CAPTURE AND TRANSLOCATION OF GOLDEN EAGLES FROM THE CALIFORNIA CHANNEL ISLANDS TO MITIGATE DEPREDATION OF ENDEMIC ISLAND FOXES

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Abstract—We trapped and translocated golden eagles (*Aquila chrysaetos*) from the Channel Islands off the southern California coast between 1999 and 2003 in an ongoing effort to mitigate a catastrophic decline in three subspecies of island fox (*Urocyon littoralis*). As of August 2003, we had removed 31 (70%) of 44 known eagles from Santa Cruz and Santa Rosa Islands. Translocated eagles were released in areas of suitable habitat in northern California from 275–880 km from the islands. Eaglets removed from nests were either fostered into mainland golden eagle nests or hacked into the wild. Eleven of the released eagles (seven adults, three subadults, one juvenile) were tracked with combination satellite and conventional VHF transmitters to determine if they would return to the islands. The satellite transmitters operated for an average of 13.6 months (range 0–28). We obtained 1,568 satellite locations of class 3, 2, or 1 (est. accuracy of <150 – <1,000 m). Locations were plotted and analyzed with the geographic information system ArcGIS 8.0. Released birds ranged over areas of 1,366–256,413 km^2. The most proximal location obtained was 304 km NNE of Santa Cruz Island. Sensor data suggested that five eagles (45%) shed their transmitters or died within 1–7 months. Six birds were still alive and wearing their transmitters when transmissions ceased (5–28 months post-release). None of the radioed eagles returned to the islands during tracking and no banded golden eagles have subsequently been observed on the islands. Since the onset of eagle removal efforts, annual island fox survivorship on Santa Cruz Island has risen to near pre-decline levels. We conclude that translocation of golden eagles is an effective non-lethal method of reducing the island golden eagle population and their potential impact on island fox recovery.

Keywords: Aquila chrysaetos, Channel Islands, Golden eagle, island fox, translocation, Urocyon littoralis

INTRODUCTION

Golden eagles (*Aquila chrysaetos*) have been implicated in the recent catastrophic decline of three subspecies of island fox (*Urocyon littoralis*) endemic to three of the northern California Channel Islands (Roemer 1999, Coonan et al. 2000, Roemer et al. 2001). Golden eagles are not native to the Channel Islands (Kiff 1980), having apparently colonized there in recent decades, and little is known about their natural history on the islands. Island fox populations on Santa Cruz, Santa Rosa and San Miguel islands declined by as much as 95% between 1994 and 1999 (Roemer et al. 2001, Coonan 2003). On the recommendation of the Island Fox Conservation Working Group (IFCWG), formed in 1999 to address the impending extinctions, the Channel Islands National Park (NPS) initiated emergency actions for island fox recovery. The IFCWG recommended the total removal of golden eagles from the northern Channel Islands (Coonan 2003). In summer 1999, the Santa Cruz Predatory Bird Research Group (SCPBRG) entered into a cooperative agreement with the NPS to begin golden eagle capture and translocation efforts on Santa Cruz Island. The Nature Conservancy (TNC), U.S. Fish and Wildlife Service (USFWS), and SCPBRG have provided additional funding for this project.

The capture and translocation of golden eagles to mitigate the depredation of livestock has been

attempted in the western U.S. with limited success (Niemeyer 1977). In a study involving the translocation of resident adult golden eagles, Phillips et al. (1991) found that 12 of 14 eagles that were relocated more than 400 km away returned to their territories within one year. Similar homing abilities were reported for black eagles (*Aquila verreauxii*), crowned eagles (*Stephanoaetus coronatus*), and martial eagles (*Polemaetus bellicosus*) that were moved less than 200 km (Boshoff and Vernon 1988).

Here we describe our efforts to estimate the number and breeding status of golden eagles on the northern Channel Islands, capture and translocate the eagles to the mainland, and monitor their post-release movements via satellite telemetry.

METHODS

We collected recent golden eagle sightings and behavioral observations from NPS, TNC, and University of California, Santa Barbara (UCSB) personnel to obtain a preliminary number of eagles and their distribution on the islands. Since most sightings were from Santa Cruz Island, we concentrated surveys and trapping activities there. We began surveys for golden eagles in August 1999 using binoculars and 20x – 60x spotting scopes. We surveyed large areas by positioning several observers across the island at panoramic overlooks, maintaining contact with handheld radios. We also conducted road surveys and foot surveys through remote areas. We searched for eagle nests on foot and by helicopter. The size and boundaries of eagle territories were estimated by observations of undulation flights, pairs soaring together, and other territorial/courtship behavior (Harmata 1982, Watson 1997).

We identified individual golden eagles based on plumage characteristics, age class, or breeding area location (pair members). We estimated age class with the assumption that young eagles progressed through standard molt patterns (Juvenile 0–1 years of age, Subadult 1 [Basic I] by 1.5, Subadult 2 [Basic II] by 2.5, Near-Adult [Basic III] by 3.5, and Adult [Definitive] by 4.5 years; Bloom and Clark 2001), and we assumed that the eagles did not emigrate from the island.

We developed four initial strategies for capturing golden eagles on the islands. The first was to use a rapidly deployable Phai trap (Beebe and Webster 1964) modified for eagles. The trap could be carried while conducting road surveys and set out opportunistically for perched eagles. The second was to use a camouflaged radio-controlled bownet (Jackman et al. 1994) at bait stations (Grubb 1988) established on open hillsides or ridge tops easily seen by passing eagles. Stations were baited with carcasses of feral pigs (*Sus scrofa*) obtained locally. Bownet triggers used 4-channel FM radio control systems with a range of over 2 km as well as the 2-channel AM systems described by Jackman et al. (1994). The third strategy was to identify areas of frequent eagle use, (e.g., habitual perches, roosts, hunting grounds) and place a bownet or a 5- x 10-m dho-gaza net (Beebe and Webster 1964, Bloom 1987) with bait visible from those locations. We set these traps under the cover of darkness and observed from well-camouflaged blinds. The fourth strategy involved an attempt to capture both members of a breeding pair after the young could thermoregulate (ca. 3 weeks of age). We tried to capture the male out of view of the female using the bownet. We would then attempt to capture the female either near the nest using the dho-gaza and a live lure eagle (a technique developed by Victor Garcia Matarranz for capturing Spanish imperial eagles [*Aquila adalberti*], see Hunt et al. 1997), or in the nest with a manually triggered, pop-up net designed by Juan Vargas (San Diego Wild Animal Park) to capture raptors and parrots in cliff cavities (see Latta 2003). We removed eaglets from the nest and transported them in small commercial pet carriers or a padded, ventilated, duffel bag.

SCPBRG also participated as advisors, observers, and potential eagle handlers during two, 2-week capture attempts conducted by NPS in June and October 2002 using a helicopter and net gun (O'Gara and Getz 1986). This project involved up to 20 observers placed at strategic locations across Santa Cruz Island (and Santa Rosa Island during the second attempt) in constant contact by radio. Upon sighting an eagle the helicopter would be dispatched to attempt a capture. The helicopter crew consisted of a pilot, a net gun operator, and an eagle handler. The helicopter would closely pursue an eagle, attempting to fatigue the bird and force it

to land in the open. The pilot would then maneuver the aircraft allowing the net gun operator to shoot a net over the grounded eagle. If successful, the pilot would then land the helicopter and the handler would exit the aircraft and secure the eagle.

Once captured, the eagles were hooded to reduce stress, banded, measured, and weighed. In addition, blood and feather samples were taken for DNA and stable-isotope analysis. We determined sex by lateral tarsus measurements (Hunt et al. 1992a, Hunt et al. 1995, Driscoll pers comm.) and age class by molt and plumage characteristics (Bloom and Clark 2001). We assigned each eagle a numerical value of 1 through 5 corresponding to its physical condition (e.g., 1 = emaciated, 5 = robust; Hunt et al. 1992a, Hunt et al. 1995). Twelve eagles were fitted with satellite transmitters (Platform Terminal Transmitters or PTTs; Microwave Telemetry, Columbia, MD, and Northstar Science and Technology, Inc., Columbia, MD) with VHF transmitters (Holohil Systems Ltd., Carp, Ontario, Canada) epoxied on the side. The combined transmitters weighed 60–70 g and were expected to transmit for two years. We attached the transmitters in backpack fashion, using 0.5-inch (12.7-mm) Teflon ribbon secured with cotton thread and designed to fall off after the transmitters expired (Garcelon 1985, Hunt et al. 1992b, Hunt et al. 1995). The eagles were then placed in individual large commercial pet carriers and kept in a cool quiet room until transport. The pet carriers were fitted with Astroturf floors to provide traction for the eagles and for hygiene. Cardboard was affixed to the inside of the door and strips of terrycloth taped over the inside of the windows to keep the interior dark, reduce stress, and to prevent feather damage. In most cases we drove the eagles to the nearest airstrip and flew them off the island within 24 hours. Occasionally they were transported off the island by the next available NPS or commercial tour boat. Once on the mainland, we drove eagles to the release site. Most (61%) were released within 48 hours of capture.

We relocated eagles into optimum golden eagle habitat as far away from the Channel Islands as was practicable and allowed under federal and state permits. Most were released east of the Sierra Nevada range and north of Lake Tahoe, at the western edge of the Great Basin. As a precaution against breeders returning to the islands, adults were released farther away than subadults and juveniles. Eaglets removed from island nests were either fostered into mainland nests or hacked into the wild (Sherrod et al. 1982).

Most of the PTTs were programmed to transmit daily for the first week, and then the duty cycle switched to transmit one day per week for the remainder of the life of the transmitter. PTT data were received through the ARGOS system and then transposed into spreadsheet format using a custom Perl-based program. We used ArcGIS 8.0 to plot and analyze the PTT location data. Only location class 3, 2, and 1 data, with an estimated accuracy of <150 m, 150 m – <350 m, and 350 m – <1000 m respectively, were included in our analysis. Temperature and activity sensor data combined with apparent movements, derived from location data, were used to assess the eagles' status. In cases where either the transmitter fell off prematurely or the eagle died (indistinguishable), we attempted to locate the transmitter/eagle using the VHF signals via aircraft, automobile, and/or on foot to determine its fate. We used an Argos R.M.D. receiver (SERPE-IESM, France) and an AR8000 wide-band receiver (AOR, Ltd. Tokyo, Japan) to attempt to locate PTTs on foot when the VHF transmitters were non-functional (see Bates et al. 2003).

We carefully and completely dismantled each golden eagle nest to recover all of the prey remains and eggshell fragments. We placed all of the surface prey remains in bags marked "Layer A" and set all the loose surface sticks aside, uncovering a layer of nest cup material. Using trowels and fingers we probed the edges of the nest cup material and were able to discern discreet layers that had been compressed like the flakes of a hay bale. We pried up each layer and sifted them separately through 1/16-in. (1.59-mm) screens, placing the remains in the bags labeled accordingly (e.g., Layer B, Layer C). We also removed and set aside all of the sticks that appeared to be associated with each layer. We used tweezers to recover the eggshell fragments and membranes from each sifted layer and placed them in sample jars. All of the nests were on cliffs and thin layers of sand often separated and helped delineate the strata of nest material. We used shop brushes to remove the sand and uncover the lower layers. We then reconstructed the nests as per our permits.

RESULTS

Surveys, Nesting, and Food Habits

Between August 1999 and June 2003, we logged 1,133 observer days on Santa Cruz (SCR), Santa Rosa (SRO), and San Miguel (SMI) islands (SCR: n = 1068 d, SRO: n = 55 d, SMI: n = 10 d). The numbers of individual golden eagles observed on Santa Cruz and Santa Rosa islands during five periods of study are presented in Table 1. We identified 44 individual eagles including 10 territorial pairs. At least 4 pairs bred successfully, producing six known young. Due to observations of new birds, there was an average of 11 known eagles remaining on the islands at the end of each period. These "new" eagles may have recently fledged from unknown island nests, been previously un-identified residents, or immigrants from the mainland.

The first golden eagle nest was discovered by helicopter in September 1999 at Coche Point on Santa Cruz Island. Measurements of the nest and analysis of eggshell fragments and prey remains suggested that golden eagles had bred successfully. Prey remains included common raven (*Corvus corax*), gull (*Larus s*pp.), cormorant (*Phalacrocorax spp*.), feral piglet, and adult island fox. As of August 2003, we had located 10 golden eagle nests in 6 territories. Prey remains from these nests include various reptiles, western meadowlark (*Sturnella neglecta*), California quail (*Callipepla californica*), common barn owl (*Tyto alba*), mallard (*Anas platyrhynchos*), deer mouse (*Peromyscus maniculatus*), spotted skunk (*Spilogale gracilis*), and mule deer fawns (*Odocoileus hemionus,* Santa Rosa Island only).

Trapping

We captured 26 free-flying golden eagles on Santa Cruz (n = 25) and Santa Rosa (n = 1) islands and removed 5 eaglets from nests (SCR: n = 4, SRO: n = 1;Table 2). All captures were made with a radio-controlled bownet. Capture success with the bownet was 100% when an eagle landed on the bait. Attempts to capture eagles with the Phai trap and dho-gazza net techniques were unsuccessful.

The first helicopter net gun operation (June 2002) proved unsuccessful primarily due to extended periods of dense fog and a lack of power in the aircraft used (Bell 206B-3). Two eagles were aggressively pursued during this operation. One was grounded five times during a 20-minute pursuit but never landed in the open or for a period of time long enough to allow the helicopter to maneuver for a shot. The second aerial capture effort (October 2002) was conducted during better weather and utilized a more powerful aircraft (Bell 206L-4). Eagles were pursued on 6 occasions, but consistent winds, thermals, and updrafts were advantageous to the eagles and made it difficult to tire them out even during chases that lasted over an hour. Eagles forced to land by the helicopter did so only briefly on very steep and rugged terrain, or for longer periods but under heavy vegetative cover. Both conditions were unsuitable for getting a clear shot with the net gun.

Translocation and Monitoring

Captured eagles were transported to the mainland (Fig. 1). Adult eagles (n = 13) were released an average of 789 km (range 550–880 km) from the islands, in areas east of the Sierra Nevada or Cascade ranges. Juveniles and subadults (n =

Table 1. Number of golden eagles known to be on Santa Cruz and Santa Rosa Islands per time period and number of eagles remaining after each period.

Period	New eagles identified per period	Total known eagles per period	Eagles captured per period	Eagles remaining at end of period
Aug. 1999 – Apr. 2000[1]	23	23	13	10
Sept. 2000 – Sept. 2001[2]	4	14	6	8
Jan. – May 2002	5	13	3	10
June and Oct. 2002[3]	4	14	0	14
Feb. – Aug. 2003	8	22	9	13
Totals	44	-	31	13

[1] Personnel on islands during five of the nine months.
[2] Personnel on islands during seven of the 13 months.
[3] NPS helicopter net gun capture attempt.

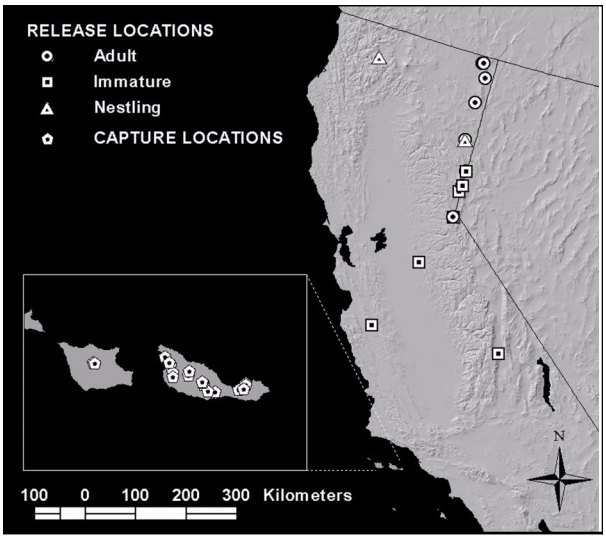

Figure 1. Golden eagle capture and release locations.

10) were released an average of 494 km (range 300–650 km) from the islands, all but one east of California's Central Valley. Twelve eagles (eight adults, three subadults, one juvenile) were fitted with PTT/VHF transmitters (Table 2). The transmitters operated for an average of 13.6 months (range 0–28 months). This includes one PTT that failed to transmit after the eagle was released even though it was functioning normally when attached.

We obtained 3,690 satellite locations of which 1,568 were class 3, 2, or 1 (Fig. 2). Released birds moved over areas ranging from 1,366–256,413 km^2. The most proximal location obtained was from an adult female (AF02) that moved to within 304 km NNE of Santa Cruz Island before re-crossing the mountains to the north and eventually residing in the Pine Flat Reservoir area of the Sierra Nevada foothills. Tracking data showed that nine of the 11 (81%) eagles with functioning PTTs moved greater distances in directions away from the islands than they did toward the islands.

Three of the eagles captured in early 2000 died prior to release. Necropsy results were inconclusive, however, all three tested positive for brodificoum, an anti-coagulant rodenticide that is the active ingredient in d-Con brand rodent control products. Secondary exposure to brodificoum has been fatal to golden eagles (Stone et al. 1999) and other raptors (Mendenhal and Pank 1980), and may decrease their ability to cope with stress (M. Miller [CA Dept. of Fish and Game] pers. comm.). Eagles captured in early 2000 were also in poor condition due to drought and low piglet production (see below), which likely exacerbated the effects of brodificoum poisoning. After these deaths we increased efforts to release eagles as quickly as possible after capture and had no subsequent fatalities.

DISCUSSION

Survey Results

Golden eagle sighting reports collected prior to the beginning of fieldwork in 1999 suggested that up to 6 golden eagles resided on Santa Cruz Island, with perhaps two or three individuals residing on or commuting to Santa Rosa and San Miguel islands. Based on the 23 individual eagles observed on Santa Cruz Island during the first field season (see Table 1) and the two nesting pairs subsequently found on Santa Rosa Island, we estimate that 27 golden eagles may have been present on the three northern Channel Islands at the start of our fieldwork in 1999.

The 1999 Coche Point nesting represents the first confirmed breeding record for golden eagles on the California Channel Islands. However, there is strong evidence to suggest that successful breeding has occurred on both Santa Cruz and Santa Rosa islands since 1997 or possibly much

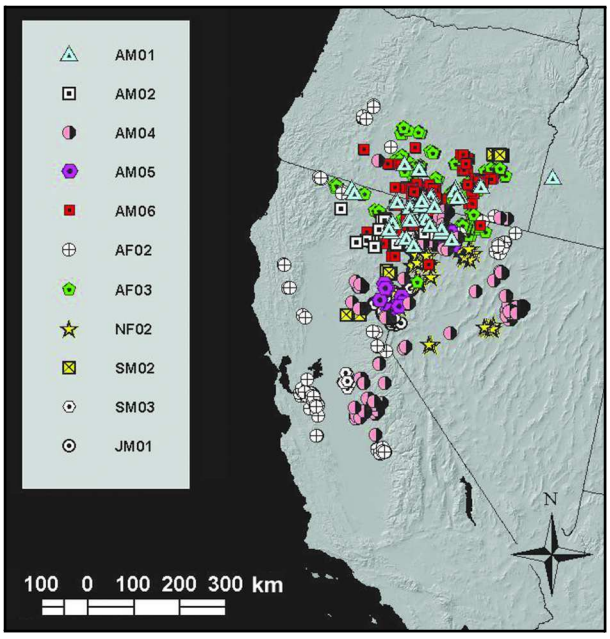

Figure 2. PTT locations from translocated golden eagles.

Table 2. Golden eagles translocated from Santa Cruz (SCR) and Santa Rosa Islands (SRO).

Eagle code[1]	Capture location	Capture date	Release location[2]	Release date	Distance from islands (km)	Transmitter applied
SCR-01-AM01	Main Ranch area	11/17/1999	Warner Range	11/27/1999	850	Yes
SCR-02-JM01	China Harbor	11/20/1999	Truckee River	11/24/1999	575	Yes
SCR-03-SM01	Willow Cyn/West End	02/09/2000	N/A	N/A	N/A	No
SCR-04-AM02	Willow Cyn/West End	02/12/2000	Fall River Vly.	02/19/2000	750	Yes
SCR-05-NF01	Willow Cyn/West End	02/12/2000	N/A	N/A	N/A	No
SCR-06-AM03	Christy Pasture	02/21/2000	N/A	N/A	N/A	No
SCR-07-AF01	Amphitheater Cyn	03/21/2000	Goose Lake	03/22/2000	880	Yes
SCR-08-SM02	Coches-Prietos Ridge	03/25/2000	Lake Tahoe	03/27/2000	550	Yes
SCR-09-AM04	Portezuela Pass	03/26/2000	Lake Tahoe	03/27/2000	550	Yes
SCR-10-AF02	Centinela Pass	03/30/2000	Goose Lake	04/01/2000	880	Yes
SCR-11-AM05	Centinela Pass	04/01/2000	Hallelujah Jct.	04/02/2000	650	Yes
SCR-12-NF02	Sauces N. Ridge	04/13/2000	Hallelujah Jct.	04/14/2000	650	Yes
SCR-13-SM03	Sauces N. Ridge	04/14/2000	Tulloch Res.	04/15/2000	420	Yes
SCR-14-SF01	Black Pt. Canyon	03/10/2001	Lone Pine	03/11/2001	320	No
SCR-15-EE01	Coche Pt. Nest	05/24/2001	Honey Lk Nest	05/27/2001	700	No
SCR-16-AF03	Sauces/Pozo Ridge	07/19/2001	Goose Lake	07/20/2001	880	Yes
SCR-17-AM06	Griffith Canyon	09/13/2001	Goose Lake	09/14/2001	880	Yes
SCR-18-AM07	Griffith Canyon	09/16/2001	Goose Lake	09/18/2001	880	No
SCR-19-AM08	Griffith Canyon	09/18/2001	Goose Lake	09/20/2001	880	No
SCR-20-AM09	China Pines Ridge	05/15/2002	Honey Lake	05/21/2002	700	No
SCR-21-EE02	Coche Pt. Alt Nest	05/19/2002	Honey Lk Nest	05/21/2002	700	No
SCR-22-EE03	Coche Pt. Alt Nest	05/19/2002	Honey Lk Nest	05/21/2002	700	No
SCR-23-AM10	China Pines Ridge	02/15/2003	Truckee River	02/18/2003	600	No
SCR-24-SF03	China Pines Ridge	02/17/2003	Truckee River	02/18/2003	600	No
SCR-25-SM04	China Pines Ridge	02/23/2003	Pinnacles	02/24/2003	300	No
SCR-26-NM01	China Pines Ridge	03/05/2003	Truckee River	03/08/2003	600	No
SCR-27-SM05	China Pines Ridge	03/06/2003	Truckee River	03/08/2003	600	No
SCR-28-JF01	China Pines Ridge	03/12/2003	Lone Pine	03/13/2003	320	No
SRO-29-AM11	Trap Canyon	5/30/2003	Goose Lake	06/02/2003	880	No
SCR-30-EM04	Cascada	6/15/2003	Etna Hacksite	07/13/2003	880	VHF only
SRO-31-EM05	Trap Canyon	6/17/2003	Etna Hacksite	07/13/2003	880	VHF only

[1] Eagle Code – xxx-yy-xxyy: xxx = Island captured (SCR = Santa Cruz, SRO = Santa Rosa); yy = total number eagles removed; xxyy = age, sex, and number of that cohort (A = adult, N = near adult, S = sub adult, J = juvenile, E = eyas or nestling, M = male, F = female) EE01-EE03 were too young to sex.
[2] N/A – Individual died prior to release.

earlier. C. Collins (California State University, Long Beach) reported an observation of one member of an adult pair passing a snake to a food-begging juvenile over Laguna Canyon, Santa Cruz Island, in November 1997 (Roemer et al. 2001). On Santa Rosa Island we carefully dismantled three nests of the Trap Canyon pair and found a total of seven distinct layers of occupation. The largest nest had four layers, each separated by a thin layer of sand. Each layer had distinct caches of eggshell fragments and differed from the layer above in terms of an increasing amount of

weathering and decomposition of the organic material. Assuming that this pair nested annually prior to and including 2003, they would have built their first nest layer as early as 1997. The presence of numerous prey remains, including island foxes, in the lower levels of these nests suggests successful breeding prior to 2000 when the remaining Santa Rosa foxes were brought into captivity.

Anecdotal evidence for earlier nesting attempts exists in a compilation of reliable reports of golden eagle sightings from the northern Channel Islands dating back to 1969 (P. Collins [Santa Barbara Natural History Museum] unpubl. data; L. Laughrin [UCSB] unpubl. data). These reports include observations of an adult pair on Santa Cruz Island in June 1987, July 1987, May 1992, and April 1995. A pair of adults and a possible juvenile were reported on Santa Rosa Island in July and August 1993. There have been sporadic sightings of single juveniles or subadults on San Miguel Island, but no observations of adults or nesting activity.

Capturing Island Eagles

Capture success was seasonal in nature (Fig. 3). We found that factors such as abundance of live prey, age and condition of eagles, weather, the reintroduction of bald eagles, and the translocation effort itself influenced the outcome of our trapping efforts. We experienced two peaks in capture success: eleven eagles between February and April 2000 and six eagles during February and March 2003.

Our capture success in 2000 may be attributable to three factors: high eagle density, low abundance of live prey, and unwary eagles during the early period of our trapping effort. The island fox population on Santa Cruz Island had been severely reduced prior to the beginning of our project, and the last 9,000 feral sheep had been removed from the island. Therefore, the eagles likely depended on piglets as their primary source of food. Due to drought conditions in 1999, the pig population experienced a die-off. We observed sows in emaciated condition and relatively few piglets. The apparent lack of available food was reflected in the relatively poor physical condition of the eagles captured from November 1999 to April 2000. Physical condition values assigned to eagles captured during this period (n = 13) averaged 3.0 (range 2.0–4.0) out of a possible 5. The average physical condition of eagles captured between March 2001 and August 2003 (n = 13) was 3.3 (range 2.5–4.5). By the end of April 2000 we had removed 13 eagles, almost half of the estimated population at that time, but had to curtail our trapping efforts due to a lack of funding. In the spring of 2000, precipitation returned to normal and it appeared that the pig population had recovered (healthy sows with piglets) when we returned to the island in September 2000.

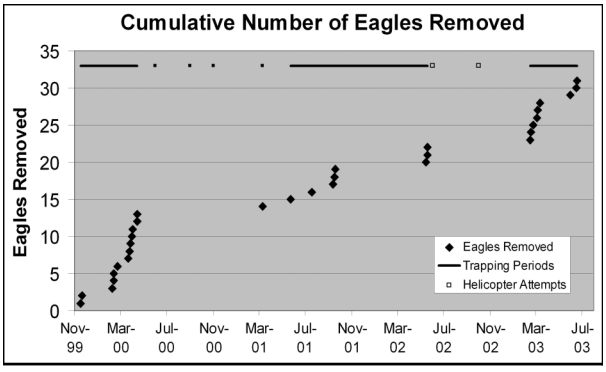

Figure 3. Cumulative number of eagles removed.

After April 2000, the remaining eagles on Santa Cruz Island should have experienced less competition for increasing resources (piglets), probably making carrion bait less desirable. In addition, some eagles had witnessed the capture of other eagles and become more wary. Since eagles were no longer attracted to bait stations, we focused on capturing territorial adults; this increased the time and effort expended per capture, as it was necessary to learn the habits of each eagle (see Methods). During July to September 2001 and January to May 2002, we captured five adult eagles (four males, one female) using live piglets as bait.

The second peak of trapping success, in February and March 2003, may be attributed to three factors: (1) there was no trapping effort from June 2002 through January 2003 (excluding the NPS helicopter effort in June and October 2002), thus the eagles may have been less wary; (2) there were a number of new eagles on the island since May 2002 that were not wise to our methods; and, (3) the presence of feeding stations (using pig carcasses) maintained by the Institute for Wildlife Studies (IWS) for the 12 bald eagles (*Haliaeetus leucocephalus*) released on Santa Cruz Island in

June 2002. All six of the golden eagles captured in February and March 2003 were captured at one bald eagle feeding station.

On three occasions we attempted to capture both members of a breeding pair when there were young in the nest. We captured two of the adult males as expected, but did not capture the females. Fourteen adults have been removed from Santa Cruz Island thus far (11 males and three females), including three complete pairs. Of the eight cases when only the male of a pair was captured, a replacement male appeared within 1–3 days (n = 3), or by the following breeding season (n = 3). As of December 2003, it was unknown if the remaining two males had been replaced.

Post-Release Monitoring

Our original strategy for the translocation was to transport the eagles out of state and release them east of the Front Range of Colorado, a distance 1,500 km. This would place the Rocky Mountains, the Great Basin, the Mojave Desert, and the Santa Barbara Channel as physical deterrents between the eagles and the islands. However, we were unable to obtain permission from any state agency for the export of California golden eagles. As a result, all were released within the state borders.

None of the eagles appeared to attempt to return to the islands during transmitter life (up to 18 months) and only one eagle even reached the coast. This eagle was observed on the coast north of Monterey Bay. She was one of two adult eagles that made significant southward movements into the Central Valley and Sierra foothills. These movements were made during the fall and winter and the eagles subsequently returned northward. Rather than turning homeward, most eagles moved out into the Great Basin area of California, Oregon, and Nevada and nearby ranges. Based on the wide-ranging movements we recorded, none of the adults appeared to gain a breeding territory while being tracked. Some eagles had favored locations they would range out from and return to, but on a scale larger than would be expected of territorial adults.

Of the 12 PTTs deployed, five functioned normally and appeared to cease transmission when expected due to normal battery life. One PTT apparently failed early, based on abnormal sensor data and erratic transmission, and one failed immediately upon deployment for unknown reasons. The other five were either shed or attached to eagles that died. When PTT signals indicated a lack of transmitter movement, and sensors confirmed the transmitter was no longer on a live eagle, we attempted to locate and retrieve the eagle or the transmitter. We recovered only one radio-tagged eagle, east of Malheur Lake, Oregon. It had been scavenged and only feathers were left, but a local rancher reported having seen five individuals in a truck shooting at four red-tailed hawks and an eagle at approximately the time and location of this eagle's death. In another case, we approached the PTT so closely over open terrain that we believe an eagle carcass was not present. Unfortunately, we have no information on the fate of the other eagles or transmitters. Only one eagle survived less than four months after release, a 1-year old bird in poor condition when captured.

CONCLUSIONS

All of the golden eagles residing on the northern Channel Islands have not yet been captured. Each year we have seen previously unidentified eagles of various age classes take up residence on Santa Cruz Island, suggesting annual recruitment from the mainland. Pending DNA and stable-isotope analysis may allow us to examine the relationships among the trapped eagles and estimate the portion that may have hatched in nest locations we recently discovered on the islands.

At the onset of this project we were concerned that the eagles, particularly territorial adults, might quickly return to the islands as described by Phillips et al. (1991). Fortunately, the translocation program is working. Thirty-one of 44 known golden eagles have been removed from the islands and no radioed or banded eagles are known to have returned. Also, our observations of the golden eagle population reveal progress. The rapid replacement of breeding adults (within 1–3 days) captured at territories in 1999–2000, indicated the presence of floating (non-breeding) adults (see Hunt 1998). In 2002–2003, two lone sub-adult males established breeding territories and did not acquire mates for several months, suggesting a lack of surplus adults. Meanwhile, the annual island fox survivorship on Santa Cruz Island has risen to a

level nearing that observed by Roemer et al. (2001) prior to the population decline (Coonan et al. 2005), the ultimate desired effect of this effort.

There are insufficient data and modeling to determine the level of golden eagle predation that can be tolerated by island fox populations (Coonan 2003). However, the hyperpredation model developed by Roemer et al. (2001) predicts that as few as seven eagles residing on Santa Cruz Island could cause the extinction of that subspecies in as little as 6.5 years. This model assumes an initial population estimate of over 1,000 foxes. With the three northern island fox populations currently at critically low levels, it is not unreasonable to assume that predation by even a few golden eagles could have significant effects on recovery.

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REFERENCES

Bates, K., K. Steenhof and R.M. Fuller. 2003. Recommendations for finding PTTs on the ground without VHF telemetry. Proceedings of the Argos Animal Tracking Symposium. Service Argos, Inc., Largo, MD.

Beebe, F.L. and H.M. Webster. 1964. North American falconry and hunting hawks. World Press, Inc., Denver, CO.

Bloom, P.H. 1987. Capturing and handling raptors. Pages 99–123. *In*: Pendleton, B.A., B.A. Millsap, K.W. Cline and D.M. Bird. (eds.), Raptor management techniques manual. National Wildlife Federation Science and Technical Series 10, Washington, DC.

Bloom, P.H. and W.S. Clark. 2001. Molt and sequence of plumages of golden eagles and a technique for in-hand ageing. North American Bird Bander 26:97–116.

Boshoff, A.F. and C.J. Vernon. 1988. The trans-location and homing ability of problem eagles. South African Wildlife Research 18:38–40.

Coonan, T.J. 2003. Recovery strategy for island foxes on the northern Channel Islands. U.S. Department of the Interior, Channel Islands National Park, Ventura, CA.

Coonan, T.J., K.R. Rutz, D.K. Garcelon, B.C. Latta, M.M. Gray and E.T. Aschehoug. 2005. Progress in island fox recovery efforts on the

northern Channel Islands. Pages 263–274. *In*: Garcelon, D.K. and C.A. Schwemm (eds.), Proceedings of the Sixth California Islands Symposium. National Park Service Technical Publication CHIS-05-01, Institute for Wildlife Studies, Arcata, CA.

Coonan, T.J., C.A. Schwemm, G.W. Roemer and G. Austin. 2000. Population decline of island foxes on San Miguel Island. Pages 289–297. *In*: Browne, D.K., K.L. Mitchell and H.W. Chaney (eds.), Proceedings of the Fifth California Islands Symposium. U.S. Department of the Interior, Minerals Management Service, Pacific OCS Region.

Garcelon, D.K. 1985. Mounting backpack telemetry packages on bald eagles. Institute for Wildlife Studies, Arcata, CA.

Grubb, T.G. 1988. A portable rocket-net system for capturing wildlife. Research Note RM-484. U.S. Department of Agriculture, Rocky Mountain Forest and Range Experiment Station, Fort Collins, CO.

Harmata, A.R. 1982. What is the function of undulating flight display? Raptor Research 16:103–109.

Hunt, W.G., D.E. Driscoll, E.W. Bianchi and R.E. Jackman. 1992a. Ecology of bald eagles in Arizona. Report to U.S. Bureau of Reclamation by Biosystems Analysis, Inc., Santa Cruz, CA. Contract No. 6-CS-30-04470.

Hunt, W.G., R.E. Jackman, J.M. Jenkins, C.G. Thelander and R.N. Lehman. 1992b. A northward post-fledging migration of California bald eagles. Raptor Research 26(1):19–23.

Hunt, W.G., R.E. Jackman, T.L Brown, J.G Gilardi, D.E. Driscoll and L. Culp. 1995. A pilot golden eagle population study in the Altamont Pass Wind Resource Area, California. Predatory Bird Research Group, University of California, Santa Cruz, CA.

Hunt, W.G., R.E. Jackman, T.L Brown, J.G Gilardi, D.E. Driscoll and L. Culp. 1997. A population study of golden eagles in the Altamont Pass Wind Resource Area, Second-year progress report. Predatory Bird Research Group, University of California, Santa Cruz, CA.

Hunt, W.G. 1998. Raptor floaters at Moffat's equilibrium. Oikos 82:191–197.

Jackman, R.E., W.G. Hunt, D.E. Driscoll and F.J. Lapsansky. 1994. Refinements to selective trapping techniques: a radio-controlled bow net and power snare for bald and golden eagles. Raptor Research 28:268–273.

Kiff, L. 1980. Historical changes in resident populations of California Islands raptors. Pages 651–673. *In*: Power, D.M. (ed.), The California Islands: Proceedings of a Multidisciplinary Symposium. Santa Barbara Museum of Natural History, Santa Barbara, CA.

Latta, B.C. 2003. Channel Islands golden eagle research and translocation project, 2002 Progress Report (Draft). Unpublished report on file at Channel Islands National Park Headquarters, Ventura, CA.

Mendenhall, V.M. and L.F. Pank, 1980. Secondary poisoning of owls by anti-coagulant rodenticide. Wildlife Society Bulletin 8:311–315.

Niemeyer, C. 1977. Montana golden eagle removal and translocation project. Final Report. U.S. Department of the Interior Fish and Wildlife Service, Billings, MT.

O'Gara, B.W. and D.C. Getz. 1986. Capturing golden eagles using a helicopter and net gun. Wildlife Society Bulletin 14:400–402.

Phillips, R.L., J.L. Cummings and J.D. Berry. 1991. Response of breeding golden eagles to relocation. Wildlife Society Bulletin 19:430–434.

Roemer, G.W. 1999. The ecology and conservation of the island fox (*Urocyon littoralis*) [Ph.D. dissertation]. University of California, Los Angeles, CA.

Roemer, G.W., T.J. Coonan, D.K. Garcelon, J. Bascompte and L. Laughrin. 2001. Feral pigs facilitate hyperpredation by golden eagles and indirectly cause the decline of the island fox. Animal Conservation 4:307–318.

Sherrod, S.K., W.R. Heinrich, W.A. Burnham, J.H. Barclay and T.J. Cade. 1982. Hacking: A method for releasing peregrine falcons and other birds of prey. Second edition. The Peregrine Fund, Inc., Fort Collins, CO, 62 pp.

Stone, W.B., J.C. Okoniewski and J.R. Stedelin. 1999. Poisoning of wildlife with anticoagulant rodenticides in New York. Journal of Wildlife Diseases 35(2): 187–193.

Watson, J. 1997. The golden eagle. T & A D Poyser, Ltd., London, UK.