

Restoration and Management of Bald Eagles on Santa Catalina Island, California, 1999

A Report Prepared for:

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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 17 of 24 chicks fostered into nests between 1989 and 1999 (Table 1). Two of these 24 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, 1988-1999.

	Year										
	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
# of Active Nests	1	2	2	3	3	2	3	3	2	3	4
# of Eggs Laid	2	2-3	3	5	5-6	3	5	5-6	6	7	8
# of Eggs Collected	1	1	3	5	4	3	5	4	5	6	6
# of Catalina Island Eggs Hatched ^a	0	0	1	2	0	0	0	0	1	1	1 ^g
# of Eggs Fostered Into Nests on Catalina Island	0	0	2	0	0	0	1	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
# of Chicks Fledged From Nests on Catalina Island	1	0	2	3	1	1	1	2	1	3	2
# of Eagles Hacked Onto Catalina Island	0	0	2	0	2	0	2	4	0	4	2
# of Island-Produced Eagles Breeding on Island	0	0	0	0	0	0	0	0	1	1	2
# of Second Generation Eagles Fledged	0	0	0	0	0	0	0	0	1	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 Big Sur, CA.

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 1999. While the USFWS, through the Montrose Trustee Council, did not fund any activities associated with fostering or hacking 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 km² (Fig. 1). Elevations range from sea level to 648 m. There is considerable topographic relief, with numerous steep-sided canyons incising the island. Annual temperatures range from 12 to 20° 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). The nest is located on a rock ledge 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.

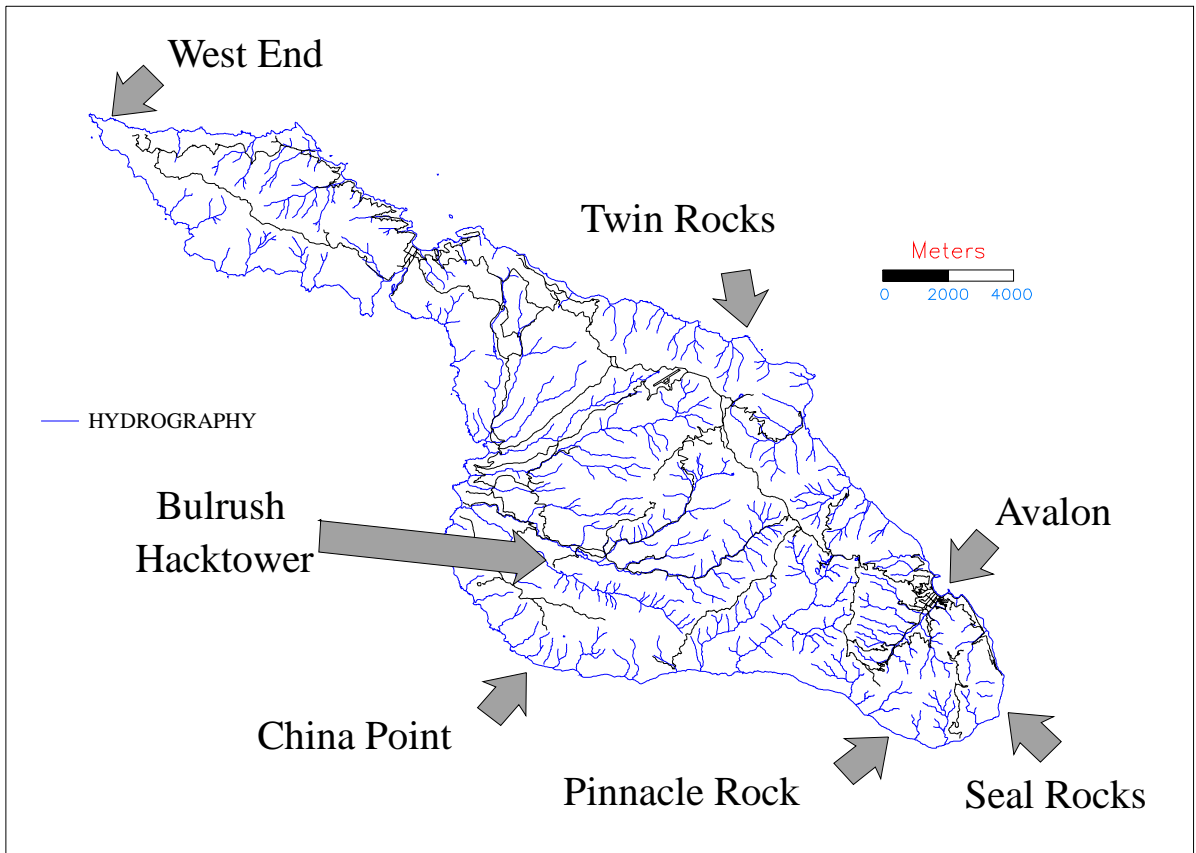


Figure 1. Map of Santa Catalina Island, CA showing the locations of bald eagle territories and points of reference. The base map of the island was provided by Dr. William Bushing, Santa Catalina Island Conservancy.

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 1990-1998 (Phillips and Garcelon 1996, Sharpe and Garcelon 1999).

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 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 and the pair was seen repeatedly in the Seal Rocks area through 1998.

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 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.

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. The blinds were used to monitor and quantify: 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 8-9 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 and West End nests by monitoring the nest 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 sex-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 1-5 days/week, up to 8 hours/day. Fog occasionally prevented or delayed sampling of behavior. We distributed sampling evenly across the daylight period during each week by ensuring similar proportions of monitoring occurred within 3-hour intervals (0600-0859, 0900-1159, etc.). 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. We also collected prey remains when we visited the nests and recorded items that were seen in the nests, but which were not delivered during our monitoring. This allowed us to verify our identification of prey

deliveries, identify prey items that we were unable to identify when they were delivered to the nest, and identify prey items delivered when we were not present. It is possible that some of the prey items that we observed being delivered to nests were also collected when we visited the nest, so the number of prey identified is not necessarily additive.

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

Two bald eagles produced by the ACC were introduced 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 2-10cc 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 1999 in three previously occupied territories: Twin Rocks, Pinnacle Rock, and West End (Fig.1). In addition, the new Seal Rocks pair constructed their first nest near Avalon (Fig. 1).

Twin Rocks

The territory was used by the same pair that used it in 1998 (Sharpe and Garcelon 1999). 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. This pair of eagles was first sighted on a new nest on 2 February. The birds built the nest on a rock pinnacle about 50-75 m above the water and about 100 m down the ridge from the previously used nest (Sharpe and Garcelon 1999).

The pair worked on the nest until 13 February, when they were observed exhibiting incubation behavior. On 17 February, we entered the nest via helicopter at 1110 and removed two eggs. Incubation resumed at 1120. Both eggs were fertile and were artificially incubated at the ACC. One chick died in the shell prior to 20 March and one hatched on 26 March. This bird was kept by the ACC until it was hacked in Big Sur by the Ventana Wilderness Sanctuary. A chick produced by captive bald eagles at the ACC was fostered into the Twin Rocks nest at 1345 on 26 March. The

male returned one minute later and began brooding. The female returned approximately 2 hours later and began brooding at 1700. We observed the nesting behavior through 4 April, when a series of storms passed through the area. Upon checking the nest on 9 April it was found that there were no longer any eagles at the nest. It is unknown what became of the chick, but it is possible that it was blown or walked off the nest which consisted primarily of grass with only a few sticks along one side. We continued to monitor the area and observed some additional nest building behavior, but no further breeding behavior was observed.

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, an 18-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 13-year-old bird released at the Sweetwater hacktower in 1986. The second, non-breeding female (referred to as Female 2 hereafter) is a 13-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 22 February. The male was observed copulating with Female 1 on 24 and 27 February, and with Female 2 on 20 February and 2 March. Incubation behavior was first observed on 6 March and we replaced two eggs with artificial eggs at 1043 on 8 March. One of the adults returned to the nest by 1045 and began incubating the artificial eggs. On 13 March another egg was observed in the nest and it was removed on 14 March. It is possible that 1) the third egg was part of the first clutch removed (laid after the first 2 eggs were removed) and was not seen until 13 March or 2) the egg was laid by a different female than the first two eggs (male copulated with both females).

There was no observed development in any of the eggs upon delivery to the ACC. One ACC-produced chick was fostered into the West End nest on 19 April. On 31 May, we returned to the West End nest to install leg bands, transmitter, and wingmarkers on the chick and to obtain a blood sample (Table 2). We continued monitoring the nest until the chick fledged on or about 29 June.

Table 2. Biographical data for bald eagle chicks successfully fostered into nests on Santa Catalina Island, California during 1999.

USFWS Band	Color Band	Wing Marker	Date Fledged	Foster Nest	Status ^a	Comments
629-39818	7/E	K-90	6/12/99	Pinnacle Rock	Unknown	From captive pair at ACC. Left island on 7/21/99
629-39819	6/E	K-91	6/29/99	West End	Alive	From captive pair at ACC

^a As of 9/13/99.

Pinnacle Rock

The Pinnacle Rock pair used the same nest as last year (Sharpe and Garcelon 1999). The 13-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 14-year-old bird hacked at the Bulrush tower in 1985. The birds were first seen at the nest on 18 February. On 24-25 February a single egg was seen in the nest, but the egg was gone on 26 February and no incubation behavior was observed. On 27 February another egg was observed in the nest and it was successfully removed via helicopter on 28 February. The female returned to the nest within 1 min of the helicopter's departure and began incubating the artificial egg. We observed the nest from a camouflaged observation blind approximately 300 m from the nest using a 15-45X or 15-60X spotting scope.

On 8 April, we introduced one chick (13 days old) into the nest, again using a helicopter, and both adults returned to the nest about 1 min after the helicopter left. We entered the nest on 25 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 12 June (Table 2).

Seal Rocks Territory

Two adult eagles were observed in this territory during January and February with 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, had replaced the former female of this pair. The male (K-25) hatched from an egg from the West End territory and was fostered into the Pinnacle Rock nest in 1992. On 2 March both birds were observed working on a nest in a eucalyptus tree above a road near Pebbly Beach in Avalon. Nest construction continued until 2 April, when a single egg was observed in the nest. Plans were made to remove the egg(s) on 5 April, but a wind storm blew the nest out of the tree on the evening of 3 April. Shell fragments from the egg were collected. Both birds were seen in the area throughout the rest of the season, but no further breeding activity was observed.

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

Although we monitored the Twin Rocks nest regularly during incubation, we did not collect incubation behavior. Because of the early breeding of this pair, the time that normally would have been spent collecting behavioral observations was spent monitoring the remaining three pairs of eagles so as not to miss any breeding behavior and egg-laying. We monitored the incubation behavior at the West End nest for 8 days between 13 March and 15 April and at the Pinnacle Rock nest for 7 days between 12 March and 8 April. In all cases 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 ($P = 0.664$) or among the West End birds ($P = 0.852$) (Table 3). When all complete bouts were combined by territory there was a significant difference in bout length between the two territories ($\bar{x} \pm 1$ SD;

Pinnacle Rock = $1:48 \pm 1:10$, $n = 10$; West End = $0:51 \pm 0:31$, $n = 36$; $F_{1,44} = 14.72$, $P < 0.001$). There was a significant correlation between bout length and day of incubation at the Pinnacle Rock nest ($r_s = 0.81$, $P = 0.0044$, $n = 10$ bouts), but not at the West End nest ($r_s = 0.15$, $P = 0.389$, $n = 36$ bouts) (Fig. 2).

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 West End and Pinnacle Rock territories on Santa Catalina Island, 12 March - 15 April 1999.

Territory	Male			Female 1			Female 2 ^a		
	n	Mean	SD	n	Mean	SD	n	Mean	SD
West End	11	0:47	0:32	14	0:54	0:25	11	0:50	0:38
Pinnacle Rock	4	2:01	1:27	6	1:40	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

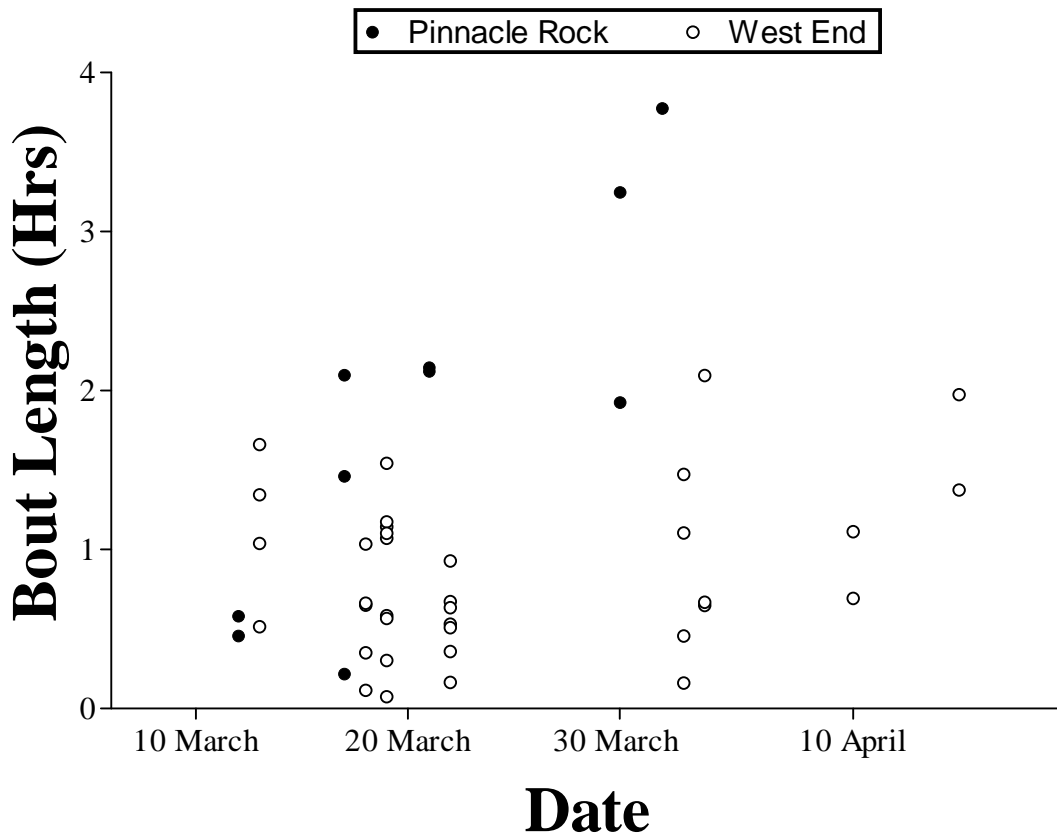


Figure 2. Length of complete incubation bouts as related to date recorded for adult bald eagles at the Pinnacle Rock and West End nests, Santa Catalina Island, CA, 1999.

We made behavioral observations for 6 days at the Twin Rocks nest (prior to the chick disappearing), 18 days at the Pinnacle Rock nest (8 April-10 June), and 19 days at the West End nest (19 April-27 June).

During the short time that the chick was in the nest at Twin Rocks, there was a significant difference in the amount of time spent at the nest by the female (100%) and the male (17.3%; $P < 0.0001$). There was a significant linear decrease in time spent at the nest by the male as the chick aged ($P < 0.05$; Fig. 3).

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 (74.1%) than did the male (40.4%, $P < 0.0001$). There was no significant linear relationship between time spent at the nest and date for the male or female ($P \geq 0.08$; Fig. 3).

The West End birds also successfully fledged the chick fostered into their nest. Although the proportion of time spent at the nest did not differ between Female 1 (40.9%) and Female 2 (51.5%; $P = 0.23$), the male spent significantly less time at the nest (13.7%) than either female ($P \leq 0.004$). All three adults had significant negative linear relationships ($P < 0.04$) between time spent at the nest and date, slowly decreasing time at the nest as the chick aged (Fig. 3).

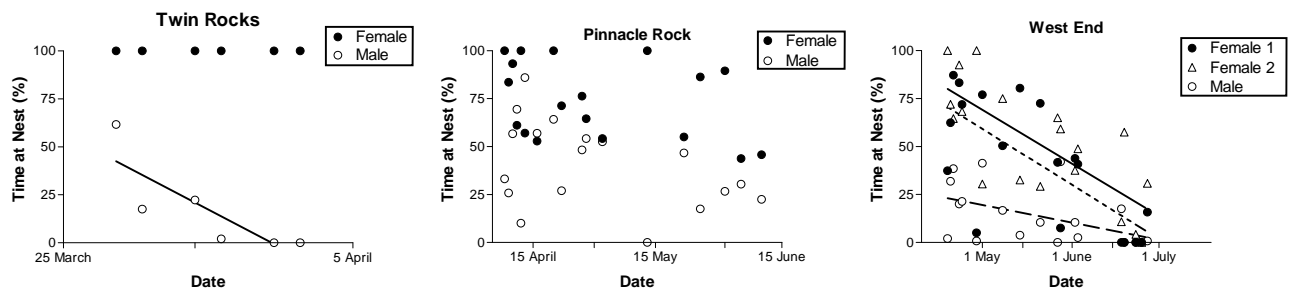


Figure 3. Proportion of time spent by adult bald eagles at the Twin Rock, Pinnacle Rock, and West End nests during chick-rearing. At the West End nest, Female 1 is the breeding female and Female 2 is a non-breeding helper. The line in the Twin Rocks graph is the best fit for the male; on the West End graph the lines are the best fit for Female 1 (—), Female 2 (-----), and the male (---).

The two females at the West End nest appear to share chick-rearing duties equally. We found no significant difference in the average percent of time either female spent brooding ($P = 0.79$; Female 1: 14.0%; Female 2: 12.2%) or feeding the chicks ($P = 0.32$; Female 1: 1.8%; Female 2: 2.1%).

The proportion of time the chicks spend standing increased rapidly starting at an age of approximately 45 days at both the Pinnacle Rocks and West End nests (Fig. 4). The chicks were

observed feeding on their own as early as 51 days of age, but did not feed solely on their own until they were older than 70 days of age (Fig. 5).

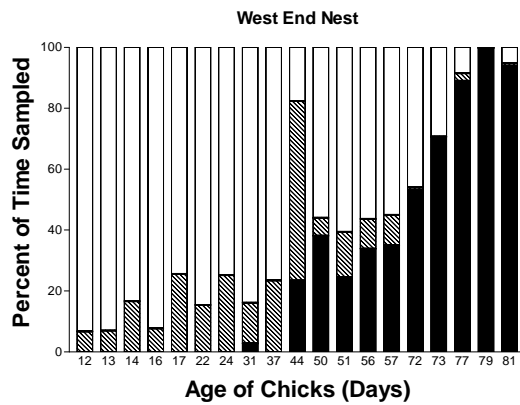
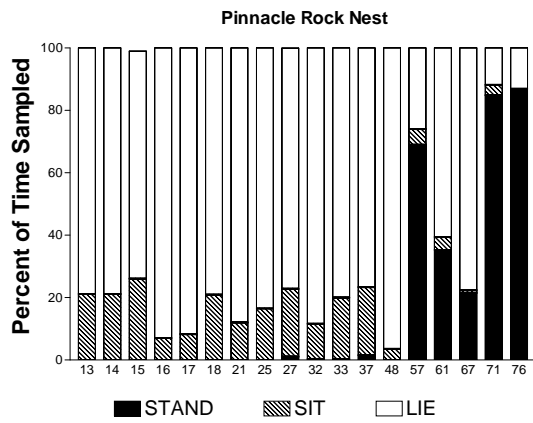


Figure 4. Percent of time spent in three major postures by bald eagle nestlings at the Pinnacle Rock and West End nests in 1999.

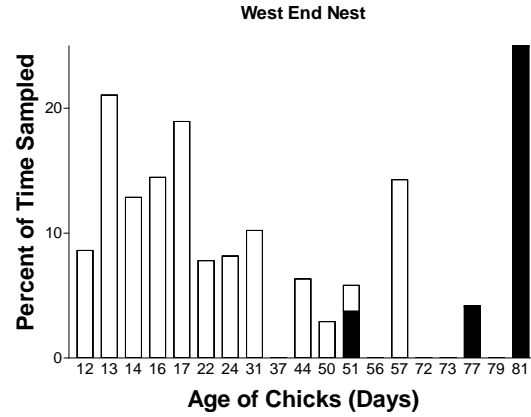
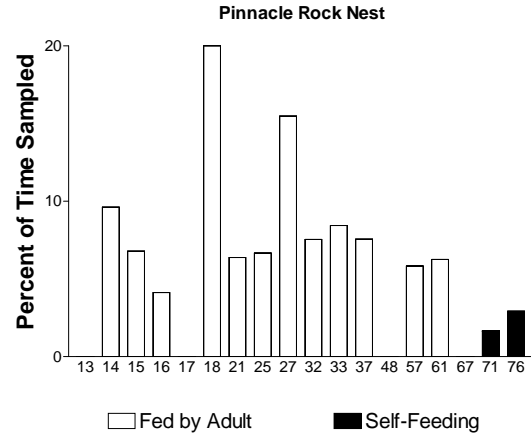


Figure 5. Percent of time bald eagle chicks at the Pinnacle Rock and West End nests spent feeding on their or own or being fed by adults in 1999.

Prey Deliveries

We observed 26 prey deliveries at the Pinnacle Rock nest during 61.4 hours of observations (0.42 items/hr), 4 prey deliveries at the Twin Rocks nest during 16.4 hours of observations (0.24 items/hr), and 31 prey deliveries during 74.3 hours of observations at the West End nest (0.42 items/hr). At all the nests the males made more deliveries than the females (Fig. 6).

We were able to identify prey items to Family or Genus for only 2 of 26 deliveries (7.7%) at the Pinnacle Rock nest and 5 of 26 deliveries (7.7%) at the West End nest (Table 4). The Class of the prey was determined for 24 of 26 deliveries (92.3%) at the Pinnacle Rock nest, 31 of 31 deliveries (100%) at the West End nest, and 4 of 4 deliveries (100%) at the Twin Rocks nest (Table 4).

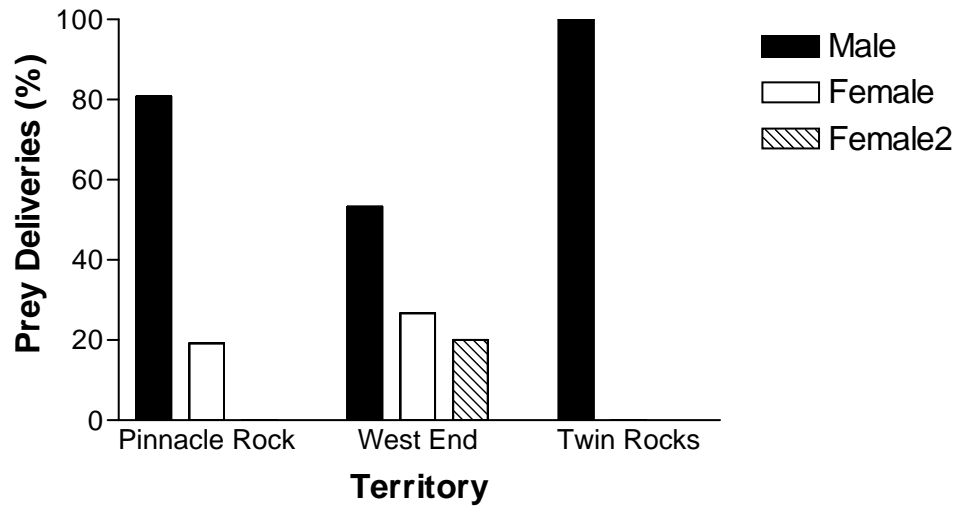


Figure 6. Percent of prey deliveries made by adults to nests in 3 different territories in 1999. Female 2 is a non-breeding helper at the West End nest.

During visits to the nests, we recovered remains of several species that either were not detected during nest observations or which were not conclusively identified (Table 5). Table 5 also includes prey items that were seen in the nests during monitoring, but which we did not observe being delivered.

Post-Fledging Behavior

The West End chick (K-91) fledged on or about 29 June. The bird remained in the vicinity of the nest until 4 September, at which time it was seen in the vicinity of Twin Rocks on Catalina Island (Fig. 1). A signal was received from the same general area on 13 September, but we have been unable to relocate the bird as of 29 September.

The Pinnacle Rock chick (K-90) fledged on or about 12 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 in close proximity to the nest canyon (within 1 km) until 21 July, at which time it is assumed that the bird left the island because we were unable to locate a signal and the bird was no longer seen around the nest.

Release of Additional Eagles

Two chicks produced and reared at the ACC were transported to Catalina Island on 15 June 1999 and placed in the Bulrush hacktower on the same day (Fig. 1). The birds were banded and fit with radio transmitters on 7 July and both birds fledged on 15 July, the same day the door was opened (Table 6). We placed food in and around the hacktower for approximately a month after release, and

both birds repeatedly were seen perched and feeding at the tower. Both birds have remained on the island and appear to be healthy.

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, 1999.

Food Item	Prey deliveries					
	Pinnacle Rock		West End		Twin Rocks	
	n	% of Total	n	% of Total	n	% of Total
<u>FISH</u>						
Unknown fish	20	76.9	22	71.0	4	100.0
Unknown herring (various spp.)	0	0.0	1	3.2	0	0.0
Unknown rockfish (<i>Sebastes</i> spp.)	1	3.8	1	3.2	0	0.0
Unknown sea bass (<i>Paralabrax</i> spp.)	0	0.0	1	3.2	0	0.0
Garibaldi (<i>Hypsypops rubicundus</i>)	1	3.8	2	6.5	0	0.0
Fish Subtotal	22	84.6	27	87.1	4	100.0
<u>BIRDS</u>						
Unknown birds	0	0.0	2	6.5	0	0.0
Birds Subtotal	0	0.0	2	6.5	0	0.0
<u>MAMMALS</u>						
Unknown mammals	2	7.7	0	0.0	0	0.0
Mammal Subtotal	2	7.7	0	0.0	0	0.0
<u>OTHER</u>						
Squid	0	0.0	2	6.5		
Unknown food items	2	7.7	0	0.0	0	0.0
Other Subtotal	2	7.7	2	6.5	0	0.0
TOTAL FOOD ITEMS	26		31		4	

Additional Eagle Sightings

Breeding activities were again reported on the mainland this year by birds previously released on Catalina Island. A bird fostered into the West End nest in 1992 (FWS Band # 629-19924) was found at Santa Margarita Reservoir in San Luis Obispo County, CA (Fig. 7). Based on behavior, the female had laid eggs and was in incubation posture. Last year this bird mated with a male released by the Ventana Wilderness Sanctuary in Monterey County, CA in 1994, but was unsuccessful

(Sharpe and Garcelon 1999). The female had a different mate this year, but was again unsuccessful, possibly due to the disappearance of the male during the latter part of the incubation period.

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 used an osprey nest and successfully fledged 1 offspring.

Table 5. Species of prey items recovered from the Pinnacle Rock, West End, and Twin Rocks nests or present in nests at onset of daily monitoring on Santa Catalina Island, California during 1999.

Species	Number
PINNACLE ROCK	
<u>FISH</u>	
Kelp bass (<i>Paralabrax clathratus</i>)	1
<u>MAMMALS</u>	
Feral goat (<i>Capra hircus</i>)	3
Feral pig (<i>Sus scrofa</i>)	1
California ground squirrel (<i>Spermophilus beecheyi</i>)	1
WEST END	
<u>FISH</u>	
Kelp bass (<i>Paralabrax clathratus</i>)	1
TWIN ROCKS	
<u>BIRDS</u>	
California gull (<i>Larus californicus</i>)	3

Table 6. Biographical data for bald eagle chicks released from hacktowers on Santa Catalina Island, California during 1998.

USFWS Band	Color Band	Wing Marker	Date Fledged	Release Hacktower	Status ^a	Comments
629-29496	5/V	K-92	7/15/99	Bulrush	Alive	From captive pair at ACC.
629-29497	5/K	K-93	7/15/99	Bulrush	Alive	From captive pair at ACC

^a As of 10/5/99.

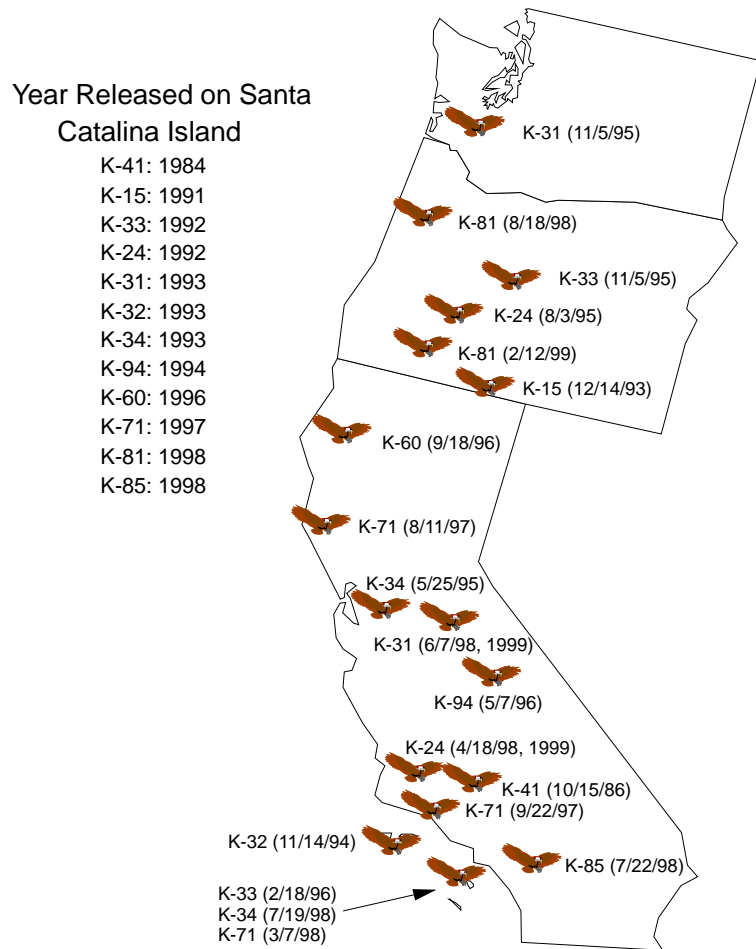


Figure 7. Sightings of bald eagles that left Santa Catalina Island, CA after being released through fostering or hacking activities. Included are the year the birds were released and the location and date on which they were seen alive.

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. However, our results from this season indicate that the reproduction of bald

eagles on Catalina Island continues to suffer from greatly reduced hatchability of eggs. Three of the 6 eggs recovered during 1999 were fertile; however, only one hatched. This is only the sixth of 37 fertile eggs removed from wild nests on Catalina Island since 1987 to hatch (16.2% hatching rate), further emphasizing 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.

Despite the loss of the chick from the Twin Rocks nest, the egg and chick manipulations during 1999 were successful as we were able to foster and hack four eagles on the island. Unlike last year, the Twin Rocks pair accepted the foster chick and were behaving normally up until the time the chick disappeared. This is a step forward compared to last year's unsuccessful fostering (Sharpe and Garcelon 1999) and gives us reason to believe that future fostering efforts at this nest will be successful. 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 Catalina Island rarely abandon nests following our manipulations.

We anticipate productivity at the Catalina Island eagle nests to be higher in 2000, 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); the male and Female 1 (thought to be the breeding female) eagles at the West End nest 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 nest in 1995 through 1999 (Phillips and Garcelon 1995, 1996; Sharpe and Garcelon 1998), 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 claim 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) 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 Pinnacle Rock and West End 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). The delivery rates at the Pinnacle Rock and West End nests were slightly higher this season than that recorded from 1995 through 1998 (0.18-0.34 items/hr; Phillips and Garcelon 1995, 1996, Sharpe and Garcelon 1998, 1999).

Release of Additional Eagles

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 successful breeding by the pair at Bass Lake is an important milestone in our program. Until now there was some question as to whether females that were released and developed on Catalina Island would be able to breed normally once the source of contamination was removed from their diet. The fact that the Catalina bird (believed to be a female based upon size) successfully raised an eaglet this year indicates that eagles on Catalina would be able to successfully reproduce if they were not residing in a contaminated environment.

CONCLUSIONS

Efforts to maintain the reintroduced population of bald eagles on Catalina Island were successful in 1999, as two eagles fledged and survived from nests and two hacked birds survived. Locating two 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.

Failure to hatch two of the three fertile eggs collected in 1999 underscores the continued

contaminant related productivity problems faced by this population. 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 effects of exposure to DDE may become apparent as juveniles produced by the nesting adults continue to return to Catalina Island to breed.

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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 1999.

Tissue Type	Collection Location	Description
Red and White Blood Cells	Pinnacle Rock Nest	2.0 cc from 8-week old eaglet (K-90)
Whole Blood	Pinnacle Rock Nest	4.0 cc from 8-week old eaglet (K-90)
Plasma	Pinnacle Rock Nest	3.0 cc from 8-week old eaglet (K-90)
Red and White Blood Cells	West End Nest	2.0 cc from 8-week old eaglet (K-91)
Whole Blood	West End Nest	5.0 cc from 8-week old eaglet (K-91)
Plasma	West End Nest	3.0 cc from 8-week old eaglet (K-91)
Red and White Blood Cells	Bullrush Hacktower	1.5 cc from 11-week old eaglet (K-92)
Whole Blood	Bullrush Hacktower	4.0 cc from 11-week old eaglet (K-92)
Plasma	Bullrush Hacktower	2.5 cc from 11-week old eaglet (K-92)
Red and White Blood Cells	Bullrush Hacktower	0.5 cc from 11-week old eaglet (K-93)
Whole Blood	Bullrush Hacktower	1.0 cc from 11-week old eaglet (K-93)
Plasma	Bullrush Hacktower	0.5 cc from 11-week old eaglet (K-93)
Egg Contents and Shell ^a	Twin Rocks Nest	Zoo ID # 26-99
Egg Contents and Shell ^a	Pinnacle Rock Nest	Zoo ID # 39-99
Egg Contents and Shell ^a	West End Nest	Zoo ID # 46-99
Egg Contents and Shell ^a	West End Nest	Zoo ID # 47-99
Egg Contents and Shell ^a	West End Nest	Zoo ID # 51-99
Egg Shell ^a	Twin Rocks Nest	Zoo ID # 27-99

^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.