



# Avian Predator-Prey Dynamics in Kenai Fjords National Park

## *Integrating Raptor and Seabird Studies*

Natural Resource Data Series NPS/KEFJ/NRDS—2013/587





**ON THIS PAGE**

A bald eagle flies over Squab Island in Aialik Bay, flushing a gull colony.

Photograph by: NPS/Jen Curl

**ON THE COVER**

View looking east from Matushka Island toward Chiswell Island, home to many seabird colonies.

Photograph by: NPS/Elisa Weiss

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# **Avian Predator-Prey Dynamics in Kenai Fjords National Park**

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## Abstract

In 2012, we initiated a study to better understand the food-web dynamics that determine upper trophic levels and bioaccumulation of contaminants in the marine environment. In combination with ongoing monitoring surveys for peregrine falcons, bald eagles and colonial seabirds, we collected biological samples to evaluate contaminant levels and diet of falcons and eagles nesting in Kenai Fjords National Park (KEFJ) and adjacent Alaska Maritime National Wildlife Refuge lands. In May, using the M/V Serac (53-ft fiberglass live-aboard boat) and helicopter surveys, we located peregrine falcon and bald eagle nest sites to determine territory status (occupancy.) We accessed nest areas of raptors from the ground to collect egg and feather samples for contaminant analyses and prey remains to assess diet. We revisited nest sites in July to determine productivity of raptor nests as well as collect additional prey and feather samples. We surveyed 19 falcon nesting territories in the Kenai Fjords study area, ten of which were occupied by adult peregrine falcons. We confirmed the presence of three chicks at the ten occupied nest territories. We surveyed 69 bald eagle nests on transects, 43 of which were occupied by incubating eagles. We collected samples at nine of these nests and 4 additional occupied nests located off transect. Eight of 13 occupied eagle nests produced at least one young. We collected two bald eagle and four peregrine falcon eggs from nests for a full suite of contaminants analyses. We collected shed feathers from 13 bald eagle and four peregrine falcon nest territories for mercury and genetic analyses. We collected 226 and 34 individual prey items at bald eagle and peregrine falcon nest sites respectively and selected feather samples from 35 of these for mercury content. Initial results suggest that fork-tailed storm petrels and common murrelets may be important prey for peregrine falcons and bald eagles respectively. Examining the predator-prey dynamics and contaminant burdens of these species will allow us to better understand changes observed in long-term monitoring programs and develop appropriate conservation strategies for KEFJ.

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## Introduction

Seabirds are integral and highly visible members of marine ecosystems and are valued indicators of healthy oceans (Piatt et al. 2006). Because various species of seabirds use different portions of the marine food web, their productivity and abundance provide insight into the health and status of marine resources at multiple trophic levels (Springer 2005). Marine birds are also specifically mentioned in KEFJ's enabling legislation (U.S. Congress 1980) adding to their significance and value to the park. Feeding on seabirds are top-level predators, including birds of prey, which shape marine food-webs through the direct and indirect effects of predation (Boyd et al. 2006). Determining the form of key predator-prey relationships is critical for understanding marine ecosystem dynamics.

A genetically distinct subspecies of peregrine falcon, Peale's peregrine falcons (*Falco peregrinus pealei*), are found in dispersed marine-oriented populations along the Pacific Coast and are thought to inhabit the Kenai Fjords area (White et al. 2002). These falcons are a species of special concern in the U.S. and Canada due to the very small population size (estimated at less than 1,000 individuals), limited distribution, declining prey base, and lack of baseline data to assess conservation status (COWEWIC 2007). As marine-based falcons, which are frequent predators of seabirds, they may be good indicators of the health of local seabird populations because their nesting and productivity reflect local seabird abundance and distribution (Beebe 1960, Nelson 1990, Velarde 1993, White et al. 2002). These falcons are known to specialize in preying on smaller seabirds including alcids and storm petrels and often breed near their colonies (Beebe 1960, White 1975, Schempf 1982.) Predation by coastal peregrine falcons has also been shown to have cascading direct and indirect effects on marine nearshore ecosystems and seabird abundance (Paine et al. 1990). These effects are particularly important in the management of threatened species such as Kittlitz's murrelets (*Brachyramphus brevirostris*), a candidate for listing under the Endangered Species Act. Peregrine falcons have been shown to specialize in predating *Brachyramphus* murrelet populations in British Columbia and Icy Bay, Alaska (Nelson and Myres 1976, S. Lewis, USFWS, pers. comm.). In 2010, KEFJ, in cooperation with Alaska Maritime National Wildlife Refuge (AMNWR), conducted the first survey of peregrine falcons in the area since 1989 (Hughes and Sanger 1999). Initial results from recent KEFJ surveys show that the distribution of peregrine falcon territories was similar to that observed in 1989 and territories were in close proximity to seabird colonies, suggesting falcons in the area may have high nest-site fidelity and be dependent on seabird colonies as their primary prey (Shook and Ritchie 2011).

Bald eagles (*Haliaeetus leucocephalus*) are avian apex predators that breed in various marine, estuarine, and freshwater ecosystems and acquire most of their prey from aquatic environments (Stalmaster 1987). Bald eagles have relatively small territories (Garrett et al. 1993), and since they have evolved as opportunistic predators (Watson et al. 1991), their diets tend to reflect the abundance of prey available to them (Buehler 2000, Anthony et al. 1999). Bald eagle's importance as predators of bird and fish populations in KEFJ led to their inclusion as a vital sign in the Southwestern Alaska Network (SWAN) Inventory and Monitoring program (Bennett et al. 2006). Bald eagles have been observed preying upon black-legged kittiwakes (*Rissa tridactyla*) and glaucous-winged gulls (*Larus glaucescens*) during seabird surveys in KEFJ and Kittlitz's murrelets in Icy Bay, Alaska (S. Lewis, USFWS, pers. comm.). Long-term monitoring protocols for bald eagles in KEFJ are being finalized in collaboration with SWAN (Thompson et al. 2009)

and some historical data exists on bald eagles nesting in the park (Tetreau 2007). Although relatively large breeding populations exist within park boundaries (Thompson et al. 2009), their reproductive success may be influenced by climate change, human impacts, food availability and environmental contaminants (Buehler 2000). As keystone predators at the top of the food chain, bald eagles are susceptible to biomagnification of contaminants such as pesticides, toxic waste, and lead shot present in prey (U.S. EPA 1993).

Elevated concentrations of contaminants can cause acute and chronic health effects including impairment of reproduction, neurological function, and suppression of immune function in birds (Walker et al. 1996). Contaminants of concern in northern ecosystems include heavy metals such as mercury and Persistent Organic Pollutants (POPs) such as organochlorines. Organochlorines accumulate in fatty tissues, possibly contributing to elevated concentrations of contaminants in seabirds living in cold environments that depend on fat reserves as a buffer against cold, stress, and periods of low food availability (Bard 1999). Apex predators, such as eagles and falcons, have particularly high concentrations of persistent contaminants such as organochlorines due to biomagnifications up the food chain (Elliot et al. 1996, Elliot and Harris 2001); consequently, they can be used to assess the more severe potential impacts to ecosystems. In the Aleutian Archipelago, Anthony et al. (1999) found that bald eagles with higher contaminant levels had lower productivity and that eagles with higher contaminant levels had diets comprised primarily of seabirds. Mercury contamination is a growing concern in the arctic and has been found at potentially detrimental levels in peregrine falcons on the Yukon River (Ambrose et al. 2000). The results of the Western Airborne Contaminants Assessment Project (Landers et al. 2008) highlighted the atmospheric deposition of contaminants in remote Alaskan parks, the ecological threat of mercury bioaccumulation in food webs, and the need for further study of mercury relative to food web structure.

Changes in global and regional climate can significantly affect seabird prey resources and rising sea levels associated with global warming could destroy seabird nesting habitat, especially on low islands (USFWS 2005). Beginning in the 1970s, ecosystem-wide changes in the Gulf of Alaska caused broad-scale declines in seabird, forage fish and marine mammal abundance (Springer 2005), which have increased concern over the status of seabird populations throughout the area. The effects of cascading changes observed in seabird populations should also be reflected in bald eagle and peregrine falcon populations that depend on food resources from the coastal marine environment (Anthony et al. 2008, Paine et al. 1990).

Upper trophic level predators in marine environments can serve as indicators of change within the broader system that they occupy (Boyd et al. 2006). Recent studies have also shown that cascading effects through complex trophic pathways can have surprising and wide-ranging causes and impacts (Ripple and Beschta 2006, Anthony et al. 2008). Sea otter activity in the Aleutian Archipelago led to a shift in the diet of bald eagles in the area, and bald eagles that ate more marine birds had lower overall reproductive success (Anthony et al. 2008). While many studies have identified the environmental and biological pathways that affect seabird population dynamics (Harding et al. 2006), little is known about the relationship between seabirds, their avian predators, and links to environmental contaminants. Recent research in Icy Bay, Alaska has suggested that peregrine falcons and bald eagles are the primary predators of threatened Kittlitz's murrelet populations, with Kittlitz's murrelets making up 90% of the prey remains collected at peregrine nests in the area (S. Lewis, USFWS, pers. comm.). How predation affects

the survival and population dynamics of seabirds experiencing population declines is critical to their management and recovery. KEFJ is and will be investing resources in long-term monitoring of seabird and raptor populations. We have documented that monitoring these species is important: 1) due to their ecological significance to the park; and 2) as cost effective indicators of marine ecosystem health. However, to truly take advantage of the power of ongoing monitoring programs and leverage limited resources available for long-term monitoring, we need a better understanding of the interactions among these top predators including predator-prey dynamics and contaminant loads.



## Methods

### Study Area

KEFJ is located in south central Alaska along the southeastern coast of the Kenai Peninsula within the Gulf of Alaska Coast Ecoregion (Figure 1, Nowaki et al. 2001). The area is dominated by a cool, hypermaritime climate with minor seasonal temperature variation, seasonally persistent snow at sea level, and extended periods of precipitation. The park possesses deeply carved glacial fjords, tidewater glaciers, the Harding Icefield, and a portion of the Kenai Mountains (Chugach—St. Elias Mountain Ecoregion) that rise abruptly from the coast to more than 1,800 m above sea level. These slopes are characterized by grassy meadows and alder thickets, interspersed with dense temperate spruce-hemlock forests and granite cliff faces. More than 800 km of marine coastline is dominated by rocky headlands, sheer cliffs, and sheltered bays. Numerous islets and larger islands including the Pye and Chiswell groups in AMNWR increase the geographic and biological diversity of the area. Marine bird life is seasonally abundant in the fjords and offshore islands and there are more than 20 large, multi-species nesting colonies for seabirds, including pelagic cormorant (*Phalacrocorax pelagicus*), black-legged kittiwake, common murre (*Uria aalge*), pigeon guillemot (*Cepphus columbia*), horned puffin (*Fratercula corniculata*) and tufted puffin (*Fratercula cirrhata*) (Sowls et al. 1978). Surveys have documented close to 100,000 breeding seabirds at these colonies (Bailey 1977). There is an abundance of cliff habitat suitable for nesting peregrine falcons especially along the exposed outer coast and offshore islands (Janik and Schempf 1985). Other predatory birds frequenting these cliffs include bald eagles and common ravens (*Corvus corax*).

Our study area included habitat along the mainland coast of KEFJ from approximately Bear Glacier Point south and west to a point approximately 2 km south of Yalik Point (north of Nuka Island) and most islands of the AMNWR in the vicinity of this section of coastline (Figure 1). Islands not surveyed included Rabbit and Outer Islands in the Pye Island group to minimize potential disturbance to Steller's sea lions (*Eumetopias jubatus*) during surveys.

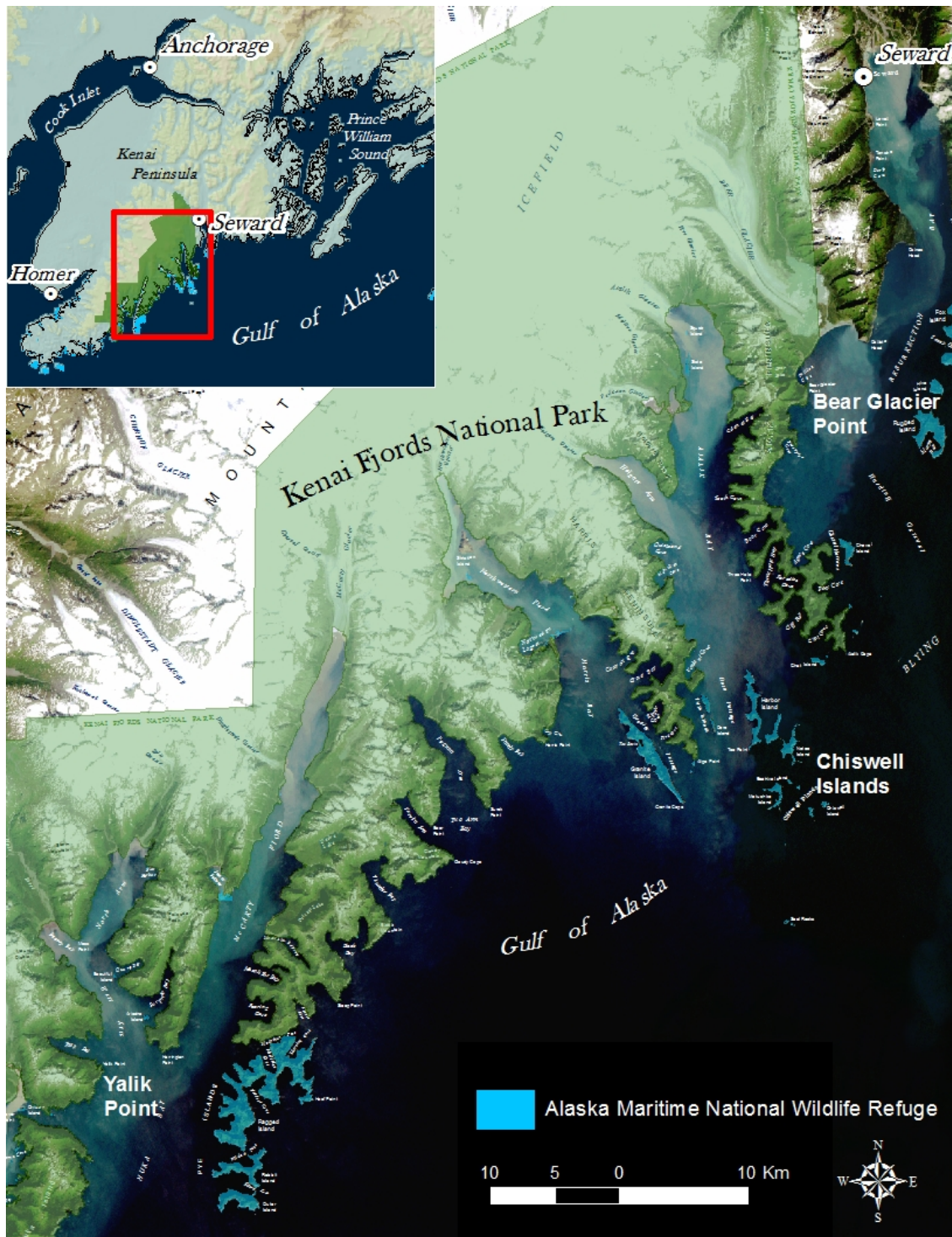


Figure 1. Map of the study area in Kenai Fjords National Park and the Alaska Maritime National Wildlife Refuge in Alaska.

## Field Methods and Terminology

### ***Nest Surveys***

#### Peregrine Falcon

In 2012, we conducted 2 surveys onboard the *M/V Serac* (53 ft fiberglass live-aboard boat) to locate peregrine falcons and to determine territory status (occupancy) and collect prey remains. The first survey occurred 21 -29 May, cut one day shorter than planned due to rough seas. The second survey took place 3 -11 July, as a secondary objective to seabird surveys. The *Serac* acted as our base working platform, in addition to a 16 ft Naiad 5.0, *Auklet*, and/or skiff for shore landings.

Survey protocols and terminology generally followed those used in 2010 and 2011 (Shook and Ritchie 2011, Phillips and Adams 2012). Standard protocol for both surveys included boating to known or suitable cliff habitat and, from a safe and reasonable distance to make observations (<100 m), searching cliffs for adult Peregrine Falcons, their sign (e.g., perches, guano, nest ledges, stick nests), or nestling or fledglings. Observers used image stabilizing binoculars including 14 × 40 Nikon StabilEyes and 10 × 30 Canons. Two, three or four observers searched cliffs during both survey periods. If adult or young were not detected during the initial scrutiny of cliff faces, we used a Foxpro3 Wildlife Caller to broadcast an ‘eechup’ call, which is used by adults during courtship and territorial encounters (Nelson 1970, Ratcliffe 1993). This call can elicit a response between members of a pair (e.g., returning calls, moving from one location to another) especially early in the incubation period (Shook and Ritchie 2011). In 2012, the occupancy survey was performed in concurrence with the contaminants study, providing opportunity for land observations and prey collection, often simultaneous with marine observations.

General terminology for nest status (Table 1) closely followed the National Wildlife Federation’s Raptor Management Techniques Manual (Steenhof and Newton 2007), with some deviations. We included young less than ~28 days in the “successful territory” status. Productivity monitoring was done opportunistically in 2012, therefore some nestlings may have been <4 weeks old while others may have fledged.

Table 1. General terminology.

| Term                                    | Definition                                                                                                                                                                                 |
|-----------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. Pair                                 | Represents a territorial pair of Peregrine Falcons and could include observations of a pair or proof of a pair's presence at nest cliff (e.g., eggs, young)                                |
| 2. Nest                                 | Structure made or the place used by birds for laying their eggs and sheltering their young                                                                                                 |
| 3. Alternate nest                       | An unoccupied nest site within the nesting territory of one pair of birds.                                                                                                                 |
| 4. Nest cliff                           | A distinct cliff or bluff with at least one confirmed nesting attempt by Peregrine Falcons during the course of the study                                                                  |
| 5. Nesting territory                    | An area that contains, or historically contained, one or more nests within the home range of a single, territorial pair                                                                    |
| 6. Occupied territory                   | A nesting territory where a single or pair of adults showed territorial/defensive behavior at a specific cliff area (e.g., vocally 'kekking' at our presence, attacking other raptors)     |
| 7. Occupied nest                        | Proof of nesting was observed during surveys; i.e. an incubating adult, fresh eggs, fresh egg shells, or young.                                                                            |
| 8. Unoccupied                           | A nesting territory with a history of occupancy but with no observations of Peregrine Falcons recorded in 2011                                                                             |
| 9. No nest                              | Observations of single birds or pairs, which did not occupy a cliff and where there was no history of nesting                                                                              |
| 10. Successful territory (nest or pair) | A nesting territory where at least one live nestling (regardless of age) was observed during the productivity survey                                                                       |
| 11. Productivity                        | The number of young (regardless of age); usually reported as the number of young produced (i.e., fledgling production) per territorial pair or per occupied territory in a particular year |

We defined the breeding status of each nesting territory using the terms defined in Table 2. We used these definitions from the Central Alaska Network Inventory and Monitoring Program's protocol for monitoring peregrine falcons (Ambrose et al. 2004) to further describe observed falcon behavior and maintain consistency with other monitoring efforts in Alaskan parks.

However, we once again changed our definition of success by including young of any age, not just young that reached 4 weeks. We may revisit this definition later as protocols for monitoring become more established; however, at our current level of effort, we feel that important data would be lost by not reporting the presence of young in nests. As a result of our limited survey efforts in May, we defined nests as unoccupied if no activity was observed at the nesting territory throughout the summer season, regardless of the amount of time spent at the site in May.

Table 2. Breeding status terminology.

| Status                                                   | Definition                                                                                                                                                                                          |
|----------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. Unoccupied                                            | A nesting territory where no birds showing an affinity for the territory during the breeding season was observed ( $\geq 4$ hours spent at territory)                                               |
| 2. Unknown                                               | A nesting territory where no bird showing an affinity for the territory during the breeding season was observed but investigators spent $< 4$ hours at the territory during the incubation period   |
| 3. Occupied -- non-breeding                              | A nesting territory where one or two birds showing affinity for the nesting territory during the breeding season were observed but no eggs were laid (requires confirmation that no eggs were laid) |
| 4. Occupied -- breeding                                  | An occupied nesting territory where eggs were laid (evidence includes young in nest, eggs or eggshells, or adults seen incubating) but where final breeding success was not determined              |
| 5. Occupied -- unsuccessful                              | An occupied nesting territory where breeding was attempted but where no young were observed                                                                                                         |
| 6. Occupied -- successful                                | An occupied nesting territory where one or more young were observed                                                                                                                                 |
| 7. Occupied -- breeding status unknown                   | An occupied nesting territory where breeding or non breeding could not be determined                                                                                                                |
| 8. Occupied -- breeding status unknown, no young fledged | An occupied nesting territory where breeding or non breeding could not be determined but it was certain no young fledged                                                                            |

### Bald Eagle

As part of the SWAN vital sign monitoring program, we conducted 2 aerial surveys during bald eagle breeding season to determine nest occupancy and productivity following methods outlined in Thompson and Phillips (2011) and Witter and Phillips (2012). The bald eagle nesting survey area consisted of 25, 7.8 mi (12.5 km) transects randomly distributed across 396 mi (637.5 km) of suitable, non-glaciated coastal nesting habitat between Bear Glacier and Beauty Bay (Thompson and Phillips 2011). We assessed occupancy and productivity of 4 nests not included on survey transects: 1 in Nuka Bay, 2 on the Outer Coast and 1 in Aialik Bay. We included these additional nests because they were safe and relatively easy to access on foot.

### **Nest Access**

The collection of diet and contaminant samples required ground access of occupied raptor nests and nest areas. We chose sites for sample collection based on accessibility, geographic location and distance from seabird colonies. Due to a limited sample size of peregrine nests in the area (10 territories occupied in 2012), we collected samples at all accessible peregrine falcon prey handling perches and nests. Because of the abundance of bald eagle nests within the park, we selected nest sites using two criteria, accessibility and distance to seabird colonies. We classified distance to seabird colonies based on home range sizes calculated by Garrett et al. (1993) with nests  $< 10$  km of colonies classified as near and those  $> 10$  km classified as far from colonies. Generally, we judged accessibility by examining photographs for feasibility of access and then scouting by boat. We inspected accessibility of sites with regard to protected boat landings and ruggedness of terrain.

### **Sample Collection**

We collected bald eagle and peregrine falcon eggs and shed feathers for contaminant and genetic analyses and prey remains for diet and contaminant analyses. We entered nests to collect eggs in May and searched the nest area for prey and shed feathers in May and July. We based our decision to enter raptor nests for sample collection on the suspected presence of eggs by evaluating adult raptor behavior, on weather conditions that limited exposure of eggs or chicks to cold or rain and accessibility. Nest accessibility was assessed by raptor biologist, Steve Lewis (USFWS) and generally included consideration of tree health, structure, and the ability to gain access to the tops of cliffs and the length of rappel from anchor points. Lewis used standard rock and tree climbing techniques to enter nests, which included rappelling from the top of cliff faces into falcon nests and climbing trees into eagle nests. Accessing falcon nests required verbal guidance from marine observers via radio to target rappel directly to a nest ledge. We collected unhatched falcon and eagle eggs when clutch size was  $\geq 2$ , targeting small or undeveloped eggs. We collected molted feathers of peregrine falcons and bald eagles found in nests and around nest sites for mercury analysis.

Contaminant samples are currently being processed following protocols established by the Central Alaska Network Inventory and Monitoring Program and USFWS (Ambrose et al. 2000, MacCluskie et al. 2005). Carbon and nitrogen stable isotope analysis will be conducted on all contaminant samples to use as covariates in analyses and interpretation of results. Carbon and nitrogen stable isotopes will provide trophic level information that will help determine if a bird is feeding primarily on birds, fish, or other prey.

We searched for prey remains on foot on the ground below eagle nests and at plucking perches that often consisted of trees, snags and exposed boulders. Lewis (USFWS) collected prey within nests as well. Peregrine falcon plucking perches are comparatively more cryptic and were usually found at top of cliff edges along ridgelines.

Samples were frozen onboard the *M/V Serac* and later brought to shore and stored in freezers while fieldwork was completed. We used a food dehydrator to dry prey samples and then sorted them into individual specimens. We used reference books to identify the majority of species and the more difficult identifications were deciphered with the help of specialists at University of Alaska Fairbanks and the Alaska SeaLife Center.

Methods for sample collection were approved by the NPS Institutional Care and Use Committee (Protocol Approval Number: AKR\_KEFJ\_Phillips\_Peregrine Falcon/Bald Eagle\_12/5/11). This project is associated with NPS accession number KEFJ-00315.

## Results

### Nest Surveys

#### *Peregrine Falcon*

In 2012, we surveyed 17 falcon nesting territories. We spent less than four hours observing one of the 17 territories, so occupancy at that site could not be determined. Peregrine falcons occupied 10 nesting territories (Table 3). We confirmed nest success at three occupied territories with visual observations of at least 1 chick. The behavior of adults at Yalik Point suggested the presence of young at that site; however, vegetation obscured the nest ledge at that site preventing observers from seeing chicks in the nest.

We had limited time to confirm the presence or absence of young at occupied nesting territories during productivity surveys which prevented our being able to classify with certainty the success or failure of nests. If we include the Yalik Point nest in our total of successful nests, a minimum of 4 of 10 or 40% of occupied territories were successful. In 2012, at least four nestlings were produced at three successful nests with brood counts in the study area for a mean brood size of 0.4 young/occupied territory ( $n=10$ ) or 1.33 young/successful pair ( $n=3$ ). This number is probably low since it is likely that the Yalik pair fledged young.

Table 3. Peregrine falcon nesting occupancy and productivity in Kenai Fjords National Park.

| Site ID        | General Area                | 1985   | 1990                              | 2010 Status              | 2011 Status          | 2012 Status, (no. of young)            |
|----------------|-----------------------------|--------|-----------------------------------|--------------------------|----------------------|----------------------------------------|
| KF001PEFA      | Granite Island (N)          | none   | occupied, successful <sup>a</sup> | occupied, successful     | unoccupied           | occupied, successful (2 <sup>a</sup> ) |
| KF002PEFA      | Harrington Point            | none   | pair <sup>a</sup>                 | occupied                 | unoccupied           | occupied                               |
| KF003PEFA      | Yalik Point                 | single | pair <sup>a,b</sup>               | unoccupied               | occupied             | occupied, pos successful               |
| KF004PEFA      | Wildcat Pass, Ragged Island | single | none                              | no nest                  | no nest              | unknown, not surveyed                  |
| KF005PEFA      | Steep Point                 | pair   | none                              | occupied, successful     | occupied             | occupied, pos failed                   |
| KF006PEFA      | Ragged Island (Hoof Point)  | none   | occupied, successful <sup>a</sup> | occupied, successful     | unoccupied           | unoccupied                             |
| KF007PEFA      | Cloudy Cape                 | none   | pair                              | occupied, pos successful | unoccupied           | unoccupied                             |
| KF008PEFA      | Chiswell A (SW)             | single | single <sup>a</sup>               | occupied                 | occupied             | occupied, successful (1)               |
| KF009PEFA      | Matushka Island (S)         | single | pair <sup>a, d</sup>              | unoccupied               | unoccupied           | unknown (<4hr)                         |
| KF010PEFA      | Harbor Island               | single | pair <sup>a</sup>                 | occupied, successful     | occupied             | occupied                               |
| KF011PEFA      | Harris Peninsula (Aligo Pt) | none   | pair <sup>a</sup>                 | occupied, failed         | unoccupied           | unoccupied                             |
| KF012PEFA      | Chat Island                 | none   | pair <sup>b</sup>                 | occupied                 | occupied, successful | occupied, successful (1)               |
| KF013PEFA      | Aialik Cape (S)             | single | pair <sup>b</sup>                 | unoccupied               | unoccupied           | unoccupied                             |
| KF014PEFA      | Aialik Cape (N)             | single | none <sup>a</sup>                 | occupied                 | occupied, successful | occupied                               |
| KF015PEFA      | Cheval Island               | none   | pair <sup>b</sup>                 | occupied, successful     | occupied             | occupied                               |
| KF016PEFA      | Matushka Island             | single | occupied, successful <sup>a</sup> | occupied, successful     | occupied             | occupied                               |
| KF017PEFA      | Natoa Island                | none   | single <sup>a</sup>               | no nest                  | occupied, successful | unoccupied                             |
| KF020PEFA      | Granite Island (S)          | single | none                              | unoccupied               | occupied             | unoccupied                             |
| total occupied |                             |        | 12                                | 12                       | 10                   | 10                                     |

a Minimum count due to obscured view of ledge

### **Bald Eagle**

In 2012, we surveyed 69 bald eagle nests on transects, 43 of which were occupied by incubating eagles. We collected samples at nine of these nests and four additional occupied nests located off transect. Eight of 13 occupied eagle nests produced at least one young (62%, Table 4). At least 10 young were produced for a mean brood size of 0.77 young/occupied nest ( $n=13$ ) or 1.25 young/successful nest ( $n=8$ ).

### **Sample Collection**

We collected 2 bald eagle and 4 peregrine falcon eggs for contaminant analysis. We climbed to four eagle nests; however, the eggs in 2 nests had already hatched. Due to finding young in eagle nests, we focused most of our effort during the May trip on locating and accessing falcon nest ledges. We collected shed feathers for mercury analysis at 13 bald eagle nest sites and 4 peregrine falcon territories.

We visited 32 nest sites and each varied in quantity of prey remains collected. We did not find prey remains at two sites, one eagle and one falcon nest; however all other sites resulted in 1 to 5 gallon-sized bags of remains from various species. We collected 226 (1-86 per nest site) and 34 (1-10 per territory) individual prey items at bald eagle and peregrine falcon nest sites respectively (Table 4).

Table 4. Samples collected at bald eagle and peregrine falcon nest sites in the Kenai Fjords area, 2012.

| Site ID   | Species | Nest Access <sup>a</sup> | No. Egg (Yng) <sup>b</sup> | Egg <sup>c</sup> | No. Prey <sup>d</sup> | Feather <sup>e</sup> | No. Yng <sup>f</sup> |
|-----------|---------|--------------------------|----------------------------|------------------|-----------------------|----------------------|----------------------|
| NU-20     | BAEA    | Yes                      | 2                          | Yes              | 1                     | Yes                  | 0                    |
| NU-45     | BAEA    | Yes                      | 1 (1)                      | Yes              | 7                     | Yes                  | 0                    |
| OU-2      | BAEA    | Yes                      | (1)                        | No               | 27                    | Yes                  | 1                    |
| OU-14     | BAEA    | No                       | 1 (1)                      | No               | 86                    | Yes                  | 1                    |
| NW-10     | BAEA    | No                       | Unk                        | No               | 12                    | Yes                  | 1                    |
| NW-19     | BAEA    | No                       | Unk                        | No               | 1                     | Yes                  | 2                    |
| NW-16     | BAEA    | No                       | Unk                        | No               | 3                     | Yes                  | 2                    |
| NU-08     | BAEA    | Yes                      | (2)                        | No               | 10                    | Yes                  | 1                    |
| NU-46     | BAEA    | No                       | Unk                        | No               | 8                     | Yes                  | 0                    |
| OU-18     | BAEA    | No                       | Unk                        | No               | 25                    | Yes                  | 0                    |
| OU-22     | BAEA    | No                       | Unk                        | No               | 12                    | Yes                  | 0                    |
| OU-21     | BAEA    | No                       | Unk                        | No               | 9                     | Yes                  | 1                    |
| AI-29     | BAEA    | No                       | Unk                        | No               | 3                     | Yes                  | 1                    |
| KF003PEFA | PEFA    | Yes                      | 3                          | Yes              | 10                    | Yes                  | prob ≥1              |
| KF014PEFA | PEFA    | Yes                      | 4                          | Yes              | 1                     | No                   | 0                    |
| KF015PEFA | PEFA    | Yes                      | 4                          | Yes              | 2                     | Yes                  | 0                    |
| KF001PEFA | PEFA    | Yes                      | 4                          | Yes              | 1                     | No                   | ≥2                   |
| KF012PEFA | PEFA    | No                       | Unk                        | No               | 2                     | Yes                  | 1                    |
| KF010PEFA | PEFA    | No                       | Unk                        | No               | 9                     | Yes                  | 0                    |
| KF016PEFA | PEFA    | No                       | Unk                        | No               | 6                     | No                   | 0                    |

a Climber entered nest; b Number of eggs or young observed in nest; c Egg was collected from nest; d Number of individual prey items collected at a nest site; e Shed feather collected at nest site; f Number of young fledged

We selected 35 prey feather samples for mercury analysis by USFWS (Table 5). We chose feathers for contaminant analysis that were associated with sites that had either a raptor egg or shed feather collected, and that represented a broad geographic distribution of our study area and the diversity of species collected.

Table 5. Inventory of prey feather samples sent to USFWS for mercury analysis. Four letter species codes defined in Appendix B.

| <b>Inventory</b> | <b>Prey Spp.</b> | <b>Date Collected</b> | <b>Predator</b> |
|------------------|------------------|-----------------------|-----------------|
| 1                | COMU             | 7/21/2012             | BAEA            |
| 2                | GCSP             | 5/23/2012             | PEFA            |
| 3                | MAMU, KIMU, ANMU | 5/23/2012             | PEFA            |
| 4                | RHAU             | 7/7/2012              | PEFA            |
| 5                | FTSP             | 7/7/2012              | PEFA            |
| 6                | FTSP             | 5/27/2012             | PEFA            |
| 7                | VATH             | 5/27/2012             | PEFA            |
| 8                | VATH             | 5/27/2012             | PEFA            |
| 9                | FTSP             | 5/27/2012             | PEFA            |
| 10               | FTSP             | 7/4/2012              | PEFA            |
| 11               | VATH             | 7/4/2012              | PEFA            |
| 12               | FTSP             | 7/4/2012              | PEFA            |
| 13               | FTSP             | 7/3/2012              | PEFA            |
| 14               | FTSP             | 5/28/2012             | PEFA            |
| 15               | FTSP             | 7/4/2012              | PEFA            |
| 16               | BLKI             | 5/23/2012             | BAEA            |
| 17               | GWGU             | 7/7/2012              | BAEA            |
| 18               | RFCO             | 7/7/2012              | BAEA            |
| 19               | COMU             | 5/22/2012             | BAEA            |
| 20               | PECO             | 5/23/2012             | BAEA            |
| 21               | GWGU             | 7/7/2012              | BAEA            |
| 22               | COMU             | 7/5/2012              | BAEA            |
| 23               | GWGU             | 7/5/2012              | BAEA            |
| 24               | MALL             | 5/24/2012             | BAEA            |
| 25               | COMU             | 5/24/2012             | BAEA            |
| 26               | GWGU             | 6/21/2012             | BAEA            |
| 27               | GRSC             | 6/21/2012             | BAEA            |
| 28               | NOPI             | 6/21/2012             | BAEA            |
| 29               | HEGU             | 7/9/2012              | BAEA            |
| 30               | RNGR             | 7/9/2012              | BAEA            |
| 31               | GRSC             | 7/9/2012              | BAEA            |
| 32               | COMU             | 7/8/2012              | BAEA            |
| 33               | GWGU             | 7/8/2012              | BAEA            |
| 34               | BLKI             | 7/9/2012              | BAEA            |
| 35               | BLKI             | 7/9/2012              | BAEA            |

## Diets

### ***Peregrine Falcon***

Diets of peregrine falcons consisted entirely of birds representing 4 taxonomic orders (Table 6).

Table 6. Diets of peregrine falcons in Kenai Fjords area, 2012.

| Order                    |        |
|--------------------------|--------|
| Common name              | Number |
| Anseriformes             |        |
| mallard                  | 1      |
| Charadriiformes          |        |
| common murre             | 5      |
| murrelet spp.            | 3      |
| rhinoceros auklet        | 1      |
| Passeriformes            |        |
| golden-crowned sparrow   | 2      |
| varied thrush            | 5      |
| unknown                  | 1      |
| Procellariiformes        |        |
| fork-tailed storm petrel | 15     |
| Unknown bird             | 1      |
| Total                    | 34     |

Fork-tailed storm petrels (44.1%), varied thrush (14.7%), and common murres (14.7%) were the most abundant prey collected at sites, followed by unknown murrelets (*Brachyramphus* or *Sythliboramphus* species, 8.8%) and gold-crowned sparrows (5.9%, Figure 2). Other bird species represented by single prey items collected included mallard and rhinoceros auklet.

### ***Bald Eagle***

Bald eagle diet consisted primarily of birds followed by fish and mammals (Table 7). Common murre (55.8%, Figure 3) were the most abundant prey item found at eagle nest sites. Larid (gull) species were the second most common prey item (15.9%) while fish were the third most frequently found (10.6%).

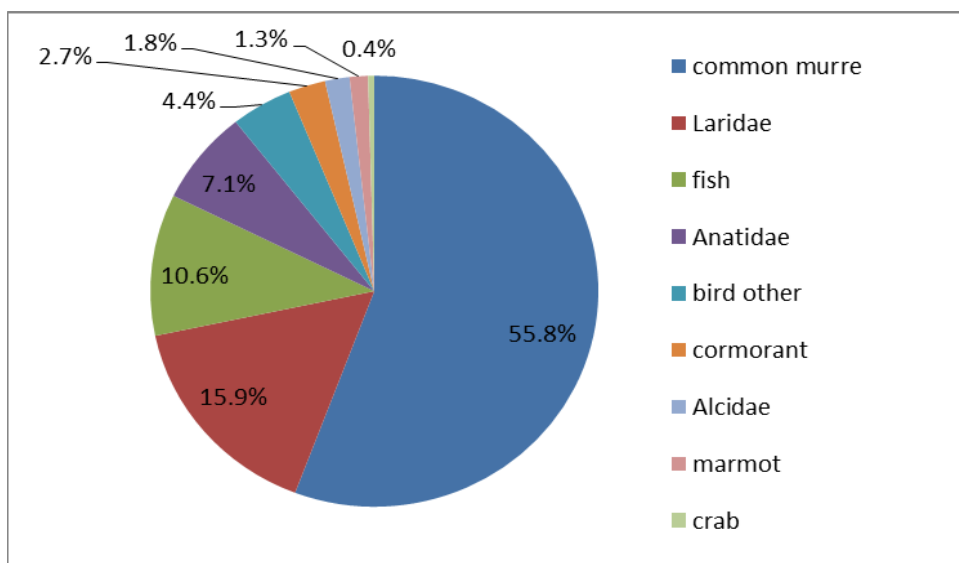
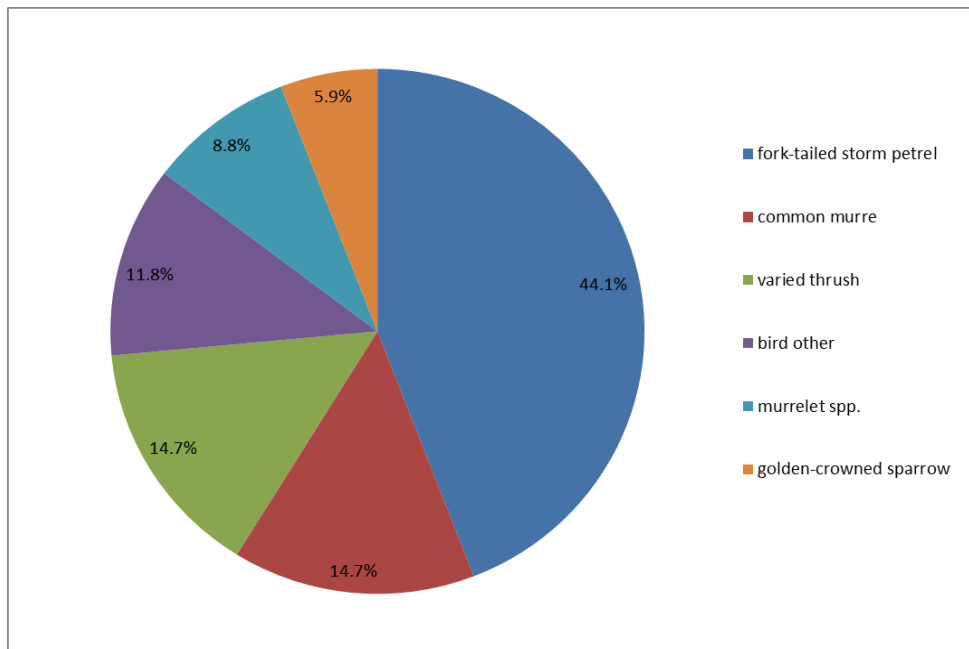


Figure 3. Diets of bald eagles in Kenai Fjords area, 2012.

Table 7. Diets of bald eagles in Kenai Fjords area, 2012.

| General category       |            | General category         |        | General category  |           |
|------------------------|------------|--------------------------|--------|-------------------|-----------|
| Order                  |            | Order                    |        | Order             |           |
| Common name            | Number     | Common name              | Number | Common name       | Number    |
| <b>Bird</b>            | <b>198</b> | <b>Bird cont.</b>        |        | <b>Crustacean</b> | <b>1</b>  |
| Accipitriformes        |            | Galliformes              |        | Decapoda          |           |
| bald eagle             | 1          | willow ptarmigan         | 1      | unknown crab      | 1         |
| Anseriformes           |            | Passeriformes            |        | <b>Fish</b>       | <b>24</b> |
| Anas spp.              | 4          | Corvid spp.              | 1      | Clupeiformes      |           |
| gadwall                | 1          | varied thrush            | 1      | pacific herring   | 5         |
| greater scaup          | 2          | Podicipediformes         |        | Perciformes       |           |
| mallard                | 3          | red-necked grebe         | 1      | pacific sandlance | 1         |
| unknown scoter         | 1          | Procellariiformes        |        | Unknown fish      | 18        |
| northern pintail       | 3          | fork-tailed storm petrel | 1      | <b>Mammal</b>     | <b>3</b>  |
| unknown duck           | 1          | Suliformes               |        | Rodentia          |           |
| unknown scaup          | 1          | double-crested cormorant | 1      | hoary marmot      | 3         |
| Charadriiformes        |            | pelagic cormorant        | 3      |                   |           |
| common murre           | 126        | red-faced cormorant      | 2      |                   |           |
| unknown alcid          | 3          | Unknown bird             | 3      |                   |           |
| unknown murrelet       | 1          |                          |        |                   |           |
| black-legged kittiwake | 5          |                          |        |                   |           |
| glaucous-winged gull   | 24         |                          |        |                   |           |
| herring gull           | 1          |                          |        |                   |           |
| Larid spp.             | 6          |                          |        |                   |           |
| unknown seabird        | 1          |                          |        |                   |           |



## Discussion

Our results suggest fork-tailed storm petrels may be important prey for peregrine falcons in the Kenai Fjords area (Figure 4); however, any conclusions should be made with caution considering the small sample of remains collected at (or in) peregrine nests and the potential biases



Figure 4. Remnants of a fork-tailed storm petrel presumably depredated by a peregrine falcon on Matushka Island. Photo: NPS/Elisa Weiss

associated with collection methods.

Studies on Langara Island, B. C. found that peregrines regularly hunted burrow nesting auklets and murrelets at dusk and dawn as they flew either to or from nesting colonies in island forests (Beebe 1960) and that peregrine falcon numbers and breeding success were closely linked to these seabirds (Nelson and Myres 1976). Little is known about the breeding distribution or population size of fork-tailed storm petrels or other burrow nesting seabirds in the study area. Marine bird surveys in 1976 (Bailey 1977) and 1986 (Nishimoto and Rice 1987) detected the presence of storm petrels on numerous islands in the Chiswell and Pye Island groups; however, a comprehensive survey of burrow nesting seabirds in the area has

not been undertaken. In this study, numerous nesting burrows suspected to be fork-tailed storm petrel burrows were found on Matushka, Harbor and Notoa Islands. A song meter deployed on Notoa and Matushka Islands in summer 2012 recorded the calls of fork-tailed storm petrels and rhinoceros auklets on those islands as they returned to the colony at night to attend nests. Fork-tailed storm petrel remains found at the Yalik Point peregrine falcon nest area, more than 10 km from the nearest known storm petrel colony, suggests the breeding distribution of storm petrels may be more extensive than we know or peregrines are travelling many kilometers from their nests to hunt.

Our results suggest common murres may be an important prey species for bald eagles in the Kenai Fjords area; however, bald eagles are opportunistic scavengers (Watson et al. 1991) and there is a strong possibility that a large portion of the common murres found at bald eagle nest sites were scavenged. A murre die-off occurred in the Northern Gulf of Alaska in winter 2012 and in the spring a large number of murre carcasses were found on area beaches. In May 2012, more than 120 murre carcasses were observed on a beach in Bulldog Cove (Fiona Ritter-Davis, NPS, pers. comm.). A Coastal Observation and Seabird Survey Team (COASST) survey was performed on an adjacent beach in May and approximately 40 dead murres were documented (Figure 5). Although the cause of the murre die-off remains unknown, there were a large number of carcasses available to eagles which may have resulted in an unusually high number of murres showing up in their diet. A study in the Klamath Basin of northern California and southern Oregon showed that bald eagles regularly scavenged waterfowl that died from avian cholera outbreaks (Frenzel and Anthony 1989).

Fish made up a large percentage of the diet of bald eagles in this study. We were not able to identify fish remains found to species due to the difficulty of identification. We consulted a number of fisheries biologists to assist with identification; however, they did not agree on even broad categorizations of the remains largely because most were broken fragments or decomposed pieces.

While this study provides some insight into the diets of raptors in the Kenai Fjords area, our results are likely biased due to small sample sizes and field methods used. Factors that may contribute to data bias are time of year and the size and detectability of prey remains (Marti et al. 2007). We identified prey remains at perch sites and under nests to determine diets; a method that better represents prey with parts that decompose more slowly such as bird feathers and mammal fur and bones. Also, only prey items that are brought back to the nest area and found are represented, so large prey eaten at the capture site and small and readily digestible prey remains may be missed (Frenzel and Anthony 1989). Prey collection in conjunction with other methods such as foraging observations or nest cameras should reduce bias and provide a more complete picture of raptor diet in the area.



Figure 5. Common murre carcasses found during a COASST survey in Bulldog Cove. Photo: NPS/Elisa Weiss

We anticipate the results of the contaminants analyses will shed further light on the predator prey dynamics of seabirds and raptors in Kenai Fjords. While a small sample, analysis of contaminant loads in eggs will provide managers with an initial screening to determine whether environmental contaminants are an issue of concern for park and refuge managers. Mercury analysis of feather samples from raptors and seabirds may be able to link contaminants in predators to those found in prey. Results of contaminants analyses will be reported once they are available.

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## Appendix A: Four-letter Code and Species Common Name

| Four-letter Code | Common Name              |
|------------------|--------------------------|
| ANMU             | ancient murrelet         |
| BAEA             | bald eagle               |
| BLKI             | black-legged kittiwake   |
| COMU             | common murre             |
| DCCO             | double-crested cormorant |
| FTSP             | fork-tailed storm petrel |
| GADW             | gadwall                  |
| GCSP             | gold-crowned sparrow     |
| GRSC             | greater scaup            |
| GWGU             | glaucous-winged gull     |
| HEGU             | herring gull             |
| KIMU             | Kittlitz's murrelet      |
| MALL             | mallard                  |
| MAMU             | marbled murrelet         |
| NOPI             | northern pintail         |
| PECO             | pelagic cormorant        |
| PEFA             | peregrine falcon         |
| RFCO             | red-faced cormorant      |
| RHAU             | rhinoceros auklet        |
| RNGR             | red-necked grebe         |
| VATH             | varied thrush            |
| WIPT             | willow ptarmigan         |