# Restoration and Management of Bald Eagles on Santa Catalina Island, California, 2000

*A Report Prepared for:*

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December 2000

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## INTRODUCTION

In 1980, the United States Fish and Wildlife Service (USFWS) and the Institute for Wildlife Studies (IWS) initiated a program to reintroduce bald eagles (*Haliaeetus leucocephalus*) to Santa Catalina Island, California (hereafter Catalina Island). Between 1980 and 1986, 33 eagles were released on the island from three different artificial nest or "hacking" platforms (Garcelon 1988). While many of these birds matured and breeding pairs were established on the island, reproduction was not successful. Concentrations of DDE in the remains of eggs removed from failed nests implicated this contaminant as the causal agent of the lack of productivity (Garcelon et al. 1989), as DDE levels had been found to be inversely correlated with eggshell thickness and productivity in bald eagles in previous studies (Wiemeyer et al. 1984). During 1991-93, IWS studied food habits of the released eagles and documented high levels of DDE in the tissues of certain prey items commonly consumed by these eagles (Garcelon 1997, Garcelon et al. 1997a,b).

Since 1989, the reintroduced population has been maintained through manipulations of eggs and chicks at each nest site and through additional hacking of birds (Table 1). Because of the high DDE concentrations in the eggs, this active program of manipulation and augmentation is the only way to maintain the Catalina Island bald eagle population at this time. In the egg manipulation process, artificial eggs are substituted for the structurally deficient eggs laid by the birds affected by DDE. The adult eagles continue to incubate the artificial eggs while the removed eggs are relocated and artificially incubated at the Avian Conservation Center (ACC) at the San Francisco Zoo. Chicks that hatch from these removed eggs, or those produced by captive adults at the ACC or by wild birds, are then placed in the nests containing artificial eggs. Adult eagles on Catalina Island have successfully reared 21 of 28 chicks fostered into nests between 1989 and 2000 (Table 1). Two of these 28 birds were removed from the nest prior to fledging because of injuries, two died accidental deaths, one bird was killed by a red-tailed hawk (*Buteo jamaicensis*) only four days after being fostered into the nest (Perkins et al. 1996), one chick was killed by the nesting female on the day the chick was fostered into the nest, and one chick disappeared from the nest under unknown circumstances (Table 1). Further, of three healthy eggs introduced to nests, two have resulted in successfully reared chicks (Table 1). Continued hacking activities have also resulted in the release of an additional 16 eagles since 1991 (13 chicks and a 1-year-old bird; Table 1).

Previous studies have documented an effect of high concentrations of organochlorine pesticides on the reproductive behavior of avian species (Peakall and Peakall 1973, Haegele and Hudson 1977, Tori and Peterle 1983). Behavioral abnormalities observed in captive and wild birds have included less aggressive nest defense (Fyfe et al. 1976), increase in the length of courtship behavior (Tori and Peterle 1983), and erratic incubation behavior (Peakall and Peakall 1973). Given the extremely high concentrations of DDE found in eggs of bald eagles and other tissues collected on Catalina Island (Garcelon 1997), it is important to determine if these eagles exhibit aberrant nesting behavior so that management practices can be modified to ensure maximum success.

Table 1. Summary of Bald Eagle egg and chick manipulations on Santa Catalina Island, 1989-2000.

| | Year | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1989 | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 |
| # of Active Nests | 1 | 2 | 2 | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 4 | 3 |
| # of Eggs Laid | 2 | 2-3 | 3 | 5 | 5-6 | 3 | 5 | 5-6 | 6 | 7 | 8 | 7 |
| # of Eggs Collected | 1 | 1 | 3 | 5 | 4 | 3 | 5 | 4 | 5 | 6 | 6 | 4 |
| # of Catalina Island Eggs Hatched[a] | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 1 | 1 | 1[g] | 2[g] |
| # of Eggs Fostered Into Nests on Catalina Island | 0 | 0 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| # of Chicks Fostered Into Nests on Catalina Island | 1 | 0 | 2 | 3 | 2[b] | 2[c] | 1 | 5[d] | 1 | 4[e] | 3[f] | 4 |
| # of Chicks Fledged From Nests on Catalina Island | 1 | 0 | 2 | 3 | 1 | 1 | 1 | 2 | 1 | 3 | 2 | 4 |
| # of Eagles Hacked Onto Catalina Island | 0 | 0 | 2 | 0 | 2 | 0 | 2 | 4 | 0 | 4 | 2 | 0 |
| # of Island-Produced Eagles Breeding on Island | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 2 | 1 |
| # of Second Generation Eagles Fledged | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |

[a] Hatched by the Santa Cruz Predatory Research Group (1991) or San Francisco Zoo (1992-Present)

[b] One chick died of asphyxiation on plastic bag.

[c] One chick died during severe storm.

[d] One injured chick was euthanized, one injured chick was treated and placed on hack tower, and one chick was killed by a red-tailed hawk.

[e] One chick killed by nesting female upon return to the nest following fostering.

[f] One chick disappeared from nest under unknown circumstances.

[g] Hacked by Ventana Wilderness Sanctuary in central California.

The purpose of this project is to maintain the breeding bald eagles on Catalina Island in the interim between completion of the injury assessment studies and the full-scale environmental restoration program that will be possible after final settlement of the case. This report

summarizes the results of the egg and chick manipulations and subsequent monitoring for the nesting season of 2000. While the USFWS, through the Montrose Trustee Council, did not fund any activities associated with fostering captive-reared eagle chicks on Catalina Island, we present data on the outcome of these efforts to provide a better understanding of the status of the population. Our restoration and management objectives were to: (1) document the chronology of nesting for all breeding pairs on the island, (2) collect eggs from wild nests on Catalina Island for artificial incubation, (3) foster viable eggs or healthy chicks into active nests, (4) collect tissues (blood, prey items, non-hatching eggs and embryos) for analyses of contaminants, (5) quantify incubation behavior, (6) quantify the behavior of adults and chicks between the time of hatching and fledging, (7) identify food items and quantify the rate at which prey deliveries were made to the nest, (8) release additional eagles on the island by using artificial nest platforms, and (9) monitor movement and behavior of all chicks fledged from wild and artificial nests on the island.

## STUDY AREA

Catalina Island is located 34 km south of Long Beach, California. The island is 34 km long, 0.8 to 13.0 km wide, and covers 194 $km^2$ (Fig. 1). Elevations range from sea level to 648 m. There is considerable topographic relief, with numerous steep-sided canyons incising the island. Mean annual temperatures range from 12 to 20$^o$ C near the coast, and yearly precipitation averages 31 cm (NOAA 1985).

Vegetation on Catalina Island has been described by Thorne (1967). Predominant habitat types include: oak woodland, dominated by scrub oak (*Quercus dumosa*) and Catalina cherry (*Prunus lyonii*); grassland, dominated by oats (*Avena* spp.); and coastal sage, dominated by sage (*Salvia apiana* and *S. mellifera*), low shrubs (*Rhus integrifolia* and *R. ovata*) and prickly-pear cactus (*Opuntia* spp.).

### Nesting Territories

Four territories of nesting bald eagles have occurred on the island since 1984, as well as one territory where no nesting was observed. Because the data collected during this study were associated with these territories, a description of their locations and attributes of the occupying adults are provided.

The West End territory is located 0.5 km from the northwest end of the island (Fig. 1), and was established in 1991. The territory was initially occupied by 2 adult (1 M, 1 F) eagles, but a second female has assisted in breeding activities since 1992 (Garcelon et al. 1995, Phillips and Garcelon 1996, Sharpe and Garcelon 1999, 2000). The nest is located on a rock pinnacle approximately 75 m above the water, and has been used since 1991. From 1991-93, the foraging area of the trio covered a linear distance of approximately 4.5 km. On the north side of the island the foraging area extended from the western tip of the island approximately 2 km to the east, and on the south side of the island extended 2.5 km to the southeast.

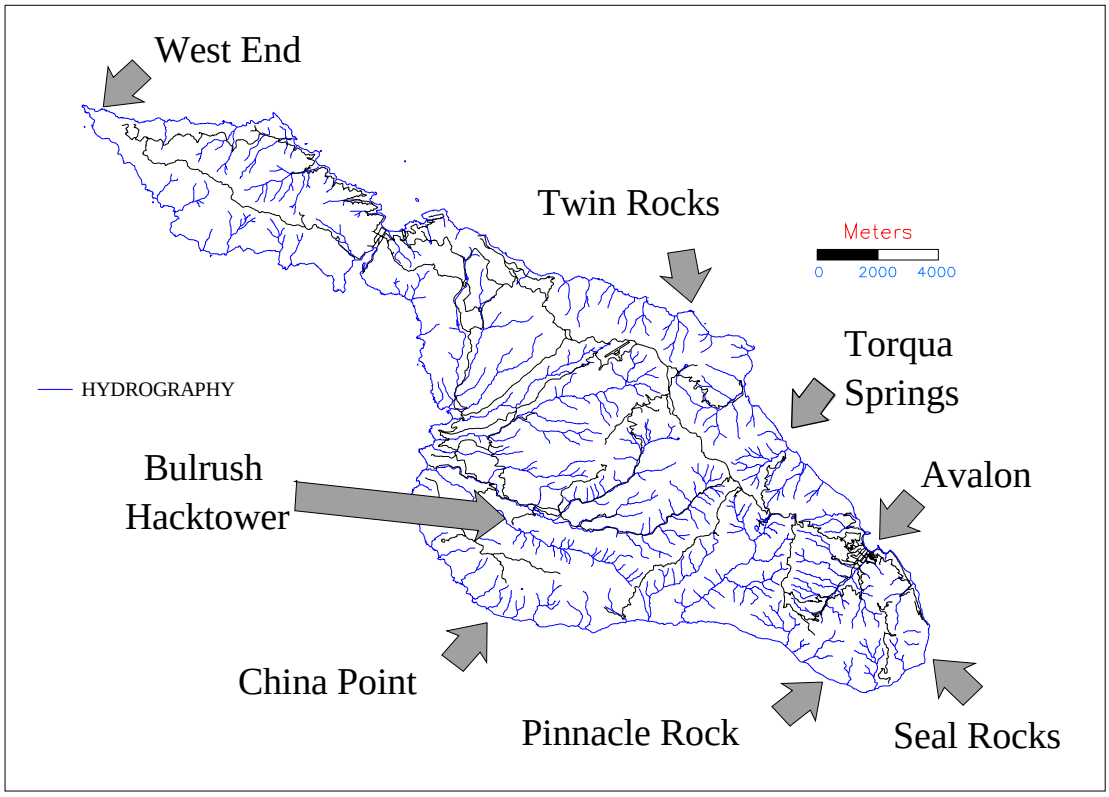


**Figure 1. Map of Santa Catalina Island, CA showing the locations of bald eagle territories and points of reference. The base map of the island was provided by the Santa Catalina Island Conservancy.**

The Pinnacle Rock territory is located 4.3 km southwest of the city of Avalon, extending from Silver Canyon to approximately 1 km east of the East End Light (Fig. 1). It was initially occupied in 1990 by a 5-year old female and a 4-year old male, and this territory has contained active nests each year since 1990. From 1991-93, the foraging area of the pair covered a linear distance of 3.5 km extending northwest from Binnacle Rock. The pair has remained intact and has used six different nests within this territory from 1990-1999 (Phillips and Garcelon 1996, Sharpe and Garcelon 1999, 2000).

The Twin Rocks territory is located 5 km northwest of the city of Avalon, extending from Torqua Springs to Little Gibraltar. This territory was initially occupied in 1984 and contained active nests in 1985, 1987 and 1989. The female remained in the territory until January 1995 when she was joined by a 4-year old male. The pair exhibited incubation behavior in 1996, but no eggs were found upon entry into the nest (Phillips and Garcelon 1996). Two eggs were removed from the nest in 1997, one of which successfully hatched, but the adults did not return to the nest following the egg switch (Sharpe and Garcelon 1998). In 1998, the original female was replaced by K-17, a bird released in 1986. A chick was fostered into the nest in 1998, but was killed by the female upon her arrival at the nest approximately 8 hours later (Sharpe and Garcelon 1999). The pair accepted a single chick

fostered into the nest in 1999, but the chick disappeared from the nest after approximately two weeks (Sharpe and Garcelon 2000).

The Seal Rocks territory is located 4.5 km SE of the city of Avalon (Fig. 1). The pair first nested in 1988, in a toyon (*Heteromoles arbutifolia*) in a canyon northwest of the East End light house. A second nest was built in 1990 in another toyon on a steep slope approximately 125 m above the ocean. From 1991-93, the foraging area of this pair covered a linear distance of approximately 3.0 km, extending from a point 0.3 km northeast of Seal Rocks to Church Rock located at the northwest end of the territory. This pair nested in 1988, 1990, and 1992. In 1993 eggs were broken in the nest prior to the attempted removal. The adult female from this territory died on 5 May 1993 from DDE contaminant poisoning (Garcelon and Thomas 1997). In 1995, another adult female laid two infertile eggs in the nest used in 1993. No male eagle was observed in the vicinity of her nest; therefore, the eggs were removed to prevent excessive stress associated with incubation by only one adult. The female abandoned the nest, and did not lay eggs again in 1995. No adults were seen in the territory in 1996 (Phillips and Garcelon 1996). In 1997, the pair that had previously been located in the China Point territory (see below) moved into the Seal Rocks territory (Sharpe and Garcelon 1998) and will be referred to as the Seal Rocks pair in this report. The pair has extended its territory slightly to include areas around Avalon. There was no evidence of nesting in 1998. Prior to the 1999 breeding season the female was replaced by K-34, a zoo-raised bird that was hacked from the Bulrush tower in 1993. In 1999 the pair built a nest in a eucalyptus tree (*Eucalyptus* sp.) and laid one egg. Unfortunately, the nest blew out of the tree the following evening and there was no further nesting activity (Sharpe and Garcelon 2000).

The China Point territory was first identified in December 1995 when a pair of eagles was initially observed near China Point (Fig.1). The male had hatched from a West End egg in 1992 and was fostered into the Pinnacle Rock nest. The female had been removed from a nest in northern California and fostered into the West End nest in 1991. Although no nesting behavior was observed in 1996, observations of the pair extended east from Ben Weston beach to the mouth of Silver Canyon, comprising approximately 12 km of shoreline (Phillips and Garcelon 1996). In 1997, this pair was observed near China Point in February, but moved the center of their territory to Seal Rocks in March 1997 (Fig. 1). There was no indication of nesting in 1997 (Sharpe and Garcelon 1998).

## METHODS

### Manipulations

Observations of adult eagles on Catalina Island to determine the location of breeding pairs and their respective nest sites began in January this year. We documented the chronology of activity during the breeding season and located nest sites by observing areas of increased use by adult eagles and searching previously used nesting areas. When nest site locations were confirmed, we set up observation blinds to observe nests. From the blinds we monitored and quantified: 1) chronology of nesting, 2) behavior during incubation, 3) nestling and adult behavior during brood rearing, 4) taxon of prey delivered to the nest and 5) rates of prey deliveries. At the West End nest we had a video

camera present (set up prior to breeding season) that allowed close observations of nesting activity.

We replaced eggs laid by nesting pairs with artificial eggs within 2-3 days of the date that eagles were confirmed incubating. We replaced the eggs with healthy chicks after the adults had incubated the artificial eggs >30 days and returned to the nests when chicks were 8 weeks of age to equip them with federal and colored leg bands, wing markers, and a backpack-style radio-transmitter. At this time we also collected a blood sample (~10 cc) for contaminant analyses and made morphological measurements to determine sex (Bortolotti 1984, Garcelon et al. 1985).

## Incubation Behavior

We sampled incubation behavior at the Pinnacle Rock, Twin Rocks, and West End nests by monitoring them for approximately 6 hours/day for 2-3 days/week. The sex of adult birds was determined by the presence of patagial wing markers, leg bands, and size of adults. We recorded the exact times that adults laid on and stood from the eggs, probed the nest, or rolled the eggs. Additionally, descriptive notes were recorded to summarize general behavior and interaction of adults during the incubation period.

We used Spearman's Rank Correlation procedure (SYSTAT v. 5.0) to test for correlation of the site-specific length of complete incubation bouts over time. We defined complete incubation bouts as those in which we observed the incubating bird both start and end its attendance at the nest (i.e. switch with its mate). We used the Mann-Whitney U-test (SYSTAT v. 5.0) to evaluate sex-specific differences in duration of complete incubation bouts.

## Chick-Rearing and Nestling Behavior

We monitored behavior of chicks and adults at the Twin Rocks, Pinnacle Rock, and West End nests using interval sampling (Tacha et al. 1985) following the fostering of chicks. Postures and behaviors (See Appendix I) of chicks and any adults on the nest were recorded at 1-minute intervals, and sampling generally was conducted 2-3 days/week, up to 8 hours/day. Fog occasionally prevented or delayed sampling of behavior. We distinguished the roles of adult male and female eagles during the chick rearing period by comparing the proportion of time that each sex spent on the nest. We calculated the proportion of time that chicks spent in postures and behaviors for each day that birds were monitored. We evaluated the relationship of the age of the chicks to the proportion of time spent in each posture and behavior to document the onset of particular behaviors as chick development progressed. Changes in the frequency of occurrence of key postures and behaviors were plotted over time to demonstrate trends in behavior during the nestling period.

## Prey Deliveries

Concurrent with interval sampling of behavior, we recorded date, time, and taxonomic information for all prey items delivered to the nests. We calculated mean rates of prey delivery for each nest as the number of items delivered divided by the amount of time the nests were observed.

## Post-Fledging Behavior

We used radio-telemetry to locate and visually observe behavior of fledged eagles. We located and observed the fledged birds every 1-3 days during their first month of flight and recorded location, behavior, and interaction with other eagles.

## Release of Additional Eagles

No additional bald eagles were released on the island this year through "hacking," a procedure by which fledgling birds are reared on artificial nest towers and then released (see Garcelon 1988).

## Collection of Tissue Samples

We collected 5-10 cc of blood for contaminant and DNA analyses during banding activities of juvenile bald eagles on Catalina Island. The ACC also collected samples of egg shells and embryos from the Catalina Island eggs transported to San Francisco for incubation. Egg contents were placed in chemically clean jars and frozen.

# RESULTS

## Manipulations and Nest Monitoring

Nests were located from February-March 2000 in three previously occupied territories: Twin Rocks, Pinnacle Rock, and West End (Fig.1).

### Twin Rocks

The territory was used by the same pair that used it in 1998 and 1999 (Sharpe and Garcelon 1999, 2000). The male (K-33) was a bird that hatched from a Catalina egg in 1992 and the female (K-17) was a bird released at the Bulrush hacktower in 1984. In early February, the pair was seen working on the same nest that they used last year (Sharpe and Garcelon 2000). The pair worked on the nest until 13 February, when they were observed exhibiting incubation behavior and one egg was confirmed to be in the nest. On 15 February, we entered the nest via helicopter at 1700 and removed two eggs. Both eggs were fertile and were artificially incubated at the ACC. A third egg was observed in the nest on 22 February, but it broke by 2 March. One chick hatched on 20 March and one hatched on 21 March. These birds were kept by the ACC until they were hacked at Lake San Antonio by the Ventana Wilderness Sanctuary.

A chick produced by captive bald eagles at the ACC was fostered into the Twin Rocks nest at 1430 on 20 March. The male returned one minute later and began brooding. The female returned approximately 2 hours later. We returned to the nest on 1 May to install leg bands, transmitter, and wingmarkers on the chick and to obtain a blood sample. We continued monitoring the nest until the chick fledged on or about 28 May.

### West End Territory

The West End trio of birds used the same nest that has been used since 1991. The male has lost his

wing markers, but is believed to be K-77, a 19-year-old bird released from a hacktower in 1981. The breeding female (referred to as Female 1 hereafter) was not marked with patagial tags, but is believed to be a 14-year-old bird released at the Sweetwater hacktower in 1986. The second, non-breeding female (referred to as Female 2 hereafter) is a 14-year-old bird (patagial tag K-69) that was also released at the Sweetwater hacktower in 1986. The birds were first observed at the nest on 8 February. Incubation behavior was first observed on 24 February and we replaced one egg with an artificial egg on 26 February. A second egg was seen in the nest on 2 March. This egg was not removed and broke on 7 March.

There was no observed development in the egg upon delivery to the ACC. One ACC-produced chick was fostered into the West End nest on 18 April. A second chick was fostered into the nest on 26 April. On 29 May, we returned to the West End nest to install leg bands, transmitter, and wingmarkers on the chicks and to obtain blood samples (Table 2). We continued monitoring the nest until the chicks fledged on or about 26 June.

Table 2. Biographical data for bald eagle chicks successfully fostered into nests on Santa Catalina Island, California during 2000.

| USFWS Band | Color Band | Wing Marker | Date Fledged | Foster Nest | Status[a] | Comments |
|---|---|---|---|---|---|---|
| 629-39820 | 7/A | K-00 | 5/28/00 | Twin Rocks | Unknown | Found dropped transmitter on 8 August. Bird last seen 27 July. |
| 629-29498 | 6/H | K-01 | 6/6/00 | Pinnacle Rock | Unknown | From captive pair at ACC. Left island around 11 August. |
| 629-29499 | 6/B | K-02 | 6/26/00 | West End | Unknown | From captive pair at ACC. Left island around 28 August. |
| 629-29500 | 6/U | K-03 | 6/26/00 | West End | Dead | Found dead about 8 km off coast of Catalina on 17 August |

[a] As of 12/15/00

**Pinnacle Rock**

The Pinnacle Rock pair used the same nest as last year (Sharpe and Garcelon 2000). The 14-year-old male (K-65) was hacked at the Bulrush tower in 1986. The female, who has lost her wing markers, is believed to be a 15-year-old bird hacked at the Bulrush tower in 1985. The female was first seen at the nest on 28 January. On 24 and 25 February a single egg was seen in the nest. The egg was gone on 26 February, but a second egg was laid around 1015 h. At 1045 h on 26 February we removed the second egg and fragments of the first egg via helicopter. The female returned to the nest within 1 min of the helicopter's departure and began incubating the artificial eggs. We observed the nest from a camouflaged observation blind approximately 300 m from the nest.

On 10 April, we introduced one chick (12 days old) into the nest, again using a helicopter, and the male returned to the nest about 20 s after the helicopter left. We entered the nest on 22 May to install leg bands, a transmitter, and wingmarkers on the chick, and to sample blood. Monitoring of

this nest continued until the eaglet fledged on or about 6 June (Table 2).

**Seal Rocks Territory**

Two adult eagles were observed in this territory throughout the breeding season, but showed no obvious breeding behavior. The female of this pair was K-34, a bird from the captive ACC eagles that was hacked at the Bulrush tower in 1993. The male (K-25) hatched from an egg from the West End territory and was fostered into the Pinnacle Rock nest in 1992.

**China Point Territory**

No birds were observed in this territory this season and this area will be dropped from future reports until another pair is found to reside in the area.

## Incubation Behavior

We monitored the incubation behavior at the Twin Rocks nest for 14 days between 15 February and 20 March, at the West End nest for 21 days between 26 February and 11 April, and at the Pinnacle Rock nest for 15 days between 26 February and 10 April. In all but one case we were able to determine the sex of the incubating adult, either by wing markers, leg bands, or size of the bird.

We detected no difference in the length of incubation bouts between the Pinnacle Rock birds ($P$ = 0.586), the Twin Rocks bird ($P$ = 0.465) or among the West End birds ($P$ = 0.307) (Table 3). When all complete bouts were combined by territory, bout lengths at the West End nest were significantly shorter than at either the Pinnacle Rock or Twin Rocks nests ($P < 0.001$). Bout lengths did not differ significantly between the Pinnacle Rock and Twin Rocks nests ($P$ = 0.959). There were no significant correlations between bout length and day of incubation at any nest ($P > 0.65$).

Table 3. Number (n), mean, standard deviation (SD), and range of length of complete incubation bouts (hrs:minutes) for adult eagles observed during incubation at the Twin Rocks, West End, and Pinnacle Rock territories on Santa Catalina Island, 15 February - 11 April 2000.

| | Male | | | Female 1 | | | Female 2[a] | | |
|---|---|---|---|---|---|---|---|---|---|
| Territory | n | Mean | SD | n | Mean | SD | n | Mean | SD |
| Twin Rocks | 5 | 1:36 | 1:06 | 7 | 2:10 | 1:22 | . | . | . |
| West End | 21 | 1:06 | 0:53 | 43 | 0:50 | 0:36 | 27 | 0:43 | 0:35 |
| Pinnacle Rock | 13 | 1:55 | 0:56 | 12 | 1:48 | 1:03 | . | . | . |

[a] Second female that was released from the same hacktower with Female 1 in 1986 and is believed to be the non-breeding female of the West End trio.

## Chick-Rearing and Fledgling Behavior

We made behavioral observations for 34 days at the Twin Rocks nest (21 March-26 May), 23 days at the Pinnacle Rock nest (10 April-9 June), and 32 days at the West End nest (18 April-21 June).

The Twin Rocks birds were successful in fledging the chick fostered into their nest. There was a significant difference in the average amount of time spent at the nest by the female (55%) and the male (27%; $P < 0.0002$). There was a significant negative relationship between time spent at the nest as the chick aged for the female ($P = 0.0001$; Fig. 2), but not for the male ($P = 0.0836$; Fig. 2).

The Pinnacle Rock birds were successful in fledging the chick fostered into their nest. The female spent a significantly greater portion of her time at the nest (76%) than did the male (35%, $P < 0.0001$). There was no significant relationship between time spent at the nest and chick age for either adult ($P > 0.14$, Fig. 2).

The West End birds also successfully fledged both chicks fostered into their nest. Although the proportion of time spent at the nest did not differ between Female 1 (36%) and Female 2 (54%), the male spent significantly less time at the nest (16%) than either female ($P \leq 0.01$). All three adults had significant negative linear relationships ($P < 0.032$) between time spent at the nest and date, slowly decreasing time at the nest as the chick aged (Fig. 2).

Although the two females at the West End nest share chick-rearing duties, we found a significant difference in the average percent of time spent brooding ($P = 0.03$; Female 1: 9.0%; Female 2: 6.1%). We found no difference in the percent of time the two females spent feeding the chicks ($P = 0.12$; Female 1: 1.7%; Female 2: 3.3%).

The proportion of time the chicks spent standing increased rapidly starting at an age of approximately 45 days at all three nests (Fig. 3). The chicks were observed feeding on their own as early as 18 days of age, but self-feeding did not increase substantially until they were approximately 36-40 days of age (Fig. 4)

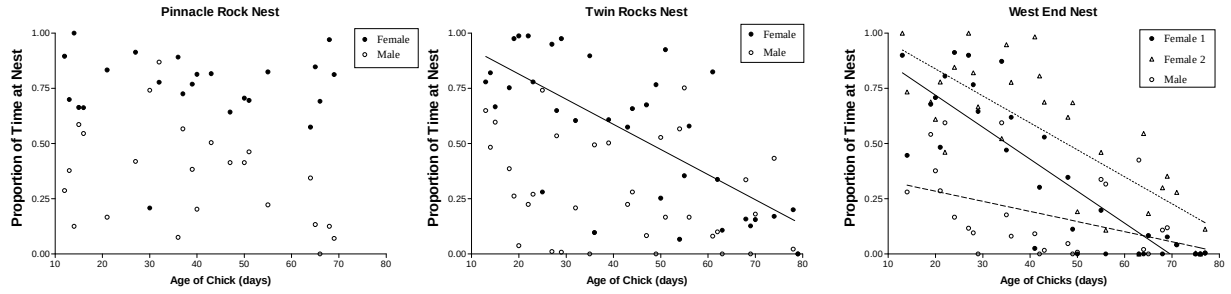


**Figure 2. Proportion of time spent by adult bald eagles at the Twin Rock, Pinnacle Rock, and West End nests during chick-rearing. At the West End nest, Female 1 is the breeding female and Female 2 is a non-breeding helper. The line in the Twin Rocks graph is the best fit for the male; on the West End graph the lines are the best fit for Female 1 (—), Female 2 (-----), and the male (– – – –).**

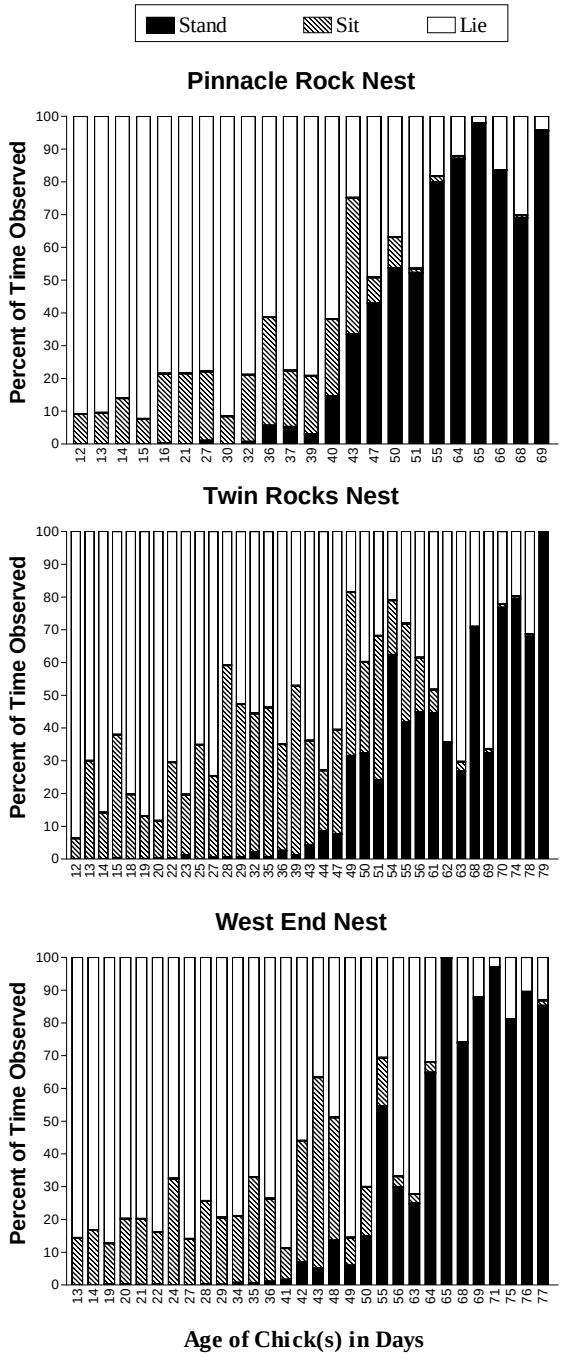


**Figure 3. Percent of time that chicks spent in 3 different postures at the Pinnacle Rock, Twin Rocks, and West End nests, Santa Catalina Island, 2000.**

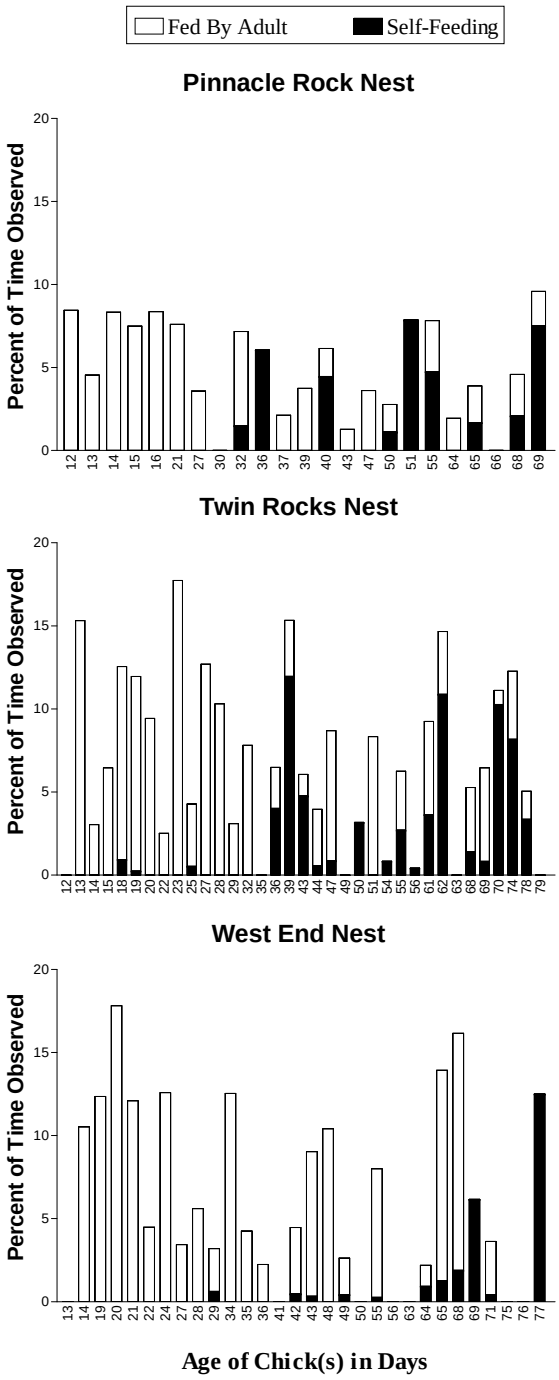


**Figure 4. Percent of time that chicks were observed being fed by adults or self-feeding at the Pinnacle Rock, Twin Rocks, and West End nests, Santa Catalina Island, 2000.**

## Prey Deliveries

We observed 33 prey deliveries at the Pinnacle Rock nest during 126.9 hours of observations (0.26

items/hr), 66 prey deliveries at the Twin Rocks nest during 209.6 hours of observations (0.31 items/hr), and 63 prey deliveries during 206.8 hours of observations at the West End nest (0.30 items/hr). At all the nests the males made more deliveries than the females (Fig. 5). We were able to identify prey items to Family or Genus for 40 of 66 deliveries (61%) at the Twin Rocks nest, 22 of 33 deliveries (67%) at the Pinnacle Rock nest, and 23 of 63 deliveries (37%) at the West End nest (Table 4). The Class of the prey was determined for 65 of 66 deliveries (98%) at the Twin Rocks nest, 32 of 33 deliveries (97%) at the Pinnacle Rock nest, and 55 of 63 deliveries (91%) at the West End nest (Table 4).

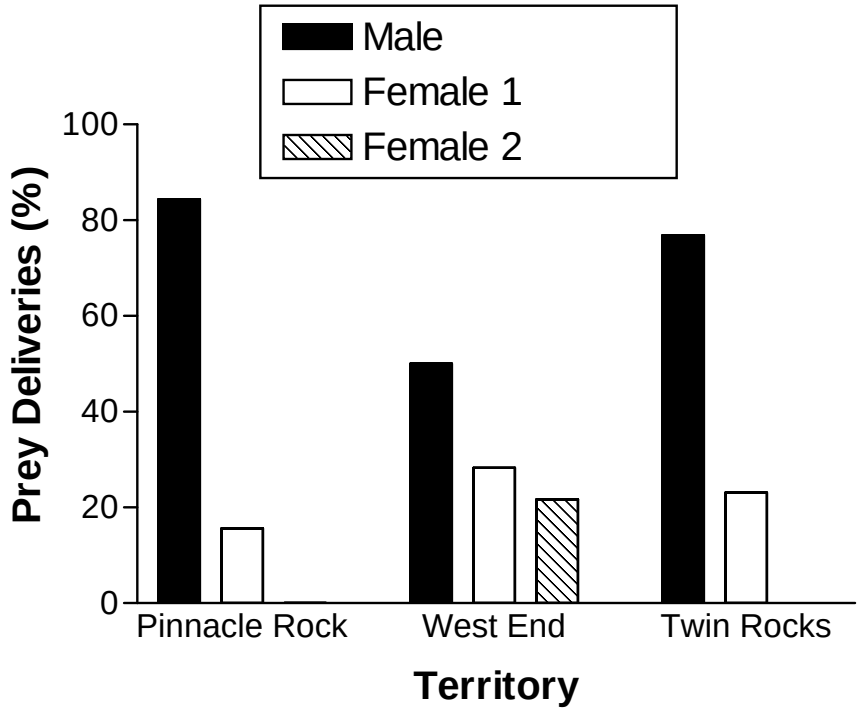


**Figure 5. Percent of prey deliveries made by adults to nests in 3 different territories in 2000. Female 2 is a non-breeding helper at the West End nest.**

## Post-Fledging Behavior

The Twin Rocks chick (K-00) fledged on or about 28 May (Table 2). The bird remained in the vicinity of the nest until 3 July when it began to fly around the island, primarily remaining south of the isthmus. The last confirmed visual sighting of the bird was on 27 July near Torqua Springs (Fig. 1). On 8 August we located the bird's transmitter on a rock pinnacle in the Torqua Springs area.

Table 4. Number and percent of food items delivered to the Pinnacle Rock, West End, and Twin Rock nests during monitoring on Santa Catalina Island, California, 2000.

| | Prey deliveries |
|---|---|



**Figure 5. Percent of time spent in three**

| Food Item | Pinnacle Rock | | West End | | Twin Rocks | |
|---|---|---|---|---|---|---|
| | n | % of Total | n | % of Total | n | % of Total |
| FISH | | | | | | |
| Unknown fish | 10 | 30.3 | 31 | 49.2 | 23 | 34.8 |
| Unknown herring (various spp.) | 8 | 24.2 | 5 | 7.9 | 10 | 15.2 |
| Unknown surfperch (various spp.) | 0 | 0.0 | 1 | 1.6 | 1 | 1.5 |
| Unknown rockfish (*Sebastes* spp.) | 0 | 0.0 | 5 | 7.9 | 3 | 4.5 |
| Unknown sea bass (*Paralabrax* spp.) | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| Garibaldi (*Hypsypops rubicundus*) | 3 | 9.1 | 0 | 0.0 | 2 | 3.0 |
| Pacific mackerel (*Scomber japonicus*) | 3 | 9.1 | 3 | 4.8 | 5 | 7.6 |
| Ocean sunfish (*Mola mola*) | 1 | 3.0 | 0 | 0.0 | 0 | 0.0 |
| Jacksmelt (*Atherinopsis californiensis*) | 0 | 0.0 | 0 | 0.0 | 1 | 1.5 |
| White seabass (*Atractoscion nobilis*) | 1 | 3.0 | 1 | 1.6 | 0 | 0.0 |
| Kelp bass (*Paralabrax clathratus*) | 0 | 0.0 | 3 | 4.8 | 0 | 0.0 |
| Red goatfish (*Pseudupeneus grandisquamis*) | 1 | 3.0 | 0 | 0.0 | 0 | 0.0 |
| Unknown halibut (*Paralichthys* spp.) | 1 | 3.0 | 0 | 0.0 | 0 | 0.0 |
| White croaker (*Genyonemus lineatus*) | 1 | 3.0 | 0 | 0.0 | 0 | 0.0 |
| Black croaker (*Cheilotrema saturnum*) | 0 | 0.0 | 0 | 0.0 | 1 | 1.5 |
| California flyingfish (*Cypselurus californicus*) | 1 | 3.0 | 4 | 4.3 | 2 | 3.0 |
| Blacksmith (*Chromis punctipinnis*) | 1 | 3.0 | 0 | 0.0 | 0 | 0.0 |
| Northern anchovy (*Engraulis mordax*) | 0 | 0.0 | 0 | 0.0 | 5 | 7.6 |
| Horn shark (*Heterodontus francisi*) | 0 | 0.0 | 0 | 0.0 | 1 | 1.5 |
| Pacific sardine (*Sardinops sagax*) | 0 | 0.0 | 0 | 0.0 | 1 | 1.5 |
| Opaleye (*Girella nigricans*) | 0 | 0.0 | 0 | 0.0 | 2 | 3.0 |
| Fish Subtotal | 31 | 93.9 | 53 | 84.1 | 57 | 86.4 |
| BIRDS | | | | | | |
| Unknown birds | 0 | 0.0 | 1 | 1.6 | 1 | 1.5 |
| Unknown Cormorant (*Phalacrocorax* spp.) | 0 | 0.0 | 0 | 0.0 | 2 | 3.0 |

Table 4. Continued

| | Prey deliveries |
|---|---|

| Food Item | Pinnacle Rock | | West End | | Twin Rocks | |
|---|---|---|---|---|---|---|
| | n | % of Total | n | % of Total | n | % of Total |
| BIRDS (Cont.) | | | | | | |
| Unknown Auklet. | 0 | 0.0 | 0 | 0.0 | 1 | 1.5 |
| Unknown Murrelet | 0 | 0.0 | 0 | 0.0 | 2 | 1.5 |
| California gull (*Larus californicus*) | 0 | 0.0 | 0 | 0.0 | 1 | 1.5 |
| Birds Subtotal | 0 | 0.0 | 1 | 1.6 | 7 | 10.6 |
| MAMMALS | | | | | | |
| Mammal Subtotal | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| OTHER | | | | | | |
| Squid | 1 | 3.0 | 2 | 3.2 | 1 | 1.5 |
| Unknown | 1 | 3.0 | 7 | 11.1 | 1 | 1.5 |
| Other Subtotal | 2 | 6.1 | 9 | 14.3 | 2 | 3.0 |
| **TOTAL FOOD ITEMS** | **33** | | **63** | | **66** | |

The Pinnacle Rock chick (K-01) fledged on or about 6 June (Table 2). We observed the eaglet in flight for short periods of time, but radiotelemetry locations and observations of the bird indicated that it remained within its parents' territory until it started moving around the island around 21 July. It was last located on the island on 11 August.

The West End chicks (K-02 and K-03) fledged on or about 26 June (Table 2). The birds remained in the vicinity of the nest until 3 August, at which time they were seen in the vicinity of Twin Rocks on Catalina Island (Fig. 1). A fishing boat found K-03 dead and entangled in kelp on 17 August approximately 8 km off of the island. On 16 August the bird had been seen bathing in a sprinkler in Avalon and there was a strong signal from its transmitter coming from Avalon on the morning of 17 August. It is likely that the bird tired while trying to fly to the mainland, tried landing on the kelp, and was unable to lift-off again. K-02 remained on the island until we lost its signal around 28 August.

## Additional Eagle Sightings

Breeding activities were again reported on the mainland this year by a bird previously released on Catalina Island. Eagle K-31 (FWS Band # 629-19926), a bird fostered into the West End nest in 1993, was found again as part of a pair at Bass Lake, Madera County, CA (Fig. 7). These birds successfully bred for the second consecutive year and fledged two offspring.

K-24 (FWS Band #629-19924), a bird that attempted to breed at Santa Margarita Reservoir last year, was seen at San Antonio Lake near San Luis Obispo, CA in December 1999 and January 2000. This

lake is about 62 km northeast of Santa Margarita Reservoir (Fig. 7).

K-90 (FWS Band # 629-39818), a captive-reared bird that was fostered into the Pinnacle Rock nest in 1999 was seen near MacDoel, CA on 2 July by Phil Detrich with the U.S. Fish and Wildlife Service. The bird was in a field with other bald eagles feeding on dead ground squirrels (Fig. 7).

K-94 (FWS Band # 629-19929) was found near Arvin, CA on 24 January with a gunshot to the right wing. A portion of the wing was amputated and the bird was moved to the San Francisco Zoo in March. The eagle is now a part of the Eagle Island exhibit. Prior to being shot, the bird had last been seen on 7 May 1996 at Lake Crowley, CA (Fig. 7).

K-81 (FWS Band # 629-39816), a captive-reared bird that was fostered into the West End nest in 1998 was seen on Catalina Island on 7 May and has remained on the island. The last known sighting of this bird was at Klamath Falls, OR in February 1999 (Fig. 7).

K-84 (FWS Band # 629-39812), a captive-reared bird that was released from the Sweetwater hacktower in 1998 was observed by IWS employees on San Clemente Island on 13 April, but returned to Catalina Island by 7 May (Fig. 7).

There are also a minimum of four additional subadults on Catalina Island from 1998 and 1999 releases that never left the island. K-80 (FWS Band #629-39815), a zoo-raised bird that was fostered into the West End nest in 1998 is frequently seen in the vicinity of Avalon. K-82 (FWS Band # 629-39817), a bird that hatched from a West End egg and was fostered into the Pinnacle Rock nest in 1998 has also been seen on the island and had an operating transmitter until the transmitter package fell off in early August. Both K-92 (FWS Band # 629-29496) and K-93 (FWS Band # 629-29497), zoo-raised birds that were hacked at the Bulrush tower in 1999, also have remained on the island.

### Collection of Tissue Samples

We collected blood samples for chemical analyses from four juvenile bald eagles on Catalina Island this season. In addition, the ACC collected the egg contents and embryos from eggs that were collected on Catalina Island and failed to hatch (Appendix II).

## DISCUSSION

### Artificial Nest Manipulation

As has been indicated in other studies of bald eagles (e.g., Anthony et al. 1994), we do not believe that continued research activities at the nest will negatively impact the nesting success of bald eagles on Catalina Island. Our results from this season indicate that the reproduction of bald eagles on Catalina Island continues to suffer from greatly reduced hatchability of eggs. Although two of the three fertile eggs recovered during 2000 hatched, these were only the seventh and eighth of 40 fertile eggs removed from wild nests on Catalina Island since 1987 to hatch (20% hatching rate). This low hatching success and the fact that three additional eggs broke in the nest this season (one within 48 hours), further emphasize the need for active management of the population and clean-up of the

contaminated environment. Failure to hatch may be a result of excessive water loss associated with abnormal eggshell structure (Risebrough 1993). The ACC is able to reduce water loss using a variety of techniques following the transport of the eggs to the Zoo, but the eggs have often lost a large amount of water prior to removal from the nest.

The egg and chick manipulations during 2000 were successful as we were able to foster four eagles on the island. Removal of eggs from bald eagle nests may cause abandonment of nests in some cases (Anthony et al. 1994), but because of our ability to access nests quickly bald eagles on

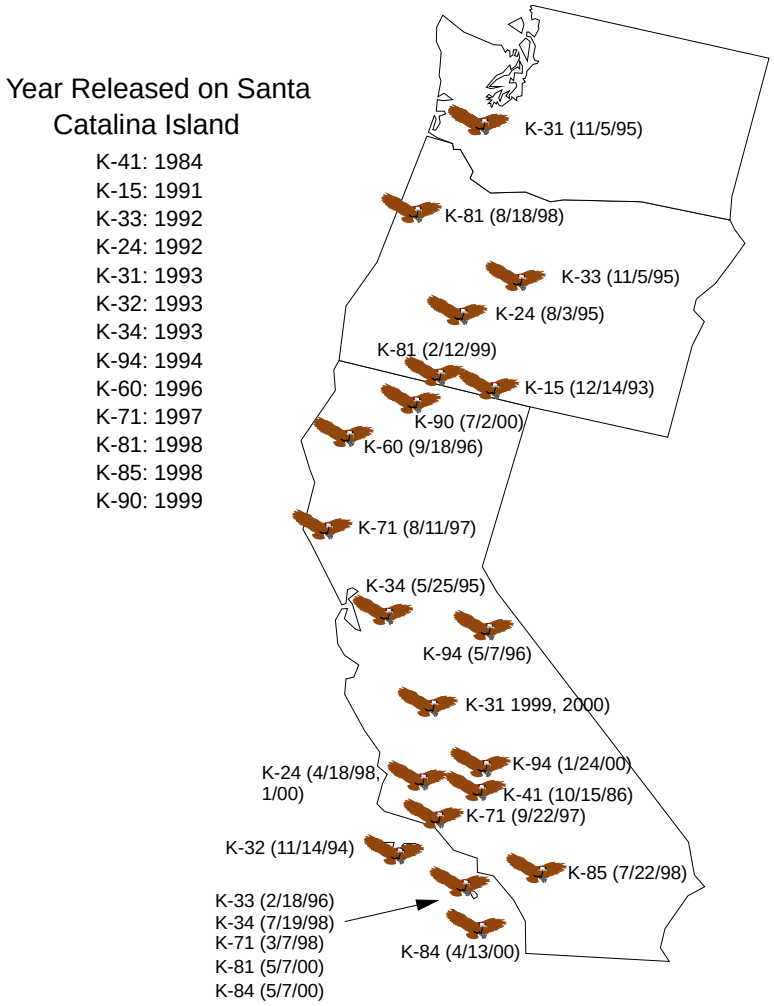


**Figure 7. Sightings of bald eagles that left Santa Catalina Island, CA after being released through fostering or hacking activities. Included are the year the birds were released and the location and date on which they were seen alive.**

Catalina Island rarely abandon nests following our manipulations.

We anticipate productivity at the Catalina Island eagle nests to be higher in 2001, as we expect to have four active nests, assuming that the Seal Rocks birds again build a nest and reproduce next season. We will again begin searching for breeding activity in mid-January next year to avoid missing active nests and locate pairs that may have formed or moved since the previous breeding season.

## Incubation Behavior

Both male and female eagles shared in the responsibilities of incubating eggs and incubation behavior (e.g. length of bouts) appears to be consistent throughout the natural incubation period (Keister and Anthony 1983). Our data contradict reports that female eagles incubate a greater percentage of the time than males (Gittens 1968); within a territory, the adults spent comparable proportions of time incubating the eggs. Cain (1985) reported mean incubation bouts of 164 minutes for the male and 144 minutes for the female, which are similar to our results from the Pinnacle Rock and Twin Rocks nests, but longer than that observed at the West End nest. The shorter incubation bouts at the West End nest are most likely a result of the presence of Female 2, who shares in incubation duties.

## Chick-Rearing and Fledgling Behavior

Stalmaster (1987, p.61) reported that during the month following hatching of the chick, adult males were primarily responsible for providing prey, while females were primarily responsible for brooding the chick. Our data support this statement because at all the nests monitored this season the males spent a smaller proportion of their time at the nest and delivered the majority of the prey items brought to the nest.

This year's data also support our previous findings (Phillips and Garcelon 1995, 1996, Sharpe and Garcelon 1998, 1999, 2000) that nestlings begin standing and eating independently more frequently starting at approximately 45-50 days of age. Eagles appear to spend a large portion of time sleeping or resting when < 50 days old, then gradually become more active and participate in more energetically demanding behaviors as they approach fledging.

## Prey Deliveries

The data collected in this study support the conclusion by Garcelon et al. (1997a,b) that bald eagles on Catalina Island exploit a wide variety of available foods. As has been found in other studies (Brown et al. 1991, Kozie and Anderson 1991, Todd et al. 1982), fish and birds comprised the majority of the bald eagle diet. Fish are the most important component of the diet of chicks on the nest, comprising greater than 84% of deliveries to the nests.

The prey delivery rates at the three active nests this season indicate that prey items are brought to the nest an average of about 3-4 times per day (assuming a 12-hour active period).

## Release of Additional Eagles

Although we did not release any eagles by hacking this season, we believe that the release of additional eagles through hacking continues to be a successful means of augmenting productivity of the eagle population on Catalina Island. Although fostering chicks into nests of wild birds uses person-hours more efficiently than hacking, this procedure is a practical and feasible management option on Catalina Island due to the abundance of fish and feral animals for use as food. Further, it is a valuable option to fall back on if the timing of production of eaglets by captive birds occurs asynchronous to the nesting of wild eagles on Catalina Island.

### Additional Eagle Sightings

The second successful breeding by the pair at Bass Lake was important because it indicates that eagles released and developed on Catalina Island are capable of breeding normally once the source of contamination is removed from their diet.

We also are finding that bald eagles released in previous years are continuing to return to Catalina Island after having been seen on the mainland. Therefore, even though many of the young birds leave the island their first year this does not mean that they are being lost from the breeding population on Catalina Island.

## CONCLUSIONS

Efforts to maintain the reintroduced population of bald eagles on Catalina Island were successful in 2000, as four eagles fledged from nests and three survived to dispersal. Locating Catalina birds nesting on the mainland also indicates that this project is adding adults to the California eagle population. Efforts should be made to determine whether birds are also returning to breed on other Channel Islands.

Collection and analysis of eagle eggs and other tissues should continue in order to provide accurate baseline data from which to compare changes that may occur if action to alleviate the contaminant burden in the sediments is ever undertaken. Because bald eagles are at the top of the food chain, they are one of the best species for monitoring the influence of organochlorine contaminants on the marine ecosystem.

Results from our study of nesting behavior do not indicate aberrant behavior associated with exposure to organochlorine contaminants; however, limited comparable data is available for wild eagles that have not been exposed to contaminants. Study of additional nests on Catalina Island during future years may provide data to detect less apparent trends and increase power of statistical tests used to make comparisons between nests. Additionally, second generation affects of exposure to DDE may become apparent as juveniles produced by the nesting adults continue to return to Catalina Island to breed.

## ACKNOWLEDGMENTS

We thank the Santa Catalina Island Conservancy for providing access to their land and for logistical support. We thank Jessica Dooley and Dan Harrington for their hard work during all aspects of this study. We also thank the staff of the Avian Conservation Center at the San Francisco Zoo,

especially Kathy Hobson, for their assistance and dedication to developing and implementing techniques to successfully hatch eggs from Catalina Island and for allowing us access to eaglets for fostering and hacking activities.

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## Appendix I

ADULT BEHAVIORS TO BE RECORDED DURING SCAN SAMPLING

POSTURES

Standing (ST): Bird is upright on one or both of its feet on any substrate.

Sitting (SI): Bird is resting its weight on its tarsometatarsus (not its feet) and does not have its sternum touching the nest substrate.

Lying (L): Bird is prone on the nest with its sternum touching the nest substrate.

Flying (F): Feet of bird are not touching any substrate (flapping or hovering).

BEHAVIORS

Brooding (BR): Bird is sheltering chick under body or wing, and may be pulling nest material around its body.

Resting (R): Bird is lying in nest with its head resting on the substrate.

Eating (EA): The act of pulling at or swallowing food.

Feeding (FE): The act of preparing or giving food to a chick.

Preening (PR): Bird has its beak buried in its feathers or is running its beak along the shaft of a feather.

Nest Maintenance (NM): Bird bringing nest material, or arranging nest material in the nest.

Walking (WA): Moving around the nest either in the standing or sitting postures.

Vocalizing (V): Head back, and appearing to vocalize.

Out of view (O): Bird is either facing away from camera and behavior is unknown, or bird is blocked from view by the nest or another bird.

Alert (A): Bird is attentively looking around or in a particular direction.

Non-Descript (N): Behavior belongs to no definite class (e.g., non-alert scanning, watching chick).

## Appendix I (continued)

CHICK BEHAVIORS TO BE RECORDED DURING INTERVAL SAMPLING

**POSTURES**

Standing (ST): Bird is upright on one or both of its feet on any substrate.

Sitting (SI): Bird is resting its weight on its tarsometatarsus (not its feet) and does not have its sternum touching the nest substrate.

Lying (L): Bird is prone on the nest with its sternum touching the nest substrate.

Flying (F): Feet of bird are not touching any substrate (flapping or hovering).

Out of view (O): Bird is blocked from view by adult.

**BEHAVIORS**

Resting (R): Bird is lying in nest with its head resting on the substrate.

Eating (EA): The act of pulling at or swallowing food without help from an adult.

Feeding (FE): Act of taking food from the adult or swallowing food offered by the adult.

Preening (PR): Bird has its beak buried in its feathers or is running its beak along the shaft of a feather.

Playing (PL): Toying with nest material, feathers, or food.

Wing Exercising (WE): Flapping both wings while the feet are in contact with the nest substrate.

Walking (WA): Moving around the nest either in the standing or sitting postures.

Wing-flap/Jump (J): Flapping wings and jumping from one part of the nest to another.

Wing Stretch (WS): Extending one wing or a wing and a leg.

Wings Out (WO): Extending both wings out, usually precedes a wing-flap/jump or flying.

Out-of-view (O): Bird is blocked from view by adult.

Non-Descript (N): Behavior belongs to no definite class (e.g., non-alert scanning, watching adult).

## Appendix II

Specimens collected from bald eagles on Catalina Island, CA for analyses in 2000.

| Tissue Type | Collection Location | Description |
|---|---|---|
| Red and White Blood Cells | Twin Rocks Nest | 2.0 cc from 8-week old eaglet (K-00) |
| Whole Blood | Twin Rocks Nest | 5.0 cc from 8-week old eaglet (K-00) |
| Plasma | Twin Rocks Nest | 3.0 cc from 8-week old eaglet (K-00) |
| Red and White Blood Cells | Pinnacle Rock Nest | 1.5 cc from 8-week old eaglet (K-01) |
| Whole Blood | Pinnacle Rock Nest | 5.0 cc from 8-week old eaglet (K-01) |
| Plasma | Pinnacle Rock Nest | 3.5 cc from 8-week old eaglet (K-01) |
| Red and White Blood Cells | West End Nest | 1.0 cc from 8-week old eaglet (K-02) |
| Whole Blood | West End Nest | 2.0 cc from 8-week old eaglet (K-02) |
| Plasma | West End Nest | 2.0 cc from 8-week old eaglet (K-02) |
| Red and White Blood Cells | West End Nest | 1.5 cc from 11-week old eaglet (K-03) |
| Whole Blood | West End Nest | 5.0 cc from 11-week old eaglet (K-03) |
| Plasma | West End Nest | 3.5 cc from 11-week old eaglet (K-03) |
| Egg Shell[a] | Twin Rocks Nest | Zoo ID # 08-00 |
| Egg Shell[a] | Twin Rocks Nest | Zoo ID # 09-00 |
| Egg Contents and Shell [a] | West End Nest | Zoo ID # 21-00 |
| Egg Contents and Shell [a] | Pinnacle Rock | Zoo ID # 22-00 |

[a] Collected by staff at San Francisco Zoo. Egg shells were rinsed in water, air dried, and stored in aluminum foil. Shell contents were placed directly into a chemically clean jar, sealed with an evidence label, and frozen.