Restoration and Management of Bald Eagles on Santa Catalina Island, California, 2001

A Report Prepared for:

U.S. Fish and Wildlife Service
Damage Assessment Branch
Sacramento Fish and Wildlife Office
2800 Cottage Way, Room W-2605
Sacramento, California 95825

Prepared by:

Peter B. Sharpe, Ph. D. and Jessica Dooley
Institute for Wildlife Studies
Post Office Box 1104
Arcata, California 95518

October 2001

Restoration and Management of Bald Eagles on Santa Catalina Island, California, 2001.

INTRODUCTION

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

Since 1989, the reintroduced population has been maintained through manipulations of eggs and chicks at each nest site and through additional hacking of birds (Table 1). Because of the high DDE concentrations in the eggs, this active program of manipulation and augmentation is the only way to maintain the Catalina Island bald eagle population at this time. In the egg manipulation process, artificial eggs are substituted for the structurally deficient eggs laid by the birds affected by DDE. The adult eagles continue to incubate the artificial eggs while the removed eggs are relocated and artificially incubated at the Avian Conservation Center (ACC) at the San Francisco Zoo. Chicks that hatch from these removed eggs, or those produced by captive adults at the ACC or by wild birds, are then placed in the nests containing artificial eggs. Adult eagles on Catalina Island have successfully reared 26 of 33 chicks fostered into nests between 1989 and 2001 (Table 1). Two of these 33 birds were removed from the nest prior to fledging because of injuries, two died accidental deaths, one bird was killed by a red-tailed hawk (*Buteo jamaicensis*) only four days after being fostered into the nest (Perkins et al. 1996), one chick was killed by the nesting female on the day the chick was fostered into the nest, and one chick disappeared from the nest under unknown circumstances (Table 1). Further, of three healthy eggs introduced to nests, two have resulted in successfully reared chicks (Table 1). Continued hacking activities have also resulted in the release of an additional 19 eagles since 1991 (16 chicks and a 1-year-old bird; Table 1).

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

Table 1. Summary of Bald Eagle egg and chick manipulations on Santa Catalina Island, 1989-2001.

	Year												
	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
# of Active Nests	1	2	2	3	3	2	3	3	2	3	4	3	4
# of Eggs Laid	2	2-3	3	5	5-6	3	5	5-6	6	7	8	7	8
# of Eggs Collected	1	1	3	5	4	3	5	4	5	6	6	4	7
# of Catalina Island Eggs Hatched[a]	0	0	1	2	0	0	0	0	1	1	1[g]	2[g]	0
# of Eggs Fostered Into Nests on Catalina Island	0	0	2	0	0	0	1	0	0	0	0	0	0
# of Chicks Fostered Into Nests on Catalina Island	1	0	2	3	2[b]	2[c]	1	5[d]	1	4[e]	3[f]	4	5
# of Chicks Fledged From Nests on Catalina Island	1	0	2	3	1	1	1	2	1	3	2	4	5
# of Eagles Hacked Onto Catalina Island	0	0	2	0	2	0	2	4	0	4	2	0	4
# of Island-Produced Eagles Breeding on Island	0	0	0	0	0	0	0	0	1	1	2	1	2
# of Second Generation Eagles Fledged	0	0	0	0	0	0	0	0	1	0	0	0	0

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

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

[c] One chick died during severe storm.

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

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

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

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

The purpose of this project is to maintain the breeding bald eagles on Catalina Island in the interim between completion of the injury assessment studies and the full-scale environmental restoration program now being planned. This report summarizes the results of the egg and chick manipulations and subsequent monitoring for the nesting season of 2001. 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 healthy chicks into active nests, (4) collect tissues (blood, prey items, non-hatching eggs and embryos) for analyses of contaminants, (5) quantify incubation behavior, (6) quantify the behavior of adults and chicks between the time of hatching and fledging, (7) identify food items and quantify the rate at which prey deliveries were made to the nest, (8) release additional eagles on the island by using artificial nest platforms, and (9) monitor movement and behavior of all chicks fledged from wild and artificial nests on the island.

STUDY AREA

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

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

Nesting Territories

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

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

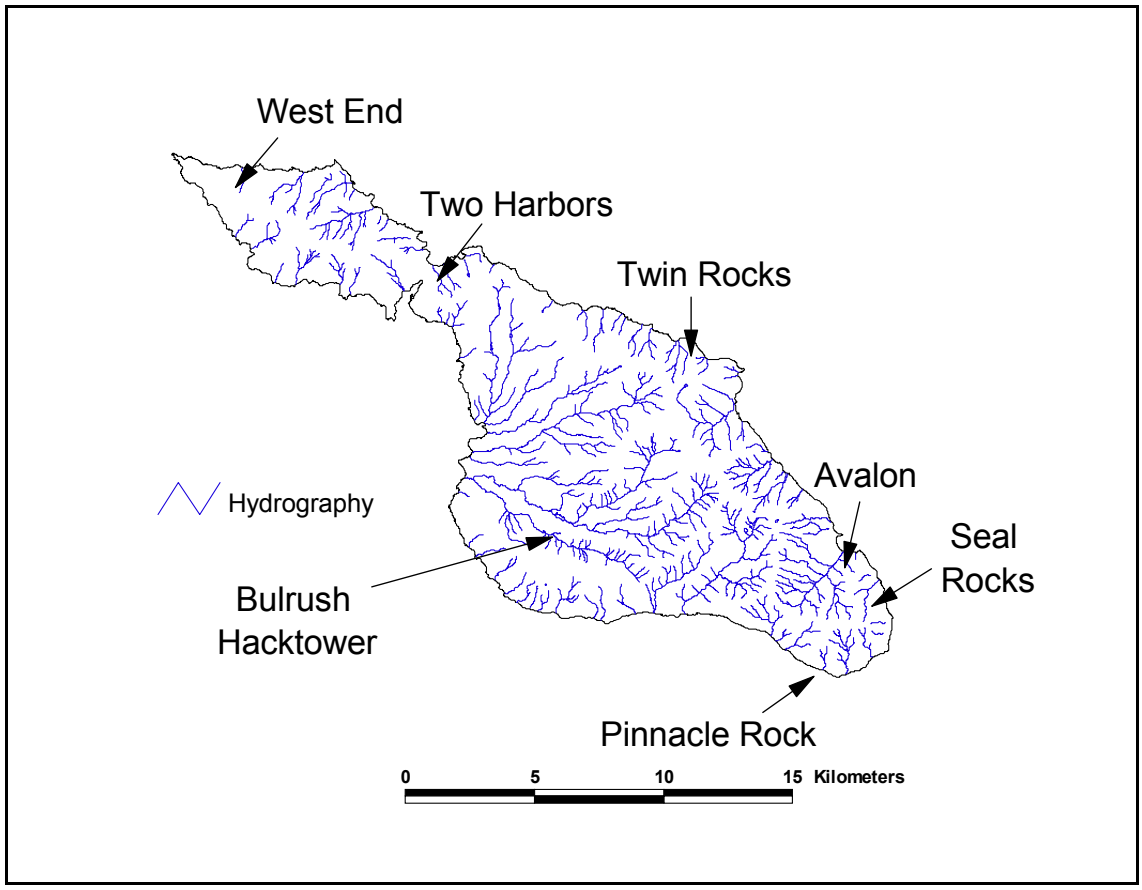

Figure 1. Map of Santa Catalina Island, CA showing the locations of bald eagle territories and points of reference.

The Pinnacle Rock territory is located 4.3 km southwest of the city of Avalon, extending from Silver Canyon to approximately 1 km east of the East End Light (Fig. 1). It was initially occupied in 1990 by a 5-year old female and a 4-year old male, and this territory has contained active nests each year since 1990. From 1991-93, the foraging area of the pair covered a linear distance of 3.5 km extending northwest from Binnacle Rock. The pair has remained intact and has used six different nests within this territory from 1990-2001 (Phillips and Garcelon 1996, Sharpe and Garcelon 1999, 2000).

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

the nest approximately 8 hours later (Sharpe and Garcelon 1999). The pair accepted a single chick fostered into the nest in 1999, but the chick disappeared from the nest after approximately two weeks (Sharpe and Garcelon 2000). In 2000 the pair successfully fledged a chick fostered into the nest.

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

METHODS

Manipulations

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

We replaced eggs laid by nesting pairs with artificial eggs within 2-3 days of the date that eagles were confirmed incubating. We replaced the artificial eggs with healthy chicks (Fig. 2) after the adults had incubated approximately 30 days and returned to the nests when chicks were 8 weeks of age to equip them with federal and colored leg bands, wing markers, and a backpack-style

radio-transmitter. At this time we also collected a blood sample (~10 cc) for contaminant analyses and made morphological measurements to determine sex (Bortolotti 1984, Garcelon et al. 1985).

Incubation Behavior

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

Figure 2. Two chicks being fostered into West End nest. Note artificial eggs in the nest.

We used Spearman's Rank Correlation procedure (SYSTAT v. 9.0) to test for correlation of the site-specific length of complete incubation bouts over time. We defined complete incubation bouts as those in which we observed the incubating bird both start and end its attendance at the nest (i.e. switch with its mate). We used the Mann-Whitney U-test (SYSTAT v. 9.0) to evaluate sex-specific differences in duration of complete incubation bouts.

Chick-Rearing and Nestling Behavior

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

Prey Deliveries

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

Post-Fledging Behavior

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

Figure 3. Hacktower used to release additional bald eagles.

Release of Additional Eagles

Additional bald eagles were released on the island this year through "hacking," a procedure by which fledgling birds are reared on artificial nest towers (Fig. 3) and then released (see Garcelon 1988).

Collection of Tissue Samples

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

RESULTS

Manipulations and Nest Monitoring

Nests were located from February-March 2001 in four previously occupied territories: Twin Rocks, Pinnacle Rock, Seal Rocks, and West End (Fig.1).

Twin Rocks

The territory was used by the same pair that used it in 1998-2000 (Sharpe and Garcelon 1999, 2000). The male (K-33) was a bird that hatched from a Catalina egg in 1992 and the female (K-17) was a bird released at the Bulrush hacktower in 1984. In early February, the pair was seen working on the same nest that they used in 2000. The pair worked on the nest until 5 February, when they were observed exhibiting incubation behavior and one egg was confirmed to be in the nest. A second egg was seen in the nest on 6 February and we entered the nest via helicopter at 1345 h on 8 February and removed two eggs. Both eggs were fertile and were artificially incubated at the ACC, but neither egg hatched.

A chick produced by captive bald eagles at the ACC was fostered into the Twin Rocks nest at 1200 h on 17 March. The female returned within one minute and began brooding. We returned to the nest on 2 May to install leg bands, transmitter, and wingmarkers on the chick and to obtain a blood sample (Table 2). We continued monitoring the nest until the chick fledged on or about 30 May.

Table 2. Biographical data for bald eagle chicks successfully fostered into nests on Santa Catalina Island, California during 2001.

Federal Band	Color Band	Wing Marker	Date Fledged	Foster Nest	Status[a]	Comments
629-02780	6/T	K-10	5/30/01	Twin Rocks	Unknown	From captive pair at ACC. Left island around 17 July.
629-02781	6/X	K-11	6/12/01	West End	Unknown	From captive pair at ACC. Left island around 28 August.
629-02782	6/W		6/17/01	West End	Dead	Found dead in Twin Rocks territory on 16 July.
629-02783	6/P	K-13	6/13/01	Pinnacle Rock	Alive	From captive pair at ACC.
629-02784	6/S	K-16	7/5/01	Seal Rocks	Unknown	From captive pair at ACC. Left island around 7 September.

[a] As of 10/15/01

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 20-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 15-year-old bird released at the Sweetwater hacktower in 1986. The second, non-breeding female (referred to as Female 2 hereafter) is a 15-year-old bird (patagial tag K-69) that was also released at the Sweetwater hacktower in 1986. Incubation behavior was first observed on 14 February and we replaced two eggs with artificial eggs on 19 February. Only one of the eggs showed signs of development, but it did not hatch.

Two ACC-produced chicks were fostered into the West End nest on 3 April. On 15 May, we returned to the nest to install leg bands, transmitters, and wingmarkers on the chicks and to obtain blood samples (Table 2, Fig. 4). We continued monitoring the nest until the chicks fledged between 12 and 17 June.

Figure 4. Removing chicks from West End nest during banding.

Pinnacle Rock

The Pinnacle Rock pair used the same nest as in 2000. The 15-year-old male (K-65) was hacked at the Bulrush tower in 1986. The female, who has lost her wing markers, is believed to be a 16-year-old bird hacked at the Bulrush tower in 1985. The birds were first seen at the nest on 2 February. On 22 February a single egg was seen in the nest, but it had disappeared by the next day. Another egg was observed in the nest on 1 March and it was removed via helicopter on the same day. The female returned to the nest within 1 min of the helicopter's departure and began incubating the artificial eggs. The removed egg showed signs of development but it did not hatch.

On 4 April, we introduced one chick into the nest, again using a helicopter. We entered the nest on 22 May to install leg bands, a transmitter, and wingmarkers on the chick, and to sample blood. Monitoring of this nest continued until the eaglet fledged on or about 13 June (Table 2).

Seal Rocks Territory

The Seal Rocks pair constructed a new nest in a eucalyptus tree southeast of Avalon. The 8-year-old female (K-34) is from the captive ACC eagles and was hacked at the Bulrush tower in 1993.

The 9-year-old male (K-25) hatched from an egg from the West End territory and was fostered into the Pinnacle Rock nest in 1992. The pair was observed working on the nest from 26 February until incubation was confirmed on 18 March. We removed two eggs on 22 March, replacing them with artificial eggs. Neither egg showed signs of development.

A single ACC-produced chick was fostered into the nest on 16 April. We returned to the nest on 6 June to install leg bands, a transmitter, and wingmarkers on the chick, and to sample blood. We continued to monitor the nest until the bird fledged on 5 July (Table 2).

Incubation Behavior

We monitored the incubation behavior at the Twin Rocks nest for 15 days between 6 February and 17 March, at the West End nest for 4 days between 22 February and 3 April, at the Pinnacle Rock nest for 8 days between 2 March and 4 April, and at the Seal Rocks nest for 7 days between 21 March and 16 April. Observations were reduced at the West End nest because the camera system temporarily failed and wet weather conditions did not allow access to the area during much of the incubation period. In all but four cases (all at the West End) we were able to determine the sex of the incubating adult, either by wing markers, leg bands, or size of the bird.

We detected no difference in the length of incubation bouts between the Pinnacle Rock birds ($P = 0.29$), the Twin Rocks bird ($P = 0.72$) or among the West End birds ($P = 0.07$) (Table 3). A complete bout was not recorded for the Seal Rocks male to allow a comparison. When all complete bouts were combined by territory, bout lengths at the West End nest were significantly shorter than at either the Pinnacle Rock or Twin Rocks nests ($P < 0.001$). Bout lengths did not differ significantly between the Pinnacle Rock and Twin Rocks nests ($P = 0.959$). There were no significant correlations between bout length and day of incubation at any nest ($P > 0.65$).

Table 3. Number (n), mean, standard deviation (SD), and range of length of complete incubation bouts (hrs:minutes) for adult eagles observed during incubation at the Pinnacle Rock, Seal Rocks, Twin Rocks, and West End nest on Santa Catalina Island, 2001.

	Male			Female 1			Female 2[a]		
Territory	n	Mean	SD	n	Mean	SD	n	Mean	SD
Pinnacle Rock	7	1:41	0:45	5	2:30	1:18	.	.	.
Seal Rocks	.	.	.	1	0:50	0:50	.	.	.
Twin Rocks	4	2:12	1:11	3	3:06	2:07	.	.	.
West End	5	1:31	0:46	6	0:27	0:19	5	0:29	0:12

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

Chick-Rearing and Fledgling Behavior

We made behavioral observations for 20 days at the Twin Rocks nest (17 March-27 May), 21 days at the Pinnacle Rock nest (5 April-10 June), 30 days at the West End nest (3 April-14 June), and 33 days at the Seal Rocks nest (17 April-2 July). All the chicks fostered into nests this year successfully fledged.

Adult females spent a significantly greater portion of their time at nests than males at the Pinnacle Rock (82% vs. 32%, $P = 0.0001$), Twin Rocks (59% vs. 31%; $P = 0.0029$), and Seal Rocks nests (51% vs. 12%; $P = 0.0001$). At the West End nest there was no significant difference in the amount of time Female 1 and Female 2 spent at the nest (45% and 39%, respectively), but the male spent significantly less time at the nest (19%) than either female ($P \leq 0.015$). There was also a significant negative relationship between time spent at the nest and the age of the chick(s) for all adults ($P < 0.02$), except the Pinnacle Rock male ($P = 0.7689$; Fig. 5).

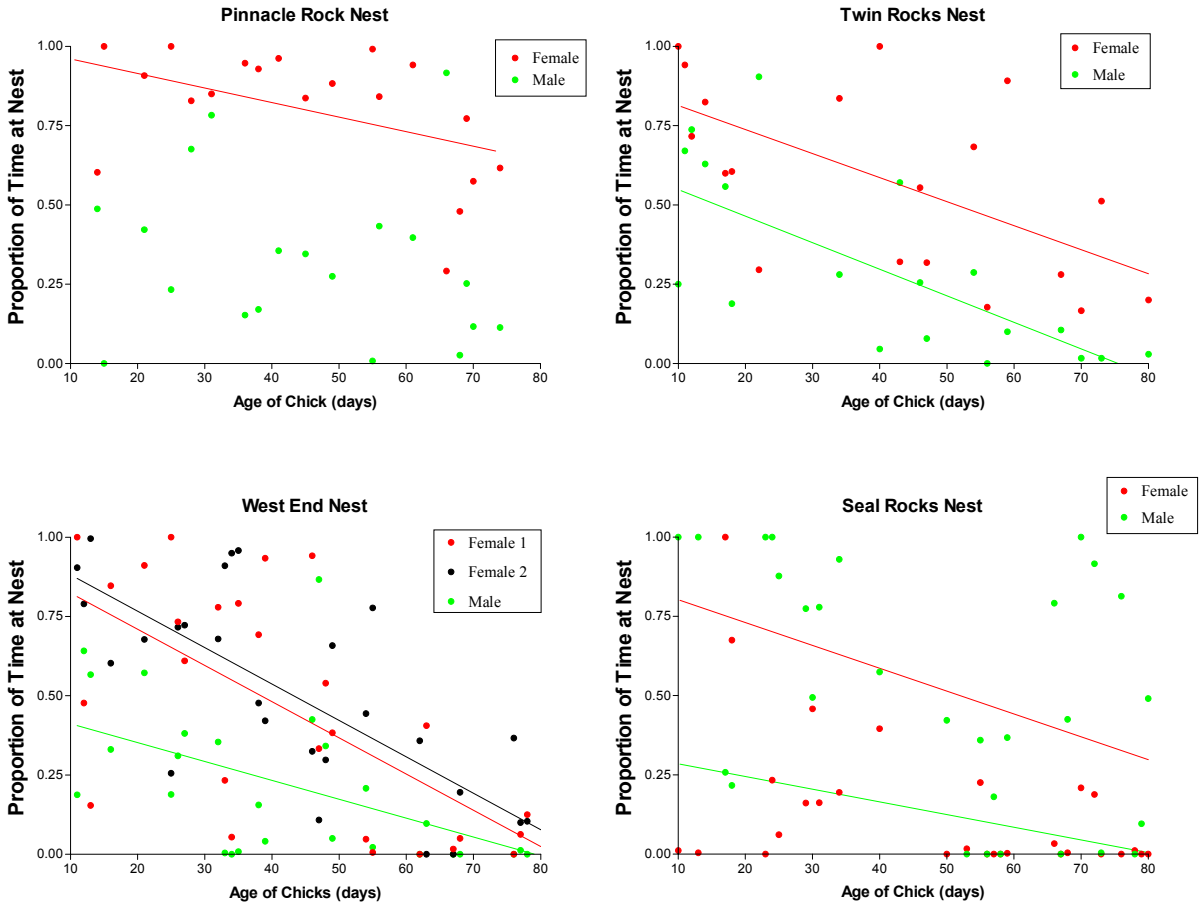

Figure 5. Proportion of time spent by adult bald eagles at the Twin Rocks, Pinnacle Rock, West End, and Seal Rocks nests during chick-rearing. At the West End nest, Female 1 is the breeding female and Female 2 is a non-breeding helper. The lines in the graphs are the best fit for the female (—) and male (—). At the West End nest, there is also line of best fit for the non-breeding female (—).

The proportion of time the chicks spent standing increased rapidly starting at an age of approximately 45 days at all four nests (Fig. 6). The chicks were observed feeding on their own as early as 27 days of age, but self-feeding did not increase substantially until they were about 45-50 days of age (Fig. 7)

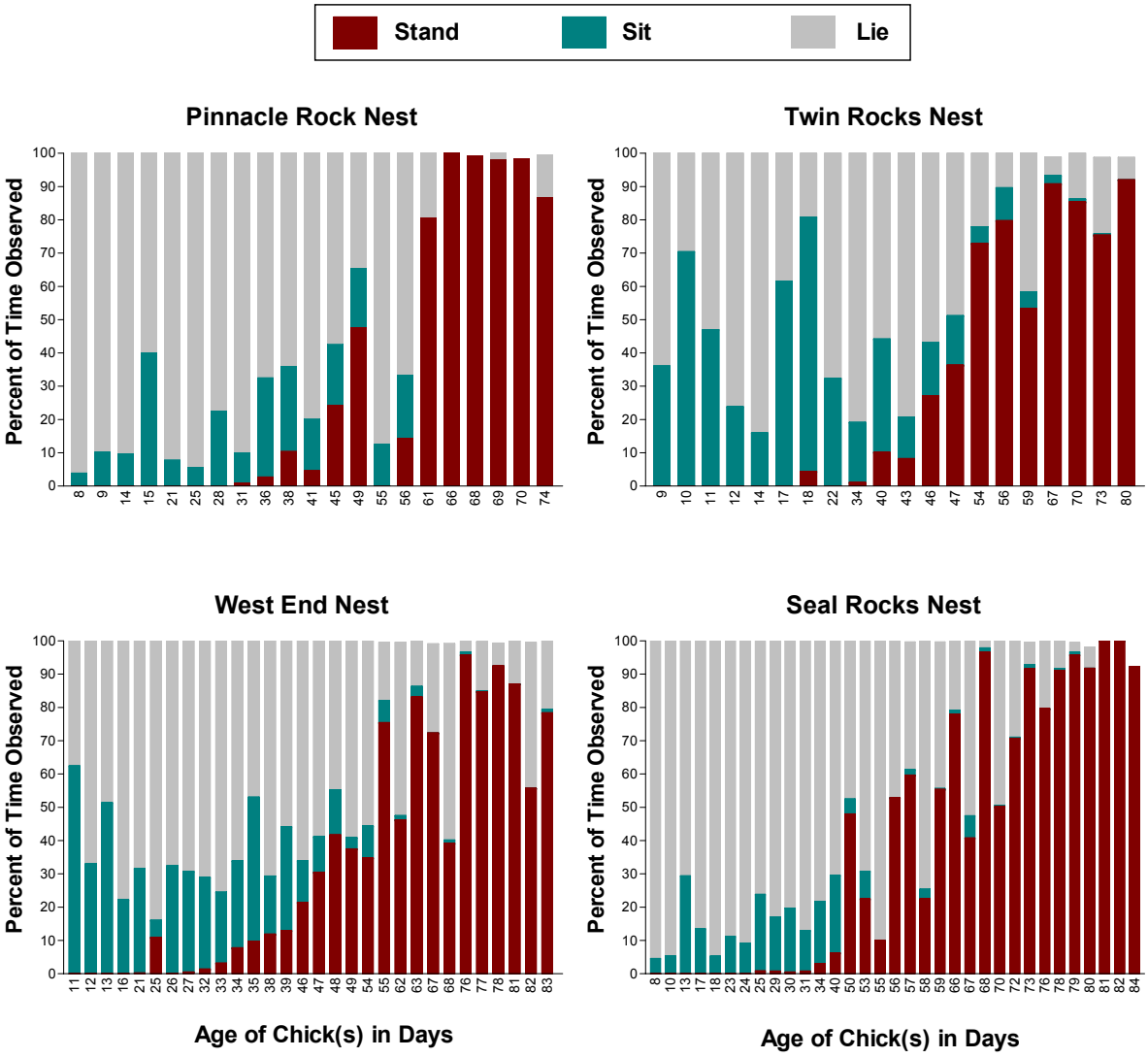

Figure 6. Percent of time that chicks spent in 3 different postures at the Pinnacle Rock, Twin Rocks, West End, and Seal Rocks nests, Santa Catalina Island, 2001.

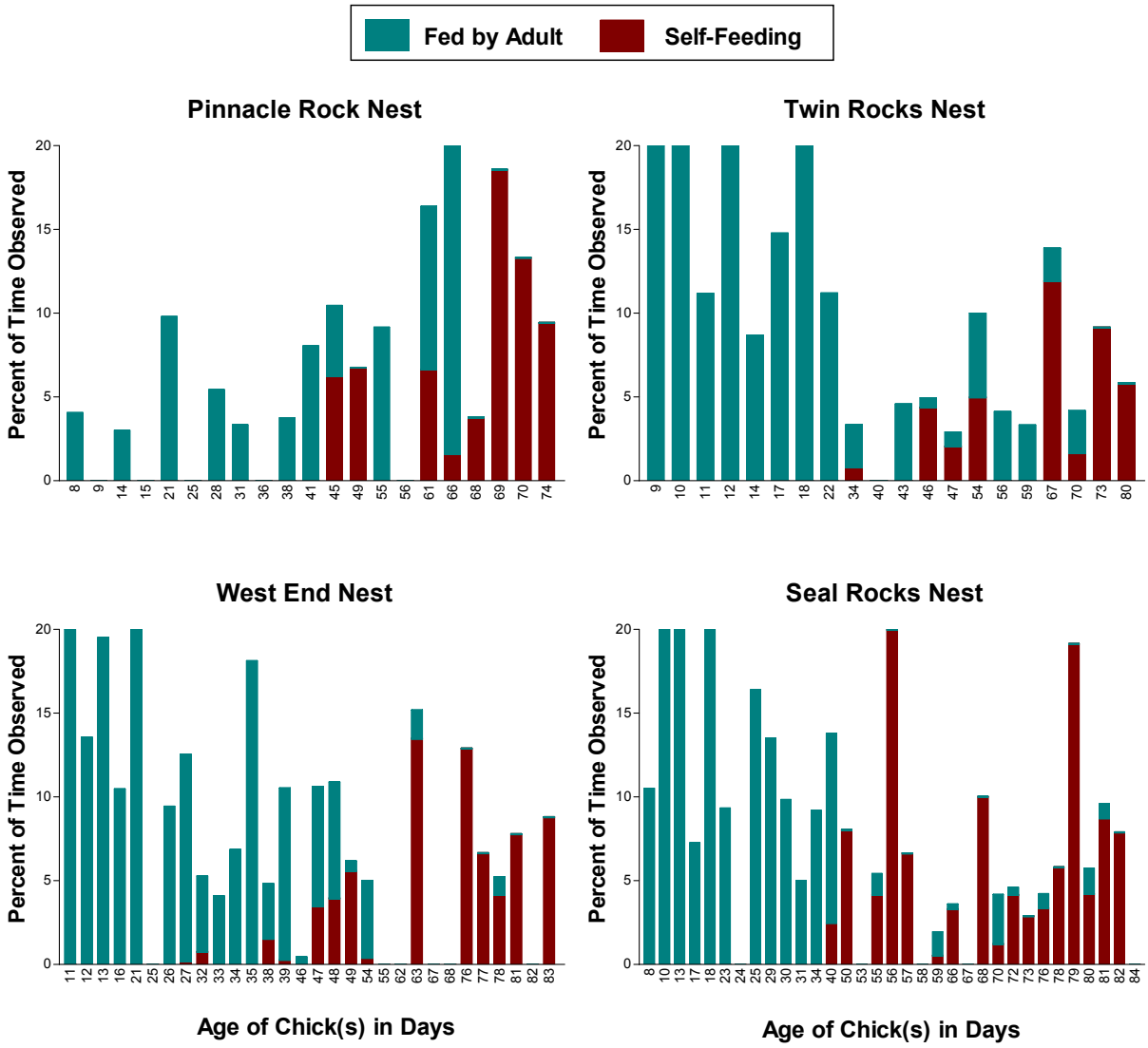

Figure 7. Percent of time that chicks were observed being fed by adults or self-feeding at the Pinnacle Rock, Twin Rocks, West End, and Seal Rocks nests, Santa Catalina Island, 2001.

Prey Deliveries

We observed 43 prey deliveries at the Twin Rocks nest during 114.7 hours of observations (0.37 items/hr), 28 prey deliveries at the Pinnacle Rock nest during 88.3 hours of observations (0.32 items/hr), 76 prey deliveries during 164.7 hours of observations at the West End nest (0.46 items/hr), and 41 prey deliveries during 155.8 hours of observations at the Seal Rocks nest (0.26 items/hr). At all the nests, except the Seal Rocks nest, the males made more deliveries than the females (Fig. 8). We were able to identify prey items to Family or Genus for 31 of 43 deliveries (72%) at the Twin Rocks nest, 24 of 28 deliveries (86%) at the Pinnacle Rock nest, 55 of 76 deliveries (72%) at the West End nest, and 34 of 41 deliveries (83%) at the Seal Rocks nest (Table 4). The Class of the prey was determined for 41 of 43 deliveries (95%) at the Twin Rocks

nest, 27 of 28 deliveries (96%) at the Pinnacle Rock nest, 74 of 76 deliveries (97%) at the West End nest, and 38 of 41 deliveries (93%) at the Seal Rocks nest (Table 4).

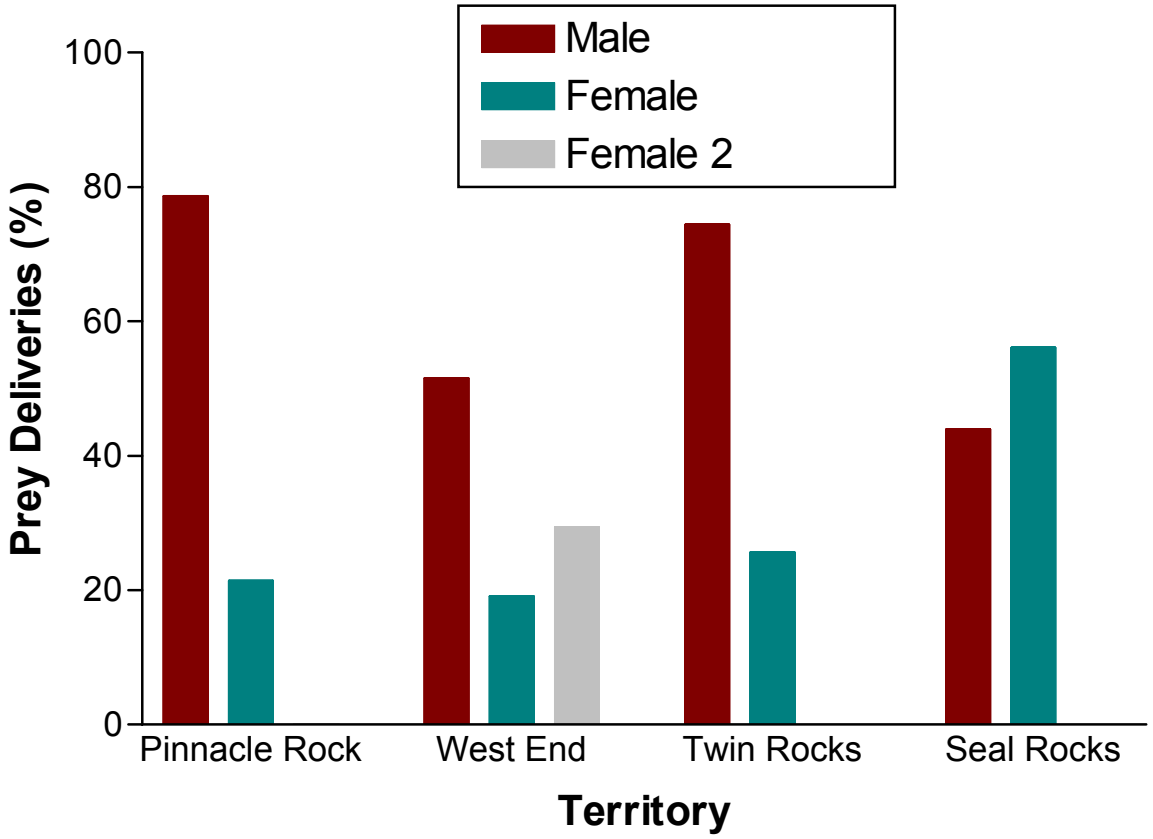

Figure 8. Percent of prey deliveries made by adults to nests in 4 different territories in 2001. Female 2 is a non-breeding helper at the West End nest.

Post-Fledging Behavior

The Twin Rocks chick (K-10) fledged on or about 30 May (Table 2). The bird remained in the vicinity of the nest until 11 July when it was seen flying near Two Harbors. The last confirmed visual sighting of the bird was on 16 July near the Twin Rocks territory (Fig. 1). Because we were unable to relocate the bird's radio signal, we assume the bird left the island around 17 July The West End chicks (K-11 and FWS Band # 629-02782) fledged approximately 5 days apart (12 and 17 June, respectively; Table 2). K-11 remained in the vicinity of the nest until 18 August, at which time it was seen near Two Harbors. We continued to get a signal from the bird on the island until 28 August, at which time it likely left the island. FWS # 629-02782 started moving around the island on 28 June, when it was located about 0.75 km northwest of Two Harbors. The bird was found dead in the Twin Rocks territory on 16 July and it had no obvious injuries. It had last been found in the vicinity of the Bulrush hacktower on 13 July (Fig. 1).

Table 4. Number and percent of food items delivered to the Pinnacle Rock, West End, Twin Rocks, and Seal Rocks nests during monitoring on Santa Catalina Island, California, 2001. Table includes prey that were present in the nest at beginning of observation periods.

Food Item	Prey deliveries							
	Pinnacle Rock		West End		Twin Rocks		Seal Rocks	
	n	% of Total	n	% of Total	n	% of Total	n	% of Total
FISH								
Unknown fish	8	28.6	34	44.7	17	36.2	8	18.2
Unknown herring (various spp.)	6	21.4	9	11.8	2	4.3	4	9.1
Northern anchovy (*Engraulis mordax*)	4	14.3	3	3.9	4	8.5	0	0.0
Unknown rockfish (*Sebastes* spp.)	3	10.7	3	3.9	1	2.1	3	6.8
Garibaldi (*Hypsypops rubicundus*)	1	3.6	4	5.3	6	12.8	2	4.5
Kelp bass (*Paralabrax clathratus*)	1	3.6	3	3.9	0	0.0	9	20.5
Unknown sea bass (*Paralabrax* spp.)	1	3.6	5	6.6	1	2.1	3	6.8
Topsmelt (*Atherinops affinis*)	0	0.0	4	5.3	3	6.4	1	2.3
Unknown surfperch (various spp.)	0	0.0	0	0.0	3	6.4	0	0.0
Pacific herring (*Clupea pallasi*)	0	0.0	1	1.3	0	0.0	2	4.5
Pacific sardine (*Sardinops sagax*)	0	0.0	0	0.0	1	2.1	2	4.5
Pacific mackerel (*Scomber japonicus*)	0	0.0	1	1.3	1	2.1	0	0.0
California flyingfish (*Cypselurus californicus*)	0	0.0	1	1.3	0	0.0	1	2.3
White seabass (*Atractoscion nobilis*)	0	0.0	0	0.0	0	0.0	0	0.0
White croaker (*Genyonemus lineatus*)	0	0.0	0	0.0	1	2.1	0	0.0
Black croaker (*Cheilotrema saturnum*)	0	0.0	1	1.3	0	0.0	1	2.3
Blacksmith (*Chromis punctipinnis*)	0	0.0	1	1.3	0	0.0	0	0.0
Halfmoon (*Medialuna californiensis*)	0	0.0	0	0.0	1	2.1	0	0.0
Opaleye (*Girella nigricans*)	1	3.6	0	0.0	0	0.0	0	0.0
Yelloweye rockfish (*Sebastes ruberrimus*)	1	3.6	0	0.0	0	0.0	0	0.0
Aurora rockfish (*Sebastes aurora*)	0	0.0	0	0.0	1	2.1	0	0.0
Rosy rockfish (*Sebastes rosaceus*)	0	0.0	0	0.0	0	0.0	2	4.5
Black rockfish (*Sebastes melanops*)	0	0.0	0	0.0	0	0.0	1	2.3
Bronzespotted rockfish (*Sebastes gilli*)	0	0.0	0	0.0	0	0.0	1	2.3

Table 4. Continued

Food Item	Prey deliveries							
	Pinnacle Rock		West End		Twin Rocks		Seal Rocks	
	n	% of Total	n	% of Total	n	% of Total	n	% of Total
FISH (Cont.)								
Black surfperch (*Embiotoca jacksoni*)	0	0.0	0	0.0	0	0.0	1	2.3
Pacific halibut (*Hippoglossus stenolepis*)	0	0.0	1	1.3	0	0.0	0	0.0
California Sheephead (*Semicossyphus pulcher*)	0	0.0	1	1.3	1	2.1	0	0.0
Fish Subtotal	26	92.9	72	94.7	43	91.5	41	93.2
BIRDS								
Unknown birds	0	0.0	1	1.3	0	0.0	0	0.0
Unknown Auklet.	1	3.6	0	0.0	0	0.0	0	0.0
Western gull (*Larus occidentalis*)	0	0.0	0	0.0	1	2.1	0	0.0
Birds Subtotal	1	3.6	1	1.3	1	2.1	0	0.0
MAMMALS								
Mammal Subtotal	0	0.0	1	1.3	1	2.1	0	0.0
OTHER								
Unknown	1	3.6	2	2.6	2	4.3	3	6.8
Other Subtotal	1	3.6	2	2.6	2	4.3	3	6.8
TOTAL FOOD ITEMS	**28**		**76**		**47**		**44**	

The Pinnacle Rock chick (K-13) fledged on or about 13 June (Table 2). We observed the eaglet in flight for short periods of time, but radiotelemetry locations and observations of the bird indicated that it remained within its parents' territory until it started moving around the island on or about 4 August. The bird was often in the vicinity of the Bulrush hacktower in the company of the eagles released by hacking (see below) and is believed to have left the island around 11 October.

The Seal Rocks chick (K-16) fledged on 5 July (Table 2). The bird remained in the Seal Rocks territory until 2 August, at which time it was seen soaring in the West End territory. The bird continued to move around the island and was last found near the Bulrush hacktower on 7 September (Fig. 1). It is believed to have left the island on or about 8 September.

Release of Additional Eagles

We released three additional bald eagles this season by hacking. All three birds were ACC-produced chicks and were released from the Bulrush hacktower (Table 5). We had to recapture K-18 on 13 July because it was on the ground and not flying when people approached. It appeared that the bird had not been finding food, as it had a prominent keel and appeared weak. It was placed back in the hacktower, fed, and released again on 24 July. Following the second release, K-18 was observed feeding on multiple occasions and has remained on the island as of 15 October.

K-12 and K-19 were released from the Bulrush tower on 25 August and remained in the vicinity of the tower until they disappeared from the island on approximately 6 October (Table 5). K-19 was reported at Point Fermin on the Palos Verdes Peninsula on 16-18 October, but returned to Catalina on 19 October.

Table 5. Biographical data for bald eagle chicks released by hacking on Santa Catalina Island, California during 2001.

Federal Band	Color Band	Wing Marker	Date Fledged	Release Tower	Status[a]	Comments
629-02785	6/N	K-18	6/22/01	Bulrush	Alive	From captive pair at ACC
629-02786	6/A	K-12	8/25/01	Bulrush	Unknown	From captive pair at ACC. Thought to have left island around 10/6/01
629-02787	6/M	K-19	8/25/01	Bulrush	Alive	From captive pair at ACC.

[a] As of 10/20/01

Additional Eagle Sightings

Breeding activities were again reported on the mainland this year by a bird previously released on Catalina Island. Eagle K-31 (FWS Band # 629-19926), a bird fostered into the West End nest in 1993, was found again as part of a pair at Bass Lake, Madera County, CA (Fig. 9). These birds successfully bred for the third consecutive year and fledged one offspring.

K-81 (FWS Band # 629-39816), a captive-reared bird that was fostered into the West End nest in 1998, has remained on the island after returning in 2000. It had previously been sighted near Klamath Falls, OR in February 1999 (Fig. 9).

K-90 (FWS Band # 629-39818), a captive-reared bird that was fostered into the Pinnacle Rock nest in 1999, was found dead of an apparent electrocution in Fresno, CA on 16 April (Fig. 9).

K-00 (FWS Band # 629-39820), a captive-reared bird that was fostered into the Twin Rocks nest in 2000, was reported near San Diego, CA in January 2001. On 3 February it was located near Avalon on Catalina Island. Subsequently it was seen on San Clemente Island on 17 March and then back near San Diego on 25 July (Fig. 9).

K-02 (FWS Band # 629-29499) was reported near Klamath Falls, OR on 15 January (Fig. 9).

There are also a minimum of four additional subadults on Catalina Island from 1998 and 1999 releases that never left the island. K-80 (FWS Band # 629-39815), a zoo-raised bird that was fostered into the West End nest in 1998 is frequently seen in the vicinity of Avalon. K-82 (FWS Band # 629-39817), a bird that hatched from a West End egg and was fostered into the Pinnacle Rock nest in 1998 is often seen with K-81, perched on the cliffs on the south side of the island near Two Harbors. Both K-92 (FWS Band # 629-29496) and K-93 (FWS Band # 629-29497), zoo-raised birds that were hacked at the Bulrush tower in 1999, also have remained on the island.

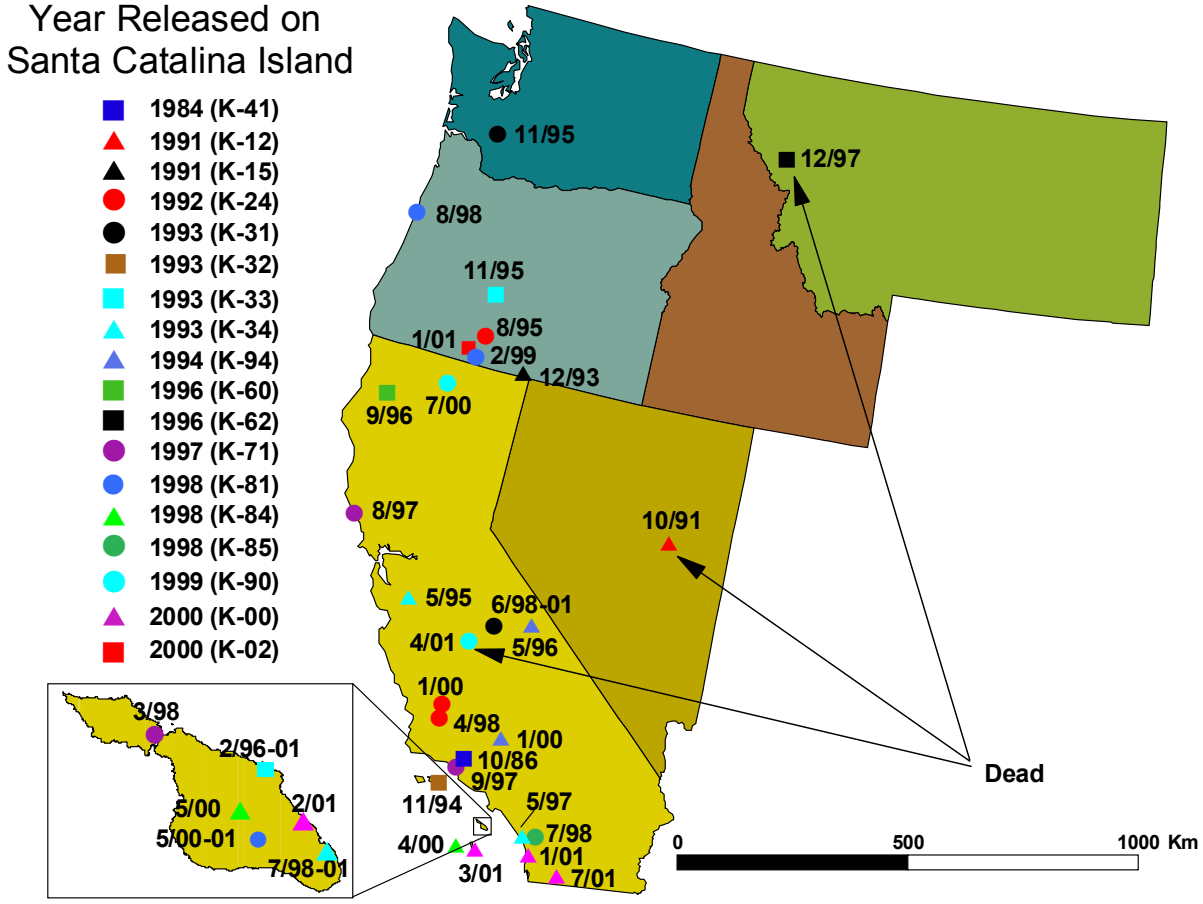

Figure 9. Sightings of bald eagles that left Santa Catalina Island, CA after being released through fostering or hacking activities. Included are the year the birds were released and the location and date on which they were seen alive or recovered dead.

Collection of Tissue Samples

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

DISCUSSION

Artificial Nest Manipulation

As has been indicated in other studies of bald eagles (e.g., Anthony et al. 1994), we do not believe that continued research activities at the nest will negatively impact the nesting success of bald eagles on Catalina Island. Our results from this season indicate that the reproduction of bald eagles on Catalina Island continues to suffer from greatly reduced hatchability of eggs. We collected seven eggs this year, of which four were fertile or exhibited any development, but no eggs hatched. Since the egg removal phase of this project began in 1989, only 8 of 44 fertile eggs have hatched (18% hatching rate). This low hatching success and the fact that an additional egg broke in the Pinnacle Rock nest prior to egg removal (within 48 hours), further emphasize the need for active management of the population and clean-up of the contaminated environment. Failure to hatch may be a result of excessive water loss associated with abnormal eggshell structure (Risebrough 1993). The ACC is able to reduce water loss using a variety of techniques following the transport of the eggs to the Zoo, but the eggs have often lost a large amount of water prior to removal from the nest.

The egg and chick manipulations during 2001 were successful as we were able to foster five eagles into a total of four nests on the island. Removal of eggs from bald eagle nests may cause abandonment of nests in some cases (Anthony et al. 1994), but because of our ability to access nests quickly bald eagles on Catalina Island rarely abandon nests following our manipulations.

We anticipate productivity at the Catalina Island eagle nests in 2002 to be similar to this year. There is a possibility that K-81 and K-82 may attempt to breed next year, because both birds have nearly complete adult plumage and have been seen together for the past year. We will begin searching for breeding activity in mid-January next year to avoid missing active nests and locate pairs that may have formed or moved since the previous breeding season.

Incubation Behavior

Both male and female eagles shared in the responsibilities of incubating eggs and incubation behavior (e.g. length of bouts) appears to be consistent throughout the natural incubation period (Keister and Anthony 1983). Our data contradict reports that female eagles incubate a greater percentage of the time than males (Gittens 1968); within a territory, the time spent incubating eggs did not differ significantly between adults. Cain (1985) reported mean incubation bouts of 164 minutes for the male and 144 minutes for the female, which are similar to our results from the Pinnacle Rock and Twin Rocks nests, but longer than that observed at the West End nest. The shorter incubation bouts at the West End nest are most likely a result of the presence of Female 2, who shares in incubation duties.

Chick-Rearing and Fledgling Behavior

Stalmaster (1987, p.61) reported that during the month following hatching of the chick, adult males were primarily responsible for providing prey, while females were primarily responsible for brooding the chick. We found this to be true at all nests except the Seal Rocks nest, where the

female made slightly more prey deliveries than the male.

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

Prey Deliveries

The data collected in this study support the conclusion by Garcelon et al. (1997a,b) that bald eagles on Catalina Island exploit a wide variety of available foods. As has been found in other studies (Brown et al. 1991, Kozie and Anderson 1991, Todd et al. 1982), fish and birds comprised the majority of the bald eagle diet. Fish are the most important component of the diet of chicks on the nest, comprising greater than 90% of deliveries to the nests. The prey delivery rates at the four active nests this season indicate that prey items are brought to the nest an average of about 3-4 times per day (assuming a 12-hour active period).

Release of Additional Eagles

The release of additional eagles using hacking continues to be a successful means of augmenting productivity of the eagle population on Catalina Island. Although fostering chicks into nests of wild birds uses person-hours more efficiently than hacking, this procedure is a practical and feasible management option on Catalina Island due to the abundance of fish and feral animals for use as food. Further, it is a valuable option to fall back on if the timing of production of eaglets by captive birds occurs asynchronous to the nesting of wild eagles on Catalina Island.

Additional Eagle Sightings

The third successful breeding by the pair at Bass Lake continues to show that eagles released and developed on Catalina Island are capable of breeding normally once the source of contamination is removed from their diet.

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

CONCLUSIONS

Efforts to maintain the reintroduced population of bald eagles on Catalina Island were successful in 2001, as five eagles fledged from nests and three fledged from hacktowers.

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 when action to alleviate the contaminant burden in the sediments is undertaken. Because bald eagles are at the top of the

food chain, they are one of the best species for monitoring the influence of organochlorine contaminants on the marine ecosystem.

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

ACKNOWLEDGMENTS

We thank the Santa Catalina Island Conservancy for providing access to their land and for logistical support. We thank Jessica Dooley and Kim Score for their hard work during all aspects of this study and the staff of the Avian Conservation Center at the San Francisco Zoo, especially Kathy Hobson, for their assistance and dedication to developing and implementing techniques to successfully hatch eggs from Catalina Island and for allowing us access to eaglets for fostering and hacking activities.

LITERATURE CITED

Anthony, R.G., R.W. Frenzel, F.B. Isaacs, and M.G. Garrett. 1994. Probable causes of nesting failures in Oregon's bald eagle population. Wildl. Soc. Bull. 22:576-582.

Bortolotti, G.R. 1984. Sexual size dimorphism and age-related size variation in bald eagles. J. Wildl. Manage. 48:72-81.

Brown, B.T., W.C. Leibfried, T.R. Huels, and J.A. Olivera. 1991. Prey remains from bald eagle nests in Sonora, Mexico. Southwest. Nat. 36:259-262.

Cain, S.L. 1985. Nesting activity time budgets of bald eagles in southeast Alaska. M.S. thesis, University of Montana. 47pp.

Fyfe, R.W., R.W. Risebrough, and W. Walker II. 1976. Pollutant effects on the reproduction of the prairie falcons and merlins of the Canadian prairies. Can. Field-Nat. 90:346-355.

Garcelon, D.K. 1988. The reintroduction of bald eagles on Santa Catalina Island, California. M.S. thesis, Humboldt State University, Arcata, CA. 58pp.

Garcelon, D.K. 1997. Effects of organochlorine contaminants on bald eagle reproduction at Santa Catalina Island. Expert Report submitted to the Damage Assessment Office, U.S. Fish and Wildlife Service, Sacramento Field Office, California. 16pp.

Garcelon, D.K., M.S. Martell, P.T. Redig, and L.C. Buoen. 1985. Morphometric, karyotypic, and laparoscopic techniques for determining sex in bald eagles. J. Wildl. Manage. 49:595-599.

Garcelon, D.K., R.W. Risebrough, W.M. Jarman, A.B. Chartrand, and E.E. Littrell. 1989. Accumulation of DDE by bald eagles *Haliaeetus leucocephalus* reintroduced to Santa Catalina Island in Southern California. Pages 491-494 *in* B.-U. Meyburg & R. Chancellor, eds. Raptors in the modern world. World Working Group on Birds of Prey and Owls, Berlin, London & Paris.

Garcelon, D.K., J.S. Romsos, and P. Golightly. 1997a. Food habits of bald eagles on Santa Catalina Island, January-July 1993. Unpublished report submitted to the Damage Assessment office, U.S. Fish and Wildlife Service, Sacramento Field Office, California. 20pp.

Garcelon, D.K., G.L. Slater, C.D. Danielson, and R.C. Helm. 1995. Cooperative nesting by a trio of Bald Eagles. J. Rapt. Res. 29:210-213.

Garcelon, D.K., and N.J. Thomas. 1997. DDE poisoning in an adult bald eagle *(Haliaeetus leucocephalus*). J. Wildl. Dis. 33:299-303.

Garcelon, D.K., S. Tomassi, D. Kristan, and D. Delaney. 1997b. Food habits of the bald eagle on Santa Catalina Island, November 1991 - December 1992. Report submitted to the Damage Assessment Office, U.S.F.W.S., Sacramento, CA. 24pp.

Gittens, E.F. 1968. A study on the status of the bald eagle in Nova Scotia. M.S. Thesis, Acadia University, Wolfville, Nova Scotia.

Haegele, M.A. and R.H. Hudson. 1977. Reduction of courtship behavior induced by DDE in male ringed turtle doves. Wilson Bull. 89:593-601.

Keister, G. P., Jr., and R.G. Anthony. 1983. Characteristics of bald eagle communal roosts in the Klamath Basin, Oregon and California. J. Wildl. Manage. 47:1072-79.

Kozie, K. D., and R. K. Anderson. 1991. Productivity, diet, and environmental contaminants in bald eagles nesting near the Wisconsin shoreline of Lake Superior. Arch. Environ. Contam. Toxicol. 20:41-48.

National Oceanic and Atmospheric Administration (NOAA). 1985. Climatological data annual summary, California 1985. Vol. 89. Nat. Oceanic Atmos. Admin., Washington, D.C.

Peakall, D.B. and M.L. Peakall. 1973. Effect of a polychlorinated biphenyl on the reproduction of artificially and naturally incubated dove eggs. J. Appl. Ecol. 10:863-868.

Perkins, D.W., D.M. Phillips and D.K. Garcelon. 1996. Predation on a bald eagle nestling by a red-tailed hawk. J. Rapt. Res. 30:249.

Phillips, D.M. and D.K. Garcelon. 1995. Bald eagle productivity, contaminant relations, and nesting behavior on Santa Catalina Island, California, 1995. Contract report submitted to the Damage Assessment Office, U.S. Fish and Wildlife Service, Sacramento Field Office, California. 26pp.

Phillips, D.M. and D.K. Garcelon. 1996. Research and Management of bald eagles on Santa Catalina Island, California, 1996. Contract report submitted to the Damage Assessment Office, U.S. Fish and Wildlife Service, Sacramento Field Office, California. 31pp.

Risebrough, R.W. 1993. Scanning electron microscopy of eggshells of bald eagles from Santa Catalina Island, 1992, and of southern California peregrine falcons. A report to the U.S. Fish and Wildlife Service. The Bodega Bay Institute, Berkeley, CA.

Sharpe, P. B., and D. K. Garcelon. 1998. Restoration and Management of Bald Eagles on Santa Catalina Island, California, 1997. Contract report submitted to the Damage Assessment Branch, U.S. Fish and Wildlife Service, Sacramento Fish and Wildlife Office. 26pp.

Sharpe, P. B., and D. K. Garcelon. 1999. Restoration and Management of Bald Eagles on Santa Catalina Island, California, 1998. Contract report submitted to the Damage Assessment Branch, U.S. Fish and Wildlife Service, Sacramento Fish and Wildlife Office. 29 pp.

Sharpe, P. B., and D. K. Garcelon. 2000. Restoration and Management of Bald Eagles on Santa Catalina Island, California, 1999. Contract report submitted to the Damage Assessment Branch, U.S. Fish and Wildlife Service, Sacramento Fish and Wildlife Office. 26 pp.

Stalmaster, M.V. 1987. The bald eagle. University Books, New York, NY. 227 pp.

Tacha, T.C., P.A. Vohs, and G.C. Iverson. 1985. A comparison of interval and continuous sampling methods for behavioral observations. J. Field Ornithol. 56:258-264.

Thorne, R.F. 1967. A flora of Santa Catalina Island, California. Aliso 6:1-77.

Todd, C.S., L.S. Young, R.B. Owen, Jr., F.J. Gramlich. 1982. Food habits of bald eagles in Maine. J. Wildl. Manage. 46:636-645.

Tori, G.M. and T.J. Peterle. 1983. Effects of PCBs on Mourning Dove courtship behavior. Bull. Environ. Contam. Toxicol. 30:44-49.

Wiemeyer, S. N., T. G. Lamont, C. M. Bunck, C. R. Sindelar, F. J. Gramlich, J. D. Fraser, and M. A. Byrd. 1984. Organochlorine pesticide, polychlorobiphenyl, and mercury residues in bald eagle eggs—1969-1979—and their relationships to shell thinning and reproduction. Arch. Environ. Contam. Toxicol. 13:529-549.

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 2001.

Tissue Type	Collection Location	Description
Red and White Blood Cells	Twin Rocks Nest	1.5 cc from 8-week old eaglet (K-10)
Whole Blood	Twin Rocks Nest	5.0 cc from 8-week old eaglet (K-10)
Plasma	Twin Rocks Nest	3.5 cc from 8-week old eaglet (K-10)
Red and White Blood Cells	West End Nest	1.5 cc from 8-week old eaglet
Whole Blood	West End Nest	5.0 cc from 8-week old eaglet
Plasma	West End Nest	3.5 cc from 8-week old eaglet
Red and White Blood Cells	West End Nest	1.5 cc from 11-week old eaglet (K-11)
Whole Blood	West End Nest	5.0 cc from 11-week old eaglet (K-11)
Plasma	West End Nest	3.5 cc from 11-week old eaglet (K-11)
Red and White Blood Cells	Pinnacle Rock Nest	1.0 cc from 8-week old eaglet (K-13)
Whole Blood	Pinnacle Rock Nest	3.5 cc from 8-week old eaglet (K-13)
Plasma	Pinnacle Rock Nest	2.5 cc from 8-week old eaglet (K-13)
Red and White Blood Cells	Seal Rocks Nest	2.0 cc from 11-week old eaglet (K-16)
Whole Blood	Seal Rocks Nest	5.0 cc from 11-week old eaglet (K-16)
Plasma	Seal Rocks Nest	3.0 cc from 11-week old eaglet (K-16)
Red and White Blood Cells	Bulrush Tower	2.5 cc from 11-week old eaglet (K-18)
Whole Blood	Bulrush Tower	4.75 cc from 11-week old eaglet (K-18)
Plasma	Bulrush Tower	2.75 cc from 11-week old eaglet (K-18)
Egg Contents and Shell [a]	Twin Rocks Nest	Zoo ID # 01-0009
Egg Contents and Shell [a]	Twin Rocks Nest	Zoo ID # 01-0010
Egg Contents and Shell [a]	West End Nest	Zoo ID # 01-0017
Egg Contents and Shell [a]	West End Nest	Zoo ID # 01-0018
Egg Contents and Shell [a]	Pinnacle Rock Nest	Zoo ID # 01-0025
Egg Contents and Shell [a]	Seal Rocks Nest	Zoo ID # 01-0030
Egg Contents and Shell [a]	Seal Rocks Nest	Zoo ID # 01-0031

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