THE REINTRODUCTION OF BALD EAGLES ON SANTA CATALINA ISLAND, CALIFORNIA

by

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ABSTRACT

In 1980 a program was initiated to reintroduce bald eagles (Haliaeetus leucocephalus) to the California Channel Islands. Bald eagles were historically found on all of the islands, and were numerous on the larger islands.

From 1980 through 1984, 20 eagles were translocated to Santa Catalina Island and reared on hacking platforms until released. All released birds returned to the platforms to feed. Early flights by the birds were comparable to other reintroduction programs and to wild reared eagles. The eagles subsisted on food provided by the investigators for up to seven weeks of age. There were seven known cases of mortality. Causes of mortality included shooting, electrocution on high power lines, and intraspecific aggression.

Birds in the first, second, and third year age classes, all used available habitats significantly different than expected from random ($P < 0.05$). Birds in their first year used only the chaparral differently than expected between seasons. Habitats used differently than expected between seasons for second and third year birds were relict coastal sage, oak woodland and relict oak woodland (second year birds); relict oak woodland and

grassland (third year birds). Availability of carrion during the fall and winter hunting seasons may effect the distribution of the eagles on the island.

Female eagles were significantly more successful (P = 0.001) in supplanting male eagles from carcasses and perches. Females were 100 percent successful in supplanting same aged males. Males of the same age only attempted to supplant females in 21 percent of the interactions (n = 58) and were successful in 42 percent of their attempts. Age does not appear to play as important of a role as sex in determining the outcome of supplanting attempts.

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INTRODUCTION

The historical distribution of bald eagles (Haliaeetus leucocephalus) in California was the coastal area between San Diego and Del Norte Counties with an inland nesting population from Fresno County north to Siskiyou County (Detrich 1985). The loss of the southern-coast mainland population of bald eagles during the 1920's and 1930's was likely associated with loss of habitat from encroaching development, and from direct harassment.

The bald eagle population on the California Channel Island's withstood human pressure for a longer period of time than the southern mainland population; adult birds were present on some of the islands into the early 1960's (Kiff 1980). The eventual loss of the Channel Island breeding population left nearly vacant a range which had extended from Plumas County to the southern border of the state.

History of Eagles on the Channel Islands

Reports on the exploits of egg collectors is the primary source of historic information on the occurrence of bald eagles on the Channel Islands. Blake (1887) described seeing eight or nine individuals on Santa Cruz Island, with three empty nests found "on island rocks."

Two sets of eggs were collected and three adult birds were shot by Breninger (1904) during a visit to San Clemente Island in 1903. In 1907, Linton (1909) also visited San Clemente Island and reported finding eagles nesting in the larger canyons. Anacapa Island was visited by Burt (1911), at which time he found one nest with young on East Island, and one nest with eggs on West Island. Howell and Van Rossem (1911) found one cliff- and one tree-nest on Santa Cruz Island during a visit in 1911. Willett (1910, 1933) noted seeing many nests with young in June of 1910 on Anacapa, Santa Cruz, Santa Rosa and San Miguel Islands; in 1911 he saw a pair of eagles on Santa Barbara Island, and took two sets of eggs from Santa Catalina Island in 1905. Wright and Snyder (1913) reported seeing an adult and a full-grown "youngster" on Santa Barbara Island in 1912 as well as an adult and an immature on Santa Cruz Island.

In his review of birds of the Channel Islands, Howell (1917) reported that eagles were numerous on San Clemente Island in 1915, and thought it was probable that one pair was resident on Santa Barbara Island. Howell further stated that "several" pairs were resident on Anacapa Island. In 1926 during a trip to Santa Cruz Island, Ross (1926) was impressed by the scarcity of bald eagles.

History of eagles on Santa Catalina Island

One of the earliest reports on the status of bald eagles on the Channel Islands was that of John Cooper (1870). Cooper reported seeing "more than 30 of these eagles in young plumage", at the north end of Santa Catalina Island on 9 July 1860, and indicated that their nests were numerous about the inaccessible cliffs. In 1897 Grinnell (1898) found eagles to be common along the precipitous margins of Santa Catalina Island (hereafter referred to as Catalina). On two trips to Catalina (1905 and 1906), Richardson (1908) saw a number of eagles circling about the cliffs. In 1921 A. J. van Rossem (field notes c.f. Kiff 1980) found four probably (sic) active eagle nests while rowing along the shoreline from Avalon on Catalina.

Eagles were present on Catalina until the mid-1950's (D. Propst, J. Sutherland pers. comm.), but no successful nesting activity was known. In the late 1940's, active nests were located on Gibralter Rock on the channel side of the island, around Salta Verde on the Pacific Ocean side of the island, and a pair (but not the nest) was found on the east end of the island (D. Bombard pers. comm.). A photograph of a nest on the west end of the island (reported as the north end) is shown in Bent (1937)

during a visit by J. R. Pemberton in 1929. Six active nests were reportedly seen by Telford Work (L. Kiff pers. comm.) in 1945 during a visit to Catalina.

Reasons for Decline in Numbers

The reasons for the decline and eventual disappearance of bald eagles on the Channel Islands are not completely understood. Kiff (1980) noted several reported causes of the decline of eagles. These causes included shooting, egg collecting, nest destruction, poisoning, removal of young from nests, nest disturbance, and the introduction of contaminants into the prey base.

Shooting occurred both by collectors (Breninger 1904), and by early island ranchers who thought the eagles were a threat to their sheep (Burt 1911). In 1930 A. J. van Rossem (field notes c.f. Kiff 1980) saw the wings of more than 20 eagles attached to the wall of a barn on San Miguel Island. The caretaker of the island claimed all the birds had been shot or poisoned in the past year. Since van Rossem noted seeing the usual number of live eagles on the island, Kiff (1980) postulated that some of the live and dead birds seen may have been individuals wintering on the island.

Poisoning programs used on some of the islands to control introduced or burrowing mammals may have been a contributing factor to the eagle's decline on some islands. Primary or secondary poisoning reportedly occurred on San Miguel Island (van Rossem field notes of 1930, c.f. Kiff 1980), Santa Rosa, and Santa Cruz Islands (Kiff 1980). On Catalina, strychnine and compound 1080 (sodium monofluroacetate) were used to poison California ground squirrels (Spermophilus beecheyi) from the late 1950's into the 1960's (D. Propst pers. comm.). In addition, compound 1080 was used to poison a large number of feral goats (Capra hircus) on at least one occasion during the late 1950's (D. Propst pers. comm.). LD_{50}'s of compound 1080 for mule deer (Odocoileus hemionus), mules, and horses (Equus caballus) are all less than 1.00 mg/kg body weight (Tucker and Crabtree 1970), and the LD_{50} for golden eagles (Aquila chrysaetos) averages 3.54 mg/kg (Hudson et al. 1984). Thus, it is unlikely that goats poisoned by compound 1080 would contain a sufficient concentration of the poison in the muscle tissue to kill an eagle. Ground squirrels poisoned with 1080 by Hegdal et al. (1986) contained a mean of 23.3 (+/- 10.5) mg/kg. Compound 1080 has not generally been found to contribute to the mortality of raptors (Hegdal et al. 1986). However, deaths have been reported (U.S.D.I. 1972) and if

the sensitivity of bald eagles to 1080 is similar to golden eagles, mortality could have been caused by feeding on squirrels. Secondary poisoning of coyotes (Canis latrans) by strychnine has been associated with the consumption of the stomach or intestines of poisoned rodents (Hegdal et at. 1981). The effect bald eagles feeding on the whole carcasses of ground squirrels poisoned with syrychnine is unknown.

Pesticides and Eagles

Eagles were not present on the Channel Islands at the time when persistent organochlorine pesticides, such as DDT (Dichloro-Diphenyl-Trichloro Ethane), were recognized as a detriment to reproduction in bald eagles; thus no direct evidence was available to link the decline of bald eagles to the introduction of these pesticides into the environment. There was, however, a temporal association between the decline of the eagles and the introduction of certain pesticides. Montrose Chemical Company was the largest manufacturer of DDT in the United States (Schmidt et al. 1971). Between 1947 and 1961, Montrose Chemical dumped an estimated 37 to 53 million liters of DDT-containing acid sludge in an ocean dump site 16 km northwest of Catalina. This represented 348-696 metric tons of DDT over the 14 year period (Chartrand et al.

1985). In addition, it was estimated that from 1954 through 1971 another 1800 metric tons of DDT was discharged from the Joint Water Pollution Control Plant outfall, 3.3 km offshore of Whites Point, California (Chartrand et al. 1985).

The introduction of DDT into the Santa Monica Basin marine ecosystem coincided with the decline of bald eagles as a breeding species on Catalina, and on other of the Channel Islands. The decline of the brown pelican (Pelecanus occidentalis) and the double-crested cormorant (Phalacrocorax auritus) on the Channel Islands during the 1950's and 1960's was associated with DDT (Risebrough et al. 1971, Gress et al. 1973). With the advent of the brown pelican recovery in southern California (Anderson et al. 1975, Anderson et al. 1977) the California Department of Fish and Game, and the U.S. Fish and Wildlife Service authorized the reintroduction of the bald eagle on the California Channel Islands.

Reintroduction is a manipulatory tool used by resource managers attempting to accelerate the re-occupation of suitable habitat by a species. Early reintroduction efforts with raptors included the reestablishment of the peregrine falcon (Falco peregrinus) to the northeastern coast of the United States (Cade and Temple 1977), and eagle owls (Bubo bubo) in Europe (Broo

1977, Forstel 1983, Radler and Bergerhausen 1988). Attempts to reintroduce members of the genus Haliaeetus began in Europe in 1975 with the white-tailed sea eagle (Haliaeetus albicilla) (Love and Ball 1979, Love 1983; 1988). Bald eagle reintroduction efforts began in 1976 with efforts to reestablish a population in New York (Milburn 1979). The first success of any sea eagle reestablishment project was seen in 1980, when a pair bred in New York (Nye 1983). Additional bald eagle reintroduction programs

STUDY AREA

Catalina is located 32 km off the coast of the Palos Verdes Peninsula in southern California. It is the largest of the four southern Channel Islands and the third largest of the eight Channel Islands. Catalina encompasses an area of approximately 194 km^2, is 34 km in length and ranges from 0.8 km to 6.0 km in width (Figure 1). Elevations range from sea level to 648 m and the island is characterized by steep north-south oriented canyons.

The climate of Catalina is classified as Mediterranean, characterized by warm, dry summers and cool, damp winters. The mean annual temperature is 16.1^{o} C and the mean July temperature is 19.2^{o} C, with an annual range of 6.3^{o} C (Dunkle 1950). Mean rainfall for the wet season (from October through March) and dry seasons (from April through September) were 26.9 cm and 4.0 cm, respectively (NOAA 1985).

Predominant vegetation communities on Catalina are grassland, coastal sage, oak woodland, chaparral and riparian (Thorne 1967). Due to long-term damage caused by introduced feral animals, vegetation communities in some areas of Catalina have lost some of their dominant plant species and have been classified as relict habitats (Santa Catalina Island Company 1975) (Appendix A). Vegetation

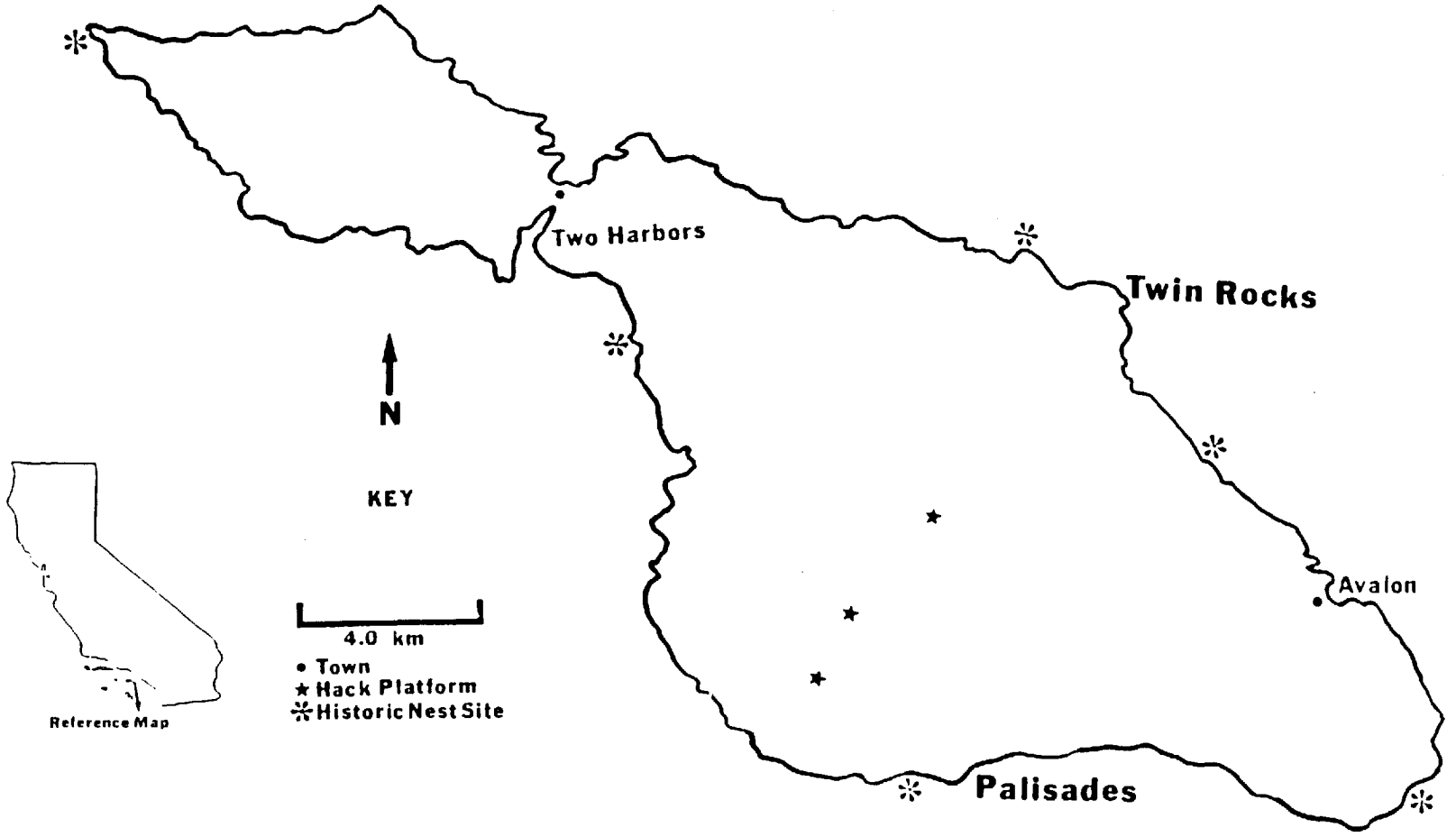

Figure 1. Location of Hacking Platforms and Historic Nest Sites on Santa Catalina Island, California.

communities were mapped by ground reconnaissance (Santa Catalina Island Company 1975).

Prey occurring on the island that might be available to the eagles include: marine and freshwater fish; and marine birds including gulls (*Larus spp.*), and western grebes (*Aechmophorus occidentalis*). Terrestrial mammals available in the form of carrion include feral goats, feral pigs (*Sus scrofa*), bison (*Bison bison*), and domestic cattle (*Bos spp.*).

MATERIALS AND METHODS

Release and Early Post-Fledging Behavior

Eagle chicks were taken from wild nests in Washington and California at seven to nine weeks of age and transported to Catalina. The hacking platforms used to rear the birds until fledging age were similar to those used by Milburn (1979); however, I redesigned them to include a blind and a different release mechanism (Garcelon 1980) (Figures 2,3,4). Platforms were located on ridge tops in grassland patches; two platforms being adjacent to oak woodland and one being adjacent to coastal sage. Birds were paired by stage of development and placed on the platforms. Food was provided at night through chutes from the blind to prevent the association of food with researchers. Food items consisted of prey the eagles might find after release which included feral goat, feral pig, ground squirrel, bluegill (Lepomis macrochirrus), large mouth bass (Micropterus salmoides), and various species of marine fish. Food not consumed by the eagles as well as large bones were removed after dark every 2 to 3 days. Removal was achieved by using a 1.2 m 'grabber stick' (Universal Tongs, Manco Inc., Fayetteville, AR 72701).

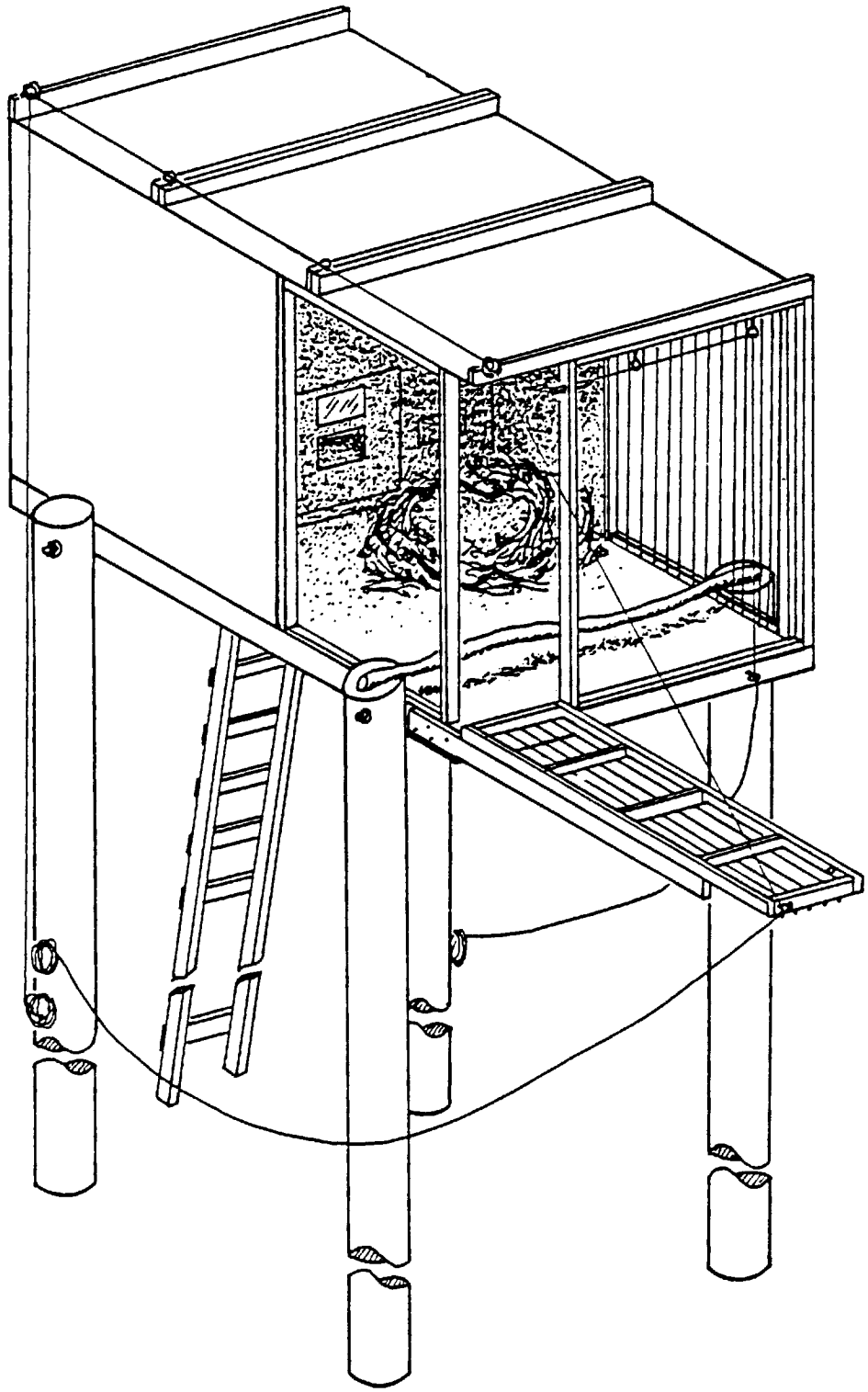

Figure 2. Diagram of a Bald Eagle Hacking Platform with Cut-away View of Nest Area. The Fledging Door is Shown in the Lowered Position. Fledging Door was Lowered By Ropes From Behind the Platform.

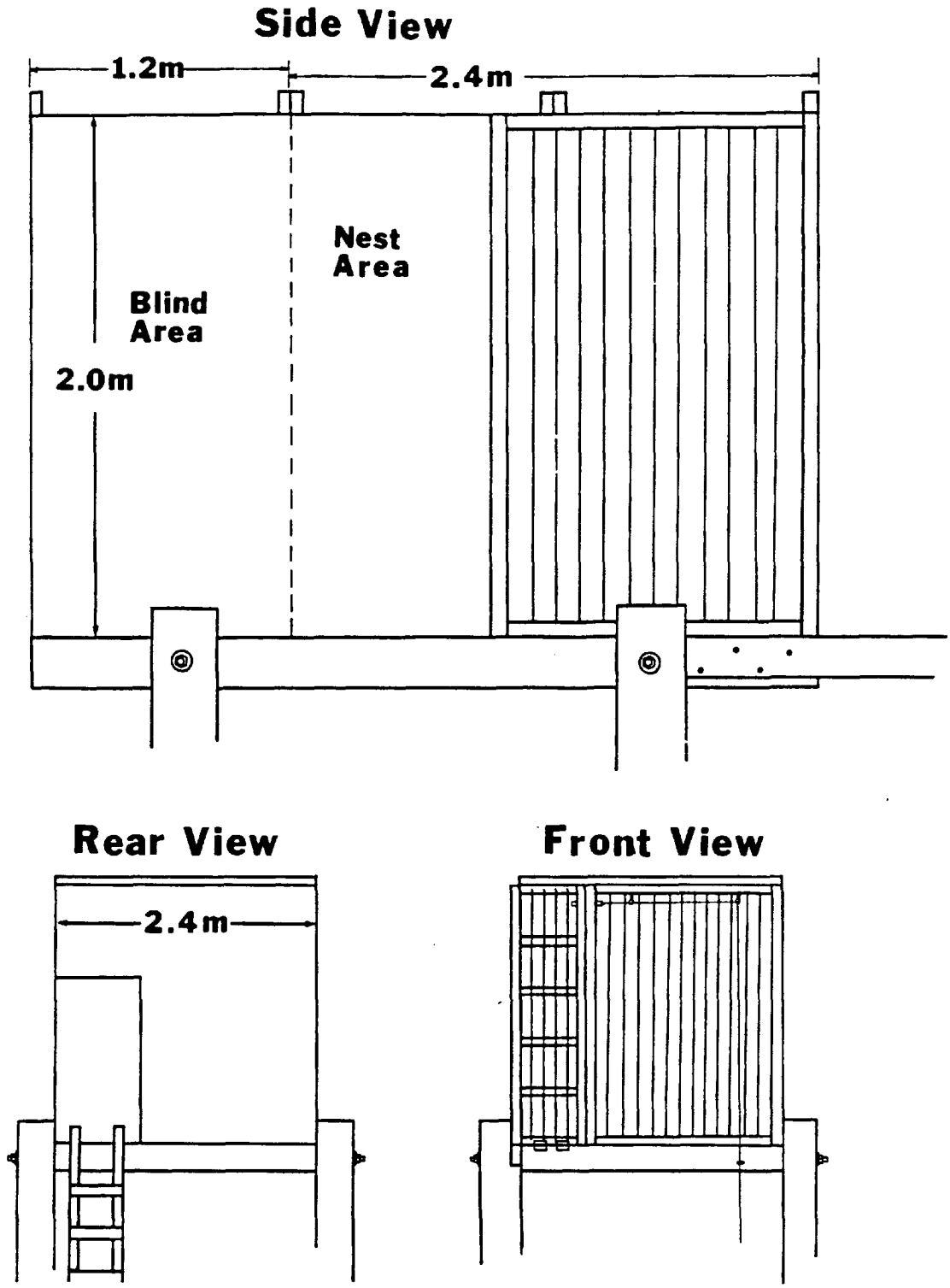

Figure 3. Views of a Hacking Platform: Side View, Showing Barred and Plywood (Solid) Portions of the Nest Area, and the Blind Area; Rear View, Showing Ladder Access to the Blind; and Front View, Showing Release Door (Left Side) and Bars.

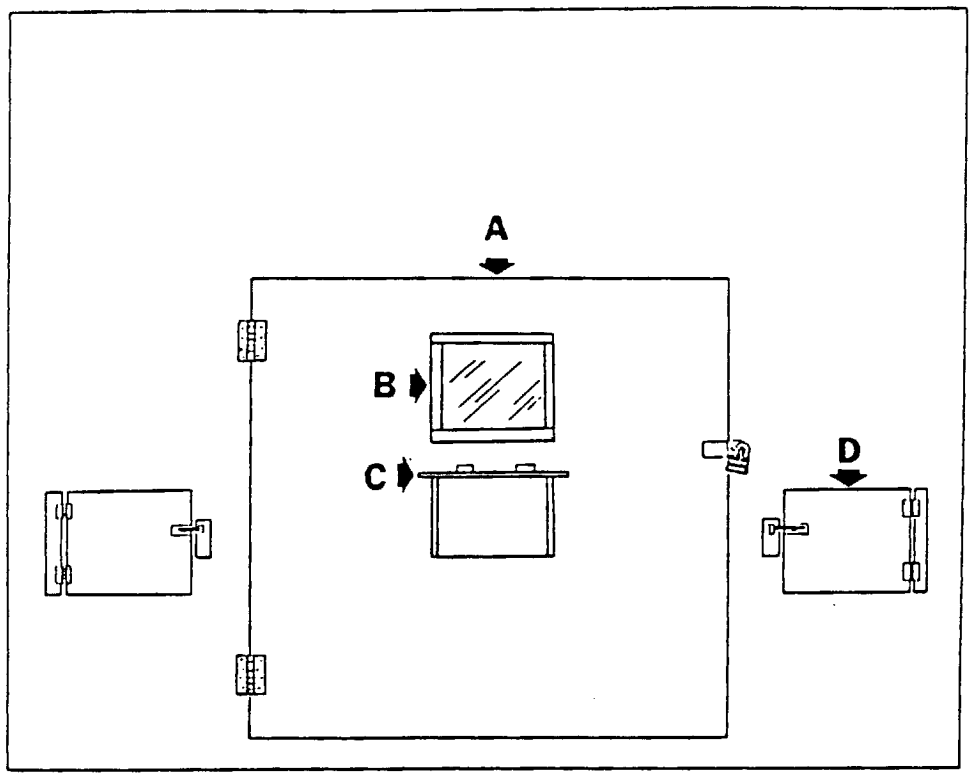

Figure 4. Diagram of the Wall Separating the Blind From the Nest Area on the Hacking Platform. A) Door Which Allows Access to Nest Area; B) One-Way Glass for Viewing the Birds; C) Surface for Note Taking; and D) One of Two Food Access Doors for Introducing Food.

Observations of the birds were made during the day from the blind through one-way glass, and with a closed-circuit television system.

Approximately one week prior to being released (approximately 11 weeks of age) the eagles were taken from the platform at night, hooded, and equipped with a telemetry transmitter, wrap around wing markers (except in 1980), and a U.S. Fish and Wildlife Service leg band. Transmitters (model S2B5, Telonics Inc., Mesa, AZ 85204) were configured as a backpack mount and strapped to the birds with 1.4 cm wide tubular teflon ribbon (Bally Ribbon Mills, Bally, PN 19503). The four ends of the teflon harness were sewn together at the breast of the birds using waxed cotton thread and then sealed with vinyl glue to prevent unraveling. Orange Herculite (King Textile, Long Beach, CA) wing markers with black alphanumeric characters were placed in wrap-around fashion on each wing and attached with a pop-rivet. In 1982 the nestlings had 3 ml of blood taken from the brachial vein for sex determination by karyotyping.

Birds were kept on the platforms until they were approximately 12 weeks old. At that age the birds were spending the night on the perch and were capable of hovering flight inside the platform. Before sunrise on the day the birds were released, a rope and pulley system

was used to lower the fledging door of the platform, out of view of the eagles, allowing the birds the opportunity to fledge.

After the birds were released, food was left on the nest for an additional three to seven days. After this period, goat and pig carcasses were left on the ground directly in front of the platforms, and cut open to reveal the red muscle tissue and blood. Over the four to seven week period between the time that whole animal carcasses were first introduced (considered the dependency period), and until the birds were foraging independently, carcasses were gradually moved further from the platforms. This was instituted in an attempt to teach the birds how to locate carrion. For the first week after carcasses were provided, movement of the carcasses was less than 30 m, to help ensure the birds could find the food. After the first week, carcasses were gradually moved greater distances (up to 2 km), and in different directions.

Previously released eagles were periodically retrapped in order to attach new transmitters. Trapping methods included rocket nets, padded jaw traps, noose carpets, and floating fish with nooses attached (Frenzel and Anthony 1982). Rocket net, jaw traps and noose carpet sets were baited with feral goat carcasses. Captured eagles were bled and/or measured for sex determination

(Garcelon et al. 1985) if not previously sexed, fitted with new transmitters and wing markers, and photographed to record plumage characteristics.

Necropsies on eagle mortalities were conducted at the U.S. Fish and Wildlife Service, Wildlife Health Laboratory at Madison, WI or by the California Department of Fish and Game, Wildlife Investigations Laboratory at Rancho Cordova, CA.

Habitat Use

Habitat use was determined by the grid square technique (Nicholls and Warner 1972, Fuller 1979). Telemetry was used to determine the vicinity of the birds, and then visual locations were recorded. Only visual locations were used in the analysis. In an attempt to keep locations on individual birds statistically independent, only the first observation on each bird each day was used in the analysis. Locations of fledged birds were not used in the analysis until they ceased visiting the release platforms. This was done to prevent biasing the data in favor of habitats around the platforms. Because the focus of the project was to determine if the eagles were surviving, a priority system was used to determine which individuals would be located on any day of telemetry tracking (see Discussion for biases associated

with habitat use determination). Once the individual of concern was located, attempts were made to locate additional radio tagged birds as time permitted. Grids (seven-hectare squares) were overlaid on topographical maps of the island and each location was placed into one grid square. A bird was placed into the respective grid square regardless of whether it was flying or perched. Habitat classification followed those described in the Appendix. Habitat types were assigned to each grid square based on the predominant (>50 percent) habitat in that square. However, because an eagles' use of coast line may be independent of the adjacent habitat type, whenever a section of coast line was found in the grid square it was assigned to a coastal bluff habitat type regardless of the predominant cover. Use of the habitats was stratified by wet season (from October through March) and dry season (from April through September).

Previously aged birds were identified with either telemetry or on the presence or absence of wing markers. Eagles with unconfirmed age (markers not visible or absent) were excluded from the analysis. Expected values (in percent) were calculated by counting the total number of grid squares assigned to each habitat type and dividing by the grand total of all grid squares for the island. If the eagles were using the habitat on the entire island

randomly, the expected use would approximate the proportion in which each habitat occurred. Chi-square contingency test was used to test for differences in habitat use of each age class from expected use, while log-likelihood ratio and Fisher exact probability (Zar 1984) was used to test for differences in habitat use by age class between seasons. An alpha of 0.05 was used in all tests.

Behavioral Interactions

Observations of eagle supplanting attempts were recorded for their location (elevated perch, carcass, or ground), sex and age of the birds involved, and whether the supplanting attempt was successful. A successful supplanting was defined as one where the aggressor replaces or removes the recipient from an elevated perch, or moves the recipient more than one meter from a carcass or position where it was perched on the ground. In order to better examine relationships between different age classes, same aged individuals were pooled disregarding sex. A chi-square contingency test was used to test for differences of age and sex on outcomes of interactions.

RESULTS

Release and Early Post-fledging Behavior

From 1980 through 1984, 20 bald eagles were brought to Santa Catalina Island for release. Fourteen of the birds were taken from nests on the San Juan Islands and along the Puget Sound of Washington, and six were taken from Shasta and Modoc counties in northern California. Sex of the eagles was determined by courtship behavior (n = 4), morphometrics (n = 8), or karyotyping (n = 4); four birds were not sexed. Of the sexed birds, eight were males and eight were females.

Of 19 birds released from 1980 through 1984, 16 (84 percent) fledged the same day they were released (Table 1). The 20th eagle was held in captivity for an additional six weeks because of feather loss problems. Observed fledging flights ranged from parachuting jumps from the end of the fledging door to the ground, to flights of approximately 500 m which included both soaring and flapping flight. Flights of the birds during their first week after fledging varied greatly between individuals. One female (#754) was found 16 km from the release site on the west end of the island two days after fledging. This bird arrived at a hacking platform

TABLE 1. Date, Time, and Distance of Fledging Flights for Bald Eagles Released on Santa Catalina Island, 1980 Through 1984[a].

BIRD	FLEDGING DATE (mo/day/yr)	TIME FLEDGING DOOR LOWERED	TIME BIRD FIRST SEEN ON DOOR	TIME OF FLEDGING FLIGHT	ELAPSED TIME[b] (hrs:min)	FLIGHT DESCRIPTION
#754	7/17/80	0400	0542	0552	0:10	Flew immediately over the top of the platform out of view.
#853	7/21/80	0445	0540	1327	7:48	Flew quickly out of view.
#604	7/21/80	0445	0821	Unknown	Unknown	Unseen.
#704	7/29/80	0528	0550	0620	0:30	Forty second flapping and soaring flight. Circled the canyon north of the platform and landed on the ground 137 m away.
#653	7/29/80	0528	0551	0622	0:31	Gained altitude, soared north of platform. Landed on ridge 500 m away.
#527	7/23/81	0115	0605	0745	1:40	Jumped off or lost balance and fell off door. Flew 35 m then returned to base of platform.
#260	7/23/81	0115	0618	Next Day	Unknown	Unseen.
#030	7/25/81	0040	0600	0914	3:14	Landed on hillside north of platform, then hop/flapped over a hill out of view.
#130	7/25/81	0040	0604	0730	1:26	Circled around platform then went out of view.

TABLE 1. Date, Time, and Distance of Fledging Flights for Bald Eagles Released on Santa Catalina Island, 1980 Through 1984[a]. (continued)

BIRD	FLEDGING DATE	TIME DOOR LOWERED	TIME BIRD FIRST SEEN ON DOOR	TIME OF FLEDGING FLIGHT	ELAPSED TIME[b] (nrs:min)	FLIGHT DESCRIPTION
#134	7/27/81	0005	0600	1445	8:45	Flew southwest approx. 400 m. Crash landed into oak grove after being mobed by ravens.
#333	7/27/81	0005	0550	1525	9:35	Circled in front of platform, went out of view.
#382	7/31/82	0457	0547	1049	5:02	Circled in front of platform, and then disappeared into Middle Canyon.
#666	7/31/82	0457	0605	Unknown	Unknown	Unseen
#60484	6/25/84	0430	0756	Unknown	Unknown	Unseen
#542	7/09/84	0445	0640	Unknown	Unknown	Unseen
#66684	7/09/84	0445	0640	1331	6:51	Flew approx. 183 m in descending flight, then went out of view.
#13084	7/09/84	0445	0735	1032	2:57	Unseen

[a]Data on releases of two birds from one platform in were not available. No eagles were released in 1983. One eagle released in 1980 was released at a late age and is not included.

[b]Time elapsed between stepping on fledging door and fledging flight.

(although not the one she fledged from) two days later. In 1981, two females (#527 and #260) released at one platform remained very close to the platform for approximately two weeks before making flights out of the area.

During the first two weeks after fledging eagles perched on the following surfaces (n = 83 perchings by 15 eagles): ground (42.8 percent), boulders (13.0 percent), trees and shrubs (22.1 percent), fence posts (15.6 percent), and power poles (6.5 percent). The birds were observed picking up sticks and dried bison feces while on the ground. All of the eagles returned to a hacking platform after fledging. In 1980, an eagle of unknown sex (#653) returned to a platform only once, and was not observed to feed during that visit. Two birds (#130 and #134), both males, did not return to a platform for 13-18 days; one female did not return for 38 days after fledging.

For three to seven days after fledging, food continued to be left on or around the nest inside the platforms. Birds reentered the platforms to feed, sometimes remaining inside to perch after feeding.

The eagles made the transition to feeding on large carcasses when provided with them, and were adept at locating carcasses placed away from the platforms.

Although not quantified, the eagles seemed to more readily find carcasses where ravens (Corvis corax), were already present.

By seven weeks after fledging the eagles did not return to the vicinity of the platforms to feed. At this point the eagles were finding food on their own. During this late post-fledging period, the eagles congregated in the Grand Canyon and Silver Canyon drainage system on the eastern half of the island. These canyons contained large numbers of feral goats and free flowing water was present in certain reaches, which the eagles were seen to use for drinking and bathing.

Of the 20 eagles released from 1980 through 1984, seven were known to have died by the end of 1985 (Table 2). The status of an additional seven birds is unknown. A male eagle perched on top of a hacking platform was struck by a female eagle of the same age in a perch supplanting attempt. Both birds fell to the ground, after which the male flew away. The male was seen attempting to feed on a carcass the following day, but could feed only briefly due to harassment by the female eagle which had attacked it the previous day. The male was found dead 200 m down slope in a group of oak trees two days later (this bird was considered killed by a conspecific). Necropsy could not confirm the cause of death.

Table 2. Year Released, Cause of Death, and Age at Time of Death for Seven Eagles on Santa Catalina Island, California, From 1980 Through 1986.

Year Released	Bird	Cause of Death	Age at Death (Years)
1980	556	Electrocution	5
1981	030	Shot	<1
1981	527	Unknown	2
1981	134	Unknown	2
1982	382	Unknown	1
1982	60484	Unknown	1
1984	542	Conspecific[a]	<1

[a]Eagle may have died due to injuries suffered in an attack by another fledgling.

Habitat Use

A total of 499 eagle locations obtained on 16 eagles from 1 September 1980 through 31 December 1982 and were used to determine habitat use. There were a similar number of locations for flying and perched birds (Table 3). Times were recorded for each location and ranged from 0500 hours to 2000 hours, with 73 percent of the locations occurring between 0900 and 1600 hours (Figure 5). Location data did not show any apparent pattern in the order in which individual birds were located.

Habitat use was stratified by age class to test for differences in use (Figure 6). Habitat types were not used as expected by any of the age classes (Table 4). Each age class used half of the available habitat types significantly different than expected ($P < 0.05$). Within each age class significant differences were found in habitat use by season (Table 5). Only in coastal sage, relict grassland, and coastal bluff were no significant seasonal differences seen within any of the age classes (Table 5). First year birds showed very similar use of habitat types between seasons, except in chaparral which was not used in summer months (Table 5). Both second and third year birds had significant differences in habitat use by season (Table 5).

Table 3. Activity of Three Age Classes of Bald Eagles (n=16) on Santa Catalina Island at the Time When their Habitat Use was Recorded. Sample Size (n) is the Number of Locations Recorded and Percent (%) is for Each Behavior Within Each Age Class. Data Were Collected From 1981 Through 1983.[a]

Activity	Age Class of Eagles					
	First Year		Second Year		Third Year	
	n	(%)	n	(%)	n	(%)
Flying	138	(47.8)	70	(49.7)	28	(44.4)
Perched	135	(46.7)	67	(47.5)	33	(52.4)
Feeding	16	(5.5)	4	(2.8)	2	(3.2)
Total	289	(100.0)	141	(100.0)	63	(100.0)

[a]Behavioral activity of the eagles during six of the 499 locations was not determined.

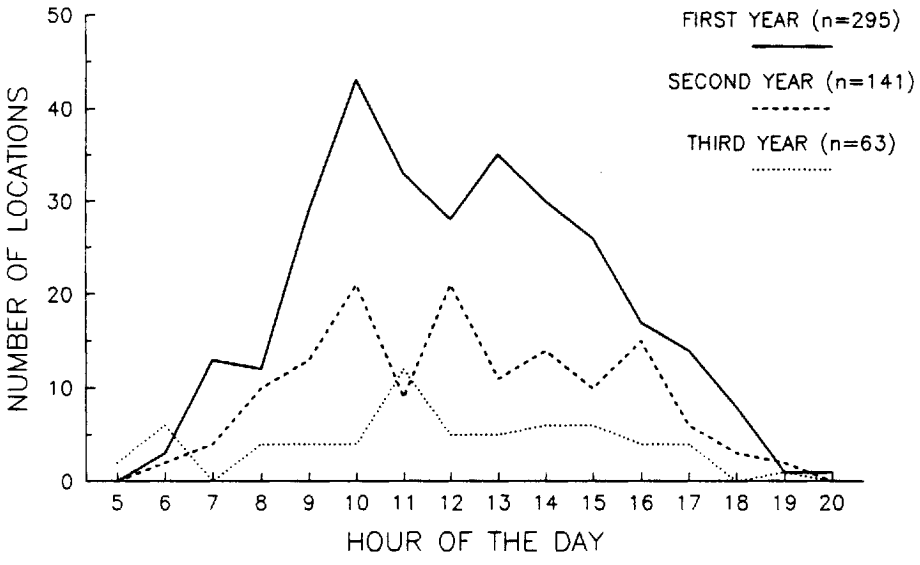

Figure 5. Time of Day that Locations Were Recorded for Bald Eagles on Santa Catalina Island, California From 1980 Through 1982.

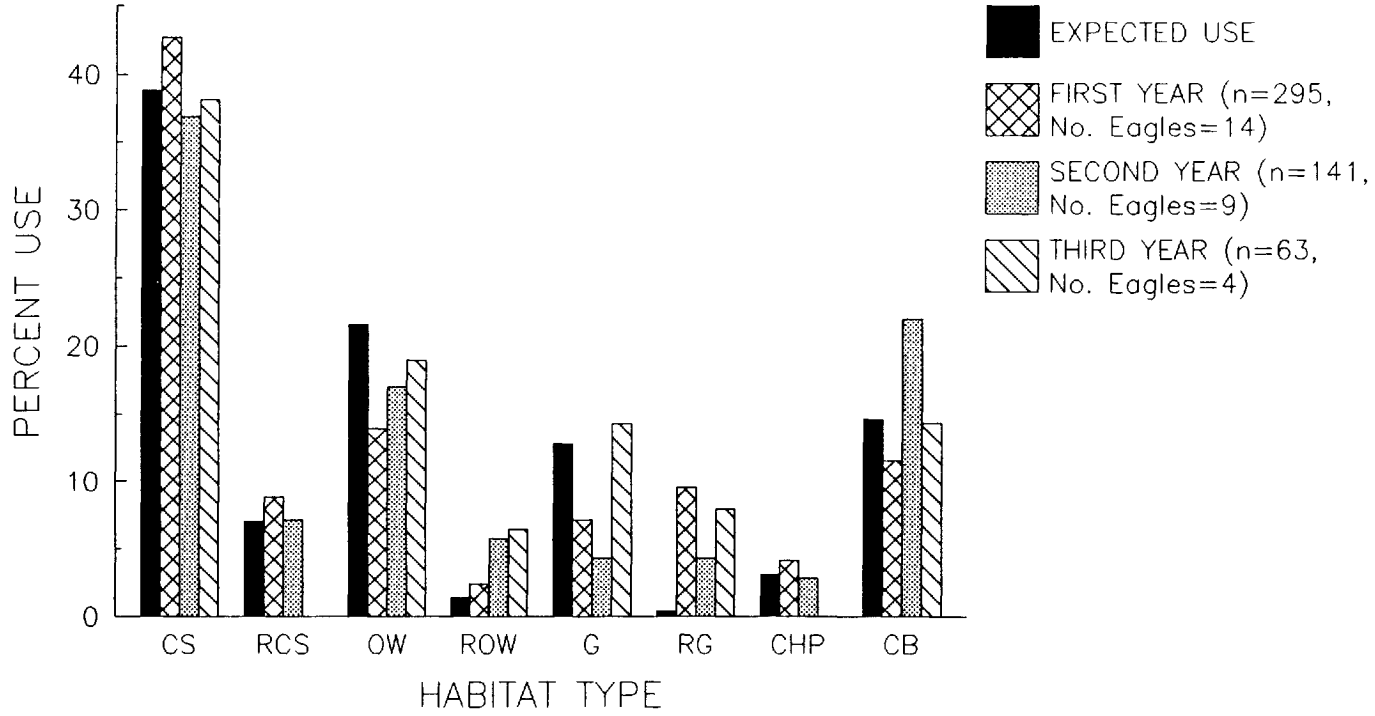

Figure 6. Habitat Use by Bald Eagles on Santa Catalina Island By Age Class. N = Number of Locations Obtained for Each Age Class. Acronym Definitions: CS=Coastal sage, RCS=Relict coastal sage, OW=Oak woodland, ROW=Relict oak woodland, G=Grassland, RG=Relict grassland, CHP=Chaparral, and CB=Coastal bluff.

Table 4. Difference in Habitat Use by Bald Eagles on Santa Catalina Island, Stratified by Age With Seasons Combined. Symbols < and > Indicate Use Significantly Lesser or Greater Than Expected, Respectively. Only Significant Differences are Noted. Values in Parentheses are the P Value Significance Levels. N is the Number of Locations in Each Habitat Type.

Habitat Type	Total No. of Grids[b]	Age Class[a]								
		First Year			Second Year			Third Year		
		<>	P	n	<>	P	n	<>	P	n
Coastal Sage	1088	>	(0.005)	126	-		52	-		24
Relic Coastal Sage[c]	196	-		26	-		10			0
Oak Woodland	604	<	(0.005)	41	-		24	-		12
Relic Oak Woodland	40	-		7	>	(0.001)	8	>	(0.001)	4
Grassland	358	<	(0.005)	21	<	(0.005)	6	-		9
Relic Grassland	11	>	(0.001)	28	>	(0.001)	7	>	(0.001)	5
Chaparral[c]	86	-		12	-		3			0
Coastal Bluff	409	-		34	>	(0.01)	31	-		9
Grid Totals	2801			295			141			63

[a]Number of individual birds from which locations were determined: First Year=14, Second Year=9, Third Year=4.

[b]Total number of grids occupied by each habitat type. Used to calculate expected values.

[c]Habitat type not used by third year birds.

Table 5. Differences in Wet and Dry Season Habitat Use by Bald Eagles on Santa Catalina Island, Stratified By Age. Letters W and D Indicate Significantly Greater Use in Wet or Dry Months, Respectively. Only Significant Differences are Noted. Values in Parentheses are the P Value Significance levels. N is the number of Locations in Each Habitat Type for Each Season (Wet (W)/Dry (D)).

		Age Class[a]					
Habitat Type	Total No. of Grids[b]	First Year P	First Year n	Second Year P	Second Year n	Third Year P	Third Year n
Coastal Sage	1088	-	51 75	-	20 32	-	8 16
Relic Coastal Sage	196	-	12 14	D (0.001)	9 1	-	0 0
Oak Woodland	604	-	18 23	W (0.05)	5 19	-	4 8
Relic Oak Woodland	40	-	5 2	W (0.005)	7 1	W (0.005)	4 0
Grassland	358	-	11 10	-	3 3	W (0.025)	7 2
Relic Grassland	11	-	9 19	-	1 6	-	1 4
Chaparral[c]	86	W (0.001)	12 0	-	1 2		0 0
Coastal Bluff	409	-	18 16	-	9 22	-	2 7

[a]Number of individual birds from which locations were determined: First Year=14, Second Year=9, Third Year=4.

[b]Total number of grids occupied by each habitat type. Used to calculate expected values.

[c]Habitat type not used by third year birds.

Table 6. Outcomes of Supplanting Attempts by Bald Eagles of Different Sex and Different Age, on Santa Catalina Island, From 1981 Through 1984. Older and Younger Refer to at Least One Year Diference in Age Between the Eagles Involved in the Supplanting Attempts.

		Outcome	
Initiator	Defender	Number Successful	Number Unsuccessful
Older Female	Younger Male	3	0
Older Male	Younger Female	4	2
Younger Female	Older Male	15	0
Younger Male	Older Female	3	1

successful in four of five attempts. Younger birds initiating supplanting attempts against older birds of the same sex were successful in all nine attempts. Supplanting attempts between eagles of the same age and sex did not elucidate any pattern of hierarchy among the birds; the number of attempts initiated by males was similar to that of females, 6 and 9 respectively.

DISCUSSION

Release and Early Post-Fledging Behavior

The hacking platform was designed for the relatively undisturbed rearing of the eagles. Introducing food at night, hooding the birds during transmitter attachment, and using a release mechanism that allowed researchers to stay out of view, allowed for minimal disturbance of the eagles. I believe survivorship may be enhanced if fledglings stay near the platforms until they reach an older, more experienced stage of development. Reducing disturbance factors during the pre-fledging period may have influenced the higher rate of return to the platforms by eagles in this study compared to studies that did not reduce disturbance at hacking platforms (Hammer et al. 1982, Hatcher and Miller 1982, Swedberg 1982, Wilson 1982). Success of a reintroduction program does not hinge solely on eagles returning to the hacking platforms to feed; however, if the eagles fail to return to the platforms, increased effort would be required to feed the eagles until they developed foraging skills.

An important aspect of reintroduction is the age at which the birds are released (Sherrod et al. 1982). Bald eagles normally fledge between 10 and 12 weeks of age

(Brown and Amadon 1968, Grubb et al. 1983, Grubb 1984). Eagles exhibit increased restlessness when confined for longer periods on the platforms (Hammer et al. 1982, Hatcher and Miller 1982). Sherrod et al. (1982) reported that peregrine falcons kept beyond natural fledging dates did not return to the hacking platforms.

Fledging flights on Catalina had a greater distance, but were similar overall to those reported by other bald eagle reintroduction programs (Lowe 1980, Hatcher and Miller 1982). In New York, released fledglings made shorter (approximately 75 m) mean flight distances (Milburn 1979). Kussman (1976) reported a wild fledgling flying approximately 200 m on its first flight.

During the first two to three days after fledging, flights of eagles released on Catalina generally were less than 500 m. Hammer et al. (1982) found released eagles to have improved flight the second day after release and to have strong but short distance flight by six to seven days after fledging. Eleven of 27 wild bald eagles in Minnesota had coordinated flight immediately following fledging, while the remainder did not show coordinated free flight (Kussman 1976). During the first month after fledging, two wild fledglings moved less than 150 m in 89 percent of observed flights (Mattsson 1974).

Newton (1979) stated that larger raptor species have longer parental dependency periods. However, both wild and reintroduced bald eagles and perhaps other members of the genus Haliaeetus have dependency periods similar to smaller members of the Accipitridae. The 42 day dependency period the Catalina eagles had on the hacking platforms for food was comparable to the 42 to 56 days reported by Kussman (1976) for wild bald eagles, and is similar to white-tailed sea eagles (Love 1983). Another scavenging raptor, the cape vulture (Gypes coprotheres), has a considerably longer parental dependency period, averaging 109 days (Robertson 1985). Red-tailed hawks (Buteo jamaicensis) were reported by Johnson (1973) to be completely dependent on the adults for 18-25 days after fledging, and to stay associated with the adults for 30-70 days.

The mortality rate of 35 percent observed in this study was low compared to estimates for wild raptor populations. However, if all of the eagles that were unaccounted for on Catalina were considered to be mortalities, then the mortality rate would be 70 percent. Sherrod et al. (1977) estimated a mortality rate of approximately 90 percent for bald eagles prior to reaching sub-adult age class at Amchitka Island, Alaska. Newton

(1979) reported first year mortality rates of 56 to 83 percent across several raptor species.

Causes of death in the Catalina eagle population did not differ from those reported for other populations. Only three of the seven mortalities were of a known cause. Newton (1979) reported that shooting accounted for 36 percent of the known causes of death in bald eagles, and electrocution accounted for another five percent. The fledgling found dead four days after an interaction with a sibling may have died as a result of an injury sustained during that interaction. Hildebrandt (1981) reported a fledgling bald eagle killed during a supplanting attempt by another eagle in Arizona; the young bird had sustained a fractured humerus and drowned after falling into a river.

Habitat Use

A major problem with examining habitat use by immature bald eagles on a year-round basis is related to their typical long range seasonal movements (Broley 1947, Gerrard et al. 1974). However, on Catalina the eagles were sedentary. I believe this was due to either a barrier to the mainland created by the Catalina Channel (at least for the young eagles that were less experienced at flying), or because the stability of the food supply

and the lack of severe seasonal weather changes precluded the need to relocate.

The use of habitats by eagles on Catalina may have been linked to the fluctuation in the level of food resources in different habitats. Sport hunting of feral goats, pigs, and mule deer occurred from October through May, and included both rifle and archery seasons. Increased availability of carrion was likely during this period, resulting from wounded animals that were not recovered by hunters, and from the remains of entrails left by hunters. Relict habitats were typically more open, and thus easier for hunters to access. I speculate that the relative openness of these areas may increase the probability that scavengers (e.g. eagles) could locate animal carrion left by hunters.

First year birds used the closed oak woodland significantly less than expected, and the open relict grassland and coastal sage significantly greater than expected. Although grassland was also an open habitat, goats were generally absent; thus habitat use less than expected would be consistent with a lack of carrion. Greater than expected use of relict oak woodland and relict grassland by second and third year birds was also consistent with the presence of carrion, as these habitats may have offered greater access to prey. Red-tailed hawks

and red-shouldered hawks (Buteo lineatus) were found to use open habitats over more closed habitats in Florida (Bohall and Collopy 1984). Barred owls, however, appeared to avoid open fields despite the apparent prey abundance (Nicholls and Warner 1972). Barred owls may have been subjected to predation by other species if exposed in open habitats, while bald eagles may be relatively immune to predation due to their large size.

The differential use of habitat by season between second and third year birds could be interpreted as evidence of learned use of habitat where prey was seasonally abundant. The use of relict oak woodland by both classes during the winter probably gave the birds better access to prey, good perching sites, and protection from the more inclement weather occurring during this time of the year. Contrary to my study, neither red-tailed hawks, red-shouldered hawks nor barred owls demonstrated seasonal use of habitats (Nicholls and Warner 1972, Bohall and Collopy 1984). Because juvenile bald eagles appeared less efficient at foraging than adults (Stalmaster and Gessaman 1984), I assumed that foraging by a bald eagle was a learned behavior. If this was the situation, two approaches to foraging may be possible for inexperienced birds. The first would be for younger birds to associate with older conspecifics who would likely be more efficient

in locating food. This approach has been discussed with respect to wintering bald eagles in Washington (Knight and Knight 1983, Stalmaster and Gessaman 1984). These researchers hypothesized that immature eagles follow adults to food sources and then scavenge carcasses or pirate food. On Catalina no adults were present during the period the habitat use data were collected, thus no mature birds could be used as "food locators." If first year immature eagles were utilizing second or third year birds as food locators a similar seasonal habitat use by age class would have resulted. However, first year birds may also use a random "search and locate" approach. Because this age class lacked the experience to know where to locate food, and was unfamiliar with the area it was searching, random searching of all available area might have been an appropriate approach to foraging. While first year birds did not use the available habitat as expected, there were fewer similarities in habitat use between first and second year birds, and first and third year birds than between second and third year birds. First year birds also used open coastal sage and relict grassland to a greater degree than the other age classes. Except in the chaparral, first year birds did not exhibit significant differences in seasonal habitat use. When compared to the other two age classes, first year birds

may not have learned about seasonal changes in availability of food resources. However, because first year birds were not seen to exploit marine prey (i.e. fishing) seasonal changes might not be an advantageous approach.

Because second and third year birds were seen foraging for marine fish and had the experience to exploit that food source, I expected increased use of the coastal bluff (associated with that resource) in older birds. A greater than expected use of the coastal bluff was evident for second year birds, but not for third year birds. A possible explanation for this is that the third year age class generally were not wearing functional telemetry transmitters, and it was difficult to find birds in the coastal bluff. Thus, third year birds may have been present in the coastal bluff more than recorded.

The habitat use results may have been biased due to several factors. First, a random method of choosing which eagle to obtain telemetry location on each day was not used, and location data obtained on non-telemetry equipped eagles were included in the analysis. Second, the small sample sizes associated with the use of some habitat types may have prevented detecting differences in habitat use. Third, the west end of the island was not sampled as frequently as other areas due to difficulty of access.

Because relict coastal sage covered 41 percent of the west end, compared to seven percent overall on the island, use of this habitat type may be under represented in my data. Fourth, only visual locations on eagles were used for determining habitat use; thus, poor visibility in a habitat may have precluded seeing a bird that was present. This would have occurred mostly in woodlands and in coastal bluffs, where birds perched on a cliff face might not be seen unless observed from a boat. Fifth, the habitat map used to determine proportions of habitat types was 12 years old and habitat alterations due to introduced animals had continued since the production of the map, thus relict areas may make up a larger amount than presented.

Behavioral Interactions

Factors affecting the outcome of pirating and supplanting attempts by bald eagles have been discussed by others (Griffin 1981, Stalmaster and Gessaman 1984, Hansen 1986, Knight and Skagen 1988) These factors included age, size, hunger level, mode of attack, displays, and availability of food. Hansen (1986) suggested that eagles assessed the relative fighting ability or expected payoffs of opponents and then acted accordingly.

In interspecific assemblages of scavenging birds, larger birds were generally shown to be dominant in both inter- and intraspecific interactions (Petrides 1959, Andersen and Horwitz 1979, Wallace and Temple 1987). With bald eagles, size also appeared to be a major factor in determining the success of an interaction. In 40 outcomes ranked by size, Hansen (1986) found larger bald eagles won 85 percent of the time. Knight and Skagen (1988) found that larger eagles, regardless of age, were successful in pirating from both large and small eagles, and observed large immature eagles to always be successful in pirating from small immature eagles. My results were consistent with these data; female (i.e. large) eagles always were successful in supplanting male (i.e. small) eagles of the same age.

The effect of age on the success of an interaction appeared to be less important than size, and was more variable in its effect. Hansen (1986) found that adult eagles won 92 contests against younger birds (subadult and immature classes) and lost 94. He also reported that juveniles attacking adults won contests much more frequently than adults pirating from juveniles. However, Stalmaster and Gessaman (1984) found older eagles were significantly more successful in supplanting and stealing food from younger birds, although relative sizes were not

reported. Griffin (1981) found both adults and immature eagles were highly successful in supplanting each other, and Fischer (1985) found that neither adults nor immatures were very successful in aerial piracy attempts. Both Griffin (1981) and Fischer (1985) classified eagles by plumage characteristics. Although data gathered in this study were classified into age classes rather than plumage classes and the sample size was relatively small, the results were similar to both Griffin and Fischer in that significant difference in age related outcomes were not found. The relative importance of size versus age in this study was further exemplified by the lack of a significant difference in the success of interactions between birds of the same sex, but of different age. With Andean condors (Vultur gryphus), where males were generally larger than females, young male condors were generally subordinate to females more than one year older, even though males may weigh as much as one third more (Wallace and Temple 1987).

While males made significantly fewer supplanting attempts against females, they escalated the interactions to include contact more often than females. However, because males almost always gave way to an approaching female, their may have been no need for females to escalate an interaction.

Knight and Skagen (1988) while studying wintering eagles in Washington, observed significantly more instances of physical contact during pirating attempts when food was scarce. Hansen (1986) also equated instances of talon-to-body contact with relative scarcity of food. He found 4.5 percent of the interactions included contact during food scarcity, however only 0.6 percent occurred when food was abundant. Hunger was likely the driving factor in the change in behavior the eagles exhibited during food scarcity. In one of the four instances where a male used contact in an interaction against a female of the same age in this study, the male had been away from the hacking platform for 16 days, and was not known to have fed during that period.

In this study size appears to be the most important factor in determining the outcome of an interaction. While age (as displayed by plumage) may be used by eagles to evaluate the potential fighting ability of opponents, it was apparently not as important as size. Knight and Skagen (1988) found that the probability of a small eagle supplanting any other eagle was low unless a small adult was attempting to pirate from a small immature. Other factors, such as hunger level (Hansen 1986), may act as modifiers which alter the risk/benefit associated with

challenging a potentially more dangerous (i.e. larger and/or older) opponent.

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APPENDIX Description of Habitat Types Used by Bald Eagles on Santa Catalina Island.

COASTAL SAGE SCRUB (CS): An open community of low deciduous and evergreen shrubs. Dominant plants are: Salvia apiana, S. mellifera, Opuntia littoralis, Rhus integrifolia, Malosma laurina, Eriogonum giganteum, Bromus pseudolaevipes, and Poa scabrella. Found on canyon slopes and sea bluffs with shallow, rock soil. The most extensive plant community, covering approximately 39 percent of the island. Relict coastal sage scrub (RCS) covers approximately seven percent of the island.

OAK WOODLAND (OW): A closed community dominated by evergreen trees. Dominant plants are: Quercus dumosa, Q. tomentella, Q. chrysolepis, Prunus lyonii, Lyonothamnus floribundus, and Heteromeles arbutifolia. Found in relatively moist, protected canyons and valleys on north- and east-facing slopes. Covers approximately 21.5 percent of the island. Relict oak woodland (ROW) covers approximately 1.4 percent of the island.

GRASSLAND (G): An open community comprised of native and introduced annual and perennial grasses and herbs. Dominant plants are: Avena barbata, A. fatua, Bromus rubens, Stipa pulchra, S. lepida, Erodium cicutarium, and

APPENDIX Description of Habitat Types Used by Bald Eagles on Santa Catalina Island. (continued)

Hordeum glaucum. Occurs in shallow soils on rocky, exposed ridges and slopes, and covers approximately 13 percent of the island. Relict grassland (GR) covers approximately 0.4 percent of the island.

CHAPARRAL (CHP): A closed community comprised of dense thickets of woody evergreen shrubs and trees. Dominant plants are: Quercus domosa, Rhus integrifolia, Malosma laurina, Ceanothus arboreus, C. megacarpus, Adenostoma fasciculatum, Rhamnus pirifolia, and Heteromeles arbutifolia. Occurs principally on north- and east-facing slopes, and in protected canyons. Covers approximately three percent of the island.

COASTAL BLUFF (CB): This habitat type is not a vegetation community charactorized by specific plants, but encompasses any community that terminates at the waters edge. Includes rocky sea bluffs, boulders and pinnacles along the shoreline, and grassy or wooded slopes that terminate near the water.