Restoration and Management of Bald Eagles on Santa Catalina Island, California, 1997

A Report Prepared for:

U.S. Fish and Wildlife Service
Damage Assessment Branch
Sacramento Fish and Wildlife Office
3310 El Camino, Suite 130
Sacramento, California 95825

Prepared by:

Peter B. Sharpe

and

David K. Garcelon

Institute for Wildlife Studies
Post Office Box 1104
Arcata, California 95518

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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). 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 1988, 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 10 of 15 chicks fostered into nests between 1989 and 1997 (Table 1). Two of these 15 birds were removed from the nest prior to fledging because of injuries, two died accidental deaths, and one bird was killed by a red-tailed hawk (*Buteo jamaicensis*) only four days after being fostered into the nest (Perkins et al. 1996) (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 10 eagles since 1991 (9 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, 1988-1997.

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

[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.

The purpose of this restoration 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 1997. 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 has yet been 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 from 1992-96, a second female has assisted in breeding activities (Garcelon et al. 1995, Phillips and Garcelon 1996). The nest was 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 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 1990-1996 (Phillips and Garcelon 1996).

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).

The Seal Rocks territory is located 4.5 km SE of the city of Avalon (Fig. 1). The pair

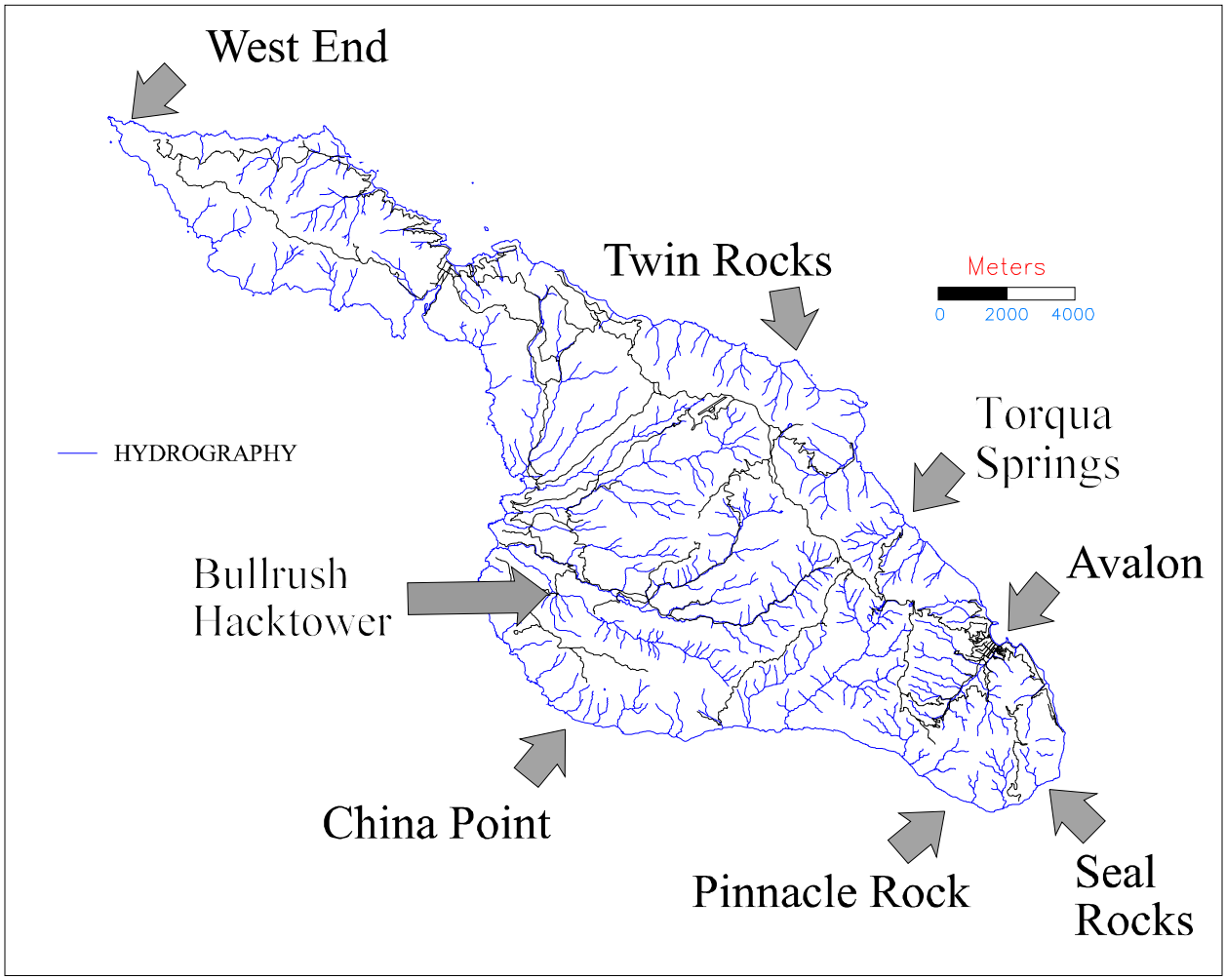

Figure 1. Map of Santa Catalina Island, CA showing the locations of bald eagle territories and points of reference. The base map of the island was provided by Dr. William Bushing, Santa Catalina Island Conservancy.

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).

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).

METHODS

Manipulations

Observations of adult eagles on Catalina Island to determine the location of breeding pairs and their respective nest sites began in February 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 as closely as possible 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.

We replaced eggs laid by nesting pairs with artificial eggs within 2-3 days of the date that eagles were confirmed incubating. After the adults had incubated the artificial eggs > 30 days we replaced the eggs with healthy chicks. We returned to the nests when chicks were 8-9 weeks of age to equip birds 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 by monitoring nests for approximately 8 hours/day for 2-7 days/week. The sex of adult birds was determined by the presence of patagial wing markers. We recorded the exact times that adults laid on and stood from the eggs, the cardinal direction that each bird faced during the respective incubation period (i.e., N, NE, E, SE, S, SW, W, NW), and the frequency that birds probed the nest and 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. To determine if orientation of incubating eagles was associated with time of day, we pooled sexes and used a chi-square contingency analysis to test if the orientation of incubating eagles differed within 3-hour time intervals (0600-0859, 0900-1159, etc.).

Chick Rearing and Nestling Behavior

We monitored behavior of chicks and adults following the fostering of chicks to the nest using interval sampling (Tacha et al. 1985). Postures and behaviors (See Appendix I) of chicks and any adults on the nest were recorded at 1-minute intervals, and sampling was conducted 5-7 days/week, up to 6 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 nest. We calculated mean rates of prey delivery for each nest as the number of items delivered/the amount of time the nests were observed. We also collected prey remains when we visited the nest and had them identified by J. Schmidt. 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.

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, posture, behavior, and perch type at the time of initial observation, and also recorded observations of foraging behavior and interaction with other eagles.

Release of Additional Eagles

No additional eagles were introduced on the island this year through “hacking”, a procedure by which fledgling birds are reared on artificial nest towers and then released.

Capture of Resident Adult Eagles

We captured resident adult eagles on Catalina Island using floating-fish snares (Cain and Hodges 1989, Jackman et al. 1993). We removed expired radio transmitters from captured birds, and attached color leg-bands and numbered wingmarkers.

Collection of Tissue Samples

We collected 5-10cc of blood for contaminant and DNA during banding activities of juvenile and adult 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 during February 1997 in two previously occupied territories: Twin Rocks and Pinnacle Rock (Fig.1).

Twin Rocks

This pair of eagles was first sighted on 6 February in the vicinity of Twin Rocks (Fig. 1). Although the identification of the female was not conclusively determined (no wing markers), the pair was thought to be the same individuals that nested there in 1996 (Phillips and Garcelon 1996). The birds selected the same nest that was used in this territory in 1984, 1985, and 1996, located in an oak (*Quercus* sp.) tree on Twin Rocks, approximately 150 m above the water.

On 6 February we discovered an egg in the nest while attempting to install a camera system. We left immediately, but the birds did not return and no eggs were seen in the nest the next day. We again observed the birds in incubating posture on 17 February. On 18 February, biologists entered the nest at 1600 and removed two eggs. The birds apparently abandoned the nest following the egg removal, although the adult birds remained in the area of Twin Rocks. Upon delivery of the eggs to the ACC, it was determined that both eggs were fertile, but that they had lost about 11% of their total weight during the first 6-10 days of incubation. Healthy eagle eggs generally lose about 15% of their weight during the entire 35-day incubation period (K. Hobson, personal communication). One of the eggs was successfully hatched by the ACC on 17 March and was fostered into the Pinnacle Rock nest (see below). This chick is a second generation Catalina Island bird because the breeding male (K-33) was hatched from an egg in the Seal Rocks territory in 1992. The embryo from the second egg died at the ACC on 2 March (K. Hobson, personal communication).

Pinnacle Rock

The Pinnacle Rock pair selected the same nest site used in 1996 (Phillips and Garcelon 1996). The 11-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 12-year-old bird hacked at the Bullrush tower in 1985. We located the nest on 25 February approximately 125 m above Binnacle Rock, positioned on a small dirt spline that protruded from a steep slope. 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.

We replaced three eggs laid in the Pinnacle Rock nest with two artificial eggs on 28 February. The eggs were transported to the ACC and two of the eggs were determined to be fertile. The infertile egg had a small puncture and was leaking albumen. One of the fertile eggs had a small crack that was repaired with wax, but the embryo died on 11 March (Day 12-14 of incubation). The remaining embryo developed until 29 March, but died on Day 32 of incubation (K. Hobson, personal communication).

On 31 March, we introduced one chick (13 days old from Twin Rocks' egg) into the nest, which was accepted by the adults approximately 20 min after being placed in the nest. We entered the nest on 12 May to install leg bands, a transmitter, and wingmarkers on the chick, and to sample blood. Monitoring of this nest lasted from 31 March until the eagle fledged on 11 June (Table 2).

Table 2. Biographical data for bald eagle chick fostered into the Pinnacle Rock nest on Santa Catalina Island, California during 1997.

USFWS Band	Color Band	Wing Marker	Date Fledged	Status[a]	Comments
629-39810	O/S Orange	K-71	6/11/97	Alive	Hatched from egg collected at Twin Rocks. Left island on or about 31 July 1997.

[a] As of 9/22/97.

West End Territory

The same nest in the West End territory has been active each year since 1991, but was not used this year, although three adult eagles were observed in the area throughout the season. We were unable to locate any other nests and observed no breeding behavior.

China Point Territory

A pair of adult eagles observed in the China Point territory in 1996 were again seen in 1997. The female of this pair was believed to be a bird fostered into the West End nest in 1991 (unable to read wing marker). The male is a second generation bird that hatched from an egg from the West End territory and was fostered into the Pinnacle Rock nest in 1992. This pair was observed near China Point in February 1997 and we observed a single bird on 4 occasions in March 1997, but repeated searches from the ground, water, and air failed to relocate the pair until they were found at Seal Rocks on 23 March 1997 (Fig. 1). There was no indication of nesting activity at the time we relocated the pair. The pair was seen repeatedly in the Seal Rocks area through 26 April 1997 and the male was captured there on 23 June 1997 (see below).

Seal Rocks Territory

We saw no eagles other than the China Point birds in the Seal Rocks territory in 1997. It appears as though the China Point birds may take up residence in this territory.

Incubation Behavior

We monitored the incubation behavior of the nesting pair at Pinnacle Rock for 19 days between 26 February and 30 March 1997. We were able to determine the sex of the incubating adult in all cases because the male had wingmarkers (K-65) and the female had none.

Length of complete incubation bouts were not correlated with day of incubation for the female (r_s = 0.11, *P* = 0.68, *n*=17 bouts) or male (r_s = 0.05, *P* = 0.88, *n* = 12 bouts). There was a tendency for the length of a bout to increase until the midpoint of incubation and then decline (*P* = 0.05; Fig. 2). We detected no sex-specific difference (*P* > 0.96) in length of incubation bouts (Table 3).

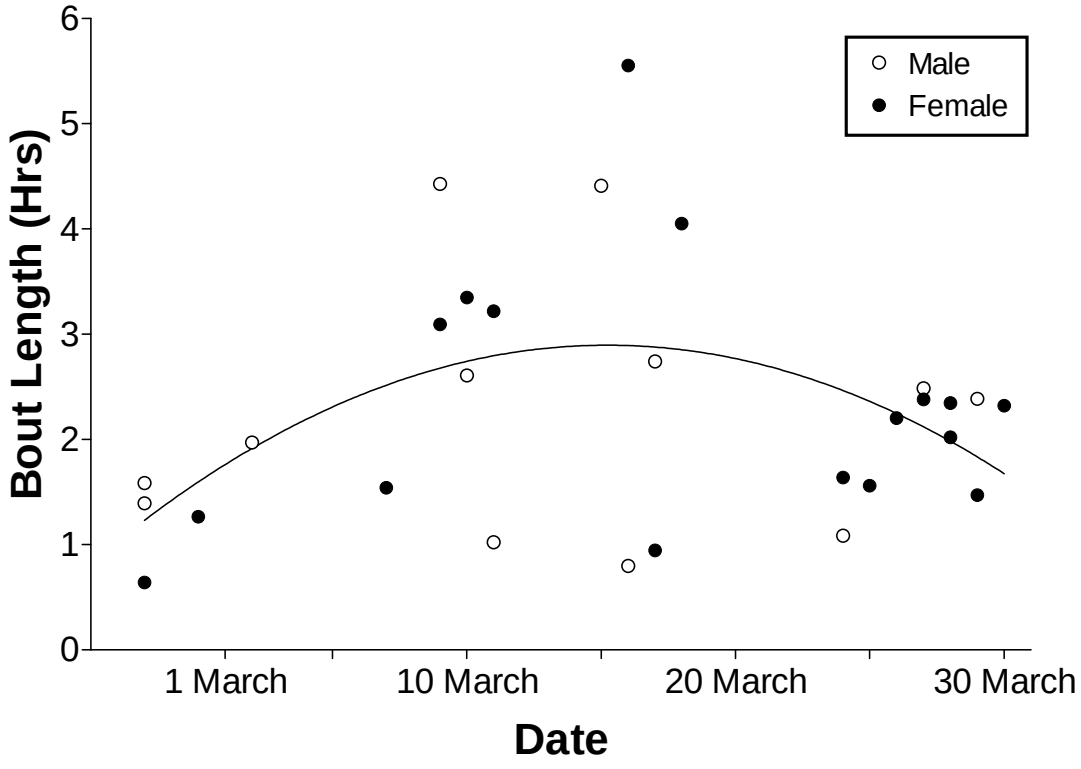

Figure 2. Relationship between length of complete incubation bouts ($\bar{x}$ ± 1 SE) and date for adults at the Pinnacle Rock nest on Santa Catalina Island, CA, 1997.

Table 3. Number (n) and mean, standard deviation (SD), and range of length of complete incubation bouts (hrs:minutes) for male and female eagles observed during incubation at the Pinnacle Rock territory on Santa Catalina Island, 26 February - 30 March 1997.

	Male				Female			
Territory	n	Mean	SD	Range	n	Mean	SD	Range
Pinnacle Rock	12	2:15	1:13	0:48 - 4:26	17	2:20	1:14	0:39 - 5:33

At the Pinnacle Rock territory, the orientations of the eagles during incubation did not differ depending on time of the day ($P = 0.95$). However, the orientations used did differ from random (Chi-square Goodness of Fit; $P < 0.001$). The pair tended to use SW, W, and NW orientations less and N, NE, and E orientations more than would be expected if orientations were chosen at random (Fig. 3).

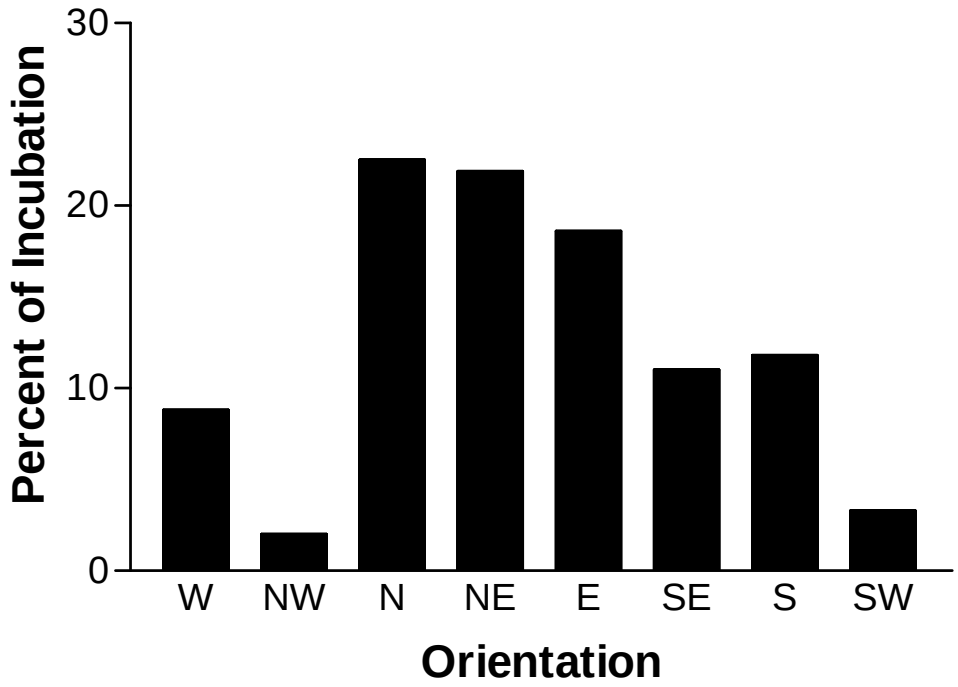

Figure 3. Frequency distribution of the orientation of incubating bald eagles at the Pinnacle Rock nest, Santa Catalina Island, CA, 1997.

Chick Rearing and Fledgling Behavior

Pinnacle Rocks

The Pinnacle Rock birds were successful in fledging the chick fostered into their nest and we observed behavior at the nest for 65 days between 31 March and 10 June 1997. The female spent a significantly greater portion of her time at the nest (57%) than did the male (20%, $P < 0.0005$). Both adults had significant negative linear relationships ($P < 0.0001$) between time spent at the nest and date, slowly decreasing time at the nest as the chick aged (Fig. 4).

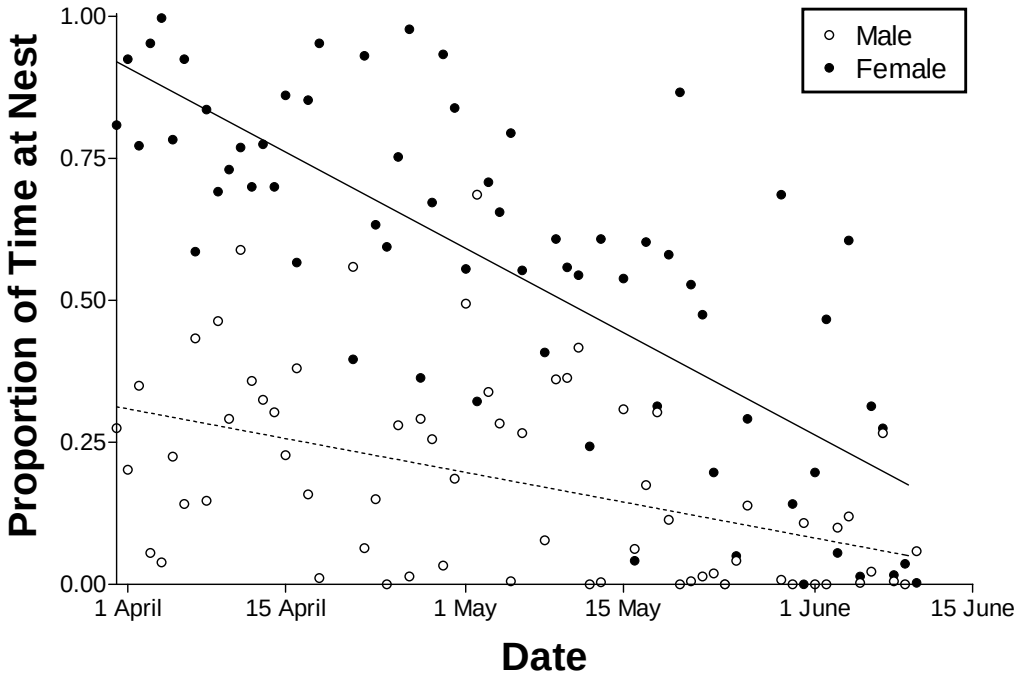

Figure 4. Proportion of time spent at the Pinnacle Rock nest by adult bald eagles. The chick was fostered into the nest on 30 March and fledged on 11 June 1997. The lines are the best fit for the male (-----) and female (—).

The proportion of time spent standing by the chick increased rapidly between the ages of approximately 38 and 71 days, eventually leveling off at about 80% (Fig. 5). The chick was observed feeding on its own as early as 17 days of age, but did not feed itself regularly until approximately 59 days of age (Fig. 6).

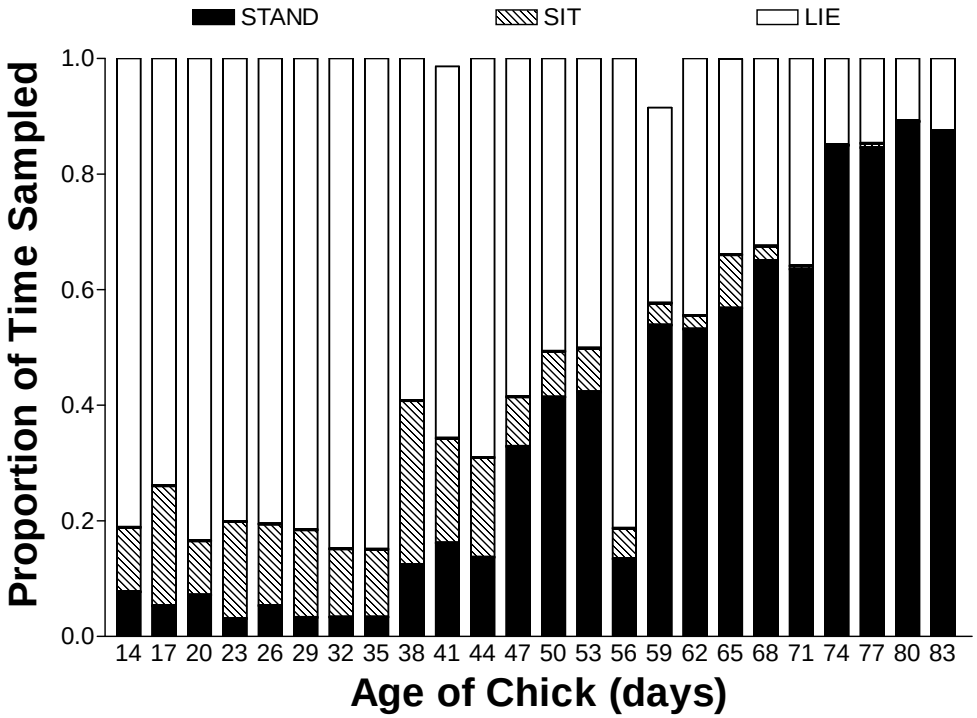

Figure 5. Proportion of time spent in three major postures by a bald eagle chick in the Pinnacle Rock territory, 1997. Observations are summarized for 3-day periods (reported age ± 1 day).

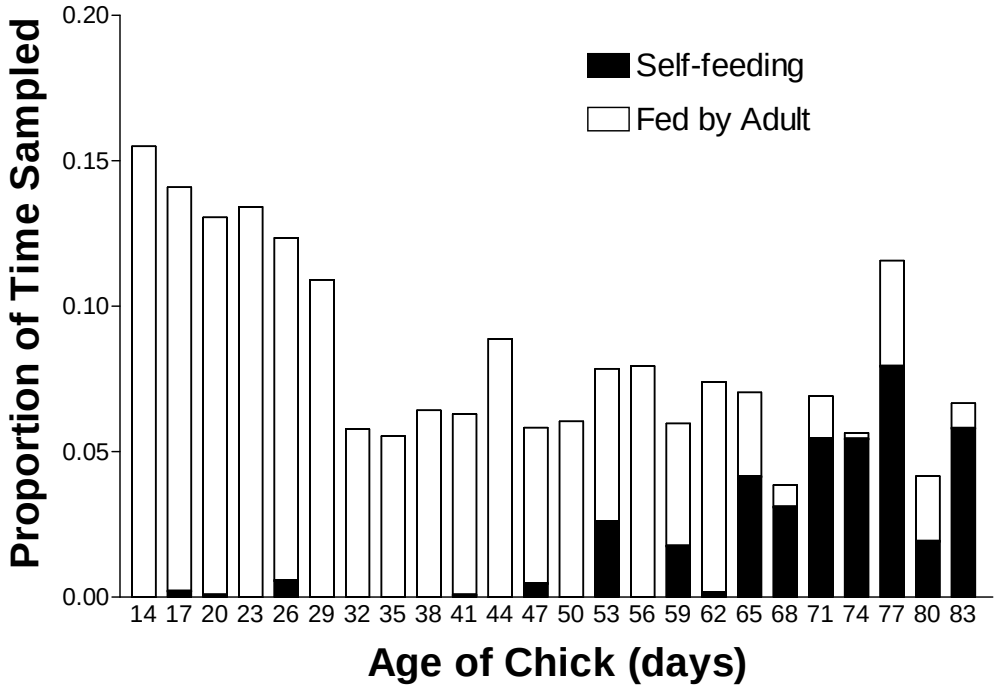

Figure 6. Proportion of time spent being fed by adult eagles or self-feeding by an eagle chick at the Pinnacle Rock territory, 1997. Observations are summarized for 3-day periods (reported age ± 1 day).

Prey Deliveries

We observed the Pinnacle Rock nest for 413 hours, during which time 137 prey items were delivered (0.33 items/hr). The proportion of prey deliveries made to the nest by each memeber of the pair was highly skewed towards the male, who made 80.8% of observed prey deliveries. We we calculated prey delivery rates by day there was a nearly significant negative linear relationship with date (P = 0.06; Fig. 7).

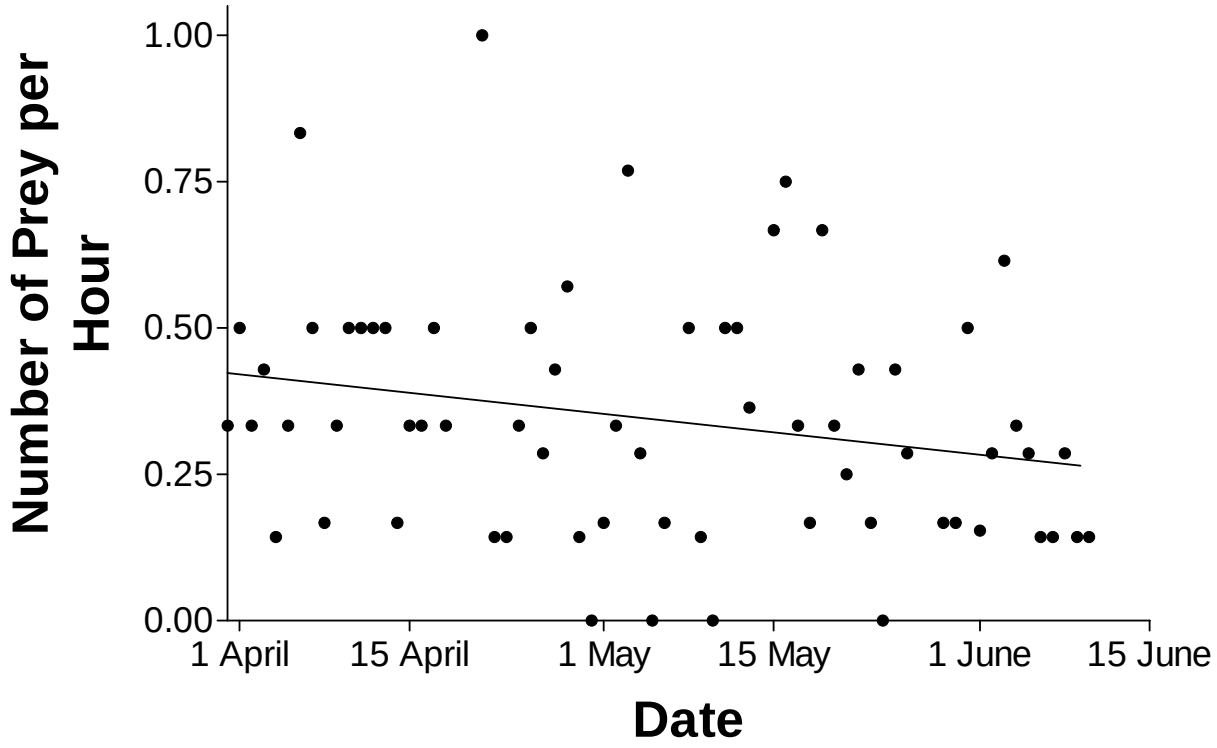

Figure 7. Relationship between the date and the number of prey delivered per hour to the Pinnacle Rock nest by adult bald eagles. The chick was fostered into the nest on 30 March and fledged on 11 June 1997.

Because of the brief period of time that prey were visible when delivered to the nests and the lack of a camera system at the nest, identification of prey items to Family or Genus was possible for only 37 of 137 (27.0%) observations at the Pinnacle Rock nest (Table 4). For 127 of 137 deliveries (92.7%) we were able to determine the Class of the prey. Of those prey identified to Class, 92.2% were fish, 7.1% were birds, and 0.8% were mammals (Table 4). During visits tothe Pinnacle Rock nest, we recovered remains of several species that were not detected during nest observations, as well as several that were conclusively identified (Table 5).

Table 4. Number and percent of food items delivered to the Pinnacle Rock nest in 413 hours of monitoring on Santa Catalina Island, California, 1997.

	Prey deliveries	
Food Item	Number Delivered	Percent of Total
FISH		
Unknown fish	86	62.8
Mackerel (*Scomber* spp., *Trachurus* spp.)	9	7.7
Kelp bass (*Paralabrax clathratus*)	6	4.4
Garibaldi (*Hypsypops rubicundus*)	3	2.2
Unknown surfperch (various spp.)	3	2.2
Unknown bass (*Paralabrax* spp.)	2	1.5
Northern anchovy (*Engraulis mordax*)	2	1.5
California sheephead (*Semicossyphus pulcher*)	1	0.7
Halfmoon (*Medialuna californiensis*)	1	0.7
Calico surfperch (*Amphistichus koelzi*)	1	0.7
Horn shark (*Heterodontus francisci*)	1	0.7
Olive rockfish (*Sebastes seranoides*)	1	0.7
Fish Subtotal	117	84.7
BIRDS		
Gulls (*Larus* spp.)	5	3.6
Unknown birds	2	1.5
Cormorants (*Phalacrocorax* spp.)	1	0.7
California gull (*Larus californicus*)	1	0.7
Birds Subtotal	9	7.3
MAMMMALS		
Unknown	1	0.7
Mammals Subtotal	1	0.7
UNKNOWN FOOD ITEMS	10	7.3
Total Food Items	137	

Table 5. Species of prey items recovered from Pinnacle Rock nest on Santa Catalina Island, California during 1997.

Species	Number
BIRDS	
Western gull (*Larus occidentalis*)	5
Sooty shearwater (*Puffinus griseus*)	2
Cassin's Auklet (*Ptychoramphus aleuticus*)	1
FISH	
Sharks (*Mustelus* sp.)	1
Shovelnose guitarfish (*Rhinobatos productus*)	1
MAMMALS	
Goat (*Capra hircus*)	1

Post Fledging Behavior

The Pinnacle Rock chick fledged on 11 June (see Table 2). An adult was usually near the eaglet immediately following its fledging, but they began leaving it alone for longer periods as the eaglet aged. From our observation points we could see and hear the eaglet vocalizing frequently. We observed the adults delivering prey to the eaglet on many occasions, but the eaglet was never seen acquiring its own food. However, it was seen walking along the beach several times, perhaps scavaging for food, and was seen standing next to a decomposing seal or sea lion carcass on the beach on 8 July. Although we observed the eaglet in flight for short periods of time (usually less than 5 min), radiotelemetry locations and observations of the bird indicated that it remained in close proximity to the nest canyon (within 1 km) until 30 July. On 1 August, a faint signal was received from a direction due north of the nesting area. Repeated searches of the island from both the land and water failed to relocate the fledgling, so it is believed that it left the island on 31 July or 1 August. On 11 August this bird was reportedly seen at Point Arena, CA (J. Gore, personal communication), approximately 760 km northwest of Catalina Island. It was seen again on 22 September near Goleta, CA (R. Mesta, personal communication), approximately 170 km northwest of Catalina Island and 40 km north of Santa Cruz Island.

Release of Additional Eagles

The ACC was unsuccessful at producing chicks for hacking activities this year. The single captive-reared chick that was to be brought to Catalina Island in June 1997 was found to have a leg injury about one week prior to transport to the island, and was later determined to be a poor candidate for release (J. Aiken, personal communication).

Capture of Resident Adult Eagles

Trapping was conducted for six days (20-25 June 1997), resulting in the capture of three resident adult eagles on Catalina Island (Table 6). We installed color leg bands and new wingmarkers, removed expired transmitters, and sampled blood for contaminant analysis. Two of the adult eagles captured were part of the original 33 eagles introduced to the island from 1980-1986.

Table 6. Biographical information for resident adult bald eagles captured on Santa Catalina Island, California during 1997.

USFWS Band	Sex	Color Band	Date of Capture	Blood Drawn	Area Trapped[1]	Location and Year of Initial Release	Comments
629-16084	F	5/W	6/20/97	11.0cc	West End	Sweetwater Hacktower 1986	Installed K-69 wingmarkers
629-19925	M	7/M	6/23/97	10cc	Seal Rocks	Pinnacle Rock 1992	Removed expired transmitter, Reinstalled K-25 wingmarkers.
629-16077	F	7/K	6/24/97	7.5cc	Torqua Springs	Bullrush Hacktower 1984	Installed K-17 wingmarkers.

[1] See Figure 1 for general locations

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 18 May 1997 near Lower Buffalo Corral Reservoir by IWS employee S. Escover (personal communication). A subadult with no wing markers has also been observed by IWS personnel near the West End of Catalina Island on several occasions.

Collection of Tissue Samples

We collected blood samples for chemical analyses from three adult and one juvenile bald eagle on Catalina Island this season. In addition, the ACC collected the egg contents and embryos from 2 of the 5 eggs collected on Catalina Island (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. Four of 5 eggs recovered during 1997 were fertile; however, only one hatched. This is only the fourth of 28 fertile eggs removed from wild nests on Catalina Island since 1987 to hatch (14% 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 Twin Rocks nest following egg removal, the egg and chick manipulations during 1997 were successful, as we were able to hatch and foster the first chick from a Catalina Island nest since 1992. Removal of eggs from bald eagle nests may cause abandonment of nests in some cases (Anthony et al. 1994). Bald eagles on Catalina Island rarely abandon nests following our manipulations, probably because we are able to access nests quickly, whereas Anthony et al. (1994) required several hours at the nest site to climb the trees. We expect productivity at the Catalina Island eagle nests to be higher in 1998, assuming that the captive eagles at the ACC resume normal production, and that pair bonds of the adult eagle pairs on Catalina Island are maintained. Because there were breeding activities about a month earlier than normal this year (i.e. the Twin Rocks nest), we will begin searching for breeding activity in mid-January next year to 1) avoid missing active nests and 2) 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; however, our data contradict reports that female eagles incubate a greater percentage of the time than males (Gittens 1968); the male and female eagles at Pinnacle Rock 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). Although the length of incubation bouts at Pinnacle Rock were slightly longer during the middle portion of incubation, results from this and previous year (Phillips and Garcelon, 1995, 1996) lead us to believe that incubation behavior is consistent throughout the natural incubation period (Keister and Anthony 1983).

The eagles at Pinnacle Rock demonstrated an avoidance of westerly orientations during incubation. However, this is likely a result of their nest location. Orienting in a westerly direction would result in the birds facing the slope on which their nest was located, severely limiting their view of their surroundings.

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. At the Pinnacle Rock nest, the male delivered a much higher proportion

of the prey to the nest and spent a much lower proportion of his time in attendance at the nest.

Our data support our 1995 and 1996 findings (Phillips and Garcelon 1995, 1996) that at approximately 45-50 days, chicks begin standing and exercising wings more frequently, and also begin eating independently. 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 in 1995 (Phillips and Garcelon 1995), we detected no correlation between daily rates of prey delivery and the age of chicks in the nest; therefore, we assumed that delivery rates were constant as chicks grew. Fish are an important component in the diet of chicks on the nest, comprising 85% of deliveries to the nests. The implications of potential organochlorine contaminant loads in prey obtained in the marine environment (fish, birds, marine mammals), are discussed by Garcelon (1997).

The prey delivery rate at the Pinnacle Rock nest this season (0.33 items/hr) indicates that prey items are brought to the nest an average of about 4 times per day (assuming a 12-hour active period). This delivery rate is consistent with the rates recorded for the same nesting pair in 1995 and 1996 (0.34 items/hr in both years; Phillips and Garcelon 1995, 1996) and is in agreement with other studies of bald eagles during the chick rearing period (Cain 1985, Kozie 1986) where 5 or 6 prey items were brought to the nest each day. Considering only prey identified to taxa, fish comprised a slightly greater proportion of identified prey delivered in 1997 (92.1%) than in 1995 (82.8%; Phillips and Garcelon 1995) or 1996 (84.6%; Phillips and Garcelon 1996), whereas birds and mammals represented a slightly smaller proportion of the 1997 prey deliveries (birds: 14.1, 12.8, and 7.1% in 1995-1997, respectively; mammals: 3.1, 2.6, 0.8% in 1995-1997, respectively; Phillips and Garcelon 1995, 1996).

Release of Additional Eagles

Release of additional eagles through hacking has been 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 because humans are not responsible for feeding the chicks, hacking 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. This technique will be employed next season, as necessary, based on the timing and availability of eaglets captive bred at the San Francisco Zoo.

CONCLUSIONS

Efforts to maintain the reintroduced population of bald eagles on Catalina Island were successful in 1997. However, modeling the population by incorporating productivity, survival rates, and probability of juveniles returning to Catalina Island may reveal insights into the long term viability of this program. If nest manipulations cannot provide sufficient productivity to maintain the population over time, additional effort should be directed at release or introduction of additional juvenile birds.

Failure to hatch of three of the four fertile eggs collected in 1997 underscores the continued contaminant related productivity problems faced by this population. Without an aggressive management strategy it is highly doubtful that any nests on the island would produce offspring. Therefore, continued fostering of chicks hatched in captivity is necessary to ensure the continued availability of nesting adult birds on Catalina Island, and efforts should be maintained to secure chicks in 1998. 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.
Prey Delivery (PD):	Bird bringing prey to nest.
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.
Flap Wings (FL):	Flapping wings with feet touching nest.
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.
Vocalizing (V):	Head back, and appearing to vocalize.
Out-of-view (O):	Bird is blocked from view by adult.
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 adult).

Appendix II

Specimens collected from bald eagles on Catalina Island, CA for chemical analyses in 1997.

Tissue Type	Collection Location	Description
Red and White Blood Cells	Pinnacle Rock Nest	2.5 cc from 8-week old eaglet (K-71)
Whole Blood	Pinnacle Rock Nest	5 cc from 8-week old eaglet (K-71)
Plasma	Pinnacle Rock Nest	2.5 cc from 8-week old eaglet (K-71)
Red and White Blood Cells	Seal Rocks	2.5 cc from 5-year old male (K-25)
Whole Blood	Seal Rocks	5 cc from 5-year old male (K-25)
Plasma	Seal Rocks	2.5 cc from 5-year old male (K-25)
Red and White Blood Cells	Torqua Springs	2 cc from 13-year old female (K-17)
Whole Blood	Torqua Springs	3.5 cc from 13-year old female (K-17)
Plasma	Torqua Springs	2 cc from 13-year old female (K-17)
Red and White Blood Cells	West End	3.5 cc from 11-year old female (K-69)
Whole Blood	West End	5 cc from 11-year old female (K-69)
Plasma	West End	2.5 cc from 11-year old female (K-69).
Egg and Embryo[a]	Twin Rocks Nest	Fertile egg that did not hatch. Sample frozen. Designated SFZoo/ACC egg # 3-97.
Egg Contents[a]	Pinnacle Rock Nest	Fertile egg that did not hatch. Sample frozen. Designated SFZoo/ACC egg # 6-97.
Embryo[a]	Pinnacle Rock Nest	Died on day 32-33 of incubation. Placed in formalin. Designated SFZoo/ACC egg # 6-97.

[a] Collected by staff at San Francisco Zoo