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Iain McKechnie, Madonna L. Moss, & Susan J. Crockford

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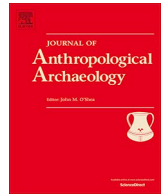
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Domestic dogs and wild canids on the Northwest Coast of North America: Animal husbandry in a region without agriculture?

Iain McKechnie^{a,b,*}, Madonna L. Moss^{c,d}, Susan J. Crockford^e

^a Department of Anthropology, University of Victoria, Victoria, BC, Canada

^b Hakai Institute, Heriot Bay, Quadra Island, BC, Canada

^c Department of Anthropology, University of Oregon, Eugene, OR 97403, USA

^d Museum of Natural and Cultural History, University of Oregon, Eugene, OR 97403, USA

^e Pacific Identifications Inc., 6011 Oldfield Rd, Victoria, BC V9E 2J4 Canada

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ABSTRACT

Domestic dogs (*Canis familiaris*) occur in the archaeological record throughout North America but few zooarchaeological studies have examined the extent of wild and domestic canids using multi-site observations across regions. Here, we present a meta-analysis of 172,310 mammal specimens identified from 210 archaeological sites along the Northwest Coast focusing on canid abundance, distribution, and osteological identifications. We show that canids have a ubiquitous geographic distribution and a high relative abundance in particular Northwest Coast sub-regions and that species-level identifications are overwhelmingly of domestic dogs in contrast to ~1% of non-domestic canids (wolf, coyote, and fox). Along with geochemical and genetic data, these zooarchaeological observations indicate a variety of roles for dogs including hunting, companionship, and wool production in a region lacking terrestrial agriculture and domestic livestock. We suggest the frequently applied taxonomic status of 'indeterminate canid' underestimates the extent to which domestic dogs played key roles in regional economies and cultural practices. Increased attention to resolving taxonomic ambiguity of canids through improving comparative collections and osteometric datasets will help clarify the non-conventional domestication pathways practiced by Northwest Coast peoples.

1. Introduction

Throughout the history of anthropology, Indigenous societies on the Pacific Northwest Coast have attracted scholarly attention due in part to an expressive material culture and complex social relationships that emerged from economic foundations of marine-oriented fishing, hunting, and gathering. Although the concept of cultural complexity is itself problematic, so too is the characterization of these societies as "hunter-gatherers" (Grier, 2017; Mackie, 2001; Moss, 2011). Aside from the wide variety of marine and terrestrial food and animal products that were highly valued and widely traded, fishing and shell-fishing likely contributed the most reliable protein across the region. Accordingly, access to the most productive places in which these foods were hunted, collected, and/or cultivated was tightly controlled through tenure and lineage-based cultural protocols that persisted over centuries and millennia. Through the multi-generational and localized nature of repetitive harvesting and use, Northwest Coast societies often transformed coastal environments. They sought to enhance access and productivity and also to sustain and expand future access to the wealth

generated from production, consumption, and distribution (Suttles, 1968).

Over the past two decades, archaeological research from southeast Alaska to southern Oregon has increasingly recognized how Indigenous peoples cultivated coastal plants and altered the habitats of various forest, meadow, wetland, and intertidal settings (Bernick, 2012; Deur and Turner, 2005; Earnshaw, 2019; Hoffmann et al., 2016; Lepofsky et al., 2001; Pellatt and Gedalof, 2014; Turner et al., 2013; Weiser and Lepofsky, 2009). Some Northwest Coast groups practiced mariculture, building extensive clam gardens and other harvesting features in the intertidal zone (Caldwell et al., 2012; Deur et al., 2015; Harper et al., 2005; Lepofsky et al., 2015; Mathews and Turner, 2017; Moss and Wellman, 2017; Smith et al., 2019). With respect to fishing, Johnsen (2009) goes so far as to characterize Northwest Coast societies as 'salmon ranchers' because of their active management of salmon streams, the installation of weirs and traps to capture fish, and the social management required to process and store salmon (Moss, 2011: 39). This analogy could be extended to many other fish species harvested in large quantities at specific locales (Langdon, 2006; McKechnie

* Corresponding author at: Department of Anthropology, University of Victoria, Cornett B246a, 3800 Finnerty Rd., Victoria, BC V8P 5C2 Canada.
E-mail address: iim@uvic.ca (I. McKechnie).

and Moss, 2016; Menzies, 2012; Moss, 2011; Patton et al., 2019; Thornton et al., 2015; Trosper, 2002) as well as the many terrestrial and marine mammal species that were consistently targeted over millennia of Indigenous hunting (Angelbeck and Cameron, 2014; Crockford, 2018; McKechnie and Wigen, 2011; McMillan, 2015).

Less well known, however, is that some Northwest Coast societies selectively bred domestic dogs. Globally, questions abound about the initial domestication of dogs in the Palaeolithic because of morphological and size-based variation and overlap between domestic dogs and wild canids (Crockford and Kuzmin, 2012; Germonpré et al., 2013; Germonpré et al., 2009; Janssens et al., 2019; Larson et al., 2012). Beyond issues of documenting domestication in different places at different times, the relationships between people, dogs, and other canids have taken numerous diverse trajectories (chapters in Bethke and Burt, 2020; Crockford, 2000; Losey et al., 2018). Compared to the range of species used on the Northwest Coast, relatively little archaeological research has focused on the roles of dogs in these societies (but see Angelbeck and Cameron, 2014; Croes, 2015; Mack, 2015). This lack of attention is partly due to difficulty identifying dogs archaeologically, as the taxonomic designation “canid” encompasses dog, wolf, fox, or coyote specimens, many of which could be identified to species provided sufficient osteological scrutiny. These tentative identifications have, by default, contributed to a lack of appreciation of the cultural importance and biogeography of both domestic dogs and wild canids. We survey the Holocene zooarchaeological record of mammalian assemblages from across the Northwest Coast to identify geographic patterns of canid abundance and distribution. Using frequencies of species-specific identifications across a large range of archaeological observations in combination with ethnographic, ancient DNA and isotopic information, we argue that most canid bones on the Northwest Coast are likely domestic dogs. Canids were especially significant in southern British Columbia, where two sizes of dogs occur, and the smaller ‘wool’ dogs were particularly abundant.

1.1. Challenges in the zooarchaeological identification of canids

Accurate species and genus identifications of osteological remains based on skeletal morphology have long been the central contribution of zooarchaeology (Driver, 1992; Driver et al., 2011; Lyman, 2002). The emphasis on accuracy underpins the sub-discipline’s scientific integrity, with results that can be replicated with additional scrutiny and congruence across multiple lines of evidence (Gifford-Gonzalez, 1991; Wolverson, 2013). This is critical with osteologically similar taxa or where characteristics of a species can have pivotal interpretive significance, such as the introduction of domestic animals to hunting and gathering economies (e.g., Arbuckle et al., 2014) or the occurrence of exotic taxa indicating long distance travel or exchange (e.g., Sloan, 2003). Zooarchaeologists must regularly ‘split the difference’ between assigning accurate identifications at the most finely resolved taxonomic level while working with often fragmentary specimens that may only be confidently identified to genus, family, class, or order. Crucial to morphological identification are the adequacy of comparative osteological collections and the skill of individual analysts (Lyman, 2019). As disciplinary conventions have moved towards more standardized quantification and protocols (Albarella, 2017), established zooarchaeologists have accumulated perspectives on the types of animals expected for a given region and time period. After more than 50 years of sub-disciplinary growth, the breadth and quality of zooarchaeological identifications have improved as has the adequacy of comparative collections. Accordingly, these accumulated taxonomic observations are well-suited to comparative evaluation, as they can offer new insights into the biogeographic, economic, and cultural history of animal utilization.

The zooarchaeological identification of canid species remains challenging globally, particularly for early domestic contexts where morphological and size-based variation can be considerable (Janssens et al., 2019; Larson et al., 2012; Ovodov et al., 2011). The confidence of

species-level identifications based on osteological and morphological characteristics can be refined by aDNA, geochemical and geomorphometric analyses (e.g., Doorn, 2014; Kemp et al., 2017; Steele, 2015). Additionally, the notion of domestication can be broadened by considering culturally specific perceptions of canid species across world regions where human associations with non-domestic canids occur (Koungoulos and Fillios, 2020; Losey et al., 2011; Monagle et al., 2018).

Here, we examine the issue of canid identification in relation to zooarchaeological research on mammalian faunas from the Northwest Coast. This region has long been a focus of zooarchaeological research (reviewed in Butler and Campbell, 2004; Monks, 2019), but many analysts have been reticent to assign canid remains species-level designations given broad morphological similarities between domesticated dog (*Canis familiaris*) and non-domestic canids such as wolf (*C. lupus*), coyote (*C. latrans*), and fox (*Vulpes vulpes* or *Urocyon cinereoargenteus*). Making a morphological distinction between domestic and non-domestic canids is difficult in the absence of a comparative collection that includes both sexes and a range of ages amongst the relevant species and domestic breeds (Crockford, 1997:12; 2009). Despite the improved quality and incremental refinement of various comparative collections in this region, relatively few facilities have complete skeletons of Indigenous domesticated dogs as well as coyote, wolf, and red and grey fox. Since modern dog breeds encompass such a wide range of sizes and breed-specific morphologies and skeletal pathologies, modern dog bones can substantially differ from those of ancient breeds and are not necessarily the most suitable for comparison to domestic dogs and wild canids (Crockford and Kuzmin, 2012; Losey et al., 2014; Perri, 2016). For example, many comparative collections typically contain a single or small number of domestic dog specimens from modern breeds which effectively serve to characterize osteological variation in domestic dogs but often have differing skull and muzzle morphologies and body proportions. Many collections in western North America have less than a full suite of wild canids which may include two species of foxes (grey and red), wolves from coastal and interior ecotypes, coyotes, and specimens from both sexes as well as adults and juveniles. Dogs and wolves as well as coyotes and wolves have the ability to hybridize (Schmutz et al., 2007; vonHoldt et al., 2011; Walker and Frison, 1982) and this has the potential to introduce additional variation into morphological and genetic methods for species identification.

We encourage continued zooarchaeological scrutiny of canid remains including careful osteological identification and strengthening of existing comparative collections. While we see an important role for verification from ancient DNA and other geochemical analyses, our review of existing data indicates that the majority of indeterminate canids on the Northwest Coast are likely to be domestic dogs whose taxonomic status has not been resolved. This circumstance has reinforced a lack of awareness of the potential ubiquity and cultural importance of indigenous dogs on the Northwest Coast during pre-contact periods and consequently under-represents the economic role that this domestic animal had. Here, we present contextual data that should encourage archaeologists to resolve canid identifications further; we suggest that dogs were of such cultural importance, species-level designations are worth pursuing, by seeking out additional comparative material and expertise.

1.2. Previous research on Northwest Coast canids

Zooarchaeological analysis of canids on the Northwest Coast began in the 1970s at Ozette on the Olympic Peninsula in Washington (Gleeson, 1970), at various sites in the Salish Sea region (Hanson, 1991; Keddie, 1993; Montgomery and Jackie, 1979; Wigen, 1980), and in the British Columbia interior (Crellin, 1994). In the 1990s, Susan Crockford reanalysed skeletal remains of canids and published osteometric and ancient DNA analyses from domestic canids (Crockford, 1994, 1997; Crockford and Pye, 1997; Koop et al., 2000) after which dogs became more broadly recognized in the regional archaeological record.

Crockford's (1997) research on domestic dogs from the Coast Salish and Makah areas of the southern Northwest Coast included detailed morphological and osteometric analyses that demonstrated the occurrence of two distinct dog types: (1) a medium-sized, dingo-like animal, and (2) a smaller, spitz-like dog similar in size to numerous ethnohistorically observed small long-haired dogs (e.g., Allen, 1920; Howay, 1918; Sproat, 1868; Swan, 1870). These physical descriptions corroborate ethnographic and historical accounts of a "village dog" associated with hunting and the smaller "wool dog" whose fur was sheared, spun into wool, and woven into blankets and garments in southern B.C. and northwest Washington. These two types of dogs have been documented elsewhere in British Columbia and as far north as southeast Alaska, Crockford (2014), Crockford et al. (2011) but this does not necessarily mean that the small northern dogs were raised for wool.

Skeletal remains of dogs are common constituents in zooarchaeological assemblages from across North America (Morey, 2010). Dogs are recognized as the first animal domesticated by humans and the only domestic animal north of Mexico until turkeys were domesticated ca. 2000 cal BP (Larson and Fuller, 2014; Speller et al., 2010). Genetic studies have shown that North American dogs were initially domesticated in Siberia and brought into the Americas by their human companions (Brown et al., 2013; Frantz et al., 2016; Koop et al., 2000; Larson et al., 2012; Ní Leathlobhair et al., 2018; Shannon et al., 2015; Sinding et al., 2020; Witt et al., 2015). Limited ancient DNA research on canids from select localities across the Northwest Coast confirmed the sustained presence of domestic dogs since at least ca. 6000 cal BP (Barta, 2006) and identified a variety of unique haplotypes (Ames et al., 2015; Barta, 2006:91; Edmunds, 2017; Koop et al., 2000; Tifental, 2016; Witt et al., 2015; Zimmerman, 2014), lending further support for multiple genetically distinct dog lineages in this region of North America. Ancient DNA research has great potential to clarify the evolutionary history of wolves and domestic dogs in the Americas (e.g., Ameen et al., 2019; Loog et al., 2019; Sinding et al., 2020) but as methodological developments become more sophisticated and scaled globally, improved standards for amplifying ancient sequences often eclipse previous research, reducing comparability of published aDNA sequences. Due to the expense and logistics of accessing zooarchaeological collections dispersed across the continent, aDNA analysis is unlikely for the overwhelming majority of canid specimens found archaeologically. Collagen fingerprinting (Doorn, 2014) is being developed for North American fauna (e.g., Hofman et al., 2018; Richter et al., 2020) but cannot replace morphological characterization of sex, age, and body size using a comparative collection.

On the Northwest Coast, various ethnohistorical sources describe domestic dogs in Indigenous communities and the use of wool from dogs in the Coast Salish and Makah regions (Allen, 1920; Howay, 1918; Kane, 1859; Swan, 1870; Vancouver, 1801). Dog and mountain goat wool blankets created with plant materials were common in the region before imported European trade goods flooded the market in the mid-19th century (Gustafson, 1980; Howay, 1918: 91). Textiles such as blankets made with dog wool were worn regularly as well as during rituals such as naming ceremonies, weddings, and dance performances and were given as gifts and traded as items with prestige value (Olsen, 2010; Suttles, 1960:302). Anthropologist Suttles (1983:70) remarked that:

Probably the most important form of wealth [among the Coast Salish] was the blanket of woven mountain goat and/or dog wool. These blankets had several advantages as wealth; they were made of materials of practical value and available in large but finite amounts and they were divisible and re-combinable, since they could be cut up or unravelled and the material re woven into new items.

Study of the species-specific proteins in the fibers of historically collected 'wool' blankets held in museum collections confirmed the presence of dog fur and plant material combined with mountain goat wool as described ethnographically (Solazzo et al., 2011). Analysis of stable carbon isotopes in dog wool blankets indicated dog(s) had marine diets (Schulting, 1994), i.e., consuming many of the same foods eaten by

people (Chisholm et al., 1982). Following what Guiry (2012) has termed the 'canine surrogacy approach,' Cannon et al. (1999), Grier (2006), and Ames et al. (2015), conducted stable isotope analyses of archaeological dogs as proxies for human diets and confirmed the importance of marine proteins for coastal dogs and humans (Ames et al., 2015:276; Schwarzc et al., 2014). Recent isotopic modelling of dog diets on western Vancouver Island has refined dietary contributions further in that region, indicating dogs consumed substantial quantities of salmon (*Oncorhynchus* spp.) and forage fish such as Pacific herring (*Clupea pallasii*) and northern anchovy (*Engraulis mordax*) (Hillis et al., 2020).

2. Materials and methods

To evaluate the archaeological extent and taxonomic status of canid remains on the Northwest Coast, we compiled a database of 172,310 morphologically identified mammal bones from 210 archaeological sites examined between 1960 and 2019 (supporting online information). These data were selected after an extensive review of zooarchaeological information from the Northwest Coast, including both conventionally published data as well as consulting reports and report appendices housed in government repositories and theses and dissertations in university libraries. All sites contain shell-bearing cultural sediments conducive to the preservation of vertebrate remains and are located within 500 m of the coastline or tidally influenced rivers. While this review encountered several hundred reports with zooarchaeological data, only those with consistently collected, identified, and sufficiently quantified mammalian assemblages based on the use of specified comparative collections are presented. Where sites had more than one zooarchaeological analysis of the same assemblage, data from the most recent analysis were utilized.

Individual mammalian assemblages deemed suitable for inclusion were those subject to systematic faunal recovery using ¼-inch (6.35 mm) or finer screen mesh and identified by established analysts or students working under the analysts' supervision using comparative osteological collections housed in university labs or museum settings. A small number of zooarchaeological assemblages identified from excavation projects conducted before 1975 (n = 6) include hand-recovered mammalian assemblages (Bryan, 1963; Savage, 1974) that are likely to include medium-sized mammal bones such as canids (Shaffer and Sanchez, 1994). Each assemblage is associated with chronological information such as radiocarbon dates and/or temporally diagnostic artifacts. The majority of assemblages represent pre-contact (i.e., prior to CE 1774) deposits that date to within the past 2,500 years with several spanning the mid-to-late Holocene. Very few sites have assemblages with substantial historic components (dating to the late 18th or 19th century) where exotic introduced dog breeds might have mixed with local breeds.

Individually identified bones were quantified by number of identified specimens (NISP) and only sites with 50 or more specimens identified to at least family or genus were included in observations of relative abundance and ubiquity discussed in this paper. This minimum threshold was established by examining the logarithmic relationship between sample size and taxonomic richness for 330 mammal assemblages across the Northwest Coast which demonstrates that 50 specimens fall just beyond the asymptote of the curve such that the addition of more specimens does not similarly influence taxonomic richness (Fig. 1). Birds, fish, and 'unidentified' mammal remains were excluded from this study. Whale bones (large cetaceans) were also excluded because bone fragments recognizable as large whale are often highly fragmentary and numerous relative to individual elements (Monks, 2003).

This analysis of 210 sites represents the largest mammalian zooarchaeological dataset reported from the Northwest Coast to date and is orders of magnitude larger than previous analyses. Butler and Campbell's key (2004) study examined assemblages from 55 sites from both the coast and the interior plateau. Orchard and Clark (2014) used multi-dimensional scaling to compare 39 coastal faunal assemblages

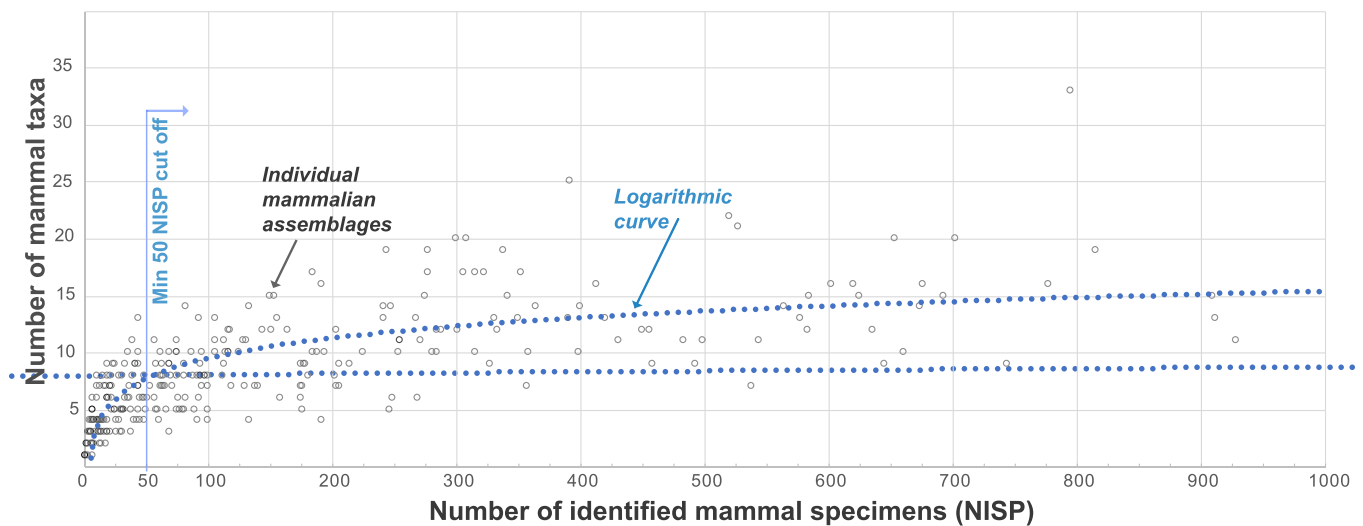


Fig. 1. Relationship between sample size and taxonomic richness for 330 mammalian assemblages including justification for establishing a 50 NISP threshold beyond which the curve flattens. Note: the x-axis is truncated in order to highlight the small assemblages but the logarithmic curve is based on all assemblages.

while Angelbeck and Cameron (2014) examined 29 mammalian assemblages from dated contexts. Orchard and Clark (2014) as well as Butler and Campbell (2004) did not distinguish canids by species but Butler and Campbell (2004:367) noted that canids were the third most ubiquitous mammalian taxon. McKechnie and Wigen (2011) examined 58 mammalian assemblages from southern British Columbia and, like Angelbeck and Cameron (2014), excluded canids due to their potential status as domestic (not targeted for food) animals. The larger dataset presented here expands on these previous analyses with greater archaeological and geographic coverage. Similar to these other studies, sites located along the Salish Sea are better represented in the dataset relative to other sub-regions reflecting the more development-driven archaeological research in this sub-region and greater proximity to urban-centered universities. Most sites date to within the past 2500 years and are large ‘shell midden’ settlements associated with late Holocene shorelines. This compilation includes data from over eight millennia of human history across 1600 km from southern Oregon to southeast Alaska and from myriad coastal settings ranging from outer coast to inner coast, estuaries, islands, and inlets.

Once these data were compiled, the first author itemized the taxonomic identifications from each site and site component using data tables listing number of identified specimens and species, genus or family level designations. Site locations were estimated in Google Earth Pro using available site maps, and coordinates were then imported along with zooarchaeological data into a geographic information system where percentage data for confidently identified ‘canid’ remains were categorized using the ‘symbology’ features in ARCGIS 10.6 (ESRI).

3. Results

This analysis compiled data for 330 sites across the Northwest Coast representing 174,637 identified mammal specimens, with 210 of these sites having minimum sample sizes deemed sufficient to assess ubiquity and relative abundance (NISP = 172,310). Within this latter dataset, an estimated 9.8% of bone specimens were identified by zooarchaeological analysts as canids (NISP = 16,891), representing a sizeable percentage of the total examined mammalian fauna across the study area (Fig. 2). Canids were also ubiquitous in archaeological sites throughout the coast – occurring in 173 of the 210 sites (82.4%). This high frequency of occurrence is repeated within the numerous geographic regions and sub-regions, such that canids are present in at least 60% of sites in all areas except Haida Gwaii, an offshore archipelago where non-domestic canids are known to be absent (Fig. 3). Canid remains are especially abundant and ubiquitous in the Salish Sea region of southern British

Columbia and Washington State where they comprise 28.4% (NISP = 10,735) of all identified mammals (NISP = 37,267) and occur in 93% of assemblages containing more than 50 specimens. Two sub-regions within the Salish Sea (eastern Vancouver Island and the Fraser Delta) have the highest proportion of canids across the study area (Fig. 3). By comparison, canids tend to be less ubiquitous and present in lower relative frequencies at sites in Haida Gwaii, Oregon, and along the outer Washington coast (Figs. 3 and 4).

Of the 16,891 canid specimens identified, the most frequent taxonomic designation is domestic dog (NISP = 10,590, 53.6% of canids) whereas the second largest category are *Canis* sp. which represents 35.7% of all identified canids (NISP = 6033). By contrast, only 148 specimens (0.88% of overall canid NISP) have been confidently identified as wolf, and even fewer have been identified as fox (either *Vulpes* or *Urocyon* spp., NISP = 22) or coyote (NISP = 4) along with 94 indeterminate ‘Canidae.’ Thus, despite perceived taxonomic uncertainty about canid designations, only 1.0% of all examined canids have been positively identified as one of the non-domestic species present across the study area and comprise only 0.1% of all identified mammalian fauna (Fig. 2), an observation consistent with biogeographic observations of coyotes and foxes reviewed further in the discussion.

This stands in stark contrast to the high proportion of domestic dogs to have been positively identified across the region (62.7% of total canid NISP) and were confidently identified in more than half of the 210 examined sites (52%, n = 109). The second-most commonly encountered canid species, wolf, is present in only 19 sites (9%) and at much lower frequencies (Fig. 2). The majority of the 148 wolf specimens occur in a single site at the head of Alberni Inlet on central Vancouver Island (Calvert and Crockford, 1982), and even here, the number of wolf specimens is significantly fewer (NISP = 87) than those identified as domestic dog (NISP = 229). Similarly, the number of identified specimens from domestic dog outnumbers wolf in 14 of the 15 sites where they co-occur (see supporting online information) (see Fig. 5).

The 22 fox bones are present in six sites with five of these occurrences at mainland settings in the southern portions of the study area (Fig. 6). A geographic outlier is represented by four fox specimens located on a small island in Prince Rupert Harbour off the north coast of British Columbia (Patton, 2011:362). This may represent an animal obtained through trade with the interior or a misidentification. In the southern region, four coyote specimens were identified from three sites, two in coastal Oregon (Losey, 2002; Tasa et al., 2009), and a tentative coyote identification from a site along southern Puget Sound (Wigen, 2013), both of which are consistent with the preindustrial biogeography of this species (Levy, 2012; Reid et al., 2018).

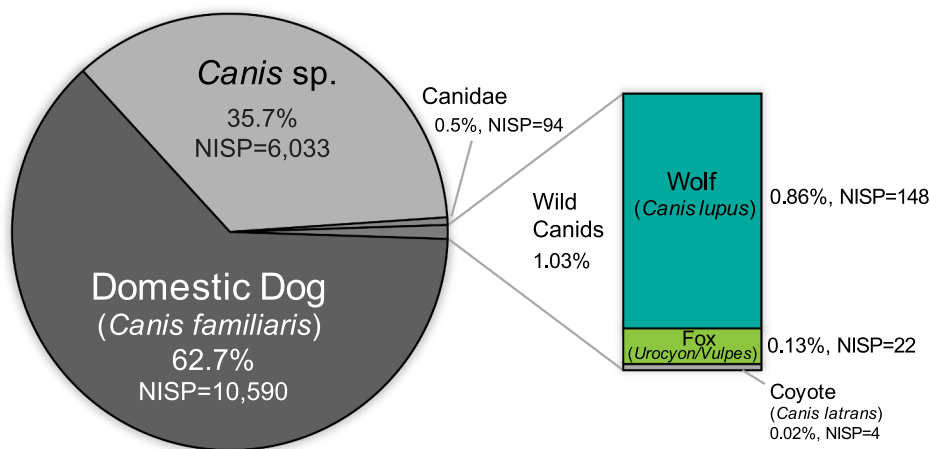


Fig. 2. Proportional abundance of canid specimens from quantified assemblages in the study area (N = 210).

3.1. Association with human burials

The large numbers of domestic canids identified in zooarchaeological assemblages indicate the sustained presence of dogs at human settlements and is well supported by ethnographic accounts discussed previously. Similar to elsewhere in the world (Losey et al., 2011; Morey, 2006, 2010; Waters, 2008), articulated dog skeletons in association with human burials indicate that dogs were often deliberately buried with people (Crockford, 2009). Therefore, a contributing factor accounting for a higher relative abundance of dog remains may be the occurrence of human interments. Since domestic dogs would be commensal species at human settlements, this circumstance may accentuate their presence relative to the proportionality of wild canids given potential offsite hunting, butchery, and transport of wild canids.

Dog remains regularly occur in Northwest Coast mortuary contexts such as cemeteries in coastal shell middens, in association with burial cairns, and in rockshelter/crevice burials (e.g., Curtin, 1998; Cybulski, 1992; Marino, 2015; McMillan and St. Claire, 2005; Digance, 1986; KristensenKira et al., 2009). The earliest Northwest Coast cases of joint human-dog mortuary interments appear ca. 5000 cal BP at Namu on the central B.C. Coast, Ts'ishaa on the west coast of Vancouver Island, and the Pender Canal site along the Salish Sea (Carlson, 1995; Carlson et al., 2017; McMillan and St. Claire, 2005; Frederick and Crockford, 2005). On the north coast of British Columbia, the Tsimshian and Nisga'a reserved special treatment for dogs; they were placed in the same burial grounds as people. Cybulski's excavations (1992:62–67) on the lower Nass River suggested that dogs held special cultural significance and were the most frequent animal interred with people (ca. 1300 cal BP). On the mainland coast of southern British

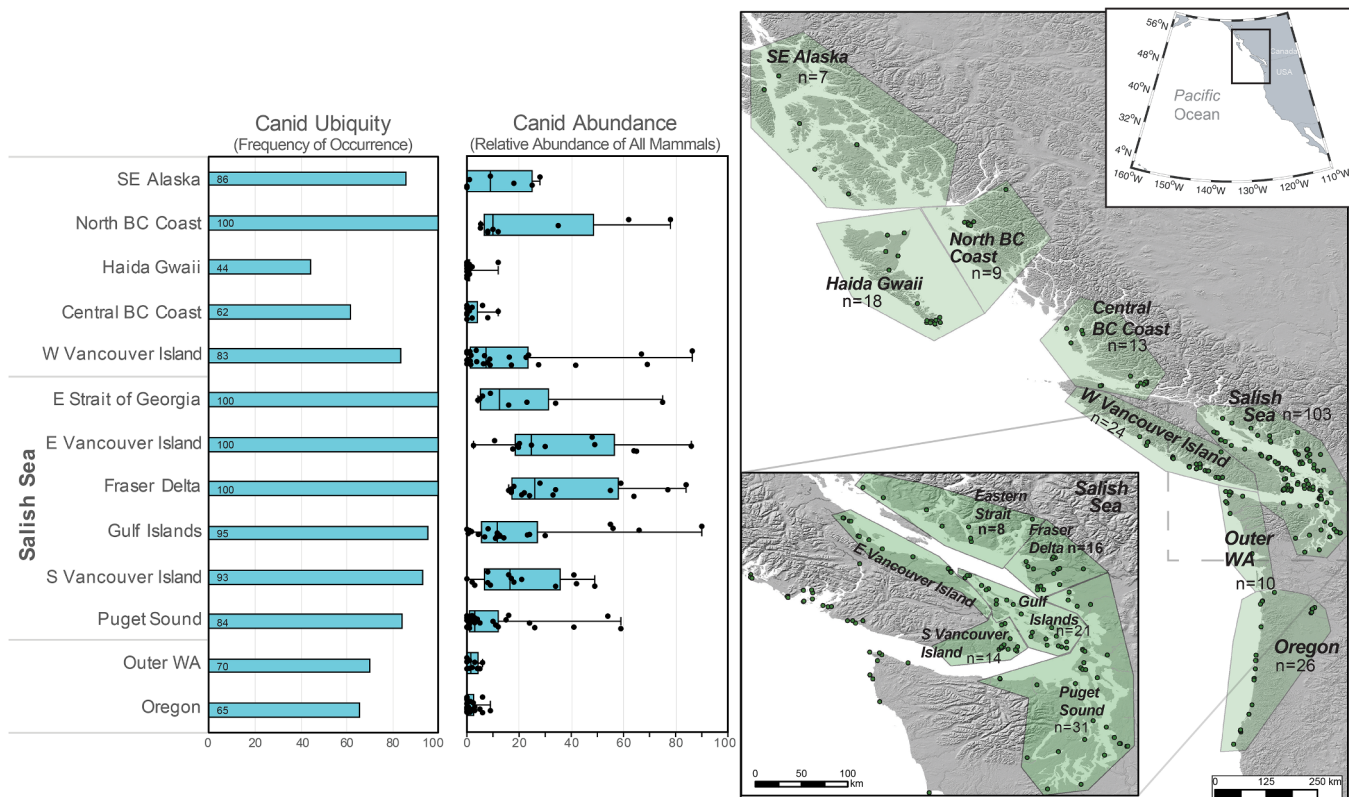


Fig. 3. Percent presence (ubiquity) and relative abundance (% NISP) of canids among the multiple sites within regions of the Pacific Northwest Coast, ordered roughly north to south with inset showing subdivisions within the Salish Sea.

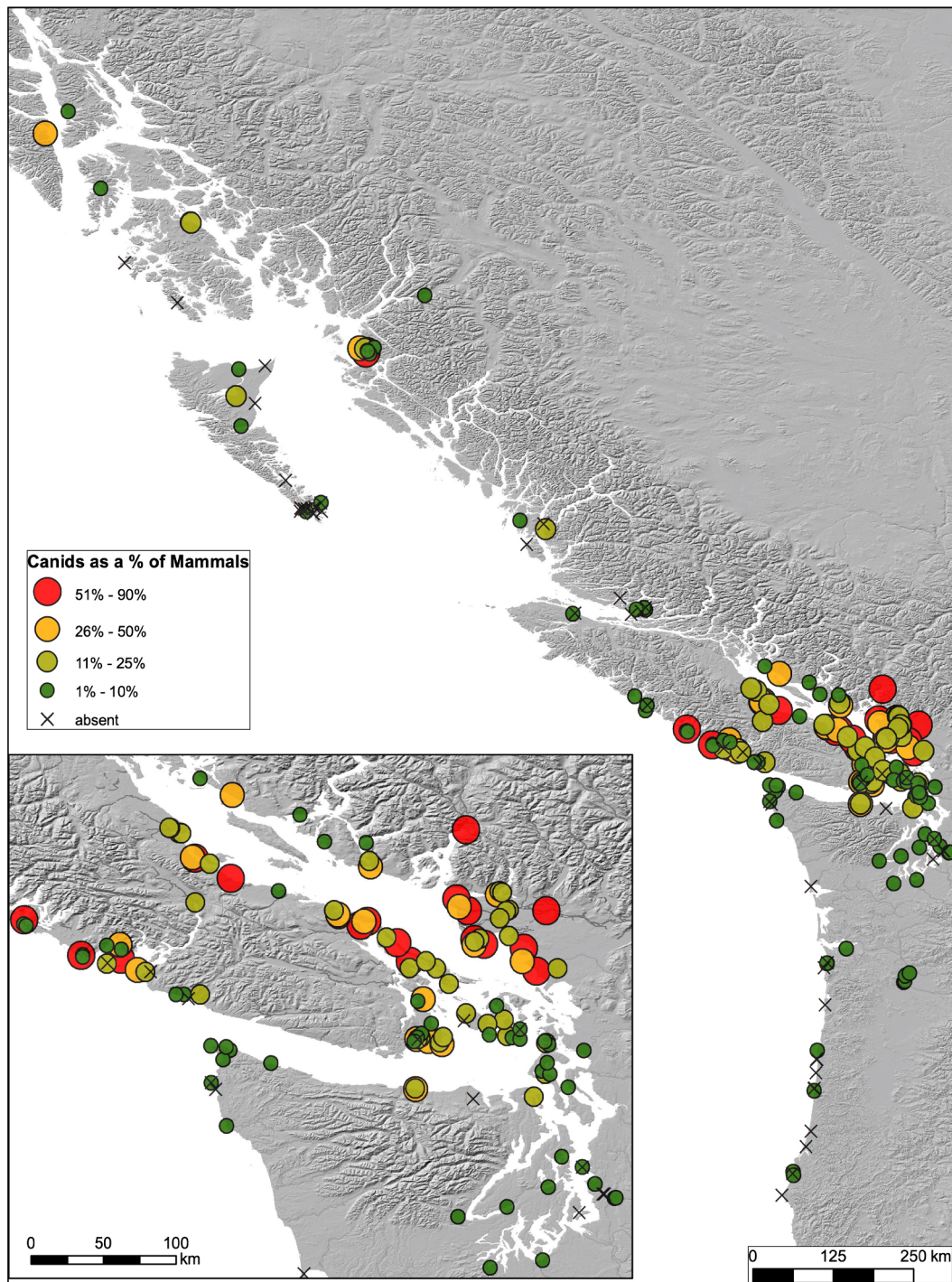


Fig. 4. Relative abundance of the canid remains in archaeological sites from southeast Alaska to Oregon.

Columbia, 10 “intentionally placed” dog crania were found in the lower component of the late-Holocene shell midden at Tsawwassen (Stryd et al., 1994:33–38). Excavators interpreted these remains as related to a Coast Salish first ancestor story in which a dog-husband father’s progeny take human form when they shed their dog-skins (Stryd et al., 1990:112–114).

The seven sites with the highest canid abundance across the coast (over 70%) are also places where excavations encountered multiple interments of ancestral human remains. Five of the seven sites are in separate areas of the Salish Sea in southern British Columbia; Marpole (DhRs-1), St’ames (DkRs-6), Tsable River (DjSf-14), Whalen Farm (DfRs-3), Parry Lagoon (DgRv-6), while the sixth is on Digby Island in Prince Rupert Harbour on the north coast of British Columbia (GbTo-28) and the seventh is located in Tofino on

western Vancouver Island (DgSl-87). Areas within each of these sites appear to have been used as cemeteries where dogs were buried in association with people. The higher canid frequency at these sites further indicates the care for dogs as human companions and individual beings which contrasts with the utilitarian butchery and discard of disarticulated wild taxa. Unfortunately, dog burials are often inconsistently documented (Crockford, 2009) and cannot be readily assessed for all previously excavated assemblages. This topic may reward future investigation.

3.2. Morphometric analyses of Type I and Type II dogs

Crockford (1997) conducted detailed morphometric analysis of a

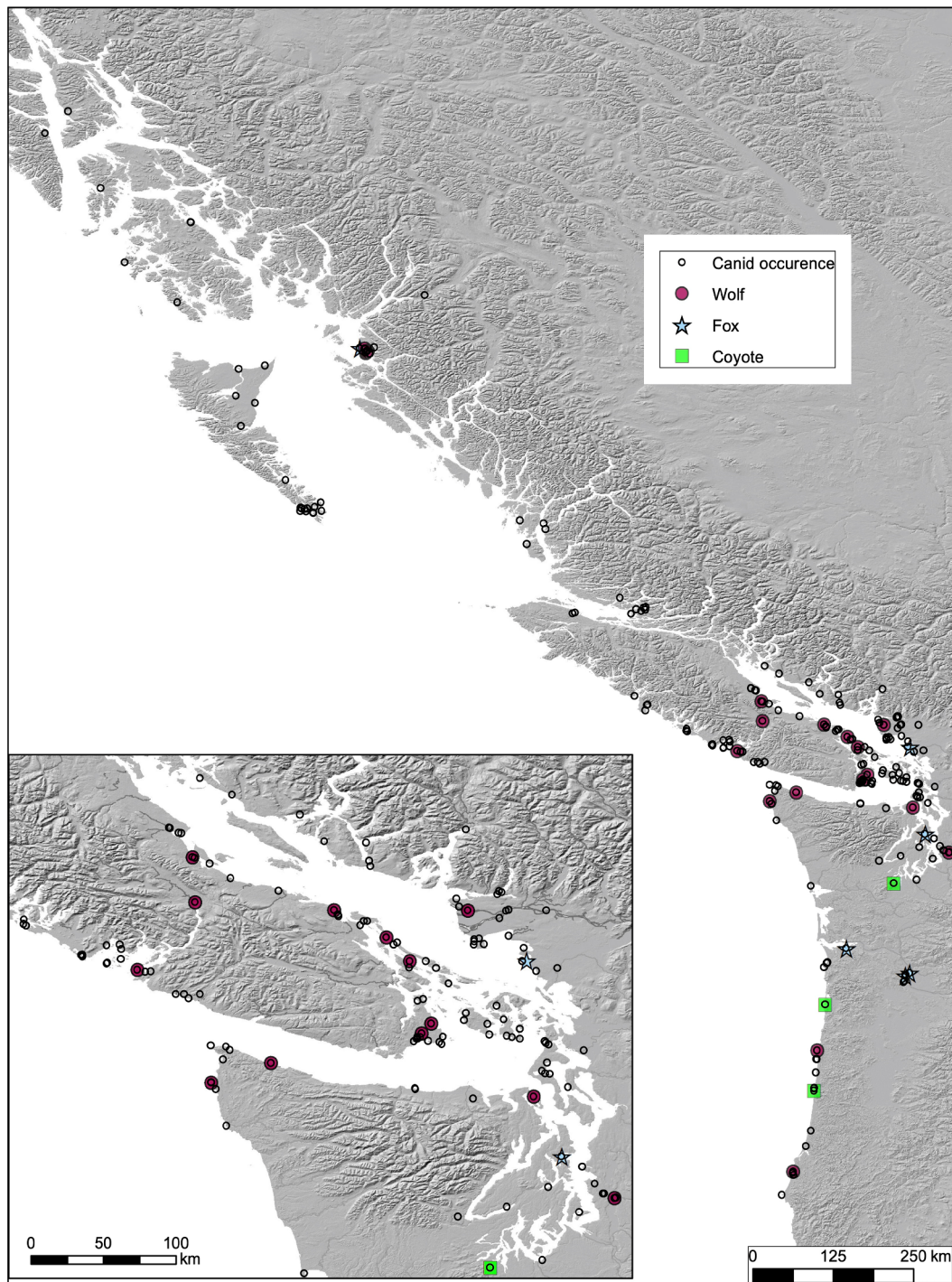


Fig. 5. Geographic distribution of osteologically identified wild canids (wolf/fox/coyote). Open circles show all locations where canid specimens have been identified.

sample of 1069 domestic dog elements at 20 sites in the Coast Salish and Makah region. These data indicate that at least two morphometrically distinct ‘types’ were present in pre-contact archaeological deposits dating to at least 4000 cal BP: the Type I smaller, ‘wool dog,’ and the Type II, larger, ‘village dog.’ Since this study, several analyses following this methodology have been conducted. We compiled these data to increase the sample to 1400 measured elements from 49 sites (Fig. 6). The majority of these sites date within the Late Holocene (< 2500 cal BP) and are situated within the Salish Sea region. The sample also includes 12 multi-component sites with mid-Holocene components (> 2500 cal BP, Table S2) including data from the west

coast of Vancouver Island (Frederick, 2012; Frederick and Crockford, 2005), southeast Alaska (Crockford et al., 2011), and as old as 6000 years ago on the central B.C. Coast (Barta, 2006). Among the 49 assemblages with measurement data, Type I (small dogs) have a higher rank order than Type II specimens in 69% of the 49 sites and this is replicated by the overall proportionality where 58% of the measured specimens are Type I (Fig. 6 and Table S2). This proportionality is similar among the 12 multicomponent sites and the six exclusively mid-Holocene sites, where small Type I dogs each have a higher rank order of 92% and 67% respectively. This indicates that small dogs were consistently more abundant in archaeological contexts spanning the

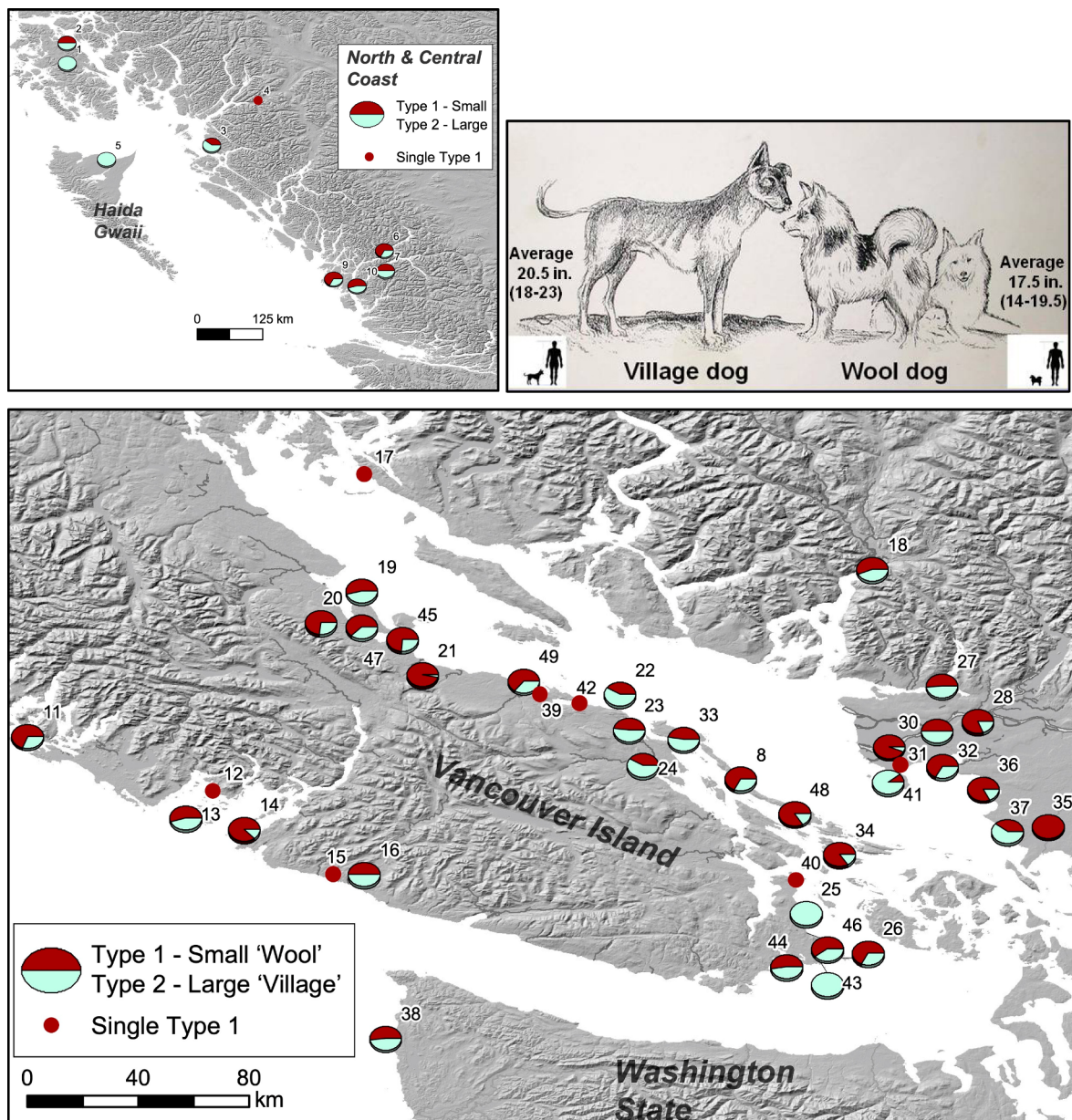


Fig. 6. Proportions of dog types based on osteological measurements in archaeological assemblages on the northern Northwest Coast (top left) and the southern British Columbia Coast and Washington State (bottom). Top right: Forensic illustration of dog types (Village Dog: Type 2, Wool Dog: Type 1) for southern British Columbia and northern Washington State. Illustration prepared by Cameron Pye and annotated in Crockford (2009). See supplementary data for detail on site numbers.

past 5000 years and are geographically associated with higher relative abundance values for canids in southern British Columbia (Fig. 4).

4. Discussion

This compilation of mammalian zooarchaeological data, representing 55 years of research by over 70 analysts working with over 15 comparative collections indicates that canids occur in 82% of adequately quantified assemblages on the Northwest Coast. The single most common species-level designation for canids is domestic dog (62.7%) in contrast to very low frequencies of non-domestic canids (1.0%). This asymmetrical distribution of species-level identifications fails to support the null hypothesis that canids in the region are predominantly 'wild' but conversely indicates that a majority are domestic dogs (*Canis familiaris*). The very low frequency of wolves, foxes, and coyotes is unlikely to reflect inadequate identification of these non-domestic canids

(Crockford, 1997; Driver, 1992; Krantz, 1959). Wolf elements are significantly larger than fully domestic prehistoric-era dogs and foxes tend to be smaller and less robust than domestic dogs (Crockford, 2009; Janssens et al., 2019). There is potential overlap between small 'wool dogs' in southern British Columbia and foxes as well as larger type II 'village dogs' and coyotes but 60% of the sites occur on island settings (Vancouver Island, Haida Gwaii, or other coastal islands) where foxes and coyotes do not occur today. If substantial numbers of foxes, coyotes, and wolves were common in preindustrial Northwest Coast environments in mainland settings and targeted by hunters, then identifications of wild canids would be expected to be considerably higher than observed.

The second largest category, '*Canis sp.*', comprises 45.4% of canid NISP and likely reflects many analysts' reluctance to confidently assign species to canid specimens in the absence of a comprehensive comparative collection containing a range of canid species. Such hesitancy

can persist despite evidence indicating the presence of domestic dogs. For example, Hanson (1995:33) stated that canids at the site of Pender Canal (DhRt-1) “were identified only as *Canis* sp. although most remains are believed to have come from domesticated canids because of the presence of deciduous teeth and the large number of elements from immature animals.” Subsequent re-analysis by Crockford (1997), using a range of comparative specimens and morphometric analyses, confirmed these same specimens as domestic dogs. In this example, Hanson (1995) acknowledged zooarchaeological evidence for domestic dogs, but simultaneously was reticent to assign species. Such an approach is reasonable, especially when working with incomplete comparative collections and following the scientific principle that every new observation warrants analytical independence from previous observations (Driver, 1992; Driver et al., 2011).

Conversely, the large number of sites with domestic dogs may reflect an opposing tendency, whereby canid specimens may have been uncritically designated dogs without sufficient scrutiny. To evaluate this possibility, we examined which comparative collections were used when domestic dogs have been confidently identified ($n = 101$) and note that a majority (54%) used the comparative zooarchaeology lab at the University of Victoria, which has a representative osteological collection of canid specimens, including local pre-contact archaeological specimens and a history of research on this issue. In contrast, the overwhelming majority of assemblages (86%) that did not specify canids beyond the genus or family level did not utilize this comparative collection.

A related explanation for the high number of domestic dog identifications is that the majority of observations may have been early analyses that were uncritically presumed to be domestic dogs. On this point, we note that the majority of assemblages with domestic dogs (62%) were identified after 1993 when zooarchaeological identification of canids became increasingly recognized and scrutinized (Crockford, 1994; Keddie, 1993; Schulting, 1994). Given this, it is unlikely early analyses exhibit a disproportionate influence on subsequent taxonomic designations. For the majority of sites where “*Canis* sp.” identifications occur, only a single taxonomic designation appears (i.e., *Canis* sp. only) rather than multiple designations (i.e., dog and wolf or canid and dog, etc.). The observation that 64% of sites have single taxonomic designations may reflect a hesitancy to identify specimens beyond genus or family when comparative collections are lacking.

Despite osteological similarities and overlapping size ranges between coyote, foxes and domestic dogs, these can be adequately resolved given a representative comparative collection and sufficiently intact skeletal specimens supplemented by geochemical and geomorphometric analyses. We hope this review stimulates further research and scrutiny of skeletal characteristics of canids, including age, sex, element distribution, and body mass (Crockford, 2009; Losey et al., 2017; Marino, 2015; Prentiss et al., 2014). To refine species identification and domesticated breed types, additional comparative specimens at zooarchaeological labs are needed to strengthen analytically independent identifications of faunal remains based on morphological characteristics (Driver, 1992; Lyman, 2002).

The analysis of ancient DNA also lends support for the ubiquity of domestic dogs in archaeological assemblages. In a study of 57 putative dog samples from 13 sites across the Northwest Coast, Barta (2006) confirmed the presence of domestic dogs, multiple dog sizes, as well as a lack of specimens misidentified as coyote, fox or wolf. Barta (2006: 164–165) included assemblages from sites in Haida Gwaii, western Vancouver Island, the central B.C. Coast and the Salish Sea regions with dogs as old as 6000 cal BP. Four recent aDNA studies have confirmed domestic dog identifications in late Holocene sites, from Prince Rupert Harbour, to the Salish Sea and the lower Columbia River (Ames et al., 2015; Ni Leathlobhair et al., 2018; Witt et al., 2015; Zimmerman, 2014). None of these studies indicate that wild canids were misidentified as dog. In contrast, two other coastal studies using aDNA to examine pinnipeds (seals and sea lions) and rockfish (*Sebastes* spp.) have confirmed that while a majority of morphological identifications are accurate, small

numbers of misidentifications also occur (Moss et al., 2006; Rodrigues et al., 2018; see also Nims and Butler, 2017). In the mid-Fraser Canyon of interior British Columbia, only one of five miscellaneous *Canis* spp. specimens subjected to aDNA extraction could not be definitively identified as either wolf or domestic dog and only 6 of 15 miscellaneous *Canis* samples were isotopically identified as wolf (40%) (Tifental, 2016:65). Overall, given the positive identifications of domestic dogs in a number of coastal studies, we surmise that zooarchaeological identifications of canids on the Northwest Coast have been prudent, and that domestic dog identifications are reliable given currently available data. Combined, these factors provide additional evidence that domestic dogs played under-appreciated roles in Northwest Coast economies and societies.

4.1. Wild canids

The geographically restricted archaeological occurrence of coyotes at two sites in southern Oregon and one along southern Puget Sound is broadly consistent with modern studies documenting the westward and northward expansion of coyote populations during the 19th and 20th centuries (Levy, 2012). Prior to the 18th century, the geographic range of coyote populations are hypothesized to have been restricted by the presence of wolves who do not tolerate coyotes but were extirpated from much of western North America by 1900 (Meachen and Samuels, 2012). When wolf populations were eliminated or reduced from much of their former extent by colonial policies and ranchers, coyote populations expanded along human development corridors to colonize much of northern North America (Newsome and Ripple, 2015). Red foxes were present in 16 archaeological sites in eastern Washington which seems to anchor their Holocene occurrence in the interior east of the Cascade Mountains (Lyman, 1991).

The extensive records of the land-based fur trade during the 19th century which document the exchange of pelts obtained and traded by Indigenous hunters and itemized by company employees also yield evidence for canid biogeography (e.g., Cowan, 1938; Mackie, 1997). Coyote, fox, and wolf pelts were not mentioned as traded items in the Fort Langley journals (ca. 1827–1830), which describe regional trade activity across the Fraser Lowland and Salish Sea (MacLachlan, 1998). In contrast, domestic dogs and “dog’s hair blankets” were regularly mentioned in this set of journals. One noteworthy encounter in September 1828 described a visit by “160 canoes” from eastern Vancouver Island [Cowan tribes] where each canoe “seldom contains more than one man with the family, and generally about half a dozen dogs more resembling Cheviot Lambs shorn of their wool” (MacLachlan, 1998: 75). This single event indicates that potentially 960 dogs were being transported across the Salish Sea in the early historic era.

Further south in Puget Sound, coyotes were not mentioned in the Fort Nisqually trading records (ca. 1833–1849) while trade in fox pelts was described as “unusual” and trade in wolves was limited to “less than a dozen hides a year during the Fort’s tenure” (Norton, 1990: 3–4). On Vancouver Island, a Fort Victoria journal entry from September 1848 mentions fox pelts but specifies the source as eastern Washington (Brazier et al., 2018). Biologists and historians have established that coyotes and foxes, as well as a wide variety of other terrestrial mammals, were not historically present on Vancouver Island, the Gulf Islands, and no canids other than domestic dogs were present in Haida Gwaii (Cowan and Guiguet, 1973; Mackie, 1997; Wigen, 2005). Combined, these biogeographic data lend increased confidence to zooarchaeological identifications of domestic dogs, as 60% of the 210 assemblages are on islands where coyotes and foxes do not occur yet canid specimens are reliably documented in 62% of sites ($n = 74$).

Aside from dogs and indeterminate *Canis* sp., the next most abundant identification is for coastal wolves which are present at low numbers in 19 of the 210 sites (NISP = 148). Shoemaker Bay, located in Port Alberni on western Vancouver Island (Calvert and Crockford, 1982), is the only site with a considerable number of wolf bones (NISP = 87), but they are still outnumbered by specimens of domestic dogs (NISP = 229). This single assemblage has the greatest relative

abundance of wolves in the entire dataset (6% NISP of all mammals). This site is situated on tidal flats close to the largest salmon river on western Vancouver Island. A historic account from 1860 describes wolves attacking a European mastiff in the Alberni valley (Sproat, 1868: 242) and today wolves come into periodic conflict with people and domestic animals including predatory attacks on dogs (Bowes et al., 2015; Friis, 1985; Munoz-Fuentes et al., 2009).

The overall paucity of wolves in archaeological contexts is notable considering that coastal wolves are generalist predators who target many of the same species as humans, occupy the same coastal environments (Darimont et al., 2003; Toweill and Anthony, 1988), and occur throughout the study area with the exception of the Haida Gwaii archipelago (Wigen, 2005) and Admiralty, Baranof, and Chichagof islands in southeast Alaska (Alaska Department of Fish and Game, 2012). This strong overlap likely increased frequency of encounters with Indigenous communities. The low frequency of wolves in archaeological sites is broadly consistent with several ethnographic accounts indicating that hunting wolves was not practiced in several regions of the coast (Curtis, 1915:35; Drucker, 1950:175; Suttles, 1974:97).

Combined with the lack of habitat for coyote and fox, the stark absence of wild canids may relate to hunting avoidance and/or cultural protocols, as they are entirely within Indigenous people's technological capacity and skill in hunting. Wolves in particular held significant roles in the cultural belief systems of coastal groups (Ernst, 1952; Sapir and Swadesh, 1955; Swan, 1870:63). Wolves are also totemic animals represented in the moiety-based lineage systems on the northern Northwest Coast including Tlingit, Tsimshian, and Haida (de Laguna, 1972; Swanton, 1908). Wolves are depicted in early Coast Salish mortuary artifacts associated with feeding of the dead (Carlson and Hobler, 1993) and in Nuu-chah-nulth whaling and winter ritual practices (McMillan, 2019:6).

Among interior Salish peoples, coyotes occupied a famous 'trickster' role, had shape-shifting capabilities (Teit, 1917), and played an out-sized role in cultural discourse (Hymes, 1996; Ritchie and Angelbeck, 2020). In the entirely different geographic context of mainland Europe, it is striking that wolves are notably absent in Mesolithic and Neolithic zooarchaeological assemblages where this paucity has been linked to an apparent avoidance of human hunting rather than a lack of wild animals in the landscape (Pluskowski, 2006).

Wolves play a significant role in Nuu-chah-nulth ritual practices and are well represented in art and ceremony (Drucker, 1951; Ernst, 1952; Sapir and Swadesh, 1955) that extends into the archaeological record (McMillan, 2019). Wolves both assisted human hunters in Coast Salish communities but disturbed villages at night as noted by Suttles (1974:97):

"The smaller rodents and rabbits were not used. Foxes, bobcats, and cougars were rarely if ever used before the fur trade. The timber wolf, a huge dark or reddish beast, was of some small positive value in that packs drove deer and elk into the water where hunters could kill them, and of some negative value in that they came to settlements at night and killed dogs."

A cultural rationale for the paucity of wolves in archaeological assemblages may relate to a taboo against killing wolves, at least among some Northwest Coast societies (Curtis, 1915:35; Drucker, 1951:61). For Nuu-chah-nulth in the late 19th century, Sproat (1868: 235) noted that wolves were "seldom shot, as these wild and savage beasts are of little use to the natives, and besides are regarded with superstitious fear." Among Coast Salish communities, Barnett (1955:93) observed:

"Wolves were people. They should never be killed. If a wolf was shot, all its fellows would quickly surround the killer. If the killer was repentant and talked soothingly to them, they went away crying; if not they killed him. Connected with these beliefs was the conviction that sea hunters became killer whales at death, while land hunters were reincarnated as wolves."

A potential interpretation of this description is that strong cultural sanctions against hunting wolves existed in certain areas of the coast

and may have contributed to the lack of wolf specimens in archaeological assemblages. Alternatively, the large number of 'Canis sp.' specimens identified to genus or family may also contain significant quantities of yet-to-be-identified wolf bones.

5. Conclusions and implications for future research

This study has demonstrated that canid remains are ubiquitous in sites throughout the Northwest Coast and comprise significant proportions of mammalian assemblages, particularly in southern British Columbia. The overwhelming majority of species-level morphological identifications are domestic dogs, consistent with previously reported osteometric, stable isotope, and ancient DNA data as well as a large range of ethnographic and historical information. Although a considerable number of canid specimens have not been identified beyond family or genus, we suggest this is due to analysts' lack of access to sufficient comparative specimens. While further research is needed, this study demonstrates that across hundreds of observations over 55 years of research, dogs are very abundant while non-domestic canids are quite rare. Collectively, this shows an enduring pattern of animal domestication and husbandry practices going back at least to the mid-Holocene and larger than appreciated economic and social roles for these commensal animals in Northwest Coast societies. The degree of the importance of wool in southern British Columbia associated with Coast Salish and Nuu-chah-nulth culture areas, appears unique in relation to the archaeological occurrence of dogs globally (e.g., Bethke and Burt, 2020; Losey et al., 2011; Morey, 2006; Shigehara and Hongo, 2000). This has implications for evaluating the extent of domestication and animal husbandry in western North America. Breeding small dogs for the production of wool-and-hair textiles enabled the production of economically valuable material for trade which was further enhanced by transforming such material into elaborately woven blankets well described in ethnographic and contemporary periods among many Salish peoples (Lutz, 2008; Olsen, 2010; Tepper et al., 2017). Although it is unlikely that all archaeological observations of dogs described here represent communities that were actively breeding dogs for wool, those specifically bred dogs would have represented considerable cultural and economic value as would dogs that served as sentinels and hunting companions. The complexity and long-term history of human-canid relationships complements other evidence for active human management of animal and plant communities on the Northwest Coast as represented in part by clam gardens, fishing weirs and traps, estuarine root gardens, camas and wapato harvesting, prescribed burning, and transplantation. Trade networks between communities, perhaps originally established for other commodities, were almost certainly used for redistributing live wool dogs as well as finished blankets and perhaps prepared wool ready for weaving. The elevated abundance of small dogs on the south coast of British Columbia and their association with wool production provides stronger evidence supporting the antiquity of textile weaving within the social economy of both Coast Salish and Nuu-chah-nulth culture areas and provides archaeologists with an even stronger basis for evaluating the variability of material technologies associated with wool-based weaving traditions. This study indicates that such historical legacies, variously represented in political and cultural practices today, were in place for millennia before the introduction of manufactured textiles in the late 18th and 19th centuries on the Pacific Northwest Coast.

CRedit authorship contribution statement

Iain McKechnie: Conceptualization, Methodology, Investigation, Formal analysis, Data curation, Writing - original draft, Writing - review & editing, Visualization, Funding acquisition. **Madonna L. Moss:** Conceptualization, Methodology, Investigation, Writing - original draft, Writing - review & editing. **Susan J. Crockford:** Conceptualization, Methodology, Investigation, Writing - review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary material

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