on other nesting islands was not collected in the same methodological manner as from the blind, but we do have anecdotal data as evidence of predator activity from the island visits during the nest checks. A summary of all evidence is presented in Appendix 12. We suspect the greatest portion of nest loss at the marine nesting islands was due to mammalian predation, based on evidence of mammalian presence on islands and the appearance of nests following destruction. Suspected depredation by mammals not only caused complete nest destruction (i.e. entire clutch destroyed, not just part of clutch typical with avian predators), but also complete destruction of all active nests on the island. Our observations indicated the most important predators of eider nesting colonies in the study area were grizzly bear (*Ursus arctos horribilis*), arctic fox (*Alopex lagopus*), and wolverine (*Gulo gulo*). Also, there did not appear to be any particular island or group of islands that grizzly bear, arctic fox, or wolverine targeted for foraging every year in our study area. For example, we observed evidence of predation by grizzly bears at eight islands over the five year study period, and only at two of those islands were bears present in more than one year.

In one year, we accessed an island at the same time a wolverine was actively foraging on eider nests. Several freshly depredated eiders (both male and female) were also discovered on the island, and we believe the mortality could certainly be attributed to the wolverine.

Records of the number and distribution of Glaucous Gulls nesting in the study area each year are presented in Appendix 13. The number at the freshwater colony remained stable at 12 to 16 nests, whereas in the marine area, numbers varied from 18 nests in 2002 to 50 nests in 2005. In all years, more than half of the Glaucous Gull nests in the marine area were located on just one island (98-1) off Cape Croker.

Lemming observations over the five year period were most frequent in 2004, and began decreasing in 2005 (Appendix 14). 2004 was also the only year we documented Pomarine Jaegers (*Stercorarius pomarinus*) nesting at Nauyak Lake, and saw both Short-eared Owls and a Snowy Owl in the area during the nesting season.

Weather

Temperatures in the first three weeks of June, just prior to or at the earliest date of nest initiations, were similar among years with the exception of 2005, a considerably warmer year (Fig. 11). Although there were no apparent large differences in timing of nest initiations, the earliest nest initiation dates occurred in 2005, the year with the warmest early June temperatures (Fig. 5).

Influence of nest site habitat on nest success

Generally, nest success estimates were higher at nest sites concealed by either rye grass or willows when compared to exposed nest sites (Table 6). This difference in success occurred at both the freshwater and the marine colonies, although the difference was much greater at the marine colonies.

DISCUSSION

Following completion of five years of banding, and four years of resighting eiders at the nesting colony, we obtained reasonably precise estimates of annual survival for females. Although the model averaged survival rates declined slightly over the course of the study, this decline was well within the limits defined by sampling error; therefore, we conclude that annual survival rates for females nesting at Nauyak have been relatively stable over the past five years. However, when compared to rates of annual survival for other subspecies of eiders, our estimates were low: Nauyak Lake estimates ranged from 0.71 to 0.78 over the 4 years compared to 0.83 ±0.10 SE for females of breeding age in St. Lawrence estuary, Quebec (Reed 1975); 0.81 for females breeding in Penobscot Bay, Maine (Wakeley and Mendall 1976); 0.87 ±0.016 SE for adult female *S. m. dresseri* (Krementz et al 1996); and an average of 0.90 ±0.01 over a 25 year period for Common Eiders nesting off the Northumberland coast (Coulson 1984). At this point, with just four years of survival data on a long-lived species such as the Pacific Eider, it is unclear to us whether this stable, but low rate of annual survival is affecting the population. However, it may be reasonable to suggest that low annual adult survival of females could be contributing to the population decline. If only seven of ten females of breeding age survive annually to return to breed in the next year, then adult female survival may be a limiting factor.

Our survival estimates are biased somewhat low due to sampling frame during 2001-2004. Although we improved our sampling effort and subsequent detection probabilities in 2005, we believe more years of data for the mark recapture study would be valuable to obtain the best possible estimates of annual survival, and subsequently, better understand the contribution of annual survival rates to population dynamics of the eiders nesting at Nauyak Lake.

We used number of nests initiated each year as an indicator of breeding propensity or nesting effort; a parameter used to evaluate productivity and subsequent population recruitment. Over the five years of study, numbers of nests initiated were relatively similar (excluding one marine island in 2002 where arctic fox predation of 100 to 200 nests prior to first nest check and continually throughout the nesting season prohibited an accurate count of active nests). Thus, assuming a relatively stable adult breeding population, there were no years during the study period when a large proportion of eiders did not nest; an event known to occur in years when environmental conditions are adverse (Coulson 1984). Environmental conditions that might affect breeding propensity such as late snow melt at nest sites, and extent of ice on the breeding area, or on spring staging areas (and subsequent availability of food), were all similar each year with no extreme conditions occurring during the study period. In all years, the eiders arrived on the nesting grounds in good body condition and nested without delay.

Another parameter we measured to determine productivity was nest success. We suspect nest success was reasonably high relative to other breeding areas, although little data are available for comparison: 33% apparent nest success during one year on a barrier island in the Beaufort Sea (Schamel 1977); 47 and 81% apparent nest success on two separate barrier islands also in the Beaufort Sea during one year (Johnson et al 1987); and 4% in one year for several islands along the North Slope of Alaska (Flint et al 2003). In comparison, we had similar apparent nest success estimates on our marine islands (19-58% over 4 years), but generally higher estimates for the large colony at Nauyak Lake (62-81% over 5 years).

Predators were the primary factor affecting nest success in all years. Although both avian and mammalian predators depredated eider eggs, the latter group seemed to have the greatest effect on nest success. Mammalian predators caused complete loss of eggs in a nest and destroyed all nests on an island, as has been reported in other studies (Ahlen and Andersson 1970, Robertson 1995b), whereas avian predators, especially Glaucous Gull and Common Raven, generally caused partial predation by taking one or two eggs from a nest. Unlike many other Common Eider nesting areas in the circumpolar region, the suite of predators in our study area included grizzly bears and wolverines (Johnson et al 1987, Quinlan and Lehnhausen 1982); two predators we surmise are reasonably abundant in the Bathurst Inlet area. Wolverines not only depredated eggs, but also nesting females and males.

In other parts of their breeding range, Common Eiders are known to delay nesting until ice breaks up around the island (Ahlen and Andersson 1970, Laurila 1989). One hypothesis proposed to explain delaying nesting is that without ice, mammalian predators have no access to the nesting islands (Ahlen and Andersson 1970, Quinlan and Lehnhausen 1982, Parker and Mehlum 1991). However, the nature of the short breeding period in arctic habitats provides selective pressure to breed as early in the season as possible to maximize reproductive potential (Rohwer 1992, Robertson 1995a). Additionally, the long fledging period for eiders, 60-65 days (Palmer 1976) provides further pressure to nest early in order to optimize reproductive success. Therefore, we suspect there is a trade off between delaying nesting to achieve greater nest success at ice free islands versus delaying nesting too long and achieving no reproductive success.

There is evidence that some eiders in our study area waited for the ice to melt prior to initiating nests; at Nauyak Lake, islands that became ice-free earliest had the earliest nest initiation dates. However, at islands where ice was present longest, many eiders initiated their nests prior to ice break-up. Eider females, and presumably young, depart Bathurst Inlet area on fall migration from mid to late October (Dickson et al. 2003a, 2003b, 2005), likely forced out by formation of ice in the shallow waters where they feed. Consequently, nests would need to be hatching by mid August, and thus initiated by mid July to allow for a 25-26 day incubation period and 60-65 day period to fledge. In much of the marine portion of the study area, ice remained until the third week of July, generally one to three weeks after median nest initiation date. Thus mammalian predators had access to nesting colonies well into the incubation period. In addition to ice bridges, a number of islands used for nesting (including three of the islands at Nauyak Lake) were close to shore and in shallow water such that mammals, especially grizzly bears, could reach them with little or no swimming required.

Due to the relatively easy access to many of the islands for mammals, we suspect annual nesting success could be linked to the lemming cycle, as reported for several other arctic nesting bird species (Cackling Goose -Wilson and Bromley 2001; Red-throated Loon -Dickson 1992; Brant -Summers and Underhill 1987; Long-tailed Duck -Pehrsson 1986). For Pacific Eiders in our study, the two years of highest nesting success occurred in years of moderate-to-high relative lemming observations. Several of the predator species, including arctic fox and Glaucous Gull, also prey on lemmings. Thus, in a year when lemmings are less abundant, those predators may put more effort into locating eider eggs, including traveling across broken ice, and wading and swimming to reach a nesting colony.

Increased vegetation at nest sites has been documented to positively influence nest success of Common Eiders (Choate 1967, Gorman 1974, Schamel 1977, Schmutz et al. 1983, Gotmark and Ahlund 1988). Results from our study showed greater nest success at marine colonies for nests with concealing vegetation. At the freshwater colony there was a similar trend of greater nest success for concealed nests, although the trend was not as pronounced.

RECOMMENDATIONS

Results of our study suggest the recent decline in Pacific Eiders was more likely due to adult mortality than poor breeding success. Although stable over four years, our estimates of annual survival of adult females were lower than estimates reported in other regions. Nesting success on the other hand, although variable, was comparable or better than estimates from other regions. Pacific eiders arrived each year in good condition, and there was little variation in timing of nesting or the number of nests initiated annually over the 5-year period. The former suggests ice conditions and abundance of prey were favorable on spring staging areas (Gorman and Milne 1971, Parker and Holm 1990, Guillemette 2001), and the latter suggests Bathurst Inlet area provided relatively stable conditions for Pacific Eiders to nest.

The lower than expected annual survival of adult females should be further investigated to ensure we have the best possible estimates. In particular, we should further examine how among year movements of nesting females from one island to another at Nauyak Lake colony influence our annual survival estimates.

A monitoring program should be implemented to determine whether the relatively low annual survival rate is causing a decline in number of Pacific Eider in the region. In response to this need, Canadian Wildlife Service and Sea Duck Joint Venture jointly initiated three years of aerial surveys beginning in 2006, to establish a baseline for monitoring number of Pacific Eider breeding pairs in the Bathurst Inlet area.

Another potential factor that could be contributing to the low annual adult female survival is high levels of mortality due to harvest. We recommend a rigorous assessment of Pacific Eider harvest be implemented. Conventional methods of assessing harvest are not practical for Pacific Eiders because so few birds are banded and because harvest is conducted primarily by subsistence hunters rather than sport hunters. At the present time, estimates of subsistence harvest tend to be periodic and obtained only from specific locations, resulting in out of date, biased, and incomplete information for all areas of harvest (USFWS 2006). Furthermore, because some of the Pacific Eiders breeding in arctic Canada moult off the coast of Russia and most over-winter there (Dickson et al 2003a, 2003b, 2005), the harvest from outside of North America could have a significant influence on these populations. Thus, improved estimates of subsistence harvest are needed for Canada, Alaska, and Russia.

Our study assessed annual adult female survival and nesting success, but did not address duckling survival or recruitment of young birds into the breeding population. To gain a more complete understanding of population dynamics of the Pacific Eider in the Kitikmeot Region, these two vital rates should also be investigated.

An important consideration arising from our research is the value of the Kitikmeot Region, specifically the Bathurst Inlet area, for breeding eiders. We have examined nesting effort and success in this area for the past five years and have found breeding conditions in the Bathurst Inlet area to be relatively stable. Similar numbers of eiders attempted to nest each year, and a relatively high percentage of nests hatched each year compared to other breeding areas for Pacific Eiders (Schamel 1977, Johnson et al 1987, Flint et al. 2003). Perhaps the undisturbed nature of this area within the Kitikmeot Region contributes to Pacific Eider populations. However, development of mineral resources has begun in the region and will likely accelerate in the near future. We recommend further studies to identify important marine areas and habitat used by Pacific Eiders, followed by implementation of measures to protect critical habitat. Protection of key marine areas in the Kitikmeot Region would not only benefit eiders, but would help maintain the overall health of the marine ecosystem within the region.

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Table 1. Dates nest searches occurred each year at 23 islands in Parry Bay, Melville Sound and eastern Bathurst Inlet, as well as the islands on Nauyak Lake.

Area	Year	Dates of surveys					
Marine	2001		7-9 Jul	18-19 Jul			
	2002	28 Jun[1]	8-9 Jul	21-22 Jul	30 Jul- 2 Aug	9 Aug	
	2003	28-29 Jun	8-9 Jul	21-22 Jul	29-30 Jul	7-11 Aug	14-15 Aug
	2004	29-30 Jun	8-9 Jul	20-21 Jul	30-31 Jul		18 Aug
	2005	29 Jun-3 Jul	10 Jul	22-25 Jul[2]	28-29 Jul	4-5 Aug	
Nauyak Lake	2001		10-11 Jul	15-16 Jul			
	2002	1-4 Jul	8-15 Jul	18-22 & 24 Jul	28-29 Jul	5 Aug	
	2003	3-5 Jul	13-15 Jul	23 Jul	28 Jul	5 Aug	12 Aug
	2004	3-6 Jul	10-12 Jul	18-23 Jul	25-28 Jul	5 Aug	9 Aug
	2005	4-7 Jul	12-15 Jul	26-27 Jul	2 Aug	10 Aug	

[1]surveyed only 4 islands (97-29, 98-1, 98-3, and 98-5)

[2]surveyed only half of islands (98-1, 3,4 ,5, 8, 11, 12, 87-10, 88-48, 89-46)

Table 2. Number of nests found and clutch sizes obtained each year at all marine and freshwater colonies from 2001-2005.

		Mean clutch size[1]	Minimum clutch size	Maximum clutch size	Intraspecific nest parasitism[2] (%)	Total nests found
Marine	2001	3.78 ±0.12 (n=386)	1	19	24	477
	2002	2.99 ±0.11 (n=124)	1	9	8	213[3]
	2003	3.45 ±0.08 (n=437)	1	14	16	666
	2004	3.36 ±0.07 (n=392)	1	9	7	535
	2005	3.91 ±0.09 (n=407)	1	13	28	517
Freshwater	2001	4.06 ±0.14 (n=216)	1	10	33	493
	2002	4.44 ±0.15 (n=244)	1	12	45	629
	2003	3.93 ±0.12 (n=291)	1	12	28	645
	2004	3.98 ±0.11 (n=314)	1	12	28	626
	2005	4.60 ±0.12 (n=358)	1	14	45	708

[1] Clutch sizes were from incubated nests only to minimize biasing clutch size counts low due to incomplete clutch laying

[2] To estimate intraspecific nest parasitism, we assumed that any nest with more than 4 eggs contained eggs from at least 2 females

[3] Total nests found was low due to fox presence on largest marine nesting colony (Island 97-29) throughout entire nesting period and subsequent depredation of an estimated 150 nests.

Table 3. Annual nesting success and timing of peak nest initiation at all marine and freshwater colonies from 2001-2005.

	Year	Apparent nest success (%)	Mayfield nest success (%)	95% confidence intervals	DSR[1]	Median nest initiation date[2]
Marine	2001	-	-	-	82.8 (n=476)	8 July (21 June-19 July) (n=476)
	2002	19.3 (n=213)	13.9 (n=213)	10.2-19.9	89.6 (n=133)	9 July (20 June-31 July) (n=213)
	2003	40.8 (n=662)	26.5 (n=662)	24.0-31.5	95.7 (n=495)	7 July (22 June- 2 Aug) (n=666)
	2004	41.3 (n=534)	29.7 (n=534)	26.7-35.1	96.9 (n=453)	6 July (22 June-29 July) (n=535)
	2005	57.8 (n=509)	43.5 (n=509)	38.7-48.8	97.1 (n=294)	2 July (18 June-1 Aug) (n=510)
Freshwater	2001	64.9 (n=262)	-	-	-	1 July (22 June-27 July) (n=248)
	2002	61.9 (n=260)	48.8 (n=260)	42.1-56.6	-	27 June (19 June-28 July) (n=260)
	2003	67.8 (n=340)	57.0 (n=340)	51.0-63.7	-	29 June (13 June-27 July) (n=343)
	2004	73.1 (n=351)	62.8 (n=351)	56.9-69.3	-	30 June (11 June- 24 July) (n=443)
	2005	80.9 (n=369)	69.0 (n=369)	63.1-75.4	-	26 June 12 June- 21 July) (n=366)

[1] DSR or Daily Survival Rate comparisons are based on subset of 2 nest searches; from end of first week of July to mid to late July (based on reduced sampling schedule in 2001).

[2] includes earliest and latest date of initiation in parentheses

Table 4. Comparisons of Mayfield nest success estimates from 2002-2005 at five spatially separate groups of islands.

Environment	Area	2002 Mayfield nest success % (95%CI)	2003 Mayfield nest success % (95%CI)	2004 Mayfield nest success % (95%CI)	2005 Mayfield nest success % (95%CI)
Marine	Cape Croker	8.2 (4.9-13.4) n=141	19.6 (14.8-26.0) n=211	11.8 (8.3-16.8) n=179	41.6 (34.7-49.8) n=218
	Parry Bay	46.7 (32.9-66.1) n=58	54.7 (46.1-64.9) n=153	54.2 (46.7-62.9) n=196	60.3 (52.1-69.7) n=162
	Hurd Islands	0.4 (0.0-6.4) n=14	1.4 (0.5-3.4) n=86	1.8 (0.5-6.2) n=41	0.5 (0.0-66.0) n=4
	97-29	fox on island	34.0 (27.4-42.2) n=212	46.6 (37.0-58.6) n=118	27.1 (19.4-37.5) n=131
Freshwater	Nauyak Lake	48.8 (42.1-56.6) n=260	57.0 (51.0-63.7) n=340	62.8 (56.9-69.2) n=351	68.1 (62.2-74.5) n=373

Table 5. Causes of nest failure at marine and freshwater nesting areas.

	Year	Total nests failed	Predation (%)	Abandonment (%)	Proportion of nests with inviable eggs
Marine	2001	140	97 (n=136)	3 (n=4)	not available
	2002	134	94 (n=126)	6 (n=8)	
	2003	367	99 (n=363)	1 (n=4)	
	2004	299	95 (n=284)	5 (n=16)	< 1%
	2005	206	95 (n=196)	5 (n=13)	1%
Freshwater	2001				not available
	2002	93	66 (n=61)	34 (n=32)	
	2003	102	95 (n=97)	5 (n=5)	
	2004	88	80 (n=70)	20 (n=19)	< 1%
	2005	69	82 (n=57)	17 (n=14)	< 1%

Table 6. Comparison of Mayfield nest success estimates between exposed and concealed nest sites from years 2002-2005.

	Nest site	Mayfield nest success % (95% CI)				
		2002	2003	2004	2005	All years combined
Marine	exposed	7.7 (4.2-13.6) n=105	27.2 (21.2-34.8) n=200	22.1 (16.8-28.9) n=196	38.9 (32.2-46.9) n=227	25.6 (22.4-29.3) n=728
	concealed	25.3 (17.1-37.2) n=102	26.0 (21.9-30.9) n=437	35.3 (30.0-41.4) n=334	48.0 (55.5-60.3) n=273	33.7 (30.7-36.9) n=1146
Freshwater	exposed	49.9 (38.5-64.6) n=80	51.1 (41.7-62.7) n=121	56.2 (47.1-67.1) n=133	68.7 (59.7-78.9) n=147	57.2 (52.1-62.8) n=481
	concealed	50.7 (42.4-60.5) n=170	58.1 (50.5-66.9) n=203	67.7 (60.4-75.8) n=217	70.0 (62.2-78.8) n=207	61.8 (57.7-66.1) n=797

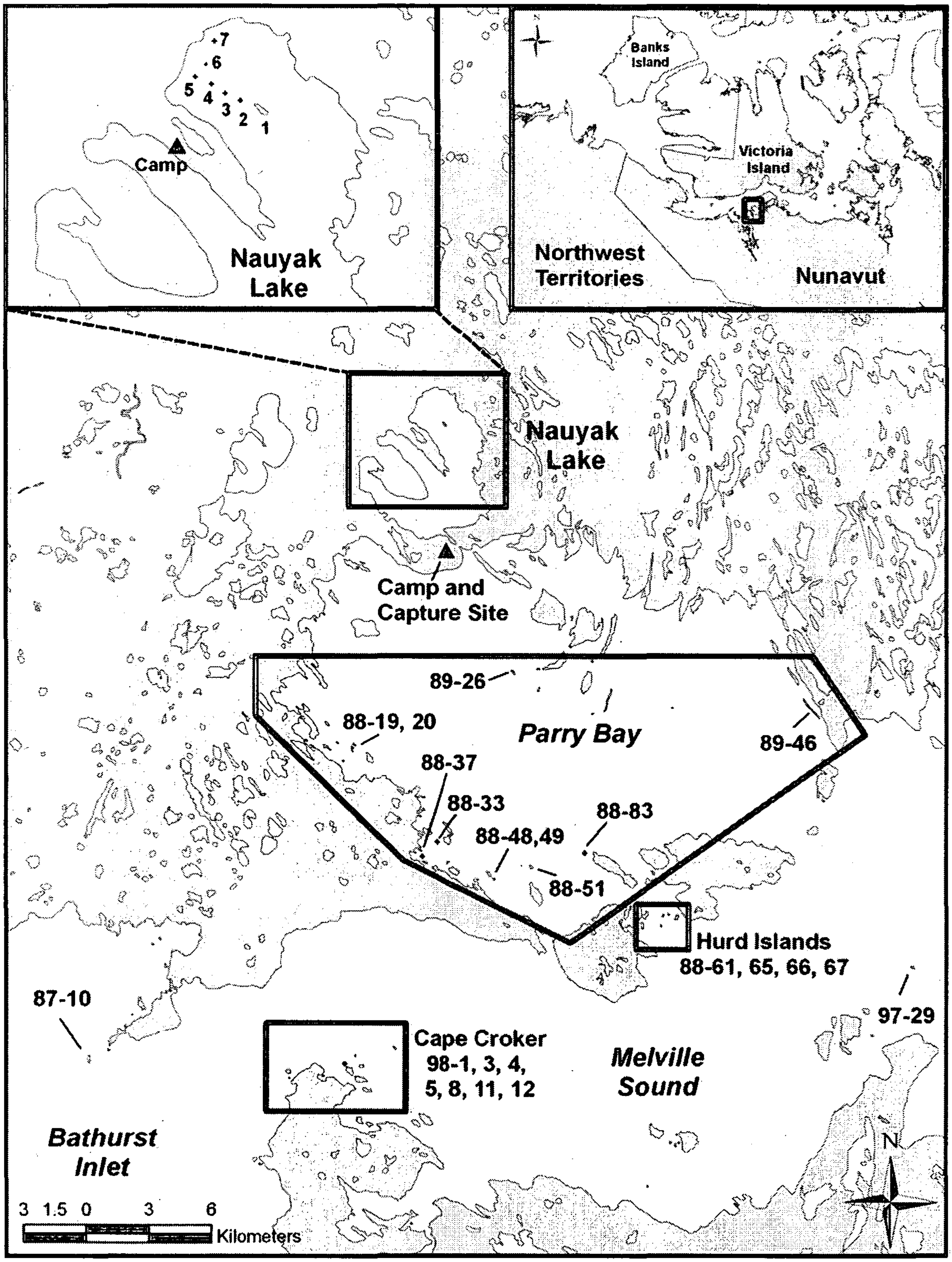


Figure 1. Location of islands surveyed for Pacific Eider nests in Parry Bay, Melville Sound, east Bathurst Inlet, and Nauyak Lake from 2001 – 2005.

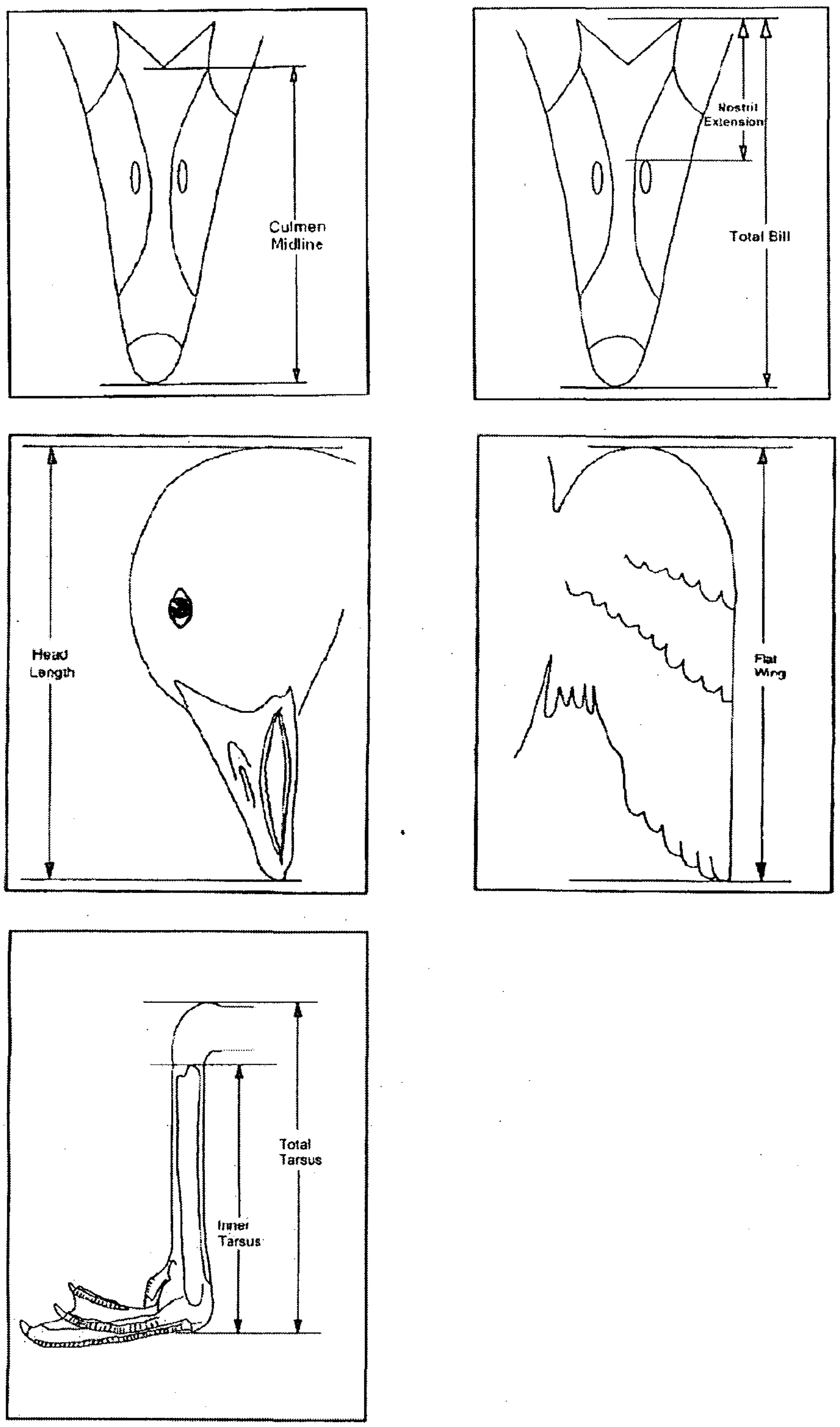


Figure 2. Diagram of morphological measurements taken to estimate body condition: culmen midline, nostril extension and total bill, head length, flat wing, inner and total tarsus. From Mendall (1986), and Dzubin and Cooch (1992).

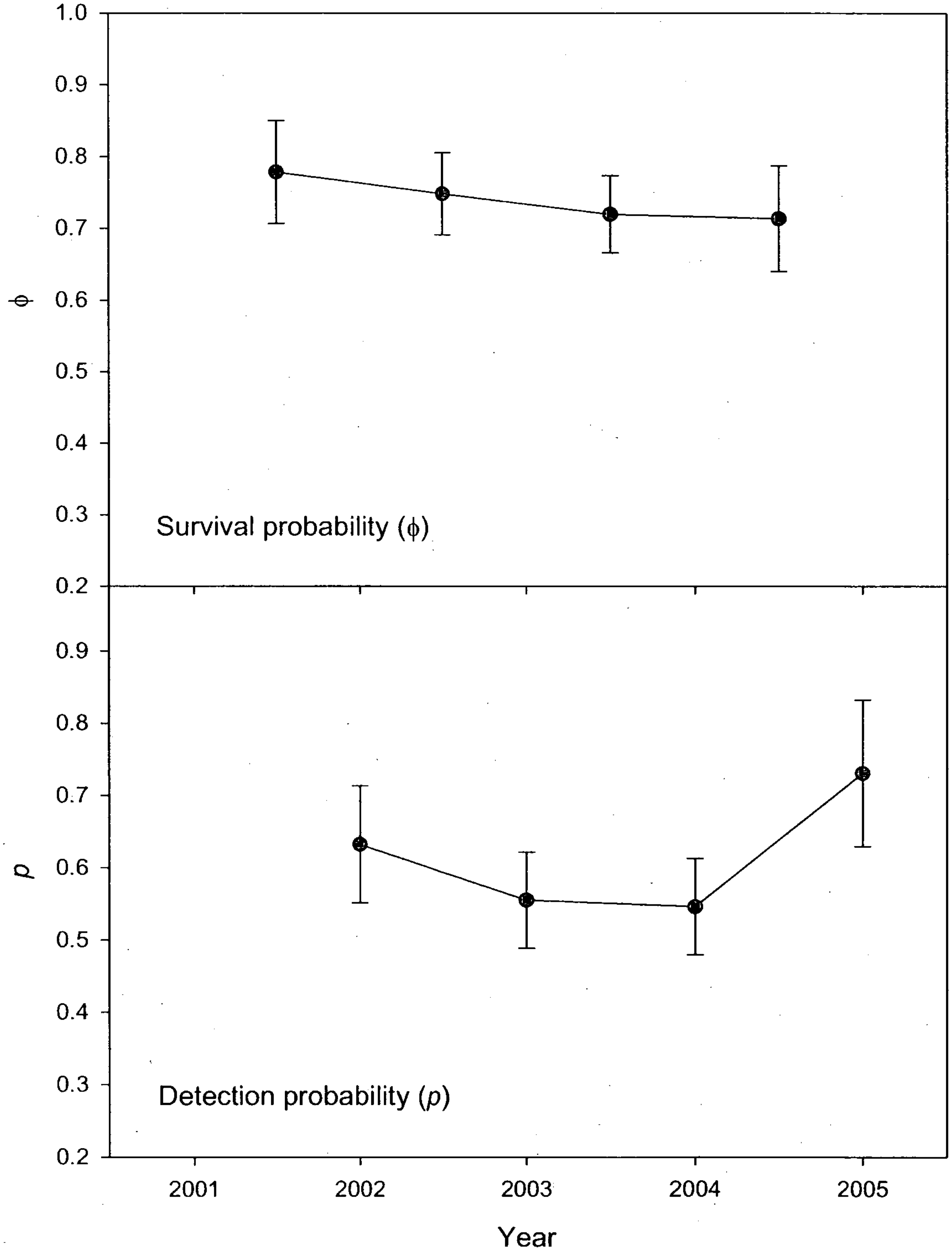


Figure 3. Model-averaged survival and detection rate estimates (±1 SE) for female Pacific Eiders trapped, banded and released, then resighted at Nauyak Lake, 2001-2005.

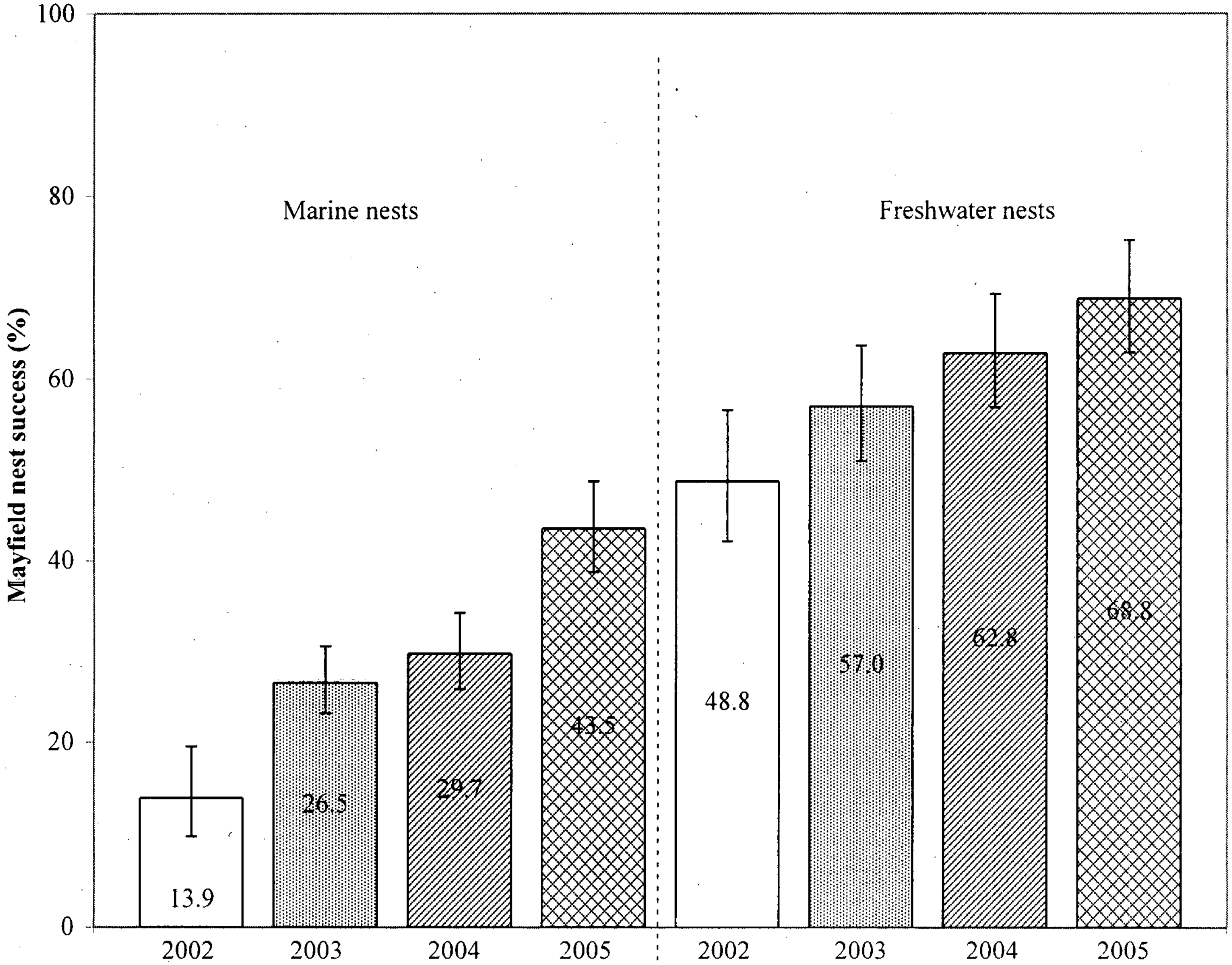


Figure 4. Mayfield nest success estimates for Pacific Eiders from 2002-2005. Error bars show 95% confidence intervals.

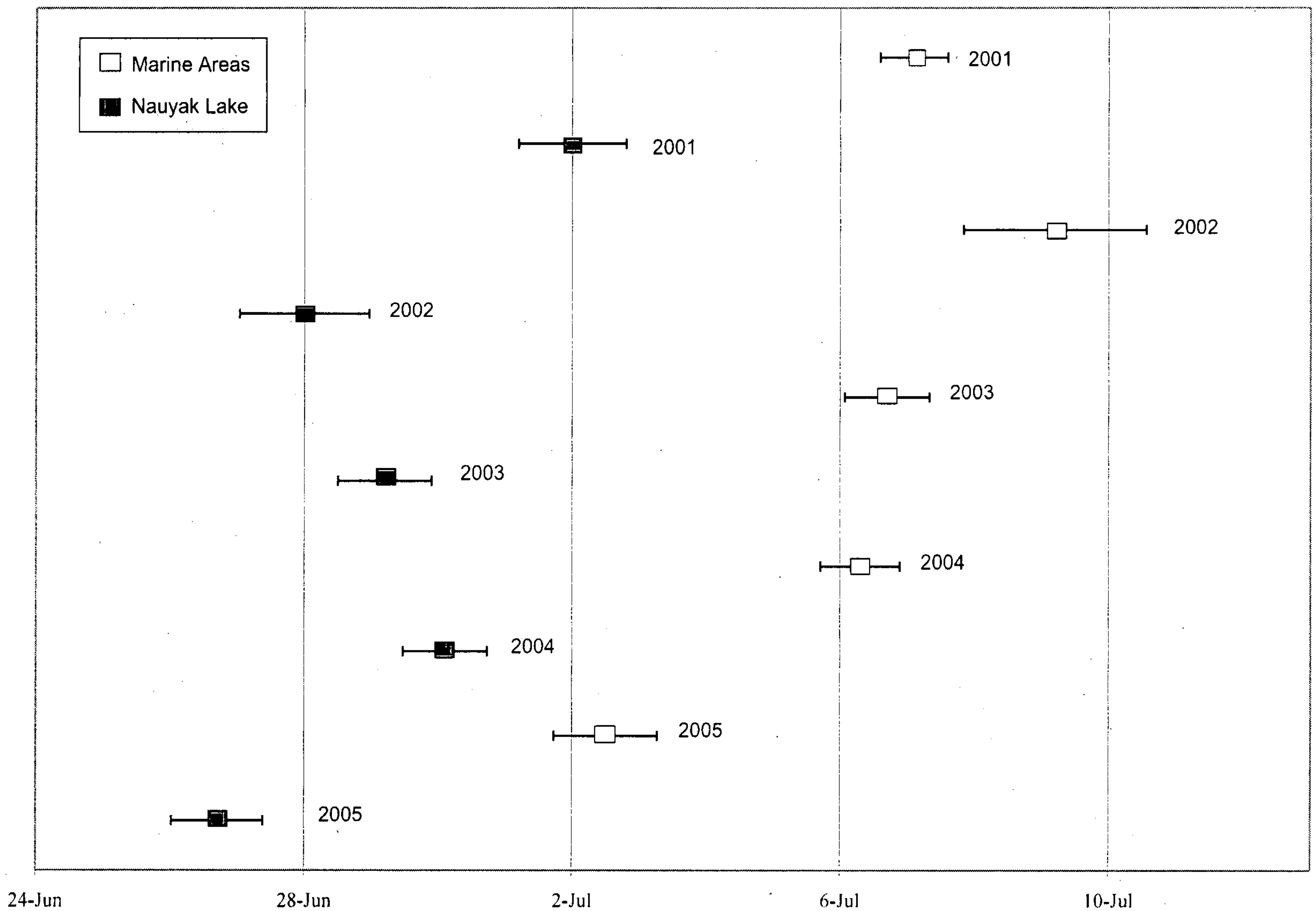


Figure 5. Mean nest initiation dates for Pacific Eiders nesting on islands in marine areas versus Nauyak Lake from 2001-2005. Error bars indicate 95% confidence intervals.

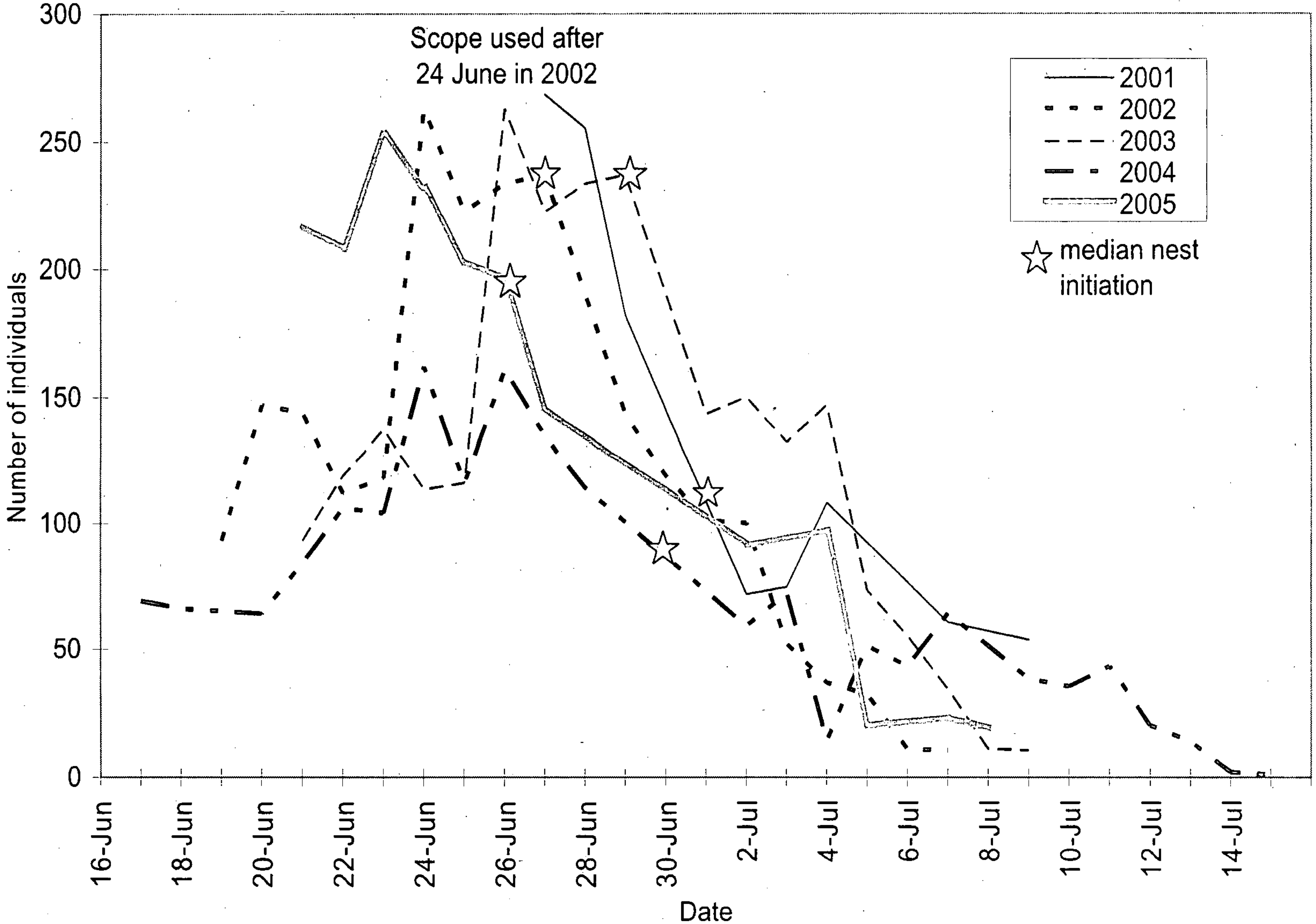


Figure 6. Number of male Pacific Eiders at nesting colony on Nauyak Lake based on counts from an observation post on shore.

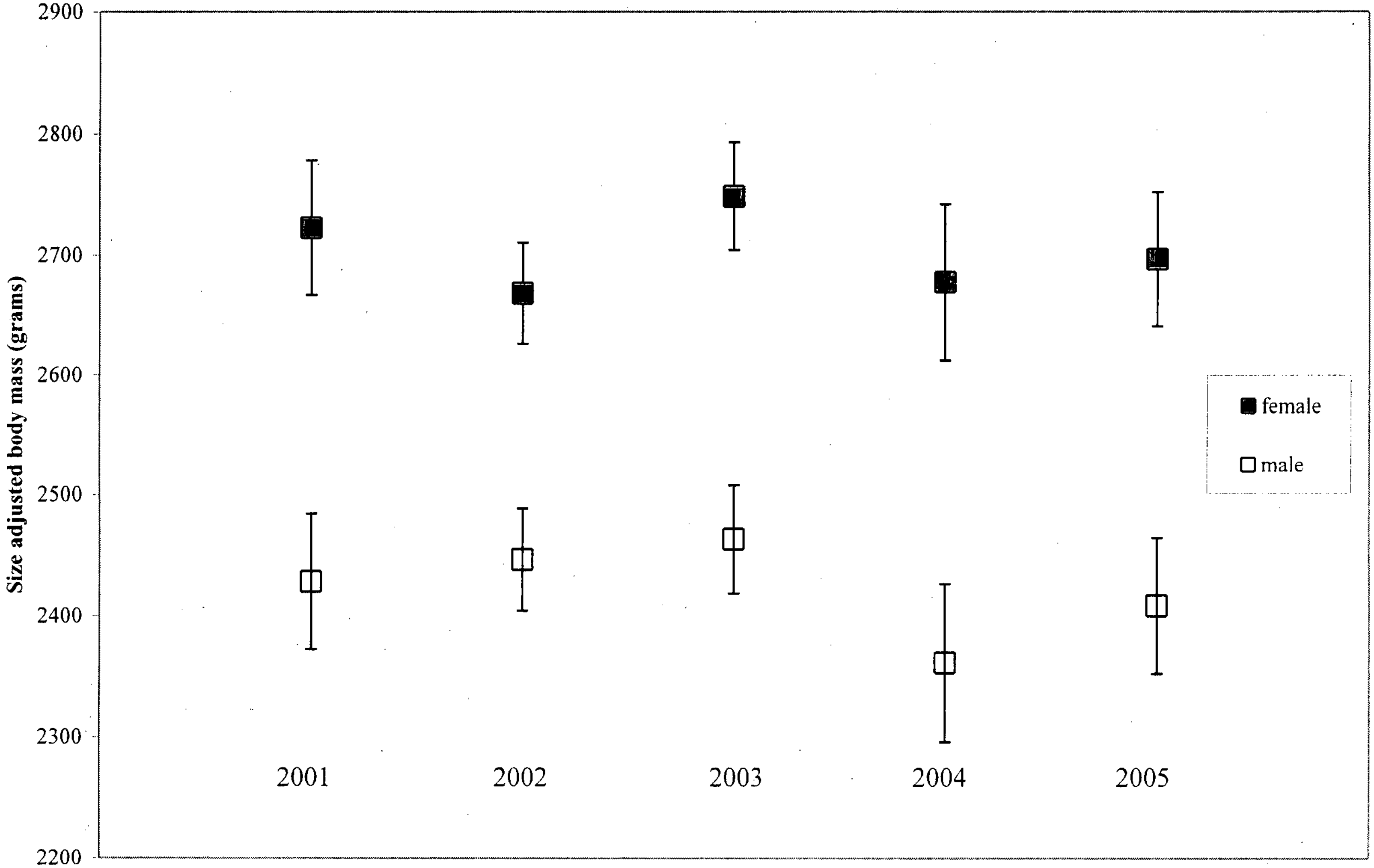
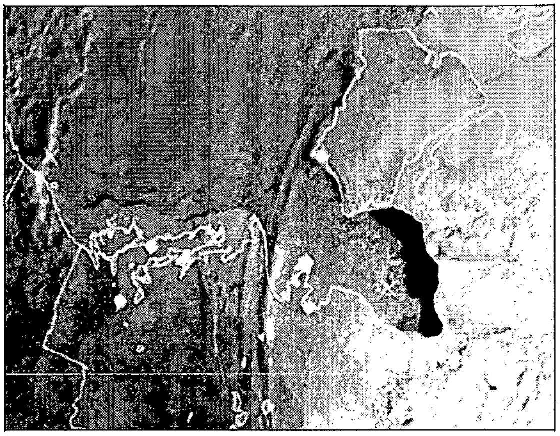
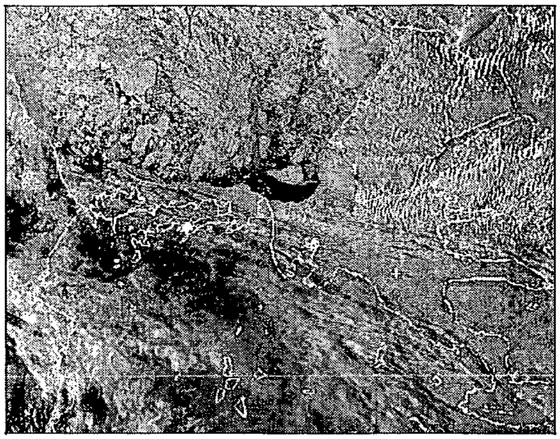


Figure 7. Annual variation in size adjusted body mass (95% confidence intervals) of female and male Pacific Eiders trapped and released at Nauyak Lake, Nunavut, from mid to late June, 2001-2005. Sample sizes: Females - n_{2001}=46, n_{2002}=85, n_{2003}=69, n_{2004}=36, n_{2005}=50, Males - n_{2001}=55, n_{2002}=89, n_{2003}=83, n_{2004}=39, n_{2005}=51.



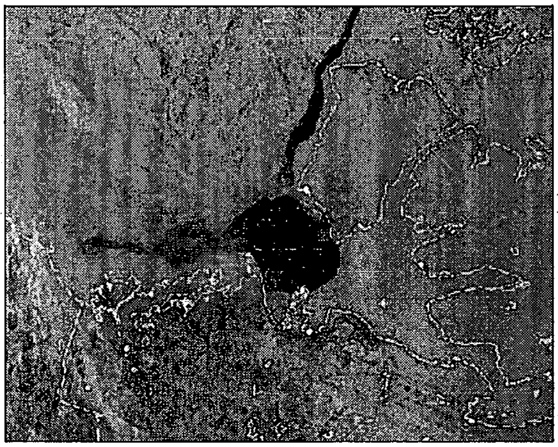
May 20, 2001



May 16, 2002

May 19, 2003

May 19, 2004



May 20, 2005

Figure 8. Satellite images showing amount of open water in mid May in spring staging area in the southeastern Beaufort Sea. Black areas on images were areas of open water and pixel size on images dictates that any area of open water must be at least 0.5 kilometre in width. Data courtesy Environment Canada and provided from the United States series of polar orbiting weather satellites managed by North American Oceanic and Atmospheric Agency (NOAA).

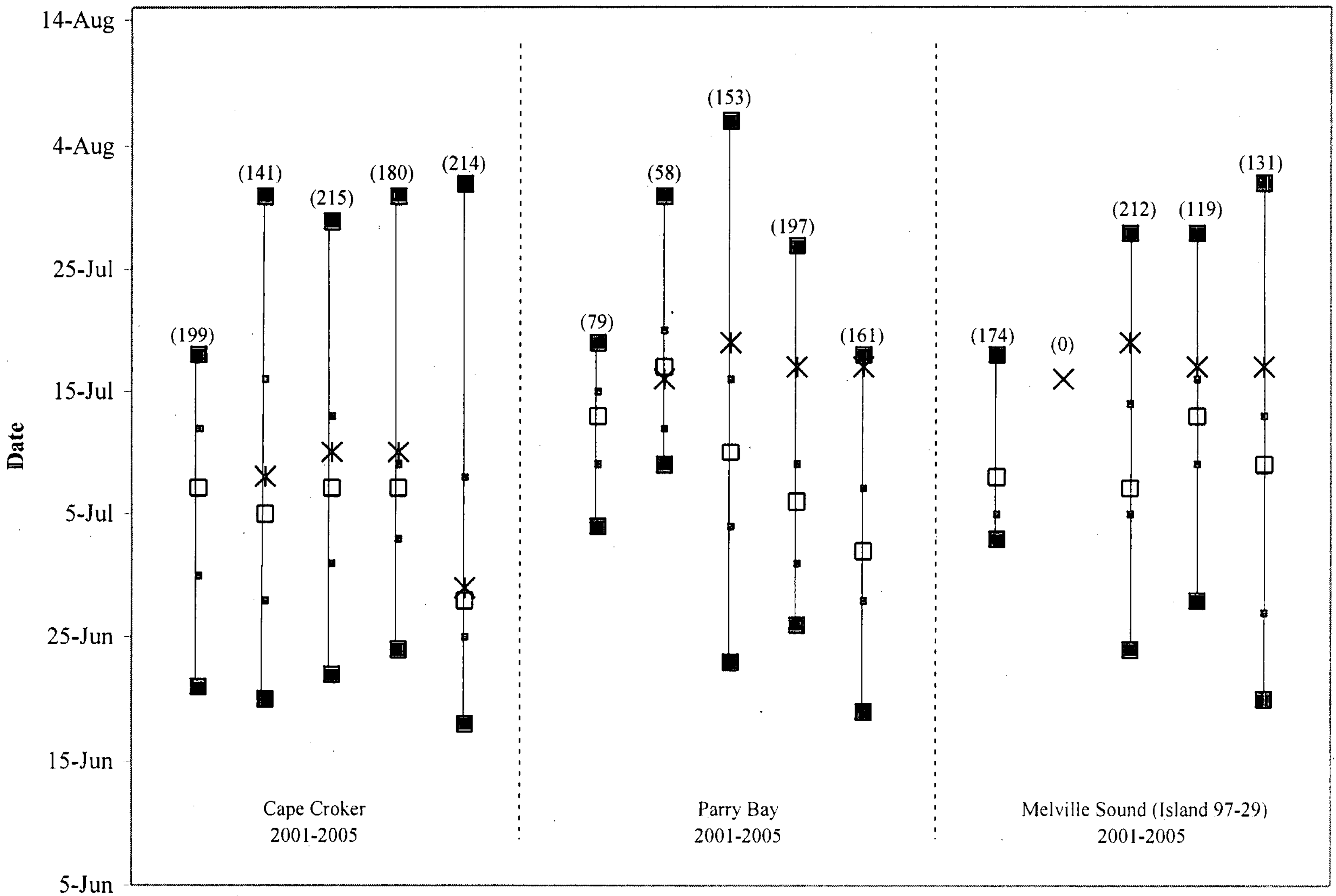


Figure 9. Description of timing of nest initiation in relation to ice break-up from 2001-2005 at Cape Croker, Parry Bay, and Melville Sound (Island 97-29). Large black squares indicate minimum and maximum nest initiation date, small black squares indicate the 25th and 75th percentile, open squares indicate median dates, X's indicate the date of ice break-up, and sample sizes provided in parentheses. Ice break-up dates were not available in 2001.

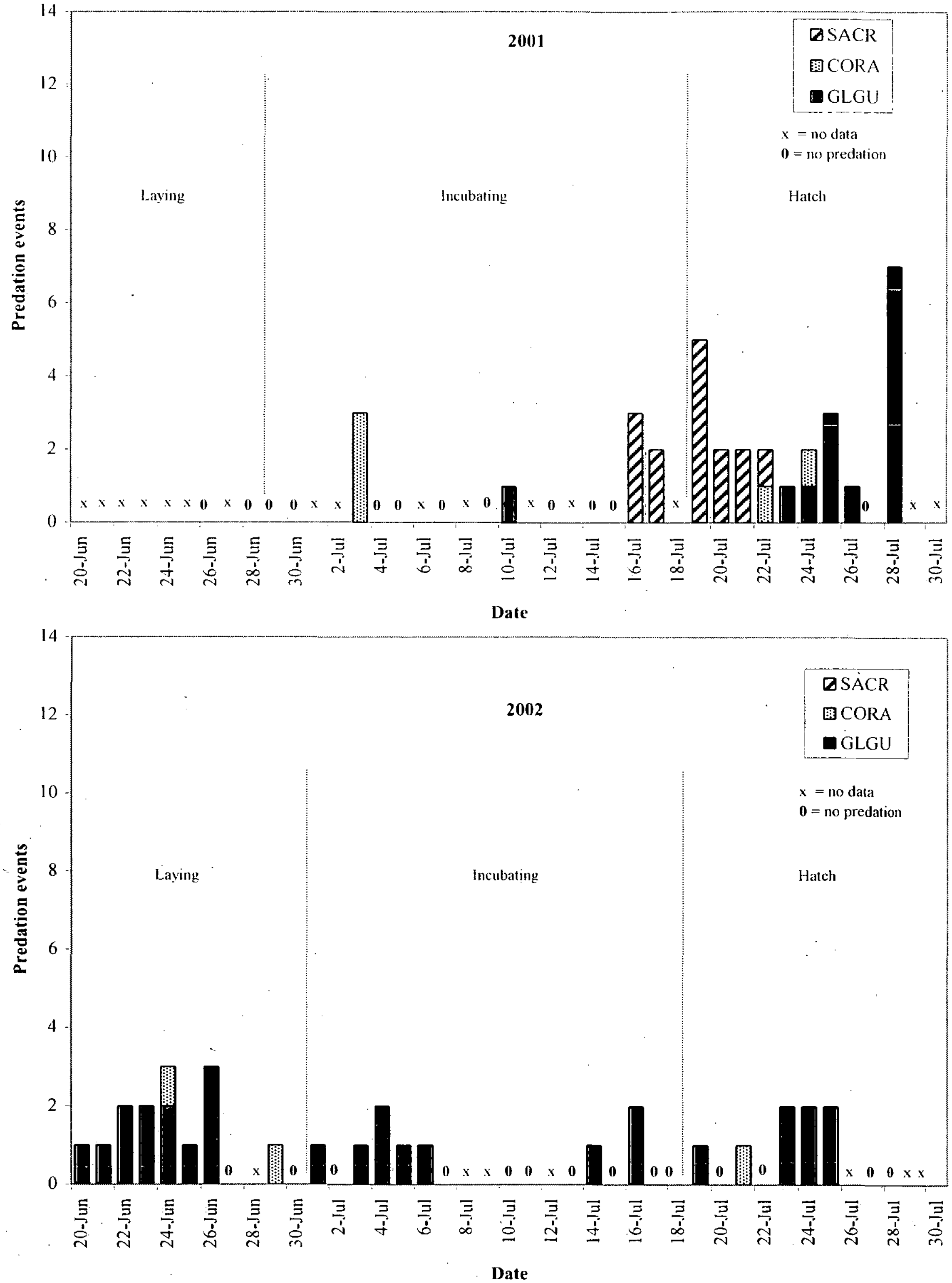


Figure 10a. Number of eggs and ducklings taken by avian predators during 5 half-hour periods of observation conducted daily from a blind on a nesting colony at Nauyak Lake in 2001 and 2002. The absence of Thayer's Gull in 2001 and 2002 indicates predator not observed in those years.

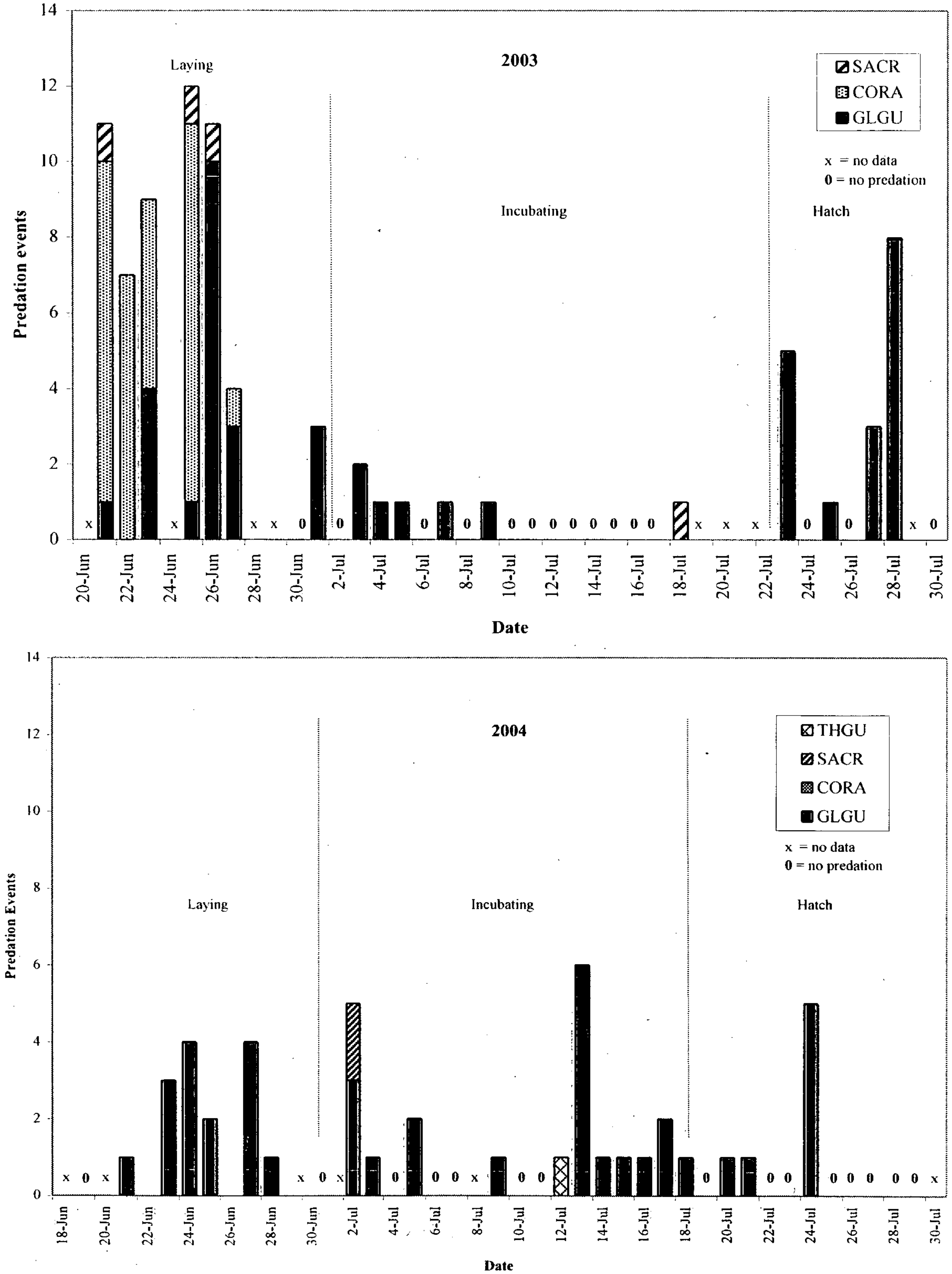


Figure 10b. Number of eggs and ducklings taken by avian predators during 5 half-hour periods of observation conducted daily from a blind on a nesting colony at Nauyak Lake in 2003 and 2004. The absence of Thayer's Gull in 2003 indicates predator not observed in that year.

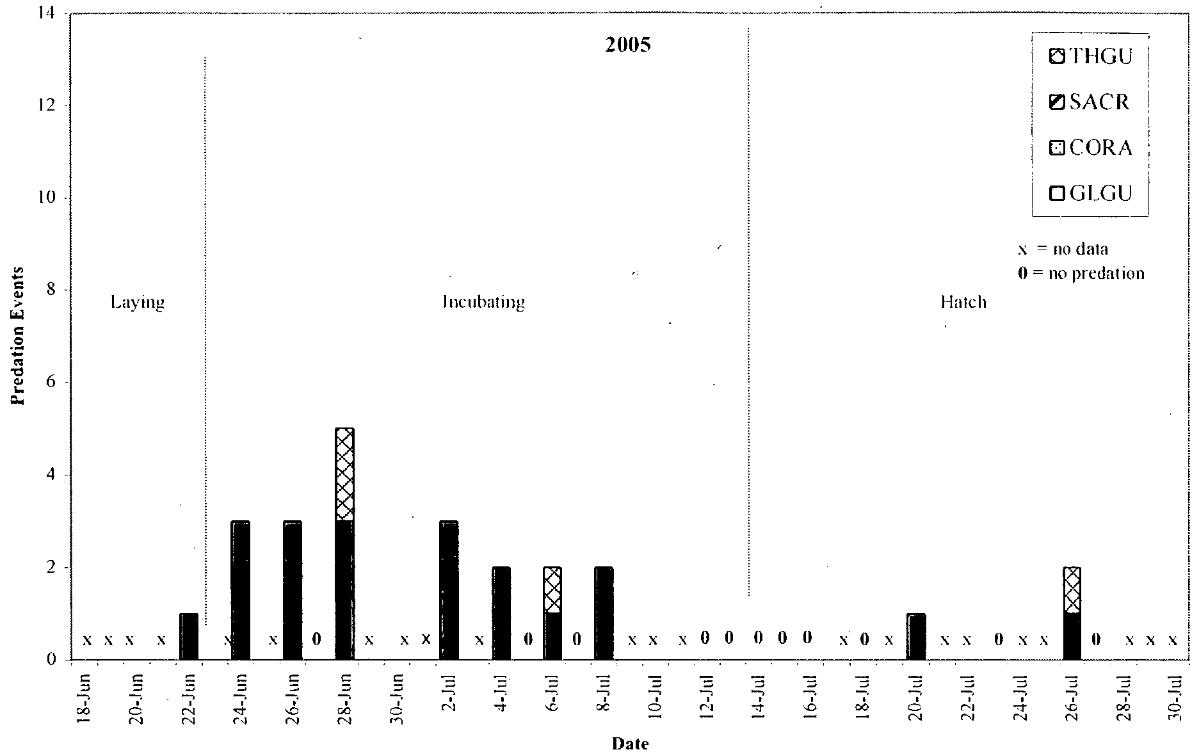


Figure 10c. Number of eggs and ducklings taken by avian predators during 5 half-hour periods of observation conducted daily from a blind on a nesting colony at Nauyak Lake in 2005.

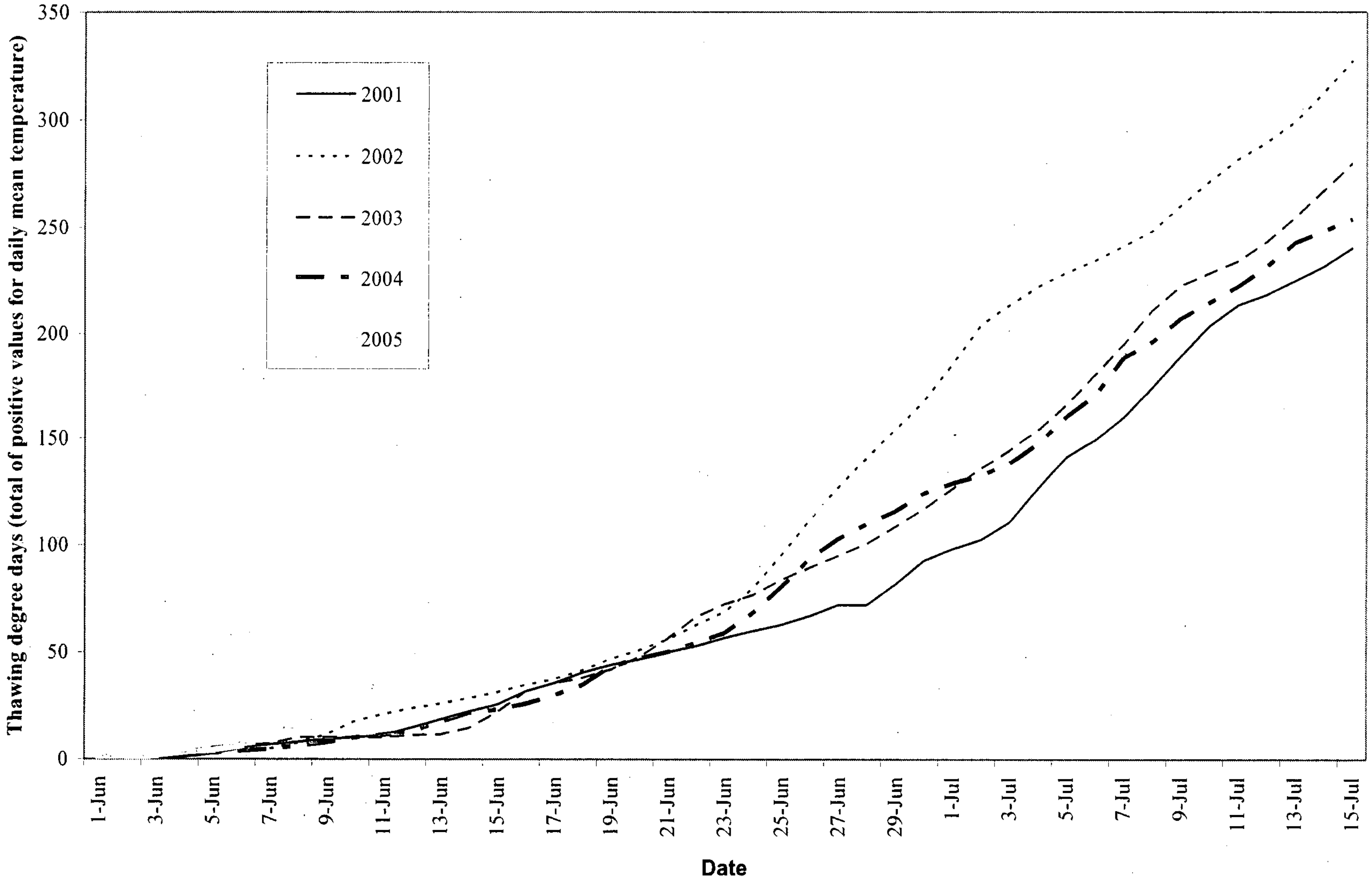


Figure 11. Timing of spring thaw each year based on temperatures recorded at a nearby weather station at Walker Bay 2001-2005 (thawing degree days was calculated as the total of positive values of daily mean temperatures starting at 1 June each year).

Appendix 1. Form used for collecting data at each nest.

Visit #	Yr	Mo	Da	Area	Isle	Nest #	Status nest	Status of eggs: warm	Cold	pip	hatching: wet	hatching: dry	mem	pred	cracked	Remarks & Observer Initials
1																
2																
3																
4																
5																
6																

Marker

Status nest

- 1=undisturbed
- 2=partly destroyed by predator
- 3=some eggs missing from last visit
- 4=eggs missing/broken previously, same this visit
- 5=totally destroyed
- 6=partly destroyed by predators and abandoned(some intact eggs in nest)
- 7=nest not found; assume predated
- 8=nest not found, assume predated or hatched
- 9=hatched (membranes present)
- 10=abandoned
- 11=investigator damage
- 12=hatching (wet or dry ducklings)
- 13=pipping (star or small hole)

Site description

- rye grass 1
- pebbles/shale 2
- seaweed 3
- boulders 4
- rocks 5
- bedrock 6
- willow 8
- turf 9
- other specify 7

Amount of Down

- 1=none
- 2=small amount
- 3=moderate
- 4=full amount

Age class information: Visit #	Technique	Egg number: 1	2	3	4	5	6	7	8	9	10	11	12
1													
2													
3													
4													
5													
6													
Condition	Visit 1												
	Visit 2												
	Visit 3												
	Visit 4												
	Visit 5												
	Visit 6												

Egg condition

1=warm 2=cold 3=destroyed by predators 4=cracked 5=hatching 6=hatched 7=missing 8=warm, but in another nest

Nest #

Appendix 2a. Summary of Pacific Eiders captured at Nauyak Lake, Nunavut from mid June to early July, 2001-2005[1].

Year	Females	Males	Total
2001	46 (7)	54 (8)	100 (15)
2002	84 (8)	88 (9)	172 (17)
2003	53 (8)	78 (8)	131 (16)
2004	30	39	69
2005	40	50	90
All years combined	253 (23)	309 (25)	562 (48)

[1]values in parentheses indicate number of the captured eiders that were implanted with satellite transmitters

Appendix 2b. Number of Pacific Eiders recaptured or resighted at Nauyak Lake, Nunavut[1].

	2001		2002		2003		2004		2005	
Year banded	Eiders recaptured	Bands resighted	Eiders recaptured	Bands resighted	Eiders recaptured	Bands resighted	Eiders recaptured	Bands resighted	Eiders recaptured	Bands resighted
2001	-	13 (1) females 3 males	3 (1) females 0 males	20 (2) females 4 males	5 (1) females 1 male	18 (3) females 3 males	1 female 0 males	5 females 0 males	4 (2) females 0 males	7 females 0 males
2002	-	-	-	46 (4) females 22 (2) males	6 (1) females 3 (1) males	28 (3) females 11 (1) males	3 (2) females 0 males	17 (2) females 3 males	2 females 0 males	18 females 4 males
2003	-	-	-	-	-	21 (2) females 19 males	2 females 0 males	19 (1) females 0 males	2 (2) females 0 males	14 (2) females 3 males
2004	-	-	-	-	-	-	-	9 females 8 males	2 females 1 males	11 females 0 males
2005	-	-	-	-	-	-	-	-	-	14 females 5 males

[1] values in parentheses indicate number of recaptured or resighted eiders that had satellite transmitters.

Appendix 3. Summary output from competing capture-recapture models developed for female Pacific Eiders trapped and released at Nauyak Lake, 2001-2005. Rates of survival (ϕ) and detection (p) are variously modeled as being time-dependant (i.e., varying annually), as increasing or decreasing over time (linear trend models), as constant, or, in the case of detection probability, as constant during the period 2002-2004 but different in 2005 (a year of increased resighting effort). Analyses conducted (1) based on a full data set that included all marked individuals (recaptures and resights), and (2) based on a reduced data set that included only those individuals resighted on the study area. Individuals implanted with satellite transmitters not included in either data set.

Model[a]	Number of parameters	Deviance[b]	AIC_c[c]	ΔAIC_c[d]	AIC_c weight[e]
All birds (n = 230)					
ϕ_{linear}, p_{t2}	4	36.75	584.70	0.00	0.26
ϕ, p	2	41.73	585.58	0.88	0.17
ϕ, p_{t2}	3	39.95	585.84	1.14	0.15
ϕ_t, p	5	36.28	586.30	1.60	0.12
ϕ_t, p_{t2}	5	36.28	586.30	1.60	0.12
ϕ, p_t	5	37.41	587.43	2.73	0.07
ϕ_{linear}, p	3	41.72	587.62	2.92	0.06
ϕ_{linear}, p_t	6	36.17	588.27	3.57	0.04
ϕ_t, p_t	7	35.87	590.07	5.38	0.02
Resighted individuals only (n = 140)					
ϕ, p_{t2}	3	29.98	358.42	0.00	0.22
ϕ, p	2	32.58	358.94	0.53	0.17
ϕ_{linear}, p_{t2}	4	28.45	358.97	0.56	0.16
ϕ, p_t	5	26.35	358.99	0.58	0.16
ϕ_{linear}, p_t	6	25.77	360.56	2.14	0.07
ϕ_{linear}, p	3	32.39	360.83	2.41	0.06
ϕ_t, p_{t2}	5	28.19	360.84	2.42	0.06
ϕ_t, p	5	28.19	360.84	2.42	0.06
ϕ_t, p_t	7	25.74	362.69	4.27	0.03

[a] Notation follows Lebreton et al. (1992); t = time-dependence (i.e., annual variation), t2 = constant during the period 2002-2004 but different in 2005, linear = linear trend over time, no subscript = constancy.

[b] Difference between -2log-likelihood of the current model and that of the saturated model.

[c] Akaike's Information Criterion with small-sample bias adjustment (Burnham and Anderson 1998).

[d] Difference between AIC_c of the current model and the minimum observed value.

[e] Normalized Akaike weight (Burnham and Anderson 1998).

Appendix 4. Model-averaged survival and detection rate estimates for female Pacific Eiders trapped and released at Nauyak Lake, 2001-2005. Estimates derive from analyses conducted (1) based on a full data set that included all marked individuals (recaptures and resights), and (2) based on a reduced data set that included only those individuals resighted on the study area. Individuals implanted with satellite transmitters excluded in both models.

		Survival[a]		Detection[b]	
Data set	Year	ϕ	SE	p	SE
Full	2001	0.760	0.056	-	-
	2002	0.729	0.045	0.575	0.055
	2003	0.668	0.041	0.576	0.050
	2004	0.665	0.059	0.562	0.051
	2005	-	-	0.744	0.060
Reduced	2001	0.779	0.072	-	-
	2002	0.748	0.057	0.633	0.081
	2003	0.720	0.054	0.555	0.066
	2004	0.713	0.073	0.547	0.067
	2005	-	-	0.731	0.101

[a] Probability of survival from year i to year i+1.

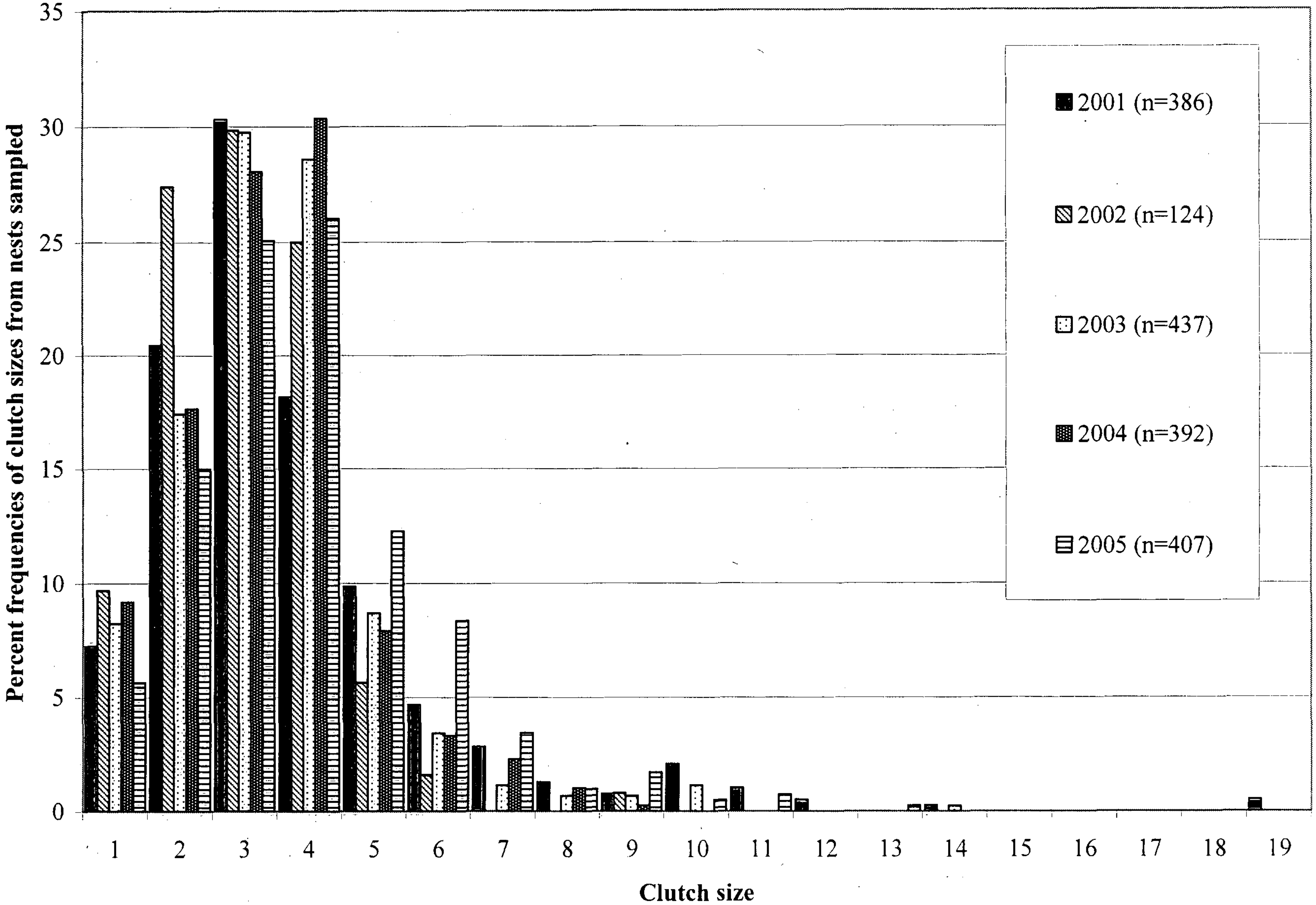
[b] Probability of detection in year i.

Appendix 5. Number of Pacific Eider nests found on each island surveyed from 2001-2005.

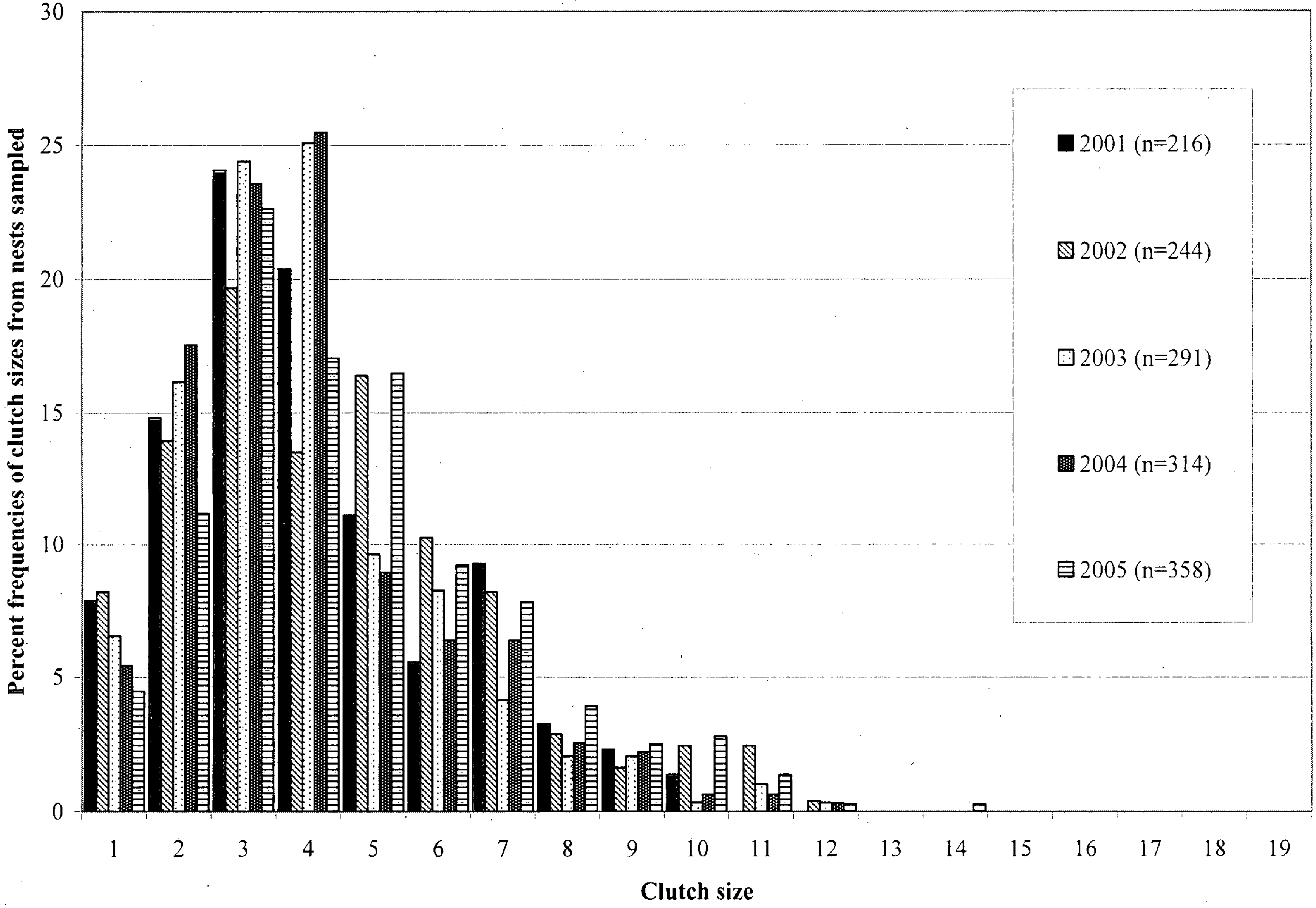
Island			Number of Nests Found				
	latitude	longitude	2001	2002	2003	2004	2005
87-10	68.113	108.090	67	8	5	18	40
88-19	68.255	107.798	1	0	2	0	2
88-20	68.253	107.798	0	2	2	4	6
88-33	68.212	107.693	13	26	24	38	49
88-37	68.206	107.714	1	0	1	0	2
88-48	68.194	107.610	37	18	42	85	65
88-49	68.198	107.620	2	1	7	5	7
88-51	68.207	107.577	2	1	20	9	4
88-61	68.187	107.436	0	1	0	0	0
88-65	68.181	107.421	6	8	11	17	2
88-66	68.186	107.417	10	2	54	20	1
88-67	68.186	107.431	8	3	21	4	1
88-83	68.211	107.518	20	2	34	22	12
89-26	68.291	107.609	2	5	13	12	7
89-46	68.270	107.241	2	3	8	21	8
97-29	68.165	107.120	174	0[1]	212	119	132
98-1	68.121	107.731	34	42	21	29	12
98-3	68.116	107.777	66	30	34	34	49
98-4	68.111	107.769	0	19	43	39	67
98-5	68.113	107.792	0	14	11	18	15
98-8	68.107	107.778	2	1	11	11	7
98-11	68.100	107.753	3	7	24	26	16
98-12	68.107	107.853	27	20	66	4	13
Cape Croker total			199	141	215	179	219
Parry Bay total			80	58	153	196	162
Hurd Isles total			24	14	86	41	4
Marine Total			477	213	666	535	517
Nauyak Island 1	68.400	107.727	3	5	8	21	12
Nauyak Island 2	68.400	107.727	15	12	104	118	131
Nauyak Island 3	68.400	107.727	100	61	63	44	34
Blind Plot on Isle 4			202	200	140	89	113
Mayfield Survey of Isle 4			89	72	66	51	50
All nonMfld Isle 4			41	169	162	186	191
Isle 4 Total	68.400	107.727	332	441	368	326	354
Nauyak Island 5	68.400	107.727	25	59	55	50	81
Nauyak Island 7	68.400	107.727	18	51	47	67	96
Nauyak Islands Total			493	629	645	626	708

[1] Arctic fox on island destroyed all nests prior to nest discovery.

Appendix 6a. Clutch size frequencies for nests at marine colonies from 2001-2005.



Appendix 6b. Clutch size frequencies for nests at Nauyak Lake from 2001-2005.



Appendix 7. Apparent nest success of Pacific Eiders at each island surveyed annually from 2001-2005.

	2001					2002				
Island	Success -ful nests	Unsuccess -ful nests	Unknown fates	Total nests	Apparent nest success (%)	Success -ful nests	Unsuccess -ful nests	Unknown fates	Total nests	Apparent nest success (%)
87-10	-	-	-	-	-	4	1	3	8	80
88-19	-	-	-	-	-			0	0	0
88-20	-	-	-	-	-	0	1	1	2	0
88-33	-	-	-	-	-	16	4	6	26	80
88-37	-	-	-	-	-			0	0	
88-48	-	-	-	-	-	2	9	7	18	18
88-49	-	-	-	-	-	0	0	1	1	0
88-51	-	-	-	-	-	0	1	0	1	0
88-61	-	-	-	-	-	0	1	0	1	0
88-65	-	-	-	-	-	0	8	0	8	0
88-66	-	-	-	-	-	0	2	0	2	0
88-67	-	-	-	-	-	0	3	0	3	0
88-83	-	-	-	-	-	0	1	1	2	0
89-26	-	-	-	-	-	1	2	2	5	33
89-46	-	-	-	-	-	0	1	2	3	0
97-29	-	-	-	-	-			0	0	
98-1	-	-	-	-	-	4	37	1	42	10
98-3	-	-	-	-	-	2	27	1	30	7
98-4	-	-	-	-	-	1	15	3	19	6
98-5	-	-	-	-	-	2	10	2	14	17
98-8	-	-	-	-	-	0	0	1	1	0
98-11	-	-	-	-	-	0	1	6	7	0
98-12	-	-	-	-	-	0	10	10	20	0
Nauyak 1	0	2	1	3	0	2	0	3	5	100
Nauyak 2	3	5	7	15	38	8	1	3	12	89
Nauyak 3	51	23	26	100	69	31	30	0	61	51
Nauyak 4	65	44	21	130	60	49	19	4	72	72
Nauyak 5	8	10	7	25	44	42	16	1	59	72
Nauyak 7	4	6	8	18	40	19	27	5	51	41

Appendix 7 continued for years 2003-2004.

	2003					2004				
Island	Success-ful nests	Unsuccess-ful nests	Unknown fates	Total nests	Apparent nest success (%)	Success-ful nests	Unsuccess-ful nests	Unknown fates	Total nests	Apparent nest success (%)
87-10	0	5	0	5	0	0	17	1	18	0
88-19	0	1	1	2	0			0	0	
88-20	2	0	0	2	100	3	1	0	4	75
88-33	11	12	1	24	48	25	12	2	39	68
88-37	0	1	0	1	0			0	0	
88-48	23	10	9	42	70	64	18	3	85	78
88-49	7	0	0	7	100	4	0	1	5	100
88-51	14	5	1	20	74	4	4	1	9	50
88-61				0				0	0	
88-65	0	11	0	11	0	0	17	0	17	0
88-66	2	52	0	54	4	1	19	0	20	5
88-67	0	21	0	21	0	0	4	0	4	0
88-83	17	16	1	34	52	8	11	2	21	42
89-26	10	3	0	13	77	5	6	1	12	45
89-46	3	2	3	8	60	6	15	0	21	29
97-29	95	99	18	212	49	66	44	8	118	60
98-1	3	14	1	18	18	10	17	2	29	37
98-3	5	29	0	34	15	6	27	1	34	18
98-4	30	9	4	43	77	1	37	1	39	3
98-5	2	9	0	11	18	0	17	1	18	0
98-8	7	2	2	11	78	5	6	0	11	45
98-11	19	4	1	24	83	2	22	2	26	8
98-12	3	62	0	65	5	0	4	0	4	0
Nauyak 1	3	0	5	8	100	14	4	3	21	78
Nauyak 2	78	16	9	103	83	85	27	6	118	76
Nauyak 3	28	31	3	62	47	20	22	1	43	48
Nauyak 4	52	8	5	65	87	43	6	2	51	88
Nauyak 5	43	11	1	55	80	37	11	2	50	77
Nauyak 7	11	36	0	47	23	46	20	2	68	70

Appendix 7 continued for 2005.

Island	2005				
	Success-ful nests	Unsuccess-ful nests	Unknown fates	Total nests	Apparent nest success (%)
87-10	2	31	7	40	6
88-19	2	0	0	2	100
88-20	4	2	0	6	67
88-33	38	11	0	49	78
88-37	1	0	1	2	100
88-48	49	15	1	65	77
88-49	7	0	0	7	100
88-51	1	3	0	4	25
88-61			0	0	
88-65	0	2	0	2	0
88-66	0	1	0	1	0
88-67	0	1	0	1	0
88-83	0	12	0	12	0
89-26	4	3	0	7	57
89-46	6	2	0	8	75
97-29	57	63	11	131	48
98-1	2	9	0	11	18
98-3	37	11	1	49	77
98-4	56	11	0	67	84
98-5	4	11	0	15	27
98-8	3	4	0	7	43
98-11	9	5	2	16	64
98-12	0	12	1	13	0
Nauyak 1	9	2	1	12	82
Nauyak 2	84	13	3	100	87
Nauyak 3	23	10	1	34	70
Nauyak 4	43	6	1	50	88
Nauyak 5	71	9	0	80	89
Nauyak 7	63	32	1	96	66

Appendix 8. Timing of nest initiation for Pacific Eiders at each island surveyed from 2001-2005.

	Initiation dates 2001				Initiation dates 2002			
Island number	median	min	max	n	median	min	max	n
87-10	13-Jul	6-Jul	18-Jul	67	15-Jul	5-Jul	30-Jul	8
88-19	6-Jul	6-Jul	6-Jul	1	-	-	-	0
88-20	-	-	-	0	21-Jul	20-Jul	22-Jul	2
88-33	13-Jul	9-Jul	18-Jul	13	14-Jul	9-Jul	27-Jul	26
88-37	4-Jul	4-Jul	4-Jul	1	-	-	-	0
88-48	14-Jul	8-Jul	19-Jul	37	18-Jul	12-Jul	31-Jul	18
88-49	15-Jul	14-Jul	15-Jul	2	18-Jul	18-Jul	18-Jul	1
88-51	14-Jul	13-Jul	15-Jul	2	20-Jul	20-Jul	20-Jul	1
88-61	-	-	-		22-Jul	22-Jul	22-Jul	1
88-65	17-Jul	14-Jul	18-Jul	6	9-Jul	9-Jul	18-Jul	8
88-66	15-Jul	4-Jul	18-Jul	10	14-Jul	6-Jul	21-Jul	2
88-67	14-Jul	7-Jul	18-Jul	8	9-Jul	9-Jul	16-Jul	3
88-83	11-Jul	6-Jul	1-Jul	20	22-Jul	18-Jul	25-Jul	2
89-26	16-Jul	16-Jul	15-Jul	1	15-Jul	9-Jul	22-Jul	5
89-46	6-Jul	4-Jul	7-Jul	2	17-Jul	9-Jul	23-Jul	3
97-29	8-Jul	3-Jul	18-Jul	174	-	-	-	0
98-1	30-Jun	21-Jun	17-Jul	34	28-Jun	20-Jun	21-Jul	42
98-3	1-Jul	24-Jun	17-Jul	66	28-Jun	23-Jun	30-Jul	30
98-4	-	-	-	0	4-Jul	28-Jun	26-Jul	19
98-5	-	-	-	0	9-Jul	28-Jun	28-Jul	14
98-8	17-Jul	15-Jul	18-Jul	2	26-Jul	26-Jul	26-Jul	1
98-11	13-Jul	10-Jul	15-Jul	3	21-Jul	8-Jul	30-Jul	7
98-12	8-Jul	3-Jul	8-Jul	27	21-Jul	6-Jul	31-Jul	20
All marine	8-Jul	21-Jun	19-Jul	476	9-Jul	20-Jun	31-Jul	213
Nauyak 1	14-Jul	14-Jul	21-Jul	3	16-Jul	8-Jul	20-Jul	5
Nauyak 2	10-Jul	5-Jul	27-Jul	15	9-Jul	4-Jul	28-Jul	12
Nauyak 3	30-Jun	23-Jun	24-Jul	100	2-Jul	21-Jun	24-Jul	61
Nauyak 4	1-Jul	23-Jun	22-Jul	87	25-Jun	20-Jun	28-Jul	72
Nauyak 5	29-Jun	22-Jun	15-Jul	25	24-Jun	19-Jun	19-Jul	59
Nauyak 7	6-Jul	30-Jun	26-Jul	18	27-Jun	19-Jun	18-Jul	51
All Nauyak	1-Jul	22-Jun	27-Jul	248	27-Jun	19-Jun	28-Jul	260

Appendix 8 continued.

Island number	Initiation dates 2003				Initiation dates 2004			
	median	min	max	n	median	min	max	n
87-10	21-Jul	27-Jun	29-Jul	5	7-Jul	4-Jul	29-Jul	18
88-19	14-Jul	7-Jul	20-Jul	2	-	-	-	0
88-20	12-Jul	10-Jul	14-Jul	2	8-Jul	28-Jun	15-Jul	4
88-33	12-Jul	28-Jun	23-Jul	24	1-Jul	26-Jun	20-Jul	39
88-37	27-Jun	27-Jun	27-Jun	1	-	-	-	0
88-48	15-Jul	28-Jun	6-Aug	42	4-Jul	24-Jun	22-Jul	85
88-49	13-Jul	11-Jul	21-Jul	7	6-Jul	5-Jul	25-Jul	5
88-51	12-Jul	23-Jun	26-Jul	20	7-Jul	28-Jun	22-Jul	9
88-61	-	-	-	0	-	-	-	0
88-65	12-Jul	26-Jun	19-Jul	11	7-Jul	6-Jul	19-Jul	17
88-66	3-Jul	22-Jun	27-Jul	54	28-Jun	25-Jun	8-Jul	20
88-67	2-Jul	24-Jun	19-Jul	21	6-Jul	28-Jun	10-Jul	4
88-83	3-Jul	25-Jun	20-Jul	34	7-Jul	28-Jun	20-Jul	22
89-26	3-Jul	28-Jun	14-Jul	13	2-Jul	26-Jun	14-Jul	12
89-46	12-Jul	7-Jul	26-Jul	8	2-Jul	26-Jun	20-Jul	21
97-29	7-Jul	24-Jun	28-Jul	212	11-Jul	26-Jun	26-Jul	119
98-1	30-Jun	23-Jun	10-Jul	21	28-Jun	22-Jun	7-Jul	29
98-3	27-Jun	22-Jun	21-Jul	34	2-Jul	23-Jun	18-Jul	34
98-4	6-Jul	25-Jun	28-Jul	43	6-Jul	28-Jun	19-Jul	39
98-5	7-Jul	25-Jun	21-Jul	11	3-Jul	26-Jun	17-Jul	19
98-8	8-Jul	25-Jun	17-Jul	11	7-Jul	1-Jul	17-Jul	11
98-11	13-Jul	29-Jun	21-Jul	24	5-Jul	28-Jun	26-Jul	26
98-12	12-Jul	27-Jun	21-Jul	66	6-Jul	28-Jun	7-Jul	4
All marine	7-Jul	22-Jun	6-Aug	666	6-Jul	22-Jun	29-Jul	535
Nauyak 1	13-Jul	10-Jul	21-Jul	8	6-Jul	23-Jun	23-Jul	21
Nauyak 2	1-Jul	23-Jun	19-Jul	104	1-Jul	11-Jun	22-Jul	118
Nauyak 3	29-Jun	15-Jun	13-Jul	63	2-Jul	20-Jun	17-Jul	44
Nauyak 4	28-Jun	16-Jun	27-Jul	66	30-Jun	17-Jun	18-Jul	142
Nauyak 5	28-Jun	22-Jun	14-Jul	55	28-Jun	19-Jun	17-Jul	50
Nauyak 7	26-Jun	13-Jun	16-Jul	47	25-Jun	11-Jun	20-Jul	68
All Nauyak	29-Jun	13-Jun	27-Jul	343	30-Jun	11-Jun	24-Jul	443

Appendix 8 continued.

Island number	Initiation dates 2005			
	median	min	max	n
87-10	7-Jul	23-Jun	1-Aug	40
88-19	7-Jul	6-Jul	7-Jul	2
88-20	6-Jul	27-Jun	7-Jul	6
88-33	27-Jun	19-Jun	13-Jul	48
88-37	1-Jul	25-Jun	6-Jul	2
88-48	5-Jul	22-Jun	18-Jul	65
88-49	4-Jul	23-Jun	12-Jul	7
88-51	7-Jul	5-Jul	18-Jul	4
88-61	-	-	-	0
88-65	1-Jul	30-Jun	1-Jul	2
88-66	1-Jul	1-Jul	1-Jul	1
88-67	2-Jul	2-Jul	2-Jul	1
88-83	30-Jun	23-Jun	7-Jul	12
89-26	9-Jul	2-Jul	16-Jul	7
89-46	8-Jul	2-Jul	16-Jul	8
97-29	9-Jul	20-Jun	1-Aug	131
98-1	27-Jun	23-Jun	10-Jul	12
98-3	24-Jun	18-Jun	23-Jul	48
98-4	27-Jun	21-Jun	21-Jul	63
98-5	27-Jun	21-Jun	7-Jul	15
98-8	7-Jul	27-Jun	20-Jul	7
98-11	9-Jul	20-Jun	26-Jul	16
98-12	8-Jul	26-Jun	22-Jul	13
All marine	2-Jul	18-Jun	1-Aug	510
Nauyak 1	4-Jul	25-Jun	19-Jul	12
Nauyak 2	30-Jun	21-Jun	16-Jul	99
Nauyak 3	30-Jun	23-Jun	9-Jul	33
Nauyak 4	24-Jun	18-Jun	18-Jul	46
Nauyak 5	22-Jun	12-Jun	17-Jul	81
Nauyak 7	25-Jun	17-Jun	21-Jul	95
All Nauyak	26-Jun	12-Jun	21-Jul	366

Appendix 9. Summary of nesting ecology data collected from a blind on Island 4 of Nauyak Lake.

Year	Median incubation onset	Median hatch date	Incubation period (days)	Mean clutch size	Percentage of nests hatched	Intraspecific nest parasitism[2] (%)	Number of nests
2001	25 June [1]	20 July	25.3 ± 2.0 (n=8)	6.1 (n=93)	83	53	200
2002	25 June	20 July	25.4 ± 1.6 (n=146)	5.1 (n=127)	94	34	200
2003	27 June	23 July	25.4 ± 2.0 (n=101)	4.3 (n=120)	93	22	139
2004	27 June	21 July	25.3 ± 1.5 (n=47)	4.1 (n=81)	81	17	89
2005	20 June	15 July	-	6.7 (n=74)	89	51	113

[1]indicates incubation onset was estimated not observed

[2]percentage of nests containing more than 4 eggs

Appendix 10. Summary of body size measurements obtained from Pacific Eiders captured at Nauyak Lake from mid to late June 2001-2005. Standard error and sample size in parentheses. See Dzubin and Cooch (1992) and Mendall (1986) for description of measurements. Culmen midline is Dzubin and Cooch's (1992) Culmen 1 and Total bill is Culmen 2.

Year	Sex	Weight (g)	Total tarsus (cm)	Inner tarsus (cm)	Wing cord (cm)	Head (cm)	Total bill (cm)	Culmen midline (cm)	Nostril-extension (cm)
2001	F	2733.91 (±25.04; 46)		52.97 (±0.33; 46)	306.30 (±1.01; 46)	128.58 (±0.58; 46)	65.81 (±0.50; 46)	47.67 (±0.41; 46)	30.68 (±0.41; 46)
	M	2438.36 (±22.81; 55)		54.89 (±0.44; 55)	315.64 (±0.89; 55)	135.11 (±0.50; 55)	74.49 (±0.45; 55)	53.05 (±0.47; 55)	37.98 (±0.37; 55)
2002	F	2677.94 (±27.30; 85)	64.49 (±0.22; 84)	53.26 (±0.22; 85)	304.13 (±1.14; 85)	126.28 (±0.37; 85)	67.23 (±0.36; 85)	49.27 (±0.34; 85)	31.83 (±0.48; 85)
	M	2442.87 (±20.73; 89)	67.05 (±0.28; 89)	55.09 (±0.20; 89)	312.57 (±0.76; 89)	132.93 (±0.49; 89)	73.16 (±0.36; 89)	51.55 (±0.34; 89)	37.43 (±0.42; 89)
2003	F	2732.61 (±27.83; 69)	63.52 (±0.34; 68)	52.25 (±0.27; 68)	302.54 (±1.01; 68)	125.33 (±0.46; 68)	67.28 (±0.53; 68)	48.86 (±0.51; 68)	31.95 (±0.47; 68)
	M	2442.05 (±27.03; 83)	65.07 (±0.30; 83)	53.97 (±0.26; 83)	308.77 (±1.28; 83)	131.31 (±0.42; 83)	74.45 (±0.39; 83)	52.13 (±0.33; 83)	37.73 (±0.31; 83)
2004	F	2673.61 (±45.92; 36)	63.59 (±0.40; 36)	53.48 (±0.51; 36)	305.19 (±1.53; 36)	125.91 (±0.59; 36)	67.61 (±0.74; 36)	48.99 (±0.45; 36)	32.14 (±0.61; 36)
	M	2376.92 (±30.00; 39)	65.98 (±0.44; 39)	56.38 (±0.46; 39)	313.87 (±1.20; 39)	131.63 (±0.51; 39)	74.65 (±0.56; 39)	52.64 (±0.78; 39)	37.68 (±0.39; 39)
2005	F	2700.20 (±26.51; 50)	63.99 (±0.30; 50)	53.42 (±0.25; 50)	307.08 (±1.20; 50)	125.28 (±0.47; 55)	66.76 (±0.43; 50)	48.84 (±0.31; 50)	30.59 (±0.41; 55)
	M	2426.08 (±21.76; 51)	66.23 (±0.39; 51)	55.13 (±0.31; 51)	318.73 (±0.79; 51)	132.17 (±0.61; 51)	75.19 (±0.41; 51)	52.65 (±0.39; 51)	37.57 (±0.33; 51)
All years combined	F	2703.48 (±13.49; 286)	63.97 (±0.15; 238)	53.03 (±0.13; 285)	304.75 (±0.54; 285)	126.20 (±0.22; 285)	66.98 (±0.22; 285)	48.80 (±0.19; 285)	31.50 (±0.22; 285)
	M	2431.06 (±11.20; 317)	66.10 (±0.18; 262)	54.92 (±0.16; 317)	313.26 (±0.50; 317)	132.60 (±0.24; 317)	74.24 (±0.19; 317)	52.27 (±0.19; 317)	37.66 (±0.17; 317)

Appendix 11. Timing of nest initiation and ice break-up at the Pacific Eider colony at Nauyak Lake from 2001-2005.

Island	Year	Date island free of ice	Median nest initiation date (n)	Days difference
Isle 5	2001	before 12-Jun	29-Jun (??)	17+
	2002	before 8-Jun	24-Jun	16+
	2003	14-Jun	28-Jun	14
	2004	before 16-Jun	28-Jun	12+
	2005	before 18-Jun	22-Jun	4+
	All years	2nd week of June	26-Jun	13+
Isle 4	2001	before 12-Jun	1-Jul	17+
	2002	before 8-Jun	25-Jun	17+
	2003	23-Jun	28-Jun	5
	2004	19-Jun	30-Jun	11
	2005	before 18-Jun	24-Jun	6+
	All years	2nd & 3rd week of June	28-Jun	11+
Isle 3	2001	17-Jun	30-Jun	13
	2002	15-Jun	2-Jul	17
	2003	27-Jun	29-Jun	2
	2004	24-Jun	2-Jul	8
	2005	21-Jun	30-Jun	9
	All years	3rd week of June	2-Jul	10
Isle 2	2001		10-Jul	
	2002	1-Jul	9-Jul	8
	2003	4-Jul	1-Jul	-3
	2004	5-Jul	1-Jul	-4
	2005	28-Jun	30-Jun	2
	All years	1st week of July	4-Jul	1
Isle 1	2001	13-Jul	14-Jul	1
	2002	8-Jul	16-Jul	8
	2003	9-Jul	13-Jul	4
	2004	10-Jul	6-Jul	-4
	2005	6-Jul	4-Jul	-2
	All years	2nd week of July	11-Jul	1

Appendix 12. Summary of evidence of predator activity as observed during nest visits on nesting islands.

Date of observation	Island	Suspected predator or evidence of predation	Outcome
8-Jul-2001	97-29	arctic fox	4 dead hens and approximately 90 depredated nests prior to first island visit on 8 July
7-Jul-2001	98-3	grizzly bear scat	unknown
10-Jul-2001	Nauyak Isle 3	grizzly bear scat	unknown
June and July 2002	97-29	arctic fox	did not ever locate one active nest due to fox presence on island; however known nesting attempts occurred due to prevalence of depredated eggs
9-Jul-2002	88-48	observed fox on nearby mainland	1 dead eider hen; unclear the impact of that fox
2-Jul-2002	Nauyak Isle 2	grizzly bear scat	unknown
28-Jun-2003	97-29	grizzly bear scat and wolf tracks	unknown; predators on island prior to first visit
8-Jul-2003	98-3	3 occurrences of grizzly bear scat	depredated all active nests (23) between island visits on June 28 and July 8; scat contained egg shell fragments
8-Jul-2003	98-11	grizzly bear scat	unknown
30-Jul-2003	98-12	suspected wolverine	depredated all but 2 active nests (55) and depredated 2 eiders hens between island visits on July 22 and July 30; suspected wolverine due to depredated eggs shells found within or near nest bowl intact but eaten from one side
13-Jul-2003	Nauyak Isle 7	observed and scared grizzly bear during foraging event	depredated all active nests (35) between island visits on July 2 and 13
29-Jun-2004	97-29	observed and scared wolverine during foraging event	depredated any nests initiated prior to this first visit (approximately 80 egg shells discovered) and depredated 3 eider hens; wolverine scared onto ice by our presence but we observed it return upon our departure in the helicopter and subsequently depredated the 10 nests we found active
29-Jun-2004	87-10	arctic fox observed on island	no nests or depredated eggs found; on next island visit on July 8, discovered 1 depredated eider hen
20-Jul-2004	87-10	suspected grizzly bear	depredated all active nests (14) between island visits July 8-20, plus and additional 9 nests initiated since July 8 visit
31-Jul-2004	87-10	golden eagle and parasitic jaeger	observers disturbed eagle foraging on eider hen near nest and jaeger foraging on eggs
30-Jun-2004	88-33	arctic fox observed on mainland across from island	unknown

8-Jul-2004	88-66	unknown	evidence of 3 freshly depredated eider hens
31-Jul-2004	98-3	grizzly bear scat; some with egg shell fragments	depredated all active nests (20) between island visits July 20-31
29-Jun-2005	97-29	suspected wolverine or arctic fox	located 108 depredated eggs on island prior to first visit; unknown predator
10-Jul-2005	98-12	large amount of fresh grizzly bear scat	depredated all active nests (6) between island visits June 29 and July 10
25-Jul-2005	87-10	large amount of fresh grizzly bear scat; some with egg shell fragments	depredated 22 active nests between island visits July 10-25; however 11 new nests initiated since predation event

Appendix 13. Summary of Glaucous Gull nesting activity on eider nesting islands for 2001-2005.

Island	Year	Number of Glaucous Gull nests	Mean clutch size
89-46	2001	3	3
98-1	2001	27	2.6
Nauyak 3	2001	11	2.1
Nauyak 7	2001	1	1
		Total nests = 42	
87-10	2002	1	?
88-33	2002	1	1
89-26	2002	1	?
98-1	2002	12	2.1
98-3	2002	1	2
98-5	2002	1	1
98-11	2002	1	1
Nauyak 2	2002	1	2
Nauyak 3	2002	15	2.1
		Total nests = 34	
87-10	2003	1	?
88-66	2003	2	1.5
88-67	2003	1	1
88-83	2003	2	2.5
89-26	2003	1	1
97-29	2003	1	1
98-1	2003	15	2.1
98-5	2003	1	2
Nauyak 2	2003	1	3
Nauyak 3	2003	12	2.1
		Total nests = 37	

Appendix 13 continued.

Island	Year	Number of Glaucous Gull nests	Mean clutch size
88-33	2004	1	3
88-49	2004	1	2
88-51	2004	1	1
88-66	2004	1	1
88-67	2004	2	2.5
88-83	2004	4	1.5
89-26	2004	4	2.5
89-46	2004	1	1
98-1	2004	34	2.7
98-3	2004	1	3
Nauyak 2	2004	1	3
Nauyak 3	2004	14	1.8
Nauyak 7	2004	1	2
		Total nests = 66	
87-10	2005	1	3
88-20	2005	1	2
88-33	2005	1	3
88-65	2005	1	2
88-67	2005	2	3
88-83	2005	2	2.5
97-29	2005	1	1
98-1	2005	32	2.5
98-3	2005	1	1
98-4	2005	1	1
98-5	2005	1	1
Nauyak 3	2005	12	2.3
Nauyak 4	2005	1	3
Nauyak 7	2005	1	?
		Total nests = 58	

Appendix 14. Summary of data collected to assess small mammal abundance at Nauyak Lake based on observations from 19 June to 15 July 2001-2005.

Location	Year	Lemming	Short-eared Owl	Snowy Owl	Pomarine Jaeger	Ground squirrel	Arctic fox
Nauyak Lake camp	2001	medium	no data	no data	no data	no difference	high
	2002	low	0	0	0	no difference	med
	2003	low	0	0	1 for 3 days early	no difference	early only
	2004	high	1-3 through summer	1 male during mid summer	2 nesting	most abundant	rare
	2005	medium	0	0	0	no difference	med