Restoration and Management of Bald Eagles on Santa Catalina Island, California, 1998

A Report Prepared for:

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INTRODUCTION

In 1980, the United States Fish and Wildlife Service 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 15 of 21 chicks fostered into nests between 1989 and 1998 (Table 1). Two of these 21 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), and one chick was killed by the nesting female on the day the chick was fostered into the nest (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 14 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, 1988-1998.

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

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 1998. 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. 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 NW 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). 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 E, and on the south side of the island extended 2.5 km to the SE.

The Pinnacle Rock territory is located 4.3 km SW 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 NW from Binnacle Rock. The pair has used five different nests within this territory from 1990-1997 (Phillips and Garcelon 1996, Sharpe and Garcelon 1998).

The Twin Rocks territory is located 8 km NW of the city of Avalon, extending from Long Point 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).

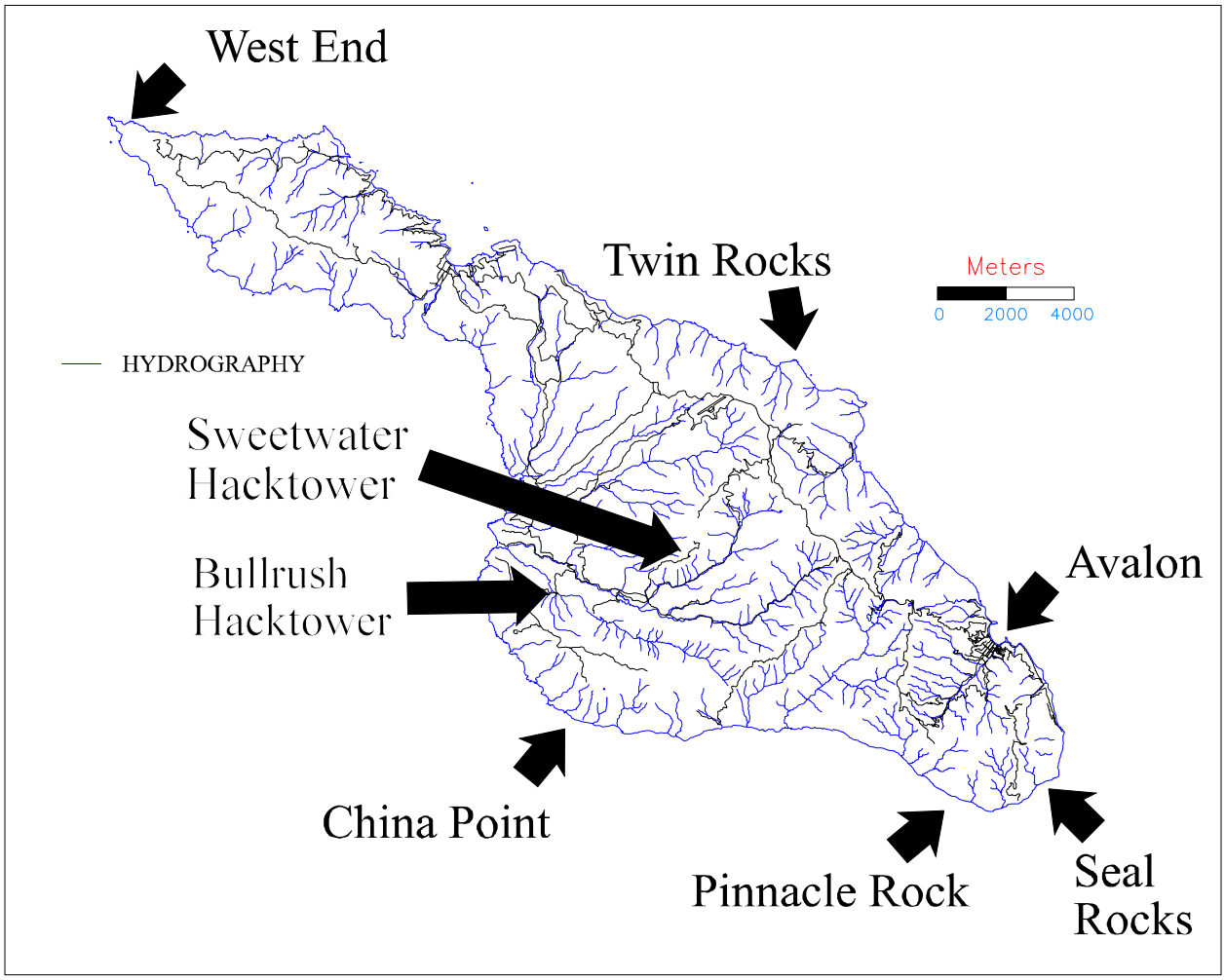

Figure 1. Map of Santa Catalina Island, CA showing the locations of bald eagle territories and points of reference. The base map of the island was provided by Dr. William Bushing, Santa Catalina Island Conservancy.

The China Point territory was first identified in December 1995 when a pair of eagles was initially observed near China Point (Fig.1). 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 NE of Seal Rocks to Church Rock located at the NW 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.

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 both the Twin Rocks and West End nests we had video cameras 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. Generally we replaced the eggs with healthy chicks after the adults had incubated the artificial eggs >30 days, however at the Pinnacle Rock nest we made the switch after only 15 days because of the timing of egg laying and the availability of young chicks (see below). We 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

Incubation behavior was collected primarily from the West End nest because of time constraints. We sampled incubation behavior by monitoring the nest for approximately 8 hours/day for 4-5 days/week. The sex of adult birds was determined by the presence of patagial wing markers 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 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 combined data for the two West End nestlings because they could not be distinguished from each other until after they were banded. 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 had them identified by J. Schmitt. 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 and recorded location, behavior, and interaction with other eagles.

Release of Additional Eagles

Four 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 5-10cc 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 or placed in formalin.

RESULTS

Manipulations and Nest Monitoring

Nests were located from February-April 1998 in three previously occupied territories: Twin Rocks, Pinnacle Rock, and West End (Fig.1).

Twin Rocks

This pair of eagles was first sighted on the nest on 1 February. The male (K-33) was the same male that occupied the territory last year (Sharpe and Garcelon 1998), a bird that hatched from a Catalina egg in 1992. The female (K-17) was a bird released at the Bullrush hacktower in 1984, a different female than the one thought to have nested in this territory last year (Sharpe and Garcelon 1998). The birds selected the same nest that was used in this territory in 1984, 1985, 1996, and 1997, located in an oak (*Quercus* sp.) tree on Twin Rocks, approximately 150 m above the water.

The pair worked on the nest until 13 February, when they were observed incubating a single egg. On 16 February, we entered the nest at 1030 and removed two eggs. The female returned to the nest after about an hour and began incubating the artificial eggs. This was the first year that the eggs were successfully switched at this nest site. Both eggs were fertile and were artificially incubated at the ACC, but the chicks died in the shell close to hatching, one while attempting to pip. A chick produced by captive bald eagles at the ACC was fostered into the Twin Rocks nest at 0945 on 3 April. The male returned after an hour and began brooding the chick, but the female did not return until 1830. As the male stood to leave the nest, the female approached, killed, and partially dismembered the chick. The nest was abandoned the next day and 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, a 17-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 12-year-old bird released at the Sweetwater hacktower in 1986. The second, non-breeding female (referred to as Female 2 hereafter) is a 12-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 3 March and were confirmed to be incubating on 16 March. On 19

March we replaced two eggs with artificial eggs at 0800. One of the adults returned to the nest by 0807 and began incubating the artificial eggs.

Upon delivery of the eggs to the ACC, it was determined that both were fertile, but had lost about 1.5-4.7% of their total weight during the first 1-5 days of natural incubation. Healthy eagle eggs generally lose about 15% of their weight during the entire 35-day incubation period (K. Hobson, personal communication). Two ACC-produced chicks were fostered into the West End nest on 27 April. One of the West End eggs hatched on 24 April, the same day the third Pinnacle Rock nest was found (see below). Because the chick from the West End egg was the youngest bird available, it was placed into the Pinnacle Rock nest (see below) instead of being returned to the West End nest.

On 7 June, we returned to the West End nest to install leg bands, transmitters, and wingmarkers on the chicks, and to obtain a blood sample (Table 2). We continued monitoring the nest until the chicks fledged on or about 3 July.

Table 2. Biographical data for bald eagle chicks successfully fostered into nests on Santa Catalina Island, California during 1998.

USFWS Band	Color Band	Wing Marker	Date Fledged	Foster Nest	Status[a]	Comments
629-39815	7/N	K-80	7/3/98	West End	Alive	From captive pair at ACC
629-39816	7/H	K-81	7/3/98	West End	Unknown	From captive pair at ACC. Left island on 8/10/98
629-39817	5/H	K-82	7/22/98	Pinnacle Rock	Alive	Hatched from West End egg

[a] As of 9/28/98.

Pinnacle Rock

The Pinnacle Rock pair selected a new nest this year, one previously used by the Seal Rocks pair. The 12-year-old male (K-65) was hacked at the Bullrush tower in 1986. The female, who has lost her wing markers, is believed to be a 13-year-old bird hacked at the Bullrush tower in 1985. The birds were first seen at the nest on 12 March, located about 1.0 km east of the East End Light. A single egg was observed in the nest on 25 March and removed at 0745 on 27 March. Although the adults remained in the area following the egg switch, they did not return to the nest.

On 26 March the pair was observed at a newly created nest located about 50 m above the ocean on a pinnacle 200-300 m west of last year's nest (Sharpe and Garcelon 1998). There was one egg present in the nest, but by the next morning the egg was gone and the nest was abandoned. On 23 April the pair was again observed at this nest with another egg, the third clutch of the season. We removed the single egg on 25 April using a helicopter because of the inaccessibility of the nest. The female returned to the nest within 30 sec of the helicopter's departure and began

incubating the artificial egg. Following the successful egg switch, we placed a camouflaged observation blind approximately 300 m from the nest to study behavior of the birds while on the nest. All observations were conducted with a 15-45X spotting scope.

On 10 May, we introduced one chick (17 days old from West End egg) into the nest, again using a helicopter, and the female returned to the nest about 20 sec after the helicopter left. We entered the nest on 19 June 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 22 July (Table 2).

Seal Rocks Territory

Two eagles were observed in this territory during the entire 1998 season. The female of this pair is believed to be K-30 (unable to read wing marker), a bird that hatched from a healthy egg placed into the West End nest in 1991 and retrapped in 1996 in the China Point territory. The male (K-25) hatched from an egg from the West End territory and was fostered into the Pinnacle Rock nest in 1992. One of the birds was seen moving sticks at a possible nest site on 3 March and a possible copulation occurred on 10 March, but no other breeding activity was observed throughout the rest of the season.

China Point Territory

No birds were observed in this territory this season.

Incubation Behavior

Although we monitored the Twin Rocks nest regularly during incubation, we only collected incubation behavior on 11 days between 18 February and 1 April. 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 25 days between 17 March and 25 April 1998. In most cases we were able to determine the sex of the incubating adult, either by wing markers or size of the bird. We monitored the Pinnacle Rock nest during incubation, but we did not systematically record incubation behavior because the artificially short incubation period (15 days) would not have allowed us to compare results with other nests or past years.

Only 10 complete incubation bouts were recorded at the Twin Rocks nest, so we did not conduct statistical analyses on incubation behavior for this pair. We detected a significant difference in length of incubation bouts ($P > 0.002$) between the three birds in the West End territory (Table 3), but there was no correlation between bout length and day of incubation for Female 1 (r_s = -0.155, P = 0.37, n=36 bouts), Female 2 (r_s = -0.002, P = 0.99, n=29 bouts) or the male (r_s = -0.08, P = 0.67, n = 28 bouts) (Fig. 2).

Table 3. Number (n), mean, standard deviation (SD), and range of length of complete incubation bouts (hrs:minutes) for three eagles observed during incubation at the West End territory on Santa Catalina Island, 17 March - 25 April 1998.

	Male			Female 1			Female 2[a]		
Territory	n	Mean	SD	n	Mean	SD	n	Mean	SD
West End	28	1:11	0:53	36	1:15	0:53	29	0:33	0:22

[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 trio.

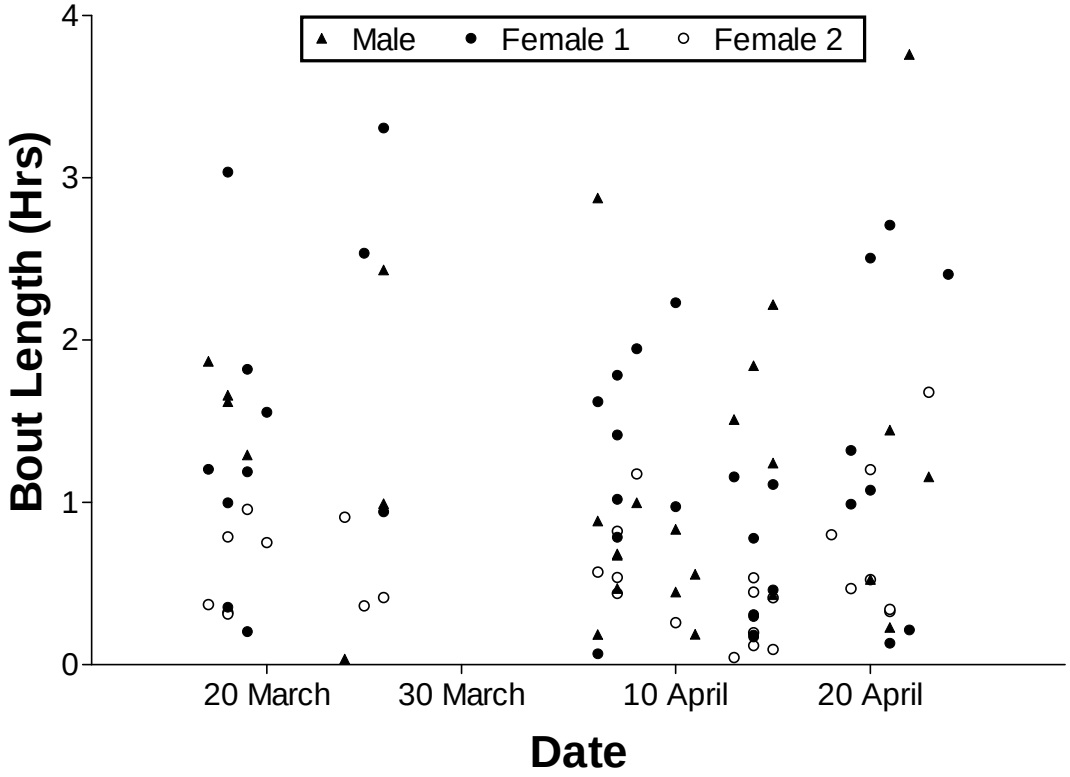

Figure 2. Length of complete incubation bouts as related to date recorded for three adult bald eagles at the West End nest, Santa Catalina Island, CA, 1998.

Chick Rearing and Fledgling Behavior

The Pinnacle Rock birds were successful in fledging the chick fostered into their nest and we observed behavior at the nest for 17 days between 10 May and 1 July 1998. The female spent a significantly greater portion of her time at the nest (70.6%) than did the male (24.0%, $P < 0.0001$). There was no significant linear relationship between time spent at the nest and date for

the male ($P = 0.75$), but there was a nearly significant negative linear relationship for the female ($P = 0.0519$) (Fig. 3).

The West End birds also successfully fledged the two chicks fostered into their nest. Although the proportion of time spent at the nest did not differ between Female 1 (50.7%) and Female 2 (39.19%; $P = 0.10$), the male spent significantly less time at the nest (17.0%) than either female ($P \leq 0.025$). All three adults had significant negative linear relationships ($P < 0.01$) between time spent at the nest and date, slowly decreasing time at the nest as the chicks aged (Fig. 3).

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 ($P = 0.31$; Female 1: 9.07%; Female 2: 5.35%) or feeding the chicks ($P = 0.83$; Female 1: 3.35%; Female 2: 3.59%).

The proportion of time spent standing by the chicks increased rapidly between the ages of approximately 40 and 45 days at both the Pinnacle Rocks and West End nests (Fig. 4) and nestlings increased the amount of time spent exercising their wings around 57 days of age (Fig. 5). The chicks were observed feeding on their own as early as 33 days of age and showed a significant increase in the amount of self-feeding with age at both the West End ($P = 0.0001$) and Pinnacle Rocks nests ($P = 0.0478$) (Fig. 6).

Prey Deliveries

We observed 13 prey deliveries at the Pinnacle Rock nest during 73 hours of observations (0.18 items/hr) and 31 prey deliveries during 108 hours of observations at the West End nest (0.29 items/hr). The Pinnacle Rock male made more deliveries than the female (61.5% and 38.5%, respectively), whereas Female 1 made more deliveries than either the male or Female 2 at the West End nest (46%, 31%, and 21%, respectively). There was no significant linear relationship between delivery rate and age of nestlings at the West End ($P = 0.28$) or Pinnacle Rock nests ($P = 0.12$).

We were able to identify prey items to Family or Genus for only 3 of 13 deliveries (23.1%) at the Pinnacle Rock nest and 11 of 31 deliveries (35.5%) at the West End nest (Table 4). The Class of the prey was determined for 12 of 13 deliveries (92.3%) and 30 of 31 deliveries (96.8%) at the Pinnacle Rocks and West End nests, respectively (Table 4). 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).

Post Fledging Behavior

The West End chicks fledged on or about 3 July. Both birds remained in the vicinity of the nest until 30 July, when K-81 was seen in the vicinity of Avalon on Catalina Island (Fig. 1). Eagle K-81 continued to be sighted until it left the island on 10 August. Its signal was picked up throughout the next day towards the area around Palos Verdes Peninsula on the mainland, but it could not be found on 12 August when a search was made on the mainland. The same bird was

Table 4. Number and percent of food items delivered to the Pinnacle Rock and West End nests during monitoring on Santa Catalina Island, California, 1998.

	Prey deliveries			
	Pinnacle Rock		West End	
Food Item	n	% of Total	n	% of Total
FISH				
Unknown fish	9	69.2	19	61.3
Unknown herring (various spp.)	1	7.7	8	25.8
Unknown kelpfish (various spp.)	0	0.0	1	3.2
Unknown rockfish (*Sebastes* spp.)	0	0.0	1	3.2
California flyingfish (*Cypselurus californicus*)	0	0.0	1	3.2
Kelp bass (*Paralabrax clathratus*)	1	7.7	0	0.0
Fish Subtotal	11	84.6	29	93.5
BIRDS				
Unknown gull (*Larus* spp.)	1	7.7	0	0.0
Unknown birds	0	0.0	1	3.2
Birds Subtotal	1	7.7	1	3.2
UNKNOWN FOOD ITEMS	1	7.7	1	3.2
Total Food Items	13		31	

reported at Boiler Bay State Park on the central coast of Oregon on 18 and 19 August by D. Pitkin of the U.S. Fish and Wildlife Service (Fig. 7). The other West End Chick (K-80) remained in the area of the nest through 7 September, at which time it moved to the general vicinity of the
Bullrush hacktower. It was seen repeatedly around the central portion of Catalina Island through 29 December.

The Pinnacle Rock chick (K-82) fledged on or about 22 July 1998 (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 3 September, at which time it was seen near the West End nest. It then also moved to the vicinity of the Bullrush hacktower and was observed on the island through 29 December.

Release of Additional Eagles

Four chicks produced and reared at the ACC were transported to Catalina Island on 5 June 1998. Two chicks were placed in the Sweetwater hacktower and two were placed in the Bullrush

Table 5. Species of prey items recovered from Pinnacle Rock and West End nests on Santa Catalina Island, California during 1998.

Species	Number
PINNACLE ROCK	
BIRDS	
California gull (*Larus californicus*)	2
Red-throated loon (*Gavia stellata*)	2
Sooty shearwater (*Puffinus griseus*)	1
Double-crested cormorant (*Phalacrocorax auritus*)	1
Xantus' murrelet (*Synthliboramphus hypoleucus*)	1
WEST END	
BIRDS	
Sooty shearwater (*Puffinus griseus*)	1
FISH	
California flyingfish (*Cypselurus californicus*)	1

hacktower (Fig. 1) on 6 June. The birds in the Sweetwater tower were banded and fit with radio transmitters on 25 June and both birds fledged on 27 June, the same day the door was opened (Table 6). We placed food in and around the hacktower, but neither bird was seen at the tower for a month following the release. On 14 July we recaptured K-84 at the West End because it was not flying. It was dehydrated and had a prominent keel associated with weight loss. It was given intravenous, subcutaneous, and oral fluids by veterinarian S. Timm and placed into the Bullrush hacktower for recovery. It had flown to the West End, where it was observed perching near the West End fledglings, became weak from a lack of food, and was not able to fly back to the hacktower where food was being placed. On 28 July we again released K-84 after placing a pig carcass in front of the hacktower. Unlike its first release, the bird remained in the vicinity of the hacktower and was repeatedly seen feeding on carcasses. We continued providing food at the hacktower for 2-3 weeks and then began moving the carcasses farther away to encourage the bird to locate food on its own. It lost its transmitter in early September, but we continued to see it on the island through 19 November.

On 25 July, K-83 was observed at the Sweetwater hacktower, apparently eating some fish in the tower. We placed a fresh carcass at the tower and the bird was seen standing on the carcass on 26 July. It was not seen on 27 or 28 July, but its signal was moving and it appeared to be soaring. On 29 July, it was found dead in Cape Canyon, directly downslope from the hacktower. It had been dead only a short time and there was no apparent trauma. The carcass was sent to the National Wildlife Health Center in Madison, WI to determine the cause of death and assess concentrations of contaminants. However, the cause of death could not be determined.

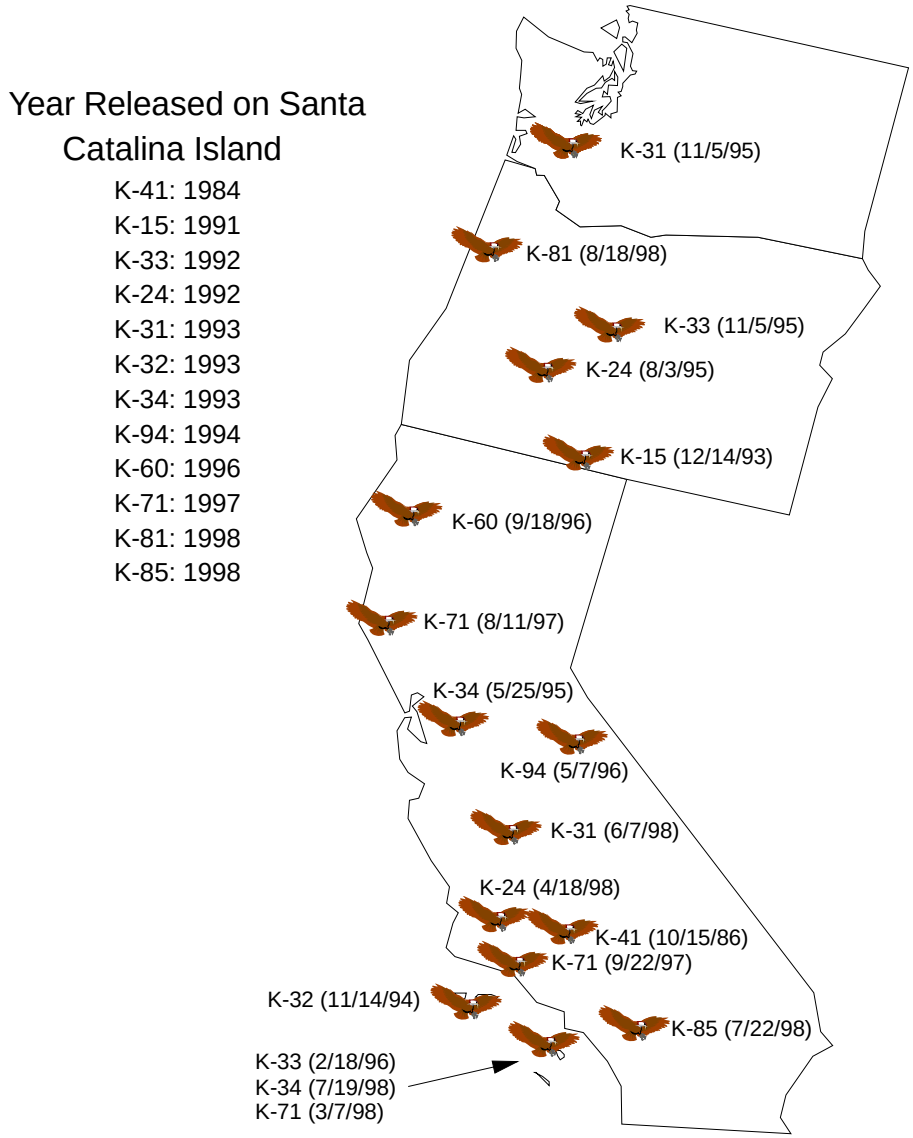

Figure 7. Sightings of bald eagles that left Santa Catalina Island, CA after being released through fostering or hacking activities. Included are the year the birds were released and the location and date on which they were seen alive.

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
629-39811	5/S	K-83	6/27/98	Sweetwater	Dead	From captive pair at ACC. Found dead 7/29/98.
629-39812	7/O	K-84	6/27/98	Sweetwater	Alive	From captive pair at ACC
629-39813	7/B	K-85	7/4/98	Bullrush	Unknown	From captive pair at ACC. Left island on 7/22/98.
629-39814	5/H	K-86	7/6/98	Bullrush	Alive	From captive pair at ACC

[a] As of 11/13/98.

The birds in the Bullrush tower were banded and radioed on 1 July and the door was opened on 4

July (Table 6). One bird (K-85) fledged on 4 July, but K-86 remained at the tower, usually perched or flapping its wings on the extended door outside the tower, until 6 July. Eagle K-85 did not return to the hacktower and was seen at various locations across the island until it left the island on 22 July. There was a probable sighting of K-85 on 23 July in Lake Elsinore, CA when a large, dark bird with orange wing tags (reported as K-65) and a radio antenna sticking from its back was reported perching on a building (Fig. 7). It is likely that the tag was misread because K-65 is an adult male in the Pinnacle Rock territory on Catalina Island. K-86 was not observed back at the hacktower until 6 August, when it was seen feeding on a fresh carcass that had been provided for K-84 (see above). Eagle K-86 remained in the vicinity following its return to the hacktower, and was often seen flying or perching near K-84. Eagle K-86 also lost its transmitter in September, but we continued to see the bird through 13 November.

Additional Eagle Sightings

An eagle produced by a captive pair at the San Francisco Zoo and hacked onto Catalina Island in 1993 has been sighted on Catalina Island several times this season. This eagle (FWS Band # 629-19928) was first seen on the island last year (Sharpe and Garcelon 1998) and was first seen this season on 19 July at Thompson Reservoir near the Bullrush hacktower (Fig. 1). K-71, the eagle fostered into the Pinnacle Rock nest last season was also seen repeatedly on Catalina Island from 7 March to 12 July 1998. However, on 26 July the bird was found dead on a slope east of Catalina Harbor. Judging by the amount of decomposition, the bird had been dead about one week. This bird was shipped to the National Wildlife Health Center in Madison, WI to confirm cause of death, and assess concentrations of contaminants. Again, the cause of death was undetermined.

For the first time, breeding activities have been reported on the mainland by birds released on Catalina Island. In April, K-24 (FWS Band # 629-19924), a bird fostered into the West End nest in 1992, was found on a nest at Santa Margarita Reservoir in San Luis Obispo County, CA (Fig. 7). This bird mated with a male released by the Ventana Wilderness Sanctuary in 1994 in Monterey County, CA. Although this pair apparently incubated for at least several weeks, no

chicks successfully hatched, probably because of the young age of the female.

Eagle K-31 (FWS Band # 629-19926), a bird fostered into the West End nest in 1993, was found as part of a pair working on a nest at Bass Lake, Madera County, CA (Fig. 7) in May. These birds were using an osprey nest and the outcome of the nesting attempt is not known.

Collection of Tissue Samples

We collected blood samples for chemical analyses from seven 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 organochlorine contamination continues to negatively impact the reproduction of bald eagles on Catalina Island. All 6 eggs recovered during 1998 were fertile; however, only one hatched. This is only the fifth of 34 fertile eggs removed from wild nests on Catalina Island since 1987 to hatch (14.7% 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 abandonment of the first Pinnacle Rock nest following egg removal and the failure of the Twin Rocks birds to accept the fostered chick, the egg and chick manipulations during 1998 were successful. We were able to foster and hack seven eagles, one of which hatched from a Catalina Island egg. This is only the second Catalina egg to hatch since 1992. Removal of eggs from bald eagle nests may cause abandonment of nests in some cases (Anthony et al. 1994), but bald eagles on Catalina Island rarely abandon nests following our manipulations. This is likely due to our ability to access nests quickly. The abandonment at the first Pinnacle Rock nest may have been partially influenced by the proximity of the Seal Rocks birds, which were generally perched within view of the Pinnacle Rock nest. Whenever the Seal Rocks birds would fly, one or both of the Pinnacle Rock birds would vocalize and fly from the nest area. It is possible that the location of the nest on the boundary between two territories could have placed additional stress on the Pinnacle Rock birds.

We expect productivity at the Catalina Island eagle nests to be higher in 1999, as it is hoped that the Seal Rocks birds will begin reproducing next season. Because there were breeding activities about a month earlier than normal this year (i.e. the Twin Rocks nest), 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 1997 (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, but at a reduced level.

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. During the first month following fostering of the chicks, the Pinnacle Rock male delivered a higher proportion of the prey to the nest and spent a much lower proportion of his time in attendance at the nest. At the West End nest, the male also spent the least amount of time at the nest, but Female 1 delivered twice as many prey (10 vs 5) as the male during the first month. Again, this difference in behavior may be related to the presence of a third adult.

Our data support our previous findings (Phillips and Garcelon 1995, 1996, Sharpe and Garcelon 1998) that nestlings begin standing, exercising their wings 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 84-94% of deliveries to the nests. The Pinnacle Rock pair appears to deliver more birds to the nest (1 of 12 identified prey) than the West End birds (1 of 30 identified prey). Prey remains collected at the nest during banding of the nestlings further supports this hypothesis, as the remains of seven birds were collected at the Pinnacle Rock nest, but the remains of only one bird was collected at the West End nest. Birds also made up a higher percentage of prey deliveries to the Pinnacle Rock nest (12%) than to the West End nest (3%) in 1996 (Phillips and Garcelon 1996), and more birds were collected from the Pinnacle Rock nest (20) than the West End nest (3) during a food habits study in 1991-1992 (Garcelon et al. 1997b).

The Pinnacle Rock female also was observed eating more birds (15.4% of observed prey) than any other breeding adult eagle on Catalina Island in 1991-1992 (Garcelon et al. 1997b). None of the eggs collected from the Pinnacle Rock nest have hatched and they tend to be in poorer condition than other bald eagle eggs removed from Catalina Island. Because gulls collected around Catalina Island had DDE concentrations more than 30 times that found in fish (Garcelon et al. 1989), the higher percentage of birds that are apparently included in the Pinnacle Rock pair's diet may be more negatively impacting their reproduction. In contrast, the West End trio appears to eat fewer birds and three of the five Catalina eggs that have hatched have come from their nest. Further research (e.g. monitoring diets and collecting blood from adults for contaminant analysis) is necessary to determine whether the relationship between hatchability and proportion of birds in the diet is a cause-and-effect relationship or merely coincidence.

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). This delivery rate at Pinnacle Rock was slightly lower than recorded from 1995 through 1997 (0.33-0.34 items/hr; Phillips and Garcelon 1995, 1996, Sharpe and Garcelon 1998). It is possible that El Niño conditions affected the availability of prey this season.

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.

CONCLUSIONS

Efforts to maintain the reintroduced population of bald eagles on Catalina Island were successful in 1998, as three eagles fledged and survived from nests and three hacked birds survived. Locating two Catalina birds nesting on the mainland also indicates that this project is adding adults to the southern California eagle population. Efforts should be made to determine whether birds are also returning to breed on other Channel Islands.

Failure to hatch five of the six fertile eggs collected in 1998 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 affects 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 1998.

Tissue Type	Collection Location	Description
Red and White Blood Cells	West End Nest	2.0 cc from 8-week old eaglet (K-80)
Whole Blood	West End Nest	5.0 cc from 8-week old eaglet (K-80)
Plasma	West End Nest	3.0 cc from 8-week old eaglet (K-80)
Red and White Blood Cells	West End Nest	1.5 cc from 8-week old eaglet (K-81)
Whole Blood	West End Nest	5.0 cc from 8-week old eaglet (K-81)
Plasma	West End Nest	3.5 cc from 8-week old eaglet (K-81)
Red and White Blood Cells	Pinnacle Rock Nest	3.0 cc from 8-week old eaglet (K-82)
Whole Blood	Pinnacle Rock Nest	4.6 cc from 8-week old eaglet (K-82)
Plasma	Pinnacle Rock Nest	2.0 cc from 8-week old eaglet (K-82)
Red and White Blood Cells	Sweetwater Hacktower	2.2 cc from 11-week old eaglet (K-83)
Whole Blood	Sweetwater Hacktower	4.0 cc from 11-week old eaglet (K-83)
Plasma	Sweetwater Hacktower	2.0 cc from 11-week old eaglet (K-83)
Red and White Blood Cells	Sweetwater Hacktower	1.0 cc from 11-week old eaglet (K-84)
Whole Blood	Sweetwater Hacktower	2.0 cc from 11-week old eaglet (K-84)
Plasma	Sweetwater Hacktower	1.0 cc from 11-week old eaglet (K-84)
Red and White Blood Cells	Bullrush Hacktower	2.0 cc from 11-week old eaglet (K-85)
Whole Blood	Bullrush Hacktower	5.0 cc from 11-week old eaglet (K-85)
Plasma	Bullrush Hacktower	3.0 cc from 11-week old eaglet (K-85)
Red and White Blood Cells	Bullrush Hacktower	2.0 cc from 11-week old eaglet (K-86)

Appendix II (continued)

Specimens collected from bald eagles on Catalina Island, CA for analyses in 1998.

Tissue Type	Collection Location	Description
Whole Blood	Bullrush Hacktower	7.0 cc from 11-week old eaglet (K-86)
Plasma	Bullrush Hacktower	3.0 cc from 11-week old eaglet (K-86)
Embryo[a]	Pinnacle Rock Nest	Frozen. Zoo ID # 9-98
Egg Contents[a]	Twin Rocks Nest	Frozen. Zoo ID # 4-98
Egg Contents[a]	Twin Rocks Nest	Frozen. Zoo ID # 5-98
Egg Contents[a]	Pinnacle Rock Nest	Frozen, without embryo. Zoo ID # 9-98
Egg Contents[a]	West End Nest	Frozen, with embryo. Zoo ID # 20-98
Egg Contents[a]	Pinnacle Rock Nest	Frozen. Zoo ID # 63-98

[a] Collected by staff at San Francisco Zoo