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Earliest Island Fox Remains on the Southern Channel Islands: Evidence from San Nicolas Island, California

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The island fox Urocyon littoralis, *a diminutive cousin of the mainland gray fox* U. cinereoargenteus, *occurs on six of the eight California Channel Islands. For years, researchers have reported finding the remains of these animals in archaeological sites. Biogeographic studies have tried to determine the evolutionary relationships of island foxes and the nature and timing of their dispersal to each of the islands. These data, along with the fossil and archaeological records, place them on the northern Channel Islands about 16,000 B.P. and on the southern Channel Islands at about 3,800 B.P. Recent archaeological excavations on San Nicolas Island recovered the remains of an island fox that dates to about 5,200 B.P. This find contributes to our current understanding of island fox colonization of the southern Channel Islands.*

ANIMALS living on remote islands have been a subject of human curiosity for generations. The plethora of scientific studies, documentary films, and popular articles attest to their importance and fascination. In fact, it could be argued that the study of island biogeography has been as important in the development of biological thought as any other subject matter. Darwin's finches are just one example of many where island life has helped to shape and develop ideas about biology. One relationship that emerges prominently from island studies is the role that humans have played in the distribution of animals across space and through time. Through processes of domestication (dogs, pigs, sheep) and as transporters of stowaways (insects, spiders, rodents), people have influenced the movement of animals the world over. The island fox of the California Channel Islands is one example where people have contributed to the spread of a species.

The Channel Islands are subdivided into two groups based on their different geologic origins. The islands of Anacapa, Santa Cruz, Santa Rosa, and San Miguel comprise the northern Channel Islands, while Santa Catalina, San Clemente, Santa Barbara, and San Nicolas Islands make up the southern group (Fig. 1). The northern Channel Islands were once connected, representing one island mass (Santa Rosae), and separated from the mainland by as little as six kilometers (Johnson 1983). The more widely dispersed southern islands have remained separate throughout their development and are located much further from the mainland. All but Anacapa Island and Santa Barbara Island are home to the island fox.

NORTHERN ISLAND FOXES

The island fox has been the subject of numerous scientific investigations, but recent genetic data (Gilbert et al. 1990; George and Wayne 1991; Wayne et al. 1991a, 1991b) and skeletal studies (Collins 1982, 1991a, 1991b) suggest a possible scenario concerning their origins and distribution. Collins (1991a) used cranial mor-

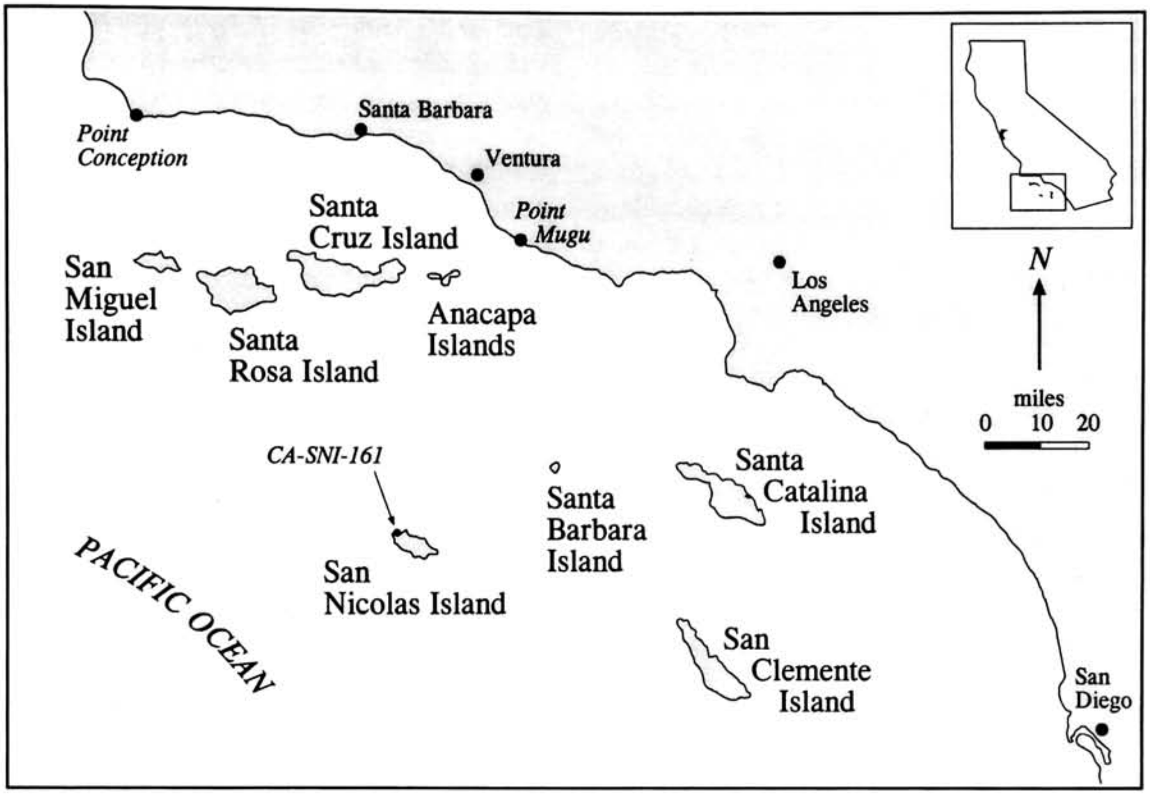

Fig. 1. The California Channel Islands.

phometrics of modern and archaeological specimens to examine evolutionary relationships between foxes on each of the islands. He maintained that the occurrence of fox bone in fossil deposits on Santa Rosa Island, dating between 16,000 and 10,400 B.P., is evidence for their colonization of the northern Channel Islands prior to the arrival of humans (Collins 1991a:62, 1993; also see Erlandson 1994). However, the association of this deposit within the Pleistocene dated Upper Tecolote Member of the Santa Rosa Island Formation is speculative. The depositional history of the bones was not addressed adequately, and since they were found in an alluvial context, their association remains questionable. Likewise, efforts to locate and further study the fox bones have been unsuccessful. Yet, as it now stands, this find represents the only evidence for foxes on the Channel Islands prior to the arrival of humans. Collins (1991a:53, 73-76) suggested that foxes may have arrived on the islands by swimming or floating on debris from the mainland during the last glacial ad-vance, when sea levels were considerably lower.

Genetic data (Gilbert et al. 1990; Wayne et al. 1991a, 1991b) tend to support Collins' conclusions. These studies compare island fox genetic variability. From these data, evolutionary trajectories are mapped out. In general, morphologic and genetic data for the evolution of foxes on the northern Channel Islands are consistent with the geologic and sea level histories of the area. As the large island mass of Santa Rosae was inundated by rising postglacial seas, fox populations living on each of the newly formed islands became geographically isolated. Through inbreeding, these isolated populations developed the genetic and morphologic differences detectable today. For example, foxes living on San Miguel and Santa Rosa islands are genetically and morphologically more similar to each other than either is to foxes on Santa Cruz Island (Gilbert et al. 1990; Collins 1991a, 1993). This correlates with the formation and separation of Santa Cruz Island from Santa Rosa and San Miguel Islands some 2,000 years before the latter two islands were separated from each other (Collins 1991a, 1993).

SOUTHERN ISLAND FOXES

Unlike the northern Channel Islands, no fossil record exists for foxes on the southern Channel Islands. Migration of foxes from the mainland or from the northern islands by their own accord seems highly unlikely, especially considering the widely dispersed nature of the southern islands. Moreover, foxes on the southern Channel Islands have been found only in Middle to Late Holocene contexts, most of these dating within the past 3,000 B.P. (see Collins 1991a: Table 4).

Evidence seems to indicate a prehistoric dispersal of foxes by Native Americans from the northern to the southern islands sometime after 4,000 years ago (Collins 1982; 1991a, 1991b; Gilbert et al. 1990; Wayne et al. 1991a, 1991b). Protein electrophoresis and mitochondrial DNA studies of present-day foxes suggest that populations on San Clemente and San Nicolas islands are most similar to those on San Miguel Island (Collins 1991a:75; George and Wayne 1991:21; Wayne et al 1991a, 1992b). Biological data for the arrival of foxes on Santa Catalina Island are not as clear. Skeletal studies (Collins 1991a) and mitochondrial DNA data (George and Wayne 1991; Wayne et al. 1991a, 1991b) suggest that Santa Catalina Island foxes are aligned most closely with the northern island foxes, while protein and genetic data (Gilbert et al. 1990) suggest that they are most similar to foxes on the southern islands.

Overall, biological and archaeological evidence for when each southern island was first inhabited by foxes remains problematic. Genetic data tend to favor San Clemente Island as the first southern island to receive foxes (Wayne et al. 1991a, 1991b), whereas skeletal morphometric data point to San Nicolas Island (Collins 1991a). Although numerous fox remains have been found in archaeological sites on the southern Channel Islands (Collins 1982, 1991a, 1991b), reliable dates are available for only a few. San Clemente Island currently has the earliest island fox evidence, with a date of about 3,800 B.P. In addition, fox bone deposits on Santa Catalina Island date to about 3,400 B.P. and to about 2,200 B.P. on San Nicolas Island (Collins 1991a, 1991b). These three dates seem to support the genetic evidence.

SAN NICOLAS ISLAND

San Nicolas, the outermost of all the California Channel Islands, is located about 120 kilometers southwest of Los Angeles and 88 kilometers from the nearest point on the mainland (Fig. 1). Geologically, it is composed primarily of Eocene sandstone and shale uplifted by faulting and anticline development, and modified by marine erosion that formed several Pleistocene terraces (Meighan and Eberhart 1953; Vedder and Norris 1963). Topographically, the island is characterized by a low-lying, wind-swept plateau (276 m. at it highest elevation), escarpment slopes, sandy and rocky beaches, and minor intermittent drainage canyons. Eolian activity continues to shape and reshape the many sand dunes that characterize much of the surface of the island.

The vegetation on San Nicolas Island is sparse, and several endemic species have become extinct in the last 50 years. Recent plant (Klug and Popper 1993) and pollen (Cummings 1993a, 1993b, 1993c; Williams 1993) studies of soil samples taken from CA-SNI-351, located at the center of the island, were inconclusive. Although some endemic species were identified, preservation problems related to wind and water erosion hindered a clear reconstruction of the local vegetation. Indigenous plants that characterize the surface of the island today, however, include silver beach weed (*Ambrosia chamissonis*), rattlesnake weed (*Duacus pusillus*), coyote brush (*Baccharis pilularis*) and giant coreopsis (*Coreopsis gigantea*) (Junak and Vanderwier 1988).

Six species of pinnipeds are found along the coast, including California sea lions (*Zalophus californianus*) and northern elephant seals (*Callorhinus ursinus*), which also breed on the island. Western gulls (*Larus occidentalis*) and Brandt's cormorants (*Phalacrocoraxpenisillatus*) also breed here, and many other seabirds feed on the rich marine life around the island. Offshore kelp beds are extremely abundant, providing habitat for a rich array of marine shellfish, fish, and sea mammals. Only six land animals are native to San Nicolas Island: the deer mouse (*Peromyscus maniculatus*), the island night lizard (*Xantusia riversiana*), the southern alligator lizard (*Elgaria multicarinata*), the side-blotched lizard (*Uta stansburiana*), the land snail (*Helix* sp.), and the island fox (*Urocyon littoralis*).

Archaeological explorations on San Nicolas Island began over 100 years ago, but systematic investigations began only during the past few decades (Schwartz and Martz 1992). Meighan and Eberhart's (1953) brief survey of the island set the stage for more sophisticated and specialized investigations that were carried out later by archaeologists associated with California State University, Los Angeles (CSULA). Reinman and Townsend (1960) conducted work on native burials, Lauter (1982) on cultural chronologies, Clevenger (1982) on lithics, and Bleitz (1987) and Salls (1988) on faunal remains. Current archaeological investigations are filling many data gaps concerning the prehistoric and historical human use of the island (Schwartz and Martz 1992; Swanson 1993; Martz 1994a, 1994b; Schwartz 1994, 1995; Thomas 1995; Vellanoweth 1995, 1996).

Over 500 archaeological sites have been recorded on San Nicolas Island (Schwartz and Martz 1992). The largest sites occur on the northwestern portion, but sites can be found on virtually every part of the island. Foxes have been excavated from four different sites, including CA-SNI-7, which contained 20 individuals that apparently had been ritually buried (Collins 1991b:Table 1). Unfortunately, only one component containing fox remains has been dated, producing a date of about 2,200 B.P. (Bleitz 1987).

Fox Evidence from CA-SNI-161

Although island fox remains are known for at least 33 different archaeological sites on the Channel Islands, only a handful have been radiocarbon dated (see Collins 1991a:Table 4). Consequently, a solid chronological foundation is lacking, leaving researchers to speculate on the antiquity of foxes on each of the islands. This problem is compounded in some cases by unprovenienced remains, stratigraphic ambiguities, and an overrepresentation of skulls due to the collection priorities of earlier researchers. The data on fox remains from San Nicolas Island suffer from all these problems. Thus, little could be said about the nature and timing of their the arrival.

However, recent excavations at CA-SNI-161, located on the northwestern shore of San Nicolas Island have unearthed a single fox bone in a deeply buried cultural deposit (Fig. 2) (Vellanoweth 1996). The site, first described by Malcolm Rogers (1930) and later recorded by Fred Reinman in 1984, is a ridge-like dune situated on a Pleistocene terrace. The terrace is fronted by a sea cliff that plummets to a rocky intertidal zone lying adjacent to a freshwater seep. Presently, it appears as an east-west trending longitudinal dune that follows the terrace ledge along a 200 m. expanse of coastline. The crest of the dune site is stabilized by vegetation and the slopes are covered with an abundance of shellfish, lithic, and bone debris. Internally, the site consists of multiple relatively well-preserved ar-

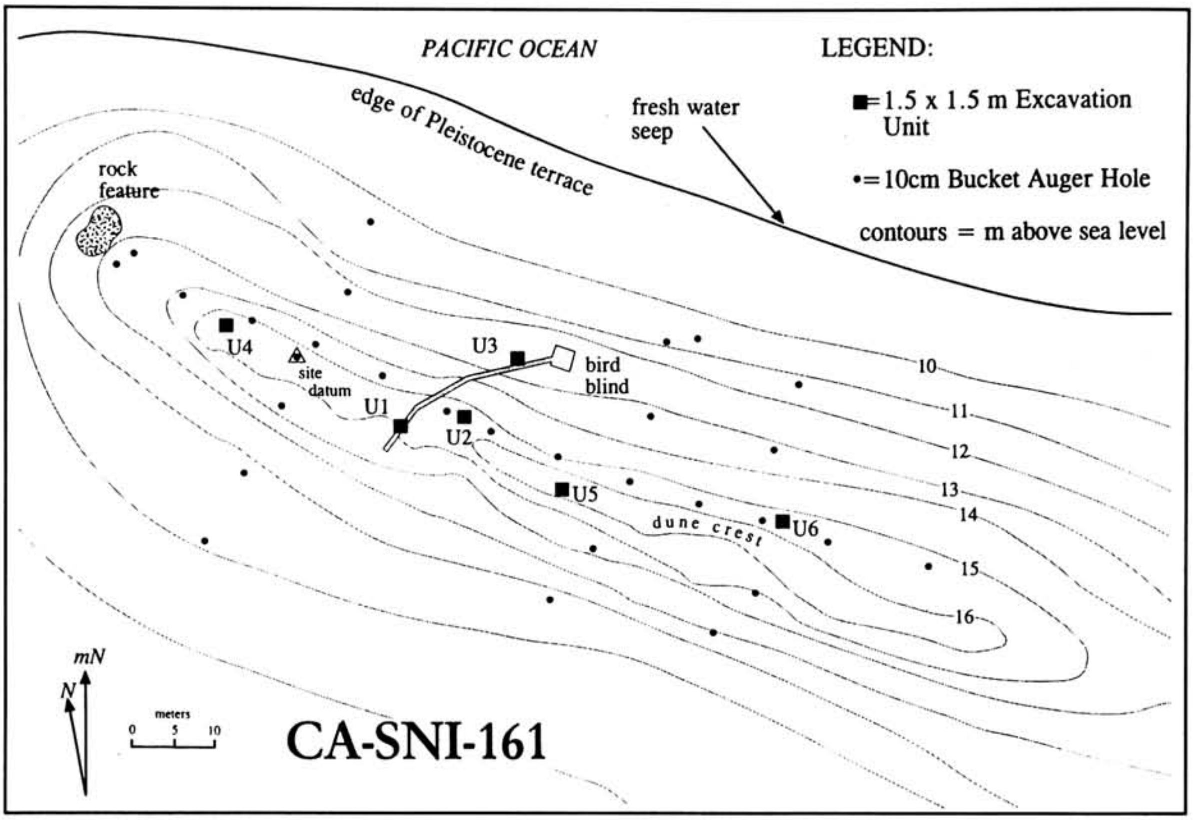

Fig. 2. Composite plan of CA-SNI-161.

chaeological deposits separated by dune sediments.

The bone, an unmodified island fox left auditory bulla element, was found in the deepest component of Unit 6, located on the eastern edge of the site (Fig. 2). A volume of 0.60 m.^{3} of sediments was excavated from this cultural component. The deposit in this component consists of a silty sand matrix laced with shell, bone, charcoal, asphaltum, stone tools, beads, and chipped stone tool and bead manufacturing debris. A contemporaneous component in Unit 4, situated on the western part of the site, was also excavated, but no fox remains were found. A combined volume of 1.65 m.^{3} of excavated sediments was retrieved from the two components in Units 4 and 6.

Eight radiocarbon dates suggest the deposit containing the fox skull fragment was formed about 5,200 B.P. (Table 1). Paired samples of marine shell and wood charcoal collected from the same levels were submitted to help compensate for problems associated with the dating of these materials. In addition, an *Olivella* Grooved Rectangle bead (per Bennyhoff and Hughes 1987) was submitted for radiocarbon analysis (Vellanoweth 1995, 1996). Radiocarbon dates on these samples securely place this component at well over 5,000 RCYBP. This date pushes back the currently accepted arrival of foxes on the southern Channel Islands by more than 1,000 years and by as much as 3,000 years for San Nicolas Island.

DISCUSSION AND CONCLUSION

The fox bone recovered from CA-SNI-161 provides the earliest evidence for foxes on the southern Channel Islands. Further discussions

Table 1
RADIOCARBON DATES[a] OF THE EARLIEST DEPOSITS AT CA-SNI-161

Lab. No.	Unit and Level (in cm.)	Material	$^{13}C/^{12}C$ Adj. Age (RCYBP)	Calibrated Age (1 sigma)
Beta-78676	Unit 6, 120-130	black abalone	4,940 ± 70	5,085 to 4,885
Beta-78679	Unit 6, 130-140	black abalone	4,940 ± 80	5,095 to 4,880
Beta-78681	Unit 6, 140-150	black abalone	5,050 ± 70	5,300 to 5,025
Beta-78675	Unit 6, 120-130	charcoal [b]	4,580 ± 40	5,365 to 5,320 5,220 to 5,180 5,165 to 5,130
Beta-78678	Unit 6, 130-140	charcoal [b]	4,560 ± 40	5,355 to 5,320 5,220 to 5,180 5,165 to 5,130
Beta-78667	Unit 4, 90-100	charcoal	4,550 ± 60	5,360 to 5,285 5,245 to 5,105
Beta-78680	Unit 6, 140-150	charcoal [b]	4,570 ± 60	5,365 to 5,310 5,230 to 5,120
Beta-78677	Unit 6, 120-130	OGR bead [c]	5,210 ± 60	5,465 to 5,305

[a] Marine shell samples were adjusted for $^{13}C/^{12}C$ ratios to compensate for the differential uptake of carbon isotopes (isotopic fractionation) by marine organisms (Stuiver and Braziunas 1993). Radiocarbon ages were then calibrated against tree ring data using the Pretoria Calibration Procedure program to provide calendar dates (Vogel et al. 1993).

[b] Samples dated using accelerator mass spectrometry.

[c] *Olivella* Grooved Rectangle bead (per Bennyhoff and Hughes 1987).

of island fox biogeography must include this find, as it is not congruent with current colonization schemes. The antiquity of this find poses several interesting questions. For example, genetic data indicate that foxes on San Nicolas Island exhibit no significant variability, a trait unique among mammals studied to date (Wayne et al. 1991b:1862). Thus, by effectively doubling the time depth of foxes on the island, the find from CA-SNI-161 presents a potentially intriguing evolutionary question. How can a population of carnivores exist on the island for at least 5,000 years, be so monomorphic, and still be viable? In part, I believe the answer to this question can be found in the human/fox relationship.

Humans played a vital role in the distribution of foxes on the Channel Islands. In fact, but for the somewhat dubious dates between 16,000 and 10,400 B.P. for Santa Rosa Island, all other fox dates for the islands fall within the period of known human occupation. It is argued herein that humans were not only responsible for the dispersal of foxes on the southern Channel Islands (a position widely agreed upon), and perhaps even the northern Channel Islands, but were also vital in maintaining, through mobility and trade, the genetic variability of island fox populations. As pets or semidomesticates, foxes were an important commodity and served as part of large trade networks in the form of live animals, pelts, and/or finished products (see Collins 1991b). Foxes also served a ritual role, as numerous ceremonial fox burials attest (Collins 1991b:213). As such, foxes were an important part of commerce and ceremony alike, and functioned in a variety of ways within California Indian groups.

After European contact, however, the movement of foxes between islands was interrupted. Traditional lifeways of Native Americans in California were disrupted and the effects of introduced diseases took their toll on coastal populations (e.g., Erlandson and Bartoy 1995). Without the usual flow of people and goods (including foxes) between the islands, fox populations became increasingly isolated. For the first time, foxes on the southern Channel Islands lived without the interaction provided by native people. The species continued to develop but new genes were no longer being introduced into the population. Additionally, decreases in food resources that were once provided by native islanders probably exacerbated conditions for foxes, perhaps leading to sudden population declines and possibly even punctuated evolutionary events. In sum, I believe the native people of California played an important role in the formation and maintenance of island fox populations. Once this interaction ceased, foxes began new developmental trajectories that are detectable in modern genetic studies.

Finally, archaeological data, like the fossil record, contribute to biogeographic reconstructions by providing both time depth and distributional information. The genetic studies described above used the archaeological record of foxes on the Channel Islands in this manner (Wayne et al. 1991b). Unfortunately, this record is not complete, and finds such as the one presented here highlight the limitations these data have in structuring evolutionary models of animals. Although new finds will undoubtedly refine our understanding of island fox distribution, the manner in which biological studies have incorporated various data sets (including the archaeological record) to reconcile this problem must be commended.

Evidence from CA-SNI-161 pushes back the date for fox occupation on the southern islands by about 1,400 years. Much of our current understanding of the prehistoric utilization of the southern Channel Islands comes from the larger and more intensively studied Santa Catalina and San Clemente islands, with little contribution from San Nicolas Island; this lamentable fact, however, is changing. With sophisticated and relatively well-funded archaeological investigations being conducted on San Nicolas Island under the direction of Steven Schwartz (Navy Archaeologist) and Patricia Martz (CSULA), a fundamentally more sound and broader regional outlook on California prehistory is emerging. Future research may well push back the appearance of foxes on the island even further.

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Nevada Indians in California

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This report details visits by Northern Paiutes to central and western California as early as 1846 and continuing through the beginning of the twentieth century. That these visits were not necessarily economically motivated makes this behavior seem somewhat unique in western native history.