

# Relatedness Among Peregrine Falcons Breeding on Kasatochi Island Pre- and Post-eruption



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## Introduction

Kasatochi Island is a small volcano located in the central Aleutian archipelago that erupted violently 7–8 August 2008 (Fig 1, 2), devastating nesting and foraging habitat for wildlife. Kasatochi Island has been an annual seabird monitoring site of the US Fish and Wildlife Service, Alaska Maritime National Wildlife Refuge since 1996. Incidental to monitoring activities, feathers from Peregrine Falcons nesting on Kasatochi Island in 2006 were collected and genetic data gathered (Fig 3). Collectively, these data coupled with the continued surveying of Kasatochi post-eruption has provided researchers with a unique opportunity to study the re-colonization of Peregrine Falcons on the island.

Most adult terrestrial avian species, including passerines and shorebirds, likely perished in the eruption. Seabirds apparently left the island and survived the eruption to return the following year (Williams et al. 2010). The fate of raptor species is unknown but raptors, including Peregrine Falcons returned to the island in 2009. In 2010, one confirmed eyrie was found on the east side of the island (Fig 3) and a Peregrine Falcon pair fledged two young, which became the first known successful avian breeding attempt post-eruption (Fig 4). It is possible that at least one other eyrie was established in 2010, but visual confirmation was not possible. The reestablishment of Peregrine Falcons on Kasatochi Island has prompted a series of questions:

1. Are the peregrines breeding on Kasatochi Island the same individuals that bred pre-eruption?
2. If not, what is the genetic relationship among peregrines pre- and post-eruption?
3. What is the genetic relationship among peregrine falcons breeding throughout the Aleutian archipelago?

We applied molecular techniques to gain insight in the relationship among Peregrine Falcons breeding on Kasatochi Island and identify potential islands in the Aleutian chain that may have contributed to the reestablishment of falcons on Kasatochi Island.

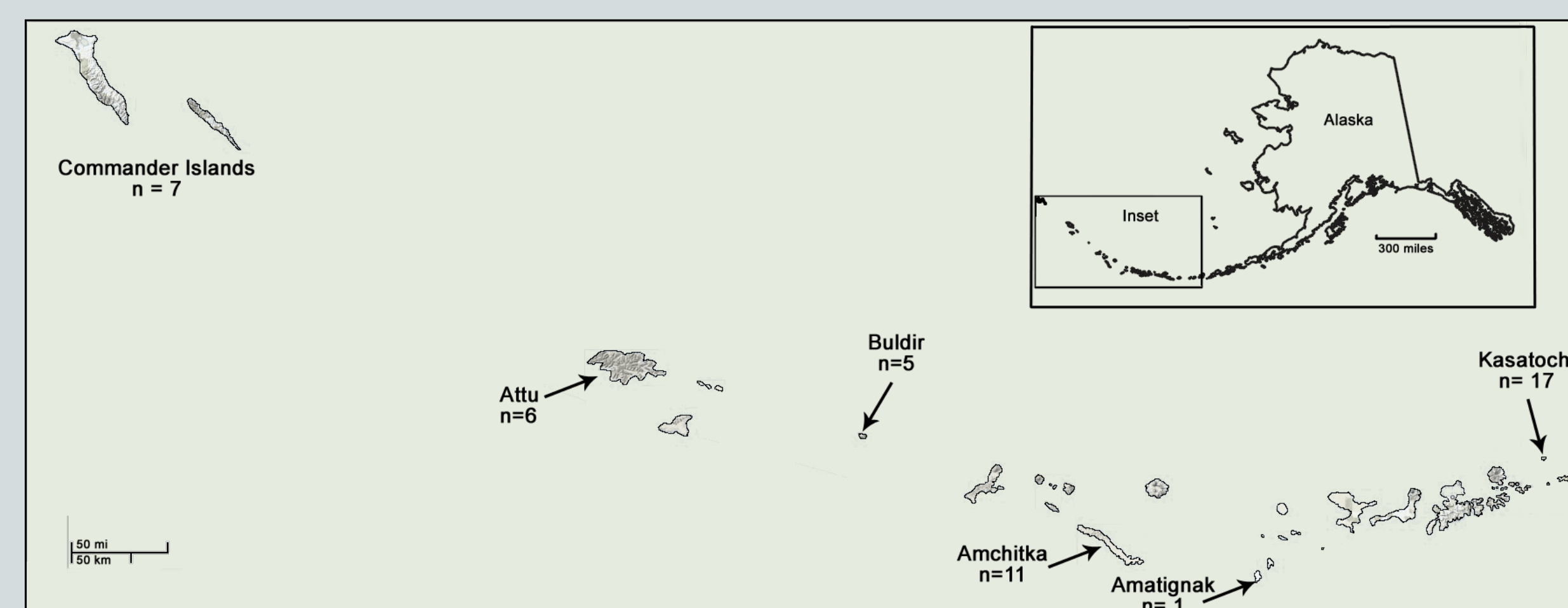


Figure 1. Localities of Peregrine Falcon populations sampled in the Aleutian archipelago with sample sizes.



Figure 2. Photograph of Kasatochi Island pre- and post-eruption.



## Methods

- **Sampling** – Molted feathers found on beaches or near eyries, along with eggshell membranes, were collected at Peregrine Falcon eyries pre- (2006) and post-eruption (2009 & 2010) of Kasatochi Island.
- **Laboratory techniques** – Multilocus genotypes from 11 microsatellite loci were collected from Kasatochi Peregrine Falcons breeding pre- ( $n = 7$ ) and post-eruption (2009  $n = 4$ ; 2010  $n = 6$ ), as well as for Peregrine Falcons breeding throughout the Aleutian archipelago ( $n = 32$ ).
- **Statistical analysis** – Multilocus genotypes were used to generate probabilities of identities (PID), identify falcons sampled across years, and estimate relatedness ( $r_{xy}$ ; Queller and Goodnight 1989) among Peregrine Falcons breeding throughout the archipelago.

## Results

- **Identification of Individual Peregrine Falcons** – Probabilities of identities revealed a high probability of identifying individuals across the Aleutians ( $PID = 5.03 \times 10^{-11}$  &  $PID_{sib} = 7.9 \times 10^{-5}$ ) with lower probabilities among Kasatochi peregrines ( $PID = 6.33 \times 10^{-6}$  &  $PID_{sib} = 4.58 \times 10^{-3}$ ).
- **Kasatochi Peregrine Falcons** – Genotypes from Peregrine Falcons breeding on Kasatochi prior to the eruption (2006) were not shared with any falcons sampled post-eruption (2009 or 2010). Interestingly, the genotype obtained from a feather sample collected in 2009 (Kas09-003) was identical to that obtained from an eggshell membrane collected in 2010 (Kas10E02E).
- **Relatedness among Kasatochi Peregrines within Years** – Overall  $r_{xy}$  value estimated for Kasatochi peregrines was close to zero ( $r_{xy} = -0.078$ , variance = 0.124), suggestive of a randomly mating population. However within years,  $r_{xy}$  values were more negative, indicating an outbred population (Table 1). Despite negative  $r_{xy}$  values, with the 2006 and 2009 years, Kasatochi Peregrine Falcons were closely related; a majority of the  $r_{xy}$  pairwise comparisons indicated a first- or second-order familial relationship (Table 1). Fewer familial relationships were observed among 2010 falcons.
- **Relatedness among Kasatochi Peregrines across Years** – All 2009 Kasatochi peregrines were closely related to 2006 falcons, with fewer first- and second-order familial relationships observed between 2006 and 2010 peregrines (Table 1).
- **Relationship of Kasatochi Peregrines to Falcons Breeding throughout the Archipelago** – The percentage of first-order and second-order familial relationships among Kasatochi Island and both Amatignak and Buldir islands were higher in 2009 & 2010 than 2006, suggesting post-eruption recruitment from nearby islands (Table 2).



Figure 4. The first young fledged from a Peregrine Falcon eyrie on post-eruption Kasatochi Island. Picture taken by J. Williams, 18 June 2010.

Table 1. Percent pairwise relatedness ( $r_{xy}$ ) values within and among Peregrine Falcons sampled in 2006, 2009, and 2010 on Kasatochi Island along with mean relatedness within years. Here we define a first-order familial relationship as having a  $r_{xy}$  value greater than 0.40 (sharing at least one allele per locus) and second-order relationship as having a  $r_{xy}$  value between 0.20–0.39.

	Familial Relationship		$r_{xy}$ (variance)
	First-order (%)	Second-order (%)	
Kasatochi 2006 ( $n = 7$ )	57.1 ( $n = 12/21$ )	14.3 ( $n = 3/21$ )	-0.337 (0.420)
& 2009	25.0 ( $n = 7/28$ )	42.8 ( $n = 12/28$ )	
& 2010	9.5 ( $n = 4/42$ )	28.6 ( $n = 12/42$ )	
Kasatochi 2009 ( $n = 4$ )	16.7 ( $n = 1/6$ )	33.3 ( $n = 2/6$ )	-0.352 (0.135)
& 2010	16.7* ( $n = 4/24$ )	12.5 ( $n = 3/24$ )	
Kasatochi 2010 ( $n = 6$ )	6.7** ( $n = 1/15$ )	6.7 ( $n = 1/15$ )	-0.179 (0.090)

\* denotes a matching sample.

\*\* denotes egg shell membranes sampled from the same eyrie.

Table 2. Percent pairwise relatedness ( $r_{xy}$ ) values among Kasatochi Peregrine Falcons sampled in 2006 and 2009 & 2010 with those peregrines sampled throughout the Aleutian chain. Here we define a first-order familial relationship as having a  $r_{xy}$  value greater than 0.40 (sharing at least one allele per locus) and second-order relationship as having a  $r_{xy}$  value between 0.20–0.39.

	Familial Relationships					
	Kasatochi 2006			Kasatochi 2009 & 2010		
	First-order (%)	Second-order (%)	Total (%)	First-order (%)	Second-order (%)	Total (%)
Amatignak	0.0 ( $n = 0/7$ )	28.6 ( $n = 2/7$ )	28.6	30.0 ( $n = 3/10$ )	10.0 ( $n = 1/10$ )	40.0
Amchitka	14.2 ( $n = 11/77$ )	15.6 ( $n = 12/77$ )	29.9	8.2 ( $n = 9/110$ )	16.3 ( $n = 18/110$ )	24.5
Attu	9.5 ( $n = 4/42$ )	19.0 ( $n = 8/42$ )	28.6	8.3 ( $n = 5/60$ )	10.0 ( $n = 6/60$ )	18.3
Buldir	5.7 ( $n = 2/35$ )	11.4 ( $n = 4/35$ )	17.1	14.0 ( $n = 7/50$ )	10.0 ( $n = 5/50$ )	24.0
Commander Islands	6.1 ( $n = 3/49$ )	24.5 ( $n = 12/49$ )	30.6	0.0 ( $n = 0/70$ )	11.4 ( $n = 8/70$ )	11.4

## Conclusions

- None of the falcons genotyped in 2006 were identified in 2009 and 2010. This lends some credence to the idea that adult terrestrial-linked species may have not survived the eruption. However, it is also possible that Peregrine Falcons breeding in the Aleutian Islands demonstrate relatively high turnover rates, similar to those observed for Queen Charlotte Island, where adult median life expectancy is 2.8 after their second year of life (White et al. 2002).
- The high percentage of first-order relatives observed between 2006 and 2009 falcons suggests that close relatives of falcons nesting on Kasatochi in 2006 returned to Kasatochi Island in 2009. However, fewer first-order familial relationships were observed between 2006 and 2010 peregrines (Table 1), suggesting that the number of immigrants increased over time.
- One sample collected in 2009 matched at all 11 microsatellite loci with a sample collected in 2010. Although this match is between a feather (2009) and an egg shell membrane (2010) and likely does not represent the same individual, it does suggest a first-order familial relationship. Therefore, at least one peregrine observed in 2009 likely returned to Kasatochi Island in 2010 to breed and fledged the first avian young on Kasatochi Island since it erupted in 2008.
- It is difficult to determine recruitment of falcons to Kasatochi post-eruption, however, the percentage of first-order and second-order familial relationships between Kasatochi and both Amatignak and Buldir islands were higher in 2009 & 2010 than 2006, suggesting post-eruption recruitment from nearby islands (Table 2).

## Literature Cited

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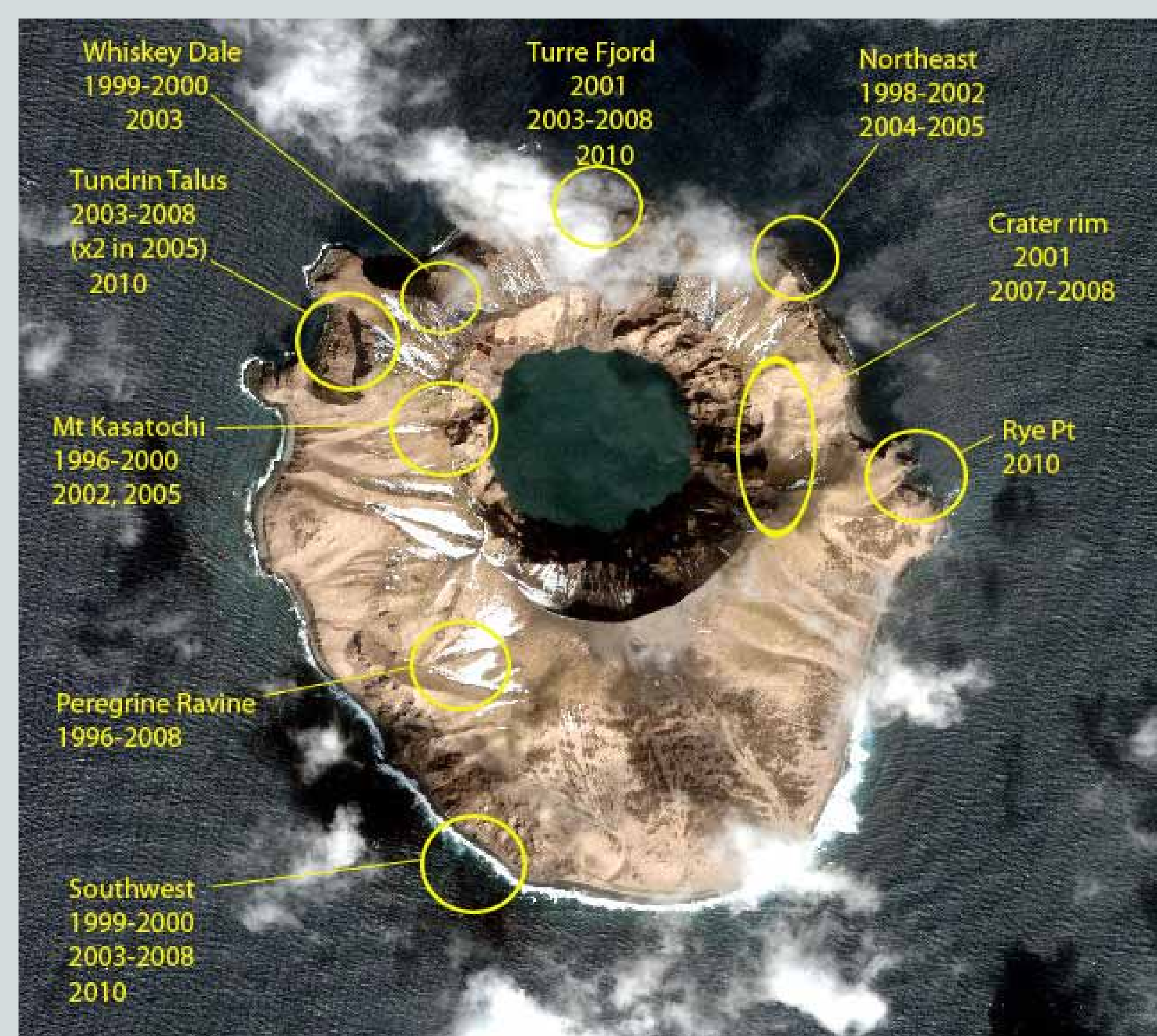


Figure 3. Localities of historic and current eyries for Peregrine Falcons on Kasatochi Island.