ANALYSIS OF PREY REMAINS EXCAVATED FROM AN HISTORIC BALD EAGLE NEST SITE ON SAN MIGUEL ISLAND, CALIFORNIA

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Abstract—This paper reconstructs the food habits of bald eagles (*Haliaeetus leucocephalus*) that nested historically on San Miguel Island by analyzing prey remains recovered from an historic nest site. Of the 9,946 faunal elements recovered, 9,743 (98%) were from vertebrates and 203 (2.0%) were from invertebrates. Based on minimum number of individuals, the percent diet composition for this sample was 61.2% birds, 18.6% fish, 13.6% invertebrates, 5.2% mammals, and 1.4% reptiles. Remains of 297 birds (45–48 species), 90 fish (four species, two genera and seven families), seven reptiles (one species), 25 mammals (seven species), and 66 invertebrates (23 species, three genera and three families) were identified. Domestic sheep (*Ovis aries*) comprised most (43.8%) of the other vertebrate remains with small numbers of three species of newborn pinnipeds (California sea lion [*Zalophus californianus*], northern fur seal [*Callorhinus ursinus*], and northern elephant seal [*Mirounga angustirostris*]) and three species of terrestrial mammals (island fox [*Urocyon littoralis*], deer mouse [*Peromyscus maniculatus*], and black rat [*Rattus rattus*]) also recorded. Marine gastropods (39 individuals of 14 species) and bivalves (15 individuals of seven species) composed 81.8% of the invertebrate prey remains but only represented 11.1% by MNI and 5.6% by weight of the eagle's nesting season diet. Three sensitive wildlife species (island fox, ashy storm-petrel [*Oceanodroma homochroa*], and Xantus's murrelet [*Synthliboramphus hypoleucus*]) were identified in the sample; all were incidental to the eagle's overall diet. Data obtained from this study clearly indicate that bald eagles nesting historically at the northwest end of San Miguel Island exploited a wide variety of marine and terrestrial foods during the nesting season with marine birds and near-shore marine fish being the most important prey categories. This study shows that it is possible to examine the food habits of an extirpated population of eagles by analyzing prey remains excavated from an historic nest site.

Keywords: bald eagle, Channel Islands, food habits, Haliaeetus leucocephalus, prey remains, San Miguel Island

INTRODUCTION

Bald eagles (*Haliaeetus leucocephalus*) were formerly an uncommon, but conspicuous breeding resident on all eight of the California Channel Islands (Kiff 1980, Jones and Collins In Press). Between the mid-1940s and early 1960s, they disappeared as a resident breeder from all of the Channel Islands due in part to historical persecution by humans (shooting, egg collecting, nest destruction, trapping, and poisoning) and reproductive failure (Kiff 1980). The decline of bald eagles on the Channel Islands was concurrent with the manufacture and use of DDT in California during the 1940s and 1950s and with the decline of bald eagles from other parts of their North American range as a result of egg-shell thinning effects of DDE (Kiff 1980, 2000, Garcelon 1988, Garcelon and Roemer 1990). Through translocation and hacking of young birds, bald eagles were reintroduced to Santa Catalina Island beginning in the early 1980s (Garcelon 1988) and to Santa Cruz Island beginning in 2002 (NOAA et al. 2002). When the reintroduced eagles at Santa

Catalina began nesting it was discovered that high concentrations of DDE in their eggs led to eggshell thinning that prevented successful hatching (Garcelon et al. 1989, Garcelon and Thomas 1997, Garcelon 1997). Because of the concentration of contaminants found in their eggs, an active program of manipulation of eggs and chicks at nests and hacking of additional birds into the population is required to maintain the bald eagle population at Santa Catalina Island.

Since DDT and its metabolites are slow to break down and are fat soluble, they tend to accumulate in the tissues of animals at higher trophic levels (NOAA et al. 2002). Bald eagles are particularly susceptible to DDT and DDE contaminants because of their position at the top of the food chain. At Santa Catalina Island they are high trophic level coastal predators and scavengers that are known to prey upon near-shore marine fish, seabirds, and the carcasses of beach-cast animals (Garcelon et al. 1994a, b, Sharpe and Garcelon 1999). Because they feed on marine organisms that are known to be contaminated with DDT and its metabolites, bald eagles accumulate harmful concentrations of these chemicals. As a result, bald eagles have been unable to naturally reestablish breeding populations on the Channel Islands.

To help restore marine resources injured by the release of DDTs and PCBs into the marine environment of the Southern California Bight, the Montrose Settlements Restoration Program (MSRP) recently funded a five-year feasibility study for reestablishing bald eagles to the northern Channel Islands (NOAA et al. 2002). One aspect of this feasibility study is to monitor contaminants in the released birds, their eggs, and their food to evaluate whether DDT and its metabolite DDE are present in sufficient concentrations to impair the ability of eagles to successfully reproduce on the northern Channel Islands (NOAA et al. 2002). Accurate food habit data for bald eagles on the Channel Islands is required to provide a basis for modeling the potential for eagles to accumulate high enough concentrations of DDE in their eggs that would prevent successful hatching. To provide a basis for modeling potential organochlorine concentrations in eggs of any reintroduced bald eagles that were to begin breeding on the northern Channel Islands, Sharpe and Garcelon (1999) evaluated the potential diet of eagles that would reside on Santa Cruz and Anacapa islands. However, the absence of any quantitative food habits data for bald eagles that nested historically on these islands has resulted in a great deal of uncertainty regarding the potential dietary composition of eagles that may reestablish residency on the northern Channel Islands. Because of this uncertainty, the MSRP funded this study to obtain more accurate quantitative data on the historic food habits of bald eagles on the northern Channel Islands.

Food Habits of Bald Eagles

Bald eagles are opportunistic foragers who eat a wide variety of readily available live and dead prey which they acquire by direct capture, scavenging of dead prey, and stealing from other eagles, large birds and mammals (Stalmaster 1987, Mersmann 1989, Buehler 2000). Based on the results from 20 food habit studies, the average diet of nesting bald eagles is composed of 56% fish, 28% birds, 14% mammals and 2% other material (Stalmaster 1987). When available, bald eagles tend to favor fish over other classes of potential prey (Haywood and Ohmart 1986, Stalmaster 1987, Jackman et al. 1999). In coastal areas, seabirds, waterfowl, and other large aquatic birds comprise a larger proportion of the bald eagle's diet (Murie 1940, Retfalvi 1970, Hehnke 1973, Cash et al. 1985, Knight et al. 1990). Until recently, the only information regarding the food habits of bald eagles on the Channel Islands was anecdotal observations made by early collectors of prey remains seen at eagle nests and prey observed being fed upon by eagles (Kiff 1980, 2000). Based on these limited food habits data, the diet of eagles on the Channel Islands was composed of a "variety of fish, birds and mammals, including a relatively high percentage of carrion" (Kiff 1980, p. 653). Between 1991 and the present, food habits data for bald eagles at Santa Catalina Island have been collected using foraging observations, nest observations, and collection of prey remains at nests and feeding perches (Garcelon et al. 1994a, b, Sharpe and Garcelon 1999, Sharpe 2003). Based on these data, the average diet of bald eagles at Santa Catalina Island from 1991–1998 was composed of 86.0% fish, 9.7% birds, 3.7% mammals, and 0.6% invertebrates (Sharpe and Garcelon 1999). The relative proportion of each taxonomic category in the overall diet of eagles at Santa Catalina Island varied slightly depending on the year. The proportion of fish ranged from 85.7–93.3%, birds ranged from 1.5–10.8%, and mammals ranged from 0–3.3% (Garcelon et al. 1994b, Sharpe and Garcelon 1999, 2000, Sharpe and Dooley 2001, Sharpe 2003).

Historical Status of Bald Eagles on San Miguel Island

Early published and unpublished records between 1886 and 1939 suggest that bald eagles were an uncommon to fairly common breeding resident on San Miguel Island (Streator 1888, Streator unpubl. field notes, Willett 1910, Sumner and Bond 1939). The last known observations of bald eagles nesting at San Miguel Island occurred in 1939 when active nests were photographed on Prince Island (Sumner and Bond 1939) and at Ferrelo Point (Fig. 1) on the northwest end of the main island (Fig. 2). Bald eagles disappeared as a resident breeder on San Miguel Island sometime between 1939 and 1962. Historic eagle nests were still visible in the late 1970s and early 1980s on Castle Rock (four nests), at the northwest end of the island (2–3 nests) and along the southwest side of Crook Point (see Fig. 2; Jehl 1980, Kiff 2000). The Ferrelo Point nest was one of three historic eagle nests observed in 1979 at the northwest end of the island (Kiff 2000). This nest was located on top of a rock outcrop 99 m (325 ft) above the water approximately 2.1 km (1.25 mi) east of Point Bennett. The Ferrelo Point nest was photographed by Herbert Lester, the island caretaker, in the spring of 1939 (Fig. 1). At that time the stick nest structure was approximately 1.2–1.5 m (~ 4–5 ft) high and 0.9–1.2 m (3–4 feet) wide. By September 2000, when the nest site was excavated, the stick structure measured 280 x 250 x 270 cm in size and was scattered across the south-facing slope of the rock outcrop on which the nest had originally been perched. Given the size of this nest in 1939, it is possible that bald eagles nested at this site from the mid-to-late 1800s until at least 1939 and perhaps longer.

Figure 1. Historic photograph of the Ferrelo Point bald eagle nest. Photo taken by Herbert Lester in the spring of 1939 (SBMNH Channel Islands Archive No. 0081).

The objectives of this study were to (1) determine the nesting season diet of bald eagles that nested historically at Ferrelo Point on San Miguel Island to potentially more accurately model the risk that DDE in eagle prey items poses to eagles that reestablish breeding populations on the northern Channel Islands, (2) compare and contrast the nesting season diet of eagles that nested historically at this site with the nesting season diet of the recently reintroduced population of bald eagles on Santa Catalina Island, and (3) examine which sensitive wildlife (e.g., island fox [*Urocyon littoralis*], ashy storm-petrel [*Oceanodroma homochroa*], Xantus's murrelet [*Synthliboramphus hypoleucus*], and snowy plover [*Charadrius alexandrinus*]) could be adversely affected if bald eagles reestablish residency on the northern Channel Islands.

STUDY AREA

San Miguel Island is the northwesternmost of the California Channel Islands, located 42 km (26 mi) south of Point Conception and 53 km (33 mi) southwest of Santa Barbara (Fig. 2). The island is approximately 12.9 km (8 mi) long, 3.2–6.4 km (2–4 mi) wide, and covers 32 km^2 (14 mi^2). Elevations range from sea level to 253 m (830 ft). The island is not very topographically diverse. From the shoreline, the land rises fairly steeply to an elevation of 91–122 m (300–400 ft) over most of the island. Predominant habitats found on the island include: coastal-bluff scrub, coastal-sage scrub, valley and foothill grassland, and southern beach and dune (Philbrick and Haller 1977). The island also has long stretches of sand beaches, substantial rocky shorelines, a number of offshore rocks and islets, and well developed kelp forests in near-shore waters.

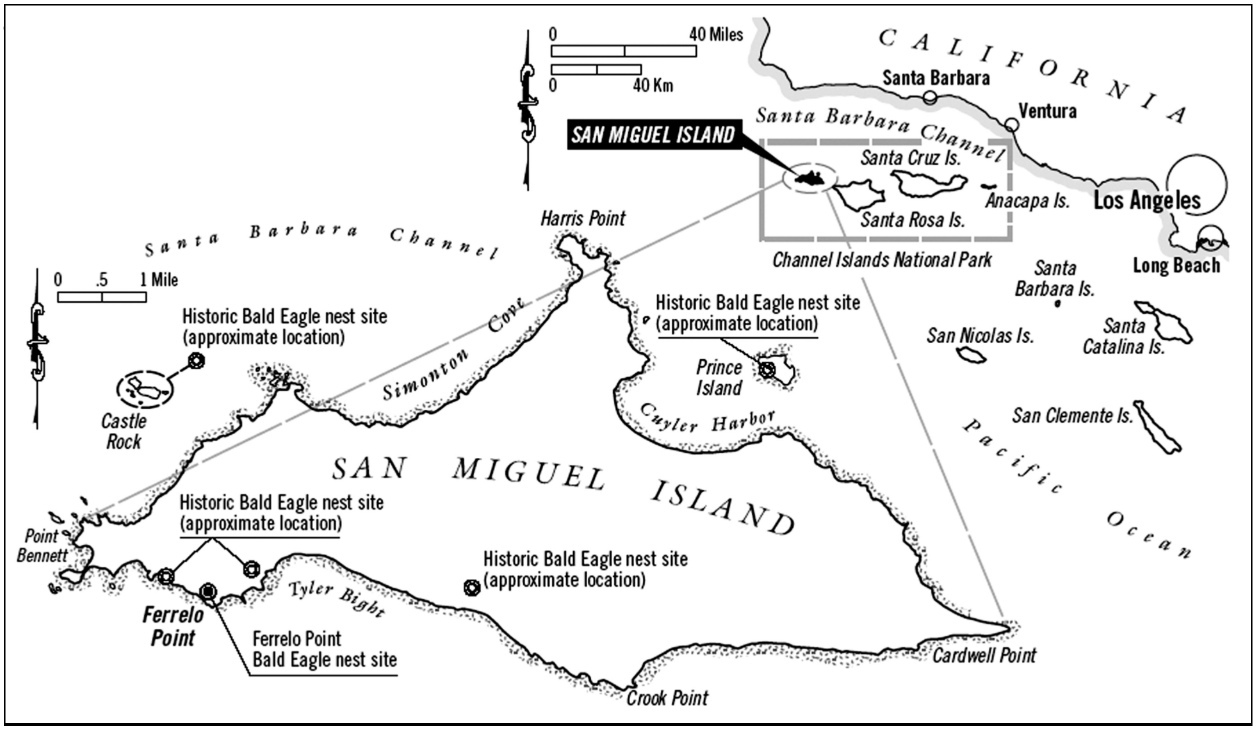

Figure 2. Site vicinity map and historic locations of bald eagle nests on San Miguel Island.

METHODS

Sample Collection

All prey remains encountered while excavating the Ferrelo Point eagle nest site were collected either by hand or with the aid of a 1.6-mm (1/16-inch) mesh screen. The nest site was initially subdivided into twelve sampling areas. Faunal material observed in nine of these areas was collected by hand while three of the areas with accumulated soil were sampled using a 1.6-mm mesh screen. During identification and preliminary data analysis, all faunal material from the site was kept separated by sampling area. All recovered faunal material was later combined when it was determined that there were no noticeable differences in the composition of faunal material recovered from the different sampling areas of the nest site.

Sample Identification

Faunal material was initially rough sorted in the field into four taxonomic groups (fish, birds, other vertebrates, and invertebrates). The material was later identified in the lab to the highest taxonomic level possible (order, family, genus, or species) by comparing diagnostic elements (bones, teeth, otoliths, and shells) with identified specimens housed in museum collections. Diagnostic elements used to identify species varied depending on the taxonomic category. For birds, 17 bones were used for species identification (see Collins et al. 2004 for a list of these bones). All of the individual bird elements recovered from the nest site were identified to species, except for bones from loons (Pacific loon [*Gavia pacifica*] and red-throated loon [*G. stellata*]), cormorants (Brandt's cormorant [*Phalacrocorax penicillatus*] and double-crested cormorant [*P. auritus*]), murrelets (ancient murrelet [*Synthliboramphus antiquus*] and marbled murrelet [*Brachyramphus marmoratus*], and large gulls. Bones were too difficult to tell apart for these species groups so they were lumped into these four species assemblages. For fish, 29 bones were used for taxonomic identification (see Collins et al. 2004 for a list of these bones). Since many of the fragmentary fish specimens could be typed by element, but had features indicative of two or sometimes three different taxa of fish, these ambiguous elements were identified to undifferentiated teleost and excluded from further identification. Fish remains were not identified beyond family or genus, except when a perfect match could be made. For other vertebrates, a total of 21 elements consisting of bones and teeth were used for species identification (see Collins et al. 2004 for a list of these bones). Invertebrates were identified by comparison with museum specimens and with standard invertebrate field guides and taxonomic reference books.

Data Analysis

Diet composition was calculated three ways. First, the number of individual specimens (NISP) was determined by counting the total number of elements identified to a particular species, genus, family or order. Second, the minimum number of individuals (MNI) for birds, reptiles, and mammals was determined to be equal to the greatest number of identical bones per taxon. (For example if seven right and six left femurs were recovered, an MNI of seven was recorded for that taxon.) Because of the excellent preservation of the fish assemblage, and the relatively large size of the sample, nine cranial elements were used in calculating MNI (see Collins et al. 2004). When cranial elements were not abundant, the number of fish vertebrae identified in the sample was divided by an average number of vertebrae for a given species, genus, or family. All MNI for fish were calculated from the assemblage as a whole not from the individual samples, providing a conservative estimate of the actual number of fish present in the sample. For invertebrates, shell apex (gastropods), number of right and left hinges (bivalves), number of end plates (chitons), number of whole or nearly whole shells (barnacles), and number of non-repetitive elements (other invertebrates) were used in calculating MNI. Third, all faunal material identified to a particular taxonomic assemblage (species, genus, or family) were weighed to the nearest 0.1 gram.

Percent diet composition was examined relative to each of these three data sources (NISP, MNI, and weight). For MNI, percent diet composition was calculated as the minimum number of individuals in a given taxonomic group, divided by the total minimum number of individuals recovered from the entire sample, multiplied by 100. A similar method was used to calculate percent diet composition using NISP and faunal element weight. Differences in percent diet composition resulted based on which of the three calculations (NISP, MNI, or weight) were used.

RESULTS

A total of 9,946 faunal elements of at least 485 individuals representing 96 different taxa were recovered from the Ferrelo Point nest site (Table 1). Of the 485 individuals identified, 66 (13.6% MNI) were invertebrates, 90 (18.6%) were fish, 297 (61.2%) were birds, 25 (5.2%) were mammals, and seven (1.4%) were reptiles. Based on the minimum number of individuals, the most common prey classes in this sample were marine birds (22.3% of total MNI), fish (18.6%), alcids (14.6%), waterfowl (9.6%), marine gastropods (8.0%), gulls and terns (6.8%), land mammals (4.3%), and bivalves (3.1%; Table 1). Based on the number of individual specimens (NISP), the most common prey classes were unidentified fish (22.7%), unidentified bird (19.8%), identified fish (18.0%), marine birds (13.7%), alcids (9.6%), waterfowl (5.8%), land mammals (3.7%), and gulls and terns (3.0%; Table 1). For birds, all three measures generated fairly similar frequencies.

A total of 4,048 fish bones were recovered from the site of which 55.8% could not be identified to species or to a higher taxonomic level (Appendix 1). Ninety individuals from 12 families are represented in the identified fish sample. Five families of fish compose most (91.1%) of the identified fish sample by MNI with rockfish (Scorpaenidae), surfperch (Embiotocidae), cabezon (Cottidae), midshipman (Batrachoididae), and sheephead (Labridae) being the most common (Appendix 1). Small numbers of other fish (nine individuals or 7.7% MNI of fish) were also present in this sample, including silversides (Atherinidae), kelpfish (Clinidae), herring/sardines (Clupeidae), sculpins (Cottidae), mackerel (Scombridae), prick-lebacks (Stichaeidae), and Pacific hake (Appendix 1).

Of the 5,261 bird bones (NISP) recovered from the Ferrelo Point eagle nest, 37.4% could not be identified to species (Appendix 1). As these unidentified bones were almost exclusively vertebrae, ribs and phalanges, identification of these elements would probably not change the MNI or the list of identified species significantly. From the remaining 3,292 bones, a total of 297 individuals of a least 45–48 species were identified (Appendix 1). With few exceptions (common raven [*Corvus corax*], bald eagle and Brandt’s cormorant), all bird

Table 1. Total number of faunal elements recovered and percent composition of nesting Bald Eagle dietary remains at the Ferrelo Point nest site, San Miguel Island.

Prey Category	NISP[a]	MNI[b]	Wt. (g)	% NISP[c]	% MNI[c]	% Wt[c]
INVERTEBRATES	(203)	(66)	(641.3)	(2.0)	(13.6)	(5.9)
Bivalves	22	15	16.6	tr	3.1	tr[d]
Marine gastropods	51	39	612.3	0.5	8.0	5.6
Terrestrial gastropods	9	1	0.3	tr	tr	tr
Echinoderms	30	2	2.9	tr	tr	tr
Polyplacophora	17	3	1.6	tr	tr	tr
Crustaceans	37	5	4.9	tr	1.0	tr
Marine shell undiff.	28	-	2.0	tr	tr	tr
Coralline algae	5	1	0.4	tr	tr	tr
Coral undiff.	4	-	0.4	tr	tr	tr
VERTEBRATES	(9,743)	(419)	(10,328.3)	(98.0)	(86.4)	(94.2)
Fish Total	(4,048)	(90)	(1,391.6)	(40.7)	(18.6)	(12.7)
Fish undiff.	2,257	-	304.2	22.7	-	2.8
Reptile Total	(21)	(7)	(0.6)	(tr)	(1.4)	(tr)
Birds Total	(5,261)	(297)	(6,427.3)	(52.9)	(61.2)	(58.6)
Marine birds	1,366	108	3,350.8	13.7	22.3	30.5
Waterfowl	580	45	987.0	5.8	9.6	9.0
Herons/egrets	3	1	7.2	tr	tr	tr
Shorebirds	15	6	5.7	tr	1.2	tr
Gulls and terns	298	33	570.6	3.0	6.8	5.2
Alcids	959	71	766.7	9.6	14.6	7.0
Landbirds	28	7	44.1	tr	1.4	tr
Bald eagle	43	3	313.2	tr	0.6	2.9
Birds undiff.	1,969	-	381.7	19.8	-	3.5
Mammals Total	(413)	(25)	(2,508.8)	(4.2)	(5.2)	(22.9)
Land mammals	371	21	2,386.8	3.7	4.3	21.8
Marine mammals	32	4	113.1	tr	0.8	1.0
Mammals undiff.	10	-	8.9	tr	-	tr
Grand Total	9,946	485	10,969.6	-	-	-

[a] NISP=number of individual specimens.
[b] MNI=minimum number of individuals.
[c] Percentages are rounded to the nearest 0.1 of a decimal point and are based on all prey remains recovered.
[d] tr=trace amount representing less than 0.5% of the total.

material was from adult or subadult birds. Marine birds composed most (86.6%) of the birds recovered in this prey category (Appendix 1). Based on MNI, the most common bird groups in decreasing order of abundance were alcids, cormorants, waterfowl, shearwaters and fulmars, and gulls and terns (Appendix 1). The most common bird species at the site included rhinoceros auklet (*Cerorhinca monocerata*), white-winged scoter (*Melanitta fusca*), Brandt's/double-crested cormorants, sooty shearwater (*Puffinus griseus*), Cassin's auklet (*Ptychoramphus aleuticus*), pelagic cormorant (*Phalacrocorax pelagicus*), and large gulls (Appendix 1). Except for white-winged scoter and rhinoceros auklet, all of these species are common today in near-shore waters around the northern Channel Islands (Jones and Collins In press). Of particular note is the low occurrence of sensitive marine birds in the prey remains recovered from this site such as ashy storm-petrels (one possible individual) and Xantus's murrelets (three individuals), and the absence of brown pelicans (*Pelecanus occidentalis*) and snowy plovers. The most unusual bird recorded in this sample was an American bittern (*Botaurus lentiginosus*), which is only the second record of this species for the Channel Islands (Jones and Collins In press). A total of 43 bones from at least three individual bald eagles were also recovered from the site. The eagle bones were from young that probably died on the nest.

Nearly all (97.7%) of the 434 bones of other vertebrates recovered from this site were identified to species. Twenty-nine individuals of eight species (one reptile, seven species of mammals) were recorded from the nest site (Appendix 1). For reptiles, seven individual southern alligator lizards (*Elgaria multicarinata*) were represented in the prey remains and were likely from animals that had been living within the nest structure. Mammals composed a relatively small proportion (5.2% MNI) of the overall diet of the eagles that nested at the Ferrelo Point nest site (Table 1). Terrestrial mammals represented 4.3% of the total diet while marine mammals made up the remaining 0.8% of the mammal prey class (Table 1). Of the seven species of mammals recorded, sheep (*Ovis aries*) was the most common by all measures (i.e., 77.4% by NISP, 43.8% by MNI, and 94.5% by bone weight), with a total of 14 individuals (seven lambs and seven subadult/adults) contained in the sample (Appendix 1). Based on the numbers of axial and appendicular sheep bones recovered from this site, it appears that intact lamb carcasses were being returned to the nest by eagles. The other six species of mammals observed occurred in small numbers. A total of 25 bones from four deer mice (*Peromyscus maniculatus*), and eight bones from one black rat (*Rattus rattus*) were found in the sample. While the deer mouse bones are probably the result of mice dying within the nest structure and not prey brought back to the nest by eagles, the rat bones could represent prey remains brought to the nest by eagles. A total of 10 island fox bones from at least two individuals were recovered. Island foxes composed 6.3% of this prey category by MNI, 2.4% by NISP, and 0.8% by bone weight. The low occurrence of island fox bones in prey remains from the Ferrelo Point nest site suggests that bald eagles were probably only occasionally scavenging island fox carcasses as carrion and were not regularly preying upon live island foxes. Three species of marine mammals were found, all were very young animals. Marine mammals composed 7.6% of this vertebrate prey category by NISP, 12.5% by MNI, and 4.4% by bone weight (Appendix 1). California sea lion (*Zalophus californianus*) was the most common marine mammal bone found at the site with a total of 25 bones from at least two individuals identified in the sample.

A total of 203 invertebrate remains from 66 individuals of 29 species were recovered from the Ferrelo Point nest site (Appendix 1). Bivalves and marine gastropods comprised 81.8% of the invertebrate MNI recovered and represent 97.6% of the weight of the invertebrate sample (Appendix 1). Marine gastropods were the most common invertebrate prey category by all measures (i.e., 25.1% by NISP, 54.1% by MNI, and 95.5% by weight). By weight, the heaviest species represented was black abalone (*Haliotis cracherodii*; 588.02 g; Appendix 1).

DISCUSSION

When comparing the results obtained from our prey remains study with other eagle food habit studies, it is important to consider the biases that result from the methods used to gather food habits data. A variety of approaches have been used to document bald eagle food habits, including direct observation of prey delivery to nests, examination of prey remains collected at nests and perches, examination of prey in egested pellets collected at communal roosts, and direct observation of foraging (Mersmann et al. 1992, Buehler 2000). Each of these reported techniques has biases. Conclusions based on prey remains/pellet analyses are skewed toward prey items with hard bony structures such as birds, medium-mammals, and larger bony fish, and tend to underestimate soft bodied prey items such as small mammals, small fish, soft-bodied fish and large-bodied prey/carrion that are too big to carry back to the nest (Todd et al. 1982, Collopy 1983, Mersmann et al. 1992). Biases also result from differences in the numbers and identifiability of bones for each animal class. Because the number and preservation of identifiable bones from each animal class varies, this factor can also have a significant bias on the abundance and percentage of the various taxa. NISP and MNI both tend to underestimate species whose bones were soft and thus do not preserve well. In our study, element weight overestimated the importance of species that have heavier bones such as sheep, loons, and cormorants. For fish, NISP showed a much higher frequency (40.7%) relative to the other two measures (Table 1). For invertebrates, MNI tended to overestimate the importance of this prey category to the eagle's nesting season diet due in part to the occurrence of numerous small marine gastropods and bivalves that were probably not eagle prey.

Fish

The complement of fish taxa observed in the prey remains from the Ferrelo Point nest is composed of common species and families of fish that frequent nearshore kelp forest and rocky shore environments in the immediate vicinity of San Miguel Island (e.g., silversides, kelpfish, sculpin, cabezon [*Scorpaenichthys marmoratus*], surfperch, pile perch [*Damalichthys vacca*], California sheephead [*Semicossyphus pulcher*], and rockfish). Exceptions to this pattern included herring and sardines that tend to be more pelagic, midshipman that occur in bays and in soft bottom areas, and hake that usually occur in moderately deep waters. While it is impossible to determine which of these taxa were fed upon as carrion, which were taken as live prey, and which were contained in the stomachs of larger fish and marine bird prey, it is likely that species that are more typical of deeper offshore waters could have been taken as beach cast or floating carcasses or represent the remains of stomach contents from other larger bald eagle prey. While some of the small fish species (e.g., silversides, kelpfish, small sculpins, herring and sardine, pricklebacks, and smaller species of rockfish and surfperch) recovered from the Ferrelo Point nest site are likely the remains of stomach contents of larger fish and marine birds that were brought back to the nest as prey by bald eagles, they could also represent prey that were captured by eagles. At Santa Catalina Island, bald eagles have been observed feeding on a variety of smaller schooling fish such as California grunion (*Leuresthes tenius*), northern anchovy (*Eugraules mordax*), topsmelt (*Atherinops affinis*), Pacific herring (*Culpea harengus*), and pacific sardine (*Sardinops sagax*; Garcelon et al. 1994a, b, Sharpe and Dooley 2001, Sharpe 2003).

As reported in other bald eagle food habit studies, prey remains recovered from nests and roosts tend to underestimate fish in bald eagle diets due in part to the fact that bones from smaller fish tend to be more easily broken and digested and are thus more difficult to find (Imler and Kalmbach 1955, Dunstan and Harper 1975, Ofelt 1975). Due to the dearth of bones in their skeletons, cartilaginous fishes such as sharks, skates, and rays (elasmobranches) would also tend to be under represented in the sample. These factors probably contributed to the lower MNI of fish remains recovered from the Ferrelo Point nest site. While these remains provide a relatively accurate indication of fish species consumed by eagles at this site during the nesting season, they probably underestimate the importance of fish in the eagle's overall diet. While the differences observed between the importance of fish and birds in the diet of nesting bald eagles on Santa Catalina and San Miguel islands (see Table 8 in Collins et al. 2004) is likely due in part to biases known to exist between observation-based and prey remains-based food habits data, these differences probably represent a preference of eagles at San Miguel Island toward marine birds based on availability. Other food habit studies of bald eagles in coastal areas and in areas where waterfowl tend to concentrate, have reported a similar shift to a greater proportion of birds in their diet than fish (Murie 1940, Hehnke 1973, Swenson 1975, Todd et al. 1982, Knight et al. 1990).

Birds

When seasonally abundant bird populations exist in close proximity to eagle nesting territories, birds compose a higher proportion of a nesting eagle's diet, sometimes representing from 44–83% of the prey items found at nests (see review in Stalmaster 1987). Birds composed 48% of the prey remains in bald eagle nests at Lake Superior (Kozie and Anderson 1991), 49% of prey remains on Amchitka Island (Sherrod et al. 1976), 55% of prey remains in Washington (Knight et al. 1990), 66% of prey remains at Klamath Lake in Oregon (Frenzel 1985), 81% of prey remains on the Aleutian Islands (Murie 1940), and 83% of prey remains on the Alaska Peninsula (Henke 1973). These food habit studies all show that when there is an abundant nearby source of birds, the relative proportion of birds in an eagle's diet increases. The nesting season diet of bald eagles that nested historically at the Ferrelo Point nest site on San Miguel Island was similar to diets reported in other food habit studies of eagles nesting in coastal areas (Murie 1940, Hehnke 1973, Todd et al. 1982, Knight et al. 1990).

Our results differed from recent observation-based food habit studies conducted on eagles nesting at Santa Catalina Island (Garcelon et al. 1994b, Sharpe and Garcelon 1999, 2000; Sharpe and Dooley 2001, Sharpe 2003). When compared with MNI, the overall diet of eagles nesting at Santa Catalina Island was composed of a much higher percentage of fish (85.7–93.3%) and a lower percentage of birds (1.5–10.8%) while the diet of eagles that nested at the Ferrelo Point site was composed of a much higher percentage of birds (61.2%) and a lower percentage of fish (18.6%) (see Table 8 in Collins et al. 2004). Differences observed in the relative proportion of major prey categories between the Santa Catalina and San Miguel Island samples is due in part to biases that result from the methods used to collect food habits data for each of these studies and to differences in the relative abundance of the nesting marine bird fauna found at each island. The Santa Catalina food habit studies were based on observational data and on prey remains collected at nests during banding activities, while our study was based entirely on prey remains recovered from an historic nest site. The nesting marine bird fauna at San Miguel Island today is comprised of approximately 33,250 marine birds of at least twelve species while the Santa Catalina Island nesting marine bird fauna is only comprised of 156 birds of a single species (Carter et al. 1992).

Bald eagles generally prey upon medium to large-sized seabirds such as loons, grebes, cormorants, waterfowl, gulls, and alcids which they obtain by direct capture or by scavenging carcasses that are either floating or have been washed onto shore (see review in Buehler 2000). The dominant bird groups found in prey remains at the Ferrelo Point nest site are similar to those reported from other bald eagle food habitat studies in coastal areas of western North America (Murie 1940, Hehnke 1973, Sherrod et al. 1976, Knight et al. 1990, Watson et al. 1991). Of the twelve species of marine birds that currently nest at San Miguel Island, six breed in substantial numbers, including Cassin's auklet (11,584 breeding birds), Brandt's cormorant (15,700 birds), western gull (*Larus occidentalis*; 1,892 birds), pigeon guillemot (*Cepphus columba*; 1,114 birds), pelagic cormorant (691 birds), and double-crested cormorant (552 birds) (Carter et al. 1992). Except for bones of one juvenile Brandt's cormorant, all bones recovered from this nest site of species known to nest at San Miguel Island were either adult or subadult individuals. This suggests that bald eagles were not preying upon young in seabird nesting colonies on San Miguel Island. It is unknown whether they were preying upon adult cormorants and western gulls at their breeding colonies and communal roost sites.

Storm-petrel remains have been found at bald eagle nest and roost sites in Alaska (Murie 1940, Sherrod et al. 1976) and British Columbia (Rodway and Lemon 1991 cited in NOAA et al. 2002), but only as incidental prey items. Possible remains of one ashy storm-petrel and one Leach's storm-petrel (*Oceanodroma leucorhoa*) in the prey remains from the Ferrelo Point nest site suggests that they too were only incidental prey for bald eagles that nested historically at this site. This is not unexpected given that both species tend to visit their nests only at night when eagles are not known to forage. Alcids, on the other hand, formed a significant portion (14.6% MNI of all remains) of the nesting season diet of eagles that nested at Ferrelo Point (Table 1). Xantus's murrelets have occasionally (n = 5 records) been observed as prey in eagle nests on Santa Catalina Island (Garcelon et al. 1994a, b, Sharpe and Garcelon 1998, Sharpe 2003). The occurrence of three Xantus's murrelets and two ancient/marbled murrelets in prey remains from the Ferrelo Point nest site suggests that murrelets were probably only incidental prey to the eagles that nested historically at this site.

Other Vertebrates

The relatively low occurrence of terrestrial and marine mammals in the Ferrelo Point eagle's diet is similar to what has been reported for the occurrence of mammals in other bald eagle food habits studies elsewhere in North America (see Appendix 1 in Collins et al. 2004). Throughout their range in North America, bald eagles have been reported to feed readily on carcasses of wild herbivores (deer, caribou, elk, and moose) and domestic livestock (cows, sheep, pigs) (Stalmaster 1987, Phillips and Blom 1988, DellaSala et al. 1989, Marr et al. 1995, Buehler 2000). There are only a few documented cases of bald eagle predation on lambs (Herrick 1924, Smith 1936, Wiley and Bolen 1971) and newborn pigs (Stalmaster 1987, NOAA et al. 2002). While there are numerous references to bald eagles eating lambs on the Channel Islands, and even a few cases in which it was suggested that eagles were killing lambs, there are no firsthand accounts of eagle predation on lambs at the Channel Islands (Kiff 1980).

On Santa Catalina Island, bald eagles have been seen feeding on carcasses of adult and newborn pigs (*Sus scrofa*), feral goats (*Capra hircus*), and on one occasion were observed returning to a nest site with a live piglet (Ross 1925, Garcelon et al. 1994b). Sheep were first introduced to San Miguel Island in the early 1850s by George Nidever. By 1862 it was estimated that there were close to 6,000 sheep on the island (Daily 1987). Given these numbers, there should have been a supply of sheep carcasses available upon which eagles could forage. Eagles were probably feeding more extensively on sheep carcasses while away from nests, which would explain their representative numbers. Today there are no feral herbivores present on San Miguel Island and as a result domestic livestock carcasses will not be available as a prey source once bald eagles reestablish a breeding presence on this island.

In Alaska, bald eagles have been observed regularly scavenging carcasses of harbor seal (*Phoca vitulina*), Steller's sea lion (*Eumetopias jubatus*), sea otters (*Enhydra lutris*), and whales that were washed up on the shore, and were also seen feeding on afterbirths from sea lions and on sea lion dung (Sherrod et al. 1976). There is even a report of bald eagles killing and feeding upon sea otter pups (Sherrod et al. 1975). The only evidence that bald eagles at the Channel Islands have fed on marine mammal carcasses comes from remains of a harbor seal found in an eagle nest on Santa Catalina Island and direct observations of bald eagles feeding on California sea lion carcasses at Santa Catalina and Santa Cruz islands (Garcelon et al. 1994b, P. Sharpe pers. comm.). Marine mammal material recovered from the Ferrelo Point nest suggests that eagles were occasionally feeding on newborn and stillborn carcasses of three species of pinnipeds (Appendix 1). It is very likely that marine mammals composed a somewhat larger proportion of the Ferrelo Point eagle's diet than these prey remains suggest because they were probably feeding on larger quantities of flesh from beach cast marine mammal carcasses and on afterbirths. This type of material would not leave any hard remains that would show up as prey remains in the nest.

It is also possible that the low occurrence of marine mammal bones in the prey remains recovered from the Ferrelo Point nest could be due to pinnipeds being uncommon on San Miguel Island in the late 1800s and early to mid-1900s, most of the period when the Ferrelo Point nest was active, as a consequence of intense commercial harvesting in the 1800s (Stewart et al. 1993). Today there are five species of pinnipeds that haulout and breed on San Miguel Island, with more than 50,000 northern elephant seals, 80,000 California sea lions, 12,000 northern fur seals, and 1,200 harbor seals breeding at San Miguel Island (Le Boeuf and Bonnell 1980, DeLong and Melin, 2000). This many pinnipeds on San Miguel Island create a substantial number of marine mammal carcasses and afterbirths upon which eagles could feed. Thus, it is very likely that if bald eagles were to reestablish a breeding presence on San Miguel Island today, they would probably make greater use of this readily available and abundant source of carcasses and afterbirths.

Invertebrates

Differentiating which invertebrates are eaten by eagles, which represent stomach contents of larger eagle prey (e.g., larger marine fish and marine birds), or which were brought to the nest by other birds such as common ravens, is difficult. Other food habit studies of nesting bald eagles have reported them eating abalones (Hawbecker 1958, Stalmaster 1987), as well as a variety of other marine invertebrates (Smith 1936, Retfalvi 1970, Ofelt 1975, Grubb and Hensel 1978, Todd et al. 1982, Knight et al. 1990). Some of the larger invertebrates found in the Ferrelo Point nest were probably transported to the site by eagles. However, most of the small bivalves, small marine gastropods, small chitons, barnacles, coral, and coralline algae were undoubtedly brought to the nest site in the stomachs of larger eagle prey or were incidental "riders" on other larger shellfish.

Including all of the smaller invertebrates in this prey remains analysis results in an over estimate of the percentage of the eagles diet composed of invertebrates.

CONCLUSIONS

In summary, this study clearly shows that it is possible to reconstruct the nesting season food habits of an extirpated population of bald eagles by analyzing prey remains that are contained in historic nest sites. However, biases exist in the prey remains data. Birds tend to be overestimated because bird bones persist for longer periods in nest sites, while fish tend to be underestimated because their remains are often more thoroughly digested and thus do not persist as long in sites. The findings from our study regarding the composition of the nesting season diet of bald eagles on San Miguel Island are at variance with the observation-based nesting season food habit studies that have been conducted on the reintroduced population of bald eagles at Santa Catalina Island. Prey remains recovered from the Ferrelo Point eagle nest site clearly indicate that at least historically bald eagles on San Miguel Island were exploiting a wide variety of available foods. Marine birds made up a significantly higher proportion of the nesting season diet of eagles at the Ferrelo Point nest site than has been reported from prey remains data for bald eagles nesting today at Santa Catalina Island. This difference is due in part to the fact that marine bird populations are much more abundant at San Miguel Island than they are at Santa Catalina Island, and to biases that result from the type of data used in each of these food habit studies. Most of the diet of the eagles that nested at the Ferrelo Point nest site was composed of marine birds and nearshore marine fish. There were also smaller amounts of land and marine mammals and marine invertebrates. Domestic sheep was the most common mammal present in the sample. Small amounts of juvenile bone from three species of pinnipeds were recovered from the site. The low occurrence of marine mammal material is probably due in part to the small size of the pinniped populations on the island when this nest site was active. Sensitive species such as island fox, ashy storm-petrel and Xantus's murrelet, were uncommon in the prey remains, suggesting that at least historically all three species were only incidental prey for bald eagles at San Miguel Island.

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REFERENCES

Buehler, D.A. 2000. Bald Eagle (*Haliaeetus leucocephalus*). *In*: Poole, A. and F. Gill, (eds.), The Birds of North America, No. 506. The Birds of North America, Inc., Philadelphia, PA, 40 pp.

Carter, H.R., G.J. McChesney, D.L. Jaques, C.S. Strong, M.W. Parker, J.E. Takekawa, D.L. Jory and D.L. Whitworth. 1992. Breeding populations of seabirds in California, 1989–

1991. Vol. 1: Population estimates. U.S. Fish and Wildlife Service, Northern Prairie Wildlife Research Center, Dixon, CA, and U.S. Fish and Wildlife Service, San Francisco Bay National Wildlife Refuge Complex, Newark, CA.

Cash, K.J., P.J. Austin-Smith, D. Banks, D. Harris and P.C. Smith. 1985. Food remains from Bald Eagle nest sites on Cape Breton Island, Nova Scotia. Journal of Wildlife Management 49:223–225.

Collins, P.W., D.A. Guthrie, T.C. Rick and J.M. Erlandson. 2004. Food habits of bald eagles that nested historically at San Miguel Island based on prey remains excavated from an historic nest site. Santa Barbara Museum of Natural History Technical Reports No. 2.

Collopy, M.W. 1983. A comparison of direct observations and collections of prey remains in determining the diet of Golden Eagles. Journal of Wildlife Management 47:360–368.

Daily, M. 1987. California's Channel Islands. 1001 Questions answered. McNally & Loftin, Publishers, Santa Barbara, CA, 284 pp.

DellaSala, D.A., C.L. Thomas and R.G. Anthony. 1989. Use of domestic sheep carrion by Bald Eagles wintering in the Willamette Valley, Oregon. Northwest Science 63:104–108.

DeLong, R.L. and S.R. Melin. 2000. Thirty years of pinniped research at San Miguel Island. Pages 401–406. *In*: Brown, D.R., K.L. Mitchell and H.W. Chaney (eds.), Proceedings of the Fifth California Islands Symposium. MBC Applied Environmental Sciences, Costa Mesa, CA.

Dunstan, T.C. and J.F. Harper. 1975. Food habits of bald eagles in north-central Minnesota. Journal of Wildlife Management 39:140–143.

Frenzel, R.W. 1985. Environmental contaminants and ecology of Bald Eagles in south central Oregon [Ph.D. dissertation]. Oregon State University, Corvallis, OR, 143 pp.

Garcelon, D.K. 1988. The reintroduction of Bald Eagles on Santa Catalina Island, California [Master's thesis]. Humboldt State University, Arcata, CA, 58 pp.

Garcelon, D.K. 1997. Effects of Organochlorine contaminants on bald eagle reproduction at Santa Catalina Island. Unpublished manuscript, 16 pp.

Garcelon, D.K., R.W. Risebrough, W.M. Jarman, A.B. Chartrand and E.E. Littrell. 1989. Accumulations of DDE by bald eagles (*Haliaeetus leucocephalus*) reintroduced to Santa Catalina Island in Southern CA. Pages 491–494. *In*: Meyburg, B.V. and R.D. Chancellor (eds.), Raptors in the Modern World. Proceedings of the Third World Conference on Birds of Prey. International Council for Bird Preservation, London, UK.

Garcelon, D.K. and G.R. Roemer. 1990. The reintroduction of Bald Eagles on Santa Catalina Island, California. Pages 63–68. *In*: Bryant, P.J. and J. Remington (eds.), Endangered Wildlife and Habitats in Southern California. Memoirs of the Natural History Foundation of Orange County No. 3. Natural History Foundation of Orange County, Newport Beach, CA.

Garcelon, D.K., J.S. Romsos and P. Golightly. 1994b. Food habits of Bald Eagles on Santa Catalina Island, January–July 1993. Prepared for U.S. Fish and Wildlife Service, Damage Assessment Office, Sacramento, CA, 17 pp.

Garcelon, D.K. and N.J. Thomas. 1997. DDE poisoning in an adult Bald Eagle. Journal of Wildlife Diseases 33:299–303.

Garcelon, D.K., S. Tomassi, D. Kristan and D. Delaney. 1994a. Food habits of the Bald Eagles on Santa Catalina Island November 1991–December 1992. Prepared for U.S. Fish and Wildlife Service, Damage Assessment Office, Sacramento, CA, 24 pp.

Grubb, T.G. and R.J. Hensel. 1978. Food habits of nesting Bald Eagles on Kodiak Island, Alaska. The Murrelet 59:70–72.

Hawbecker, A.C. 1958. Abalones eaten by Bald Eagles. Condor 60:407–408.

Haywood, D.D. and R.D. Ohmart. 1986. Utilization of benthic-feeding fish by inland breeding bald eagles. Condor 88:35–42.

Hehnke, M.F. 1973. Nesting ecology and feeding behavior of bald eagles on the Alaska Peninsula [Master's thesis]. California State University, Humboldt, Arcata, CA.

Herrick, F.H. 1924. The daily life of the American eagle: late phase. Auk 41:389–422.

Imler, R.H. and E.R. Kalmbach. 1955. The Bald Eagle and its economic status. U.S. Fish and Wildlife Service Circular 30.

Jackman, R.E., W.G. Hunt, J.M. Jenkins and P.J. Detrick. 1999. Prey of nesting Bald Eagles in Northern California. Journal Raptor Research 33:87–96.

Jehl, J.R., Jr. 1980. Status of Peregrine Falcon in the Channel Islands, 1979–1980. Pages 31–44. *In*: Jehl, J.R., Jr. and C.F. Cooper (eds.), Potential Effects of Space Shuttle Sonic Booms on the Biota and Geology of the California Channel Islands: Research Reports. Center for Marine Studies, San Diego State University Technical Report 80–1.

Jones, H.L. and P.W. Collins. In press. Birds of California's Channel Islands. Their Status and Abundance. Santa Barbara Museum of Natural History, Santa Barbara, CA.

Kiff, L.F. 1980. Historical changes in resident populations of California Islands raptors. Pages 651–671. *In*: Power, D.M. (ed.), The California Islands: Proceedings of a Multidisciplinary Symposium. Santa Barbara Museum of Natural History, Santa Barbara, CA.

Kiff, L.F. 2000. Further notes on historical Bald Eagle and Peregrine Falcon populations on the California Channel Islands. Unpublished manuscript, 43 pp.

Knight, R.L., P.J. Randolph, G.T. Allen, L.S. Young and R.T. Wigen. 1990. Diets of nesting Bald Eagles, *Haliaeetus leucocephalus*, in western Washington. Canadian Field-Naturalist 104:545–551.

Kozie, K.D. and R.K. Anderson. 1991. Productivity, diet, and environmental contaminants in Bald Eagles nesting near the Wisconsin shoreline of Lake Superior. Archives of Environmental Contamination and Toxicology 20:41–48.

Le Boeuf, B.J. and M.L. Bonnell. 1980. Pinnipeds of the California Islands: Abundance and distribution. Pages 475–493. *In*: Power, D.M. (ed.), The California Islands: Proceedings of a multidisciplinary symposium. Santa Barbara Museum of Natural History, Santa Barbara, CA.

Marr, N.V., W.D. Edge, R.G. Anthony and R. Valburg. 1995. Sheep carcass availability and use by Bald Eagles. Wilson Bulletin 107:251–257.

Mersmann, T.J. 1989. Foraging ecology of Bald Eagles on the north Chesapeake Bay with an evaluation of techniques used in the study of Bald Eagle food habits [Master's thesis]. Virginia Polytechnic Institute: Blacksburg, VA, 116 pp.

Mersmann, T.J., D.A. Buehler, J.D. Fraser and J.K.D. Seegar. 1992. Assessing bias in studies of Bald Eagle food habits. Journal of Wildlife Management 56:73–78.

Murie, O.J. 1940. Food habits of the northern Bald Eagle in the Aleutian Islands, Alaska. Condor 42:198–202.

National Oceanic and Atmospheric Administration (NOAA), U.S. Fish and Wildlife Service, National Park Service, California Department of Fish and Game, California State Lands Commission and California Department of Parks and Recreation. 2002. Feasibility Study for Reestablishment of Bald Eagles on the northern Channel Islands, California. Environmental Assessment. Prepared for Montrose Settlements Restoration Program, Long Beach, CA, 54 pp. + appendices.

Ofelt, C.H. 1975. Food habits of nesting Bald Eagles in southeast Alaska. Condor 77:337–338.

Philbrick, R.N. and J.R. Haller. 1977. The Southern California Islands. Pages 893–906. *In*: Barbour, M.G. and J. Major (eds.), Terrestrial Vegetation of California. John Wiley and Sons, New York, NY.

Phillips, R.L. and F.S. Blom. 1988. Distribution and magnitude of eagle/livestock conflicts in the western United States. Proceedings of Vertebrate Pest Conference 13:241–244.

Retfalvi, L. 1970. Food of nesting Bald Eagles on San Juan Island, Washington. Condor 72:358–361.

Rodway, M.S. and M.J.F. Lemon. 1991. British Columbia Seabird Colony Inventory: Report #8–Queen Charlotte Straight and Johnstone Straight. Technical Report Series No. 123. Canadian Wildlife Service, Pacific and Yukon Region, British Columbia.

Ross, R.C. 1925. Field notes on the raven. Condor 27:172.

Sharpe, P.B. 2003. Restoration and management of Bald Eagles on Santa Catalina Island, California–2002. Prepared for U.S. Fish and Wildlife Service, Damage Assessment Branch, Sacramento, CA.

Sharpe, P.B. and J. Dooley. 2001. Restoration and management of Bald Eagles on Santa Catalina Island, California, 2001. Prepared for U.S. Fish and Wildlife Service, Damage Assessment Branch, Sacramento, CA.

Sharpe, P.B. and D.K. Garcelon. 1998. Restoration and management of Bald Eagles on Santa

Catalina Island, California, 1998. Prepared for U.S. Fish and Wildlife Service, Damage Assessment Branch, Sacramento, CA.

Sharpe, P.B. and D.K. Garcelon. 1999. Analysis of the potential diet of Bald Eagles reintroduced to Santa Cruz and Anacapa Islands, California. Prepared for U. S. Fish and Wildlife Service, Sacramento, CA, 16 pp.

Sharpe, P.B. and D.K. Garcelon. 2000. Restoration and management of Bald Eagles on Santa Catalina Island, California, 2000. Prepared for U.S. Fish and Wildlife Service, Sacramento, CA, 25 pp.

Sherrod, S.K., J.A. Estes and C.M. White. 1975. Depredation of sea otter pups by bald eagles at Amchitka Island, Alaska. Journal of Mammalogy 56:701–703.

Sherrod, S.K., C.M. White and F.S.L. Williamson. 1976. Biology of the Bald Eagle on Amchitka Island, Alaska. Living Bird 15:145–182.

Smith, F.R. 1936. The food and nesting habits of the Bald Eagle. Auk 53:301–305.

Stalmaster, M.V. 1987. The Bald Eagle. Universe Books, New York, NY, 227 pp.

Stewart, B.S., P.K. Yochem, R.L. DeLong and G.A. Antonelis. 1993. Trends in abundance and status of pinnipeds on the southern California Channel Islands. Pages 501–516. *In*: Hochberg, F.G. (ed.), Third California Islands Symposium: Recent Advances in Research on the California Islands. Santa Barbara Museum of Natural History, Santa Barbara, CA.

Streator, C.P. 1888. Notes on the birds of the Santa Barbara Islands. Ornithologist and Oologist 13:52–54.

Sumner, E.L. and J.M. Bond. 1939. An investigation of Santa Barbara, Anacapa, and San Miguel islands, California. Unpublished report to Channel Islands National Monument, National Park Service, Ventura, CA.

Swenson, J.E. 1975. Ecology of the bald eagle and osprey in Yellowstone National Park [Master's thesis]. Montana State University: Bozeman, MT.

Todd, C.S., L.S. Young, R.B. Owen and F.J. Gramlich. 1982. Food habits of Bald Eagles in Maine. Journal of Wildlife Management 46:636–645.

Watson, J.W., M.G.Garrett and R.G. Anthony. 1991. Foraging ecology of Bald Eagles in the Columbia River Estuary. Journal of Wildlife Management 55:492–499.

Wiley, R.W. and E.G. Bolen. 1971. Eagle-livestock relationships: livestock carcass census and wound characteristics. Southwestern Naturalist 16:151–169.

Willett, G. 1910. A summer trip to the northern Santa Barbara islands. Condor 12:170–174.

Appendix 1. Summary of prey remains recovered from the Ferrelo Point bald eagle nest site at the northwest end of San Miguel Island.

Common name (scientific name)	NISP[a]	MNI[b]	Wt.	%NISP[d]	%MNI[d]	%Wt.[d]
FISH						
Silversides (Atherinidae)	11	1	0.4	0.6	1.1	tr[c]
Toadfishes (Batrachoididae)						
Midshipman (*Porichthys* spp.)	89	4	9.1	5.0	4.4	0.8
Kelpfish (Clinidae)	12	1	1.8	0.7	1.1	tr
Herring and sardine (Clupeidae)	4	2	0.6	tr	2.2	tr
Sculpins (Cottidae)	3	1	0.9	tr	1.1	tr
Cabezon (*Scorpaenichthys marmoratus*)	98	6	89.0	5.5	6.7	8.2
Surfperch (Embiotocidae)	375	17	86.7	20.9	18.9	8.0
Pile perch (*Damalichthys vacca*)	73	6	29.7	4.1	6.7	2.7
Senorita and wrasses (Labridae)						
California sheephead (*Semicossyphus pulcher*)	55	3	342.2	3.1	3.3	31.5
Mackerels (Scombridae)	2	1	0.1	tr	1.1	tr
Hake (Merlucciidae)						
Pacific hake (*Merluccius productus*)	13	2	3.4	0.7	2.2	tr
Rockfish (Scorpaenidae)						
Rockfish (*Sebastes* spp.)	1,012	45	509.3	56.5	50.0	46.8
Pricklebacks (Stichaeidae)	44	1	14.4	2.5	1.1	1.3
Subtotal identified fish	1,791	90	1,087.3	44.2	100.0	78.1
Undifferentiated Teleost (fish)	2,257	-	304.2	55.8	-	21.9
FISH GRAND TOTAL	4,048	90	1,391.6	100.0	-	100.0
BIRDS						
Loons	75	7	227.5	1.4	2.4	3.5
Common loon (*Gavia immer*)	8	1	27.2	tr	tr	tr
Red-throated/Pacific loon (*Gavia* sp.)	67	6	200.3	1.3	2.0	3.1
Grebes	124	14	91.6	2.4	4.7	1.4
Western grebe (*Aechmophorus occidentalis*)	22	3	45.6	tr	1.0	0.7
Eared grebe (*Podiceps nigricollis*)	102	11	46.0	1.9	3.7	0.7
Shearwaters, fulmar, and petrels	407	38	547.1	7.7	12.8	8.5
Black-vented shearwater (*Puffinus opisthomelas*)	5	2	5.3	tr	0.7	tr
Sooty shearwater (*Puffinus griseus*)	315	25	452.8	6.0	8.4	7.0
cf. Pink-foot shearwater (*Puffinus creatopus*)	13	2	19.1	tr	0.7	tr
Northern fulmar (*Fulmarus glacialis*)	71	7	69.5	1.3	2.4	1.1
cf. Ashy storm-petrel (*Oceanodroma homochroa*)	1	1	0.1	tr	tr	tr
cf. Leach's storm-petrel (*Oceanodroma leucorhoa*)	2	1	0.3	tr	tr	tr
Cormorants	760	49	2,484.6	14.4	16.5	38.7
Pelagic cormorant (*Phalacrocorax pelagicus*)	308	21	740.3	5.9	7.1	11.5
Double-crested/Brandt's cormorant (*Phalacrocorax* spp.)	452	28	1,744.3	8.6	9.4	27.1
Herons and egrets	3	1	7.2	tr	tr	tr
American bittern (*Botaurus lentiginosus*)	3	1	7.2	tr	tr	tr
Waterfowl (ducks, scoters, mergansers)	580	45	987.0	11.0	15.2	15.4
cf. American wigeon (*Anas americana*)	4	1	1.0	tr	tr	tr
Surf scoter (*Melanitta perspicillata*)	112	10	148.3	2.1	3.4	2.3

Appendix 1. (Continued) Summary of prey remains recovered from the Ferrelo Point bald eagle nest site at the northwest end of San Miguel Island.

Common name (scientific name)	NISP[a]	MNI[b]	Wt.	%NISP[d]	%MNI[d]	%Wt.[d]
White-winged scoter (*Melanitta fusca*)	418	29	769.3	7.9	9.8	12.0
Red-breasted merganser (*Mergus serrator*)	45	4	66.3	0.9	1.3	1.0
Ruddy duck (*Oxyura jamaicensis*)	1	1	2.1	tr	tr	tr
Shorebirds	15	6	5.7	tr	2.0	tr
Black-bellied plover (*Pluvialis squatarola*)	8	2	4.1	tr	0.7	tr
Willet (*Catoptrophorus semipalmatus*)	1	1	1.3	tr	tr	tr
Sanderling (*Calidris alba*)	2	1	0.1	tr	tr	tr
cf. Black turnstone (*Arenaria melanocephala*)	1	1	0.4	tr	tr	tr
Red phalarope (*Phalaropus fulicaria*)	3	1	0.1	tr	tr	tr
Gulls and terns	298	33	570.6	5.7	11.1	8.9
Black-legged kittiwake (*Rissa tridactyla*)	8	1	7.9	tr	tr	tr
Bonaparte's gull (*Larus philadelphia*)	9	1	4.5	tr	tr	tr
California gull (*Larus californicus*)	76	9	136.0	1.4	3.0	2.1
Ring-billed gull (*Larus delawarensis*)	3	1	4.9	tr	tr	tr
Heerman's gull (*Larus heermanni*)	26	4	22.3	0.5	1.3	tr
large gulls (*Larus* spp.)	170	14	391.0	3.2	4.7	6.1
cf. Glaucous gull (*Larus hyperboreus*)	1	1	1.3	tr	tr	tr
Royal tern (*Sterna maxima*)	3	1	2.6	tr	tr	tr
cf. Common tern (*Sterna hirundo*)	2	1	0.1	tr	tr	tr
Alcids (Murres, Auklets, Murrelets, Puffins)	959	71	766.7	18.2	23.9	11.9
Common murre (*Uria aalge*)	88	6	104.5	1.7	2.0	1.6
Rhinoceros auklet (*Cerorhinca monocerata*)	736	55	587.8	14.0	18.5	9.1
Xantus's murrelet (*Synthliboramphus hypoleucus*)	9	3	3.1	tr	tr	tr
Ancient/marbled murrelet (*Synthliboramphus/ Brachyramphus* spp.)	5	2	2.8	tr	tr	tr
Pigeon guillemot (*Cepphus columba*)	11	2	6.8	tr	tr	tr
Tufted puffin (*Fratercula cirrhata*)	14	3	12.6	tr	1.0	tr
Cassin's auklet (*Ptychoramphus aleuticus*)	96	23	49.1	1.8	7.7	0.8
Landbirds (except for bald eagles)	28	7	44.1	0.5	2.4	0.7
Bald eagle (*Haliaeetus leucocephalus*)	43	3	313.2	0.8	1.0	4.9
Red-tailed hawk (*Buteo jamaicensis*)	1	1	0.5	tr	tr	tr
Northern flicker (*Colaptes auratus*)	2	1	0.3	tr	tr	tr
Common raven (*Corvus corax*)	23	3	43.3	tr	1.0	tr
Cedar waxwing (*Bombycilla cedrorum*)	1	1	tr	tr	tr	tr
cf. Song sparrow (*Melospiza melodia*)	1	1	tr	tr	tr	tr
Subtotal identified birds	3,292	297	6,045.6	62.6	100.0	94.1
Undifferentiated birds	1,969	-	381.7	37.4	-	5.9
BIRDS GRAND TOTAL	5,261	297	6,427.3	-	-	-
OTHER VERTEBRATES						
Reptiles	21	7	0.6	1.7	21.9	tr
Southern alligator lizard (*Elgaria multicarinata*)	21	7	0.6	1.7	21.9	tr
Mammals	413	25	2,508.2	97.4	78.1	99.9
Rodentia	33	5	1.6	7.8	15.6	tr
Deer mouse (*Peromyscus maniculatus*)	25	4	0.6	5.9	12.5	tr
Black rat (*Rattus rattus*)	8	1	1.0	1.9	3.1	tr

Appendix 1. (Continued) Summary of prey remains recovered from the Ferrelo Point bald eagle nest site at the northwest end of San Miguel Island.

Common name (scientific name)	NISP[a]	MNI[b]	Wt.	%NISP[d]	%MNI[d]	%Wt.[d]
Carnivora	42	6	134.3	9.9	18.8	5.4
Island fox (*Urocyon littoralis*)	10	2	21.2	2.4	6.3	0.8
California sea lion (*Zalophis californianus*)	25	2	86.1	5.9	6.3	3.4
Northern fur seal (*Callorhinus ursinus*)	2	1	3.3	0.5	3.1	tr
Northern elephant seal (*Mirounga angustirostris*)	5	1	23.7	1.2	3.1	0.9
Artiodactyla	328	14	2,363.4	77.4	43.8	94.5
Sheep (*Ovis aries)*	328	14	2,363.4	77.4	43.8	94.5
Subtotal identified mammals	403	32	2,499.9	92.9	100.0	99.6
Undifferentiated mammals	10	-	8.9	2.3	-	tr
OTHER VERTEBRATES GRAND TOTAL	434	32	2,508.8	-	-	-
INVERTEBRATES						
Bivalves	22	15	16.6	10.8	22.7	2.6
California mussel (*Mytilus californianus*)	9	4	15.4	4.4	6.1	2.4
Brown mussel (*Modiolus modiolus*?[e])	1	1	0.1	0.5	1.5	tr
Platform mussel (*Septifer bifurcatus*)	1	1	0.3	0.5	1.5	tr
Carpenter's cardita (*Glans subquadrata*?)	3	3	0.1	1.5	4.5	tr
Arctic saxicave (*Hiatella arctica*)	2	2	0.1	1.0	3.0	tr
Purple dwarf venus (*Nutricola tantilla*?)	3	3	0.1	1.5	4.5	tr
Clam, undiff (*Cryptomya*?)	3	1	0.6	1.5	1.5	tr
Marine Gastropod	51	39	612.3	25.1	59.1	95.5
Black abalone (*Haliotis cracherodii*)	5	4	588.0	2.5	6.1	91.7
Red abalone (*Haliotis rufescens*)	2	2	3.8	1.0	3.0	0.6
Abalone, undiff. (*Haliotis,* undiff.)	2	-	4.1	1.0	-	0.6
Whitecap limpet (*Acmaea mitra*)	5	5	2.0	2.5	7.6	tr
Rough keyhole limpet (*Diodora aspera*)	2	1	0.4	1.0	1.5	tr
Volcano limpet (*Fissurella volcano*)	3	1	0.8	1.5	1.5	tr
Ribbed limpet (*Lottia digitalis?*)	3	3	0.2	1.5	4.5	tr
Giant owl limpet (*Lottia gigantea*)	5	1	6.7	2.5	1.5	1.0
Limpet, undiff. (Acmaeidae)	9	9	3.43[f]	4.4	13.6	0.5
Carinated dove (*Alia carinata*)	2	2	0.1	1.0	3.0	tr
Variegate amphissa (*Amphissa versicolor*?)	3	3	0.5	1.5	4.5	tr
Blue topsnail (*Calliostoma ligatum*?)	4	2	1.3	2.0	3.0	tr
Dark dwarf turban (*Homalopoma luridum*?)	4	4	0.7	2.0	6.1	tr
Purple olive (*Olivella biplicata*)	1	1	0.0	0.5	1.5	tr
Worm shell (*Serpulorbis squamigerus*)	1	1	0.2	0.5	1.5	tr
Terrestrial Gastropod	9	1	0.3	4.4	1.5	tr
Land snail (*Helminthoglypta ayresiana*)	9	1	0.3	4.4	1.5	tr
Echinoderms	30	2	2.9	14.8	3.0	0.5
Green sea urchin (*Strongylocentrotus drobachiensis*)	23	1	2.0	11.3	1.5	tr
Purple sea urchin (*Strongylocentrotus purpuratus*)	7	1	1.0	3.4	1.5	tr
Polyplacophora	17	3	1.4	8.4	4.5	tr
small chitons[g], undiff. (Amphineurans)	17	3	1.6	8.4	4.5	tr
Crustaceans	37	5	4.9	18.2	7.6	0.7
Barnacle, undiff. (*Balanus* spp.)	24	3	3.5	11.8	4.5	0.5
Leaf or gooseneck barnacle (*Pollicipes polymerus*)	4	1	0.3	2.0	1.5	tr

Appendix 1. (Continued) Summary of prey remains recovered from the Ferrelo Point bald eagle nest site at the northwest end of San Miguel Island.

Common name (scientific name)	NISP[a]	MNI[b]	Wt.	%NISP[d]	%MNI[d]	%Wt.[d]
Crab, undiff (*Cancer* spp.)	9	1	1.0	4.4	1.5	tr
Undifferentiated marine invertebrates	37	-	2.7	18.2	-	tr
Marine shell, undiff.	28	-	2.0	13.8	-	tr
Coralline algae undiff.	5	1	0.4	2.5	1.5	tr
Coral, undiff.	4	-	0.4	2.0	-	tr
INVERTEBRATE GRAND TOTAL	203	66	641.3	-	-	-

[a] NISP= number of individual specimens.
[b] MNI= minimum number of individuals.
[c] tr=trace amount representing less than 0.5% of the total.
[d] Percentages are rounded to the 0.1% and are calculated on all remains recovered from a taxonomic group (i.e. fish, birds, vertebrates, and invertebrates).
[e] A question mark next to a scientific name indicates that the species identification is uncertain.
[f] Limpet weight inflated by specimen with asphaltum adhering to it.
[g] At least 3 chiton species appear to be present among amphinuerans.