ABUNDANCE AND MULTI-YEAR OCCUPANCY OF GYRFALCONS *FALCO RUSTICOLUS* ON THE SEWARD PENINSULA, ALASKA

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ABSTRACT.—The purpose of this work is to determine interannual variability in abundance, occupancy, distribution, and nesting success of Gyrfalcons (*Falco rusticolus*) and other cliff-nesting raptors within 14,150 km^2 of the Seward Peninsula in western Alaska. From 2005 through 2010, comprehensive helicopter surveys were used for annual inspections of 679 discrete rock cliffs typically occupied by raptors within the study area. Based on 1,372 cumulative nesting events at 454 unique locations, Gyrfalcons comprised 18% of total raptor occupancy, ranging from 40 – 43 locations annually. Individual Gyrfalcon observations (n = 250) show use of 154 separate cliff locations by single birds (16%; n=39), unsuccessful pairs (11%; n=28), and successful pairs (73%; n=183). Nest types and usage included: cliff stick nests constructed by other raptors and ravens, 73%; rock ledges, 16%; man-made structures, 7%; and tree stick nests, 2%. Mean nearest neighbor distances varied from 8.8 to 10.0 km with distances ranging from 0.8 to 37.6 km indicating that both clustered and dispersed nesting are characteristics of this area, each strongly influenced by local topography, dissected rock cliffs and broad lowland areas with no cliffs. Clustering of closely spaced alternate nesting locations yields 96 unique nesting areas with minimal interannual overlap and maximum distance separation among occupied sites, suggesting that pairs have relatively high rates of movement to 'new' nesting areas in successive years. Based on iterative counts of pair occupancy at the same location (n=248 nesting events), the majority were occupied 1 year (n=79 nesting events) before becoming vacant. Longer periods of pair occupancy were observed at 30 locations with 2-year tenure (n=60), 14 locations with 3-year (n=42), 8 locations with 4-year (n=32), 4 locations with 5-year (n=20) and 3 locations with 6-year occupancy (n=18). Since abundance of pairs is stable through time, the high frequency of 1-year nesting events suggests variable site selection and low nest site tenacity among pairs. Gyrfalcon occupancy ranged from 31–39 pairs, yielding a maximum nesting density of 2.7 pairs per 1,000 km^2. Successful pairs varied annually from 72–93% of total occupied locations; brood size (n=183 locations with nestlings) ranged from 2.35–2.70 young/successful pair (1.50–2.23 young/total pair). Hatch dates ranged from 7 May to 27 June with low intra- or interannual nesting synchrony and little evidence of recycling due to nesting failure. Brood size rates are probably minimum values due to errors associated with finding or counting nestlings from an aerial survey platform. Even if brood rates assessed in June decline as fledging approaches, the observed values remain high enough to explain the stability of numbers and pairs in the Seward Peninsula population. *Received 28 February 2011, accepted 22 July 2011*.

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Gyrfalcons, *Falco rusticolus,* largest of falcons, are characterized by their Arctic distribution, large size, and wide color variation ranging from white to very dark plumages. They have a broad circumpolar nesting distribution and are typically found nesting above the timberline in remote tundra environs punctuated with rock cliff habitats. Interest in this species is keen due to its Arctic associations, remote nesting locations, inaccessibility, predatory skills and relationships, and color variation. Aspects of general biology, distribution, ecology, behavior, and species characteristics in North America are summarized by Clum and Cade (1994) and revised by Booms and Cade (2008). Additionally, Potapov and Sale (2005) present worldwide information and give detailed descriptions for a wide variety of biological and historical topics.

Within Alaska, distributional and ecological studies of Gyrfalcons have been completed along the Colville River (Cade 1960), Alaska Range (Bente 1981), and Seward Peninsula (Roseneau 1972, Walker 1977, Kessel 1989). A statewide summary of abundance in Alaska has estimated the population at 375–635 pairs (Swem et al. 1994). Satellite telemetry of juvenile Gyrfalcons from the Seward Peninsula, Alaska, has been reported by McIntyre et al. (1994). Of the known occurrence of Gyrfalcons in Alaska, the Seward Peninsula represents an important area with high densities and improved access allowing for additional study of this species.

This work reports a 6-year study of nesting Gyrfalcons and other raptors in a portion of the southern Seward Peninsula in western Alaska. Based on survey observations, estimates are developed for abundance, density, occupancy, nearest neighbor distance, kernel density distribution, nest site tenacity, hatch dates, and brood sizes. Consecutive, multi-year surveys reveal interesting characteristics for this localized, relatively stable Gyrfalcon population.

Methods

Gyrfalcons and other cliff-nesting raptors within 14,150 km^2 of the Seward Peninsula in western Alaska (Figure 1) were surveyed each June or early July during 2005 though 2010 using a Robertson R 44 helicopter as an observation platform. Comprehensive aerial flights were used to inspect 679 previously catalogued rock cliffs to determine raptor occupancy by Gyrfalcons, Peregrine Falcons (*Falco peregrinus*), Golden Eagles (*Aquila chrysaetos*), Rough-legged Hawks (*Buteo lagopus*), Common Ravens (*Corvus corax*), and several other incidental raptor and non-raptor species.

Prior to initiation of this project, potential rock cliff habitat was catalogued during Alaska Department of Fish and Game (ADF&G) aerial surveys for game species and during preliminary raptor inventories of the area. Also, aerial photographs, interpretation of Google Earth images, and other incidental observations provided by ADF&G were used to identify potential raptor cliff habitat. All locations were converted to Global Positioning System (GPS) route waypoints using Garmin Map60C or Model 296 receivers (Garmin International, Inc., Olathe, Kansas, USA) to allow efficient, economical navigation among widely separated locations during approximately 18 h of survey time. Under good weather conditions, surveys were completed on consecutive days, usually a 3- or 4-day period, to provide consistency in data collection and reduce detection bias related to advancement of the nesting season. In 2006, particularly poor weather delayed completion of surveys until early July. Observations were made primarily by a front seat observer (author) with contributions from the pilot; on a few flights, additional observations were made by a back seat observer engaged in photography of nesting habitat. Any newly discovered locations received GPS waypoints and were added to the comprehensive list of locations to be checked on future surveys.

Aerial flights included frontal approaches to rock cliffs to avoid surprise disturbance of nesting birds and, wherever possible, rock structures and nesting habitat were placed on the observer's side of the aircraft at close distances (varying from 50–200 m), depending on size and detail of the cliff structure, status of detected birds, and surface winds. Due to the relatively discrete nature of rock cliffs, single aerial passes were typically needed to document raptor occupancy and status; however, when birds or occupied nests were not found, up to three additional passes at varying observation perspectives were used to improve detection. Brief descriptive notes for each cliff were recorded by the observer to include cliff identity and location, species, number of birds, nest type, nesting status (single, pair, no nest, incubating, brooding, fledged), number of young, estimated age of young, plumage, and other notable attributes. Occupancy information was categorized as: 1) 'single' birds when only one individual was observed; 2) 'failed pairs' when pairs were observed with no evidence of nest, eggs, or young; and 3) 'successful pairs' when pairs were incubating/brooding or observed nests contained eggs, nestlings, or nearby fledglings; 4) 'total pairs' equaling the sum of failed and successful pairs; and 5) 'total occupancy' equaling the sum of singles and total pairs. Since pairs observed in June (this study) have not completed nesting activities,

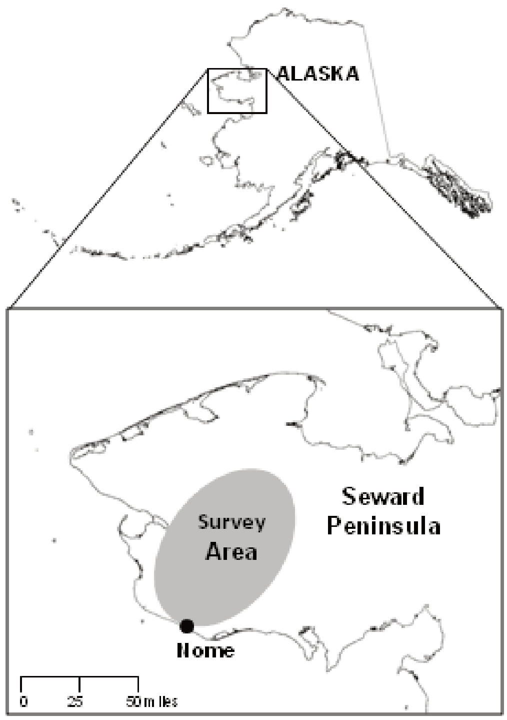

Figure 1. Aerial survey study area of cliff-nesting raptors, Seward Peninsula, Alaska, 2005–2010.

the category of successful pairs used here only becomes a loose approximation for comparison to studies reporting success or productivity based on fledging of young.

Mapping and geospatial analysis was completed with ESRI ArcView 3.3 and ArcGIS 9.3 software (Environmental Systems Research Institute, Inc., Redlands, CA, USA). For each species, cumulative occupancies, displayed as scattergrams of clustered points, were used to identify alternate nesting locations selected in successive years. Based on occupancy attributes and visual inspection of closely spaced points, clustered locations were subsequently reduced to unique zones of occupancy selected for nesting by each species. These unique nesting areas become roughly equivalent to 'nesting territories' with no overlap among adjacent occupied locations. However, single annual observations make it impossible to estimate the size or dimensions of each unique area.

Nest types used by Gyrfalcons were tallied after each survey, and nearest neighbor distances (NND) to the closest occupied location were determined using an ArcGIS distance measurement tool calibrated to fractional kilometers. Nest types were classified as: rock ledge, cliff stick nest, tree stick nest, man-made structures, and unknown type resulting from missing observations. NND was based on a measurement to each neighboring location, even when two or more locations in the array were the same distance apart. Summary statistics, annual and multi-year, were based on arithmetic mean and ranges for each set of values.

The spatial distribution of annual and cumulative Gyrfalcon occupied locations was examined with kernel density analysis using an ArcGIS 9.3 kernel density tool to generate 50, 90, and 95% utilization density isopleths. Hawth's Analysis Tools for GIS (Hawthorne L. Beyer, Spatial Ecology, LLC) was used to create polygons for exported isopleths. Core areas of cumulative selection were developed by stacking semitransparent GIS layers of annual occupancy within the study area boundary.

Consecutive years of occupancy by Gyrfalcons during the 6-year study period were determined by parsing iterative counts of observations into each of six classes of successive occupancy (1-year, 2-year, etc.). Breaks in continuous occupancy were determined by absence of Gyrfalcons, at which times the location was either vacant or occupied by other raptor species. In this analysis, 1-year or 2-year consecutive occupancy may occur more than once during the 6-year study period and, if that happened, each occurrence was tallied as a separate nesting event. A frequency distribution histogram was used to show numerical summaries of occupancy classes.

Hatch dates for nesting pairs were determined by using the estimated age of young observed on survey flights and back dating from the date of observation. In some cases it was difficult to determine the age of nestlings, so a subsample of pairs with broods was used in this calculation. Estimated calendar dates were approximate due to inaccuracies related to observation from an aerial platform.

Gyrfalcon brood sizes (young/successful pair) for six classes of consecutive occupancy were compared using a subsample of data where nestlings were observed during survey flights. Data were analyzed to test the hypothesis that a positive relationship exists between production of young and years of consecutive occupancy at a nesting location due to a variety of potential factors including: experience by pairs, security from predators, access to foraging areas, etc. The null hypothesis was that no relationship exists between years of site occupancy and production of young, such that young/nest would be independent of years of consecutive occupancy at a nesting location. The alternative hypothesis was that young/nest varies with years of consecutive occupancy at a nesting location.

Bootstrap simple linear regression (Davison and Hinkley 1997) was used to test the relationship between young/nest and consecutive occupancy. Prior to the regression analysis, Bartlett's test for unequal variances (Miller 1986) was performed to determine if remedial measures would be necessary to adjust for unequal variances. Bootstrap methods for regression were chosen over parametric methods (ordinary least squares regression) to avoid assuming normality when the data being analyzed were counts of small integers. Observations were assumed to be mutually independent, using one observation of young/nest per site per year. The assumption of mutual independence may be violated as there were undoubtedly repeated observations of some nesting pairs through successive years in these data. However, as the adult birds are not marked and identifiable from year to year, there were no means to describe or model these repeated measures.

One hundred thousand bootstrap realizations were drawn from the data set of 164 paired observations. Ordinary least squares regression

Table 1. Cumulative number and density of cliff-nesting raptors and ravens (ranked by abundance), Seward Peninsula, Alaska, 2005–2010.

Species	Cumulative number observed	Pairs			Mean annual pairs,	Mean density pairs/1000km²
	Single	Failed	Successful	Total	$\bar{x}$ (range)	$\bar{x}$ (range)
Peregrine	18	5	24	47	4.8 (2 – 8)	0.81 (weak data)
Golden Eagle	38	92	94	224	31.5 (18 – 39)	1.94 (1.13 – 2.44)
Raven	12	55	177	244	38.7 (25 – 49)	2.42 (1.56 – 3.06)
Gyrfalcon	39	28	183	250	35.1 (31 – 39)	2.20 (1.94 – 2.44)
Rough-leg	95	82	317	494	66.5 (41 – 105)	4.16 (2.56 – 6.56)

was performed on each bootstrap realization to provide bootstrap estimates of the regression parameters (slope and intercept) and predicted values of the dependent variable at each level of the independent variable. Regression parameter estimates, standard errors, and 90% confidence intervals were determined using the CDF's of the bootstrap distributions for these parameters. Significance of regression parameters was evaluated using alpha=0.10.

RESULTS

During the 6-year project period, a total of 3,337 observations were made at 679 cliff locations in the study area using aerial flights completed on: 15–17 and 23, 24 June 2005; 27 June and 5–6 July 2006; 25, 26, 27, and 30 June 2007; 27–29 June and 1 July 2008; 21, 24, and 25 June 2009; and 24–27, 29 June 2010. Table 1 shows a summary of 1,374 observations of cliff-nesting raptors and ravens (Golden Eagle, Rough-legged Hawk, Gyrfalcon, Peregrine Falcon, Common Raven) yielding a 41% cumulative raptor occupancy rate at 454 separate locations (67% of available cliffs). Unoccupied cliffs accounted for a cumulative total of 1,963 observations (59% vacancy) at 225 discrete locations. Incidental cliff or tree nest occupancy was also documented for Canada Goose (*Branta canadensis,* n=36), Glaucous Gull (*Larus hyperboreus,* n=14), Northern Goshawk (*Accipiter gentilis,* n=6), Merlin (*Falco columbarius,* n=4), and Great Horned Owl (*Bubo virginianus,* n=1). Variable annual abundance and distribution of occupied locations left a residual of 53 cliffs (8%) that were never observed occupied in any year, even though these locations contained evidence of nesting (e.g., nest structure, cliff color, whitewash) at the time cliffs were catalogued.

Figure 2 shows the number of occupied locations by cliff-nesting species during the survey period. Gyrfalcons occurred in relatively stable numbers and comprised 18% of total raptor occupancy over all years, ranging from 40–43 total locations annually. Gyrfalcons were observed as single birds (16%; n=39), unsuccessful pairs (11%; n=28), and successful pairs (73%; n=183). Golden Eagles were slightly more variable with 16% of total occupancy at 24–46 locations, annually. Common Ravens showed an increasing trend of occurrence with 17% of total occupancy at 27–52 locations. Greatest variation was shown by Rough-legged Hawks, with total occupancy at 36% of all occupied sites and annual numbers ranging from 55 to 118 locations.

Based on 250 cumulative observations of Gyrfalcons, 154 separate cliff locations were occupied during the 6-year study. Visual inspection of scattergram plots of closely spaced alternate Gyrfalcon nesting locations reduced the total observed locations to 96 unique nesting areas with minimal interannual overlap and maximum distance separation among occupied sites. These preferred locations have an esti-

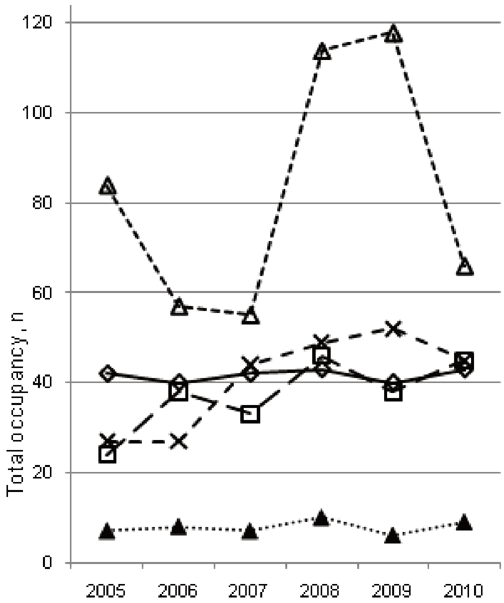

Figure 2. Number of locations occupied by cliff-nesting raptors, Seward Peninsula, Alaska, 2005–2010.
Legend:
open triangle=Rough-legged Hawk;
diamond=Gyrfalcon;
square=Golden Eagle;
X=Common Raven;
solid triangle=Peregrine Falcon.

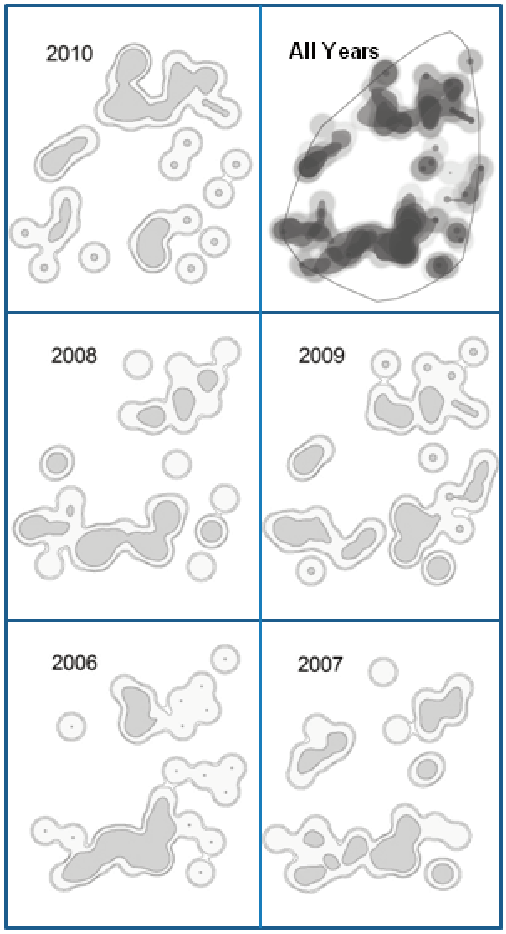

Figure 3. Gyrfalcon kernel density polygons at 95, 90, 50% isopleths showing skewed annual occupancy, Seward Peninsula, Alaska, 2006–2010.

mated 45% annual usage rate in any single year and a 100% usage rate over the 6-year study period. The high number of cumulative unique nesting locations, low annual occupancy rates, and relatively stable numbers of pairs suggests considerable spatial variation in annual distribution of Gyrfalcons.

The usage of differing nest types (structures) was very similar in each year of study. Occupancy by Gyrfalcons of cliff stick nests constructed by Golden Eagle, Rough-legged Hawk, and Common Raven was 67–76% each year, which is consistent with the availability of this nest type in the pool of unique locations used by Gyrfalcons (n=66 cliff stick nests among 96 locations yielding 69% availability). Rock ledges showed the highest interannual variation and were used 9–21% each year compared to 15% availability (n=14). Man-made structures consisted of roadway bridges, antenna towers, derelict mining equipment, or dredges where stick nests were present; this nest structure type was used 5–10% each year compared to 5% availability (n=5). Tree stick nests, constructed by Northern Goshawk,

Table 2. Consecutive occupancy of Gyrfalcons and other cliff-nesting species (ranked by abundance of single year use), Seward Peninsula, Alaska, 2005–2010.

	Consecutive years of occupancy (number of nesting events)					
Species	**1**	**2**	**3**	**4**	**5**	**6**
Raven	119	23	9	4	2	4
Rough-leg	106	60	28	8	6	3
Gyrfalcon	79	30	13	8	4	3
Golden Eagle	60	16	11	7	4	4

Rough-legged Hawk, or Common Raven, were present in Balsam Poplar (*Populus balsamifera*) and willow (*Salix* sp.) and were used 0–3% each year compared to 3% availability (n=3). The 6-year cumulative usage of 248 nest structures was: cliff stick nest, 73% (n=183); rock ledge, 16% (n=40); man-made structures, 7% (n=18); tree stick nest, 2% (n=4); and unknown structures, 2% (n=6). Clearly, the presence (or absence) of cliff stick nests dominates and influences the distribution of nesting Gyrfalcons in this area of Alaska.

NND values showed consistent patterns in frequency among survey years. Annual mean values were quite tight and varied from 8.9 to 10.0 km (cumulative mean=9.4 km, n=248) and distances ranged from 0.8 to 37.6 km. The wide range of distances reflects the topography in the study area, where broad zones of lowland tundra meadow are interspersed with rocky uplands used for nesting. Rocky tors occurring in these broad, lowland areas are commonly used by Gyrfalcons and these locations contribute NND measurements that often exceed 20 km. In other areas, where close proximity of successful pairs with young occurs at distances less than 2.0 km (e g., 0.8, 1.0, 1.4, 1.7 km, respectively), the dissected nature of closely spaced prominent rock cliffs allows close spaced nesting to occur. The wide variation in distribution of rock cliffs attractive for nesting, coupled with broad areas of unsuitable nesting habitat, make it difficult to assess the comparative importance of NND data reported here. The high dispersion of pairs, often at great distances, in combination with varied annual occupancy, are inherent characteristics of this population and suggestive that nesting structures are short-lived, limited in availability, and strongly influencing the 'nesting areas' used by Gyrfalcons.

Annually, the distribution of Gyrfalcons shows considerable variation as density changes in localized sectors of the study area through time. Figure 3 compares kernel density of occupied locations (95, 90, and 50% isopleths) for individual years. Many years show shifts in core areas of occupancy: in 2006 occupancy has shifted westerly and southerly; 2007 has an easterly shift; 2008 has a southerly pattern; 2009 has a uniform pattern except the northeast corner; and 2010 has a northerly distribution. Pooled data for all years shows several localized areas with high concentrations of Gyrfalcon occupancy.

Table 2 summarizes iterative counts of consecutive years of occupancy for cliff-nesting raptors observed on the Seward Peninsula. Gyrfalcon pairs have 137 occupancy events totaling 248 years of observed occupancy with the majority of locations occupied for 1 year (n=79 occupancy years, 32% of total occupancy years) before becoming vacant. Longer periods of pair occupancy were observed at 30 locations with 2-year tenure (n=60 occupancy years, 24%), 13 locations with 3-year (n=39 occupancy years, 16%), 8 locations with 4-year (n=32 occupancy years, 13%), 4 locations with 5-year (n=20 occupancy years, 8%) and 3 locations with 6-year occupancy (n=18 occupancy years, 7%). Common Ravens, Golden

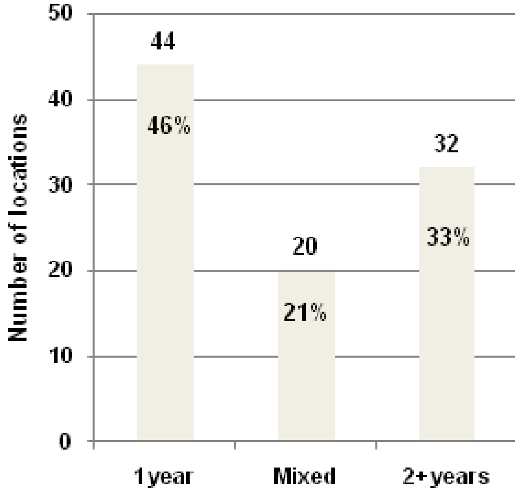

Figure 4. Consecutive occupancy (number and proportion) of Gyrfalcon nesting locations, Seward Peninsula, Alaska, 2005–2010 (n=96 nesting locations).

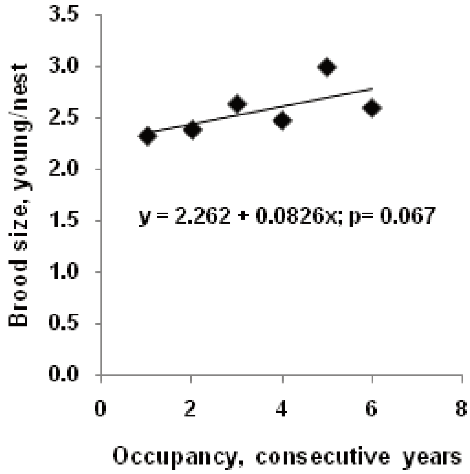

Figure 5. Linear regression relationship between Gyrfalcon brood size and years of consecutive occupancy at the same nesting location, Seward Peninsula, Alaska.

Eagles, and Rough-legged Hawks show similar patterns of diminishing frequency of multiple consecutive years of occupancy at the same location (Table 2). All cliff-nesting species on the Seward Peninsula show annual differences in patterns of distribution, largely attributable to the high frequency of 1-year use of nesting locations.

Figure 4 shows the number and proportion of consecutive years of occupancy by Gyrfalcons in three classes of usage: 1-year occupancy, 2+ years of consecutive occupancy, and mixed occupancy (mixture of 1-year and another multi-year occurrence). This summary shows 46% of all Gyrfalcon locations (n=96) have a pattern of being occupied for a single year, whereas multiple-year occupancy occurs at 33% and mixed occupancy occurs at 21% of all locations. The high frequency of 1-year nesting events by a stable number of pairs suggests interannual mobility, low site tenacity, and variable site selection among pairs.

Gyrfalcon occupancy ranged from 31–39 pairs, yielding a maximum nesting density of 2.7 pairs per 1,000 km^2. Successful pairs varied annually from 72–93% of total occupied locations; brood size at 183 locations with observed nestlings ranged from 2.35–2.70 young/successful pair (1.50–2.23 young/total pair). Analysis of the relationship between brood size and consecutive years of occupancy by Gyrfalcons showed no significant evidence of unequal variances (p=0.905) using Bartlett's test for unequal variances; therefore no remedial measures to stabilize variances were necessary for the linear regression analysis. Based on bootstrap realizations, the estimated regression equation (Figure 5) was:

young/nest = 2.262 + 0.0826 * consecutive years occupancy at the nest site.

Since the estimated slope parameter was significantly different from zero (p=0.067), the null hypothesis of no relationship between brood size and consecutive years of occupancy was rejected. Instead, the deviation from zero supports the conclusion that a positive relationship exists between young/nest and consecutive years of occupancy.

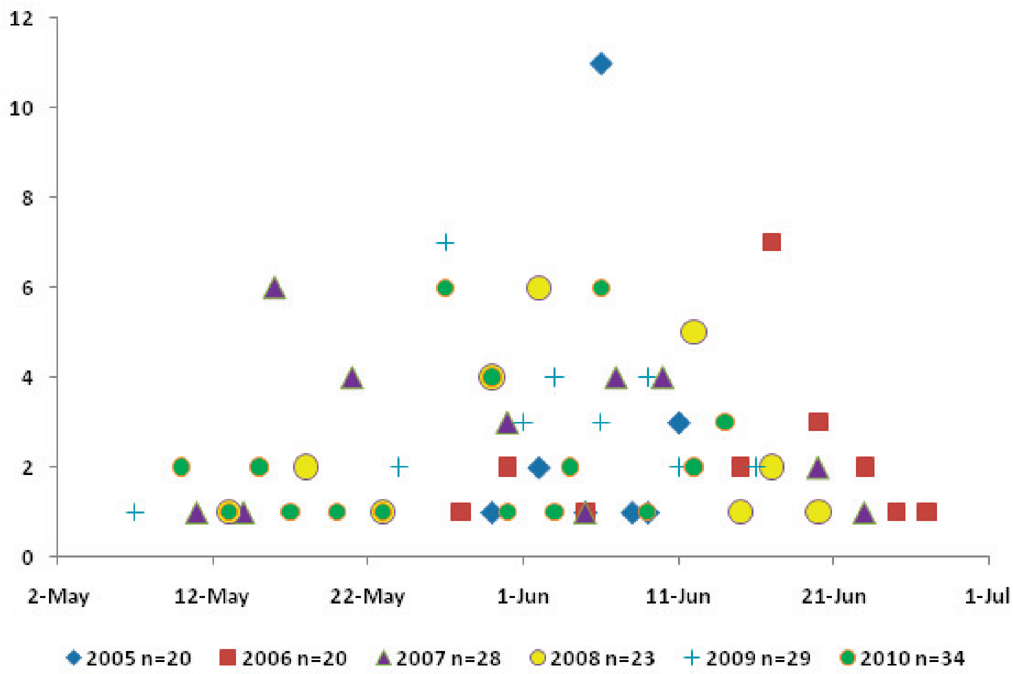

Figure 6. Annual and cumulative Gyrfalcon estimated hatch dates, Seward Peninsula, Alaska, 2005–2010.

Brood size estimates reported here are minimum values due to errors associated with finding or counting nestlings from an aerial survey platform. However, even if brood size declines as fledging approaches, the observed values remain high enough to explain the long period of population stability characteristic of the Seward Peninsula.

Based on observations of 154 broods with young of estimated age, Gyrfalcon hatch dates ranged from 7 May to 29 June (Figure 6). These data show hatching may occur over a 50-day period with start dates varying between early and mid-May. In two years, 2005 and 2006, the onset of hatching was delayed until late May, and in only one year (2005) was hatching compressed into a 15-day period, indicative of a rather high level of intra-annual synchrony. In all other years, hatching was rather asynchronous with varying peaks of activity and little evidence of delayed population-wide hatching peak associated with recycling or renesting by pairs. Undoubtedly, some pairs have produced second clutches that have hatched, but these situations were not detectable or evident in the broad and varying periods of hatching among years.

DISCUSSION

Compared to reports by Roseneau (1972), Kessel (1989), and Swem et al. (1994), the abundance and density of Gyrfalcons on the Seward Peninsula has remained relatively high and stable for a long period of time. The earlier studies covered the majority of the Seward Peninsula, so estimates of 70–100 pairs for the peninsula are easy to extrapolate from the approximate 40 occupied locations confirmed in this study. Mean density of 2.20 occupied locations/1000 km^2 (Table 1) would be considerably higher in the zones of localized concentrations (Figure 3) and comparable to the maximum density of 5.7 pairs/1000 km^2 reported by Swem et al. (1994).

The most notable characteristic of the Seward Peninsula Gyrfalcon population is the propensity for interannual mobility and variable site selection across multiple years. Roseneau (1972) first documented that a large number of occupied locations were not occupied in subsequent years. This study enumerates the complexity of Gyrfalcon occupancy and shows that other cliff-nesting species are similarly disposed. The Seward Peninsula is unlike other nesting areas where pair movements are relatively minor, as described by Potapov and Sale (2005). The consecutive use of territories in Denali National Park (40% of territories occupied more than 6 years; Swem et al. 1994) is also notably different than consecutive use of territories on the Seward Peninsula. Of the many factors that probably influence this characteristic, the loss of stick nest structures during the non-nesting season may contribute significantly to the modified distribution of pairs. Although not quantified, it is not uncommon to observe that stick nests are stripped from cliffs by winter wind storms, so that repeat nesting at specific locations is reduced by lack of suitable structures available to Gyrfalcons, a non-nest building species. Most cliffs in this study exhibit scars of bleached rock showing the previous location of nests that have fallen or been removed from the cliff face. The high mobility of Common Ravens and Rough-legged Hawks (Table 2), the primary nest-building species creating nests used by Gyrfalcons, suggests that lack of available nest structures is influencing distribution rather than food sources (prey) or predators. To further assess the factors affecting annual nesting distribution, future studies would benefit from marked birds or genetic signatures through feather collections to identify the presence of individuals at specific locations through time.

The relationship of improved brood size for nesting locations with multiple years of occupancy is interesting, but not unexpected. Nesting for multiple consecutive years in a single location is probably most influenced by the quality, stability and security of the nest structure/nest cliff, although other factors include the behavioral bonds and experience of pairs, competition from other pairs or cliff-nesting species, protection from predators, and proximity to high quality food sources. Any of these factors could contribute to increased brood sizes, either individually or collectively. Since nesting locations were observed only once per season, the ranking of these factors has not been attempted and remains unknown.

Another interesting attribute of the Seward Peninsula Gyrfalcon population is rather low synchrony of hatching for 5 of 6 years of study. The typical hatching period of May and June is longer than most other areas (Potapov and Sale 2005) and does not show secondary peaks associated with recycling and renesting of pairs. Weather conditions during March-April-May are punctuated with frequent storms arriving from the Bering Sea which may be responsible for the range in hatch dates. Interior locations, being more protected or insular, would have early nesting, whereas coastal locations influenced by strong storms would be more prone to having late nesting. Further analysis of hatch dates in relation to position within the study area is needed to confirm this relationship.

In summary, the Seward Peninsula contains excellent cliff habitat that is used by a variety of raptor species for nesting. The cliffs are widely dispersed in lowland and upland tundra habitats and they have attracted Gyrfalcons in relatively stable numbers for decades. For reasons that are not fully understood, Gyrfalcons have a high degree of interannual mobility and nesting distributions are skewed into differing localized areas each year. Hatching typically occurs across a broad period from early May to late June and there is little intra-annual or interannual synchrony. Further studies with marked birds will be needed to help clarify the role of site fidelity and multiple-year occupancy of the same location by nesting pairs. This location offers opportunities for long-term monitoring due to its accessibility for study, broad geographic area, guild of species present, and comparability to earlier studies.

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