Dogs, humans and island ecosystems: the distribution, antiquity and ecology of domestic dogs (*Canis familiaris*) on California’s Channel Islands, USA

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Abstract: Archaeologists have made significant contributions to our understanding of ancient island environments, including the timing and implications of the introduction of non-native animals (pigs, chickens, rats, etc.) by humans. Here, we focus on the historical ecology and biogeography of domestic dogs (*Canis familiaris*) on California’s Channel Islands during the Holocene. Dogs are the only animal known unequivocally to have been introduced by Native Americans to the islands, but relatively little is known about their distribution, antiquity or influence on native island fauna and flora. We identified a minimum of 96 dogs from 42 archaeological sites on six of the eight islands. Dogs were present for at least 6000 years and appear to have increased in abundance through time. Our analysis suggests that dogs, along with humans and island foxes (*Urocyon littoralis*), would have had an impact on native animals and ecosystems, especially breeding birds and marine mammals. Dogs and island foxes likely competed with one another for food, however, and the impacts of dogs on island ecosystems may have been reduced by the presence of island foxes and the symbiotic relationship between dogs and humans. Dogs have been removed from all but one of the islands today, eliminating one of the few terrestrial carnivores present for most of the Holocene.

Key words: Dogs, palaeoecology, human environmental impacts, zooarchaeology, *Canis familiaris*, Channel Islands, Holocene.

Introduction

The domestication of animals and plants was a major milestone in human history, when numerous species around the world were selectively bred to increase their value (food, labour, protection, etc.) for people (see Bellwood, 2004; Barker, 2006; Zeder, 2006; Kennett and Winterhalder, 2006). Developments in the domestication of plants and animals significantly contributed to the acceleration of human population growth and the growing impacts of people on Earth’s natural ecosystems. A major source of such impacts is related to the translocation (intentional or unintentional) of both wild and domestic animals to new regions of the world. Such biotic introductions often result(ed) in significant alterations in natural landscapes and ecological communities, including numerous extinctions (Kirch and Hunt, 1997; Grayson,
2001; Kirch, 2005), a process that continues to pose costly and
global ecological challenges for human societies worldwide.

Some of the best documented cases of ancient animal introduc-
tions and their environmental impacts come from islands, specific-
ally analyses of island zooarchaeological and palaeontological
collections. On Pacific Islands in Polynesia, for example, the
transport of chickens, dogs, pigs and rats had a devastating effect
on native floral and faunal communities (Steadman, 1995, 2006;
Kirch, 2000, 2005). Rats, often transported unintentionally as
stowaways on long ocean voyages and possibly sometimes inten-
tionally introduced, had particularly devastating impacts on local
bird populations and played a role in avian extinctions. In
Southeast Asia and western Melanesia, hunter-gatherers and later
agriculturalists also appear to have carried animals to islands (eg,
the Bismarcks, Solomons, Moluccas, Sulawesi and Lesser
Sundas) for at least 20 000 years, contributing to very early, but
still poorly understood transformations of their endemic land-
capes (White, 2004). Introduced domestic and wild animals have
also been documented on islands in the Caribbean (dogs, guinea
pigs, agouti and hutia), Mediterranean (red deer, wild goats, etc.),
North Atlantic (dogs, sheep, pigs, cattle, horses) and beyond,
demonstrating similar practices around the world (Grayson, 2001;
Newsom and Wing, 2004: 204–208). While domestic dogs may
have had less profound ecological consequences than rats and
some other animals, they were a predator that often had an impact
on naïve insular fauna. In New Zealand, for example, a single feral
dog killed over half of a brown kiwi (Apteryx australis) colony of
900 birds in about six weeks (Taborsky, 1988), and on the
Galapagos Islands feral dogs have been observed to prey heavily
on marine iguanas (Kruuk and Snell, 1981). The middle- to late-
Holocene introduction of the dingo (Canis lupus dingo) to
Australia also appears to coincide with significant ecological
changes, including the extinction of three vertebrates (see Corbett,
1995; Johnson and Wroe, 2003; Savolainen et al., 2004).

In this paper, we provide evidence for the transport of domestic
dogs (Canis familiaris) by hunter-gatherers to California’s
Channel Islands during the Holocene (Figure 1). Dogs are one of
the few domestic animals to be found in most areas of the world
among hunter-gatherers and agriculturalists. In the Americas, they
have a long presence probably spanning at least 10 000–8500
years (Morey and Wiant, 1992; Lupo and Janetski, 1994; Fiedel,
2005; Snyder and Leonard, 2006). Recent mtDNA analysis of
modern and ancient dogs around the world points to their domes-
tication about 15 000 years ago in East Asia, with New World
dogs currently thought to be derived from Old World populations
rather than independently domesticated from American grey
wolves (Leonard et al., 2002; Savolainen et al., 2002; Wayne
et al., 2006). The available data suggest that dogs were present
throughout much of the Americas (Schwartz, 1997) by the early
Holocene, including a few potential early Holocene dogs in

Owing to excellent archaeological integrity and an archaeologi-
cal record spanning some 13 000 calendar years, California’s
Channel Islands provide an important laboratory for investigating
animal translocation to islands by foragers, the historical biogeog-
draphy of domestic dogs, and the effects that dogs may have had on
island ecosystems. Archaeologists have known for some time
that Native Americans brought dogs to the islands (Schumacher, 1877:
48; Bowers, 1890; Wagner, 1929; Nidever, 1937), but the distribu-
tion, antiquity and potential effects of dogs on island ecology have
received limited attention. A few researchers have discussed the
role of dogs in Channel Island ritual (eg, Collins, 1991a; Raab
et al., 1994; Hardy, 2000; Hale and Salls, 2000), but there has been
no attempt to assess when dogs were introduced or how wide-
spread they became on these islands. To help fill this void, we syn-
thesize published and unpublished occurrences of Channel Island
dogs, including specimens from southern California museums.

Cultural and environmental context

The eight Channel Islands are located between 20 and 98 km off
the southern California Coast, and range in size from about 2.6 to
249 km² (Table 1). The islands are divided into northern
(Anacapa, Santa Cruz, Santa Rosa and San Miguel) and southern
(San Clemente, Santa Catalina, San Nicolas and Santa Barbara)
groups, which were never connected to the mainland during the
Quaternary. The northern islands are an east–west trending chain
along the Santa Barbara Channel, but the southern islands are con-
siderably more dispersed and isolated. All of the islands have a

Figure 1  The Channel Islands and southern California Coast
Mediterranean climate, with mild summers and generally cool, wet winters, but climatic conditions fluctuated throughout the Holocene (Kennett and Kennett, 2000; Kennett et al., 2007a).

The Channel Islands have a limited terrestrial flora and fauna, lacking many plants and animals found on the mainland (Schoenherr et al., 1999: 7–17). The marine environment surrounding the islands, in contrast, is rich in marine mammals, seabirds, fish and shellfish. Except for the diminutive (roughly house-cat sized) island fox (Urocyon littoralis) and spotted skunk (Spilogale gracilis), and a few rodents (eg, deer mouse (Peromyscus maniculatus)), the islands lack terrestrial mammals. Subspecies of the island fox occur on each of the islands except Anacapa and Santa Barbara. Skunks are currently only found on Santa Cruz and Santa Rosa. Pygmy mammoths roamed the northern islands during the Pleistocene, but it is unclear if they persisted into the human era (see Erlandson et al., 2004; Agenbroad et al., 2005). Vegetation communities on the islands are also distinct, including a number of endemic and relict species, but are generally impoverished compared with mainland communities. The limited terrestrial fauna on the Channel Islands suggests that domestic dogs, along with the people who introduced them, would have had significant effects on potentially naïve natural species, especially breeding marine mammals and seabirds. Collins (1999a, b), Vellanoweth (1998), Kennett (2005; 49) and Rick et al. (2008a) have also suggested that island foxes may have been introduced by humans to some or all of the islands, raising further questions about the role of introduced animals in island ecology during the Holocene.

While terrestrial resources are generally limited, Channel Island marine environments are exceptionally productive, with the upwelling of nutrient-rich waters supporting large populations of pinnipeds, cetaceans, seabirds, shellfish and fishes. These rich marine communities also include scores of breeding seabirds, seals and sea lions. Located on a boundary between colder currents to the north and warmer currents to the south, the waters surrounding the Channel Islands contain a mix of cold- and warm-water marine fauna.

These productive and diverse marine environments fostered human occupation spanning the last 13 000 years (Erlandson et al., 1996; Johnson et al., 2002). Thousands of archaeological sites, ranging from large shell middens and villages to small lithic scatters, have been documented on the eight islands (Kennett, 2005; Rick et al., 2005). At the time of European contact, the northern Channel Islands were inhabited by Chumashan-speaking peoples, while the southern islands were inhabited by Uto-Aztecan-speaking peoples (Kennett et al., 2007a, b). Although linguistically and culturally distinct, both groups had a similar maritime technology and kept domestic dogs. Although the Channel Islands contain a lengthy record of human occupation, analyses of dog skeletal remains from the Channel Islands suggest that they are not a relict population of animals brought out by the earliest inhabitants. Instead many of these dogs appear to fall within the ‘small short-faced pueblo dog’ size category (cf. Colton, 1970; Olsen and Olsen, 1970), which is considerably smaller than the earliest known North American dogs such as those found at the Koster site (Morey and Wiart, 1992). The size of these island dogs suggests that there was at least sporadic exchange of dogs between the islands and mainland as part of the highly developed island mainland exchange systems. The exchange of dogs also likely worked against the development of a distinctive breed of island dog such as those in other island contexts (eg, Busuttil, 1969).

### Methods

For this study, we systematically reviewed the published and unpublished literature for accounts of dogs from the California Channel Islands. The available literature on Channel Island dogs is widely scattered, with few researchers consistently noting the amount or types of recovered dog remains. Nonetheless, we have assembled a comprehensive data set. We also included unpublished data from archaeological specimens housed at the Santa Barbara Museum of Natural History and the Fowler Museum at the University of California, Los Angeles. These and other specimens are part of our ongoing analysis of ancient southern Californian dog populations.

Table 2 presents the available domestic dog data, including site or location, minimum number of individuals (MNI) and the elements recovered or degree of skeletal completeness. We were as specific as possible, but in many cases some or all of these data were not available. We caution that researchers were not always clear on how they determined if specimens were from dogs rather than other species of Canis (eg, C. latrans (coyotes)) or hybrids, but we suspect that these species would be very rare on the Channel Islands. There are likely dog remains from early antiquarian projects on the islands during the late eighteenth and early nineteenth centuries housed at the Smithsonian and other institutions that lack detailed provenance and are not included in this study.

To our knowledge, there are currently no direct 14C dates for archaeological dog remains from the Channel Islands. Consequently, in Table 2 all of the dates for the various dog remains are from 14C associations. In some cases we listed general time frames (eg, late Holocene) based on the presence of multiple 14C dates from a single site. These dates are generally for a site or site component rather than directly for a dog burial or dog remains. These dates provide a reasonable estimate of the age of the dog remains, but future direct dating of dog specimens could significantly enhance their chronology. Our estimates of the age of

<table>
<thead>
<tr>
<th>Island</th>
<th>Area (km²)</th>
<th>Max elevation(m)</th>
<th>Distance from mainland (km)</th>
<th>No. of land mammals</th>
<th>Native plant taxa</th>
<th>No of sites wia dogs</th>
<th>Dog MNI</th>
<th>a</th>
<th>b</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anacapa</td>
<td>2.9</td>
<td>283</td>
<td>20</td>
<td>2</td>
<td>190</td>
<td>–</td>
<td>–</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Santa Cruz</td>
<td>249</td>
<td>755</td>
<td>30</td>
<td>12</td>
<td>480</td>
<td>11</td>
<td>21</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Santa Rosa</td>
<td>217</td>
<td>484</td>
<td>44</td>
<td>4</td>
<td>387</td>
<td>3</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>San Miguel</td>
<td>37</td>
<td>255</td>
<td>42</td>
<td>3</td>
<td>198</td>
<td>7</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Santa Barbara</td>
<td>2.6</td>
<td>149</td>
<td>61</td>
<td>2</td>
<td>88</td>
<td>–</td>
<td>–</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Santa Catalina</td>
<td>194</td>
<td>648</td>
<td>32</td>
<td>9</td>
<td>421</td>
<td>1</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>San Nicolas</td>
<td>58</td>
<td>277</td>
<td>98</td>
<td>2</td>
<td>139</td>
<td>13</td>
<td>29</td>
<td></td>
<td></td>
</tr>
<tr>
<td>San Clemente</td>
<td>145</td>
<td>599</td>
<td>79</td>
<td>6</td>
<td>272</td>
<td>7</td>
<td>25</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Physical characteristics based on Schoenherr et al. (1999:7).

a MNI, minimum number of individuals.
<table>
<thead>
<tr>
<th>Site or Locality</th>
<th>Age</th>
<th>MNI</th>
<th>Comments</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>San Clemente Island</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCLI-43</td>
<td>~2000 cal. yr BP</td>
<td>7</td>
<td>Dog burials, as well as scattered additional bones</td>
<td>Porcasi, 1995:9; Hardy, 2000; Walker, unpublished data, 2008</td>
</tr>
<tr>
<td>SCLI-119</td>
<td>Historic</td>
<td>1</td>
<td>Large dog in a bundle wrap with fibers, sea otter robes, and mission cloth</td>
<td>Woodward, 1941; McKusick and Warren, 1959; Salls, 1990:38</td>
</tr>
<tr>
<td>SCLI-120</td>
<td>~1050 cal. yr BP</td>
<td>1</td>
<td>3 metacarpals and 1 axis vertebra</td>
<td>Noah, 1987:71; age estimated from Porcasi and Fujita, 2000:549</td>
</tr>
<tr>
<td>SCLI-126</td>
<td>Historic</td>
<td>8</td>
<td>Dog burials, as well as scattered additional bones</td>
<td>Raab et al., 1994; Walker, unpublished data, 2008</td>
</tr>
<tr>
<td>SCLI-1487</td>
<td></td>
<td>1</td>
<td>Numerous canine/island fox bones in disturbed context, but no NISP or MNI</td>
<td>Hale and Salls, 2000:83</td>
</tr>
<tr>
<td>SCLI-1492</td>
<td>post 1000 cal. yr BP to Historic</td>
<td>1</td>
<td>Remains of 1 dog</td>
<td>Noah, 1987:62</td>
</tr>
<tr>
<td>SCLI-1524</td>
<td>1170–320 cal. yr BP</td>
<td>6</td>
<td>Six dog burials and some contain ritual goods</td>
<td>Raab et al., 1994</td>
</tr>
<tr>
<td><strong>Santa Catalina Island</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCAI-17</td>
<td>Middle–Late Holocene</td>
<td>1</td>
<td>No NISP or MNI available</td>
<td>Porcasi, 2002:584</td>
</tr>
<tr>
<td><strong>San Nicolas Island</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SNI-4</td>
<td>Late Holocene?</td>
<td>1</td>
<td>Left and right premaxilla and maxilla</td>
<td>Santa Barbara Museum of Natural History specimen</td>
</tr>
<tr>
<td>SNI-8</td>
<td>Late Holocene?</td>
<td>1</td>
<td>Fairly complete skeleton</td>
<td>Santa Barbara Museum of Natural History specimen</td>
</tr>
<tr>
<td>SNI-10</td>
<td>Late Holocene?</td>
<td>2</td>
<td>Two crania</td>
<td>Santa Barbara Museum of Natural History specimen</td>
</tr>
<tr>
<td>SNI-11</td>
<td>4900–4500 and 2400–600 cal. yr BP</td>
<td>5</td>
<td>39 bones present; 1 burned element; 2 MNI and 2 NISP are from early stratum</td>
<td>Bleitz, 1995:527</td>
</tr>
<tr>
<td>SNI-12</td>
<td>Late Holocene?</td>
<td>1</td>
<td>Cranium minus rostrum</td>
<td>Santa Barbara Museum of Natural History specimen</td>
</tr>
<tr>
<td>SNI-13</td>
<td>Late Holocene?</td>
<td>3</td>
<td>Three crania</td>
<td>Santa Barbara Museum of Natural History specimen</td>
</tr>
<tr>
<td>SNI-18</td>
<td>415 (115) 80 cal. yr BP</td>
<td>1</td>
<td>Dog burial</td>
<td>Reiman and Townsend, 1966; Kerr et al., 2002:33</td>
</tr>
<tr>
<td>SNI-21</td>
<td>2120–1630 cal. yr BP</td>
<td>3</td>
<td>Complete articulated skeleton and parts of two other dogs</td>
<td>Santa Barbara Museum of Natural History specimen; dates from Vellanoweth et al., 2002</td>
</tr>
<tr>
<td>SNI-25</td>
<td>670 cal. yr BP-Historic</td>
<td>4</td>
<td>Three complete burials and 1 partially scattered dog</td>
<td>Dates from Vellanoweth et al., 2002</td>
</tr>
<tr>
<td>SNI-25</td>
<td>0 cal. yr BP-Historic</td>
<td>1</td>
<td>Dog burial</td>
<td>Kerr et al., 2002:33</td>
</tr>
<tr>
<td>SNI-25</td>
<td>670 cal. yr BP-Historic</td>
<td>3</td>
<td>Three specimens from the same locality, with several mandibles, one from a puppy</td>
<td>Santa Barbara Museum of Natural History specimen, Dates from Vellanoweth et al., 2002</td>
</tr>
<tr>
<td>SNI-26</td>
<td>Late Holocene?</td>
<td>1</td>
<td>Complete cranium</td>
<td>Santa Barbara Museum of Natural History specimen</td>
</tr>
<tr>
<td>SNI-33</td>
<td>930–790 cal. yr BP</td>
<td>1a</td>
<td>No NISP or MNI available</td>
<td>Martz, 2005:73; Dates from Vellanoweth et al., 2002</td>
</tr>
<tr>
<td>SNI-160</td>
<td>1710–930 cal. yr BP</td>
<td>1a</td>
<td>No NISP or MNI available</td>
<td>Martz, 2005:73; Dates from Vellanoweth et al., 2002</td>
</tr>
<tr>
<td>SNI-214</td>
<td>Historic</td>
<td>1</td>
<td>Dog burial</td>
<td>Kerr et al., 2002:33</td>
</tr>
<tr>
<td><strong>Santa Cruz Island</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCR-?</td>
<td>n/a</td>
<td>1</td>
<td>Complete dog from biological collection with very heavily worn teeth</td>
<td>Glassow et al., 2008</td>
</tr>
<tr>
<td>SCR-109</td>
<td>Middle Holocene</td>
<td>1</td>
<td>Bone pins from dog tibia and ulna</td>
<td>Colten, 1993:90, 2001:210, personal communication, 2007</td>
</tr>
<tr>
<td>SCR-192</td>
<td>Historic</td>
<td>2</td>
<td>N = 5 from House 4 (2 Canis sp. as well); N = 7 from House 8 (5 Canis sp. as well)</td>
<td>Noah, 2005:165, 171</td>
</tr>
<tr>
<td>SCR-236</td>
<td>Historic</td>
<td>2</td>
<td>NISP = 5 from House 5; NISP = 2 from House 9</td>
<td>Noah, 2005:194</td>
</tr>
<tr>
<td>SCR-240</td>
<td>Late Holocene</td>
<td>1</td>
<td>Dog burial found by Olson at B-83</td>
<td>Hoover, 1971:120</td>
</tr>
<tr>
<td>SCR-328/330</td>
<td>Historic</td>
<td>2</td>
<td>NISP = 3 from two different houses</td>
<td>Noah, 2005:206; this paper</td>
</tr>
<tr>
<td>Site or Locality</td>
<td>Age</td>
<td>MNI</td>
<td>Comments</td>
<td>References</td>
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<td>-----------------</td>
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<td>--------------------------------------------------------------------------</td>
<td>-------------------------------------------------</td>
</tr>
<tr>
<td>SCR1-Localita 125</td>
<td>Late Holocene</td>
<td>2</td>
<td>Two complete crania, Coches Prietos</td>
<td>Santa Barbara Museum of Natural History specimen</td>
</tr>
<tr>
<td>SCR1-Forney’s</td>
<td>Late Holocene</td>
<td>2</td>
<td>Two complete crania</td>
<td>Santa Barbara Museum of Natural History specimen</td>
</tr>
<tr>
<td>SCR1-434</td>
<td>Late Holocene</td>
<td>1</td>
<td>Almost complete crania probably aboriginal dog</td>
<td>Santa Barbara Museum of Natural History specimen</td>
</tr>
<tr>
<td>SCR1-474</td>
<td>Late Holocene</td>
<td>1</td>
<td>Fully articulated dog skeleton buried on its side and recovered by Olson</td>
<td>Hoover, 1971:137</td>
</tr>
<tr>
<td><strong>Santa Rosa Island</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SRI-2</td>
<td>500–150 cal. yr BP</td>
<td>1</td>
<td>Partially complete dog burial eroding out of sea cliff</td>
<td>Santa Barbara Museum of Natural History specimen</td>
</tr>
<tr>
<td>SRI-2</td>
<td>2000–150 cal. yr BP</td>
<td>6</td>
<td>Seven specimens excavated by Orr, including juvenile and adult remains</td>
<td>Santa Barbara Museum of Natural History specimen</td>
</tr>
<tr>
<td>SRI-41</td>
<td>Middle-Late Holocene</td>
<td>2</td>
<td>Two separate specimens with cranial and post-cranial elements</td>
<td>Santa Barbara Museum of Natural History specimen</td>
</tr>
<tr>
<td>SRI-60</td>
<td>Late Holocene–Historic</td>
<td>1</td>
<td>Miscellaneous dog bones recovered by David Banks Rogers in early 20th century</td>
<td>Santa Barbara Museum of Natural History specimen, J. Johnson, personal communication, 2008</td>
</tr>
<tr>
<td><strong>San Miguel Island</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SMI-1</td>
<td>7140–3250 cal. yr BP</td>
<td>1</td>
<td>Canid remains identified in 12 units</td>
<td>Walker, unpublished data, 2008</td>
</tr>
<tr>
<td>SMI-87</td>
<td>ca. 2500–3500 cal. yr BP</td>
<td>1</td>
<td>Fragmentary cranium</td>
<td>Rick, 2007</td>
</tr>
<tr>
<td>SMI-261</td>
<td>Early Holocene?</td>
<td>1</td>
<td>Left mandible; morphology indicative of short-faced breed</td>
<td>Walker et al., 1978:11, 78</td>
</tr>
<tr>
<td>SMI-330 and</td>
<td>na</td>
<td>1</td>
<td>Right mandible found on surface near these two sites</td>
<td>Santa Barbara Museum of Natural History specimen</td>
</tr>
<tr>
<td>SMI-392?</td>
<td>Late Holocene?</td>
<td>1</td>
<td>Nearly complete, heavily weathered cranium</td>
<td>Walker and Snethkamp, 1984:140, D-12</td>
</tr>
<tr>
<td>SMI-481?</td>
<td>Late Holocene?</td>
<td>2</td>
<td>Two crania and mandibles, Otter Harbor</td>
<td>Santa Barbara Museum of Natural History specimen</td>
</tr>
<tr>
<td>SMI-485</td>
<td>570–480 cal. yr BP</td>
<td>1</td>
<td>NISP=4 probably from a single individual</td>
<td>Walker and Snethkamp, 1984:140, D-14</td>
</tr>
<tr>
<td>SMI-525</td>
<td>650–168 BP</td>
<td>1</td>
<td>Mandible</td>
<td>From Kennett excavations</td>
</tr>
<tr>
<td>SMI-525</td>
<td>-620–520 cal. yr BP</td>
<td>1</td>
<td>Mandible that lacks first premolar</td>
<td>Walker and Snethkamp, 1984:140–41</td>
</tr>
</tbody>
</table>

* MNI (Minimum number of individuals) unknown but at least one individual is present.

b Garlinghouse, 2000:106 reported an NISP of 18 and MNI of 9 for SCLI-43, -126, and -1524 but it is unclear what site or time period these come from.
each of these dog specimens suggest that, as elsewhere in North America, dogs have a long history on the Channel Islands, probably spanning most of the Holocene, and their presence appears to increase significantly through time.

Results

At least 42 Channel Island archaeological sites or localities are known to contain dog remains, with a number of other known dog parts assigned to an island but to no known location. This includes at least 96 individual dogs; a conservative value given the absence of MNI data from many reports. A number of sites (e.g., SRI-2, SCRJ-240, SCLI-1524 and SNI-25) also produced multiple dog remains or sometimes multiple dog burials. Dogs were found on six of the eight Channel Islands, with only the smallest islands (Anacapa and Santa Barbara, each about 2.5–3 km² in total area) lacking documented dog remains (Figures 2 and 3). These two islands have also seen the least amount of archaeological research. The larger islands had relatively sizeable human settlements during the middle and late Holocene, and most of these have a number of sites with dog bones. Santa Catalina, the largest and closest to the mainland of the southern islands, has the most sites with dogs, including several sites with dog burials. Similarly, San Clemente Island, located about 79 km offshore, has seven sites with dog remains, including late Holocene sites such as SCLI-1524 that produced six dog burials alone (Hale and Salls, 2000).

The oldest dog remains from the Channel Islands appear to be a left mandible fragment from Daisy Cave on San Miguel Island, the depth of which may correlate with the site’s early Holocene (~8600–10 000 cal. yr BP) deposits (Walker et al., 1978; Erlandson, 1994: 194). An early-Holocene date would make these remains among the oldest dog bones in the Americas (see Morey, 2006), but the specimen has not been directly dated and it could be from one of the younger site components. The possible early-Holocene age of the Daisy Cave specimen may be supported by dog remains identified in a few early mainland sites (Erlandson, 1994), but stratigraphic mixing is an issue in many of these sites and mainland specimens have not been directly dated. Four sites contain dog remains that are either middle or early late Holocene in age. Two dogs identified from SNI-11 were from Stratum 3, dated between about 6500 and 4500 years ago, providing a reasonably

The largest number of sites or localities with dog remains occurs on San Nicolas Island (n = 13), followed by Santa Cruz (n = 11), San Clemente (n = 7), San Miguel (n = 7), Santa Rosa (n = 3) and Santa Catalina (n = 1). San Nicolas, at roughly 98 km from the mainland, has the most sites with dogs, including several sites with dog burials. Similarly, San Clemente Island, located about 79 km offshore, has seven sites with dog remains, including late Holocene sites such as SCLI-1524 that produced six dog burials alone (Hale and Salls, 2000).

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secure middle-Holocene age for these materials. Dog remains from SRI-41 on Santa Rosa Island and SCA-17 on Santa Catalina Island may also be middle or early late Holocene in age. The majority of sites \((n = 38)\) date to the late Holocene, indicating that dog populations, similar to human populations, increased through time on the islands. More late-Holocene sites have been excavated than middle- and early-Holocene sites, however, which may contribute to the dearth of earlier dog evidence.

Dog remains are found in a wide range of archaeological contexts, including shell middens and formal burials. The latter are better documented on the southern islands, where several sites on San Clemente (eg, Eel Point, Lemon Tank and Big Dog Cave) and San Nicolas islands (SNI-25) have produced formal dog burials, some with grave goods. On San Clemente, researchers have suggested that these dog burials, including apparently dismembered dogs, may be part of ancient religious ceremonies (Raab et al., 1994; Hardy, 2000; Hale and Salls, 2000). On the northern islands formal dog burials are less common, but dogs have been found fully articulated in midden deposits, where they were either discarded, intentionally buried or died naturally in place. Although some of the San Clemente dogs may have been ritually modified and perhaps decapitated (Hardy, 2000), signs of butchery or other indicators of human consumption are rare. At SNI-11 a burned dog bone was identified (Bleitz, 1993), and a few San Clemente sites also contained burned dog bones (Garlinghouse, 2000).

However, this burning may be a product of inadvertent burning of bones buried near to hearths or the use of fire to dispose of the remains of dogs who were not consumed. Overall, these data suggest that dogs were generally not consumed, except perhaps during times of scarcity. The two dog-bone pins identified by Glowsow et al. (2008) from middle-Holocene deposits on Santa Cruz Island suggest that dog bones were occasionally used to make utilitarian objects. Gnaw marks that are probably from dogs, and possibly foxes, have been noted on human remains from Eel Point (SCLI-43) on San Clemente Island (Titus and Walker, 2000: 85) and on non-human faunal remains from three Santa Cruz Island sites (SCRI-192, -236 and -240; Noah, 2005: 120) and at SRI-2 on Santa Rosa Island. These data demonstrate that canids were also scavengers and agents of taphonomic disturbance.

**Discussion**

Dogs were a significant component of Holocene Channel Island ecosystems and were widespread during the late Holocene. Humans and dogs had a symbiotic relationship, with dogs probably functioning as hunting companions, sentinel animals, pets, offal scavengers, food sources and potentially as status symbols as they did elsewhere in the world. During periods of high interpersonal violence, dogs may have also served an important function by warning people of intruders (Walker and Smethkamp, 1984: 142; Walker, 1989). Ethnographic data for the Chumash (Blackburn, 1975: 242), Hopi (Titiev, 1972), Navajo (Downs, 1972), Chippewa (Sharp, 1976) and Mundurucú (Murphy, 1985) suggest that dogs also consume human excrement, which is important for disposing of waste. Dogs likely did the same on the Channel Islands.

Like their wolf ancestors, dogs are pack animals that generally have good hunting skills. A few ethnographic accounts of Chumash and Gabrieleno peoples on the mainland, however, suggest that some Chumash groups may not have employed dogs for hunting, but occasionally used them for food (Kroeber, 1941; Harrington, 1942: 6–7). Given the dearth of terrestrial animals on the Channel Islands, dogs probably were of limited use in hunting. They would hinder hunting sea mammals hauled out along the coast, for example, because they would likely scare them into the water before they could be taken. With their presence on the islands for at least 6000 years, we argue that dogs, together with foxes and humans, negatively affected breeding bird and sea mammal populations on the mainland portions of the islands, likely driving these animals to offshore islets or other isolated areas. If feral dog populations were present, as they were historically (see below), these impacts would have been more pronounced. Guthrie (1993) has identified the fossil remains of *Chendytes lavi*, a ground-nesting, flightless scoter, on San Miguel Island dated to c. 12,000 BP (~14,000 cal. yr BP). Extensive *Chendytes* breeding colonies would not have been possible with the regular presence of dogs, foxes and humans. It is conceivable that dogs contributed to the extinction of the flightless goose near the end of the middle Holocene or beginning of the late Holocene (see Guthrie, 1993; Jones et al., 2008; Rick et al., 2008b).

One of the most significant ecological impacts of Channel Island dogs was probably related to their propensity to disturb aggregations of breeding animals. A recent study on disturbance to western snowy plovers (*Charadrius alexandrinus nivosus*), a threatened shore bird, and other birds near the Devereux Slough on the Santa Barbara mainland demonstrated that unleashed dogs had some of the highest impacts on plovers, probably influencing reproduction, survivorship and distribution (Lafferty, 2001a, b). Since snowy plovers are also found on the Channel Islands, including a protected area near Skunk Point on Santa Rosa Island, Native American dogs may have had much the same impact on these and other birds in the more distant past. This is especially true since no disturbances to snowy plovers were observed at the protected area of Santa Rosa today (Lafferty, 2001a, b), but in the past Skunk Point was close to numerous large centres of Native American habitation, including the historic Chumash Village of *Qivngqishow* that would have almost certainly had dogs.

Dogs would also have competed directly with island foxes for food and other resources. Although a great deal of attention has been given to the biology and ecology of island foxes (eg, Collins, 1991a, 1991b; Roemer et al., 2001, 2002; Coonan et al., 2002, 2005), few studies have examined the possible interactions between dogs and foxes in the distant past. Collins (1991a) discussed the burials of both dogs and foxes in island sites, demonstrating that people often gave the same ritual treatment to these animals. Collins (1991b) and Vellanoweth (1998) argued that Native Americans introduced island foxes to the Channel Islands but, based on a single ‘Pleistocene’ specimen from Santa Rosa Island recovered in the 1950s by Phil Orr, it has been suggested that foxes arrived naturally on the northern islands prior to human arrival (see Collins, 1991b). However, recent direct 14C dating of this and several other fox specimens, previously thought to be as much as 38,000 years old, suggests that they are all middle or late Holocene in age, raising significant questions about the natural dispersal of foxes to the northern islands (Shelley, 2001; Rick et al., 2008a). As Collins (1991a) noted, island fox behaviour meshes well with humans, and their presence in formal burials clearly demonstrates their importance in Island Chumash society.

Dogs and foxes appear to have lived side by side another since at least the middle Holocene, but it is still unclear how they would have influenced each others’ lives. They would have competed for food and the small size of island foxes would have made them potential prey for feral dogs (eg, Ralls and White, 1995). Dog pups could also have been prey for island foxes, but we suspect direct predation may have been limited, especially if people actively discouraged it. In this context, both island foxes and dogs may have provided an additional benefit to people by eating discarded food and human waste, preying on rodents and other pests around habitation sites and providing protection from intruders.

The introduction of dogs to the Channel Islands and occasional prehistoric transport of mainland dogs to the islands could also
have had deleterious consequences by transmitting potential lethal pathogens such as canine distemper, canine adenovirus, canine parvovirus and toxoplasma to endemic island foxes (Clifford et al., 2006).

Despite these potential negative consequences for foxes, we know from archaeological evidence that both canids coexisted for several thousand years, making it clear that potential niche overlap between the two species resulted in some form of equilibrium rather than competitive exclusion. The key adaptive difference that made this possible is likely the symbiotic relationship between humans and their domestic dog companions. Interestingly, the earliest secure date for island foxes is about 7000 cal. yr BP, a date comparable with the earliest secure dates available for dogs. Future research on the antiquity and distribution of dogs and island foxes should prove important for delineating the relationship between these two animals and their ecological impacts.

Historically, dogs were present on all the islands and were introduced during successive ranching occupations since the nineteenth century (Schoenherr et al., 1999). The fate of Native American dogs on the islands during the Historic period is poorly documented. Many dogs were probably left behind when Native peoples left the islands for mainland missions, and a few accounts suggest that ‘wild dogs’ were present historically (Schumacher, 1877). Juana Maria, the lone woman of San Nicolas Island, who survived alone on the island for many years in the mid-nineteenth century, had several dogs (Nidever, 1937). Juana Maria even suggested that her child was eaten by wild dogs (Hardy, 2000: 95). Schoenherr et al. (1999: 41) noted that feral dogs descended from Native American dogs were removed from San Nicolas Island by shepherders because they were impacting sheep populations. Native American dogs may have survived on the other islands as well, but the fate or abundance of these dogs is poorly known. In recent years, dogs were removed and banned from some of the islands by the National Park Service and US Navy, with dogs present only on Santa Catalina today. Canine diseases and parasites were implicated as one component of the dramatic reduction of island fox populations during the last decade, although predation by golden eagles appears to be the major cause of the fox decline (Coonan et al., 2002, 2005; Roemer et al., 2002). The introduction of dogs in the distant past by Native Americans raises questions about the nature of such dog/fox interactions. Canine diseases may have passed back and forth between the two populations in the past, but both foxes and dogs appear to have co-existed for much of the Holocene and we argue played a role in island ecology, biogeography and Native American culture.

Conclusion

The evidence we have presented in this paper for the translocation of dogs to the Channel Islands adds to our growing understanding of the influence of Native Americans and other pre-industrial peoples on ecology and biogeography (Redman, 1999; Grayson, 2001; Kirch, 2005). These impacts are particularly significant on islands, which contain unique fauna and ecosystems that are generally more vulnerable to human activities than continental landmasses. Although we are just beginning to understand the role of people in shaping ancient Channel Island marine and terrestrial ecosystems (Erlandson et al., 2004, 2005; Kennett, 2005; Braje, 2007; Rick, 2007; Braje et al., 2007; Rick et al., 2008a, b), the introduction of domestic dogs to the islands is part of a much larger ‘domestication’ of the Channel Islands landscape. The Channel Islands contain unique ecosystems distinct from the nearby mainland, with a number of island endemic and relict species (Schoenherr et al., 1999). It is clear, however, that these environments were also influenced by the direct and indirect actions (e.g., hunting, setting of wildfires, dune stabilization and de-stabilization, and animal translocations) of Native peoples for at least 13,000 calendar years.

Understanding and documenting the activities of ancient people, and the animals they introduced, we can improve models of ancient island ecosystems and significantly enhance the management and restoration of these habitats by providing important baseline data on how island ecosystems may have been structured and functioned in the past. Dogs were a predator/scavenger introduced to the Channel Islands by humans that, along with island foxes and humans, influenced the biogeography and breeding behaviour of birds, marine mammals and other animals that, largely free from predation today, breed in large numbers on several of the islands, including over 100,000 seals and sea lions on San Miguel Island alone (Delong and Melin, 2002). The greatest ecological influence of dogs would have been in the areas closest to human communities. Since Native villages and their dogs were present across much of the islands, especially around the coastlines and near good water sources, these impacts may have been fairly widespread.

There is still much to be learned about the antiquity and effects of the prehistoric introduction of domestic dogs on the ecology of California’s Channel Islands. At the very least, dogs may have scared marine mammals and birds off island beaches and other landforms, driving them to breed, roost and haul-out elsewhere. On San Miguel Island, all foxes were pulled into captivity for breeding starting in the late 1990s, which resulted in the rapid spread of ground-breeding northern harriers (Circus cyaneus), western gulls (Larus occidentalis) and Brandt’s cormorants (Phalacrocorax penicillatus) in vulnerable and conspicuous locations around the island (Drost et al., 2008). This significant expansion of bird breeding habitat provides a possible glimpse of what seabird populations may have looked like prior to the late Pleistocene/Holocene arrival of foxes, dogs and humans. Given the lengthy presence of people and dogs on the islands, the modern situation appears to be radically different from much of the Holocene.

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References


Walker P., Craig, S., Guthrie, D. and Moore, R. 1978: An ethnozoological analysis of faunal remains from four Santa Barbara Channel Island archaeological sites. Report on file at the Central Coast Information Center, University of California, Santa Barbara.


