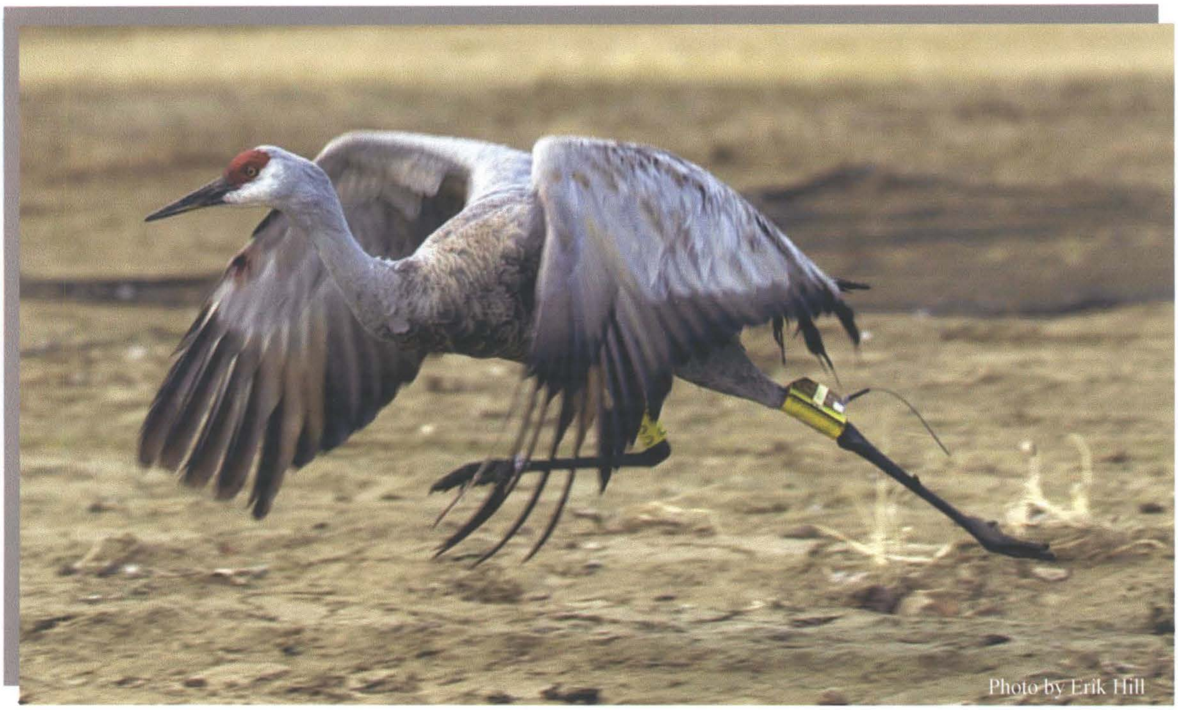

Migration Chronology, Routes, and Winter and Summer Range of Pacific Flyway Population Lesser Sandhill Cranes

Michael J. Petrula and Thomas C. Rothe.
Alaska Department of Fish and Game, Division of Wildlife Conservation,
Waterfowl Program
525 W 67th Ave
Anchorage, Alaska 99518

Final Report: Prepared for the Webless Migratory Game Bird Research Program.

December 2002

Migration Chronology, Routes, and Winter and Summer Range of Pacific Flyway Population Lesser Sandhill Cranes

Michael J. Petrula and Thomas C. Rothe. Alaska Department of Fish and Game, Division of Wildlife Conservation, Waterfowl Program, 525 W 67th Ave, Anchorage, Alaska 99518

Abstract: We used satellite telemetry to determine migration chronology and routes, and winter and summer range of Pacific Flyway Population (PFP) lesser sandhill cranes. Satellite transmitters were deployed on 19 flightless young (colts) in the fall and 3 adults in the spring over a 3-year period (2000-2002) in the upper Cook Inlet and Bristol Bay regions of Alaska. PFP cranes began fall migration in early to mid- September. Cranes followed the northern Gulf coast of Alaska in a southeasterly direction and entered interior British Columbia through the Alaska panhandle near the Stikine River Delta. On average, cranes entered British Columbia 12 days after departing summer range. PFP cranes traveled south through central British Columbia, Washington and Oregon and, on average, arrived on their wintering grounds in the Central Valley of California by Oct. 7 (range Sept. 19-Oct. 20) completing their 3,600km migration in an average of 27 days (range 13-44 days). Common stopover areas were identified. PFP cranes utilized the Sacramento – San Joaquin River Delta and the East Grasslands region (Merced County) of the Central Valley during winter. PFP cranes began spring migration in early March following a similar migration route north and arrived on their summer range in Alaska by early May taking approximately twice as long to complete migration (range 45-64 days). Most cranes (75%) used the Potholes Reservoir region in central Washington for staging in the spring. Cranes captured as colts showed varying degrees of philopatry to natal sites in their second summer. PFP cranes that summer in the Cook Inlet and Bristol Bay regions of Alaska use identical migration routes and wintering areas. PFP cranes monitored with satellite transmitters did not mix with cranes from the Mid-Continent Population or with coastal segment PFP cranes.

Introduction

Sandhill cranes (*Grus canadensis*) that summer in Alaska belong to one of two currently recognized populations: the Pacific Flyway Population (PFP) and the Mid-Continent Population (MCP). The MCP is composed of 3 subspecies (lesser [*G. c. Canadensis*], Canadian [*G. c. rowani*], and greater [*G. c. tabida*]) of sandhill cranes (Walkinshaw 1973, Johnson and Stewart 1973, Tacha et al. 1984). Recent progress in mitochondrial DNA research, however, has questioned the validity of a separate Canadian subspecies designation (Rhymer et al. 2001, Glenn et al. 2002), even though they are intermediate in morphology to lesser and greater subspecies (Walkinshaw 1965). Only lesser and Canadian subspecies of the MCP are believed to summer in Alaska (U.S. Geological Survey 1998). Lessers primarily spend the summer on the coastal plain of the Yukon-Kuskokwim Delta and Canadians use interior regions (U.S. Geological Survey 1998) (Fig. 1). During fall migration, the MCP remains north of the Alaska Range, travels east of the continental divide and winters in Texas, New Mexico, Oklahoma, and northern Mexico (Boise 1979, Kessel 1984, Tacha et al. 1984). Much of the current information describing the geographic extent of the MCP has been acquired through marking of cranes on the breeding grounds (Boise 1979), winter range, and staging areas (Tacha et al. 1984, U.S. Geological Survey 1998). Available evidence to date suggests that the MCP and PFP do not integrate during winter, migration or on summer range (Pogson et al. 1988, Krapu pers. comm.).

The PFP are identified as lesser sandhill cranes and use the western states and provinces of North America (Pacific Flyway Council 1983). The Cook Inlet and Bristol Bay regions of Alaska are the major breeding areas for this population (Pacific Flyway Council 1983) (Fig. 1). However, a small number of cranes have also been reported nesting on islands in southeast Alaska and northern British Columbia (Gabrielson and Lincoln 1959). The status, range and sub-specific classification of these island-nesting cranes is currently under investigation (Ivey pers. comm., Littlefield and Ivey 2002). However, preliminary evidence suggests that they are Canadian subspecies and use a coastal route during migration (Ivey pers. comm., Littlefield and Ivey 2002).

PFP lesser sandhill cranes are believed to winter exclusively in the Central Valley of California (CVC) (Littlefield and Thompson 1982) where they mix with the Central Valley Population of greater sandhill cranes (Pogson and Lindstedt 1991, Littlefield and Ivey 2002).

Information describing the geographic extent of PFP lesser sandhill cranes has been acquired through ground (Herter 1982, Littlefield and Thompson 1982) and aerial (Conant et al. 1985) observations of flock aggregations and limited re-sightings of marked individuals (Pogson 1987, Pogson et al. 1988). Migration routes, especially in northern areas, have not been verified. Stopping and staging areas have been identified for some locations (Herter 1982, Mickelson 1985), yet their relative importance to migrating cranes is not known (Pacific Flyway Council 1983). Because few individuals have been marked and subsequent re-sightings have been limited, much of the current information delineating the range of PFP lesser sandhill cranes has been speculative. As a result, current hypotheses describing affinities among breeding, staging and wintering areas have gone untested.

Managers of migratory game birds require increasingly more information about bird movements to delineate populations, protect important habitats, and regulate harvest. This is especially true for species that exhibit isolated distributions during certain periods of the year. The geographic separation in breeding range of PFP cranes in upper Cook Inlet from those in western and southeastern Alaska warrants investigation of the discreteness of these population units. For management purposes, it is important to determine whether gene flow exists among breeding areas in Alaska, whether cranes from these areas differ in ecology and behavior, and whether these groups function as separate population segments throughout the year.

Delineating affinities among wintering, staging and nesting areas is necessary to manage PFP cranes through reliable inventories and appropriate harvest regimes. The need for this information is particularly important for habitat protection, in that current proposals for development projects in Alaska, Washington, Oregon and California could have deleterious impacts on habitat quality and quantity and cause increased disturbance. Potential impact on cranes from local developments has generated public concern and the demand for additional information regarding their breeding origin, population estimates and harvest rates.

Objectives

The primary objectives of this study are to:
1. Identify migration routes, stopover areas and length of stay at staging areas for Cook Inlet and Bristol Bay PFP sandhill cranes using satellite telemetry.
2. Strengthen information on affinities among breeding, staging and wintering areas for Cook Inlet and Bristol Bay PFP cranes.
3. Obtain blood samples for genetics work to compare with samples from other parts of the PFP range and with the MCP.
4. Further investigate the discreteness of the PFP and MCP breeding range.

Study Area and Methods

We captured sandhill cranes in the upper Cook Inlet and Bristol Bay regions of Alaska (Fig. 1). Twelve satellite transmitters were deployed on flightless young (colts) at 4 locations in upper Cook Inlet (Palmer Hay Flats, Anchorage Coastal Wildlife Refuge, Susitna Flats, Point McKenzie) in 2000 and 2001, and 7 satellite transmitters were deployed on colts in Bristol Bay (Nushagak Peninsula) in 2002 (Fig. 1). Colts were captured with the aid of an Robinson 22 helicopter. When a family group was observed from the air, the pilot would hover the aircraft over a colt at approximately 1m AGL allowing a person to exit the aircraft, capture, and restrain the bird. Only one colt per family group was captured. At the capture site, we sampled blood for sexing and genetics analysis, and recorded morphological measurements. We attached a satellite transmitter with a leg-band attachment (Melvin et al. 1983, Ellis et al. 2001) above the tibio-tarsal joint with the stainless steel antenna pointing down. On the other leg we applied a USFWS metal leg band and a yellow colored leg band with a unique alphanumeric code for identification in the field (Appendix A). On average, colts weighed 2.4 kg (standard deviation ± 0.34kg). After release, the colt immediately reunited with adults waiting nearby for all but 2 captures. Three satellite transmitters were deployed on adult cranes at a spring staging area in upper Cook Inlet (Matanuska Valley) on April 27, 2002. Adult cranes were captured with the use of a rocket net over bait. Markers and processing protocol used for colts were also used for adults.

Each satellite transmitter weighed approximately 55g (with band attachment), was programmable, and was manufactured with an ambient temperature and battery voltage sensor. To maximize battery life, satellite transmitters were programmed to transmit at various duty cycles depending on expected bird activity and movements (Table 1).

Transmitter signals were received by 4 NOAA polar-orbiting satellites. Sensor data was transmitted approximately every 60 seconds during the on cycle in frames of four, 8-bit messages (i. e. a total of 32 bits per transmission). Signals were analyzed using Argos Data Collection and Location Systems. Locations were calculated from a Doppler shift in signal frequency. We used Argos "standard" and "auxiliary" location data processing services. The accuracy of "standard locations" (class codes 1, 2, and 3) is generally <1000m and requires that the satellite receives at least 4 messages during a pass over the transmitter (Argos 1996). Location accuracy for "standard locations" with class code 0 is generally >1000m with no maximum limit (Argos 1996). The accuracy of "auxiliary locations" (class codes A and B) cannot be calculated because the normal system specifications are relaxed to provide locations calculated from 2 or 3 messages. The lack of an estimate of accuracy, however, does not necessarily mean "auxiliary locations" are inaccurate. Argos locations with class code Z were rejected. To filter inaccurate locations with class codes A and B, we used a SAS (SAS Institute Inc.) program developed by David C. Douglas (U. S. F. W. S.) based on comparing distance, rate, and angle of consecutive locations. Additionally, locations with class codes 1, 2, 3, 0, and filtered As and Bs were checked manually for accuracy.

Because satellite transmitters did not transmit continuously we can only report locations acquired during the transmission cycle. To provide a complete description of the migration route used by PFP cranes while at the same time maximizing battery life, we programmed our satellite transmitters to transmit more frequently during migration than other times of the year (Table 1). Nevertheless, stopping areas used by cranes for brief periods may have gone undetected, and the precise route taken during migration may not be apparent for cranes that traveled long distances between transmission cycles. For similar reasons, the number of days reported for cranes while in route and spent at stopping areas was approximated; their accuracy being dependent on the number of hours during the off cycle (Table 1).

Only the best location per transmission cycle (regardless of class code) was used to illustrate crane locations on winter and summer range. However, all acceptable locations per transmission cycle were used to illustrate movements during migration. Locations were frequently obtained during active migration. Data reported for transmitters currently transmitting are from date of deployment until November 11, 2002.

Locations for individual cranes were mapped using a Geographic Information System (ArcView) and posted at http://www.state.ak.us/adfg/wildlife/duck/crane/crane.htm.

RESULTS

Seventeen satellite transmitters provided informative location data (Table 2). However, 3 went off the air prior to the expected life of the transmitter, and 5 were deployed on cranes that either died or shed the transmitter during migration. Two are currently active (Table 2). No useful information was received from 5 satellite transmitters because the birds were depredated soon after capture (n=3), shot during the hunting season (n=1), or the transmitter failed for unknown reasons soon after capture (n=1) (Table 2).

Satellite transmitters applied with a leg band attachment provided ample location data even with the antenna pointing towards the ground, and had the potential to remain active for over a year (Table 2). Locations with class codes 1, 2, and 3 (combined) comprised 22.3% of the total locations received, class code 0 and class codes A and B (combined) comprised 34.6% and 40.1% of the total locations received, respectively (Table 2).

Fall Migration

Coastal route: PFP cranes began their southerly migration in early September with first substantial movements beginning September 11 (on average) (Table 3). PFP cranes captured in Bristol Bay in 2002 began fall migration approximately 8 days later than cranes captured in upper Cook Inlet (Table 3). We cannot determine whether the later departure by Bristol Bay cranes was the result of location differences or simply annual variability in departure dates because Cook Inlet cranes were not captured in 2002. Similar departure dates for upper Cook Inlet cranes in 2000 and 2001 is evidence for the former explanation.

PFP cranes departed Bristol Bay and traveled east directly to the Kenai Peninsula where they potentially mix with Cook Inlet cranes (Fig. 2). We suspect Bristol Bay cranes entered Cook Inlet through passes in the Alaska Range south of Iliamna Lake. Bristol Bay cranes continued east and accessed the Gulf Coast of Alaska by flying directly over the Kenai Peninsula and through Prince William Sound (Fig. 2). PFP cranes captured in upper Cook Inlet accessed the Gulf Coast by traveling southeast over the Chugach Range. We believe Portage Pass and the Knik Glacier are two primary access corridors to Prince William Sound. Once reaching the Gulf coast in south central Alaska, upper Cook Inlet and Bristol Bay cranes followed the coastline in a southeasterly direction (Fig. 2). At Pt. Spencer PFP cranes left the outer coast and continued migration through the islands and straits of the Alaska panhandle (Fig. 2). In contrast to the low lying areas used by cranes along the outer coast high elevation locations were commonly used by cranes while traveling through the panhandle. We suspect berry production in perched muskegs and alpine meadows attracted cranes to higher elevations.

We identified 5 stopping areas in Alaska frequently used by cranes during fall migration (Table 4). Twelve of 15 (80%) cranes stopped near the Yakutat Forelands, 40% in the vicinity of the Bering Glacier lowlands and on the Stikine River Delta, and 27% stopped on the Copper River Delta and near Gustavus. Cranes remained at Gustavus for the longest duration (average 7.0 days) followed by the Yakutat Forelands (average 3.8 days). Other areas less frequently used by cranes include Cape Yakataga, Prince William Sound, Kenai Peninsula, and the lowlands near the mouth of Icy Bay and Lituya Bay (Table 4).

On average, PFP cranes left Alaska and entered British Columbia 12 days after beginning fall migration (range 5 –19 days) (Table 3). However, cranes captured in Bristol Bay spent less time traveling through Alaska (8 days on average) than did cranes captured in upper Cook Inlet (14 days on average).

Interior route: Near the Stikine River Delta, PFP cranes migrated inland and entered central British Columbia near Stewart (Fig. 3). They continued south through the Fraser River and Okanogan Valleys. PFP cranes traveled through British Columbia in approximately 5 days, on average (range 1-18 days) (Table 2). Because most cranes spent little time in British Columbia, stopping areas were used for brief periods and only a few could be reliably identified (Table 4). Locations near Smithers, and Kamloops were used more frequently (Fig. 3), however, one crane spent 14 days near Prince George (Table 4).

PFP cranes continued south staying west of the Selkirk Mountains and entered north central Washington near Oroville (Fig. 4). The primary stopping area was in central Washington in the vicinity of the Potholes Reservoir (Fig.4) where 71% of radioed cranes spent, on average, 5.5 days (range 1-13) (Table 4). Two cranes, however, stopped for a brief period east of Monse, WA (Okanogan County) north of the Columbia River (Fig. 4). PFP cranes continued migration through central Oregon, spending little time in this state before entering California (Table 2). Few locations were obtained while cranes were in Oregon and most of those were for actively migrating birds (Fig. 4). Five stopping areas, however, were identified (Table 4). Locations of migrating cranes indicate that a portion of the population enters California by crossing the northwest corner of Nevada (Fig. 4). Cranes traveled directly to wintering areas once entering California (Table 3).

On average, it took approximately 27 days (range 13-44 days) for PFP cranes to complete the ca. 3,600-km migration from summer range in Alaska to winter range in California (Table 3). Arrival dates on wintering grounds were similar between upper Cook Inlet and Bristol Bay cranes even though Bristol Bay cranes began migration later. On average, it took Bristol Bay cranes 10 days less to complete the journey because they made fewer stops. The maximum distance traveled by cranes calculated for individual flight segments indicates that cranes can attain an average flight speed of up to ca. 78 km/hr when actively migrating.

Winter Range

PFP cranes arrived on wintering grounds in the Central Valley of California (CVC), on average, October 7 (range Sep. 19-Oct. 20). We obtained location data for 11 cranes in the CVC; 8 cranes were monitored throughout the winter, 2 cranes are presently on winter range with active transmitters, and 1 crane went off the air in late October. We received location data for 372 of 389 possible transmission cycles (11 cranes combined) while cranes were on winter range. Only the best location for each transmission cycle was used to identify winter distribution (Fig. 5). Seventy three percent of the locations were class code 1, 2 and 3 (combined), 26% were class code 0, and 1% were class code A.

Winter locations were concentrated at 2 primary areas with less frequent use occurring elsewhere (Fig. 5). Sixty four percent of the total winter locations from 9 radioed cranes were in the Sacramento – San Joaquin River Delta (Delta), with the majority (63%) concentrated on Staten Island, Tyler Island, Canal Ranch, Brack Tract, Terminous Tract and New Hope Tract. Ninety four percent of locations in the Delta region were within a core area that encompassed 425 sq. km (Table 5).

Thirty three percent of the total winter locations from 6 radioed cranes were ca. 130km to the south in Merced County (Merced), with most occurring between state highways 140 and 33/52 near Sandy Mush Country, Kesterson, San Luis and Merced National Wildlife Refuges, and the Los Banos and Volta State Wildlife Areas. The core area used by cranes in this location encompassed 1473 sq. km and included 94 % of the total locations (Table 5). Three percent of the total winter locations from 3 cranes were outside these two primary wintering areas primarily in the vicinity of Vernalis near the San Joaquin River at the border of Stanislaus and San Joaquin Counties (Fig. 5).

Winter locations obtained for individual PFP cranes were generally localized. Of the 8 radioed cranes monitored throughout the winter, location data for 2 cranes (13386 and 29503) indicated that they did not move substantial distances from the general vicinity of their primary wintering area during the winter period (Table 5). Six cranes spent little time (<12% of total winter locations) away from their primary wintering area. Most (69%) movements were between primary wintering areas (Delta and Merced) with no apparent trend with respect to timing or direction of travel. Approximate home ranges of individual cranes averaged 190 sq. km (standard deviation=123 sq. km) in the Delta region (range=46-371 sq. km) and 924 sq. km (standard deviation=981 sq. km) in Merced County (range=67-2,332 sq. km) (Table 5).

Spring Migration

We obtained location data for 8 cranes during spring migration (Fig. 6). PFP cranes began migration north from winter range in the CVC in early March with first substantial movements beginning March 6 (on average) (Table 3). The travel route north used during the spring was similar to that used in the fall (Fig. 6), but took approximately twice as long to complete (56 days, on average) (Table 3). PFP cranes spent an average of 45 days at staging areas in the Pacific Northwest before continuing north. The Harney Valley in Oregon, and the Potholes Reservoir and Banks Lake regions in Washington were the most frequently used stopping areas in those states (Table 6). Two cranes traveled further east than expected based on the observed fall migration route and spent significant time (≥ 35 days) near the Oregon and Idaho border in the vicinity of Fruitland and Wilder, Idaho before entering Washington (Fig 6). Stopping areas in British Columbia and Alaska used during the spring were the same as those used during the fall, however relatively less time was spent traveling through Alaska in the spring (Table 3). PFP cranes arrived on their summer range during the first week of May (average=May 2).

Summer Range

Adults: Adult cranes captured during late April at a spring staging area in the Matanuska Valley, AK remained near the capture site for approximately 10 days before dispersing to breeding areas in the Susitna and Kahiltna river drainages (Fig. 7). Location data indicated little movement throughout the summer therefore we presume nest sites were initiated in this boreal forest, muskeg habitat. Transmitters on 2 adults failed just prior to anticipated fall migration. Location data for a male (33092) indicates the bird visited the capture location (staging area) the following spring then returned to summer in the same general location (Susitna River Valley) as the previous year (Fig. 7).

Colts: Between fledging and fall migration PFP cranes captured as flightless young remained relatively close to capture locations until migrating south. The following spring colts captured in upper Cook Inlet exhibited varying degrees of philopatry to natal sites. Only one crane (female 29302) returned to the immediate vicinity of its natal site the subsequent year (Fig. 8). Four cranes (2 males, 2 females) returned to upper Cook Inlet but did not revisit their natal location (Fig. 8 and Fig. 9). Two cranes did not return to summer in Cook Inlet. A female (13381) spent the summer on the Gulf Coast of Alaska between Cape Suckling and the Yakutat Forelands, over 360 km east of Cook Inlet (Fig. 8). The last spring location obtained for a male (29052b) was on the Alaska Peninsula indicating the bird had traveled through Cook Inlet possibly heading to summer range in Bristol Bay (Fig. 9).

Of the 5 juveniles returning to upper Cook Inlet, 2 spent the summer on the Kenai Flats (Fig. 8 and 9), one of which made a brief foray to the upper Kahiltna drainage (a previously described breeding area) (Fig. 8). Two juveniles summered near the Palmer Hay Flats (Fig. 8) and one on Chickaloon Flats (Fig. 9).

Future Work

We will continue to monitor the 2 remaining cranes with active transmitters. We anticipate these radios will expire in July 2003 after cranes return to summer range in Alaska. We are currently conferring with potential collaborators with regard to microsatellite DNA analysis of blood samples taken from PFP cranes. A comparison between PFP and MCP cranes will evaluate whether genetic interchange occurs between these populations.

DISCUSSION

Using satellite telemetry we were able to describe in detail the movements of individual PFP lesser sandhill cranes on summer range in Alaska, winter range in California, and through fall and spring migration. We realize that the majority of our satellite transmitters were deployed on colts and may not accurately reflect movements and distribution of other age classes in the population. Colts, however, remain with their parents at least through their first migration and winter (Tacha 1988). Therefore, we believe our results also reflect movements of breeding adults during those periods. Whether the geographic range of all PFP cranes breeding in Alaska is similar during the fall and winter to that of our radioed cranes is uncertain. However, without exception, cranes captured in both upper Cook Inlet and Bristol Bay followed the same migratory path during spring and fall (Fig. 6), and wintered in only 2 locations in the CVC that were relatively small in area and well defined (Fig. 5).

Our location data suggests that most juveniles do not return to their natal sites the first year following hatch, indicating that they do not accompany their parents at least during the later stages of spring migration. Tacha (1988) reported that juvenile cranes remain with their parents until April, approximately 10 months after hatch. Consequently, we cannot say with certainty that migration chronology and path exhibited by our radioed birds in the spring can be extrapolated to include all other segments (age and breeding status) of the population. However, we saw no obvious differences in spring movements through the Pacific Northwest and British Columbia between the 7 juveniles and 1 adult monitored during the study.

Stopping, Staging and Wintering Areas

Our satellite transmitters were programmed to transmit more frequently during migration (Table 1). We could not, however, precisely quantify the lengths of stay made by PFP cranes at stopping areas. Crane use may have gone partially or completely undetected because the area was visited at some point during the transmitters off cycle. Locations that were used for longer durations, however, were easily identified and, in relative terms, are probably more important to migrating cranes than locations used for shorter periods.

PFP lesser sandhill cranes completed migration from summer range in Alaska to winter range in the CVC in 13 to 40 days (Table 3). Both the minimum and maximum transit times were from individuals monitored during the fall in 2001 indicating that either cranes exhibit different migration strategies, or experienced different weather conditions. Weather conditions can affect movements of migrating cranes (Kessel 1984), and probably explain much of the variation exhibited by our radioed birds (Table 3).

More time was spent in Alaska during fall migration than other states or province (Table 3), but partly because Alaska makes up the largest proportion of the travel route. Stops in Alaska were, for the most part, of short duration (<2 days) with more extensive stopovers occurring at Gustavus and the Yakutat Forelands. That 80% of radioed cranes stopped at the Yakutat Forelands indicates that the area provides a desirable resource. The relatively high use of the Bering Glacier lowlands, Stikine and Copper River Deltas, and Gustavus indicates the importance of these areas to migrating cranes. Streveler and Matkin (1983) reported a minimum of 12,899 cranes passed through Gustavus during the fall in 1981, 6,870 of which landed on the Dude Creek uplands. Herter (1982) indicated a similar numbers of cranes migrating through the Copper River Delta, however stops were usually for brief periods.

British Columbia also comprises a large proportion of the total migration route but most cranes spent relatively little time (≤5 days) in this province during fall and spring migration (62% and 100% of radioed cranes, respectively). As was the case in Oregon, a large proportion of locations obtained during the fall were of cranes during active migration and not at rest. Stopping areas were used for short durations and not easily identified with satellite transmitters programmed with on-off duty cycles. Most cranes migrated through these regions during the short duration of the transmitters off cycle, and were located a considerable distance along the migration route during the next transmission period.

The Pothole Reservoir region, including the Columbia River National Wildlife Refuge in central Washington, received more use by radioed cranes than other locations along the migration corridor. This was more apparent in the spring when 75% of radioed birds used the area for 10 – 42 days (Table 6). The Banks Lake area, north of the Potholes Reservoir, also was used frequently by cranes in the spring, but cranes were not detected there in the fall. These staging areas in Washington, plus locations used for long periods in Oregon and Idaho (Table 6) are important to cranes in that they undoubtedly provide a large proportion of the nutritional resources used for the energetic demands of migration (Krapu 1987).

The geographic extent of PFP lesser sandhill cranes monitored during the winter was restricted to 2 primary locations within the CVC with little interchange between areas (Fig 5). With exception of the federal wildlife refuges and state wildlife areas in Merced County, most of the winter locations appear to be on private lands. This is especially true for cranes using lands west of Lodi. Future development of these wintering areas should be monitored closely because traditionally important roost and foraging areas may be limited (Pogson 1990).

Affinities Among Breeding and Wintering Areas

The western boundary separating the breeding range of the PFP and the MCP are in close proximity (Fig. 1). We, as did others (Pogson et al. 1988, U.S. Geological Survey 1998), found no evidence indicating that migration routes, and winter and summer range of these populations overlap. Granted we marked few cranes where overlap in breeding range may have occurred, and these juvenile cranes have yet to return to summer range in Alaska.

PFP cranes breeding in Bristol Bay and Cook Inlet utilize identical migration routes and wintering areas. Juvenile cranes showed little affinity to natal sites during their first summer back in Alaska. One juvenile crane (29502b) captured in upper Cook Inlet was located last near Naknek Lake on the Alaska Peninsula the following spring (Fig. 9). We believe the bird was traveling to Bristol Bay, however the transmitter failed after 19 May probably before reaching its summer range. While these breeding populations may be geographically distant, we believe it is unlikely that they are genetically isolated. However, genetics analyses are in progress and will provide an initial assessment.

Sandhill cranes nesting on islands in southeast Alaska and along the coast of northern British Columbia are believed to be Canadian subspecies (Cooper 1996, Littlefield and Ivey 2002, Ivey et al., in prep) that stage on Sauvie Island, OR and Ridgefield NWR, WA during the spring and fall. Lesser sandhill cranes have also been reported using these staging areas (Littlefield and Thompson 1982). Historically, this group was believed to winter near Red Bluff, CA (Littlefield and Thompson 1982), north of wintering areas used by cranes monitored during this study. In recent years, however, sandhill cranes have not used the Red Bluff area during winter, and their current wintering location is being investigated (Ivey pers. comm.). Previously described by Littlefield and Thompson (1982) as the "western segment" of the PFP of lesser sandhill cranes, their migration corridor included the Willamette Valley, Oregon, the Washington coast through Puget Sound, and the coast of British Columbia and Alaska (Littlefield and Thompson 1982, Littlefield and Ivey 2002). We found no evidence suggesting that PFP lesser sandhill cranes breeding in Cook Inlet and Bristol Bay use an all-coastal route along British Columbia and Washington state during migration. During the fall, radioed cranes left the coast near the Stikine River Delta in Alaska and used an interior route through central British Columbia, Washington and Oregon to wintering areas in the CVC. A reverse route was taken in the spring. No overlap appears to exist in the breeding range of PFP cranes captured in Bristol Bay and Cook Inlet (this study) with cranes breeding to the south along the Pacific Coast (Ivey et al., in prep). However, the possibility of gene flow between these populations warrants further study. The possibility also exists that pairs are formed between PF lesser and Central Valley greater sandhill cranes on wintering or spring staging areas (Tacha et al. 1985) and the Canadian subspecies observed are hybrids of this crossing (Glenn et al. 2002). Based on morphological measurements, Herter (1982) classified 8 of 39 cranes as the Canadian subspecies on the Copper River Delta, a location where cranes were previously thought to be lessers.

ACKNOWLEDGMENTS

We thank Herman Griese, Doug Hill, Dan Rosenberg and Rick Sinnott for their assistance during captures of adult cranes. We are grateful to Doug O'Hare and Erik Hill (Anchorage Daily News) for the public attention their local news story gave to our project. We thank Sandy Talbot and the staff at the USGS-BRD genetics lab (Region 7, Anchorage, Alaska) for determining the sex of our radioed cranes. We're extremely grateful for the diligent effort by helicopter pilots Troy Cambier and Larry Larrivee. We thank David Ellis and Gary Krapu for technical assistance with crane marking. We appreciate assistance from Jim Woolington (ADF&G), Patrick Walsh and Gail Collins (Togiak NWR). We thank the Webless Migratory Game Bird Research Program and the U.S.F.W.S. Migratory Bird Management (Region 7) for partially funding this project.

LITERATURE CITED

Argos. 1996. User's manual. Service Argos, Inc. Landover, MD.

Boise, C. M.. 1979. Lesser sandhill crane banding program on the Yukon-Kuskokwim Delta, Alaska. Pages 229-236 in J. C. Lewis, ed., Proceedings 1978 Crane Workshop. Colorado State Univ. Print. Serv., Ft. Collins.

Conant, B., J. G. King, and H. A. Hansen. 1985. Sandhill cranes in Alaska: A population survey 1957-1985. American Birds 39(5):855-858.

Ellis, D.H., P.W. Howey, and G.L. Krapu. 2001. Recommendations for the attachment of satellite transmitters to cranes. Pages 211-212 in D. H. Ellis, ed. Proceedings of the Eighth North American Crane Workshop, 11-14 January 2000, Albuquerque, New Mexico. North American Crane Working Group, Grand Island, NE.

Gabrielson, I. A. and F. C. Lincoln. 1959. The birds of Alaska. Stackpole Co., Harrisburg, PA. 922pp.

Glenn, T. C., J. E. Thompson, B. M. Ballard, J. A. Roberson, and J. O. French. 2002. Mitochondrial DNA variation among wintering Midcontinent Gulf Coast Sandhill Cranes. J. Wildl. Manage. 66(2):339-348.

Herter, D. R. 1982. Habitat use and harassment of sandhill cranes staging on the eastern Copper River Delta, Alaska. M. S. thesis, Univ. Alaska, Fairbanks. 170pp.

Ivey, G. L., T. J. Hoffmann, and C. P. Herziger. *In prep.* Tracking movements of sandhill cranes using Ridgefield National Wildlife Refuge, Washington and Sauvie Island Wildlife Area, Oregon through their annual cycle.

Johnson, D. H. and R. E. Stewart. 1973. Racial composition of migrant populations of sandhill cranes in the northern plains states. Wilson Bull. 85:148-162.

Kessel, B. 1984. Migration of sandhill cranes, *Grus canadensis*, in east-central Alaska with routes through Alaska and western Canada. Can. Field. Nat. 98:279-292.

Pacific Flyway Council. 1983. Pacific Flyway management plan for the Pacific Flyway Population of Lesser Sandhill Cranes. Pacific Flyway subcommittee. c/o U.S. Fish and Wildl. Serv., Portland, OR. 19 pp.

Krapu, G. L. 1987. Use of staging areas by sandhill cranes in the mid-continent region of North America. Pages 451-462 in G. W. Archibald and R. F. Pasquier, eds., Proceedings 1983 International Crane Workshop. International Crane Foundation, Baraboo, WI. 595 pp.

Littlefield, C. D. and S. P. Thompson. 1982. The Pacific coast population of lesser sandhill cranes in the contiguous United States. Pages 288-294 in J. C. Lewis, ed., Proceedings 1981 Crane Workshop. Nat. Aud. Soc., Tavernier, FL.

____________, and G. L. Ivey. 2002. Washington State Recovery Plan for the Sandhill Crane. Washington Department of Fish and Wildlife, Olympia, WA. 71 pages.

Melvin, S. M., R. C. Drewien, S. A. Temple and E. G. Bizeau. 1983. Leg-band attachment of radio transmitters for large birds. Wildlife Society Bull. 11(3):282-285.

Mickelson, P. G. 1985. Management of lesser sandhill cranes staging in Alaska. Pages 264-275 in J. C. Lewis, ed., Proceedings 1985 Crane Workshop. U. S. Fish and Wildl. Serv., Grand Island, NE.

Pogson, T. H. 1987. Sandhill crane banded in Alaska migrates to California and Oregon. North Am. Bird Bander 12:90-92.

__________. 1990. Distribution and abundance of large sandhill cranes (*Grus canadensis tabidia*) wintering in California's Central Valley. M. S. thesis. University of Alaska, Fairbanks, Alaska. 52 pp.

__________, and S. M. Lindstedt. 1991. Distribution and abundance of large sandhill cranes (*Grus canadensis tabidia*) wintering in California's Central Valley. Condor 93:266-278.

__________, D. R. Herter, and R. W. Schlorff. 1988. Sightings of lesser sandhill cranes color-marked in California. J. Field Ornithol. 59(3):252-257.

Rhymer, J., M. Fain, J. Austin, D. Johnson, and C. Krajewski. 2001. Mitochondrial phylogeography, subspecific taxonomy, and conservation genetics of sandhill cranes. Conservation Genetics 2:203-218.

Streveler, G. P. and C. O. Matkin. 1983. A preliminary evaluation of wildlife populations and habitats on Gustavus beaches and Dude Creek uplands. Unpbl. Rep. By the North Gulf Oceanic Society for the AK. Dept. Fish and Game, Juneau, AK. 19 pp.

Tacha, T. C. 1988. Social organization of sandhill cranes from midcontinental North America. Wildl. Monogr. 99. 37pp.

__________, P. A. Vohs, and G. C. Iverson. 1984. Migration routes of sandhill cranes from mid-continental North America. J. Wildl. Manage. 48(3):1028-1033.

__________, P. A. Vohs, and W. D. Warde. 1985. Morphometric variation of sandhill cranes from mid-continental North America. J. Wildl. Manage. 49(1):246-250.

U.S. Geological Survey. 1998. Operation crane watch. Northern Prairie Wildlife Research Center Home Page. http://www.npwrc.usgs.gov/perm/cranemov/cranemov.htm. (Version 20NOV02).

Walkinshaw, L. H. 1949. The sandhill cranes. Bull. 29, Cranbrook Inst. Sci., Bloomfield Hills, MI. 202pp.

______________. 1965. A new sandhill crane from central Canada. Can. Field. Nat. 79:181-184.

______________. 1973. Cranes of the world. 1973. Cranes of the world. Winchester Press, New York. 370pp.

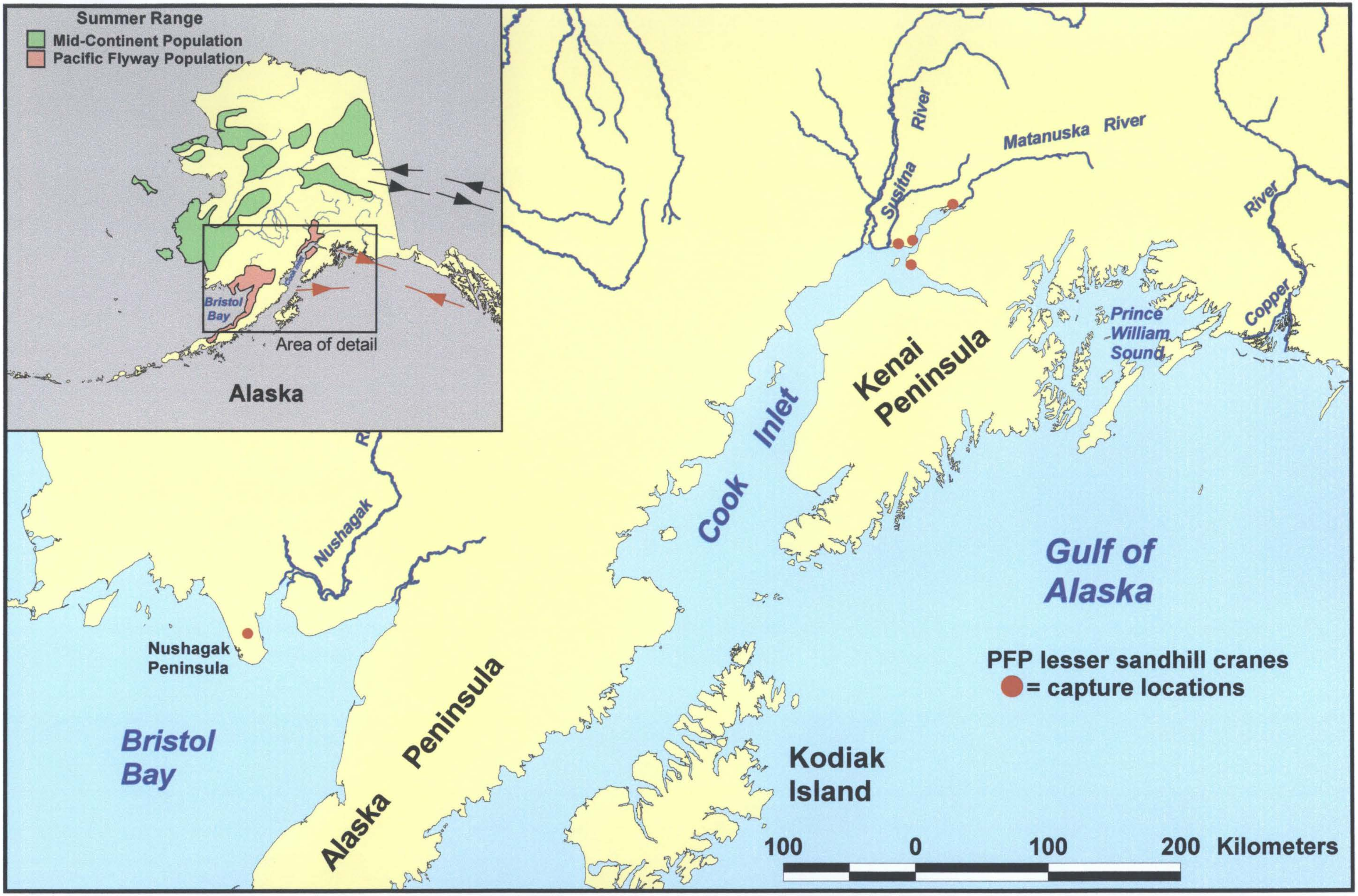

Fig. 1. Map of Alaska illustrating primary summer range and general migration paths for the Pacific Flyway and Mid-Contintent Populations of sandhill cranes (inset). Locations in the upper Cook Inlet and Bristol Bay regions of Alaska where satellite transmitters were deployed on Pacific Flyway Population lesser sandhill cranes in 2000, 2001 and 2002 (area of detail).

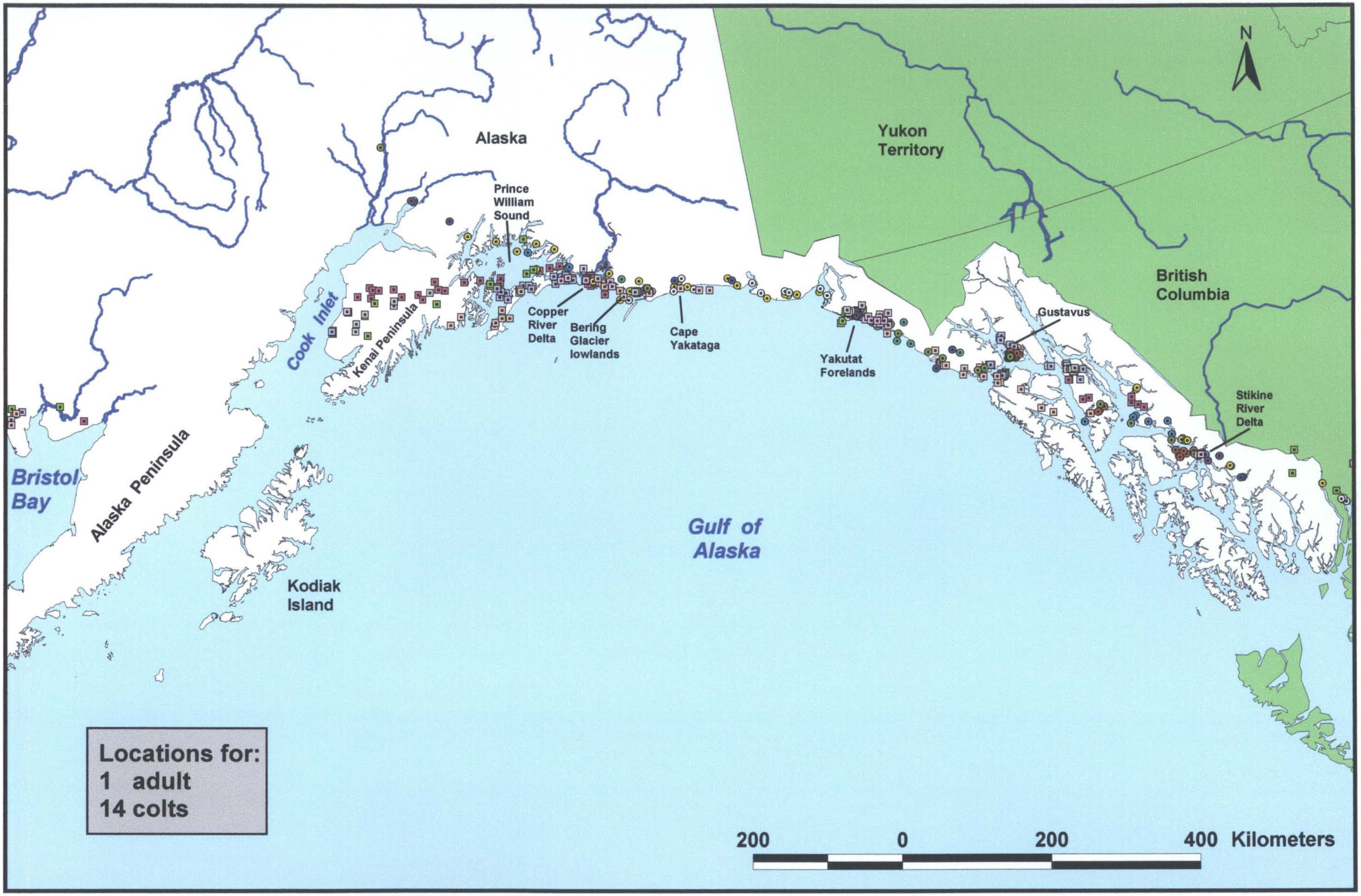

Fig. 2. Locations of Pacific Flyway Population lesser sandhill cranes during fall migration through Alaska in 2000, 2001 and 2002. Circles depict cranes captured in upper Cook Inlet. Squares depict cranes captured in Bristol Bay.

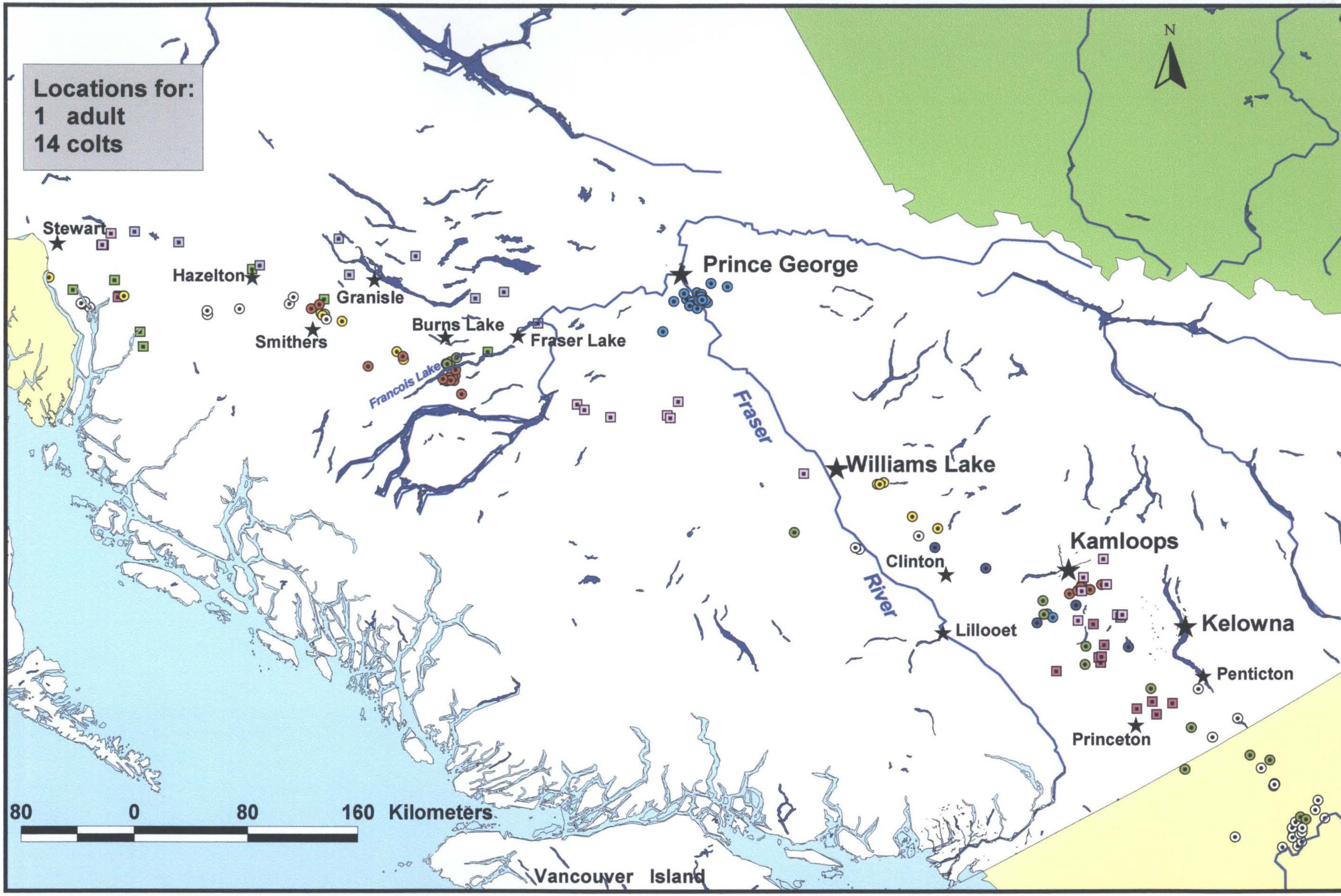

Fig. 3. Locations of Pacific Flyway Population lesser sandhill cranes during fall migration through British Columbia in 2000, 2001 and 2002. Circles depict cranes captured in upper Cook Inlet. Squares depict cranes captured in Bristol Bay.

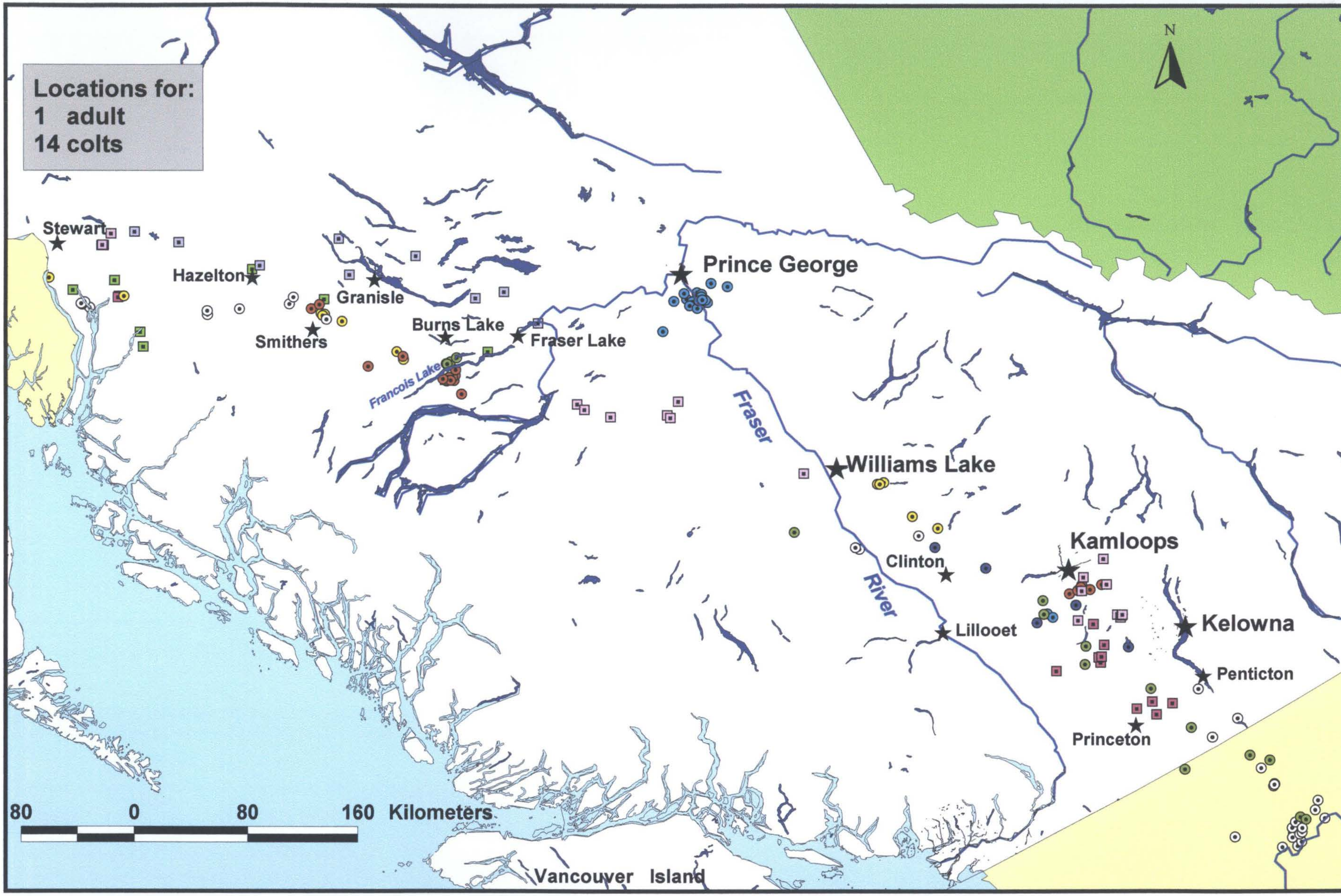

Fig. 3. Locations of Pacific Flyway Population lesser sandhill cranes during fall migration through British Columbia in 2000, 2001 and 2002. Circles depict cranes captured in upper Cook Inlet. Squares depict cranes captured in Bristol Bay.

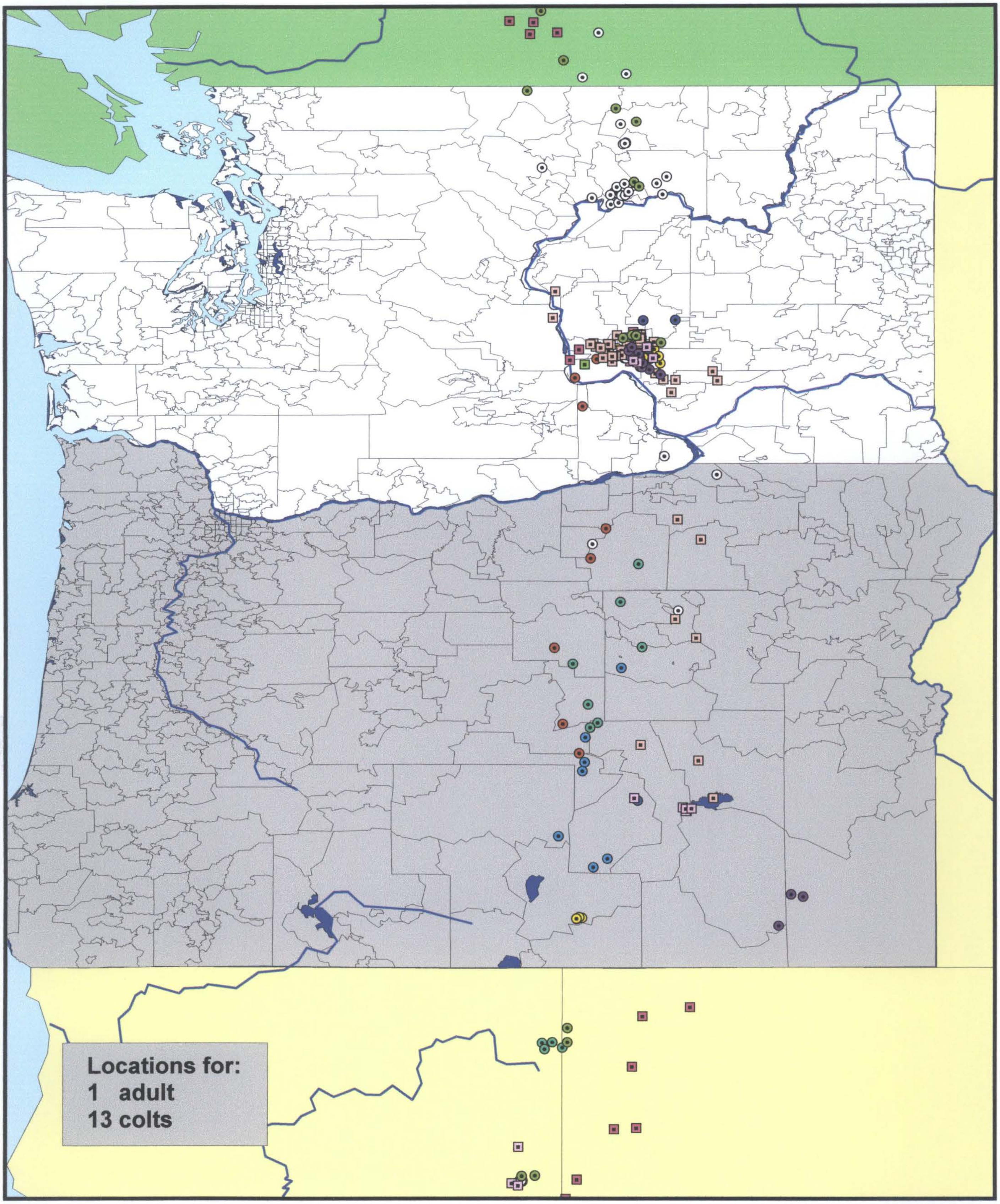

Fig. 4. Locations of Pacific Flyway Population lesser sandhill cranes during fall migration through Washington and Oregon in 2000, 2001 and 2002. Circles depict cranes captured in upper Cook Inlet. Squares depicts cranes captured in Bristol Bay, AK.

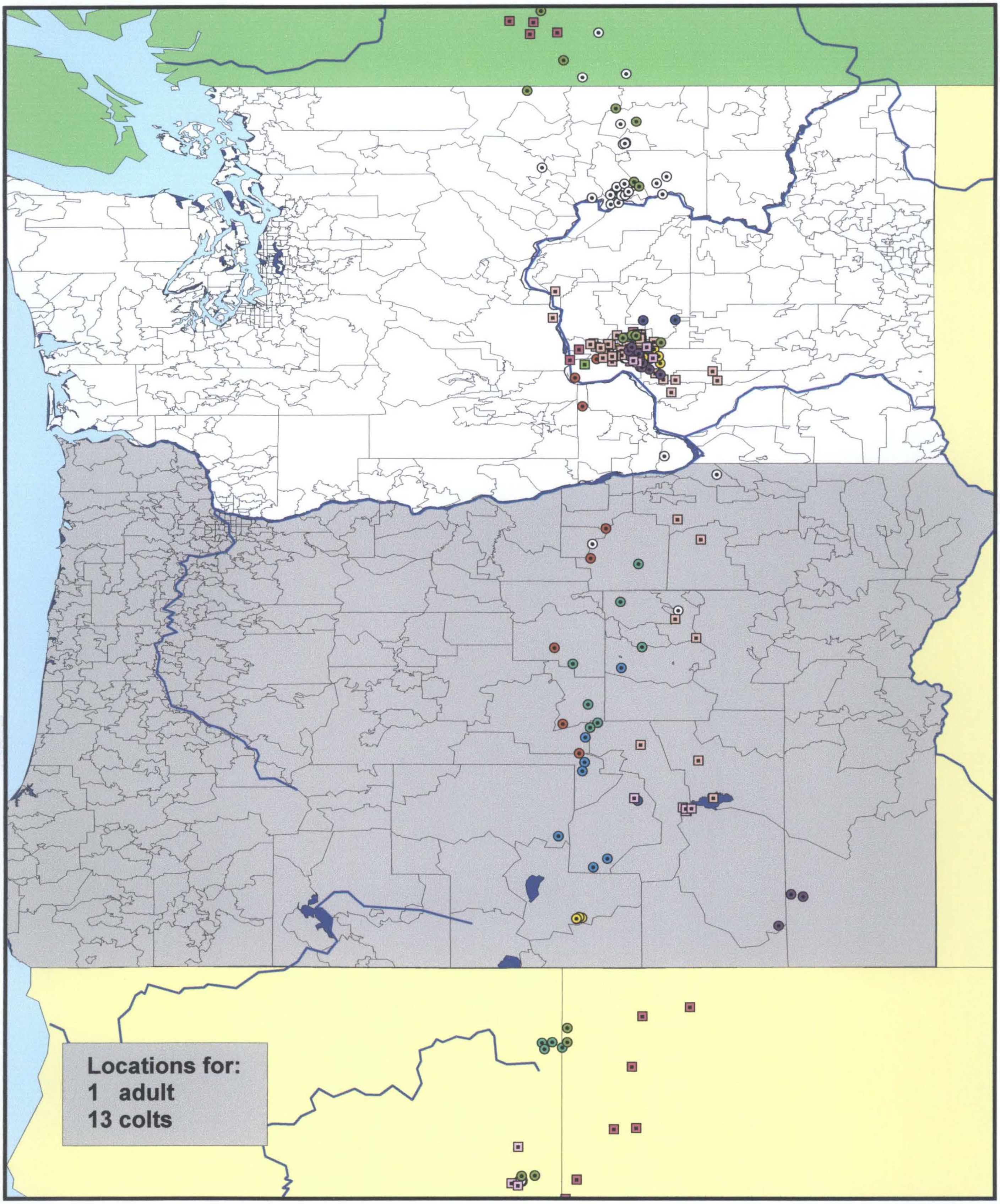

Fig. 4. Locations of Pacific Flyway Population lesser sandhill cranes during fall migration through Washington and Oregon in 2000, 2001 and 2002. Circles depict cranes captured in upper Cook Inlet. Squares depicts cranes captured in Bristol Bay, AK.

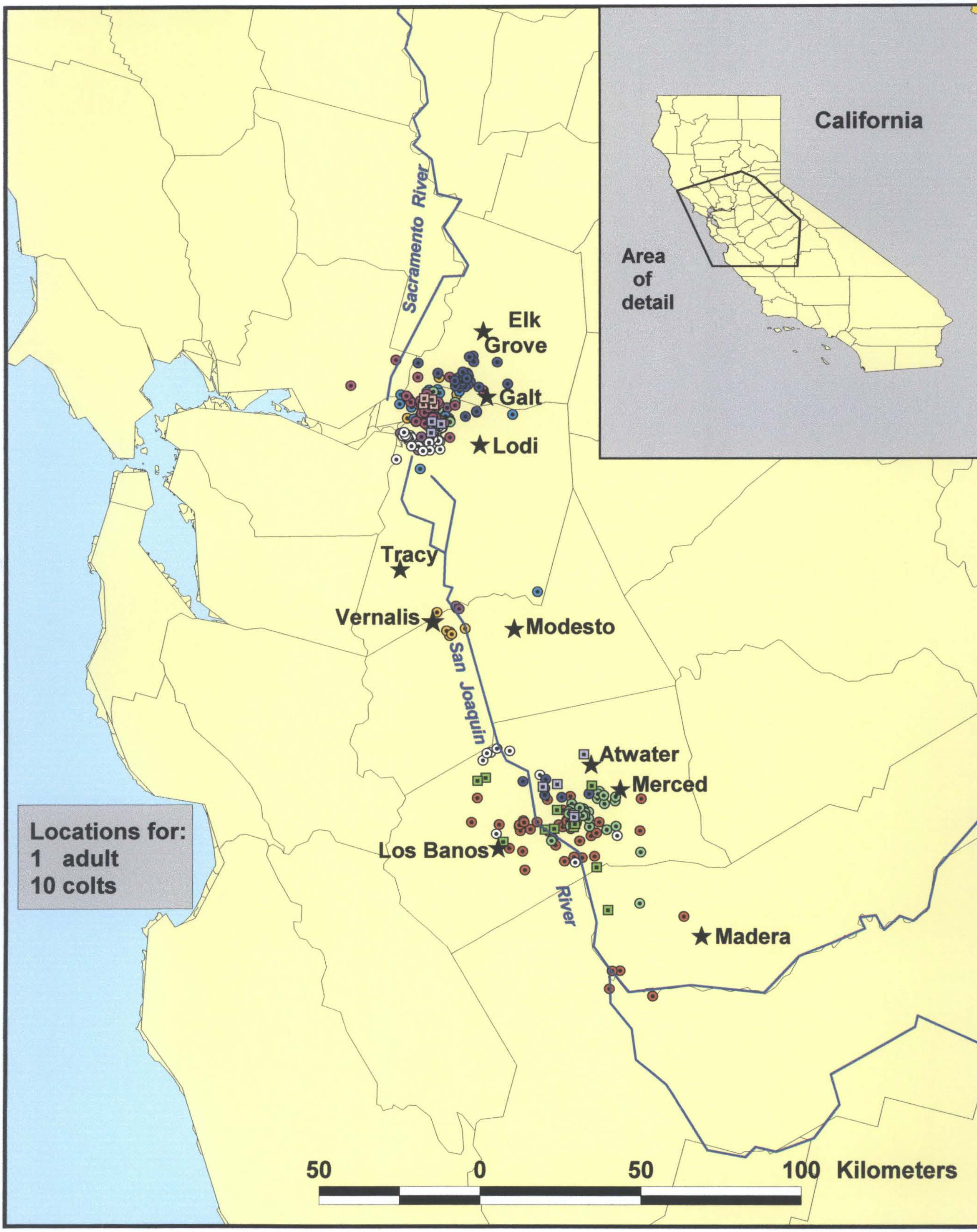

Fig. 5. Locations of Pacific Flyway Population lesser sandhill cranes in the Central Valley of California during the winter (2000, 2001, and 2002) acquired with satellite telemetry. Circles depict cranes captured in upper Cook Inlet. Squares depict cranes captured in Bristol Bay. Only best location per duty cycle mapped.

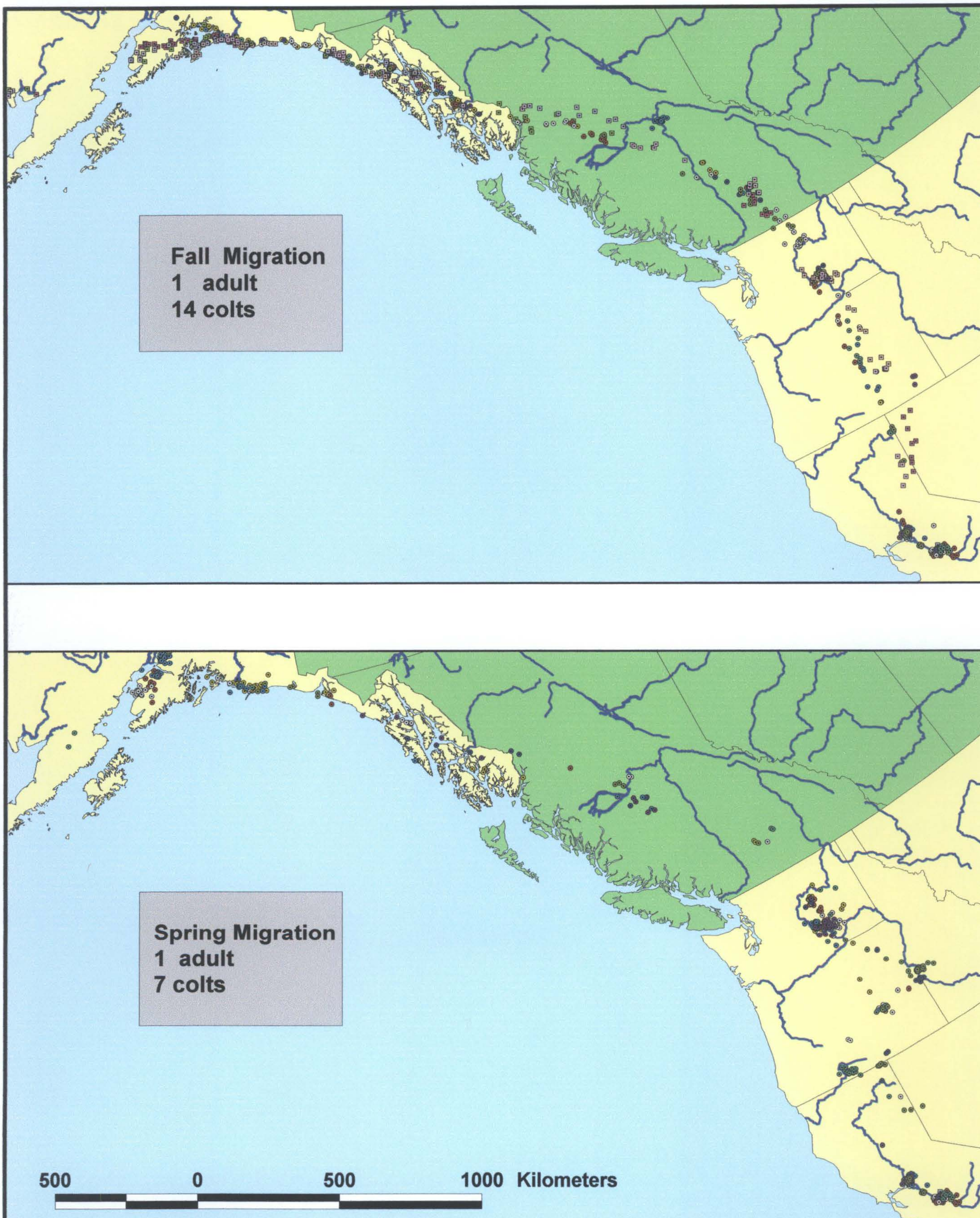

Fig. 6. Fall and spring migration route used by Pacific Flyway lesser sandhill cranes captured in Alaska. Locations acquired with satellite telemetry.

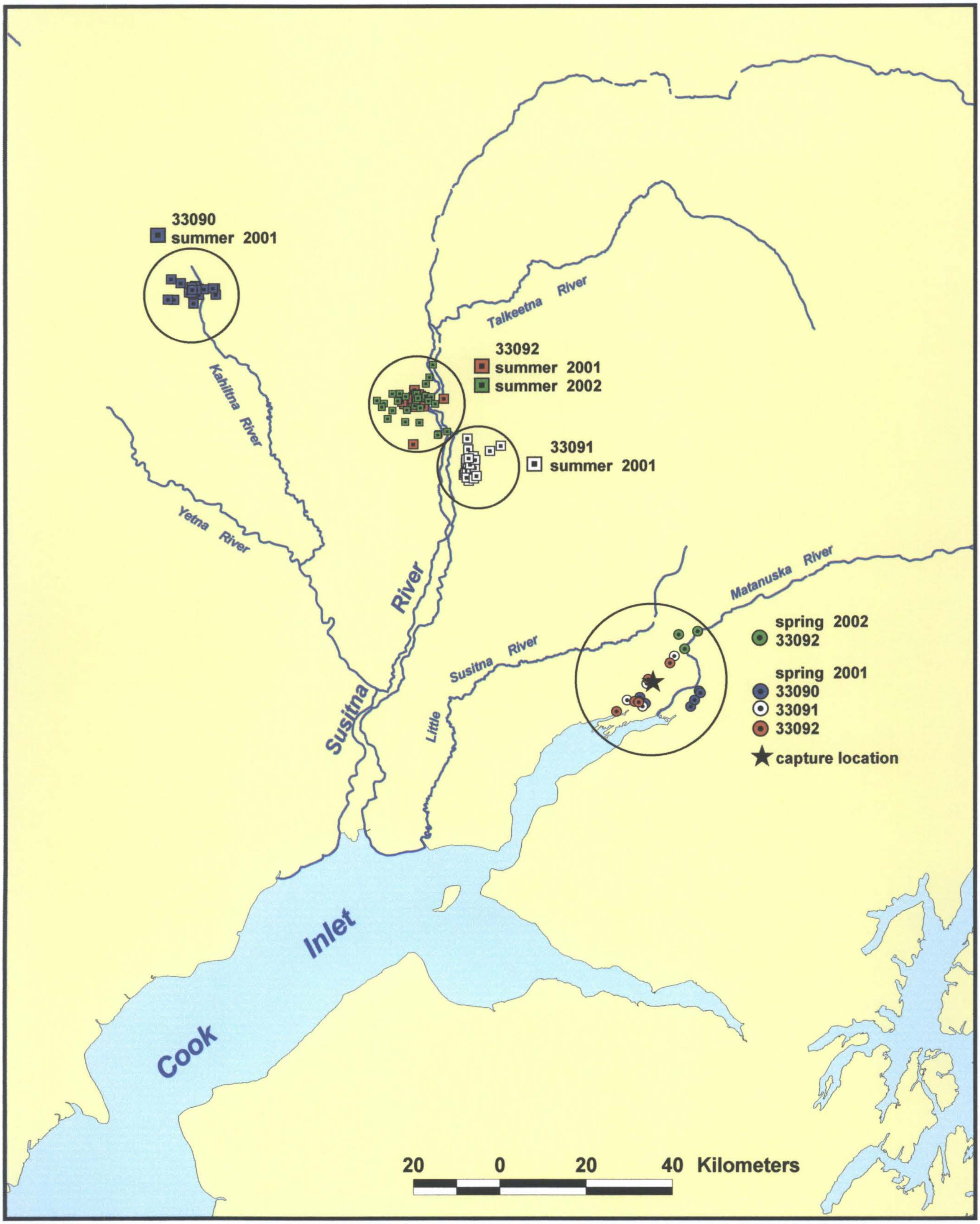

Fig. 7. Spring and summer locations of adult Pacific Flyway Population lesser sandhill cranes captured in Alaska in April 2001.

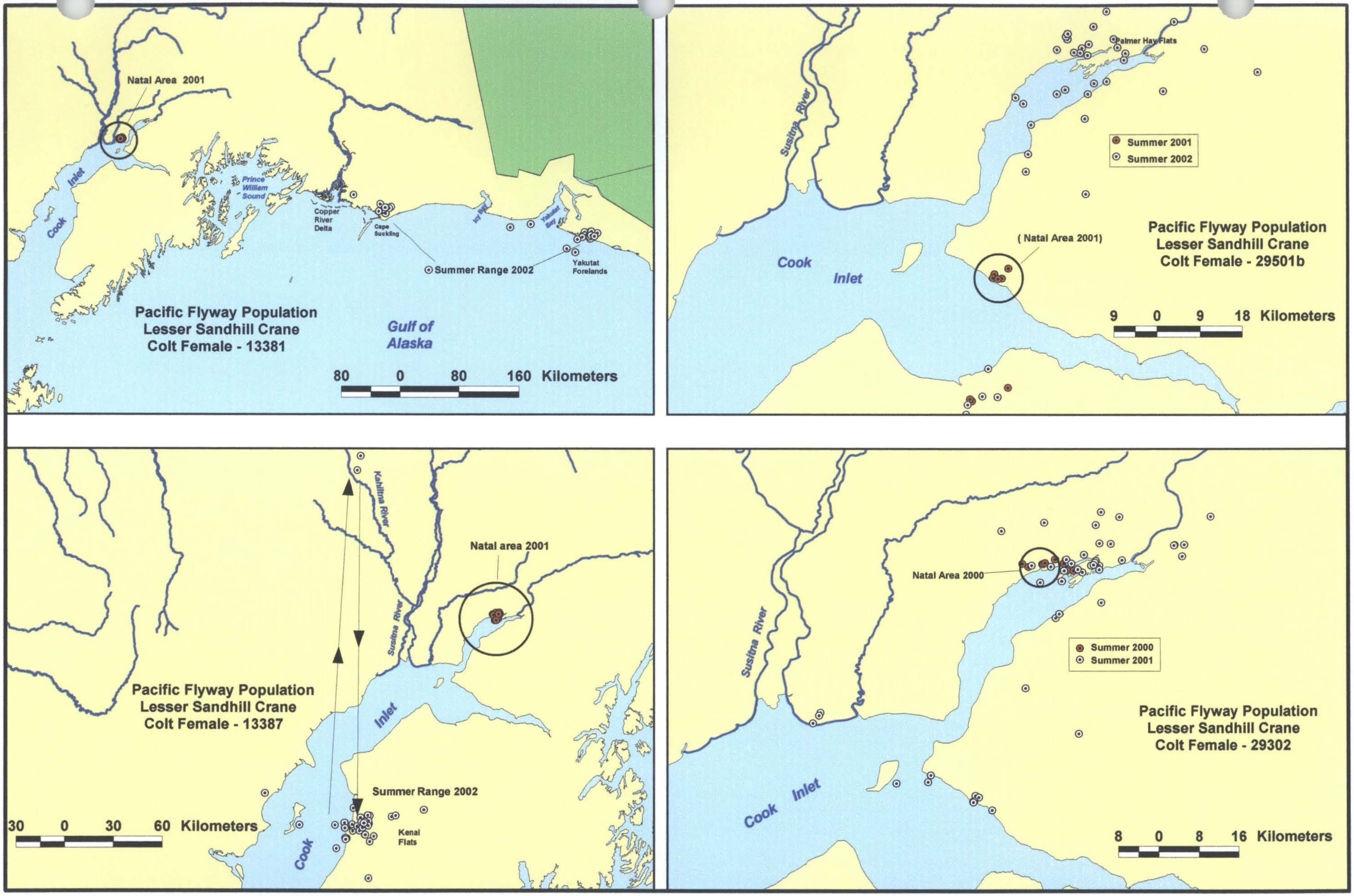

Fig. 8. Natal areas and summer range used by female Pacific Flyway Population lesser sandhill cranes captured as flightless young in Alaska. Only best location per duty cycle mapped.

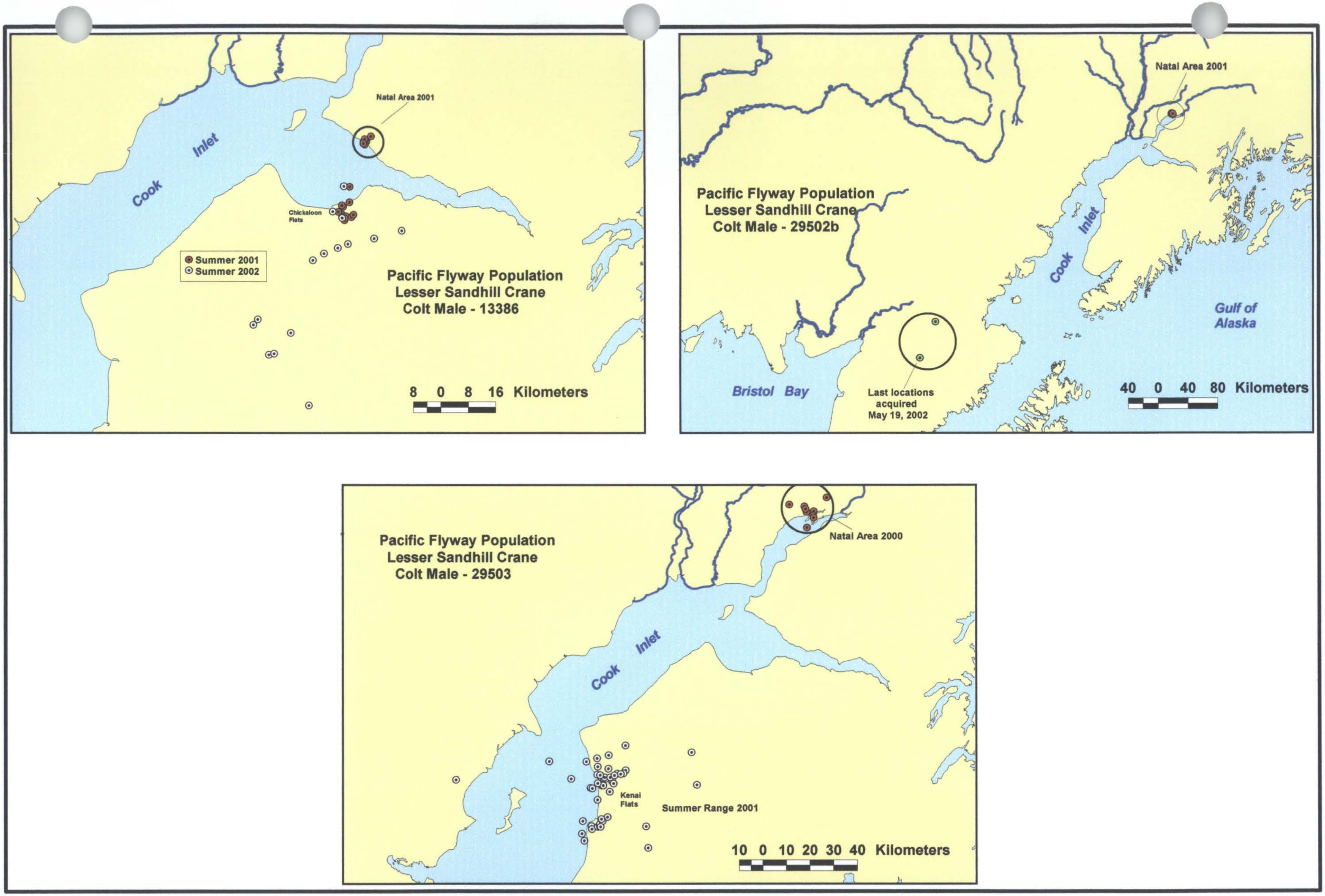

Fig. 9. Natal areas and summer range used by male Pacific Flyway Population lesser sandhill cranes captured as flightless young in Alaska. Only best location per duty cycle mapped.

Table 1. Duty cycles used for programming satellite transmitters deployed on Pacific Flyway Population lesser sandhill cranes captured in Alaska (2000-2002).

	Duty Cycle (hours on and off)														
	1			2			3			4			5		
Date deployed	on	off	#cycles	on	off	#cycles	on	off	#cycles	on	off	#cycles	on	off	#cycles
July 17-18, 2000	6	120	9	8	48	39[a]	6	96	21	8	48	to end[b]			
April 27, 2001	6	48	20	6	120	14	8	48	26[a]	6	96	26	8	48	to end[b]
July 27-28, 2001	6	72	10	8	34	27[a]	8	96	24	8	48	to end[b]			
August 02, 2002	8	26	42[a]	6	106	32	8	34	28[b]	6	120	25	6	34	to end

[a] Indicates duty cycle during fall migration.
[b] Indicates duty cycle during spring migration.

Table 2. Date and location deployed, date off air, number of days active, and number and quality of locations received for satellite transmitters deployed on Pacific Flyway Population lesser sandhill cranes captured in Alaska in 2000, 2001 and 2002. Data for active transmitters are from date of deployment until November 11, 2002.

							Number of locations per class code[c]							
ID	Date deployed	Capture location	Age	Sex	Days active[a]	Fate[b]	3	2	1	0	A	B	Z	total
29302	7/18/00	Palmer Hay Flats	Colt	F	417	off air	15	27	71	163	57	77	8	418
29303	7/18/00	Palmer Hay Flats	Colt	M	77	unknown	3	6	13	28	29	24	1	104
29304	7/17/00	Anchorage Coastal Refuge	Colt	F	46	shot	2	0	2	16	4	10	13	47
29501	7/18/00	Palmer Hay Flats	Colt	M	55	depredated	4	5	23	30	36	38	1	137
29502	7/17/00	Anchorage Coastal Refuge	Colt	F	51	depredated	0	1	5	2	12	15	1	36
29503	7/18/00	Palmer Hay Flats	Colt	M	425	off air	8	36	79	318	142	170	40	793
33090	4/27/01	Matanuska Valley	Adult	M	96	unknown	2	8	30	67	32	35	3	177
33091	4/27/01	Matanuska Valley	Adult	U	131	unknown	2	11	49	62	42	50	2	218
33092	4/27/01	Matanuska Valley	Adult	M	487	off air	18	59	151	300	175	189	24	916
13381	7/28/01	Point McKenzie	Colt	F	373	off air	9	47	161	338	139	175	21	890
13385	7/28/01	Susitna Flats	Colt	M	38	depredated	1	5	20	43	22	23	2	116
13386	7/27/01	Anchorage Coastal Refuge	Colt	M	380	off air	13	28	88	167	98	131	21	546
13387	7/28/01	Palmer Hay Flats	Colt	F	401	off air	14	48	125	283	144	174	23	811
29501b	7/27/01	Anchorage Coastal Refuge	Colt	F	420	off air	11	34	107	265	151	183	19	770
29502b	7/27/01	Palmer Hay Flats	Colt	M	295	off air	8	24	82	154	60	82	7	417
13380	8/02/02	Nushagak Peninsula	Colt	U	61	unknown	6	16	53	108	69	82	2	336
13382	8/02/02	Nushagak Peninsula	Colt	U	102	active	1	5	12	119	45	59	47	288
13385b	8/02/02	Nushagak Peninsula	Colt	U	102	active	9	28	79	135	86	78	10	425
29304b	8/02/02	Nushagak Peninsula	Colt	U	87	unknown	2	12	58	146	74	90	2	384
35667	8/02/02	Nushagak Peninsula	Colt	U	52	unknown	6	18	42	103	48	68	8	293
35668	8/02/02	Nushagak Peninsula	Colt	U	18	unknown	0	0	0	2	2	5	1	10
35669	8/02/02	Nushagak Peninsula	Colt	U	53	unknown	7	18	35	42	65	62	3	232

[a] Number of days from deployment to date when fate determined.

[b] Sandhill cranes with unknown fates either carried a defective transmitter, shed the transmitter, or died.

[c] See methods for description of class codes.

Table 3. Migration chronology for the Pacific Flyway Population of lesser sandhill cranes obtained with satellite telemetry in 2000, 2001 and 2002. X indicates where the transmitter either failed, the bird died, or shed the transmitter.

				Fall migration								Spring migration							
					Approximate days in					Arrive	Total		Approximate days in					Arrive	Total
Year/ID	Alaska area of capture	Age	Sex	Begin	AK	B.C.	WA.	OR.	CA.	winter range	trip length	Begin	CA.	OR.	WA.	B. C.	AK.	summer range	trip length
2000																			
29302	Cook Inlet	Colt	F	9/6	16	2	11	2	2	10/8	33 days	3/7	3	39[a]	3	4	3	4/28	52 days
29303	Cook Inlet	Colt	M	9/7	14	2	1	X											
29503	Cook Inlet	Colt	M	9/7	14	1	9	2	1	10/3	27 days	3/4	5	1	46	4	3	5/1	59 days
2001																			
33092	Cook Inlet	Adult	M	9/7	17	6	3	2	2	10/6	30 days	3/4	10	37[a]	2	5	4	4/30	58 days
13381	Cook Inlet	Colt	F	9/7	19	6	13	4	2	10/20	44 days	3/6	1	5	43	3	5	5/1	57 days
13386	Cook Inlet	Colt	M	9/8	15	8	4	2	1	10/7	30 days	3/20	1	4	32	3	5	5/3	45 days
13387	Cook Inlet	Colt	F	9/5	5	5	12	2	2	9/30	26 days	3/4	4	19	26	5	5	5/1	59 days
29501b	Cook Inlet	Colt	F	9/12	15	18	1	2	1	10/18	37 days	3/5	1	13	41	3	6	5/7	64 days
29502b	Cook Inlet	Colt	M	9/7	unk	unk	unk	unk	3	9/19	13 days	2/28	4	49	19	5	X		
2002																			
13380	Bristol Bay	Colt	U	9/11	9	2	4	1	X										
13382	Bristol Bay	Colt	U	9/18	9	3	2	1	1	10/3	16 days								
13385b	Bristol Bay	Colt	U	9/19	10	2	2	1	4	10/7	19 days								
29304b	Bristol Bay	Colt	U	9/19	6	1	13	3	1	10/12	24 days								
35667	Bristol Bay	Colt	U	9/8	6	4	1	1	X										
35669	Bristol Bay	Colt	U	9/16	9	X													
Average				9/11	12	5	6	2	2	10/7	27 days	3/6	4	21	27	4	4	5/2	56 days

[a] Oregon-Idaho border.

Table 4. Principal stopping areas used by Pacific Flyway Population lesser sandhill cranes during fall migration identified with satellite telemetry in 2000, 2001 and 2002.

Location (total cranes)	Proportion of cranes detected	Number of cranes per origin of capture[a] BB	UCI	Approximate number of days spent (average)
Alaska (1 adult, 14 colts)				
Kenai Peninsula	20%	3	0	1.0
Prince William Sound	13%	1	1	1.0
Copper River Delta	27%	2	2	2.3
Bering Glacier lowlands	40%	1	5	1.5
Cape Yakataga	13%	1	1	1.0
Yakutat Forelands	80%	5	7	3.8
Icy Bay	20%	0	3	1.0
Lituya Bay	13%	1	1	1.0
Gustavus	27%	0	4	7.0
Stikine River Delta	40%	2	4	2.2
British Columbia (1 adult, 14 colts)				
near Smithers	27%	1	3	1.5
François Lake	13%	1	1	1.5
near Prince George	7%	0	1	14.0
near Williams Lake	13%	0	2	2.0
near Kamloops	27%	2	2	2.3
Washington (1 adult, 13 colts)				
near Monse	14%	0	2	5.0
Potholes Reservoir region	71%	4	6	5.5
Oregon (1 adult, 13 colts)				
Harney Valley	14%	1	1	2.0
Rabbit Valley	7%	0	1	1.0
Coyote Lake	7%	0	1	2.0
Warner Valley	14%	0	2	1.5
Twelve Mile Table	7%	0	1	1.0

[a] BB=Bristol Bay; UCI=upper Cook Inlet

Table 5. Approximate home ranges (sq. km) of individual Pacific Flyway lesser sandhill cranes while on winter range in the Central Valley of California.

	Wintering Area					
	Delta		Vernalis		Merced	
ID	Area	no. of locations	Area	no. of locations	Area	no. of locations
13381	124	36	na	2	--	--
13386	--	--	--	--	2,332	48
13387	119	40	--	--	758	10
29302	239	30	--	--	67	6
29501	329	40	na	1	--	--
29502	46	8	--	--	539	43
29503	371	44	--	--	--	--
33092	106	29	45	8	--	--
Core Area	425	213	156	11	1473	101

Table 6. Approximate number of days spent at spring staging areas in the Pacific Northwest by Pacific Flyway Population lesser sandhill cranes in 2000, 2001 and 2002 estimated with satellite telemetry.

	Crane identification number								
Staging area	29302	29503	13381	13386	13387	29501	29302	33092	Total days
Warner Valley, OR	3	-	-	-	-	-	-	-	3
Harney Valley, OR	-	-	3	-	10	12	1	1	27
Yonna Valley, OR	-	-	-	-	-	-	42	-	42
near Wilder, ID	35	-	-	-	-	-	-	34	69
Potholes Reservoir region, WA	-	42	34	10	13	40	15	-	154
Banks Lake, WA	1	1	8	20	7	-	-	-	37

Appendix A. USFWS metal leg band number, yellow leg band alpha-numeric code, satellite transmitter (PTT ID), capture location, capture date, age and sex of Pacific Flyway Population lesser sandhill cranes captured in Alaska in 2000, 2001, and 2002

USFWS leg band	Color code	PTT ID	Capture location	Capture date	Age	Sex
608-59825	CJ25	29302	Palmer Hay Flats, AK	7/18/00	Colt	F
608-59823	CJ23	29303	Palmer Hay Flats, AK	7/18/00	Colt	M
608-59822	CJ22	29304	Anchorage Coastal Refuge, AK	7/17/00	Colt	F
608-59826	CJ26	29501	Palmer Hay Flats, AK	7/18/00	Colt	M
608-59821	CJ21	29502	Anchorage Coastal Refuge, AK	7/17/00	Colt	F
608-59824	CJ24	29503	Palmer Hay Flats, AK	7/18/00	Colt	M
608-59828	CJ28	33090	Matanuska Valley, AK	4/27/01	Adult	M
608-59830	CJ29	33091	Matanuska Valley, AK	4/27/01	Adult	U
608-59829	CJ30	33092	Matanuska Valley, AK	4/27/01	Adult	M
958-87603	A03	13381	Point McKenzie, AK	7/28/01	Colt	F
958-87604	A04	13385	Susitna Flats, AK	7/28/01	Colt	M
958-87602	A02	13386	Anchorage Coastal Refuge, AK	7/27/01	Colt	M
958-87605	A05	13387	Palmer Hay Flats, AK	7/28/01	Colt	F
958-87601	A01	29501b	Anchorage Coastal Refuge, AK	7/27/01	Colt	F
958-87606	A06	29502b	Palmer Hay Flats, AK	7/27/01	Colt	M
958-87610	A10	13380	Nushagak Peninsula, AK	8/02/02	Colt	U
958-87612	A12	13382	Nushagak Peninsula, AK	8/02/02	Colt	U
958-87615	A15	13385b	Nushagak Peninsula, AK	8/02/02	Colt	U
958-87613	A13	29304b	Nushagak Peninsula, AK	8/02/02	Colt	U
958-87607	A07	35667	Nushagak Peninsula, AK	8/02/02	Colt	U
958-87608	A08	35668	Nushagak Peninsula, AK	8/02/02	Colt	U
958-87609	A09	35669	Nushagak Peninsula, AK	8/02/02	Colt	U